Decision-support for Optimizing Supply Chain Formation Based on CSET Model

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***Abstract*—Supply chain formation problem is one of the important research topics in e-Commence. In an e-Marketplace where buyers and sellers meet and trade online, dynamic supply chains can be formed among them by mediating agents. SET and CSET are two typical make-to-order supply chain models. CSET represents a scenario that has a central authority in charge of the formation, management and dissolution of a supply chain. The principal authority selects the partners under certain principles which may either aim for maximizing profits of the whole supply chain or for ensuring every partner to receive a job for communal prosperity. In SET, every supply chain partner uses local knowledge to compete for jobs at each supply chain level. We have implemented a Java-based simulator for simulating the process of dynamic supply chain formation. The simulator can operate in both modes whose results may be useful in decision-support in supply chain planning.**

***Index Terms*—CSET model, Automated negotiation, Supply chain, Simulation.**

I. Introduction

Supply chain formation is the problem of determining the production and exchange relationships across a number of companies engaged in coalition. Traditionally, supply chains have been formed and maintained over long periods of time by means of extensive manual efforts, involving a small number of companies at a time [1]. By the advancement of e-Marketplace technology, companies can easily outreach to a large virtual community and stay connected; the process of supply chain formation becomes more dynamic than ever.

This dynamic formation that allows business interactions flexibly and rapidly formed and dissolve can better respond to rapidly changing market conditions. Some models of built-to-order supply chain management have hence emerged. They are characterized by high-speed and automated operations, with an aid of software agents [2, 3]. In particular, agents were used to mediate the formation and subsequent coordination of supply chain. The agents when given a set of jobs which are originated from the clients, they would find a supply chain coalition formation such that the total profits gained from fulfilling the jobs can be maximized subject to agents' resource capacities.

Two general approaches are computation-based and negotiation-based. Computation-based approach extensively considers all the complex factors for finding a solution that would best satisfy some high-level goals. Negotiation-based approach is for companies across each level of a supply chain compete for jobs by their individual efforts.

Techniques and protocols that enable dynamic supply chain formation coalition among agents have been widely proposed in the literature. They are more or less focused on the technical aspects of the formation (integration) and lack of concerns about how a supply-chain would operate as a whole picture. Therefore a high level view would be desired that shows how a dynamic supply chain is formed from selecting the right candidates from all the available parties connected in an e-Marketplace. This view is important because it helps supply chain managers to visualize the anticipated formation outcomes as a decision-support before the implementation.

In this paper, we built a simulator in Java that searches for an optimal dynamic supply chain formation via visualization and computation over many complex factors such as cost, timing, constraints, utilities and satisfactions. The simulator is based on SET model and CSET model [4, 5, 6] that are classical representatives of negotiation-based approach and a hybrid of both approaches respectively.

There are many attributes in a supply chain negotiation; while each entity plays an autonomous role that holds certain deciding factors. A decision-support method based on automated negotiation is applied for optimizing resource allocation in supply chain [7]. However, most methods are relying on the price/cost as the only deciding factor to optimize supply chain formation in negotiation [8, 9]. Our simulator realistically considers several more.

The contribution of this paper is in two-folds. It provides a simulation tool that demonstrates the process of dynamic supply chain formation for decision support. The simulator calculates empirical results in the modes of SET and CSET as anticipated outcomes. The results obtained would be useful in supply chain demand-forest planning, in managing resources as well as references for job allocation.

II. Background

A. Single Machine Earliness/Tardiness (SET) Model

The SET model [9] is a negotiation-based supply model which uses Pareto-optimality in the supply chain automated negotiation. This model aims to solve the allocation problem within dynamic supply chains. It is a scheduling model that considers the earliness costs and tardiness costs in the production of a single machine. Such model is established for make-to-order and for optimizing the supply chain formation using automated negotiation agents.

Fig 2 indicates the overall workflow of SET model, which includes three downstream participants (Orders), three midstream participants (Manufacturers) and four upstream participants (Suppliers). A typical SET workflow is briefly described as the following process:

First step, each order makes a request for an estimate through the Manufacturer Mediator Agent, and then the agent sends order information to all the manufacturers participated in the supply chain. According to the orders which originated from distributors for example, every manufacturer makes a request for an estimate through Supplier Mediator Agent, which sends the orders information to all the suppliers. Then the suppliers make scheduling.

Second step is the scheduling information returning from Suppliers to Orders. Each Manufacturer selects the least supply cost, the agent schedules to send the information to the Orders.

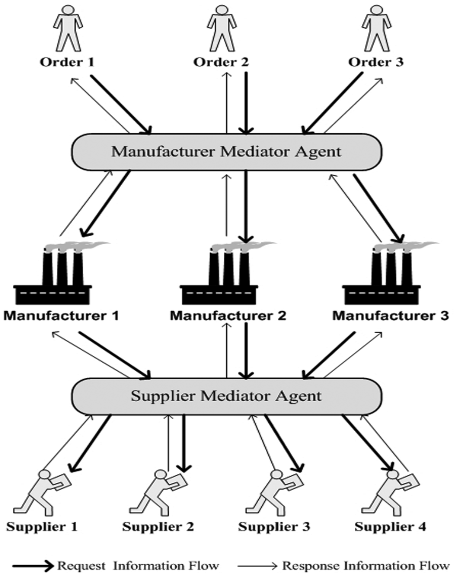


Fig 2. SET Model Order Placement & Manufacturing Process

However, since SET model uses cascading approach to pass information along the supply chain, before making an optimal solution from Mediator-Agents, the information has to be transferred via every participant through each stream back and forth. Usually there are dozens of participants inside a supply chain in an e-Marketplace. Working on SET model is expected to take a lot of time and transfer cost because of the inter-streams connections. As a result, the overall efficiency of supply chain may not be optimal.

B. Collaborative-SET (CSET) Model

CSET model has two functional agents – Pareto-Agent (PA) and Collaborative-Agent (CA). Shown as Fig 3, between every two streams there is a PA running Pareto-optimal computation for resource distributing. With a central CA representing the authority that connects to all the PAs, the information flow is simplified. The optimal resource allocation can be estimated without returning the information back and forth. Comparing SET model and CSET model, the information relaying times are defined as following:

For the SET model, the information transfer times are:

$$2m_1 + 4(m_2 + m_3 + ... + m_n) + 2m_{n+1}$$

For the CSET model, the information transfer times are:

$$m_1 + 2(m_2 + m_3 + ... + m_n) + m_{n+1} + 2n$$

where, m is the number of participants in the same stream

$n+1$ is the number of stream, n>=0

CA plays a coordinator role amongst PAs so that conflicts are avoided during the resource allocating course [4]. As our proposed model, CSET model agents' interactions conversing within a multi-agent system (MAS) [5].

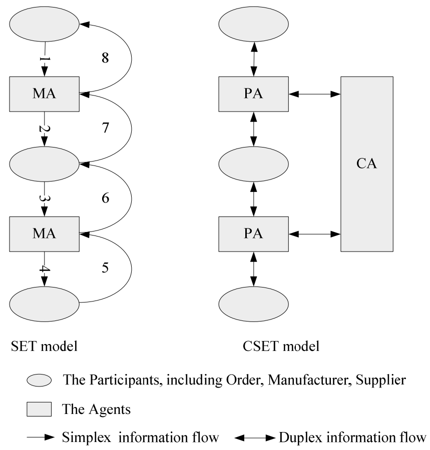


Fig 3. SET and CSET System Structure Specification

In our previous study, we applied Just-in-Time principle [6] as the CA's scheduling algorithm to collaborate with each PA. The original requests are reconstructed as new Sequent Requests according to the JIT algorithm. The new Sequent Requests are utilized as the parameters for Pareto-optimal computation as shown in Fig 4.

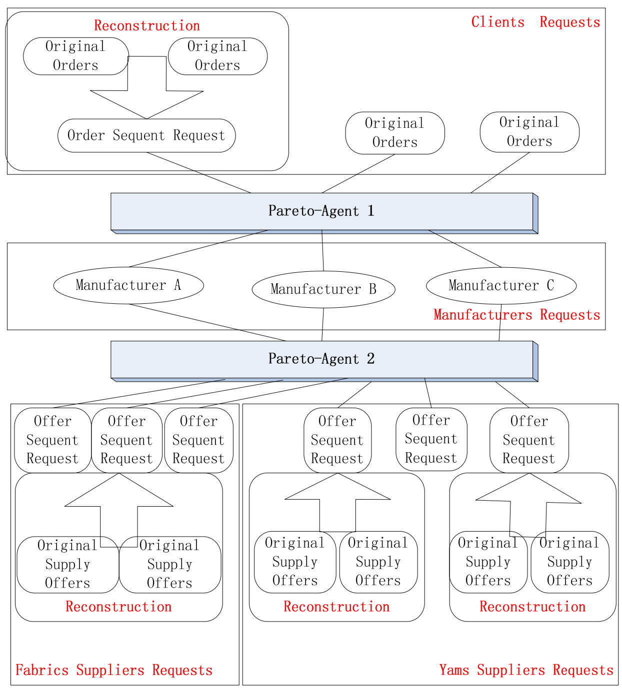


Fig. 4. CSET New Supply Chain Formation Reconstructed

After the requests reconstructing processing, automated negotiating comparison is running amongst the participants. The negotiation is involved in the aspects as shown in Tab 1, including the factors of Time, Cost as well as Satisfaction.

Tab 1. Negotiating Factors

Cost	Fixed	Fabrics Procuring Cost
		Yams Procuring Cost
	Manufacturing	Daily Manuf. Cost × Working Days
	Inventory	Daily Inventory Cost × Inventory Days
	Penalty	Daily Penalty × Penalty Days
	Freight	Fabrics Supplier - Factory
		Yams Supplier - Factory
		Factory - Client
Time	Supply	Fabrics
		Yams
	Start Manuf.	Supply + Freight
	Finish Manuf.	Start Manuf. + Working Days
	Delivery	Finish Manuf. + Freight
	Inventory	Anticipant Delivery - Delivery
	Penalty	Delivery - Anticipant Delivery (Latest Delivery⩾Delivery)
	Freight	Fabrics Supplier - Factory
		Yams Supplier - Factory
		Factory - Client
Satisfy	Global	Minimum Total Cost
	Local Client	Delivery Time
	Local Factory	Profit Margin
	Local Fabrics Supplier	Supply Amount
	Local Yams Supplier	Supply Amount

III. Assumptions

There are four types of entities in e-Marketplace supply chain defined in our simulation, Client, Manufacturer, Supplier and Logistic Provider, each of whom has his specified business goal and attributes. CSET_SIM provides Mediator Machines for the entities. The resource allocation is obtained by the negotiation amongst those agent machines. The demand/supply relationship is linked up by scheduling along the supply chain workflows. Client sends out an order, factory gets this order and estimates manufacturing process. To fulfil the work, factory needs some other raw materials from supplier. Amongst the chain, the freight is provided by Third Party Logistic Provider.

Tab 2. CSET System Required Attributes

Supply Chain Ecosystem			
Client	Manufacturer	Supplier	Logistic Provider
Final Product Amount	Final Product Amount	Max Raw Material Supply Amount	Unit Delivery Time
Anticipant Delivery Time	Raw Material Amount	Supply Time	Unit delivery Price
Latest Acceptable Delivery Time	Manuf. Ratio	Raw Material Price	
Location	Location	Location	
Daily Penalty	Daily Manuf. Cost		
Final Product Price	Daily Inventory Cost		
	Working Duration		

From Tab.2, each entity has his own attributes, while all entities together form the supply chain in an e-Marketplace.

A. Client

Client is the order request initiator. He sends the order into a supply chain, and expects his order to be fulfilled on time. He is an independent entity and has the following characteristic attributes:

Amount is the quantity of final product that the client proposes to purchase. *Location* is where the client is. It is used to calculate 3PL delivery cost. *Anticipant Delivery Time* is the expecting due date by which the final product shall be delivered. Before the date, the client refuses to receive the goods from its upstream due to storage space contention. *Latest Acceptable Time* is the latest delivery date which the client is willing to accept the goods. However, if the delivery is later than anticipant delivery time, manufacturer shall pay the Penalty. In other words, the delivery date between the anticipant delivery time and latest acceptable time is the acceptable zone; otherwise, the delivery is rejected. When this happens, the manufacturer shall bear with the loss by himself. *Daily Penalty* is the penalty for late delivery per day. *Price* is the final product procurement price.

B. Manufacturer (Factory)

Manufacturer is the factory that implements the manufacturing work. He is the midstream between the downstream client and upstream supplier. He is responsible for converting raw material into final product, and expects to gain profit in the manufacturing processing. His characteristic includes:

Final Product Amount is outbound final product amount which factory is able to provide. *Raw Material Amount* is the inbound raw material amount which factory needs to fulfil the manufacturing. *Manufacturing Ratio* is the ratio of final products and raw materials amount. For instance, one unit amount of final product comes from two of raw material A, and one of raw material B, the manufacturing ratio is Final Product : Raw Material A : Raw Material B = 1:2:1. *Location* is the location where the factory is. It is used to calculate 3PL delivery cost. *Working Duration* is the manufacturing period. *Daily Manufacturing Cost* is the manufacturing cost that factory has to suffer per day. *Daily Inventory Cost* is the cost of inventory that factory has to suffer per day for final product storing.

C. Raw Material Supplier

Raw Material Supplier is accountable to providing raw material to manufacturing factory. His characteristic are:

Max Supply Amount is maximum raw materials supply amount to be provided to manufacturer. *Supply Time* is date when supplier is able to provide the supplement. *Location* is the location where the supplier is. It is used to calculate 3PL delivery cost. *Price* is the raw material supplying price.

D. Third-Party Logistic Provider (3PL)

3PL is accountable to the freight amongst clients, factories and suppliers. It has the following attributes:

Delivery Price is the cost in terms of distance and goods weight. *Delivery Time* is the delivery time in relation to the distance between start point and destination.

For optimal supply chain formation, there are many complex factors in an e-Marketplace, most of which are flexibly changeable. We make the assumption that: The trading contract between Factory and Suppliers is Free-on-broad (FOB), which means the freight cost is incurred by factory. The factor between Factory and Client is Cost-and-Freight (CFR), which means the freight cost is also bear by factory. In summary, factory is responsible for paying all delivery bills.

IV. Definitions

Generally, there are five kinds of cost to be computed in our supply chain simulator: *Fixed Cost, Manufacture Cost, Inventory Cost, Penalty Cost as well as Freight Cost*. The sum of them is so called the total cost.

Fixed Cost is the cost for raw material procuring.

$$f_{FixedCost} = \sum_{i=1}^{x} Price_i \times Amount_i$$

where x is the total number of suppliers

Manufacturing Cost is the cost of manufacturing final products from the raw materials.

$$f_{ManufCost} = \sum_{j=1}^{m} (Duration_j \times DailyCost_j)$$

where m is the total number of manufacturers

Inventory Cost shall be paid in the case that, if the factory deliveries the final product earlier than the client's anticipant delivery time, the delivery is refused by client. Thus the factory must suffer the inventory cost in this duration.

$$f_{InventoryCost} = \sum_{j=1}^{m} (DailyCost_m \times StorageDay_m)$$

Penalty Cost shall be paid in the case that, if the factory delivery time is later than client's anticipant delivery time while no later than his latest accepted time, the product is accepted by the client but with some penalty. Likewise, the factory delivery time is evaluated by finishing time and 3PL delivery time.

$$f_{PenaltyCost} = \sum_{j=1}^{m} (DailyPenaltyCost_m \times PenalDay_m)$$

Freight Cost is the cost that factory shall suffer by itself. The cost includes that from Supplier to Factory and Factory to Client.

$$f_{FreightCost} = \sum_{j=1}^{m} (amt_m \times distance_m \times unitCost_m)$$

A Global Scheme Satisfaction (GSS) is derived from the total cost calculation, which also reflects the supply chain total productivity. The Utility Function of GSS is:

$$Min \sum_{n=1}^{p} \begin{pmatrix} FixedCost_n + ManufCost_n + InventoryCost_n \\ + PenaltyCost_n + FreightCost_n \end{pmatrix}$$

where n is the number of resource allocation

$$U_{GSS}(Cost_x) = 100 \bullet \left(\frac{Cost_{Max} - Cost_x}{Cost_{Max} - Cost_{Min}}\right)$$
$$U_{GSS}(Cost_x) \in [0, +100]$$

Seeking for a Pareto-optimal resource allocation not only do we consider the total productivity but also the entities' satisfactions. For different types of participants, their satisfactions are specified in terms of different factors. We defined those factors as three Local Scheme Satisfactions (LSS). They are:

- The Client's Scheme Satisfaction (CSS);
- The Manufacturer's Scheme Satisfaction (MSS);
- The Supplier's Scheme Satisfaction (SSS).

CSS is calculated by the time factors. CSS utility value is ranging from -100 to +100; however, we only take the positive values as the client's satisfaction value. CSS function is defined as:

$$U_{CSS}(DeliveryTime_x) = 100 \bullet \left(\frac{LatestAcceptableDeliveryTime - DeliveryTime_x}{LatestAcceptableDeliveryTime - AnticipantDeliveryTime}\right)$$
$$U_{CSS}(DeliveryTime_x) \in [0, +100]$$

SSS can be deduced as the supplying amount. The more raw material amounts supplier offers, the more profit he can gain. For this reason, SSS function is:

$$U_{SSS}(SupplyAmount_x) = \frac{SupplyAmount_x}{MaxSupplyAmount} \times 100$$

MSS is determined by the profit margin. For every factory, profit margin is a vital measurement of benefit. Gaining the maximum profit margin is the business goal for factories. Hence, MSS function is:

$$U_{MSS} = \frac{Sales - Cost}{Sales} \times 100$$
$$f_{SALES}(ProductAmount, Price) = ProductAmount \times Price$$

It is assumed that there is no preference bias amongst each individual in the same stream. Therefore, all resource allocations are competitive. $Allocation^*$ is defined as the fairness principle allocation. Compared with one resource allocation to the others, the $Allocation^*$ with a higher satisfaction of the four schemes than any other $Allocation_x$ can be found as the Pareto-optimum. The formula is shown as following:

$$\begin{aligned} &Utility(Allocation_x) = \\ &\quad GSS(Allocation_x) \wedge CSS(Allocation_x) \wedge \\ &\quad MSS(Allocation_x) \wedge SSS(Allocation_x) \end{aligned}$$

M is the marginal minimum acceptable utility. For each utility function, *M* is set as a different value by the individuals, thus Pareto-optimal allocation shall meet the following conditions:

$$Utility(Allocation^*) \geq Utility(Allocation_x)$$
$$Utility(Allocation^*) = MAX(Utility(Allocation_x))$$
$$MAX(Utility(Allocation_x)) =$$
$$(CSS(Allocation_x) \geq M_{CSS}) \wedge (MSS(Allocation_x) \geq M_{MSS}) \wedge$$
$$(SSS(Allocation_x) \geq M_{SSS}) \wedge (CSS(Allocation_x) \geq M_{CSS}) \wedge$$
$$MAX(GSS(Allocation_x))$$

The following pseudo code presents about how CSET_SIM system processes the above algorithms:

```
int PossAllo# // total number of possible allocations
int M_CSS , M_MSS, M_SSS // distinct M for each local satisfaction

FOR (int i=1;i<PossAllo#; i++)
{
 Calculate allocation_i relevant negotiation attributes;
}

For (j=1; j< PossAllo# , j++)
{
  IF (CSS_i >= M_CSS and MSS_i >= M_MSS and SSS_i >= M_SSS)
  {
     THEN Save allocation_j into
            Table_Local_Availible_Allocation;
  }
  ELSE
  {
  Drop allocation_j;
  }
}
SELECT Allocation_X with the Minimum Total Cost
FROM Table_Local_Availible_Allocation as result;
```

In terms of the Pareto-optimal algorithm, the resource allocation result is preferred by all participants, so that no one will be defeated in the competition consequently. In other words, Pareto-optimal algorithm plays a significant role for seeking a win-win situation in the supply chain sourcing.

V. CSET SIMULATION

CSET_SIM is developed by Java. The relevant algorithms are packaged as Java API, which are called in Java Server Pages (JSP) Graphic User's Interface (GUI). CSET_SIM composes of three parts: Mediator-agent, Negotiation-agent and Analysis-agent. Mediator Agent works as the information collector. In terms of different data input, system establishes the testing template as the resource set automatically. Negotiating Agent implements the automated negotiation in the lights of the created template. The Pareto-optimal resource allocation is found consequently. Analysis-agent is responsible for generating visualization result for decision support.

A. Mediator-agent

Mediator-agent is presented by JSP GUI. It is a web-based application that is responsible for gathering negotiation parameters from entities. In experiment we use the data shown in Tab 3, which is applied for a Sports Wear marketplace derived from a US textile industrial survey [10].

TAB 3.1. CLIENTS' ORDERS PARAMETERS

ID	AMOUNT (KG)	ANTICIPANT DT (DAY)	LATEST ACCEPT DT (DAY)	LOCATION (KM)	PENALTY ($/DAY)
1	3000	20	24	100	3000
2	4500	22	24	150	3300
3	2000	20	24	100	3000
4	6000	25	27	200	3500

TAB 3.2. FABRICS SUPPLIERS' SUPPLY REQUESTS PARAMETERS

ID	MAX SUPPLY AMT	SUPPLY TIME	LOCATION
1	3000	12	100
2	6000	13	150
3	7000	10	120
4	5000	12	100

TAB 3.3. MANUFACTURE FACTORIES' JOB REQUESTS PARAMETERS

ID	MAX FINAL PROD	MANUF. RATIO F:Y	WORK DAYS	MANUF. COST ($/DAY)	STORAGE COST ($/DAY)	LOC
1	6000	1:1:1	8	1100	1800	100
2	8000	1:1:1	10	1200	1850	120
3	10000	1:1:1	13	1350	1780	110

TAB 3.4. OTHER NEGOTIATING PARAMETERS

ATTRIBUTES	VALUES
PRODUCT PRICE ($/KG)	800
3PL PRICE ($/KG*KM)	2
FABRICS PRICE ($)	150
3PL TIME (DAY/1000KM)	1
YAMS PRICE ($)	40

For different participants, the system provides a distinct GUI. For instance, clients' information, such as Order Amount, Location, Expecting Delivery Time, Latest Acceptable Delivery Time and Daily Penalty, is collected by Client's IC as a part of attributes to run Pareto-optimal improvement shown in Fig 5. In addition, an Electronic Order is generated to be transferred to Negotiation-agent. (Fig 6)

Likewise, Factories' and Raw Material Suppliers' information are collected by Factory's IC and Supplier's IC respectively. They are represented by electronic request and offer, and then transferred to Negotiation-Agent.

B. Negotiation-agent

In electronic copy of request collected from Mediator-agent, Negotiation-agent creates overall information of the original supply chain (Fig 7). System implements relevant algorithms of Pareto-optimality automatically. And then system reflects the textural result of utilities and cost shown as Fig 8, which contains each kind of utilities values and costs.

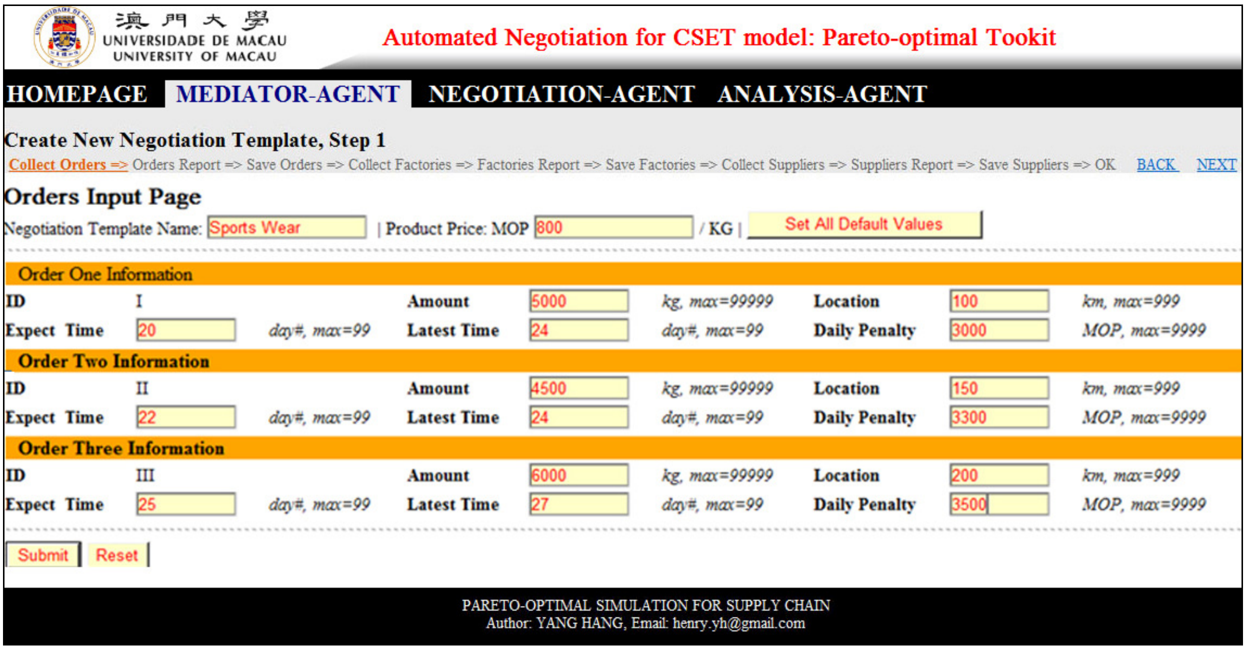
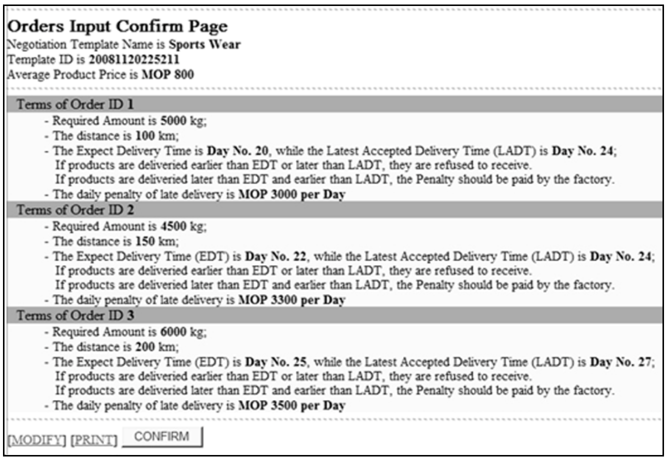


Fig 5. Mediator-agent: Client's Information Collection



Orders Input Confirm Page
Negotiation Template Name is **Sports Wear**
Template ID is **20081120225211**
Average Product Price is **MOP 800**

Terms of Order ID 1
- Required Amount is **5000** kg;
- The distance is **100** km;
- The Expect Delivery Time is **Day No. 20**, while the Latest Accepted Delivery Time (LADT) is **Day No. 24**;
  If products are deliveried earlier than EDT or later than LADT, they are refused to receive.
  If products are deliveried later than EDT and earlier than LADT, the Penalty should be paid by the factory.
- The daily penalty of late delivery is **MOP 3000 per Day**

Terms of Order ID 2
- Required Amount is **4500** kg;
- The distance is **150** km;
- The Expect Delivery Time (EDT) is **Day No. 22**, while the Latest Accepted Delivery Time (LADT) is **Day No. 24**;
  If products are deliveried earlier than EDT or later than LADT, they are refused to receive.
  If products are deliveried later than EDT and earlier than LADT, the Penalty should be paid by the factory.
- The daily penalty of late delivery is **MOP 3300 per Day**

Terms of Order ID 3
- Required Amount is **6000** kg;
- The distance is **200** km;
- The Expect Delivery Time (EDT) is **Day No. 25**, while the Latest Accepted Delivery Time (LADT) is **Day No. 27**;
  If products are deliveried earlier than EDT or later than LADT, they are refused to receive.
  If products are deliveried later than EDT and earlier than LADT, the Penalty should be paid by the factory.
- The daily penalty of late delivery is **MOP 3500 per Day**

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Fig 6. Mediator-agent: Client's E-Order

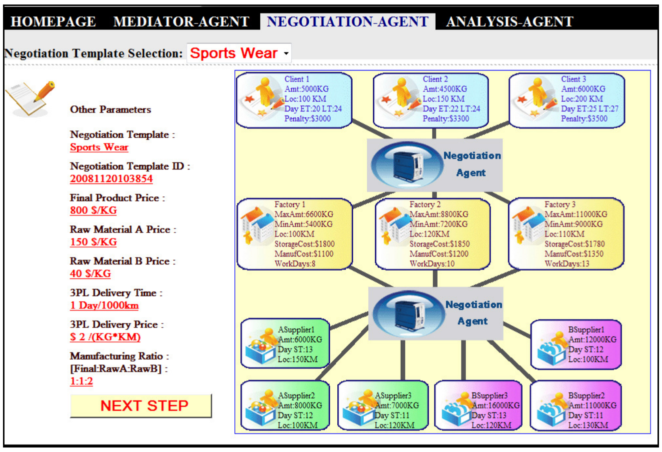
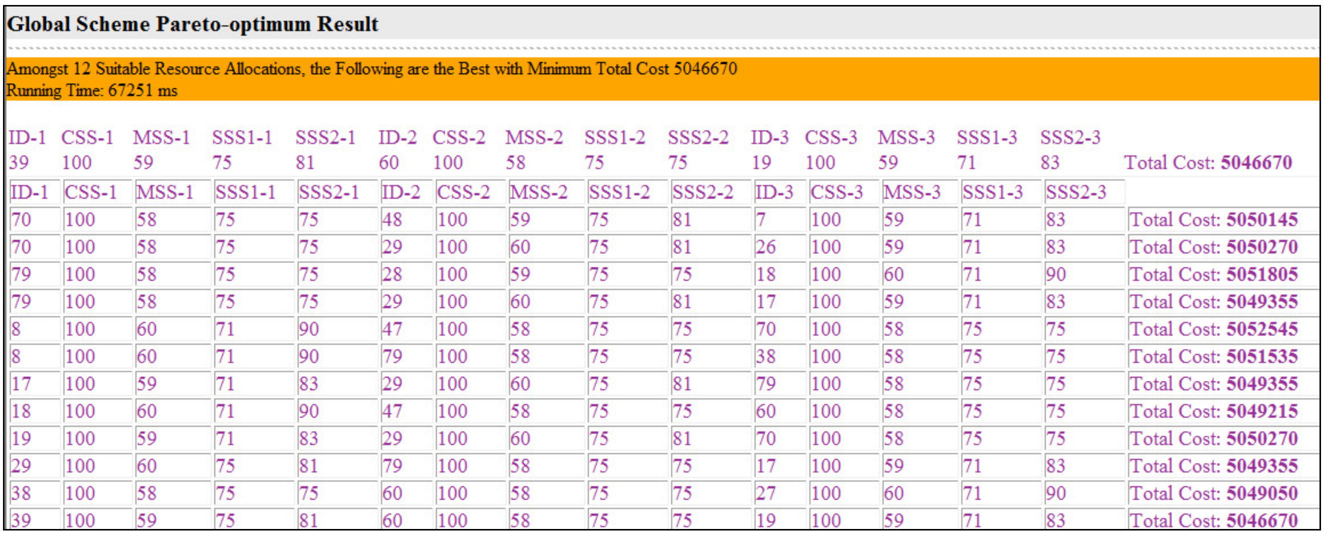


Fig 7. Negotiation-agent: Client's E-Order



Global Scheme Pareto-optimum Result

Amongst 12 Suitable Resource Allocations, the Following are the Best with Minimum Total Cost 5046670
Running Time: 67251 ms

ID-1	CSS-1	MSS-1	SSS1-1	SSS2-1	ID-2	CSS-2	MSS-2	SSS1-2	SSS2-2	ID-3	CSS-3	MSS-3	SSS1-3	SSS2-3	
39	100	59	75	81	60	100	58	75	75	19	100	59	71	83	Total Cost: **5046670**

ID-1	CSS-1	MSS-1	SSS1-1	SSS2-1	ID-2	CSS-2	MSS-2	SSS1-2	SSS2-2	ID-3	CSS-3	MSS-3	SSS1-3	SSS2-3	
70	100	58	75	75	48	100	59	75	81	7	100	59	71	83	Total Cost: **5050145**
70	100	58	75	75	29	100	60	75	81	26	100	59	71	83	Total Cost: **5050270**
79	100	58	75	75	28	100	59	75	75	18	100	60	71	90	Total Cost: **5051805**
79	100	58	75	75	29	100	60	75	81	17	100	59	71	83	Total Cost: **5049355**
8	100	60	71	90	47	100	58	75	75	70	100	58	75	75	Total Cost: **5052545**
8	100	60	71	90	79	100	58	75	75	38	100	58	75	75	Total Cost: **5051535**
17	100	59	71	83	29	100	60	75	81	79	100	58	75	75	Total Cost: **5049355**
18	100	60	71	90	47	100	58	75	75	60	100	58	75	75	Total Cost: **5049215**
19	100	59	71	83	29	100	60	75	81	70	100	58	75	75	Total Cost: **5050270**
29	100	60	75	81	79	100	58	75	75	17	100	59	71	83	Total Cost: **5049355**
38	100	58	75	75	60	100	58	75	75	27	100	60	71	90	Total Cost: **5049050**
39	100	59	75	81	60	100	58	75	75	19	100	59	71	83	Total Cost: **5046670**

Fig 8. Negotiation-agent: Negotiating Processing

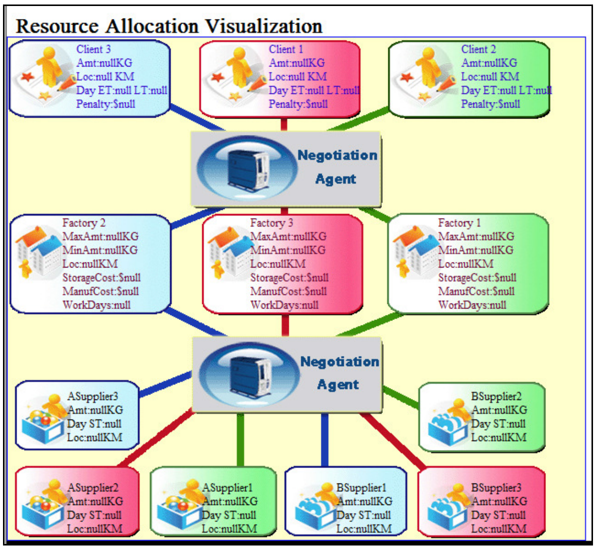


Fig 9. Analysis-agent: Resource Allocation Visualization

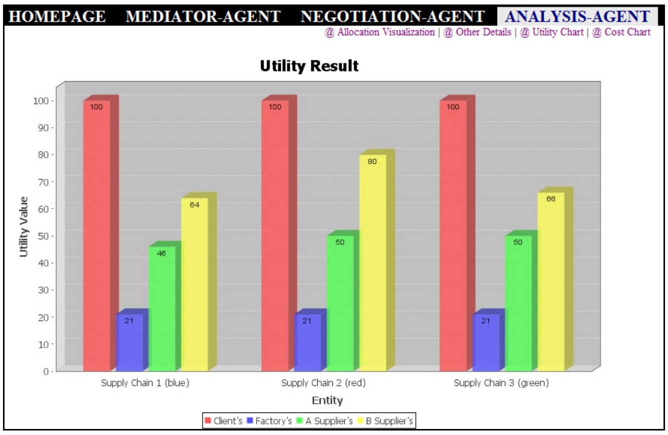


Fig 10. Analysis-agent: Utilities Result

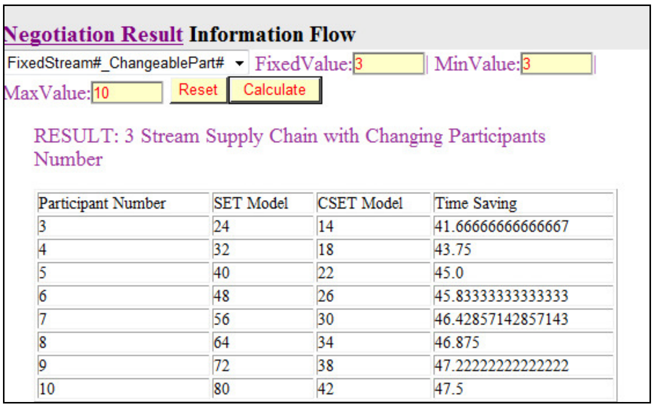
C. Analysis-agent

Analysis-agent is accountable for generating visualization results from the negotiation recourse. Firstly, the allocation result is presented by image shown in Fig 9, which obviously shows the supply chain relationship amongst every entity. As a result, through Negotiation-agent computation, original supply chain decomposes to three sub-supply-chains, for instance, one of which is consisted of Client 1, Factory 3, A Supplier 2 and B Supplier 3, shown in dark grey in Fig 9.

Also, the utilities result is represented graphically by Analysis-agent (Fig 10). By the Pareto-optimal algorithm, each entity is able to receive a fair allocation that no one fails to gain a job. For those three sub-supply chains, all clients' orders are fulfilled in time (100% utility), meanwhile, the raw material suppliers can also benefit from the resource allocation, for example in the first sub-supply-chain, Raw Material A Supplier can achieve 46% of his inventory while Raw Material B Supplier does 64%; consequently, the allocation brings profit margin at the level of 21% for the factory. Furthermore, the utilities of each sub-supply-chain are similar so as to guarantee the fairness.

In addition, amongst all allocating choices, the result comes with the minimum total cost, which is the sum of three sub-supply-chains (supply chain 1: 131772; supply chain 2: 125600; supply chain 3: 125760). CSET's has a relatively lower cost than most possible supply chain formations.

Besides the analysis on the basic of resource allocation result, CSET_SIM provides the information flow transferring comparison of CSET model and existent SET model. See from Fig 11 with the number of entities of the same stream growing, obviously, the transferring flow of CSET model is much less than that of SET model. With reference of Fig 11, Fig 12 shows the transferring flow saving. We observed that the time saving keeps an increasing trend with the number of entities of the same stream rising.


Negotiation Result Information Flow

FixedStream#_ChangeablePart# FixedValue: 3 MinValue: 3 MaxValue: 10 Reset Calculate

RESULT: 3 Stream Supply Chain with Changing Participants Number

Participant Number	SET Model	CSET Model	Time Saving
3	24	14	41.66666666666667
4	32	18	43.75
5	40	22	45.0
6	48	26	45.83333333333333
7	56	30	46.42857142857143
8	64	34	46.875
9	72	38	47.22222222222222
10	80	42	47.5

Fig 11. Analysis-agent: Fixed Stream# but Changing Entities#

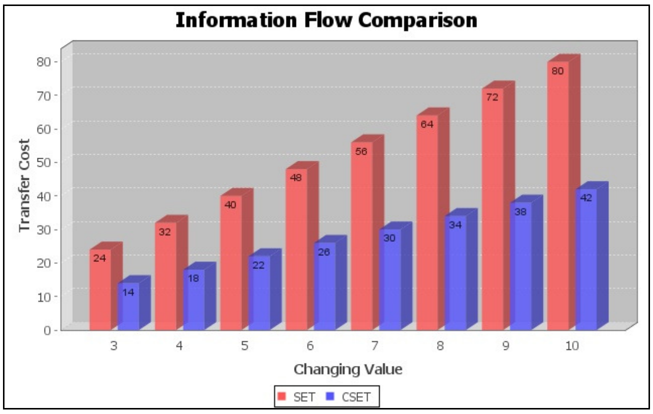
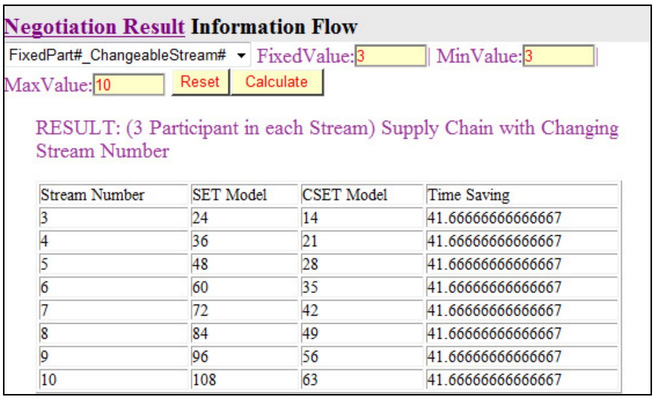


Fig 12. Analysis-agent: Information Flow Comparison of Fixed Stream#

Likewise the analysis on the basic of resource allocation result, CSET_SIM also provides the information flow transferring comparison of fixed stream number with the increasing entities number in the same stream between CSET model and existent SET model (Fig 13). See from Fig 14, the transferring flow of CSET model is also much less than that of SET model. Similar we noticed that the time saving keeps an increasing trend with the number of entities of the same stream rising in Fig 11 while the trend is relatively stable in Fig 13.


Negotiation Result Information Flow

FixedPart#_ChangeableStream# FixedValue: 3 MinValue: 3 MaxValue: 10 Reset Calculate

RESULT: (3 Participant in each Stream) Supply Chain with Changing Stream Number

Stream Number	SET Model	CSET Model	Time Saving
3	24	14	41.66666666666667
4	36	21	41.66666666666667
5	48	28	41.66666666666667
6	60	35	41.66666666666667
7	72	42	41.66666666666667
8	84	49	41.66666666666667
9	96	56	41.66666666666667
10	108	63	41.66666666666667

Fig 13. Analysis-agent: Fixed Entities# but Changing Stream#

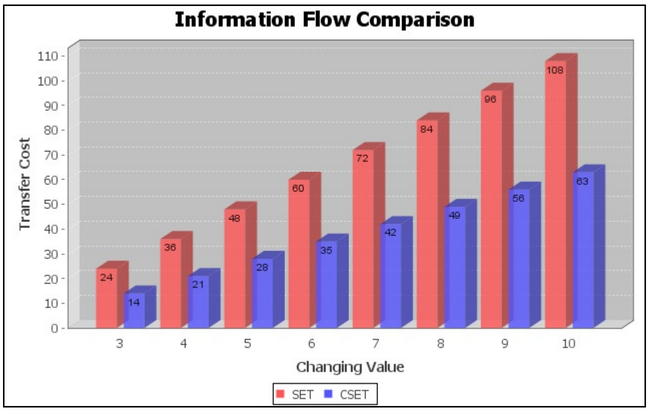


Fig 14. Analysis-agent: Information Flow Comparison of Fixed Entities#

VI. Conclusion

A supply chain is a network of production and exchange relationships that spans across multiple levels of production. High-speed networks and software agent technology cultivate e-Marketplace where dynamic supply chains can be easily formed online. While most research in the past focused on technical issues such as B2B integration and supply chain processes automation, the acceleration of commercial decision making is creating a need for more advanced support.

Companies that capitalize on B2B commerce are basing their business models on rapid development, make-to-order, and customized products to satisfy ever-changing consumer demand. And fluctuations in resource costs and availability mean that companies must respond rapidly to maintain production capabilities and profits. As these changes increasingly grow at speed, scale, and complexity unmanageable by humans, the need for automated dynamic supply chain formation becomes crucial.

This paper looked into the problem of supply chain formation based on CSET model. We implemented a Java simulator called CSET_SIM to simulate information flow in CSET model as well as calculating the Satisfaction Utilities that serves as a benchmark of feasibility for a possible formation and job allocation mode. As a decision-supporting tool, CSET_SIM is established by three intelligent agents: Mediator-agent, Negotiation-agent and Analysis-agent. By the interactions of these three agents, the results of a particular supply chain formation are computed, from which we can search for configuration that yields the maximum overall utilities and minimum total cost.

Furthermore, Analysis-agent shows that CSET model generated approximately 45% less information flow when compared to SET. Various visualization charts and data displays offered by the simulator should provide some insights on the operation of supply chains when it comes to the decision-support in forecast planning for supply chain managers.

In terms of the Pareto-optimal principle in CSET model, everyone is able to obtain a job in resource allocating. Consequently, no one will suffer a loss so as to create a win-win situation across each level of supply chain. Although we illustrated one example derived from a recent survey of a Textile industry, it is believed that the simulator will cater for other industries and supply chain planning scenarios of various sizes.

VII. References

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