E-Procurement in Catalogue Based E-Marketplace by Multi Agent Approach

Paolo Renna, DIFA – University of Basilicata, Potenza, Italy, paolo.renna@unibas.it

Abstract

The research presented in this paper proposes an innovative agent-based approach for planning and "no-negotiation" approach in catalogue based e-marketplace. In e-marketplace, production planning tools allow creating a link between commercialization and production activities providing a better service for the customer and for the supplier. On the other hand, negotiation tools allow making transactions able to take into account buyer's and seller's identities and goals, providing a better global satisfaction. The paper proposed an approach based on a single round among customer and suppliers to reach an agreement. The purposes of this approach are to reduce the time to reach an agreement and to reduce the behavior information to set for the agents. A discrete event simulation environment has been developed in order to test the proposed approach. The performance of the proposed approach are compared with a negotiation approach as a benchmark. The simulation results show that the proposed approach outperforms the negotiation approach.

Keywords: E-marketplaces, Multi Agent Systems, Production Planning, Discrete Event Simulation

1. The Reference Context

The recent development of Information and Communication Technologies (ICT) is deeply changing the way to do business for several manufacturing companies. Especially, Business-to-Business (B2B) applications are demonstrating the capacity to provide real value to manufacturing industries by allowing industry global performance to increase. A recent research of The Forrester group has projected that business transactions over the Internet will have a value of 7000 billion US dollars i.e. the 8.6% of the global sales of goods and services by the end of 2004 [1].

According to Favier [2] most of the B2B applications are procurement-oriented (such as e-marketplace) and their main added value lies on the possibility to expand the seller business and to save procurement costs for buyers. Researchers and consulting companies agree that e-marketplaces are the most promising and profitable B2B applications. Specifically, a comparison research from Jupiter Communications [3] estimates that in 2004 the transactional volume for B2B e-marketplace will reach an amount ranged among 2.071 and 7.300 billions of US dollars.

E-marketplace can be classified according to the buying behavior in MRO Hubs, Catalogue, Yield Managers and Exchange, according to whom the buyers are in Horizontal and Vertical e-marketplace, and on the centricity base in Buyer Centric, Seller Centric, Neutral linear and Neutral exponential [4].

In particular, the context authors are concerning with is a private neutral linear e-marketplace owned by a third part where a set of registered buyers, customers, and a set of registered sellers, suppliers, are allowed to play procurement actions. Examples of such e-marketplace are CPGmarket, Tribon Marketplace, ChemConnect, etc…

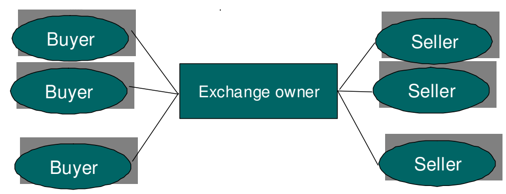

Fig 1. A private neutral linear e-marketplace

According to Barrat et al. [5] reduces waste and inefficiency in highly fragmented industries, by increasing visibility and a neutral knowledge base for both buyers and sellers. Buyers or sellers do not establish such marketplaces, which are usually set-up by an independent company such as an ICT provider or a bank, whose aim is to put together separate group of buyers and sellers in order to establish a sort of "procurement virtual district". The seller benefits generally comes from getting access to more buyers, expanding in this way its market, while the buyer benefits come from the possibility to get lower procurement costs, wider choice of products and better quality. The exchange owner usually gets its income from the transaction fees and eventually from some added value service fees such as secure transactions or financial services. In such e-marketplace, procurement actions are usually catalogue-based and the relation among the traders is generally based on repetitive "one-off" trades, that ends at along with the specific transaction, even if several transactions can take place among the same partners in forthcoming periods [6].

2. Motivation

Recent researches have located a set of value added services (VAS) that could improve B2B applications spreading and profitability; among those, "*link with distribution and logistic planning*" and "*settle the dispute among buyers and sellers*" have received respectively a 90% and 78% of preferences among the research participants [5].

In order to provide such kind of services within B2B applications it is necessary to develop a direct and real-time connection between the client order and the production planning activity of the supplier. Moreover, in order to put flexibility in the relationship between the client and the supplier, the

application should be able to bargain business agreements. In other words, the B2B application needs to be provided along with some planning and negotiation intelligence [7].
A recent research of the Aberdeen group [8] has drawn the following improvements performance:
- Increased their spend under management by 36%;
- Reduced their requisition-to-order cycles by 75%;
- Reduced their requisition-to-order costs by 48% ;
- Reduced their maverick spend by 36%.

The following table reports the trend of the e-procurement applications upon 2001 and 2006:

Table 1: E-Procurement Performance

Performance area	2001	2004	2006
Total Suppliers enabled	30	253	361
Total End-Users	1,000	2,309	1,381
Users: Current vs. Planned (%)	12%	43.5%	68%
Transactions per Month	1,340	5,244	2,977
Percentage of Indirect Spend managed by system	18%	37.6%	55%
Percentage of Services Spend managed by system	--	32.7%	29.3%

In e-marketplace in order to create real value added both for sellers and customers, the following tools have strongest relevance:
- Production planning tools;
- Negotiation tools.

Production planning tools allow creating a link between commercialization and production activities providing a better service for the customer that can gain reliable information about order availability and timing and for the supplier, which can correctly plan resource use in order to achieve lower costs. On the other hand, negotiation tools allow making transactions able to take into account buyer's and seller's identities and goals, providing a better global satisfaction.
In this research the authors propose an innovative approach for planning and negotiation in catalogue based e-marketplace based on a single step to reach an agreement. The proposed approach uses workflow management methodologies for the design activities, agent-based technologies for the implementation phases, and open source IT tools for the software platform development. A negotiation approach is used to benchmarked the proposed approach.
Moreover, a discrete-event simulation has been developed to test the proposed approach and to evaluate the economic value of adopting planning and negotiation tools in e-marketplace.

The paper is structured as it follows: section 3 provides a general description of the proposed models through workflow management tools; the planning, the negotiation model and the proposed approach "no negotiation" are described in section 4; in section 5 the simulation environment that has been developed is briefly presented and a case study is analyzed. Finally, conclusions and further research paths are withdrawn in section 6.

3. E-marketplace conceptual design

Figure 2 shows the E-marketplace structure through the interaction with external actors. As the reader can notice three kinds of actors have been located:

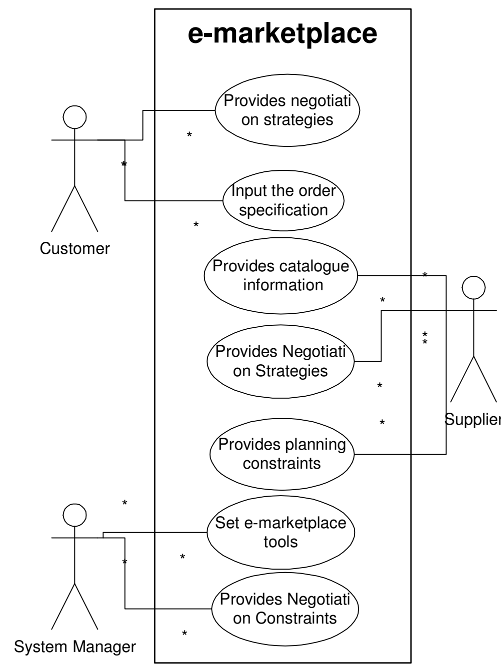

Fig 2. E-marketplace use cases

- the system manager, is the independent party that sets and manages the e-marketplace. He sets e-marketplace tools ("Set e-marketplace tools" use case) and provides negotiation constraints ("Provides Negotiation Constraints" use case) that bounds the negotiation behavior of both suppliers and customers;
- the customer, is the generic registered e-marketplace client, who is allowed to provide its negotiation strategies and to input a catalogue based order;
- the supplier, is the generic registered e-marketplace supplier, who provides catalogue information, negotiation strategies and planning information.

Once the customer inputs its order, the procurement transaction proceeds automatically being handled respectively by the customer and supplier agents. An exhaustive workflow design of the e-marketplace is reported in [9].

4. Negotiation and planning process

4.1 The negotiation process and algorithm

In the following paragraphs is presented the negotiation (benchmark) and planning process that provide the information to the suppliers [10].

Figure 3 shows, through an UML activity diagram, the detail of the negotiation process involving the three agents Customer Negotiation Agent (CNA), Supplier Negotiation Agent (SNA) and Supplier Planning Agent (SPA).

The negotiation process is characterized by the following constraints (Negotiation constraints):

- the negotiation is bilateral and it involves exclusively one customer and one supplier; it is not allowed for a customer to negotiate with more suppliers in the same time;
- the negotiation is an iterative one with a maximum number of rounds, *rmax* ; after that an agreement is reached or the negotiation fails;
- during each round the supplier is allowed to submit a new counter-proposal to the customer, while the last can only accept (A), reject (R) or ask for a new counter proposal (N), therefore the customer answer at the round *r* can be referred as $(A \vee R \vee N)_r$;
- the agreement is reached if the customer accepts the supplier counter proposal at a round *r<rmax*; in this case customer and supplier sign an electronic contract;
- supplier and customer behavior is assumed to be rationale according to their utility functions;
- supplier utility function is not known to the customer and vice versa; however supplier and customer can argue, by applying proper learning algorithms, the behavior of their counterparts.

The negotiation process starts with the order submission by the customer. The order is processed through the *Customer Order Inputting Menu* and it is delivered to the CNA. The order consists of the array $(i, V_i, dd_i, p_i)_0$ being *i*, the selected product from the supplier catalogue, V_i the required quantity, dd_i, the requested delivery date, and p_i, the asked price. By the activity diagram of Figure 3 the following actions are carried out:

Transmits order; the CNA transmits the order array $(i, V_i, dd_i, p_i)_0$ to the SNA.

Computes utility thresholds; The CNA computes the thresholds of its utility function.

Provides Order Proposal Constraints; the above values are transmitted to the SPA and they will constraint production planning activities.

Runs PrP; the SPA runs the production planning (PrP) algorithm that is described in section 4.2.

Computes Production Alternatives; as output of the Pr algorithm the SPA computes an array of production planning alternatives $\boldsymbol{PA_j}$ $(j = 1 \ldots n)$ that associates a supplier profit (Pr_j) and an offered volume (V_j) to each combination of offered due date (dd_j) and price (p_j): that is $\boldsymbol{PA_j} = (Prj, Vj, dd j, pj)$ □$_j$, where $V_j \leq V_i$.

Provides production alternatives; $\mathbf{PA_j}$ is transmitted to the SNA.

Computes counter-proposal; If *r = 1*, the SNA builds the set $K_0 = \{1,2,..k,\ldots,n^*\}$ of alternatives such as:

$$Pr_k = Pr_{max} = \max_{j=1,\ldots,n} \{Pr_j\} \quad \forall k \in K_0 \tag{1}$$

and it searches within K_0 for the alternative j^* such as:

$$j^* / \min_{j \in K_0} \left(\frac{|dd_j - dd_i| + |p_j - p_i| + |V_j - V_i|}{3} \right) \tag{2}$$

On the other hand, if $r > 1$, the SNA applies a profit reduction strategy according to the customer importance and the negotiation round, that is it computes the new acceptable profit at the round *r* as in (4):

$$Pr_r = Pr_{max} - \frac{PR_{max} - PR_{min}}{r\,max} \cdot r \tag{3}$$

Afterwards SNA builds the set of production alternatives $K_r = \{1,2,..k,\ldots,m^*\}$ such that:

$$Pr_k \geq Pr_r \quad \forall k \in K_r \tag{4}$$

and it finds the alternative j^* that minimizes the relation (3) with $j \in K_r$. The array $(dd_{j^*}, p_{j^*}, V_{j^*})$, both in cases $r = 1$ and $r > 1$, represents the supplier counter-proposal.

Transmits counter proposal; $(dd_{j^*}, p_{j^*}, V_{j^*})$ is transmitted to the CNA. At this time the SNA remains waiting for a CNA answer.

Updates utility thresholds; the CNA updates the utility function thresholds at the round *r* according to the following expression:

$$Thu(r) = Thu_{\max} \cdot \left(1 - \frac{r-1}{r\max - 1}\right)^2 + F \cdot \left(\frac{r-1}{r\max - 1}\right) \cdot \left(1 - \frac{r-1}{r\max - 1}\right) + Thu_{\min} \cdot \left(\frac{r-1}{r\max - 1}\right)^2 \tag{5}$$

where *F* is the utility function slope (see table 1).

Evaluates counter-proposal; the CNA evaluates the utility of the counter-proposal:

$$U^{c-p}{}_r = U_v + U_{dd} + U_p \tag{6}$$

where U_v, U_{dd}, U_p are respectively the utilities of the volumes, the due date and the price, computed as:

$$U_v = \left(\frac{V_{j^*}}{V_i}\right), \tag{7}$$

$$U_{dd} = Max\left(Min\left(\frac{dd_{j^*} - dd_{min}}{dd_i - dd_{min}}; \frac{dd_{max} - dd_{j^*}}{dd_{max} - dd_i} \right); 0 \right) \tag{8}$$

$$U_p = Min\left(\left(\frac{p_i}{p_{j^*}} \right); 1 \right) \tag{9}$$

where dd_{max} and dd_{min}, are respectively $dd_i \pm 3$.

If the $U^{c-p}{}_r \geq Thu(r)$ the CNA accepts (A) the counter-proposal and it signs the agreement with SNA; afterwards they update their database with agreement data. Conversely, if the $U^{c-p}{}_r < Thu(r)$ and *r<rmax*,

CNA asks for a new counter-proposal (N), otherwise if $r>rmax$, CNA rejects the proposal and quits the negotiation.

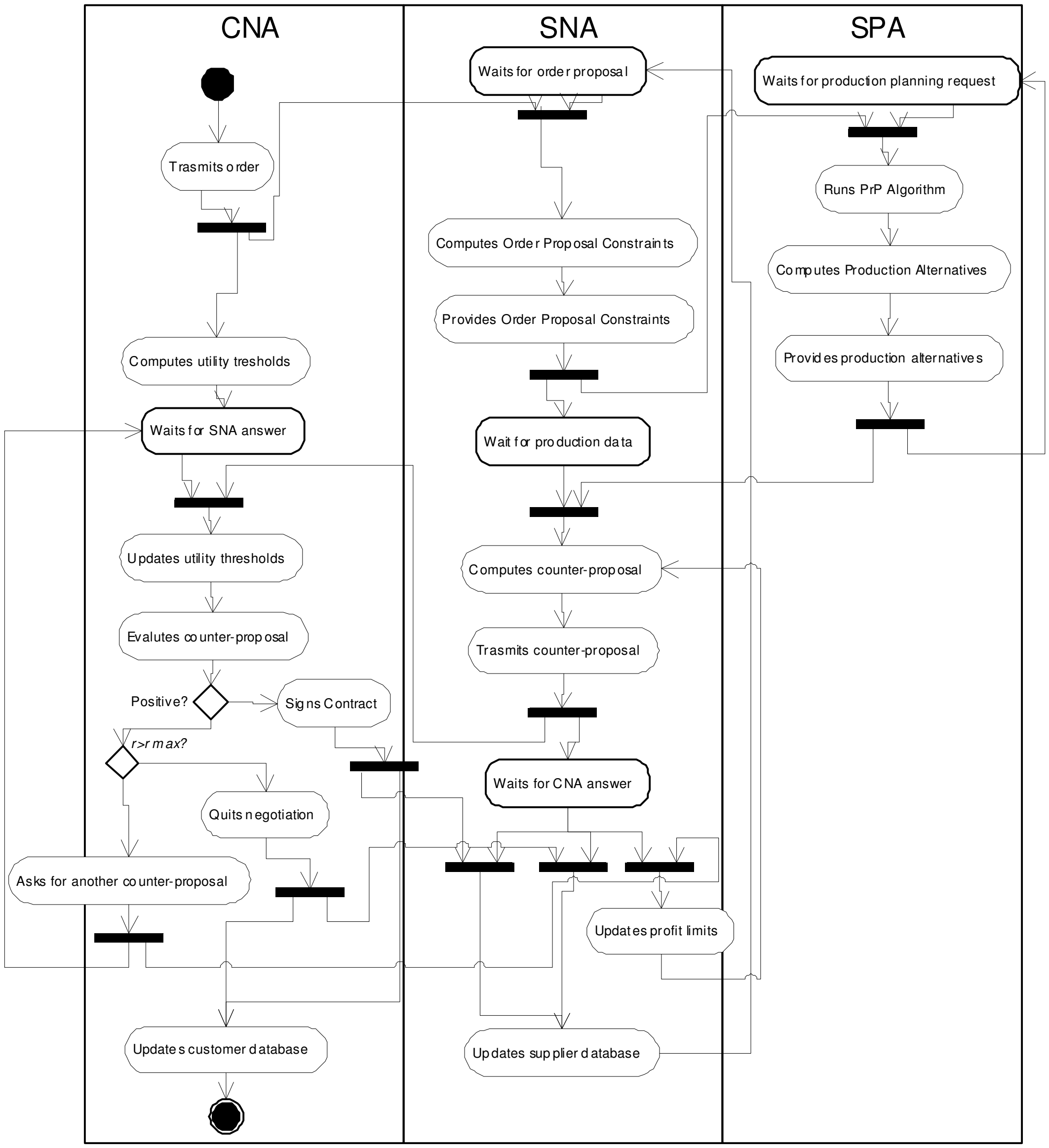

Fig 3. Negotiation Process Activity Diagram

4.2 The production planning algorithm
It has been assumed that production plan activity proceeds by planning period of fixed length T, i.e. all the orders received within the period T can be re-planned in the period; once the period is over, re-planning is not allowed for orders of the previous period. The algorithm is depicted in the activity diagram of Figure 4.
Initializes algorithm parameter; the SPA set the orders counter $i = 1$. Since the incoming order is surely a new one it needs to be planned for the first time (*In Negotiation*).
Set N.O. parameters; the SPA sets the following Negotiation Order (*N.O.*) parameters:

- $i^* = i$, index of the N.O.;
- $Fmin_{i^*} = 0$, minimum production volume fraction;
- $Fmax_{i^*} = 1$, maximum production volume fraction.

If i is lower than the number of orders arrived in the period $t<T$, $N\_ord(t)$, therefore there must exists other orders already planned.
In this case, the algorithm loads planned order information (*Load Planned Order*) and sets for each planned order $j = 1,\ldots,N\_ord(t)$ the following Firm Orders (F.O.) parameters (*Sets F.O. Parameters*):

- $Fmin_j = Fmax_j = F^p_j$, i.e. the production volume fraction is fixed to the amount already planned (F^p_j);

- $dd^{int}{}_j = dd^{end}{}_j = d^p{}_j$, i.e. the due date lower (dd^{int}) and upper bounds (dd^{end}) are fixed to the agreed value ($d^p{}_j$);
- $p^L{}_j = p^H{}_j = p^p{}_j$, i.e. the lowest ($p^L$) and the highest ($p^H$) price are fixed to the amount agreed one ($p^p{}_j$);

Set initial N.O. constraints; the SPA sets the planning constraints that is:

- $p_{i*} = p^H{}_{i*} = p_i{}^{(max)}$, $p^L{}_{i*} = p_i{}^{(min)}$
- $dd_{i*} = dd^{int}{}_{i*} = dd_i^{(min)}$, $dd^{end}{}_{i*} = dd_i^{(max)}$

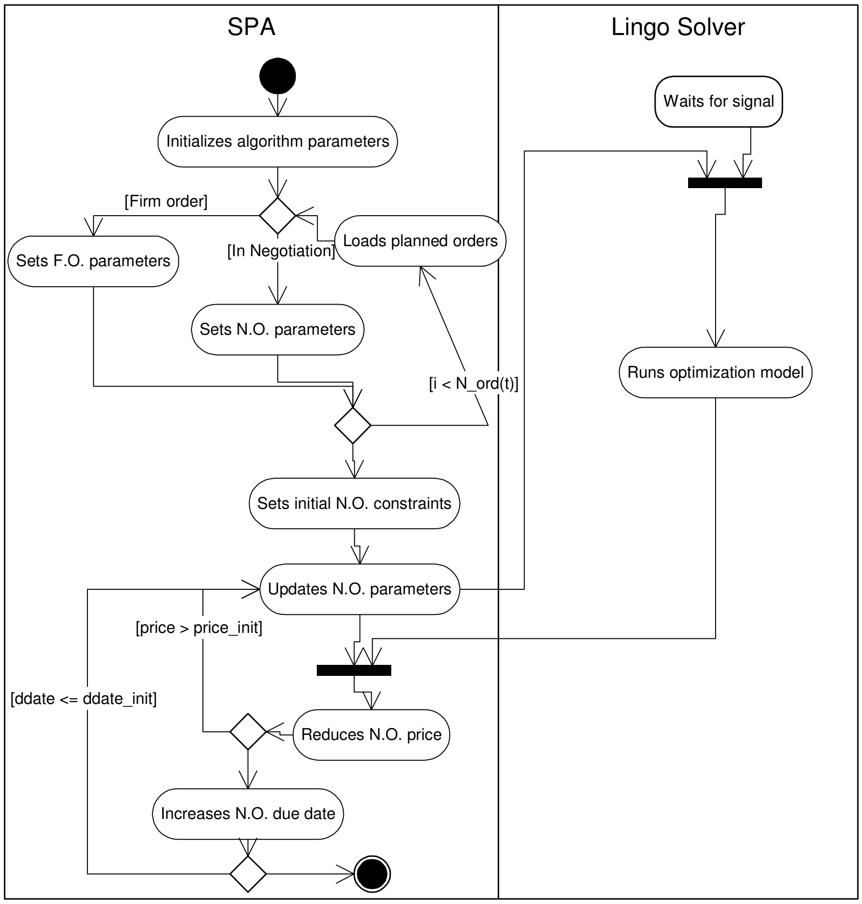

Fig 4. Production Planning Process Activity Diagram

where $p_i{}^{(max)}$, $p_i{}^{(min)}$ and $dd_i^{(min)}$, $dd_i^{(max)}$ are respectively the bounds of p_i and dd_i intervals. The intervals for each parameter are the following:

- $dd_i^{(min)} = dd_i - 3$
- $dd_i^{(max)} = dd_i + 3$

- $p_i{}^{(max)} = p_i + 1.2 * p_i$
- $p_i{}^{(min)} = p_i - 1.2 * p_i$

The minimum profit of the supplier in negotiation is the following:

- $Pr_{min} = 0.6 * Pr_{max}$

Updates N.O. parameters; the SPA passes p_{i*} and dd_{i*} to the LINGO Solver (*Runs optimization model*). Once the Lingo optimization ends, the LINGO Solver passes to the SPA the volume and profit level associated to p_{i*} and dd_{i*} and SPA builds the production alternative array (***PA***).

Reduces N.O. price; the SPA reduces the previous price p_{i*}' according to the following expression:

$$p_{i*} = p_{i*}' - \alpha \cdot (p^H{}_{i*} - p^L{}_{i*}),\ \alpha \in [0,1] \qquad (10)$$

Increases N.O. due date; the SPA increases the previous due date $dd(i*)$' as in (11):

$$dd_{i*} = dd_{i*}' - \alpha \cdot (dd^{end}{}_{i*} - dd^{int}{}_{i*}),\ \alpha \in [0,1] \qquad (11)$$

4.3 "No Negotiation" approach

A negotiation approach is characterized by the following drawbacks that affect the performance of the procurement process:

- the customer's and supplier's strategies have to be defined, the generative function typology for each role (creative or reactive counteroffer);
- the maximum number of rounds. The performance of the agreement depends of the round of the negotiation.

- the information exchange; for example one agent simple refuses or indicates the issues to improve;
- the negotiation ending criteria; if the negotiation end with the maximum number of round or, in case of disagreement a centralized approach is implemented.

The proposed approach is computed by only one step and no strategies have to be designed over the time of negotiation. Therefore, the main advantages are the following:

- the reduction of time to reach an agreement;
- the reduction of information exchange;
- the "*intelligence*" of the agents can be limited.

The proposed approach performs a single step in which the suppliers compute their proposal by the same information of the negotiation approach.

The supplier computes the counter-proposal by the following algorithm:

- The first step is to compute the distance between the customer request and supplier proposal. The distance is computed among the production alternatives PA_j. The supplier for each PAj computes the distance between the customer requested and the supplier's production alternatives by the following expression:

$$dist_j = \frac{1}{3}\left(\frac{|dd_j - dd_i|}{dd_i} + \frac{|p_j - p_i|}{p_i} + \frac{|V_j - V_i|}{V_i}\right) \quad (12)$$

The expression (12) is the average of the distance between the customer requested and the supplier Production Alternatives, therefore the value is between 0 and 1.

If the value of (12) is 0, then the counter-proposal matches the customer request and therefore the probability to obtain an agreement is 100%.

Otherwise, the increase of the (12) leads to minor probability to obtain an agreement with the supplier. The figure 5 shows a qualitative trend of the probability to reach an agreement

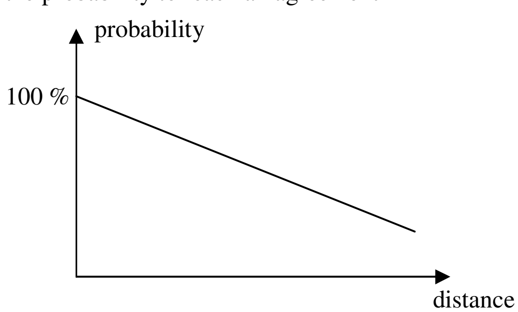

Fig 5. Probability to reach an agreement

- The second step is the evaluation of a expected profit for each production alternatives, computed by the following expression:

$$Ex\Pr_j = \Pr_j \bullet dist_j \quad (13)$$

The expression (13) estimates the profit that the supplier can gain by a PAj as a compromise between the profit and the correlate "distance".

- Finally, the supplier computes the counter proposal among the PA_j by the following expression:

$$j^* | \max\left(Ex\Pr_j\right) \quad (14)$$

The expression (14) evaluates the best compromise between the profit of the supplier and the probability to reach an agreement.

The customer evaluates the counter-proposal and if the $U^{c-p} > Thu_{\min}$, the agreement is singed, otherwise the customer and suppliers quit and no-agreement is reached.

4.4 The production Planning Model

The production planning model is a mixed integer linear programming one, whose notation is the following [10].

Indexes:

$i = 1, ..., m$ products (job);
$j = 1,...,n$ resources;
$t = 1,...,T$ time buckets;
$l = 1,...,L$ process plans;

Decision variables:

v_{il} 1 if job i is chosen by plan l, 0 otherwise
x_{il} fraction of the job i to be processed through plan l
y_{ijt} amount of resources j allocated to job i at time t
r_{jt} amount of ordinary manpower work to allocate to the resource j at time t
o_{jt} amount of overtime work to allocate to the resource j at time t
s_{jt} amount of resource j to outsource at time t

Model parameters:

p_i product price
d_i product due date
$F\,max_i$ as above
$F\,min_i$ as above
FC_{il} process plan l fixed cost when selected for job i
rs_{ilj} amount of type j resource needed for processing job i with work plan l
$nplan_i$ number of process plans for job i
CRG_j j time unit cost when used during ordinary time
COV_j j time unit cost when used during over time
CSB_j resource j time unit cost when outsourced
$CAPR_{jt}$ resource j ordinary time capacity at time t
$CAPO_{jt}$ resource j overtime capacity at time t
$CAPS_{jt}$ resource j supplier capacity at time t

Objective function: Supplier Profit maximization

$$\max\left\{\sum_i \sum_l x_{il} \cdot p_i - C1 - C2 - C3\right\}$$

Constraints:

$$\sum_{t \le d_i} y_{ijt} \ge \sum_l x_{il} \cdot rs_{ilj} \qquad \forall\, i,j \quad (15)$$

$$\sum_l v_{il} \le 1 \qquad \forall\, i \quad (16)$$

$$x_{il} \le v_{il} \qquad \forall\, i,l \quad (17)$$

$\sum_{l>nplan_i} v_{il} \le 0 \quad \forall i \quad (18)$

$\sum_l x_{il} \le F\,max_i \cdot \sum_l v_{il} \quad \forall i \quad (19)$

$\sum_l x_{il} \ge F\,min_i \cdot \sum_l v_{il} \quad \forall i \quad (20)$

$\sum_i y_{ijt} \le CAPR_{jt} + o_{jt} + s_{jt} \quad \forall i,t \quad (21)$

$o_{jt} \le CAPO_{jt} \quad \forall j,t \quad (22)$

$s_{jt} \le CAPS_{jt} \quad \forall j,t \quad (23)$

$r_{ij} = \sum_i y_{ijt} - s_{jt} - o_{jt} \quad \forall j,t \quad (24)$

$C1 = \sum_i \sum_l FC_{il} \cdot v_{il} \quad (25)$

$C2 = \sum_j \sum_t (CRG_j \cdot r_{jt}) \quad (26)$

$C3 = \sum_j \sum_y (COV_j \cdot o_{jt} + CSB_j \cdot s_{jt}) \quad (27)$

$y_{ijt} \ge 0 \quad \forall i,j,t \quad (28)$

$r_{jt} \ge 0 \quad \forall j,t \quad (29)$

$o_{jt} \ge 0 \quad \forall j,t \quad (30)$

$s_{jt} \ge 0 \quad \forall j,t \quad (31)$

$x_{il} \ge 0 \quad \forall i,l \quad (32)$

$v_{il} \in \{0,1\} \quad \forall i,l \quad (33)$

Constraint (15) forces the total amount of working time units of each resource to be at the least equal to the amount of working time units need, for the chosen process plan, to complete the job. It is to be highlighted that the job must be completed within the specified due date. Constraints (16) and (17) force each job to be assigned only to one work plan. Constraint (18) assures that plans not declared for job *i* cannot be chosen. Constraints (19) and (20) force the production fraction to be respectively lower than the maximum and higher then the minimum fraction required for the order. (21 - 24) are production capacity constraints. Constraint (25) computes the cost of using a specific process plan, constraint (26) computes costs for regular time resource use, while constraint (27) calculates costs of using resources in overtime and outsourcing. Constraints (28 - 33) define decision variables domain.

5. Simulation environment and case study

It has been developed a test environment of the e-marketplace context. It consists of a simulation environment that can be used to test the functionality of the proposed approaches and to understand advantages of added value services in e-marketplace.

In order to cut times and costs for the development of the actual e-marketplace environment, the simulation environment has been developed directly in open source architecture by using Java development kit package.

The modeling formalism here adopted is a collection of independent objects interacting via messages. This formalism is quite suitable for Multi Agent Systems development. In particular, each object represents an agent and the system evolves through a message sending engine managed by a discrete event scheduler. In particular, the following agents have been developed: the CNA, the SNA, the SPA and the scheduler agent. The former three agents have been deeply described in the previous sections. The scheduler agent is in charge with system evolving by managing the discrete event of the simulation engine.

Moreover, the customer and the supplier agents have been provided with a local Microsoft ACCESS database to manage supplier and customer data. A proper interface has been developed to connect the Java code to the database. Finally, the SPA has been linked with a Lingo Solver by a proper Visual Basic interface.

With the described simulation environment a test case consisting of 48 orders of 10 different product types has been analyzed. Table 2 reports the order sequence, the order arrival time (t_a), the required due date (dd_i), price (p_i) and quantity (V_i), the customer identification number (*C_num*) and the product type required (*type*).

Table 2: Orders sequence and data

Order	t_a	dd_i	p_i	V_i	*C_num*	*Type*
1	2	9	556690	356	3	2
2	15	20	391249	276	1	7
3	19	24	100678	73	2	8
4	25	30	250819	165	8	9
5	42	51	641576	446	2	8
6	48	53	50816	33	1	4
7	55	60	82577	55	7	5
8	56	60	141847	94	8	10
9	52	60	123921	80	2	1
10	63	71	409207	271	9	8
11	67	89	759415	562	7	10
12	72	77	262234	166	5	3
13	78	82	81574	60	5	10
14	79	88	735504	475	9	2
15	95	100	228229	160	7	1
16	98	106	90266	60	3	6
17	100	117	540165	336	1	2
18	103	115	699524	486	6	7
19	111	116	394020	284	2	1
20	122	128	507832	312	8	3
21	136	141	256757	181	7	1
22	137	143	263635	172	5	7
23	142	148	402521	282	1	9
24	145	150	115069	74	2	7
25	157	168	397363	276	9	2
26	160	172	750230	542	6	1
27	166	175	383990	259	4	3

28	169	173	120418	88	1	9
29	171	177	274699	170	4	9
30	181	187	209061	140	2	9
31	184	197	533574	362	7	1
32	189	200	464609	327	8	6
33	194	204	520106	348	6	7
34	201	210	80650	48	8	5
35	218	236	1267693	902	1	2
36	230	238	288852	181	9	10
37	232	236	183398	129	3	8
38	233	237	376985	230	9	9
39	235	240	177906	108	8	6
40	244	251	316362	206	2	7
41	246	253	323239	206	5	7
42	263	268	337758	224	2	10
43	265	270	273187	172	8	1
44	271	276	149202	94	1	9
45	273	283	660202	411	4	3
46	274	295	1119717	728	1	4
47	279	300	1176105	728	7	10
48	296	298	170216	116	6	3

The orders have been generated taking into account the following peculiarities:

- order arrival time t_a is randomly generated in order that, at least, five orders within the same re-planning time bucket are assured;
- the order due date dd_i, is randomly generated following a uniform distribution with lower bound $t_a + \Delta_t$ and upper bound given by the end of the re-planning time bucket;
- the volume of the order V_i, is randomly generated by using the following expression:

$$V^* = Unif\left[0.1, 1.1\right] \cdot \underset{s \in N}{Max}\left(Ord\_cap_s\right) \cdot \left(dd - t_a + 1\right) \quad (34)$$

being Ord_cap_s the ordinary production capacity of a supplier as reported in Table 4.

- The order price p_i, is computed according to the following expression:

$$p^* = mk\_up \cdot \underset{s \in N}{Min}\left(\frac{\underset{s}{Max}\left(CU_s\right) + \underset{s}{Min}\left(CU_s\right)}{2}\right) \cdot V^* \quad (35)$$

being CU_s the unit ordinary cost for manufacturing a single product of a order in a supplier manufacturing system and mk_up the mark up applied for computing the price obtained by a uniform distribution *Unif [1.1, 1.4]*. As the reader can notice, the price is computed by applying a mark-up strategy.

Orders enter the supplier system during a time horizon of 360 periods (days) dividend in buckets of 30 periods where is possible to make re-planning. Each part type have to be manufactured by three types of manufacturing resources (M1, M2, M3) and according with three alternative process plans (pp_1, pp_2 and pp_3), whose manufacturing times (hours) are shown in table 3. Finally, table 4 reports resources costs and production capacity (hours).

Table 3: Part types routing and manufacturing times (hours)

type	pp_1			pp_2			pp_3		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1	2	9	10	9	18	6	1	15	6
2	8	11	6	9	17	6	8	16	7
3	5	16	4	3	10	12	4	17	12
4	6	14	8	8	15	13	7	15	5
5	3	13	13	3	13	11	1	17	13
6	4	12	12	3	17	6	8	11	7
7	1	11	4	6	17	8	4	15	11
8	7	17	8	8	9	4	3	16	5
9	3	18	12	2	18	11	1	15	6
10	6	10	12	9	17	12	8	18	8

Table 4 : Resources cost and production capacity

	Cost (€/hr)		*Production Capacity (hours)*
FC_{il}	$20 \ \forall i,l$		
CRG_j	$20 \ \forall j$	$CAPR_{jt}$	$102 \ \forall j,t$
COV_j	$40 \ \forall j$	$CAPO_{jt}$	$78 \ \forall j,t$
CSB_j	$30 \ \forall j$	$CAPS_{jt}$	$54 \ \forall j,t$

The described context has been simulated in order to understand what kind of advantage or disadvantage of the proposed approach. The negotiation approach is considered as a benchmark. Simulation results have been reported in Table 5; the following performance measures are reported:

- Refused orders. The customer and suppliers don't reach an agreement for this orders.
- Average customer utility. It is the average of the customer utility for the orders with agreement between customer and supplier.
- Supplier's utility. It is the total profit of the network of suppliers.
- Total volume of the procurement actions.
- Profit for product unit.
- Total turnover of the supplier network.
- The average round to reach an agreement.
- The ratio between total volume requested and total volume supplied
- The ratio between the total potential turnover of the requested orders by the customer and the total turnover of the supplier network of the orders with an agreement.

As the reader can notice the proposed approach "No-negotiation" outperforms the negotiation benchmark in terms of global performance. However, the major advantages is reached by the supplier network; the profit increases about 16%, while the customer utility decreases about 10%. Moreover, the time to reach the agreement is reduced over the 60%.

The performance measures due to the counter-proposal formulation by the proposed approach, because the production planning process is the same for the two approaches compared.

Table 5: Simulation results

performance	negotiation	No - negotiation	Var %
Refused orders	5	6	20.00%
Customer utility	2.48	2.22	**-10.48%**
Supplier's utility	12,825,618	14,913,551	**16.28%**
volume	9434	9668	2.48%
Profit unit	1359.51	1542.57	13.47%
Total turnover	16,855,834	19,510,452	15.75%
Turnover for product	1786.71	2018.04	12.95%
Agreement round	2.79	1	**-64.16%**
Volume/volume requested	0.76	0.78	2.63%
Turnover/requested	0.84	0.74	-11.90%

The table 6 reports the distribution of the profit among the suppliers. In particular, the proposed approach ("No-nego") leads to share the profit among more suppliers than the negotiation approach. Also, for this performance index, the counter-proposal formulation of the proposed approach outperforms the negotiation approach.

Table 6: Supplier's profit

	Supplier 1	**Supplier 2**	**Supplier 3**
Negotiation	0	1,897,425.14	933,193.4
No-nego	0	6,081,062.6	1,219,426.6
	Supplier 4	**Supplier 5**	**Supplier 6**
Negotiation	2,253,639.05	0	0
No-nego	1,339,087.2	908,692.01	221,292.4
	Supplier 7	**Supplier 8**	**Supplier 9**
Negotiation	0	2,378,138.715	5,363,222.589
No-nego	121,490.8	160,810.873	4,861,689.424

6. Conclusions and research paths

This paper deals with real added value services in e-business applications. In particular an innovative approach for production planning and "no-negotiation" in "neutral e-marketplace" is proposed. The proposed approach is compared with a negotiation approach by a discrete event simulation environment. The proposed approach leads to obtain a real value added for the supplier's network, while a reduction of the customer utility is reached. Moreover, the proposed approach involves more suppliers in profit distribution.

The proposed approach is a valid alternative to the negotiation approaches that are affecting by several parameters to set.

Moreover, the research suggests how, through simulation, to evaluate the real value of planning and negotiation tools in e-business environment and who, among customers and suppliers, get the main advantages from them, and, therefore, should pay for them.

The simulation results show how the suppliers gain the main advantage form the proposed approach, therefore a compensative methodology will be developed for the customer.

Further research path concerns the development of "no – negotiation" approach with more equilibrium between the value added to suppliers and to customer and a deeply simulation analysis by input orders obtained by statistical distributions.

Moreover, a cooperative approach has to be investigated in order to distribute the profit among all the supplier of the network. In this case the research on coalition building among the suppliers can improve the valued added to the suppliers. Finally, the application of the proposed methodology to a real case application.

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