DEVS MODELING OF SELF ORGANIZED COMPANIES' NETWORK

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ABSTRACT

The appearance of complex products on the market involved a change and an increase of complexity at the Customer/Supplier Relationship (CSR) level. Indeed, the company had recourse to outsourcing in order to ensure their survivals. Accordingly we present a new approach of the CSR, where the whole of the entities (customer/suppliers) are self organized in order to better answer to a given call for proposal launched by the customer, and in order to exploit the capacities of a supplier with better way. First, we describe the operation of the proposed approach. Then, we detail the DEVS modelling of self organized customers / suppliers.

INTRODUCTION

The efforts carried out in order to improve the production management were concentrated on the improvement of internal management within each company with an aim of better answering the customer needs. Indeed, the studies were multiplied in order to install tools allowing companies to achieve their goals in term of performance improvement and profiles maximization. Researches were focused on the times and cost reduction and the increase in the products diversity like their quality. Industries globalization, customer requirements evolution and appearance of complex products, allow companies to realize that the internal improvement is important but not sufficient. This deduction pushed researchers to go so further to prove that the integration of company into a network is essential (Brito and Roseira 2003)(Castelain et al 2003)(Cousins and Spekman 2003)(Faems and Van 2003)(Silvadasan et al 2001). Thus, the companies had recourse to outsourcing and externalization (Ounnar and Pujo 2001) in order to realize the complex products. Through the externalization phenomenon, companies tend to gather for the realization of a joint project. Indeed, company fits in a customers/suppliers network, forming thus a supply chain network in order to optimize it by satisfying the customer. With the appearance of this new form of organization, the research widened, the targeted objectives does not relate to only one company but must meet the whole corporate network. Accordingly, several topics were accosted, certain were focused on the co-operation between firms, noting that more recently, the agreements cooperation inter companies appeared as major form of valorization, competence, innovation capacity and reputation (Despontin et al 2002)(Telle 2003). Owing to the integration of the company into the network which generated the complexity of the Customer/Supplier Relationships (CSR), other studies were interested in the influence of these relations on costs inter organizational management (Brun and Staudacher 2000)(Harri 2002), durability of these relations (Alccouffe and Corrégé 2004), dynamics of these relations (Lauras 2004). At last, other studies were interested on modeling of corporate network and on setting up of methodologies allowing modeling of this type of network (Bisigniano and Palermo 2003)(Bruzzone 2002)(Burlat 2004) (Chen and al 2001) (Dong and Nagurney 2002)(Villa 1998)

From these researches, we can conclude that the CSR control[1] is based on co-operation of various entities in order to achieve a common goal (Alvarez and Diaz 2004). This co-operation imposes integration of negotiation and communication means between companies. In other words, the development of the durable Customer/Supplier Relationships (CSR) depends on existing degree of confidence. Suggested solution in order to avoid any imbalance at the network is the implementation of the winning - winning principle. We attend these last years, to the appearance of industrial partnership relation. On this basis, we propose a new approach of CSR control by considering that the whole of the entities (customers/suppliers) partners communicating on the same medium of communication, negotiate to answer with the better way to the customers needs. In other words, to respond to Calls For Proposal (CFP) launched on the network by the customers, and to exploit suppliers' capacities with the better way. We propose thus to provide each supplier with a decision-making centre: Autonomous Control Entity (ACE), which allows him to self evaluate his performance in order to be able to take part to negotiation within a self organized network. This centre allows a supplier to become an intelligent production unit able to operate in self organization with other companies with an aim of seeking the best response to a

[1] Actions developed together in order to achieve common goals and react at a good moment to any dysfunction.

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CFP launched on the network (Ounnar et al 2004). This entity is made up of four modules: Communication module, Interaction module, Optimization module and Planning module

In this paper, we will particularly presented Optimisation module. For that, we will present a formal description of this module and we will detail the calculation methods used for the self evaluation of an ACE with respect to a given CFP.

GENERAL OPERATION OF THE ACE

The suggested approach allows the increase of the autonomy of the network entities. For that, the entities must have the capacity to negotiate and communicate among them in order to achieve their common goal which is to ensure collectively the distribution of the orders coming from the various customers with respecting the interests of each one. A partner can be customer, supplier or both. One of the customers launched a CFP on the network. This latter will be provided with a certain number of information such as: name of the transmitting entity (customer), description of the requested product, the quantity expected by the customer, lead time of end of negotiation, delivery lead time, etc …All the ACEs which are connected to the network will received this CFP. Once the CFP received by a given ACE, via its communication module, the latter transmits the received information to the interaction module. The interaction module will check the feasibility of the CFP in technical term and then transmit the CFP to the optimization module. The optimization module starts the application of the selected multicriteria method (Ounnar 1999): Analytic Hierarchy Process (AHP) in order to obtain a classification of all the CFPs received, according to the entity capacity to treat them. The application of this method requires a set of qualitative or quantitative criteria (Ounnar and Pujo 2005). Among the quantitative criteria, appears operating time of the CFP. This data depends on the planning state and on the availability of equipments. We propose to obtain this data by the execution of an analytic method at the level of the planning module. This latter calculates the operating time of the CFP by studying the various possible states of insertion of this one in the entity planning. This result will thus be transmitted to the optimization module in order to finish the application of the multicriteria method. The interaction module compares then this performance with regard to the best actual performance and then sends it on the network if it is the best one. The various messages circulating on the network can be summarised as follow: CFP, RCFP, LCFP (Local Call for Proposal which is diffused by the entity), RLCFP (Response to Local Call for Proposal, response proposed by a given network partner), ERCFP (Entity Response to a Call for Proposal which is a proposed response to a CFP launched by a given partner). The objective of the suggested approach is to obtain a balance between charge/capacity at the level of one supplier and to achieve a loads smoothing between the various suppliers with a further objective to propose an equitable system between network suppliers. For that, and in order to test the validity of the suggested approach through the test of the number of CFPs treated, negotiated, refused, at the level of each entity, we modeled the ACE by using DEVS formalism (Discrete EVent systems Specification) developed for modeling and simulation of discrete events dynamic systems. (Zeigler 1984). This validation allows the evaluation of the CFPs distribution on the partnership network.

As it was mentioned above, this paper is focused on the study of Optimization Module of an ACE. First, we describe the general operation of this module. Thus we explain how it allows the ACE to self evaluate its performance with respect to the received CFP, in order to estimate its own capacity to respond to this one. Then, we present DEVS models corresponding to this module and how they allow to validate the suggested approach. These models will be used as formal specifications in the system realization.

Operation of Optimization Module

The performance evaluation is based on a multicriteria method. The selected method corresponds to the Analytic Hierarchy Process (AHP) method (Ounnar 1999). AHP is a powerful and flexible tool of decision-making for complex problems involving multiple qualitative and quantitative criteria. The method helps decision-makers to structure the significant components of a problem in a hierarchical tree-like structure. The results are then synthesized by reducing complex decisions into a series of simple comparisons and arrangements. AHP is thus a decision-making process that directly interprets the data by forming judgments through a scale of measurement inside a hierarchical structure. AHP involves four distinct steps.

1 Step 1 (setup): Decision-making criteria are generated. Hierarchical relationships are established among the criteria and are then represented in the form of a matrix.

2 Step 2 (weighing): The matrices are filled with criteria comparisons. The comparisons allow the calculation of the criteria-weighing vector.

3 Step 3 (ranking): The various solutions are ranked according to their ability to satisfy the various criteria.

4 Step 4 (evaluation): The final solution ratings are then calculated using the rankings determined in Step 3 and the weighing vector calculated in Step 2.

This process organizes a hierarchical decision-making problem in a mathematically rigorous manner to ensure proper results. It separates the decision-making process into stages to enable the team working on the problem to focus successively on each step needed to make a decision. On the basis of qualitative or quantitative criteria, AHP method ensures to classify CFPs, according to the capacity of the entity to treat them. Among the quantitative criteria, appears operating time of the CFP. This data is obtained by the planning module. For that, the knowledge of the states of CFPs is necessary. The different CFPs received by the entity are placed in the planning module. A CFP can be in one of the following states:

1 Negotiated CFP: characterizing the fact that we have no information about its assignment.

2 Engageable CFP: characterizing the fact that an entity is the most successful on an order (the offer is better than the best of the received offers).

3 Pre-engaged CFP: a CFP is pre-engaged if it is "engageable" and it is selected as being one of the most priority of the CFP list. The entity appropriates temporarily this CFP. This CFP will be the following one that will take the state "Engaged" if there is no overbid.

4 Engaged CFP: the entity appropriates definitively the "pre-engaged" CFP on its planning at its engaged date.

5 Refused CFP: specify the fact that no proposition was made for this call for proposal.

Formal Description of Optimization Model

In this section we present the DEVS model corresponding to the optimization module described above. This model is a coupled DEVS model composed of four atomic DEVS models (see figure.1).

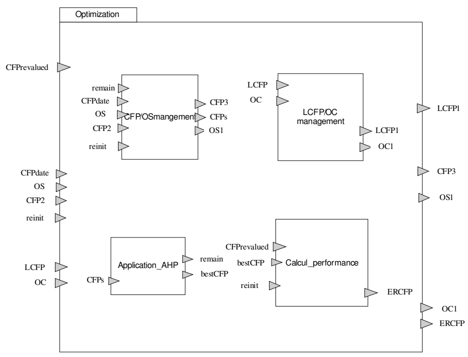

Figure 1. DEVS Model of Optimization Module

Atomic DEVS model specification is structured as follow:

DEVS = ($\underline{X}_M$, $\underline{Y}_M$, $\underline{S}$, δ_{ext}, δ_{int}, δ_{con}, λ, *ta*) ; Where:

X_M: The set of input ports through which external events are received.

Y_M: The set of output ports through which external events are sent.

S: The set of the sequential states.

δ_{ext}: the external transition function which specifies how the system changes state when an input (x) is received during the time "e" where e ta, then , the system passes from the current " s" state to a new one "s'" by applying the function . ext (s, e, x).

$_{int}$: The internal transition function which specifies to which next state the system will transit after the time given by the time advance function has elapsed. The latter can generate an external output just before it takes place.

λ: The output function, the latter generates an output event.

Ta(s): For a given state, s, ta (s) represents the time interval during which the model will remain in the state "s" if no external event occurs.

Formal description of the "CFP/OS management" submodule

This module receives CFP as well as the orders of suppression of CFP_is coming from the interaction module. The CFP/OS management submodule sends the CFP to the planning module which tests the possibility of insertion of this CFP and returns the CFP provided with its operating time (result of insertion). In addition, the Application_AHP submodule informs the CFP/OS management submodule of its availability to receive CFP by sending to it the result of AHP in the form of a classified CFPs list. Then the CFP/OS management submodule sends to the Application_AHP submodule the new list of CFPs to be classified.

Input ports: X_{CFPOS} = *{CFP2, CFPdate, OS, rest, reinit}, where:*

1 *CFP2* = *{*CFP_i*}*: indicates the arrival of a CFP_i from the interaction module. The latter is represented by:

$Num_i \in N$: number of the CFP_i.

$Entity_i$: name of the entity defined on the set of string.

$CFP.Type_i \in$ {feasible, unfeasible}: it describes the feasibility of CFP_i in technical term.

$CFP.state_i \in$ {negotiated, engageable, pre-engaged, engaged}*:* it describes the state of the CFP_i.

$CFP.cond_i \in$ {OK, not OK} : describes the availability of the execution conditions.

$Q_i \in R$: CFP quantity expected by the customer.

$drecept_i \in R$: reception date of CFP_i .

OT_i: operating time of CFP_i defined on the set of reals.

$DE_i \in R$: date of beginning of the execution of the CFP_i .

D_i: execution span defined on the set of reals.

DL_i: delivery lead time defined on the set of reals.

$TEN_i \in R$: lead time of end of negotiation.

CR_i: conformity rates defined by the customer who launches a CFP_i. It is defined on the set of reals.

RR_i: return rates, it is defined by the customer who launches the CFP_i. It takes its values on the set of reals.

2 *CFPdate= {CFP_i}:* It indicates the arrival of a CFP_i coming from the planning module on which a calculation of OT was carried out.
3 *OS= {CFP_i}:* it indicates the arrival of a suppression order coming from the interaction module concerning a given CFP_i. It is represented by: {num_i, $entity_i$, $CFP.type_i$, $CFP.state_i$, $CFP.cond_i$, Q_i, $drecept_i$, OT_i, DE_i, D_i, DL_i,TEN_i, CR_i, RR_i}.
4 *rest = {listeCFPs}:* allows the reception of the result of AHP method applied at the Application_AHP submodule. This result is represented by a list comprising all the CFP_is received classified according to the capacity of the entity to treat them except the CFP classified first.
5 *reinit= {on}:* allows the reinitialization of all the system.

State variables: S= {phase, , T busy, LT, L5} where:

1 Phase = {wait, wait_calcul, CFP_reçept, fusion_L5_LT, insertion, launch_AHP, date_recept, suppresion, CFP_recept}.
2 $\in R^+$: defined the life time of the current state.
3 T: defined the instance of the class object of CFP frame.
4 busy: Boolean variable indicating if AHP method is carried out at the Application_AHP submodule. It is initialized with false.
5 LT: List where are stocked the classified CFP_is by the Application_AHP submodule.
6 L5: list where are stocked CFP_is launched by the network partners intended to be classified by AHP method.

Output ports: Y_{CFPOS}= {CFP3, CFPs, OS1}, where:

1 *CFP3= {CFP_i}:* send the CFP_i to the planning module with an aim of calculating its operating time.
2 *CFPs= {listeCFPs}:* Send the list of the CFP_is to the Application_AHP submodule, in order to classify them.
3 *OS1= {CFP_i}:* send the OS to the planning module.

The corresponding DEVS model is defined in Figure 2:

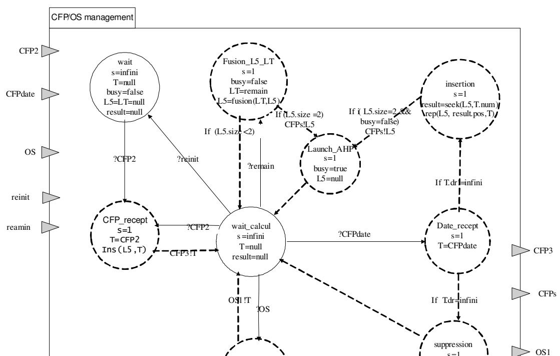

Figure 2 DEVS Model of CFP/OS management submodule

Formal description of the "LCFP/OC management" submodule

This module ensures the management of CFPs coming from the planning module. It has to transmit them to the interaction module.

This submodule also ensures the management of Order of Change (OC) of a given CFP_i state. Indeed, with the reception of an OC the submodule transmits it to the planning module.

Input ports: X_{LCFPOC} = {LCFP, OC}, where:

1 *LCFP = {CFP_i}:* it indicates the arrival of a Local CFP coming from the planning module. This LCFP is composed of {num_i, $entity_i$, $CFP.type_i$, $CFP.state_i$, $CFP.cond_i$, Q_i, $drecept_i$, OT_i, DE_i, D_i, DL_i,TEN_i, CR_i, RR_i}.
2 *OC= {CFP_i}:* It represents an order of change of a given CFP_i state. This order is launched by the interaction module. This event is represented by: {num_i, $entity_i$, $CFP.type_i$, $CFP.state_i$, $CFP.cond_i$, Q_i, $drecept_i$, OT_i, DE_i, D_i, DL_i,TEN_i, CR_i, RR_i}.

State variables: S= {phase, , T} where:

1 Phase = {wait, LCFP_recept, OC_recept}.
2 R^+: it is the life time of the current state.
3 T: defined the instance of the class object of CFP frame.

Output ports: Y_{LCFPOC}= {LCFP1, OC1}, where:

1 *LCFP1 = {CFP_i}*: send the LCFP to the interaction module.
2 *OC1= {CFP_i}:* send the OC on the state of a given CFP_i to the planning module.

The corresponding DEVS model is defined in Figure 3:

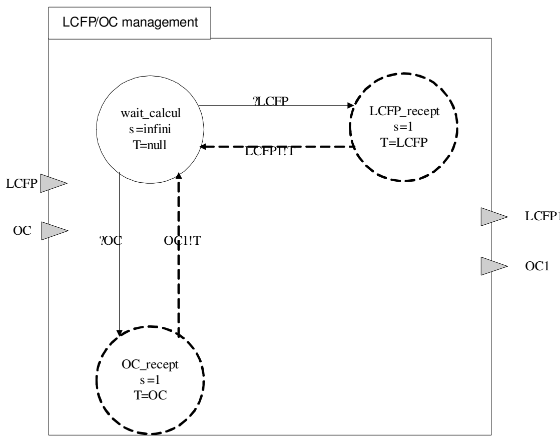

Figure 3 DEVS model of "LCFP/OC management" submodule

Formal description of the "Application_AHP" submodule

This module allows the application of the AHP on receiving CFPs list coming from the CFP/OS management submodule, with an aim of obtaining a classification of these CFPs.

Input ports: $X_{Ap.AHP}$ = {CFPs}, where:

1 *CFPs = {listeCFPs}:* allows the reception of a CFPs list coming from the management CFP/OS submodule, intended to be classified.

State variables: S= {phase,   , T, L9} where:

1 Phase = {wait, App_AHP, suppression}.

2 $\in R^+$: defined the life time of the current state

3 T: defined the instance of the class object of CFP frame.

4 L8: list where the CFPs which are classified by AHP method are stocked.

Output ports: $Y_{Ap.AHP}$= {bestCFP, rest}, where:

1 *bestCFP = {CFP_i}:* send the CFP classified first to the calcul_performance submodule.

2 *res t= {listeCFPs}:* send the list of the CFPs classified except the CFP classified first to the CFP/OS management submodule.

The corresponding DEVS model is defined in Figure 4:

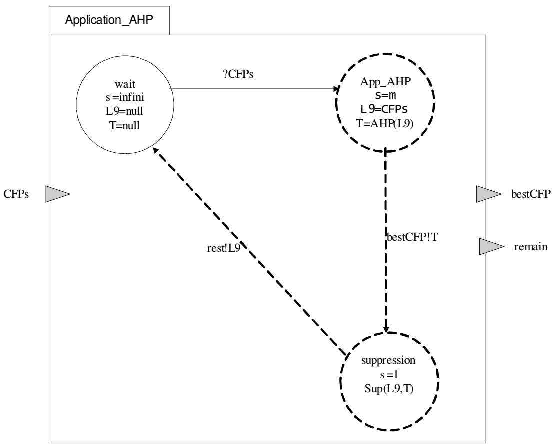

Figure 4 DEVS model of "Application_AHP" submodule

Formal description of the "calcul_performance" submodule

This module allows the calculation of the entity performance with respect to the CFP_i classified first by AHP method. In the calculation of this performance it calls upon a mathematical formula based on a set of indicators applied by calcul_perf function.

Input ports: X_{CP} = {CFPrevalued, bestCFP}, where:

1 *CFPrevalued = {CFP_i}:* it indicates the arrival of revalued CFP_i coming from the planning module. This last is represented by: {num_i, $entity_i$, CFP.$type_i$, CFP.$state_i$, CFP.$cond_i$, Q_i, $drecept_i$, OT_i, DE_i, D_i, DL_i,TEN_i, CR_i, RR_i}.

2 *bestCFP= {CFP_i}:* allows the reception of the CFP_i on which the entity is better. This CFP is sent by the Application_AHP submodule. It is represented by: {num_i, $entity_i$, CFP.$type_i$, CFP.$state_i$, CFP.$cond_i$, Q_i, $drecept_i$, OT_i, DE_i, D_i, DL_i,TEN_i, CR_i, RR_i}.

3 *reinit: {on}:* allows the reinitialization of all the system.

State variables: S= {phase,   , T, TR, L6, L7, result}, where:

1 Phase = {wait, seek_RCFP, seek_CFP, Insertion_end, Insertion_end1, Insertion_end2, cruch}.

2 R^+: defined the life time of the current state.

3 T: defined the instance of the class object of CFP frame.

4 TR: defined the instance of the class object of RCFP frame.

5 L7: list where the responses for a different CFP_is proposed by the entity ($ERCFP_i$) are stocked.

6 L7: list where the revaluate CFP_is are stocked.

For these variables are applied following functions:

1 seek (L,T.num): seek the element T in the list L This function returns a pointer which points on the element T, if the element exists, or on the null value.

2 ins (L,last, T): inserts the element T at the last of the list L.

3 remp (L,pos,TR): replaces the element being in the position "pos" in the list L by element TR.

4 calcul_perf (T): function allowing the calculation of the performance of a given CFP stocked in T by the application of a formula based on a set of indicators. This function returns a vector mad up of the following fields: {numi, entityi, pi, drecepti, TEN_i}.

Output ports: Y_{CP}= {ERCFP}, where:

1 *ERCFP= {$ERCFP_i$}*: allows the sending of the entity response concerning CFPi on which it is better. This answer will be provided with the following information : {num_i, $entity_i$, P_i, $drecept_i$, TEN_i}.with:

P_i: performance of the entity with respect to this call for proposal. It takes its values on the set of reals.

$drecept_i$: date at which the response has been transmitted by the entity.

TEN_i: lead time of end of negotiation defined on the set of reals.

The corresponding DEVS model is defined in Figure.5:

Figure 5 DEVS model of "calcul_performance" submodule

CONCLUSION

The goal of our study is to improve the decision making structures at the CSR level. After a presentation of the literature review on the work carried out on the improvement of the CSR, we have proposed a new approach of CSR control by considering that the whole of the entities (customers/suppliers) partners, communicating on the same medium of communication, negotiate to answer with the better way to the customers needs. We have thus provided each supplier with a decision-making centre: Autonomous Control Entity (ACE), which allows him to self evaluate his performance in order to be able to take part to negotiation. The objective of the suggested approach is to obtain a balance between charge/capacity at the level of each supplier and to achieve a loads smoothing between the various suppliers with a further objective to propose an equitable system between network suppliers. For that, and in order to test the validity of the suggested approach we have modeled the optimization model. Indeed, we have presented DEVS models corresponding to this module. These models will be used as formal specifications in the system realization. Further research will focused on the simulation of these models in order to validate the proposed approach.

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