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Towards a business process reconfiguration

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***Abstract*— The continuous search for flexibility leads companies to implement reconfigurable supply chains. In this article, we focus on the reconfiguration of supply chains through the business processes that compose them. We propose an approach of reconfiguration based on an integrated QFD "Quality Function Deployment"/ AHP "Analytic Hierarchy Process" model that allows to determine the processes, activities, roles and actors that require reconfigurations. Our aims is to determine a compromise between the scenario of reconfiguration chosen and the business processes on the one hand, and to prioritize activities, roles and actors on the other hand.**

Keywords*— *Reconfiguration, Business process, Supply chain, Quality Function Deployment (QFD), Analytic Hierarchy Process (AHP)

I. INTRODUCTION

Nowadays, companies are subject to strong competition. In a changing and uncertain market, the objective is to be able to modify the configuration of the supply chain with the least resources. As the problem of reconfiguration is relatively recent, we are interested in the work developed since the emergence of the concept of reconfigurable manufacturing systems by [1]. Nevertheless, we focus on work that has proposed models, approaches and methods for the design of reconfigurable supply chains. The reconfigurable supply chain is a supply chain possessing flexibility of altering its configuration with relatively minor resource requirements and without losing its operational efficiency in response to changing customer demands and operating environment [2].

Several other authors have focused on reconfiguration to build supply chains and networks that are able to adapt to change [3, 4]. The reconfiguration of supply chains mainly concerns their production systems, information systems and business processes. Furthermore, the latter plays a crucial role in ensuring a reconfigurable chain. Several approaches have been proposed to address this issue. In fact, the business process is a set of linked tasks that convert inputs into outputs to achieve a certain objective. Several approaches have been proposed as part of the business process reconfiguration in the supply chain. Our objective is to propose a new approach of reconfiguration by extending the work of [5] and to the business-processes in the supply chain. They have proposed an approach of change management for implementing an Enterprise Resources Planning (ERP). In addition, we will use the business process concepts defined by [6] to identify the reconfiguration scenario that allows for successful process reconfiguration.

The rest of the article is organized as follows. In section 2, we present a state of the art on the models proposed for the reconfiguration of supply chains. Then, we study in particular the reconfiguration of supply chains through business processes to determine the concepts treated (activity, role, resource...). Then, we propose an approach of business process reconfiguration in the supply chain. Our approach is a hybrid of QFD "Quality Function Deployment" and AHP "Analytic Hierarchy Process" which aims to determine a compromise between the chosen reconfiguration scenario and the business processes on the one hand and on the other hand to determine the correlation and prioritize activities, roles and actors to identify those that require reconfiguration as a priority.

II. LITERATURE REVIEW

Morley [6] considered that improvement is achieved through the reconfiguration of business processes and information systems processes on the one hand, and through process maturity on the other hand. Indeed, the reconfiguration aims to achieve effectiveness, efficiency, flexibility and improved customer relations. Several approaches have been proposed as part of business process reconfiguration in the supply chain. Based on models that have taken into account the change or reconfiguration phase in business process, we have aimed in this work to define the different reconfiguration concepts that have been integrated during the design and modelling of business processes.

Al-Mashari [7] addressed the problem of ERP implementation with the aim of reconfiguring the supply chain from an organizational and structural point of view. In this paper, the authors focused on the particular role of SAP in creating value in supply chains in order to ensure an integrated supply chain and improve interactions in the business process network.

Trienekens [8] suggested a set of modelling methods for supply chain reconfiguration. Each model has a particular dimension of supply chain management. This article is inspired by the methodologies proposed by [9] to analyze and reconfigure business processes. In order to do this, the authors used three types of modelling: Event Process Chain (EPC), Activity Chain Model (ACM) and the Graph with Results and Activities Interrelated GRAI method adapted to supply chains. The first modeling focuses on the temporal relationships between processes/functions and customer orientations that optimize resources. The second modeling focuses on functions/processes and information flows that reduce time and improve processes. The third modeling focuses on decision-making structures and information flows that can improve them.

Changchien [10] addressed the problem of business process reconfiguration in supply chains to ensure the improvement of the performance of these funds. They proposed a methodology based on a set of steps using an analysis matrix and an object-oriented simulation. The first step consists in creating a vision and objectives, i.e. the company should review its current profile and develop a global strategic vision. The key activities of this step are to assess the organizational structure and environment by

identifying needs and setting reconfiguration objectives. The second step is to identify which process needs to be reconfigured. They developed a reconfigurable supply network model through enterprise and supply network modeling techniques based on reconfigurable manufacturing system models. In order to build a reconfigurable network, the authors mentioned that companies must design their supply chain network using visible design rules.

Kelepouris [11] developed a design for an intelligent supply chain network through the implementation of a reconfigurable supply network to meet the different requirements. They developed a reconfigurable supply chain network model through enterprise model and supply network techniques based on reconfigurable production system models. In order to build a reconfigurable network, the authors mentioned that companies must design their supply chain network using visible design rules.

Masood [12] proposed a model-based approach so that business processes and production systems can be reconfigurable and transformable in an increasingly unstable environment. To do so, they used the concept of the role on the one hand, to answer the question "who" and the concept of resource on the other hand, to answer the question "how" so that the decision-maker, can face the requirements of change.

Palma-Mendoza [13] discussed the concept of business process reconfiguration in supply chain building. In order to ensure continuous improvement of supply chains, companies are engaged in collaboration and alliance strategies with their partners to achieve a competitive advantage to establish an integrated supply chain. As a result, the reconfiguration of supply chains is achieved through their business processes. The proposed approach is based on SWOT method in order to identify the activities, which needs reconfiguration actions. Then, the identification of business processes is based on the SCOR (Supply Chain Operations Reference) model. Thus, the AHP method is used to identify and prioritize performance measures.

TABLE I. CLASSIFICATION OF ARTICLES ACCORDING TO THEIR DIMENSIONS

Article	Methods	Dimension
[7]	SAP	Process, activities
[8]	EPC, ACM, GRAI	Process, activities, resources
[10]	Core Process Analysis Matrix, Object Oriented Simulation	Process
[11]	Enterprise model/ SCOR model	Process, activities, resources
[12]	CIMOSA	Process, resources, role
[13]	AHP, SCOR model	Process, activities

These articles treat the reconfiguration of supply chains through their activities, resources, processes and roles associated with them (Table I). Our objective is to address the reconfiguration of supply chains through their business processes, in particular through their activities, roles and actors in order to ensure reconfiguration actions on the processes that require these actions of reconfiguration as a priority. Most of the proposed changes have been implemented in order to deal with automation process. However, work that has focused on the reconfiguration business process in order to deal with hazard disruption that can affect business process is poorly developed.

III. THE PROPOSED APPROACH

The proposed approach consists on implementing a model for business process reconfiguration. Indeed, our work starts by defining the objectives of reconfiguration as the consequence of the event that causes this need. To deal with these disruptions, several scenarios are then made available. The selection of scenarios must be made objectively, i.e. the decision-maker fixes a set of criteria in order to choose the most appropriate scenario for the business processes in the supply chain. The next step is process analysis. Indeed, we will begin this phase by identifying all the business processes in order to be able to identify the correlation between them and the reconfiguration scenarios previously determined. Thus, the identification of the activities associated with each process and the determination of the correlation between them. Then, the identification of the roles associated with each activity. It is important to define them in order to determine the correlation between them and the activities that compose each process. Then, the definition of the actors assigned to them the different roles identified previously to determine the correlation between them. After analyzing the process through the concepts of activity, role and actor, we will evaluate the choice of reconfiguration scenario(s) according to criteria that can be used to evaluate the scenario's effectiveness in order to complete the reconfiguration phase. The next step is to implement the selected reconfiguration actions. Finally, the last step is to evaluate the reconfiguration actions. Our approach suggests a set of steps to propose reconfiguration actions for supply chain business processes (Figure 1).

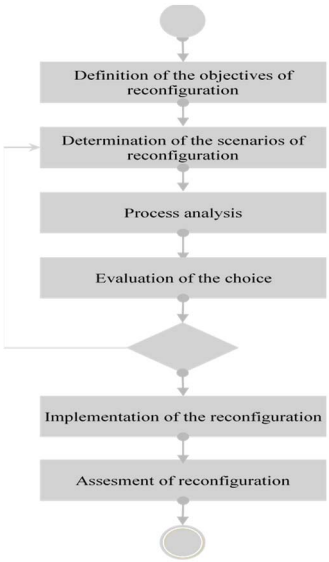

Figure 1. Activity diagram of the proposed approach

We have built on the approach proposed by [5, 14] who proposed approaches to driving change in integration projects. In fact, we relied on the work of [5, 14] who proposed approaches to driving change in integration projects. In fact, [14] has focused on the implementation of ERP in an integrated industrial company, so that performance objectives are expressed in terms of internal processes. [5] focused on performance objectives that are expressed in terms of external process. He proposed a methodology composed of four steps that consist in modelling the company network and the strategic motivations of the various partners, collecting and modelling interoperability situations of business processes as well as the exchange scenarios associated with them. Then specifying the application service

chains that support these business scenarios and finally defining the execution model that will be simulated in order to prepare the appropriate configuration. [5] used the different phases proposed by [14] by replacing the phase of determining organizational characteristics with a phase of characterization and prioritization of roles and actors.

A. Definition of reconfiguration objectives

The need for reconfiguration is caused by a hazard disruption in the supply chain. This failure affects, in particular, the business processes of the chain, which are considered as a set of activity, role and actor to be able to implement best practices for the reconfiguration of business processes in the supply chain. The identification of objectives consists in delimiting the reconfiguration problem in order to focus in particularly on the process (activities, roles and actors) that requires this need.

B. Determination of reconfiguration scenarios

Our approach consists in prioritizing reconfiguration scenarios by taking into account the different objectives defined previously to determine the most appropriate reconfiguration scenario. A "scenario" has been defined as a description of the simulation of a detailed process instance [6], i.e. the scenario that illustrates the new options for a new process. Each process has several scenarios to test different specific cases to validate their reactions after reconfiguration. To this aim, AHP method (Analytic Hierarchy Process) is used. Indeed, AHP is a multi-criteria decision method that allows decision makers to establish priorities for different alternatives in order to choose the best of them.

Then, the decision makers analyze this structure through a series of pairwise comparison that derive numerical, scales of measurement for the nodes. The reconfiguration objectives are pairwise compared against the goal for importance (matrix A). The matrix (1) is composed of a_{ij}^0 which designate the comparison between the objective j and i.

$$A = [a_{ij}^0] = \begin{pmatrix} 1 & a_{12}^0 & \cdots & a_{1n}^0 \\ \frac{1}{a_{12}^0} & 1 & \cdots & a_{2n}^0 \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}^0} & \frac{1}{a_{2n}^0} & \cdots & 1 \end{pmatrix} \quad (1)$$

Once the pairwise comparison matrix is created, we determine the appropriate matrix: matrix A' (2).

$$A' = \begin{pmatrix} \frac{1}{\sum_{i=1}^n a_{i1}^0} & \frac{a_{12}^0}{\sum_{i=1}^n a_{i2}^0} & \cdots & \frac{a_{1n}^0}{\sum_{i=1}^n a_{in}^0} \\ \frac{a_{21}^0}{\sum_{i=1}^n a_{i1}^0} & \frac{1}{\sum_{i=1}^n a_{i2}^0} & \cdots & \frac{a_{2n}^0}{\sum_{i=1}^n a_{in}^0} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{a_{n1}^0}{\sum_{i=1}^n a_{i1}^0} & \frac{a_{n2}^0}{\sum_{i=1}^n a_{i2}^0} & \cdots & \frac{1}{\sum_{i=1}^n a_{in}^0} \end{pmatrix} \quad (2)$$

The choice will then be made for the highest value through the matrix *A"*. The matrix (3) constitutes the weights and the importance coefficients of the different criteria (reconfiguration objective).

$$A'' = \begin{bmatrix} \left(\frac{\frac{1}{\sum_{i=1}^n a_{i1}^0} + \frac{a_{12}^0}{\sum_{i=1}^n a_{i2}^0} + \cdots + \frac{a_{1n}^0}{\sum_{i=1}^n a_{in}^0}}{n} \right) \\ \left(\frac{\frac{a_{21}^0}{\sum_{i=1}^n a_{i1}^0} + \frac{1}{\sum_{i=1}^n a_{i2}^0} + \cdots + \frac{a_{2n}^0}{\sum_{i=1}^n a_{in}^0}}{n} \right) \\ \vdots \\ \left(\frac{\frac{a_{n1}^0}{\sum_{i=1}^n a_{i1}^0} + \frac{a_{n2}^0}{\sum_{i=1}^n a_{i2}^0} + \cdots + \frac{1}{\sum_{i=1}^n a_{in}^0}}{n} \right) \end{bmatrix} = \begin{bmatrix} w_k^1 \\ w_k^1 \\ \vdots \\ w_k^1 \end{bmatrix} \quad (3)$$

C. Process Analysis

The selected appropriate reconfiguration scenario aimed at being applied to the business processes. Then, the process is decomposed according to the basic concepts: the activity, the role and the actor. First, this phase describes the identification of these concepts. Second, it allows determining the correlation between them to lead to a reconfiguration scenario that will succeed in achieving the reconfiguration objectives.

The process analysis phase allowed us to deal with the reconfiguration problem through the basic concepts: activity, role and actor. After identifying reconfiguration scenarios, we analyzed the correlation between these scenarios and business processes. The reconfiguration of critical business processes starts with the decomposition of processes into a set of activities. Next, we studied the correlation between the processes and the various activities identified. Second, we identified the roles associated with the most critical activities identified earlier. Finally, we studied the correlation between the roles and actors related to each role.

All these steps allowed us to determine the processes that require reconfiguration actions while ensuring a compromise between these actions and the different concepts related to the business processes (Figure 2).

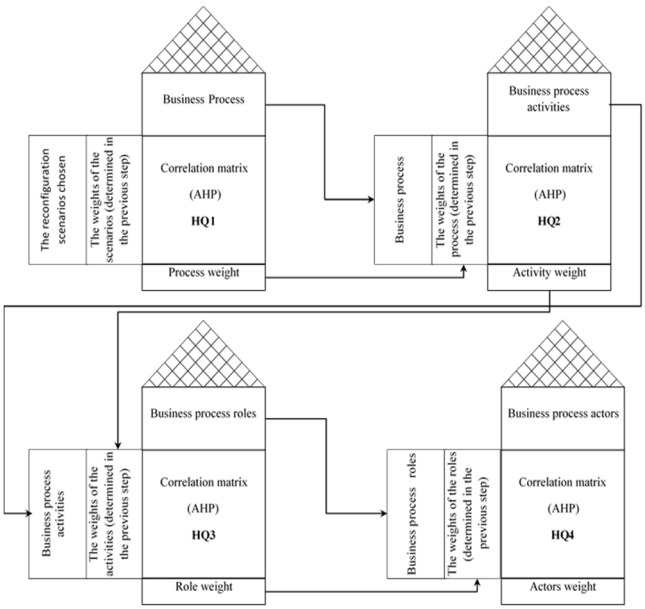

Figure 2. The QFD-AHP applied method

Each phase includes two steps:

- Identification of the concept (process, activity, role, actor);
- The hierarchy of each concept.

We designate by a_{ij}^1 the importance value that indicates the comparison between two processes according to the defined criterion (the reconfiguration scenario) for the first house of Quality HQ1. The scale proposed by [15] will express this comparison.

$$A = [a_{ij}^1] = \begin{pmatrix} 1 & a_{12}^1 & \cdots & a_{1n}^1 \\ \frac{1}{a_{12}^1} & 1 & \cdots & a_{2n}^1 \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}^1} & \frac{1}{a_{2n}^1} & \cdots & 1 \end{pmatrix} \quad (4)$$

Thereafter, this matrix will be normalized by dividing each element a_{ij}^1 by the total of the column to which it refers (5).

$$A' = \begin{pmatrix} \frac{1}{\sum_{i=1}^n a_{i1}^1} & \frac{a_{12}^1}{\sum_{i=1}^n a_{i2}^1} & \cdots & \frac{a_{1n}^1}{\sum_{i=1}^n a_{in}^1} \\ \frac{a_{21}^1}{\sum_{i=1}^n a_{i1}^1} & \frac{1}{\sum_{i=1}^n a_{i2}^1} & \cdots & \frac{a_{2n}^1}{\sum_{i=1}^n a_{in}^1} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{a_{n1}^1}{\sum_{i=1}^n a_{i1}^1} & \frac{a_{n2}^1}{\sum_{i=1}^n a_{i2}^1} & \cdots & \frac{1}{\sum_{i=1}^n a_{in}^1} \end{pmatrix} \quad (5)$$

To determine the correlation between the different process i and the reconfiguration scenario k noted b_{ik}, we will calculate the matrix B (6).

$$B = \begin{bmatrix} \left(\frac{\frac{1}{\sum_{i=1}^n a_{i1}^1} + \frac{a_{12}^1}{\sum_{i=1}^n a_{i2}^1} + \cdots + \frac{a_{1n}^1}{\sum_{i=1}^n a_{in}^1}}{n} \right) \\ \left(\frac{\frac{a_{21}^1}{\sum_{i=1}^n a_{i1}^1} + \frac{1}{\sum_{i=1}^n a_{i2}^1} + \cdots + \frac{a_{2n}^1}{\sum_{i=1}^n a_{in}^1}}{n} \right) \\ \vdots \\ \left(\frac{\frac{a_{n1}^1}{\sum_{i=1}^n a_{i1}^1} + \frac{a_{n2}^1}{\sum_{i=1}^n a_{i2}^1} + \cdots + \frac{1}{\sum_{i=1}^n a_{in}^1}}{n} \right) \end{bmatrix} = \begin{bmatrix} b_{1k} \\ b_{2k} \\ \vdots \\ b_{nk} \end{bmatrix} \quad (6)$$

Determining the correlation simplifies the analysis of comparisons between process and the determination of the most critical process that needs to be reconfigured. The determination of the weight is based on the correlation degree values and the weight of each scenario k obtained in the first step. Then, the weight of each process I noted p_i is:

$p_i = \sum_{k=1}^n b_{ik} w_k$ (Figure 3).

	Process 1	Process 2	Process 3	…	…	…	…	Process n	Weight of scenario
Scenario 1	b_{11}	b_{21}	b_{31}	…	…	…	…	b_{n1}	w_1
Scenario 2	b_{12}	b_{22}	b_{32}	…	…	…	…	b_{n2}	w_2
Scenario 3	b_{13}	b_{23}	b_{33}	…	…	…	…	b_{n3}	w_3
⋮	⋮	⋮	⋮		⋱			⋮	⋮
⋮	⋮	⋮	⋮			⋱		⋮	⋮
⋮	⋮	⋮	⋮				⋱	⋮	⋮
⋮	⋮	⋮	⋮					⋮	⋮
Scenario n	b_{1n}	b_{2n}	b_{3n}	…	…	…	…	b_{nn}	w_n
Weight of process	p_1	p_2	p_3	…	…	…	…	p_n	

Figure 3. House of Quality HQ1

D. Evaluation of the choice

The chosen reconfiguration scenario must be evaluated according to the supply chain reconfiguration characteristics mentioned in the literature. This characteristic allows evaluating several variables that can contribute to the success of the reconfiguration. Indeed, we have refereed to [16]. In fact, the variables developed by [16] facilitate the change in the supply chain and characteristic satisfaction (Table II).

Table II. Supply chain characteristics [16]

Characteristic	Variables
Modularity	Network structure design, responsiveness, total cycle time
Integrability	Real time integration, collaboration, transfer Pricing
Convertibility	Adaptability, leagility, Trust
Diagnosability	Visibility, data reliability, resilience
Customization	New product development, customer satisfaction, sustainability

The reconfiguration scenarios will be evaluated using a QFD matrix to determine the degree of satisfaction of each criterion. This matrix is used to determine the correlation between the reconfiguration scenario chosen and the evaluation criteria f_{ij}. If the reconfiguration scenario does not satisfy the criteria mentioned, the decision-maker should return to the second step to determine the reconfiguration scenario that can satisfy these criteria.

IV. THE ILLUSTRATIVE EXAMPE

We consider a company ABC that is looking to develop and improve its supply chain to deal with the problem of fluctuating demand. Indeed, this company aims to meet the new demand requirements, which require the assurance of reliable information in real time between all the actors of the supply chain. As a result of the increase in demand, this company decided to take the necessary measures and take possible actions to deal with this problem. Therefore, before analyzing and proposing the reconfiguration scenarios, the managers set the objectives of the reconfiguration actions. These objectives depend on the business processes of the supply chain as well as the requirements of their actors involved. To deal with this problem, we will focus on the sourcing process (PS), production process (PP) and logistic process (PL) processes. Indeed, this company's objective is to meet the new demand, reduce the time lost due to instability and uncertainty of demand, ensure reliable information in real time and reduce the cost of the supply chain, which will increase due to uncertainty.

According to these defined objectives, decision makers make available reconfiguration scenarios to deal with the consequences of fluctuating demand in the supply chain. We propose two reconfiguration scenarios Figure 4:

- Outsourcing;
- Digitalization of some of the company's activities (towards company 4.0).

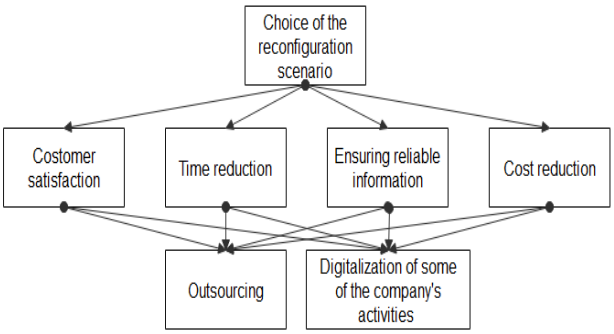

Figure 4. Hierarchy of problem

After having determined the matrices of comparisons between the reconfiguration objectives on the one hand, and the reconfiguration scenarios according to the different objectives on the other hand, the decision makers synthesize the priorities and determine the weight of each scenario to determine the reconfiguration scenario to be implemented.

Table III. Determination of scenarios weights

Scenario	Customer satisfaction	Time reduction	Ensuring reliable information	Cost reduction	Weight of scenario
Scenario 1	0,731	0,320	0,726	0,6	0,24
Scenario 2	0,3569	0,1280	0,2574	0.2	0,76

The synthesis of priorities illustrates that the second reconfiguration scenario is more appropriate to the objectives than the first scenario (Figure 5).

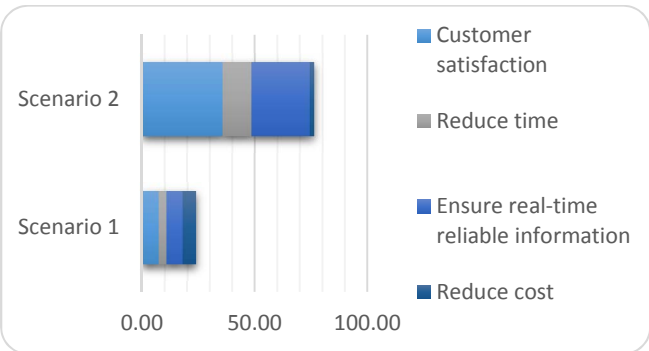

Figure 5. Scenario prioritization

After having identified the reconfiguration scenario, the company ABC analyses it based on these processes before decomposing them according to the concepts of activity, role and actor. We will assume that each process can be decomposed as shown in the Figure 6.

The application of comparison matrices between business processes, activities, roles and actors makes it possible to prioritize them and determine which ones require reconfiguration.

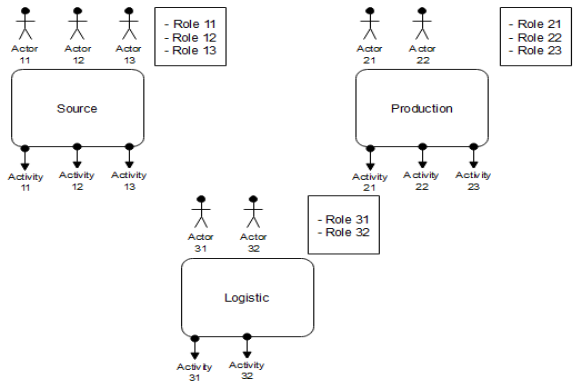

Figure 6. The decomposition of ABC process

Indeed, the identification and prioritization phase of the processes allowed us to conclude that the logistics process is the one that has a higher weight than the purchasing or production process.

Table IV. House of Quality 1

	PS	PP	PL	Scenario weight
Scenario 1	0,11	0,31	0,58	0,24
Scenario 2	0,07	0,49	0,44	0,76
Process weights: p_n	0,0796	0,4468	0,4736	1

Table V. House of Quality 2

	Activity 31	Activity 32	Process weight
PA	0,83	0,17	0,0796
PP	0,33	0,67	0,4468
PL	0,14	0,86	0,4736
Activity weights: v_n	0,2798	0,7202	1

Table VI. House of Quality 3

	Role31	Role32	Activity weight
Activity 31	0,83	0,17	0,2798
Activity 32	0,2	0,8	0,7202
Role weight: x_n	0,3763	0,6237	1

Table VII. House of Quality 4

	Actor31	Actor32	Role weight
Role31	0,89	0,11	0,3763
Role32	0,86	0,14	0,6237
Actor weights: y_n	0,8713	0,1287	1

Then, by examining the correlation of activities, roles and actors, we were also able to identify those that require reconfiguration as a priority. This analysis showed us that

Activity32, Role32 and Actor31 are those which must be reconfigured as a priority because they have the highest weight values.

Before implementing reconfiguration actions, decision makers must evaluate reconfiguration scenarios according to the following criteria: modularity, convertibility, integrability, diagnosability and customization.

Table VIII. House of Quality 5

	Modularity	Convertibility	Integrability	Diagnosability	Customization	Weight of scenario
Scenario 1	0,1	0,25	0,15	0,3	0,2	0,24
Scenario 2	0,15	0,2	0,3	0,05	0,3	0,76
Criteria weights: q_n	0,138	0,212	0,264	0,11	0,276	1

This matrix allows decision makers to identify the correlation between the criteria defined above and the two proposed scenarios. Indeed, the weights of the criteria allow us to have an overall view on the degree of satisfaction of the criteria by each scenario. Thus, this matrix shows the weight of each criteria, i.e. the criteria with the highest weight value represent the criteria that can be most satisfied by one of the proposed scenarios. In the case of company ABC, customization is the criterion with the highest weight value; this means that the second scenario is the one that satisfies the customization more than the first scenario (as well as the other criteria).

V. Conclusion

Several concepts have emerged to deal with market uncertainties such as reconfiguration, reengineering, alignment. In this context, several studies have been developed such as design and modelling of supply chain reconfigurations, through their processes, information systems and production systems. In this context, companies have committed to change strategies to ensure a reconfigurable supply chain that can cope with market fluctuations. In addition, business process reconfiguration is a concept that has been introduced to focus on ensuring a reconfigurable supply chain. From this perspective, we have proposed an approach that deals with this issue through several concepts.

In this paper, we have proposed an approach that aims to ensure the reconfiguration of business processes by introducing the concepts of activity, role and actor. In fact, this approach aims to determine the process, activities, roles and actors that need to be reconfigured as a priority. The QFD method allows identifying the correlation between these concepts. The AHP method allows reducing the sizes of correlation matrices by choosing the processes, activities, roles and actors with the highest weights. Further works aims to integrate other concepts to ensure an effective reconfiguration, including process resources. Thus, we propose to develop the evaluation phase of the reconfiguration (after its implementation). Many extensions of the AHP method have been developed. The difference between them resides mainly in the type of uncertainty associated to the problem in particular in the way of dealing with that uncertainty when making a decision. In future research, we will take into account the uncertainty of the information.

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