Technic and Collaboration Breakdown Structures: Drivers of collaborative problem solving approaches in a supply chain context

ROMERO Juan Camilo [a,b] **COUDERT Thierry** [a]
GENESTE Laurent [a] **VALROGER (De) Aymeric** [b]

[a] ***Laboratoire Génie de Production / INP-ENIT / University of Toulouse***
47Avenue d'Azereix, 65016 Tarbes Cedex, France
[b] **AXSENS SAS,** *20 Impasse Camille Langlade, 31100 Toulouse, France*
e-mail:*{ j.romerobejarano ; thierry.coudert ; laurent.geneste} @enit.fr, aymeric.devalroger@axsens.com*

Abstract: Problem Solving Methodologies have been par excellence a cornerstone element of the firms' strategy on achieving effective continuous improvement. But the enterprise evolution towards an extended environment characterized by network-based organization has radically changed the problem solving paradigms. This paper aims to propose a generic and collaborative methodology addressing more complex and distributed problems, dealing with Supply Chain issues and having a key role as a driver for building global competitive advantages and create superior performances at a Supply Chain level.

Keywords: Problem Solving Methodology, Collaboration, Supply Chain, Experience Feedback Processes, Collaboration Breakdown Structure, Technic Breakdown Structure

1. INTRODUCTION

The *Problem Solving Methodologies* (PSM) has become one of the key elements of enterprise strategy on long-term costs reduction, effectiveness improvement and added value activities increase [Foguem et al., 2008]. The positive results, traduced on best performances and high enterprise competitiveness levels, which have been clearly measured have motivated firms to continue investing and mobilising resources on this area. As a result of this strategy, the Problem Solving is driven today within organisations by (1) well-tried and well-controlled methodologies showing high-level performances (2) addressing problems more and more complex (3) with powerful backbone-tools supporting decision making processes (4) addressing organisation context and people empowerment and (5) with dramatic improvements on tools ergonomics and easy-to-use interfaces. Additionally important progresses have been achieved by incorporating *Experience Feedback* Processes to drive and structure knowledge capitalisation and reuse during the solving phase [Jabrouni et al., 2010]. By coupling with *Knowledge Management* techniques, the PSM have demonstrated their key role as vehicle for continuous improvement and consolidation of *Learning Organisations* [Foguem et al., 2008].

Although the progresses, all the achievements on the *Problem Solving* area are still strongly limited to the enterprise perimeter with centralized methodologies solving local problems. The actual methodologies are not yet well-adapted to answer and address the incoming challenges carried by the evolution towards the concept of *Extended Enterprise* [Knowles et al., 2005]. This concept of enterprise sets that organisations are not considered as individual actors looking for local profits; they are now considered as part of a self-organized network of organisations acting as a whole and looking for global benefits. This network, known as *Supply Chain*, considers the set of all the actors, activities, resources and their interactions as a co-dependant system working synergically for ensuring the efficient movement of physical flows from supplier's supplier to customer's customer in order to fulfil final customer needs [Jain et al., 2009]. This paradigm of network-based firms triggers more complex & distributed global problems [Cantor et al., 2009] and demands from organisations: (1) strategies synchronisation and objectives alignment (2) structured and common-to-all processes (3) collaborative practices contributing to effective communication [Zhou et al., 2007] and (4) global benefits policies over local profit ones. A *Collaborative Supply Chain* dealing with these points empower the new-generation firms to build global competitive advantage and create superior performances [Cao et al., 2011].

This article, as part of further researches, leads to meet the challenge of successfully extend PSM and their benefits to Supply Chain context and aims to propose a generic collaborative methodology adapted to new-generation network-based organisations. The proposed methodology has been designed to address solution of Supply Chain Problems (1) from a "multi-partner" context, (2) focusing on collaborative solving approaches, (3) with distributed (and non-centralized) activities, (4) leveraging high-impact Supply Chain Problems and (5) using distributed *Experience Feedback* processes. This article summarizes the key elements and their interactions and the global structure of such methodology.

The consideration of the enterprise as a co-dependant network gives to *Problem Solving* reasoning an extra complexity not only on *Technical* aspects but also on *Collaborative* ones: the power and trust relations, the incentive alignments, confidentiality issues, information sharing and core competency gaps are some of the focal points being analysed and integrated on this proposal thought the definition of the *Collaboration Breakdown Structures* (CBS). The definition of this concept and its coupling with a *Technic Breakdown Structure* (TBS) is one of the major contributions of this article that positions it as a driver and as structural element on *Collaborative Problem Solving Approaches* in *Supply Chain* contexts.

The document is organized from here on three sections as follows:

- A first section dedicated to introduce the key structural concepts of the proposed methodology and their articulation in a two-layered model. A special focus on problem solving requirements based on *Technical* and *Collaboration* aspects of Supply Chains is included.
- Second section describes the two-layered model and details on its integration into the proposed generic Problem Solving Methodology. Conclusions regarding to benefits, assets and advantages about this notion are presented. The role of this element for structuring the Collaborative Problems Solving processes in Supply Chain contexts is widely discussed.
- Perspectives in regard of further researches are finally presented.

2. THE CORNERSTONE ELEMENTS FOR PROBLEM SOLVING ON SUPPLY CHAIN CONTEXTS

The first step on defining an effective PSM well-adapted to network-based organisations lies on a transversal understanding of all processes, flows, requirements and dynamics behind Supply Chains. A better comprehension guiding the key choices on the methodology definition has been reached by analysing and reasoning Supply Chains from:

- ***Technical Axis***: This axis focus on Supply Chain requirements in terms of technical details. Particularly the physical and information flows modelling through the network is analysed. Issues associated with product architecture, flows tracing, network modelling and their impact on solving problem process are included.
- ***Collaboration Axis***: Includes all the relational and collaborative aspects being critical on the effectiveness of supply chain practices operation [Cao et al., 2011]. Existing literature on this domain provides with theoretical models describing a fragmented framework contributing to the understanding of collaborative efforts in a Supply Chain context [Manthou et al., 2004] [Angerhofer et al., 2006]. A double effort has been deployed in the frame of this research in order to extend and adapt these concepts to guide the definition of a model (1) easy-to-incorporate in a generic operative methodology and (2) focused on Problem Solving Practices.

In both the *Technical* and *Collaboration* axis, the analysis of the key factors impacting on problem solving process in distributed contexts leads towards the introduction of the core elements making up the proposed two-layer model. The interaction between technical-oriented and collaboration-oriented layers is addressed at the end of the section.

2.1 Technical Axis:

Immediate recovery of large quantities of complete and meaningful technical information concerning the products affected by problems and their entire related context through all stages of the Supply Chain allows simplifying and enhancing problem specification phase and thus focusing team efforts on further and more added-value phases. This is the main benefit that can be reached by incorporating effective supply chain modelling and tracing technics in PSM [Zhang et al., 2011].

Existing modelling technics address product functional dimension by using hierarchical top-down decomposition structures [Le et al., 2011], which are completed with standalone Project, Resources and Organisation Breakdown Structures in a multi-dimensional approach especially used on Project Management domain [Heredia et al., 1991]. These structures are widely used and are well-adapted to processes inside the enterprise perimeter but, as the same as PSM, their extension towards a Supply Chain context triggers important adaptation efforts. To materialize these efforts an analysis work inspired on existing supply chain literature and leading to identify the key requirements in terms of product modelling on Supply Chains has been deployed and its synthetized on Table 1. This analysis is the depart point on the definition of a modelling solution regarding to supply chain problems.

Dimension	Requirements for modelling technical aspects on S.C. contexts
Products *(Refered to all physical flows moving through network)*	- More complex products with more complex functional configurations - Products understood as Supply Chain Final products - transition from local to Supply Chain products - transition from intermediate to final products - Products distributed through complex networks formed by nodes and links - Dynamic products moving through network
	- Product decomposition choices are no more exclusively done in terms of functional or technical parameters. - Some of the new wide range of criteria to be considered for product decomposition on Supply Chains are : - Network configuration and economic advantages - Logistic constraints due to product movements - Knowledge and skills distribution on Supply Chain - Collaboration aspects ../.. - Depending on Supply Chain specifics, large number of decomposition levels can exist. For Problem Solving approaches a commitment between sufficiency and performance must be evaluated on each case.
Processes *(Refered to all processes put in place to deliver Products)*	- Processes coupled with Products breakdown structures - Processes defined at each product decomposition level - Processes distributed as the same as the Products through the network - Processes can involve contribution of several actors from network through different configuration models : - Cooperation model - Competition model - Sub-contractor model - For a same product different specific processes can be defined : - Design Process - Industrialization Process - Build/Assembly Process - In Supply Chain context the "Transport" Processes defined on links between nodes of the network must be considered to have a complete context comprehension.
Actors *(Refered to all responsibles or contributors of put in place processes)*	- Not more hierarchical but network-based organizations - Accountabilities are distributed through network as the same as the Product and the Processes - Depending on configuration model chosen at each stage of the Supply Chain and at each product level, there is always only one responsible but it could exist diferents actors contributing on specific processes (Design, Industrialization, Built, Transport). - Nodes and Transportation actors are important for a complete understanding of supply chain contexts

Table 1 – Key requirements for Product Modelling on SC

A PSM based on supply chain modelling technics to support problem specification phase must incorporate a robust model tackling the three dimensions listed on Table 1. As part of this research a proposal combining under a unique representation model these three dimensions, adapted to work on extended Supply Chain contexts and easy-to-incorporate in a global and structured problem solving methodology is proposed. This model, named *Technic Breakdown Structure (TBS)* corresponds to the first of two proposed levels addressing the complete *technical* context of Supply Chain problems. In this article, only the key general principles of this first layer structure are presented with the objective of allowing global understanding of the complete model.

For each final product in a given Supply Chain, the *TBS* proposes a set of interconnected *technical packages* distributed through the network. Each package is defined for each element on the product decomposition structure and groups the entire technical context concerning this element by taking into account product architecture, related processes and network aspects. The operating principle is that a *package*, owned by one partner, is assembled from lower-level packages coming from left partners on the network by starting with left-side *material raw packages* and finishing with right-side *final products packages*. The model assumes that a package can only be owned by one actor on the network who is the responsible of the package assembly and eventually of the coordination of other actors' participation. This contribution can be represented for each package through one of the four specific *package processes*:

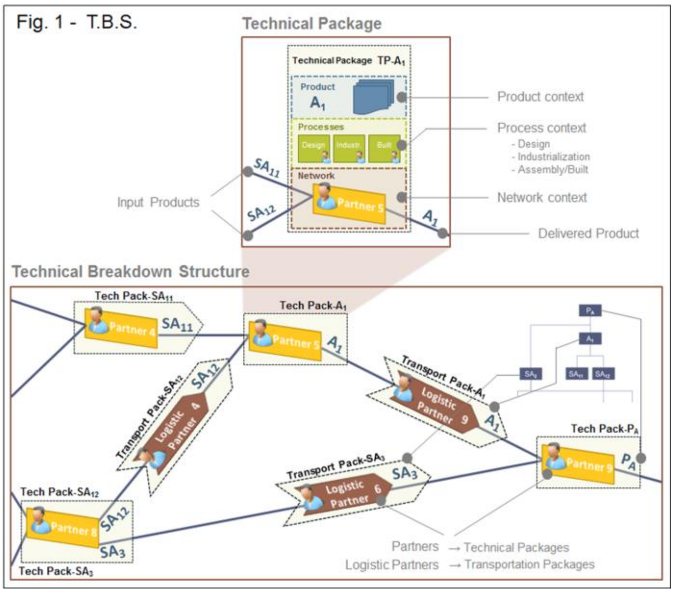
- *Design:* Involves the definition of engineering data related to package built/assembly. Can be done internally or under a model involving contribution from other network partner. (e.g. Cooperation and/or Sub-contractor models)

- *Industrialisation:* Involves the definition of actions to bring the package assembly from development status to series production. Can be done internally or under a model involving contribution from other network partner. (e.g. Cooperation and/or Sub-contractor models)

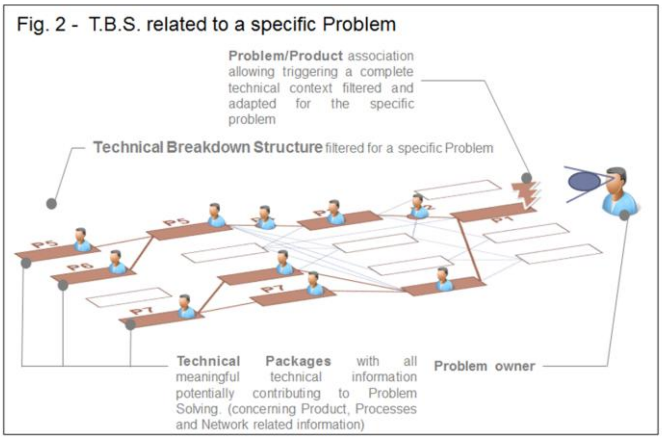
- *Assembly/Built:* Involves the actions of production/assembly of the package in series phase. It is under responsibility of actor owning the package.

- *Transport:* The transport of both lower-level and final package can be executed or not by the actor owning the package. If the transport is done by a partner different from the one owning the package/lower-packages, this new actor is included in the model by a new simplified *Transportation Package* placed between the two nodes.

If we study the *Technic Breakdown Structure* for a specific final product on a specific Supply Chain it doesn't necessary cover all the partners on the network but if we consider all the final products on the same Supply Chain at the same time, the *TBS* covers this time all the partners on the network with some of them owning several packages, one for each final product. The technical layer issued of the analysis of all the final products on a given Supply Chain at the same time can be considered as the complete technical model representing supply chain in question. On Figure 1 the principles of the *Technic Breakdown Structure* and its *technical and transportation packages* are illustrated through an example:



During early problem declaration phase, the identification of the products on which the problems are detected, allows to associate a *TBS* to a specific problem. This structure can be still enhanced by incorporating decision support elements and automated pre-filtering options. For instance, by the simple characterisation of a problem in the declaration phase regarding to a pre-defined standard problems list, an automated filtering of the *TBS* keeping only elements directly contributing to specific problem context and respecting problem type definition can be thus executed *(e.g. Number of technical packages reduced and thus TBS simplified following the characterization of the problem as an "Electric" one: All Packages concerning hydraulic and non-electric pieces can be excluded for the current structure because they are not concerned by the problem and they are not potential contributors of solutions to problem solving process)*. This approach allows identifying not only a complete but also a pertinent *technical context* for a problem appeared for any of the products moving through the supply chain as shown on Figure 2:



2.2 Collaboration Axis

In a network-based organizations scenario the *Technic Breakdown Structure* layer is a necessary but not a sufficient element to characterize the entire context of problems, because Supply Chains are dynamic structures affected also by non-technical factors that evolve permanently through the time. Factors such as trust and power relations, confidential and information sharing issues, cooperation aspects and competencies distribution are some of the dynamic factors governing supply chains operation between actors. In the frame of this research, these factors are addressed by the proposition of a second level completing the first technical one in a global two-layered proposal for Supply Chain modelling.

This level, named the *Collaboration Breakdown Structure*, integrates all the collaboration and relational aspects on Supply Chain modelling in a unique structure. This structure has an important role on context specification and team definition phase, and can be only launched after the first technical layer element has been completed. At this stage, we have all technical packages defined, validated for all the product, processes and network aspects and filtered in regards of standard criteria. With this proposal a re-organization of the suggested technical layer is negotiated between concerned actors. The entire technical configuration, automatically proposed by the model, is re-defined and adapted by a negotiation process to propose a new collaboration structure that respects all the collaboration conditions. In other words, all the technical *packages* are re-organized and grouped on *Collaboration packages* that respect collaboration and relational supply chain factors.

As the same way as the *Technical axis*, an analysis work leading to define and characterize the key principles impacting the *collaboration packages* definition regarding to main supply chain collaborative factors existing on literature has been done and the results inspiring this proposal are shown on Table 2:

Key factors conditioning S.C.	Guidelines for Collaboration Packages definition
Trust	- Trust must be positioned over Control as a key factor to favor collaboration practices, especially when knowledge management efforts are involved. - Collaboration Packages configuration must allow intensifying trust when it already exists and must allow favoring trust when it doesn't exist or when it is not yet so deep. - Trust intensifies information sharing in a more natural and implicit way. This intensification cannot be reached with conditions formalized through contracts. - In collaborative practices involving shared knowledge creation, the trust based on rationality is fundamental. - In Collaboration packages, only the Rational Trust guarantees an effective analysis of root causes leading to durable solutions. - In collaborative problem solving approaches, trust between all contributors is a mandatory condition to ensure effective problem solution. At first, a *Rational Trust* based model can be the trigger for long term relations based on other types of Trust.
Conflict	- Conflict must be assessed on Collaborative practices to minimize their apparition. Means to solve conflicts when appeared must be considered as well. - Actors objectives and values must be evaluated during Collaboration Packages constitution. - Collaboration Packages must favor communication and information sharing. - In case of conflicts, the Collaboration Package operating rules and the Power configuration must allow overcoming conflicts.
Knowledge and Competencies	- In problem solving contexts the knowledge and the competencies owned by actors are a key factor on the Collaboration Package constitution phase. Knowledge clusters grouping certain competencies can be an advantage and can structure problem solving analysis phases.
Power	- Power is necessary in any collaborative approach involving decision making processes. It allows progressing when agreements between actors are not possible. - Collaboration Breakdown Structure must evaluate the notion of Power at the definition stage. It is analyzed and incorporated because it is necessary but it mustn't be promoted as the key driver of collaborative relations. Rules favoring more constructive factors as the Trust must be deployed. - In collaborative practices, the power between actors must be shared in an equitable way. - Collaboration packages must reflect this equitable distribution. - Collaboration packages operation rules must allow compensating Power gaps. - In problem solving approaches the power must be defined in terms of positioning of actors in regards to problem. - Problem owner must have more Power than the other actors . - Collaboration Packages coordinators must have more Power than the other actors inside the package. - Collaboration Packages actors must have simmilar Power positions.
Control	- Excesive Control is not desirable in collaborative practices because it constraints positive interchanges and limits the intensification of relations. However, a formalization effort leading to identify the list with all the fundamental control actions must be always done to ensure objectives achievement and performances evaluation. - On Collaboration Packages only the minimal quantity of control actions allowing track the general objectives achievement and the critical actors commitments and performances are formalized through simplified "Collaboration Contracts". - Positive benefits reached through collaborative practices, leads towards a scenario where the control becomes more and more implicit and less formalized with time progress and methodology maturity. - After constructive relations are built "Collaboration Contracts" become not mandatory and can be simplified to promote the intensification of existing trust between actors.
Information Sharing and Confidential issues	- Symmetric information sharing is a positive factor on collaborative practices - For actors on the same Collaboration Package, symmetric information must be distributed by the coordinator. In the same way, actors must be able to share information with the other actors inside the Collaboration Package in an open way. - Analysis related to a problem can be decomposed on different levels or encapsulated on several perimeters in order to promote critical information sharing. - Information issued from problem analysis can be decomposed on strategic, tactic and operation levels and afterwards through collaboration packages definition the access to each information level can be limited. By this mean, actors are less constraint to share confidential information because it will be only accessible for concerned chosen actors. - At least, previously agreed and critical information must be provided by the actors on the Collaboration Packages. Minimal conditions in terms of information sharing must be negotiated at the Collaboration Package constitution phase to guarantee process completion and objectives achievement. "Collaboration Contracts" play a key role on this phase.

Table 2 – Key Principles of C.B.S. per S.C. key factor

Unlike an automatic definition process for *technical packages*, the *Collaboration packages* definition is done through a model-guided negotiation process. Regarding to key factors defined on Table 2, the model supports external negotiation process through standard and pre-defined forms piloting partners' decision making. By this mean the model leads to *Collaboration packages* and further CBS definition. For a given problem, an example of the re-organization of the *Technical Breakdown Structure* on a complementary *Collaboration Breakdown Structure* is shown in Figure 3.

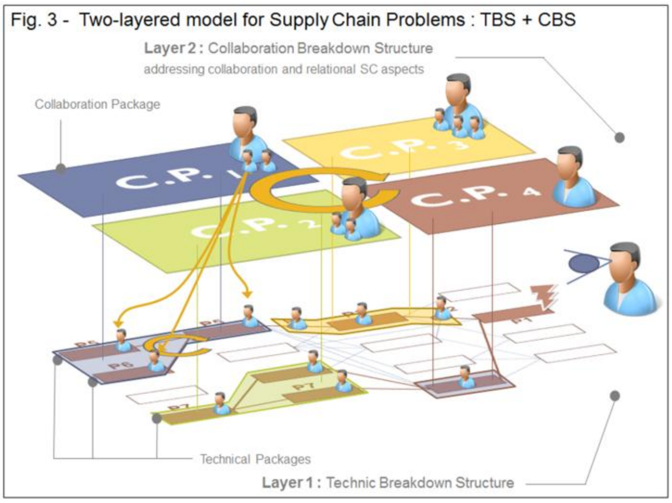


Fig. 3 - Two-layered model for Supply Chain Problems : TBS + CBS

One *Collaboration Package* can (or not) group several *Technical Package* representatives. A Coordinator for each Package is chosen to coordinate package internal efforts and to communicate with other Collaboration Packages coordinators. The accountabilities and the different roles inside the package are distributed in regard of agreed *Collaboration Contracts* governing *Collaboration Package* operation.

2.3 A two-layered model incorporating Technical and Collaboration aspects

The collaborative layer completes the supply chain context understanding and in any case has the objective of replacing the technical one. The real challenge has been to interconnect both of them in a two-level model allowing addressing the entire context of supply chains from both technical and collaborative points of view. Positioning these two elements as the driver of a unique model for representation of Supply Chain contexts sets an important progress on the area. Existing theoretical models and practical methodologies address only one of the two axes and any of them is designed to deal with problem solving practices on network extended contexts.

As mentioned before, the role of the TBS is to summarize and encapsulate into *Technical Packages* the entire context of problems on Supply Chains from a point of view Product, Process and Network. In a complementary way, the role of the CBS is to re-organize, aggregate and group the *Technical Packages* into more global *Collaboration Packages* answering to more complex and not formalized collaboration aspects of the Supply Chain. The first layer aims to provide robustness while the second aims to provide adaptability to model. Table 3 synthetize the contributions and roles of each layer.

LAYER 1 Technic Breakdown Structure	LAYER 2 Collaboration Breakdown Structure
- Summarize Technical Context of SC	- Describes Collaborative Context of SC
- Defined as a network of Technical Packages	- Defined as a network of Collaboration Packages
- Each Technical Package adresses Product, Process and Network aspects	- Each Collaboration Package is set by one or several Technical Packages
- Static Structure	- Dynamic Structure
- The definition can be automated with filters customizing structure in regards of a specific problem context	- The definition is supported by the model but done through a negotiation process between actors.
- Technical Package Representatives act in a lower and reduced perimeter (the one of the Collaboration Package)	Collaboration Package Coordinators act in a more global and agregated perimeter (the one of the Collaboration Breakdown Structure)

Table 3 – Contribution of a two-layered model

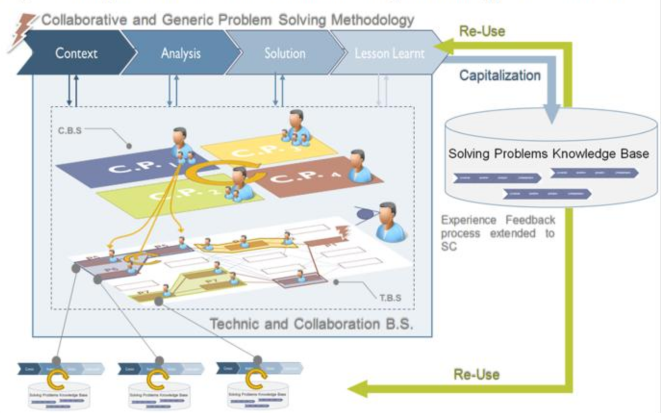
As mentioned on Table 3, Technical context can be characterized as *static* through the time because elements included on *Technical Packages* are relatively never-changing (or with evolutions with long term cycles). In opposite the Collaborative aspects evolve constantly through the time, almost on weekly/daily cycles for some specific supply chains because these last ones are directly impacted amongst others by macro-economic policies and stock markets fluctuations and crisis [Trkman et al., 2011] [Kull et al., 2008]. As a consequence of the existing cycle gap, for a same problem with two different appearances, the TBS is potentially the same in the two problem declarations, while the CBS is potentially different in both of them, because collaboration aspects are surely not the same. This behaviour shows the adaptability of the model to solve problems on complex and always-changing contexts. The model evolves in "real" time to allow providing up-to-date and reliable contexts on problem specification phase.

3. THE TWO-LAYER MODEL AS THE DRIVER FOR A COLLABORATIVE SOLVING PROBLEM METHODOLOGY

As demonstrated the proposed two-level model can boost the context specification and the team building phases. But these are only few of the great achievements that can be obtained on this field through the use of this type of model. With a complete synchronization the benefits can be measured across all the problem solving phases. This section aims to illustrate the integration of the TBS/CBS model as a driver of a Collaborative PSM on extended contexts.

The methodology considers that *Problem Solving* is a generic process that can be understood from a simplified approach with four phases: *Context*, *Analysis*, *Solution* and *Lesson Learnt* [Foguem et al., 2008]. The fact that all the existing methodologies for problem solving can be expressed in term of these four standard phases provides this choice with a generic reasoning contributing to adaptability and deployment in a widely range of contexts. The methodology has been equally enhanced with a global *Experience Feedback* process adapted to Supply Chain contexts and structured as a set of interconnected and cooperating knowledge systems distributed through the network and harmonized with the *Collaboration Packages*. The statements and harmonization principles of the *Experience Feedback* process are out of the scope of this article and will be the subject of future papers. A schema synthetizing the integration logic between the generic methodology, the two-layered model and the Experience Feedback system is shown on Figure 4. The different flows existing between the four steps methodology and the two-level model are represented with two-directional arrows and are detailed and widely discussed afterwards.

Fig. 4 - Principles of a Collaborative Problem Solving Methodology on SC contexts

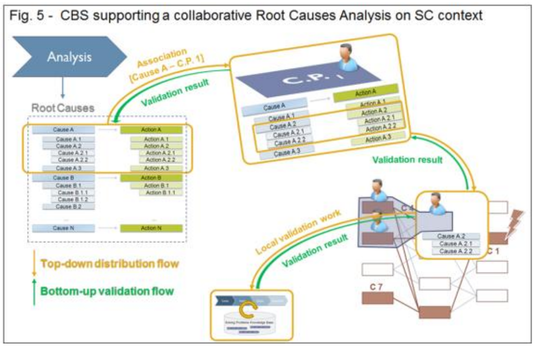


Context: As shown on Section 1 with a simple association at the problem declaration phase of a problem with a product, the further specification one can be significantly enhanced. The tracking and restore of the entire technical and meaningful related information across all the stages of the Supply Chain helps to complete the problem understanding. The *TBS* encompassing this context includes the entire product, process and network reasoning. Additionally through standard criteria, this context can be filtered and adapted to current problem requirements. A problem context characterized by the completeness, pertinence and accuracy of the information provides problem solvers with added-value information that enhances the decision making process. In distributed and complex environments, the possibility of reducing the space of research with prior and more pertinent information is a fundamental gain.

But on network-based systems the technical-oriented models address only one of the Supply Chain dimensions. The modelling of collaborative aspects is the other critical factor on supply chain effectiveness and as part of this research it has been coupled with the technical model by the definition of a second co-dependant layer addressing this time all the non-technical aspects. The *Collaboration Breakdown Structure* re-organizes and groups the technical context on *Collaboration Packages*. This second layer of Collaborative and interdependent packages guides problem solvers in the constitution of teams by distributing and sharing the workload not only in regard of technical but also of other factors such as knowledge and competencies proximity and power and trust relations. The definition of dynamic teams contributes to synergic collaborative work and intensifies positive supply chain efforts.

Analysis: On Problem Solving processes the Analysis phase can be understood as the effort of finding the root causes producing the problem. On extended contexts, where problems are highly complex and distributed through intricate networks, the root causes analysis can be boosted by *Collaboration Breakdown Structures*. A top-down flow distributing causes to be validated and a bottom-up flow providing validation results are the backbone of the collaborative model addressing complex problems analysis on extended and distributed contexts. Within this frame, a first global and aggregated analysis concerning problem and first-level root causes can be managed at *coordinators* level while a more reduced and local analysis can be driven inside each *Collaboration Package* by synchronization of individual efforts. The principle of the top-down and bottom-up flows based on the association of causes/partners is illustrated on Figure 5.

Fig. 5 - CBS supporting a collaborative Root Causes Analysis on SC context



In both descending and ascending flows team collaborative work is deployed at each level in order to align and coordinate efforts. In the bottom-up flow the sharing of the results of validation processes and the consolidation of the tree of causes contributes to effective root causes identification. Through this collaborative approach the resources participating on the solving process are optimized and both individual and network competencies and knowledge are consolidated.

Solution: After root causes identification and priorities defined, the two-layered model can focus the team collaborative work on the definition of an action plan addressing problem root causes. The same top-down and bottom-up flows deployed on the analysis phase can be used now to define an action plan distributed in horizontal through the different stages of the network and in vertical through the different firm decision levels. A global and aggregated action plan synchronizing vertical and horizontal flows of supply chain contexts ensures the effectiveness of the solution put in place.

Lesson Learnt: Great knowledge management benefits are obtained because both global and local knowledge and competencies are created, shared and diffused through this process contributing at the same time to the consolidation of Learning Organizations but the most important to the consolidation of Learning Supply Chains with global and higher performances and superior competitiveness.

4. PERSPECTIVES

This proposal dealing at the same time with technical and collaborative aspects of extended and distributed environments such as Supply Chains for solving more complex problems through a generic and collaborative methodology is part of a PhD research exploring other improvement opportunities to enhance the methodology. The possibility of re-using and integration of knowledge issued from problem solving experiences on other supply chain collaborative practices such as *Product Lifecycle Management* to improve product design phases and *Risk Sharing Management* to improve risk assessment on extended contexts are planned. The consolidation and deep studies leading to define collaboration indicators on problem solving contexts and more structured knowledge systems are some other hints to be pursuit.

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