Lire
la première partie
de la thèse
5. THE MECHANISMS SUPPORTING THE INTERACTION BETWEEN THE MODULES

The global methodology and its three modules (SCm, PSm, EFm) have been specified in the previous chapter. However, the effectiveness of the methodology depends strongly on the effective articulation between them. In consequence, the harmonization of all the problem solving, supply chain and experience feedback aspects need to be studied in more detail. In order to enhance this task and emphasize on the role that it has on the effective solving of distributed problems, a set of six dedicated mechanisms has been defined. These mechanisms (FiM, PaM, CoM, CaM, ReM, AmM) are intended to simultaneously support the operation of the methodology in practice and the integration of its modules to execute critical activities. For each mechanism, concentrating on one of the aspects of the process being critical in light of the solving of problems in distributed contexts, the models, tools and algorithms that support its operation are presented. In order to illustrate the main elements of the proposed mechanisms, the case study introduced in the previous chapter is improved and completed with additional examples.
5.1. PLAN FOR ESTABLISHING THE METHODOLOGY MECHANISMS

In order to ensure an effective interaction between the three modules of the methodology (SCm, PSm, EFm) and to allow the firms to jointly solve distributed problems, six mechanisms have been developed and integrated into this proposal. They support the critical steps of the process that require the interaction between the elements of at least two of the aforementioned modules so that the consistency of the global methodology can be guaranteed. They are developed in detail all along this chapter and their integration is based on the requirements of the generic process defined in chapter 3.2.4. Each mechanism comes up with a set of algorithms and models that enable the fulfillment of such requirements in practice and the interoperability between the three modules setting the global methodology.

The mechanisms cover the gathering and consolidation of a relevant set of technical knowledge thanks to the Filtering Mechanism (FiM), the team constitution thanks to the Partners Assessment Mechanism (PaM) and the Collaboration Mechanism (CoM), the capitalization and reuse of the experiential knowledge derived from the solving experiences thanks to the Capitalization Mechanism (Cam) and the Reuse Mechanism (ReM) and finally the monitoring and control of distributed actions thanks to the Action Management Mechanism (AmM). The aforementioned mechanisms are positioned in Figure 5.41.
5.2. THE FILTERING MECHANISM (FiM)

The FiM filters the TBS to propose a simplified structure including exclusively the technical knowledge relevant with respect to the understanding of a particular problem. It supports the gathering and consolidation of data and evidence during the context phase and in the frame of distributed and networked contexts (cf. 4.2.2). The mechanism compares the attributes of a given problem against the attributes of a given network in order to be able to propose a TBS\(^{(k)}\) providing a set of meaningful evidences useful in light of the study of the k-th resolution cycle of a given problem \(p\). Depending on the nature of the information that is considered during the filtering, the model is able to propose two complementary structures:

- **Structural context (or network-based context):** it is a simplified TBS defined as a set of TPs filtered in terms of the structural aspects of the network on which the problem appears. This structure takes into consideration both the level of contribution and the level of proximity of elements within the supply chain to the problem. This TBS provides relevant product, process and network information for elements converging into the product affected by the problem and, in consequence, potentially being at the origin of some of the causes that produce it.

- **Conceptual context (or product-based context):** it is a simplified TBS defined as a set of TPs filtered in terms of the conceptual similarity between the products they contain and the product on which the problem has been detected. The conceptual relevancy between products is based on the calculation of semantic similarities. This TBS provides relevant product, process and network information for similar elements in the network and, in consequence, potentially being useful for understanding the current problem.

While the structural context provides meaningful information on the upstream flows of the product on which the problem has been identified, the conceptual context gathers information of similar products on the network that can be useful in light of the understanding of the current problem. Then, if a problem is identified in a forward fuselage section of an aircraft, the first structure will provide information about all its constituents while the second one will provide technical knowledge regarding, for instance, the central or aft fuselage sections. Both structural and contextual TBS are illustrated in Figure 5.42.
The TBS filtered through the Filtering Mechanism can be formally denoted as follows:

\[ TBS_p^{(k)} = TBS_{\text{struct}}^{(k)} \cup TBS_{\text{concept}}^{(k)} \]

Simplified TBS including the structural technical knowledge for the k-th resolution cycle of problem p
Simplified TBS including the conceptual technical knowledge for the k-th resolution cycle of problem p

5.2.1. The mechanism supporting the filtering of the structural TBS

In order to obtain a structural TBS, the FiM starts with the identification of the set of TPs contributing to the problem. To this purpose, the model uses both the product and the key constituents impacted by the problem to filter the technical knowledge across the network. This activity reuses the two first problem attributes in the PCR (i.e. the impacted element or \( e_p^{(k)} \) and the set of key constituents or \( W_p^{(k)} \)) to propose a first preliminary set of evidence. This task is covered by the sequential steps A and B of the FiM:
Once the set of TPs contributing to the problem has been identified, the level of proximity between each TP in this set and the problem can be measured. The calculation of the proximity degree (denoted $s_1$) for each contributing TP and the filtering of the technical structure with regards to a proximity threshold defined by the problem solvers is covered by the sequential steps C and D of the FiM:

### C. Calculation of the proximity degree

**c.1 For each TP of $TBS_{contr\rightarrow w}^{p(k)}$ the proximity degree is calculated**

\[
s_1_j = 1 - \frac{LTP_{p(k)} - LTP_j}{l - LTP_{p(k)}} \quad \forall TP_j \in TBS_{contr\rightarrow w}^{p(k)}
\]

- $LTP_{p(k)}$ : Level of the $TP^{p(k)}$ in the supply chain
- $LTP_j$ : Level of the $TP_j$ in the supply chain
- $l$ : Number of levels in the supply chain
- $0 \leq s_1 \leq 1$
D. Filtering considering the proximity degree

**d.1** Based on a set of proximity thresholds, a panel of solutions is proposed. Example:

<table>
<thead>
<tr>
<th>Proximity threshold $s_1$</th>
<th>Number of TPs with proximity degree &gt; proximity threshold</th>
<th>Average of proximity degrees in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>3 TPs</td>
<td>0.92</td>
</tr>
<tr>
<td>0.8</td>
<td>7 TPs</td>
<td>0.86</td>
</tr>
<tr>
<td>0.7</td>
<td>13 TPs</td>
<td>0.73</td>
</tr>
</tbody>
</table>

**d.2** Problem solvers select the proximity threshold that better satisfies the needs in terms of information required for the problem. In the example a threshold of 0.8 has been retained:

<table>
<thead>
<tr>
<th>Proximity threshold $s_1$</th>
<th>Number of TPs with proximity degree &gt; proximity threshold</th>
<th>Average of proximity degrees in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>7 TPs</td>
<td>0.86</td>
</tr>
</tbody>
</table>

$s_1$ : selected proximity threshold, $s_1 = 0.8$

In this case 7 TPs have a proximity degree that exceeds 0.8. They have an average proximity of 0.86.

**d.3** The $TBS_{contr-s1}^{p(k)}$ is filtered: only TPs for which $s_1 > s_1$ are kept

$TBS_{contr-s1}^{p(k)}$ : Set of TPs contributing to $TP^{p(k)}_{k}$ adjusted for proximity degree

Once the filtering has been executed horizontally across the network, a filtering is executed vertically at the TP level in order to keep only the technical knowledge which is relevant in light of the problem being solved. This filtering compares the relevant processes defined in the PCR against the process information defined in the TPs. Then, and if a problem is likely to be a design problem, only the information concerning the design process of the pre-selected TPs is kept. This activity, supporting decision making in light of the understanding of the problem, is covered by step E of the FiM:

E. Filtering considering the relevant processes

**e.1** The relevant processes are obtained from the PCR

$S_{p(k)} = \text{Relevant processes concerned by the k-th resolution cycle of problem p}\$

* e.g. a problem can likely be a design problem

**e.2** The $TBS_{contr-s1}^{p(k)}$ is filtered: only relevant processes of $TPs \in TBS_{contr-s1}^{p(k)}$ are kept

$TBS_{contr-s}^{p(k)}$ : Set of TPs contributing to $TP^{p(k)}_{k}$ adjusted for relevant processes

**e.3** Structural TBS for k-th resolution cycle of problem p is proposed

At the end of step E, the FiM is able to propose a structural TBS for a given problem. It includes meaningful information, documentation and pieces of evidence of elements contributing to the problem. The FiM is illustrated thanks to the extension of the case study:
Once the problem characterization has been completed by the main landing gear manufacturer as part of the context phase of the first resolution cycle – or $p(1)$ – the model is able to launch the mechanism supporting the filtering of the TBS. Based on the problem attributes defined in the PCR $p(1)$ (refer to case study in section 4.3.2.1), and considering a proximity threshold of 0.5, the structural TBS that is obtained for this problem is:

The structural TBS (composed by $TP_{32}$, $TP_{34}$, $TP_{46}$, $TP_{47}$ and $TP_{48}$) provides a set of information – filtered across the network – which is relevant in light of the understanding of the problem. This set gathers and consolidates: (1) factual technical information and key characteristics about the main landing gear and its main constituents, (2) pieces of evidence and critical elements about the processes required to industrialize and manufacture those products and,
Finally, (3) the interactions between all those elements and the way they converge into the main landing gear. Then, the team of experts—or CP\textsuperscript{h(1)}—can improve the further analysis phase and, thus, improve the plausibility of suggested potential causes by considering this set of information. This has been the case for h\textsuperscript{1}, h\textsuperscript{2}, h\textsuperscript{3} (refer to case study in 4.3.1.1).

Once the structural TBS has been defined, the mechanism leading to the identification of the conceptual one can be launched. It is explained in the next section.

5.2.2. The mechanism supporting the filtering of the conceptual TBS

Both the product impacted by the problem and the products moving through the network are defined from terms of the same taxonomy. Then, in order to be able to define a conceptual TBS, the level of similarity between products in the taxonomy needs to be measured. This activity is executed by the FiM on the basis of the similarity measure of Wu and Palmer (Wu and Palmer, 1994) presented in section 3.3.3. The evaluation of the similarity between the product impacted by the problem and the products of the network (denoted s\textsubscript{2}) is covered by the sequential steps A and B of the FiM:

**A. Identification of the impacted TP**

\begin{itemize}
  \item a.1 The impacted element is obtained from the PCR
    \[ e^{p(k)} \in \text{Products, Products is the « taxonomy of products »} \]
  \item a.2 The TP to which the impacted element belongs is identified as TP\textsuperscript{p(k)}
    \[ TP^{p(k)} = \text{TP impacted by the k-th resolution cycle of problem p} \]
\end{itemize}

**B. Calculation of the semantic similarity degree**

\begin{itemize}
  \item b.1 For each TP in the TBS the semantic similarity is calculated
    \[ s2_j = \text{sim}(e^{p(k)}(j), e_j) \]
    \[ \text{sim}(e^{p(k)}(j), e_j) = \frac{2 \cdot \text{depth}(CCA)}{\text{depth}(e^{p(k)}(j)) + \text{depth}(e_j)} \quad \forall TP_j \in \text{TBS} \]
    \[ TP_j : j\text{-th TP of TBS} \]
    \[ e_j : \text{Output element produced by TP}_j \]
    \[ e_j \in \text{Products, Products is the « taxonomy of products »} \]
    \[ \text{depth}(e_j) : \text{depth of } e_j \text{ in Products} \]
    \[ \text{depth}(e^{p(k)}) : \text{depth of } e^{p(k)} \text{ in Products} \]
    \[ \text{depth}(CCA) : \text{depth of the Closest Common Ancestor of } e_j \text{ and } e^{p(k)} \text{ in Products} \]
    \[ 0 \leq \text{sim}(e^{p(k)}, e_j) \leq 1 \]
\end{itemize}
Once all the similarity degrees have been evaluated, the TBS can be filtered. This is covered by step C of the FiM:

### C. Filtering considering the similarity degree

**c.1** Based on a set of similarity thresholds, a panel of solutions is proposed. Example:

<table>
<thead>
<tr>
<th>Similarity threshold $s_{s1}$</th>
<th>Number of TPs with similarity degree &gt; similarity threshold</th>
<th>Average of similarity degrees in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>2 TPs</td>
<td>0.94</td>
</tr>
<tr>
<td>0.8</td>
<td>4 TPs</td>
<td>0.81</td>
</tr>
<tr>
<td>0.7</td>
<td>6 TPs</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**c.2** Problem solvers select the similarity threshold that better satisfies the needs in terms of information required for the problem. In the example a threshold of 0.8 has been retained:

<table>
<thead>
<tr>
<th>Similarity threshold $s_{s2}$</th>
<th>Number of TPs with similarity degree &gt; similarity threshold</th>
<th>Average of similarity degrees in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>4 TPs</td>
<td>0.81</td>
</tr>
</tbody>
</table>

$\delta_{s2}$ : selected similarity threshold, $\delta_{s2} = 0.8$

In this case 4 TPs have a similarity degree that exceeds 0.8. They have an average similarity of 0.81.

**c.3** The TBS is filtered: only TPs for which $s_{s2} > \delta_{s2}$ are kept

$\{ TBS_{conc}^{p(k)} :$ conceptual TBS filtered with regards to the similarity degree $\}$

As well as for the structural TBS, the FiM executes a filtering at the TP level in order to obtain the conceptual TBS. Then, the mechanism filters the information of the pre-selected TPs with regards to the processes identified by the problem solvers during the problem characterization as explained in the step E of previous section. Once the vertical filtering is executed, the conceptual TBS for the problem can be proposed to experts. It includes meaningful information, documentation and evidences for similar products potentially contributing to the understanding of the problem. An example, based on the case study, is presented hereinafter:

**Once the problem characterization has been completed by the main landing gear manufacturer as part of the context phase of the first resolution cycle –or p(1)–, and once the structural TBS has been identified thanks to the FiM, the mechanism supporting the conceptual filtering of the TBS can be launched. Based on the problem attributes defined in the PCR$^{p(1)}$ (refer to case study in section 4.3.2.1), and considering a similarity threshold of 0.7, the conceptual TBS that is obtained for this problem is represented below:**
The conceptual TBS (composed by TP10, TP36) provides useful information and pieces of evidence about the nose and tail LGs. That information can improve the understanding of the problem detected on the main LG and thus the further phase of root causes analysis.

The gathering and consolidation of a set of technical knowledge (structural and conceptual) enhances the context—as well as the further analysis and solution—phases of the problem solving process. However, the context phase also requires the assessment of the partners in light of the constitution of a team able to deal with this filtered evidence. This activity is discussed in the next section introducing the Partners assessment Mechanism (PaM).
5.3. THE PARTNERS ASSESSMENT MECHANISM (PaM)

The PaM supports, as illustrated in Figure 4.33, the evaluation of partners across the network prior to the constitution of a team. The mechanism covers both the technical and collaborative aspects discussed in sections 2.3.4 and 2.3.5 in order to support the selection of a team of partners that not only have the ability to solve the problem but that, in addition, are able to work as a cohesive entity. Both dimensions are covered by the PaM as part of two complementary assessments:

- **Technical Assessment (PaM-T)**: it compares the technical information of all the partners of the network against the attributes of the problem so that a capability index can be estimated for each partner with respect to a particular problem. This evaluation is done on the basis of the proximity between the partners and the problem, the level of expertise the partners have on products and domains concerned by the problem and the level of adequacy between the activity of partners and the processes concerned by the problem. The aggregation of all those measures into a unique value, representing how able is a partner to solve a given problem, enables the identification of a set of Eligible Contributors (EC).

- **Collaborative Assessment (PaM-C)**: Once a reduced set including the more capable partners -or EC- has been identified, a second evaluation intended to leverage the collaborative aspects between those partners is done. This time, a set of relational criteria is evaluated between the partner that first identified the problem -or future CP coordinator- and each of the partners belonging to EC in order to estimate in each case a compatibility index. This value takes into consideration general factors evaluating the context surrounding their relationship as well as specific factors evaluating the performance of collaborative initiatives already deployed. The aggregation of all those factors into a unique value provides a measure of how compatible are two partners of the network.

The interaction between the technical and collaborative assessments is synthetized in Figure 5.43.
Thanks to the articulation of the two assessments, the PaM plays a central role in the methodology since it enables the constitution of the team in distributed contexts considering the technical and collaborative dynamics behind their operation. Finally, both the capability and compatibility are consolidated into a unique appropriateness index providing for a given partner a consolidated picture of his proven technical and collaborative performances. The criteria and algorithms used by the PaM to execute the aforementioned assessments and to come up with their underlying indexes are developed all along this chapter.

The main elements resulting from the PaM are formalized into a dedicated Partners Assessment Record (PAR). Therefore, it contains, for all the partners belonging to EC, the capability, the compatibility, the criteria used to their calculation and the appropriateness index. The PAR is also used and completed by the model during the Collaboration Mechanism (CoM) where the evaluation of the preferences and the strategy to build the team is defined. A PAR is illustrated in Figure 5.44.
5.3.1. The mechanism supporting the Technical Assessment (PaM-T)

The technical assessment is executed for all the partners of the network, each for which the *capability index* is calculated. Its evaluation is done on the basis of the comparison between the attributes of the problem defined in the PCR and the technical information of partners formalized in the PR. The capability of each partner is obtained through the aggregation of four normalized elements:

- **Level of proximity** ($ca_i$): it measures, for one partner of the network, its level of proximity in terms of contribution to the problem. It is based on the structure of the network and the distance that separates both the partner and the problem across it. The mechanism considers that the more a partner is close to the problem in the upstream flow that converge to it, the more he is concerned by it and the better understanding he has of the impacted product and/or its constituents. Then the higher is this index, the more relevant the contribution of the partner to the team can be. The *level of proximity* is calculated following the sequential steps A,B and C of the PaM-T:
A. Identification of the impacted element

a.1 The impacted element is obtained from the PCR

\[ e^{(k)}_p = \text{Element impacted by the k-th resolution cycle of problem } p \]

a.2 The TP to which the impacted element belongs is identified as \( TP^{(k)}_p \)

\[ TP^{(k)}_p = \text{TP impacted by the k-th resolution cycle of problem } p \]

B. Identification of TPs in the scope of each partner

b.1 For each partner \( b \) in the network, the set of all the TPs where he is contributor is identified:

\[ TBS_b = \{ TP_j \mid b \text{ is contributor of } TP_j, TP_j \in TBS \} \]

\( b \) is considered as contributor of \( TP_j \) when at least one of following is true:

- \( Od_j \) : Design partner of \( TP_j \)
- \( Oi_j \) : Industrialization partner of \( TP_j \)
- \( Of_j \) : Manufacturing partner of \( TP_j \)
- \( OtE_j \) / \( OtD_j \) : Entry/Delivery transport partner of \( TP_j \)

\( b \in J, J \) : Set of partners in the supply chain

C. Calculation of the “level of proximity” of each partner

c.1 The level of proximity is calculated for each partner in the network

\[ c_{a1}(b) = \max_{TP_j} \{ c_{a2}(b) \} \quad \forall TP_j \in TBS_b \]

\[ c_{a2}(b) = \begin{cases} 0 & \text{for } TP_j \notin \overline{TP}^{(k)}_p \medskip \cr 1 - \frac{|LTP_{TP^{(k)}_p} - LTP_{TP_j}|}{L - LTP_{TP^{(k)}_p}} & \text{for } TP_j \in \overline{TP}^{(k)}_p \end{cases} \]

\( \overline{TP}^{(k)}_p \): Set of predecessors of \( TP^{(k)}_p \)

\( LTP_{TP^{(k)}_p} \): Level of the \( TP^{(k)}_p \) in the supply chain

\( LTP_{TP_j} \): Level of the \( TP_j \) in the supply chain

\( L \): Number of levels in the supply chain

\[ 0 \leq c_{a2}(b) \leq 1 \]

\[ 0 \leq c_{a1}(b) \leq 1 \]

- **Level of understanding of the impacted product (ca2):** it measures for one partner of the network its level of understanding about the product affected by the problem. It considers all the products in the scope of the partner and how similar they are with the product impacted by the problem. The similarity is calculated based on the taxonomy of products and the distance separating the concepts it contains. This criterion considers that the more a partner works with similar products, the more relevant can be his contribution during the analysis of the problem. The **level of understanding of the impacted product** is calculated for a given partner following the sequential steps D, E and F of the PaM-T:
Collaborative problem solving within supply chains

D. Identification of the impacted element

d.1 The impacted element is obtained from the PCR

\[ e^{p(k)} = \text{Element impacted by the k-th resolution cycle of problem p} \]

\[ e^{p(k)} \in \text{Products, Products is the « taxonomy of products »} \]

d.2 The TP to which the impacted element belongs is identified as \( TP^{p(k)} \)

\[ TP^{p(k)} = \text{TP impacted by the k-th resolution cycle of problem p} \]

E. Identification of products in the scope of each partner

e.1 For each partner \( b \) in the network, the set of all the TPs where he is contributor is identified:

\[ \text{TBS}_b : \text{Set of TPs where partner } b \text{ is contributor} \]

\[ \text{TBS}_b = \{ TP_j / b \text{ is contributor of } TP_j , TP_j \in \text{TBS} \} \]

e.2 Then, the set of all the products in the scope of the partner \( b \) are identified:

\[ \text{E}_b : \text{Products in the scope of the partner } b \]

\[ \text{E}_b = \{ e_j / TP_j \in \text{TBS}_b \} \]

F. Calculation of the “level of understanding” that each partner has about the product

f.1 The “level of understanding” is calculated for each partner \( b \) in the network

\[ ca_2(b) = \max_{e_j \in \text{E}_b} \left\{ \text{sim}(e^{p(k)}, e_j) \right\} \]

\[ \text{sim}(e^{p(k)}, e_j) = \frac{2 \cdot \text{depth}(\text{CCA})}{\text{depth}(e^{p(k)}) + \text{depth}(e_j)} \]

\[ e_j \in \text{Products, Products is the « taxonomy of products »} \]

\[ \text{depth}(e_j) : \text{depth of } e_j \text{ in Products} \]

\[ \text{depth}(e^{p(k)}) : \text{depth of } e^{p(k)} \text{ in Products} \]

\[ \text{depth}(\text{CCA}) : \text{depth of the Closest Common Ancestor of } e_j \text{ and } e^{p(k)} \text{ in Products} \]

\[ 0 \leq \text{sim}(e^{p(k)}, e_j) \leq 1 \]

\[ 0 \leq ca_2(b) \leq 1 \]

- **Level of overall expertise on the problem domains (ca_2):** it captures, for one partner of the network, the level of the overall adequacy between his domains of competence and the domains required to solve the problem. From a general standpoint, it provides a consistent picture of the ability of a partner to deal with the problem and its context. To evaluate this index, the algorithm starts by determining the level of expertise that one partner has with regards to each problem domain. This is done on the basis of the distance of concepts in a semantic taxonomy of domains. Once calculated, each local expertise is compared against the expertise threshold of the corresponding problem domain to determine whether the partner has the required level of expertise to be considered as an expert on this domain. Therefore, the introduction of this notion leads to the identification of the problem domains where each partner can be considered as an expert. This first set of elements, being fundamental in the evaluation of the overall level of expertise of one partner in regards of a problem, is covered by steps G, H and I as presented hereafter:
G. Identification of the domains of competence required by the problem

\[
T^{p(k)} : \text{Set of domains concerned by the k-th resolution cycle of problem p}
\]

is defined by a set of \(t^{p(k)}_i\) where

\(t^{p(k)}_i\) is the i-th domain concerned, \(t^{p(k)}_i \in \text{Domains}\)

\text{Domains} is the semantic « taxonomy of domains »

H. Identification of the domains of competence of each partner

\[
\text{DoC}_b : \text{Set of domains of competence of partner b}
\]

is defined by a set of \(\text{DoC}_b^j\), where

\(\text{DoC}_b^j\) is the j-th domain of competence, \(\text{DoC}_b^j \in \text{Domains}\)

\text{Domains} is the semantic « taxonomy of domains »

I. Identification of the problem domains for which each partner is an expert

\[
c_{a_3}(b)^i : \text{level of expertise of partner b for the i-th problem domain (} t^{p(k)}_i)\]

\[c_{a_3}(b)^i = \max_{\text{DoC}_b^j \in \text{DoC}_b} \left\{ \text{sim}(t^{p(k)}_i, \text{DoC}_b^j) \right\} \]

\[
\text{sim}(t^{p(k)}_i, \text{DoC}_b^j) = \frac{2 \cdot \text{depth(CCA)}}{\text{depth}(t^{p(k)}_i) + \text{depth}(\text{DoC}_b^j)}
\]

\[
\text{depth}(t^{p(k)}_i) : \text{depth of } t^{p(k)}_i \text{ in Domains}
\]

\[
\text{depth}(\text{DoC}_b^j) : \text{depth of } \text{DoC}_b^j \text{ in Domains}
\]

\[
\text{depth(CCA)} : \text{depth of the Closest Common Ancestor of } t^{p(k)}_i \text{ and } \text{DoC}_b^j \text{ in Domains}
\]

\[
0 \leq \text{sim}(t^{p(k)}_i, \text{DoC}_b^j) \leq 1
\]

\[
0 \leq c_{a_3}(b)^i \leq 1
\]

I.2 The expertise threshold of the i-th problem domain is obtained from the PCR:

\[
s_{t^{p(k)}_i} \text{ : expertise threshold of the i-th problem domain (} t^{p(k)}_i)\]

representing the minimal level of expertise required

\[
0 \leq s_{t^{p(k)}_i} \leq 1
\]

I.3 The level of expertise of partner b for the i-th problem domain (i.1) is compared against the expertise threshold of that domain (i.2):

\[
\text{if } c_{a_3}(b)^i \geq s_{t^{p(k)}_i}, \text{ then } \bar{c}_{a_3}(b)^i = 1, \text{ otherwise } \bar{c}_{a_3}(b)^i = 0
\]

\[
\bar{c}_{a_3}(b)^i : \text{variable defining if partner b can be considered as expert for the i-th problem domain (} t^{p(k)}_i)
\]

\[
\bar{c}_{a_3}(b)^i = 1 \text{ partner b has the required level of expertise to be considered as expert for the i-th problem domain (} t^{p(k)}_i)
\]

\[
\bar{c}_{a_3}(b)^i = 0 \text{ partner b has not the required level of expertise to be considered as expert for the i-th problem domain (} t^{p(k)}_i)
\]

\[
\bar{c}_{a_3}(b)^i \in \{0,1\}
\]
Based on the list of domains for which a partner is considered as an expert, the model evaluates two complementary measures that are then aggregated to propose an overall expertise. While the first captures the coverage or proportion of problem domains where a partner is considered as an expert, the second provides the level of expertise that the partner has in the covered area. Then, and taking into consideration that a partner is only considered as an expert when he exceeds the threshold imposed by the problem solvers, the coverage provides a good indication of the proportion of problem domains for which the contribution of the partner is likely to be relevant. The level of expertise of the partner within its coverage area is a good indication of the ability of the partner to deal with the problem domains and can be determinant when multiple partners cover the same domain to determine the more capable ones. Both coverage and expertise in the covered area are finally aggregated for each partner into the level of overall expertise. This index, denoted as $ca_3$, considers that the more a partner is able to cover the domains of a problem with at least the required level of expertise, the more relevant can be his contribution during the analysis of the problem. The coverage, the expertise in the covered area and their integration into the level of overall expertise are covered by steps J, K and L:

**J. Calculation of the coverage scope for each partner**

- **j.1 The coverage** is calculated for each partner $b$ in the network

$$ca_3(b) = \frac{\sum_{i=1}^{nbt_p(k)} \tilde{c}_3(b)^i}{nbt_p(k)}$$

$0 \leq ca_3(b) \leq 1$

**K. Calculation of the expertise of each partner within its coverage scope**

- **k.1 The expertise** is calculated for each partner $b$ in the network

$$ca_3(b) = \left\{ \begin{array}{ll}
0 & \text{if } \sum_{i=1}^{nbt_p(k)} \tilde{c}_3(b)^i = 0 \\
\sum_{i=1}^{nbt_p(k)} \tilde{c}_3(b)^i \cdot ca_3(b)^i & \text{otherwise}
\end{array} \right.$$  

$0 \leq ca_3(b) \leq 1$

**L. Calculation of the level of overall expertise of each partner**

- **l.1 Both the coverage degree (j.1) and the expertise of each partner within this coverage area (k.1) are aggregated to propose an overall expertise**:

$$ca_3(b) = w_c \cdot ca_3(b) + w_e \cdot ca_3(b)$$

$w_c$: Weight allocated to the coverage degree

$w_e$: Weight allocated to the expertise within the coverage area

$0 \leq w_c \leq 1$, $0 \leq w_e \leq 1$, $w_c + w_e = 1$

$0 \leq ca_3(b) \leq 1$
- **Level of adequacy with the processes concerned by the problem** (*ca₄*) : it measures, for one partner of the network, the processes concerned by the problem that he would be able to cover. The mechanism considers that the more processes he is able to cover, the more relevant would be his contribution during the solving process. The *level of adequacy* between the processes of both the problem and one partner is calculated as explained in steps M, N and O:

**M. Identification of the processes concerned by the problem**

**m.1** The set of processes concerned by the problem is obtained from the PCR

\[ \mathcal{S}_{p}^{(k)} : \text{set of processes concerned by the k-th resolution cycle of problem } p \]

is defined by a set of \( \mathcal{S}_{i}^{(k)} \) where:

- \( \mathcal{S}_{i}^{(k)} \) is the control variable determining whether the process \( \langle i \rangle \) is concerned
- \( \mathcal{S}_{i}^{(k)} \in \{0,1\} \)
- \( i = \{ \text{design, industrialization, fabrication, e/transport, d/transport} \} \)

**N. Identification of the processes in the scope of each partner**

**n.1** Based on the information of the PR, the model identifies the processes in the scope of each partner.

\[ c(i)_{b} : \text{control variable determining whether partner } b \text{ covers the process } \langle i \rangle \]

\[ c(i)_{b} = \begin{cases} 1 & \text{if } \sum_{j \in \mathcal{TBS}_{b}} c(i)_{b}^{j} \geq 1 \\ 0 & \text{otherwise} \end{cases} \]

\( \mathcal{TBS}_{b} : \text{set of TP}s where partner } b \text{ is contributor} \)

\( \mathcal{TBS}_{b} = \{ TP_{j} / b \text{ is contributor of TP}_{j}, TP_{j} \in \mathcal{TBS} \} \)

\( c(i)_{b}^{j} : \text{control variable indicating whether the partner } b \text{ is responsible of the process } \langle i \rangle \text{ of TP}_{j} \)

\( i = \{ \text{design, industrialization, fabrication, e/transport, d/transport} \} \)

\( c(i)_{b} \in \{0,1\} \)

**O. Calculation of the level of adequacy between problem and partner processes**

**o.1** The adequacy between the processes concerned by the problem (**m.1**) and the processes in the scope of the partner (**n.1**) is calculated

\[ ca_{4}(b) : \text{Level of adequacy between the processes of the problem and the processes of the partner } b \]

\[ ca_{4}(b) = \begin{cases} 0 & \text{if } \sum_{i} c(i)_{b} \cdot \mathcal{S}_{i}^{p(k)} = 0 \\ \frac{\sum_{i} c(i)_{b} \cdot \mathcal{S}_{i}^{p(k)}}{\sum_{i} \mathcal{S}_{i}^{p(k)}} & \text{otherwise} \end{cases} \]

\( i = \{ \text{design, industrialization, fabrication, e/transport, d/transport} \} \)

\( 0 \leq ca_{4}(b) \leq 1 \)
The evaluation of the capability criteria is illustrated thanks to the extension of the case study:

The evaluation of the capability criteria for one of the partners of the network (partner \( P_{28} \)) is based on the Technical Information (TI) contained into his PR:

Based on the \( PR_{28} \), the \( PCR^{p(1)} \) and the network (Figure 4.17), it can be considered that:

- **The level of proximity** of the partner in terms of contribution to the problem —or \( ca_1(P_{28}) \)— is equal to 0.8. The high proximity level can be explained because the partner is very close in the network to the impacted product. He delivers, indeed, the braking system which is one of the constituents of the main landing gear being impacted by the current problem. In consequence, this partner is very likely to be concerned by the problem, or even at its origin.

\[
TP^{p(1)} = TP_9, \quad e^{p(1)} = Main \, LG \\
TBS_{P_{28}} = \{TP_{32}, TP_{10}, TP_{30}\} \\
ca_1(P_{28})^1 = 0.80 \quad \text{for} \ TP_{32}, \text{for which partner} \ P_{28} \ \text{is responsible of design, industrialization and fabrication} \\
ca_1(P_{28})^2 = 0 \quad \text{for} \ TP_{10}, \text{for which partner} \ P_{28} \ \text{is responsible of design, industrialization and fabrication} \\
ca_1(P_{28})^3 = 0 \quad \text{for} \ TP_{30}, \text{for which partner} \ P_{28} \ \text{is responsible of design, industrialization and fabrication} \\
ca_1(P_{28}) = \max \{0.80, 0, 0\} = 0.80
\]

- **The level of understanding** that the partner has about the Main Landing Gear —or \( ca_2(P_{28}) \)— is equal to 0.75. This can be explained because as part of his activity in the network, the partner is in charge of the design, industrialization and fabrication of both the Nose and Tail Landing Gears. The knowledge that this partner has about those products can be very useful for the current problem concerning the Main Landing Gear. The similarity has been evaluated on the basis of the “taxonomy of products” presented in the case study of section 5.2.2.
- The overall level of expertise of the partner on the problem domains --or $ca_3(P_{28})$-- is equal to 0.76. This can be explained because, on the one side, the partner has a good coverage degree (i.e. he covers two over the three required domains) with a cumulated expertise of 0.85. Then, the partner can be considered as having the required level of expertise in hydrodynamics and electronics, which can be important in light of the constitution of the team. The similarities have been evaluated on the basis of the “taxonomy of domains” as illustrated hereinafter.

$$TP^{(1)} = \{Hydrodynamics, Electronics, General Mechanics\}$$
$$DoC_{P_{28}} = \{Hydraulics, Electrics, Mechanics\}$$
- The **level of adequacy** between the processes in the scope of the partner and the processes concerned by the problem is equal to 1. This can be explained because the partner covers all the processes concerned by the problem. Then, the partner has the required skills and resources in terms of industrialization and fabrication.

\[
\mathcal{S}^{(1)} = \{ \text{Design} = 0, \text{Industrialization} = 1, \text{Fabrication} = 1, \text{E/D Transport} = 0 \} \\
\mathcal{C}(I_{P_{28}}) = \{ \text{Design} = 1, \text{Industrialization} = 1, \text{Fabrication} = 1, \text{E/D Transport} = 0 \} \\
ca_1(P_{28}) = 1.00
\]

Therefore, the evaluation of the capability criteria for this partner results on following values: \(ca_1(P_{28}) = 0.80, ca_2(P_{28}) = 0.75, ca_3(P_{28}) = 0.76, ca_4(P_{28}) = 1.00\).

Once the four normalized criteria (\(ca_1\) to \(ca_4\)) have been estimated for each partner in the network, the model aggregates their values to propose the **partner capability index** (denoted as \(\delta_b\)). The aggregation is done based on a GOWA operator for which both the rationale for application and the benefits it offers in the estimation of the capability are explained in the box hereinafter:

**The Generalized Ordered Weighted Aggregation** or GOWA has been introduced by Yager in (Yager, 1988). This aggregation operator has been widely used in literature to deal with multi-criteria decision problems when the final solution must be obtained from the synthesis of performance degrees of criteria (Herrera et al., 2003). It brings much more flexibility than the classic evaluations (Beliakov, 2005) since it provides a parameterized family of aggregation operators that includes amongst others the maximum, the minimum and both the classic and weighted average functions (Merigó and Gil-Lafuente, 2008). Then and depending on the value that decision makers allocate to the parameter of the GOWA function -or \(\lambda\)-, it has been demonstrated that it generalizes a wide range of aggregation operators (Chiclana et al., 2002). The general formula, the argument variables and a summary of all the family of aggregation operators that the GOWA function covers with its corresponding parameters is proposed in Appendix - V.

The flexibility of the GOWA operator, to be adjusted depending on the needs of the particular context of application, justifies its integration as part of the methodology. To enable the illustration of the principles supporting this mechanism, we focus on one of the operators that can be generalized from the GOWA function and that possess two particular behaviors which are suitable in light of the definition of a capability index. The function corresponds to the weighted geometric mean obtained when \(\lambda \to 0\) (Chiclana et al., 2002; Xu and Da, 2002). This operator not only offers the possibility to integrate the degree of importance that each component has in the aggregation but also 1) penalizes the extreme observations and 2) requires a larger improvement in one element to compensate for a loss in another one. Nevertheless, it has also been demonstrated that the results it yields in the case of the strict geometric operator (\(\lambda=0\)) are only relevant when criteria to be aggregated are different from 0 (Merigó and Casanovas, 2008). Then, and in order to obtain simultaneously the desirable benefits of the geometric mean without having an operator that is cancelled by the presence of 0 within the arguments, a GOWA parameter of 0.5 has been selected (\(\lambda=0.5\)). A set of data illustrating the aggregation with different values of \(\lambda\) from \(\lambda=0\) (strict geometric mean) to \(\lambda=1\) (strict arithmetic
mean) and leading to the selection of 0.5 is included in Appendix - V. As demonstrated in that section, the selected parameter provides a good compromise for the purposes of this research and will be used for all the aggregations where GOWA is deployed. For other contexts or desirable behaviors during the aggregation, another value for λ can be selected by problem solvers inspired from (Yager, 2004).

The way the GOWA is integrated into the mechanism to enable the aggregation of all the criteria contributing to the capability into a unique consolidated value is covered by step P:

**P. Calculation of the capability index for each partner of the network**

The capability index is aggregated by using the GOWA aggregation operator

\[
\delta_b = \left( \sum_{i=1}^{4} w_i \cdot cai(b)^{\lambda} \right)^{1/\lambda}
\]

- \(w_i\): weight allocated to the i-th criterion contributing to the capability
- \(cai(b)\): performance of the i-th criterion contributing to the capability of partner b
- \(ca_1(b)\): level of proximity of partner b with the problem
- \(ca_2(b)\): level of understanding that partner b has about the product
- \(ca_3(b)\): level of overall expertise of partner b over problem domains
- \(ca_4(b)\): level of adequacy between the processes of the problem and the processes of partner b

\(\lambda\) is the GOWA parameter

\[0 \leq \delta_b \leq 1\]

All the aforementioned steps (from A to P) lead to the definition of the capability index of a given partner in the network. This index matches the problem context—in terms of position in the network, product being affected, domains concerned and related processes— with the partner proven performances—in terms of activity and proximity in the network, products he works with, his domains of competence and the processes in his scope—in order to evaluate the degree to which the partner has the technical ability to positively contribute during the problem solving process.

The aggregation of the capability criteria to obtain an overall capability index is illustrated for the case study:

The capability index or degree to which the partner P_{28} has the technical ability to deal with the problem in the MLG—as part of the first resolution cycle or p(6)—is equal to 0.82.

\[
\begin{align*}
ca_1(P_{28}) &= 0.80 & \text{Level of proximity in terms of contribution of partner P}_{28} \text{ to the problem} \\
ca_2(P_{28}) &= 0.75 & \text{Level of understanding that partner P}_{28} \text{ has about the impacted product} \\
ca_3(P_{28}) &= 0.76 & \text{Level of overall expertise of partner P}_{28} \text{ over problem domains} \\
ca_4(P_{28}) &= 1.00 & \text{Level of adequacy between the processes concerned by the problem and the processes where partner P}_{28} \text{ participates} \\
\delta_{P_{28}} &= 0.82
\end{align*}
\]
The mechanism repeats the whole steps for all the partners in the network in a way such that when all the *capability indexes* have been calculated, the model is able to synthesize all this information and propose a panel of solutions based on a set of *capability thresholds*. This activity enables the identification of the *Eligible Contributors* (EC) which consists of a set of partners that in light of proven evidence and performance are the more capable to solve the problem. It allows reducing from the whole set of partners of the network towards a reduced set including exclusively the ones who are likely to be the more competent to deal with a given problem and its contexts. Once the *Eligible Contributors* set has been selected, and in order to enable the further steps of the PaM, a dedicated *Partner Assessment Record* (PAR) is created. This record summarizes, as shown in Figure 5.44, the whole technical and collaborative information that is used during the assessment of partners in light of the constitution of the team. At this stage, the model initializes the criteria contributing to the capability (ca₁ to ca₄) as well as the capability index (δ) for all the members of EC. The identification of the more capable partners with respect to a given problem and the initialization of their technical information into the PAR are covered by the last two steps of the partners technical assessment (PaM-T):
The technical assessment or PaM-T, covered by steps A to R, plays a major role within the proposed global methodology since it acts as the enabler of the technical evaluation of partners that are distributed across complex networks. This mechanism enhances significantly the constitution of the team of experts because it ensures the technical ability of its members. A synthesis of the main elements obtained once the mechanism is executed is presented in Figure 5.45.

**Q. Panel of solutions and definition of the set of Eligible Contributors - EC**

**q.1** Once all the capability indexes for all the partners across the network have been calculated, and based on a set of capability thresholds, the model proposes a panel of solutions. Example:

<table>
<thead>
<tr>
<th>capability threshold ( \delta )</th>
<th>number of partners with capability index ( \geq ) capability threshold</th>
<th>average of capability indexes in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>2 partners</td>
<td>0.91</td>
</tr>
<tr>
<td>0.8</td>
<td>9 partners</td>
<td>0.84</td>
</tr>
<tr>
<td>0.7</td>
<td>15 partners</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**q.2** Problem solvers select the capability threshold that better satisfies the needs in terms of capabilities required for the problem. In the example a threshold of 0.8 has been retained:

<table>
<thead>
<tr>
<th>capability threshold ( \delta )</th>
<th>number of partners with capability index ( \geq ) capability threshold</th>
<th>average of capability indexes in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>9 partners</td>
<td>0.84</td>
</tr>
</tbody>
</table>

\( \delta : \) selected capability threshold , \( \delta = 0.8 \)

In this case, 9 partners have a capability index that exceeds 0.8. They have an average capability of 0.84.

**q.3** The set of Eligible Contributors (EC) is established based on the outcomes of step (q.2):

\[ EC^{p(k)} : \text{set of Eligible Contributors for the } k\text{-th resolution cycle of problem } p \]

\[ EC^{p(k)} = \{ b / \delta_b \geq \delta, b \in J \} \]

\( J : \) set of partners in the supply chain

\( \delta_b : \) capability index of partner \( b \) with regards to the \( k\)-th resolution cycle of problem \( p \)

**R. Consolidation of the technical information related to the assessment into the PAR**

**r.1** The mechanism initializes a dedicated Partner Assessment Record (PAR) where a global picture of each partner belonging to the EC set (q.3) is consolidated.

At this stage the model is able to complete for each partner \( b \) belonging to EC its:

- \( ca_1(b) : \) level of proximity of partner \( b \) with the problem
- \( ca_2(b) : \) level of understanding that partner \( b \) has about the product
- \( ca_3(b) : \) level of overall expertise of partner \( b \) over problem domains
- \( ca_4(b) : \) level of adequacy between the processes of the problem and the processes of partner \( b \)

\( \delta_b : \) capability index of partner \( b \) in regards of the \( k\)-th resolution cycle of problem \( p \)

The technical assessment or PaM-T, covered by steps A to R, plays a major role within the proposed global methodology since it acts as the enabler of the technical evaluation of partners that are distributed across complex networks. This mechanism enhances significantly the constitution of the team of experts because it ensures the technical ability of its members. A synthesis of the main elements obtained once the mechanism is executed is presented in Figure 5.45.
Even if the consideration of the technical aspects is a determinant factor in ensuring the constitution of successful teams because it endeavors to select capable partners, this is only the first step towards a global evaluation of partners that integrates all the dynamics behind the supply chain operation. Then, a second collaborative assessment between the partners of the EC is required.

5.3.2. The mechanism supporting the Collaborative Assessment (PaM-C)

The partners collaborative assessment (or PaM-C) completes the first technical one by evaluating the level of compatibility between the CP coordinator and each potential member to work together and jointly solve a problem. Then, it leads to the definition of a compatibility index that provides, for each partner belonging to EC, their ability to work collaboratively. To be calculated, this index considers the performance of partners during past problem solving experiences with respect to the set of collaborative criteria that has been identified and studied in section 2.3.5 after a review of the literature. The mechanism proposed in this section articulates and structures those criteria in a consistent manner and in a way such that they can be integrated as part of a general model to evaluate the relationship between two industrial partners.

5.3.2.1. The general model to evaluate the relationship between partners

The proposed model considers that the relationship between two firms has two complementary dimensions from which it can be studied. It proposes a first general dimension addressing the context that surrounds the relationship between the partners and a second one focusing on the proven performance of common initiatives existing between them. The first level intends to capture on the one hand the level to which general relational factors –such as the economic model in the
marketplace, the balance of power and the interdependency—favor the implementation of collaborative working relationships and, on the other hand, both the stability and uncertainty related to this general environment. The study of this level enables the evaluation of the first component of the compatibility index between two partners, which corresponds to the general compatibility index. By taking into account that this level only considers a set of general relational factors, the general compatibility index can be then estimated even for two partners that have never worked together before. Conversely, if the partners are used to work together in the frame of common initiatives, not only a general index but also a proven compatibility index capturing the performance of their exchanges can be integrated into the evaluation of the compatibility. This second component of the compatibility results, indeed, from the study of the second dimension characterizing the relationship between the two partners. Unlike the first dimension, providing a picture of the general context of the relationship and the level of favorability to establish collaborative practices, the second one studies existing initiatives to propose a picture of their performance in terms of collaboration. At this level, factors such as the information sharing, communication, involvement, resources sharing and decision style are assessed by the model. The articulation of the two dimensions as part of a general model to evaluate the relationship between two firms is synthesized in Figure 5.46.

As part of the second dimension, and to enable the evaluation of the proven compatibility, the mechanism structures all the initiatives between two partners into exchange domains representing their general areas of exchange. To illustrate this situation, let us consider an example where an airframe manufacturer buys one of the major assemblies of the fuselage as well as one of the structural components of the engines to the same supplier (refer to Figure 4.17). Additionally, both manufacturer and supplier work together in the frame of two distinctive projects: one in the frame of a partnership in R&D to develop a new product and another one as part of a collaborative problem solving process leading to the deployment of this methodology. For this relationship, four exchange domains can be defined: one to cover the activity within the scope of each product, another one to cover the activity within the partnership and a last one to cover the activity of the collaborative
process. The notion of exchange domain allows then considering that multiple general areas of exchange may simultaneously exist within a given relationship and that, for each area, the context and conditions are not necessarily the same and, in consequence, the way the partners work and the level of collaboration can be significantly different. This means that the proven compatibility between two partners, determining how compatible they are based on the way they already work together, needs to be interpreted in terms of a given context or exchange domain to be considered as meaningful.

From now, and for the purpose of this research, the mechanism considers that firms have an exchange domain emphasizing on the joint problem solving process and grouping their entire problem solving initiatives. Additionally, the model will focus on this exchange domain by considering that each time we refer to the proven compatibility index, it will refer to the compatibility calculated on the basis of performance of partners within this particular scope and then considering exclusively the common problem solving experiences.

The evaluation of both general and proven compatibility between partners is based on the 25 relational factors presented in Figure 2.5 and detailed in Appendix - II. Nevertheless, the study of the influence they have into the distributed problem solving as well as the study of their interdependencies in light of the two dimensions of the proposed model for evaluating the relationship between partners, led to their clustering into six main criteria: two contributing to the calculation of the general compatibility index and four contributing to the calculation of the proven compatibility index. Then, those criteria not only structure the initial factors but in addition are, in turn, aggregated from their values as illustrated in Figure 5.47:

![Figure 5.47 - Elements contributing to the calculation of the compatibility](image-url)
The mechanism leading to the evaluation of the compatibility between the CP coordinator and each eligible contributor of EC is based on a bottom-up approach that covers the structure presented above. Then, it captures the performance of each partner with respect to the sub-criteria which are then aggregated up to the upper level corresponding to the compatibility index between them. Each sub-criterion has a numerical value and is defined between 0 and 1. In order to provide a consistent framework for interpreting the values assigned to sub-criteria and, in consequence, ensure that proposed compatibility index is meaningful, the mechanism includes the interpretation of each sub-criterion and all its possible values. Such an interpretation has been done on the basis of the level to which each sub-criterion contributes to the effectiveness of the collaborative problem solving process. When it contributes positively the value tends to 1. Conversely, when it contributes negatively the value tends to 0. This general definition used to normalize the model, has been tailored for each sub-criterion and then a meaningful interpretation describing how to understand each particular sub-criterion in light of both the collaborative problem solving process and the evaluation of the compatibility is included in this section. The synthesis of the general approach used to normalize and interpret sub-criteria of the model is presented in Figure 5.48. The adaptation of this definition to each sub-criterion is defined in further sections of this chapter where the way both the general and proven compatibility and the mechanism behind them are presented.
5.3.2.2. The mechanism supporting the general compatibility evaluation

The general compatibility between two partners captures the level to which the general context surrounding the relationship between two partners is favorable to the establishment of effective collaborative relationships in the long term. It considers both the overall structure (criterion \( cg_1 \)) and the stability (criterion \( cg_2 \)) of the operating environment surrounding the relationship.

- **Operating environment structure (\( cg_1 \))**: It evaluates the environment of the relationship between the two partners and provides a global picture of the conditions that may influence the way the partners collaborate and the way the collaborative strategies are selected. It not only considers the position of the partners in the marketplace, but in addition captures the level and the nature of their interdependency, the way the power is distributed between them and finally the level of consistency between their strategies as well as the consistency with the overall strategies of the supply chain. The interpretation of these factors in light of the establishment of collaborative working relationships is presented:

- **Operating environment stability (\( cg_2 \))**: It evaluates the inherent stability of the environment surrounding the relationship. Then, and while the previous criteria measures the favorability of the environment to establish collaborative relationships at the moment of the evaluation, this one intends to integrate the stability of that environment in the long term. The stability is measured in terms of the level to which the uncertainty related to both the partner’s...
internal and external operating environment can influence the way the partners collaborate and the way the collaborative strategies are selected in the long term. The interpretation of each one of this factors is presented:

- **Calculation of the general compatibility (cg):** Once all the sub-criteria contributing to both the operating environment structure (cg\(_{11}\) to cg\(_{14}\)) and operating environment stability (cg\(_{21}\) to cg\(_{22}\)) have been evaluated, then the model is able to calculate the value of cg\(_{3}\) and cg\(_{2}\) that are, in turn, used by the model to aggregate the general compatibility index (cg). This process can be formally expressed as follows:

\[
\text{cg}(ab) = \left( \sum_{i=1}^{2} w_i \cdot \text{cg}_i(ab)^{\lambda} \right)^{1/\lambda}
\]

where:
- \(w_i\): weight allocated to the i-th criterion
- \(\text{cg}_i(ab)\): performance of the i-th criterion contributing to the general compatibility of partners a and b

\[
\text{cg}_i(ab) = \left( \sum_{j=1}^{\text{nc}_i} w_{ij} \cdot \text{cg}_{ij}(ab)^{\lambda} \right)^{1/\lambda}
\]

where:
- \(w_{ij}\): weight allocated to the j-th sub-criterion of the criterion i
- \(\text{nc}_i\): number of sub-criteria of the i-th criterion
- \(0 \leq \text{cg}_{ij}(ab) \leq 1\)

The **general compatibility (cg)** provides an a priori estimation of the compatibility between two partners based on the favorability/stability of their environment. Therefore, the more the
environment on which firms operates is favorable and stable (cg→1), then the more likely is the possibility that effective collaborative practices can be established and then the better would be the compatibility between the partners to work together.

The evaluation of all the sub-criteria and the calculation of the general compatibility is formalized through the first part of the Collaboration Matrix (CoMax) presented in Appendix - VI.

5.3.2.3. The mechanism supporting the proven compatibility evaluation

The proven compatibility measures the performance in terms of collaboration of the common initiatives between two partners so that the relevancy of the general compatibility between them can be improved. As explained in section 5.3.2.1, the proven compatibility needs to be interpreted in terms of a particular area of exchange to be meaningful. Hence, and depending on the particular context of evaluation, its calculation can be done either for one –or a set of– exchange domains or for the entire scope of the relationship. In the first case the model computes a filtered proven compatibility index while in the second case the model yields a generalized proven compatibility index. In the frame of this research, we focus on the first option by considering that the proven compatibility is calculated exclusively based on the initiatives in the scope of the exchange domain emphasizing in the collaborative problem solving. In consequence, and in order to determine the degree to which two partners are compatible to solve a new problem, the model will aggregate their collaborative performance consolidated during the generalization phase of all the initiatives where they have already worked together to solve a problem.

The collaborative performance, used to calculate the proven compatibility (cs) and aggregated from past common initiatives, is measured on the basis of the:

- **Involvement of partners (cs\(_1\))**: it evaluates the degree to which partners demonstrate a real involvement during collaborative initiatives. This criterion provides a global picture of the real willingness and commitment of a partner to invest in the establishment of win-win relationships.

- **Integration and coordination (cs\(_2\))**: it evaluates the degree to which partners succeed as part of common initiatives to integrate their processes and establish effective coordination mechanisms. This criterion provides a global picture of the ability of partners to synchronize them with the others to achieve common objectives.

- **Information sharing and collaborative communication (cs\(_3\))**: it evaluates the degree to which partners are able to establish relationships based on proactive communication and information sharing. It considers as well the willingness of partners to use information and communication technologies to improve efficiency of communication.

- **Maturity and effectiveness of collaborative initiatives (cs\(_4\))**: it evaluates the degree to which partners are able to establish effective relationships resulting on benefits at both firms and supply chain levels. This criterion provides a global picture of the contribution and involvement of partners into the improvement strategies at the network level.

The interpretation of each aforementioned factor in light of the establishment of collaborative relationships and the definition of the sub-criteria involved in its calculation are presented as follows:
### CS1 Involvement of partners

**CS11 Risk/reward sharing**
- It captures both the level of fairness and coverage of the risk/reward sharing strategy
- **No gains, losses or risks sharing** → Unfair and incomplete sharing (covering only gains/losses or only risks)
- **Fair but incomplete sharing** → Fairly but incomplete sharing (covering only gains/losses or only risks)
- **Fair and complete sharing** → Fair and complete sharing (covering gains, losses and risks)

**CS12 Resources sharing**
- It quantifies the willingness of partners to share resources
- **No resource sharing**
- **Operational resource sharing**
- **Tactical Resource sharing**
- **Strategic resource sharing**

**CS13 Joint knowledge creation and sharing**
- It quantifies the degree to which partners are able to create and share knowledge
- **There is no common initiatives for jointly create or share knowledge**
- **Firms have common initiatives for joint knowledge creation and sharing**
- **Firms have common initiatives that promote the sharing, capture and creation of knowledge**
- **Firms have common initiatives that promote the sharing, capture, creation and exploitation of knowledge**

**CS14 Degree of participation**
- It evaluates the degree to which partners participate and involve themselves
- **Both firms have a passive participation**
- **One partner has an active participation. The other one has a passive participation**
- **Both firms have an active participation**
- **Both firms have a proactive participation**

**CS15 Partners engagement**
- It captures the degree to which partners are committed to the relationship and are willing to invest on it
- **Firms do not make efforts or investments necessary to maintain the relationship**
- **Firms make only minimal efforts and investments to barely ensure the survival of the relationship**
- **Firms make efforts and investments that allow maintaining the relationship**
- **Firms make significant efforts and investments to maintain and improve continually the relationship**

**CS16 Partners flexibility**
- It captures the degree to which partners are willing to adjust conditions of the relationship
- **There is only one of the partners that shows a willingness to adjust or adapt conditions. Nevertheless, his margin of flexibility is very low**
- **Both partners show a willingness to adjust or adapt conditions. Nevertheless, their margin of flexibility is very low**
- **Both partners show a real willingness to adjust or adapt conditions. In addition, their margin of flexibility is important enough to allow overcoming critical situations and keeping relationship evolving**

**CS17 Respect of engagements mutually agreed**
- It captures the degree to which partners respect engagements mutually agreed
- **No respect of engagements mutually agreed**
- **Only one of the partners respect the engagements mutually agreed**
- **Both partners respect the engagements mutually agreed**
- **Both partners respect and exceed the engagements mutually agreed**

### CS2 Integration and coordination

**CS21 Process integration**
- It captures the degree to which partners have succeeded in integrating their processes
- **Firms have not integrated processes for key common activities**
- **Firms have some integrated processes not robust enough and covering only part of the key common activities**
- **Firms have robust and integrated processes covering only part of the key common activities**
- **Firms have robust and integrated processes covering at least all the key common activities in the scope of the exchange**

**CS22 Decision style and synchronization**
- It captures the degree to which firms are able to synchronize with others to establish effective coordination mechanisms
- **Centralized decisions without coordination for key common activities**
- **Decentralized decisions without coordination for key common activities**
- **Centralized decisions involving effective coordination for key common activities**
- **Decentralized decisions involving effective coordination for key common activities**
Collaborative problem solving within supply chains

### CS22 Implementation of shared planning
- **It captures the willingness of firms to establish a collaborative and integrated planning**
  - **Standalone and confidential plannings**: Sharing of some planning assumptions but still standalone and confidential plannings
  - **Collaborative planning including sharing of strategic resources/assumptions**

### CS24 Conflicts and crisis management
- **It quantifies the ability of firms to identify and overcome conflicts**
  - **Firms do not possess a preventive approach to identify potential sources of conflicts or crises. In addition they do not have means for overcoming those situations**
  - **Firms possess a preventive approach to identify potential sources of conflicts or crises. Nevertheless they do not have means for overcoming those situations**
  - **Firms possess a preventive approach to identify potential sources of conflicts or crises. In addition they have established proactive and collaborative methods and tools for overcoming those situations**

### CS25 Control
- **It quantifies the ability of firms to define meaningful control strategies**
  - **Insufficient or no controls to monitor the other firms’ activity**
  - **Excessive controls to monitor the other firms’ activity**
  - **Only necessary controls with strict and detailed rules as the only way of monitoring**
  - **Only necessary controls with a balanced mix of formal, informal and group rules for monitoring**

### CS26 Formalization
- **It quantifies the willingness of firms to formalize the relationship**
  - **No formalization**
  - **Not enough formalization to regulate partners exchanges and cooperation**
  - **Comprehensive formalization that regulates the relationship without flexibility**
  - **Comprehensive formalization that structures the relationship while staying flexible**

### CS3 Information sharing and collaborative communication
- **It quantifies the willingness of firms to share information**
  - **No (or very low) exchanges of information**
  - **Unidirectional, Asymmetric or non-intensive exchanges at any decision level**
  - **Bidirectional, symmetric or Intensive exchanges at any decision level**
  - **Bidirectional, symmetric and Intensive exchanges at operational, tactic and strategic level**

### CS32 Collaborative communication
- **It quantifies the willingness of firms to establish a collaborative communication**
  - **No communication**
  - **Punctual communication**
  - **Regular but not balanced communication**
  - **Proactive communication (frequent, balanced, bidirectional, open, formal and informal)**

### CS33 Use of information and communication technologies
- **It quantifies the willingness of firms to use information and communication technologies**
  - **Firms have not implemented common ICT tools for key common activities**
  - **Firms have implemented some ICT tools not robust enough and covering only part of the key common activities**
  - **Firms have implemented robust ICT tools covering only part of the key common activities**
  - **Firms have implemented robust ICT tools covering at least all the key common activities in the scope of the relationship**

### CS4 Maturity and effectiveness of collaborative initiatives
- **Initiative Lifecycle**
  - **Exploration phase (mutual discovering)**
  - **Launching phase (mutual adjustment)**
  - **Maturity phase (good mutual understanding)**
  - **Consolidation phase (long-term partnership)**

### CS41 Effectiveness of the collaborative initiative
- **If captures the degree to which firms are able to establish effective relationships resulting on benefits at both firms’ and supply chain level**
  - **Collaboration has a reduced impact on the overall performance of the Supply Chain with an opportunistic behavior in the allocation of efforts/benefits**
  - **Collaboration has a reduced impact on the overall performance of the Supply Chain with balanced efforts/benefits allocation**
  - **Collaboration has a significant positive impact on the overall performance of the Supply Chain with an opportunistic behavior in the allocation of efforts/benefits**
  - **Collaboration has a significant positive impact on the overall performance of the Supply Chain with balanced efforts/benefits allocation**
Calculation of the proven compatibility (cs): The proven compatibility between two partners is calculated on the basis of criteria/sub-criteria presented above. First, the mechanism aggregates the value of each sub-criterion from the collaborative performance information consolidated during the generalization phase of all the past problem solving experiences where the two partners have participated (refer to section 4.3.2.4). Then, it aggregates the values of sub-criteria to yield the criteria which are, in turn, aggregated to produce the proven compatibility index. This process is formalized as follows:

**Calculation of the proven compatibility index between two partners**

The proven compatibility index is aggregated by using the GOWA aggregation operator

\[
\text{cs}(ab) = \left[ \sum_{i=1}^{4} w_i \cdot csi(ab)^{1/\lambda} \right]^{1/\lambda}
\]

\[w_i\] : weight allocated to the i-th criterion

\[csi(ab)\] : performance of the i-th criterion contributing to the proven compatibility of partners a and b

\[
csi(ab) = \left[ \sum_{j=1}^{nbc_i} w_{ij} \cdot csij(ab)^{1/\lambda} \right]
\]

\[w_{ij}\] : weight allocated to the j-th sub-criterion criterion i

\[nbc_i\] : number of sub-criteria of the i-th criterion

\[csij(ab)\] : performance of the j-th sub-criterion of criterion i contributing to the proven compatibility of partners a and b (generalized from past initiatives)

\[
\text{csij(ab)} = \left[ \frac{1}{nbkab} \sum_{k=1}^{nbkab} cs_{ij}^k(ab)^{1/\lambda} \right]^{1/\lambda}
\]

\[nbkab\] : number of resolution cycles where partners a and b have worked together

\[cs_{ij}^k(ab)^{1/\lambda}\] : performance of the j-th sub-criterion of criterion i contributing to the proven compatibility of partners a and b for the k-th initiative where they have worked together

\[0 \leq csij(ab) \leq 1\]

\[0 \leq csi(ab) \leq 1\]

\[\lambda\] is the GOWA parameter, \(\lambda = 0.5\)

\[0 \leq cs(ab) \leq 1\]

Unlike the general compatibility, that provides an a priori estimation of the degree to which two partners are compatible in light of the structure and stability of the environment that surrounds them, the proven compatibility provides an a posteriori evaluation of the degree to which they are compatible based on actual performance. Both general and proven compatibilities can be integrated into a unique measure of the compatibility between two partners.

The evaluation of all the sub-criteria and the process leading to the calculation of the proven compatibility is formalized through the second part of the Collaboration Matrix (CoMax) presented in Appendix - VI.
5.3.2.4. The mechanism supporting the compatibility evaluation

At this stage, and based on the general model defined from 5.3.2.1 to 5.3.2.3, the collaborative assessment (PaM-C) is able to calculate the compatibility index ($\Omega$) between the CP coordinator and each potential member of EC. This index, providing a global picture of the degree to which they are compatible to work together and solve the problem, is aggregated and considers both the general and proven compatibility indexes as explained hereinafter:

**Calculation of the compatibility index between two partners**

For each couple

( CP coordinator , i-th member of EC )

1. CP coordinator (partner a) evaluates the factors included in the first part of the Collaboration Matrix or CoMax (Appendix VII)

\[ \Omega_{ab} = cg(ab) \]

2. The mechanism calculates the general compatibility based on (a.1)

\[ 0 \leq cg(ab) \leq 1 \]

3. The mechanism calculates the compatibility considering only the general compatibility (a.2)

\[ 0 \leq \Omega_{ab} \leq 1 \]

4. The mechanism calculates the general and proven compatibility (a.3)

\[ \Omega_{ab} = \left[ w_1 \cdot cg(ab) + w_2 \cdot cs(ab) \right]^{1/\lambda} \]

\[ w_1 : \text{weight allocated to } cg(ab), w_1 = 0.4 \]

\[ w_2 : \text{weight allocated to } cs(ab), w_2 = 0.6 \]

\[ \lambda \text{ is the GOWA parameter, } \lambda = 0.5 \]

\[ 0 \leq \Omega_{ab} \leq 1 \]

5. The mechanism calculates the general and filtered proven compatibility (a.4)

\[ \Omega_{ab} = \left[ w_1 \cdot cg(ab) + w_2 \cdot cs(ab) \right]^{1/\lambda} \]

\[ w_1 : \text{weight allocated to } cg(ab), w_1 = 0.3 \]

\[ w_2 : \text{weight allocated to } cs(ab), w_2 = 0.7 \]

\[ \lambda \text{ is the GOWA parameter, } \lambda = 0.5 \]

\[ 0 \leq \Omega_{ab} \leq 1 \]

As shown in the schema above the more both CP coordinator and each member of EC have worked together with the same roles and within the same scope, the more the compatibility between them is meaningful. This can be explained because while in the first workflow (at the left in the schema) the mechanism calculates an a priori estimation of the compatibility between them based on the...
favorability/stability of their environment, in the third one (at the right in the schema) the mechanism improves this measure with an a posteriori evaluation of the compatibility based on the actual performance of partners within the same scope of exchange (e.g. the problem solving process). Another important aspect to be considered is that the compatibility index ($\Omega$) produced by the model corresponds to the degree to which both the CP coordinator and the i-th member of EC are compatible to solve a problem from the point of view of the CP coordinator. This can be explained because sub-criteria contributing to both general and proven performance have been evaluated by the CP coordinator on the basis of its own level of perception of both the general context and the proven performance of the relationship. This is a desirable situation if we consider that, on the one side, he will be leading the actions of the CP and, on the other one, he detected the problem, he is suffering the immediate effects of it and, finally, he is the more interested in finding an effective solution to it.

An example, based on the case study, is proposed for illustrating the process leading to the evaluation of the compatibility index between two partners:

The capability index of the partner $P_{28}$ has been already evaluated during the technical assessment phase. This partner has been retained as part of the EC $p^{(1)}$ since his capability index exceeded the capability threshold ($\delta = 0.82 \geq 0.8$). Now, the assessment can be improved by considering the level to which this partner is compatible with the partner leading the process. Then, the compatibility index between partners $P_{28}$ belonging to EC set, and $P_{45}$; the one that first identified the problem –and that act as CP coordinator–, can be evaluated. In the frame of the case study, we consider that both partners have already worked together in the past to jointly solve problems and, in consequence, a dedicated exchange domain emphasizing the problem solving exists between them. Therefore, the compatibility index can be evaluated based on both the general and the filtered proven compatibility (i.e. as per explained in the third column in the schema in previous page).

First, the mechanism retrieves the first part of the Collaboration Matrix (CoMax) containing the favorability/stability criteria for the operating environment surrounding the relationship between partners $P_{28}$ and $P_{45}$:

As illustrated in the first part of the CoMax, the partners have a general compatibility index of 0.74. Then, the environment surrounding their relationship favors the implementation of effective collaborative practices. In addition to this, the operating environment has a proven stability due to low internal and external uncertainty levels. However, this measure provides an a priori evaluation of the compatibility. It can be improved by considering the actual

---

### CoMax - Part I

<table>
<thead>
<tr>
<th>General environment assessment</th>
<th>Criteria used for evaluating the general compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_g$</td>
<td>Operating environment structure</td>
</tr>
<tr>
<td>$c_g_{11}$</td>
<td>Relationship economic model</td>
</tr>
<tr>
<td>$c_g_{12}$</td>
<td>Level of interdependency</td>
</tr>
<tr>
<td>$c_g_{13}$</td>
<td>Balance of power</td>
</tr>
<tr>
<td>$c_g_{14}$</td>
<td>Goal congruency</td>
</tr>
</tbody>
</table>

| $c_g$ | Operating environment stability | 0.75 |
| $c_g_{21}$ | Partner's internal environment stability | 0.65 |
| $c_g_{22}$ | Partners' external operating environment stability | 0.85 |
collaboration performance in the exchange domain of interest (i.e. the one including the deployment of the proposed problem solving methodology). Then, the model retrieves the second part of the CoMax to evaluate a filtered proven compatibility index considering the actual collaborative performance of partners $P_{28}$ and $P_{45}$ in this scope:

As observed in the second part of the CoMax, partners have a –filtered– proven compatibility of 0.71. This means that partners have succeeded to collaborate and jointly solve problems, even if there is still a potential for collaboration and some opportunities that have not been exploited. The level of involvement of partners as part of the deployment of the methodology, the extent to which they succeeded to coordinate themselves to solve problems, the positive degree of information sharing and communication that were observed and the level of mutual understanding and effectiveness achieved during the problem solving can be considered as positive. Then, and based on actual performance of common problem solving initiatives, partners are compatible and could work as a cohesive entity to solve new distributed problems.

Based on both the general compatibility ($c_g=0.74$) and the proven compatibility ($c_s=0.71$), the mechanism is able to identify the overall compatibility index between partners $P_{28}$ and $P_{45}$. The compatibility index is then equal to 0.72, which means that both partners are compatible and able to work collaboratively with an extent of 0.72 –over a scale going from 0 to 1–.

Once the evaluation for the CP coordinator and the first of the members of EC has been performed, the collaborative mechanism (PaM-C) repeats the same steps for all the members so that, at the end,
all the compatibilities are calculated and stored into the Partner Assessment Record (PAR). A synthesis of the main elements obtained once the PaM-C is executed is presented in Figure 5.49.

The collaborative assessment enables the integration into the proposed methodology of all the relational aspects influencing simultaneously both the operation of the network and the effectiveness of the distributed problem solving process. In addition, the compatibility measure it yields improves the evaluation of partners prior to the constitution of the team. Its integration with the capability index to provide an appropriateness index is discussed in the next section.

5.3.2.5. Evaluation of the appropriateness index for each partner of EC

Thanks to technical assessment (PaM-T) presented in section 5.3.1, the model is able to identify across all the partners in the network the ones with the highest capability index. Now, and thanks to collaborative assessment (PaM-C) presented in section 5.3.2, the model is able to identify the compatibility index between them. The first index intends to capture the proven technical ability of each partner to solve the problem while the second one assesses its ability to work collaboratively.

Then, and in order to have a global picture of the degree to which the participation of a partner into the team is relevant, the model aggregates both its technical and collaborative performance into an appropriateness index. The calculation of this index is done in a way such that the more the proven technical performance of the partner is consistent with the problem requirements and the more he has succeeded in establishing collaborative working relationships, then the more appropriate becomes his participation into the team. This value, denoted as θ, is calculated as shown hereinafter:
The appropriateness index has been applied to the case study:

Once the capability index ($\delta = 0.82$) and the compatibility index ($\Omega = 0.72$) have been evaluated for partner $P_{28}$, the appropriateness index can be evaluated:

$$\theta_{p_{28}} = 0.77$$

The Partners Assessment Mechanism (PaM) discussed all along this section plays a major role as part of the proposed methodology since it enhances the evaluation of partners within distributed contexts. It enables, as illustrated in Figure 5.43, the identification of the more capable and the more compatible partners across the network and considers both technical and collaborative dynamics behind it. Once this mechanism has been executed, and once the appropriateness index have been calculated for all the partners in the set of EC, the methodology is able to deploy the Collaboration Mechanism (CoM) defining the strategy to constitute the CP.
5.4. THE COLLABORATION MECHANISM (CoM)

The scope of the Collaboration Mechanism (CoM), illustrated in Figure 5.43, can be defined in terms of two major activities. The first activity covers an additional partners’ evaluation that—unlike the previous ones—focuses on the beliefs of the partner leading the process. This activity results in the definition of a preference index for each partner belonging to EC. The second major activity corresponds to the definition of the strategy leading to the constitution of the team or Collaboration Package (CP). This strategy combines both the level of appropriateness—based on the capability and compatibility of partners—and the level of preference—based on their subjective beliefs—so that a team of experts that is able to work as a cohesive entity to solve the problem is defined. The mechanisms supporting both the evaluation of the preferences and the strategy for constituting the CP are developed all along this section.

5.4.1. The mechanism supporting the preferences evaluation

As introduced in section 2.3.5, the trust is a fundamental relational factor that influences positively the development, operation and performance of collaborative working relationships in a supply chain. The presence of trust increases the chances of development of the relationship (Ring and Van de Ven, 1994), limits opportunistic behavior (Derrouiche et al., 2008; Dwyer et al., 1987; Uzzi, 1997), intensifies information sharing (Gallivan and Depledge, 2003), ensures the congruence of values among partners (Mohr and Spekman, 1994), strengthens cooperation in a way that does not exist in formal contracts (Handfield and Bechtel, 2002; Morgan and Hunt, 1994) and in general facilitates the establishment of a virtuous circle of successful relationships. Then, and in light of the constitution of a team, the assessment of the overall level of trust between the potential members may have a positive impact on its later operation.

To trust means to believe strongly in someone or something, to have a sense of security in a relationship and to approve the overall behavior of another partner (Ouzrout et al., 2013). In the case of inter-organizational trust, it can be defined as the subjective belief with which members of one organization collectively assess the intention of another organization to perform a transaction effectively and reliably (Pavlou, 2002). Both definitions highlight the fact that there is a high level of subjectivity involved in the evaluation of the trust, because it can be influenced by a set of abstract principles such as reputation, credibility, honesty, integrity and transparency (Ouzrout et al., 2013). In order to offer to the partner leading the process the possibility of expressing his beliefs and predilections, the mechanism defines a dedicated preference index that captures the overall level of trust that he has in each partner belonging to the set of Eligible Contributors or EC. This index has a numerical value and goes from 0 to 1. The mechanism assumes that the more the CP coordinator trusts and believes in one partner, then the more he will prefer to work with him and in consequence the higher (or closer to 1) will be the preference index that he will assign. Nevertheless, the trustworthiness—or subjective evaluation of another’s motives and actions— is only the first of the two conditions required for ensuring the rationality of a trust decision. It is also necessary, as
explained in (Zsolnai, 2005), to consider the competence of the others to do what is expected from them. Then, and to ensure that the CP coordinator has the possibility of providing a rational basis and thus improving his trust decision, the mechanism proposes the level of capability, compatibility and appropriateness previously calculated during the PaM so that CP coordinators can integrate them into their own strategy for evaluating the preference index of each partner belonging to EC. The scope and general framework characterizing the trust decision as part of the proposed mechanism as well as the way objective and subjective evidences (or trustworthiness and competence) can be integrated to improve the trust are summarized in Figure 5.50.

Figure 5.50 - The scope of the trust decision framing the evaluation of the preference index

As illustrated in the Figure above, the proposed mechanism eliminates the two extreme areas of the rationality scale: the first one (or A in the Figure) by providing a set of objective evidence regarding the level of competence of partners to solve the problem and the last one (or D in the Figure) thanks to the introduction of the preference index itself. This ensures that trust decision, in the frame of proposed mechanism, covers both objective evidence and subjective beliefs (B and C in the Figure). Nevertheless, and taking into consideration that each CP coordinator defines his own strategy to integrate both objective and subjective elements, then it is possible to have a trust decision where elements are either consistent (C in the Figure) or contradictory (B in the Figure). While the first case corresponds to the ideal scenario for the trust decision the second one is a failure of rationality because it can lead to develop trust in partners who are trustworthy but incompetent or non-trustworthy but competent. The situations where there is a failure of rationality are accepted by the mechanism because they provide on the one hand a mean for integrating aspects not covered by the
objective evidence and on the other hand they emphasize on the collaborative dynamics of the network.

All the preference indexes, defined according to the framework presented before and representing the degree to which one partner prefers to work with another one in terms of the trust he has in his behavior, are defined by the CP coordinator into the Partners Assessment Record (PAR) so that they can be recuperated by the mechanism during further phases. An example as well as the formal definition of the preference index is presented hereinafter:

<table>
<thead>
<tr>
<th>Definition of the preference index for each partner of EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>The preference index is defined by the CP coordinator for each partner of EC</td>
</tr>
<tr>
<td>( \alpha_b ): preference index of partner ( b ) defined by the CP coordinator of the ( k )-th resolution cycle of problem ( p )</td>
</tr>
<tr>
<td>( 0 \leq \alpha_b \leq 1 )</td>
</tr>
</tbody>
</table>

At this stage the partners assessments are achieved. Then, the strategy integrating their results and leading to the constitution of the team can be presented.

### 5.4.2. The mechanism supporting the constitution of the CP

The strategy for selecting the team of experts that will handle the problem or Collaboration Package (CP) is based on the levels of preference and appropriateness of each partner belonging to EC. The first index, as described in section 5.4.1, represents the extent to which the CP coordinator trusts and believes in another’s behavior. The second one, developed in section 5.3, provides a global picture of the competence of the partner to solve the problem and work collaboratively. While the first one deals with the beliefs of the CP coordinator, the second one addresses the proven technical and collaborative performances of partners calculated on the basis of qualified evidence. The consideration of the preference and appropriateness ensure that team of experts will have both the technical competence to analyze the problem and the ability to work as a cohesive entity. Then, a bi-objective approach intended to select among all the partners belonging to EC the ones that better score with respect to the two retained criteria has been defined. In order to enable such an approach, a framework for interpreting each criterion in terms of groups of values is proposed:

- **Interpretation of the preference index**: Three groups of values can be defined depending on the nature of the preference defined by the CP coordinator. Then, partners being evaluated may be in the zone of preference, the zone of neutrality or the zone of non-preference of the CP coordinator. The three categories are explained hereinafter:
Interpretation of the appropriateness index: Two groups of values can be defined depending on the level of appropriateness calculated by the model. Then, and in light of qualified evidence, partners being evaluated may either have or not the necessary level of competence and readiness to collaborate that is required to solve the problem. This is illustrated as follows:

Now, and based on the interpretation of each single criterion, the mechanism combines both of them into a unique two-dimension chart on which vertical axis is the preference index and horizontal one is the appropriateness index. Resulting chart and the areas that are generated are interpreted in light of both the interaction of criteria and the objective of selecting a team of partners. The chart and the interpretation of the regions are presented as follows:
At this stage the mechanism is able to position all the partners belonging to EC into the *preference-appropriateness chart* presented above. Then, and based on the interpretations of the 6 intersections and 3 zones, the mechanism defines a strategy able to rank all the partners with respect to the extent to which their selection contributes to the constitution of a successful team. This is done in a way such that the more the partners are competent and inspire trust in the CP coordinator, the more they will be at the top of the ranking. Similarly, the less competent they are and the less trust they inspire, then the more they will be at the end. The strategy supporting this process is supported by two complementary steps. The first of them defines the sequence through which the 6 intersections need to be studied. At each intersection, and thanks to the second step of the strategy, the mechanism is able to define the way the partners in this area need to be selected. Once both steps are executed and the ranking of partners obtained, the CP can be constituted depending on the number of partners that are required. The whole strategy as well as an example of ranking is presented:
Collaborative problem solving within supply chains

### Strategy for defining the Collaboration Package (CP)

**a.** All the partners of EC are positioned in the chart
- partners 1 to 9 in the figure
- ranking (r) is empty

**b.** First step of the strategy is launched

**b.1** First intersection studied is A because in this area partners are competent and trustworthy

**b.1.1** Second step of strategy is launched for partners in this area:
- priority to “preference”
- r : P5, P4

**b.2** Next intersection studied is B because in this area partners are still competent and CP coordinator is neutral

**b.2.1** Second step of strategy is launched for partners in this area:
- priority to “appropriateness”
- r : P5, P4, P1, P7

**b.3** Next intersection studied is D because even if partners are incompetent they are trustworthy

**b.3.1** Second step of strategy is launched for partners in this area:
- priority to “preference”
- r : P5, P4, P7, P1, P8

**b.4** Next intersection studied is E because even if partners are still incompetent the CP coordinator is neutral

**b.4.1** Second step of strategy is launched for partners in this area:
- priority to “appropriateness”
- r : P5, P4, P1, P8

**b.5** Next intersection studied is C because even if partners are non trustworthy and they are competent

**b.5.1** Second step of strategy is launched for partners in this area:
- priority to “preference”
- r : P5, P4, P7, P1, P8, P3, P2

**b.6** Next intersection studied is F because partners are non trustworthy and incompetent

**b.6.1** Second step of strategy is launched for partners in this area:
- priority to “preference”
- r : P5, P4, P7, P1, P8, P3, P2, P6, P9

**c.** CP coordinator defines the number of partners (n) required in the team and then the CP is constituted
- n = 4 in the figure

The **Collaboration Mechanism** (CoM) leading to the constitution of the **Collaboration Package** (CP) plays a major role since it enables the phase of constitution of the team during the context phase of the generic problem solving process (G-PSP). It allows the identification of a team of partners within distributed and networked contexts characterized by both technical and collaborative dynamics. The proven technical and collaborative performances of partners as well as the degree of trust they inspire in the CP coordinator are considered as part of the strategy that has been defined.
5.5. THE CAPITALIZATION MECHANISM (CaM)

The Capitalization Mechanism (CaM) supports the capitalization phase of the Experience Feedback module (EFm) described in section 4.4. It is used, as shown in Figure 4.38, during the generalization phase of the generic problem solving process (G-PSP) to enhance two main activities. First, the mechanism supports the consolidation and generalization of the collaborative performance of the partners that have participated in the process. Second, it enhances the capitalization into the Problem Solving Knowledge base (PSK) of the Experience Synthesis Sheets (ESS) containing all the meaningful experiential knowledge derived from the problem experience.

5.5.1. The mechanism supporting the collaborative knowledge generalization

In order to be able to contribute to the establishment of a collaborative knowledge providing a good basis for the improvement of the collaboration between partners in the supply chain it is then necessary to consolidate the partners’ collaborative performance during each problem solving experience to which they have participated. This process is achieved during the generalization phase where the CP coordinator completes for each member of the team (CP) his actual collaborative performances. This a posteriori evaluation is done by using the second part of the Collaboration Matrix (CoMax) presented in Appendix - VI. The matrix is based on a set of collaborative criteria that measures for each partner of the team his level of involvement, the degree of coordination, the extent to which they shared information and the effectiveness of his contribution to the establishment of a collaborative working relationship. Those criteria correspond to the same used in 5.3.2 for evaluating the proven compatibility and in 4.2.6 for determining the collaborativity.

Once the CP coordinator has completed the CoMax for each one of the partners belonging to the CP, the mechanism is able then to reuse this information to improve two important processes. First, the actual performance in terms of collaboration of each partner during the problem that has been just solved can be used to improve his collaboration information in the Partner Record (PR). In doing so, his collaborativity index, providing a global picture of the overall readiness of this partner to collaborate in the initiatives of the supply chain can be recalculated so that it takes into consideration his performance during this problem solving experience. Second, the a posteriori evaluation of the partners’ collaborative performance performed by the CP coordinator can be used as evidence for improving the proven compatibility between them. Then, and as explained in section 5.3.2.3, the degree to which both partners are compatible based on the proven performance of their common initiatives can be updated so that it considers the new set of data. The use of the collaborative performance of partners during each experience on which they participate as a source of improvement of both his collaborativity index and the proven compatibility index between he and the CP coordinator is summarized in Figure 5.51.
Collaborative problem solving within supply chains

5.5.2. The mechanism supporting the experience capitalization

The collaborative performance of partners is, as illustrated in Figure 4.39, the last element to be stored into the Experience Synthesis Sheet (ESS). Then, and once it is completed, the mechanism is able to store the ESS of each problem/sub-problem into the Problem Solving Knowledge base (PSK) so that it is available to be reused during the resolution of new problems. The Reuse Mechanism (ReM) dealing with this issue is presented in next section.

Figure 5.51 - The scope of the Capitalization Mechanism (CaM)
5.6. THE REUSE MECHANISM (ReM)

The Reuse Mechanism (ReM) extends the process defined in section 3.3.4 so that it can be integrated with the other modules and mechanisms of the proposed global methodology to be applied in practice. The aim of this mechanism, supporting the Reuse phase of the Experience Feedback module (EFm), is to enable the retrieval and reuse of the contextual knowledge derived and capitalized from past problem solving experiences during the solving of a new problem. In order to be able to work in distributed contexts and provide effective means for facilitating the reuse of past experiential knowledge, the mechanism takes into consideration the semantic similarity between concepts, the structural aspects of the network and the context characterizing the problem (Romero Bejarano et al., 2013).

The overall framework defining the scope and main activities of the ReM has been presented in Figure 3.14. In this section the mechanisms supporting the execution of those activities are studied. First, the definition of the target case (current problem) and the attributes that will be used to query the Problem Solving Knowledge base (PSK) are presented. Then, a first preliminary filtering of the experience base with respect to the similarity of the concepts is addressed. After, a second filtering of the PSK base considering the remaining problem descriptors is considered. Last, the panel of solutions and the selection of the more similar experiences are discussed.

5.6.1. The definition of the target case

In order to be able to query the experience base, the mechanism starts by defining a target case that contains all the attributes of the current problem being solved and that, in consequence, defines the search criteria. This case is initialized with the problem attributes defined in the Problem Context Record (PCR). So, it will be characterized by the impacted element –or \( e^{p(k)} \), the set of key constituents that are affected –or \( W^{p(k)} \), the domains it concerns –or \( T^{p(k)} \)– and finally the set of relevant processes –or \( S^{p(k)} \). The target case is formally expressed as follows:

\[
\text{Target case} = \{e^{p(k)}, W^{p(k)}, T^{p(k)}, S^{p(k)}\}
\]

The mechanism will filter the PSK base by comparing the target case to all the Experience Synthesis Sheets (or source cases) stored in it. The comparison is achieved in two steps. A first one, leading to a pre-filtering of the experience base and comparing the impacted element of both the target case (current problem) and the source cases (past problems). A second one, comparing the attributes of

<table>
<thead>
<tr>
<th>A. Definition of the target case</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Target case} = {e^{p(k)}, W^{p(k)}, T^{p(k)}, S^{p(k)}} )</td>
</tr>
<tr>
<td>( e^{p(k)} ): element impacted by the k-th resolution cycle of problem p</td>
</tr>
<tr>
<td>( W^{p(k)} ): set of constituents of ( e^{p(k)} ) concerned by the k-th resolution cycle of problem p</td>
</tr>
<tr>
<td>( T^{p(k)} ): set of domains concerned by the k-th resolution cycle of problem p</td>
</tr>
<tr>
<td>( S^{p(k)} ): relevant processes concerned by the k-th resolution cycle of problem p</td>
</tr>
</tbody>
</table>

The mechanism will filter the PSK base by comparing the target case to all the Experience Synthesis Sheets (or source cases) stored in it. The comparison is achieved in two steps. A first one, leading to a pre-filtering of the experience base and comparing the impacted element of both the target case (current problem) and the source cases (past problems). A second one, comparing the attributes of
both the target and the source cases in the pre-filtered set is then executed to be able to select the more similar ones.

5.6.2. The first filtering of the experience base

The first filtering aims at reducing the search space on the basis of the similarity of concepts in the taxonomy of products. Then, the mechanism compares the impacted element of the target case—or \( e^{p(k)} \)—to the impacted element of each source case in the experience base—or \( e_j \)—in order to define the similarity between both cases. At this stage, the similarity between the target and the source cases is based on a strict evaluation that can be equal either to 0 or 1. The similarity is equal to zero when the impacted product of the source case being evaluated does not correspond in the taxonomy of products to the impacted product of the target case or to one of its descendants. Conversely, the similarity is equal to one when \( e_j \) corresponds to \( e^{p(k)} \) or to one of its descendants. At the end, only the source cases (or ESSs) with a similarity equals to 1 are kept by the model. This pre-filtering of the experience base allows retrieving amongst all the past problem solving experiences only the ones that concern the same or at least the most similar products. The whole process is described hereinafter:

**B. Evaluation of the similarity for each source case (or ESS) in PSK**

**b.1** A set of similar products is identified based on the taxonomy of products

\[
S_{Products}^{p(k)} : \text{set of similar products to } e^{p(k)}
\]

where \( S_{Products} \) is defined by \( e^{p(k)} \) and all its descendants in \( Products \), the semantic taxonomy of « products »

**b.2** The mechanism evaluates a strict similarity for each source case in the base

\[
sim(Target^{p(k)}, ESS_j) : \text{strict similarity between the target case and the } j\text{-th source case (ESS) in PSK}
\]

\[
sim(Target^{p(k)}, ESS_j) = \begin{cases} 1 & \text{if } e_j \in S_{Products}^{p(k)} \\ 0 & \text{otherwise} \end{cases}
\]

**C. First filtering of the Problem Solving Knowledge base (PSK)**

**c.1** The PSK base is filtered by keeping only source cases with strict similarity = 1

\[
PSK' : \text{PSK filtered with regards to the similarity in the taxonomy of products}
\]

\[
PSK' = \{ ESS_j / \text{sim}(Target^{p(k)}, ESS_j) = 1, j \in PSK \}
\]

5.6.3. The second filtering of the experience base

Even if the set of pre-filtered experiences (or PSK') concerns problems that occurred in products similar to the one being currently impacted, it can be still filtered and the relevancy of the results improved by considering additional problem-related aspects. Then, the mechanism evaluates as part of the second filtering and for each source case in the pre-filtered space the extent to which its attributes are similar with the ones of the target case. The similarity index, leading to the
identification of the more similar past experiences, is determined on the basis of the following criteria:

- **The similarity of concerned constituents (cc$_j$):** it measures the degree to which the source case is consistent with the target case in terms of the constituents they impact. The interest of this criterion is to identify the past problem solving experiences that not only concern the same or similar products but that in addition have been observed for the same or at least a similar set of constituents. Then, the more the source case has been detected on similar constituents of the impacted product, the higher (or closer to one) is the value of its first criterion. The mechanism evaluates the similarity as shown in the steps D to G:

**D. Identification of the constituents concerned by the target case**

\[ W^{(k)}: \text{set of constituents of } e^{(k)} \text{ concerned by the } k\text{-th resolution cycle of problem } p \]

is defined by a set of \( W^{(k)} \), where:

\[ W^{(k)}_i \text{ is the control variable determining whether the } i\text{-th constituent of } e^{(k)} \text{ is concerned} \]

\[ W^{(k)}_i \in \{0,1\} \]

**E. Identification of the constituents concerned by each source case**

\[ W^j: \text{set of constituents of } e_j \text{ concerned by the } j\text{-th experience in PSK} \]

is defined by a set of \( W^j \), where:

\[ W^j_i \text{ is the control variable determining whether the } t\text{-th constituent of } e_j \text{ is concerned} \]

\[ W^j_i \in \{0,1\} \]

**F. Constituents of the target case in the scope of each source case**

\[ c(i)_j: \text{control variable determining whether the } j\text{-th source case concerns the } i\text{-th constituent of the target case} \]

\[ c(i)_j = \begin{cases} 1 & \text{if the } j\text{-th source case concerns the } i\text{-th constituent of the target case} \\ 0 & \text{otherwise} \end{cases} \]

\[ i \text{ is the set of constituents of } e^{(k)} \]

**G. Calculation of the level of similarity of each source case**

\[ cc_j(j): \text{Level of similarity between constituents concerned by the target case and the } j\text{-th source case in PSK} \]

\[ cc_j(j) = \begin{cases} 0 & \text{if } \sum_i W^{(k)}_i = 0 \\ \text{otherwise} \end{cases} \]

\[ 0 \leq cc_j(j) \leq 1 \]
• **The similarity of problem domains (cc$_2$):** the mechanism compares both $T^p(k)$ (problem domains of the target case) and $T_j$ (problem domains of the j-th source case) in order to evaluate the extent to which they are similar. The interest of this criterion is to be able to identify the past problem solving experiences that not only concern the same or similar products but that in addition concern the same or at least a similar set of domains. Then, the more a source case has problem domains that are similar to the ones of the target case, the higher (or closer to one) is the similarity level. This evaluation is based on the mechanism proposed in section 5.3.1 (steps G to L) where the level of adequacy between the domains of both problem and partners has been compared. By replacing in that mechanism the domains of competence of partners (or DoC) by the domains concerned by the j-th source case ($T_j$) and the level and threshold of expertise by the level and threshold of similarity, it can be extended to calculate the similarity between domains (or cc$_2$). The formal definition of this criterion is presented hereinafter:

\[
cc_2(j) : \text{Level of similarity between domains concerned by the target case -} T^p(k), \text{ and domains concerned by the j-th source case -} T_j, \text{ in PSK}
\]

\[
0 \leq cc_2(j) \leq 1
\]

• **The similarity of relevant processes (cc$_3$):** it measures the degree to which the source case is consistent with the target case in terms of the processes they impact. The interest of this criterion is to be able to identify the past problem solving experiences that not only concern the same or similar products but that in addition impact the same or at least a similar set of processes. Then, the more the source case impacts the same or similar processes to the ones impacted by the target case, the higher (or closer to one) is the value of its third criterion. The mechanism supporting this evaluation is covered by steps I to K:

---

**H. Calculation of the level of similarity of domains**

\[
cc_2(j) = \frac{\text{Number of common domains}}{\text{Total number of domains}}
\]

---

**I. Identification of the processes concerned by the target case**

\[
S^p(k) : \text{set of processes concerned by the k-th resolution cycle of problem p}
\]

is defined by a set of $S^p(k)_i$, where:

$S^p(k)_i$ is the control variable determining whether the process $i$ is concerned

$S^p(k)_i \in \{0,1\}$

$i = \{$ design, industrialization, fabrication, e/transport, d/transport $\}$

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Once the similarity in terms of constituents (or $cc_1$), domains (or $cc_2$) and processes (or $cc_3$) is calculated for each source case in PSK', the mechanism is able to aggregate them into an overall similarity index (or cc) that measures the extent to which the source case is similar to the target case and in consequence the extent to which it can be useful and can provide useful contextual knowledge for solving the current problem. The aggregation is performed as indicated hereinafter:

$$cc(j) = \left( \frac{cc_1(j)^{\lambda} \cdot cc_2(j)^{\lambda} \cdot cc_3(j)^{\lambda}}{\sum_{i=1}^{3} w_i \cdot cc_i(j)^{\lambda}} \right)^{1/\lambda}$$

$w_i$: weight allocated to the i-th criterion contributing to the similarity

$cc_i(j)$: performance of the i-th criterion contributing to the similarity of the j-th source case

$cc_1(j)$: level of similarity between constituents concerned by the target case and the j-th source case in PSK'

$cc_2(j)$: level of similarity between domains concerned by the target case and the j-th source case in PSK'

$cc_3(j)$: level of similarity between processes concerned by the target case and the j-th source case in PSK'

$\lambda$ is the GOWA parameter, $\lambda = 0.5$

$0 \leq cc(j) \leq 1$
5.6.4. The panel of solutions and the reuse of past experiences

Once all the similarity indexes for all the source cases in PSK’ have been evaluated, the mechanism proposes a panel of solutions from which the team of experts selects, depending on a similarity threshold, the past experiences that can be useful in the solving of the current problem. This activity is covered by the step M of the ReM:

### M. Panel of solutions and definition of the set of the more similar experiences

#### m.1 Once all the similarity indexes for all the source cases in PSK’ have been calculated, and based on a set of similarity thresholds, the model proposes a panel of solutions. Example:

<table>
<thead>
<tr>
<th>similarity threshold $s_{cc}$</th>
<th>number of source cases with similarity index $\geq$ similarity threshold</th>
<th>average of similarity indexes in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>1 source case</td>
<td>0.94</td>
</tr>
<tr>
<td>0.8</td>
<td>3 source cases</td>
<td>0.89</td>
</tr>
<tr>
<td>0.7</td>
<td>4 source cases</td>
<td>0.76</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

#### m.2 Problem solvers select the similarity threshold that better satisfies the needs in terms of information required for the problem. In the example a threshold of 0.9 has been retained:

<table>
<thead>
<tr>
<th>similarity threshold $\hat{s}_{cc}$</th>
<th>number of source cases with similarity index $\geq$ similarity threshold</th>
<th>average of similarity indexes in this category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>1 source case</td>
<td>0.94</td>
</tr>
</tbody>
</table>

$\hat{s}_{cc}$: selected similarity threshold, $\hat{s}_{cc} = 0.9$

In this case, one past experience has a similarity index that exceeds 0.9. It has an average capability of 0.94.

#### m.3 The set of similar experiences ($\Psi$) to be reused is established based on the outcomes of step (m.2)

$$\varphi^{P(k)} = \{ ESS_j / cc(j) \geq \hat{s}_{cc} , ESS_j \in PSK' \}$$

$cc(j)$: overall similarity index of the j-th source case (ESS$_j$) with regards of the target case

#### m.4 The Experience Synthesis Sheet (ESS) of each selected experience in $\Psi$ is proposed to problem solvers as a source of meaningful information to enhance the analysis of the current problem

The Reuse Mechanism (ReM), covered by steps from A to M, plays a fundamental role as part of the proposed methodology since it contributes to the positioning of the problem solving as a real driver for the improvement of the quality in distributed contexts. It enhances the reuse of the contextual knowledge derived from the solving of past problems during the analysis of new similar ones, which can help problem solvers and facilitate the analysis phase in light of the identification of the root causes. Once the ReM has been executed and the experiential knowledge encapsulated into the Experience Synthesis Sheets (ESSs) of the more similar experiences has been proposed to experts, they can resume with the analysis phase of the G-PSP already explained in section 4.3.2.2.
5.7. THE ACTION MANAGEMENT MECHANISM (AmM)

The *generic problem solving process* (G-PSP) requires, as described in section 4.3.2, the definition and implementation of dedicated actions enabling the achievement of the objectives and goals of each process phase. The action plan resulting from those actions and depicting how the activities of the process will be reached includes:

- The *containment actions* deployed during the context phase to mitigate the effects of the problem (i.e. providing protection and temporary fixing the problem),
- The *validation actions* implemented during the analysis phase to ensure the plausibility of suggested causes (i.e. contributing to the identification of the actual root causes),
- The *corrective actions* deployed at the solution phase to definitively eradicate the factors at the origin of the problem (i.e. providing durable solutions) and,
- The *preventive actions* implemented during the generalization phase to prevent similar problems (i.e. providing systemic improvement).

The ability to define a meaningful action plan addressing each of the critical activities of the process and the actual extent for its implementation, monitoring and control is one of the enablers of the problem solving process (Shiba and Walden, 2002). This is all the more relevant when the scope of application is characterized by distributed and networked contexts with multiple decentralized partners that collaborate to jointly solve problems. In such a case, an additional set of tools is required to effectively coordinate the partners and ensure that actions are defined and reached in a timely and cost-effective manner. This aspect has been extensively studied by researchers such as in (Ginter, 2013; Hunger and Wheelen, 2011; Jabrouni, 2012; Pillet et al., 2013) and practitioners such as in (AIAG, 2012; IAQG (International Aerospace Quality Group), 2010) that have succeeded in providing both a general framework for managing an action plan and a set of methods and tools for supporting the process in practice. As part of the proposed methodology, and in order to emphasize in this aspect, a dedicated *Action Management Mechanism* (AmM) dealing with the centralization and management of actions is proposed. Nevertheless, the interest of the positioning of such a mechanism as one of the drivers of the global methodology lies in stressing the importance it has in the effective management of an action plan and not in developing a new set of constructs. Indeed, this mechanism could be easily structured by extending the existing approaches and supported by available tools.
5.8. SUMMARY OF THE METHODOLOGY MECHANISMS

In this section, the six mechanisms that enable the interactions between the three methodology modules have been specified: the Filtering Mechanism (FiM), the Partners assessment Mechanism (PaM), the Collaboration Mechanism (CoM), the Capitalization Mechanism (CaM), the Reuse Mechanism (ReM) and finally the Action management Mechanism (AmM). For each mechanism, covering a critical activity of the problem solving process in distributed contexts, a set of algorithms, models and tools has been defined in a way such that the methodology can be implemented in practice. The role of the mechanisms as part of the proposed global methodology is central since they support the articulation between the methodology modules. In consequence, they ensure the effective solving of problems within the frame of network-based contexts and considering the experiential knowledge derived from the process.

The articulation of both the three modules and the six mechanisms in a consistent manner allow the methodology to support the continuous improvement strategies of both the firms and the supply chains. Unlike the existing approaches and methods studied in literature and applied in practice (refer to 2.2.2), the proposed global methodology is able to deal with the solving of problems in distributed and networked contexts.
Lire
la troisième partie
de la thèse