CHAPTER 7

ENHANCED DECISION-MAKING WITH DISTRIBUTED CASE BASES

Distributed case-based reasoning can be applied to enhance performance of conventional CBR based real time applications. The conventional CBR are is suitable for single agent having single case base approach designed with purpose of real time problem solving. Unfortunately this approach seems as failure due to privacy and scalability factors. These factors are concerned with access to the centralized case repository and the impracticability of accessing the centralized case base consisting huge amounts of data. These two issues are being successfully resolved with help of the distributed CBR approach. This approach provides the numerous supplementary benefits in applying this approach instead of the conventional case-based reasoning approach. The distributed case-based reasoning is not limited to single case based having limited knowledge along with improved efficiency due to its distributed nature. This approach is more efficient in making the decisions in the MAS based SCM. If there exist efficient decision taking mechanism in the MAS based SCM system, then this system may be capable to tackle the bullwhip effect properly.

7.1 COMPLEXITY OF SCM DECISION MAKING PROCESS

In MAS based SCM, there exist multiple supply chain activities which involve different types of the decisions for completion of the SCM operation. The supply chain decision making becomes the complex process due to the existence of huge range nature of the supply chain networks, hierarchical configuration of decisions and unpredictability of various inputs and operations with their energetic environment of interactions among supply chain elements. These decisions have been divided into various types depending on their temporal and functional consideration. Every decision makes great impact on the
performance of the whole supply chain system. Any wrong decision generates the worst impact on the organization goals and customer satisfaction during the SCM operations. There are a lot of structural issues which makes the nature of the decision making phenomena very complex. These issues may be internal and external to the supply chain organization. In the SCM, the effective decision making is straight reliant on perceptions of the barriers faced by the facilitators of the decision process. There are following barriers faced as given below:

- There exist disinclination of managers regarding information sharing with members of their SCM department or with supply chain partners due to the concerns about integration expenses and hammering of bargaining influence. The managers do not provide the accurate information regarding real situations to their partners and their employees.
- There is not full faith between the companies involved in the supply chain activities. These lacks of faith among companies delay the approval of supply chain integration. The lack of standardized communication and business processes hamper the execution and cripple the decisions making procedure.
- Due to the survival of the human factor, it becomes most challenging of all in this process. The human nature tries to avoid the modifications and complicated decisions as possible but it is required to manage the changes in efficient supply chain management.
- There subsist technological difficulties in sharing data and coordinating workflows crossways business partners through the information system. The information system faces the problems of having its outdated designs having a lack of technical proficiency.
- Current supply chain based organizations face the implementation problems consisting of the accomplishment of significant decisions in environment of novel business processes, innovative skills, and synchronized action among various organizations.
- The financial difficulties and shortage of resources interrupts the interior operations of the supply chain partners. This factor greatly affects the decision making process.
• There don’t exist any commonly approved framework designed for managing impartial profits and expenditure sharing amongst all participants. This complexity in apportioning these profits & prices between partners often can produce decision paralysis.

• The shared resources are a frequent competence basis in the chain of two or more different SCM organizations. These resources turn out the complexity of planning and control decisions.

• The long-standing supply chain management accomplishment involve the broad variety of changes in organizational civilization, capacity, observation and organization, need of widespread ethics, behaviors and attitude which may cause risk to the entire supply chain operation. These factors make the supply chain decision making process complex. These decisions are directly base of the bullwhip effect in the SCM. These decisions are directed oriented on the customer requirement fulfillment. All these factors are being resolved with the concept of the case-based reasoning technology. The CBR technology enables the managers and SCM partner to use the past experiences to take the decisions. These types of the decision makers remember the past history of the SCM activities. Hence to use the case-based reasoning, we are going to use the CBR-BDI agents in the MAS based SCM system. This approach makes the intelligent agents to take the decisions on the basis of the case-based reasoning.

7.2 CASE BASE FOR MAS BASED SCM SYSTEM

The conventional CBR consists single case base for storing the past experiences in the problem solving process. This approach has major limitations of having not any decisive factor for selecting the nearest cases on the basis of similarity measurement between the cases. The conventional CBR does not generate the most favorable comparable neighbors for a variety of objective cases. The single intelligent agent based applications can store the single case on the single locations. But in real time situations, the applications are run in the distributed nature. To handle such distributed environment, the multi-agent system consist the ability to adapt to such environments. There is a different approach of using the case base with the multi-agent system. There may be single case base or multiple case
bases along with multi-agent system. Let’s discuss cons and pros of both approaches along with multi-agent system.

7.2.1 Limitations of single case base

In Multi-agent single case base approach, all existing agents in the MAS share the solitary case base. There exists only distinct case base for storing the past experiences. The agents in this system retrieve the similar cases from solitary case and retain the solved solution as the case in the case base. The major advantage of this approach is that it is very easy to implement.

The main problems encountered in this type of systems having single case base source is limited by the scale of particular knowledge resources. The presence of the solitary case base, the knowledge is limited to access between multiple intelligent agents. In presence of single case base, it faces the problem of the deadlock during accessing the particular case base at the same time by multiple intelligent agents.

The case structure may be varying regarding every intelligent agent. The case structure for the supplier agent may be different for structure used by production agent in the MAS based SCM system. To decide the universal case structure for multiple intelligent agents in the MAS based SCM system is very much complex process. There should be one
particular case structure which contains all fields in case structure that are mandatory for all intelligent agents in MAS based SCM system.

7.3 BENEFITS OF DISTRIBUTED CASE BASES APPROACH

The conventional case-based reasoning system may be classified as the approach of having the single case base for storing and retrieving the past experiences in form the case. The distributed case-based reasoning approach support availability of the multiple case bases for storing the cases at the different locations. :

- **Growing the efficiency**
  The performance of the traditional case-based reasoning system can be enhanced by increasing the number of cases available for the CBR reasoner. Such system supports efficient case retrieval regarding particular upcoming problem. Hence the overall efficiency of the distributed CBR system is much higher than the conventional CBR system.

- **Improving case availability**
  The distributed CBR system consists multiple case bases which are being located on the different locations. These case bases increase retrieval efficiency of the CBR system. There are more efficient case retrieval results.

- **Lessening case maintenance**
  This approach reduces the cost of case base maintenance. The subcases are being easily stored and retrieved with minimum cost in terms of access time and storage. These subcases can be easily merged and generated the final case.

- **Single case base independency**
  As the availability of multiple case bases, the distributed CBR system is not dependent on solitary case base. In case of single case base, the system becomes dependent to single case base. Inaccessibility of this case base prevents the working of the whole system.

- **Efficient retaining of embedded information**
  The cases in the distributed case base are being divided into the subcases. The subcases are being easily retained or stored in the different locations. The system is not dependent of storing the information on the single locations.
- **Universal case structure independence**
  The distributed case bases contain phenomena of storing cases in term of multiple subcases. Hence whole system is not dependent of the particular case structure. The universal case structure is considered as fixed for the whole working system.

- **Speeding the case retrieval**
  The major problem faced in the traditional CBR system is the size of the case base. As the size of the case base grows, the speed of the whole system goes down. The size of the case bases increase as the more numbers of the cases is being stored in the existing case bases. The cases in the distributed case base are being stored in different case bases at different locations. The system is not reliant of storing the information on the solitary site.

- **Managing the case base size**
  With the help of distributed case base, the major case base size problem of the traditional CBR system can be easily handled efficiently. The size of the case base can be controlled with the help of distributed case bases located on different locations. The size of the case bases does not increase when the more numbers of the cases are being stored in the existing cases. The cases in the distributed case base are being stored in different case bases at different locations. The size of the case base does not grow with the process of solving the problems and storing the past experiences.

Thus these features represent the benefits of using the distributed case base along with MAS approach.

### 7.4 ENHANCING DECISION MAKING WITH DISTRIBUTED CBR

The distributed case based reasoning can be applied in the MAS based SCM system for improving the decision making process. This process has great impact on the performance of the designed MAS based SCM system. If this proposed system is capable of taking the decisions efficiently, then it may tackle the bullwhip effect very efficiently. The decision making is one of the crucial tasks of managing the supply chain management system. On the basis of the supply chain decisions, the SCM actions are being performed and supply chain resources are being utilized during the supply chain
operation. The supply chain decision-making involves planning regarding fulfillment of organization goals and customer satisfaction maximization.

The planning phase provides the tangible form to extensive decisions about business goals. The decision-making process face novel problems constraints and challenges faced during resolving the crises in the supply chain operations. The right decisions provide the prospect of growth of the organizations. The erroneous decisions directs to defeat and volatility to an industrial component. These decisions are the basis of the whole supply chain activities occurring during the supply chain operations. Hence the decision making process should be performed with great intentions of customer satisfactions.

### 7.4.1 Decision-making process in distributed CBR

In general, the decision-making process is not a single step. It involves multiple numbers of steps which are being executed in a logical manner to produce the right decision regarding the constraints of the new problem. So this process is long-lasting and time consuming for the supply chain managers in the phase of controlling the supply chain activities. The decision-making in the supply chain management system may involve the following six steps as given below:

1. **Recognizing the supply chain problem.**
   
   On the first stage, the supply chain problems are being recognized. This phase helps in finding the basic facts related to the current problems. These facts represent all aspects of the current problems.

2. **Scrutinizing the supply chain problem.**
   
   This phase analyzes the facts related to the current problem. The output of this phase is the information regarding the roles of its constraints. The manager comes to know hard and soft constraints of the particular problem. Hard constraints are defined as the constraints of the problem which must be resolved during solving the problems. Soft constraints are defined as the constraints of the problem which may be resolved in providing more efficient solution during solving the problems. Both constraints play very important roles in the problem solution.

3. **Budding alternative solutions for supply chain problem.**
   
   After knowing the constraints related to the current problem, the alternative solutions are being generated for generating the optimized solution for the current
problem. These alternative solutions are designed for the purpose of solving the problems.

4. **Choosing the superlative solution out of the existing options.**
   At this stage, the alternative solutions are being analyzed to generate the finalized solution. The final solutions are being selected among the alternative solution regarding the hard and soft constraints of the current problem. The output of this phase is the optimized solution for the current problem.

5. **Translating the superlative decision into action.**
   After generating the optimized solution for the current problem, the next phase is to convert the superlative solution to the action which applies the optimized solution to solve the problem.

6. ** Guaranteeing reaction for follow-up.**
   After applying the final solution to the current problem, then it is necessary to know the result of applying the solution to the current problem.

The figure 7.2 given below suggests the steps in the decision-making process.

![Figure 7.2 Decision making procedure](image-url)
The distributed case-based reasoning follows this decision-making process with the aim of generating the right decisions by the intelligent agents in the MAS based SCM system. The distributed case-based reasoning may improve the decision-making process occurred in the multi-agent system in the proposed system. The distributed CBR enables the intelligent agents to use the past experience stored in the distributed case base.

7.4.2 Improved decision-making in distributed CBR

There are following benefits provided in applying the distributed case-based reasoning as given below:

1. Using the concept of distributed case-based reasoning, the individual intelligent agent is capable of creating own case structure. There is no problem to finalize the common case structure for all intelligent agents.

2. The intelligent agents are capable of accessing the case base stored in different locations. The distributed case bases enable the MAS based SCM system to store the experiences faced by all these intelligent agents.

3. The distributed CBR approach makes the intelligent agent not being dependent on the single case base. There exists the separate own case base for each intelligent agent stored in different locations.

4. The intelligent agents gain the capability of accessing the case bases of other intelligent agents. The intelligent agents can interact with other agents to access the case bases of other agents.

5. The intelligent agents utilize the past experience of problem solving stored by other case bases of intelligent agents. On accessibility of other case bases of other intelligent agents, they utilize the knowledge stored into another case bases to generate the efficient results.

6. The distributed CBR increase the availability of the cases corresponding the new problems. If the similar cases are not available in its own case, then it can look up into other case bases.

7. There is no problem related to access to the cases by multiple intelligent agents at the same time. In case of single case base, the deadlocks may be occurring due to simultaneous retaining of new cases after adaptation of the existing cases.
In this way, the distributed CBR provides an efficient mechanism to produce the accurate decisions in the supply chain activities in the MAS based SCM system. These benefits enable the proposed system to take the decisions through utilization of the experiences of past problem solving by other intelligent agents through similar cases found in other intelligent agents’ case bases. Hence this approach improves the process of decision-making by availability of distributed case base for running all intelligent agents for achieving the organizational goals.

7.5 DIMENSIONS OF DISTRIBUTED CASE BASE

The distributed case base approach provides a lot of the benefits over the conventional case base. It can be used with the multi-agent system to enhance the performance of proposed MAS based SCM system. If the single case base is being used with the MAS system, then all intelligent agents share the single case base and way of accessing the case base becomes slow. They become dependent on the single case base for retrieving and retaining the cases in the case base.

The distributed case base makes the intelligent agent in the proposed MAS based SCM system to access the multiple case bases stored at different locations. This approach provides the efficient way of accessing bulk of the cases located in the different case bases. The process of retrieving and retaining the cases from different case bases generates much of the issues related to accessing of the theses cases. The distributed case base has following dimensions as given below:

- **Method of organizing the multiple case bases**
  The distributed case base has major dimensions related the method of accessing or organizing the multiple case bases for particular application running by the group of the intelligent agents in the proposed MAS based SCM system. There must be an efficient method for organizing these multiple case bases.

- **Manner of accessing the information from the multiple cases**
  Such system requires the efficient mechanism for accessing the information from the multiple case bases. The efficient information retrieval mechanism provides a way of retrieving the subcases from the multiple case bases used in the proposed MAS based SCM system.
To resolve these issues related to the distributed case base, the multi-case base reasoning approach may be applied to improve the better performance of the whole proposed MAS based SCM system.

### 7.5.1 Multi-case base reasoning

This approach is being considered every efficient in handling the several cases-bases involved the distributed case bases. This approach provides the effective use of the information in numerous case bases. In case of the distributed case base, there are two major decisions are being taken during the process of the whole system. These issues are being described as given below:

- **Case dispatching process**
  
  This process is being related to conclude the case base whose the cases are being helpful to solve the problem. The process play a very important role in the working with distributed case bases. There exist multiple case bases associated with the intelligent agents. On encountering the new problem, it is one of the most important issue to find out which case base contains useful information required for generating the final solution instead of searching the all case bases. The accomplishments of the particular process depend on opting for the precise strategies for particular case bases and task domains.

- **Cross-case base adaptation process**
  
  This process is related to alter the solutions from particular case base regarding to the dissimilarity between the two case bases. It helps in the process of creating the final solution and retaining the particular cases in concerned case base. The phase of developing high-quality case dispatching strategies could require arbitrarily-large quantity of knowledge about the task domain and available case bases.

The efficient case retrieval from distributed case bases is directly dependent on the dispatching strategies and cross-case base adaptation knowledge. These facts maintain the accurate details about the case bases for supplementary comparable problems with performance improvement compared to relying on the limited case base unaccompanied. This information is more ubiquitous regarding these case bases for solving the upcoming problems.
In distributed case base, the MCBR perform the task of the congregation and integration between the cases from all obtainable case bases. These tasks have three major advantages for operating the distributed case bases as given below.

- This approach ensures about the usage of the cases in solving the problems and then this approach allows retaining the cases in the case bases to make the case base more condensed.
- It avoids enthusiastic assimilation which generates the suppleness for depicting the case bases available through selection of superior-quality cases.
- With help of the cross-case base adaptation strategies with MCBR, the solution quality can be improved.

These facts indicate the impacts of the multi-case base reasoning in managing the distributed case base along with proposed MAS based SCM system. This approach builds the case adaptation strategies for managing the numerous case bases.

### 7.6 CASE REPRESENTATION FOR DISTRIBUTED CASE BASE

In the distributed case base, the case representation is totally different from the conventional CBR approach. The conventional CBR consists the universal structure for the all cases stored in the case base. In single agent single case base, the cases consist following multiple fields as given below:

- Problem Description
- Justification
- Result

All these fields are being used to store the all information about the new problems and its proposed solutions. But this approach is not suitable for distributed case bases as whole attributes of existing cases maybe not useful for the upcoming problems. There may be some portion of the case found useful for upcoming problems. For such situations, to retrieve entire case is not required in designing of proposed solutions.

To resolve these issues, the distributed case bases divide the case into sub-cases. These sub-cases follow the case structures as used in the conventional CBR. Now instead of retrieving whole case, only required sub-cases are being retrieved on depending on the constraints of upcoming problems. The divisions of the case into sub-cases are directly
dependent on the parameters of the CBR-BDI intelligent agents working together in the proposed MAS based SCM system.

Figure 7.3 Case structure of distributed case base

Figure 7.3 shows the case representation in the distributed case base. The divisions of the case into sub-cases are done on the basis of the parameters discussed in table 5.1, 5.2 & 5.3 along with every intelligent agent. In the system, the indexes are used to find the most appropriated cases for solving the current problem during retrieval. The major issue associated with case representation is case indexing. The efficient case indexing is required for making retrieval phase more proficient. The case indexes have following roles in the CBR retrieval phase as given below:

- The indexes are used to recognize cases for the circumstances regarding the new problem faced.
- Indexes prompt the search process through the distributed case base for the proposed system.
- The case indexes can highlight the significance of some of the case’s attributes in existing case base.
Hence the case indexes play very crucial roles in the case representation process. There are various methods that can be applied for case indexing. The feature-based similarity measure is accepted for case indexing mostly in the case-based reasoning system.

### 7.7 RETRIEVAL IN DISTRIBUTED CASE BASE

In proposed MAS based SCM system, every CBR-BDI agent consists own case base in the distributed case base. Every agent has some constraints representing the goals of their working regarding whole system operation and the contexts in which a local case of that agent can participate in the overall case. The constraints are used to define the variables used in the agent program whose scope may be local or global representing features derivable from partial cases.

As shown in figure 7.4, the individual intelligent agents have some constraints along with case base. These attributes play very important role in case retrieval. The case retrieval phase may be defined as the process in which the retrieval algorithm is applied to recover the majority related cases to the current problem. This phase requires the mixture of the search and matching processes.

![Case retrieval in Distributed Case base](image)

There exist a lot of the case retrieval algorithms for case-based reasoning systems. Mainly used two retrieval techniques are nearest neighbor retrieval algorithm and inductive retrieval algorithm in CBR applications. The nearest neighbor algorithm is very simple and easy to use and implement but it becomes slow when the size of case base
grows. On the other hand, the inductive retrieval algorithm is faster than the nearest neighbor algorithm. But it has been found inefficient in case of missing data in case stored in the case base. Second, it is directly dependent on pre-indexing process which is also time consuming phenomena. The case retrieval from distributed case bases may be seen as the distributed constraint optimization problem because whole case will be compatible with the local constraints of every CBR-BDI intelligent agents and it should be the best such case (in terms of credibility measures). Local case consistency constraints arise from the knowledge that an agent has about the generic requirements of the context in which its local subcases can usefully participate.