CHAPTER III
PROBLEM SPECIFICATION AND
METHODOLOGY

3.1. Introduction

In any semantic solution, data is annotated using ontologies. Ontologies are shared specifications and therefore the same ontologies can be used for the annotation of multiple data sources, like web pages, eXtensible Markup Language documents, relational databases, and so on. Their shared terminologies enable a certain degree of interoperability between the data sources using the same ontologies. To enable such an interoperation, mediation is required between the ontologies. Ontology mediation includes operations such as, ontology mapping, ontology alignment, ontology matching, ontology merging, and ontology integration.

An ontology mapping \( M \) is a declarative specification of the semantic overlap between two ontologies \( O_S \) and \( O_T \). The correspondences between different entities of the two ontologies are typically expressed using some axioms formulated in a specific mapping language. Mapping can be unidirectional or bi-directional. The different phases in the generic mapping process [59] are depicted in Figure 3.1.

![Figure 3.1. Mapping Process](Image)

(i) Import of Ontologies: Ontologies can be specified in different languages, which indicate a need to convert them to a common format so that the mapping can be specified. Furthermore, the ontologies need to be imported in the tool, which is used to specify the mapping.
(ii) *Finding Similarities*: Many systems use the match operator to automatically find similarities between ontologies. For any two-source ontologies, the matcher returns the similarities between ontologies.

(iii) *Specifying Mapping*: After similarities between ontologies have been found, the mapping between the ontologies needs to be specified.

The automated or semi-automated discover of correspondences between two ontologies are called *ontology alignment*. Ontology alignment is the task of creating links between two original ontologies. Ontology alignment is made, if the sources found to be consistent with each other, but are kept separate or when sources are from the complementary domains.

*Ontology matching* is the process of discovering similarities between two source Ontologies. The result of matching operation is a specification of similarities between two ontologies. Ontology matching is carried out through the application of match operator.

In ontology merging a new ontology is created which is the union of source ontologies in order to capture all the knowledge from the original ontologies. There are two different approaches in ontology merging. In the first approach, the input of the merging process is a collection of ontologies and the outcome is a new merged ontology which captures the original ontologies, as given in Figure 3.2.

![Figure 3.2. Merging Process (Approach 1)](image)

In the second approach the original ontologies are not replaced, but rather a view called bridge ontology is created which imports the original ontologies and specifies the correspondence using bridge axioms as in Figure 3.3.
Ontology integration is the process of generating a single ontology in one subject from two or more existing and different ontologies in different subjects. The different subjects of the different ontologies may be related. Some change is expected in a single integrated ontology.

### 3.2. Problem Statement

This section specifies the problem statement and the objectives of the research along with the methodologies used to carry out the research.

One of the aims of this research work is to define matching of ontologies using directed graphs and present the mathematical aspects of matching of ontologies with fitness score as an evaluation metric.

An attempt is made to give a comprehensive overview of ontology operations such as ontology merging, ontology difference, and ontology matching using Ontology Abstract Machine. This research work is an exclusive approach of ontology management using Ontology Abstract Machines.

A framework for ontology matching and merging is proposed. The framework is validated by an innovative approach for developing Ontology based Question Bank System. The Ontology based Question Bank System is distinctive because of two important features:

(i) The Ontology based Question Bank System is based on Domain Ontologies,

(ii) The Ontology based Question Bank System demonstrates the ontology merging and matching methods in its implementation.
The proposed Ontology based Question Bank System identifies important concepts and generates multiple choice questions along with the distracters. Each Question Bank consists of sets of test items each of which consists of a question or stem. The *java ontology* developed in this research work is used as domain ontology for the implementation of the Ontology based Question Bank System.

A methodology for developing a teaching ontology for learning a programming language is presented along with the *java ontology* developed in this thesis. Further the effectiveness of the learning process with the use of *java ontology* is justified with an experiment conducted in a class room situation.

### 3.3. Objectives

The objectives of the research work are:

(i) to present a comprehensive overview of ontology mediation methods, tools and systems,

(ii) to define matching of *m* directed graph and present the mathematical aspect of matching and binding of *m* directed graphs with fitness,

(iii) to present a comprehensive overview of ontology operations such as ontology merging, ontology difference, and ontology matching using Ontology Abstract Machine,

(iv) to propose a framework for ontology matching and merging,

(v) to validate the framework using Ontology based Question Bank System, and

(vi) to bring out an approach to develop ontologies for learning programming languages.

### 3.4. Methodologies

In order to achieve the objectives proposed above, the different methodologies adopted are illustrated in this section.
A comprehensive understanding of ontology mediation is achieved through a literature survey and a comparative analysis of the various ontology matching systems. This leads to the points to various research aspects specific to the roles on ontology mediation.

A common requirement to many knowledge applications is to determine whether two or many knowledge representations, encoded using the same ontology, capture the same knowledge. The task of determining whether two or more representations encode the same knowledge is treated as a graph matching problem. The knowledge representation is encoded using conceptual graph. The representations capture the same knowledge if their corresponding graphs are matched.

Knowledge management applications need to determine whether two or more knowledge representations encode the same knowledge. Solving this matching problem is hard because representations may encode the same content but differ substantially in form. Previous approaches to this problem have used either syntactic measure or semantic knowledge to determine the distance between two representations.

One of the aims of this research work is to define matching of ontologies using directed graphs and present the mathematical aspects of matching of ontologies with fitness score as an evaluation metric. Algorithms for matching and merging of ontologies using directed graphs are developed and the theoretical aspects are discussed in detail.

An attempt is made to give a comprehensive overview of ontology operations such as ontology merging, ontology difference, and ontology matching using Ontology Abstract Machine. This research study demonstrates a new approach of ontology management using Ontology Abstract Machines. Ontology matching, Ontology merging and Ontology difference methods are illustrated using examples from a health care domain. The results obtained are encouraging and leads to further research of relating ontology and automata in a formal way.

A framework for ontology matching and merging is proposed. The framework is validated by an innovative approach for developing Ontology based Question Bank System. Although other approaches have been discussed in the literature, the approach presented in this work is based on domain Ontologies. It identifies important concepts and generates multiple choice questions about these concepts along with the distracters. Each question bank consists of sets of test items each of which consists of a question or stem. An
ontological system integrated with an educational platform can support teachers in building effective question bank system and students are tested using generated questions. To this end an ontological approach is proposed to semantically enrich question bank generation. In particular the association of semantics to the question bank system can greatly improve their organization and management, both for students and teachers. The java ontology developed in this research work is used as domain ontology for the implementation of the Ontology based Question Bank System.

Several research frameworks are proposed for the development of teaching ontologies. Ontology as a conceptual structure may work as a mind tool for effective teaching and a visual navigation interface to the learning objects. An approach to the practical ontology development is discussed in detail and presented the designed ontology for learning Java programming. The described approach can be applied for developing teaching systems where the general understanding is more important than the factual details. Further the effectiveness of the learning process with the use of java ontology is justified with an experiment conducted in a class room situation.

3.5. Summary

The problem statement of the research work is highlighted in this chapter. The research methodologies adopted to do the research work are also elaborated to provide a better understanding of this research study.