CHAPTER 3

OVERVIEW OF ARGUMENTATION FRAMEWORK
FOR KNOWLEDGE SHARING

3.1 ARGUMENTATION FOR KNOWLEDGE SHARING

In this work, we have attempted to utilize various Indian philosophical perspectives of argumentative reasoning to model the knowledge sharing scenario. The main focus is on the Indian philosophical definition of ‘tarka’ approach to pursue the process of argumentation for knowledge sharing. This is achieved by adapting the refutation recommendations of Nyāya Sastra and Nannool for deciding on the generation of counter-arguments, by utilizing a Nyāya based ontological framework. The continuous participation in argumentative discussion enables the knowledge sharing entities to discuss effectively, thereby paving way for knowledge evolution. This paves way for elimination of invalid beliefs in one’s knowledge base.

Thus, the objective of argumentation is to remove almost every inconsistency associated with the knowledge by eventually upgrading the level of knowledge of knowledge sharing entities, which will facilitate better reasoning and inferencing. In this thesis, the emphasis is on the use of arguments for persuasion where the focus is not on the result of arguments, rather on the actual process of exploration and observation used in obtaining the conclusion. Here, we explain our notion of argumentation as follows:
‘The argumentative discussion initially originates when a proponent explains his thoughts or beliefs in the form of arguments to the opponent. The knowledge shared by the proponent may be invalid or inconsistent with respect to the opponent’s common sense knowledge. Every argument proposed may have inconsistencies or invalid information, which is identified by the opponent through hole-finding (or defect-finding) mechanisms. Holes or defects are then projected to the opponent through intelligent counter-arguments, which reveals the defects (not all, but a few).

This identification of inconsistency in the shared world knowledge help the arguers build new knowledge components or drastically restructure old ones. After the refutation from the opponent, the proponent then removes the contradictions and proposes subsequent argument to the opponent. This continues until the participant(s) is convinced about the shared knowledge. This scheme of knowledge refinement and sharing through recursive cycle of proposing an argument, defect finding, and projecting a counter-argument through refutations is known as argumentative reasoning or procedural argumentation’.

The scope of argumentative discussion is decided by the amount of valid information shared between the arguers. The reason is that, when invalid information is shared through an argument proposal, the argument gets defeated instantly by the counter-arguments of other knowledgeable experts who are listening to the discussion. The validity of shared knowledge will be evaluated by measuring the components of the participants’ knowledge base after argumentative discussions. This chapter portrays an overall perspective about argumentative reasoning methodology and the special techniques utilized from Indian Logic to reason with inconsistent knowledge during knowledge sharing.
3.2 NEED FOR ADAPTING FROM INDIAN LOGIC

In traditional times, argumentative discussion was performed as a means to eradicate one’s false beliefs or to prove one’s scholarly knowledge over the subject of discussion (Radhakrishnan and Moore 1989). There is enough evidence from the history, that, Emperors who ruled India encouraged argumentative discussions or ‘tarka’ in their Durbars (Aya 2007) for knowledge sharing. The ancient school of Hinduism, originally known as ‘Gurukulam’ adapted a very similar strategy of argumentative procedures for learning.

Most Indian philosophical texts, like the Bhagavat Gita (Judge 1890), describe the essence of tarka between the proponent, the Guru, and the opponent, the disciple, by means of discourses. This system of argumentative discussion followed a series of syllogistic interactions between the arguers. By following syllogistic pattern of argumentation, the arguers were able to explain their inferences to others in a more convincing manner. Therefore, the system of interpretations of vedic literatures in Indian philosophy, provided enough motivation which inspired the idea of procedural argumentation to be carried as a separate research work.

In this work our idea of reasoning from argumentative discussion for knowledge sharing constitutes analyzing the input arguments to identify defects, which in turn leads to projecting appropriate refutations, through which the argument is attacked. Availability of suitable frameworks for knowledge sharing facilitates the storage and retrieval of knowledge during the process of argumentative reasoning. Removal of old ideas, revision/expansion of existing ones and addition of new ideas are important
aspects of the argumentation process for knowledge sharing. Thus, in essence, the knowledge used for reasoning is dynamic in nature.

In this scenario there is a special requirement to have suitable modeling techniques like ontologies, to reason with the dynamic nature of knowledge. Ontologies are appropriate for storing world knowledge which shall be used for argumentation. Ontologies are common vocabularies in which shared knowledge shall be represented (Gruber 1995). Ontological structures proposed by Nyāya Sastra (Sinha and Vidyabhusana 1930) provide enough support to store and reason with dynamically changing beliefs of world knowledge, which would suit the argumentation process.

The ontological commitment or agreement to use the ontology for argumentation is guided by the invariable concomitance relation (Wada 1990) existing between the concepts of ontology. Generally, Western Logic insists the relation existence between a concept pair (Herbert 2004). But, mere existence of concepts and relations by name, will not suit the defect analysis of procedural arguments due to the following two reasons:

• concepts possess different behavior depending on the variations in constituent qualities

• presence of relations (including all the sub-relations (Virupakshananda 1994)) play a major role in determining the type of defects.

Therefore, in this thesis, we have utilized the Indian philosophical approach of classification of world knowledge in the form of ontologies.
However, the efficiency of knowledge sharing is highly dependent on the knowledge representation formalism, which is the major issue in building the ontology. Therefore, some logic similar to description logics (DL), has to be used for effective knowledge representation from a detailed knowledge base. Moreover, in the proposed work of argumentation, it can be recalled (for more details refer chapter 1 Introduction) that defect identification is a prime factor, which decides the generation of counter-arguments. Identification of defects from arguments becomes easier when the world knowledge embedded in the submitted arguments are represented in the form of a conceptual ontology, which facilitates the interpretation and continuation of argumentation process.

Description logic formalisms for knowledge representation did not satisfy or thoroughly explain the ontological definitions of Indian philosophy (Virupakshananda 1994), and hence, some extensions to description logics was earlier attempted, in the form of extended description logics (Aghila et al 2003). Apart from general definitions of ontology (Gruber 1995), extended description logics had the flexibility in defining a concept more elaborately by allowing the declarational existence (i.e. existence by name) of additional relations between a concept and its member qualities (Aghila et al 2003).

However, there were hardly any definitions of relations both within the concept and across the concepts of ontology. To suit detailed defect identification in procedural argumentation, relations by similar names have to be treated differently by the nature of qualities or properties attached to the relation definitions. For instance, invariable concomitance relation, which exists inherently between any concept pair (Virupakshananda 1994) unveil a
new dimension in reasoning and inferencing throughout the procedure of argumentation (Baader et al 2002).

Invariableness is the property, which demands the existence of relating concepts simultaneously at any instant (Wada 1990). Therefore, in an argument, when a concept’s existence is questioned, provided one of the invariably relating concepts exists, by the presence of invariableness, it is implied that both the relating concepts simultaneously exist; and hence, a separate proof for proving the concept existence is not necessary. This relation is not available in the ontological classification which utilizes extended description logics (Aghila et al 2003). Therefore, extended description logics had to be improved in attaching properties to relation existence.

For the reasons stated above, we have adapted ideas from Indian logic to model argumentation for knowledge sharing. The following section explains in detail, the process of procedural argumentation for knowledge sharing.

3.3 INDIAN LOGIC BASED FRAMEWORK FOR ARGUMENTATION

3.3.1 Argumentation Framework for Knowledge Sharing

In the context of knowledge sharing, the entire procedure of argumentative discussion (Figure 3.1) is defined as follows: Initially, the input argument is split into concept and relation elements of arguments, which carry the essence of information depicted in the submitted argument. The elements of arguments are then analysed for presence of defects (or holes) by referring to the pre-defined defect table. The harvested defects are populated into ‘defect set’.
After the generation of ‘defect set’, the elements of arguments are mapped across the defeat table to identify the applicable defeat strategies in order to refute (or oppose) the submitted argument. The applicable defeat strategies are populated into ‘defeat set’. Final outcome of knowledge sharing is based on the ability to find and choose best defects and defeat strategies for generation of every counter-argument.

![Argumentation Framework for Knowledge Sharing](image)

**Figure 3.1 Argumentation Framework for Knowledge Sharing**

The best defect-defeat pair(s) qualifies with the following criteria: ‘With any refutation strategy recommended, the maximum relevant holes of the input argument need to be attacked at the next response, which is to be given out as counter-argument’.

Selection of best hole-defeat pair lies central to the theme of knowledge sharing through argumentation. The hole that projects the flaw in
the argument due to mismatch in relation between the given concepts under discussion, holes that tend to alter knowledge base consistency, dominant and repeated holes etc. should be given due consideration and be included in the counter-argument generated at the next response.

The efficiency of knowledge sharing process actually lies in three fundamental issues of the arguer’s ability: the ability to pick holes in stated arguments, the ability to find appropriate defect categories of holes identified, and, the ability to find methods to defeat the stated argument by attacking identified defects. Evaluation of hole-defeat pair requires careful analysis of the components of holes which contribute to generating strong and powerful refutations. These refutations have to be optimal, so that, for every move (or proposed argument), there is a definite counter-move (or counter-argument). The optimality of refutations is decided by the rewards procured after submitting the argument.

3.3.2 Classifications of Argumentation

Argumentation, by all means, is to argue and counter-argue with one another. When the proponent proposes the argument, the opponent is supposed to keep listening to the argument. At this stage, the opponent is referred to be the listener. After the proposal is over, the opponent may do reasoning over the argument proposed and shall respond to it. This becomes the basic criteria for argumentative discussions. An arguer / counter-arguer while proposing an argument is called proponent; members on the other side to whom the proponent proposes the argument are called opponents. If the opponent does some reasoning over the argument proposed and responds to the proponent with a counter-argument, then the opponent is called respondent.
In this work, we consider the essential purpose of argumentative discussion as knowledge sharing. Therefore, learning is an integral component of argumentative discussions. Learning shall both be direct, between the arguer and counter-arguer, and indirect, between the arguer and the listener. A counter-arguer initially listens to the arguer (or the proponent) and later responds with the counter-argument. Therefore, a counter-arguer does both direct as well as indirect learning during argumentative discussions.

If two parties are involved in argumentation (Figure 3.2), obviously one will be the proponent and the other will be the respondent. Argumentation is not only between two parties; any number of arguers and counter-arguers may get involved in fruitful discussion. Figure 3.3 shows the 3-party argumentation scenario. However, in a rational knowledge sharing environment, when members argue among themselves, there will be few other members who keep listening to the discussion. Figure 3.4 shows the rational knowledge sharing environment including a proponent, a respondent and a listener. More formally (Figure 3.5), the discussing entities or agents, shall put the points of argument over the discussion board to which every other member keeps listening. This transforms the entire argumentation into an e-discussion scenario, referred to as virtual communities.

Figure 3.2 Two-Party Argumentation
3.3.3 Design of Arguer / Counter-Arguer

Every entity involved in argumentation is supposed to have a knowledge base which is seen as a collection of concepts and relations, as in DL systems. The concept definitions form the T-box or Terminological box,
and Instance definitions form the A-box or Assertions box, of the respective knowledge base (Alex et al 1989). The terms ABox and TBox are used to describe two different types of statements in ontologies.

TBox statements describe a system in terms of controlled vocabularies, for example, a set of classes and properties. ABox are TBox-compliant statements about that vocabulary. TBox statements tend to be more definitional in nature such as a dictionary of words. TBox statements are sometimes associated with object-oriented classes and ABox statements associated with instances of those classes (Alex et al 1989). Together ABox and TBox statements make up a knowledge base.

In addition, every entity (Figure 3.6) performs three major functions: knowledge representation, querying and reasoning, and discussion.

- Knowledge representation and querying is the primitive functionality that can be performed with a knowledge base. This shall be utilized for proposing / analyzing arguments over discussions. Various schemes for knowledge representation exist, like concept-relation definition language, concept-relation manipulation language and querying language (Mahalakshmi and Geetha 2008a).

- Reasoning involves not only the most recommended reasoning services like, concept satisfiability, subsumption, consistency and instance checking, but also the enhanced reasoning services required for productive knowledge sharing.

- Discussion deals with the role management of the participating entity, as proponent, respondent or observant (listener). Apart
from role management, discussion services also include listening to the message board or discussion board, communication components, and, tracking and evaluation of argumentative discussions.

The mechanism of tracking the argumentation and evaluating the arguments during argumentative discussion form the unique and major contribution of our work. In addition, we have designed a special architecture for defining and representing the knowledge units which are to be utilized for argumentation. The architecture follows Nyāya-Vaiśesika’s strict classification hierarchy. Built over this is the argument representation logic, which also takes inspirations from Tarka Sastra (Virupakshananda 1994).

Figure 3.6 Design of an Arguer / Counter-Arguer

Moreover, additional reasoning services are introduced from a special perspective to suit Indian philosophical methodology of argumentative discussion. These reasoning services include defect identification from the
proposed arguments, and recommendation of suitable refutation mechanisms for generation of counter-arguments. Defects are flaws present in parts of argument. By identifying and targeting at the accurate flaws present in the submitted argument, mistakes in the argument can be corrected at the next proposal, thus providing increase in the amount of valid knowledge shared between the arguers involved in rational discussion.

To enable appropriate defect identification, we have utilized the definitions of defects (or fallacies) and definitions of defeat techniques recommended by Indian philosophy (Virupakshananda 1994; Saaminatha Iyer 1995). However, we recognized the need to categorise the defects as concept-originating or relation-originating, in order to analyse the impact of defects over the submitted argument. The reason is that, we visualize an argument as a combination of concepts and relations with internal definitional variations. The standard defect definitions thus obtained are populated into defect table.

Defeats are methodologies with which the proposed argument is refuted. Indian philosophy states various methodologies of defeat. However, we formulated further classifications of defeat techniques with respect to their motive of defeat as: attack, introduce, expand, change, or repeat, and further as concept-based defeat strategies or relation-based defeat strategies. The standard defeat strategy definitions thus obtained are populated into defeat table. These definitions of defect and defeat guide us through the procedure of argumentation.

In our work, the systematic and recursive pattern of argument – counter-argument generation in an alternate repetitions between the proponent and opponent (or respondent) is referred to as argument gaming. In argument gaming, the proponent and respondent strictly take turns by making moves.
The proponent puts forward an argument designed to incur the commitment of the respondent to the conclusion. The respondent can make objections in the form of counter-argument. The argument and its reply have to be evaluated as a pair of moves, thereby allowing new evidence to come in at a later stage of argument scenario. The following section describes the mathematical model of argument gaming for knowledge sharing.

### 3.4 THE MODEL OF ARGUMENT GAMING

The purpose of argument gaming is generally twofold: (a) to resolve contradictions (b) to attain a mutual consensus. While arguing against an argument, the counter-argument(s) may include knowledge, information, explanations; preferring one counter-argument may depend on the rewards obtained for the discussion upto that point of argument exchange. Thus, the choice of preference over counter-arguments cannot be pre-determined and hence, after every input argument, the system is non-deterministic in deciding upon the output counter-arguments.

In addition, the knowledge base or belief base about world knowledge is native to every arguing entity. Every entity may have different beliefs about their environment (or world) and therefore, they have difference in their respective knowledge base. This difference in knowledge base induces more (or less) defects. Therefore, counter-arguments in response to a particular argument submitted by various arguing entities (or arguing agents) at their output also vary by default. This is the reason behind the rationality of arguments that are exchanged during knowledge sharing.

Every proponent entity gets to know the opinion of opponent entity only through it’s (the opponent’s) counter-argument. Moreover, the opinion
expressed through the counter-argument is only a representation of all the doubts raised during the inference of proponent’s argument at the opponent’s knowledge base. We refer to this situation as partially observable, because only partial knowledge of the state of environment is being explored by any argument gaming agent. The exact inferences made by the opponent from the environment are not clear. By attempting to guess at the opponent’s observations, every knowledge-sharing entity attempts to guide the discussion without any deviation, in a more focused manner thus aiming to reach a definite conclusion.

Three important functions in argument gaming are: observation, refutation and reward assignment. The theory behind each of these is discussed below.

3.4.1 Theory of Observation

The observation in knowledge sharing is twofold: prior to the generation of counter-argument and after the generation of counter-argument. Prior to generating a counter-argument, every arguing entity performs a prediction of expected oppositions from the opponent thereby guessing at the opponent’s knowledge base. The maximum benefit from every prediction (of opposition) is analysed and that particular counter-argument which is expected to generate more prominent doubts in the opponent is chosen and is proposed. This is called anticipatory probability.

After generating the counter-argument, every arguing entity waits and listens to the inferences made at the opponent. At the same time, the opponent entity attempts at finding appropriate defects from the counter-argument proposed by the proponent. This is called actual probability or
observation probability. The difference obtained in the anticipated observation with that of the corresponding actual observation, tells how close the proponent is able to predict the opponent’s flow of arguments during discussion.

Partial observability is a salient feature of argument gaming because, in reality, except the abstract fundamental world knowledge, other higher-level domain knowledge tends to vary between the knowledge sharing gaming entities thereby injecting the degree of uncertainty in knowledge sharing.

3.4.2 Theory of Refutation

After determining hole set and defeat set the gaming entity is now supplied with a pool of counter-arguments out of which the optimal counter-argument has to be selected. The constraint here is such that, the recommended counter-argument should cover the best defect-defeat pair that will help to construct the effective opposition. This is done by the process of refutation. The optimal policy returns the defeat strategy that maximizes the utility. The gaming entity simultaneously constructs all counter-arguments under the optimal refutation policy. In a scenario, where more than one counter-argument possessing equal strength factor are recommended, the counter-arguments are selected in a random manner. The projection of counter-argument receives an immediate reward and an observation.
3.4.3 Theory of Reward Assignment

The objective for every arguing entity is to maximize the expected sum of rewards it receives. The reward is a direct measure of quantity and nature of holes or defects obtained for every argument exchange. Through this, the knowledge sharing system is expected to evolve in learning the right knowledge by discussion. The result of argument status after every refutation, i.e. whether the argument is defeated, or undefeated, does not count much for calculation of rewards. The reason is that, the main objective is only to provide a forum for exchange of opinions and clarification of perspectives. The evaluation of actions made by the gaming entity and the non-monotonic nature of knowledge obtained is cascaded implicitly in the knowledge base. This helps to improve the gaming entity’s ability to behave more optimally in future.

3.5 ARGUMENT GAMING AS KNOWLEDGE SHARING

On the whole, the knowledge sharing entity interprets the input argument, derives inferences from its very own knowledgebase and puts forth the inferences in the form of respective counter-argument. If we model the entire setting as a teaching-learning scenario, the above criterion amounts to raising questions that covers the best possible doubts of the teacher’s statements. Therefore, for an input argument of the proponent, the opponent generates an immediate counter-argument after considerable effort on reasoning over arguments.

Arguments and counter-arguments along with the intermediate inferences thus generated are updated into the knowledge base. This argument/counter-argument exchange is performed in a recursive fashion,
which simulates a discussion environment. While this kind of exchange of arguments is a continuous process where valid knowledge is shared among the rational arguers, there should be some conclusion that needs to be attained in finite steps. Therefore, we assume that if there is no counter-argument generated as response, the rational discussion comes to a halt.

The discussion of procedural argumentation based on Indian philosophy theoretically satisfies the inference from the represented argument by a unique kind of interpretation, which is specific to Indian philosophy (and, which is absent in other argument reasoning strategies based on western philosophical perspectives). In addition, knowledge sharing is also efficient because adequate knowledge, utilized for reasoning and inferencing, is captured during the initial stages of classification and representation.

For implementation purposes, the arguers can be modeled as knowledge-sharing agents discussing about any given domain where argument gaming is used for spontaneous knowledge sharing in resolving knowledge inconsistencies. The scheme of argumentative discussion continues until a definite conclusion is reached. At the end of discussion, the discussing agents would have elaborated the seed knowledge by automatically performing some amount of procedural reasoning.

A running example with two agents discussing about the inference of fire from the occurrence of smoke over the mountain, continues through every chapter of the thesis, mentioning the step-by-step process of argumentative reasoning for knowledge sharing. The same is extended to nine agents transforming it into a group discussion. In the group, few agents guess a distant object to be a ‘snake’ for which others argue it to be a ‘rope’. In
another scenario, navigation robots explore a military region and discuss about tankers and missiles as they march towards the enemy target.

The following chapter discusses the unique approach called Nyāya logics to represent the arguments which could later be used by a partially observable non-deterministic argument gaming model for knowledge sharing. As discussed earlier, the argument representation also embeds the underlying world knowledge which needs to be interpreted using special knowledge representation formalism. Therefore, the classification of world knowledge according to Nyāya Sastra and the NORM model for ontology representation is also discussed along with Nyāya logics. In a nutshell, the approach discussed in this work, handles classified world knowledge by syllogistic interactions as per Indian philosophy (Radhakrishnan and Moore 1989). The school of reasoning, Nyāya, concerns with the nature of inferential reasoning and constructed a system of rules for conducting debates.

To model the advanced reasoning and refutation mechanisms of Indian philosophy, we propose ‘Nyāya logics’, for expressing world knowledge through procedural arguments. Here, we consider every argument as a collective representation of concept and relation elements, proposed as NORM - Nyāya Ontology Reference Model, which follows the Nyāya-Vaiśesika system of world knowledge categorisation. In the next chapter, we first explain the Indian philosophical foundations for procedural argumentation and later, propose the knowledge representation formalism, ‘Nyāya logics’.