CHAPTER 3

NYAYA SHASTRA

3.1 INTRODUCTION

As history shows Science and Philosophy have always learned from each other; every major scientific discovery is a step forward in the development of the philosophical world-view and methodology and vice versa (Nigel 1999). The evolution of a knowledge representation system based on philosophy is a good basis for representing and reasoning with world knowledge to build a representation framework. The framework developed should provide sufficient common ground for various applications like Natural language understanding and generation, Machine translation etc. Moreover, the representation of knowledge for computational modeling requires a set of entities, relations between them and inferencing about the classified entities (Keshab 1991). All the processes and events may be based on philosophical work or may be intuitive in nature. This chapter discusses both Indian and Western philosophies in general. In addition, it also deals in detail with Nyaya shastra, its reasoning mechanisms and the essence of knowledge that has been adopted from Nyaya shastra for the development of the knowledge representation framework discussed in this thesis.
3.2 PHILOSOPHY

Philosophy as a discipline, thought about the fundamental nature of the world, the grounds for human knowledge, and the evaluation of human conduct and its chief branches which include logic, metaphysics, epistemology, and ethics (Nigel 1999). From a sense of wonderment about life and the world, it often involves a keen interest in major questions about man, his experience, and his place in the universe as a whole. Emerging as a central feature of Western culture, philosophy is a tradition of thinking and debating about particular issues from divergent view points. Thus, philosophy must be regarded both as content and as activity (Bryan Magee 2000). It considers alternative views of what is real and the development of reasons for accepting them. It offers the chance to create and adopt significant beliefs about life and the world, but requires the ability to perform critical thinking. From the AI perspective, philosophy provides a framework to form top-level categories in which lower-level categories may be placed. The following section discusses briefly western philosophy and various philosophers' views about the classification of entities.

3.2.1 Western Philosophy - Greek Philosophy

The ancient Greeks, with their active and tumultuous social life, provided ample opportunities for the expression of philosophical thinking of three sorts:

- Speculative thinking expresses human curiosity about the world, striving to understand in natural (rather than super-natural) terms
how things really are, what they are made of, and how they function.

- Practical thinking emphasizes the desire to guide conduct by comprehending the nature of life and the place of human beings and human behavior in the greater scheme of reality.

- Critical thinking (the hallmark of philosophy itself) involves a careful examination of the foundations upon which thinking of any sort must rely, trying to achieve an effective method for assessing the reliability of positions adopted on significant issues.

Beginning with clear examples of thinking of the first two sorts, a gradual emergence of inclinations toward the third was examined. Ontological categories inevitably play major role in representing the knowledge. Philosophers right from Plato, Aristotle, Kant, Peirce, Husserl, Whitehead to Heidegger contributed greatly to this research by providing the ontological categorization.

**Plato’s criterion:** Plato realized and adopted, the distinction between the ever-changing flow of all things, and the intangible things that determine the flow. Therefore, he proposed the intangible, unchanging mathematical forms or ideas as true reality, which is reflected in the changeable, illusory flow of physical things.

**Aristotle’s categories:** Aristotle reversed the emphasis of Plato’s distinction, when he considered the physical world to be the ultimate reality and treated the forms as abstractions derived from sensory experience. Substance,
Quality, Quantity, Relation, Activity, Passivity, Having, Situatedness, Spatiality and Temporality are his ten basic categories.

**Kant’s Categories:** Immanuel Kant devised his categories starting with the logically possible ways of combining relationships in a proposition and organised his table of categories in four groups of three each: *Quantity* (Unity, Plurality, Totality), *Quality* (Reality, Negation, Limitation), *Relation* (Inherence, Causality, Community), *Modality* (Possibility, Existence, Necessity). Kant suggested for each of the four categories, a different act of understanding for combining the first two concepts, to produce the third concept.

**Peirce’s Categories:** After extensive analysis of Kant’s categories, Peirce concluded Firstness, Secondness and Thirdness as three more categories which had resulted from the abstraction of Kant’s work. Peirce’s principle is a metalevel distinction for generating new categories by viewing entities from different perspectives. A category of Firstness is determined by qualities inherent in something, Secondness by a relation or reaction directed toward something else, and Thirdness by some mediation that brings multiple entities into relationship.

**Husserl’s Categories:** Like Peirce, Edmund Husserl, a mathematician who turned to philosophy, brought intentionality to the forefront of ontology. Husserl developed a ‘logic of ideal content’ which contains the meaning and expression, genus and species, parts and wholes, the role of grammar in combining meanings, intentional experiences and their contents, and the knowledge, in terms of meaning intention and meaning fulfillment. This logic of ideal content is primarily central to knowledge representation in Artificial Intelligence and natural language semantics.
**WhiteHead’s Categories:** Whitehead defined categories for actual entities, prehensions and nexus which make up a triad of physical Firstness, Secondness and Thirdness. According to Whitehead, an actual entity can exist by itself. A prehension is a directed relation or reaction between two entities. A nexus is a bundle of two or more prehensions. Apart from the three physical categories, Whitehead classified the abstractions in the categories of eternal objects, propositions, and subjective forms, which constitute a triad of abstract Firstness, Secondness, and Thirdness. A Circle, for example, is an abstraction that can be realized or instantiated in a particular physical object, such as moon or a lilly pad. Whitehead’s other two categories are principles for generating new categories: multiplicities and contrasts.

The central focus of these philosopher’s categories emphasizes the classification of the physical or conceptual entities, which may be a base to the development of an ontology. Based on these ontological categories many knowledge representation systems have been evolved. Doug Leant (Sowa 2000) and his colleagues have been developing the CYC system whose ultimate goal is to accommodate all human knowledge and is based on Greek philosophy, which distinguishes between tangible and intangible objects. The philosophy behind the work, described in this thesis is based on an Indian philosophy, Nyaya shastra.

### 3.2.2 Indian Philosophies

Indian philosophy generally aims at liberation, freedom from deluded views, mental illusions and fuddled thinking. It is a deep spiritual therapy. From the earliest times, debate and verbal combat have been an integral part of Indian
philosophical life. Many have the mistaken belief that all Indian Philosophy is concerned with religious questions, especially theological ones about the nature of God. This is not so. Indian Philosophical schools include a sharply sceptical, atheistic and generally materialistic tradition, an Atomist tradition, a viewpoint centrally concerned with questions of logic, and the interpretation of texts. Nonetheless, Indian Philosophical tradition has generally committed itself to the view that the aim of philosophy is liberation (Moksha). Philosophy, in other words is, not merely an intellectual discipline pursued for its own sake: it is a discipline pursued so as to free the mind from bondage to unsound concepts, false and deluded beliefs, and deceptive maps of reality (Richard King 1999).

Indian religious thought has expressed itself in a number of philosophies. From the point of view of Hindu theology, a study of the philosophies can be traced back to 800 B.C. or even earlier. Indian philosophy has its rationalistic literature, a literature that deals with mathematics, astronomy, grammar, semantics and logic. The main systems of Indian philosophy are: Samkhya, Yoga, Purva Mimamsa, Vedanta, Nyaya, and Vaiseshika.

3.2.2.1 Samkhya and Yoga

Kapila, who probably lived in the seventh century B.C, founded the Samkhya School. The system can be regarded as dualistic, since it recognizes two basic categories in the universe - the purusha and the prakriti. The Purusha consists of selves or spirits, eternal entities of consciousness. The prakriti represents the potentiality of nature, the basis of all objective existence. It does not consist of matter alone and includes all resources of nature, material and
physical. The Prakriti is thus the fundamental substance out of which, the Samkhya claims, the world evolved. Samkhya believes very strongly in the principle of causation and in fact uses this to show the necessity of assuming the eternal existence of prakriti, for something cannot come out of nothing. Another important Samkhya contribution to Hindu thought is the doctrine of triguna, the three qualities of nature. The three qualities are sattva (light, purity, harmonious existence), rajas (energy, passion), and tamas (inertia, darkness). These three conflicting aspects of prakriti play different roles in its evolution. Bondage, according to this philosophy, is due to ignorance, and emancipation comes through knowledge.

The philosophical basis of the Yoga is the same as that of the Samkhya, except that a personal God is introduced into the system. God controls the process of evolution and is, as one might expect, omniscient and omnipotent. Periodically God dissolves the cosmos and then initiates the process of evolution again. The Yoga of Sage Patanjali set forth the process of psychological discipline by which one could attain this release from the misery of mundane experience and transmigration and all emphasized knowledge of one kind or another. In practice, the Yoga system of discipline consists of exercises of the mind and the body, including the very difficult exercise of not exercising them at all. In addition to making anyone healthier in mind and body in this world, these exercises are supposed to facilitate emancipation.

3.2.2 Purva-Mimamsa and Vedanta

The main text of Purva-Mimamsa is the Purva-Mimamsa Sutra by Jaimini (400 B.C.). It is a scholastic piece of work and confines itself almost
entirely to the interpretation of the Vedas. This school of philosophy is interested mainly in inquiring into the nature of dharma (right action), and since it accepts the Vedas to be both infallible and the sole authority of dharma, one can call it a fairly orthodox school. Its interest is more practical than speculative and its importance is less as a school of philosophy than as a useful system of interpreting the Vedas. On the other hand, Vedanta, a spring from the Upanishads and its central thesis, is the Upanishadic doctrine of the Bhraman. Its founder was Badarayana, whose Brahma Sutra (also called the Uttar-MimAmsA) makes up, along with the Upanishads and the Bhagavad-Gita, the foundation of the Vedanta System.

3.2.2.3 Nyaya and Vaiseshika

The Nyaya primarily deals with logical methods and the Vaiseshika uses analytical methods to study the nature of the world. Nyaya and Vaiseshika accept and apply each other's methodology in understanding the atomistic constitution of the world. The Nyaya recognizes four sources of knowledge: perception (pratyaksha), inference (anumana), analogy (upamana), and credible testimony (sabda). The Nyaya School accepts the principle of causation. In addition, considerable attention is paid to problems arising from noncausal antecedents and plurality of causes. Gautama, who lived in the third century B.C was the most important exponent of the Nyaya. His Nyaya Sutra is the first systematic exposition of its approach. Gangesa of Mithila was the founder of the Modern Nyaya School (about 1200 A.D.) His Tattva cintAmani is the standard text for the Modern Nyaya school of thought. Gangesa tried to build a more rigorous structure for the discipline to describe the external world. There were various critics of the Nyaya school, and the critics more often used the
methods of reasoning of the Nyaya school to dispute the claims. This really illustrates the importance of this school in Indian philosophical history.

The Vaiseshika is more interested in cosmology. All material objects, it claims, are made of four kinds of atoms. Different combinations of these atoms of earth, water, fire, and air make different materials. Additionally, five subtle substances: space, time, ether (AkAsa), mind, and soul were included. It accepts a personal God who created the world, but not out of nothing. The nine substances (four material and five subtle) existed before the world was formed; He fashioned them into an ordered universe. God is thus the creator of the world, but not of its constituents. Therefore, the philosophy of the Vaiseshika, while not atheistic, is different from that of most schools of traditional Hindu theology. The first notable theologian was Kanada (third century B.C.), whose Vaiseshika Sutra occupies the same place as the Nyaya Sutra in the Nyaya school. The evolutions of the two systems have, throughout history, been very closely linked with each other. Together they represent the relatively analytical branch of the early Hindu philosophical thoughts.

Indian philosophy is extensive, rich, and complex. Scholars analyze not only its significance and its insights, but also its classical teachings about knowledge and language. Most of the classical Indian schools present veritable worldviews—comprehensive philosophies formed by interlocking positions of the main branches of philosophy (metaphysics, epistemology, and ethics). In some schools of classical Indian philosophy, such as Nyaya (Logic), neither religion nor mysticism is central. Rather, the questions of how human beings know what they know—and how they can mean what they say—are given priority.
According to the Nyaya theory, the world is more or less as it is perceived. However, the defects in the sense organs like improper or partial perception of something and the influence of fear, anticipation and other mental conditions lead to inappropriate and defective perception of the same. Nyaya regards that clear perception, in general, is a sound means of cognition, which discloses things to us as they really are.

The following section describes the Nyaya school of thought, which is the basis of this thesis, in detail.

3.3 NYAYA - THE PHILOSOPHY OF LOGIC AND REASONING

Nyaya philosophy is primarily concerned with the conditions of correct knowledge and the means of receiving this knowledge. Nyaya is predominantly based on reasoning and logic and therefore is also known as Nyaya Vidya or Tarka Sastra -- 'the science of logic and reasoning'. Because this system analyzes nature and source of knowledge, its validity and non-validity, it is also referred to as anviksiki, which means 'the science of critical study'. Using systematic reasoning, this school of philosophy attempts to discriminate valid knowledge from invalid knowledge.

This philosophy asserts that obtaining valid knowledge of the external world and its relationship with the mind and self is the only way to attain liberation. If one masters the logical techniques of reasoning and constantly applies them in daily life, the person will rid himself of all suffering. Thus, the methods and conditions of determining true knowledge are not the final goal of Nyaya philosophy; logical criticism is viewed only as an instrument that
enables one to discriminate valid knowledge from invalid knowledge. The ultimate goal of Nyaya philosophy, like that of the other systems of Indian philosophy, is liberation -- the absolute cessation of pain and suffering.

According to Nyaya shastra, this liberation can be attained by direct perception or knowledge of ultimate realities of Self and the universe. These ultimate realities include categories (padartha), which are termed as dravya (substance), guna (qualities), karma (action or motion), samanya (genus), vishesah (species), samavaya (relation), and abhava (negation).

Out of these, substance (dravya) is a basic and independent category. Other categories are dependent on this basic substance. Substance, in turn, consists of nine objects: The Self, Manas or mind, Earth, Water, Air, Fire, Ether, Space and Time. Self is the substratum of consciousness. Manas, when it comes in contact with Self, is birth, and when detached from it, is death. Man or individual self is jivatman, and is distinct from paramatman or Supreme Self. Cause and effect cycle creates new world in each cycle. All these categories deal with the means to understand the universe.

3.3.1 The Nature of Physical World

The Nyaya system groups all the objects of the world into twelve major categories: soul, body, senses, objects of the senses, cognition (buddhi), mind (manas), activity, mental modifications, rebirth, feelings, suffering, and absolute freedom from all sufferings. Not all these objects of knowledge are found in the physical world because the physical world is composed only of the four gross elements — earth, water, air and fire. Although the soul and the mind
are involved in the physical world, they are not physical elements. Likewise, time and space are completely nonmaterial, but they nonetheless belong to the physical world. Ether and time and space are also eternal and infinite substances, each being one single whole.

3.3.2 Knowledge

According to Nyaya, perception, inference, identification and verbal knowledge are four types of valid knowledge. A special instrument for their production such as the perceptual instrument, the inferential instrument, the identifying instrument and the verbal instrument distinguishes each of them. Out of these four, Nyaya is chiefly concerned with the inferential process in the task of inferring for oneself and others. Inferring for oneself consists of the three-stage process namely knowledge of pervasion, operative knowledge and knowledge of inference. Knowledge of pervasion is the instrumental cause of inference.

3.3.3 Components of Nyaya

Nyaya specifies its terms and relations largely by four means: *qualifiers, abstract properties, describer-described pairs* and *limitors*. Among them qualifier is known as a distinguisher since this determinate knowledge distinguishes one object from another. A natural application of the term 'qualificand' is to refer to what is expressed by the subject of the sentence. The use of terms qualificand and qualifier is most frequent where the entities expressed respectively by subject and predicate are connected by a relation other than contact or inherence.
According to Nyaya, determinate knowledge is a knowledge, the object of which is distinguished from other things. For example, a bucket may be before my eyes, but until I differentiate it from stick, ground, mat, dog and cat, the knowledge of it will remain indeterminate. To differentiate or determine the bucket, beyond the indeterminate knowledge of bucket, one must have at least two other knowledges: an indeterminate knowledge of a differentiating factor (in this case, the bucketness, the generic character common to all buckets) and a knowledge that this thing in front of my eyes is distinguished by this differentiating factor. Accordingly, determinate knowledge is defined as knowledge pertaining to the relation between a qualificand and a qualifier.

Everything that has a determinate knowledge is set off from other objects by some sort of distinguisher, known as qualifier. A qualificand can have many qualifiers. But every qualificand must have at least one qualifier. These qualifiers are always either generic characters or imposed properties. The difference between generic character and imposed property is based partly on the extent to which they distinguish the qualificand from other entities. The difference is important since the relation into which a generic character is traditionally said to enter, differs from the relation entered into, by an imposed property. A qualifier is an imposed property, if it is compound. Compound imposed property means, the character by which the product of two classes is recognized. An example is beastness, since beast is defined as that which has hair and tail. The parts of beastness are hairyness and tailedness.

The most distinctive and perhaps the most important technical terms in Nyaya are *limited* and *limitor*. The basic use of the word *limited* is in connection with relational abstracts where other entities are said to be qualified
by a qualifier; a relational abstract is said to be limited by a limitor. A relational abstract residing in an entity may always be limited by the specific relation in which that entity, as a locus of the said abstract, occurs.

3.3.4 Types of Absence

Nyaya divides absences into two main types—mutual absences and relational absences. Mutual absences are denials of identity. An example of a mutual absence is fire possesses mutual absence of water. Relational absences are denials of relations other than those of identity. Relational absences are said to be of three sorts: prior absence, posterior absence and constant absence. Prior absence signifies the absence of a thing somewhere, before it is created. On the other hand posterior absence is the absence of a thing somewhere, after it has been destroyed. Constant absence signifies the absence of a thing somewhere, when this absence is not limited to a portion of time. The Nyaya does not make a distinction between negating a term and negating a statement or formula. For it all absences are single terms, and they can all be expressed by single compound words.

An absence is limited in two ways. The first is by its own limitors and the relation in which the absence stands. These are the limitors, which distinguish an absence from everything, which is not an absence. But to distinguish one absence from another, a different system of limitation is necessary. Obviously that which distinguishes one absence from another is the difference in that which is negated. Accordingly, the second way in which an absence is limited is by the limitors of the counterpositive to it.
3.3.5 Concept of Negation

The problem of negation gives a definite shape to the system of thought. The problem of negation is connected with the change in the universe. The problem of change is a metaphysical change. The Nyaya school of thought holds that before the creation of an effect, an effect does not exist in its cause and that it is a new beginning. The doctrine of the new beginning of an effect, pre-supposes pre-nonexistence of the effect in its cause. Similarly when an object passes away it does not return to its inherent cause. It leaves a negative counterpart behind it. It is called post negation of an object.

Thus Nyaya basically recognizes two types of negation: absence and difference. Most peculiar features of Nyaya emerge in connection with its interpretation of negation of properties. Sentential negation is usually avoided. A negation is constructed as a term-negation. Here the absence of a property is treated as another property. For example, 'The pot is not blue' is first rephrased, as 'the pot does not have the blue color' which is further rephrased as 'the pot has the absence of blue color'. In the technique of Nyaya, negation or absence plays a very important role. Almost all the definitions and elaborate treatment of facts and ideas are put forward with the help of the absence.

3.3.6 Relation handling of Nyaya

The most important and one of the most debated issues in Nyaya terminology is the problem of relation, which is the nucleus of all the major epistemological and ontological problems of philosophy. There can be a large number of relations possible between two entities and they can be classified
into occurrence-exacting and non occurrence-exacting relation. An occurrence-exacting relation would be one where one of the relata may be said to occur in or on the other, whereas non occurrence-exacting relation is possible where one is not related to the other through ‘in or on’ relationship.

From another perspective, Nyaya differentiates relations into direct and indirect relations. Contact, inherence and particular qualification are direct relations and an indirect relation is one where ‘a’ is related to ‘c’ through ‘b’. Here the relation is said to subsist only between two terms, a and c. Here b is not a term of the indirect relation, but is a term of two different direct relations which go to make up the indirect relation.

3.3.6.1 Types of relations

The number of possible relations between entities is greater than the number of entities, but there are certain types of relation that cover a great number of cases.

Contact (C) (samyoga)

Contact is a direct relation and inhere in substances in pairs rather than in single individuals. Contact is an occurrence-exacting relation of incomplete occurrence.

Inherence (H) (samavaya)

Inherence is an occurrence-exacting relation between entities. It is a relation of complete occurrence. Generic characters inhere in substances,
qualities and actions. Actions and qualities inhere in substances. Substances inhere in their parts.

**Particular Qualification Relation (P) (svarupa-sambandha)**

Particular Qualification Relation is an occurrence-exacting relation of complete occurrence and generally described as when x resides by P in y, x qualifies y. Two types of peculiar relation are especially important in Nyaya i) the positive relation between an imposed property or relational abstract and its locus; and ii) the negative relation between an absence and its locus.

Thus Nyaya shastra deals with various types of relations between entities and Punita Sharma in her work classified them (Punitha 1998). It defines a hierarchical classification of relations. This hierarchy of relations gives a holistic view of expressing relations and deduction based on these relations. The fundamental aspects of Nyaya thus redefine entity and provide a new interpretation to relational linkages. Thus Nyaya always tries to push further back, to explain the relations of the things themselves.

**3.4 NYAYA/ TARKA CLASSIFICATION OF ENTITIES**

The metaphysical basis of Navya-nyaya is thoroughly realistic, yet its logic is a formal logic showing an unusual power of abstraction (Ingalls 1987). Its realism is seen in its dissatisfaction with the mere analysis of words. It deals rather with 'knowledge' which when valid is said to represent facts as they actually are. Nyaya does not distinguish names from descriptions; it distinguishes the entities that describe, from the entities described. One part of Nyaya theory is Tarka Samgraha, generally known as Tarka (Virupa 1994).
Tarka means compendious elucidation of the nature of the seven ontological categories beginning with substance for the purpose of easy comprehension of knowledge. Category is a thing corresponding to name. The general definition of categories is an object named or denoted by the corresponding word. Substance, quality, action, generality, particularity, inherence and negation are the seven categories. Of the seven categories, the substances are only nine viz, earth, water, light, air, ether, time, space, soul and mind.

Color, taste, odour, touch, number, magnitude, separateness, conjunction, disjunction, remoteness, proximity, weight, fluidity, viscidity, sound, intellect, pleasure, pain, desire, aversion, volition, merit, demerit and tendency are the twenty-four qualities.

Action is of five kinds: upward motion, downward motion, contraction, expansion and motion from one place to another. The more comprehensive and less comprehensive are the two kinds of generality. Antecedent negation, destructive negation, absolute negation and mutual negation are the four types of negation.

Since, it would be impossible to give an account of a complete system of Nyaya/Tarka shastra, the following section describes the basics, adapted from Nyaya/Tarka shastra for the work described in this thesis.

3.5 CONCEPTUALIZATIONS ADAPTED FROM NYAYA

Nyaya specifies a clear-cut classification scheme of world knowledge that enables it to be used as the basis of a conceptual ontology (Punitha 1998) (Aghila et al 2001a). The work described in this thesis, uses Nyaya's world
knowledge classification framework for the design of an ontology for knowledge representation. A new three-dimensional model concept-quality-value has been designed, for the entities of the ontology. This allows finer distinctions in the classification paradigm. In other words, quality has been introduced as an inherent part in the definition of an entity. Qualities have been further classified into mandatory and optional and this classification is allowed to change across levels of ontology. The entities being derived from the higher-level entities, inherit the qualities and values. In the case of multiple parents in the hierarchy, the model should provide constraints on whether to derive the qualities or not. In many cases, the presence or absence of qualities decides the classification fit of the entity. To accomplish this, conventional and scoping operators have been defined for qualities and their associated values. In addition to the definitional change explained above, Nyaya introduces a number of additional generic abstract relations, between concepts, and also between concepts and qualities. This addition of new relations increases the expressiveness of the ontology (Aghila et al 2001a). This ontology dictated by Nyaya, has been adapted for classifying and interpreting the knowledge of the knowledge representation system described in this work.

### 3.5.1 Basic components of Nyaya ontology

Table 3.1 depicts the higher level concepts defined by Nyaya and the associated qualities of each concept.
Table 3.1 Higher level Concepts defined by Nyaya

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Concepts</th>
<th>Qualities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>EARTH</td>
<td>Color, taste, odour, touch, number, dimension, distinctness, conjunction, disjunction, remoteness, heaviness, fluidity, impression</td>
</tr>
<tr>
<td>2.</td>
<td>WATER</td>
<td>color, taste, odour, touch, number, dimension, distinctness, conjunction, disjunction, remoteness, heaviness, fluidity, impression, viscidity</td>
</tr>
<tr>
<td>3.</td>
<td>LIGHT</td>
<td>color, touch, number, dimension, distinctness, conjunction, disjunction, remoteness, fluidity, impression</td>
</tr>
<tr>
<td>4.</td>
<td>AIR</td>
<td>touch, number, dimension, distinctness, conjunction, disjunction, remoteness, impression</td>
</tr>
<tr>
<td>5.</td>
<td>AKASA</td>
<td>number, dimension, distinctness, conjunction, disjunction, sound</td>
</tr>
<tr>
<td>6.</td>
<td>DIRECTION</td>
<td>number, dimension, distinctness, conjunction, disjunction</td>
</tr>
<tr>
<td>7.</td>
<td>TIME</td>
<td>number, dimension, distinctness, conjunction, disjunction</td>
</tr>
<tr>
<td>8.</td>
<td>SOUL</td>
<td>number, dimension, distinctness, conjunction, disjunction, cognition, pleasure, pain, desire, aversion, volition, merit, demerit, impression</td>
</tr>
<tr>
<td>9.</td>
<td>MIND</td>
<td>number, dimension, distinctness, conjunction, disjunction, remoteness, impression</td>
</tr>
</tbody>
</table>

As discussed earlier, Nyaya also defines a large number of generic relations between abstract concepts that make it a good basis for conceptual ontology. Further Nyaya defines quantification using a combination of abstract qualities defined at the upper level and different types of time dependent
negations. The concept qualities may have a value or a set of values associated with them. The sample sets of values for the qualities are:

- **Color** — Violet, indigo, blue, green, yellow, orange, red; taste — Sweet, acidic; saline, pungent, astringent, bitter. Values may default, or change under restrictions.

### 3.5.2 Nyaya’s Relations

Most knowledge representation schemes have relations such as ‘is-a’ which is a generalization relation and ‘has’ which is part-whole relation (Russel and Norvig 1995). As dictated by Nyaya, the relations can exist both between concepts and between concepts and its member qualities (Punitha 1998). Certain relations are said to exist only between concepts; or only between concept and its qualities; some have both the perspectives. According to Nyaya quality is an inherent property of a concept, hence the ‘Inherence’ relation that can exist only between concept and its associated qualities. This is one of the most fundamental relations of Nyaya theory. Relations such as, ‘part-whole’, ‘generality’, ‘contact-action’, ‘contact-contact’, ‘pervade’ and ‘use’, exist only at the conceptual level, while there are other relations such as ‘Absence-temporal’, ‘Presence-temporal’, ‘Cause-effect’, ‘Limit’, ‘Determinant’, ‘Qualify’, ‘Absence-environment’ which exist mostly at the lower levels of the hierarchy. It is at these lower levels in the hierarchy that domain dependant entities and relationships are defined.

The relation between two entities is divided into two main classes, viz., occurrence-exacting and non occurrence-exacting. Occurrence-exacting is
one in which two entities related to one another co-occur in a physical sense while non-occurrence relation is one in which the two entities are related conceptually. Occurrence-exacting relations can be primary or secondary. Each entity can be related to another by causation of action or by contact. The entity, which has subcategories of quality, can inherently be present in another entity or an entity can be associated with the absence or temporal presence of qualifying properties. In non-occurrence exacting, the important aspect of the hierarchy is the association of one entity with the other. Nyaya shastra defines eight types of abstract associations between entities. These associations are cause and effect, part-whole, determining aspect and what is determined, limiting aspect and what is limited, pervading aspect and what is pervaded, the chief qualifier and what is being qualified, the underlying promoter and what is produced by it. Relations in the ontology described in this paper have been adapted from the types of relations described above. Two concepts can also be related by way of more than one relation (Mahalakshmi et al 2002).

The associated qualities, which characterize the concept, may be mandatory or optional. The concepts being derived from the higher-level entities inherit the qualities and values. In the case of multiple parents in the hierarchy the model should provide constraints on whether to derive the qualities or not.

3.5.3 Nyaya’s Negations

The Nyaya theory analyzes the terminology of negation in different ways. One of the possible negations ‘Prior non-existence’ describes that it is prior to the production of an effect and is characterized as beginning less but
having an end. The other negation 'posterior non-existence' describes that this type of non-existence occurs after an effect is destroyed and is characterized as having a beginning and no end. Thus interpretations of negation associated with concepts and qualities, account for the temporal perspective of defining and reasoning about state changes. Generally, modeling of the information, about the reversible and irreversible change of states is vital to the knowledge representation scenario. In this work, an attempt has been made to achieve the modeling of state changes, by adapting the negation handling methodology of Nyaya shastra.

This chapter discussed Western and Indian philosophies in general and in detail the Nyaya theory. It also elaborated on the adaptation of the classification scheme of Nyaya and its contribution to the computational-representational model. The following chapter describes a conceptual model, known as the Nyaya conceptual model, which incorporates the ontological commitments, entities, relations, and negations of Nyaya.