Intelligent Disease Diagnosis of Respiratory Diseases

Developed By:

Ch Muhammad Shahzad Faisal
(361-FBAS/MSCS/F07)

Supervised by:

Syed Muhammad Saqlain
Assistant Professor, DCS, FBAS, IIUI

Co-Supervisor:

Dr. Ahtisham Aslam
Assistant Professor, DCS, COMSATS Lahore

Department of Computer Science
Faculty of Basic and Applied Sciences
International Islamic University Islamabad
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Faculty of Applied Sciences
Department of Computer Science

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Final Approval

It is certified that we have read the project report submitted by **Ch Muhammad Shahzad Faisal Reg No. 361-FBAS/MSCS/F07**. It is our judgment that this project is of sufficient standard to warrant its acceptance by the International Islamic University, Islamabad for the award of degree of Master of Science in Computer Science.

Committee

External Examiner
Dr. Muhammad Zubair
Assistant Professor,
Department of Computing
Riphah International University, Islamabad

Internal Examiner
Mr. Muhammad Nadeem
Assistant Professor,
Department of Computer Science
International Islamic University, Islamabad

Supervisor
Syed Muhammad Saqlain
Assistant Professor,
Department of Computer Science
International Islamic University, Islamabad

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Dedicated To:

My Sheikh

Hazrat Alama Pir Alaudin Siddique Sahib

Declaration

I hereby declare that this work, neither as a whole nor a part of it has been copied out from any source. It is further declared that I have developed the model, the software on the base of proposed model and the results with my personal efforts; and under the sincere guidance of Syed Muhammad Saqlain and Dr. Ahtisham Aslam. If any part of this project is proved to be copied from any source or found to be reproduction of some other project, I shall stand by the consequences. No portion of the work presented in this dissertation has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning.

Ch Muhammad Shahzad Faisal

(361-FBAS/MSCS/F07)

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Ch Muhammad Shahzad Faisal

(361-FBAS/MSCS/F07)

Abstract

In the filed of medicine, disease diagnosis is an assessment of all possible grounds for a set of symptoms in order to recommend treatment. This method, basically a process of elimination, is used by physicians to analyze the actual disease in a patient. One major problem is the enormous volume of knowledge that doctors are required to possess, in order to be able to make a correct diagnosis. The main difficulty is that the number of diseases which exist worldwide is huge and increasing sharply. It is beyond the scope of the human mind to remember them all simultaneously. To overcome this difficulty the usage of semantic web knowledge representation formalism in combination with general purpose reasoning for pneumonia disease diagnosis is proposed. Ontology based disease exploration along with searching and inference upon it is proposed which apply the use of ontologies combined with logical inference. The proposed system aimed to optimize disease diagnosis and treatment process and it will support in taking clinical decisions related to diagnosis, prognosis and treatment more effectively.

A Pneumonia domain Ontology, based on Pneumonia disease, has been developed in protégé ontology editor tool. The ontology consists of complete class hierarchy, object properties along with domain and range, data properties and sample instances. Various Description Logic Queries have been run to depict the proper role of ontology, This new ontological model is capable of different tasks and this work can be link to other health care repositories like semantic health grid.

Table of Contents

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Respiratory illness is the term for diseases related to human respiratory system. Pulmonology diseases vary from mild such as the common cold to life-threatening such as bacterial pneumonia. They are widespread and main cause of illness and death. Treatment of respiratory disease depends on the specific disease being treated, the severity of disease itself and patient. The domain of respiratory disease diagnosis is in fact characterized by a large number of different diagnostic hypotheses, connected to each other by complex relationships of causality, specialization and possible co-existence. In particular, throughout time many cases have emerged where incorrect medical diagnoses were made. This was a forceful motivation for the proposed idea. Medical practitioners have the ability to make opinions based on their skills and experience; [1] however their decisions are subjective and are not aided by some sort of highly sophisticated decision making procedure. Moreover the system, trying to model the physician's reasoning, should be able to rapidly explore the problem, emit hypotheses for the specific symptom case on the basis of few preliminary data, assess their consistency and gather more specific information to refine the initial hypotheses The usual practice to diagnose a patient's disease is started with indications of symptoms and further exploration of disease is then proceeded and treatment usually advise on the basis of clinical findings and lab tests. Former approaches to disease diagnosis include medical expert systems which often with the use of knowledge bases at the time of the initial diagnosis. Pneumonia domain ontology is proposed for disease prediction, tests recommendation and treatment decisions.

1.1 Introduction

Here we introduce Pneumonia domain along with its elements and semantic interpretation in Pneumonia disease domain.

1.1.1 Overview of the Pneumonia disease

Pneumonia disease is an inflammation of the lung tissue affecting either side of the chest that frequently occurs as an outcome of an infection. Illness can be caused by a bundle of different micro organisms viruses like bacteria, fungi and parasites. Adding up to infection, pneumonia can also be caused by acidic chemicals breathed or poisonous smoke inhalation from a fire. It is infrequent that pneumonia can result from you breathing in something that you are allergic to. This may be connected to a hobby or to your job nature. The medical word for pneumonia caused by an allergic reaction is extrinsic allergic alveoli is. An instance of this condition is farmer's lung, caused by breathing in the dust from mould feed or grass mowed.

Public with transferable pneumonia frequently have a cough producing greenish or yellow sputum and a high fever that may be come with by shaky chills. Shortness of breath is also common, as is pleuritic chest pain, an acute pain, either experienced in deep breaths or coughs. Patients with pneumonia may cough up blood, experience headaches, or develop sweaty and clammy skin. Additional possible symptoms are loss of appetite, nausea, vomiting, mood swings, fatigue, and blueness of the skin. Pneumonia can be caused by microbes, irritants and unknown causes. If pneumonia is suspected on the basis of a patient's symptoms and findings from bodily examination, further examination is needed to confirm the diagnosis. Information from blood tests and chest X-ray are helpful, and sputum cultures in some cases. However, in a society setting, pneumonia is usually diagnosed based on symptoms and physical examination alone. Diagnosing pneumonia can be hard in some people, especially those who have other sickness. Rarely a chest CT scan or additional tests may be needed to distinguish pneumonia from other illnesses. There are quite a few ways to prevent pneumonia. To left smoking is important not only because it helps to bound lung harm, but also because cigarette smoke interferes with many of the body's natural defenses against pneumonia. Majority cases of pneumonia disease can be treated in non hospitalized environment. Normally antibiotics, rest, fluids, and bed rest are adequate. However, people with pneumonia that are having difficulty breathing, people with other health problems, and the aged may need more sophisticated treatment.

1.1.2 Disease diagnosis

During Pneumonia diagnosis it is important to determine if the cause of Pneumonia is bacteria, atypical bacteria, or a virus, since they all require different treatments. In children, for example, Streptococcus pneumonia is common cause, but RSV may also cause pneumonia disease. Although symptoms may be different, they often have common characteristics, which can make it difficult to identify the organism only by symptoms. However, in numerous cases of mild-to-moderate CAP, the physician is able to diagnose and treat pneumonia based exclusively on a history and physical test. The patient's history is a key part of the pneumonia diagnosis. In physical test or examination several things are evaluated like Rales (crackling sound). Rales on one side of the chest and rales heard while the patient is lying down are strong signs of pneumonia. The doctor also uses a test called percussion, in which he knocks the chest lightly. Some other disease diagnosis techniques are

- Lab tests for diagnosing infection and discover bacterial agents belong to pneumonia
- Tests for fewer common organisms
- Chest X-Rays and other visual techniques
- Invasive diagnostic measures
- Exclude other disorders that cause coughing or affect the lung

1.2 Semantic Exploration

Human being are able of using the Web to carry out tasks such as finding the Spanish word for "lion", reserving a ticket, and searching for a low price for a laptop. Nevertheless, a computer cannot achieve the same tasks without human direction because web sites are designed to be read by people, not machines. The semantic web technology is a vision of information that is understandable by computers, so that they can perform more of the boring work involved in finding, combining, and acting upon information on the web. Semantics interpretation is basically investigation of meanings If we generalize the term semantics we got understanding of problem and if we see it in specialized context it reaches at common words. While semantic search try to improve search accuracy by understanding searcher intention and the contextual meaning of terms as they appear in the data space, whether on the Web or within a blocked system, to produce more relevant results [2]

1.2.1 Semantic interpretation in Pneumonia domain

As we know that for several years Semantic interpretation in the domain of medicine became a hot topic. Semantic interpretation in medicine domain and particularly in diagnosis of pneumonia achieve a vital role of inter relating different concepts of disease elements and then infer them through special mechanism. These inferences can be based on linking symptoms, tests, and medicine details with disease causes. Several medical expert systems have been proposed to facilitate experts in their relative areas but the design of these systems does not reason on models. Majority of work on different search engines is based on key word matching techniques which are not semantic in nature thus producing irrelevant results to users and different search engines experiencing these problems these days. All these problems lead to a solution. A technique which should have some methodology to bring accurate results to user in order to posses result relevancy. This technique has been demonstrated in this ontology model. All Pneumonia disease related concepts are defined explicitly along with their relation ships and individuals. Reasoner automatically inferred the exact disease, cause or any other element on the basis of Existential and Universal restrictions defined in ontology. Any type of concept or individual can be inferred easily by setting its semantics in ontology design process.

1.3 Complete Document guideline

Pneumonia disease domain has been investigated thoroughly. During the modeling process of ontology several properties of Pneumonia disease including symptoms, causes, medicines, lab test and exams for reasoning have been sorted out. Then by a comprehensive survey of the different medicine libraries including disease diagnosis centre's several documents have been prepared as an input to this proposed disease ontological model. Comparative analysis of many other medicine vocabularies and text with Pneumonia ontology has been provided in literature survey. This descriptive research in the domain of pneumonia disease provides new base line to domain experts in order to carry out positive diagnosis. Also this work will provide other modelers with a sound knowledge modeling back ground. As a part of this ontology construction most of ontology modeling constructs has been used like Concepts definition, imposing existential and universal restrictions on them. Manchester OWL- DL query syntax has been followed properly. Much of this work is based on Instance level restrictions which provide ease in reason over Pneumonia ontology using Pallet reasoner.

1.4 Goals and objectives

This work has been done to accomplish following objectives:

- Handle Semantic interpretation in respiratory disease domain
- To facilitate physician by automatically extracting list of possible diseases along with suitable drug recommendations and other advices.
- To analyze other important disease aspects on the basis of derived causes and drugs.
- Pneumonia disease domain has been selected due to its nature of carrying immense knowledge along with enormous modeling potential.

➢ Currently this ontology is limited to Pneumonia disease only but it can be further integrated to some other semantic network of medicine.

1.5 Research span

Current work has an imperative impact as human health is a Devine precious gift and better cure of disease is a vital to human happiness and healthy society. Motivation of implementing semantic technique is to utilize its feature of machine understandability. Useful knowledge can be inferred from this model using Pallet or other reasoner. This model has capability to work with some other intelligent domain. Scope of current work comprises following things:

- This ontological model is very helpful to physician's , so they will be able to explore disease in a conceptual and multidimensional way
- Physician will be able to view causes on the basis of disease symptoms.
- Drugs recommendations will also presented to doctors for particular disease
- Recommended Lab tests will be presented to doctors on the base of specific set of symptoms
- All important information regarding lab tests and drug details will also be useful for other disease domains.
- Ontology is extendable, domain experts can add new concepts with few alterations, e.g. new symptom, cause or drug or patient living habits.
- Searching criteria's can be increased or modified easily on the base of ontology structure.
- Pneumonia ontology will be able to support reasoning for other pulmonary diseases by little modification to original one.
- It's a Pneumonia disease diagnosis prototype, therefore integration with other pulmonary diseases semantic network will be very useful
- If accessibility options provided other medicine libraries can make use of this knowledge base for useful purposes.
- If adjusted for an enterprise semantic health grid this prototype will play an important role by providing a shareable knowledge to other members of grid for better disease cure

1.6 Summary of Thesis

Several chapters have been included as a part of thesis documentation which contains Overview of current work described in first chapter. Previous research efforts has been deeply explored and different medicine libraries has been investigated, all this included in second chapter, Problems regarding knowledge representation in medical domain has been presented with different aspects including complications regarding human disease along with medicine allergy in third chapter. Next are ontology construction details with possible queries in chapter fourth. In the last I concluded my work with a motivation of this work along with future directions in fifth chapter.

CHAPTER 2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

Medical sciences comprise of so many fields including medicines, surgery, cardiology, urology etc. Massive amount of knowledge have to be managed properly. Little work has been contributed on semantic management of medicine literature especially when we talk about diseases and their relevant causes along with their anatomical interactions. We can say that manual terminology structure cannot convince anymore the new desiderata of healthcare information systems. Ontologies can support effective knowledge sharing in medicine science. Literature survey presented here cover immense area of Knowledge management regarding semantic web applications which include data annotating, retrieval of medical information. In the present survey study, some of the high-impact biomedical ontologies usually upper ontologies presented, classifying into three major groupings: knowledge organization, including the indexing and retrieval of data and information; data incorporation and semantic interoperability.

2.1 Overview of Past research efforts

The ontologies under study in this literature survey include

SNOMED

It is a widespread concept system for healthcare [3];

LOINC

It is Logical Observation Identifiers, Names, and Codes (LOINC) which a vocabulary for laboratory exams and clinical interpretation [4];

FMA

Foundational Model of Anatomy (FMA) which is domain ontology of structural human anatomy [5];

Gene Ontology

It is a restricted vocabulary for the functional annotation of gene products across species [6];

RxNorm

It is a restricted vocabulary of normalized names and codes for clinical drugs [7];

National Cancer Institute Thesaurus

It is a community wide terminology that provides broad coverage of the cancer domain [8,9]; the International Classification of Diseases, the 115-year-old medical terminology, now part of a family of health classifications [10,11];

Medical Subject Headings (MeSH)

It is a restricted vocabulary for the indexing and retrieval of the biomedical literature [12,13];

Unified Medical Language System (UMLS)

A vocabulary integration system in which all the above ontologies are integrated [14, 15].

2.2 Biomedical ontologies evaluation

Features of some medical ontologies based on information present in the UMLS (2007AC) are given below:

Ontology	**Range**	**Notion**	**Subsumes**
LOINC	Clinical observations and laboratory tests	46,406	no
SNOMED CT	Clinical medicine (patient records)	310,314	yes
Gene Ontology	Functional annotation of gene products	22,546	yes
NCI Thesaurus	Cancer research, clinical care, public information	58,868	yes
RxNorm	Standard names for prescription drugs	93,426	no
FMA	Human anatomical structures	72,000	yes
ICD-10	Diseases and conditions (health statistics)	12,318	no
MeSH	Biomedicine (descriptors for indexing the literature)	24,767	no
UMLS Meta.	Terminology integration	1,4 M	n/a

Ontology	Range	Notion	Subsumes
	in the life sciences		

Table 2.1 Biomedical research work

In addition to prototypical illustration of MeSH and Gene ontologies used for indexing the biomedical text and for the practical annotation of gene products respectiviley. [16] Indexing is principally used to refer assignment of entries from a controlled terms to documents, e.g MEDLINE is performed manually for the most part, automatic indexing systems have been developed (e.g., [17]). Although the objective is to assign MeSH descriptors, these systems often take advantage of the large set of terms and relations provided by the UMLS. Systems such as GoPubMed coannotate the biomedical text to both MeSH and the Gene Ontology [19]. The indexing of medical documents is generally referred to as coding and biomedical ontologies are sometimes called "code sets" [9]. SNOMED is becoming adopted as customary terms for health records by several countries [20] and has also been estimated as a resource of terminology for clinical research [21]. The UMLS Meta thesaurus as a whole has also been used to support the coding of clinical documents, such as pathology reports [22]. Similar to indexing, a large amount coding is still performed manually. However, automatic techniques have been developed and evaluated (e.g., for ICD [23]), some of which exhibit high accuracy in some degree of domains. Partially automatic ways for acquiring annotations from text have been examined recently [25,26]. Functional annotation is not restricted the annotation in Gene Ontology, but more generally can be seen as a "normalization" process applied to datasets to enable further processing. For example, [27] used SNOMED and the NCI Thesaurus to annotate tissue micro array data. Analogously, MeSH was used to annotate mentions of human diseases in the Gene Expression Omnibus [28]. Related to the concept of indexing is that of term recognition, i.e., the process of automatically identifying mentions of entities of interest in text through natural language processing (NLP) techniques. A number of biomedical term identification systems have been developed for the medical domain, take advantage of the rich sources of vocabulary provided by biomedical ontologies [45]. UMLS-based systems include MetaMap [29] and MetaPhrase [30]. Developed more recently are systems such as Termine [31] and Whatizit [32], which cover genomics (e.g., gene and protein names) in addition to clinical medicine. The main function of the indexing of large document collections such as MEDLINE is to support precise retrieval, i.e., with high recall and high precision. With hierarchical controlled vocabularies such as MeSH [33] or the UMLS [34,35], queries can be expanded to the descendants of the original input term. Medical dss generally take advantage from ontologies in two most important ways. First ontologies provide a standard vocabulary for biomedical entities, helping standardize and integrate data sources [36]. Second, ontologies are a source of computable domain knowledge that can be exploited for decision support purposes, often in combination with business rules [37, 38]. Addition to clinical decision support, ontologies support reasoning in applications. The Foundational Model of Anatomy (FMA) was used as a source of anatomical knowledge for reasoning about penetrating injuries [39]. Additionally automatic reasoning services, [40] developed an automatic grading system for gliomas. Ontologies sometimes contribute not directly in reasoning processes. For example, [41] emphasizes the role of the Gene Ontology in pulling out of information required for creating an ontology of phosphatases.

Ontologies are element of the data driven approach to medical research, interactive with the conventional hypothesis-driven approach [42]. Furthermore, data mining often operates on datasets resulting from the integration of ontologies [43]. Since of the availability of datasets which are International Classification of Diseases coded, clinical data exploration often involves the mining of ICD codes, along with, for example, geographic data [44] or meteorological data [45]. The accessibility of large quantity of data makes it possible to detect rare events, such as adverse reactions to drugs (e.g., diabetic ketoacidosis [46] and hepatic toxicity [47]). In natural sciences, the functional annotations of gene products from multiple model organisms to the Gene Ontology represent an important knowledge source, particularly in combination with sequence similarity [48,49], gene expression data [50,51], or both [52]. Predicting the molecular function or sub cellular localization of uncharacterized genes is an active field of research. [53].

From the above literature survey it is clearly evident that a comprehensive ontological model is needed for Pneumonia disease which should cover domain concepts in detail rather then upper ontological concepts. This proposed conceptual model with implementation will be then available for better searching and reasoning pneumonia disease. Semantic interpretation has been carried out with the help of newly constructed pneumonia disease ontology which will facilitate physicians to diagnose pneumonia disease in an excellent way.

2.3 Summary

Still we have a little application of semantic interpretation in medical sciences. How to perform semantic interpretation in this domain has not yet fully explore as research topic especially when we talk about disease diagnosis. Although some upper ontologies are there but very few task domain ontology has been designed. Therefore it's a timely approach to implement this technology in medical science and particularly in respiratory diseases.

CHAPTER No. 3

INVESTIGATION of PROBLEM

&

Research Question?

CHAPTER No. 3

INVESTIGATION of PROBLEM

3.1 Complications of human body and disease elements

Human body is very complicated and it is very hard to understand its entire functioning by a physician. Similarly there is a diversity of diseases found in children. There is a variety of symptoms and causes for a single disease and some time different diseases has same symptoms, therefore it is very difficult for physicians to remember all causes or symptoms of highly inter related diseases that resulted difficulties in diagnose the exact disease. It requires complete understanding of entire body sections because infected area of the body is link with other parts of the body, so it is extremely complicated to tell that which linked portion of body is causing problem to this infected area without revealing symptom cause relation ships. So it's become a challenging issue faced by the medical Industry the management of patients who suffer from chronic illnesses such as diabetes, heart disease, asthma, and renal disease. This also creates challenges in how to handle increasing amounts of information in, both, clinical and research field Even if a large volume of medical information is available, pathological conditions are still poorly understood and diagnoses can be ambiguous.

- It is difficult to diagnose disease on the basis of symptoms and initial findings because different disease can have similar nature of symptoms and environmental conditions.
- Handling of drug allergies is complicated task because different types of disease causes can have different drug recommendations.
- Evaluation of lab test reports (like x-ray, ct-scan, and blood tests) is also a tedious job because some times test results do not reveal accurate predictions and to make interpretations becomes challenging.
- It is also obvious that traditional modeling techniques are not suitable to model complex domain behaviors in a semantic way and they do not posses a strong inference mechanism, therefore unable to get relevancy in results.

- Only few disease ontologies have been proposed in current era. Most of them are upper ontologies rather than domain ontologies. Upper ontologies normally present knowledge in much generalized manner which is not suitable for this domain. Most of upper ontologies are working on human gene system rather than its internal working. Gene ontology, Sequence ontologies are some of them.
- Another notable concern is that respiratory diseases have not yet been completely explored using semantic web approach. Only little research work has been done on domain ontologies by NBC biomedical research group and OBO Foundry research group.

3.2 The growing Role of Knowledge organization in medication

The practice of medicine is at a moment of truth. Clinicians, knowledge workers, are finding their time packed down, their responsibilities lengthened, and their control dissipated. In this time of disorder, technology is often viewed as a lifeboat in a sea of uncertainty.

1. Clinicians are today burden with the liability of exactly documenting the procedures and diagnostic studies that are used to diagnose their patients. In addition, they are expected to follow clinical guidelines that have been developed by any number of bodies, from local hospitals to national level in diagnosing and treating their patients. In personal practice, clinicians are moreover faced with competition from the larger health care organizations. Many of these minor practice clinicians view knowledge management as a mean of competing effectively. Conventionally, their tasks include gathering patient data, analyzing the data for pattern that they recognize, and then formulating a differential diagnosis, which in turn leads to a treatment plan. Differential diagnosis, a way of accomplishment of exact disease while questioning different parameters fro patients. One of the qualities of a skilled clinician is the ability to quickly create a short list of differential diagnoses that most probably contains the true diagnosis,

2. Therefore, knowledge management is foremost challenging due to the unavailability of firm conceptual model for knowledge acquisition and its representation for respiratory diseases which in turn cause different problems like exploring disease. Permanent data storing techniques like database are not capable of bringing out accurate results on the base of relation ships among disease elements.

3.3 Documentation problems faced by Knowledge representation media

At the moment, medical knowledge is most often communicated using traditional resource channels such as books or magazines or other electronic Medias. These mediums offer the advantage of covering wide segment of specific medical specialty areas. However, these forms of knowledge communication are limited by long publication intervals, complicated publication procedures, a non-uniform presentation of content and varying media during knowledge communication. In commonly used media, language also presents a serious hurdle for knowledge communication, since medical terminology is poorly standardized and contains a large variety of synonymous specialty terms.

Formless medical terms also lead to communication problems. Knowledge contained in common media resources causes yet another problem: accessing the content is time-consuming and seriously delayed by tedious manual searches for the desired information. For example, an efficient search for possible evident base medicine using common resources is hardly possible due to their sequential knowledge structure. However, the hunt for and separation between similar disease patterns is immediately required for ensuring complete patient treatment. Some techniques have been experienced for adaptive knowledge navigation, and have concentrated their efforts on web technologies or the usage of XML and XML-Schema. Others have concentrated on domain knowledge but have not covered the whole breadth of the medical domain. However, the inclusion of a large range of diseases is especially important for diagnostic purposes and the support of practitioners outside their own medical specialty. Many researchers stress that knowledge has to be 'represented in the form of rules, constraints, calculations, guidelines, and other logical/algorithmic formats' to be executable.

3.4 Contemporary knowledge management issues

Knowledge management has an important position in the current medical practice. While research is carry on in how to best apply knowledge management techniques to clinical decision support, most of the effort in the field is focused on data gathering, in defining best practices for maximum quality of care, in managing electronic medical records. These days, the pressures of outcomes measures, determining best practices and quality controls, all require timely, accurate information. Clinician interest is firmly stuck on the economic survival of their practice. As such, there is considerable inspiration to understand; catalogue, and have readily available timely local patient demographics, disease prevalent figures, and other population's specific problems.

Therefore we need such an ideal system which should have enough capability of achieving all goals presented in document scope. Required features include strong and meaningful relationship among different ontology elements (include hierarchy construction in tree style and then to perform different queries on it in order to infer useful information).

3.5 Proposed Solution

This solution is adequate due to its nature of encompassing a thorough study of pneumonia disease domain and then construction of an ideal ontology which reflect all real world scenarios in an appropriate way. Physicians can now diagnose disease in an authorative way.

3.5.1 The Aspiration

The aspiration of current work is to conduct a thorough study of pneumonia disease and to model in a semantic way in order to achieve research goal.

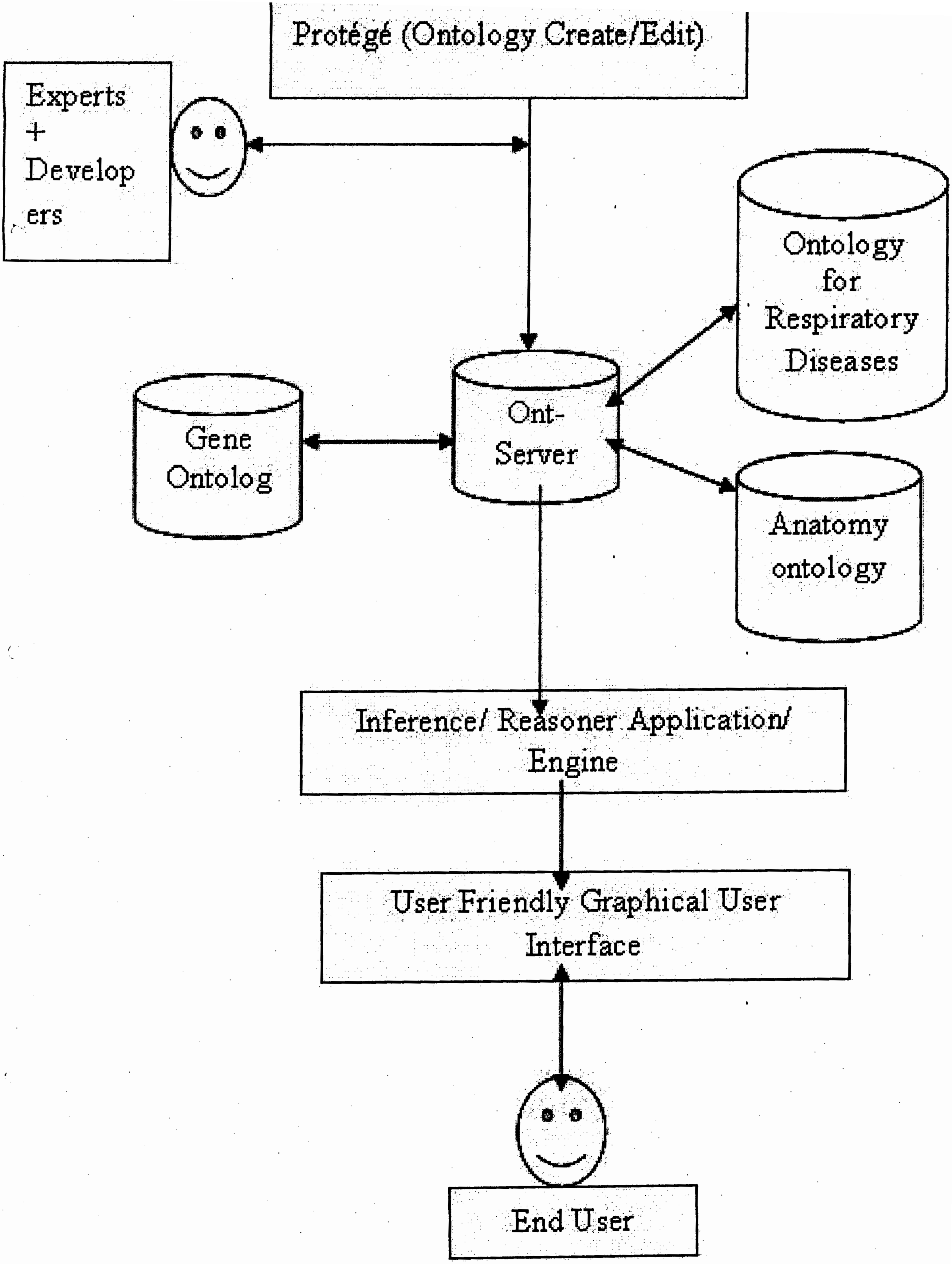
How to carry out the job of semantic interpretation in the domain of respiratory disease?

We have to do several things in order to answer this research question like:

a) By sorting out all domain problems of modeling particularly in context of knowledge representation.

b) By analyzing different disease element hierarchies and existing correlations among them like analysis of similar symptoms for different causes.

c) By knowing expected results in order to accomplish accurate disease diagnosis.



Protégé (Ontology Create/Edit)
Experts + Developers
Ontology for Respiratory Diseases
Gene Ontolog
Ont-Server
Anatomy ontology
Inference/ Reasoner Application/ Engine
User Friendly Graphical User Interface
End User

3.6 Several ways of medical Knowledge representation

As literature survey reveals that there are several ways to represent knowledge including Lists which are use to represent hierarchical knowledge. We have Tree's also to do the same thing. Additionally we have semantic networks which consist of nodes and links use to reveal semantically related classes. We have schemas to store document type storage formats and other constraints in order to validate documents. Then we have rule based knowledge representation which is especially use in Expert systems along with logic based knowledge representations.

Chapter no. 4

Pneumonia

CHAPTER No. 4

Pneumonia

It is a pulmonary disease which causes inflammation and other several infections to lungs.

4.1 When and how Pneumonia disease occurs

During breathing some germs related to bacteria, Viral or fungal become expose to lungs therefore lungs become infected or more precisely lungs become infected when:

- Exposing to bacteria or virus.
- Consequences of some previous illness cause immune system weak.
- A consistent illness which include chronic diseases

It has been found that Pneumonia kills more children than any other disease like measles, malaria and AIDS combined [54]

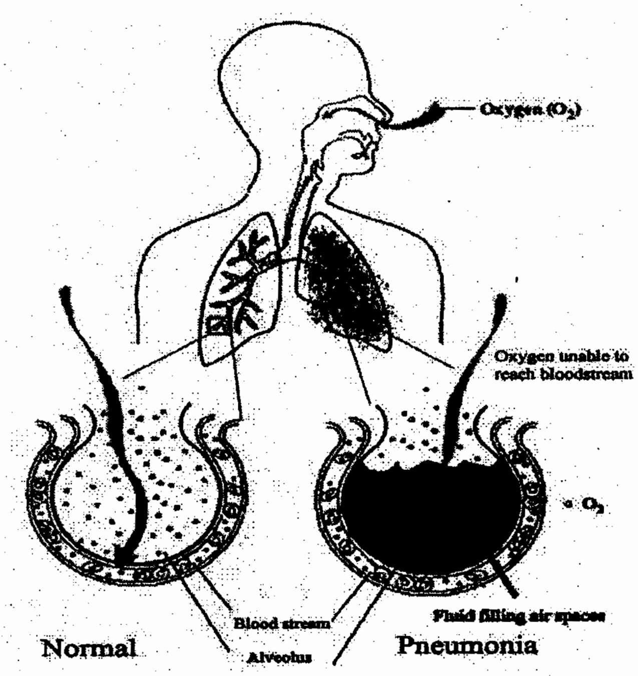


Figure 4.1 A view of lungs exposing to germs that cause pneumonia

4.2 General Indications / symptoms for Pneumonia illness

According to different cause of pneumonia we can arrange the symptoms with respect to causes.

4.2.1 Indications for Bacterial Pneumonia

According to experts opinions following are the most significant symptoms of bacterial pneumonia in different age groups [55]

- For Typical pneumonia following symptoms are considerable:
    - A high temperature and chills
    - Production of greenish, yellow sputum with cough
    - Problems with chest can also arise with cough and short of breath
    - Possibility of breath shortness
- While with Walking or atypical pneumonia following are significant:
    - Patient can have a series of other sickness
    - Less temp and shaking chills
    - Headaches are common
    - Dry cough
    - Abdominal pain.
    - Presence of Tiredness
    - Memory loss and confusion can occur to old age people.

4.2.2 Indications for Viral Pneumonia

- Less than 103° F temperature
- Producing mucus with cough in a small amount
- Possible Drowsiness
- Pain in head
- Muscular stiffness and aching
- Presence of Sweating
- Chills presence
- Appearance of fatigue in body
- Throat appear to be dry

4.2.3 Indications for Walking Pneumonia

Key indications of walking pneumonia given as following

- Cough is common
- Average to high temperature
- Common existence of day chest pain
- Usual Vomiting
- Appearance of bluish Color on lips and face
- Wheezing is common
- Begin with some unclear symptoms
- Finally, many of people with dry cough and some of them feel breath problem

4.2.4 Indications for Fungal Pneumonia

- Persistent fever may occur
- Non productive cough can produce
- Boring uneasiness
- Respiratory system breakdown cause by Dyspnea
- Hindering indications
- Record of traveling to germs or allergy areas
- Allergic reactions
- Brain abscess in Aspergillus species
- Skin rash
- Kidneys problem
- Liver troubles
- Muscle (Candida species) stress ness

4.3 Pneumonia Diagnosis process

Several things a doctor usually observes before medicine recommendation, we can say it disease diagnosis process which include some physical examination of patient along with his medical history evaluation. This gives a great support to physician in taking treatment decision for patient. Physician can ask for several tests in order to get a final decision. So there are three main aspects of disease diagnosis.

In the figure below there is an internal view of body which shows an inhalation process and we can easily see Trachea which is the path way of oxygen, similarly we can see Bronchi inside the lungs, and especially we can see infected are of lung, this situation sometime indicate the presence of pneumonia. [56]

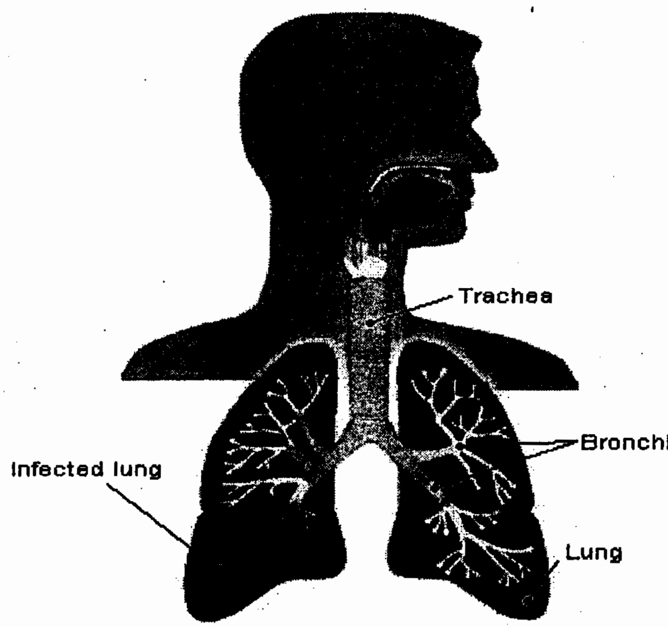


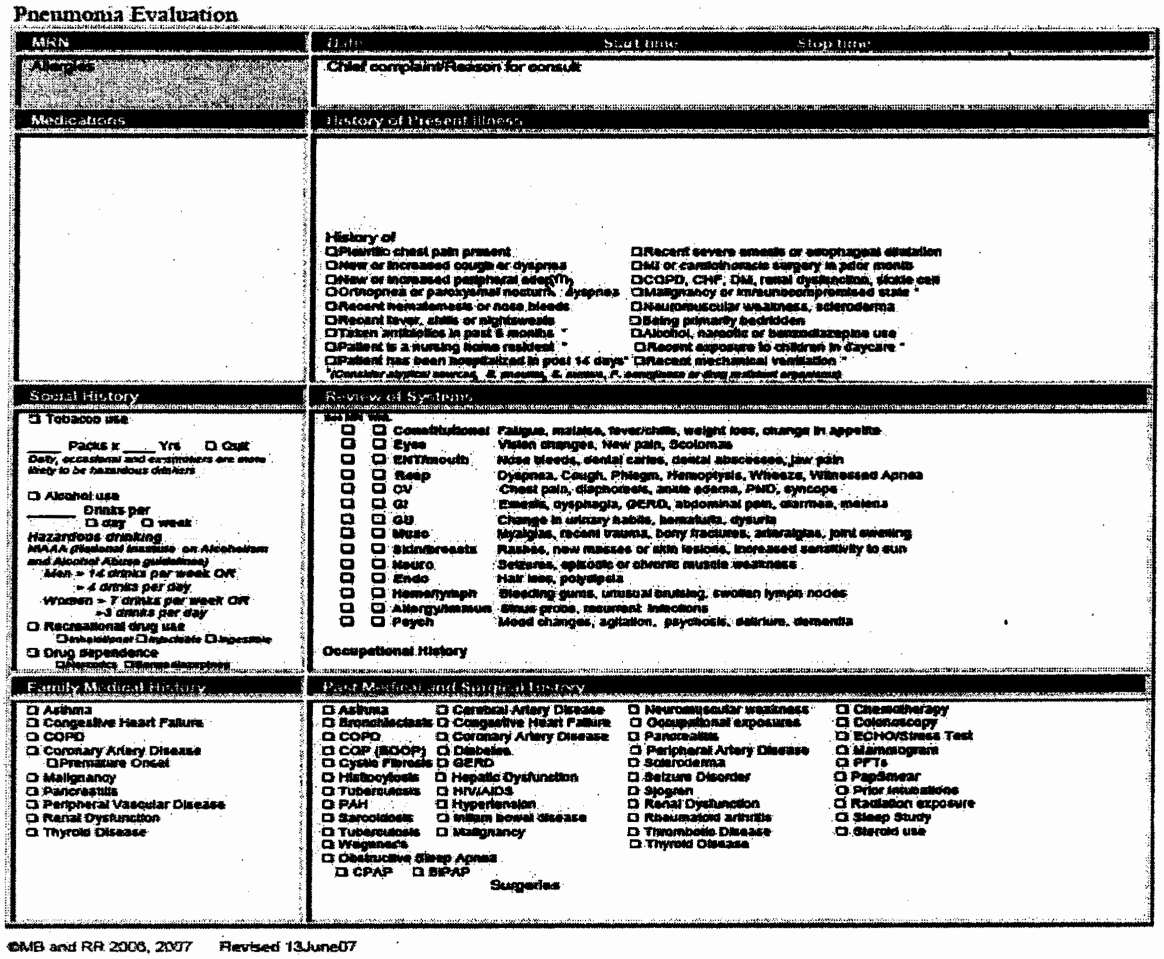
Figure 4.2 Lungs portion along with an infected area of lung

4.4 Pneumonia disease chart

I have used a sample of Pneumonia disease diagnosis chart which is for the demonstration of several disease diagnosis elements of this disease. [57] This chart contains the following details:

1. Main complaint
2. Allergies
3. History of patient and its social history
4. Medication
5. Anatomical view of system
6. Family history

7. Past medical history



Pneumonia Evaluation

MRN | Date | Start time | Stop time

Allergies

Chief complaint/Reason for consult

Medications

History of Present illness

History of
- Pleuritic chest pain present
- New or increased cough or dyspnea
- New or increased peripheral edema
- Orthopnea or paroxysmal nocturnal dyspnea
- Recent hematemesis or nose bleeds
- Recent fever, chills or nightsweats
- Taken antibiotics in past 6 months *
- Patient is a nursing home resident *
- Patient has been hospitalized in past 14 days *
- Recent severe emesis or esophageal dilatation
- MI or cardiothoracic surgery in prior month
- COPD, CHF, DM, renal dysfunction, sickle cell
- Malignancy or immunocompromised state *
- Neuromuscular weakness, scleroderma
- Being primarily bedridden
- Alcohol, narcotic or benzodiazepine use
- Recent exposure to children in daycare *
- Recent mechanical ventilation *

Social History
- Tobacco use

____ Packs x ____ Yrs Quit

Daily, occasional and ex-smokers are more likely to be hazardous drinkers

- Alcohol use

____ Drinks per day week

Hazardous drinking
Men > 14 drinks per week OR > 4 drinks per day
Women > 7 drinks per week OR > 3 drinks per day

- Recreational drug use
- Drug dependence

Review of Systems

Constitutional	Fatigue, malaise, fever/chills, weight loss, change in appetite
Eyes	Vision changes, New pain, Scotomas
ENT/mouth	Nose bleeds, dental caries, dental abscesses, jaw pain
Resp	Dyspnea, Cough, Phlegm, Hemoptysis, Wheeze, Witnessed Apnea
CV	Chest pain, diaphoresis, ankle edema, PND, syncope
GI	Emesis, dysphagia, GERD, abdominal pain, diarrhea, melena
GU	Change in urinary habits, hematuria, dysuria
Musc	Myalgias, recent trauma, bony fractures, arthralgias, joint swelling
Skin/breasts	Rashes, new masses or skin lesions, increased sensitivity to sun
Neuro	Seizures, episodic or chronic muscle weakness
Endo	Hair loss, polydipsia
Heme/lymph	Bleeding gums, unusual bruising, swollen lymph nodes
Allergy/immun	Sinus probs, recurrent infections
Psych	Mood changes, agitation, psychosis, delirium, dementia

Occupational History

Family Medical History
- Asthma
- Congestive Heart Failure
- COPD
- Coronary Artery Disease
  - Premature Onset
- Malignancy
- Pancreatitis
- Peripheral Vascular Disease
- Renal Dysfunction
- Thyroid Disease

Past Medical and Surgical History
- Asthma
- Bronchiectasis
- COPD
- COP (BOOP)
- Cystic Fibrosis
- Histiocytosis
- Tuberculosis
- PAH
- Sarcoidosis
- Tuberculosis
- Wegener's
- Obstructive Sleep Apnea
  - CPAP BIPAP
- Cerebral Artery Disease
- Congestive Heart Failure
- Coronary Artery Disease
- Diabetes
- GERD
- Hepatic Dysfunction
- HIV/AIDS
- Hypertension
- Inflam bowel disease
- Malignancy
- Neuromuscular weakness
- Occupational exposures
- Pancreatitis
- Peripheral Artery Disease
- Scleroderma
- Seizure Disorder
- Sjogren
- Renal Dysfunction
- Rheumatoid arthritis
- Thrombotic Disease
- Thyroid Disease
- Chemotherapy
- Colonoscopy
- ECHO/Stress Test
- Mammogram
- PFTs
- PapSmear
- Prior intubations
- Radiation exposure
- Sleep Study
- Steroid use

Surgeries

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Figure 4.3 Pneumonia medical and physical history

4.5 Techniques of disease diagnosis by Physical evaluation

Physicians normally use their stethoscope to diagnose pneumonia. Sounds from body indicate the presence of Pneumonia; they can be crackling sounds which we can call rales .If such sounds become clear on either chest side when the patient is lay down then it's a vital sign of pneumonia disease. Beating or percussion is another useful technique in which doctors tap the chest, and if sound produces then it indicates lungs inflammation which can further be consolidated as Pleural effusion. Several tests may be ordered to help in the diagnosis:

- X-rays of chest can have infections indications in lungs, but x-rays can be of different types and patterns depending upon the anatomical aspect of patient.
- Another important test is sputum culture if physician suspects some organism to cause pneumonia.
- Other option is lung biopsy but in rare cases.

Following is diagram fro Protégé editor which shows a large number of tests which a doctor can perform in order to diagnose pneumonia disease.

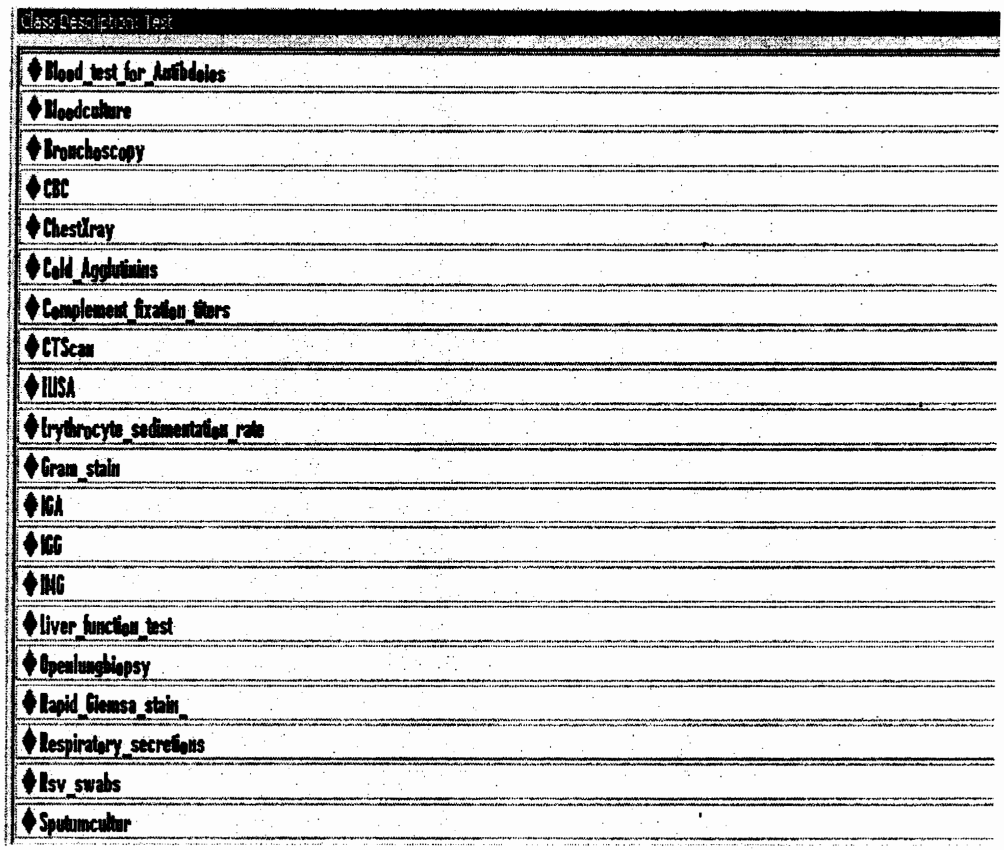

Figure 4.4 Tests for Pneumonia

4.6 Treatment decision for Pneumonia disease

Disease cause and its nature are the elementary elements for treatment of disease. Normally medicines are classified in to two main big categories which are Antibiotics and Anti viral medicines. While bacterial causes are nicely handled by Antibiotics but they are not good for viral ones. Recommendation of antibiotics can depend upon different age groups, risks, and illness nature.

Figure 4.5 Pneumonia medicines

Some antibiotics are given below as a sample:

- AMOXYFEST-500 Capsules
- AMOXYFEST-250 DT Tablets
- BACTAZ-P Injection
- BACTAZ-P 1.125 G. Injection
- FLUDIA Tablets
- GEMINORM - 320 Tablets
- KASINO-100/200 Injection
- KASINO-500 Injection
- MATCHFIX-100/200 DT Tablets
- MATCHFIX Dry Syrup
- MATCHFIX - CV Tablets
- MERONORM-1000 Injection

Antibiotics are not always suited to all patients, because cause nature can be different and symptoms may vary among patients, age groups are also of significant nature, therefore medicine suggestion requires a complete suited state of body.

4.6.1 How one can recover from Pneumonia

If pneumonia is of sever nature with vital cause and patient overall health is not very good it can last for long time, but if cause is simple and immune system of patient is good then it can be recover in sort time. Especially children take long time to recover due to their weak body structure. Good care can result in quick recovery. [58]

4.7 Statistics of Pneumonia disease

United Nations statistics (Sep-2006) indicate several parameters of pneumonia as follows: [59]

- Number of children getting pneumonia treatment according to base on their gender
- Results of Urban and rural health care facilities
- Mothers literacy factor
- Children care comparison among rich and poor families

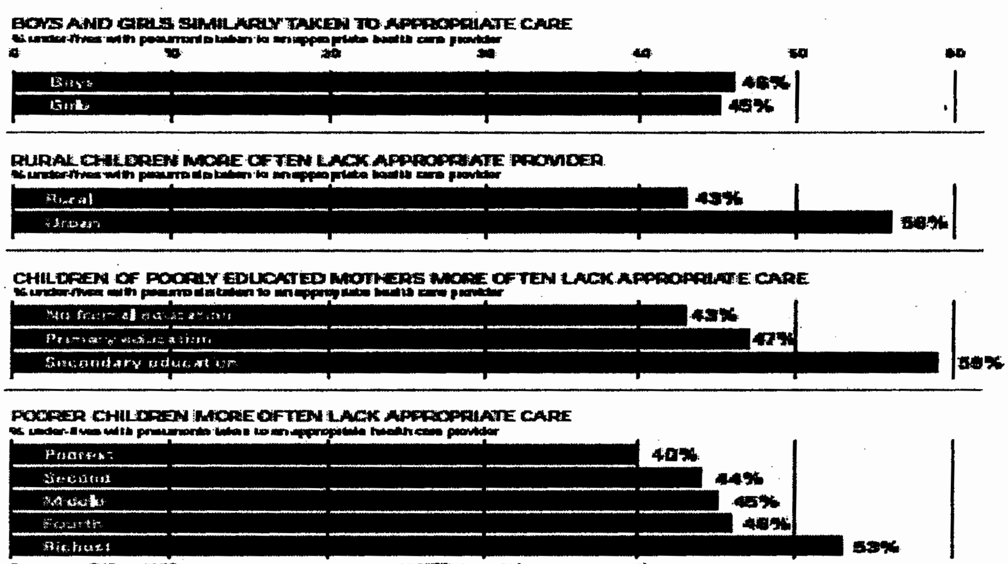

Figure 4.6 United Nations children's fund and world health organization

4.7.1 A report from Pakistan on curing Pneumonia disease

These statistics are based WHO guide lines for Acute Respiratory Infections. These guidelines involve better treatment and diagnosis of Pneumonia disease. Chart shows a sharp fall in number of deaths in children due to pneumonia disease. This technique has been applied on Islamabad hospitals and impact of this technique is very good. This includes better diagnosis and treatment process activities.[60]

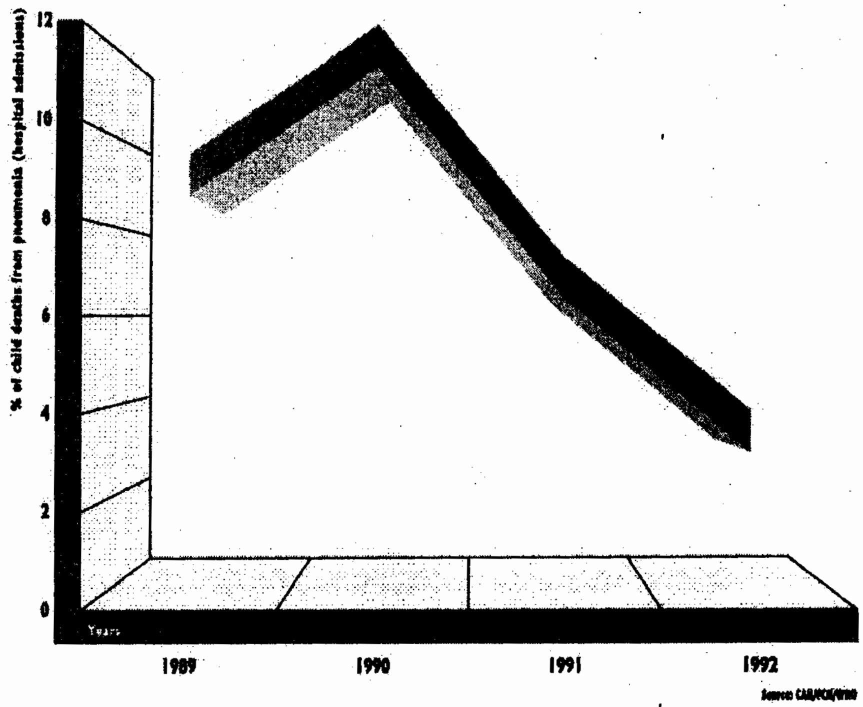

Figure 4.7 Graphical view of ARI guidelines to reduce pneumonia deaths in Pakistan

Chapter No. 5

Ontology Design

Chapter No. 5

Ontology engineering and diagnosis results

5.1 Accomplishment Issues regarding domain

Several issues came across during ontology construction session. Some of them were including data collection regarding pneumonia disease and some involves in Correlation detection process among disease elements and domain characterization etc

5.1.1 Identification of Pneumonia disease for ontology construction

Present literature work including publication material, on line medicine libraries etc contain massive amount of knowledge regarding diseases and medicines. Enormous number of discipline has also been discovered regarding human body and its interaction with different diseases. A lot of drug recommendation expert systems are also functioning. Particularly all this happen mostly with respiratory diseases. Because there is a diverse nature of Pneumonia disease and disease elements correlation is also very high therefore this domain is significant. Major disease diagnosis methods are differential diagnosis and event base medicine. With some specific diagnosis procedure it is difficult to establish interconnection among several body parts and functioning therefore it was difficult to explore such diverse domain. Additionally there are few attempts on disease diagnosis in health care and some of them lie on heart and lung disease diagnosis or few on skin disease diagnosis. But this work is mostly carried out on expert systems rather then semantically. Therefore much other disease domains have been discarded and pneumonia has been selected as final domain to manage due to availability of resources regarding Pneumonia and its richness of having modeling constructs.

5.1.2 Difficulties in Pneumonia disease domain

If we talk about a simple domain with no or few inter related concepts then it is easy to design and manage it, but if our domain is rich with many correlated elements such as pneumonia disease then it is difficult to explore all those relation ships in a true way.

Although care have been taken in classifying and organizing concepts. Most of the exploration consists of Causes and their dependent symptoms, tests, drugs and precautions.

. There are about eight types of pneumonia. Following difficulties encountered during descriptive work of pneumonia disease.

- It is difficult to diagnose disease on the basis of symptoms and initial findings because different disease can have similar nature of symptoms and environmental conditions.
- Handling of drug allergies is complicated task because different types of disease causes can have different drug recommendations.
- Evaluation of lab test reports (like x-ray, ct-scan, and blood tests) is also a tedious job because some times test results do not reveal accurate predictions and to make interpretations becomes challenging.
- It is also obvious that traditional modeling techniques are not suitable to model complex domain behaviors in a semantic way and they do not posses a strong inference mechanism, therefore unable to get relevancy in results.

5.1.3 Data acquisition

Data acquisition is a great issue in this work. Several online medicine libraries, course text, research publications along with expert opinion are part of data acquisition for this domain, because it can cause death of human so high care have been followed. Although some vocabularies regarding medical terms has been published but mostly of them covered upper domain concepts. NBC Bicorporal and OBO foundry are examples of quality work. For collection of pneumonia disease details several medicine libraries has been explored. Interviews with child specialist and other related field personals also conducted. Literature of MBBS also utilized for disease classification with respect to different age groups.

5.2 Ontology engineering steps for Pneumonia

One has to be very imaginative while constructing ontology. Any domain ontology follows iterative development approach due to having adaptation nature. Because any domain can be extended in future therefore we can not say ontology to be final one for specific time. Numerous steps are involved in proper ontology construction and we can't ignore the hard efforts of Stanford university team who worked very devotedly in giving this ontology development environment to research community.

5.2.1 Reasons for selection of a disease domain for semantic interpretation

There are many areas which need implementation of semantic technology to improve their knowledge management. But I choose this disease domain due to following reasons:

1. Firstly, several disease elements possess strong correlation among them; for example different patient symptoms belong to a single disease cause while many similar symptoms also belong to different disease causes. Like wise some drugs are recommended for some bacterial causes but on the other hand same drugs can have allergic reactions for different patients. If these hidden correlations explore out properly and in a well defined structure then huge useful knowledge can be reveal.

2. Secondly, disease domain is rich with modeling terms which have several connections to other terms; therefore it is good to apply semantic structuring to this domain. Therefore it is good utilize this option for disease domain.

3. Thirdly and lastly human health is a precious Devine gift and proper disease diagnosis can prevent it from damage or big loss, therefore I choose Pneumonia disease domain, especially children get stuck of it in majority.

If we look at domain it self it is very congested. Exploration is very hard to achieve, because one has to consult many patent resources due in order to finalize some business rule. Lack of medical research in different areas of world also cause difficulties in disease management because in some advance countries rich set of lab tests or modern evaluation systems are present which are not available to some poor countries. At the end pneumonia has been chosen as a target domain.

5.2.2 Neglecting the factor of reusing existing ontology

Majority of work in disease or medicine domain has been carried out on genes, anatomical structures of human body, surgery and cardiology etc but this work has mostly upper level ontologies. Only a small amount of work is supporting disease diagnosis ontologies for other disease rather than Pneumonia disease. Another thing which is hurdle in reusing existing upper ontologies is their integration problem, because it needs some sophisticated programming suite which is not freely available.

5.2.3 List of important terms / classes in the ontology

Initially it was very hard to eliminate exact terms related to pneumonia disease, but after surveying several medicine libraries and after discussion with domain experts many lists have been sorted out including list of all classes , domain and range with their object properties and in last data properties for all terms have been classified. Following is a sample list of terms:

Disease types	**Cause Classes**	**Symptom Instances**	**Object properties**	**Data Property**
General pneumonia	Viral cause	Fever, Diarrhea, Cough, Confusion	Has cause	Duration
Bacterial pneumonia	Bacterial cause	Headache, Loss of appetite, Short of breath	Has symptom	Colour
Viral pneumonia	General cause	General ill feeling, Rapid breathing	Has test	Nature
Aspiration pneumonia		Cough , High BP	Has disease	Type
Mycoplasma		Diarrhea	Test belong to	Last for
Atypical		Fever	Has medicine	Static
Cytomegalovirus		Temperature, Rash, Cough	Has allergic medicine	Mover
Community Acquired		Headache	Cause belongto	Dry

Pneumonia				
Legionnaire's disease		Loss of appetite	Symptom belongto	Bubbling sound
Hospital-acquired pneumonia		Muscle stiffness and aching	Allergic disease belongto	Cracking sounds

Table 5.1 Details of Important Terms in the domain knowledge

5.2.4 Protégé Class hierarchy description

This was an important and multi step process.

1. Firstly, main terms from Pneumonia domain has been identified, then their data properties have been analyzed that whether they are real data properties or they can become other classes in domain. Then after careful analysis all qualified terms have been selected as main classes.

2. Secondly correlation process among all terms belong to pneumonia domain has been done. This includes all symptoms, vital signs, lab tests and medicines linked with disease main causes which were viral, bacterial pneumonia causes.

3. Thirdly, all verbs have been identified in order to classify them as object properties. Then sub properties for all object properties have been defined.

4. Lastly all classes have been assigned as Domain and Range using object properties between them in Protégé editor. All object properties have been appropriately associated with each domain and range.

Consequently a final class hierarchy has been designed using Protégé editor. Following is a sketch of Class hierarchy diagram from this research work.

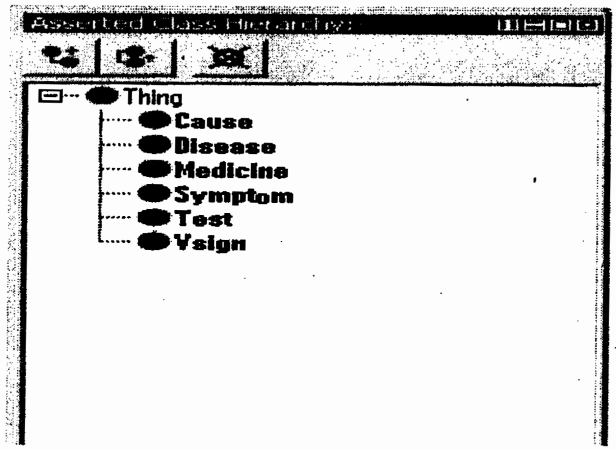

Figure: 5.1 Pneumonia disease elements class hierarchy

5.2.5 Object properties for Pneumonia domain

Normally ontology engineering involves a unique type of object properties construction environment. A tab is available in Protégé editor to create object properties and user can select at the same time the respective domain and range for that object property. Not only domain and range can be selected at the same time but Object level restriction can also apply at the same time.

The list of properties is as follows:

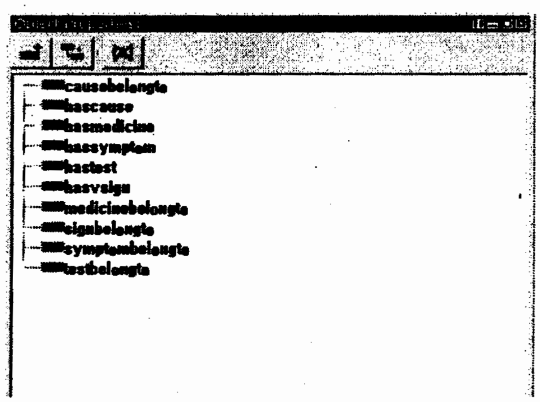

Fig. 5.2 List of Pneumonia domain Object Properties

5.2.6 Data properties definition for Pneumonia domain classes

The list of data properties is as follows:

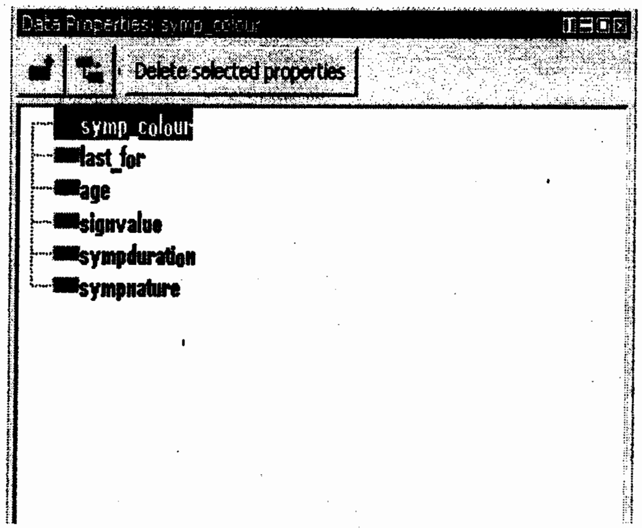

Fig. 5.3 Pneumonia domain classes data properties

5.2.7 Class level Restrictions

Restrictions are the back bone of any ontology. They provide a clear way of simulating relations between different type of classes. A class can interact with other class using some restriction. Two types of restrictions are provided with Protégé editor.

- Universal restriction
- Existential restriction

I have used existential restriction with its type necessary conditions, necessary and sufficient conditions can also be applied which provide more powerful assumptions during reasoning process.

Main role of these restrictions is visible during reasoning process because reasoner do its work on the basis of restrictions defines among classes. Therefore they are important one.

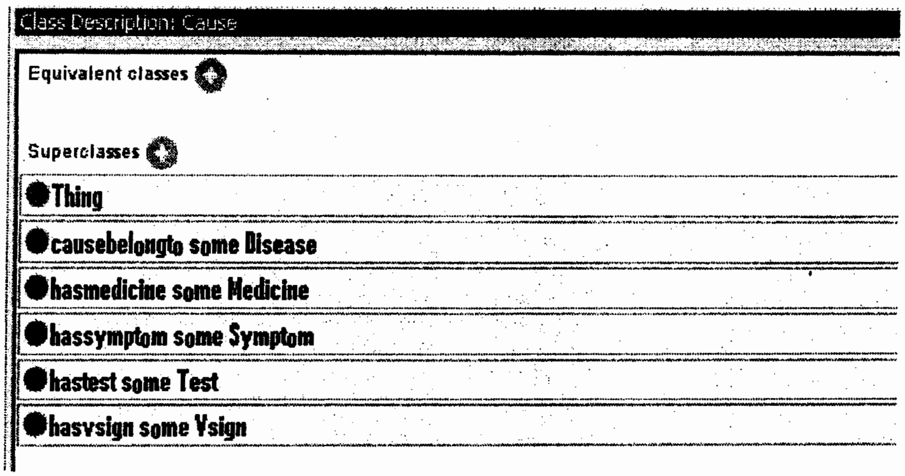

Fig. 5.4 List of Class restrictions

Instance level Restrictions

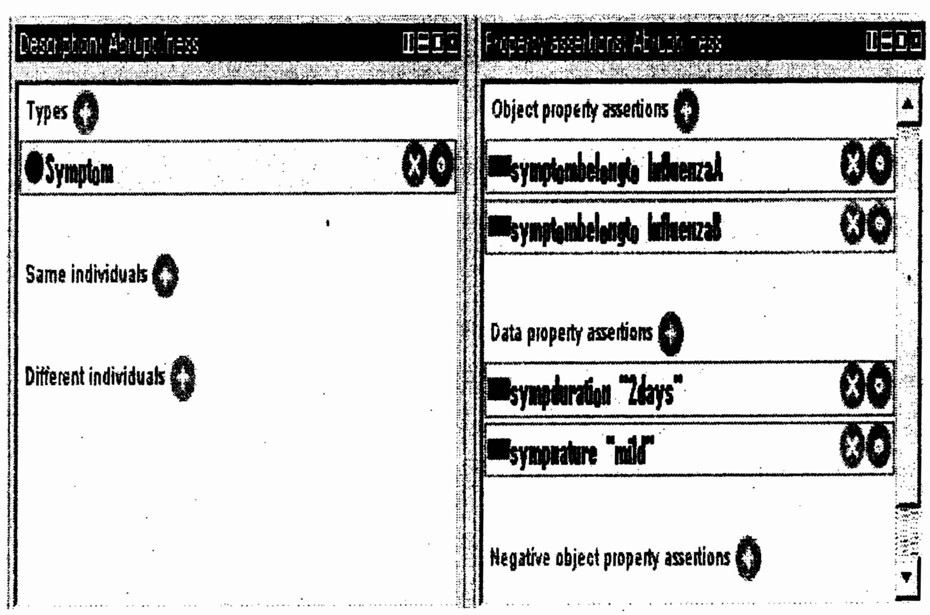

Fig. 5.5 List of Instance level restrictions

5.2.8 Instance creation for Pneumonia domain

When ever there is a schema or newly constructed data model there is a need of actual instance or individuals in order to test newly constructed structure. Similar applies on ontology where we add instances to our ontology in order to test and to accomplish our required results from ontology. Therefore after careful and thorough analysis of literature several instances have been found and their loading process has been done successfully. Round about 130 instances has been used for all classes. Some of them are here:

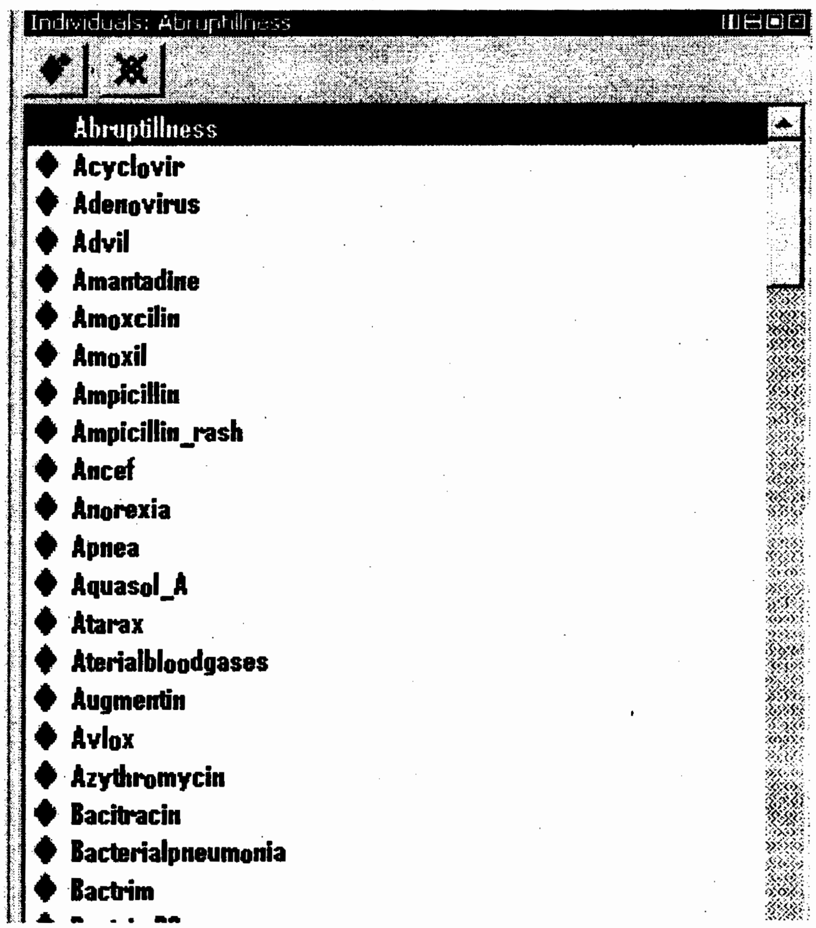

Fig: 5.6 List of Instances

5.3 Ontology engineering challenges in Pneumonia domain

- Correctness of class hierarchy is very important, but if we follow domain business rules we can create good class hierarchy. This contains all super and sub classes which can be defined in Protégé editor. This hierarchy when checked we can have asserted and inferred hierarchies.

- Sibling's correctness is also of big importance and one should make sure about their consistency with respect to their classes.
- We can utilize an Object oriented concept Multiple inheritance in ontology creation in which a class can be multiple inherited from several classes means that it can share the properties of other classes too.
- Decision regarding adding more classes to existing ontology depends upon the need and it shows its scalability that one can add new class any time.
- Selection of term as new class or as a data property of class is very crucial, but the basic idea is to choose a term as a class if it has some properties or contain composite attributes.
- By following business rules correctly one can make good use of disjoint class concept in which an individual can't be a member of more then one class at a time.
- Like other programming constructs naming convention must be very valid which ensures uniqueness of all classes
- Problems relating data acquisition for ontology construction is also of great importance, because availability of data is critical one.

5.4 Consistency and Class hierarchy checking of Pneumonia ontology

An ontology engineer can make good use of consistency checking feature provided in Protégé by which reasoner can be used to check the class. Several reasoners are provided with Protégé like Fact++, DIG, and Pallet. The terms asserted and inferred are named as user defined class hierarchy and reasoner generated class hierarchy. During this inferencing process results of all applied class level and instance level restrictions can be discovered. In case of an inconsistent ontology editor can display respective results in the quick way. A glimpse of hierarchy and consistency checking of classes from current Pneumonia ontology is given here

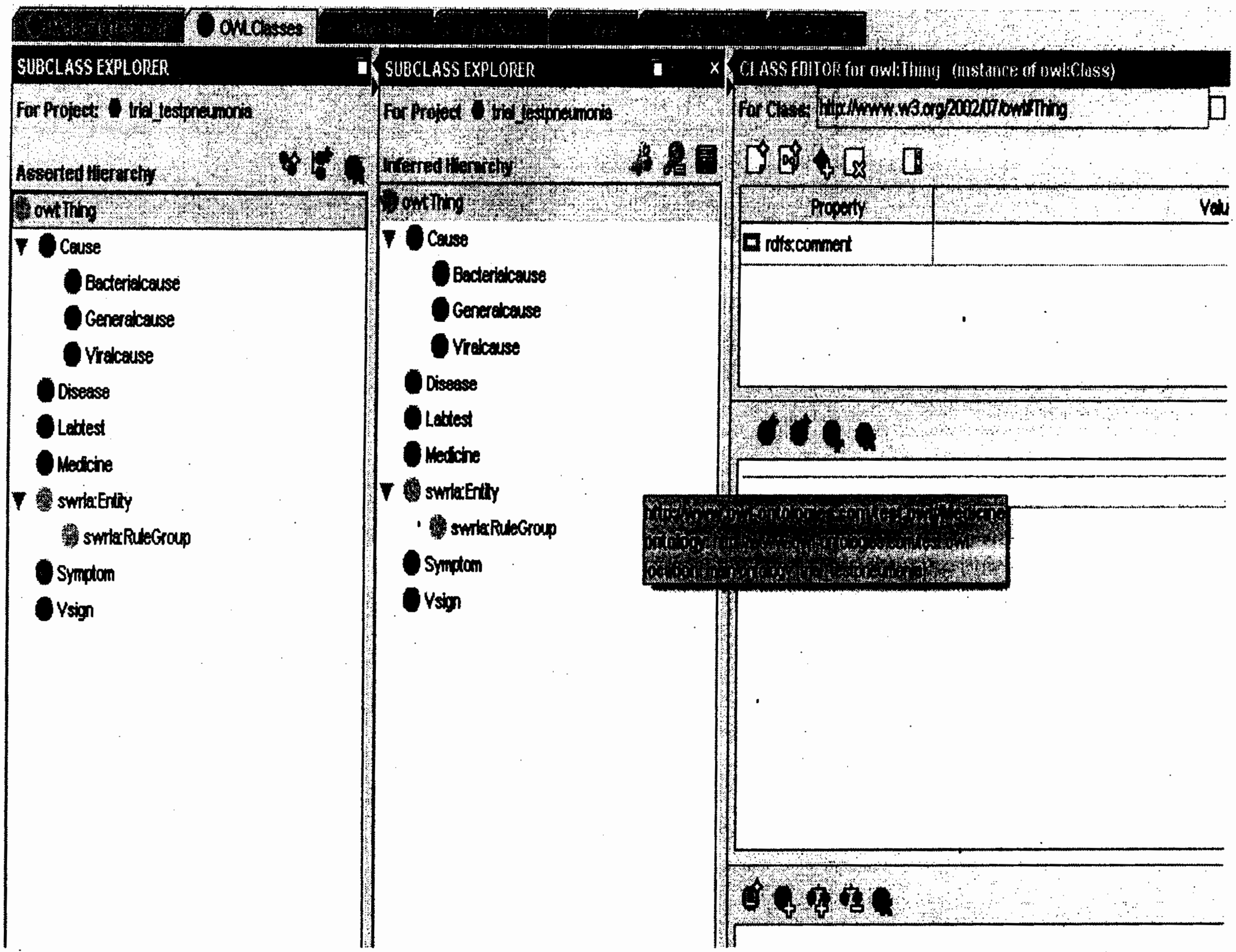

Fig. 5.7 checking of consistency of ontology by Pallet reasoner

5.5 Application of Description logic to Pneumonia ontology

Finally, in order to achieve results from our newly constructed ontology, that is what we mentioned in competency questions list, we can retrieve results using DL queries in respective DL-query tab. Manchester-OWL syntax have been used to write DL queries. Interesting results has been found by running queries on f\different scenarios.

These query results actually ensure restriction application genuineness applied on ontology.

5.5.1 Pneumonia disease Classes hierarchy

Subclasses

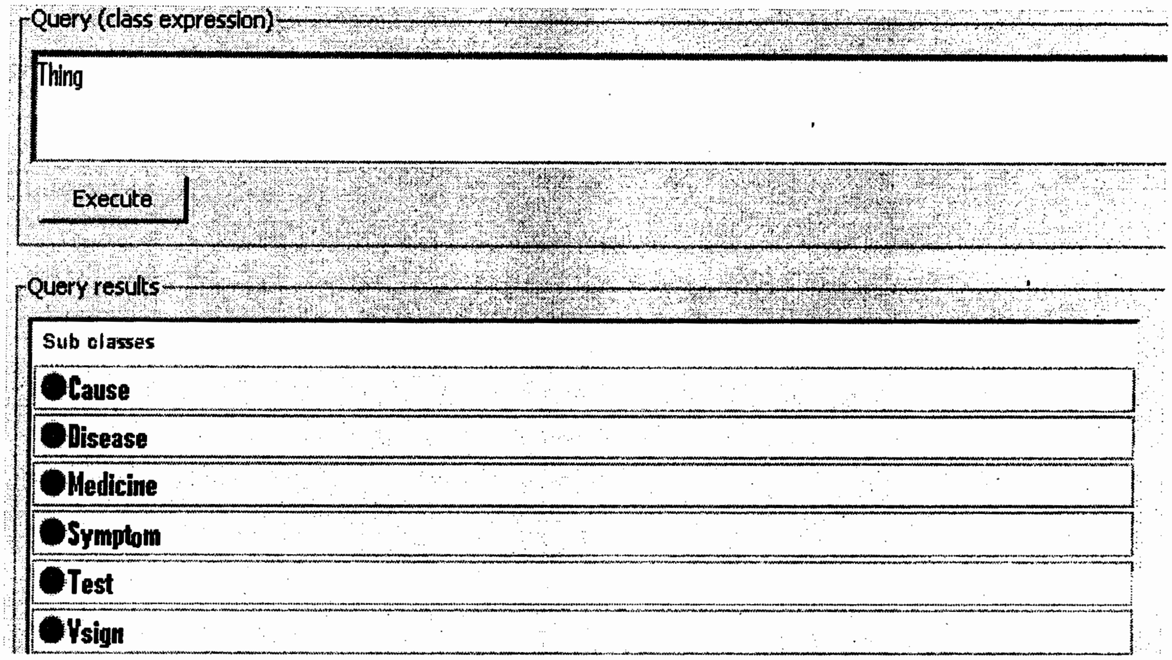

Fig 5.8 List of sub classes

Instances:

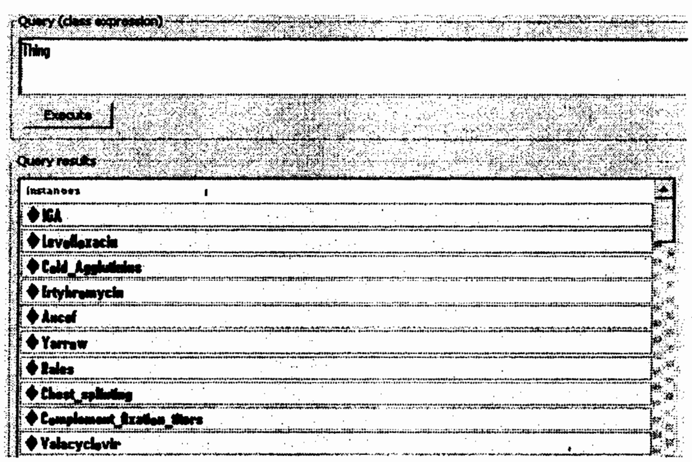

Fig. 5.9 List of All Instances on the base of DL Query

5.5.2 Queries in Description Logic for Semantics examination

Scenario 1: There are two questions in which concepts are searched w.r.t to its object property to other concept. The recommended medicine will be returned upon entering disease symptoms.

Qno1. Which medicine is recommended for symptoms Chills, fever and cough?

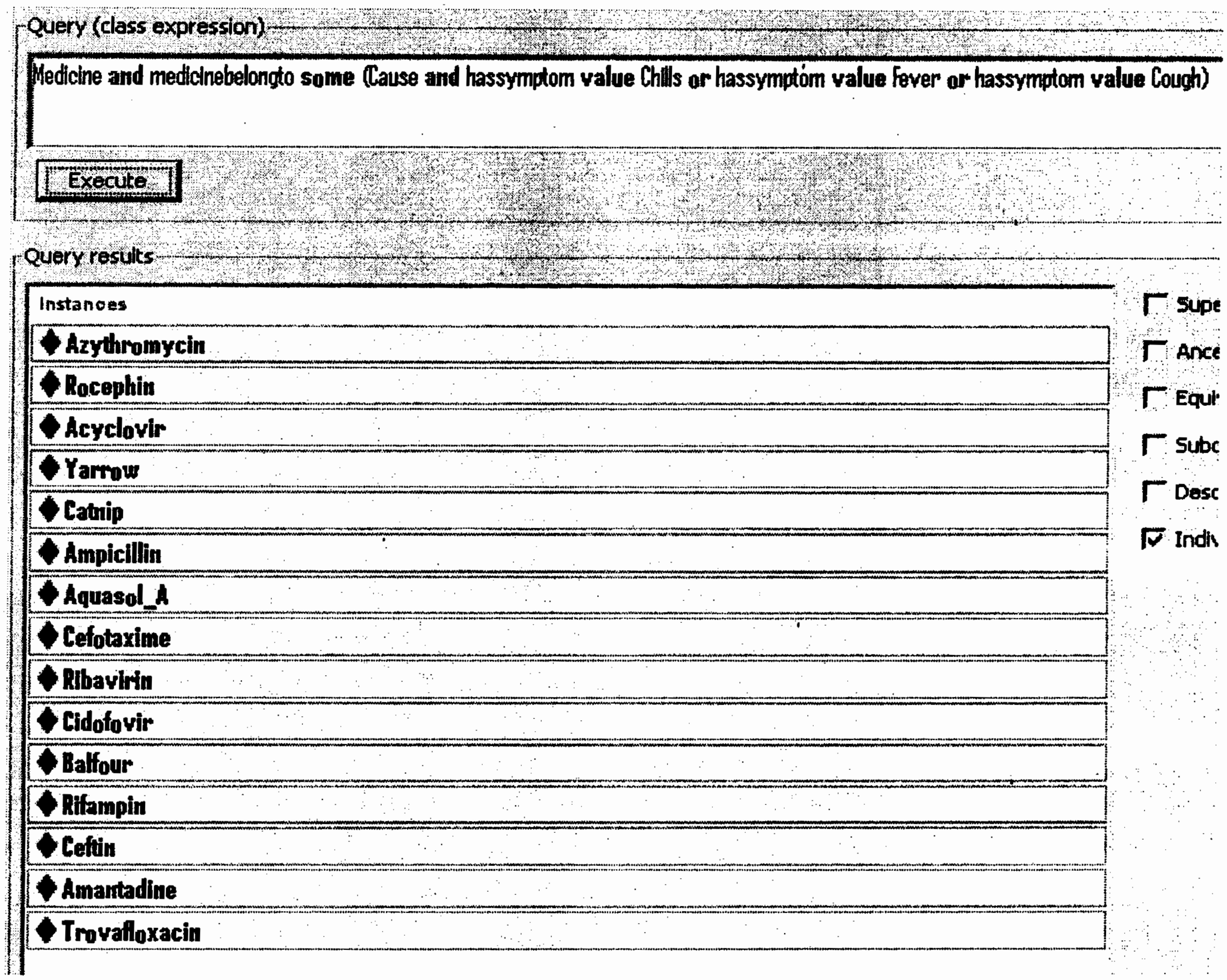

Fig. 5.10 List of Medicine on the base of DL Query

Qno2. Which medicine is recommended for symptoms Headache?

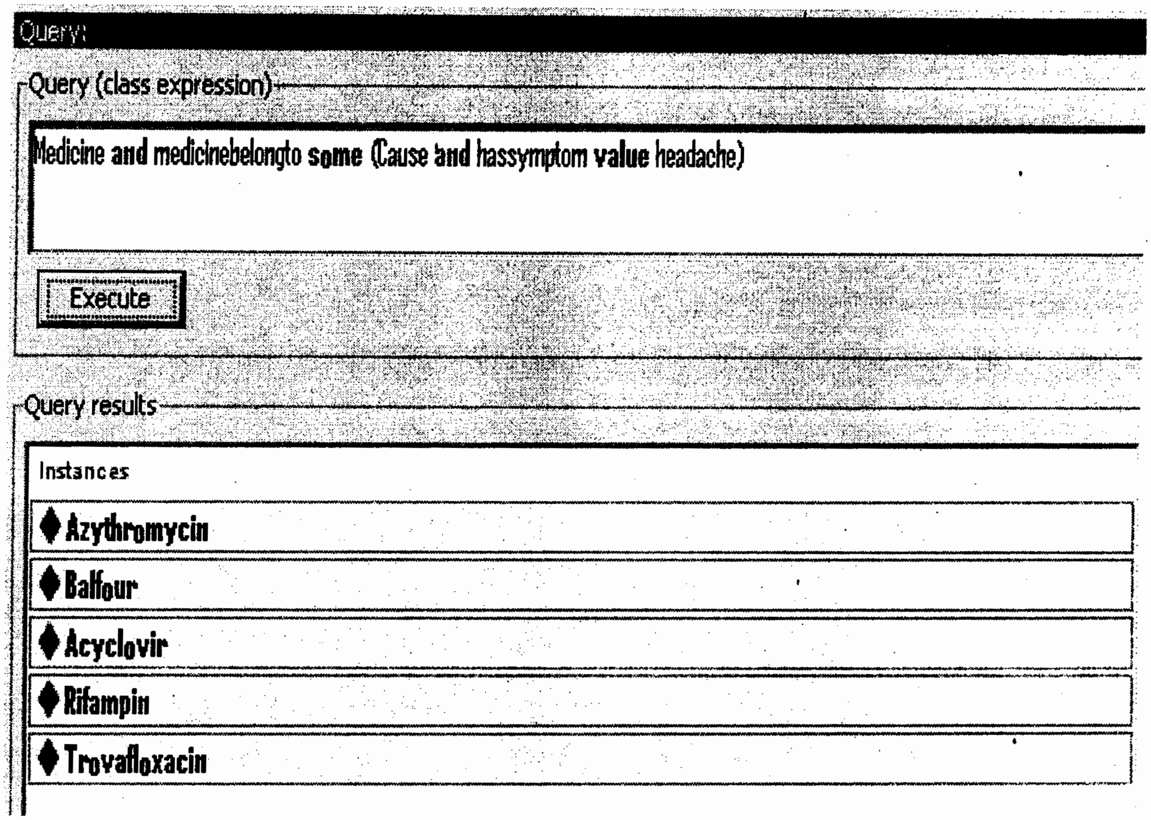

Fig. 5.11 List of Headache symptom Medicine on the base of DL Query

Scenario 2: Correlation among disease elements has been provided by applied instance level restrictions. The exact related cause due to some vital sign or symptom will be returned.

Q1: Which cause is responsible for abrupt illness or Diarrhea ?

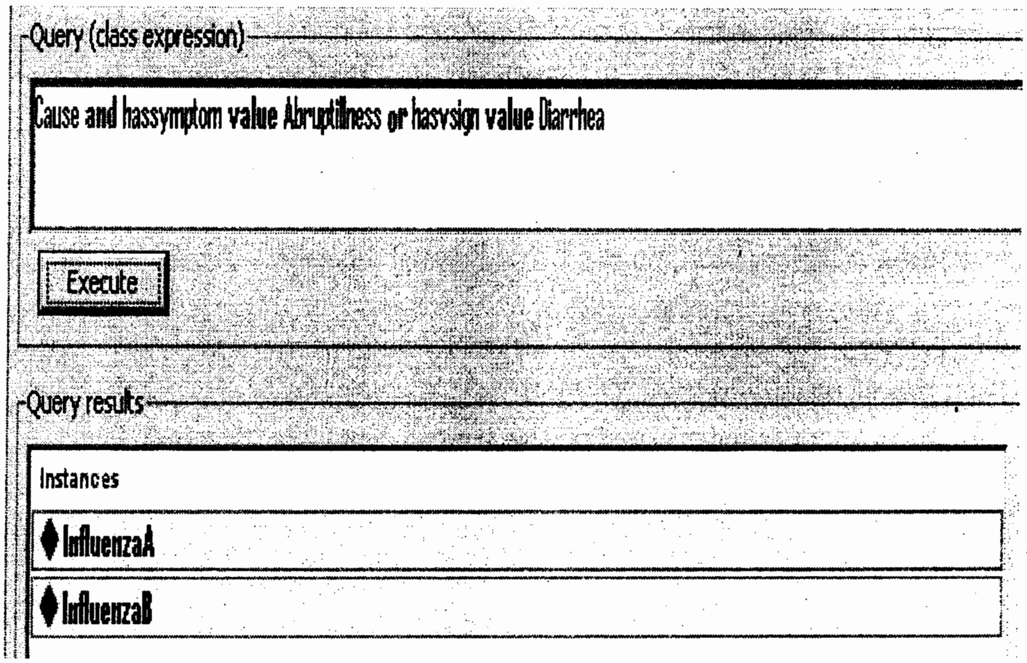

Fig. 5.12 List of Viral Causes for different symptom Query

Scenario 3: Cause can have several symptoms and a symptom belong to more then one cause further more test recommendation is also provided.

Q1: List all symptoms which belong to causes Influenza A or Adenovirus

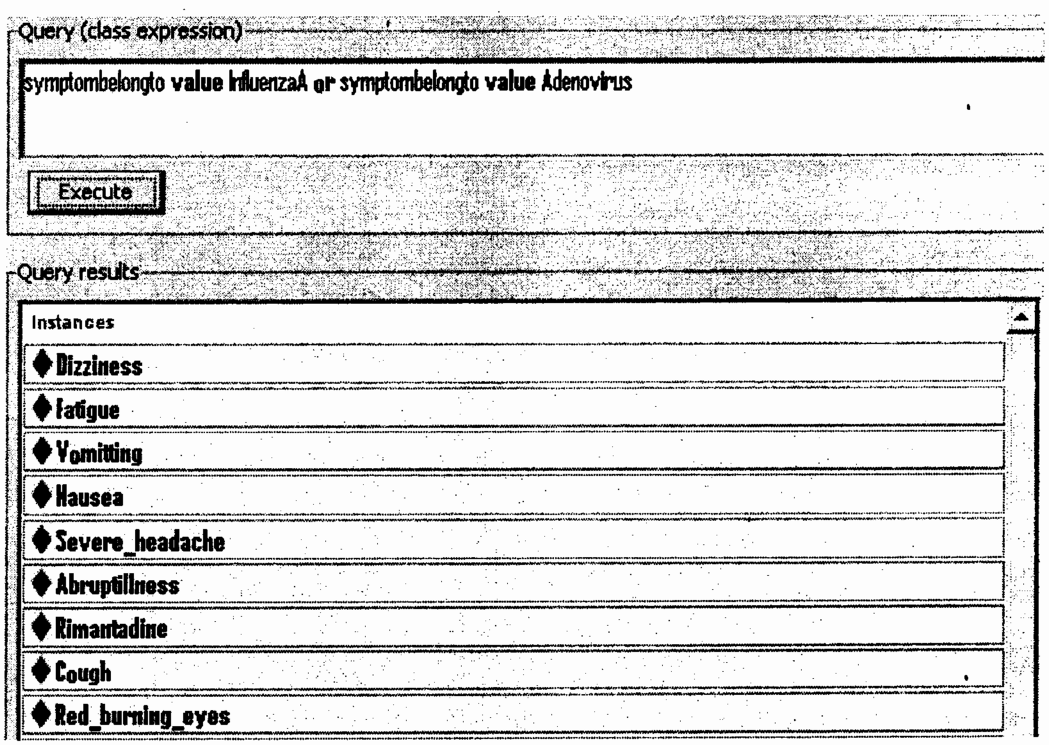

Fig. 5.13 List of Symptoms

Qno2. Which test / exam is belong to cause Chlamydia

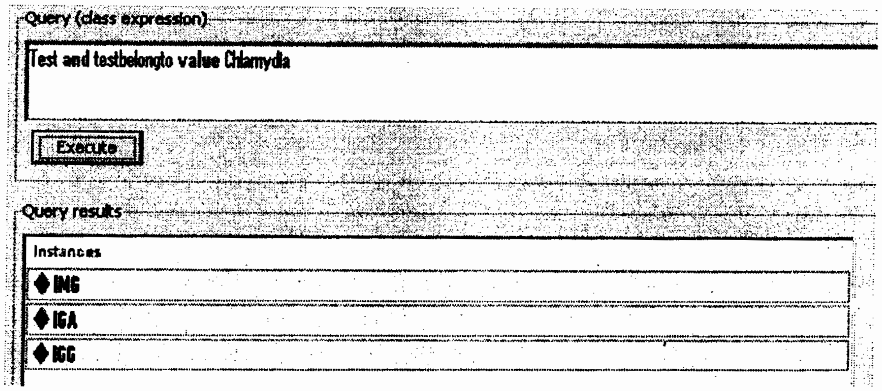

Fig. 5.14 List of Test / exam for Viral cause

Scenario 5: Lastly, Pneumonia ontology checking via data property and reflexive associations based on object properties has been done. One data property symptom nature and string values Mild and symptom duration with string value 2 days are linked to class symptom. Cause wise symptoms are also provided.

Qno1. List the symptoms which are mild in nature and last for 2 days.

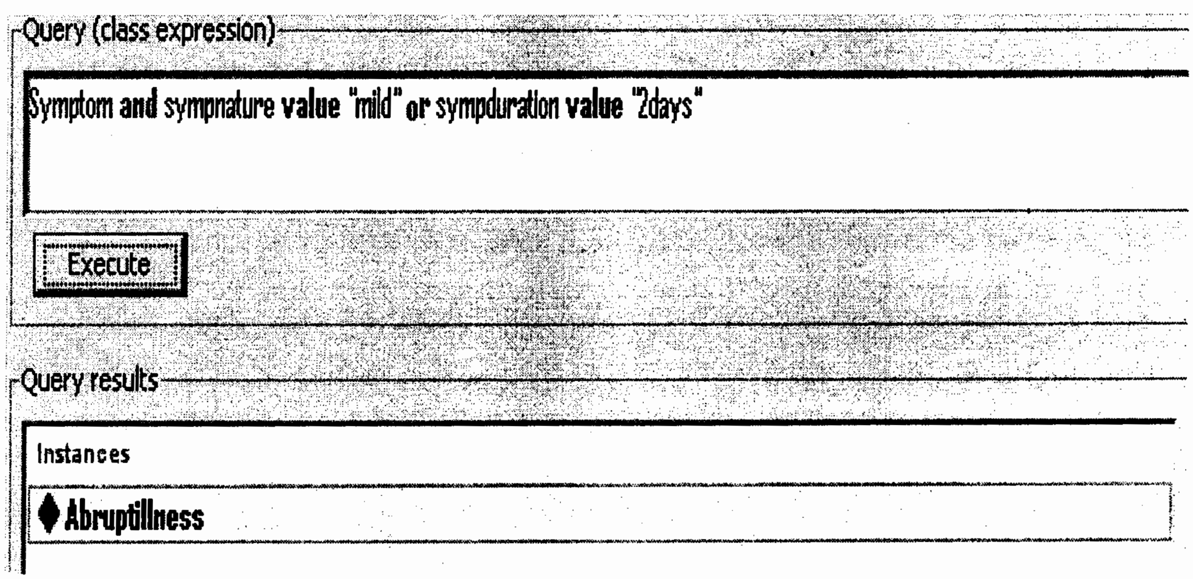

Fig. 5.15 Symptom classification on base of data properties

Qno2. List all medicines belong to cause Influenza A.

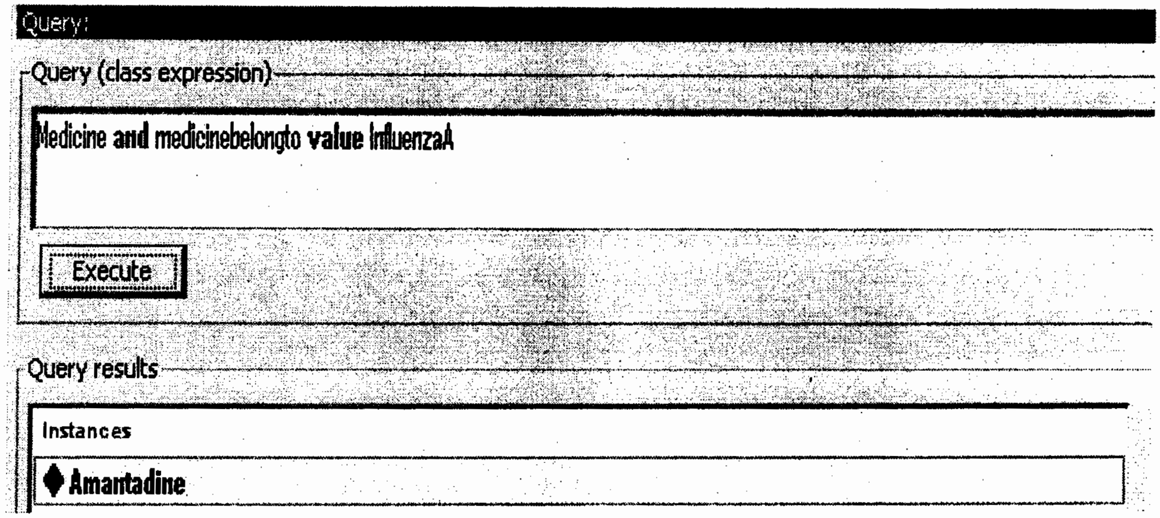

Fig. 5.16 Cause based medicines

Scenario 5: Drug allergies with respect to several medicines are also provided.

Qno1. List all the allergic medicines for PencillinVK

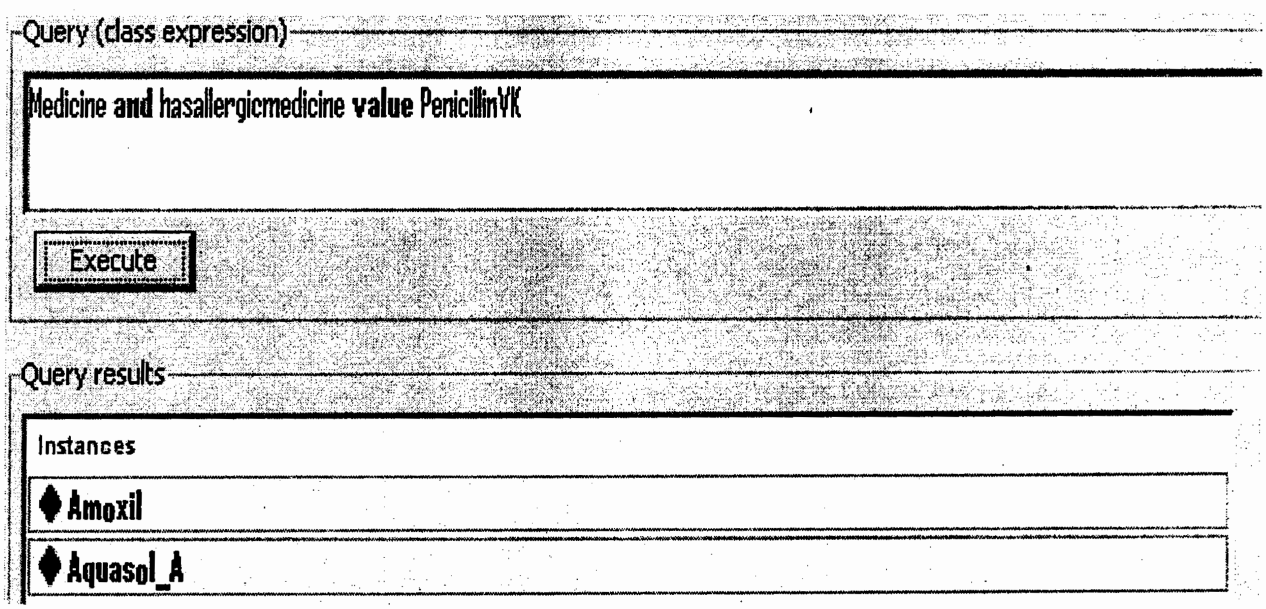

Fig. 5.17 List of Allergic medicines

Qno2. List all allergic medicines for the patients who have symptom Rash. (Reflexive)

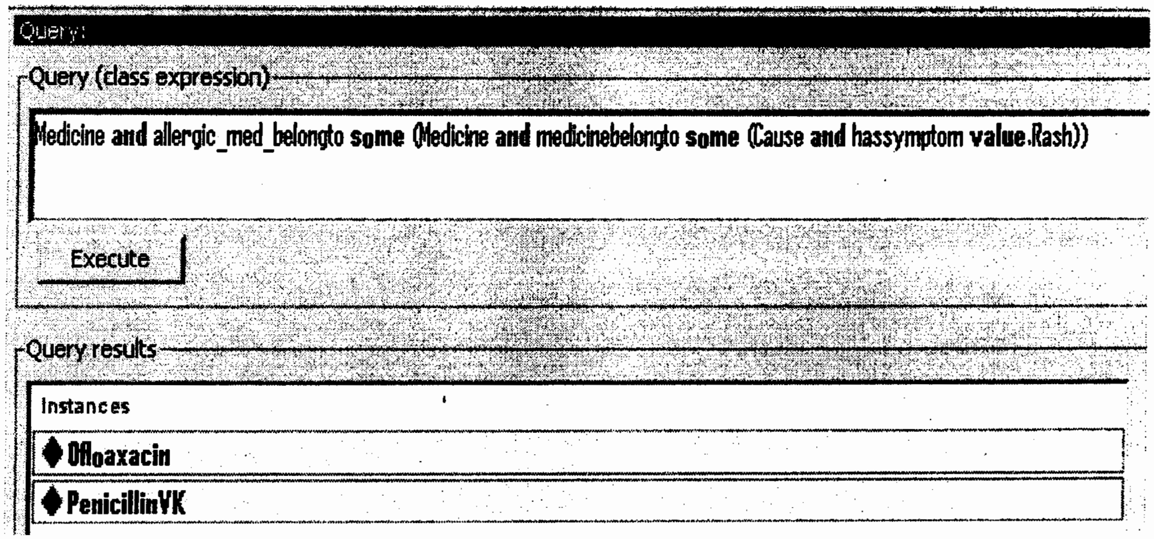

Fig. 5.18 List of Allergic medicines on the base of non allergic medicines

5.5.3 Ontology architecture (Pneumonia)

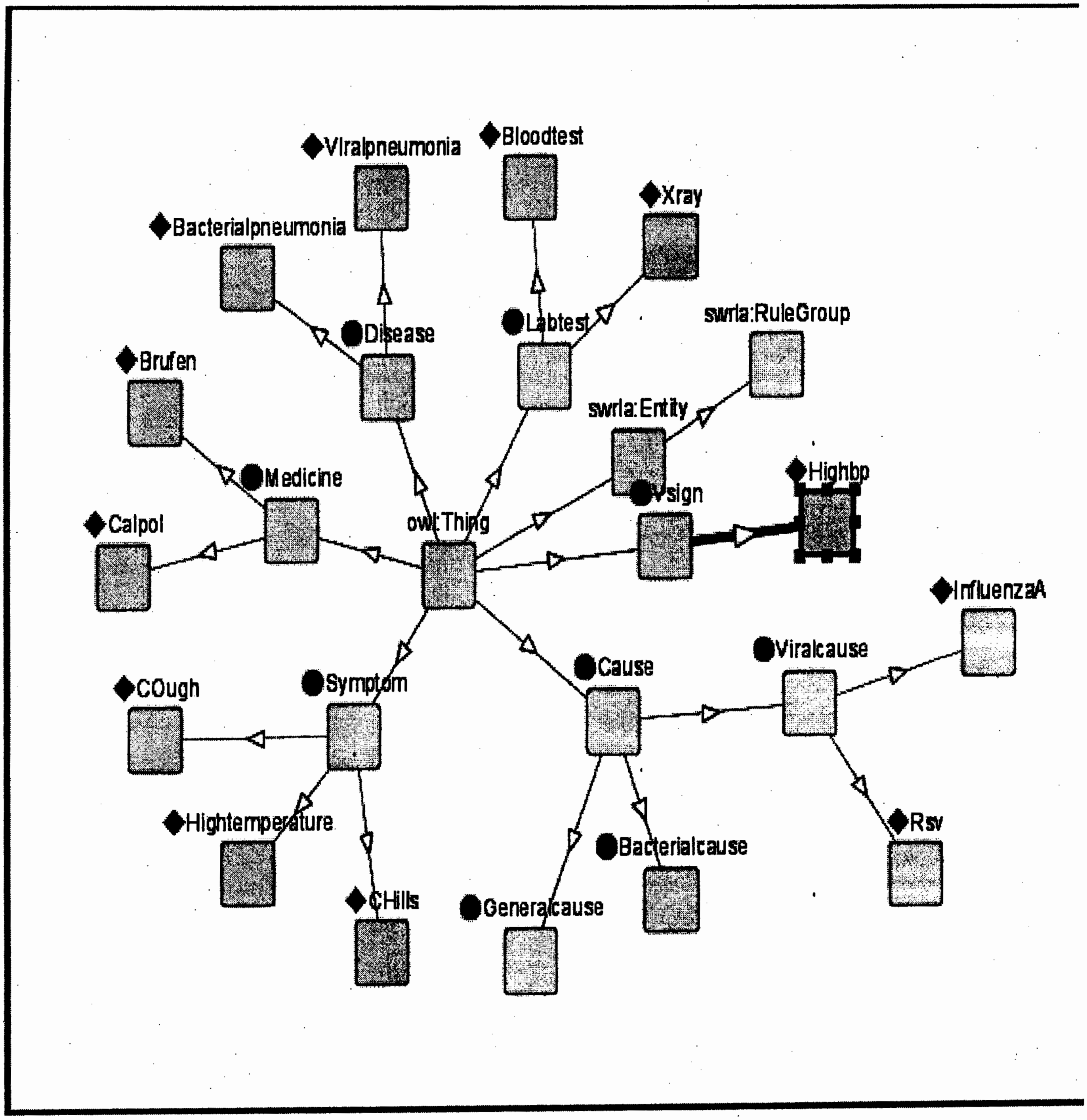

Fig: 5.19 Pneumonia Ontology structure

5.5.4 Disease cause and its link with other disease elements

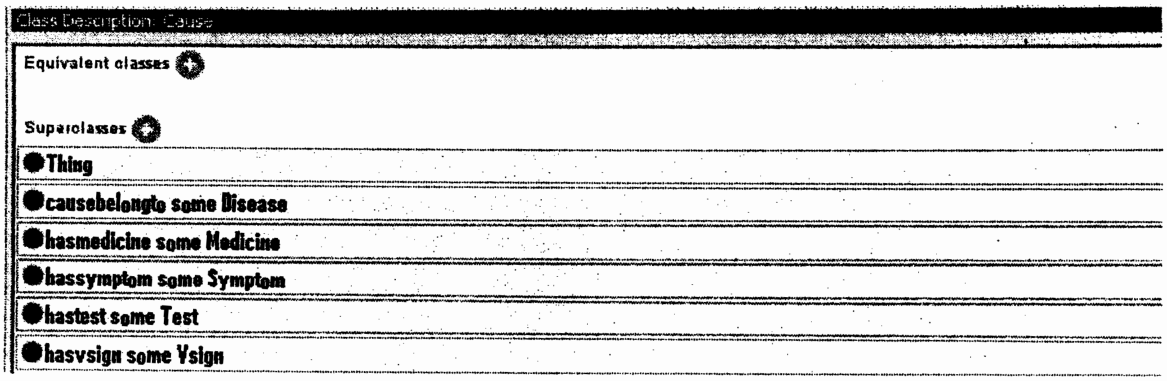

Fig: 5.20 Restrictions belong to Disease cause

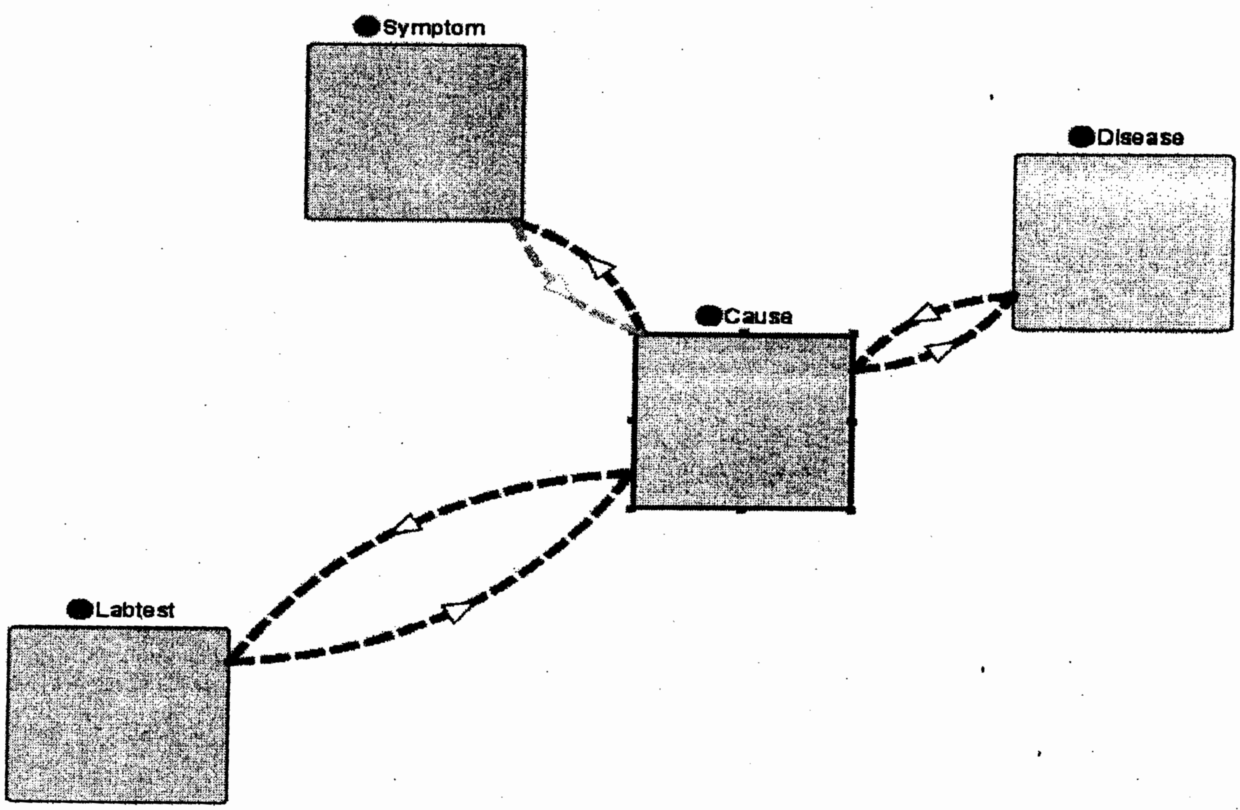

Fig: 21 Visualization in reasoning context

Chapter No. 6

Conclusion

Chapter no.6

Conclusion

6.1 Conclusion

Pneumonia disease diagnosis has been addressed in this research effort. We can a see a huge work in medical sciences but this respiratory disease lacks semantic contributions. Therefore, this effort proposes that the concepts of semantic web can be used for implementation of disease domain. It is basically descriptive work, thus initially, the causes of disease has been explored along with symptom, medicine and test discovery. Then the extensive exploratory work has been carried out to get the knowledge in pneumonia domain. After deep efforts on disease elements classification domain and range lists have been finalized. Object and data properties have been associated with all classes. In the last several DL queries have been designed to test ontology accuracy which in turn remained successful. NCBO Bio portal and OBO foundry are important milestones in this dynamic area. But already existing applications are mostly upper ontology which doesn't cover detail aspects of disease in order to diagnose it. Remaining research has mostly focused on upper domains but this work carries detail disease concepts and their correlation.

6.2 Contribution

The main contribution of this work is that it added a new dimension in existing semantic health care work by providing rich capabilities of disease diagnosis. Several new terms has been introduced which were short before. Multi dimensional correlation has been inducted with disease cause as base element. Experts can make it more useful by adding their new concepts in this ontology. Drugs allergies have been handled on the basis of drug characteristics. New tests has been added which are very rare in Pakistani medical community due to unavailability of their resources. Most convincing is the domain knowledge which has been collected from several international and national resources.

6.3 Future work:

An ontology-based approach for the diagnosis of Pneumonia disease has been implemented. The foremost objective of this work is to underline the potential applicability of this new approach in order to support pulmonologists in the disease diagnosis process. For this cause, the created ontology is based on a descriptive and thorough analysis of pneumonia disease domain. At the moment, the technique has been experienced only over a few proof data. Future study may include how to make this work distributed in order to integrate it with some enterprise semantic grid and to provide experts the best opinions while diagnosing diseases. Several anatomical and surgical predictions will be properly carried out on the basis of inferred knowledge.

Appendices

Appendix A

XML code for Pneumonia disease ontology

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [
<!ENTITY owl "http://www.w3.org/2002/07/owl#" >
<!ENTITY swrl "http://www.w3.org/2003/11/swrl#" >
<!ENTITY swrlb "http://www.w3.org/2003/11/swrlb#" >
<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >
<!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >
<!ENTITY assert "http://www.owl-ontologies.com/assert.owl#" >
<!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >
<!ENTITY protege "http://protege.stanford.edu/plugins/owl/protege#"
>
<!ENTITY xsp "http://www.owl-ontologies.com/2005/08/07/xsp.owl#" >
<!ENTITY swrla "http://swrl.stanford.edu/ontologies/3.3/swrla.owl#"
>
<!ENTITY sqwrl "http://sqwrl.stanford.edu/ontologies/built-
ins/3.4/sqwrl.owl#" >
]>
<rdf:RDF xmlns="http://www.owl-ontologies.com/test.owl#"
    xml:base="http://www.owl-ontologies.com/test.owl"
    xmlns:swrla="http://swrl.stanford.edu/ontologies/3.3/swrla.owl#"
    xmlns:sqwrl="http://sqwrl.stanford.edu/ontologies/built-
ins/3.4/sqwrl.owl#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:xsp="http://www.owl-ontologies.com/2005/08/07/xsp.owl#"
    xmlns:swrl="http://www.w3.org/2003/11/swrl#"
    xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
    xmlns:swrlb="http://www.w3.org/2003/11/swrlb#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:assert="http://www.owl-ontologies.com/assert.owl#">
```

```
    <owl:Ontology rdf:about="">
        <owl:imports                              rdf:resource="http://www.owl-
ontologies.com/assert.owl"/>
        <owl:imports
rdf:resource="http://swrl.stanford.edu/ontologies/3.3/swrla.owl"/>
        <owl:imports
rdf:resource="http://sqwrl.stanford.edu/ontologies/built-
ins/3.4/sqwrl.owl"/>
    </owl:Ontology>
    <swrl:Imp rdf:ID="Rule-1">
        <swrla:isRuleEnabled
rdf:datatype="&xsd;boolean">false</swrla:isRuleEnabled>
    </swrl:Imp>
    <owl:Class rdf:ID="Bacterialcause">
        <rdfs:subClassOf rdf:resource="#Cause"/>
    </owl:Class>
    <Disease rdf:ID="Bacterialpneumonia"/>
    <Labtest rdf:ID="Bloodtest"/>
    <Medicine rdf:ID="Brufen"/>
    <Medicine rdf:ID="Calpol"/>
    <owl:Class rdf:ID="Cause"/>
    <owl:ObjectProperty rdf:ID="Causebelongsto">
        <rdfs:domain rdf:resource="#Cause"/>
        <owl:inverseOf rdf:resource="#hascause"/>
        <rdfs:range rdf:resource="#Disease"/>
    </owl:ObjectProperty>
    <Symptom rdf:ID="CHills"/>
    <Symptom rdf:ID="COugh"/>
    <owl:Class rdf:ID="Disease"/>
    <owl:Class rdf:ID="Generalcause">
        <rdfs:subClassOf rdf:resource="#Cause"/>
    </owl:Class>
    <owl:ObjectProperty rdf:ID="hascause">
        <rdfs:domain rdf:resource="#Disease"/>
        <owl:inverseOf rdf:resource="#Causebelongsto"/>
        <rdfs:range rdf:resource="#Cause"/>
    </owl:ObjectProperty>
    <owl:ObjectProperty rdf:ID="hassymptom">
```

```
        <rdfs:domain rdf:resource="#Cause"/>
        <owl:inverseOf rdf:resource="#symptombelongsto"/>
        <rdfs:range rdf:resource="#Symptom"/>
    </owl:ObjectProperty>
    <owl:ObjectProperty rdf:ID="hastest">
        <rdfs:domain rdf:resource="#Cause"/>
        <owl:inverseOf rdf:resource="#testtruefor"/>
        <rdfs:range rdf:resource="#Labtest"/>
    </owl:ObjectProperty>
    <Vsign rdf:ID="Highbp"/>
    <Symptom rdf:ID="Hightemperature"/>
    <Viralcause rdf:ID="InfluenzaA"/>
    <owl:Class rdf:ID="Labtest"/>
    <owl:Class rdf:ID="Medicine"/>
    <Viralcause rdf:ID="Rsv"/>
    <owl:Class rdf:ID="Symptom"/>
    <owl:ObjectProperty rdf:ID="symptombelongsto">
        <rdfs:domain rdf:resource="#Symptom"/>
        <owl:inverseOf rdf:resource="#hassymptom"/>
        <rdfs:range rdf:resource="#Cause"/>
    </owl:ObjectProperty>
    <owl:ObjectProperty rdf:ID="testtruefor">
        <rdfs:domain rdf:resource="#Labtest"/>
        <owl:inverseOf rdf:resource="#hastest"/>
        <rdfs:range rdf:resource="#Cause"/>
    </owl:ObjectProperty>
    <owl:Class rdf:ID="Viralcause">
        <rdfs:subClassOf rdf:resource="#Cause"/>
        <assert:notEmpty rdf:datatype="&xsd;string"
            >SELECT ?subject ?object
WHERE { ?subject rdfs:subClassOf ?object }</assert:notEmpty>
    </owl:Class>
    <Disease rdf:ID="VIralpneumonia"/>
    <owl:Class rdf:ID="Vsign"/>
    <Labtest rdf:ID="Xray"/>
</rdf:RDF>
```

Appendix B

Sample Protégé-OWL Java Code

```
import impl;
import edu.stanford.smi.protege.model.FrameID;
import edu.stanford.smi.protegex.owl.model.*;
import edu.stanford.smi.protegex.owl.model.impl.OWLUtil;
import edu.stanford.smi.protegex.owl.javacode.ProtegeJavaMapping;

import java.util.*;

/**
 * Generated by Protege-OWL  (http://protege.stanford.edu/plugins/owl).
 *
 * @version generated on Tue Sep 20 03:33:44 GMT+05:00 2005
 */
public class Protege_owl_java_code {

    private OWLModel owlModel;

    static {

ProtegeJavaMapping.add("http://swrl.stanford.edu/ontologies/3.3/swrla.o
wl#Entity", Entity.class, DefaultEntity.class);

ProtegeJavaMapping.add("http://swrl.stanford.edu/ontologies/3.3/swrla.o
wl#RuleGroup", RuleGroup.class, DefaultRuleGroup.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Bacterialcause", Bacterialcause.class,
DefaultBacterialcause.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Cause", Cause.class, DefaultCause.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Vsign", Vsign.class, DefaultVsign.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Medicine", Medicine.class,
DefaultMedicine.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Symptom", Symptom.class, DefaultSymptom.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Disease", Disease.class, DefaultDisease.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Viralcause", Viralcause.class,
DefaultViralcause.class);
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Generalcause", Generalcause.class,
DefaultGeneralcause.class);
```

```
        ProtegeJavaMapping.add("http://www.owl-
ontologies.com/test.owl#Labtest", Labtest.class, DefaultLabtest.class);
    }

    public Protege_owl_java_code(OWLModel owlModel) {
        this.owlModel = owlModel;
    }

    public <X> X create(Class<? extends X> javaInterface, String name)
{
        return ProtegeJavaMapping.create(owlModel, javaInterface,
name);
    }


    public RDFSNamedClass getEntityClass() {
        final String uri =
"http://swrl.stanford.edu/ontologies/3.3/swrla.owl#Entity";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Entity createEntity(String name) {
        final RDFSNamedClass cls = getEntityClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultEntity(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Entity getEntity(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Entity) {
            return (Entity) res;
        } else if (res.hasProtegeType(getEntityClass())) {
            return new DefaultEntity(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Entity> getAllEntityInstances() {
        return getAllEntityInstances(false);
    }

    public Collection<Entity> getAllEntityInstances(boolean transitive)
{
        Collection<Entity> result = new ArrayList<Entity>();
        final RDFSNamedClass cls = getEntityClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultEntity(owlModel,
owlIndividual.getFrameID()));
```

```
        }
        return result;
    }


    public RDFSNamedClass getRuleGroupClass() {
        final String uri =
"http://swrl.stanford.edu/ontologies/3.3/swrla.owl#RuleGroup";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public RuleGroup createRuleGroup(String name) {
        final RDFSNamedClass cls = getRuleGroupClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultRuleGroup(owlModel,
cls.createInstance(name).getFrameID());
    }

    public RuleGroup getRuleGroup(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof RuleGroup) {
            return (RuleGroup) res;
        } else if (res.hasProtegeType(getRuleGroupClass())) {
            return new DefaultRuleGroup(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<RuleGroup> getAllRuleGroupInstances() {
        return getAllRuleGroupInstances(false);
    }

    public Collection<RuleGroup> getAllRuleGroupInstances(boolean
transitive) {
        Collection<RuleGroup> result = new ArrayList<RuleGroup>();
        final RDFSNamedClass cls = getRuleGroupClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultRuleGroup(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getBacterialcauseClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Bacterialcause";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
```

```
    }

    public Bacterialcause createBacterialcause(String name) {
        final RDFSNamedClass cls = getBacterialcauseClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultBacterialcause(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Bacterialcause getBacterialcause(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Bacterialcause) {
            return (Bacterialcause) res;
        } else if (res.hasProtegeType(getBacterialcauseClass())) {
            return new DefaultBacterialcause(owlModel,
res.getFrameID());
        }
        return null;
    }

    public Collection<Bacterialcause> getAllBacterialcauseInstances() {
        return getAllBacterialcauseInstances(false);
    }

    public Collection<Bacterialcause>
getAllBacterialcauseInstances(boolean transitive) {
        Collection<Bacterialcause> result = new
ArrayList<Bacterialcause>();
        final RDFSNamedClass cls = getBacterialcauseClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultBacterialcause(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getCauseClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Cause";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Cause createCause(String name) {
        final RDFSNamedClass cls = getCauseClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
```

```
        return  new DefaultCause(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Cause getCause(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Cause) {
            return (Cause) res;
        } else if (res.hasProtegeType(getCauseClass())) {
            return new DefaultCause(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Cause> getAllCauseInstances() {
        return getAllCauseInstances(false);
    }

    public Collection<Cause> getAllCauseInstances(boolean transitive) {
        Collection<Cause> result = new ArrayList<Cause>();
        final RDFSNamedClass cls = getCauseClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultCause(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getVsignClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Vsign";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Vsign createVsign(String name) {
        final RDFSNamedClass cls = getVsignClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultVsign(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Vsign getVsign(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Vsign) {
            return (Vsign) res;
        } else if (res.hasProtegeType(getVsignClass())) {
```

```
            return new DefaultVsign(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Vsign> getAllVsignInstances() {
        return getAllVsignInstances(false);
    }

    public Collection<Vsign> getAllVsignInstances(boolean transitive) {
        Collection<Vsign> result = new ArrayList<Vsign>();
        final RDFSNamedClass cls = getVsignClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultVsign(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getMedicineClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Medicine";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Medicine createMedicine(String name) {
        final RDFSNamedClass cls = getMedicineClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultMedicine(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Medicine getMedicine(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Medicine) {
            return (Medicine) res;
        } else if (res.hasProtegeType(getMedicineClass())) {
            return new DefaultMedicine(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Medicine> getAllMedicineInstances() {
        return getAllMedicineInstances(false);
    }

    public Collection<Medicine> getAllMedicineInstances(boolean
transitive) {
```

```
        Collection<Medicine> result = new ArrayList<Medicine>();
        final RDFSNamedClass cls = getMedicineClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultMedicine(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getSymptomClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Symptom";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Symptom createSymptom(String name) {
        final RDFSNamedClass cls = getSymptomClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultSymptom(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Symptom getSymptom(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Symptom) {
            return (Symptom) res;
        } else if (res.hasProtegeType(getSymptomClass())) {
            return new DefaultSymptom(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Symptom> getAllSymptomInstances() {
        return getAllSymptomInstances(false);
    }

    public Collection<Symptom> getAllSymptomInstances(boolean
transitive) {
        Collection<Symptom> result = new ArrayList<Symptom>();
        final RDFSNamedClass cls = getSymptomClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultSymptom(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
```

```
    }

    public RDFSNamedClass getDiseaseClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Disease";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

    public Disease createDisease(String name) {
        final RDFSNamedClass cls = getDiseaseClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultDisease(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Disease getDisease(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Disease) {
            return (Disease) res;
        } else if (res.hasProtegeType(getDiseaseClass())) {
            return new DefaultDisease(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Disease> getAllDiseaseInstances() {
        return getAllDiseaseInstances(false);
    }

    public Collection<Disease> getAllDiseaseInstances(boolean
transitive) {
        Collection<Disease> result = new ArrayList<Disease>();
        final RDFSNamedClass cls = getDiseaseClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultDisease(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getViralcauseClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Viralcause";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }
```

```
    public Viralcause createViralcause(String name) {
        final RDFSNamedClass cls = getViralcauseClass();
        if (name == null) {
            name = owlModel.getNextAnonymousResourceName();
        }
        return  new DefaultViralcause(owlModel,
cls.createInstance(name).getFrameID());
    }

    public Viralcause getViralcause(String name) {
        RDFResource res =
owlModel.getRDFResource(OWLUtil.getInternalFullName(owlModel, name));
        if (res == null) {return null;}
        if (res instanceof Viralcause) {
            return (Viralcause) res;
        } else if (res.hasProtegeType(getViralcauseClass())) {
            return new DefaultViralcause(owlModel, res.getFrameID());
        }
        return null;
    }

    public Collection<Viralcause> getAllViralcauseInstances() {
        return getAllViralcauseInstances(false);
    }

    public Collection<Viralcause> getAllViralcauseInstances(boolean
transitive) {
        Collection<Viralcause> result = new ArrayList<Viralcause>();
        final RDFSNamedClass cls = getViralcauseClass();
        RDFResource owlIndividual;
        for (Iterator it =
cls.getInstances(transitive).iterator();it.hasNext();) {
            owlIndividual = (RDFResource) it.next();
            result.add(new DefaultViralcause(owlModel,
owlIndividual.getFrameID()));
        }
        return result;
    }


    public RDFSNamedClass getGeneralcauseClass() {
        final String uri = "http://www.owl-
ontologies.com/test.owl#Generalcause";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFSNamedClass(name);
    }

        public RDFProperty getNotEmptyProperty() {
        final String uri = "http://www.owl-
ontologies.com/assert.owl#notEmpty";
        final String name = owlModel.getResourceNameForURI(uri);
        return owlModel.getRDFProperty(name);
    }
```

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