International Journal of Computer and Communication Technology

Volume 2 | Issue 4 Article 6

October 2011

Design and Discovery of Sensor Web Registry Services for Wireless Sensor Network with x-SOA Approach

Manoranjan Parhi
Dept. of Computer Applications1, 2, Dept. of Computer Science & Engineering3 ITER, Siksha 'O' Anusandhan University, Bhubaneswar, Orissa, manoranjanparhi@iter.ac.in

B. M. Acharya
Dept. of Computer Applications1, 2, Dept. of Computer Science & Engineering3 ITER, Siksha 'O' Anusandhan University, Bhubaneswar, Orissa, biswamohanacharya@iter.ac.in

B. Puthal
Dept. of Computer Applications1, 2, Dept. of Computer Science & Engineering3 ITER, Siksha 'O' Anusandhan University, Bhubaneswar, Orissa, bputhal@iter.ac.in

Design and Discovery of Sensor Web Registry Services for Wireless Sensor Network with x-SOA Approach

Manoranjan Parhi[1], B.M. Acharya[2], B. Puthal[3]
Dept. of Computer Applications[1, 2], Dept. of Computer Science & Engineering[3]
ITER, Siksha 'O' Anusandhan University, Bhubaneswar, Orissa
manoranjanparhi@iter.ac.in[1], biswamohanacharya@iter.ac.in[2], bputhal@iter.ac.in[3]

Abstract--**The application of wireless sensor network is emerging as a new trend in different sphere of modern society. However due to the advancement of SWE, designing & discovering sensor web registry services throughout heterogeneous environments is becoming a challenging task and raises several concerns like performance, reliability, and robustness. Many approaches and frameworks have been proposed to discover the sensor web registry services. Some of the approaches assume that the requests are placed in SOAP compatible formats while others focus on GUI based parametric query processing. We have formulated an approach that uses the Natural Language Query Processing which is a convenient and easy method of data access, especially for casual users who do not understand complicated database query languages such as SQL or XML based Query Language like XQuery and XPath. SOA is the proven technology for designing an efficient Sensor Web Registry by describing various parameters and sensor web services needed. We also propose an architecture based on x-SOA that organizes the method of sensor web registry service discovery in an efficient and structured manner using an intermediary, requester friendly layer called the Request Parser & Query Generator (RPQ) between the service provider and service requester via a service registry. We describe how RPQ facilitates the processing of plain text request query to a most appropriate sensor web service and also an algorithm with implementation for a complete cycle of sensor web registry service discovery.**

Keywords: *Sensor Web Enablement Standard (SWE), Sensor Web Registry, Natural Language Processing, Request Parser & Query Generator (RPQ), Service Oriented Architecture (SOA), Extended SOA (x-SOA)*

1. INTRODUCTION

Recently the sensor network services that provide useful function by sensing the condition of physical, biological, chemical and meteorological phenomena in order to build expert systems in domains like wildlife tracking, precision agriculture, risk monitoring or hazard management. Therefore it becomes challenge for the external users or systems to discover and invoke the sensor-derived data. It requires immediate attention to facilitate smooth search and query operations on all the sensor networks and to get a global view of the data. This will facilitate accuracy and comprehensiveness in analysis, and synthesis of the data. The OGC SWE [1] framework, which is based on the service-oriented architectures (SOA) concept that defines the interfaces of (web) services for accessing sensor data, for controlling sensors and for alerting based on measured sensor data. Within the last few years, the SWE architecture has been advanced to a solid and mature state. It has provided a comprehensive markup language called SensorML which is used to describe various aspects of wireless sensor networks like its description, processes, process chains, parametric representations of the sensed entities. As the technology of web services is offering exciting new way to increase the communicational and process efficiency of web, A Service Oriented Sensor Web [2] was developed to access the data and processes at gateway location. The authors in [2] emphasized the need of web services for retrieving the data and executing the processes or process chains. More and more networks are adopting the sensor web architecture with the goal of achieving worldwide integrated sensor network that may provide the functionalities similar to those available through internet. However, to achieve the same there is need of providing a centralized or distributed registry for wireless sensor network. The SOA is the proven technologies which can be considered for design, implementation and discovery of efficient sensor web registry.

In this paper we have used an AI technique called Natural Language Query Processing [9] [10] for human-sensor web registry interaction without using any parametric choice graphical user interface. By the help of this approach the client request written in English sentence can be translated into SQL using semantic grammar for discovering corresponding sensor web service. We propose an improvised architecture called x-SOA (Extended SOA) using an intermediary, requester friendly layer called Request Parser & Query Generator (RPQ) between the service provider and service requester via a service registry that organizes the method of sensor web service discovery in an efficient and structured manner.

The rest of the paper is organized as follows. In Section 2, we discuss the related work in sensor web registry and state their limitations. In section 3,

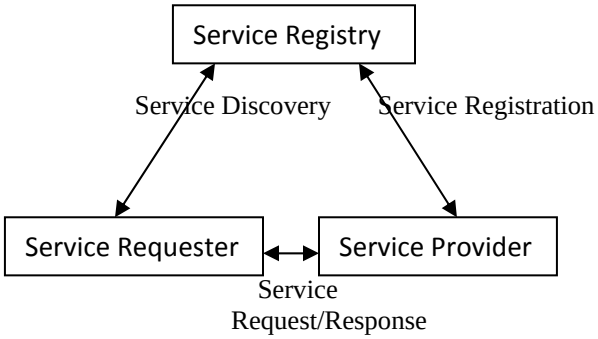

Figure 1. General Architecture of the Service Discovery

we describe architecture of sensor web registry and the query parameters for sensor web registry discovery. In section 4, our proposed work covers an improvised architecture called x-SOA, an efficient algorithm using NLP for sensor web service discovery, the information flow between various layers of our proposed architecture and an experimental evaluation of our proposed technique and finally in section 5 we give some concluding remarks and outline future work.

2. RELATED WORK

Many approaches and frameworks have been proposed to design and discover the sensor web registry services.

In [2] the authors proposed several important components on the sharing of sensor network data using the Web services and SWE standards. The Sensor Web proposed a registry for sensor network discovery and registration called Sensor Registry Service. The Sensor Registry Service is too abstract in the service oriented sensor web because too little attention has been given to the detail functionality of the sensor registry service.

In [3] a unique SOA approach is presented to design a sensor web registry that can be hosted on a special server called Sensor Name Server that cooperates and collaborates in searching a sensor network. However the author has given more emphasis on design of sensor web registry rather than sensor discovery process. This paper explains that the client is given a web based GUI interface to search a sensor network based on single or combination of parameters given in the registry. But it may not be an efficient approach for the casual users who have no idea about the above type of sensor search interface with parametric choice.

In [4] a sensor network registry is proposed and the query parameters for sensor network discovery are analyzed by 5W1H method. Here the authors have mentioned that the sensor network registry receives the discovery query using XML (XQuery). However XQuery and XPath are the advanced XML based technology which is very difficult for the novice requesters to understand.

In GEOSS [5], a community of researchers emphasized the need of sensor web registry with SWE compliance. It also discusses ad hoc network and moving (nomadic) sensor. But It does not provide any solution for design and discover of sensor registry service.

The author in [6] proposed that the sensor register is part of the web framework but emphasis is given on classification of domain name system like naming for different region. It is very conceptual and does not elaborate the other contents which can be the part of the registry.

The IrisNet [7] also proposes the software infrastructure for the sensor network discovery. The IrisNet is different from the SensorWeb in that it operates the independent registry for each sensor-based service. The configuration of an independent registry for the each service causes a problem because the user can not be sure of the sensor network address at the first stage of the service discovery.

Trabelsi et al [8] also present sensor web registry but their primary focus is on the context based security of sensor networks. The author has mentioned about providing the security against various attacks. It is also suggested to use the Web Ontology language to classify the sensor information relationship and behaviors. The ontology is still the state of art and lot of research is going in this area, and will be really useful but again it poses a limitation on the kind of search engine and complexity of logic which one has to put in developing a registry for search.

As per the above discussion a concrete proposal is yet required for the design and discovery of universal distributed sensor registry database service which can handle heterogeneous sensor networks more efficiently. The most important points of sensor network data sharing is defining the different functions of the sensor web registry such as the registered information and the request query.

3. DESIGN OF SENSOR WEB REGISTRY

In this section we describe the overall architecture and design of the sensor web registry and define the necessary querying parameters for sensor service discovery. There are two objectives of our Sensor Web Registry Services. One is to provide the capabilities to store, manage and version service information and their artifacts. The other is to define a XML Schema for service description and generates WSDL (Web Service Description Language) accordingly, when needed.

3.1 Architecture of Sensor Web Registry

The main purpose of universal sensor web registry is to offer the heterogeneous sensor network information corresponding to user's query. The schematic diagram of sensor web registry architecture and operations are explained below.

- The sensor network service provider registers the services of sensor network through sensor web registration interface for sensor-derived data opening.
- The registration module sends the information, which is registered by the sensor network service provider to the Information Storage (IS) of sensor registry.
- When the user sends the query message to sensor web registry the sensor web discovery interface delivers it to the query processor.
- The query processor processes the user query and brings related sensor network information from the information storage of sensor registry.

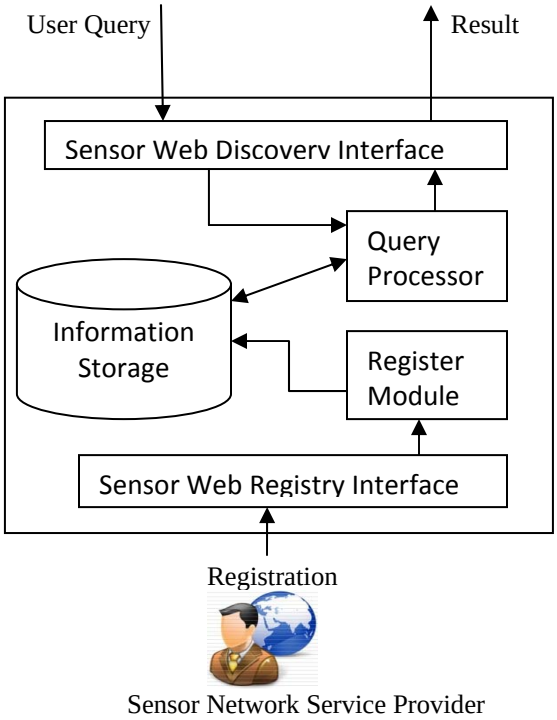

Figure 2: Architecture of Sensor Web Registry

3.2 Query Parameters for Sensor Web Registry

An efficient Sensor Web Registry should contain the following parameters for satisfying the sensor service discovery query efficiently.

- Sensor Domain Name

A unique name representing sensor network like http://www.wsn.env.orissa.in

- Gateway IP Address

The IP address of the host where all the data about the sensor network is hosted. It is directly mapped to the Sensor Domain name.

- Port

The port at which the gateway host responds to the outside world

- Mobility Status

It indicates the topology status of the sensors i.e. either fixed or nomadic (moving)

- Geo Spatial Data

The Geo location attribute represents the position and area cover under sensor network.

- Meta Data

It indicates the complete information for the concerned sensor network

- Data Type Sensed

It represents the name of physical and non physical entities which are measured in the concerned sensor network

- Registration Required

A flag indicates yes/no that directs the user to a registration form before accessing any data

- Political Data

This covers the data regarding the political location on the world map. The data is relevant to fixed networks. It includes Continent, Country, Region, State, District, City/Village etc.

- Sensor Network Description Service

It is the URL of the web service represented by Web service Definition Language (WSDL) on the gateway which will return the description of sensor network, Sensor Observation Service (SOS) etc.

- Sensor Network operator

The name and address of the owner of the sensor networks.

3.3 A Sample XML document for Sensor Network Description

The Sensor Web Service gives the overall description of the sensor network. In our service registry, a XML schema is defined for describing the services. The service registry is the master catalog for service description. The concept of service here includes the traditional web services that implements WSDL interfaces with SOAP/HTTP

The following XML document represents a sample for sensor description.

```
<?xml version="1.0" encoding="UTF-8" ?>
<SensorNetDescription>
<SensedEntity>
   <Name>Temperature</Name>
   <Unit>Centigrade</Unit>

<ProcessChainName>TemperatureService</Pr
ocessChainName>

<StarterService>http://www.wsn.env.orissa.in:
85/GetTemperature?wsdl</StarterService>
  <BindingType>SOAP_BINDING
</BindingType>
```

<Return>**ARRAY2D-x,y,data**</Return>
<PortNo>**85**</PortNo>

<RegistrationRequired>**True**</RegistrationRequired>
<RolesAllowed>

<Roles>**Admin,SuperVisors,Wellwishers**</Roles>
<Users>**Manoranjan, BiswaMohan, Bhagabat**</Users>
</RolesAllowed>
</SensedEntity>-

</SensorNetDescription>

4. PROPOSED WORK

Our proposed architectural framework is inspired by extended Service Oriented Architecture (x-SOA) for the sensor web service discovery mechanism based on Natural Language Query Processing using semantic grammar. The main focus of our framework is the intermediate layer called Request Parser & Query Generator (RPQ) which provides interoperability between the service requester and service registry. We also propose an algorithm for various stages involved in the process of sensor service discovery and outline the interaction between different layers of the proposed architecture using UML sequence diagram. We have constructed the prototype of the sensor web registry which shows a process where the users searches the sensor network through the sensor web registry. Finally we have done an experimental evaluation by designing the sensor web registry using MySQL database and creating the Natural Language interface using Java technology [11].

4.1 x-SOA Architecture

Our proposed architectural framework (x-SOA) is an enhancement over the existing 3-tier SOA (Figure 1) architecture consists of

- Sensor Service Requester
- Request Parser and Query Generator
- Sensor Service Registry
- Sensor Service Provider

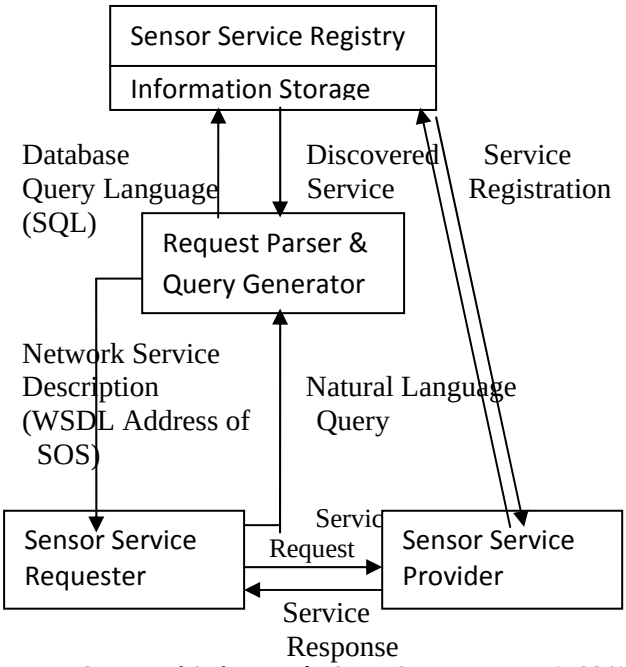

Figure 3: Proposed Architecture for Sensor Service Discovery(x-SOA)

In the above architecture the new layer RPQ sits on top of a sensor service requester that facilitate the preprocessing activities of a request query before it is being handed over to the sensor service registry for discovery. The roles and functionalities of RPQ are enumerated as follows:

- The RPQ shall act as an intermediate layer between Sensor Service Registry and Sensor Service Requester.
- The RPQ will accept the request from the requester and parse the request query string into its technical form by deriving the semantics of the natural language query.
- After successful parsing of the statement given by the requester, the RPQ generates a query against the user statement in SQL and further passes on to information storage of sensor service registry.
- After processing of the SQL statement the most appropriate sensor web service (WSDL address of the Sensor Observation Service) will be returned back to the requester via RPQ.
- The requester will than invoke the corresponding service in order to obtain sensor-derived data from sensor network.

4.2 Proposed Algorithm

Our algorithm describes various phases for a complete cycle of a sensor web registry service discovery which is based on the proposed framework. The overall algorithm can be broken down into 5 phases.

i. Raise Request
ii. Parse Request and Generate SQL
iii. Discover
iv. Publish
v. Return Service

Algorithm: Sensor Web Registry Service Discovery Mechanism (SWRSD)

Input: Natural Language Request Statement
Output: Appropriate Sensor Service

i. Raise Request

Let S be the natural language statement raised as a request
S= {W} set of words

ii. Parse Request and Generate SQL

1. **for** each word W_i from S **do**
2. **if** (W_i ← Grammer G) then
3. Add W_i to Symbol Table ST
4. **end if**
5. **end for**
6. **for** each W_i from ST **do**
7. add W_i to Parse Tree/s T for What-type question/s
8. **end for**
9. Diplay What-type of question/s Q
10. Read Input Q
11. **for** each Wi from Q **do**
12. **If** (Wi ← G) then
13. Add Wi to parse tree for SQL Query
14. **end if**
15. **end for**
16. Display SQL Query

iii. Discover

- The Sensor Service Registry has an information storage.
- The SQL Query generated in the previous step is passed to the information storage.
- After processed by the Query processor the sensor service is discovered from Sensor Registry.

iv. Publish:

- The sensor network service is registered/ published in Sensor service registry if it is not available

v. Return Service

- Return the appropriate sensor service to the requester

4.3 Interaction between layers of x-SOA

The request Parser and Query Generator will be built as a middleware on a client machine. Figure 4 shows the UML sequence diagram between various entities in our proposed framework

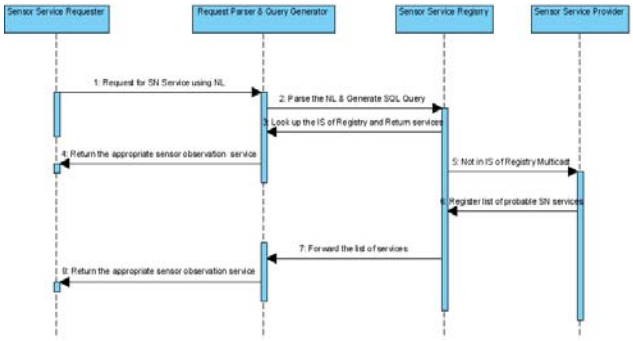

Figure 4: UML Sequence diagram for our proposed architecture (Sensor Service Discovery)

4.4 Prototype System

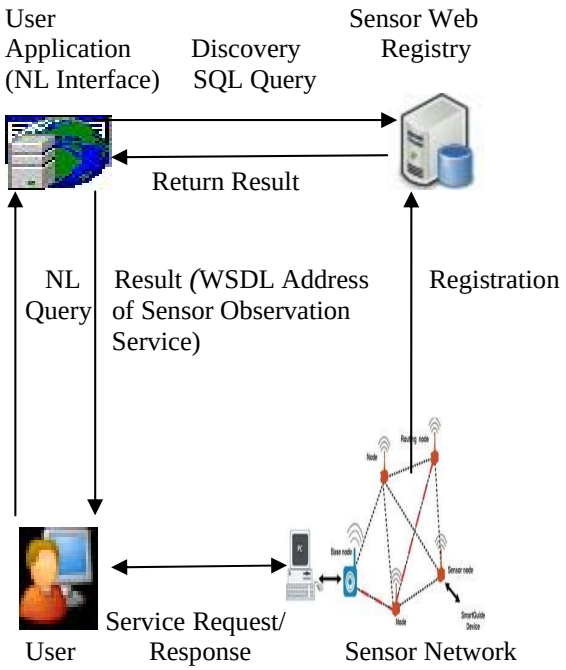

Figure 5: Operation of the prototype system

The Sensor Web Registry receives the generated SQL query. However, we can image the user application that provides NLP interface for easy use of Sensor Web Registry. In this

prototype system, we make the user application (Sensor Network Natural Language interface) for the end-user. Figure 5 depicts the interaction among the sensor network, the sensor web registry, the user application and end-user.The above prototype system works as follows.

i. The sensor network is registered to the sensor web registry.
ii. The user requests specific sensor network to the user applications (Natural Language Interface) using natural language (Here we have taken English query)
iii. The user application converts the user input to the sensor network discovery query (SQL Query) and transmits it to the sensor web registry.
iv. The sensor web registry replies with the information corresponding to the query.
v. The user application sends the appropriate sensor web service (WSDL Address of the Sensor Observation service) to the user system.
vi. Finally the user requests the services and uses them.

4.5 Experimental Evaluation

Our Natural Language Interface system for discovering sensor registry service is programmed on Java SE 6 platform is a distributed, loosely-coupled system, which can run on multiple operating systems, such as Linux, Windows, or Solaris. The Information Storage of Sensor Web Registry is designed using MySQL database package.

By the help of the above system a snapshot of the query is tested in the following way.

Input English Query by the User: List WSDLAddressOfSensorObservationService where SensorType equals Temperature
Semantic Query: What are the WSDLAddressOfSensorObservationService with SensorType Temperature?
Generated SQL Query:
SELECT sensornetworkregistry.WSDLAddressOfSensorObservationService FROM sensornetworkregistry WHERE sensornetworkregistry.SensorType = 'temperature'

Final Result obtained by the User:

Query results:
The value of WSDLAddressOfSensorObservationService is http://www.wsn.env.orissa.in:85/GetTemperature?wsdl.

Our proposed system implementation is tested for variety of NL statements under various categories and the results obtained are satisfactory under the known constraints.

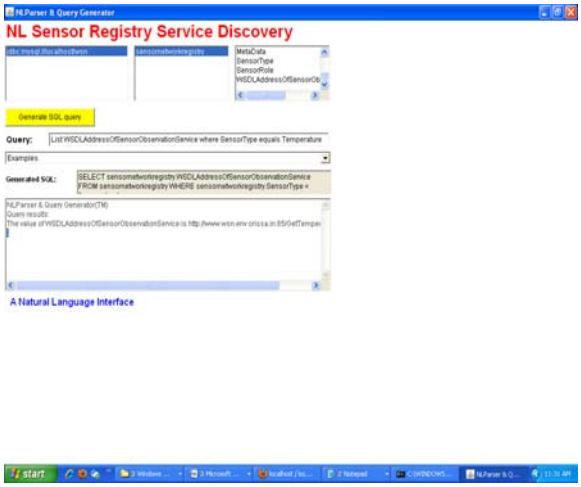

Figure 6: A Natural Language Interface System for Sensor Registry Service Discovery

5. CONCLUSION & FUTURE WORK

In this paper, a unique x-SOA approach is presented to discover a sensor web registry service. This architecture will help to reduce the burden of novice requesters or casual users from placing the request in XML or SOAP compatible formats. Exploring the natural language semantics instead of GUI based parametric search technique make the selection of sensor service more appropriate. Another advantage of introducing RPQ layer in our architecture offloads the message handling and preprocessing functionalities of the Service Registry. The future work aims at make the natural language query processing interface more dynamic so that requester can obtain the detailed and complete picture of sensor-derived data.

6. REFERENCES

[1] Mike Botts, George Percivall, Carl Reed, John Davidson., (2006), "OGC Sensor Web Enablement: Overview and High Level Architecture", Open Geospatial Consortium, OGC White Paper, OGC 06-050r2 v2, 19th July 2006

[2] Chu X., Buyya R., (2007), "Service Oriented Sensor Web, in Sensor Networks and Configuration: Fundamentals, Standards, Platforms and Applications" , N. P. Mahalik, (ed). Springer-Verlag, 2007, pp. 51-74, 978-3-40-37364-3

[3] Pandey, K.K. Patel, S.V. (2009) "A Design of Sensor Web Registry for Wireless Sensor Networks with SOA Approach", Proceedings of the 1st IEEE international

conference on Computational Intelligence, Communication Systems and Networks(CICSYN2009), Indore, India, July 23-25, pp.247-252

[4] Jeongkyu Park; Jiung Han; Kibong Kang; Keung Hae Lee.,(2007), "The Registry for Sensor Network Discovery", Proceedings of the 12th IEEE International Conference on Engineering Complex Computer Systems (ICECCS2007), Auckland, New Zealand, July 11-14, pp.129-137.

[5] Ingo Simonis " Meraka Institute, CSIR, South Africa , Johannes Echterho! " IfGI, University of Muenster, Germany June 2008 , GEOSS Sensor Web Workshop Report

[6] Ian Rhead, Madjid Merabti, Hala Mokhtar, Paul Fergus, *Worldwide Sensor Web Framework Overview* The 9th Annual Postgraduate Symposium on the Convergence of Telecommunications, Networking and Broadcasting, 23rd - 24th June, Liverpool, UK, 2008.

[7] P. B. Gibbons, B. Karp, Y. Ke, S. Nath and S. Seshan, "IrisNet: An Architecture for a World-WideSensor Web," IEEE Pervasive Computing, vol 2, no4, Oct.-Dec. 2003.

[8] Trabelsi, S.; Gomez, L.; Oudier, Y. Context-Aware Security Policy for the Service Discovery Advanced Information Networking and Applications Workshops,2007, AINAW apos;07. 21st International Conference on Volume 1, Issue , 21-23 May 2007 Page(s):477 –482

[9] Androutsopoulos, I., Richie, G.D., Thanisch, P. *"Natural Language Interface to Database – An Introduction."* Journal of Natural Language Engineering, Cambridge University Press. 1(1), 29-81, 1995.

[10] Huangi,Guiang Zangi, Phillip C-Y Sheu "A NaturalLanguage database Interface based on probabilistic contextfree grammar", IEEE International workshop on Semantic Computing and Systems 2008

[11] Watson, Mark "Practical Artificial Intelligence Programming in Java**",** 2002