The Design and Implementation of Malaysian Indigenous Herbs Knowledge Management System based on Ontology Model

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ABSTRACT

This paper introduces the design and implementation of an Ontology-Based Malaysian Herbal Knowledge-Based System (MiHerbs). The ontology model used in this research is based on a previous research with title, 'Malaysia Indigenous Herbs Knowledge Representation'. The research proposed an Ontology-based knowledge representation model of Malaysian indigenous herbs using Web Ontology Language (OWL). The model can be used to encode and store knowledge in a "Knowledge Base" such as database, repository or library. The model also can enhance search formulation in information retrieval of herbal knowledge with ease, fast and accurate. However, the backend databases which is based on the OWL language needs to be transformed to relational database format. The transformation from OWL to Relational database is based on the OWL2DB algorithm guideline will be further discussed in this research. Assisted by the System Development Life Cycle (SDLC) methodology, MiHerbs is expected to help herbal research agencies, private sector and government to store and share their herbal related information via the system to provide an ease information access to public or even people around the world.

Keywords*:* Herbal system, ontology, taxonomy, Malaysia herbs, knowledge management system

I INTRODUCTION

Herbs are one of the most useful medicinal plants with a rich and fascinating history that dates back thousands of years (Rizwan et al., 2007). In Malaysia, there are more than 2000 plant species that have healing qualities and highly potential to be commercialized with the gross profits of more than RM 5.4 billion a year could be reached from herbal related products selling (MARDI, 2015). It is important to preserve the medicinal plants since it is not only capable to bring economical importance as remedies but also has valuable knowledge of how the plant can be used, medicinal values, preparation methods and others. This is because as Malaysia moves towards the stream of global modernization, the art of traditional healing using medicinal plants suffers from the global emphasis on modern biomedical healthcare facilities and the disinterest of younger generations in traditional knowledge and practices (Kulip, 2003, Lin, 2005). Herbal related knowledge found from ethonobotanical studies by Kulip (2003), Lin (2005), Ahmad (2008), Ahmad & Ismail (2003), Ong & Nordiana (2009), and Samuel (2010) such as medicinal uses of plants, plant part uses, preparation methods and the local name of the plants have being published widely in the internet. However, the knowledge was scattered and unorganized in the internet, only can be accessed by academic journal subscription and merely own by local people that led to difficulty in designing knowledge based system.

This paper introduces the design and implementation of Malaysian herbal knowledge-based system based on an ontology model developed by Sahri et al. (2012). The research studied the development of new ontology representation model of Malaysia indigenous herbs based on thirty herbs which were collected from previous ethonobotanical studies and experts in herbal field. The ontology was used as the knowledge representation of Malaysia indigenous herbs due to its ability to identify the concepts or classes available in the herbal domain, its relationship between concepts and instances. The ontology model can be used to encode and store knowledge in a database or "Knowledge Base" (Rosenberg, 1986). Figure 1 shows the overall view of the Malaysia indigenous herbs knowledge representation using ontology model based on identified classes and instances. The ontology design in Figure 1 shows all herbs domain classes or concepts found in this research along with the subclasses and instances. In order to ensure the knowledge model and ontology view is well defined, this paper discusses the design and implementation of a Malaysian Herbal Knowledge-Based system based on the ontology classes and relationships defined. This process requires conversion of the OWL ontology into the relational database system and involved typical Software Development Life Cycle (SDLC) in designing the system which will be discussed further.

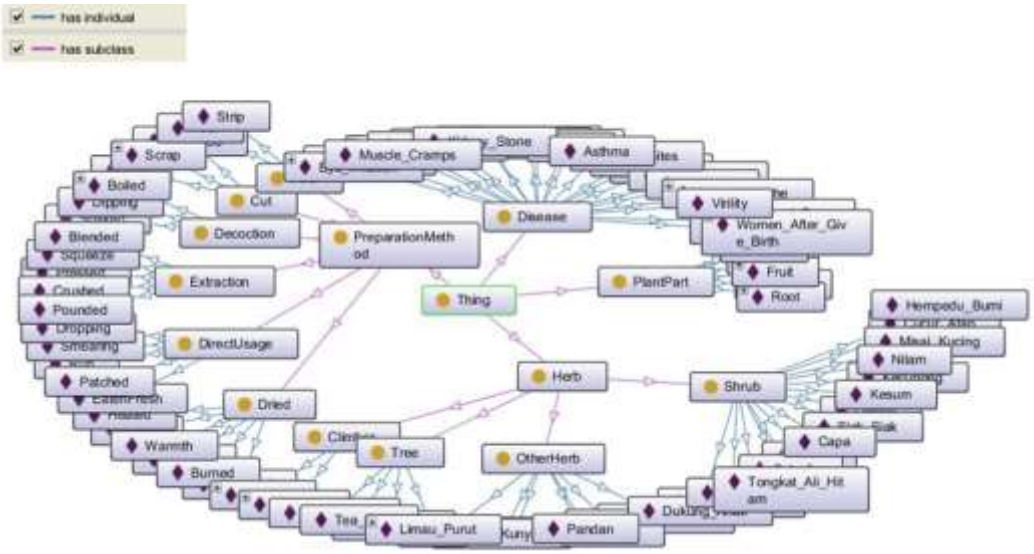

Figure 15. Malaysia Indigenous Herbs Knowledge Representation using Ontology (Sahri et. al, 2012)

In this paper, we research the ontology model developed by Sahri et al. (2012) and find the best way to develop a knowledge-based system based on the model. The system will be the end product of the developed model and the research studies, which can help people to easily access to Malaysian herbal knowledge-based system anytime and anywhere. This paper is organized as follows: Literature Review presents the conceptual understanding on ontology knowledge representation model, the software development life cycle and similar research. Methodology section describes the development of MiHerbs system from preliminary investigation and analysis on how to develop the system till the conversion process from ontology model to relational databases based on OWL2DB algorithm. The detail result of system development will be described in Result and Discussion section. Finally, concluding remarks are given in Conclusions section.

II LITERATURE REVIEW

A. Indigenous Knowledge of Medicinal Plants in Malayia

Malaysia has been granted with estimated of 15 000 known plants species, 3700 of useful species, 2000 species with medicinal value and the balance remain unexploited MARDI (2015). This has lead Malaysia as one of the research centers with a huge biodiversity plantation. One of the focuses of research in Malaysia is Herbs species which relate to the biotechnology is in the area of food and medicine industry (Foo, 2008). One of the focuses of research in Malaysia is Herbs species which relate to the biotechnology is in the area of food and medicine industry (Foo, 2008). In addition, Malaysia herbs are known with its medical value and economic importance with profits is more than RM 4.5 Billion a year in herbal based products (MARDI, 2015). Therefore, continuous research and development is needed in order to preserve the value of herbs. This can be done by considering the indigenous knowledge of medicinal plants uses by local people. Malaysia also can be a global player in providing products based on its natural medicinal plants. This is due the two strength points hold by Malaysia which are the plants growing in its forests and the local know-how about the numerous uses of medicinal plants; which is the indigenous knowledge (Nicholas & Lasimbang, 2004). Therefore, existing plants resources and traditional practices must be protected and expanded before forest depletion leads not only to the loss of valuable species but to the loss of valuable, indigenous knowledge as the people who hold that knowledge are displaced to other area (Ahmad, 2008). This is to show how important to preserve that knowledge by capturing, storing and disseminates the knowledge by conducting research study.

B. Ontology as a Knowledge Representation

Knowledge Representation describes the way on how particular domain knowledge can be best represented symbolically and manipulated in an automated medium by reasoning program (Brachman & Levesque, 2003). In relation to knowledge

management field, knowledge representation is required to convert tacit knowledge to explicit knowledge, and to represent the explicit knowledge in the form of suitable knowledge representation before it can be modelled and applied in knowledge sharing system such as database, repository or library (Obamsawim, 2002). There are many knowledge representation techniques in Artificial Intelligent (AI) field, the most popular and commonly used are *Logic, Production Rules, Semantic Nets and Frame* (Davis et al. 1993). However, Ontology representation has become the most preferred knowledge representation technique in recent years for a range of computer science specialties including the semantic web and bioinformatics (Thunkijjanujkij, 2009).

Ontology is a medium of expression whereby it gives ways for us to communicate with machines in order to tell them about the world (Thunkijjanujkij, 2009). Ontology can provide an organization framework about a concept which organized in a system of hierarchy and associative relations that allows reasoning about the knowledge. Generally, ontology as a graph/network structure consisting of;

- A set of concepts (vertices edges in a graph)
- A set of relationship connecting concept (directed edges in a graph)
- One set of instances assigned to a particular concepts (data records assigned to concepts or relation

Noy & McGuinness (2001) defined an ontology as a formal explicit description of concept in a domain of discourse (class or concept), properties that describe the characteristic of the concept (slots or roles), and restriction on slots (facet or role restriction). A complete Ontology with a set of individual instances of classes is able to form a knowledge base. In addition, the ontology can be used to develop the knowledge based by constructing the ontology model through the relevant concepts and their relationship. Therefore, the formalized ontology knowledge representation makes knowledge sharing and reuse possible through the knowledge based system. In contra to other knowledge representation techniques, Salem et, al (2008) found in the summary of their research that the ontology provides a robust knowledge representation technique for building a knowledge based system compared to semantic network in terms of restriction on relationship and property characteristic.

C. Knowledge Based System

Knowledge based system is one of the three components in an expert system, while another two components are an inference engine and user interface. Knowledge based system can be defined as a system that perform a task by applying rules in (Astari et. al, 2011). The underlying concept of knowledge based system is where knowledge is acquired and represented by using any of the knowledge represented such as semantic nets, production rules or frame before it can be encoded in the system. Astari et. al (2011) stated that the advantages of knowledge based system are as follows;

1) Provides permanent knowledge
2) Can be used as decision support system
3) Provides explanation of recommendation
4) Provides fast response to problems
5) Provides a stable and complete responses

The Malaysian Herbal Knowledge-based system satisfies the definition of knowledge based system and its components. This is because the system development is based on an ontology knowledge representation developed by previous research and it has the components of a knowledge expert system such as knowledge base, inference engine and user interface.

D. Review on Current Research

Previous researches (Kato et al. 2009; Zakaria et al. 2014; Tungkwampian et al. 2015) have studied the use of ontology technique in developing herbal related information system. Kato et al. (2009) proposed an ontology-based E-Health system that can helps users to search for Thai herbs to cure disease. The research applied existing tools and technologies which focus on inference engine. The research employed RDF, RDF Schema, OWL to describe Thai herb knowledge and Protégé ontology editor to edit the ontology. In order to simulate the inference process, JESS inference engine and SWRL were used. The research uses Jena as their system's inference engine with the implementation of JSP Java Servlet technologies to execute Java program in Jena to infer Thai herb recommendations. Zakaria et al. (2014) suggested a lightweight ontology for herb domain which is comparatively simple and easier to construct by do not capture the semantics in the ontologies. Finally, Tungkwampian et al. (2015) uses ontology in creating conceptual knowledge and to understand the whole pictures of illness and treatment with Thai medicine plants. Then, a Thai herb database was integrated with the ontology to create the knowledge base in RDF (Resource Description Framework) format by using Ontology Application Management (OAM) framework developed by

NECTEC before it can be queried by SPARQL query facility. Comparatively, this research try to convert the Malaysia indigenous herb ontology design to relational database by using OWL2DB mechanism, rather than using existing technologies such as RDF, JESS and Jena. The successful of the conversion will enable the design of system development by using interactive AJAX Web 2.0 functionality, such as to suggest and recommend other herbs, part uses and preparation methods based on same category with the query result.

III METHODOLOGY

The overall development of MiHerbs system employs the system development life cycle (SDLC) which involves five phases namely, Preliminary Investigation and planning phases, Analysis, Design, Implementation and maintenance phase. Figure 2 depicts the common system development phases that need to be implemented in developing MiHerbs.

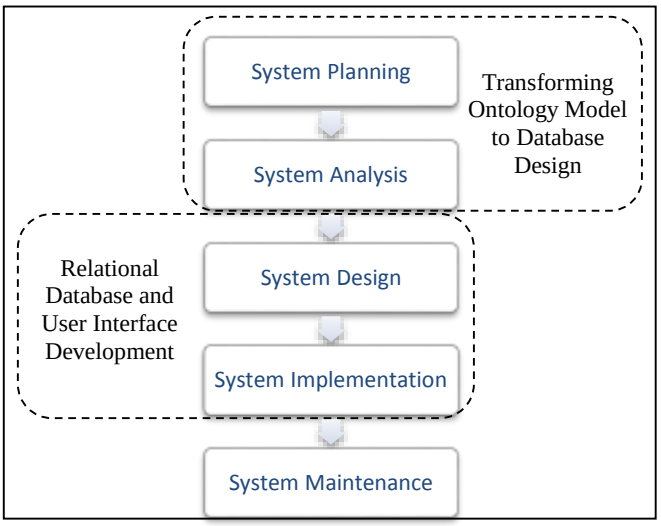

Figure 2. System Development Life Cycle

In investigation and analysis phase, the challenges in developing the MiHerbs system is the possibility to store the ontological information and processing this information by user queries. For this purpose, relational database will be used since it can cope with large amount of data. Hence, the first thing need to do is to transform the ontology representation in the form of OWL developed by sahri et al. (2012) to a relational database. This transformation is based on the outline algorithm of OWL2DB explained by Vysniauskas & Nemuraite (2006). The OWL2DB algorithm describe the process to transfer classes, properties and relationships (in ontology model) into relational database format which will result the mapping of *class to table*, *property to table relation* and *property restriction to database cardinality*. Figure 3 shows the process matching that the research need to satisfy in transforming the ontology model to a relational database based on the characteristics as defined in the ontology model. This transformation allows the Malaysia herbs ontology can be represented in the form of relational database which include table, table relation and data set.

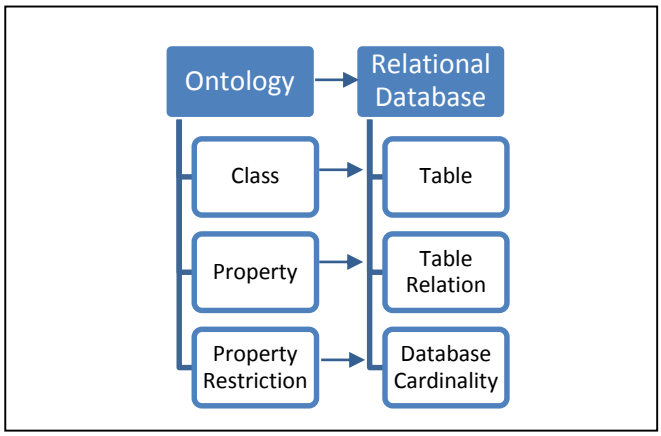

Figure 3. Transformation from Ontology Model to Relational Database Process Matching

To support the conversion from ontology model to a relational database, the research adapt the algorithm suggested by Vysniauskas & Nemuraite (2006) to map the OWL to relational schema as below:

TABLE I. **OWL2DB TRANSFORMATION STEPS**

Step	Description
1	The given OWL file is first parsed for Root classes that iterate over all the root classes.
2	Iterate through the root classes to determine the depth of the descendants.
3	The show class method is called that keeps track of the depth of the subclasses from the root and when the depth of the graph is 3 then a relation table is created for all the subclasses above it with attribute names/instances as column names.
4	The above step is repeated starting from the last subclass and traversing the graph and collecting the list of all the table names and column names of subclasses that are at the depth of three from the starting node.
5	The depth of the Union/complement/disjoint subclasses on the same level is the same.
6	Separate relations are created for classes that are disjoint from each other.
7	Once the information on tablenames and corresponding attributes are collected, we need to collect the values of the instances to populate the database. The graph is parsed again to collect the values that are stored in a data structure.
8	Finally, a database connection is established and all the tables are created and then the values are inserted.

In design and implementation phase of the SDLC, the construction of database logical design was conducted

by using BiZagi Process Modeler and the physical relational database is constructed by using MySQL. Meanwhile, the development of overall web system interface and functionality is based on the open source framework which is PHP and Asynchronies JavaScript and XML (AJAX). AJAX technology is selected to enhance user interactivity where its allows the search result appear simultaneously during user key-in compared to normal searching which user need to click 'Submit' button to send the search keyword to database for processing. Finally, the maintenance phase will be kept in view for future research and improvements.

IV RESULT AND DISCUSSION

A. The Proposed System Architecture

The proposed system is based on knowledge-based system architecture as the objective of the research is to transform the ontology knowledge model to a system that can give easy accessibility to the Malaysian herbal knowledge. The developed system consists of three main components which are user interface for user interaction, inference engine which will derive the conclusion from the relational databases (encoded from OWL Ontology) based on the matches index that occurs in an AJAX file and relational database. The components relation can be illustrated as below Figure 4.

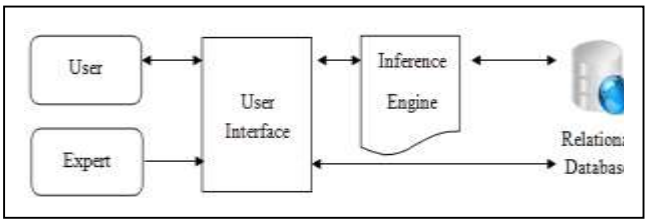

Figure 4. Proposed Architecture for MiHerbs

a) User Interface
It allows user to interact with the system find information by means of keyword searching and related concept browsing. There are two types of user which is the expert/researcher/valuator who will insert or update the herbs information and normal user who will use the system to find information insert by the expert/researcher/valuator.

b) Inference Engine
The heart of the system which accepts user input and matches the input in the database. The inference engine will try to derive the conclusion from the relational databases (encoded from OWL Ontology) based on the matches index that occurs in an AJAX file.

c) Relational Database
The relational database technology is able to provide the best facilities for storing, updating and manipulating the information of problem domain. The ontology knowledge representation developed is encoded in the knowledge based system which allows the inference engine to examine the rules.

B. Ontology Model to Relational Database

The result of transformation from the ontology model into relationship database is discussed in this section. The transformation process is based on the algorithm of OWL2DB outlined by Vysniauskas & Nemuraite (2006). Figure 5 shows the list of classes, subclasses hierarchy and its associated individual data (Disease) from Sahri et al. (2012) in OWL using Protégé 4.2. Meanwhile, the overall ontology model can be visualized in Figure 1 along with the associative relationship among classes and subclasses.

Figure 5: Class Hierarchy and Individuals View in OWL

The transformation of the OWL language into relational database by using OWL2DB algorithm allows us to convert class and subclass to table, class property to table relation such as one-to-many, many-to-many and many-to one, and also to convert property restriction to database cardinality such as Foreign-key. The final result of transforming OWL language as shown in Figure 5 to relational database schema can be seen in Figure 6 below.

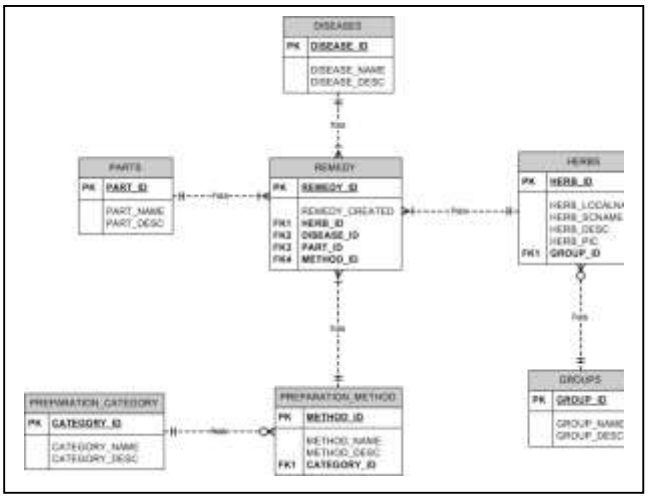

Figure 6. Transformation Result from OWL to Relational Database Schema (ERD)

There are seven tables has been created in the relational database based on the classes and subclasses defined in the OWL language. For example, *Disease* (OWL) to *Diseases* (ERD), *Herb* (OWL) to *Herbs* (ERD), Sub-Classs of *Herb* (OWL) to *Groups* (ERD), *PlantPart* (OWL) to *Parts* (ERD), *PreparationMethod* (OWL) to *Preparation_Method* (ERD) and Sub-Class of *PreparationMethod* (OWL) to *Preparation_Category* (ERD). Additional Composite table, namely, *Remedy*, must be add that act as the bridge or linker between all tables based on the Primary Key (PK) defined in all tables. In this case, *Remedy* can be assumed as *Thing* (OWL) that shows all classes defined in the research is in one herbal domain and it must be related to each other. The relationship define in ERD is based on detail relationship defined in ontology model view in Figure 1. For example, Figure 1 shows that *Herb* <has subclass> of *Climber, Shrub, Tree* and *OtherHerb* can be represented in ERD as *Herbs* table has <Many to One> relationship with *Groups* (the sub table of Herbs). <Many to One> is the database cardinality that the research derived from the ontology *Property Restriction* which can be found in the OWL.

C. The Knowledge-Based System User Interface

The interface of MiHerbs system shows in Figure 8. The homepage of the system will shows a textbox that allows user to key in searching keywords such as herbs name, disease or by preparation methods and herbs parts. Since the ontology has concepts and relationship, this research is able to design a system that provide search box that allows user to find information by keywords-search. The inference engine infers the input based on the if-else rules to derive desired result from the database as below example.

Figure 8. MiHerbs system with search box

From the query result, the system is able to suggest the related information based on the same category (Sub-Classes in OWL) of the existing result search. The result also can be used to retrieve every category of documents in a particular domain written in all languages. For example, when user search for the keyword "Mengkudu", the result will shows that Mengkudu falls under herbs category "Tree" and is able to cure "High Blood Pressure". Then, the system is able to suggest all herbs that fall under category "Tree" and all herbs that can cure "High Blood Pressure". This example can be further view in Figure 9. The result page not only contains the information on selected herbs, but also will recommend other herbs which in the same category of herb which are Tree.

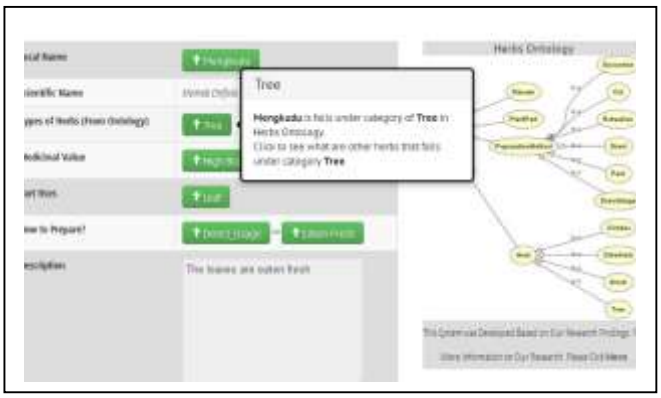

Figure 9. Result page with recommendation of other Herbs that falls under same category

V SYSTEM LIMITATION

The limitation of the system is identified especially in the search facilities that only can accept 'keyword' based queries rather than multiple keywords or sentences. This weakness is due to the way ontology design and model the domain in the form of class name and its associated elements mostly in the form of

individual keywords. Further study will be conducted in order to rectify the weaknesses.

VI CONCLUSION

This research succeeded in building a Malaysian Herbal Knowledge-Based system in an effort to preserve the Malaysian treasures and provide searching facilities for future generation. The development of MiHerbs system also validate that the Malaysia indigenous herbs knowledge representation using ontology model is able to encode and store knowledge in a database as well as reasoning rules that support the processing of information retrieval.

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