Workbench with Authoring Tools for Collaborative Multi-lingual Ontological Knowledge Construction and Maintenance

Mukda Suktarachan[1], Dussadee Thamvijit[1], Sachit Rajbhandari[2], Daoyos Noikongka[1], Puwarat P. Na Mahasarakram[1], Panita Yongyuth[1], Asanee Kawtrakul[1], Margherita Sini[2]

[1]Department of Computer Engineering, Kasetsart University, Bangkok, Thailand
[2]Food and Agriculture Organization of the United Nations, Rome, Italy
E-mail: {mukda, dussadee, daoyos, imm}@naist.cpe.ku.ac.th, asanee.kawtrakul@nectec.org,
sachit.rajbhandari@fao.org, margherita.sini@fao.org

Abstract

An ontological knowledge management system requires dynamic and encapsulating operation in order to share knowledge among communities. The key to success of knowledge sharing in the field of agriculture is using and sharing agreed terminologies such as ontological knowledge especially in multiple languages. This paper proposes a workbench with three authoring tools for collaborative multilingual ontological knowledge construction and maintenance, in order to add value and support communities in the field of food and agriculture. The framework consists of the multilingual ontological knowledge construction and maintenance workbench platform, which composes of ontological knowledge management and user management, and three ontological knowledge authoring tools. The authoring tools used are two ontology extraction tools, ATOM and KULEX, and one ontology integration tool.

1. Introduction

Currently, knowledge management systems (Linger H., et al, 2004) have been considered useful for knowledge sharing. In specific domains such as agriculture or nutrition, experts need considerable time to build and share common knowledge, using several ad-hoc resources such as documents, databases[1,2] or traditional thesauri[3]. Sharing accepted terminologies is the result of collaboration where terms creation comes from computer-to-human interaction and human-to-human interaction via computers.

Recently, the needs of monolingual and multilingual ontologies have been increased because of their possible use into many applications or systems (Reddy, P , et al,2007; Kemp, Z., Tan, L., and Whalley, J., 2007) . These systems may be search engines[4,5], query & answer systems[6], web applications such as RSS feeders and query expansion web services, etc. General web search services (e.g. Google, Yahoo) also use ontology-based approaches to find and organize content over the Web. Because of knowledge and information explosion over the web, and the increased number of communities using them, a need arises for combining automatic ontology construction and collaborative ontology development (Ahmad, M. N. and Colomb, R. M., 2007). The resulting knowledge base must be accessible over internet to external specific applications.

Ontology construction has been a hot research topic (Liu, C., Chen, W., and Han, Y. 2006; Alani, H. 2006; Casellas, N. et al, 2007) in the past few years. The researches focus on various types of sources, methodologies and applied domains (e.g. agriculture, health) tackling issues related to ontology specification, ontology domain, conceptualization and integration.

This paper proposes the workbench platform for collaborative multilingual ontological knowledge construction and maintenance, updating by end-user community tackling with three ontological knowledge authoring tools in order to add value and support communities in the field of food and agriculture. The framework consists of the multilingual ontological knowledge construction and maintenance workbench platform, which composes of ontological knowledge management and user management, and three ontological knowledge authoring tools. The authoring tools used are two ontology extraction tools, the Automatic Thai Ontology Construction and Maintenance tools (ATOM) (Asanee Kawtrakul, Mukda Suktarachan and Aurawan Imsombut, 2004) and the Semi-automatic Computational Lexicon Construction (KULEX) (D. Noikongka, M. Suktarachan and A. Kawtrakul, 2007), and one ontology integration tool. The ontology extraction has been processed by using three types of corpora: unstructured, structured, and semi-structured textual resources. The ontology-learning technique, in this paper, applied a hybrid approach that can be utilized for extracting both taxonomic and non-taxonomic relations.

2. Overview of Ontology Management Architecture

Figure 1 shows the generic Workbench platform for collaborative multilingual ontological knowledge construction and maintenance with authoring tools. The AOS (Agricultural Ontology Server) construction workbench is plugged in with three above mentioned authoring tools ATOM, KULEX, and an ontology integration tool. The AOS Workbench, originated by the Food and Agriculture Organization of the United Nations (FAO), is a web-based java tool for collaborative building and structuring multilingual ontology and terminology

---

systems in the area of agriculture with a distributed environment. For the proposed workbench, we moved away from a centralized development of AOS to a Web2.0 inspired way of networking and distributed contribution. This will create a system with richer semantics greatly enhancing both the resource indexation and related search, and the information organization in the agricultural domain. The ontological knowledge authoring tools ATOM, KULEX and an ontology integration tools developed by NAiST[7] laboratory, Kasetsart University (NAiST-KU) in order to integrate to AOS workbench for extending domains and adding more value.
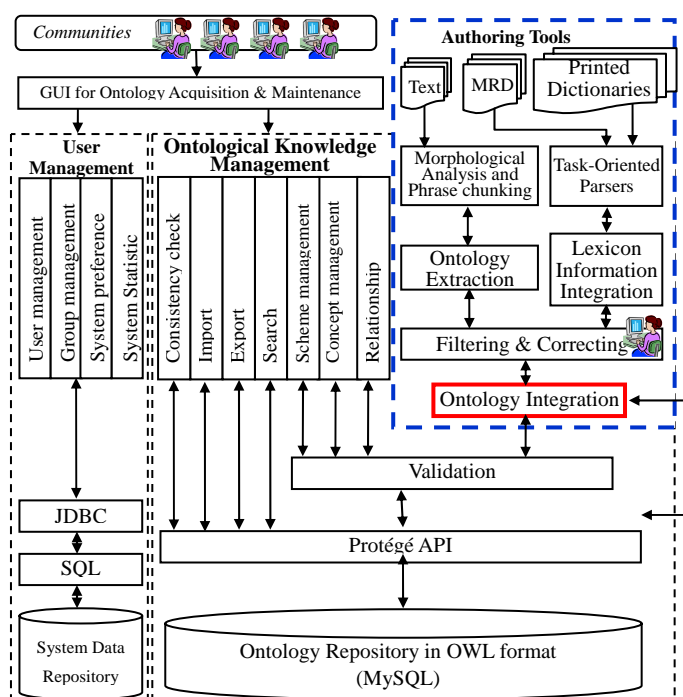

Figure 1: Architecture of Ontological Knowledge Construction and Maintenance Workbench with Authoring Tools

The system is divided into two main parts: the Multilingual Ontological Knowledge Construction and Maintenance workbench and the Ontological Knowledge authoring tools.

3. Multilingual Ontological Knowledge Construction and Maintenance Workbench

The workbench supporting collaborative multilingual ontological knowledge construction and maintenance is divided into two parts: ontological knowledge management and user management. The next section will describe these two parts in detail.

3.1 Ontological Knowledge Management

The ontology is stored in OWL (Ontology Web Language)

---

format, using MySQL as the persistent repository. The Protégé API has been used to access the data in OWL format, querying them using the SeRQL[8] query language.

Sesame[9] API and SeRQL[10] query language for querying used in the previous version of the work was replaced with Protégé API. (Noikonka, et al., 2007), as some difficulties was experienced with the Sesame API to handle Domain and Range of OWL property. Furthermore, while using Sesame duplicate URI problem was encountered in the OWL model. Using Protégé API is much easier than Sesame reducing much of the developing time and showing better performance. There are eight functions available to users to manage the ontology.

3.1.1 Concept Management Function

This module provides the functionality of concept navigation. The workflow enables to understand how users can work with this module by adding, editing and deleting concepts and associated information in each component (see figure 2).
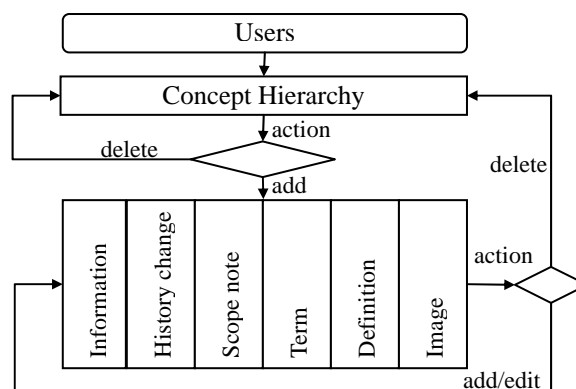

Figure 2: Workflow of concept management module

From figure 2, end users can start creating or deleting concepts from the concept hierarchy. After adding the new concept, users can add, edit or delete more information in each component as indicated below.

- **Information:** This component shows the basic information of concept such as creation-date = 2006-10-03, update-date = 2006-10-03, status = published
- **History change:** This shows the history of changes of the concept, in any language.
- **Scope note:** important note about the concept.
- **Term:** This component is for storing terms, which have the same meaning in every language. For example, if users browse the concept "public administration", then terms associated could be

---

[7] Specialty Research Unit in Natural Language Processing and Intelligent Information System Technology (NAiST)

[8] http://protege.stanford.edu/overview/protege-owl.html
[9] www.openrdf.org/doc/sesame/users/ch06.html
[10] http://protege.stanford.edu/overview/protege-owl.html

"public administration" in English and "Administration publique" in French.

- **Definition:** This component is used to store the definition of the concept in any language. For example, if users browse the concept cycadaceae (en), then the definition is "ancient palmlike plants closely related to ferns, whose fertilization is by means of spermatozoids (en)"
- **Relationship:** This component shows the relationships between the selected concept and other concepts.
- **Image:** This shows image(s) associated to the concept.

3.1.2 Search Function
This function consists of basic search and advanced search.

Basic search returns the concept(s) that contains the query term. Some options are available to provide better results, such as regular expressions (contain, exact match and start with), case sensitive and include description.

Advanced search: provides more accurate results by filtering concepts using concept relationships, sub-vocabulary (geographic, scientific term, etc.), term code, and concept status or classification scheme

3.1.3 Relationship Management Function
The ontology based data model of this system is kept in OWL format. As OWL format follows triple pattern (subject-predicate-object), users can use the relationship management module to add, edit or delete these predicate that will be used in the system. These predicate can be a relationship between concept-to-concept, concept-to-term, or term-to-term.

The relationship hierarchy consists of two types of relationship properties (object property and data type property). The users can also add more related information to the relationship and edit or delete the related information components (see figure 3).
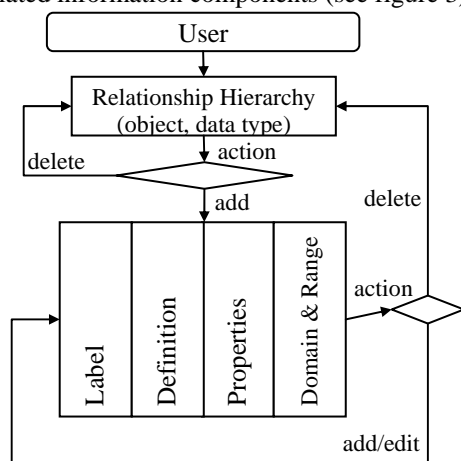

Figure 3: Workflow of relationship management

3.1.4 Consistency Check Function
An important advantage of the Workbench tool is the ability to check whether the loaded ontology contains parts that are inconsistent. This functionality checks the ontology over consistency conditions such as do not has duplicated preferred terms for different concepts, do not has published sub-concepts for deprecated concepts, etc. This function will return inconsistent sections with a proposed solution for that issue.

3.1.5 Validation Function
All ontology elements contained in the workbench need to be approved by two types of users: "validators" and "publishers" (ontology expert). The validation function allows these users to accept or reject changes done by all other users before releasing the updates to the public.

3.1.6 Import Function
Enables to import external ontologies in OWL format that have the same schema used by the system. In case of duplications, the system will alert the user.

3.1.7 Export Function
To be enable to export all or sections of the ontology from the system to RDF, XML, TBX, SKOS, OWL and RDBMS (SQL in UTF8) format.

3.1.8 Scheme Management
This module is used for grouping concepts into user's defined categories.

3.2 Users and groups management
The users/groups management section defines the permissions for users accessing and registering to any module in the workbench. It is also used to broadcast news to the community. Information about user's actions is also used to produce statistical data which are kept in the MySQL database.

3.2.1 User Management
The user management module provides the functionality to view user's profiles, add, edit or delete users.

3.2.2 Group Management
Each user in this system belongs to a specific group (administrators, ontology editors, term editors, etc.). Each group has different permissions to use or access some functionalities of the system.

The group management module provides the functionality to assign users to a specific group, create new groups, edit or delete the existing groups.

3.2.3 System Preferences
System preferences allow the user to customize his/her own environment, for example by selecting and storing for later reuse the language for the interface, the initial page and the default ontology to be loaded.

3.2.4 System Statistics Reports
This module provides statistics on the use of the system, using event logs.

4. Ontological Knowledge Authoring Tools

The ontological knowledge authoring tools, (semi-) automatic ontology acquisition component, are added value tools that can be supported the users for acquiring the complete and up-to-date ontology, allowing the ontological terms, their lexicon information and their relations extraction from different sources, i.e. texts and dictionaries, and integrating them into the core ontology. There are three authoring tools in this project. Two are ontology extraction tools and one is integration tool.

4.1 Ontology Extraction Tools

There are two Ontology Extraction tools those are the Automatic Thai Ontology Construction and Maintenance tools (ATOM) and the semi-automatic Computational Lexicon construction (KULEX). The difference of these tools is that the ATOM is a tool for ontology extraction from various sources those are plain text, thesaurus and dictionary while the KULEX is a tool for extracting ontology from various dictionaries or various sources with different structures and then integrated and restructured as the process describing in section 4.1.2. The dictionary that used in the ATOM is a dictionary that has the structure appropriately to analyzed as ontological concept by using task oriented parsing technique and transferring to a relational database as the example in the figure 4 and table 1.

Figure 4: Dictionary structure analyzed in the ATOM

Feature	Database field	Example
All upper case at the top-rightmost corner	Family/Sub-Family	GESNERIACEAE
Starts with upper case at the top-left most corner	Genus	Chirita
All lower case	Specific epithet	involucrata
Thai alphabet in bold font	Formal Name	น้ำดับไฟ /Nam–dap-fai/
Thai alphabet	Local Name	มะและ /Malae/

Table 1 Features of the alphabet for dictionary conversion

4.1.1 The Automatic Thai Ontology Construction and Maintenance tools (ATOM)

The Automatic Thai Ontology Construction and Maintenance tools (ATOM) (A. Kawtrakul, M. Suktarachan and A. Imsombut, 2004) developed in 2004 by applying a hybrid approach for especially (semi-)automatic building and maintaining ontology from corpus, thesaurus and dictionary. Concerning to the corpus, a methodology for extracting ontological concepts and taxonomic relations was utilized explicit cue expressions, i.e. lexico-syntactic patterns (e.g. NP such as NP1, NP2,…) (Hearst, M, 1992) and an item list (i.e. bullet list and numbered list). This technique poses certain problems, i.e. ambiguity of cue words, item list identification, and numerous candidate terms. The problems solving methodology is proposed in (A. Imsombut, and A. Kawtrakul, 2007) by using lexicon and co-occurrence features and weighting technique from information gain. Besides, the semantic relations embedded in Thai NPs were inserted, by translating Thai words into English, with a method of selecting the word sense from WordNet and by applying machine learning techniques to learn the semantic relations. In order to extract ontology from a specific dictionary, a task oriented parser is used to build the ontological tree. From the thesaurus resource, the thesaurus' relationships were refined to ontological relations by using machine learning and some heuristic rules. Finally, all of the ontologies were integrated to the ontological sub-trees by using the technique of term matching and then the ontology is reorganized for consistency. The accuracy of the final result from three sources is 0.86

4.1.2 The semi-automatic Computational Lexicon construction (KULEX)

The semi-automatic Computational Lexicon construction (KULEX)) (D. Noikongka, M. Suktarachan and A. Kawtrakul, 2007) purposes to greatly reduce the labor work and time consuming in acquiring the lexical information. It is originated in concept hierarchy with varieties of necessary word information by integrating word information from multiple Thai language dictionaries such as Klangkam (Nawawan Pantumata , 2004), Royal Institute Dictionary (RID) (Royal Institute, 1988) and Matichon Dictionary (Matichon Public Co.,Ltd., 2004). These dictionaries were respected as very good and reliable sources that are in printed form. Thus the optical characters recognition is applied for converting the image document into the electronic text. The lexicon construction by this process consists of two main steps.

Figure 5: Parsing of Klangkam dictionary

Figure 6: Parsing of Royal Institute dictionary

Task-Oriented Parsing for analyzing dictionaries content structure. Since each dictionary has different structures, such as organizing in concept hierarchy structure and alphabet ordering as in figure 5 and 6.

Lexicon Information Integration from various dictionaries. After the process of task-oriented parsing, the system has to acquire word entries and theirs information from Klangkam e.g. concept hierarchy, and then acquires word entries and theirs information from RID e.g. part of speech, word definition. Next, the system will integrate extracted information into the concepts by using word definition based classification. This semi-automatic classification is based on two approaches: using head word matching and using definition of words with the same concept matching.

The first approach applied the algorithm (M., Lesk, 1986) for finding similarity of word senses where the surface forms from RID are consistent to the word in Klangkam. The correctness is 91.50%.

The second approach has been applied for the rest words which have different head word and the rest senses. This approach uses term weighting (Christopher, D. M., S., Hinrich, 2002) for integrating the rest words and theirs information with the appropriate concept. The correctness is 65% of a top ten rank's concepts.

4.2 Ontology Integration tool

As mentioned in section 2 that AOS Workbench is a collaborative work between FAO and Kasetsart University. The workbench is distributed by FAO for the community to develop agricultural ontology in their language(see figure7). However, to construct ontology manually is laborious and time consuming. In order to integrate the existing ontology and ontology created by different communities in their languages, an integration system is necessary.
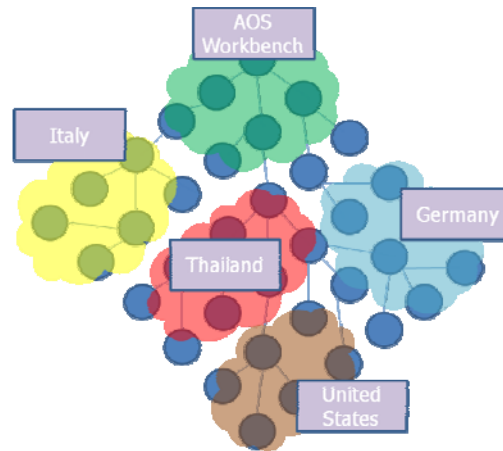

Figure 7: Shows multi-lingual ontology integration

Thus, Ontology integration is the process of combining two (or more) ontologies into a single one. It is a very important process for building multi-lingual ontology from existing ontology resources and also a challenging task for Ontology Construction System. Before integrating ontologies, it should be carefully checked so that the ontology will be reliable, realistic and useful. The automatic ontology integration system should have high precision. Thus in this paper, the integration tool was developed using two techniques: automatic strings matching and manual mapping process, called as "DRAG & DROP".

The string matching technique is used to find the appropriate concept node of existing ontology tree in AOS workbench and inserting the new term extracted by ATOM. If that new term extracted from ATOM tool cannot be matched with existing AOS's ontology, the tool will be switch to "Drag & Drop" for manual insertion by experts. The system was developed by using Java and Google Web Toolkits.

4.2.1 Ontology Integration Operation
In general, to merge the ontology, two steps ontology integration and ontology reorganization process are used.

4.2.2.1 Ontology Integration
In this step, the related word/phrase pairs, collected from different sources will be united: AOS's ontology and ATOM's ontology. In order to integrate them, two heuristics are applied:
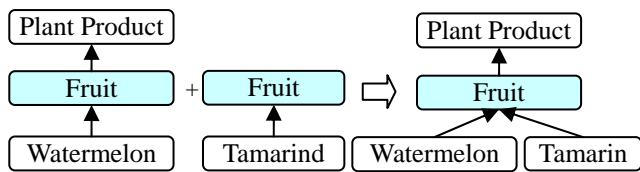**Same label or term matching**
If the separated ontological trees have the same label nodes, then they are merged. Figure 8a) shows the example of ontology integration by using this technique.
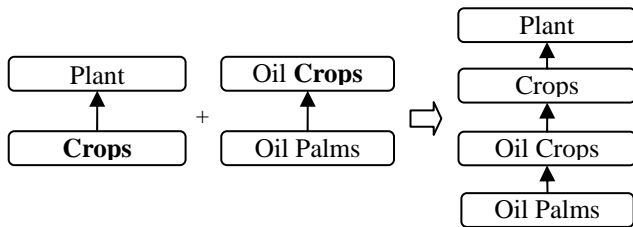
Partially Term's Head Words Matching
If the terms' head words match partially, then matched terms can be merged. The partially term's head words matching technique is shown in figure 8b)
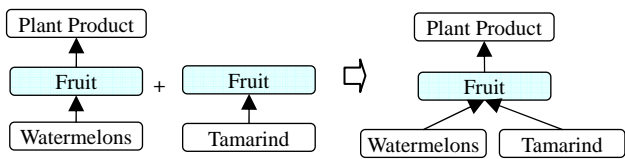
2505

Figure 8 (left column):

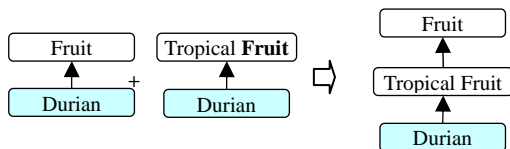8a) Same Label (Term Matching)

8b) Partially Term's Head Words Matching

Figure 8: Basic idea of ontology integration

There are two operations involved in this process of integration: Addition and Insertion. Figure 9 shows operations for ontology integration of a core-tree (left-hand-side tree) into a new ontological tree (right-hand-side tree).

9a) Addition

9b) Insertion

Figure 9: Operations for ontology integration

Addition: A Child node will be added to the core tree, if the parent node has the same label or partially term's head word matching to the existing node in the core tree in figure 9a)

Insertion: If the children nodes have the same label as the head word of the parent nodes then the new, more specific term will be inserted between two existing ontological terms in figure 9b)

The remaining terms that could not be integrated are left for the expert to be added later on, manually.

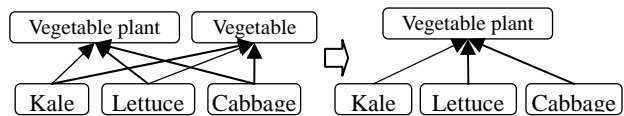### 4.2.1.2 Ontology Reorganization

When all nodes and relationships from the ontologies are added to the core ontology tree completely, the ontology reorganizing operation will be processed respectively. It involves three operations in ontology reorganizing: deleting, pruning and merging. Figure 10 shows the example of the process of these operations.

Figure 10 (right column):
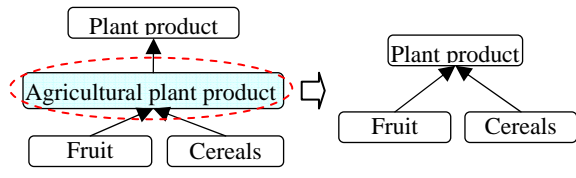
10a) Deleting

10b) Pruning

10c) Merging

Figure 10: Operations for ontology reorganization

Deleting: In any case if there are duplicate relations, the system will delete the relation of the last node in the tree as shown in figure 10a).

Pruning: Node, which does not have its own property and its children is the same set as its parent, such nodes should be deleted and its children should be transferred to under its immediate parent as shown in figure 10b).

Merging: If the two nodes or more than two have the common set of children nodes and these node's labels are similar then these nodes are merge to the new node and the common set of children will be transferred to the new node. The similarities of node's label are compared by using edit distance technique. Furthermore, the system will select the label that is the most frequency occurred in the corpus to be concept label or concept representation of the new node in figure 10c).

4.2.2 Ontology Integration System Architecture

The work flow of the integration system is shown in the figure 11. In the first step, the concepts tree will be extracted from ATOM as a new entry's concept in order to match with AOS Workbench's concept.

In case of new entry's concept already existed in AOS Workbench, it will store in Matched table to show the lists of matched concept between the new entry's concepts and AOS Workbench's concepts as shown in figure 11 a).

In case of new entry's concept that does not fits in AOS Workbench, it will be shown in Drag and Drop panel where user can see the concept's tree of both sources and can Drag and Drop concept from the new entry's concept tree into AOS Workbench's concept tree as illustrated in figure 11 b).

Afterward, the end-user sends the merged concept to validation process before adding up new entry's concept to be new concept in the AOS Workbench concept tree.
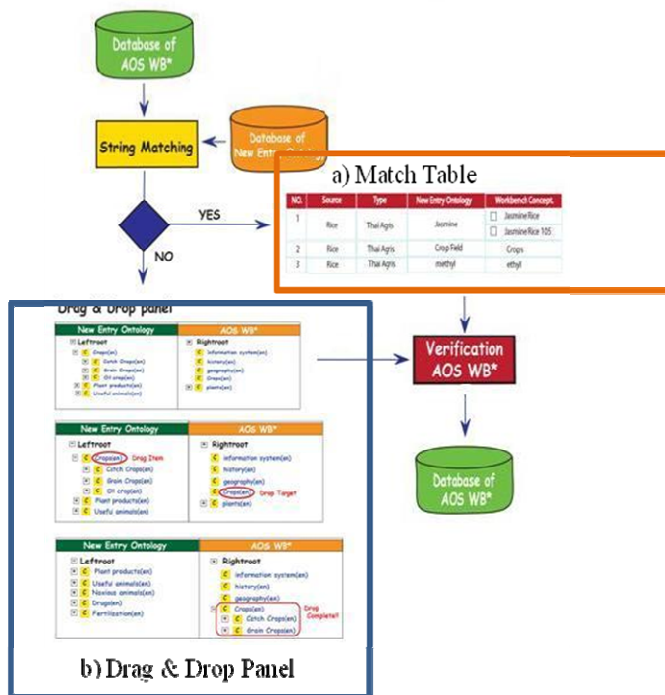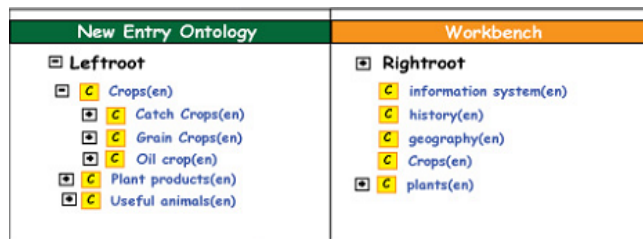
Figure 11: Merging tool's Architecture

Figure 14: Drag & Drop's tree panel

The new entry concept is populated in the left root and existing concept of AOS Workbench in the right root of the tree panel (see figure 15).
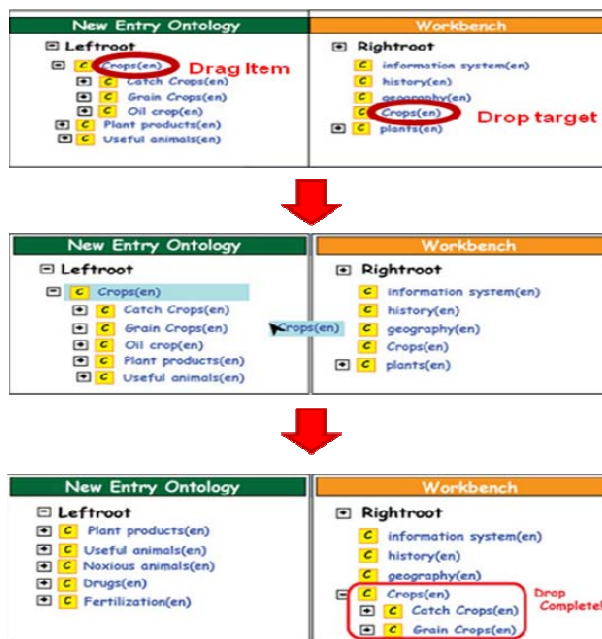

Figure 15: Drag & Drop process

Matching process

The string matching techniques was used to find the appropriate concept node of existing ontology tree in AOS to insert the new term extracted by ATOM. If that new term cannot be matched with AOS's ontology, the tool will switch to "Drag & Drop" to insert manually. Refer figure 12 and 13, to see the matched table and query used to show matched concept.

```
SELECT
  authoring_tool.id, authoring_tool.destination_uri,
  authoring_tool.destination_label, authoring_tool.isValidate,
  ontology_detail.description,ontology_detail.concept,
  ontology_type.source, ontology_type.type
FROM
  authoring_tool, ontology_detail, ontology_type
WHERE
  authoring_tool.source_id = ontology_detail.id AND
  ontology_detail.type_id = ontology_type.id AND
  authoring_tool.destination_uri IS NOT NULL AND
  authoring_tool.destination_label IS NOT NULL
ORDER BY
  authoring_tool.destination_uri DESC
```

Figure 12: Matched Table's Query
Figure 13: Match Table.

To ease drag & drop process for end user, two graphic user interfaces, Matched Onto panel and Drag & Drop panel (GUI) developed is shown in figure 16.
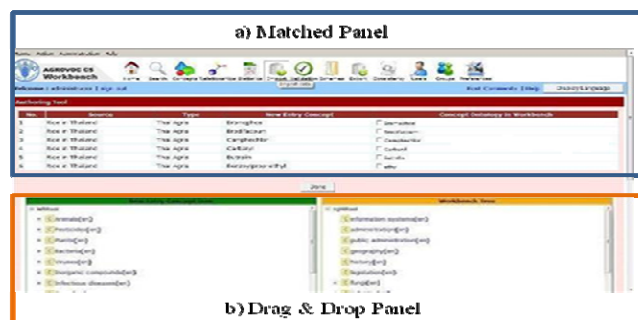

Figure 16: User Interface

Drag & Drop process

This algorithm searches the concept's position on AOS that new entry concept cannot fit. Therefore, system can switch into manual tool allowing end-user to drag new entry concept and drop into exisiting AOS tree. Figure 14 shows the Drag & Drop panel.

5. Conclusion

The workbench, hereby, is originated by The Food and Agriculture Organization of the United Nations (FAO) and has been developed based on web 2.0 with Kasetsart University. In order to add value to the existing AOS ontology management tool, ATOM, KULEX and integration tool were plugged-in, supporting users to

acquisite the new terms from textual resources and provide collaborative work environment. The ontology integration tool contributes an important role in merging existing ontology and new ontology term created in their language by different communities around the globe.

This workbench was tested on e-conference, organized by FAO, for four weeks with 170 participants from 43 countries in Europe, Asia and America, etc. The workshop was organized to find out the usefulness of workbench participated by Thai AGRIS Center and the member of Ontology based management for Diabetic and health care groups extending the use in other domains as well. The system was also tested by the same groups for two times. The benefits of the system is that users in different places, countries and languages can access and use at any time. The next step will be to find the strategies to promote this workbench and get the feedback for tuning of the system.

7.   References

Ahmad, M. N. and Colomb, R. M. (2007). Managing ontologies: a comparative study of ontology servers. In Proc. *of the 18th Conf. on Australasian Database - Volume 63* (Ballarat, Victoria, Australia, January 30 - February 02, 2007).

Alani, H. (2006). Position paper: ontology construction from online ontologies. In Proc. of *the 15th Intl. Conf. on WWW* (Scotland, 2006). ACM Press, New York, NY, 491-495.

Casellas, N., Casanovas, P., Vallbé, J., Poblet, M., Blázquez, M., Contreras, J., López-Cobo, J., and Benjamins, V. R. (2007). Semantic enhancement for legal information retrieval: Iuriservice performance. In Proc. of *the 11th Intl. Conf. on Artificial intelligence and Law* (Stanford, California, June 04 - 08, 2007). ICAIL '07. ACM Press, New York, NY, 49-57.

Christopher, D. M., S., Hinrich. (2002). *Foundation of Statistical Natural Language Processing.* The MIT Press. Fifth printing, England.

Hearst, M.(1992). Automatic acquisition of hyponyms from large text corpora, In Proceedings of *the 14th International Conference on Computational Linguistics.*

Imsombut A., Kawtrakul A. (2007). Automatic building of an ontology on the basis of text corpora in Thai, *Language Resources and Evaluation Journal special issue on Asian Language technology*, December.

Kawtrakul A., Suktarachan M. and Imsombut A., (2004). "Automatic Thai Ontology Construction and

Maintenance System", *Workshop on Papillon 2004*, Grenoble, France.

Kawtrakul, A. (2006) BootsLEE: Bootstrapping moderately large lexical knowledge from multiple-sources for NLP applications. In: Open Problems in Linguistics and Lexicography. Polimetrica Publisher, Italy, pp. 189-224

Kemp, Z., Tan, L., and Whalley, J. (2007). Interoperability for geospatial analysis: a semantics and ontology-based approach. In Proc. of *the 18th Conf. on Australasian Database - Volume 63* (Ballarat, Victoria, Australia, January 30 - February 02, 2007).

Linger H., Fisher J., Wojtkowski W. G., Zupanci J., Vigo K., and Arnold J.(2004). *Constructing the Infrastructure for the Knowledge Economy: Methods and Tools, Theory and Practice, Plenum Pub Corp* (2004/10), 716 pp, ISBN 0306485540.

Liu, C., Chen, W., and Han, Y. (2006). DODO: a mechanism helping to dynamically construct domain ontologies for services integration. In Proc. of *the Intl. Workshop on SOSE '06.* ACM Press, New York, NY, 13-18.

M., Lesk. (1986). Automatic Sense Disambiguation using Machine Readable Dictionaries: How to Tell a Pine Cone from an Ice Cream Cone. In: *5th International Conference on Systems Documentation (ACMSIGDOC).* Toronto.

Matichon Public Co.,Ltd. (2004). *Matichon Dictionary.* Pickanes printing center, Thailand.

Nawawan Pantumata. (2004). *Klangkam Dictionary.* Amarin P&P, Thailand

Noikongka D, et al. (2007) "A Workbench for Collaborative Ontological Knowledge Construction and Maintenance with Authoring Tools*". OntoLex07 - From Text to Knowledge: The Lexicon/Ontology Interface.* Workshop at ISWC07 - 6th International Semantic Web Conference. November 11th , Busan, South-Korea, pp. 98-107.

Noikongka, D., Suktarachan M., A., Kawtrakul. (2007). Semi-Automatic Thai Computational Lexicon Construction: KULEX. In: *The 7th international Symposium on Natural Language Processing*, SNLP2007. Pattaya, Chonburi, Thailand

Reddy, P. K., Ramaraju, G. V., and Reddy, G. S. (2007). eSagu™: a data warehouse enabled personalized agricultural advisory system. In Proceedings of *the 2007 ACM SIGMOD* (Beijing, China, June 11 - 14, 2007). SIGMOD '07. ACM Press, New York, NY, 910-914.

Royal Institute: *Royal Institute Dictionary.* Aksorn Jarurntad printing, Thailand (1988)