A Knowledge Base Repository Model for Multiple Domain Problems of Distributed Expert System

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Abstract—**An expert system that accommodates multiple domain problems is potentially accessed by a large number of users. This can degrade service performance if it is applied only at a single service center. The distributed service centers are an alternative to solve the problem, but the knowledge base between dispersed servers needs synchronization mechanism. This study proposes a knowledge base repository model in the form of a database for multiple domain problems and scattered expert systems. The repository model was developed to mark the knowledge base elements to be exchanged between servers. A data exchange mechanism is illustrated to accommodate the data exchange between expert system servers.**

Keywords— Online Expert System; Decision Tree; Database; Android

I. INTRODUCTION

Expert systems are generally used for consulting services, which are made possible online through the web and mobile devices[1]. The scope of this consulting service is generally in a particular domain of the problem. However, the Expert System that accommodates multiple domain-problem features has the potential to be accessed by more users. This can degrade service performance if it is performed on a single service center (server). The dispersed service center is an alternative to solve the problem, but to maintain the integrity of the expert system's knowledge base on the scattered server it is necessary to represent knowledge base to support the synchronization mechanism. This synchronization is required to match the server's knowledge base data when the data on the knowledge base of the primary server are updated.

The development of expert system services is generally performed for specific domains. Bilal and Mohsin in [2], developed a distributed expert system to support the classification of hadith, Mary-Magdalena et al in [3], developed a distributed expert system for optimization of railway controls. When expert systems are developed for generic services such as for multiple domain problems, consulting services require some kinds of repository to accommodate knowledge base representation.

This study is a continuation of research in [1, 4] which proposes a knowledge base repository model in the form of a database for multi-case and distributed expert systems. This repository is expected to be accessible by web-based and mobile-based (Android) services. The repository model was developed to organize the representation of the knowledge base and mark its elements to be exchanged between servers. A data exchange mechanism is described to accommodate the exchange of data between expert system servers.

II. PROPOSED MODEL

An expert system is an approach that maps the knowledge of experts in the form of a knowledge base into computer programs [5]. Initially, the expert system was developed for services on a single computer, but along with the growth of information technology and communication services expert system scale is also increasingly widespread. Expert systems are not only developed locally but become online services that can be accessed through fixed or mobile devices. Therefore the knowledge base as the core of the expert system needs to be developed into a model that can be accessed by expert system applications on different platforms. When the knowledge base needs to accommodate many cases, it will establish a kind of repository. The developed repository also needs to consider the conditions when it is required for the scattered servers. In this section, we will explain the concept of the database as a knowledge base repository, then an architectural model is proposed for the distributed expert system.

A. Development of database model for knowledge base repository

The knowledge base is the core of the expert system that needs to be represented in the system. This representation can utilize the decision tree approach used in this study. A decision tree is a representation model with a number of nodes of a hierarchical relationship as illustrated in Fig. 1. The decision tree consists of the root node at the top level, the decision nodes on the second level and so on, and the leaf nodes at the bottom. A root node is the starting point for the identification of a fact or a symptom. Decision nodes play a role in continuing the identification process to the next points. Leaf nodes will be the final point of conclusion on a
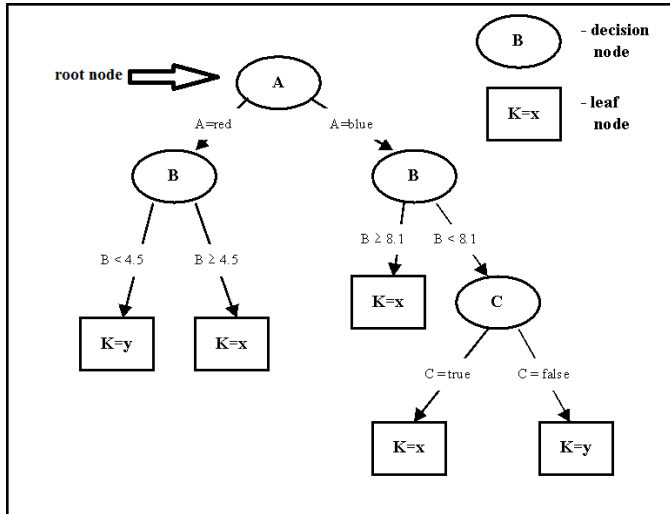
solution.

Fig. 1. Example of decision tree [6].

A decision tree represents a problem domain. If the system accommodates many domains of the problem, there will be a number of decision trees. This certainly requires organizing. Decision trees need to be classified on a certain hierarchical basis. This classification can describe the categorization of a broad domain to a narrow domain so that it can direct users to an expected domain problem. Fig. 2 illustrates the model of organizing the decision tree as knowledge objects in a hierarchical structure.
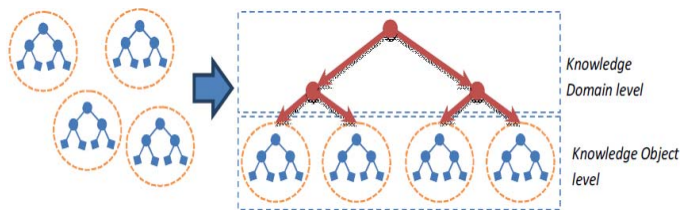

Fig. 2. The concept of organizing knowledge bases

Based on Fig. 2, there is a need to organize a knowledge base for multiple problem domains. A layer is needed to form the classification of various problem domains. This will help guide users in tracking the problem domain sphere to the expected case.

The knowledge base is the main part of the expert system as the basis for service operation, so it needs to be expressed in a form accessible to the application. In this study, the representation of the knowledge base will be mapped on the database. There are several elements that should be accommodated in the database according to the concept of a decision tree, including tables for defining cases, tables that define facts (symptoms), tables that define the diagnostic results (conclusions) and suggestions provided, and tables to represent structure rules. In addition, to organize a variety of cases, a table that accommodates case categorization is required. In the meantime, to accommodate the indication of data changes on each element there needs to be an update time

field. This field aims to show the time of change of data so that on a dispersed system it can be utilized for synchronization between knowledge bases. In accordance with the requirements, Fig. 3 presents the proposed database design.
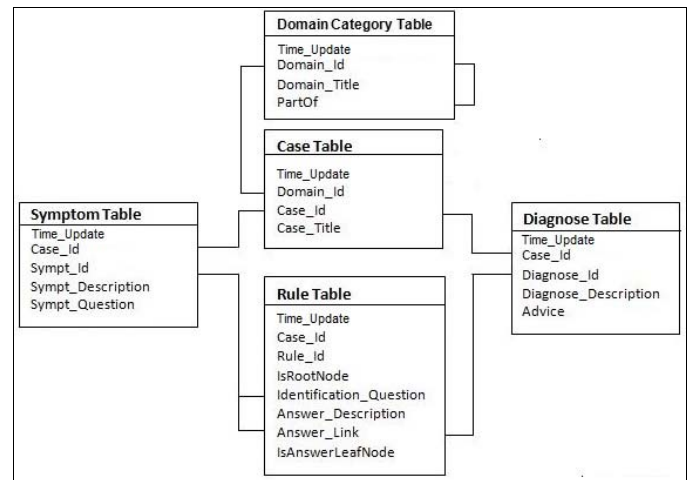

Fig. 3. Database model of knowledge base repository.

The database design as the knowledge base repository as shown in the Fig. 3. consists of several tables. The Domain Category table serves to represent the repository structure of the knowledge bases. The domain category table has a relation to the case table to declare the categorization of cases in its domain. The case table becomes the reference for the symptom table, the diagnose table and the rule table through the Case_id field. Symptom table to accommodate the definition of facts or symptoms and contains questions for identification. The diagnostic table will serve to store the conclusion data as well as the suggestions. Table rules are intended for representing the decision tree structure so that the system can do the reasoning.

In order to establish the organizational structure of the repository, the domain category table is enabled to state the scope of the problem and provide a multilevel relationship between the scopes. A part_of field holds domains associated with other domains. This will form the structure hierarchically from a wide scope to a narrow scope.

Meanwhile, to form a decision tree structure a rule table which states the relationship between nodes through some fields is used. An IsRootNode field marks the starting point of symptom identification. An identification_question field is used to accommodate symptom id associated with identification. An answer to the_description field contains labels to represent answer choices. An IsAnswerLeafNode field is used to mark the final process or a conclusion.

B. Distributed Expert System Model

The concept of a distributed expert system is an expert system services which are provided on a separate server. The purpose of this separation is that the user access load can be shared between servers so that the performance of the service is maintained. However, the integrity of the knowledge base

between service centers should be paid attention. If there is a change of data on a server then the data on the other server should be able to adapt. A sync mechanism should be accommodated on this system. Fig. 4 shows the proposed system architecture model.
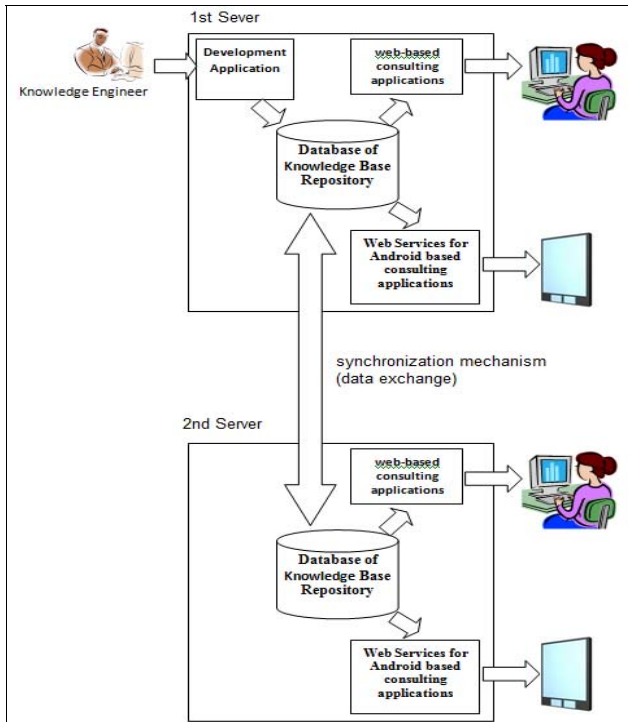

Fig. 4. Proposed Architecture of Distributed Expert System

Based on the Fig. 4. It can be seen the existence of two servers for a separate expert system. Both servers contain databases from the knowledge base repository and consulting applications for web and Android services. On the first server, there is a development application for the knowledge engineer to update the knowledge base. On the second server, there is no application development but there is a synchronization mechanism for data exchange with the first server. This mechanism synchronizes the knowledge base on the second server to database changes on the first server. This data exchange mechanism is illustrated in the Fig. 5.
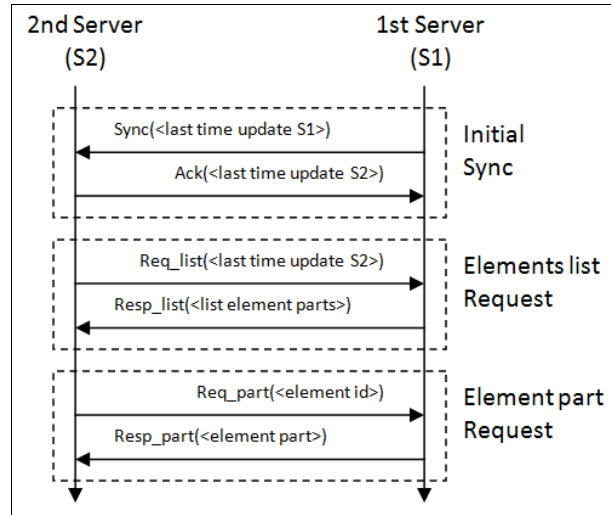

Fig. 5. Illustration of sync process

The data exchange mechanism uses a web services approach. This mechanism is triggered by the change of Time_update on the knowledge base of the first server (S1) by giving a synchronization request message containing last_time_update data until there is an acknowledgment response from the second server (S2). This indicates a change in knowledge base data. Furthermore, S2 can request to get update service data from S1. A list of the latest elements will be sent to S2, and then element by element will be requested by S2 from S1 which is used to renew the internal knowledge base.

III. RESULTS AND DISCUSSION

A prototype was developed for system testing. The database used is MySQL as a repository of knowledge bases. The web-based system using PHP was developed for web-based development application and a consulting application. A web service is developed for Android-based consulting services with data format using JSON. Data exchange services among servers use RESTful PHP.

The repository test is performed by filling the database with cases in the health domain and engineering domain. Examples of cases of tropical diseases such as dengue fever, malaria, chikungunya and ascariasis are applied to the health domain. Examples of computer troubleshooting cases are applied to the engineering domain as in [7]. Illustration of the test example refers to the decision tree as in [1]. Tests are performed for both web-based and android-based consultancy application services.

Testing is done through a scenario. Testing services on the first server is accessed through a web-based application, while services on the second server are accessed through android apps. A change is made on the first server and the result is displayed in the web application. Furthermore, after the synchronization on the second server then the results are accessed through the android app. The results of both services are compared to the changes that occur.

A. Web based expert system testing

Web-based consulting services are tested through the first service center (1st Server).Web based expert system Web-based consultancy testing is done with the selection of health domains followed by case selection (Fig. 6a). As an illustration, the user takes the case of dengue fever. The consultation process will begin with the first question as a form of initial identification (Fig. 6b). The consultation process will proceed step by step until it stops at a conclusion (diagnosis) (Fig. 6c). The results of this conclusion are also accompanied by suggestions.
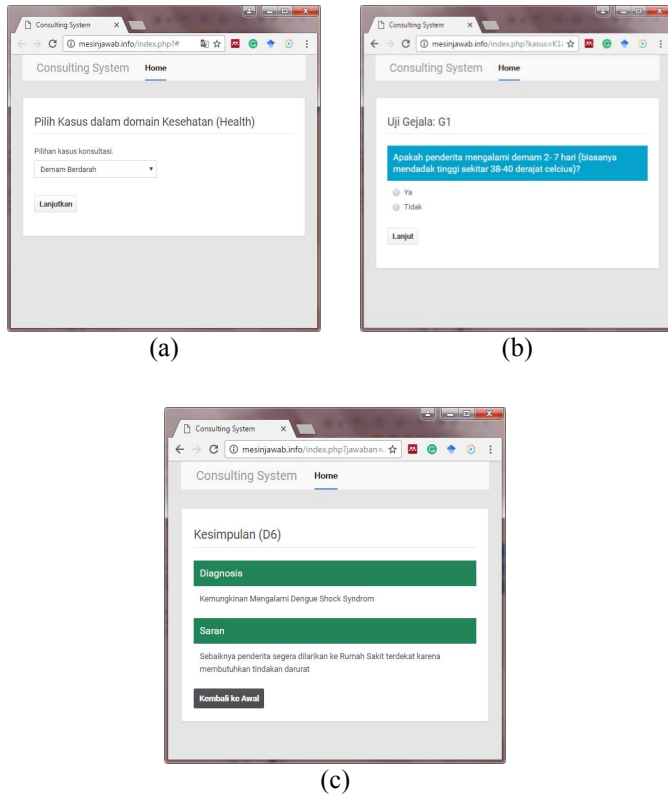

(a) (b)

(c)

Fig. 6. Display of web-based consulting applications a. Select case b. Initial question identification c. Conclusion page.

Based on the description of this test, web-based consulting services will load data from the repository with a selection of domain categories to user-selected cases. When the user has chosen a case, then the consultation process will run according to the selected decision tree object. This will follow the path of the identification process from the root node and decision node to reach the leaf node.

B. Android based expert system testing

The android based consulting service is tested through a second service center (2nd Server). This service is an android app that runs on a mobile device. This service requires an internet connection because it is used to access the knowledge base on the server. The service process starts by selecting the domain category loaded from the server, then the user can point to the case offered (Fig. 7a). Once a case has been selected, the consultation process can be undertaken. Like web-based services, this consultation service begins with an initial identification question (Fig. 7b). The identification process will go on until it reaches a conclusion (Fig. 7c).
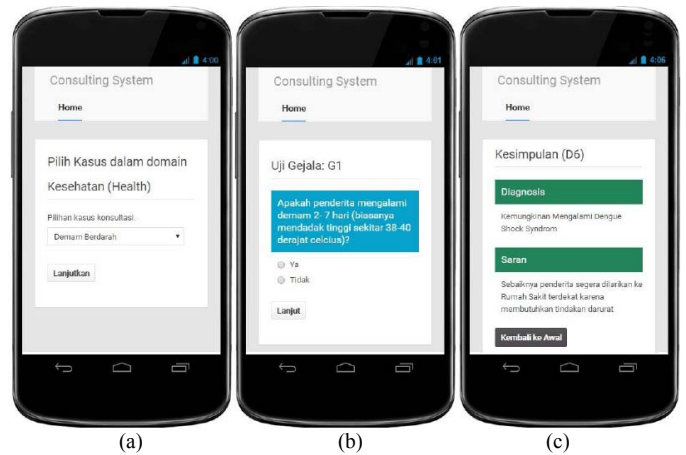

(a) (b) (c)

Fig. 7. Display of Android-based consulting applications a. Select case b. Initial question identification c. Conclusion page.

Based on the services testing that have been carried out, it shows that the consultation process can run to follow paths which are accommodated on a decision tree model. The decision tree as a representation of the knowledge base allows it to be stored in the database as a repository. The sync mechanism can work to match both repositories. The existence of two identical repositories can be accessed by the application, so that users can consult the similar between web-based and Android-based services.

IV. CONCLUSION

This study has proposed the concept of representation of knowledge bases that are organized hierarchically in the form of databases. A knowledge base is used in the form of a decision tree. Each element of the knowledge base is assigned id and time updates that are intended to be recognizable when changes occur. The tagging allows synchronization between service centers for distributed expert systems.

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