Consultation Services Using IVR Telephony Based on Expert System Perspective

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***Abstract*—This paper aims to develop consulting services using telephone. Consultation mechanisms conduct questions and answers by using interactive voice response (IVR) based on expert system approach. A decision tree model is selected to represent the knowledge base of expert system, because it is possible to provide such scenario of interaction. This representation illustrates a multilevel structure, from the initial state with the first question until the final state as a decision or a conclusion. Furthermore, the knowledge base is mapped into a database that can be accessed by applications. Some fields of database tables contain a location of the voice files. This application will play the question voice files and receive answers (tone code from phone keypad) of users for each state in its path to reach a decision or conclusion that is played to the user. In accordance with the testing indicated by the monitoring application and experts' justification, the system is able to trace the path in a predetermined interaction consultation.**

Keywords—consultation service; telephone; expert System

I. INTRODUCTION

IVR telephone service has been widely used, particularly for companies to provide services to their customers. This service is commonly used to replace an operator as an automatic answering machine. The service has become one of the disseminations of information because telephone service infrastructure has been widely available in many countries and its use is simpler compared with today's technology like the Internet that requires specialized knowledge [1]. In addition, this information allows the service performed interactive compared dissemination media such as TVs and radios [1].

The existence of the interactive communication features, IVR potential to be developed as consulting services. Many of problems in societies need support solutions that can be done with the consultation approach. But IVR services are still in the context of dissemination of information that is merely directed to specific information. Generally, these services provide a kind of a multilevel menu, and users can follow to navigate towards information that is expected [1,2,3]. On the other hand Consulting services are required to identify facts or symptoms that arise so that it can be done inference or diagnosis on certain conclusions and provide appropriate advice [4,5]. This is in line with the concept of an expert system that is developed in a question-and-answer application. The expert system maps the knowledge of experts in a structured way that allows reasoning to the facts that are identified [6]. Therefore, in this paper we propose an approach that resembles IVR consulting services with the perspective of an expert system.

II. RELATED WORK

Studies on IVR has been undertaken to optimize the services on the menu system. In [7], IVR services developed in the form of personalization that allows users to customize the information services they need. In [8], IVR services developed with adaptive menu. This adaptation is based on users' behavior, so it can save time. This feature is the result of an investigation on [1]. In [9], IVR is developed as a dynamic service by providing the features of the service scenario setting, so that service arrangements can be done through configuration without changing the program. Dynamic IVR services to find a set of composed services have been proposed in [10]. These services are related to the targeted user QoS and the regulation of business policy constraints that are required by the company. This approach use Fuzzy AHP method for analysis to support the decision. Furthermore, this system is developed in [11], which provides a kind of knowledge base to improve the reasoning in the decision making.

In addition, the IVR services are also widely used for data acquisition such as the services survey, feedback, or monitoring and support services to the user intervention. Implementation of the service is generally used in the field of health. In [12], IVR is used with the Internet for survey of risky alcohol and drug usage. In [13], IVR and text messaging services are used to support intervention in low-income diabetic patients in order to maintain self-care. On the other hand in [14], IVR is used as a monitoring medium to provide an assessment of risk factors and to reduce HIV disease in the community.

In this paper, we propose IVR services as a media consultancy. The services use an expert system approach which contains a knowledge base. It is expected that these

services can work to replace the operators to provide advice that users seek.

III. Online Expert System Using Decision Tree

Expert system is software that works on a computer system [6]. In a broad scale, the computer is not only an independent computing machine, but also a computing machine that is accessible by the user from a remote place through a specific interface. Application interface expert system provides a service for users that allows them to interact. This interface is a medium to express the facts that appear in a systematic way and to present the results of reasoning systems. Fig. 1 captures an online expert system interaction model adapted from [15]. In the development of expert systems as an on-line service, it uses various media interfaces. As in a web-based expert system, the interface used is the browser application [4], whereas for the SMS service the interface uses mobile phones [5]. When the service is applied to voice communications services, the interface that can be used is a telephone line. With the online media, the usability of expert system application services will be affordable for users.

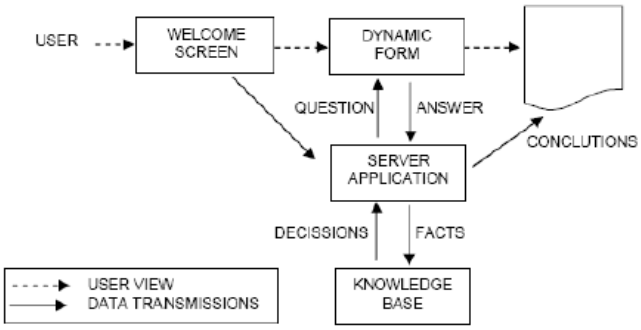

Fig. 1. Model of online Expert System [15].

An Expert system works with reference to the expert knowledge that is mapped in a representation. This representation is called a knowledge base that accommodates the description of the facts and description of the conclusions, and the availability of the rule base as the basis for reasoning [6]. One form of the representations is a decision tree [4,5]. The decision tree model describes the multilevel structure from the initial state to the final state as a decision or a conclusion. Branches as option would establish the rule that directs the state gradually towards a particular decision. This decision tree is a kind of conceptual model, so it requires a form that can be recognized or accessed by an application program such as a database

IV. Representing Decision Tree into Database

This study employs a decision tree model as a knowledge representation of the developed application. Fig. 2 illustrates that decision tree contains several connected nodes. The nodes have a role based on its category. Nodes that function in the process of identification of facts or symptoms called decision nodes. The decision node in the initial identification is called a root node. Decision node provides branches to the next nodes, so that will be formed paths which ended in leaf nodes. Paths will form a kind of rules that accommodate variations of the decision. A conclusion or diagnosis results obtained from the leaf nodes are usually accompanied by suggestions.

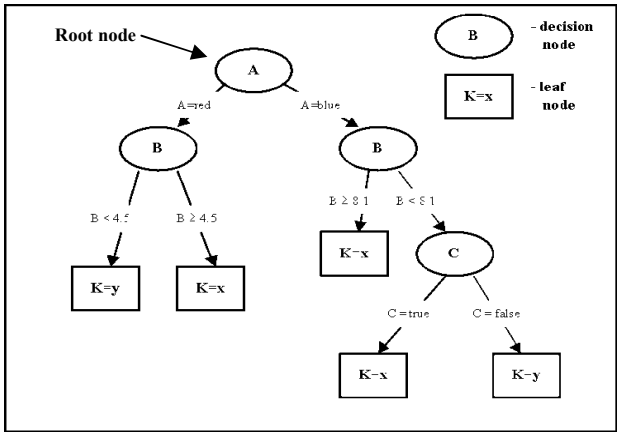

Fig. 2. A decision tree example [16]

In order to provide a knowledge base, which is accessible by applications, the decision tree model must be mapped into a database model. Based on decision tree concepts, there are four elements that are important to be accommodated in a particular database including problem domain definition, facts or symptoms definition, possible conclusion (diagnosis) definition, and rule structure representation that illustrates the relationships between each nodes. Fig. 3 alleges the database design for storing the knowledge base using decision tree approach in accordance with previous work [4,5].

Several tables in the database above own some functions. Case Table provides a domain scope of a particular problem; Symptom Table stores facts definition as symptoms of possible problem; Diagnose Table accommodates possible conclusions and corresponding suggestions; Rule Table represents a rule base with a decision tree approach.

Some fields are accommodated in the Rule Table. Those fields are IsRootNode field that stores indication data from initial identification to distinguish whether it is a root node or a decision node that exists. Identification_question field holds question data according to symptoms table. Answer_Description field stores options of label data. Answer_Link field holds links to appropriate answers. The links can direct to the next question (decision node) or a conclusion (leaf node). IsAnswerLeafNode field that indicates answer type, whether it is interaction process should continue or not.

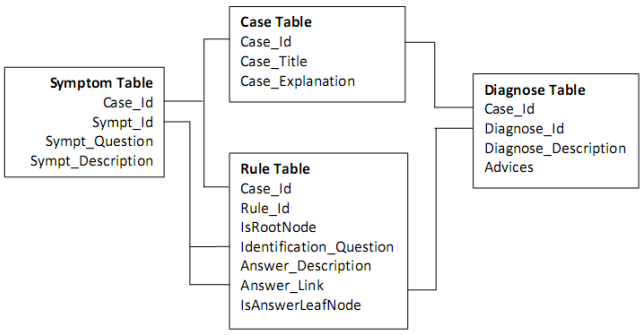

Fig. 3. Database design for storing knowledge base.

In the context of the IVR application, some fields accommodate the voice files to be played. Case_Explanation field serves to store the location of the voice file of the system description. Sympt_Question field serves to store the location of the voice file of the questions of symptoms identification, and Diagnose_Description field serves to store the location of the voice file of the diagnosis results, and Advices fields to accommodate the location of the voice file of the suggestions will be given.

V. SYSTEM DESIGN

A. System Architecture

The system architecture consists of hardware elements and software elements (Fig. 4). Hardwares are in the forms of server systems that support computing services. This server is connected to telephone interface that connects to telephony system (PBX). Phone interface plays a role channeling voice messages and detects the code tone (DTMF) sent by the user through the telephone keypads pressed. Users connected to a telephone line can take an advantage of aural consulting services.

Elements of the software system consist of a database representation of the knowledge base, development application, and consulting application. The database serves to accommodate the knowledge of experts in the form of a knowledge base. Application development is a medium for knowledge engineers to manage data representation of knowledge. Consulting application is software that becomes the user interface for the service. This application will work to bring the user to trace a path on decision tree.

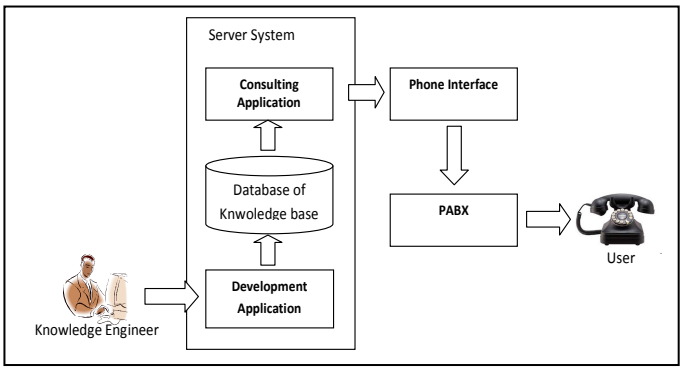

Fig. 4. System Architecture.

B. Tracing Mecanism of Decesion Tree

The main element of the proposed system is the database, which accommodates the knowledge base models. Knowledge engineer can create or modify data of the knowledge base that is stored in the tables through the interface of the application development. The consultation process can be done after the knowledge base is formed. Then, application consultation expected to be able interpret the knowledge base models. Furthermore, a mechanism is needed so that the interpretation of the consultation process can work as referring in [5], as shown in Fig. 5.

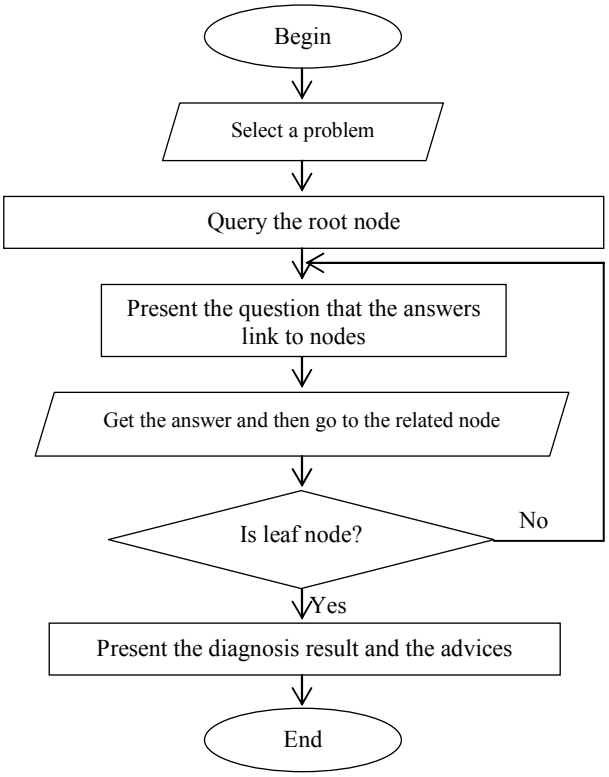

Fig. 5. Mechanism of Decision tree tracing.

In accordance with Fig.5, the consultation process begins after a case is selected. Root node containing the initial question acts as a starting point the identification process of symptoms or facts. The question in the form of the multiple choice answers are links to other nodes. The branches of the answers to these questions are used to determine the next step, whether it is a branch leading to a decision node or leaf node. If the branch is a decision node then show further identification questions were also to determine next steps. But if the branch is life node then show the results of the diagnosis as well as suggestions. At this point the consultation process ends. Furthermore, the application program can utilize these mechanisms based on the programming language used.

VI. DENGUE FEVER SEVERITY CONSULTING CASE

Dengue fever is a disease that has become all over the world attention, as is frequently cause of death. According to WHO [17], there are more than 900.000 cases in more than 60 countries just between 2000 and 2007. Moreover, dengue fever incidents are continuously monitored through Dengue Map[18]. Certain deaths are mostly because later treatment. Thus, prevention efforts have to be improved. Interactive information preparation (consultative) for this occurrence is necessarily needed for public. An example of this, is online consultation application that employs an expert system.

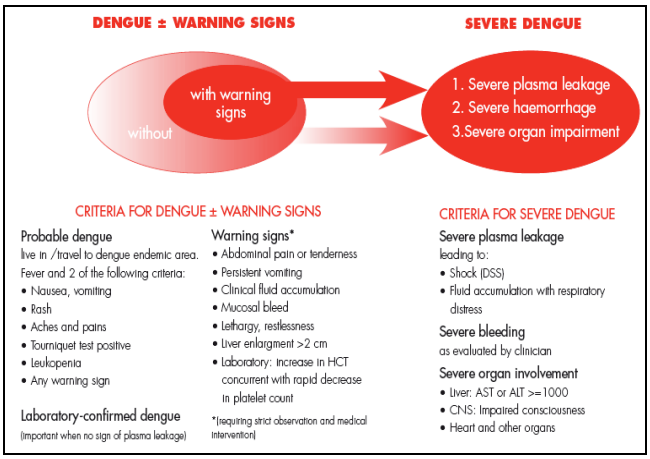

Fig. 6. WHO's classification of dengue based on the severity levels [17].

This study refers to a dengue fever example case from WHO regarding dengue fever case classification [17]. Dengue without warning sign is the lowest level. Dengue with warning signs is the upper level, while the severe dengue is the most dangerous. The classification of dengue severity is seen in Fig. 6. Each classification has specific symptoms that indicate the diagnosis and proper treatments. According to this reference, the expert system case is aimed as a dengue fever consultation media to identify the disease level and appropriate treatments. Identification process is carried out based on easily known facts from the patients.

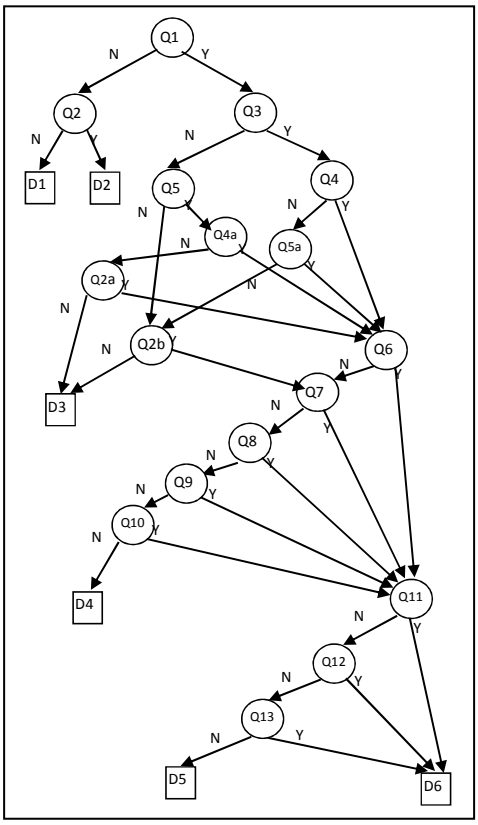

Fig. 7. Example decision tree of Dengue Fever.

Fig. 7 illustrates an example of a decision tree of a dengue fever model. This model is developed through consultation and discussion with three physicians, one of them is an internist. The physicians play as experts in this domain problem.

The model in the form of decision tree consists of some nodes. Nodes with Q code indicate branch node as question item identification. The questions have yes (Y) or no (N) answer choices that will direct to the next node. In the context of IVR, answer yes or no can be presented by code 1 or 0 from phone keypad. Node with D code is a conclusion in the leaf node.

This consultation service is tested by referring to a case example that is represented in the decision tree described in Fig. 7. The scenario will lead user to go through this following path: Q1-Q3-Q4-Q6-Q7-Q8-Q9-Q10-D4. Fig 8 and Fig. 9 shows monitoring application during testing.

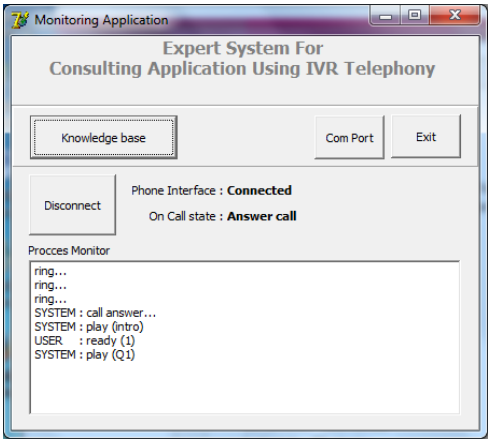

Fig. 8. Beginning consulting procces and first identification question.

Fig 8 illustrates the indication of starting consulting process. A voice of service introduction (Intro) is playing. After the users are ready for the consultation, they should press "1" to begin. A first question (Q1) will play, then users must ask yes/no by pressing keypad code 1/0. This phase will occur for a couple of activities until the last question (Q10) that will lead to reach conclusion (D4) which is shown on Fig. 9.

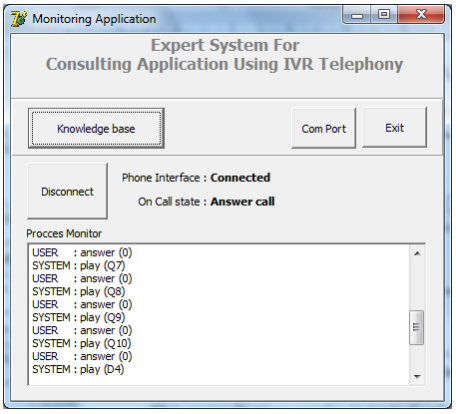

Fig. 9. Final symptom identification (Q10) that will lead to a conclusion(D4)

Testing result illustrates that the interaction mechanism (questions and answers) has worked through the correct path according to the plan. The tests were also conducted on the all paths (123 times). Validation was undertaken during testing by the experts (three physicians) as user representation. The experts agreed with the results of the all tests. The tests show that the application is able to read the data for symptom identification until it reaches a particular conclusion, which is provided by the IVR system according to users' answers. Thus, the rules that represent a constructed decision tree are able to show the interaction mechanism between machine and user. Finally, the model presented in a decision tree can be implemented in handling other cases.

VII. CONCLUSSION

IVR telephony as a voice communication medium allows to be used as consulting services. This service can be developed by an expert system approach that utilizes a decision tree representation. The decision tree will serve to provide path consulting services from initial identification questions towards a particular conclusion interactively. The test results show that the proposed tracking mechanism was able to follow a predetermined path.

ACKNOWLEDGMENT

The authors express a gratitude to Indonesian Ministry of Research Technology and Higher Education that provide research grant in 2015.

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