Personalized Ubiquitous Diet Plan Service Based on Ontology and Web Services

Chuan-Jun Su, Yin-An Chen, and Chia-Wen Chih

***Abstract*—With the popularization of computers and advancement of information technology (IT), there has been a rapid growth in the application of IT, thus greatly changed living habits, consumption behaviors, and health awareness of the modern society. Meanwhile, the demand is ever increasing for healthcare services based on information and knowledge that lead to personal health attention by people gradually.**

This research aims to design and develop an ontology driven knowledge-base system for generating personalized Diet-Aid web services based on standard Health Level Seven (HL7) health screening data. The system provides intelligent, personalized web services of Diet plan for users through an ontological knowledge engine. The system developed is capable of generating a dietetic plan and filter out unsuitable food on site according to user's health conditions and the accessible recipe information. The REST-based Diet-Aid web services can be accessed service ubiquitously by using any Internet-enabled device.

***Index Terms*—Diet plan, health level seven international (HL7), health screening, ontology.**

I. Introduction

Rapid economic development and advancement of medical knowledge has elevates public awareness of health issues. Meanwhile, improved living standards have also coincided with increased stress, leading to the development of the concept of "sub-health" [1], a state which lies between health and sickness. A World Health Organization (WHO) survey classifies 75% of the world's population as being "sub-healthy" while only 5% are classified as "healthy" [2]. For example, a "healthy" person who's fasting blood sugar is 6.0 (mmol/L) might be easily ruined by diabetes if without controlling blood sugar levels, and thus would actually be considered to be "sub-healthy". Sub-health and its related factors require urgent attention in the area of modern preventive medicine.

Healthy diet habits generally lead to better the levels of physiology data acquired from health screening tests and thus improve sub-health conditions. The physiology data, such as levels of BMI (Body Mass Index), blood pressure and blood sugar etc., serves as the most important indicators of the relative benefits of a person's health state. The science of nutrition illustrates how and why specific dietary aspects influence health [3]. Healthy diet habits not only make it easier to maintain psychological health but also make the body less susceptible to common diseases.

In some cases, a "one size fits all" approach to healthy diet habits can actually be harmful to a person's health. However, acquiring a personalized healthy diet plan from domain professionals can be time-consuming and costly. Moreover, the domain professionals may recommend inconsistent diet plans because they are pulling their information from a variety of sources and favored practices vary depending upon a range of factors including geographic location. Inconsistent plans may result in an inappropriate dietary. A knowledge-driven information system which encapsulates the knowledge of domain professional and is capable of generating consistent healthy diet plans based on users' existing health and medical conditions may successfully address these issues.

Ontology is an emerging technology which enables the advanced representation, management, and sharing of knowledge [4]. Through an ontology-based knowledge engine, cross-domain knowledge solicited from human experts can be visualized and applied to reasoning and modeling. An ontology-based Knowledge Engine could offer the following advantages over a similar engine based on conventional database architecture [5]:

- more efficient and flexible in capturing knowledge about concepts in the domain and relationships between these concepts;
- the ability to maintain and extend a knowledge corpus and the ability to track the effects of changing a section of the knowledge base; and
- the ability to infer broaden knowledge that might be associated with the user's query.

Ontological knowledge engines have potential academic and industrial applications. Reference [6] presented an ontology-based programming framework, OPEN, for rapid prototyping, sharing, and personalization of context-aware applications. The prototype OPEN adopts SPARQL as the context querying language and uses Jess as inference engine to execute SWRL rules.

A knowledge engine, consisting of an ontological knowledge base and a SPIN-based (SPARQL Inference Notation) inference module for generating healthy diet plans, was built in OPEN. However, the authors fail to clearly address issues of data interoperability, which is of concern in that the inputs for such a system are personal health data, which could come in proprietary formats. A uniform medical information standard format is required to ensure the interoperability of electronic health screening data in an ontological knowledge engine. HL7[1] is a global authority on

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The authors are with the Department of Industrial Engineering and Management, Yuan Ze University, Taiwan, ROC (e-mail: iecjsu@satuen.yzu.edu.tw, helloisocute@gmail.com, deake.chen@gmail.com).

[1]HL7. http://www.hl7.org/

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standards for the enhancement and integration of health information to promote data interoperability among hospitals at the regional level [7], providing a set of standards for the exchange, integration, and retrieval of electronic healthcare records [8].

A. SPARQLMotion and Knowledge Engine

SPARQL is well established as the standard RDF query language; its name is a recursive acronym that stands for the SPARQL Protocol and RDF Query Language. It was standardized by the RDF Data Access Working Group (DAWG) of the World Wide Web Consortium [9]. On 15 January 2008, SPARQL became an official W3C Recommendation [10]. Comparable to SQL, SPARQL provides the SELECT keyword to extract information out of an RDF/OWL repository. SPARQL also provides the CONSTRUCT keyword to construct new triples from existing ones, making SPARQL an attractive solution for defining ontology mappings or rule bases.

SPARQLMotion™ is a visual scripting language and engine for semantic data processing [11]. It is fully compliant with W3C standard languages SPARQL, RDF, and OWL. SPARQLMotion scripts can be defined and shared as OWL models, based on a dedicated SPARQLMotion ontology and module library. Furthermore, SPARQLMotion scripts can be executed as RESTful (REpresentational State Transfer) Web Services [12], an architectural style that allows access to services over the Web using only a simple URL. It leverages REST technology to extend SOA (Service-Oriented Architecture) to the web, making it possible to use the Web as an SOA platform. Using SPARQLMotion with RESTful services, we can easily expose data and content for use and reuse by current and future applications. Reasoning/inferencing may be performed using SPARQLMotion based on the SPIN-encoded knowledge base to generate knowledge-oriented results. SPIN is a standards-based way to define rules and constraints for Semantic Web data. SPIN is able to link class definitions with SPARQL queries to capture constraints and rules that formalize the expected behavior of those classes. In this research, we used SPIN to express rules in SPARQL and execute them directly on RDF data and models.

The proposed Diet-Aid adopts SPARQLMotion as the inference engine to derive knowledge required to generate personalized healthy diet plans and publish Diet-Aid as a RESTful Web service. With consideration for future expansion of the proposed system, TopBraid™ Composer - Maestro Edition (TBC-ME) [2] was adopted as the development platform, which allows for the construction and execution of SPARQLMotion scripts for processing data chains and creating integrated web services.

The remainder of this paper is organized as follows. In Section II we discuss studies related to ontology, HL7, and ubiquitous computing. The Diet-Aid design and framework of the knowledge-based system which includes the ontology-based knowledge engine is presented in Section III. In Section IV we illustrate major implementation details including the system configuration and implementation of a sample scenario. Finally, in Section V we provide conclusions and suggestions for future research.

[2] TopBraid Composer.
http://www.topquadrant.com/products/TB_Composer.html

II. Related Works

A. Ontology-Based Applications

Generally, an ontology is defined as a formal, explicit specification of a shared conceptualization [13]. An ontology describes the concepts and relationships that are important in a particular domain, providing a vocabulary for that domain as well as a computerized specification of the meaning of terms used in the vocabulary [13]. An ontology consists of classes, properties and instances. Classes define a concept. Instances are elements of classes and are linked to classes via properties. Properties can be used to state relationships between individuals, or between individuals and data values. The aim of an ontology is to formalize domain knowledge in a generic way and provide a common understanding of a domain, which may be used and shared by applications and groups. Ontology is also an emerging technology for knowledge representation [14] in which it helps realize reasoning and can be used in data integration [15].

Ontological technology has been widely adopted in the business and scientific communities as a way to share reuse and process domain knowledge. The technology is also central to many applications in fields including information management, systems integration and semantic web services [16]. Many studies have also demonstrated that ontology is essential for the development of knowledge-oriented systems.

Huang *et al*. developed a medical ontology to serve as the foundation for an intelligent Chinese Medical Diagnostic System (CMDS) which acts as a human expert to diagnose a number of digestive system conditions including stomachache, vomiting, hiccups, diaphragmatitis, bellyache, diarrhea, dysentery, constipation, jaundice, tympanites, etc [17]. Reference [18] presented the design and implementation of an ontological knowledge-based preoperative assessment support system, which is a generic clinical screening process, intended to identify early on in a patient journey potential risks of complications during or after surgery.

Reference [19] proposed an ontology-based medical knowledge base called the Causal and Temporal Knowledge Acquisition (CATEKAT2), which provides physicians with a broad spectrum of medical knowledge. Reference [20] developed an ontological knowledge base to drive an Occupational Health Application (OCHWIZ) which provides suggestions as to possible causes and industries associated with a given clinical finding related to a specific occupation. Based on these suggestions, it is also capable of inferring other diseases and conditions to watch for.

Reference [21] proposed using semantic Web technology to build an ontology-based semantic search system for planning health-related fitness training programs in elementary schools. Reference [22] presented a semantic location service to locate active mobile objects such as mobile devices and RFID-tagged objects in smart and intelligent environments.

Medical differential diagnosis is based on the estimation of multiple distinct parameters to determine the most probable diagnosis. Reference [23] proposed an ontology-driven medical diagnosis system, ODDIN, which uses ontologies representing specific structured information, computation of probabilities of various factors, and logical inferences of the patient's signs and symptoms. ODDIN may serve as a training tool for decision-making by medical personnel and students.

Reference [24] described an ontological software platform SEMPATH, which can offer personalized treatment plans by using and managing health care business processes (clinical pathways). During the execution of clinical pathways, the system considers the patient's clinical status and reaction to the treatment scheme according to the SWRL rules in reconfiguring the next treatment steps.

Reference [25] designed and proposed a counseling system, Food-oriented ontology-Driven System (FOODS), for food or meal planning in restaurant, clinic/hospital, or at home. The FOODS system equips with a knowledge engine which works to inferring appropriate foods or meals for customers based on the food ontology. The food ontology specifies the related knowledge of the meals involving gastronomy, ingredients, substances, nutrition facts, and recommended daily intake, etc. It provides a reference and base for us to construct our food ontology in Diet-Aid.

B. Health Level Seven (HL7)

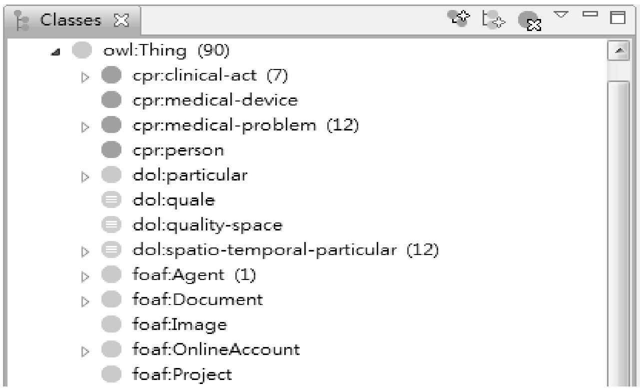

Fig. 1. Partial "HL7-sample-plus-owl" ontology.

Interoperability is a fundamental requirement for health care systems to derive the benefits promised by the adoption of HL7-based systems and Electronic Medical Records (EMRs). Reference [26] proposed a data exchange model that follows the HL7 protocol in the eXtensive Markup Language (XML) format, to represent clinical information in healthcare domains. The model can also provide suggestions to hospitals for their future work on the development of Electronic Medical Records (EMR).

The Taiwan Association for Medical Informatics (2006) developed a system called HWS (HL7 electronic patient records and Web Services exchange system) to achieve health care information exchange and interoperability. HWS gives developers access to longitudinal medical records for the development of interoperable health care systems [27].

To ensure interoperability, we developed Diet-Aid, an HL7-compliant system driven by a knowledge engine built on top of the ontology HL7-sample-plus-owl developed by the World Wide Web Consortium (W3C) [28] (Fig. 1). Diet-Aid can process inputs such as HL7-compliant user health screening data and personal information from any medical organization.

C. Ubiquitous Environment

A ubiquitous health service system must be based on the technology paradigms of mobile, pervasive and autonomic computing [29]. A number of ubiquitous capture and access applications have been developed in the past [30].

Reference [31] introduced a mobile u-health service system called Total Health Enriching-Mobile U-health Service System (THE-MUSS). THE-MUSS is a framework that aims to implement a ubiquitous health service environment with the functions, modules and facilities required by various mobile u-health services. In addition, THE-MUSS uses bio-sensors which are worn by users or embedded into cell phones to collect data remotely for analysis, with the cell phone acting as a gateway between the bio-sensors and the u-health service.

Reference [32] presented a grid portal application, MASPortal, to provide medical advice to home-bound patients. MASPortal is a portlet-based application that provides remote and automated medical supervision via adaptive, easy-to-use interfaces and interactions. This supervision focuses on providing on-demand diagnosis and treatment advice which is derived from a collection of data provided manually by the patient. In addition, the integration of mobile and wireless devices with grid technology can provide ubiquitous and pervasive access to grid services. Reference [33] examined several sources of data on smart phone use, finding evidence for the popular conjecture that mobile devices are "habit-forming", and results in behavior known as the "checking habit" - brief and repetitive inspections of dynamic content quickly accessed on the device. Their work reveals the importance of mobile access in the context of ubiquitous computing.

III. Methodology

A. Diet-Aid Logical Architectures

The logical architecture of the proposed Diet-Aid system is illustrated in Fig. 2. The system is initiated with the data retrieval process:

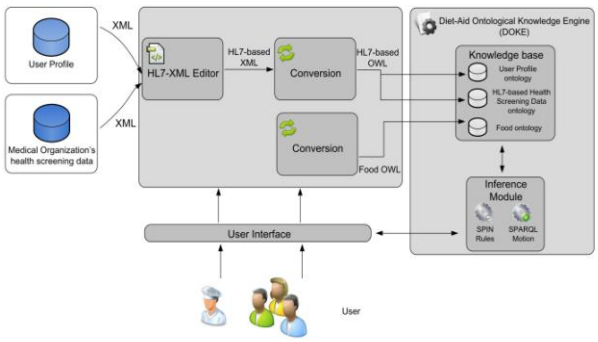

Fig. 2. The logical architecture of Diet-Aid.

- Data Retrieval: User profile and health screening data are first retrieved from the database of a health-screening center or medical institution by RFID (Radio Frequency Identification) or NFC (Near Field Communication).

- Ontology Conversion: The HL7-compliant user profile and health-screening data are subsequently converted into OWL ontologies through tools such as TopBraid™ Composer (TBC). These converted ontologies will be used to derive personalized diet plans through reasoning.
- Diet-Aid Ontological Knowledge Engine (DOKE): The DOKE is the main component of the Diet-Aid architecture. The engine encapsulates an ontological knowledge base consisting of the food ontology, user profile ontology, HL7-based health-screening ontology, a high-level abstraction of rules in the form of constraints, and low-level SPIN rules for inferring diet advices.
- RSETFUL Web Service: The restful way of Diet-Aid implementation enables smooth deployment of the service. Consequently, the Diet-Aid generates a personalized diet device, which can be accessed through any Internet-enabled device.
- User Interface: The User Interface is the graphical interface, which allows users to access the food supplier (e.g. restaurants) recipes information in Diet-Aid service.

B. Diet-Aid Physical Architecture

The physical architecture of Diet-Aid illustrates the delivery and ubiquitous access of the designed functions. As shown in Fig. 3, the architecture consists of three main components: Diet-Aid Ontological Knowledge Engine, Database Repository, and App. Server.

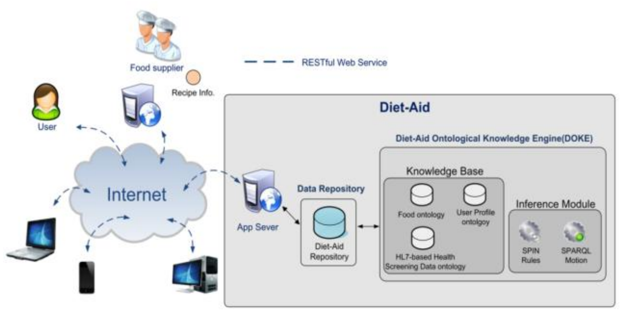

Fig. 3. The physical architecture of Diet-Aid.

Diet-Aid Ontological Knowledge Engine (DOKE)

The DOKE is the core component of Diet-Aid Service, which is comprised of Knowledge Base and Inference Module:

- Knowledge Base is driven by three ontologies: 1) the food ontology, 2) the user profile ontology, and 3) the HL7-based health screening ontology. These provide knowledge acquired from domain experts and the user's health status to generate a personal diet plan.

1) Food ontology

The Food Ontology is defined according to the dietitians and the Department of Health, Executive Yuan[3]. The relation between classes and instances are derived from the consultation with the dietitians of MJ Health Screening Center.

[3]Dietitians and the Department of Health, Executive Yuan, R. O. C. (Taiwan) Avaliable: http://www.doh.gov.tw/cht2006/index_populace.aspx

2) User profile ontology

The User profile ontology is built according to the ACPP ontology mentioned in section 2, some properties are defined based on the food and health screening and some defines personal data.

3) HL7-based health screening ontology

HL7-based health screening ontology comprises the normal test (e.g. height, weight, etc.), the examination test (e.g. blood glucose, blood fat, etc.), X-ray test, Electrocardiogram (ECG) test, and so on. The classes and properties of health screening are defined by the hierarchy of HL7 standards; these are extended from the HL7-sample-plus ontology mentioned in section 2.

- The Inference Module is comprised of two components: 1) SPIN Rule and 2) SPARQLMotion. Our SPARQL Motion scripts first load a user's personal data from the user profile and health screening report. A series of SPARQL queries are then performed to generate a personalized diet plan. The resulting plan may be displayed on a screen, stored in the database server, or stored as a dynamic model that can be imported into other ontologies.

For example, suppose that a person has a fasting blood glucose value (i.e. AC) of 110. By executing the SPARQL query, the first rule (SPIN rule 1) would suggest that the person's fasting blood glucose is higher than 100 while the second rule will infer that the person has a medical condition ("high-AC"). The third (SPIN rule 3) then creates the goal (reduce-blood-glucose), as shown in Fig. 4. Once the goal has been determined, a personalized diet plan can be derived from in-depth inferencing according to the person's health status.

SPARQL query	SELECT ?User ?Goal WHERE { ?User DOKE:hasAC ?ACV.}
SPIN rule 1	CONSTRUCT { ?User DOKE:hasHighAC ?HighAC} WHERE { ?this DOKE:hasAC ?ACV. FILTER (?ACV >100).}
SPIN rule 2	CONSTRUCT { ?ACV DOKE:isMedicalSignofValue ?MS} WHERE { ?User DOKE:hasHighAC ?ACV.}
SPIN rule 3	CONSTRUCT { ?user DOKE:hasGoal ?Goal} WHERE { ?Goal DOKE:hasMedicalSign ?MS ?AC DOKE:hasHighAC ?MS. ?User DOKE:hasAC ?AC. }

Fig. 4. The simple illustrations for the inference module.

C. Data Repository

The Data Repository stores the User Profile, Health Data, and Diet Plans. A user profile includes general information such as name, gender, age etc. The Health Data stores data from the user's health screening. The Diet Plan stores the user's personalized such as the goal of diet.

Application Server

The Application Server (App. Server) is a software framework that provides an environment for running and delivering Diet-Aid applications and services. The server-side Diet-Aid Web Application allows users to maintain data stored in the Data Repository while the RESTful Web Services enable users to access their Diet-Aid services ubiquitously.

- Diet-Aid Web Application provides a GUI (Graphical User Interface) through which users maintain their health screening data, and user profile.
- RESTful web services in Diet-Aid provide an abstraction for publishing information and provide remote access to the Data Repository. Traditional web-services are memory and processor-intensive, and are thus not appropriate for the limited memory and processing of the mobile devices. RESTful Web Services, however, are very suitable for such devices [34]. The Diet-Aid was designed in accordance with the REST architectural style, which offers ubiquitous access through virtually any Internet-enabled device.

IV. Implementation

A. Hardware and Software Configurations

TABLE I: Hardware and Software Configuration of Diet-Aid

CPU	Intel(R) Xeon(R) E5310 1.6GHz
Memory	2.0 GB
Operation System	Microsoft Windows Server 2003 Standard Edition
Database	Microsoft SQL Server 2008 Express Edition
Java Platform	Java SE Development Kit 1.6
Application Server	Apache Tomcat 6.0
RESTful Framework	Jersey 1.1.5.1
JDBC Driver	Java DataBase Connectivity 3.0
Knowledge Engine Framework	TopBraid™ Composer - Maestro Edition

Diet-Aid was built on Microsoft Windows Server 2003 Standard Edition, with the Java™ SE Development Kit 1.6 installed. TBC-ME was used to develop the DOKE because the Eclipse-based TBC-ME is not only a visual ontology editor but also serves as a knowledge-based framework capable of integrating inference engines through hybrid inference-chaining. Most notably, TBC-ME can be used to develop and execute SPARQLMotion scripts including web services for processing data chains and creating integrated data services. The hardware and software configuration of the prototype system is summarized in Table I.

B. Knowledge Base Design in Diet-Aid

DOKE is the core component of Diet-Aid, which comprises the Knowledge Base and Inference Module. The Knowledge Base uses food type, user profile, and HL7-based health screening ontologies to represent explicit specifications of the diet domain and to serve as a backbone for inferencing. The classes, instances, and properties defined in the Knowledge Base are partially shown in Fig. 5. Fig. 6 depicts the partial classification and relations of the entities in these three ontologies, as developed in TBC-ME.

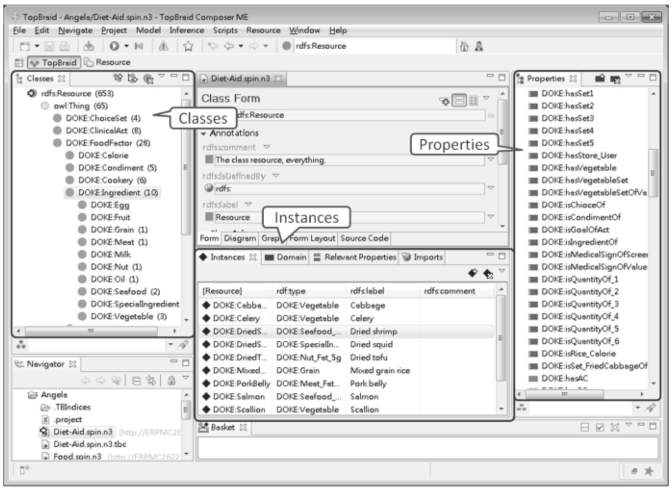

Fig. 5. Classes, instances and properties of knowledge base design.

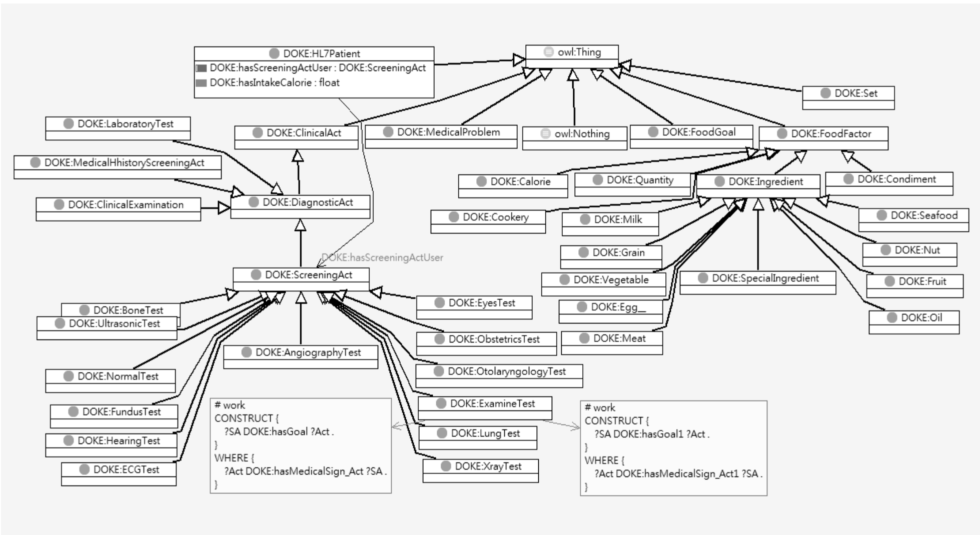

Fig. 6. HL7-based Health screening data ontology, User profile ontology, and Food ontology (classification and relation of the entities).

C. Inference Module Design

As described in section 3.2, the Inference Module is composed of SIPN rules which encapsulate the ontology-specified domain knowledge, and SPARQLMotion which performs inferencing. Each of the three ontologies has an associated set of SPIN rules. Fig. 7 shows the example of SPIN rules defined for the HL7-based Health screening data ontology.

Generating a personalized diet plan requires connecting to databases that support the storage of RDF models or are able to import data into the RDF structures. D2RQ was used to establish a connection to the relational database server storing personal information, including user profiles and health data. D2RQ is a declarative language used to describe mappings between relational database schemata and OWL/RDFS ontologies.

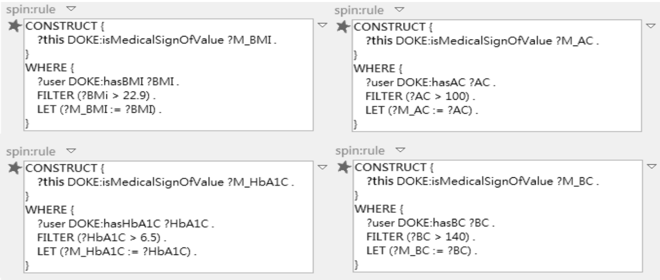

Fig. 7. SPIN Rules of HL7-based Health screening data ontology.

D. *Restful Web Service Provisioning for Diet-Aid*

App. Server is a software framework that handles all application operations between users and the Diet-Aid backend applications, which involve Web Application and RESTful Web Services. Diet-Aid's RESTful web services are implemented using the Jersey framework configured on Apache Tomcat. Jersey is an open source community that is building a production quality reference implementation of JSR-311, which is an annotation-based API for implementing RESTful web services. Jersey provides an intuitive way to develop RESTful web services by providing annotations and APIs standardized in JSR 311. Fig. 8 provides a screen capture of a sample personal diet plan published via the RESTful web service.

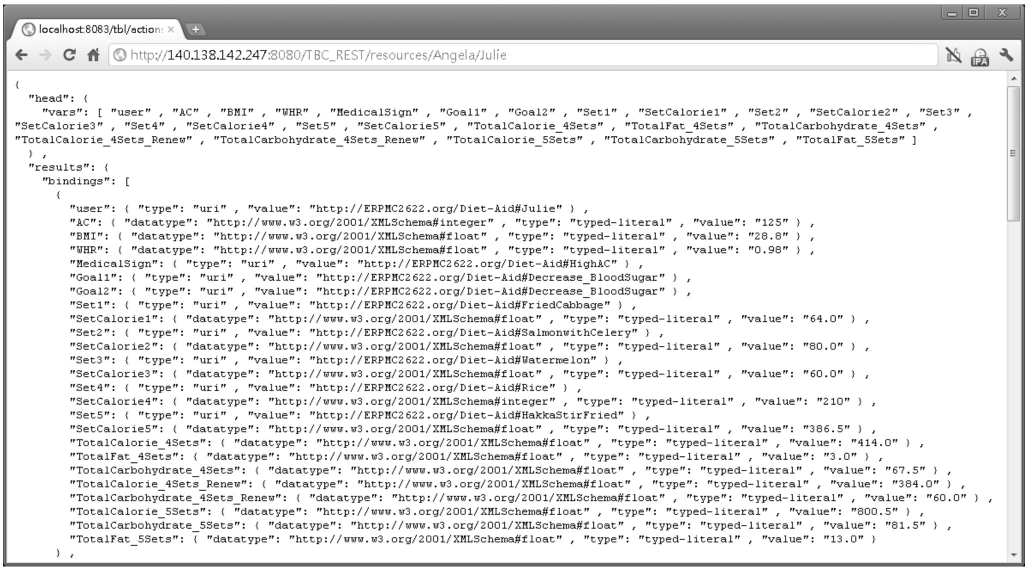

Fig. 8. Diet plan access via RESTful web service.

V. CONCLUSION

This paper describes the design and development of an ontology-based web service (Diet-Aid) to generate personalized healthy diet plan consistently based on personal health screening data and profile (preference). Diet-Aid addresses interoperability issues in health and personal data by adopting the international standard HL7 as the input format. Furthermore, Diet-Aid was developed and deployed using the Restful architecture, allowing for ubiquitous access via any Internet-enabled device.

The Diet-Aid takes personal health data and available recipes as input to generate a personalized food advice onsite. Nevertheless, it would be advantageous for the system to add nutritious information about the ingredients, such as amount of vitamins in the ingredients for users to consider. The system could be further enhanced by generating a diet plan by putting the nutritionist recommended daily intakes into consideration.

REFERENCES

[1] X.-S. Li, Y. Huang, Y, Li, and Z.-H. Yuan, "Establishment and evaluation of the sub-health diagnosis model based on decision tree," in *Proc.* 2010 *International Conference on the Computer Application and System Modeling*, 2010, pp. 15-21.

[2] World Health Organization, "World Federation of Chinese medicine Societies Sub-health professional committee," presented at the first sub-health academic conferences in the world compilation of Information, Beijing, 2006.

[3] C. Snae and M. Bruckner, "FOODS: A Food-Oriented Ontology-Driven System," in *Proc. 2nd IEEE International Conference on the Digital Ecosystems and Technologies*, 2008, pp. 168-176.

[4] I. Jurisica, J. Mylopoulos, and E. Yu, "Ontologies for knowledge management: An information systems perspective," *Knowledge and Information Systems*, vol. 6, no. 4, pp. 380-4018, July 2004.

[5] J. Kivimaa, A. Ojamaa, and E. Tyugu, "Graded Security Expert System," *Critical Information Infrastructure Security*, Berlin, Heidelberg: Springer, pp. 279-286, 2009.

[6] B. Guo, D. Zhang, and M. Imai, "Toward a cooperative programming framework for context-aware applications," *Personal and Ubiquitous Computing*, vol. 15, no. 3, pp. 221-233, March 2011.

[7] D. Pascot, F. Bouslama, and S. Mellouli, "Architecturing large integrated complex information systems: an application to healthcare," *Knowledge Information System*, vol. 27, pp. 115-140, April 2011.

[8] D. Vassis, P. Belsis, C. Skourlas, and G. Pantziou, "Providing advanced remote medical treatment services through pervasive environments," *Personal and Ubiquitous Computing*, vol. 14, no. 6, pp. 563-573, September 2010.

[9] J. Rapoza. (2006). SPARQL Will Make the Web Shine. *eWeek*. [Online]. Available: http://www.eweek.com/c/a/Application-Development/SPARQL-Will-Make-the-Web-Shine

[10] I. Herman. (2008). SPARQL is a Recommendation. *W3C Semantic Web Activity News*. [Online]. Available: http://www.w3.org/blog/SW/2008/01/15/sparql_is_a_recommendatio n

[11] TopQuadrant. (2009). SPARQLMotion tutorial Version 3.0. [Online]. Available: http://topquadrant.com/sparqlmotion/tutorial/SPARQLMotionTutorial-3.0.pdf
[12] R. T. Fielding, "Architectural Styles and the Design of Network-based Software Architectures," unpublished Ph.D., Irvine Univ., California, 2000.
[13] T. R. Gruber, "Toward Principles for the Design of Ontologies Used for Knowledge Sharing," *International Journal of Human-Computer Studies*, vol. 43, no. 5-6, pp. 907-928, November-December, 1995.
[14] M. K. Smith, C. Welty, and D. L. McGuinness. (2004). OWL Web Ontology Language Guide. *W3C Recommendation*. [Online]. Available: http://www.w3.org/TR/owl-guide/
[15] Y. Tang and R. Meersman, "DIY-CDR: an ontology-based, Do-It-Yourself component discoverer and recommender," *Personal and Ubiquitous Computing*, vol. 16, no. 5, pp. 581-595, June 2011.
[16] A. Smirnov, N. Shilov, T. Levashova, L. Sheremetov, and M. Contreras, "Ontology-driven intelligent service for configuration support in networked organizations," *Knowledge and Information Systems*, vol. 12, no. 2, pp. 229-253, July 2007.
[17] M. J. Huang and M. Y. Chen, "Integrated design of the intelligent web-based Chinese Medical Diagnostic System (CMDS) - Systematic development for digestive health," *Expert Systems with Applications*, vol. 32, pp. 658-673, January 2007.
[18] M. M. Bouamrane, A. Rector, and M. Hurrell, "Using OWL ontologies for adaptive patient information modelling and preoperative clinical decision support," *Knowledge and Information Systems*, vol. 29, no. 2, pp. 405-418, November 2011.
[19] J. M. Juarez, T. Riestra, M. Campos, A. Morales, J. Palma, and R. Marin, "Medical knowledge management for specific hospital departments," *Expert System Application*, vol. 36, no. 10, pp.12214-12224, December 2009.
[20] J. Kola, B. Wheeldin, and A. Rector, "Lessons in building OWL Ontology driven applications: OCHWIZ - an Occupational Health Application," in *Proc. e-Science All Hands Conf.*, UK, 2007, pp. 71-78.
[21] K. F. Tseng, "Developing a Semantic Search System for Planning the Physical Fitness Training Program in Elementary School," Master thesis, Dept. Information Management. Nanhua Univ., Taiwan, ROC, 2010.
[22] A. Coronato, M. Esposito, and G. D. Pietro, "A multimodal semantic location service for intelligent environments: an application for Smart Hospitals," *Personal and Ubiquitous Computing*, vol. 13, no. 7, pp. 527-538, October 2009.
[23] G. C. Ángel, R. Alejandro, M. Mencke, G. B. J. Miguel, and R. Colomo-Palacios, "ODDIN: Ontology-driven differential diagnosis based on logical inference and probabilistic refinements," *Expert System Application*, vol. 37, no. 3, pp. 2621-2628, March 2010.
[24] D. A. Alexandrou, I. E. Skitsas, and G. N. Mentzas, "A Holistic Environment for the Design and Execution of Self-Adaptive Clinical Pathways," *IEEE Trans. on Information Technology in Biomedicine*, vol. 15, no. 1, pp. 108-118, January 2011.
[25] C. Snae and M. Bruckner, "FOODS: A Food-Oriented Ontology-Driven System," in *Proc. 2008 2nd IEEE International Conference on Digital Ecosystems and Technologies*, 2008, pp. 168-176.
[26] S. H. Shieh, "Construct A Data Exchange Model within Medical Databases－A case study of implement of HL7 on NHI apply data," Master thesis, Dept. Information Engineering and Computer Science. Feng Chia Univ., Taiwan, ROC, 2005.
[27] C. H. Wu, E. W. Huang, R. S. Hong, Y. T. Chou, H. D. Huang, Y. H. Lin, and J. M. Lin, "The study on Web Services based Health Level Seven for Electronic Health Record exchange system," *Taiwan Association for Medical Information*, vol. 15, no. 2, pp. 41-54, June 2006.
[28] W3C. (2007). HL7-sample-plus-owl. [Online]. Available: http://www.w3.org/2001/sw/grddl-wg/doc29/hl7-sample-plus-owl.turtle
[29] B. Blobel, "Ontology driven health information systems architectures enable pHealth for empowered patients," *International Journal of Medical Informatics*, vol. 80, no. 2, pp. e17-e25, October 2011.
[30] Z. Yu, Z. Yu, X. Zhou, and Y. Nakamura, "Multimodal sensing, recognizing and browsing group social dynamics," *Personal and Ubiquitous Computing*, vol. 14, no. 8, pp. 695-702, December 2010.
[31] D. Han, M. Lee, and S. Park, "THE-MUSS: Mobile u-health service system," Comput *Methods Programs Biomed*, vol. 97, no. 2, pp. 178-188, February 2010.
[32] V. Koufi, F. Malamateniou, and G. Vassilacopoulos, "A system for the provision of medical diagnostic and treatment advice in home care environment," *Personal and Ubiquitous Computing*, vol. 14, no. 6, pp. 551-561, September 2010.
[33] A. Oulasvirta, T. Rattenbury, L. Ma, and E. Raita, "Habits make smartphone use more pervasive," *Personal and Ubiquitous Computing*, pp. 1-10, July 2011.
[34] J. H. Christensen, "Using RESTful web-services and cloud computing to create next generation mobile applications," in *Proc. 24th ACM SIGPLAN Conf. companion on Object oriented programming systems languages and applications*, Orlando, Florida, USA, 2009, pp. 627-634.

Chuan-Jun Su was born on August 20, 1956 in Taiwan. Prior to joining the University, he was an assistant professor in the Department of Industrial Engineering and Engineering Management at The Hong Kong University of Science and Technology University. He was also the founder of Horky.com Corporation. He received his Ph.D in industrial engineering from Texas A&M University in College Station, Texas. His research interests include Information Technology, Mobile Commerce, Enterprise Information Systems, and Virtual Reality.

He is currently an associate professor in the Department of Industrial Engineering & Management, Yuan Ze University, Taiwan. His recent related publications: 1) Chuan Jun Su*, Hsin-Chi Chuang, Toward Mass Customized Product Deployment in E-Commerce: The Modularization Function and Postponement Strategy, Journal of Organizational Computing and Electronic Commerce, Volume 21(1), Jan. 2011, pp. 24-49. 2) Chuan Jun Su*, Chia-Ying Wu, JADE implemented mobile multi-agent based, distributed information platform for pervasive health care monitoring, Applied Soft Computing, Volume 11(1), Jan. 2011, pp. 315-325. 3) Chuan Jun Su*, Mobile multi-agent based, distributed information platform (MADIP) for wide-area e-health monitoring, Computers in Industry, Volume 59(1), Jan. 2008, pp. 55-68.

Yin-An Chen was born on June 17, 1983 in Taiwan. He received his master in Department and Graduate Institute of Information Management from Yu Da University, Taiwan, ROC. He is currently a PhD. student in the Department of Industrial Engineering & Management, Yuan Ze University. His research interests include health care, web services, mobile commerce, RFID technology, ontology base, and information management. His recent related publication: Chien-Liang Chuang*, Yin-An Chen, "Research of RFID Data Security protection Mechanism Research of RFID Data Security protection Mechanism", 2008 International Conference on Information Management.

Chia-Wen Chih was born on July 14, 1985 in Tai wan. She received an M.Eng. from industrial engine ering and management at Yuan Ze University, Taiw an (ROC.) in 2011. Her area of specialization is ont ology in health care.

Her research interests include ontology, personal ization service, health care, and web service. Her re cent related publication: "Intelligent, Personalized Diet plan provision using ontology and Web Service Based on HL7 Health Screening Data", Master Thesis, 2011.