eHealth Recommendation Service System using Ontology and Case-based Reasoning

Hyun Jung Lee
Yonsei Institute of Convergence Technology, School of Integrated Technology
Yonsei University
85, Songdogwahak-ro, Yeonsu-gu, Incheon, 406-840, Republic of Korea
Hjlee5249@gmail.com

Hee Sun Kim
Yonsei Institute of Convergence Technology, School of Integrated Technology
Yonsei University
85, Songdogwahak-ro, Yeonsu-gu, Incheon, 406-840, Republic of Korea
elisavette@gmail.com

***Abstract*— The proposed *eHea*lth *R*ecommendation *S*ervice *S*ystem (*eHeaRSS*) is to recommend health service information to patients whenever and wherever. Nowadays, depending on online networks popularity, there are a lot of research starting to focus on patient-context to apply health care fields like tele-health, tele-care, medical traveling, and so on. The proposed *eHeaRSS* is like a family doctor to care patients, especially to use generated patients-context. *eHeaRSS* is a recommendation system for immediate and appropriate medical services using crowd sourcing in cloud computing environment. To do this, it is necessary to classify the data into symptoms, diseases, departments and doctors related data types. To consider hierarchies or subsume relationships among them, *eHeaRSS* Ontology (*eHeaRSS-Ont*) is developed through integration of 4-static ontology (*4-Ont*) which is comprised of symptom-, disease-, department- and doctor-Ont to create tailored recommendations depending on patient-context. For the recommendation service, Case-based reasoning (CBR) is applied. The extracted cases using *4-Ont* are integrated by *eHeaRSS-Ont* depending on the patient-context. For customization, it is necessary to reconfigure the case using *eHeaRSS C*onstraints *V*alue *C*ompatibility *M*ap (*eHeaRSS-CVCM*). To prove the significance and efficiency of the *eHeaRSS*, we experimented using ontology-based data processing and proved the superiority of *eHeaRSS* with the provision of better recommendation than other DB-based systems.**

Keywords*— *Crowd sourcing; Health; Recommendation Service System; Healthcare; Ontology; Case-based Reasoning; Cloud computing environment

I. INTRODUCTION

In this research, the proposed ***eHea***lth ***R***ecommendation ***S***ervice ***S***ystem (***eHeaRSS***) is for recommendation of health information to patients just like a family doctor. In general, it is difficult for patients to get appropriate health information from online network like Web, Facebook, Twitter, etc. Even if mobile computing environment is popularized and there is a lot of health information, it is still being asymmetry of specialized knowledge like medical knowledge between patients and doctors. So it is necessary to decrease the asymmetry between patients and doctors. It helps for patients to get proper and qualified health service anywhere and anytime.

In ***eHeaRSS***, crowed sourcing is applied to decrease asymmetry of knowledge between patients and doctors. It is a good chance to share experiences of medical treatments and improve understanding of medical expression. Patients can share their experiences like therapies, medicines, departments, symptoms, progresses, and so on. The patients experiences related to health knowledge can be specified as patients' records. Nowadays it is easy to collect them from Q&A web boards that are operated by hospitals as well as SNS like blog, twitter, Facebook, etc. Even if there are a lot of hospital systems to provide health information to patients, it is not easy to understand the information since it is comprised of a lot of medical terms, expressions, attentions, postoperative recovery, etc.

In this research, we tried to transform the personal health records to health knowledge in case-base. In this light, the proposed system ***eHeaRSS*** is based on cases for recommending health services using the collected information from SNS. Cases are generated by formulation of the collected information from crowd sourcing. Ontology is adopted to take a role of meta-knowledge to manage the cases. Constraints Satisfaction Problem (***CSP***) is also applied to check compatibility among the components of the customized knowledge owing to the patients' contexts. Health information of ***eHeaRSS*** is composed of 4-static ontology (***4-Ont***) and ***eHea***lth ***S***ervice ontology (***eHeaRSS-Ont***). ***4-Ont*** is comprised of symptoms, diseases, doctors and departments. ***eHeaRSS*** is dynamically integrated with the extracted components from ***4-Ont*** according to patients' contexts. Cases are also generated on the ***eHeaRS-Ont***. The constructed cases are transformed into patients' customized cases depending on customers' queries which are including symptoms, diseases, departments and doctors. ***eHeaRSS C***onstraints ***V***alue ***C***ompatibility ***M***ap ***(eHeaRSS-CVCM)*** uses CSP to check the compatibility among the components for the customized health service, which includes the priority of therapies, proper

978-1-5090-1893-2/15 $31.00 © 2015 IEEE
DOI 10.1109/SmartCity.2015.217

departments, doctors that patients undergo medical treatments, and so on. The customized knowledge as a case is stored in case-base and reused to recommend health information to patients.

In the proposed ***eHeaRSS***, it is possible to share patients' experiences. Patients experience their own conditions, symptoms, treatments, and progresses, etc. For instance, if patients suffer from multiple diseases, then they should be struggled by multiple combined symptoms. Even though doctors are experts in health service, it is general that doctors are specialized in the specified departments, clinics, and so on. The proposed ***eHeaRSS*** is focusing on recommendations for qualified health services which contain medical treatments' processes, doctors, departments and symptoms depending on patients' experiences.

To prove the effectiveness of Ontology-based ***eHeaRSS***, it should be compared of general DB-based health system. The proposed ***eHeaRSS*** is focusing on integrated recommendations based on patients' experiences. In the other hand, generally used DB-based health systems are having limitation to propose integrated recommendations to patients. However, the proposed ***eHeaRSS*** is based on meta-knowledge using Ontology and it is possible to return more satisfying integrated recommendations. It is significant to improve the patients' satisfactions for health services.

In the rest of this paper, Section II mentions some related works. Section III describes ***eHeaRSS*** overall architecture and patient personal health record collected by crowd sourcing. The knowledge-base is described with ***4-Ont***, ***eHeaRSS-Ont*** and ***eHeaRSS-CVCM*** in Section IV. Section V illustrates case selection, classification and customization for customized recommendation. Section VI discusses the superiority of ***eHeaRSS***. Finally, concluding remarks are given with further research.

II. Related Works

A. Healthcare Systems and Recommendation Services

Many healthcare service systems have been developed and also studied by several institutions, companies, and universities like George Mason University [16], Stony Brook University [21], Mason Center for Health Information Technology [18], Duke University Medical Center [15] and Bit computer [13], and so on. Medical intelligence 2001 of Bit computer [13] was developed for the systematic and advanced management of a hospital system. To do this, DW (Data warehouse) and EMR (Electronic Medical Record) [12] were applied to patients' medical cases which are clustered according to patients' places. In view of the results so far achieved, most healthcare systems are more concentrating on the improvement of management efficiency using hospital resources for the increasing profits than improvements of patients' services.

In the view point of health services for recommendations [14, 17, 19, 20], most systems are focusing on the supporting of doctors' decision making or depending on the simple combination of patient data without considering the relationships among health services. When patients need more customized health services, the recommendation services are not proper and helpful. Patients need more expertized and customized recommendation for health service. Therefore, the proposed ***eHeaRSS*** is focusing on patients to provide customized recommendation services by integrating medical data. It should be an opportunity for future-oriented hospital systems.

B. Personal Health Record Service and crowd sourcing

To collect patients' health records, it is usual to use patients' medical records like prescriptions [12]. However, ***eHeaRSS*** obtains patients' records by crowd sourcing [8]. The patients' personal records have been collected by Microsoft's HealthVault [19], Google Health [17], Dossia [14], and so on. Microsoft's HealthVault [19] is 'Information about me' brings me to the exciting launch of the 'Health Choices' apps on Windows Phone, Android and iPhone. Dossia [14] is a personal health record service offered by some of the largest employers in the United States. Initiatives such as Google Health and Microsoft's HealthVault that allow patients to create their own health records are moving in this direction. The patients' records made out by doctors have limitation to share them between patients and doctors. So recommendations by ***eHeaRSS*** are based on patients' generated health records and crowd sourcing. The collected data are transformed into cases which are comprised of general terms and expressions.

C. CBR and Ontology

In this research, cases with ontology [1, 4, 6, 7, 9, 10] as a structured data express cross-duplicated data of health service information. The cases can be easily recycled by patients because they contain patients' experiences like requirements, treatment processes and results, and so on. Furthermore, it can be applied into the doctors' collaboration [2, 5, 11] to give qualified health service to patients. In CBR [3], cases are selected and customized depending on patients' context. To guarantee the compatibility of the customized case, it is necessary to adopt constraints satisfaction problems (CSP). Ontology is also adopted as a meta-knowledge to manage the cases, because health information has a variety of types of relationships among cases as the structured data-type.

III. eHeaRSS Overall Architecture

As presented in **Fig. 1**, ***eHeaRSS*** is composed of a knowledge-base with ***4-Ont***, ***eHeaRSS-Ont***, and ***eHeaRSS-CVCM***, and case-base for ***CBR*** which is applied for selection, classification, and customization of the cases.

In the knowledge-base, ***4-Ont*** is composed of symptom-, disease-, department- and doctor-ontology. The ontology is constructed by collecting patient personal health records (***PPHR***) by crowd sourcing. ***PPHR*** is defined by patients' contexts and a health service goal as a recommendation. We assumed that data of ***PPHR*** is collected by crowd sourcing and transformed into a structured case-type with medical terms and expressions. ***PPHR*** is a unit of personal health record that is composed of a set of symptoms, diseases, departments and doctors as follows.

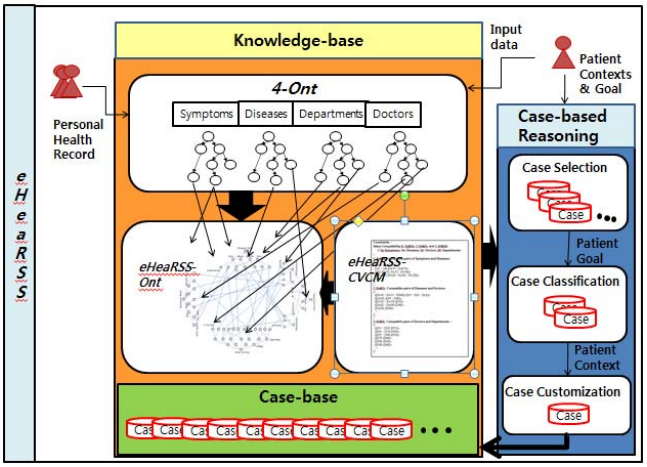

Fig. 1. Overall Architecture of ***eHeaRSS***.

PPHR = {***Sy***, ***Ds***, ***Dt***, ***Dr***}

Sy ∋ {sy_i| sy_i is i^{th} symptom of ***Sy***, $1 \le i \le w$}, ***Sy*** is a set of symptoms,

Ds ∋ {ds_j| ds_j is j^{th} disease of ***Ds***, $1 \le j \le x$}, ***Ds*** is a set of diseases,

Dt ∋ {dt_k| dt_k is k^{th} departments of ***Dt***, $1 \le k \le y$}, ***Dt*** is a set of departments,

Dr ∋ {dr_l| dr_l is l^{th} doctors of ***Dr***, $1 \le l \le z$}, ***Dr*** is a set of doctors.

Patient contexts (***PCxt***) and a patient goal (***PG***) contain components of ***PPHR***. For example, if a patient doesn't have any information of a disease but symptoms, then the ***PCxt*** is a set of ***Sy***. ***PG*** becomes a set of ***Ds*** as follows.

PPHR ⊃ ***PCxt,***

PCxt = {sy_i | sy_i is i^{th} symptom of ***Sy***, $1 \le i \le n$}.

PPHR ⊃ ***PG***,

PG = {ds_j | ds_j is j^{th} disease of ***Ds***, $1 \le j \le m$)}.

In addition, health service goal (***HG***) is a final goal to recommend it that contains a set of ***PPHR*** as a solution. In short, ***HG*** is comprised of all of components of ***PPHR*** depending on the ***PCxt*** and ***PG*** as follows. ***HG*** is a recommendation including highly qualified medical treatments for patients.

HG = {{$sy_i \times w_i$, $1 \le i \le a$} {ds_j, $1 \le j \le b$} {dr_k, $1 \le k \le c$} {dt_l, $1 \le l \le d$}}

eHeaRSS-Ont is integrated using extracted components from ***4-Ont*** by patients' contexts depending on queries. ***eHeaRSS-Ont*** selects cases depending on patients' queries. The selected cases are customized based on ***eHeaRSS-Ont***. To customize the case, compatibility among the configured components should be checked by ***eHeaRSS-CVCM***. Finally, the cases are customized by patients' contexts.

To construct the knowledge-base, it is necessary to collect personal health records on SNS by crowdsourcing. In addition, it is important to extract personal health records on cloud computing environment like SNS.

IV. Knowledge-base for eHeaRSS

The knowledge-base contains ***4-Ont***, ***eHeaRSS-Ont***, and ***eHeaRSS-CVCM***. To process the complicated relationships, graph-based DB can be considered like ontology-based DB.

*A. **4-Ont** and Relationships*

4-Ont is composed of symptom-, disease-, department- and doctor-ontology. The symptom- and disease-ontology is based on body parts like eyes, legs, face, hands, etc. If a patient is struggled by 'Flu,' then he can express the pains by a part of his/her body. So, the related diseases can be linked into the body parts. Department- and doctor-ontology are classified with specialties. Doctors can give several treatments to patients depending on specialty-type. The ***4-Ont*** is illustrated as in Fig. 2. ***PCxt*** is matched into ***4-Ont*** to recommend proper health information. The selected cases are comprised of components from the ontologies according to the ***PCxt***.

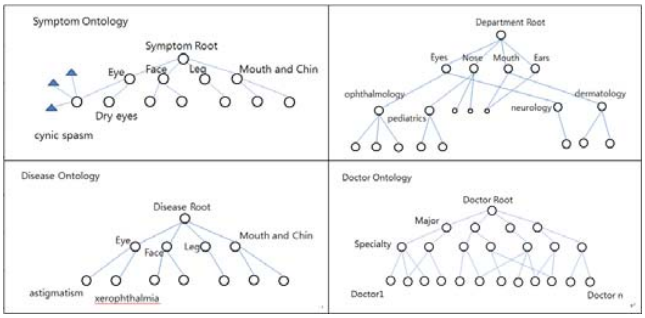

Fig. 2. **4-Ont** with symptoms, diseases, departments and doctors.

Fig. 3 illustrates an extraction of a case which is constructed by components from ***4-Ont***. A case is constructed by a configuration of instances of symptom-, disease-, doctor- and department-ontology. The illustrated case includes two symptoms, a disease, a doctor and a department according to ***PCxt.***

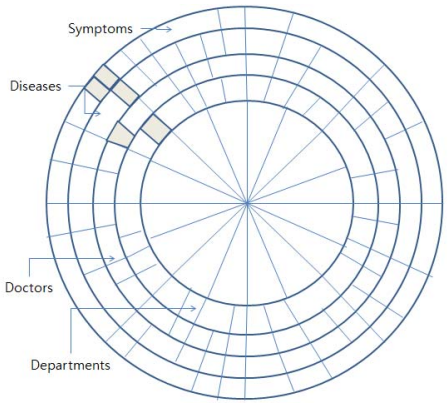

Fig. 3. An example of extraction of a case from **4-Ont**.

The extracted components from ***4-Ont*** are linked into each other based on semantic or causal relationships. The proposed each ontology has relationships which include subsumption, part-of and causal relationships. For an instance, in symptom ontology, thing node is linked into each body parts as classes. It is linked into each symptom like dry-eyes as a symptom. The dry-eyes subsumes symptoms dull-eyes and dazzling. Other symptom classes also subsume several symptoms. Blepharospasm and facialspasm are on part-of relationship of a class spasm as in **Fig. 4**.

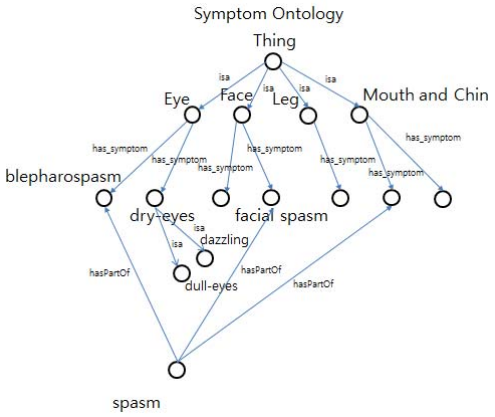

Fig. 4. Relationships among nodes on ontology.

B. *eHeaRSS-Ont*

As in **Fig. 5**, ***eHeaRSS-Ont*** is dynamically constructed by combination of extracted components from ***4-Ont*** according to the ***PCxt***. As in **Fig. 4**, dry-eyes as a symptom class is subsuming symptoms of dull-eyes and dazzling. They are linked into a disease "xerophthalmia" of disease-ontology. The relationships are also used as constraints to check the compatibility.

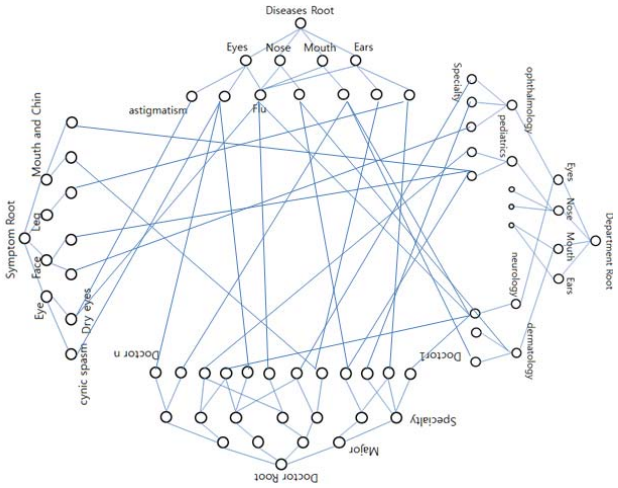

Fig. 5. ***eHeaRSS-Ont*** using ***4-Ont***.

As in **Fig. 5**, ***PCxt*** is an initiated node to construct a configuration as ***eHeaRSS-Ont*** to recommend health information. If ***PCxt*** is selected from components of a symptom-ontology, then the selected components become initiated nodes to construct the ***eHeaRSS-Ont*** and they are linked into *thing* node. It means that the components can be upper nodes of all other nodes and are dynamically linked into other ontologies like disease-, department- and doctor-ontology. Finally, the constructed ***eHeaRSS-Ont*** has been integrated with diseases as ***PG*** and others including departments and doctors depending on ***PCxt*** like fever, cough, and runny nose as symptoms.

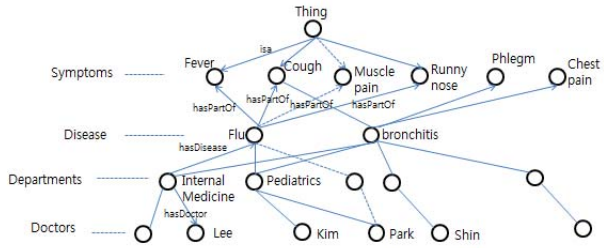

Fig. 6. *An example of **eHeaRSS-Ont** which is extracted from **4-Ont***

Fig. 6 is an example of ***eHeaRSS-Ont*** that is dynamically integrated by ***PCxt*** using ***4-Ont***. The classes with solid arrow are directly linked into ***PCxt***, but the dotted arrows are inferred by relationships on ***4-Ont***. Even though 'Muscle pain' is not a component of ***PCxt***, it is inferred as an estimated disease according to ***PCxt*** because the 'Muscle pain' as one of symptoms on ontology.

C. *eHeaRSS -Constraints Value Compatibility Map*

eHeaRSS-CVCM is composed of compatible pairs of symptom- and disease-ontology, disease- and doctor-ontology, and doctor- and department-ontology. Each pair of ontologies guarantees the compatibility of relationships between values of the pairs. The compatibility is illustrated as in **Fig. 7**. As a compatible pair of symptom- and disease-ontology, the expression of ((sy1 ∨ sy2) (ds10)) shows that symptoms 'sy1' or 'sy2' is on part-of relationship on disease 'ds10'.

Constraints Value Compatibility (C-Sy&Ds, C-Ds&Dr, and C-Dr&Dt) // Sy:Symptom-, Ds: Disease-, Dr: Doctor-, Dt: Department-ontology

C-Sy&Ds. Compatible pairs of Symptom- and Disease-ontology

{((sy1 ∨ sy2) (ds10)) ((sy3 ∨ sy4) (ds11 ∨ ds21)) ((sy5) (ds12, ds13 ∨ ds14)) ((sy6 ∨ sy7) (ds22 ∨ ds24 ∨ ds 25)) …}

C-Ds&Dr. Compatible pairs of Disease- and Doctor-ontology

{((ds10 ∨ ds11 ∨ ds45) (dr1 ∨ dr2 ∨ dr3)) ((ds21) (dr5 ∨ dr6)) ((ds12 ∨ ds13) (dr7)) ((ds22 ∨ ds24) (dr8)) ((ds25) (dr9)) …}

C-Dr&Dt. Compatible pairs of Doctor- and Department-ontology

{((dr1 ∨ dr2) (dt1)) ((dr2 ∨ dr3) (dt2)) ((dr5 ∨ dr6) (dt3)) ((dr7) (dt4)) ((dr8) (Dt5)) ((dr9) (Dt6)) …}

Fig. 7. ***eHeaRSS**-Constraints Value Compatibility Map.*

V. Case-based Reasoning

A. Case Construction

It is true that general patients may have multiple symptoms from a disease and they can undergo similar or different treatments from same or different doctors. It is important to share these kinds of knowledge among patients or doctors or patients and doctors. Depending on the treatments, it is possible for the repair progresses and therapy outcomes to be same or different. Even if doctors can have any opportunity to share the information through medical conferences, it is not enough to share all health information that is needed by doctors. Further, patients don't have any opportunity to share any health information with other patients or doctors. Therefore, the constructed cases that are based on health information can overcome these kinds of limitations. For an illustration, if a patient is struggled by some symptoms, then the patient tries to find similar cases from the ***eHeaRSS***. Finally, ***eHeaRSS*** recommends patients health information including suspected diseases, proper departments, and recommendable doctors. In short, whenever patients need a recommendation of health information, ***eHeaRSS*** creates recommendation by extraction of information from cases.

B. Case Selection

PCxt is a kind of requirements to select a case from the case-base. ***PCxt*** depends on disease-, symptom-, department-, and doctor-ontology. According to the ***PCxt*** as was illustrated in **Fig. 6**, the extracted ontology is determined. A disease 'Flu' of disease-ontology is linked into a 'cough' of symptom-ontology. The 'cough' is linked into 'Internal Medicine' of department-ontology. The 'Internal Medicine' is linked into an instance 'Dr. Jason' of doctor-ontology. ***eHeaRSS-Ont*** is constructed by the linked instances of the ontologies. To complete construction of ***eHeaRSS-Ont***, it is necessary to newly define relationships among the instances using pre-defined and inferred relationships. Pre-defined relationships are previously defined relationships among nodes of ***4-Ont***. Inferred relationships are built by generation of a case that is dynamically produced by integration of ***4-Ont***. Therefore, relationships of ***4-Ont*** to construct ***eHeaRSS-Ont*** are dynamically adjusted to reach ***HG*** and ***PG*** by ***PCxt***. ***PCxt*** is extracted from ***4-Ont*** and becomes a *thing* node to reach at a goal as a recommendation of health information.

Case Selection is processed by depth first search to find a case which is the most similar with ***PCxt*** from ***eHeaRSS-Ont***. Cases are extracted by ***PCxt*** (1, 3, 4) and are possibly configured as (1, 1, 1, (1, 2)), (3, 1, 1, (1, 2)) and (4, 2, 2, (3, 4, 5)). Another case (2, 1, 1, 1) which is generated by estimated disease '1' by the symptom '2.' The disease '1' has other symptom '1' and '3.' As in **Fig. 6**, the 'Muscle pain' is an illustration which is inferred by estimated disease. As the result, selected cases depending on ***PCxt*** are especially composed of Symptoms (1, 3, 4) like as cases (1, 1, 1, (1, 2)), (3, 1, 1, (1, 2)) and (4, 2, 2, (3, 4, 5)). Symptom '2' is estimated by disease '1.' The extracted cases can be (2, 1, 1, (1, 2)).

C. Case Classification

Selection of the most similar case finally depends on ***PG***. The selected cases are classified with ***PG*** including doctors as a final goal. Case is classified with two-type as a simple case and multiple-case. From a precedent example, Cases c_i and c_j with a final goal ***PG*** are c_i = ((1, 3), (1), (1), (1, 2)) and c_j = ((4), (2), (2), (3, 4, 5)). These are examples of simple cases. The multiple-case c_k is (((1, 3), (1), (1), (1, 2)) ((4), (2), (2), (3, 4, 5))). The multiple-case is compound simple-cases. However, if the selected similar case is not satisfied with the patient, then it is necessary to customize the case.

D. Case Customization

To customize and adjust the case, it is necessary to check compatibility among values of nodes to construct ***eHeaRSS-Ont***. The compatibility is illustrated in ***eHeaRSS-CVCM***. The components of selected cases are composed of a combination of nodes and relationships from ***4-Ont***. To check the compatibility, constraints satisfaction problem (CSP) is applied into adjusted components of the selected case. Constraints and compatibility are based on relationships among nodes are defined in ***eHeaRSS-CVCM***.

VI. Discussion of an Experiment and Result

eHeaRSS has health knowledge depending on patients' experiences. The health knowledge is constructed by ontology and cases using crowd sourcing. It is necessary to evaluate the superiority of ***eHeaRSS.*** So, we compared ***eHeaRSS*** with other general DB-based Health Systems. The patients' satisfactions of the recommending services are used to prove its superiority.

A recommendation service for patients' reservation in DB-based Health System is compared with that of our proposed system ***eHeaRSS***. In DB-based Health System, if patients select a symptom, disease, or department to get recommendation for health service reservation, then it shows several doctors' information who are related to patients' requests. In ***eHeaRSS***, the reservation service returns health information related all symptoms, diseases, doctors, and departments. The recommendation *((1, 3), 1, 1, 1)* and *(4, 2, 2, (3, 4, 5))* depends on ***PCxt*** *(1, 3, 4)*. For an example, if the patient has three symptoms 'fever,' 'cough' and 'chest pain,' then 'fever' and 'cough' linked into a disease 'Flu', a department 'Internal Medicine' and a doctor 'Lee' as (('fever,' 'cough') 'flu,' 'Internal Medicine,' 'Lee'). They are inferred by ***eHeaRSS-Ont*** as in ***Fig. 6***. The 'chest pain' returns a disease 'bronchitis,' departments 'Internal Medicine' and 'Pediatrics' and doctors 'Lee,' 'Kim,' 'Park,' and 'Shin' as ('chest pain,' 'bronchitis,' ('Internal Medicine,' 'Pediatirics') ('Lee,' 'Kim,' 'Park,' 'Shin')). However, in others, if a patient selects a symptom 'fever,' then the system returns 5 doctors with different specialties and departments like 'Internal Medicine' and 'Pediatrics.' It is not enough information to complete the reservation process. To do this, patients need to know the doctor's specialties and departments. In addition, if the patient has other symptoms 'cough' and 'chest pain,' then it is necessary to repeat at most three times same processes to

get recommendation. Even though the patient has done it, the recommendation is not integrated. So, the patient should ask a human expert to make a decision about doctors, departments and suspected diseases, and so on. ***eHeaRSS*** processes several patients' context at a time and returns an integrated recommendation result. In this case, the number of recommendation processes is decreased by 33.3%. In addition, ***eHeaRSS*** provides integrated recommendation information such as (((‘fever,’ ‘cough’) ‘flu,’ ‘Internal Medicine,’ ‘Lee’), (‘chest pain,’ ‘bronchitis,’ (‘Internal Medicine,’ ‘Pediatrics’) (‘Lee,’ ‘Kim,’ ‘Park,’ ‘Shin’))) at one go. It proves that ***eHeaRSS*** serves more efficient recommendation service than other DB-based health service. If the knowledge-base is constructed successfully, then it is positively expected to decrease the gap of medical information between patients and doctors.

VII. Conclusion and Further Study

eHeaRSS provides a recommendation service like a family doctor to support qualified health services to patients. ***eHeaRSS*** considered ***PPHR***, ***PCxt***, ***PG*** and ***HG***. ***eHeaRSS*** is built by collected information by crowd sourcing on cloud computing environment. Health information is comprised of cases to recommend health information based on patients' context using instances of ontology. We compare ***eHeaRSS*** with other DB-based system to prove the efficiency and significance of ***eHeaRSS***. In further study, we will focus on development eHealth system to collaborate with doctors and sharing medical information among patients or doctors, doctors, and patients in cloud computing environment.

Acknowledgment

This research was supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the “IT Consilience Creative Program” (IITP-2015-R0346-15-1008) supervised by the IITP(Institute for Information & Communications Technology Promotion).

References

[1] A. Anjum, P. Bloodsworth, A. Branson, T. Hauer, R. McClatchey, K. Munir, D. Rogulin, and J. Shamdasani, The Requirements for Ontologies in Medical Data Integration: A Case Study, Database Engineering and Applications Symposium, International, 11th International Database Engineering and Applications Symposium (IDEAS 2007) pp. 308-314., 2007.

[2] R.C. Antonelli, Enhancing Collaboration Between Primary and Subspecialty Care Providers for Children and Youth With Special Health Care Needs, GEORGETOWN UNIVERSITY CENTER FOR CHILD AND HUMAN DEVELOPMENT, SUMMER 2005.

[3] I. Bichindaritz, “Prototypical case mining from biomedical literature for bootstrapping a case based,” Intel. vol. 28(3), pp. 222-237, 2008.

[4] W. Ceusters, B. Smith, and G.D. Moor, “Ontology-Based Integration of Medical Coding Systems and Electronic Patient Records,” Relation 4077, vol. 10, no. 1.73, 2008.

[5] L.L. Ellingson, “Communication, Collaboration, and Teamwork among Health Care Professionals,” Communication research trends, vol. 21, pp.1-3, 2002.

[6] J.M. Juarez, J. Salort, J. Palma, and R. Marin, CASE REPRESENTATION ONTOLOGY FOR CASE RETRIEVAL SYSTEMS IN MEDICAL DOMAINS, In Proceeding of the IASTED International Conference on Artificial Intelligence and Applications (AIA2007), pp. 168-173, 2007.

[7] E.J. Ko, H.J. Lee, and J.W. Lee, “Ontology-Based Context Modeling and Reasoning for U-HealthCare,” IEICE TRANS. FUNDAMENTALS/COMMUN./ELECTRON./INF. & SYST., vol. E85-A/B/C/D, no. 1 (JANUARY 2002), pp. 1-10, 2002.

[8] A. Lymberis, and A. Dittmar, “Advanced Wearable Health Systems and Applications,” IEEE Engineering in Medicine and Biology Magazine, May/June, pp. 29-33, 2007.

[9] C. Ogbuji, “A Framework Ontology for Computer5Based Patient Record Systems,” International Conference on Biomedical Ontology, pp. 217-223, 2011.

[10] C. Schlenoff, R. Ivester, D. Libes, P. Denno, and S. Szykman, An Analysis of Existing Ontological Systems for Applications in Manufacturing and Healthcare, NISTIR 6301 National Institute of Standards and Technology, 1999.

[11] D. Way, L. Jones, and N. Busing, Implementation Strategies: Collaboration in Primary Care–Family Doctors & Nurse Practitioners Delivering Shared Care: Toronto, The Ontario College of Family Physicians, 2000.

[12] Z. Zhang, A. Mittal, S.G. Alexander, and E. I. Dimitriyadi, Ramakrishnan, R. Zhao, A. Viccellio, and K. Mueller, A Visual Analytics Framework for Emergency Room Clinical Encounters, IEEE Workshop on Visual Analytics in Health Care, 2010.

[13] Bit Computer, http: //www.bit.co.kr.

[14] Dossia, http: //www.dossia.org

[15] Duke University Medical Center, Diagnosis Related Group (DRG), http://www.mc.duke.edu/.

[16] George Mason University, http://www.gmu.edu/.

[17] Google Health, http:// www.google.com/health/.

[18] Mason Center for Health Information Technology, http://hit.gmu.edu/.

[19] Microsoft’s HealthVault, http: //www.healthvault.com.

[20] Yonsei University Health System, http://sev.iseverance.com/

[21] Stony Brook School of Health Technology and Management, http://www.hsc.stonybrook.edu/shtm/index.cfm.