2010 2nd International Conference on Computer Technology and Development (ICCTD 2010)

eHealth Service Discovery Framework for a Low Infrastructure Context

Tesfa Tegegne
Radboud University Nijmegen, the Netherlands
T.Tegegne@cs.ru.nl

Benjamin Kanagwa
Makerere University Kampala, Uganda
bkanagwa@cit.mak.ac.ug

Theo van der Weide
Radboud University Nijmegen, the Netherlands
tvdw@cs.ru.nl

***Abstract*— *eHealth* services but also general Health services emphasize patient record management. Unfortunately the information in these records is not used to provide quicker, personalized eHealth services and appropriate treatment. Especially in a low infrastructure context where Health service providers are often overwhelmed by large number leads to degradation in service delivery. Domain specific service discovery with personalization aims at providing user-centric services. This is very important in a low infrastructure context where demands on the health services range over various aspects that reflect the massive variation in social economic development synonymous with developing countries. The focus of this paper is a framework for eHealth service discovery in low infrastructure context. To do this, we categorize the context of users and augment it with user specific profile. Our framework provides ontology based, context-aware semantic and personalized services.**

Keywords-eHealth, Service Discovery, Service Oriented Architecture(SOA)

I. INTRODUCTION

Health services in low infrastructure context are characterized by long queues, insufficient drugs, inefficient service providers and generally low literacy levels on the side of service consumers – patients ([10], [8], [7], [4]). In addition, the health services tend to be generic due to lack of specialized resources. A number of health consumer demands can be satisfied with appropriate education and advisory services only if they can be easily identified. As eHealth services proliferate into countries with limited infrastructure (electrification, Internet) as means of supporting the general health services, there is need to support such services with software architectures that are low cost, flexible, and easily build on the existing infrastructure.

Service-oriented architecture (SOA) (see [1], [6]), and the corresponding service-oriented computing (SOC) provide a system architecture in which a collection of loosely coupled services (components) directly communicate with each other using standard interfaces and message-exchanging protocols. According to Papazoglou (2008), software services or simply services are self contained, platform-agnostic computational elements that support rapid, low-cost and easy composition of loosely coupled distributed software applications. The functionality provided by a service can range from answering simple requests to executing sophisticated processes requiring peer to peer or client/server relationships between multiple layers of service consumers and providers ([1], [6]).

Services are described, published, discovered and can be assembled to create complex service based systems and applications. Service discovery is the activity of resolving consumer requests in terms of (advertised) services. Some requests may only be resolvable by a (complex) combination of services. Service discovery involves matchmaking of services, selection of appropriate services and prioritizing (ranking) of services. Service discovery can be done manually, automatically or by a combination.

Existing service oriented health care systems emphasize on patient record management, giving personalized health care assistance to patients, online consultation and advisory of patients. However, the communication among health professionals by modern technology has not yet been addressed. For example, Uganda implemented a wireless regional health care network to assist the rural health workers in providing learning material, email, and to enable outbreak reporting. Generally, this network is used for data collection systems. The eHealth systems developed so far do not provide professional assistance, for example when new cases or symptoms are encountered.

To support eHealth service discovery, we split this activity into: (1) adaptation: extending a request with personal and contextual information, (2) reasoning: about the request in terms of (3) domain knowledge. The framework proposed in this paper will be tested in Ethiopia for the following reasons:(1) non existence of an eHealth system, (2) only a few number of health care professionals and the emigration of (local) doctors to developed countries, (3) the availability of some infrastructure such as the school network, the district network, and the expansion of mobile networks, (4) the country policy for electrification of districts and rural areas, and (5) the high spreading of diseases such as HIV/AIDS and malaria.

Ontology has been defined as: "a formal, explicit definition of a shared conceptualization" [2]. A 'conceptualization' refers to an abstract model of some phenomenon in the world that identifies the relevant concepts of that phenomenon. Ontologies are used for the classification of the objects based on their properties. Properties have been described by the service provider. The service requester describes the need of properties. The match maker will

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match the service demand with the service supply. An ontology-base approach will help to avoid the problem of mismatch.

The paper is structured as follows: in section 2 related works is presented. Section 3 discusses service discovery in low infrastructure. An overview of eHealth framework is given in section 4. Finally, we present conclusion and future work in section 5.

II. RELATED WORK

Service discovery is one of the challenging activities of SOA. For example, [6] describes the process of finding services. Most studies done so far include service semantics, ontology based and context based service discovery. To the best of our knowledge, these three components have not been used together to discover services. In previous work service personalization or user profiling (user behavior and preferences) was given no attention. However, [6] and [14] report that contextual information of services is available, complete and unambiguous. They ignore how to handle missing, redundant, or incomplete context information. In this paper we have divided context-awareness of services into service context and user context, which enables a richer handling of context.

In relation to health care service discovery very few researches has been conducted ([4], [10]). For example, [10] mentions eHealth projects are under implementation in Uganda, South Africa and Nigeria (UHIN, Cell-Life and MindSet Health, LAMIS respectively). However as cited by ([7], [4]), there are about 12 million AIDS orphans in Africa. In line with this, [7] indicated that developing countries face challenges in providing accessible, efficient and equitable quality health services to their people. Recently, the first draft version of the application of SOA in healthcare domain is presented by HL7 standard group on June 2010 at http://hssp.wikispaces.com/PracticalGuide.

III. SERVICE DISCOVERY IN LOW INFRASTRUCTURE

Typical eHealth setups in a low infrastructure context involve Health Extension Workers (HEW) whose main role is to link the largely uneducated masses with Health service providers. Generally the HEW serves the role of a "broker" and a typical session is described in subsection A. The proposed framework is presented in Figure 1. In later sections we will discuss the components.

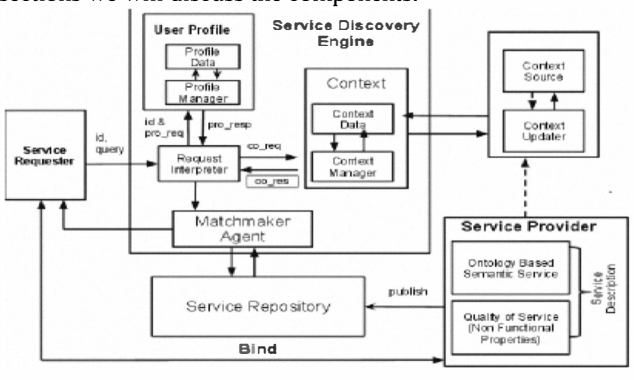

Figure 1. Service Discovery Framework/Architecture

A. Sample Session

In this part we present a sample session within our framework. The example also is described in Figure 2.

1) A Health Extension Worker (HEW) meets a patient who has a symptom of high fever.
2) The HEW sends the patient conditions to the query interpreter adding information as: the patient lives in one of the coldest area of the Semen Mountain region, I have no laboratory to check, I have antibiotics, pain killer, and HIV/AIDS medicine. I treated with a pain killer medicine. The patient is 2 days in this condition.
3) The request interpreter identifies the context and profile information by consulting the context manager and the profile. The profile manager updates the data of that HEW. The received context information contains such information as: actual weather condition, distance to nearest hospital.
4) The request interpreter transmits the enriched query to matchmaker agent.
5) The matchmaker agent will analyze the enriched query, using knowledge obtained from the service repository. This will lead to a treatment proposal in terms of available services. The matchmaker agent performs the matching process on the basis of the HEW requirements (functional and non-functional). The matchmaker agent will prioritize more matching services on the basis of semantics, context and requester profile.
6) Finally, the matched service (appropriate treatment procedure and medicine prescription) will be sent to the HEW

The above scenario depicts the working of the proposed framework. This framework can run at the client side on a mobile phone since the communication with the HEW is based on relatively short messages.

B. Ontology based Semantic Service

1) Semantic Service Discovery: The process of semantic service discovery consists of two steps, namely, (1) matching of service functionality (functional requirement), and (2) service selection based on non functionality aspect of service. Service selection involves semantic matching and ranking to select a single most relevant service to be invoked, starting from a given set of available services. Semantic service matching is the pairwise comparison of an advertised service with a desired service (query) to determine the degree of their semantic match [3]. This process can be non-logic-based, logic-based or hybrid, depending on the nature of reasoning style used by the matchmaker to compute partially or totally ordered matching degrees between representations of service semantics. Subsequent ranking of services determines the

order of their individual degrees of semantic matching with the given query ([1], [3]).

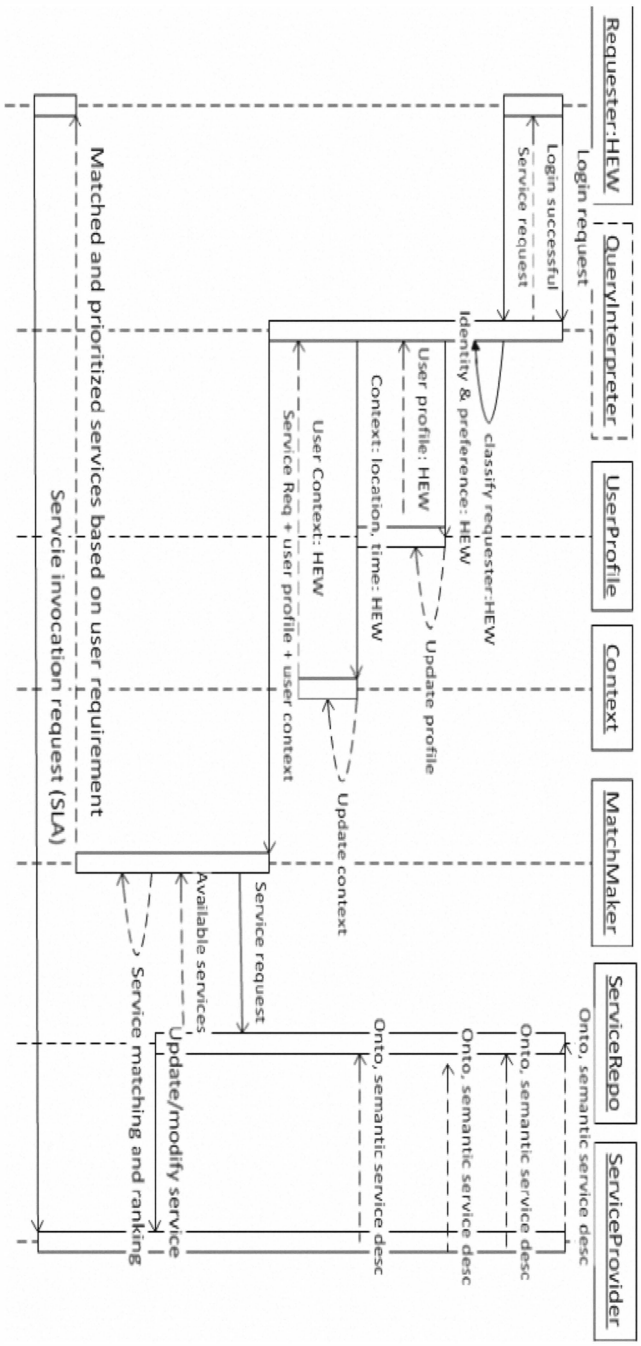

Figure 2. A sample session

C. User Profile (Consumer Profile)

A user profile is used as a basis to provide service behavior that is personalized to the user. A user profile is a set of information, preferences, rules and settings that has been recorded for that user [5]. In our framework we use personalization of service discovery as important element to discover eHealth services that better suit the user needs. Profiles may contain many individual data items (information, preference and rules) coming from various sources [5]. The profile will change by its usage or may be changed by a special profile updater agent.

D. Context-aware Service Discovery

The context updater agent provides additional information about a service and a user, for example the location. For that purpose, the context updated is equipped with special agents. For example a GPS agent that can track the user position, which has the added benefit of utilizing location-related information. This extra information will improve service discovery.

The context can vary in time, therefore the context update may also involve a tracking function to signal context changes when they occur. The context updater might be a human, a system, or an digital agent on the Internet. During service discovery the user context is matched against the service context in order to retrieve relevant services with respect to context-awareness. Context is very important for service discovery in an infrastructure-less and infrastructure based networks, since it can retrieve services that conform to the user's current context and service context. Health care services are very sensitive since the services are related to prevent human beings from death. Hence the context of the patient (such as blood pressure, temperature and other symptoms) should be accurate to provide remotely appropriate prescription, consultancy and support. Otherwise it would be cumbersome to treat the patient and to provide assistance to the health worker at a distance.

E. eHealth Service

Internet-based health care is the application of information and communication technology in the whole range of health care functions. It covers everything from electronic prescriptions and computerized medical records to the use of new systems and services. This will cut down waiting times and reduce data errors [8]. Obviously the use of Internet, alike other sectors (e-business), has facilitated the health care industry with access to information anywhere and anytime. Different challenges of eHealth have been identified (see [10]), for example process of design, implementation, delivery of services, identity management, infrastructure (wired/wireless), and security of information. However, most existing systems are in an experimental or infant stage [10]. In developing countries eHealth is an almost non-addressed issue. The emergence of e-Health has

been shown to reduce the cost of health care and to increase efficiency through better retention and retrieval of records, better management of chronic diseases, shared health professional staffing, reduced travel times, and fewer or shorter hospital stays ([9],[15]).

According to [13], there is an eHealth paradigm shift: hospitals have been downsizing, reducing staff and closing hospital beds, a new form of health providers' alliance and new modalities of health service delivery is emerged in the introduction of the eHealth system. Thus the evolving eHealth system is a dynamic entity that is being continually shaped by economic, political, technological, and social forces [13].

Email, phone, PDA, cellular phones enhance long distance communication among health workers, patients, and other professionals. Besides, the eHealth empower the health workers and patients through e-learning, e-consultations, teleconferencing, etc. Moreover, eHealth system can help attract and retain health professionals in rural areas by providing professional development training and by creating a collaborative environment among the health professionals ([4], [13]).

1) Healthcare Infrastructure: The health care infrastructure is spread thin and poorly equipped. Health care facilities, in the relatively few locations where they exist, are usually overcrowded and in need of physical repair. The human capacity problem is perhaps even more serious. Despite the expansion of the healthcare institutions, the number of health institutions is not sufficient yet. According to the MoH report on the year 2008, Ethiopia has 149 hospitals, 732 health centers, 1517 health stations, 271 non profit clinics, 1788 private clinics and 11446 health posts.

MoH to outreach health service for the rural areas launched different projects. One of the projects is to train 30000 Health Extension Works (HEW) and to build fifteen thousand health posts at community level. These HEWs all are females and completed grade ten. They took a one year training at technical and vocational colleges. The main responsibilities of the HEW are: manage operations of health posts, conduct home visits and outreach services to promote preventive actions, provide referral services to health centers and follow up on referrals, identify, train and collaborate with voluntary community health workers, and provides report the district health office. This huge numbers of health workers address the main health problems of the society in rural community with only one year training. According to 2008 MoH data, there are about 54534 healthcare professionals among these 2085 are physicians, 1242 are health officers, 16 765 nurses and 24571 health extension workers. The physician population ratio is 1:37996 people.

According to some study more than 60% of doctors leave to abroad or to private health institutions due to low pay, difficult working conditions, lack of opportunities for professional development, and insufficient autonomy. There are some ICT based projects running in Ethiopia like telederamatology. It links the teaching hospitals of Tikur Ambessa and ten regional secondary care hospitals throughout the country. WoredaNet and SchoolNet, and Agrinet are some of the ICT projects have been implementing in the country.

2) Current ICT Initiatives and Projects (Ethiopia):

a) WoredaNet Initiative

This is a major e-government initiative that connects all 611 of Ethiopian local councils (woredas or districts) to 9 regional capitals through Internet telephone and tele-conferencing. Half the links are by cable, and half by satellite. The initiative also provides connectivity to the SchoolNet, eHealth, and the soon-to-be launched AgriNet. WoredaNet is implemented by the Ethiopia Telecommunication Agency with funding from the World Bank and the African Development Bank through the Ministry of Capacity Building. Using this network eHealth can be launched without incurring extra expense. Currently, the woredanet provides various ICT services: video conference (meeting, education and training, workshops and seminars), court services, training and distance education, internet and messaging services, other service like reporting epidemic disease and early warning of natural disasters (flood, famine, etc).

b) School-Net Ethiopia

The joint initiative by the Ministry of Education and UNDP is probably the most visible project in the country with a total of 500 schools equipped with a minimum of 15 networked computers per lab all connected to the Internet. There are new programs around this initiative in the planning stages, including creating an extranet that will connect the schools.

IV. EHEALTH FRAMEWORK

A. Service Discovery Engine

The service discovery framework form Figure 1 contains the Service Discovery Engine main components. We will discuss its modules and agents in this section.

Context Data. It contains the context of services and users. The context of the request will be provided by the context provider. Two types of context are stored in the context database: service context and user context. Service con-text includes information about services such as location, version, cost, and provider's identity. User context, a context different from the user profile, contains such information as location, weather condition, status of the user (busy, on phone), time.

Context Manager. The context manager will contact the context data repository to update or modify the context of the user. For example, the context updater may discover the user has moved, and thus send an update request to the context manager. The context manager also is responsible

for aggregating or deriving new context information based on domain specific rules.

Profile Data. The user profile includes personal bio-data, preferences, rules and constraints. This can be updated based on user's behavior, for example using the invoked services or the history of use. User preferences provide a personalization mechanism, which can be seen as part of the overall context, and enable service discovery in a way that matches best the explicit or implicit user requirements. The user profile should be stored in a secure manner based on the user agreed level of privacy.

Profile Manager. The profile interpreter receives the consumers' request from the context interpreter. After the profile interpreter gets the profile of the requester/consumer it verifies if the requester has a profile in the profile database. If the consumer/requester is new for the system it will send the profile to the database. After verifying the user profile and the preference, his/her context, the profile interpreter sends the data to the context interpreter. The context interpreter will add the profile information with the context information is forwarder to the matchmaking agent.

Request Interpreter. The context interpreter receives the request from the consumer and propagates the request query into the context manager and to the profile interpreter. These two agents extracted the information from the query and verify the information against the information in the database. The context interpreter after receiving the response from the profile interpreter and context manager, it will merge the profile information the context information and forward it to the matchmaking agent to match the request against the service specification in the service registry.

Matchmaker Agent. Generally speaking matchmaking broadly divided into two: syntactic matchmaking which uses the structure or format of requester service with the provider service. The second one is uses the semantic or meaning of the requester's service with the provider's. This matchmaking agent will gather requested services from the query interpreter and the ontology based semantic service from the service registry. Based on this information, the matchmaking agent decides if the request and advertise services match or not.

B. Service Registry(Repository)

The Service registry contains information about the services provided by third parties. To improve the semantic of service descriptions we use semantic web technology, notably OWL [11], to create additional annotations of service elements. This way, the platform enables service providers to formally describe their services in detail and to bring those service descriptions in correspondence with existing ontologies. On the other hand, it enables search services to perform a subtle search, by using constraints, relations between concepts, approximate matches and semantically rich queries [12], which deliver a more manageable result.

V. CONCLUSION

The emergence of Internet is changing the way people live. Service orientation is being applied to all sectors of human life, such as health care. Most developing countries have little coverage of society health even though the spread of disease is high. In order to reduce this problem electronic health is an option. As eHealth has impacted on developed countries, it will bring a change also in developing countries such as Ethiopia that suffer from high migration of medical doctors inside and outside the country. In this paper we propose an eHealth service discovery framework which can facilitate the effectiveness of eHealth. The framework provides various facilities to create, specify, discover and select health care services. Especially, the framework covers the ignored part of service orientation to customize services based on user/consumer requirements. Our framework will serve for both wired and wireless networks.

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