User Context Query Service Supporting Home Person-Centered Care for Elderly People

Haruhisa Maeda(✉), Sachio Saiki, and Masahide Nakamura

Graduate School of System Informatics,
Kobe University, 1-1 Rokkodai, Nada, Kobe, Japan
haruhisa@ws.cs.kobe-u.ac.jp,
sachio@carp.kobe-u.ac.jp, masa-n@cs.kobe-u.ac.jp

Abstract. Our research group has been studying person-centered care (PCC) support systems for home elderly care, using contextual information of individual users (called user context). Since the current systems individually manage the user context, reusing the contexts across multiple systems is quite different. In this paper, we propose a new service that uniformly manages the user context, and allows external applications to retrieve necessary user contexts efficiently. More specifically, the proposed service gathers heterogeneous data from different systems, and standardizes the data with a common database with general attributes of when, who, whom, where, what, how, and why. Using a practical use case, we show how the proposed service efficiently manages user contexts.

Keywords: Smart health-care · Context-aware services · Person-Centered Care

1 Introduction

Japan is currently facing hyper-aging society, which causes many social issues. According to the report by Government of Japan, the number of elderly people over the age of 65 is 34.59 million in 2016, which is 27.3% of the total population [1]. There are many challenges, including a lack of caregivers and the increasing cost of social security. In particular, the issues concerning dementia are extremely serious. Dementia is a general term for a decline in mental ability by an organic brain disease.

There are several kinds of dementia. Alzheimer's type dementia is a representative disease, which is 60% of the total. People with dementia have trouble carrying out daily activities. For example, they struggle with memory loss, impair their reasoning and judgement, and wander and become lost. The number of people with dementia will reach 7 million in 2025, where one-fifth of five elderly people in Japan will suffer from dementia. It is thus important to take effective measures for people with dementia as soon as possible. However, the main cause of dementia is yet ambiguous. There is no silver bullet that can completely cure the dementia. Nowadays, the symptomatic treatment is taking a leading part for dementia care, including the music therapy.

Reflecting these situations, Person-Centered Care (PCC), proposed by Tom Kitwood in the 1990s [2], is attracting a lot of attention. He said there are five psychological needs of people with dementia, inclusion, comfort, identity, attachment, and

W. Karwowski and T. Ahram (eds.), *Intelligent Human Systems Integration*,
Advances in Intelligent Systems and Computing 722,
https://doi.org/10.1007/978-3-319-73888-8_19

occupation. However, in order to cover these needs, a large amount of effort is required for caregivers. Moreover, the caregivers must carefully observe people with dementia, and face every person for a long time. Therefore, it is difficult to achieve PCC at the nursing home, likewise it is almost impossible to do at home.

To mitigate the heavy burden of PCC, our research group has been studying PCC support systems at home, using the virtual agent, IoT and cloud technologies [3–5]. These systems typically obtain contextual information of individual user from various data sources, in order to achieve the PCC.

2 Preliminaries

2.1 User Context

User context refers to every information that indicates user's current situation in a certain system. The information includes "What is the user doing", "Where is the user?", and "What circumstances is the user in?" Additionally, user's preference is also a part of user context. In [6], an adaptive message notification service that utilizes user context is proposed. This service sends a context-aware and personalized message to a smartphone, based on user's current place, physical limitation, and so on. To provide useful information for the user, the service integrates various user contexts.

2.2 PCC Supporting Service Using User Contexts

Our research group is extensively using the user contexts to implement PCC support systems at home. For example, the person-centered dialogue system with a virtual agent [4] obtains user contexts from user's speech communication. On the other hand, the ADL recognition system [5] manages user contexts from environmental sensor data. Using the user contexts is essential for these PCC support systems.

However, since these two systems manage the user contexts individually, reusing the contexts across the two systems is quite difficult. More generally, each service acquires and manages the user context exclusively by itself, which is quite inefficient.

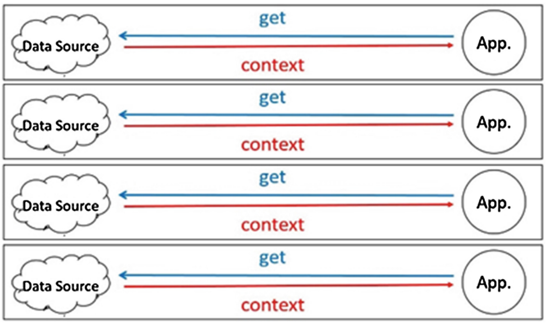

Fig. 1. The conventional architecture of PCC support systems

Figure 1 shows the architecture of the conventional PCC systems, where each application obtains user contexts from individual data sources. In order to achieve more efficient development and deployment of PCC support systems, it is essential to establish a uniform framework for sharing user contexts among multiple applications.

3 Proposed Method

3.1 System Architecture

The goal of this paper is to propose a framework that universally manages PCC-centric user contexts. Figure 2 shows the system architecture of the proposed service. To share various user contexts from different data sources, the proposed service deploys a *common database* in the center of the architecture. The database manages heterogeneous types and formats of data in a *standard data model*. Since individual data sources pro-duce contextual information in proprietary semantics and formats, the *data importer* standardizes the format before inserting the data to the common database. The standardized user contexts are exposed to external applications via *general-purpose API*. Thus, all the applications can easily query user contexts in a standard manner.

The following subsections describe the two key components of the proposed service: The common database and the general-purpose API.

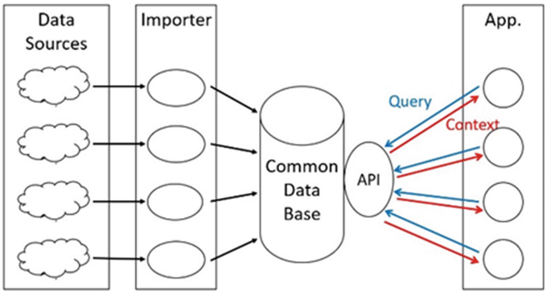

Fig. 2. The proposed system architecture

3.2 Common Database for Managing User Contexts for Person-Centered Care

User contexts from different data sources have their own semantics and formats. Thus, the challenge here is how to define a *universal* data schema that can accommodate such heterogeneous data within the common database.

To cope with the challenge, we design the data schema based on the 6W1H perspective (i.e., WHAT, WHO, WHOM, WHERE, WHEN, WHY, and HOW). We empirically know that this perspective can cover most of user contexts in a MECE (Mutually Exclusive and Collectively Exhaustive) fashion.

Table 1. User context from the 6W1H perspective

Perspective	The contents of information
The WHAT	An activity that a user (or a system) did within PCC
The WHO	The subject of the WHAT (a human user, or a systems)
The WHOM	The object of the WHAT (a human user, or a systems)
The WHERE	The location where the WHAT was done
The WHEN	The time when the WHAT was done
The WHY	The previous activities that motivated WHAT
The HOW	The description of the WHAT

Table 1 shows the 6W1H perspective that determines the data schema of the common database. The database records time-series activities of a target user within PCC, from which various kinds of user contexts can be retrieved. From a viewpoint of PCC, the WHY and the HOW is especially important, because they construct a causal chain of activities explaining why the user is currently like that. The causal information is es-sential for making a personalized care plan considering the reason.

Currently, we develop the common database by relational database (RDB), since we take the advantage of SQL, which can implement various types of queries efficiently.

3.3 General-Purpose APIs on Top of the Data Model

On top of the common data model, we then develop general-purpose APIs, which allow external applications to retrieve necessary user contexts. Each API is implemented by an SQL statement. The followings show examples of the proposed APIs:

- `Activity getActivity(user_id, datetime)`: returns an activity of a user for a given time, querying “What is (was) the user doing?”.
- `Location getLocation(user_id, datetime)`: returns a location of a user for a given time, querying “Where is (was) the user?”.
- `Activity[] getCausalActivities(user_id, since, until)`: returns a causal chain of activities, querying “What happened during the period?”.

In addition to the above, we are currently implementing APIs for more detailed and advanced queries.

3.4 Practical Use Case

To illustrate the effectiveness of the proposed service, we here describe a practical use-case scenario, showing how the user contexts from different heterogeneous systems are integrated and shared. In the scenario, we assume the following four actors:

The Actors

– *Takeshi*: 78 years old man with mild dementia living alone.
– *Danny*: A home environment sensing system with sensors and beacons [7].

Table 2. The timetable of the care scenario

Time	Activity	Number
5:30	Takeshi wake up	(1)
5:35	Danny detects Takeshi's awaking	(2)
6:15	Takeshi goes to the living room	(3)
6:16	Danny detects Takeshi's entering to the living room	(4)
6:16	Greg notices Takeshi's entering to the living room	(5)
6:20	Greg instructs Mei to greet to Takeshi	(6)
6:20	Mei: "Good Morning, Takeshi. How are you today?"	(7)
6:20	Takeshi: "Fine, thank you"	(8)
6:21	Mei: "Good. Do you measure your blood pressure?"	(9)
6:21	Takeshi: "I do it right now. Wait a minute"	(10)
6:26	Mei: "How much? I will make a note of it"	(11)
6:26	Takeshi: "155 over 105"	(12)
6:27	Mei: "OK. Fine. Have a nice day!"	(13)

– *Greg*: A care execution service that triggers a PCC based on the situation.
– *Mei*: A communication chat-bot using Virtual Agent technology [3].

Table 2 describes the scenario in a timetable. First, Takeshi gets up. He then goes to a living room, and have a greeting with Mei. Mei asks Takeshi to measure the blood pressure. During the scenario, the three systems (Danny, Greg, and Mei) individually perform PCC-related activities. In the proposed service, each of the activity is gathered to the common database.

Table 3 shows the activities recorded in the common database. For instance, in (4), Danny detects the entering living room from the brightness of the living room turn on, based on the light sensor. This activity is described as data {time: "6:16", subject: "Dunny", object: "Takeshi", location: "Living room", activity: "Detecting", description: "Entering the living room"}. Similarly, the data is accumulated from the activities of Greg and Mei. Through the interaction between Takeshi and Mei, Takeshi's responses are also recorded in the database. Thus, we can see that the heterogeneous data from different systems are well accommodated within the proposed common database.

Using the data, we obtain various contexts about Takeshi, which explain his physical or mental state in his daily living. For example, "Did Takeshi gets up on time?" or "How much is his blood pressure?" Currently, we assume that basic contexts are covered by the proposed APIs, and that the application-specific contexts are defined and managed within individual applications.

Table 3. The activities recorded in the common database

Log_ID	When	Who	Whom	Where	What	How	Why
Context_ID	Time	Subjct	Object	Location	Activity	Description	References
L01	2017-10-26T05:35:24	Danny	Takeshi	Bedroom	Detecting	Awaking	–
L02	2017-10-26T06:16:03	Danny	Takeshi	Livingroom	Delecting	Entering	–
L03	2017-10-26T06:16:07	Greg	Takeshi	Livingroom	Detecting	Entering	–
L04	2017-10-26T06:20:04	Greg	Mei	Livingroom	Instructing	To speak	L03
L05	2017-10-26T06:20:25	Mei	Takeshi	Livingroom	Asking	"Good moming, Takeshi. How are you today?"	L04
L06	2017-10-26T06:20:45	Takeshi	Mei	Livingroom	Replying	"Fine, thank you."	L05
L07	2017-10-26T06:21:11	Mei	Takeshi	Livingroom	Asking	"Good. Do you measure your blood pressure?"	L06
L08	2017-10-26T06:21:21	Takeshi	Mei	Livingroom	Replying	"1 do it right now. Wait a minute"	L07
L09	2017-10-26T06:26:44	Mei	Takeshi	Livingroom	Asking	"How much? I will make a note of it."	L08
L10	2017-10-26T06:26:53	Takeshi	Mei	Livingroom	Replying	"155 over 105"	L09
L11	2017-10-26T06:27:02	Mei	Takeshi	Livingroom	Asking	"Ok. Fine. Have a nice day!"	L10

4 Conclusion

To achieve efficient development of person-centered care (PCC) support systems for elderly people, we have proposed a framework that universally manages PCC-centric user contexts. The proposed method manages heterogeneous data within a common data base with 6W1H perspectives. It also provides standardized user context for external applications via general-purpose API. We also showed a practical use case to see how the proposed system efficiently shares the data among different systems.

Our future work includes the implementation and evaluation of the proposed method.

References

1. Government of Japan: Annual Report on the Aging Society (2017). http://www.cao.go.jp/
2. Kitwood, T.: Dementia Reconsidered: The Person Comes First. Open University Press, Buckingham (1997)
3. Tokunaga, S., Tamamizu, K., Saiki, S., Nakamura, M., Yasuda, K.: VirtualCareGiver: personalized smart elderly care. Int. J. Softw. Innov. (IJSI) **5**(1), 30–43 (2016)
4. Sakakibara, S., Saiki, S., Nakamura, M., Yasuda, K.: Generating personalized dialogue towards daily counseling system for home dementia care. In: Digital Human Modeling 2017 (DHM 2017). LNCS, vol. 10287, pp. 161–172. Springer, Cham (2017)
5. Niu, L., Saiki, S., Nakamura, M.: Recognizing ADLs of one person household based on non-intrusive environmental sensing. In: 18th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD 2017), No. CFP1779A-USB, Kanazawa, Japan, pp. 477–482, June 2017
6. Egami, K., Matsumoto, S., Nakamura, M.: A consideration of user context managing service for ubiquitous cloud. The Institute of Electronics, Information and Communication Engineers Technical report, vol. 111, No. 255, pp. 85–90, October 2011
7. Tamamizu, K., Sakakibara, S., Saiki, S., Nakamura, M., Yasuda, K.: Capturing activities of daily living for elderly at home based on environment change and speech dialog. In: Digital Human Modeling 2017 (DHM 2017). LNCS, vol. 10287, pp. 183–194. Springer, Cham (2017)