Activity Data Collection Platform for Resident-Centered Local Community Vitalization

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(Received July 11, 2018)

In this paper, we aim to achieve resident-centered local community vitalization utilizing information communication technology (ICT). The relationship between local community residents should be based on social assets, and how to make use of this relationship is significant for vitalization of the community. If residents can be made aware of this invisible relationship that they are usually unconscious of, and understand its importance, they could vitalize their community through sustaining and promoting it, which is the concept underlying resident-centered local community vitalization. In this paper, we describe the concept of resident-centered local community vitalization and provide an overview of the platform and method for relationship visualization of residents using passing-each-other data based on graph theory. We build an activity data collection platform for resident-centered local community vitalization, which is compatible with terabyte class data collection. The number and frequency of passing-each-other occurrences between individual residents are analyzed, normalized, and represented as a graph. Through users' evaluation, we could confirm that the proposed representation using a graph is an adequate tool for visualizing the relationship among residents.

Key words: relationship visualization, resident-centered vitalizing, local community, passing-each-other data, cloud computing

1. Introduction

Following the Tohoku earthquake in 2011, the structure of local communities in Japan was compromised. Japan is the first country to have a super-aging society, as first noted in 2007. According to the Annual Health, Labour and Welfare Report 2013-2014, the number of people wanting to help in a local community increased, despite an observed weakening of the connections among community members.[1)]

In recent years, information and communications technology (ICT) has become more familiar to people as the result of the increasing use of smartphones. The cyber-physical system (CPS) has become an active research area in computer science. A CPS collects data on both inanimate objects and humans, and then integrates and analyzes the data for application to the community. In its Strategy Proposal for 2012, the Japan Science and Technology Agency proposed the use of CPS for promoting community involvement among the elderly.[2)]

While research on constructing a CPS system has been successful, but that on its usage is still in the developmental stage (Fig. 1). Moreover, introducing such a system does not always guarantee local activation, which inevitably depends on whether the locals who will take note of their problems and act to solve them. Therefore, our research focuses on residents and the promotion of ICT-aided visualization, that is, enabling the locals to take note of their community's problems using ICT. In this paper, ICT is used as a tool to help the locals, who are the subject of a problem solving approach.

This research aims to construct a mechanism to activate resident-centered local community vitalization with the support of ICT. We collect activity data from smartphones used by residents and visualize communications in the local community. Then, we remind residents of the challenges faced by the community and contribute to its vitalization.

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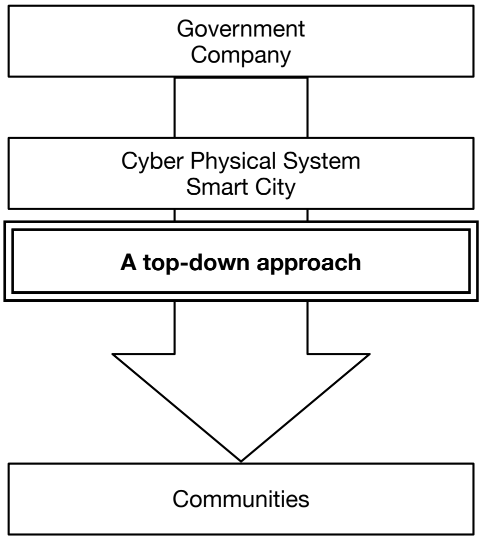

Fig. 1. Municipalities and private enterprises, so far, have often used a top-down approach for solving issues within local communities.

We have been conducting the field experiments since 2013 to implement resident-centered local community vitalization, focused on the communication in the community.[3–5] In the experiments, we lent smartphones to the experimental participants and collected the activity data such as location information, passing-each-other data, and telephone reception and transmission, then carried out analysis using this data.

We built an activity data collection platform on the cloud environment for collecting terabyte class data. In this paper, we describe the concept of resident-centered local community vitalization, and provide an overview of the platform and method for relationship visualization of residents using passing-each-other data based on graph theory.

2. Research Concept and Related Research

2.1 *Resident-centered local community vitalization*

Ushino's research (1982) on local resident-based regional development explained the significance of such a concept, and proposed the "Kande System.[6]" According to Ushino, following the industrialization and urbanization of the 1950s, rural village communities were divided by the agricultural policy, and reintegrated in the 1970s to create a new regional system. The value of local resident-based regional development has been an important research topic since the 1980s.

Yoshizumi's case study (2013) analyzed the sustainable development of regions by locals and suggested the Eco Card System, in which locals are given a stamp card called an Eco Card that promotes environmental activities, thus encouraging involvement in the region.[7] This system highlights the importance of visualizing, or making the locals aware of problems, in order for them to manage resident-centered local community vitalization.

Thanks to the introduction of ICT, it is possible to overcome local community challenges on a temporary basis. However, in order to achieve continual local community vitalization, residents should positively solve community problems, which requires them to be conscious of the challenges. "Resident-centered" means that the residents solve local community challenges themselves, and we aim to establish a methodology that enables this through visualization (Fig. 2).

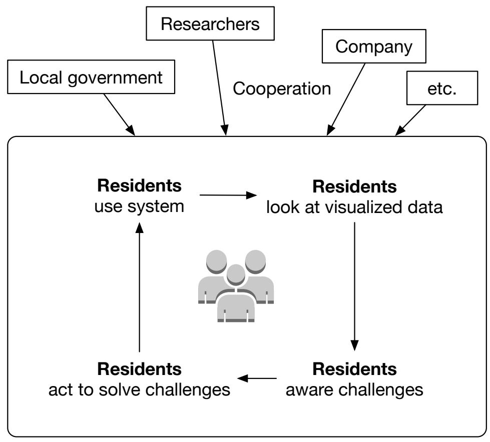

Fig. 2. Concept of resident-centered local community vitalization. Our research aims to solve issues by using a bottom-up approach instead of a top-down one.

2.2 *Relationship visualization using passing-each-other data*

Research and commercial systems development has become actively focused on the Bluetooth communication range (within 10 m). For example, iBeacon[8] is the Bluetooth location system developed by Apple Inc., in which Bluetooth low energy (BLE) advertising frames sent to the iBeacon transmitter (broadcasting device) enable indoor positioning. This system is utilized for online-to-offline (O2O) services; for example, when positioning is finished, particular goods may be introduced. It can be used not only between beacon devices and smartphones, but also between BLE-compatible smartphones. In this research, we acquire passing-each-other data focused on the Bluetooth communication range. If people pass within the communication range, it can be said that there is a type of relationship between them, according to Nishide's definition (1985) of interpersonal distance.[9] Therefore, we visualize passing-each-other data for awareness of the relationship between residents and local community vitalization.

2.3 *Activity data collection platform for local community challenges discovery*

Systems for telecommunications carriers to grasp the state of communication between users, such as People Flow Project[10] and mobile spatial statistics available from NTT Docomo[11] are some of activity data collection systems. These systems are built for managers to grasp the state of communication. In terms of utilizing data, People Flow Project and mobile spatial statistics are used for carriers or researchers to analyze the flow of people and actual population from a viewpoint of statistics.

In this research, we are aiming to make a change in residents' behavior by feeding the activity data collected from residents back to them. This should be a unique point and absolutely different from the existing systems. An important thing which we should emphasize is to construct a mechanism for residents to be naturally involved and spontaneously provide their data for local community challenges. Local community challenges are visualized by the data provided by residents who have open minds through this platform. Moreover, this platform should be needed and can work for reminding residents of the challenges faced by the community and driving to a movement of solving problems by themselves.

3. Experimental Method

3.1 *Overview of Field Experiment*

We acquired activity data with smartphones that were lent to experimental participants. Activity data includes location information, sending and receiving emails, telephone reception and transmission, and passing-each-other Bluetooth data. In this paper, we analyze the relationship between residents using passing-each-other Bluetooth data.

3.2 *Experimental area and participants' attributes*

This field experiment was conducted in the Makishima area of Uji City, Kyoto, Japan.

Uji City is located in the south of Kyoto, on the south side of Kyoto City. As of April 1, 2016, the population of Uji City was approximately 190,000, with 15,000 (approximately 8%) living in the Makishima area. Uji City has attracted a great deal of attention as a residential area located near Kyoto, Osaka, and Kobe since the early 1960s. As a result, residential land was developed in Uji City and the population increased substantially. Makshima is one of the development areas in Uji City, and contains densely populated areas, such as housing complexes. Certain blocks of the area developed in the early 1960s are aging, but the population of Makishima as a whole continues to increase slightly.

The experimental participants live in the Makishima area. Table 1 shows the attributes of these experimental participants. Many of these are over 65 years old, the reason for this being that people who retire at the mandatory age usually assist with regional development.

Table 2 shows the field experiment periods. We instructed the experimental participants to use the smartphones lent to them at all times for the duration of the experiment. However, taking into account informed consent, we told the participants they could switch off the smartphone when they did not want their location information to be known.

Table 1. Attributes of the field experiment.

Area	Makishima, Uji, Kyoto, Japan
Participants	20 to 50
Age	30 to 70yo

Table 2. Periods of the field experiment.

1st. period	Nov. 11, 2013 to Dec. 10, 2013
2nd. period	Feb. 11, 2015 to Mar. 27, 2015
3rd. period	Jul. 11, 2015 to Jan. 11, 2016

3.3 *Activity data collection platform*

For this research, we built a residents' activity data collection platform on Amazon Web Services (AWS), a public cloud company. Fig. 3 presents an overview of this platform. This platform is built on a "serverless architecture" that creates a system without building its own server and utilizes the managed services provided by cloud service providers. The serverless architecture is a technically unique feature of this platform. Generally, managed services are pay-as-you-go, and the cloud service providers manage and operate these services. Therefore, this enables us to concentrate only on our application, and makes it possible to reduce operating costs as well as simplify the operation. The simpler the platform, the easier deployment is, and costs can then be reduced. The platform is compatible with terabyte class data collection. The following services are used on AWS.

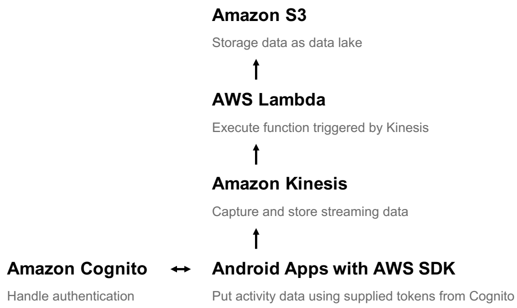

Fig. 3. Overview of activity data collection platform on AWS.

- **Amazon Cognito**

Amazon Cognito provides an authentication platform between an application and AWS. Only an Android application authenticated by Cognito can access server-side applications. Therefore, Cognito realizes safety access, without having to build a separate authentication platform.

- **Amazon Kinesis**

Amazon Kinesis processes massive amounts of streaming data (continuously created data) in real time. In this research, we acquired activity data every minute. Acquired data is immediately sent to a Kinesis endpoint, tagged with a sequence number, which is a particular number for each piece of data, and is kept for 24 hours.

- **AWS Lambda**

AWS Lambda executes Lambda functions as triggers for some kind of event. Data stored in Kinesis is deleted after 24 hours; therefore, it is necessary to maintain the data by storing it in a database or storage. Lambda can execute a function as a trigger that data has been sent to Kinesis, so that the data persists through a Lambda function.

- **Amazon Simple Storage Service**

Amazon Simple Storage Service (S3) is a storage service optimized for the Internet. Data stored in S3 can be operated on by the API, and S3 has a high affinity with various AWS services. Storing the data in S3 it to be extracted and analyzed with ease.

3.4 *Flexibility of the platform*

This platform is specified for collecting data, it is possible to collect data from organizations, cars, things, and as well as local residents. In addition, the infrastructure of this platform is written as a code utilizing the features of the public cloud services, and it can be deployed easily in the public cloud, what is called "infrastructure as code (IaC)." Moreover, public cloud services are deployed worldwide, hence this platform can be deployed not only in Japan but also around the world. Japan is the first country to have a super-aging society, and other countries may have super-aging societies in the future. Knowledge acquired using this platform can be utilized all over the world through the Internet.

3.5 *Experimental installation*

Table 3 shows the specifications of the smartphones used in the field experiment.

The smartphones used during the first period (left side of Fig. 4) were discredited, mainly due to their sluggish actions and small screen. Therefore, we gave the participants stylus pens to use in order to improve usability, which partly resolved the issues. Based on the suggestions from the first period, smartphones used during the second and third periods (right side of Fig. 4) were chosen for their quick actions and large screens. Due to the spread of smartphones, more experimental participants had their own than in the first period, which also significantly resolved the original problems.

3.6 *Android application*

We developed an Android application for data collection, an overview of which is illustrated in Fig. 5. This application runs in the background and collects activity data, which is sent to the endpoint as a JSON-format file.

Table 3. Specification of smartphones.

	First period	Second and third period
Manufacture	Fujitsu	ASUS
Model number	ARROWS Kiss F-03E	ZenFone 5 A500KL
OS	Android 4.0.4	Android 4.4.2
Network career	NTT docomo	IIJ Mobile (MVNO of NTT docomo)
CPU	Qualcomm Snapdragon S4 MSM8960	Qualcomm Snapdragon 400 MSM8926
Clock frequency	1.5GHz	1.2GHz
Core	Dual Core	Quad Core
RAM	1GB	2GB
Location information	GPS	GPS and GLONASS
Bluetooth	4	4
Sensor	G-Sensor	G-Sensor/E-Compass/ Proximity Light/Hall Sensor

Fig. 4. Smartphones using the field experiment (left: first period, right: second and third period).

Table 4. Specification of the Android application.

OS	Android 5.0
Language	Java
Libraries and SDKs	AWS Mobile SDK Google APIs for Android RxAndroid Realm Java

3.7 *Acquisition method of passing-each-other data using Bluetooth*

Communication between devices by means of Bluetooth requires "pairing" for the devices to authenticate one another. However, it is not practical to implement pairing with every passing occurrence. Passing-each-other data between experimental participants should be acquired without consciousness of the acquisition. Therefore, we implemented the following algorithm as a smartphone application to acquire passing-each-other data. Firstly, the smartphones obtain names of peripheral devices. Next, if a specific device name is detected, the MAC address of that device is recorded. Finally, the MAC address and acquisition time are sent to the server, where linking of the passed device and its owner is conducted (Fig. 6).

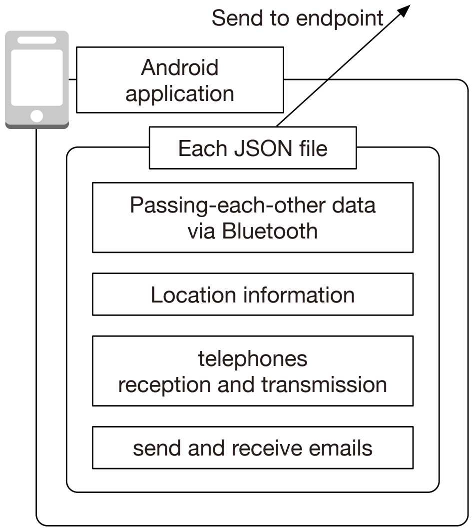

Fig. 5. Logic of the Android application.

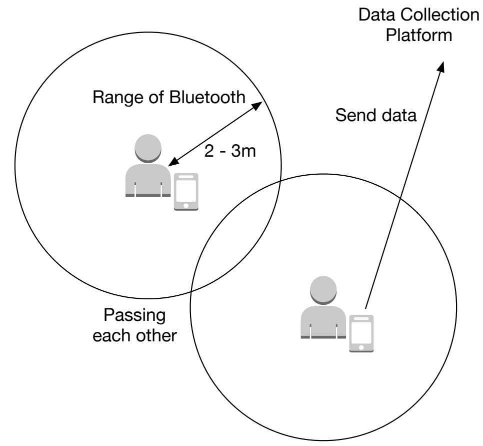

Fig. 6. Logic of the acquiring passing-each-other data.

3.8 *Visualization method using passing-each-other data*

Passing-each-other data is tabulated as shown in Table 5. The "`unique passing-each-other data id`" refers to the unique ID of each instance of passing-each-other data; the "`unique user id`" is the recorded experimental cooperator's ID; and "`passed user id`" refers to the experimental cooperator's ID detected by the recorder. The amount of passing-each-other data collected during the second period of the experiment was approximately 600,000.

Table 5. Type of raw data (example).

unique passing-each-other data id	12345
unique user id	678
type	passing
timestamp	1474707015
passed user id	910

We aggregated the passing-each-other frequency between experimental participants using the passing-each-other data. This data is which is tabulated as shown in Table 6, where "`count`" refers to the passing-each-other frequency. However, the frequency differs with each experimental cooperator as a result of the smartphone and communication environment operation ratio. In this paper, we aggregated the passing-each-other frequency of every experimental cooperator and applied normalization to divide the passed frequency by the summary value. In the experimental results, "`weight`" refers to the normalized value.

For this paper, we drew the passing-each-other data as a graph using Cytoscape.[13] We used the "edge-weighted spring embedded layout" algorithm, which is a graph layout that uses the Kamada-Kawai algorithm.[12] We applied the edge weight as the "weight" of Table 6.

Table 6. Type of summarized data (example).

unique user id	passed user id	count	weight
678	910	1234	0.823

4. Results and Discussions

4.1 *Activity data collection platform*

The data used in this section is from the third period, which was the most recent and longest. Tables 7 and 8 show the amount of collected data. The platform collected approximately 19,000 instances of activity data per day. Furthermore, the platform operated continuously during this period, whereas on-premises servers must usually stop at certain times due to legal inspections. This is one advantage of building the platform on a cloud service.

Table 7. The amount of collected data (passing-each-other).

Passing-each-other data (all)	547,741
Passing-each-other data (per day)	3,083

Table 8. The amount of collected data (location information).

Location information (all)	3,058,894
Location information (per day)	16,624

4.2 *Passing-each-other data visualization*

Fig. 7 and 8 show graphs for passing-each-other data using Bluetooth, which were drawn using Cytoscape with the edge-weighted spring embedded layout algorithm.

Fig. 7 shows the relationships among experimental participants based on passing-each-other data. The amount of data representing the relationship is described by 547,741 rows. The circular layer observed at the center of No. 10 suggests that this participant passed others frequently.

Fig. 8 shows the relationships between No. 10 and other experimental participants based on passing-each-other data. The amount of data representing the relationship is described by 28,610 rows. The weight depends on the passing-each-other frequency; therefore, people who passed by No. 10 often were drawn near to this person. No. 9 is No. 10's spouse and Nos. 37, 41 and 44 are work colleagues. These results suggest that this graph representation represents proximity adequately.

Fig. 9 shows the relationships between No. 24 and the other participants of this experiment based on passing-each-other data. The amount of data describing the figure is 5,373 rows. No. 24 emerged as a leader through the questionnaire that was used in the previous research. This questionnaire included an item that asked participants to provide the name of the person who they thought was the leader in an area. We found that there are some people whose graphs resemble that of a leader (Fig. 10). The amount of data describing the graphs are 9,564, 7,542, and 6,286 rows from the left respectively.

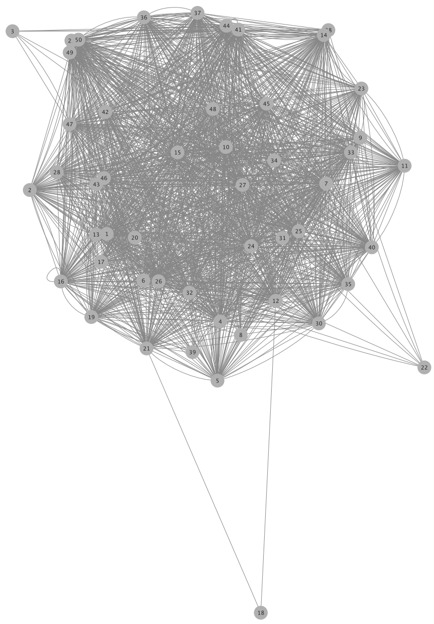

Fig. 7. Passing-each-other data between experimental participants.

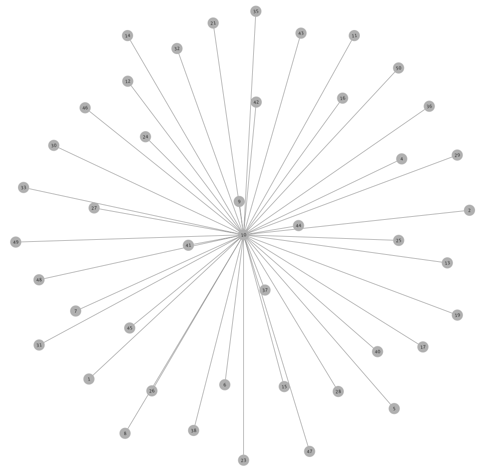

Fig. 8. Passing-each-other data from No. 10 to other experimental participants.

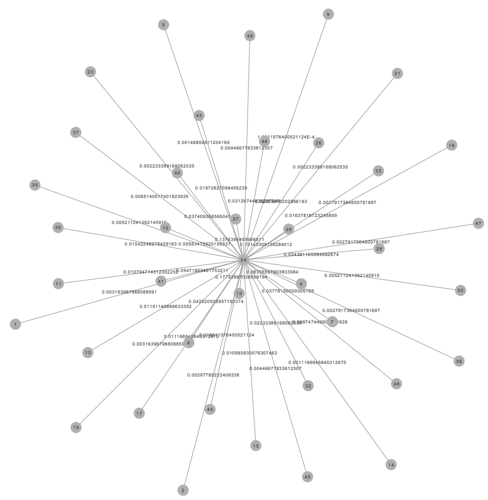

Fig. 9. Passing-each-other data from No. 24 to other participants. No. 24 was voted as the leader of the local community.

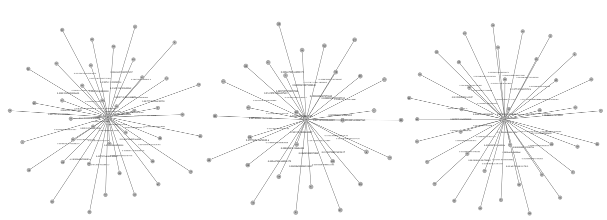

Fig. 10. Passing-each-other data are similar in structure to that of No. 24.

5. Conclusion

The purpose of this research is resident-centered local community vitalization utilizing ICT, for which awareness by means of visualization is very important. In this paper, we built an activity data collection platform for visualization, as a mechanism to promote awareness. Then, we proposed a relationship visualization method using passing-each-other data, which was acquired using Bluetooth installed on smartphones. We aggregated the passing-each-other data, normalized them, and represented the results with a graph.

The activity data collection platform was able to collect with terabyte class data by utilizing cloud services. As a result of visualization, we conclude that the graph representation method is an adequate tool for visualizing relationships between a person and those around them. However, there are still certain issues with this representation method as a social network.

Further studies are necessary to propose more useful relationship visualization methods through drawing, taking into account individual attributes (for example, gender and age) and representing combined time series and location information. Also, we should verify whether the behavior of residents will be changed by visualizing the data collected using this platform and feeding back to the residents. Further, we should develop visualization tool that can respond to any request from residents.

This work was supported by JSPS KAKENHI Grant Numbers JP16J03602, JP16K03718, and JP17KT0086.

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