Design of Relationality to Enable the Vitalization of Resident-centered Communities

by

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Contents

List of Figures

List of Tables

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Abstract

Japan faces two serious problems; an inevitable super-aging society and an abrupt decrease in population. These problems are causing some people being left behind, isolated, and alienated from their community/society. This phenomenon is particularly evident in communities. Thus, rebuilding and sustainably managing communities have become imperative.

A community is a system that cannot exist without the self-motivated involvement of community members, and it is composed of humans, "Mono," "Koto", and their relationality with each other which are naturally formed by community members during the course of their daily lives. Relationality among humans, "Mono," and "Koto", that are formed between members in a community on a daily basis should be regarded as an asset in the sense that relationality can be considered as social and economic value expected to provide some benefit to the community in the future. The focus of this dissertation is to postulate relationality as an asset that community members earn individually, and to elicit their awareness of relationality as trust.

For rebuilding communities, in this research, we aim to quantify and visualize the relationality between humans, "Mono," and "Koto", in a community as relationality assets, develop an awareness of the significance and meaning of relationality in a community, and provide an incentive to members of a community to develop relationality, so that they themselves can manage, sustain and enrich their community through relationality.

Hence, an integrated approach to combine modeling and practice has been applied as follows: We examined simulation models of relationality assets to theoretically establish relationality assets. In addition, to investigate how the approach for designing the proposed mechanisms and verify their effectiveness, we have conducted fieldwork with residents in a community for several years. For modeling, we built simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system. These models were then refined by proof-of-concept in the field.

In the field study, we built an activity data collection platform for resident-centered community vitalization, which is compatible with terabyte class data collection. The activity data includes location information, sending and receiving emails, telephone reception and transmission, and Bluetooth data obtained while residents passed by each other. 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.

A community is a system. In other words, a community is a typical example of a complex adaptive system, and it can be simulated using a suitable model such as a multi-agent systems approach. This implies that it is possible to develop a community as a complex adaptive system using appropriate design and analysis. In this study, we investigated the methods to analyze a community. We visualized the relationships on a daily basis among participants in the experiment using the passing-each-other data collected from them. As a result, we confirmed that each participant forms clusters that varies day-wise. We could also confirm several features that helped establish that a community is a complex adaptive system. Furthermore, the results for a weekday were significantly different to that of a holiday.

In addition, we investigated a method to visualize relationality assets more effectively. For that purpose, we introduced a new core concept of "media spots", not only as places where residents could communicate with each another more frequently than in other areas, but also as a prospective platform to mediate relationality between humans, "Mono," and "Koto." That is, "media spots" should have the potential to proactively promote resident-motivated communications and activities in a community. We have proposed a visualization method

for “media spots” estimation from residents’ location information that uses density-based spatial clustering of applications with noise (DBSCAN) for cleaning enormous amount of raw location information data. The present results suggest that representative points extracted using DBSCAN can be used to visualize activities in a community more effectively and estimate media spots more accurately than the previously used method.

Prior research mainly focused on collecting and analyzing data sent unconsciously by the residents themselves, including location information and passing-each-other data. However, in the process of analysis, we initially observed that a behavioral change of sharing the information voluntarily promotes a resident-centered community vitalization, rather than solving individual residents’ community challenges by analyzing data. Shared information is also the source of relationality assets because it makes relationships strong. Therefore, we discussed a platform for promoting the transition of behaviour of residents towards resident-centered community vitalization by sharing and visualizing the information that they voluntarily send. We confirmed that residents shared data regarding dangerous places voluntarily.

Finally, we described the development of future studies on vitalization of resident-centered local communities by design of relationality.

Chapter 1

Introduction

1.1 Background

The structure of local communities in Japan needs to be changed after the Great Tohoku Earthquake. Japan faces two serious problems; an inevitable super-aging society and an abrupt decrease in population [1], and these problems are leading to some people being left behind, isolated, and alienated from their community and society. These phenomena are particularly evident in communities, and thus rebuilding and sustainably managing communities has become imperative. Some research has revealed that loneliness and social isolation are risk factors for mortality, and subsequently, loneliness, social isolation, and living alone have been emphasized as emerging public health issues in the U.S [2][3].

According to the Annual Health, Labor and Welfare Report 2013-2014, the connections have been weak among members of the communities, but the number of people who want to help in the community has increased [4]. This type of social situation has prompted the development of several approaches from the computer science field. Examples of these approaches include the person-watching system of the Japan Science and Technology Agency in the Strategy Proposal of 2012 and the smart-city system [5]. However, despite the need for these approaches, most communities cannot use them casually.

1.2 Research Motivation

A community is a system that cannot exist without the self-motivated involvement of community members in the community, and it is composed of humans, "Mono," and "Koto" and their relationality, which community members naturally generate through their daily lives. The concept of relationality here denotes interactions through which two entities mutually influence each other; linkage over time and space, and context as a result of accumulated interactions, and linkage. "Mono" in Japanese denotes tangible and physically perceived things/entities, while "Koto" denotes intangible and cognitively conceived things/entities.

Relationality among humans, "Mono," and "Koto" that people daily generate in a community should be regarded as an asset in a sense that relationality should be a social and economic value expected to provide some benefit to the community in the future. The original idea in this research is to postulate relationality as an asset that community members individually earn, and to elicit their awareness of relationality as trust. In order for relationality to function as an asset, it should result in trust that community members value and desire.

1.3 Research Objective

For rebuilding communities, in this research, we aim to quantify and visualize the relationality between humans, "Mono," and "Koto" in a community as relational assets. In addition, for relationality to function as an asset, we propose a mechanism through which community members can invest their relationality assets with relationality itself to increase their assets, so that they themselves can manage and sustain the mechanism.

In academic fields, on the other hand, a system-science-based approach to social phenomena such as computational social science [6] has been active in the past, but a new system-science-based approach that can model the reality of community members' lives into system dynamics is now required. In this paper, we focus on the concept, scheme, and approach of this research and discuss their significance based on the results of field experiments and simulations.

Hence, an integrated approach to combine modeling and practice has been applied as follows: We examined simulation models of relationality assets to theoretically establish relationality assets. In addition, to investigate how the approach for designing the proposed mechanisms and verify their effectiveness, we have conducted fieldwork with residents in a community for several years. For modeling, we built simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system. These models were then refined by proof-of-concept in the field.

1.4 Thesis Outline

Fig. 1.1 shows the overview of this research. In chapter 2, we introduce concepts of relationality, community design, relationality assets, anb resident-centered vitalization of communities.

We focus on, in chapter 3, the following issues: whether or not the introduction of relatiaolity assets in a community influence the increase of acquaintance, the total amount of relationality assets, and some change in their behavior. For modeling, we build simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system.

In chapter 4, we build an activity data collection platform for visualization, as a mechanism to promote awareness. The activity data collection platform is able to collect with terabyte class data by utilizing cloud services.

In chapter 5, we investigate the methods to analyze a community considering that it is a complex adaptive system. We visualize the day-wise relationships among the experimental cooperators using the passing-each-other data collected from them.

In chapter 6, “media spots” are defined as not only the places where communication occurred more frequently among residents as compared to other areas but also prospective platforms to mediate relationality among humans, “Mono”, and “Koto”.

In chapter 7, based on prior research, we discuss a platform for promoting the transition of behavior of residents towards resident-centered community vitalization by sharing and visualizing the information that they voluntarily send. Finally, in chapter 8, we conclude the thesis.

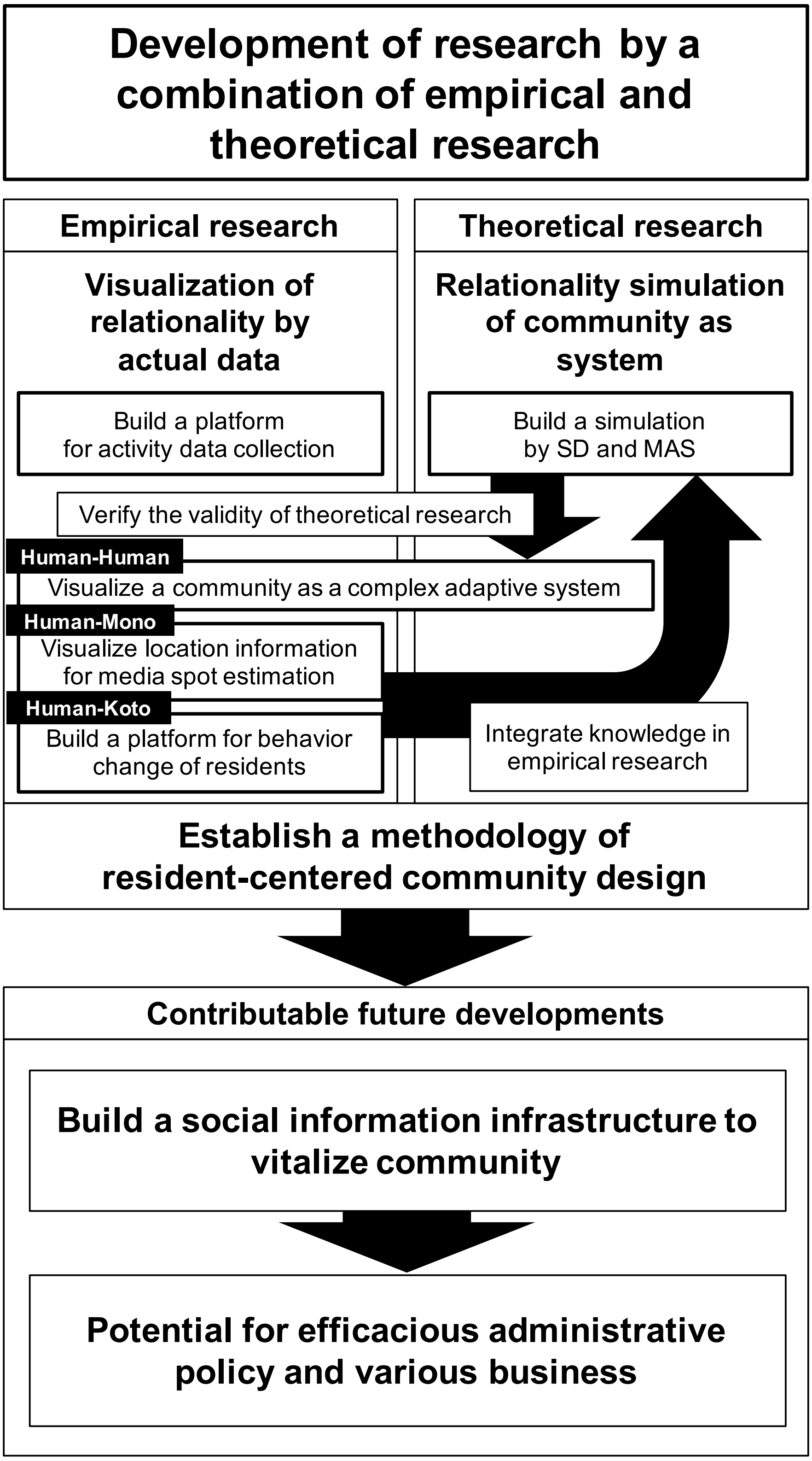

Fig. 1.1 Overview of this research

Chapter 2

Concepts

2.1 Viewing System as Dynamics

Here, systems denote collective systems composed of elements and their relationality that have mechanisms to maintain and regulate themselves autonomously. Assuming, for example, that a football team is a system, the players are the elements and teamwork or collaboration between the players is the relationality. No matter how skillful or talented a player is, he cannot play any football games without the collaborated teamwork with other players. There would be no meaning if the team did not work as a system, and the performance of the team depends on the collaborations between players.

Additionally, the opposing team is also a system, and these systems can interact with each other. Collaborations and teamwork of both teams form interactions between the two systems; in turn, these interactions influence the collaborations between players. Collaboration between players, therefore, is closely related to the interactions between systems.

System behavior and its properties should be dynamically generated; not through a simple summation of individual elements but by the relationality between the elements. In addition, the change of relationality over time could be considered as an evolutionary process of the system, and subsequently, it is very important to view the dynamics of systems from the viewpoint of relationality.

2.2 What is Relationality?

The concept of relationality here denotes interactions through which two entities mutually influence each other; linkage over time and space and context as a result of accumulated interactions and linkage. Interactions and linkage form a context with the passing of time, and in turn both the context and linkage affect the upcoming interactions. Thus, interactions, linkage, and context are mutually related. Relationality is not limited to the physical and spatial arena; rather, it is invisible and information-driven, and sometimes ecological and environmental. Social and economic systems, culture, region, and senses of value, therefore, are a part of relationality.

Human beings are entities that wish for relationality or relationships with others and hope to find meaning in these relationships. Human beings, in other words, live in relationality and are alive with relationality. Relationality should work to form a structure of "dependence and governance," as illustrated in Fig. 2.1.

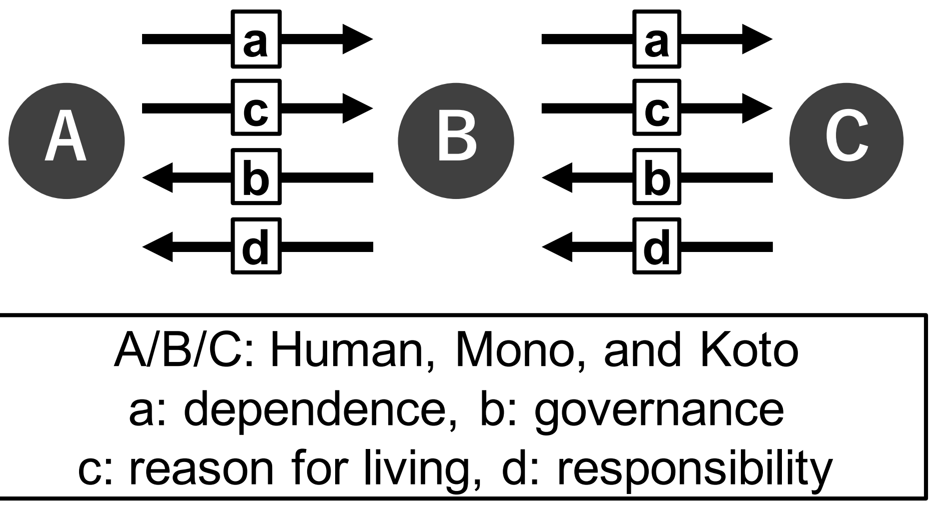

Fig. 2.1 Dependence and governance in relationality

Nodes A, B, and C in Fig. 2.1 are elements of a system, and the directed links represent the relationality between these elements. From this, we may conclude that nodes and other objects or entities with which human beings have some relationality, such as social rules, economic systems, culture, religion, thoughts, senses of value, and so forth, typically represent human beings. For example, assuming that A represents a baby, B is its mother, and C is its father, the baby depends on the mother and the mother depends on the father, as illustrated by a in Fig. 2.1.

From the figure, dependence is accompanied by governance as the inverse, as demonstrated by b in Fig. 2.1. That is, the mother governs the baby, and the father governs the mother. The mother, however, is responsible for the baby and the father is responsible for the mother, as demonstrated by c in Fig. 2.1. Moreover, the mother has something to live for because of the baby's dependence on the mother, and the father similarly has something to live for because of the mother's dependence on him, as demonstrated by d in Fig. 2.1.

Thus, duplicated relationality eventually fosters trust between entities, although human beings often remain unconscious of this relationality.

2.3 Community Design

A community is a system that is composed of humans, "Mono," "Koto," and their relationality, which community members naturally generate through their daily lives. A community cannot exist without the self-motivated involvement of the community members. That is, the vitalization of a community cannot be achieved without sustainable incentives for community members to implement community activities, as illustrated in Fig. 2.2.

In reality, residents communicate with one another and live with spatial resources such as places and facilities as "Mono" and invisible institutions and events such as festivals as "Koto" in their communities. However, the relationality among humans, "Mono," and "Koto" that community members generate daily in their community, vanishes naturally without being stored and accumulated, and people are unconscious of its presence.

Assuming that a community with rich relationality is active and bustling, it is essential to enrich relationality in a community and to know how to utilize relationality for vitalizing a

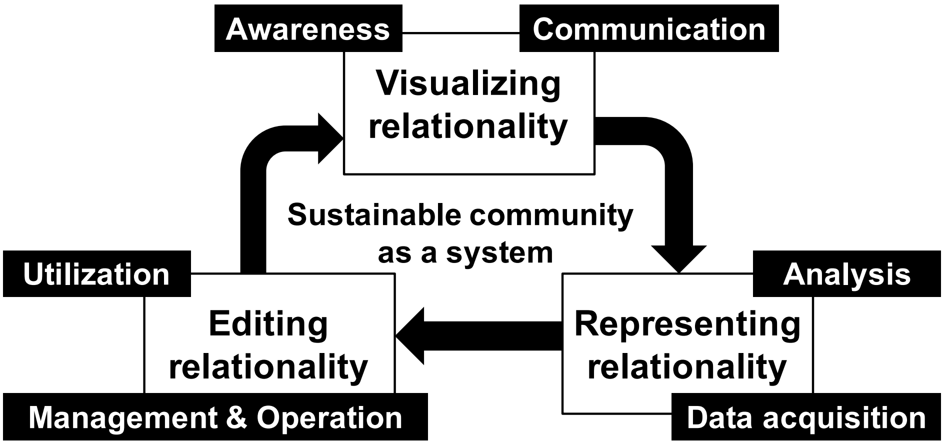

Fig. 2.2 Community design focusing on relationality

community. Some ways to answer these questions are as follows;

- To develop an awareness of the significance and meaning of relationality in a community.
- To make people have an incentive to develop relationality.

2.4 Relationality Assets

2.4.1 Investment and Dividends

As for the former, we propose that relationality should be regarded as an asset, as a social and economic value expected to provide some benefit to communities in the future. We also propose to quantify and visualize relationality among humans, "Mono," and "Koto" as relationality assets in the community.

However, it is not until relationality results in trust, which everyone values and desires, that relationality functions as an asset. As for the latter, we propose a mechanism to develop a change in people's consciousness and behavior in communities by arousing their awareness of relationality that they are unconscious about. To achieve this, we employ an analogy; investors receive interest by investing their assets in stocks and securities, they react nervously to the up and down movement of these stocks and eventually work to sustain the mechanism behind these movements.

However, a possible drawback of introducing such a mechanism to relationality assets is that they are naturally accumulated and then continue to increase. We introduce a Local Exchange Trading System (LETS) or local currency mechanism, which plays a role in maintaining person-to-person connections, activating intercommunications, and works as a medium for people to share and transmit a sense of value. Some local currencies have no interest or negative interest to promote and activate their exchange between people. That is, the mechanism we introduced here is for people to receive a dividend by investing their assets with others, but their assets automatically decrease if they retain them, as illustrated in Fig. 2.3.

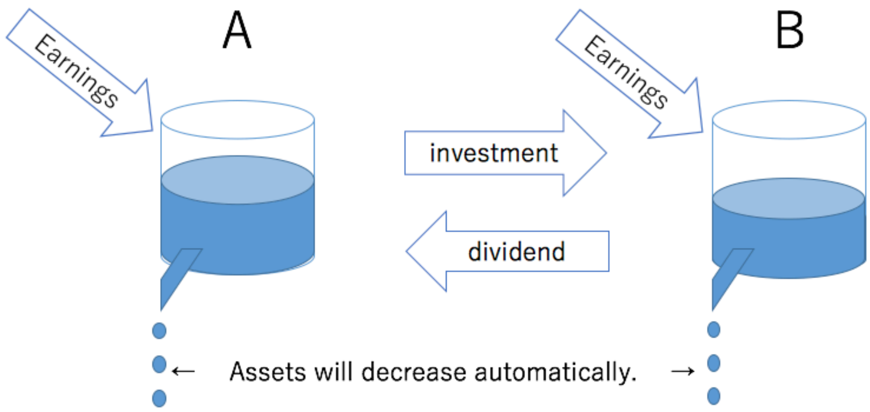

Fig. 2.3 Model of investment and dividends

People could express, for example, a form of goodwill, a smile, thank, feelings of empathy or sympathy, or a sense of linkage to others by investing their assets with the other people. A person who can earn a large number of relationality assets can provide a larger dividend corresponding to the number of assets of those who have invested in them. A person who can increase their assets by investing might also be regarded as a supporter of the community, and a person who has many investments from others might be regarded as a person of virtue.

2.4.2 Gift and Circulation

On the other hand, there should be a big difference between relationality assets and the local currency. Relationality assets are sort of assets but not currency for equivalently exchanging something and something. Here we propose a model of gift and circulation instead of a model of investment and dividend, as shown in Fig. 2.4

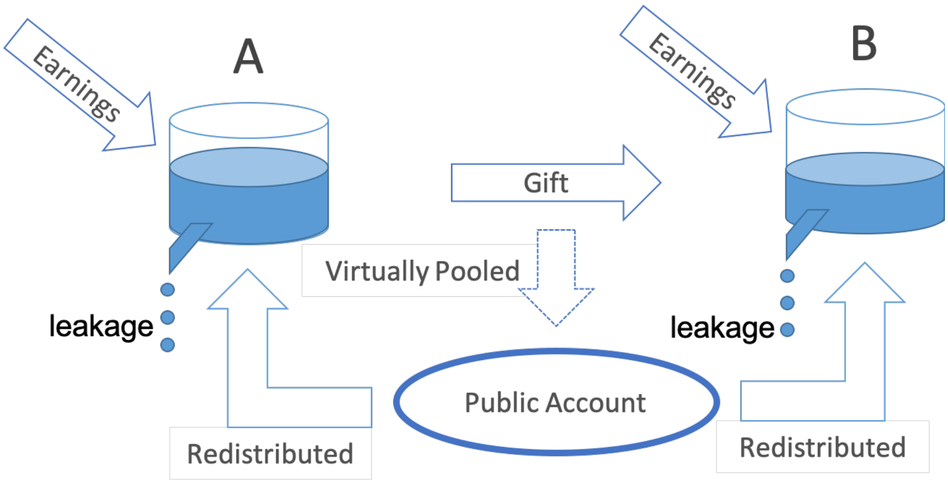

Fig. 2.4 Model of gift and circulation

What we want to promote is not equivalent exchange based on one-time pay-it-back relationship but gift and circulation that activate successive pay-it-forward relationship within people. For that purpose, we introduce a public account to accumulate the same amount of assets gifted from someone to someone. People could express, for example, a sort of goodwill, smile, thank, feeling of empathy or sympathy, and/or a sense of linkage to others by gifting their assets to the others.

At that time, the same amount of assets gifted is automatically accumulated in the account. The accumulated amount of assets indicates how active pay-it-forward activities are among people, and people get to know and monitor it. Also, some amount of assets is redistributed to people in a given time such as a week, a month or a few months from the public account. It seems to be the same as dividend to investment, and should work to make people have incentive to such movement. What we want to emphasize, however, is that such movement is driven not by pay-it-back activities but by pay-it-forward activities among people. A person who can earn a lot of relationality assets should be active in the community in a sense that he/she can gift his/her earned assets to others as a big supporter to the community as well. A person who has a lot of assets gifted from others might be regarded as a person of virtue.

Subsequently, we are building a platform through which community members are positively involved in managing and sustaining relationality assets in a community.

2.5 Resident-centered Vitalization of a Community

Ushino (1982) explained the importance of the concept of local resident-based regional development, and proposed a system called "Kande System [7]." After the industrialization and urbanization in the 1950s, the village communities in rural areas were divided by agricultural policies and then re-integrated in the 1970s to create a new regional system (Ushino, 1982). The importance of this concept has already been a significant research topic since the 1980s.

Meanwhile, Yoshizumi (2013) analyzed the way for locals to develop regions sustainably, and suggested the "Eco Card System [8]." In this system, the locals are given a stamp card called an "Eco Card" that promotes environmental activities, thereby creating a setup for the locals to be involved in the region. This system highlights the importance of visualizing or making the locals notice the problems and thus incites them to manage local resident-based regional development efforts.

With the introduction of information communication technology (ICT), it is temporarily possible to solve the challenges of a community. However, to vitalize a community continuously, residents must solve them positively. For residents to solve the challenges of a community by themselves, they must be conscious of these challenges. Thus, "resident-centered" development means that "residents themselves solve the challenges faced by their community." In this research, we aimed to establish a methodology that enables them to do so by visualization, as shown in Fig. 2.5.

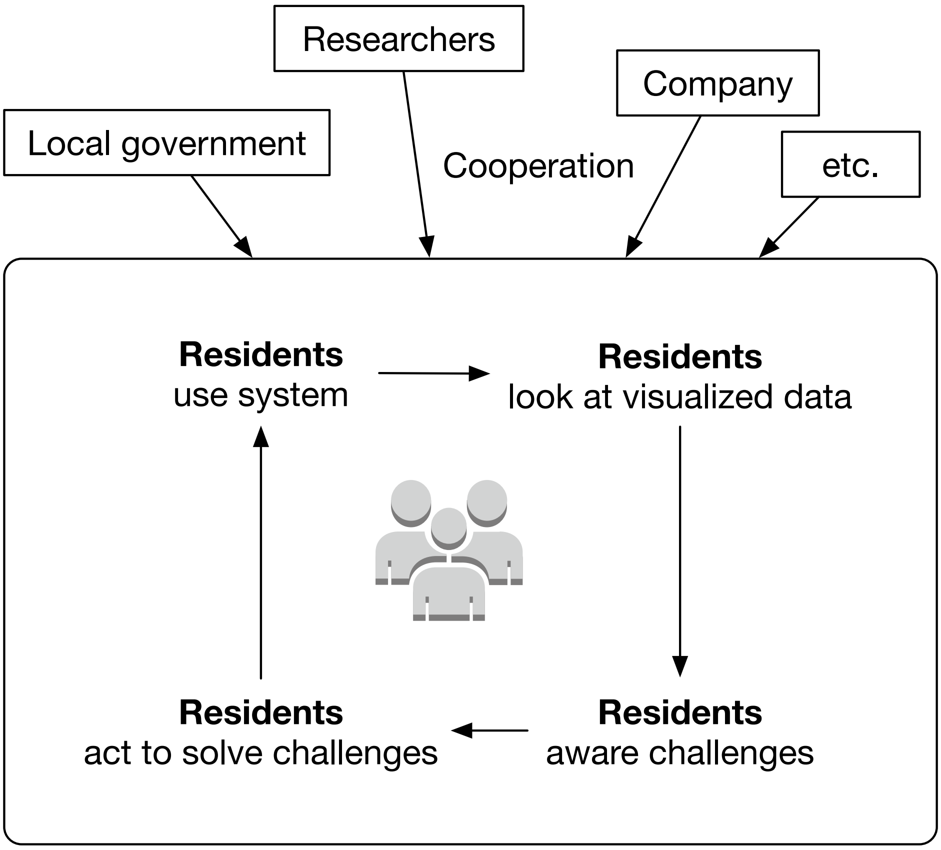

Fig. 2.5 Concept of resident-centered community vitalization. Our research aims to solve issues by using a bottom-up approach instead of a top-down one

Chapter 3

Simulation for Visualizing Relationality Assets

3.1 Introduction

In this chapter, we are targeting "a community" as a system that does not function unless residential people are voluntarily involved. In other words, a community as a system is composed of humans, "Mono" and "Koto" and their relationality which residents naturally generate through making their daily lives. We are aiming to quantify and visualize relationality between humans, "Mono" and "Koto" in a community. Original ideas are to postulate relationality as assets the community people individually earn, and to elicit their awareness of relationality assets as trust.

We focus on, in this chapter, the following issues: whether or not the introduction of relationality assets in a community influence the increase of acquaintance, the total amount of relationality assets, and some change in their behavior. In order to investigate those issues, we built simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system.

Now, we are building a simulation model through which community people themselves are positively involved in managing and sustaining relationality assets in a community.

3.2 System Dynamics

System Dynamics (SD) is a method to explore dynamic characteristic of a target system by modeling the internal structure of a system that fluctuates within changes over time and simulating the behavior of system [9]. We investigated the optimal combination of the rate of redistribution and damping for the model of Gift and Circulation.

Fig. 3.1 shows the stock and flow diagram of gift and circulation model.

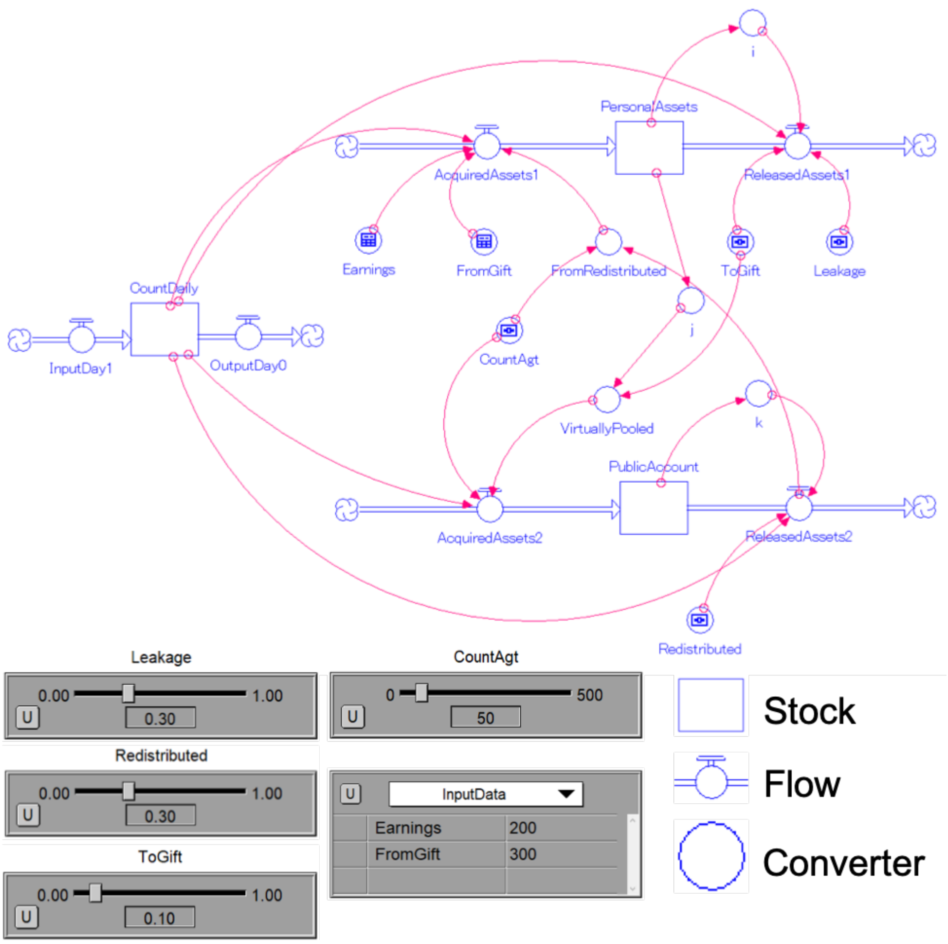

Fig. 3.1 Relationship between characteristics and attributes of a person agent

We use STELLA 9.1.4 to build the stock and flow diagram of gift and circulation model. The followings are description of the diagram in Fig. 3.1;

- Gift: People could express linkage to others by gifting their assets to the others.
- Public Account: People can monitor changes.
- Redistributed: Some amount of assets is redistributed to people in a given it every week.
- Earnings: The amount of assets that people earn individually.
- Leakage: The value of the asset falls automatically.
- Virtually Pooled: The same amount of assets gifted is automatically accumulated in the account.

In this model, relationality assets are distributed with one week as one unit (Table 3.1).

Table 3.1 Distribution of Relationality Assets: Each Week as One Unit

	Personal Assets	Public Account
Monday	FromGift	
Tuesday		
Wednesday	Redistributed	Released Assets
Thursday		
Friday	ToGift	Virtually Pooled
Saturday		
Sunday	Leakage	

We set up to saturate the total amount of relationality assets for the following reasons;

- Physical viewpoint: An image of a tank which stores water, and the tank has capacity of storing water.
- Economic viewpoint: To prevent inflation and an inexhaustible increase in relationality assets within a given region.

3.3 Agent-Based Social Simulation (ABSS)

The ABSS [10][11] which we use for simulations enables us to construct an artificial community model in which human agents make actions autonomously and interact with other agents based on rules we defined.

Every resident in a community has his/her own characteristics and attributes such as age, gender, social position and so on. In other words, there should be diversity in residents' involvement in a community depending on their characteristics and attributes. In order to simulate residents' behaviors in the community, therefore, how to model diverse residents and their interactions is very important. Also, it is indispensable that the model should be interpretable so that we could analyze their behaviors later.

In that sense, the ABSS is enough powerful for our simulations, and we think it the best way.

3.3.1 Overview of Simulation by ABSS

We focus on, in this chapter, the following issues: whether or not the introduction of relationality assets in a community influence the increase of acquaintance, the total amount of relationality assets, and some change in their behavior. In order to investigate those issues, we have been working on an ABSS model.

In this model, a local resident modeled as an agent encounters other persons in walking in a town, and then they become acquainted. They can keep such connection by mailing and/or making a phone call. Through such activities, every person can earn some points, and accumulate them individually day by day. On the other hand, some of the individual points accumulated should be decreased based on the damping rate of the points.

We set the daily action cycle divided into three time zones; "time to do nothing like sleep," "time to walk in the town," and "time to e-mail and phone-call." In this model, the latter two are simulated.

In addition, every person can gift his/her earned points to others, and the same amount of the points is virtually pooled in a public account. Some of the points pooled in the public account is redistributed to every person based on the redistribution rate weekly.

3.3.2 Agent Model

As for an agent for a local resident, we set the following parameters as characteristics; "aggressiveness," "normative consciousness," and "self-efficacy [12]".

One of possible reasons of problems in real communities would be peoples' negative motivation to the community, for example, which a person feels some obligation because of his/her relationships with his/her neighborhood, rather than positive and self-motivated one. Depending on "normative consciousness," people behave cooperatively feeling fear from deviation from the neighborhood. On the other hand, people would be able to get some "self-efficacy" by having a fun to be involved in practical activities in a community [13].

In addition, we set three attributes such as "age," "gender," and "social position" to an individual agent, because a reference reports that age and gender are closely related to participation to community activities, and that "social position" affects frequency of participation to community activities [14].

To sum up, we set the relationship between peoples' characteristics and attributes as shown in Fig. 3.2. Concretely, young people are not so positive to community activities, and rarely take part in them in reality. Middle-aged people who have to work harder are also not so positive even if they might have interests in community activities, while females are more positive than males. Elderly people who can have relatively free time after retired are often active in the community. In elderly people, males are more positive than females.

In addition, the motivation to community activities would be influenced by whether they are married or not, and/or whether they have a child or not. Some study says that married people are more positive than not-married one because married one are apt to be concerned about the neighborhood especially when they have a child [15].

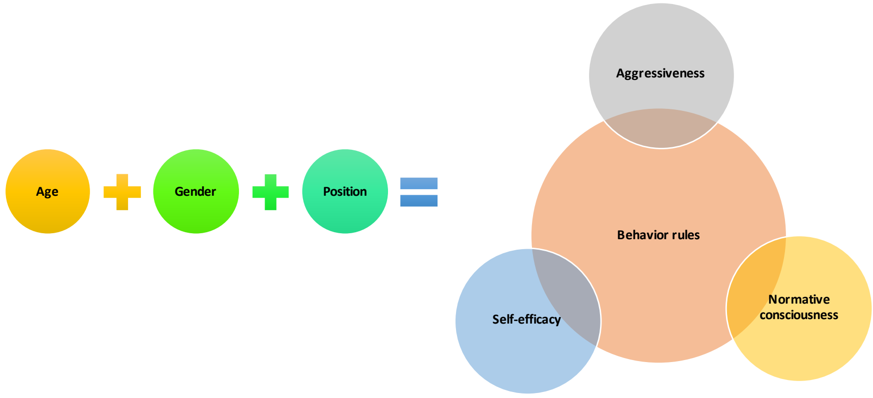

Fig. 3.2 Relationship between characteristics and attributes of a person agent

3.4 Results and Discussions

In this section, we discuss the results of the simulation by System Dynamics using the model of Fig. 3.1 We also improved the model based on the results. Therefore we described consideration at that time.

3.4.1 Task 1: Suitable Parameter as Dynamically Changing

If all parameters are made static, the relationality assets increase indefinitely. Therefore, one parameter is set to change dynamically. Figures 3.3, 3.4, and 3.5 show simulation results of the value of personal assets and public account with gift, leakage, redistributed parameters, respectively. In this chapter, redistributed with a small amount of change of personal assets was set as a dynamic parameter.

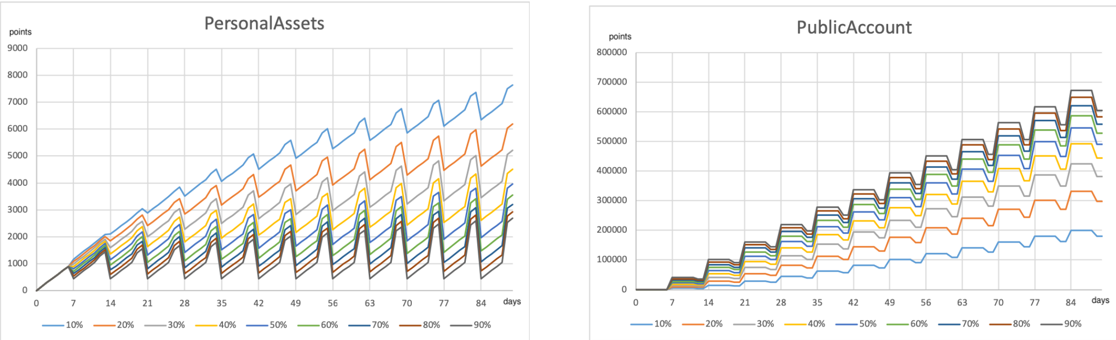

Fig. 3.3 "Gift" dynamically changed

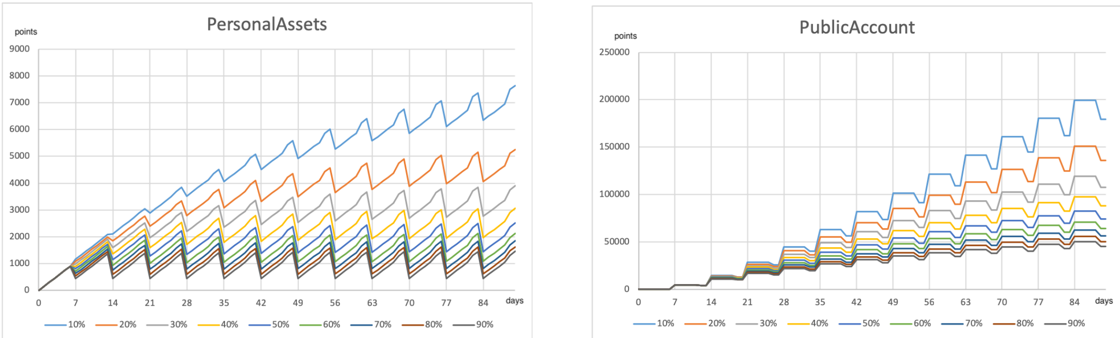

Fig. 3.4 "Leakage" dynamically changed

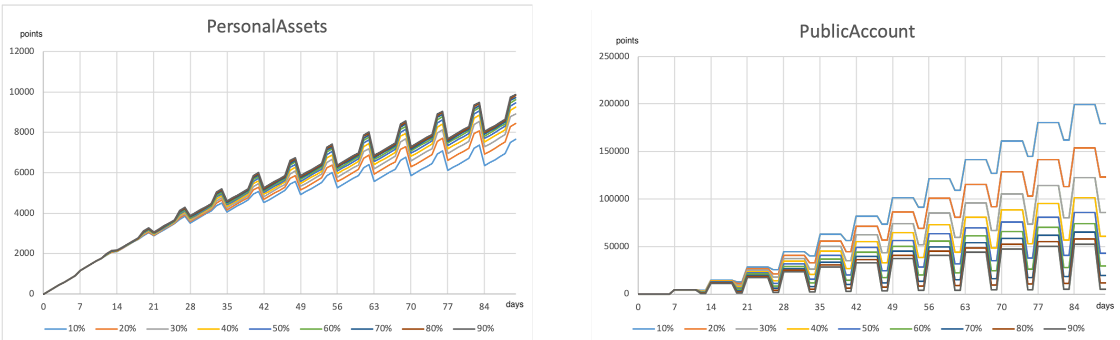

Fig. 3.5 "Redistributed" dynamically changed

3.4.2 Task 2: Formula for Dynamic Parameter

Following the previous section, we considered the dynamic value of redistributed such that the value of public account is saturated as a mathematical expression. Here, we decided that public account is saturated with a fixed value using the following formula;

$$Redistributed(x) = 0.4\left(1 - e^{0.000015x}\right). \tag{3.1}$$

Fig. 3.6 shows the simulation result of the value of personal assets and public account using the formula (3.1). We confirmed that the value of personal assets and public account was saturated with a fixed value.

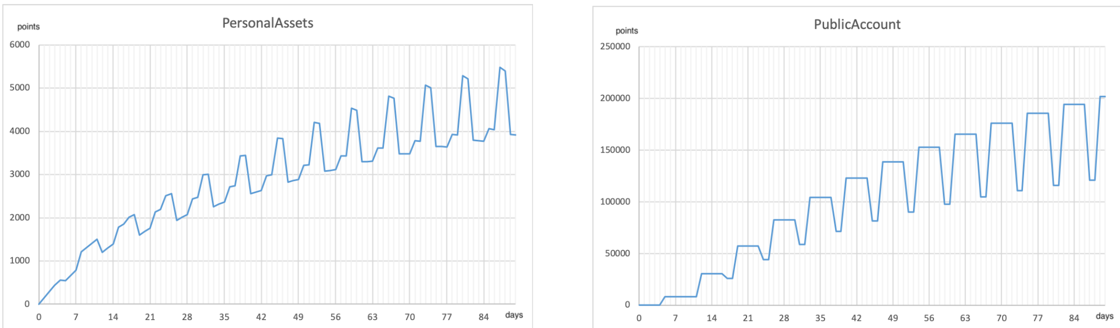

Fig. 3.6 "Redistributed" dynamically changed

In this model, we set and test the following parameters that we acquire in the SD simulations;

- Gift rate from 10 to 50% of points which every person possesses
- Damping rate from 10% to 30% of points which every person possesses
- Redistribution rate from 10% to 50% of points pooled in the public account is redistributed to all persons at the end of week

3.5 Conclusion

A community is a system that cannot exist without community people's self-motivated involvement in itself, and that is composed of humans, “Mono”, “Koto” and their relationality which community people naturally generate through making their daily lives. Relatonality among humans, “Mono” and “Koto” that community people daily generate in a community should be regarded as assets in a sense that relationality should be social and economic value expected to provide some benefit to a community in the future.

Towards rebuilding of a community, we have proposed a system model to quantify and visualize relationality between humans, Mono and Koto in a community as relationality assets that residents individually earn, and to elicit their awareness of relationality assets as trust. In order for relationality to function as assets, in addition, we have proposed a mechanism through which community people gift their assets to others and they can share a sort of common assets virtually pooled by their gifting activities among people.

For modeling, in this chapter, we built simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system. These models were then refined by proof-of-concept in the field.

Chapter 4

Activity Data Collection Platform

4.1 Introduction

We built an activity data collection platform on the cloud environment for collecting terabyte class data. In this chapter, we describe the concept of resident-centered 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.

4.1.1 Activity Data Collection Platform for Community Challenges Discovery

Systems for telecommunications carriers to grasp the state of communication between users, such as People Flow Project [16] and mobile spatial statistics available from NTT Docomo [17] 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 community challenges. 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.

4.1.2 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 [18] 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 [19]. Therefore, we visualize passing-each-other data for awareness of the relationship between residents and community vitalization.

4.2 Experimental Method

4.2.1 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 chapter, we analyze the relationship between residents using passing-each-other Bluetooth data.

4.2.2 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 4.1 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 4.2 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 4.1 Attributes of the field experiment

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

Table 4.2 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

4.2.3 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. 4.1 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.

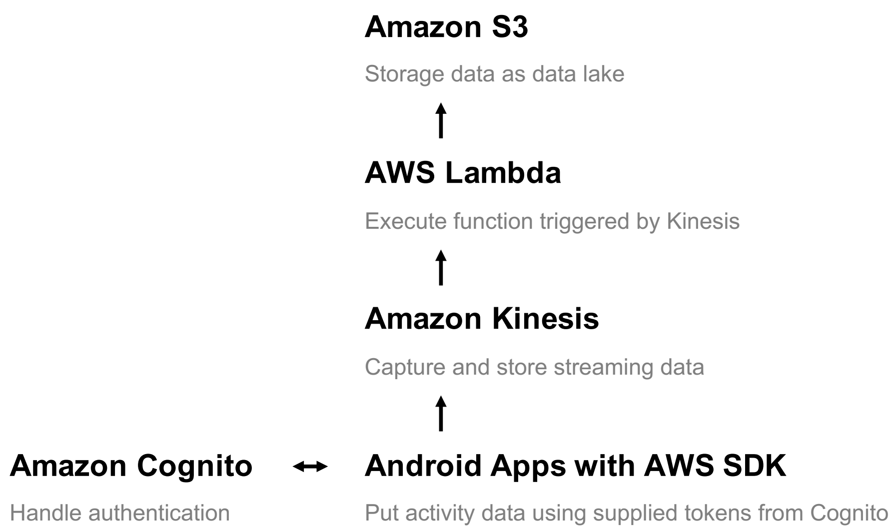

Fig. 4.1 Overview of activity data collection platform on AWS

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.

Amazon 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.

4.2.4 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.

4.2.5 Experimental Installation

Table 4.3 shows the specifications of the smartphones used in the field experiment.

The smartphones used during the first period (left side of Fig. 4.2) 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. 4.2) 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.

Table 4.3 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

4.2.6 Android Application

We developed an Android application for data collection, an overview of which is illustrated in Fig. 4.3. This application runs in the background and collects activity data, which is sent to the endpoint as a JSON-format file.

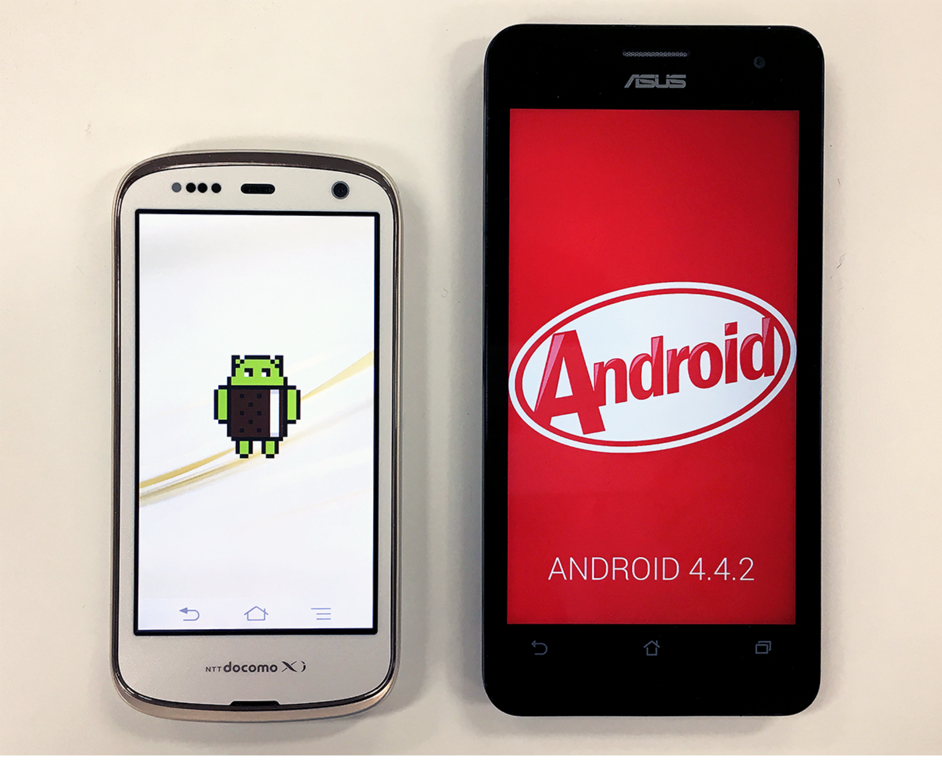

Fig. 4.2 Smartphones using the field experiment (left: first period, right: second and third period)

Table 4.4 Specification of the Android application

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

4.2.7 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

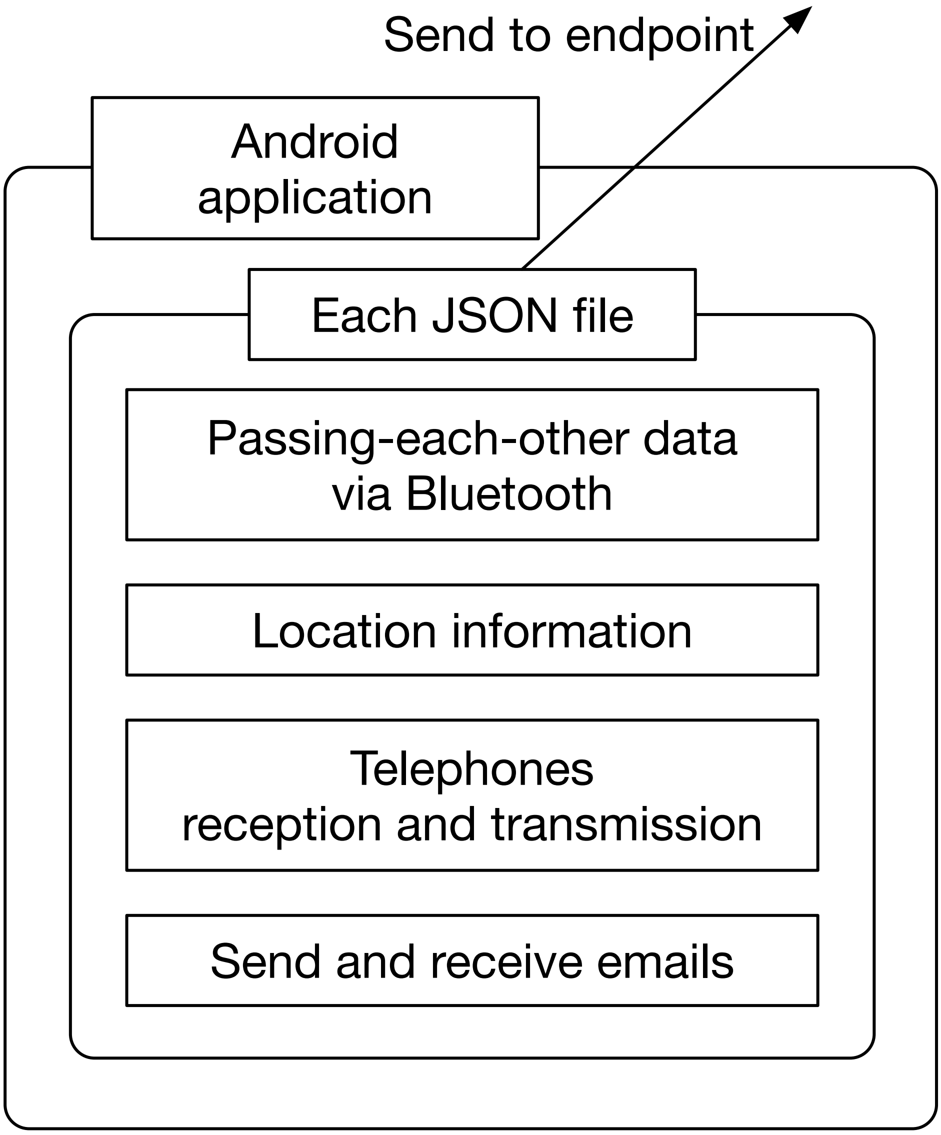

Fig. 4.3 Logic of the Android application

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. 4.4).

4.2.8 Visualization method using passing-each-other data

Passing-each-other data is tabulated as shown in Table 4.5. The "`unique passing-each-other data id`" refers to the unique ID of each instance of passing-each-other data; the "`unique`

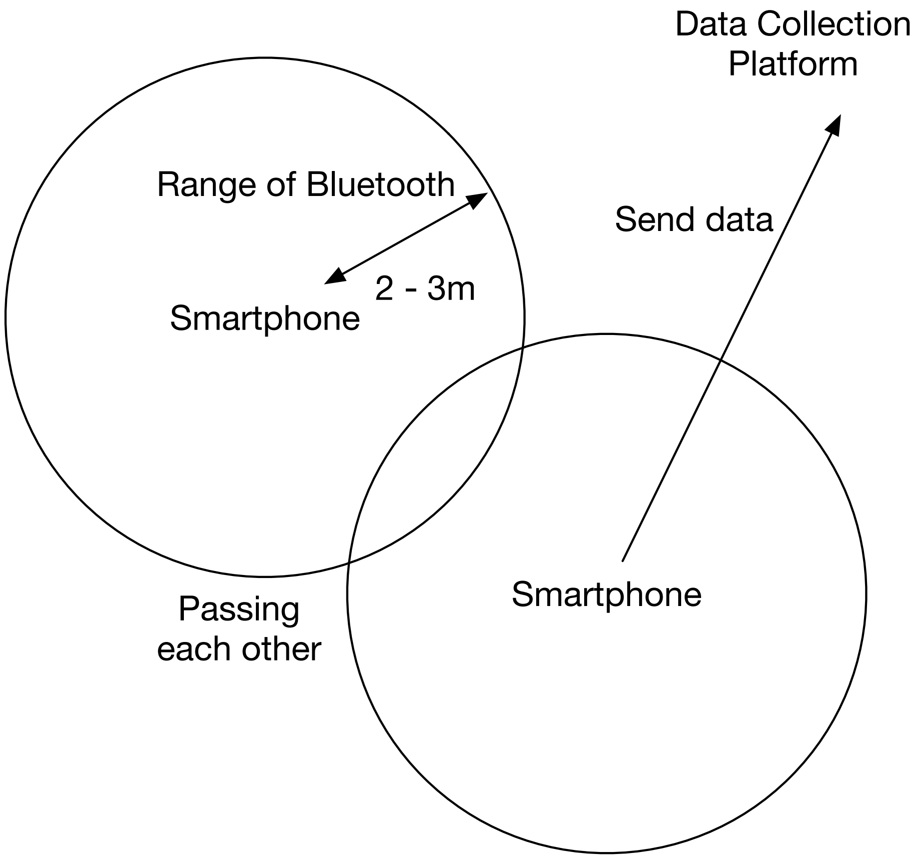

Fig. 4.4 Logic of the acquiring passing-each-other data

`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 4.5 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 4.6, 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 chapter, 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 chapter, we drew the passing-each-other data as a graph using Cytoscape[20]. We used the "edge-weighted spring embedded layout" algorithm, which is a graph layout that uses the Kamada-Kawai algorithm [21]. We applied the edge weight as the "weight" of Table 4.6.

Table 4.6 Type of summarized data (example)

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

4.3 Results and Discussions

4.3.1 Activity Data Collection Platform

The data used in this section is from the third period, which was the most recent and longest. Tables 4.7 and 4.8 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 4.7 The amount of collected data (passing-each-other)

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

Table 4.8 The amount of collected data (location information)

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

4.3.2 Passing-each-other Data Visualization

Figures 4.5 and 4.6 show graphs for passing-each-other data using Bluetooth, which were drawn using Cytoscape with the edge-weighted spring embedded layout algorithm.

Fig. 4.5 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. 4.6 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. 4.7 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 (Figures 4.8, 4.9, and 4.10). The amount of data describing the graphs are 9,564, 7,542, and 6,286 rows from the left respectively.

4.4 Conclusion

The purpose of this research is resident-centered community vitalization utilizing ICT, for which awareness by means of visualization is very important. In this chapter, 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

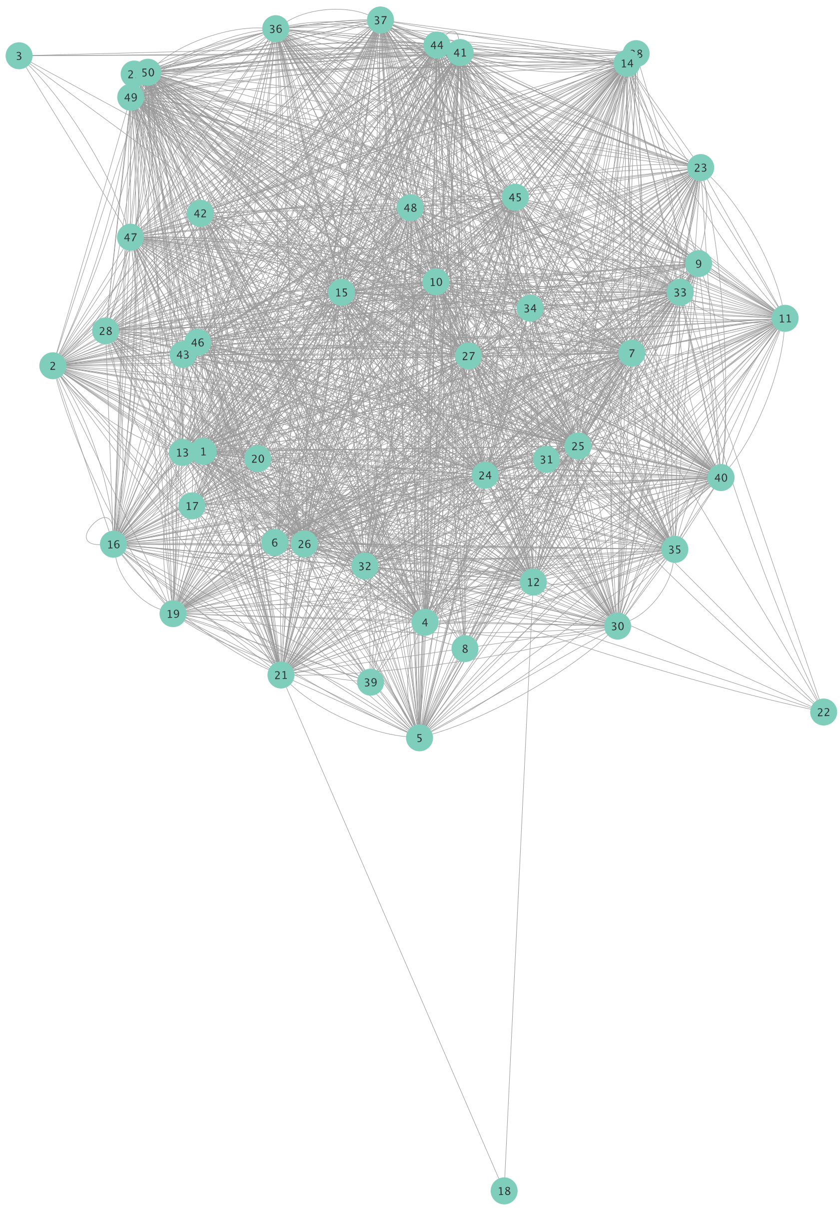

Fig. 4.5 Passing-each-other data between experimental participants

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.

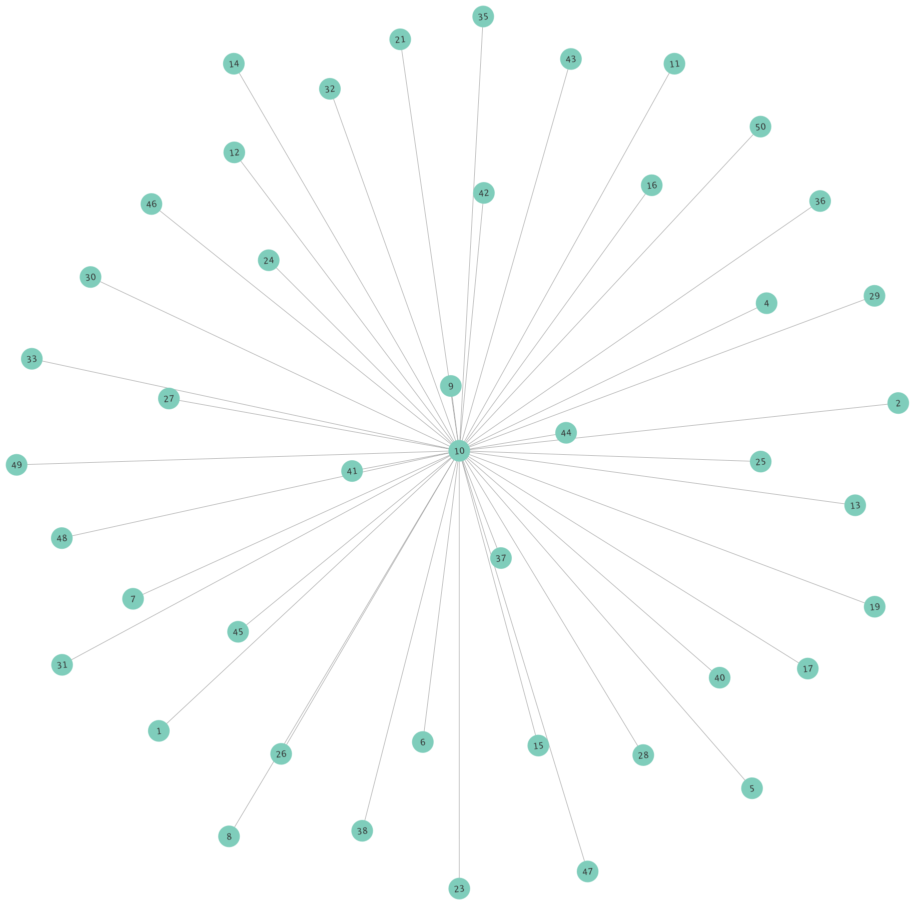

Fig. 4.6 Passing-each-other data from No. 10 to other experimental participants

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.

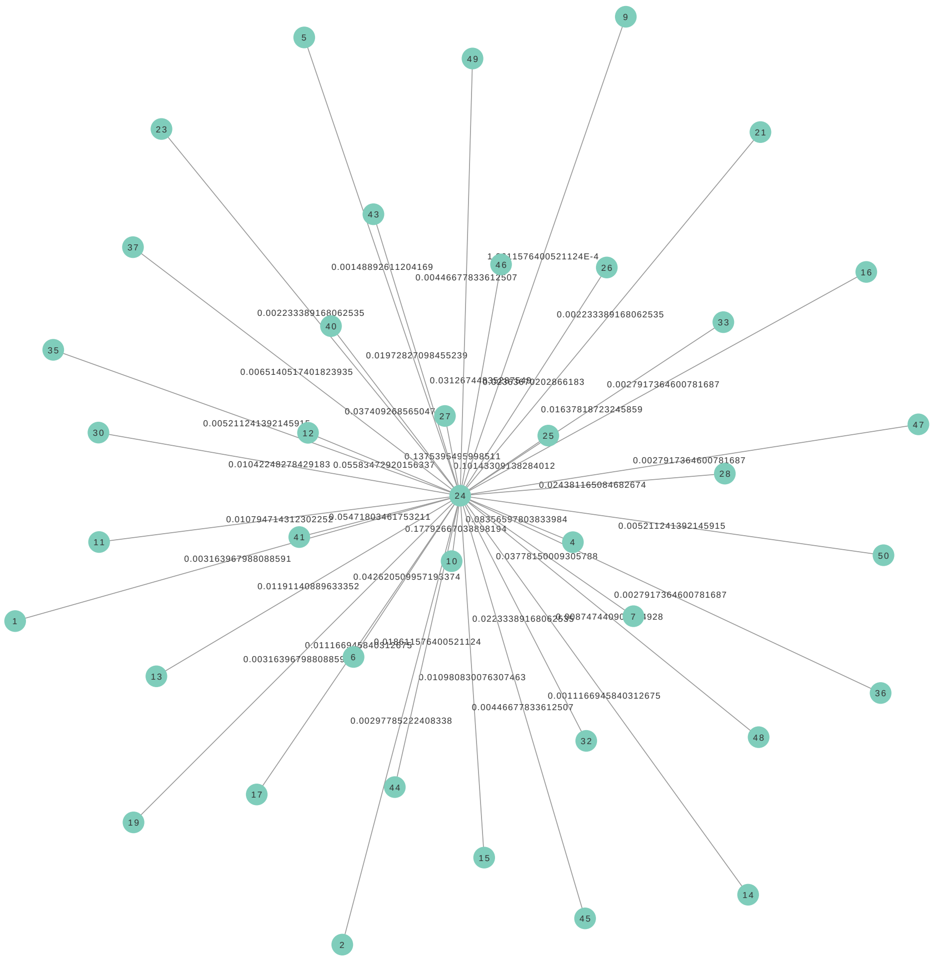

Fig. 4.7 Passing-each-other data from No. 24 to other participants. No. 24 was voted as the leader of the community

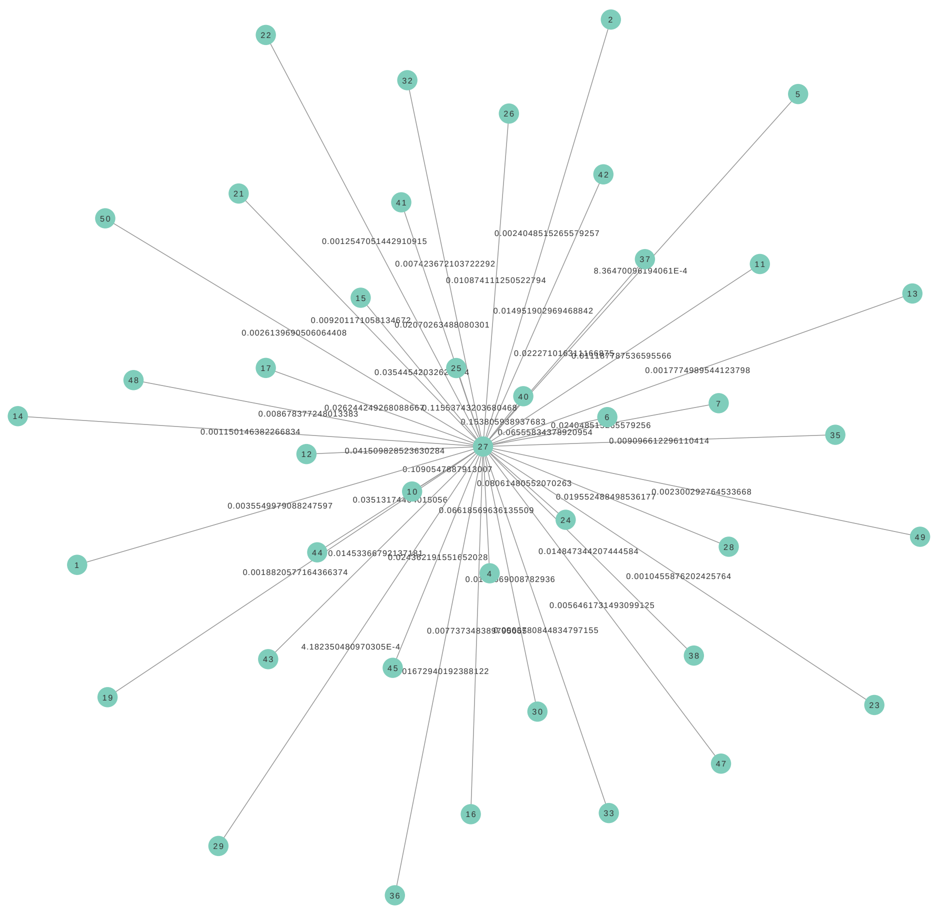

Fig. 4.8 Passing-each-other data from No. 27 to other experimental participants

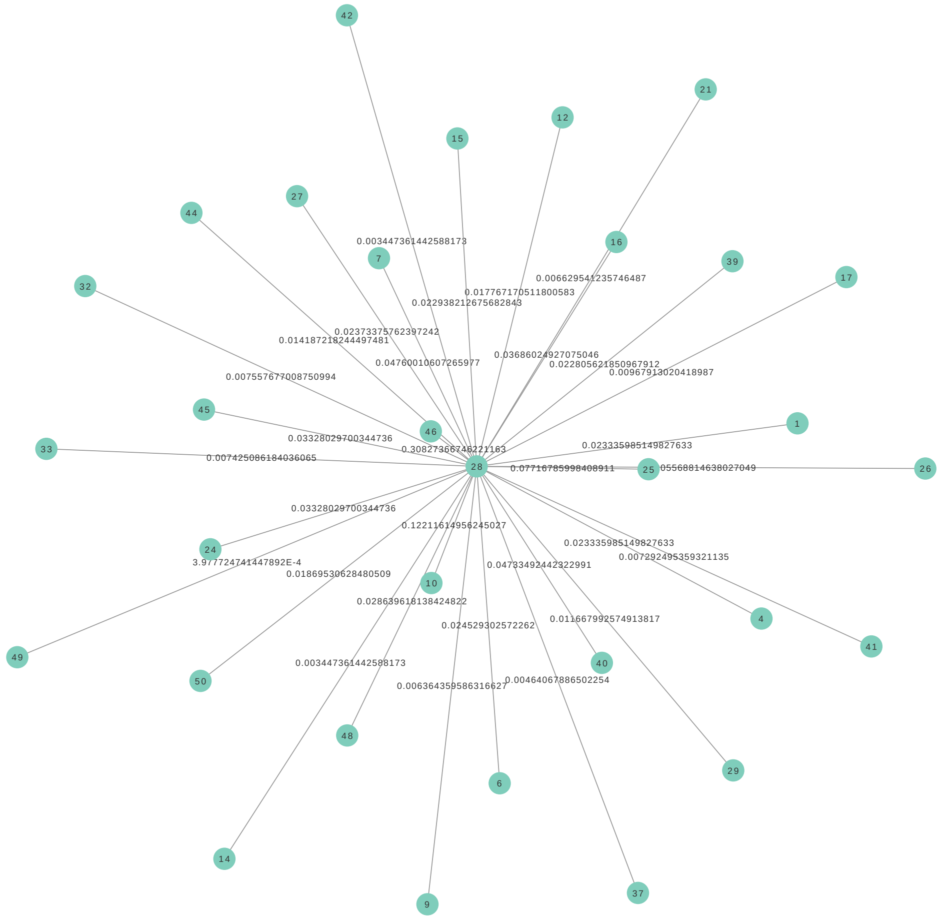

Fig. 4.9 Passing-each-other data from No. 28 to other experimental participants

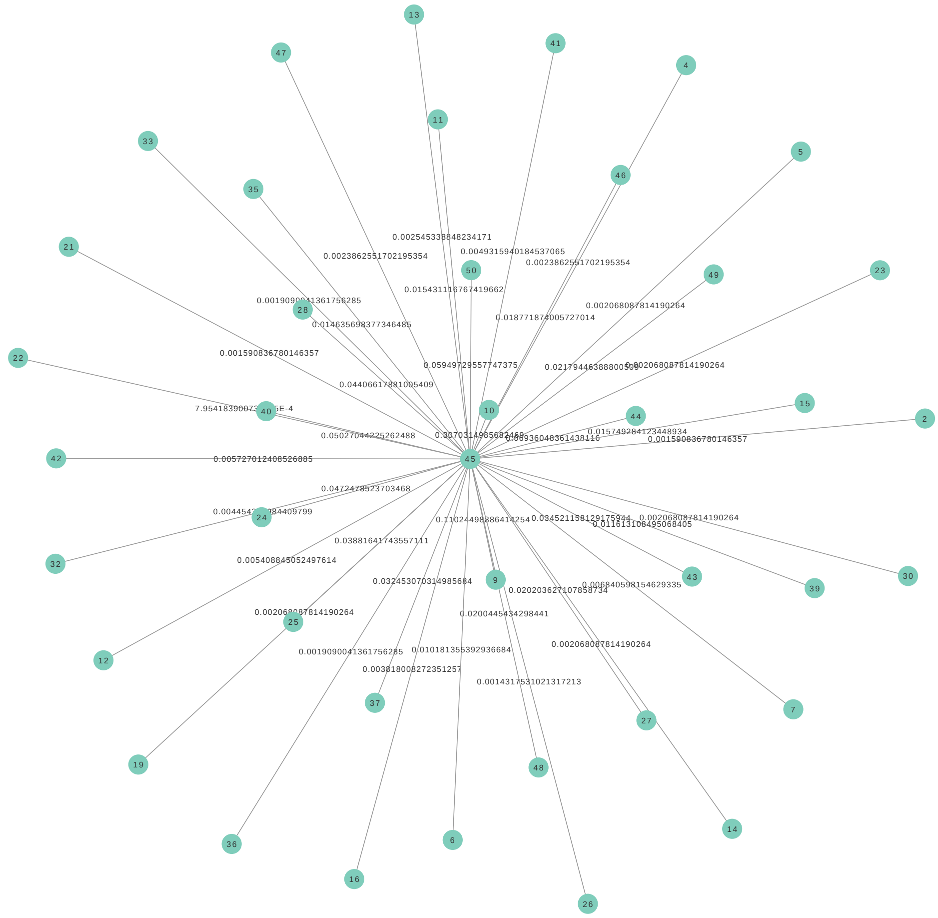

Fig. 4.10 Passing-each-other data from No. 45 to other experimental participants

Chapter 5

Method to Analyze a Community as a Complex Adaptive System

5.1 Introduction

A community is a system. In other words, a community is a typical example of a complex adaptive system, and it can be simulated using a suitable model such as a multi-agent systems approach. This implies that it is possible to develop a community as a complex adaptive system using appropriate design and analysis. In this study, we investigate the methods to analyze a community. We visualize the day-wise relationships among participants in the experiment using the passing-each-other data collected from them.

5.2 Experimental Method

5.2.1 Overview of Field Experiment

We acquired the activity data using the smartphones lent to the residents of the Makishima area in Uji City, Kyoto, Japan, in cooperation with the members of the Makishima Kizuna-no-Kai, a non-profit corporation; activity data means “location information,” “send and receive emails," "incoming/outgoing calls", and "passing-each-other data from Bluetooth." In this paper, we analyzed "passing-each-other data from Bluetooth" using a suitable system.

5.2.2 Inspection Method

We drew day-wise network diagrams (undirected graphs) interconnecting the experimental cooperators (nodes) based on their passing-each-other data via Bluetooth. We carried out comparative analysis of the network diagrams and investigated the observed differences. For drawing the network diagrams, we used a Python's network analysis library (NetworkX).

The steps used in the preparation of the graph are described here. First, we created an instance for graph generation using the graph method of NetworkX. Then, we constructed an array of combinations of people who were close to each other in the instance mentioned above. Using this array as the input and the Fruchterman-Reingold force-directed algorithm [22] as the output, we drew a dimensionless network graph whereby the nodes (cooperators) with high degree of centrality (interconnectivity) were found to be located at the center of the cluster.

5.3 Results and Discussions

Figures 5.1 and 5.2 show parts of the rendered network diagrams that indicate the clusters of connections among the experimental cooperators. Figures 5.3 and 5.4 help us understand the typical changes in the network diagrams on a weekday and a holiday. It is observed that the network clusters are large on a weekday, whereas they are small on a holiday.

By drawing the network diagrams, we could clearly observe the connections among the experimental cooperators. Considering that a community is a complex system, we could also confirm that the boundary is not defined uniquely. Furthermore, the connections are found to change dynamically over time.

However, these network diagrams may not be clearly expressive of some specific features seen in other complex systems; for example, it may not be possible to infer from the diagrams

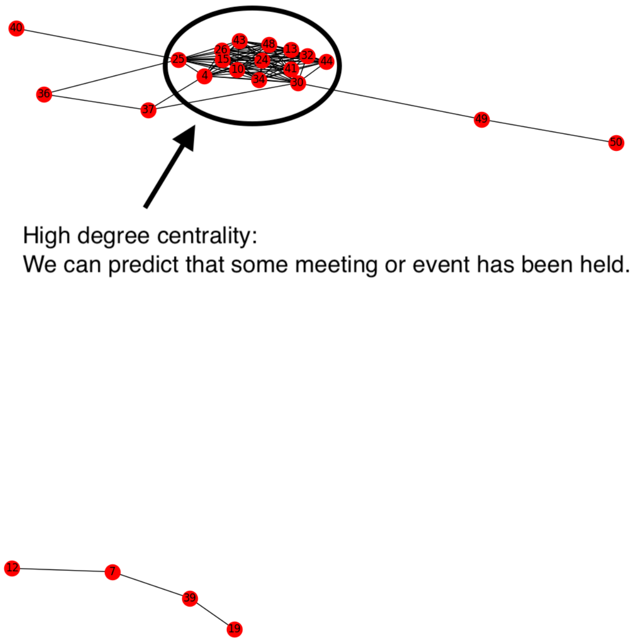

Fig. 5.1 Network diagram (one large network)

whether the community is an open system. Furthermore, it is difficult to interpret the "connection" for its correct meaning, although we can understand from the network diagrams that each experimental cooperator has connections. The larger the size of a network, the more the difficulty to interpret the meaning.

In order to overcome the above limitation related to interpretation, it is necessary to carry out a holistic analysis of the observed connections using the location information in addition to the passing-each-other data.

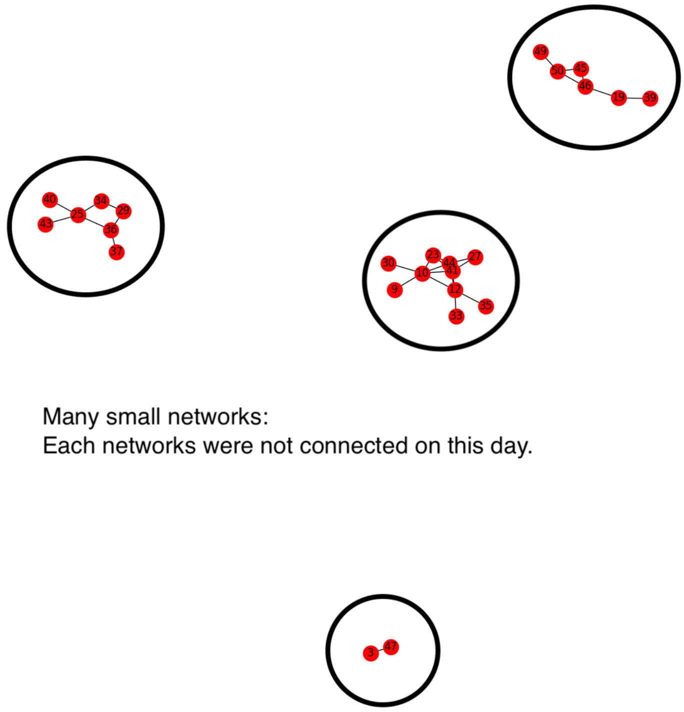

Fig. 5.2 Network diagram (many small network)

5.4 Conclusion

We collected the activity data from the smartphones used by the residents of the community to visualize the communications among them.

We investigated the methods to analyze a community considering that it is a complex adaptive system. We visualized the day-wise relationships among the experimental cooperators using the passing-each-other data collected from them. As a result, we confirmed that each experimental cooperator forms clusters that varies day-wise. We could also confirm several features that it can be said that a local community is a complex adaptive system. Furthermore, we found that the results are strikingly different for a weekday compared to a holiday.

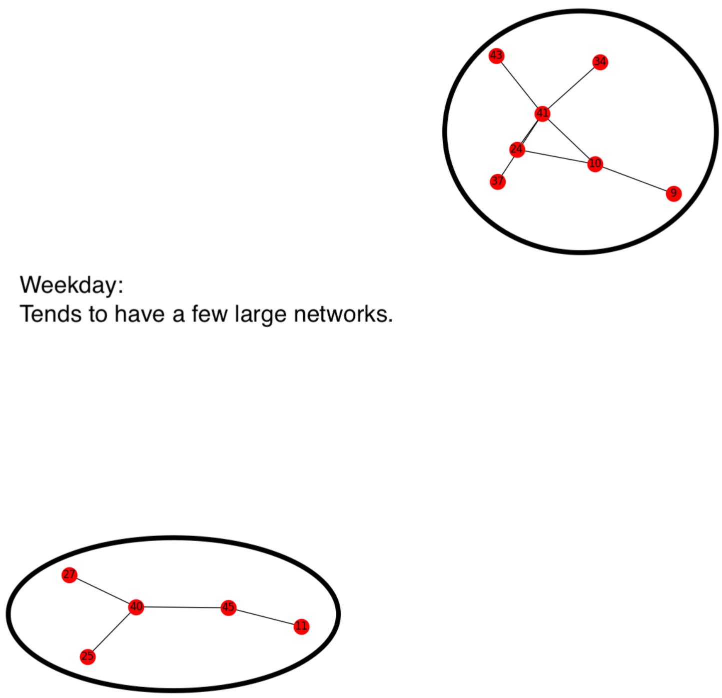

Fig. 5.3 Network diagram (weekday)

In future, we would like to apply a complex adaptive system approach using the location information in addition to the passing-each-other data for a holistic analysis of a community and by acquiring more data by increasing the number of experimental cooperators.

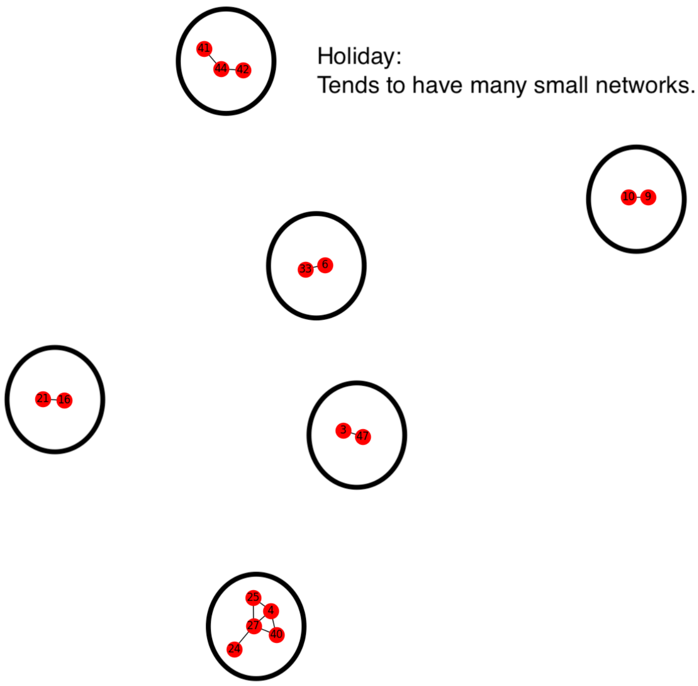

Fig. 5.4 Network diagram (holiday)

Chapter 6

A Visualization Method of Residents' Location for Media Spots Estimation

6.1 Introduction

Following the chapter, we investigate a method to visualize relationality assets more effectively. For that purpose, we introduce a new core concept of "media spots", not only as places where residents could communicate with each another more frequently than in other areas, but also as a prospective platform to mediate relationality between humans, "Mono" and "Koto". That is, "media spots" should have the potential to proactively promote resident-motivated communications and activities in a community. That is, "media spots" must have the potential to promote proactively the resident-motivated communications and activities in local communities. The resident-centered vitalization of a community will not be realized until residents themselves find regional challenges and/or issues and tackle them spontaneously.

To visualize media spots as places for creating and strengthening relationships, and to create an opportunity to regain relationship within the community, this study explored a method of estimating media spots, which are the places where there were greater possibilities of residents communicating with each other, using residents' location information, which was obtained through smartphones. However, enormous amounts of raw data are unsuitable for visualization because useful information is buried in them. In addition, data obtained through smartphones are often less accurate. Thus, when handling an enormous amount of location information, it is indispensable to be able to slice the data efficiently.

6.2 Experiment Method

6.2.1 Overview of Field Experiment

The residents' activity data were acquired using the platform. This study referred to "activity data" as "location information," "sent and received emails," "telephone reception and transmission," and "data passed among each other via Bluetooth." In this work, "location information" was analyzed to improve the media spot estimation method. This field experiment was conducted in the Makishima area in Uji City, Kyoto, Japan.

The experimental cooperators were instructed to use the lent smartphones at all times for the duration of the experiment. The location information was acquired every minute, except in the following situations:

- From the perspective of informed consent, the experimental cooperators were instructed to switch off the smartphone when they did not want to inform others of their location information.
- The smartphone has run out of battery, or the experiment cooperator forgets to carry the smartphone.
- The smartphone cannot transmit location information as it is out of range.
- The timing when Android finishes to acquire location information is not determined exactly.

6.2.2 Experimental Installation

Smartphones used in the first period (the right side of Fig. 6.1) were discredited mostly owing to their sluggish actions and small screens. Accordingly, stylus pens were lent to the experimental cooperators for the improvement of usability; these pens partly resolved such discredit.

Following the suggestion of the first period, smartphones used in the second and third periods (the left side of Fig. 6.1) were chosen for their quick actions and big screens. Certain experimental cooperators had their smartphones because of the spread of smartphones compared with the first period. The discredit was also significantly resolved by these external factors.

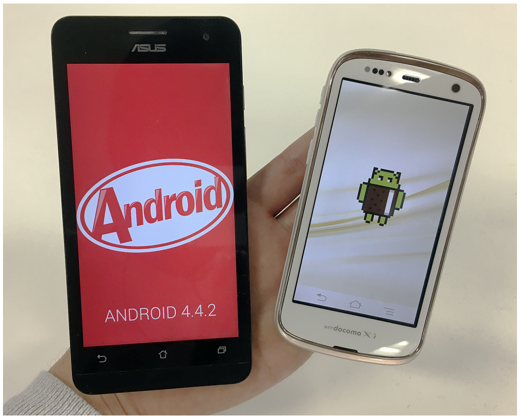

Fig. 6.1 Smartphones

6.2.3 Method of Data Cleansing

For data cleansing, DBSCAN[23], which is a density-based clustering algorithm, was used. Location information gathered by Android smartphones has meter accuracy. The accuracy is defined as the 68% confidence interval, or true with a probability of 68% in the circle with accuracy as the radius, according to Android specification. In other words, location information gathered by smartphones cannot have pinpoint accuracy, and can be noisy.

DBSCAN is robust with noise, and matches excellently for processing location information. Data cleansing with DBSCAN was executed using the following steps:

1. Cluster location information into each experimental cooperator daily.
2. Extract the location information with the highest accuracy as a representative point.
3. Execute clustering of location information for all representative points on each experimental cooperator for the whole period, and extract the location information with the highest accuracy as a representative point.

After conducting these steps, the above data were aggregated to estimate media spots.

6.2.4 Inspection Method for Media Spots Estimation

Kernel density estimation (KDE), a nonparametric technique, was employed to estimate probability density function. It was not necessary to set a boundary. The estimated kernel probability density function was expressed as follows:

$$\widehat{f_h}(x) = \frac{1}{Nh} \sum_{i=1}^{N} K\left(\frac{x - x_i}{h}\right). \tag{6.1}$$

The function $\widehat{f_h}(x)$ is a kernel probability density function, x_i is a sample, N is the size of samples, $K(x)$ is a kernel function, and h is a bandwidth. We used the Gaussian kernel (6.2) for a kernel function:

$$K(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}. \tag{6.2}$$

In addition, we applied Scott's Rule expressed in (6.3) to the bandwidth:

$$h = \frac{1.06\sigma}{n^{0.2}} \tag{6.3}$$

$$\sigma = \min\left\{SD, \frac{q(0.75) - q(0.25)}{1.34}\right\}, \tag{6.4}$$

where n is the number of dimensions, SD is standard deviation, and $q(0.75) - q(0.25)$ is the interquartile range acquired by subtracting the first quartile from the third quartile.

6.2.5 Estimation Method of Media Spot

The 2D location information (the point showing a position) consisted of latitude and longitude that recorded a person's action at a specific time. The point that showed many positions at the spot where the person stayed would be plotted, and then density would become higher. The part that is high in density appears as the maximum value. Subsequently, the probability density function of this location information was measured using KDE, and then the place where each person was usually found was estimated by counting the number of maximum value locations. The inspection of the hypothesis followed. A media spot was defined as the place where communication was active in an area. "Active communication" referred to the place where many residents gathered in an area. In this work, media spots were estimated using KDE from the data cleansed by DBSCAN.

Numpy, scipy, and scikit-learn, which are libraries for high-level scientific calculations of Python, were used for the inspection.

6.3 Results and Discussions

This section describes the results of the analysis on the proposed method, using the data of the third period.

6.3.1 DBSCAN

Fig. 6.2 shows the scatter diagram of raw location information of one of the experimental cooperators. Fig. 6.3 shows the scatter diagram of a sliced location information of the same one using DBSCAN. Fig. 6.4 shows the scatter diagram of raw location information of all experimental cooperators. Fig. 6.5 shows the scatter diagram of a sliced location information of all experimental cooperators using DBSCAN.

As a result of aggregating the representative points of each cooperator, 101 location information could be acquired. The location information was then converted into real addresses by reverse-geocoding with Google Maps Geocoding apprication programming interface (API). Table 6.1 shows a result of checking whether the location information and address match. "Undeterminable" means that there were multiple meeting places of, among others, towns and commercial facilities around the location information. "Exclusion" means that there must be a residential quarter around the location information. This result shows that location information could be compressed while ensuring measurable accuracy, by extracting the representative points by DBSCAN.

This result shows whether the representative points of the location information derived by DBSCAN point to public facilities or commercial facilities on the map. Considering the accuracy of each location information, this result shows we could derive the representative points more accurately by the proposed method.

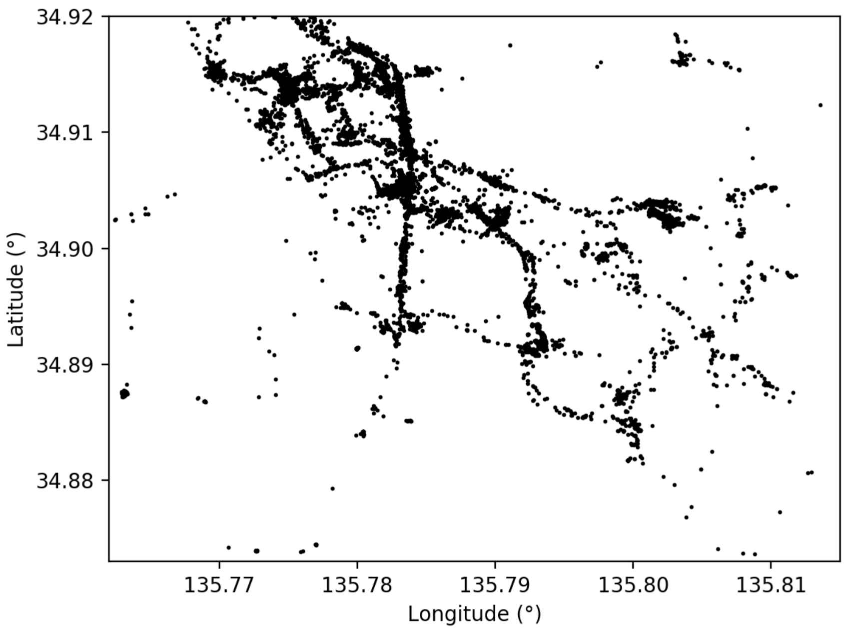

Fig. 6.2 Scatter diagram of raw location information data (one of experimental cooperators) (2015-07-11 - 2016-01-11)

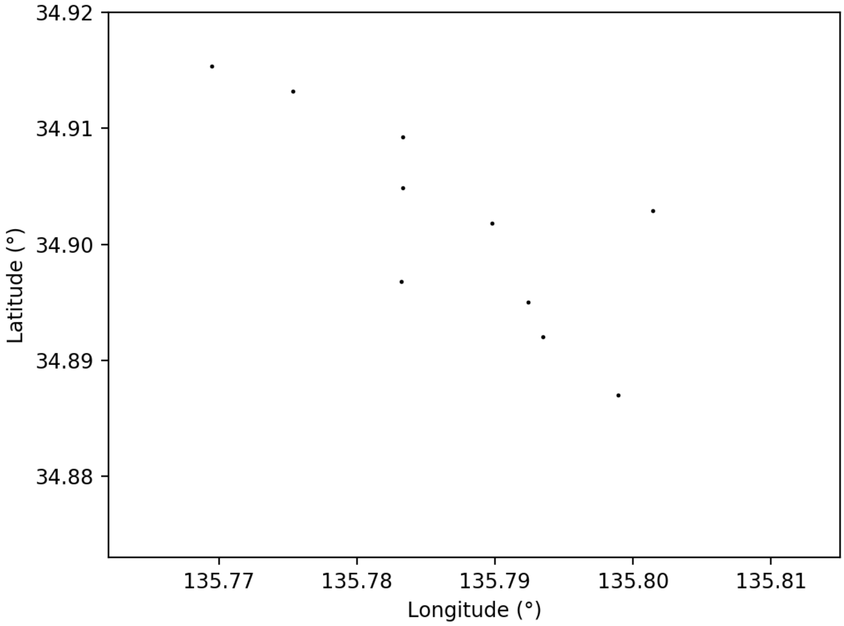

Fig. 6.3 Scatter diagram of location information data after DBSCAN (one of experimental cooperators) (2015-07-11 - 2016-01-11)

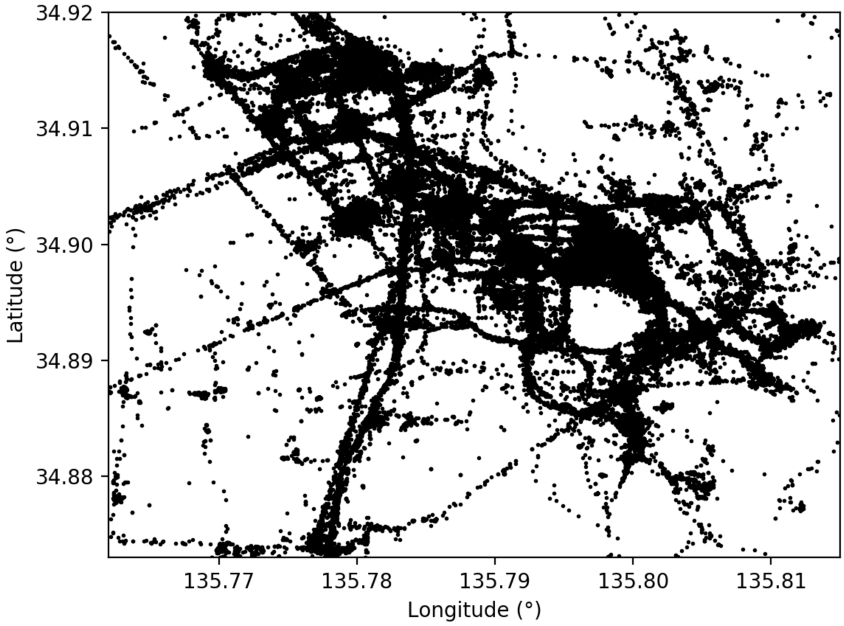

Fig. 6.4 Scatter diagram of raw location information data (all experimental cooperators) (2015-07-11 - 2016-01-11)

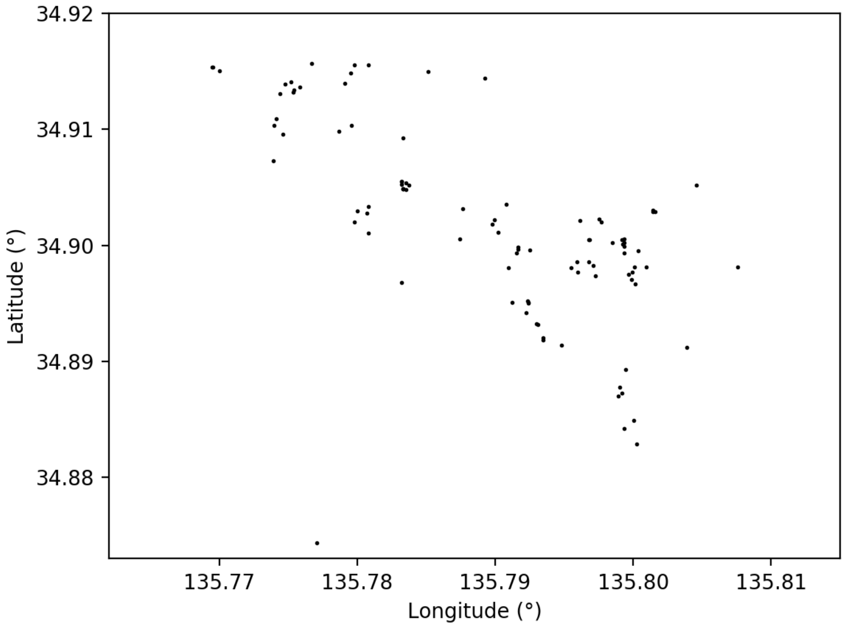

Fig. 6.5 Scatter diagram of location information data after DBSCAN (all experimental cooperators) (2015-07-11 - 2016-01-11)

Table 6.1 Results of checking whether the location information and the address match (101 samples)

Accord	13
Not accord	32
Undeterminable	26
Exclusion	30

6.3.2 Media Spots Estimation

Figures 6.6 and 6.7 show the results of applying KDE to location information (period: 2015-08-01 to 2015-08-31) using the previous method[24]. Fig. 6.6 shows 2D figures. The vertical and horizontal axes represent latitude and longitude, respectively. The dark part is the place of the point's high density. Meanwhile, Fig. 6.7 shows 3D figures. Figures 6.8 and 6.9 show the results of applying KDE to a sliced location information (period: 2015-08-01 to 2015-08-31) by DBSCAN. The left and right axes represent latitude and longitude, respectively. The upper axis represents density. The dark part means the place of the point's high density.

The media spots estimation method, together with the previous method [24], entailed the following steps:

- Find the local maxima of places where location information is in high density using KDE from each person's location information.
- The local maxima show places where a person was usually found, as they show the density of location information.
- Delete location information around the global maxima, which are expected to be main activity places, such as the home and workplace.
- Collect the dataset with deleted information on the home and workplace.
- Apply KDE to the collected dataset and then find the local maxima as media spots.

Location information was acquired at regular intervals. Therefore, the density of the location information became high in fixed and long-staying places (main activity places) such as their home or workplace. When we estimated the media spot using raw data, places where there was a high possibility that communication was active, with the exception of their home and workplace, were evaluated as relatively worthless. To prevent such phenomena, we deleted location information around the global maxima, which were expected to be main activity places such as their home and workplace.

As a result of the comparison with the previous method, it appears that the proposed method for media spots estimation was more accurate than the previous one because the deviation of the data was reduced. The previous method had a problem that the local maxima were significantly influenced by the data volume of each person, since places where a person who acquired large amounts of location information stayed long were visualized as high density.

As a result of interviews presenting these results to the organizer of the experimental cooperators, we found that the area where the experimental cooperators lived and had meetings in the community had high density.

Figures 6.10 and 6.11 show the results of applying KDE to a sliced location information (period: 2015-07-11 to 2016-01-11) by DBSCAN. As a result of the comparison of it with the result of the whole period, we found that the figure was almost the same as the figure described by the whole period. We also found that there was hardly any change in the place where people usually stayed in the whole period and during a certain period.

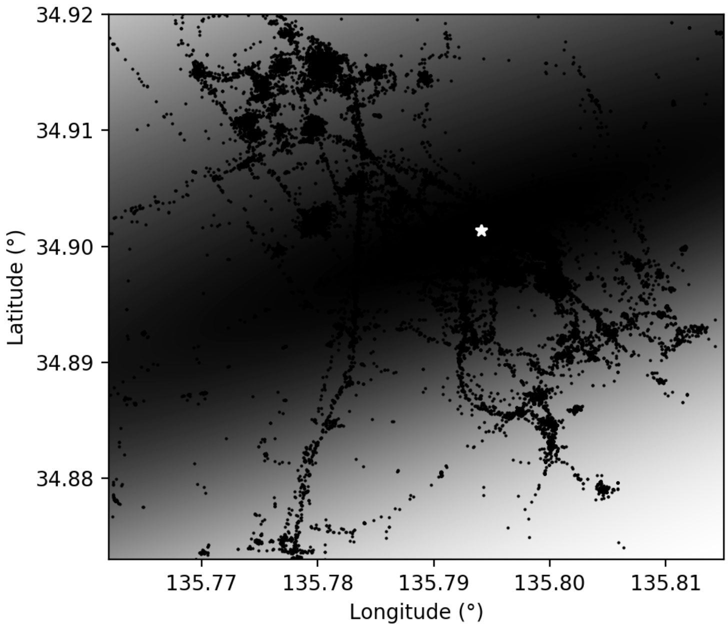

Fig. 6.6 Result of media spots estimation using previous method (2D) (2015-08-01 - 2015-08-31)

6.4 Conclusion

In attempt to achieve the resident-centered community design by utilizing ICT, "media spots" were defined as not only the places where communication occurred more frequently among residents as compared to other areas but also prospective platforms to mediate relationality among people, "Mono" (i.e., tangible and physically perceived things), and "Koto" (i.e. intangible and cognitively conceived things).

To visualize media spots as places for creating and strengthening relationships, and to create an opportunity to regain relationships within the community, a visualization method of residents' location information was proposed to estimate media spots, using DBSCAN as among the clustering algorithms.

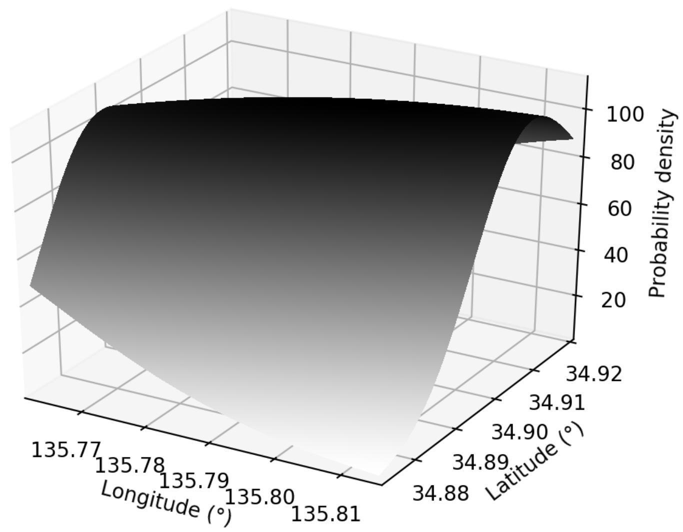

Fig. 6.7 Result of media spots estimation using previous method (3D) (2015-08-01 - 2015-08-31)

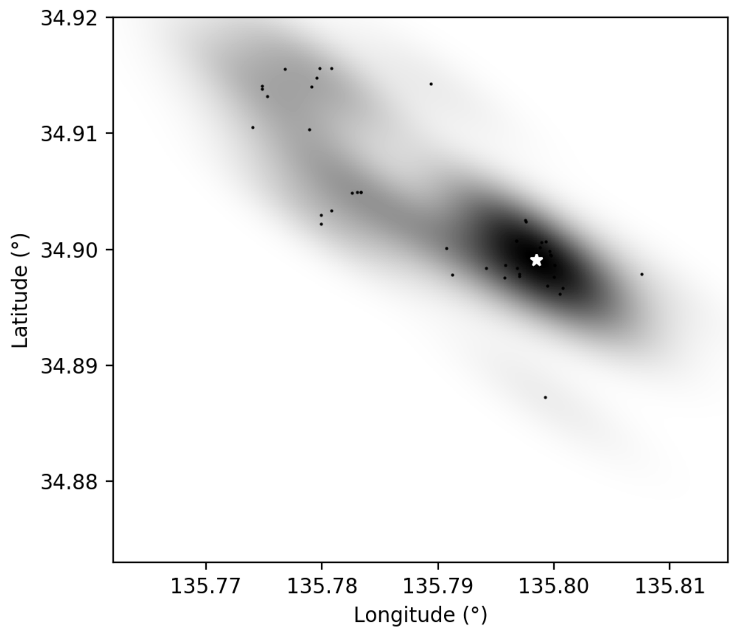

Fig. 6.8 Result of media spots estimation using clustered data by DBSCAN (2D) (2015-08-01 - 2015-08-31)

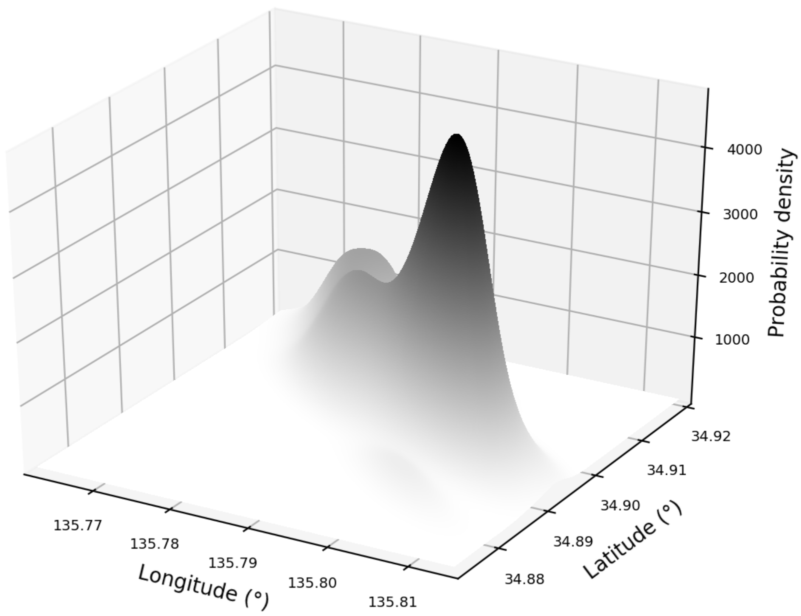

Fig. 6.9 Result of media spots estimation using clustered data by DBSCAN (3D) (2015-08-01 - 2015-08-31)

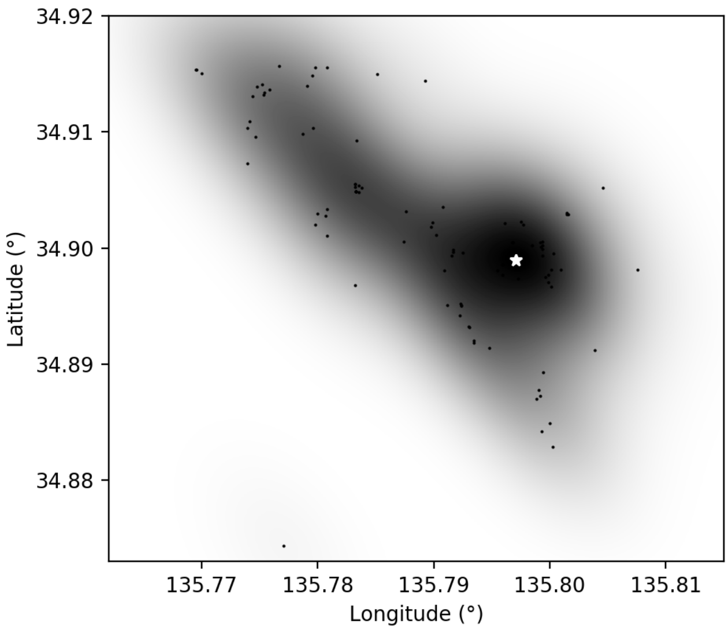

Fig. 6.10 Result of media spots estimation using clustered data by DBSCAN (2D) (2015-07-11 - 2016-01-11)

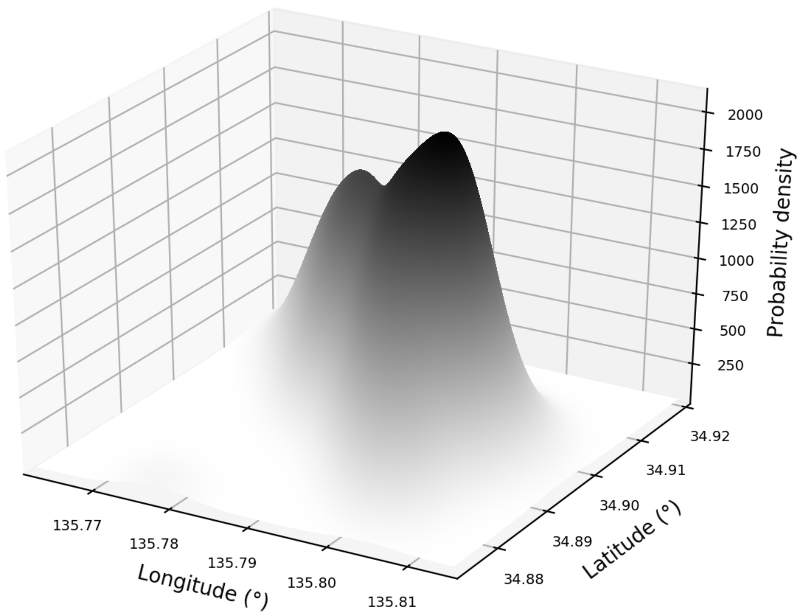

Fig. 6.11 Result of media spots estimation using clustered data by DBSCAN (3D) (2015-07-11 - 2016-01-11)

The present results suggested that representative points extracted by using DBSCAN could visualize activities in a community more effectively, and estimate media spots more accurately, than the previously used method.

Further studies are needed to improve the accuracy of representative points and evaluate the validity of media spots. Moreover, we will work on how to develop the potential of media spots to promote proactively the resident-motivated communications and activities in a community.

Chapter 7

Platform for Promoting Behavior Change of Residents

7.1 Introduction

Prior research mainly focused on collecting and analyzing data sent unconsciously by the residents themselves, including location information and passing-each-other data. However, in the process of analysis, we initially observed that a behavioral change of sharing the information voluntarily promotes a resident-centered community vitalization, rather than solving individual residents' community challenges by analyzing data. Shared information is also the source of relationality assets because it makes relationships strong. Therefore, we discuss a platform for promoting the transition of behavior of residents towards resident-centered community vitalization by sharing and visualizing the information that they voluntarily send.

7.1.1 Behavior Change

Behavior change has been studied as to how to intervene in behavior for health especially in the field of medical science. One of the accomplishments of these studies is the Behavior Change Technique Taxonomy Project [25]. In this project, behavior change technique is classified into 16 fields 93 techniques. In our research, we would like to establish a methodology to promote behavior change not only for health but also for community challenges such as crime prevention and disaster evacuation.

7.2 Overview of the Platform for Promoting Behavior Change

This platform was composed of a front-end part made of Android application and a back-end part consisting of API and database.

Fig. 7.1 shows the main screen of the Android application. Users can post photos about issues which a place where one lives, and share it to all users. Users can take reaction for shared photos (Fig. 7.2).

Fig. 7.3 shows the architecture of the platform. We use Amazon Web Services (AWS), one of public cloud providers, and optimize the platform for cloud computing.

7.3 Results and Discussions

Table 7.1 shows the field experiment period and the number of posts.

Table 7.1 Attributes and period of the field experiment

Period	June 12, 2018 - August 31, 2018
Posts	89

Fig. 7.4 shows the map pinned a posted image using location information. Residents post information near arterial roads, this result indicates that they are interested in risks of traffic. In addition, we confirmed that a lot of attention to intersection has been posted.

Next, Fig. 7.5 shows the window included in a posted image and reactions. This post has three reactions, and it suggests that residents other than the contributor feel in danger at the place.

Fig. 7.1 The main window

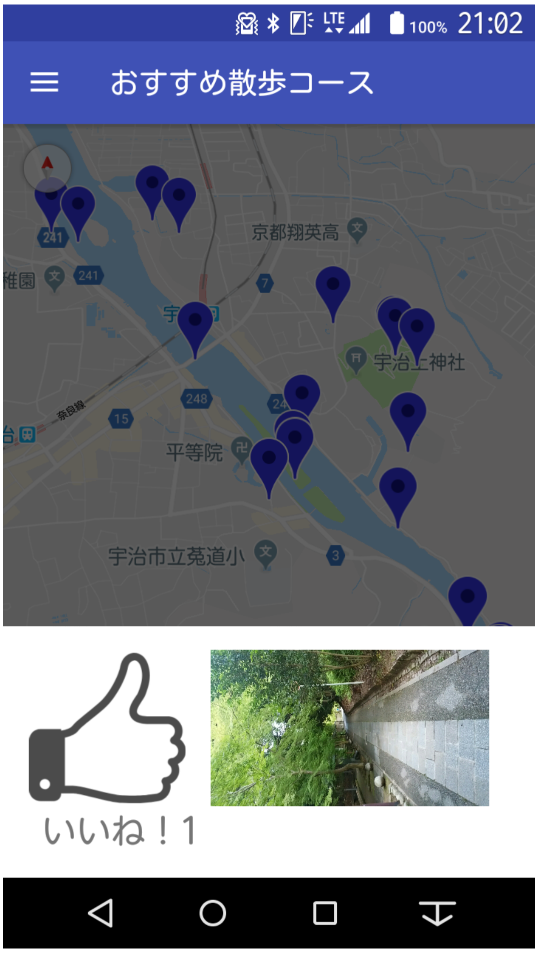

Fig. 7.2 The post window

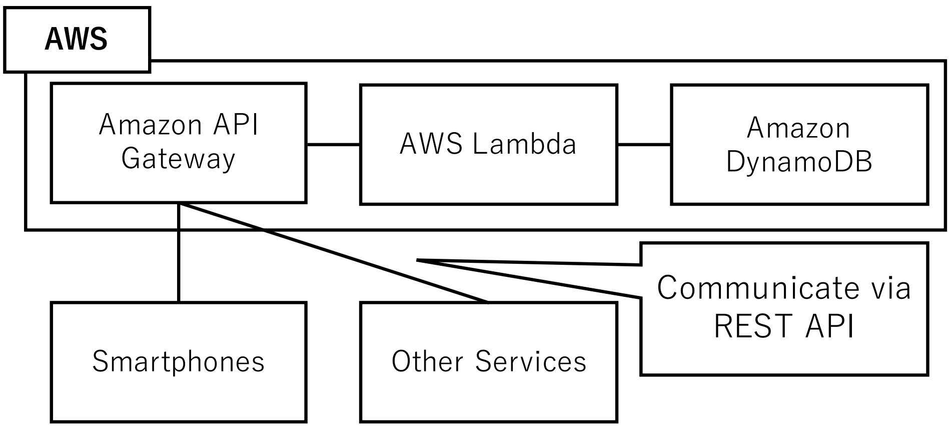

Fig. 7.3 The architecture of the platform

Fig. 7.4 The map pinned a posted image

Fig. 7.5 The architecture of the platform

From these results, we found that residents shared not only information, but also intention to sympathize through this platform.

7.4 Conclusion

The present research aims to realize a resident-centered community vitalization by utilizing the information and communication technology (ICT). Prior research has mainly focused on collecting and analyzing data that is unconsciously sent by themselves, such as location information and passing-each-other data. However, in the process of analysis, we preliminarily observed that behavior change by sharing information that they voluntarily send promote a resident-centered community vitalization rather than solving community challenges the residents selves by analyzing data.

Therefore, in this paper, we discussed the platform for promoting behavior change of residents toward resident-centered community vitalization, by sharing and visualizing information that they voluntarily send. We confirmed that residents shared data regarding dangerous places voluntarily.

Chapter 8

Conclusion

A community is a system that cannot exist without the self-motivated involvement of community members, and it is composed of humans, “Mono,” and their relationality “Koto”, which are naturally formed by community members during the course of their daily lives. Relationality among humans, “Mono” and “Koto”, that are formed between members in a community on a daily basis should be regarded as an asset in the sense that relationality can be considered as social and economic value expected to provide some benefit to the community in the future. The focus of this dissertation was to postulate relationality as an asset that community members earn individually, and to elicit their awareness of relationality as trust.

For rebuilding communities, in this research, we aim to quantify and visualize the relationality between humans, “Mono” and “Koto”, in a community as relationality assets, develop an awareness of the significance and meaning of relationality in a community, and provide an incentive to members of a community to develop relationality, so that they themselves can manage and sustain the mechanism.

We focused on, in chapter 3, the following issues: whether or not the introduction of relatiaolity assets in a community influence the increase of acquaintance, the total amount of relationality assets, and some change in their behavior. For modeling, we built simulation models using system dynamics (SD) and a multi-agent system to investigate how the proposed mechanisms work and influence the behaviors of the community as a system. These models were then refined by proof-of-concept in the field.

In chapter 4, we built an activity data collection platform for visualization, as a mechanism to promote awareness. 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.

In chapter 5, we investigated the methods to analyze a community considering that it is a complex adaptive system. We visualized the day-wise relationships among the experimental cooperators using the passing-each-other data collected from them. As a result, we confirmed that each experimental cooperator forms clusters that varies day-wise. We could also confirm several features that it can be said that a local community is a complex adaptive system. Furthermore, we found that the results are strikingly different for a weekday compared to a holiday.

In chapter 6, "media spots" were defined as not only the places where communication occurred more frequently among residents as compared to other areas but also prospective platforms to mediate relationality among humans, "Mono", and "Koto". The present results suggested that representative points extracted by using DBSCAN can visualize activities in a community more effectively, and estimate media spots more accurately, than the previously used method.

In chapter 7, based on the prior research, we discussed a platform for promoting the transition of behavior of residents towards resident-centered community vitalization by sharing and visualizing the information that they voluntarily send. We confirmed that residents shared data regarding dangerous places voluntarily.

Further studies are needed in order to refine the simulation model of relationality assets and conduct field studies as proof-of-concept.

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3. Koya Kimura, Yurika Shiozu, Kosuke Ogita, Ivan Tanev, Katsunori Shimohara, "A Visualization Method of Residents' Location for Media Spots Estimation," *SICE Journal of Control, Measurement, and System Integration*, vol. 11, no. 2, pp. 122-127, 2018/3/24.

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