An Evaluation of Method for Encouraging Participation

Hitoshi Kawasaki
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
kawasaki.hitoshi@lab.ntt.co.jp

Hiroshi Sato
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
sato.hiroshi@lab.ntt.co.jp

Atsushi Yamamoto
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
yamamoto.atsushi@lab.ntt.co.jp

Motonori Nakamura
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
nakamura.motonori@lab.ntt.co.jp

Hisashi Kurasawa
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
kurasawa.hisashi@lab.ntt.co.jp

Ryuma Kakinuma
NTT Corporation.
3-9-11 Midori-cho, Musashino -shi, Tokyo 180-8585, Japan
kakinuma.ryuma@lab.ntt.co.jp

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Abstract
Much attention is being focused on participatory sensing, in which real-world data are collected using personal mobile devices as sensor nodes to sense various conditions of the world we live in. In participatory sensing, there is a problem in that the supply of data is insufficient if users are not motivated to participate in sensing services. We previously proposed *Top of Worlds*, a method for encouraging user participation by presenting rankings in multidimensional hierarchical sets. In this paper, we describe the development of a ranking system and a real-world evaluation to confirm that Top of Worlds can encourage user participation.

Author Keywords
Participatory sensing; Intrinsic motivation; Ranking

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design; Experimentation; Human Factors

Introduction

Worldwide smartphone use is currently estimated to be 12% and is predicted to increase to 50% in five years [9]. These mobile devices are usually equipped with several sensors that capture visual, acoustic, tactile, location, acceleration, and other data. This makes them suitable devices for participatory sensing, which has been attracting global attention [1, 2, 4, 8, 10]. Participatory sensing, also called human/people-centric sensing, is an approach for collecting and analyzing data in which individuals, acting alone or in groups, use their personal mobile devices and cloud services to sense and share various conditions of their surroundings.

In participatory sensing, sensor nodes are under the control of observers and not under the control of data collectors; observers move and sense independently. Therefore, the problem is that the supply of data is insufficient if observers are not motivated to participate in sensing services. We assumed most observers are users of sensing services that use sensed data. We previously proposed Top of Worlds [6], a method for encouraging user participation by presenting rankings in multidimensional hierarchical sets. Top of Worlds is focused on improving intrinsic motivation [3], which is more effective for continued participation than extrinsic motivation. In our previous study [6], we conducted an online questionnaire which presented examples of ranking in a hypothetical situation. We verified the possibility that Top of Worlds can improve motivation in continuously using a service.

In this paper, we describe the development of a ranking system and a real-world evaluation of this system. In the evaluation, we presented users' actual rankings to users by using the system and confirmed that Top of Worlds can in fact encourage user participation.

The rest of the paper is organized as follows. Section 2 describes our method for encouraging users' participation, Top of Worlds, and Section 3 describes the development of a ranking system. Section 4 describes a real-world evaluation, and Section 5 concludes the paper with a brief summary of key points.

Rankings in multidimensional hierarchical sets

Top of Worlds [6] is a method for encouraging user participation by presenting rankings in multidimensional hierarchical sets. Previous methods [5, 7] only rank each user among all other users, so most users have little chance of being ranked in the top group and may have little motivation to participate. Top of Worlds creates many sets with varying granularity to increase the chance of many users being ranked in the top group and presents these rankings in those sets. We define the top group as users ranked in the top k% in term of Values used to Compare Rankings (VCR). Examples of VCR are the amount of sensor data, a score calculated from a certain period of sensor data (e.g., the number of steps walked, which is calculated using an acceleration sensor and movement distance calculated using GPS), and an increase in such score. We define hierarchical sets based on address attributes (worldwide, nationwide, or statewide (citywide)), age attributes (all ages, a certain age range, e.g., 20s and 30s, or a specific age), and affiliation attributes (company-wide, department-wide, or section-wide), as shown in Figure 1. We define a multidimensional

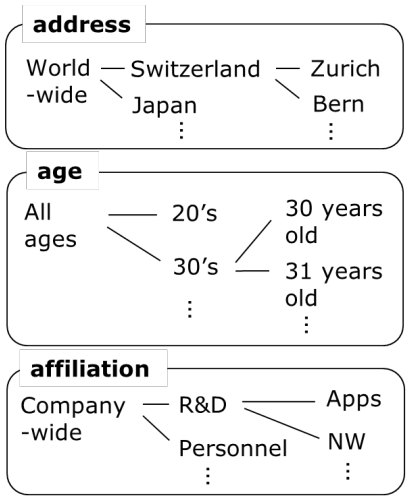

Figure 1. Hierarchical sets

hierarchical set as a common subset of each hierarchical set. Top of Worlds does not create a too small set that contains less than n users. It helps to prevent a situation that a user is 1st out of one.

If a user ranks in the top group in multiple sets, the following steps are involved in Top of Worlds: 1 a set in which the user ranks in the highest percentage is selected; 2 information on the set and ranking is sent to the user (we skip step 1 if the user ranks in the top group in only one set).

An example of Top of Worlds is shown in Figure 2. We assume the user lives in Zurich and is 31 years old. If the user is given information such as "You are 80,000th in Switzerland among all ages out of 100,000 people", the user may not be encouraged to participate.

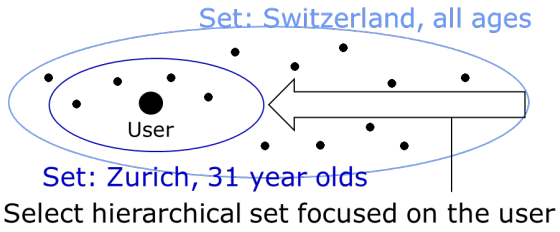

Figure 2. Example of Top of Worlds

Therefore, Top of Worlds selects a hierarchical set focused on the user and presents information such as "You are ranked 1st in Zurich among ten 31-year-olds" to the user. As a result, the user will be encouraged to continue participating. Thus, Top of Worlds effectively encourages many users to participate.

Ranking system

We describe our ranking system implemented as an example application of Top of Worlds. Figure 3 shows our system configuration. The system consists of a database (DB), module for selecting users ranked in top group (user selection module), and module for selecting a set (set selection module) whose information is sent to a user.

The DB receives attribute information and VCR data from users and accumulates them into the following items.

- user ID, attribute n-1, attribute n-2, attribute n-3, … (e.g., if attribute n is age attribute, attribute n-1 is all ages, attribute n-2 is 30's, attribute n-3 is 32 years old.)
- user ID, VCR

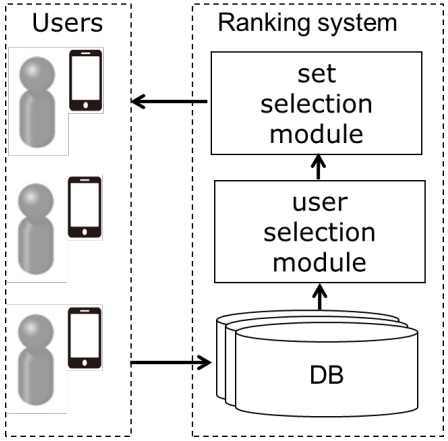

Figure 3. System configuration

The user selection module creates multidimensional hierarchical sets by combining attributes from the data in the DB. This module then outputs information about users who are in the top group in each multidimensional hierarchical set. The data items of the output are as follows.

- attribute 1, …, attribute n, the number of users in the set, rank, user ID, VCR

The set selection module inputs the output of the user selection module and selects a set in which the user ranks in the highest percentage, as stated in the preceding section. This module then sends information on the set and ranking to each user.

Evaluation

We conducted an evaluation to confirm that Top of Worlds can encourage user participation.

Experimental environment

We conducted a real-world evaluation in which 180 individuals participated for three months.

NTT is conducting a health improvement trial. Employees are given activity monitors that allow them to send general health data (e.g., blood pressure, body weight, and the number of steps walked) daily. This trial provides a web service where users can check their data shift regarding daily health. We applied our ranking system to this trial. In this trial, data collection and service participation are similar to those in participatory sensing. The reason is that users were not under the control of system and data collectors because they were not forced participate and send data. Therefore, if Top of Worlds can encourage participation in this trial, we think that it can also encourage participation in participatory sensing service.

We set the VCR as total number of steps from Monday to Sunday, set k of Top k% as 50, and set n (minimum set size) as 10. The participants were randomly divided into two groups: participants who were sent Top of Worlds' ranking information (experimental group) and those who were not sent the information (control group). Both groups can check a normal ranking (single ranking among all participants) on the web service. We evaluated the number of logins to the web service as a criteria regarding participation in the service. We also evaluated the number of steps as a criteria regarding participation to the activity.

Experimental procedure

The experimental procedure was as follows.

Before evaluation, we notified all participants that they would be sent ranking information regarding total number of steps from Monday to Sunday via e-mail. We also notified them that they might not be sent ranking information if they were in the control group or not in the top group.

During the three-month evaluation period, our system sent Top of Worlds' ranking information to participants who were in the experimental group and ranked in the top group via e-mail once a week. We used age attributes (all ages, a certain age range, e.g., 20s and 30s) and affiliation attribute (company-wide, department-wide) for creating multidimensional hierarchical sets. An example of an e-mail is as follows.

- Dear [participant's name], Your total number of steps from November 5th to 11th (70172) ranks 3rd (top 10%) in [40s, department] (30 people).

We did not add information, such as URLs, that facilitates logging in to the web service.

After the evaluation, we conducted a questionnaire with the following questions.

- Did being e-mailed the ranking information regarding your total number of steps walked per week encourage you to use the web service more?
-> "Yes" or "No" response
- Why did or didn't you would use the web service more?
-> free description
- What information should be added for you to use the web service more?
-> free description
- Did being e-mailed the ranking information regarding your total number of steps walked per week encourage you to walk more?
-> "Yes" or "No" response caption
- Why did or didn't you walk more?
-> free description
- What information should be added for you to walk more?
-> free description

Experimental results (number of logins)
Figure 4 shows weekly average number of logins of participants in each group who sent step data and confidence interval (alpha = 0.05). The experimental group was sent ranking information, and the control group was not. We conducted a t-test (alpha = 0.05) to verify that the experimental group had a greater number of logins than the control group. Before conducting the t-test, we conducted an F-test (alpha = 0.05) to analyze the equality of variance between the two groups. We found significant differences ($p = 0.0004$).

We now explain the results of the questionnaire. Forty-eight participants answered the question: "Did being e-mailed the ranking information regarding your total number of steps walked per week encourage you to use the web service more?" 18 participants (38%) answered "yes", and 30 participants (62%) answered "no". Answers to "Why did you use the web service more?" are as follows.

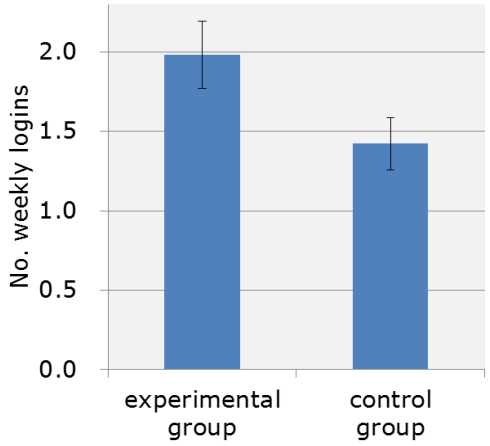

Figure 4. The result of the number of logins

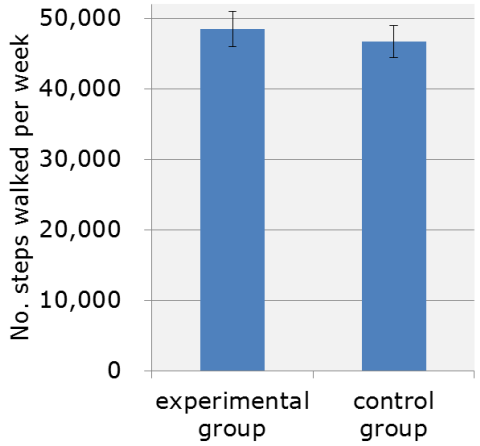

Figure 5. The result of the number of steps walked

- I was competitive.
- My ranking was good.
- I wanted to check ranking among all participants by looking at ranking information in the e-mail message.

Answers to "Why didn't you use the web service more?" are as follows.

- I used the web service only for my needs.
- I did not pay much attention to the ranking.
- I could not get information related to the e-mail message.

Answers to "What information should be added for you to use the web service more?" are as follows.

- How many more steps I should walk to increase my ranking or achieve something
- Personal record and comparison with my goal
- Distance walked ranking

Experimental results (number of steps walked)
Figure 5 shows the average number of steps walked per week of participants in each group who sent step data and confidence interval (alpha = 0.05). We conducted a t-test (alpha = 0.05) to verify that the experimental group walked more than the control group. Before conducting the t-test, we conducted an F-test (alpha = 0.05) to analyze the equality of variance

between the two groups. We found a non-statistically significant trend ($p = 0.1944$).

We now describe the results of the questionnaire. Fifty-eight participants answered the question: "Did being e-mailed the ranking information regarding your total number of steps walked per week encourage you to walk more?" 37 participants (64%) answered "yes", and 21 participants (36%) answered "no". Answers to "Why did you walk more?" are as follows.

- I was competitive.
- My ranking was good.
- I recognized amount of my effort.
- My ranking was not so good.
- My ranking was about to increase if I walked a little more.

Answers to "Why didn't you walk more?" are as follows.

- My goal (e.g., 10000 steps per day) was more important for me than the ranking.
- I thought that my ranking was good enough.
- I did not pay much attention to the ranking.
- I had already walked a lot and couldn't walk more.

Answers to "What information should be added for you to walk more?" are as follows.

- How many more steps I should walk to increase my ranking or achieve something.
- Personal record and comparison with my goal
- Comparison with last week's data
- Recommended popular walking course

Discussion

From the number of logins, we verified that Top of Worlds encouraged user participation in the service. From the number of steps walked, however, we could not verify that Top of Worlds encouraged user participation in the activity. We believe this is because increasing the number of steps walked is more difficult action than increasing the number of logins. However, many participants were motivated to walk more as a result of the questionnaire. Therefore, we argue that our method can encourage user participation in an activity if information and a mechanism that translates motivation to action are added to Top of Worlds. For example, the VCR of another user who ranked one point higher than a user and how many more VCR the user needs to increase his/her ranking. This may encourage a user to increase his/her VCR.

Conclusion and future work

We described the development of a ranking system and a real-world evaluation to confirm that Top of Worlds can encourage user participation in fact. We applied our ranking system to a health improvement trial in NTT. Our system sent Top of Worlds' ranking information regarding the number of steps walked to participants. We evaluated the number of logins to the trial's web service as a criteria regarding participation in the service. We also evaluated the number of steps as a criteria regarding participation to the activity. As a result, we verified that Top of Worlds encouraged user

participation in a service but did not encourage user participation in an activity.

For future research, we will improve our method in encouraging user participation in an activity by adding information and a mechanism that translates motivation to action.

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