

# OTOTONARI: A Pervasive Game of Sound Composition based on Users' Collaboration

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## ABSTRACT

Pervasive Games, also known as Pergames are games based on real space and holds the features of both the traditional real space games before computers and computer games that use computer graphics and sound. Existing Pergame proposes methods to accelerate communication between users. In those Pergames, there is a problem of not being able to create a direct collaboration between users by sharing the location, face to face interactions and ended as a communication on network like online games. In this paper, we propose a Pergame content ototonari to accelerate communication among the users participating in the games through sound composition by users' collaboration. Ototonari creates sound based on position, proximity and density of users in real space using mobile ad hoc network as the direct collaboration among users sharing the same time and the same place. Also, ototonari saves the sound data created by the user and enables other users who play afterwards to refer to it as an indirect collaboration among users sharing the same place and at a different time. Ototonari aims to accelerate communication among the users participating in the game through these 2 methods of collaboration. We carry out an evaluation experiment at the site of Expo Aichi 2005 and studied its result.

## Keywords

Pervasive Game, Mobile ad-hoc network, Collaboration, Communication, Experience, Design, Sound

## 1. INTRODUCTION

Presently, a new entertainment category, which is called Pervasive Game, is highlighted. Pervasive Games, also known as "Pergames", are games based on real space and holds the feature of both the traditional real space games before computers and computer games that use computer graphics and sound [1]. Interactions of games played on real space before computers consists of two elements. One is the interaction of "human to physical space / environment" and the other is the interaction of "human to human". These elements are fading as games started to introduce computers. Actually, computer games are more immersive and attract user's interest in terms of graphics and sound as virtual space. But, computer games forced the user to gaze the monitor and to use the controller or mouse, so the actual action of human and the interaction of human to human are restricted. Regarding this state, the entertainment category, called Pervasive Game, is the game based on real space incorporated with the more physical human action and the communication of human to human in order to retrieve two interactions of traditional games on real space while making use of the merits of computers – graphics processing and more. The opportunity of presentation is increasing as ACM Computer in

Entertainment had a special topic [2] and Pervasive Workshop [3] was held as a sub-group on International Conference Pervasive. Not only are many projects about contents in themselves presented, but also are some projects that argue Pergames from more inclusive viewpoints [1] [4] [5].

Existing Pervasive Games achieve the interaction of human with physical space, of the two elements of traditional games in real space, in various ways – RFID [6], wi-fi [7], GPS [8] and wi-fi + GPS [9] [10] [11] [12] [13]. On the other hand, many projects have presented various methods to accelerate the communication among participants for the interaction of human to human. But, these methods have problems that they are only to present the communication through network like on-line computer games. Therefore those methods do not consider the direct face-to-face interaction and collaboration emerged by sharing the atmosphere of a place. And some projects only add computer technology to games based on real space before computers, so computations have no involvement in their entity as games. "Ototonari" proposed in this paper aims to solve these problems and accelerates communication among participants.

Against the prior researches, we propose a Pergame content ototonari based on sound composition with user's collaboration. Ototonari has the features below.

1. Create a sound through users' collaboration using mobile ad hoc network based on the position, proximity and density.
2. Saves the sound created by the user as data and enables other users who play afterwards to refer to it using mobile ad hoc network.

Firstly, ototonari adopts the real space-centered interaction unlike the existing Pergame contents as described in feature 1. We attempt the direct collaboration among users sharing the same time and the same place by changing the generated sounds depending on the users' way of moving and gathering in real space. Next, ototonari adopts storage for user's experience in real space, which any existing Pergame content has not implemented as described in the feature 2. We attempt the indirect collaboration among users in the same place and at a different time by enabling other users, who play afterwards, to refer to the sound created by users. Ototonari aims to accelerate communication among users participating in the games with these two methods of collaboration based computation.

## 2. RELATED WORKS

As related works of this proposal, we state some problems of the existing Pergame contents' method to accelerate communication among the participants. The existing methods can be categorized into 3 categories as below.

- Direction type [6] [9] [14] : this method proposes the interaction between the players participating in games and the helper on network

- Match-up type [15] [16] : this method proposes the face-to-face interaction among the players in real space.
- Hybrid type [7] [10] : this method proposes the face-to-face interaction among the players in real space and the between each player participating in games and with each helper on network

In addition, Direction type has no division between friend and foe but Match-up type and Hybrid type have a division between friend and foe.

As an example of Direction type, we quote the Space Race [14]. In Space Race, the users are divided into the player(s) moving over real space and the navigator(s) on network. The Player(s) have to move in real space following the directions from the navigator(s) and search the crystal hidden in the virtual space linked to the real space. As the cooperation of the player(s) and the navigator(s) is compelled in the game design, consequently they can not help each other by communicating. Thus, Direction type has a problem that the participants can't get the effect of communication based on the direct face-to-face interaction.

As an example of Match-up type, we quote AR2 Hockey [15]. AR2 Hockey aims to play Air Hockey on AR (Augmented Reality) environments and the players in real space plays the game with a puck on a virtual space. Here, the players can play the game face-to-face with each other, so they can communicate directly. But many cases of Match-up types actually establish the game in only the physical space and have a problem that the essential amusingness of the game doesn't come from computation. In addition, Mach-up type has cases that the game goes on by parting the player into real space and on network, for example Can You See Me Now (CYSMN) [11] and Uncle Roy All Around You (URAAAY) [12]. In this case, a problem occurs that the direct face-to-face interaction can't consist like Direction type.

As an example of Hybrid type, we quote Human Packman [10]. In Human Packman, the players, wearing HMD (Head Mount display) , are separated into a team of Packman and Ghost. The aim of Packman is to collect the biscuits in the virtual space by looking through the HMD. And the aim of Ghost is to touch Packman. The helpers on the network indicate the position of each player as one team in real space can't detect the other team in real space. Also, Hybrid type has a problem that the users can't get the effect of communication based on the direct face-to-face interaction. To solve this problem, Human packman adopts the element of Ghost's touching Packman. It

was remarkable that in evaluation of Human Packman, 95% of the users answered that this tangible interaction increased the fun of the game and the users wanted to have more interactions like this adopted. On the other hand, 35% of the users answered that the collaboration between the players and the helpers made it less enjoyable. Thus, we think the users want direct face-to-face communication.

There is a limit of communication emerged by transmitting atmosphere of the place which arises in the case of direct communication on network like Direct type and Hybrid type. Therefore ototonari adopts the real space-centered game design to realize direct face-to-face communication (feature 1). At the same time, ototonari adopts the game design that computation is indispensable for the entity of the game (feature 1, 2).

### 3. OTOTONARI

Ototonari creates a sound based on the position, proximity and density of the user in real space using mobile ad hoc network. In concrete terms, ototonari is formed with multiple sub areas as the game area. Each user plays a unique instrument at each sub area, then as the user gets closer to each other, it creates a different sound.

Also, ototonari saves the created sound to the location as data through a particular terminal using mobile ad hoc network. This enables not only the current users that exist at that location, but also the users that appear afterwards at that location to share the sound. In concrete terms, the sound created by each user is merged and saved at each sub area. Users who play the game afterwards can listen to the saved sound at that location.

In addition, ototonari has a specification which the game can only be done with mobile ad hoc network, considering the simplicity in its introduction in terms of being able to play wherever you want if a player and a place are ready without the condition of a specific network infrastructure.

#### 3.1 Game Design

There are 2 types of games in ototonari and each is expressed as "term 1" and "term 2" (Table 1). In term 1, the sound data created is saved to the game area. Then another user gets the data left in that game area and listens to the reconstructed sound based on that data in term 2 "2. Listening time". The process of reconstructing the sound in the application based on the data left in that game area is called "remain". Term 1 and term 2 can be rephrased as remaining term and non-remaining term. However, there is no need for term 1 and 2 to be done

Table 1. Game Flow

Term 1		Term 2	
Phase	Time line	Phase	Time line
1. Moving Time (1 min.)	00 : 00~01 :	1. Moving Time (1 min.)	00 : 00~01 : 00
2. Creating Time (3 min.)	01 : 00~04 :	2. <b>Listening Time (3 min.)*</b>	01 : 00~04 : 00
3. Mixing Time (1 min.)	04 : 00~05 :	3. Creating Time (3 min.)	04 : 00~07 : 00
4. Mini Game Time (3 min.)	05 : 00~08 :	4. Mixing Time (1 min.)	07 : 00~08 : 00
5. Mixing Time (1 min.)	08 : 00~09 :	5. Mini Game Time (3 min.)	08 : 00~11 : 00
6. Listening Time (3 min.)	09 : 00~12 :	6. Mixing Time (1 min.)	11 : 00~12 : 00
	~	7. Listening Time (3 min.)	13 : 00~16 : 00

\*phase"2. Listening Time" exists only in term 2. The sound data created and saved in term 1 can be listened to.

continuously, and can be done at particular.

**Moving Time:** Users spread to a particular place in the game area.

**Creating Time:** A sound is created based on the users' position, proximity and density. The created sound is output in real time. In this creating time, communication between users is made easier as it is unable to create sound unless a user approaches another. Also, the instrument differs for each sub area, so the users can enjoy the sound by moving from one sub area to another with other users.

In addition, each sub area has the different kind of music and each user has a instrument for each sub area. Instruments given to each user is a dismantled part of a complete musical piece. A musical piece for the sub area is reconstructed by the users' location information in the sub area, the proximity and the density. This specification was made considering the perfection of the music and entertainment as a game. Of course, there is a method of putting the users' position data in a creating parameter like the chord. But there are some problems such as the recognition of the change in sound being unclear and the dissonance when sounds are created.

**Mixing Time:** The sound data created by each user is mixed to a sound data for the sub area.

**Mini Game Time:** A mission is sent to the user from the agent in the application. There is a change in sound by clearing the mission. The aim of this mini game time is for the users to communicate with each other and clear the mission together.

**Listening Time:** The created sound can be listened to. Also, the sound saved in the area can be listened to only in term 2. The aim of this is for the sound to have influence on the users' action in the game by listening to the saved sound.

In each phase above, not only the sound but also a graphic is presented. To be concrete, (1) each user visualizes the instrument (refer 3.2.2) and (2) supports the progress of the game. The latter can be subdivided into presenting the left time in each phase, directing the user's action in each phase and supporting the progress of the mini game time (refer 3.2.4).

## 3.2 System

### 3.2.1 System Structure

The system structure for ototonari is shown in Figure 1. The application of ototonari is operated in a PDA. The PDA used is the ai-MATE terminal developed by KDDI CORPORATION [17]. ai-MATE has Windows Mobile 2003 Second Edition for Pocket PC and enables communication functions such as wireless LAN (802.11b) and CDMA 1X WIN. Ototonari uses

this ai-MATE as the mobile terminal that the user carries and also for the fixed terminal that is set in the game area.

Macromedia Flash is used for the interface of ototonari, and the game flow is shown graphically by this (Figure 3, Figure 4). The ototo player is described by .NET C# and is taken a picture with a camera. Then the created sound is output within the hardware, the data is input and output, and then the communication log is output. Cast Service and JPEG Lib Wrapper are described in Native C++. Cast Service is a dll (dynamic link library) module using CCS (Contents Crusing System) developed by Murai Laboratory, Keio University [18]. As a communication architecture, CCS modulizes the communication part with GPS. But, in this proposal, as we use only the mobile ad hoc network, we omitted the GPS module and use dll for the distributing function of the mobile node (=One Hop Neighbors).

The file list used in ototonari is shown in Table 2. And the flow of the file movement between mobile terminals and fixed terminals are shown in Figure 2. In the following sections after 3.2.2, only the file name is described.

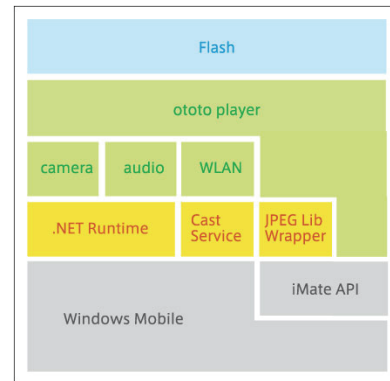


Figure 1: System Structure

### 3.3.2 Creating Time

We implemented 2 modules in the mobile terminal to create sound in a mixing style.

First module, the base rhythm module, decides the type of music based on the sub area. Ototonari consists of a maximum of 4 sub areas (abcd) in a game area. Each sub area has a fixed terminal. It casts an area message for each 5000 milliseconds to mobile terminals existing in its coverage area. Then, the mobile terminals that receive this area message play the basic rhythm formed of bass and drums. Each sub area has the maximum of 4 unique types of basic rhythms, Disco, Funk, Samba and Electro. In addition, these basic rhythms should be set to each sub area

Table 2: Tasks and types of files in ototonari

File name	File structure	Sender	Function
Area message	Terminal MAC address -A- area ID (abcd)	Fixed terminal	Notify the area
Created message	Terminal MAC address -G- area ID (abcd) -terminal ID (0-9)	Mobile terminal	Notify the area and the instrument used for creating the sound.
Mix file	Terminal MAC address -M- area ID (abcd) -terminal ID (0-9)	Mobile terminal	Record data of the sound created by each player or recorded sound mixed at each area.
Remain file	Terminal MAC address -R- area ID (abcd)	Fixed terminal	Merges the mix file in term 1 and saves it for each area. Used in phase 2 of term 2.

\* Record data in the file is recorded as high (=1) and low (=0)

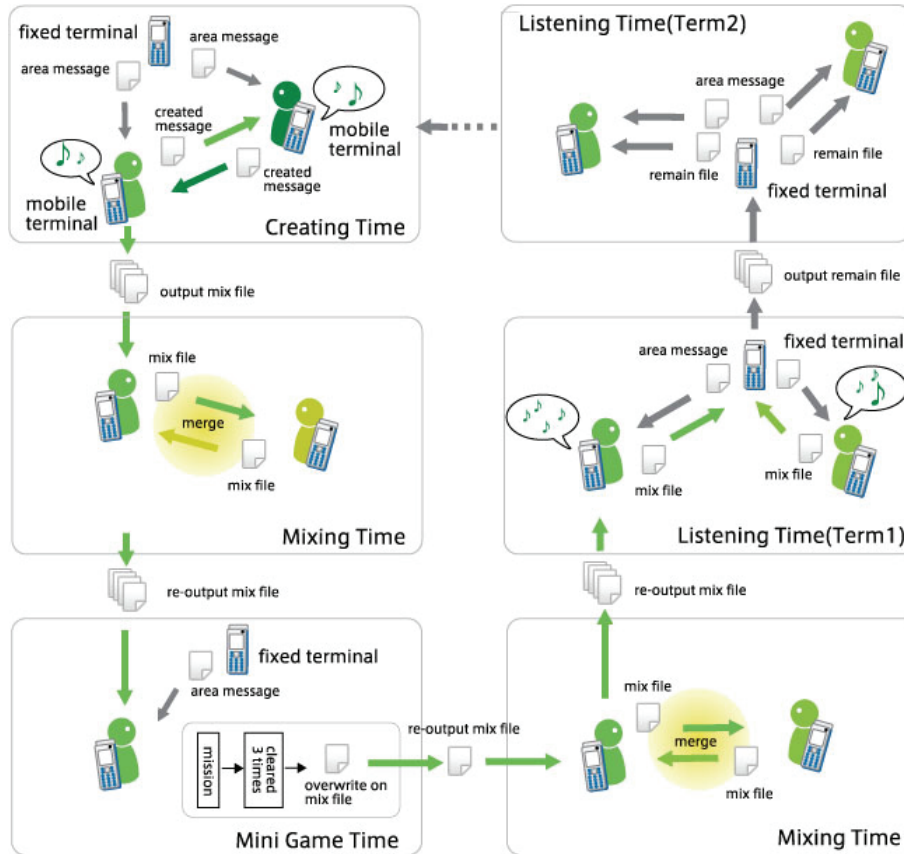


Figure 2: File movement flow

before the game starts.

The second module, instrument module, plays the instrument assigned to each sub area. Mobile terminals have an assigned instrumental set for each terminal ID corresponding to each sub area. For example, the user with ID {1} has an instrumental set of a-1, b-1, c-1 and d-1 in area abcd. Mobile terminals play an instrument corresponding to the ID in that area at the same time they receive an area message from the fixed terminal. Furthermore, in the present version, there are 10 types of instrumental sets for each sub area. These instruments sets should be set to each sub area before the game starts.

In creating time, the sound is created using these modules. The sound based on the position information is created by using the base rhythm module and the instrument module. The sound based on the proximity and density is created by the collaboration of the instrument module and the message casted by each mobile terminal. The mobile terminal {1} with ID {1} casts a created message to other terminals in its coverage area. For example, if a mobile terminal {1} exists in area A, it casts a created message with the file name G-a-1. All mobile terminals which received the created message from mobile terminal {1} and also in area A plays instrument 1 for type “a” together with its own instrument for 5000 milliseconds. Here, the display on the terminal graphically shows the played instrument so that the user can distinguish which instrument is being played (Figure 3). To be concrete, in creating time, a trapezoid corresponding to the instrumental set assigned to each user repeats expanding and reducing along with the played instrument (Figure 3a). If a user

receives a created message from another user, the trapezoid for that ID repeats expanding and reducing (Figure 3b).

Also, if mobile terminal {2} exists in a different area from mobile terminal {1}, and receives a created message from mobile terminal {1}, errors are avoided by comparing the area ID of the final received area message and the area ID of the received created message in mobile terminal {1}. In connection with this, we will refer to the error processing of the overlapping of coverage areas of fixed terminals in each sub area. First, the space between each fixed terminal should be decided considering the reception status of the fixed terminals before the game starts. If a mobile terminal exists in a blank area which is not covered by any fixed terminals area, the sound is created by processing uncertainty based on the last area message received [11].

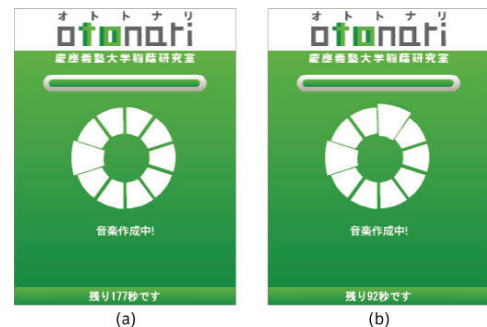


Figure 3: Image of the display for Creating time  
 (a) State when instrument of only the user with ID8 is played  
 (b) State when instruments of users with ID1, ID8 are played

The receiving record of the created message is recorded as a matrix value consisting of “the corresponding instrument (10 rows: 0-9) \* time (36 columns: 3 min/5000 msec)”. Then, it is output as a mixed file as soon as the phase of creating time is over. However, the mix file is not output for areas where the user did not exist.

### 3.3.3 Mixing Time

In the mixing time, the mix files, that exists as many as the number of “mobile terminals\*sub area” output in the creating time, are merged for each sub area. Each users’ sound is changed into the whole users’ sound in a sub area. It is merged by a logical sum of each cell in the matrix within the mix file. The merge is done only once to each file by enclosing the terminal MAC address, area ID and the terminal ID in each terminal’s memory. The relevant memory is released as soon as the first mixing time is over. As the new data is overwritten its own mix file in this mixing time, a new file is not output at the end.

### 3.3.4 Mini Game Time

In mini game time, a mission is sent to each user from the ototo Player. In creating time, users can listen to the instrument played by other mobile terminals if it exists in the same area as the sending user and is in the coverage area of the mobile terminal. On the other hand, all users in the corresponding area can listen to the user’s instrument if that mobile terminal clears the mission in the mini game. An instruction in the mission is to take a picture of a real object that has the indicated color, red, blue and green. Users take a picture with the camera on the mobile terminal. They must clear the game 3times in order to clear the mission.

When the mini game time starts, the image on the display changes, and the image from the embedded camera is shown on the display (Figure 4). The display shows the current mission, left time and the position of the shooting button for the camera. When the game is cleared, the data is enclosed in the memory and after the mini game time, a cast is done regarding that all the rows of the user’s instrument has been played according to the mix file which has the area ID and the terminal ID to where the user is at present.



Figure 4: Image of the display for mini game time

### 3.3.5 Listening Time

There are 2 ways for listening time, one is when the user participating at present listens to the created sound, and the other is when another user listens to a sound created and saved by participants before (Table 1, Figure 2). The former is enabled by playing each instrument based on the data from the matrix cell

in the corresponding mix file after choosing a mix file regarding the area ID of the received area message. This is done after the second mixing time. The latter can be realized by the fixed terminals in each area re-merge the mix file in the terminal in the second mixing time and outputting the remain file. In the first listening time of term 2, each fixed terminal in each sub area casts a remain file with an area message, so it enables the users to listen to the sound data when the mobile terminals receive that message.

## 4. USER EXPERIMENT

We carried out an experiment game to volunteers in EXPO 2005 Aichi, Japan using the proposed content ototonari. We confirmed the performance by operating the game to a large scale of participants. Using the log data and the questionnaire results, we verify whether the methods to accelerate communication among the users are effective, one of which is the direct collaboration among the users sharing the same time and the same place and the other of which is the indirect collaboration among users on the same place and on a different time.

### 4.1 Experiment Environment

The experiment was done in the Ai-Chikyu open space in EXPO 2005 Aichi, Japan. This round open space’s diameter was about 180m and about 25,000 square meters. It was a good location for it had no obstacles around to cut the reception. We used this area as a game area and divided it into sub areas abcd (Figure 5). Also, the type of music to be created was fixed for each sub area. The fixed terminals were set close to the center of each sub area and one terminal covered about 45m radius regarding the packet loss confirmed in the experiment beforehand.

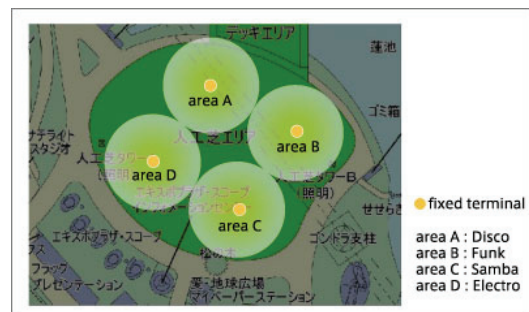


Figure 5: sub area setting

The experiment was done on July 8, 2005 with 50 volunteers. The volunteers were people from 18 to 55 years old who registered beforehand. There were 25 men and 25 women. The volunteers were randomly divided into two groups, group (A) with 20 people and group (B) with 30 people. The experiment was done in order, A (term 1) – B (term 2) – A (term 2) – B (term 1), without explaining the intention of the experiment but just explaining the game rule.

After each term, we asked the participants to fill out the questionnaire. The questionnaire for term 2 has some questions about the information left in the location. In this experiment, there are some overlapping instrumental sets which are assigned to each terminal ID as there are 20 or 30 people in each group.

Therefore, users of terminal ID {1}, {11} and {21} have the same instrumental set.

### 4.2 Log Data

The analyzed log data of term 1 and 2 is shown in Figure 6. The target data of Figure 6 are the created messages that mobile terminal had received in the creating time and the mix files that mobile terminals had merged in the second mixing time. With these data, we verify the method of the direct collaboration among the users sharing the same time and the same place.

Figure 6a, 6b visualize the receiving status for created messages of each terminal for each term of group A and group B from the log data. The horizontal axis has a number of the received files per 10. The vertical axis has a number of terminals having received the created messages. In creating time, the maximum number is 95 files and the average number is 23.8 files per one mobile terminal for 3 minutes in the case of group A with 20 people. In the case of group B with 30 people, the maximum number is 101 files and the average number is 57.03 files per one mobile terminal for 3 minutes. Comparing these graphs in creating time, we surmise group A with 20 players had formed some small groups and group B with 30 people had formed some small, medium and large groups evenly.

Figure 6c, 6d visualize the receiving status for mix files of each terminal for each term of group A and group B from the log data. The horizontal axis has a number of the received files per 10. The vertical axis has a number of terminals having received the mix files. In mixing time, the maximum number is 58 files and the average number is 17.5 files per one mobile terminal for 2 minutes in the case of group A with 20 people. In the case of group B with 30 people, the maximum number is 60 files and the average number is 32.7 files per one mobile terminal for 2 minutes. Comparing these graphs in mixing time, we surmise group A with 20 players had formed some small groups and

group B with 30 people had formed some groups from small to medium.

### 4.3 Questionnaire Result

The questions and the results of the questionnaire are shown in Figure 7. With these data, we verify the method of the indirect collaboration among users on the same place and on a different time. We assume that term 2 user’s action is based on the action of user in term 1, if the action of the user in term 2 who had listened the sound saved in the location is particularly different from the action of the user who hadn’t listen to it in term 1. Therefore, we assume that there is an indirect collaboration. Here we state the questions in the questionnaire results where there was a notable difference in whether there was a remaining phase or not.

In question a, compared to the positive answers from 30% of the users in term 1, there were positive answers from 48% of the users in term 2. Therefore, we surmise that there was an effect on the user who creates the sound by listening to the saved sound in the location.

In question e, compared to the positive answers from 52% of the users in term 1, there were positive answers from 62% of the users in term 2. Therefore, we surmise that there was an increase in interest for not only the game experience of oneself but also for the game experience of other players by experiencing the remain phase.

We asked question f, to users who answered “Yes” to question e, to compare with question d. Compared to the positive answers from 81% of the users in term 1, there were positive answers from 87% of the users in term 2. There is a slight increase in positive answers by experiencing the remaining phase. Also, there were more people who had good impressions to the sound that other users made than to their own music in both terms.

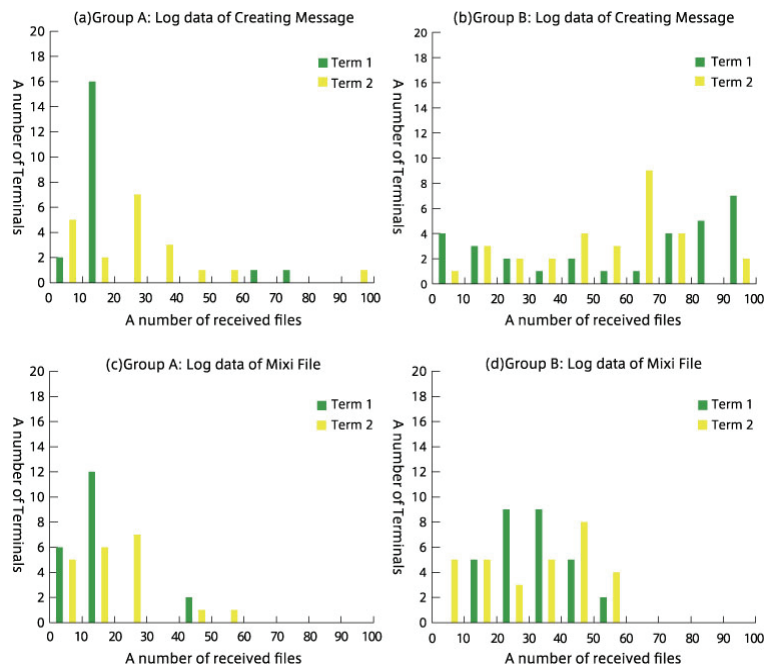


Figure 6: Data Log of created messages and mix files (row: instrument ID, column: time transition per 5000msec)

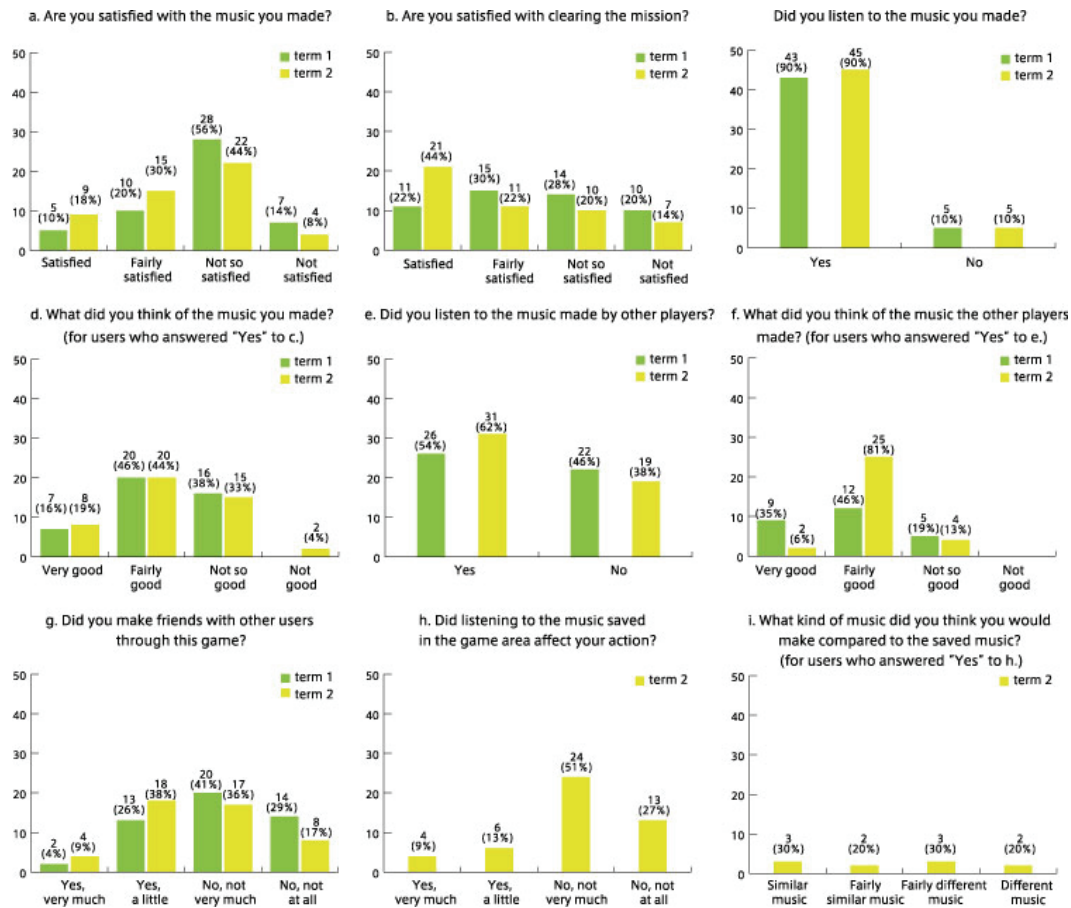


Figure 7: Questions and Results to the Questionnaire

In question g, compared to the positive answers from 30% of the users in term 1, there were positive answers from 47% of the users in term 2. Therefore, there was an increase in positive answers by experiencing the remaining phase.

Moreover, in question h, which meant to directly inquire the user whether or not it had influence, only 22% of the users answered that they were affected. We surmise that there is an unconscious effect on the user as the 4 questions examined above clearly show a difference in their action by figures. Furthermore, we asked these people who answered "yes" to question h, the next question i. There were about 50% of each similar music and different music. This is a very interesting result for behavioral sociology that it has the same range.

Moreover, there were notable comments on the free sections of the questionnaire, such as "I felt like I was communicating using the power of music" and "It's interesting for we can talk to each other and have communication". These comments were concerned about communication among users.

## 5. DISCUSSION

We study the 2 features that we adopted in this proposed contents to accelerate communication among users.

### Feature1: Direct collaboration among users sharing the same time and the same place

In the proposed content, we adopted the method of creating sound based on the users' position, proximity and density to

realize the direct collaboration among users participating in the games. To be concrete, the creation of sound was made possible under the 2 conditions; 1) the area information agrees with each other and 2) can receive created messages between users. In addition, we adopted the 2 methods as game design to accelerate the direct collaboration. One is the method that 10 instruments were allocated to each user per one sub area and a musical composition can be complete till all the users gathered. The other is the method that we adopted mini game and we set the situation to make it easy for users to communicate naturally face-to-face through the mission. These methods were the methods which were achieved by using computer technologies in contrast to traditional games and which were unique for Pergames.

Through the analyzed log data of created message and mix files shown in 4.2, we confirmed that the users had formed groups in various scale and realized collaboration among users. In addition, we observed in the game that many users had cleared the mission with other users in the mini game time. As a fact, we saw some comments on the free comment section of the questionnaire, such as "I was glad to make a chance to talk with other users through mini game" and "we created a interesting sound when we moved around together in a group".

The limit of this method is the point that creating sound of the direct collaboration is based on the two conditions. In an extreme case, if users exist in the same sub area and is in each others' coverage area, they can create a sound even if they do

not move close to each other. It is necessary to adopt more motivation to the game design to approximate the users and to accelerate communication. To be concrete, it is achieved by controlling the coverage area of mobile terminals to change the created sound due to the radio intensity in controlling or by adjusting the set up so that an interaction is made only when there is a fixed radio intensity.

**Feature2: Indirect collaboration among users on the same place and on a different time.**

In the proposed content, we adopted the method of saving the sound created by the current user as data and enabling other users who play afterwards to refer to it to realize the indirect collaboration among not only the current users that exist at that location but also the users that appear afterwards at that location.

In 4.3, we verified whether there is a difference in action between term 1 and term 2. By examining the results of the questions a,e,f and g in each term, we came to a conclusion that there is a difference in the action between term 1 and 2. Also, according to question h, it can be said that it is an unconscious difference. We can assume that the users' action in term 2 is based on an influence of the user's experience in term 1 as a particular but as there are unconscious difference existing between the users' action in term 2 who listened the sound saved in the location and the users' action in term 1 who didn't listen. Therefore an indirect collaboration is realized.

The limit of this method is that the effect of a user's experience to the other user's action is indirect from the perspective of the action based on listening sound. This method can be stated as uncontinuous inheriting model. On the other hand, there is a direct inheriting model which accelerates a collaboration. This model inherits directly or continuously to one or all the attributes saved in the location as parameters to the sound created by other users. Namely, the created sound by other user oneself is directly influenced by the sound created and saved to the location by user. This model accelerates collaboration between both users.

## 6. CONCLUSION

In this paper, we proposed a Pegame content ototonari to accelerate communication among the users participating in the games through sound composition by users' collaboration. We realized the direct collaboration among users sharing the same time and the same place by creating sound based on position, proximity and density of users in real space. Also, we realized the indirect collaboration among users on the same place and on a different time by saving the sound created by the user as data and enabling other users who play afterwards to refer to it.

Ototonari not only brings face-to-face communication in direct lacking in the existing Pergames into the heart of the game design but also adopts the storage and inheritance of game experience not seen in any of existing Pergames. In the future, we adopt a better motivation in the game design to accelerate communication between users. Also, we implement a method to inherit directly or continuously to one or all the attributes saved in the location.

## 7. ACKNOWLEDGEMENT

This project is granted by CREST and JST.

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