A Framework for Developing Software Always Beside Users

日々の生活に溶けこみ生活の質を向上させるソフトウェアのためのフレームワーク

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Hiroaki KIMURA

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Abstract

The rapid advancement of information technologies including sensors, algorithms, networks, packaging and so on, will change the interaction between users and applications. This dissertation proposes a new application area to be closely connected with human daily life, and is running every time and endeavor to enrich their quality of life by shepherding users to their goals, which is named *life assist applications*. However, there is a lack of knowledge to develop and to evaluate these types of applications. Usability, which is the study of ease of use, cannot fully evaluate these applications because this study does not take into account how blended right in people's daily life.

This research has focused on the development of a framework for building life assist applications. This dissertation extracts main issues of the development of life assist applications by applying psychological and technological understandings. The dissertation designs a framework for developing life assist applications to resolve those issues.

Two systems in accordance with the framework, *ambient lifestyle feedback systems* and *social effect reflection systems*, are introduced for confirming the feasibility of life assist applications. Ambient lifestyle feedback systems encourage people to change behavior by reflecting their own behavior using ambient displays. Social effect reflection systems encourage people to change behavior or attitude by forming virtual groups and by visualizing social effects. From six case study applications of these systems, the dissertation argues how the framework guides developers and extracts implications for practical issues for future life assist applications.

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Chapter 1

Introduction

The rapid advancement of information technologies including sensors, algorithms, networks, packaging and so on, have made it possible for people to use computers anytime and anywhere. Recently, men and women of all ages as well as technicians and office workers have utilized computers without any reserve. Under this circumstance, applications that are used by them are no longer limited to business applications. In particular, applications that use context awareness [23] techniques with sensors must be used in different styles because those applications do not require manual input given by users. Those applications think about what they ought to do from users' contexts. One applied area of those novel applications is closely connected with their everyday life, and is running every time and endeavors to enrich their quality of life. I named these types of novel applications *Life Assist Applications*.

1.1 Life Assist Application

This section describes the features of the life assist applications in detail.

1.1.1 Differences from existing applications

One of the biggest differences between the life assist applications and existing applications is those use style. Generally people use existing applications to reduce their workloads and take over their tasks (e.g. enormous simple calculation,) and it takes short time to complete those tasks. People understand the path to complete the tasks in advance, and they make themselves near the goal using ap-

propriate functions that those applications provide (Figure 1.1.) Thus it could be said that their use style of existing applications is active and voluntary.

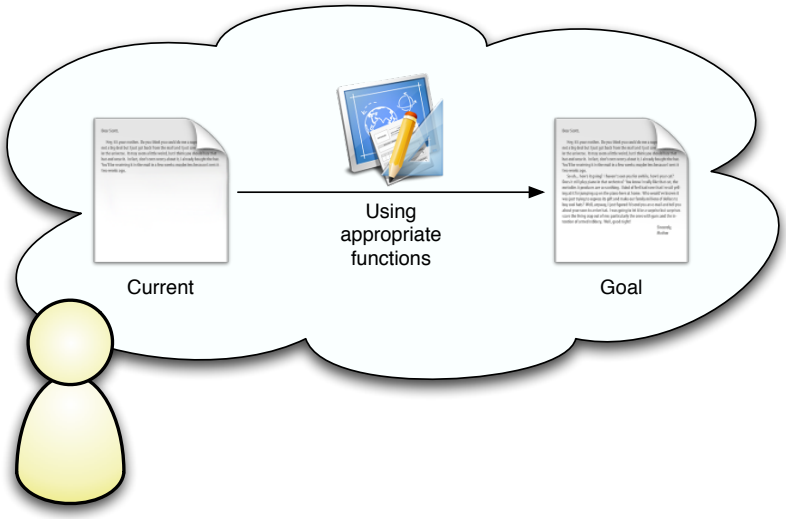

Figure 1.1: Users know which functions of application should be used in advance

When people use the life assist applications, on the contrary, those users do not clearly know the path to reach the goal in many cases even though they understand the goals themselves (Figure 1.2.) When a user who has desires to be slip is going to use dieting software, for example, s/he understand his/her goal —reducing his/her weight or building up his/her muscles— however s/he would not understand how to reach the goal because there are many options to reduce his/her weight and the user does not know which is the most appropriate option for him/her. Thus these applications need to recognize users' daily behavior, and to act in response to the behavior in order to shepherd the users to their goals. The users' actions are passive because they near their goals along the paths designed by the applications.

1.1.2 Three stages of life assist applications to work on users

The differences of the use style described in Section 1.1.1 require developers to implement additional features for the effective use of life assist applications. In the nature of the applications, it is a primary challenge of the applications to make the potential users start using those applications. Besides, users are required to associate longer with the life assist applications than existing applications because

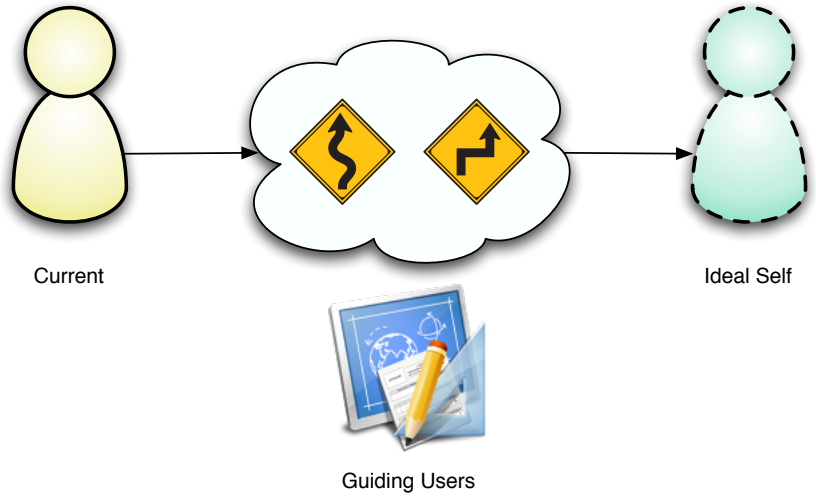

Figure 1.2: The novel application shepherds user to his/her goal

it takes much time and energy to reach their goals. This means the life assist applications have to possess a feature to make them continue using the applications. Thus life assist applications need to encourage users in three stages, *making use*, *attitude change*, and *continuous use* (Figure 1.3.)

Figure 1.3: Three stages of life assist applications to encourage users

1.1.3 Environment where life assist applications are used

Ubiquitous computing environment [83] is just around the corner. In recent years, computers have become increasingly advanced and sophisticated. They have been smaller and lighter, and have been carried anywhere. Those computers are equipped with wireless communication modules and sensor devices including acceleration sensors, geomagnetic sensors, and GPS sensors in order to acquire users' current context. Wireless network infrastructures have been widely built, so every mobile device is able to communicate with other devices anytime and anywhere. Many

computers and ambient displays [85] are going to blend with the surroundings (Figure 1.4). More these computers are integrated into our environment, the technology seems to be disappeared. Users become less and less concerned about the computers and the computers run without input given by users manually. These environments are called ambient intelligence. Life assist applications run on these environments [1].

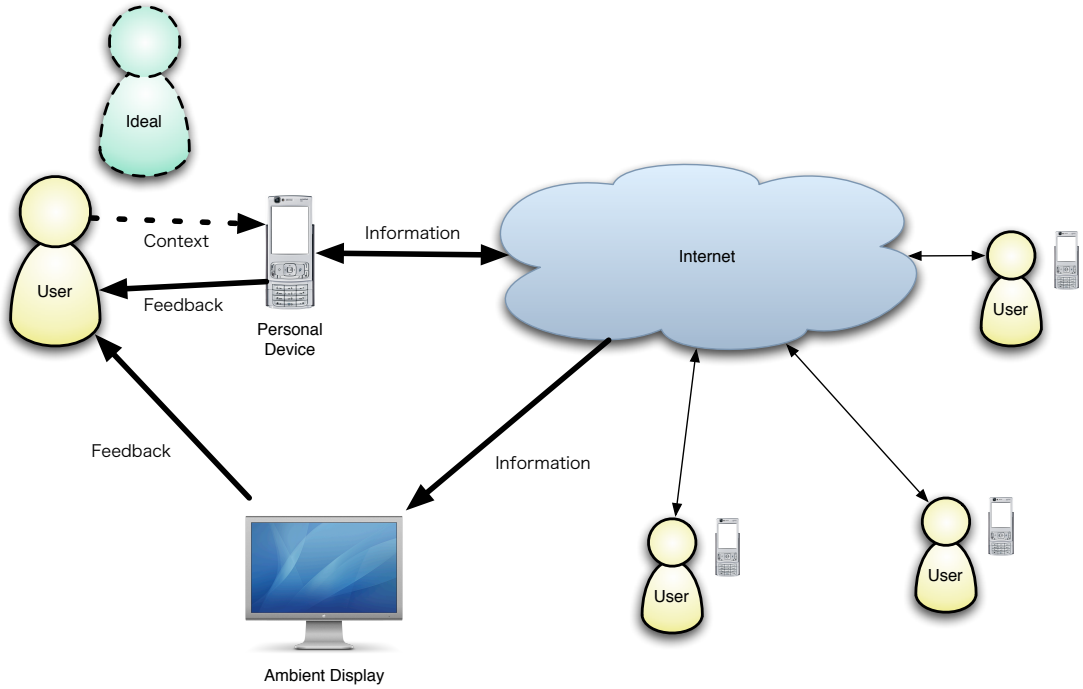

Figure 1.4: Environment where the Life Assist Applications are used

1.1.4 Link with persuasive applications

Persuasive application is the application which aims to change users' behavior or attitude [33]. In fact, one of the most important roles of life assist applications is to shepherd them to their desirable lives by changing their behavior or attitude. However, target users of existing persuasive applications is relatively active and those researches do not postulate the environment that mentioned above.

1.2 Research Motivation and Contributions

There is insufficient knowledge for development of the life assist applications because the utilization form of the software and the relationship to the users are totally different from existing software. In the case of existing software, the software place emphases on providing useful and easy-to-use functions, and on reducing users' workloads. On the other hand, the novel software place emphases on improving users' quality of life unobtrusively and on providing effective feedbacks for attitude changes. Moreover, usability, which is the study of ease of use, cannot fully evaluate these applications because this study does not take into account such passive users. Therefore we need a new knowledge to develop these novel applications effectively.

In this dissertation, the author weaves the knowledge to develop *life assist applications*, and provides developers with a framework for designing those applications. In order to develop them, developers have to consider more carefully about the psychological side of users than ever before to shepherd users. There are many psychological understandings that could be applied to the development of the software such as behavioral psychology and social psychology, however, it is not always true that we can apply them inconsiderately. Therefore this dissertation explores approaches to utilize the understandings for developing and for evaluation these types of applications.

The contribution of this dissertation is providing a series of guiding principles for designing and implementing life assist applications by proposing a framework. Specifically, the framework provides developers with following information:

Categorization of life assist applications The framework categorizes three types of life assist applications in terms of target behavior. Developers are able to classify the applications that they want to develop according to the characteristics.

Suggestion of appropriate persuasion techniques The framework suggests persuasion techniques that can be used for each application category. Developers easily choose appropriate persuasion techniques that fit into their applications.

Presentation of example implementations The framework presents example implementations for each persuasion technique. These examples are good clue

to implement their own applications.

Presentation of guideline for preventing setbacks The framework offers a guideline for prevention of setbacks in use of the applications. This makes users to continue to use applications.

These features boost development speeds and quality of the applications, which encourages broad use of the applications in near future.

1.3 Dissertation Overview

The rest of this dissertation is structured as follows.

Chapter 2 highlights one of the main issues regarding life assist applications, attitude change. First this chapter defines two persuasion forms according to the relationship between the stakeholders and describes the characteristics of each form. Then I explain various persuasion techniques based on psychological theories that are used in each form and then introduce three representative attitude change models.

Chapter 3 proposes a framework for developing life assist applications based on the persuasion forms described in chapter 2. First, in this chapter, I focus on the advantages and differences of attitude change using computers. From this knowledge, I derive design issues for developing the novel applications. After introducing three existing frameworks for developing persuasive applications, I propose a framework for developing life assist applications. The framework defines two persuasion forms using computers and three application types.

Chapter 4 introduces *Ambient Lifestyle Feedback Systems* that are designed to motivate changes in a person's lifestyle by using the knowledge especially on behavioral psychology, operant conditioning. Ambient lifestyle feedback systems acquire users behavior by using physical sensors and generate feedbacks on ambient displays to affect users' operant behavior. To confirm the effectiveness of the systems, three case study applications were developed: 1) *Persuasive Art*, which encourages users to walk enough daily; 2) *Virtual Aquarium*, which encourages people to do regular toothbrushing; 3) *Mona Lisa Bookshelf*, which encourages people to keep a shared bookshelf organized.

Chapter 5 introduces *Social Effect Reflection Systems* that are designed to mo-

tivate changes in a person's lifestyle by using the knowledge of social psychology. Social effect reflection systems use the knowledge of social psychology such as social facilitation, conforming behavior, social comparison, and social loafing to change users behavior. Social effect reflection systems gather receivers by using networks to form virtual groups. Generally social effects are invisible, and it does not affect anything if the target people do not become aware of that. Social effect reflection systems visualize the social effects to make the people become aware of that. To confirm the effectiveness of the systems, this research developed three case studies: 1) *EcoIsnald*, which encourages users to reduce CO2 emissions; 2) *Driving Behavior Change System*, which encourages people to drive more safely and efficiently; 3) *iDetective*, which encourages people to do daily exercise.

Chapter 6 discuss the framework for life assist applications based on the findings of six case studies described in chapter 4 and chapter 5, and then I conclude this dissertation in Chapter 7.

Chapter 2

Attitude Change

One of the most important roles of life assist applications is to shepherd them to their desirable lives. It should also be appreciated that those applications have to make them continue to use themselves because it takes much time to change their attitude. This chapter describes various types of psychological techniques to encourage people to change their attitude for shepherding users (*attitude change* stage in Section 1.1.2), and also describes how to prevent users from setbacks (*continuous use* stage in Section 1.1.2.) First, in this chapter, I define two types of attitude change according to the relationship between stakeholders in the attitude change, and describes well-used persuasion techniques in each type and introduce three representative attitude change models. Lastly I discuss how to sustain the desired behavior.

2.1 Two Types of Attitude Change

People have a deep history of *persuasion*. Generally people have a desire to change their behavior or attitude to break themselves of bad habits. Although we fully understand that it is important to keep desirable habits with a great effort, we are apt to being lazy, and having an easy life. Thus many kinds of persuasion techniques have been developed since ancient times. Book and pamphlet are most typical examples of ancient persuasive media for attitude change.

In order to illuminate the mechanism of persuasion, I classify classical persuasion techniques into two types in terms of the relationship between those stakeholders. This classification will be instrumental in designing a framework for developing life assist applications introduced in Chapter 3. First I introduce two key

stakeholders, *receiver* (persuadee) and *source* (persuader) . Then I define two types of attitude change and introduce persuasion techniques that could be used in each type.

2.1.1 Stakeholders

Under usual persuasion situations, there are two key stakeholders, *receiver* (persuadee) and *source* (persuader) . Receiver is a human who intends to change his/her own behavior/attitude, or is wanted to change his/her behavior/attitude by using persuasion. Source is a human who persuades its receiver(s) or a medium that has a power to change receiver's behavior. A source encourages a receiver to change behavior by sending persuasion messages such as asking a request or speaking an opinion (Figure 2.1). Though there are other stakeholders such as *mediator* who intermediates between the receiver and the source under present circumstances, I omit them to keep these forms simple.

There are one or more sources and receivers. In many cases, receivers are motivated to change behavior by sources' messages and social effects between receivers. From next section, these two factors are described in detail.

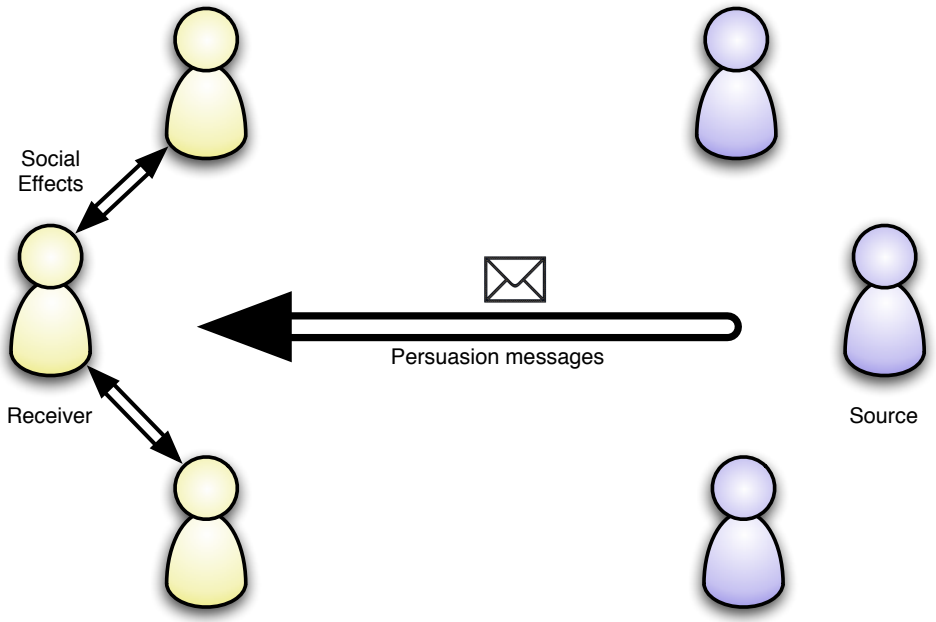

Figure 2.1: The relationship between sources and receivers

2.1.2 Attitude change by persuasion messages

This is the most classical and traditional form of attitude change [71, 70]. One person—*source*—asks a request or speaks an opinion, and the other person—the *receiver*—changes attitude or behavior (Figure 2.2.) This form has been heavily researched in a long time therefore nowadays we have learnt characteristics of the source and the receiver, and the persuasion techniques that can be applied. From now on, I describe key characteristics of these stakeholders and persuasion techniques that use persuasion messages.

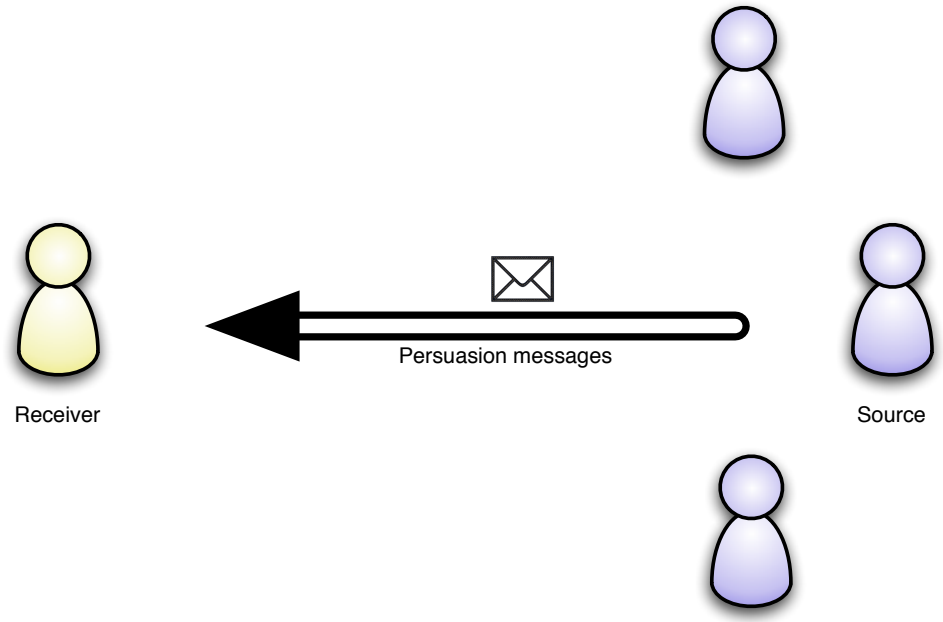

Figure 2.2: Attitude change by persuasion messages

Authority

Milgram experiment [61] is one of the most famous experiments to clarify the relationship between source and receiver. This experiment was conducted in 1961 just after the trial of Adolf Eichmann, a German Nazi war criminal who was *the architect of the Holocaust*, in order to answer the question: "Does he and his accomplices during the Holocaust merely obey the order from their senior officers?" In this experiment, subjects were asked to administer an (pseudo) electric shock to another person when the person made a mistake. The voltage was increased in 15 volt for each wrong answer. If at any time the subject indicated his desire to stop

the experiment, he was asked to continue by a *specialist in a white coat*. In his first set of experiments, 65 percent (26 out of 40) of the subjects administered the final massive 450-volt electric shock. One of the leading explanations for this result is *the authority of the source*, —specialist in a white coat, in this case— which means that the millions of accomplices were merely following orders, despite violating their deepest moral beliefs. His subsequent research [62] showed that the authority as shown by title of the researcher or the attributes of the researcher carried the compliance.

Slater et al. reported that this was also effective in an immersive virtual experiment [79]. In this experiment, a (female) virtual human displayed on a large screen was introduced for the *victim* instead of the real human voice. In spite of the fact that all participants knew for sure that neither the *woman* nor the electric shocks were real, they who saw and heard her tended to respond to the situation at the subjective, behavioral and physiological levels as if it were real.

Friendliness, Liking

As we have understood it intuitively, people are inclined to listen to friends than strangers [15]. The source who brings a sense of affinity effects the compliance of a receiver. Kaptein et al. reported that simple social cues such as praise encourage people to perceive friendliness of a virtual source [46].

Repetition

Repetition such as multiple exposures to the same source over time increases compliance [53]. This is one of the most simple persuasion techniques. One of the examples is well observed during election campaign in Japan. Most candidates blast their own names from their noisy sound trucks.

Reciprocity

People feel obligated to return a favor, and respond to a negative action with another negative action [15]. Naturally, these reciprocal actions are important to maintain our social norms. Behavioral economists have demonstrated that the reciprocal actions increase the rate of contribution to the public good in social situations [29].

In the field of game theory, there are some similar strategies. For example,

Komorita et al. reported that the tit-for-tat strategy (the strategy of reciprocation is the foundation of the tit-for-tat strategy) was found to be most effective in computer simulation studies of the prisoner's dilemma conducted by Axelrod [3]. Human might have mastered these strategies empirically.

The number of sources

The absolute number of sources who make requests influences compliance. This is a kind of social influence. This can lead to conformity of large groups of individuals in either correct or mistaken choices.

Besides, the large number of sources has another effect. The variety of persuasion messages makes receivers comply with the sources. Second opinion is a good example. A patient gets a different point of view about his/her serious illness by visiting more than one physician. If many physicians' plans are similar, the patient can believes what the physician in charge says.

Education

Human have tried encouraging others to change their behavior since ancient times. Parenting such as instilling good manners and raising children not to become picky eaters are typical examples of the most ancient methods to shape children's behavior. Moreover education itself is a part of persuasion depending on a perspective. Children learn social ethics and right norm by obtaining an adequate knowledge of daily lives. According to elaboration likelihood model (See Section 2.3.1), relevant knowledge about the persuasion message topic has strong power to change behavior via the central route.

Mimicry

Chartrand et al. reported that the *chameleon effect* refers to nonconscious mimicry of the postures, mannerisms, facial expressions, and other behaviors of one's interaction partners, such that one's behavior passively and unintentionally changes to match that of others in one's current social environment [10]. Kaptein et al. reported that the mimicry used by an artificial social agent enhances the perceived intelligence of the robot [46].

Operant conditioning

Behavioral psychology is a discipline dealing with the relationship between behavior and consequences, which was formulated by Skinner [78]. It posits that the form and frequency of behavior can be affected by controlling the consequences. This is called operant conditioning [25].

There are mainly two tools of operant conditioning, *reinforcement* and *punishment*. These tools are either positive or negative. In this sense, positive means delivering following a response and negative means withdrawing following a response. Reinforcement is a consequence that causes a behavior to occur with greater frequency. Punishment is a consequence that causes a behavior to occur with less frequency. Thus this creates a total of four basic consequences as follows:

Positive reinforcement This consequence occurs when a behavior is followed by a favorable stimulus. This is commonly recognized as reinforcement.

Negative reinforcement This consequence occurs when a behavior is followed by the removal of an aversive stimulus. This is commonly recognized as escape.

Positive punishment This consequence occurs when a behavior is followed by an aversive stimulus. This is commonly recognized as punishment.

Negative punishment This consequence occurs when a behavior is followed by the removal of a favorable stimulus. This is commonly recognized as penalty.

By using these consequences appropriately, a source can modify a receiver's behavior. One of the strong points to use operant conditioning is that the receiver does not noticed that his/her behavior is conditioned and the presence of the source. Thus operant conditioning is applied to autism education. Generally more immediate consequence (feedback) will be more effective than less immediate consequence.

Goal setting theory

Setting a goal has a strong persuasive effect to encourage desirable behavior. When a user defines an explicit goal, s/he pays an attention and makes an effect for encouraging desirable behavior. For example, tight deadlines lead to more rapid work pace than loose deadline in a student's lab work [55].

Midden et al. [60] discusses the use of goal-setting in persuasive applications, and they reported that the effect is very strong for persuading environmentally sustainable behavior. A large number of existing persuasive applications use goals as a persuasive technique. The applications give rewards when users meet the goals for increasing their motivation. For example, *UbiFit Garden* [16] is a mobile, persuasive application to encourage users to maintain the desirable level of their physical activity in everyday life. The application shows attractive pictures on a display when the user reaches a certain goal. Gasser et al. [37] also proposed an application that requires the user to meet a goal, and it gives a positive feedback when s/he meets the goal, but a negative feedback is returned if the goal is not met.

Cognitive dissonance

Festinger proposed a theory that inconsistency among elements in one's cognitive system produces dissonance [32]. People have a motivation to reduce the dissonance. In other words, attitude change is motivated by the uncomfortable feelings that result once individuals have attributed their arousal to a dissonant action [19].

One famous example is a heavy smoker's dissonance. When the smoker recognizes the risk of smoking, following two recognitions produce dissonance.

1. I smoke full time.
2. Smoking increases the risk of developing lung cancer.

In order to reduce the dissonance, s/he is going to annul the inconsistency. There are two options. First option is changing the former recognition, the most logical way.

1. *I try to quit smoking.*
2. Smoking increases the risk of developing lung cancer.

However, most heavy smokers who want to quit cannot quit smoking because it is associated with distress. Thus some of them add other recognitions.

1. I smoke full time.

2. Smoking increases the risk of developing lung cancer.

3. *Some smokers live long.*

4. *The odds are far greater that I will die of a traffic accident than of lung cancer.*

Economic incentive

Needless to say, economic incentive is one of the most powerful incentives to change human behavior. Credit card reward program is generally designed for encouraging consumption. The widespread use of digital money using near-field communication (NFC) shortens the transaction time and prevents miscalculation at cash registers by providing consumers with airline miles or cash-back [56].

From elaboration likelihood model's point of view, however, this behavior change is conducted via *peripheral* route. Because their behavior are modified by the power of money, they do not change their attitudes easily. Once the supply of money is stopped, their behavior are turned back in many cases.

2.1.3 Attitude change by social effects between receivers

In this type, social effects between receivers encourage attitude change (Figure 2.3.) One of the famous examples is teaching in a classroom. One teacher gives a lecture at a class for ethical training for many pupils. Though it stands to reason that students are intended to comply with *friendly* teacher of great *authority* who takes care of the students kindly as we explained in Section 2.1.2, there are other characteristics of sources and receivers for better persuasion.

Social proof

One of the frequently researched social effects is social proof, also known as informational social influence. Conforming behavior is the desire not to act against group consensus, colloquially known as peer pressure [2]. Each receiver tends to behave similarly to the other receivers in a group, even if doing so goes against the receiver's own judgment. This effect is well observed in collectivist societies [42].

There is a side effect. When other people are also present, individuals do not offer help in an emergency situation [22]. This phenomenon is called bystander effect. When an emergency situation occurs, bystanders look at other people to see if they think that it is necessary to intervene. Since every people do the same,

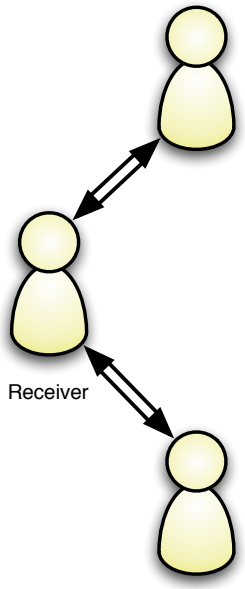

Figure 2.3: Attitude change by social effects between receivers

wait-and-see attitude, they conclude that help is not needed. This is especially true when the incident occurs in a busy area where lots of people are around.

From these examples, researchers have known that it is difficult for a receiver to break common practice in his/her neck of the woods.

Dynamic social impact

Latané proposed a dynamic theory of social impact [52]. According to the theory, people are more influenced by their closest neighbors, and so clusters of group members with similar opinions emerge in the group. Over time the group members' opinions on other issues, even one that are not discussed in the group, converge, so that their opinions on a variety of matters are correlated [67].

Social facilitation

Social facilitation is the phenomenon where a person performs better at a task when someone else (e.g. a colleague or a supervisor) is watching [87]. This effect has been demonstrated in a variety of species. Gasser et al. [37] proposed a mobile lifestyle coaching application, intended to improve user's healthy behavior using social facilitation.

Social comparison

Social comparison is a theory of social psychology. This theory explains how individuals evaluate their own opinions and desires by comparing themselves to others [31]. People tend to compare themselves to the others especially when they are looking at the same goal. If another person's achievement is less than a user's achievement, the user has a feeling of superiority.

2.2 Applicability of Social Effects

From the description above, it might seem obvious that the both use of the persuasion messages and the social effects is the most powerful for attitude change. However, social effects cannot be adopted blindly. There are some preconditions and drawbacks.

2.2.1 Existence of a social group

As a matter of course, receiver is not affected by any social effects if there is no social group. Alcoholics Anonymous is an international mutual aid to stay sober and help other alcoholics achieve sobriety [75]. If a receiver finds such a social group, the group might work on the receivers for their attitude change. However the construction of such groups and the gathering many receivers require a lot of time and effort.

2.2.2 Social loafing

Social loafing occurs where people make less effort to achieve a goal when working in a group. When a group gets bigger, each individual person feels his/her responsibility smaller and more s/he is likely to be neglectful [48]. Therefore various ideas to keep out social loafing are important when applying social effects.

2.2.3 Negative feeling arising from comparison

When a user realizes that another person achieves more than the user, the user may feel a sense of humiliation. The feeling can be a driving force to change

behavior. However if the feeling is too strong, the user may depart from the group and perhaps may detest the target behavior itself.

2.3 Attitude Change Models

There have been many researches about the mechanism of attitude change. For the sake of effective persuasion, this section describes three representative attitude change models, *elaboration likelihood model*, *transtheoretical model*, and *ambient attitude change model*.

2.3.1 Elaboration likelihood model

The elaboration likelihood model (ELM) is a model of how attitudes are formed and changed introduced by Petty and Cacioppo [69, 70]. This model defines two routes to persuade people: the "central route," where a receiver considers an idea logically, and the "peripheral route," in which the receiver uses preexisting ideas and superficial qualities to be persuaded.

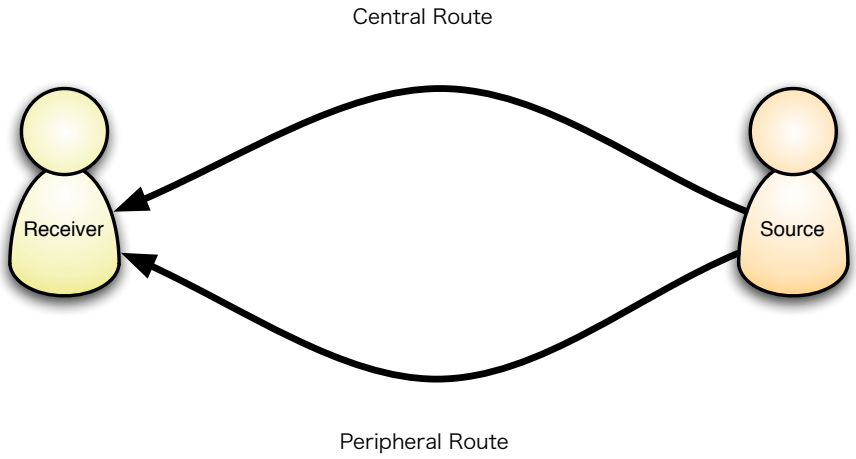

Figure 2.4: Elaboration likelihood model

There are two factors that most influence which route an receiver will take in a persuasive situation, *motivation* and *ability*. Both factors determine elaboration. When the receiver has a powerful *motivation* to think about the persuasive message topic and to enjoy thinking about the topic, and when s/he has sufficient *ability* to think about the topic (e.g. the presence or absence of time pressures or

distractions) or relevant knowledge needed to do that, the persuasion message is processed via the central route. If not the persuasion message is processed via the peripheral route.

Generally attitudes formed under high elaboration, the central route, are stronger than those formed under low elaboration. This means that this level of persuasion is stable over time and is less susceptible to decay or any type of counter-persuasion. Attitudes formed under low elaboration, the peripheral route, are more likely to cause a short-term attitude change.

2.3.2 Transtheoretical model

Transtheoretical model [72] is a model of intentional behavior change especially applied in health psychology, which was originated by Prochaska. According to the model, change is a process involving progress through a series of six stages [73] (Figure 2.5.)

Precontemplation is the stage in which people are not intending to take action in the foreseeable future, usually measured as the next 6 months.

Contemplation is the stage in which people are intending to change in the next 6 months.

Preparation is the stage in which people are intending to take action in the immediate future, usually measured as the next month.

Action is the stage in which people have made specific overt modifications in their life styles within the past 6 months.

Maintenance is the stage in which people are working to prevent relapse but they do not apply change processes as frequently as do people in action.

Termination is the stage in which individuals have zero temptation and 100% self-efficacy.

The model also defines ten processes of change, which are covert and overt activities that people use to progress through the stages. For movement from precontemplation to contemplation stage, the processes of *consciousness raising*, *dramatic relief* and *environmental reevaluation* are emphasized. For movement from contemplation to preparation, the process of *self reevaluation* is emphasized.

For movement from preparation to action, the process of *self liberation* is emphasized. For movement from action to maintenance, the processes of *contingency management*, *helping relationship*, *counterconditioning*, and *stimulus control* are emphasized.

The model describes the way to progress through the stages, for example, in early stages, people apply cognitive, affective, and evaluative processes. As people move toward maintenance or termination, they rely more on commitments, conditioning, contingencies, environmental controls, and support.

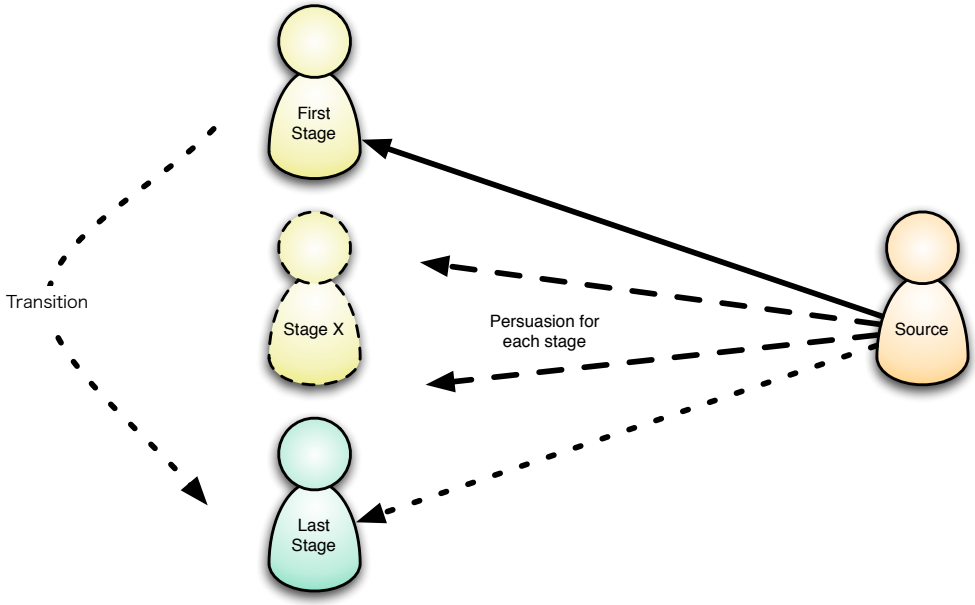

Figure 2.5: Transtheoretical model

2.3.3 Ambient persuasion model

This model was introduced by Kaptein et al [47]. It could be said that this model is a combination with elaboration likelihood model, transtheoretical model and operant conditioning (Figure 2.6). This model was designed especially for ambient persuasive applications.

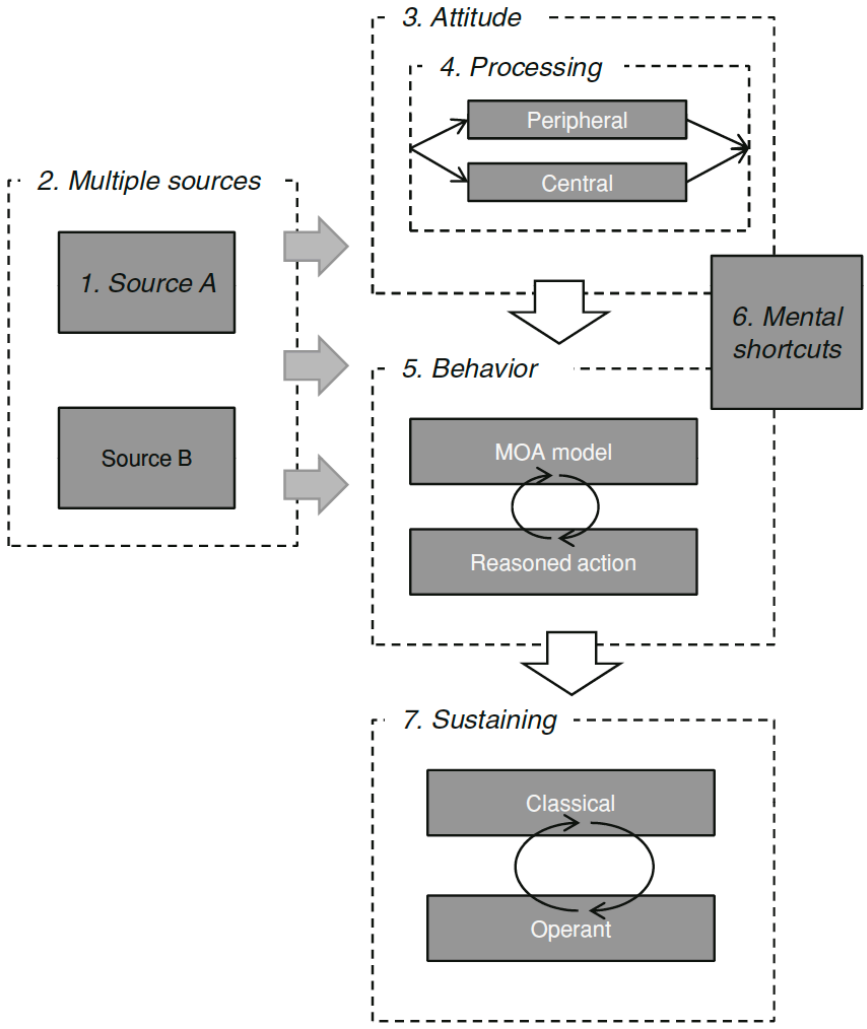

Figure 2.6: Ambient Persuasion Model cited from [47]

2.4 Prevention of Setbacks and Sustainment of the Desired Behavior

Transtheoretical model mentioned in Section 2.3.2 takes the prevention of setbacks and sustainment of the desired behavior into consideration. A source encourages a receiver to move to a next stage through appropriate processes defined in the model. This prevents receiver from setbacks.

Moreover the choice of appropriate processes sustains the receiver's desired behavior. As I mentioned in Section 2.3.2, the processes of *contingency management*, *helping relationship*, *counterconditioning*, and *stimulus control* are emphasized for movement from action to maintenance stage. For example, in order to maintain healthy behavior, stimulus control process removes cues for unhealthy habits and adds prompts for healthier alternatives.

2.5 Summary

This chapter described three persuasion forms and characteristics of stakeholders, and introduced various persuasion techniques could be used in each form. However developers of life assist applications may not be able to design the applications from these information directly. Developers need some clues such as which form should be applied, which persuasion techniques could be applied to the applications, and so on. In the next chapter, I will introduce a framework for developing life assist applications.

Chapter 3

A Framework for Developing Software Always Beside Users

This chapter describes requirements and design of a framework for developing software always beside users. As I described in Chapter 2, one of the most important roles of life assist applications is persuading users for attitude change. However, most persuasion techniques in Chapter 2 were discovered and developed in pre-computer era, and for that reason, just learning these techniques is not enough to develop life assist applications because there is no clue to apply such techniques to the applications. Besides, all of those techniques are not suited for every life assist applications.

First, in this chapter, I describe the advantages and differences of attitude change using computers and prevention of setbacks using computers. Then I derive design issues for developing life assist applications. After that, I introduce three existing guidelines for persuasive applications and describe those characteristics and drawbacks. Based on the characteristics and drawbacks, I introduce a framework for developing life assist applications.

3.1 Attitude Change Using Computers

According to Fogg, persuasion that uses computers has a number of advantages. First, computers are more persistent than human being. Second, computers offer greater anonymity. Third, computers manage huge volumes of data. Fourth, computers use many modalities to influence. Fifth, computers scale easily, and Sixth,

computers go where human cannot go or may not be welcome [33]. However, these are description of features, not description of how computers extend the existing theories. In fact, many theories mentioned in Section 2.1 were researched when computers were not so sophisticated. Therefore in many cases latest computers and informational environment have been able to extend those theories. This section describes how computers extend those theories.

3.1.1 Extension of persuasion techniques by computers

This section describes the advantages and differences of computers for attitude change and how computers extend existing techniques that were explained in Chapter 2.

Giving authority and credibility

Unlike human being, computers give same answers when they receive same input. If their algorithms do not contain errors, their answers are always correct. The consistent behavior of computers makes receivers feel the authority of the source, in this case, computers.

Substitution for expert by applying context awareness techniques

Usually sources are experts and in many cases they are rare because they have been trained for long time to perceive receiver's current attitude in order to choose appropriate persuasion techniques. Latest computers that are attached with several sensors are able to acquire various types of users' status or conditions, which is called context awareness [23]. By applying this technology, computers are able to make a decision about attitude change instead of experts.

Persuasion anytime and anywhere

Due to the rarity of sources, receivers have needed to go to specific locations such as hospitals for only a limited time. Persuasion using context awareness technique makes it possible for receivers not to go to such specific locations.

Moreover, receivers can be persuaded anytime and anywhere if the persuasive application runs on a mobile device. Mobile device can be always around its owner. When a source tries to give information to its receiver, this makes no sense to the receiver if the receiver is not there. Particularly with mobile phones, users

always keep them on themselves even if they do not care about their life assist applications running on it because mobile phones have many other features to be carried on at any time.

Casual and passive persuasion

In order to conduct operant conditioning mentioned in Section 2.1.2, sources need to observe receiver's operant behavior with extreme caution. While this is conducted especially for several skill trainings or behavior therapy, the receiver who is accompanied by sources every time cannot lead a regular life. Thus it is difficult to incorporate such operant conditioning into receiver's lifestyle. However, by using context awareness techniques and applying mobility feature of computers, the receiver's behavior are acquired silently and unobtrusively. This makes it possible for sources to use operant conditioning for casual purposes.

Adaptive persuasion

Modalities As Fogg mentioned in [33], often people are influenced not by information itself but by how it is presented. Nowadays, in order to persuade receivers, computers can present information as graphics, sound, video, and so on. Computers are able to choose appropriate modalities depending on content of persuasion and receiver's context.For example, SenSay, a context-aware mobile phone, detected the user ' s status by using a number of sensors which were mounted at various points on the body and the phone, and changed settings of the mobile phone dynamically such as turning the ringer off when the user is uninterruptible [77].

A matter of personal preference Everyone has his or her own thing. When a person purchases a piece of furniture, she may take into account her taste such as color and shape as well as size and price. This is a matter of personal preference. This can be applied to computers [30, 41, 26]. For example, mobile phone manufacturers have increased the variety of color in each device for this purpose, and such mobile phones allow those users to customize those user interfaces and to change ringtones after purchase. Customizing feature improves the degree of liking for the sources. User has a personal attachment to the application that fit comfortably in hand. Dillahunt et al. reported that emotional attachment motivated behavior change [24].

Besides, Ebisui et al. emphasized that the customization feature of persuasive applications keep users from getting bored [26].

Formation of social groups

As I mentioned in Section 2.2, if there is no social group, receiver is not affected by any social effects. However, latest computers make it possible for them to interact with more than one person simultaneously by using network capability like individuals found a way to talk someone in a distance when the telephone was invented. As we mentioned in Section 2.1.3, according to the dynamic social impact theory, people are more influenced by their closest neighbors. However network capability has a power to reverse the major premise, the spatial limitation. Computers are able to form virtual groups.

Cummings et al. reported that the Internet is less effective than other means of forming and sustaining strong social relationships. The consequences of using the e-mail for social relations depended not only on the quality of the relationships sustained using it, but on opportunity costs as well [20]. However times have changed. There have been invented many types of online media to form social relationships such as social networking systems and Twitter. These technologies would cover the shortcomings of e-mail. Cummings et al. also reported that people who have few acquaintances in the same situation in the real world such as the hard of hearing form strong online communities [21].

Visualization of unnoticed social effects

Needless to say, social effects are invisible. Thus even if a receiver gets tossed in a group, perhaps s/he might not notice social effects around him/her. Computers make them aware that the social effects exist by using various output devices including displays by visualizing those effects.

3.2 Types of Attitude Change Using Computers

Though I have introduced persuasion forms in Section 2.1, those forms should be adjust especially for computers for developers of life assist applications. One of the biggest differences to use computers is that each receiver interacts with computers, not sources directly. In this section, I introduce two extended persuasion

forms using computers.

3.2.1 Attitude change by persuasion messages using computers

This form is corresponding to the former type: *Attitude change by persuasion messages* in Section 2.1. In this case, applications need to change users' behavior by applying appropriate persuasion techniques. As I mentioned in the section, the absolute number of sources making a request influences compliance. However, there is no other big difference in these types because the receiver is persuaded by one computer in either type. In either type, one computer collects all persuasion messages and provides a receiver all at once. In this form, computer works as an aggregator (Figure 3.1).

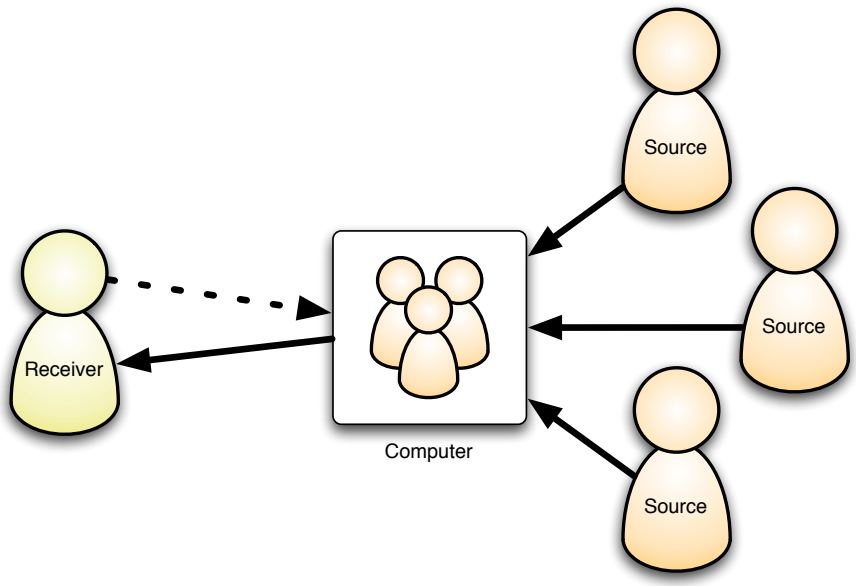

Figure 3.1: Attitude change by persuasion messages using computers

3.2.2 Attitude change by social effects between receivers using computers

This form is corresponding to the latter type: *Attitude change by social effects between receivers* described in Section 2.1. This means that this form of life assist applications uses social effects. In this case, applications need to form a group and visualize unnoticed social effects.

As I mentioned in Section 3.1.1, the Internet is less effective than other means of forming and sustaining strong social relationships. So I define two types, using real-world social relationships or not. In former case, two or more receivers share one computer. They can communicate with each other in the real world. This case is fit into family, ambient shared display on a street and so on (Figure 3.2). In latter case, each receiver has his/her own computer. They are asunder and interact with each other using network communication through the computers (Figure 3.3).

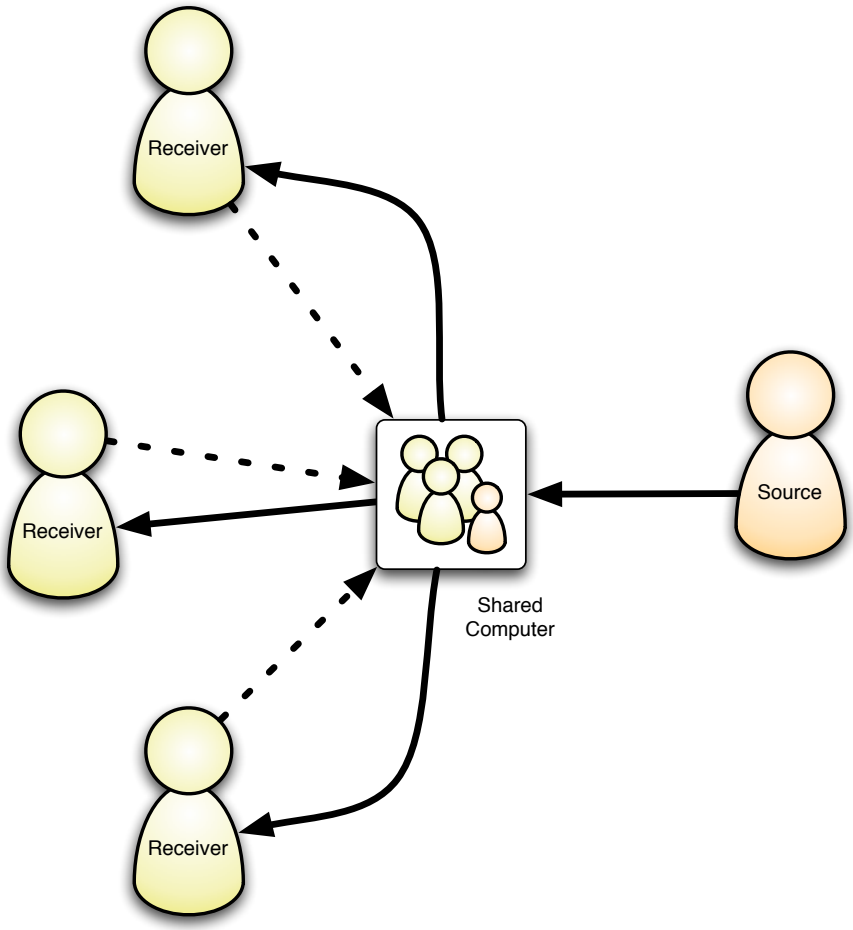

Figure 3.2: Multiple receivers share one computer

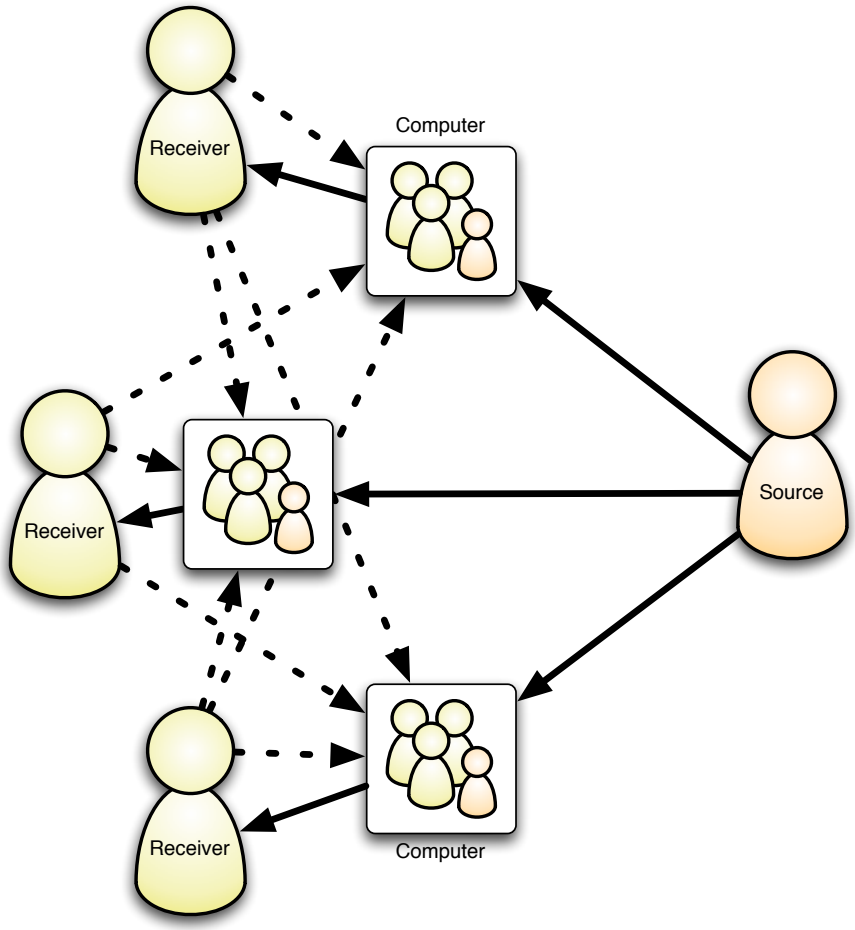

Figure 3.3: Each receiver owns a computer

3.3 Design Issues for Framework for Life Assist Applications

While I have introduced persuasion forms using computers and persuasion techniques, it is still difficult for developers to apply these knowledge for building applications because design and implementation of the application is determined by the target behavior. This means that persuasion techniques that are used for the application are determined by the behavior.

Moreover, as I mentioned in Section 1.1.2, life assist applications need to encourage users in three stages, *making use*, *attitude change*, and *continuous use*. Thus the framework provides the way to encourage users in each stage.

In order for developers to build life assist applications easier, the following design issues need to be addressed.

Making receivers use applications

It is extremely hard for developers to make passive receivers use their applications. These applications might be unnoticed or ignored. The framework needs to provide how to make receivers use the applications.

Attitude Change

Selection of appropriate persuasion techniques Needless to say, when a developer decides to build a life assist application, s/he needs to make sure of the target behavior. Persuasion techniques that are used in the application must be determined by the target behavior. Developers need a principle or guideline that indicates usable persuasion techniques depending on characteristics of the target behavior.

Presentation of example implementations As I mentioned in the beginning of this chapter, persuasion techniques mentioned in Chapter 2 were discovered and developed in pre-computer era. Developers of life assist applications need some examples how to apply these techniques into computers.

Continuous Use

Guidelines for preventing setbacks and sustaining desired behavior From the nature of life assist applications, those applications should be used over a long period without setbacks. Developers need a guideline to make users use the applications long time.

Referenced attitude change model

This framework follows the model that combines elaboration likelihood model and transtheoretical model for the reference attitude change model.

3.4 Related work

In this section, I introduce three existing guidelines or design strategies for persuasive applications and point out what these guidelines lack in terms of a framework for developing life assist applications in light of the design issues mentioned above.

3.4.1 Behavior Wizard

Fogg and Hreha presented a method for matching target behaviors with solutions for achieving those behaviors called Behavior Wizard [34]. This method classified behavior change targets into 15 types (Table 3.1).

The *Behavior Grid* is formed two axes, "Flavor" for the horizontal axis, and "Duration" for the vertical axis. There are five flavors: Green, Blue, Purple, Gray, and Black. Green behavior means doing new unfamiliar behavior. Blue behavior means doing familiar behavior. Purple behavior means increasing behavior. Gray behavior means decreasing behavior. Black behavior means stopping behavior. Also, there are three durations: Dot, Span, and Path. Dot behavior is a behavior that is done one time. Span behavior has specific duration. Path behavior is done from now on, a permanent change. By using this grid, users are able to know the characteristics of the target behavior change.

As Fogg et al. mentioned, the grid might make it possible for users to think clearly about the behavior change that interests them. However this wizard lacks mappings between each cell and usable implementation techniques. For example,

Table 3.1: Fogg's Behavior Grid cited from [34]. The items in italics are sample behaviors, all related to eco-friendly actions.

	Green behavior Do new behavior, one that is unfamiliar	**Blue** behavior Do familiar behavior	**Purple** behavior Increase behavior intensity or duration	**Gray** behavior Decrease behavior intensity or duration	**Black** behavior Stop doing a behavior
Dot behavior is done one-time	**GreenDot** Do new behavior one time *Install solar panels on house*	**BlueDot** Do familiar behavior one time *Tell a friend about eco-friendly soap*	**PurpleDot** Increase behavior one time *Plant more trees & local plants today*	**GrayDot** Decrease behavior one time *Buy fewer bottles of water now*	**BlackDot** Stop doing a behavior one time *Turn off space heater for tonight*
Span behavior has specific duration, such as 40 days	**GreenSpan** Do new behavior for a period of time *Carpool to work for three weeks*	**BlueSpan** Do familiar behavior for a period of time *Bike to work for two months*	**PurpleSpan** Increase behavior for a period of time *Take public bus for one month*	**GraySpan** Decrease behavior for a period of time *Take shorter showers this week*	**BlackSpan** Stop a behavior for a period of time *Don't water lawn during summer*
Path behavior is done from now on, a permanent change	**GreenPath** Do new behavior from now on *Start growing own vegetables*	**BluePath** Do familiar behavior from now on *Turn off lights when leaving room*	**PurplePath** Increase behavior from now on *Purchase more local produce*	**GrayPath** Decrease behavior from now on *Eat less meat from now on*	**BlackPath** Stop a behavior from now on *Never litter again*

the Wizard offers following information to encourage people to do "GreenPath" behavior.

> *We focus on the unique aspect of Green Path Behaviors: Getting people to commit to a lifelong change.*
>
> *As with the 14 other behavior change types. Green Path Behaviors are the result of three elements: Motivation, Ability, and Triggers. As the Fogg Behavior Model describes, you must Trigger the behavior when the person is both Motivated and Able to perform it. The specific steps*
>
> 1. *Boost motivation (if needed)*
> 2. *Enhance ability by making the commitment act simple*
> 3. *Issue the trigger when #1 and #2 are in optimal states.*

There is no concrete description about its implementation issues, and implementation issues and persuasion techniques could not be separated into the 15 cells. In short, this wizard does not explain how the suggested cell should be

transformed into software requirements and further implementations. This classification is not related to the differences of implementation or design. This means that developers are not fully guided to build their desirable persuasive applications.

3.4.2 Persuasive Systems Design Model

Kukkonen and Harjumaa proposed a model for persuasive systems design named P.S.D. model [68]. They defined a generic path that consists of three steps in persuasive system development. Their claim is that developers first need to understand key issues behind persuasive systems in the first step. Then developers need to analyze persuasion context and to select appropriate persuasive design principles. After that developers have to define requirements for software qualities, and then they implement software (Figure 3.4.)

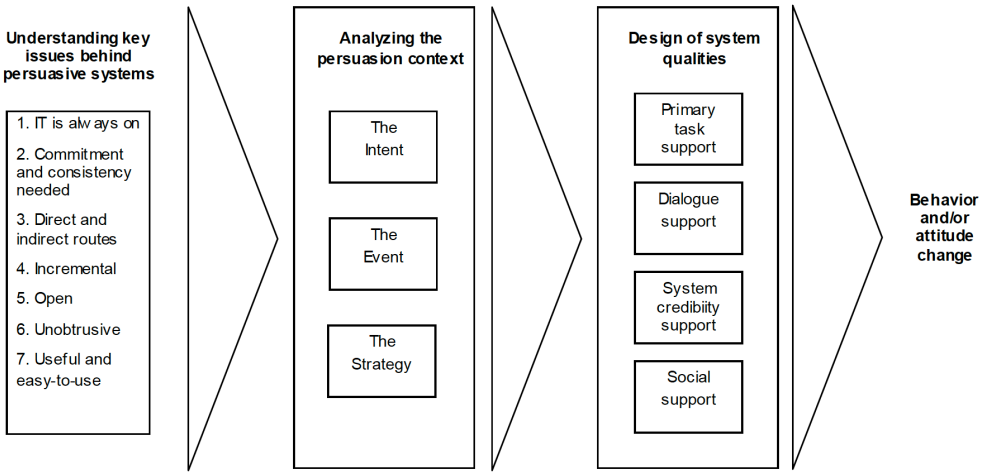

Figure 3.4: Kukkonen's P.S.D. model cited from [68]

The authors introduced seven postulates that relate to how developers see the users, persuasion strategies, and system features that can be used in the first step. These postulates describe the characteristics of information technology and persuasion using the technology, which are similar to the description in Section 3.2. These postulates seem to be applied to every persuasive system.

In the second step, the authors claim that developers need to analyze persuasion context as follows.

1. *Developers confirm what kind of behavior they want to change.*
2. *Developers need to know what kinds of user contexts could be used.*
3. *Developers consider how to use these user contexts by using technology.*
4. *Developers decide which route should be used, direct or indirect route.*

Actually this analyzation process necessary to develop any persuasive applications, however, this is not so special. Even existing application developers have done same things.

The most valuable part for developers is the last step. They defined four categories for persuasive system design principles: *Primary Task Support, Dialogue Support, System Credibility Support,* and *Social Support*. Each category contains seven design principles, and each design principle describes example requirements and example implementation. For example, Rewards Principle is described as follows,

Reward Principle *Systems that reward target behaviors may have great persuasive powers.*

Example Requirement *System should provide virtual rewards for users in order to give credit for performing the target behavior.*

Example implementation *Heart rate monitor gives users a virtual trophy if they follow their fitness program.*

Social Comparison Principle is like this,

Social comparison Principle *System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others.*

Example Requirement *System should provide means for comparing performance with the performance of other users.*

Example implementation *Users can share and compare information related to their physical health and smoking behavior via instant messaging application.*

While dialogue support and social support are especially useful for developers to review the development process of persuasive applications, this model does not provide any information how the developers choose appropriate design principles. Unlike general design guidelines such as Nielsen's ten usability heuristics [63, 66, 65, 64], every persuasive application cannot apply all of these design principles. What developers want to know is how to apply these principles, however this research only put a collection of heuristics and it have not answered this question from developers yet.

3.4.3 Consolvo's Theory-Driven Design Strategies

Consolvo et al. proposed theory-driven design strategies for persuasive applications used in everyday life [17]. Proposed strategies used psychological theories and prior work in order to extend a set of existing design goals. They cited Breakaway's four design heuristics [44] and extended them as follows.

Abstract and Reflective *Use data abstraction to display information to encourage the user to reflect on his/her behaviors.*

Unobtrusive *Present and collect data in an unobtrusive manner.*

Public *Present and collect the data, which is personal in nature.*

Aesthetic *If the display and any accompanying devices function as a personal object(s) that may be used over time, they need to be inquisitive and sustain interest.*

Positive *Use positive reinforcement to encourage change.*

Controllable *When appropriate, permit the user to add to, edit, delete, and otherwise manipulate data so that it reflects the behaviors that s/he deems suitable.*

Trending / Historical *Provide reasonable and accessible information about the user's past behavior as it relates to his/her goals.*

Comprehensive *Account for the range of behaviors that contribute to the user's desired lifestyle.*

The second strategy, unobtrusive, is similar to my statements in Section 3.1.1. The sixth strategy, controllable, is similar to my statement also mentioned in Section 3.1.1. The first, a part of the second, fourth, seventh, and eighth strategies

are about presentation of persuasive applications. Developers need to keep these strategies in mind when designing presentation of the applications.

Consolvo et al. pointed out the importance to make a user use the persuasive application for long time in the fifth strategy. In order to sustain the user's interest, the application should not make his/her feel too bad. Fogg emphasized that positive punishment in operant conditioning should be avoided due to ethical reasons [33]. However, it is unavoidable for these kinds of feedback in persuasive applications because users have negative feelings when they feel not like the others (See dynamic social impact in Section 2.1.3). We have no guideline to know what kinds of feedbacks strike users as "negative" feedbacks. When a user neglects to do desirable behavior, of course we could design that an application does not offer "negative" feedback — for example, feedback unchanged. But the user still feels negative because s/he knows his/her neglect cause the feedback unchanged. Furthermore, giving negative feelings while training such as scolding is widely accepted in collectivist societies. Hofstede noted this is a typical characteristic of many collectivist countries [42]. In addition, Midden et al. reported that negative social feedback provided by an embodied agent, iCat, had the strongest persuasive effects [59] even though the experiments were conducted in an individualist country, Netherlands. Therefore I believe that persuasive applications should sustain user's interest by using another way.

Like Kukkonen's P.S.D. model, developers of persuasive applications need to understand these generic strategies to polish the qualities of the applications, however, these strategies does not answer the developers' question, how to choose appropriate strategies and how to apply these strategies.

3.5 Design

Framework for life assist applications needs to address the design issues mentioned in Section 3.3. In order to address the issues, this framework provides developers with following information.

1. The framework provides general heuristics to make users use the applications.
2. The framework suggests an appropriate persuasion form according to target behavior.

3. The framework classifies three life assist application types and provides suitable persuasion techniques for each style.

4. The framework provides general heuristics that prevent setbacks and sustain the desired behavior.

3.5.1 Making receivers use applications

This framework offers following heuristics to make receivers use life assist applications.

Attractive design

One of the most effective ways to make receivers use applications is to design them attractively. Even though a receiver does not care about the target behavior at first, s/he might want to use the application when his/her friend uses the application with relish. Besides, s/he might start the application if s/he noticed the application was easier to use than expected. Developers try to push forward the applications at market.

Running imperceptibly

Another way to make receivers use applications is weaving persuasion messages into other applications or an ambient intelligence environment. For example, if a developer weaves persuasion messages into an attractive video game, users might play the game unnoticed. Peekaboom is an entertaining web-based game that can help computers locate objects in images [82]. As you can imagine, adding annotations to images is a boring task for people. This application hides the task and weaves it into a game, and players are willing to play the game. Besides, by applying operant conditioning that mentioned in section 2.1.2, an application that utilizes ambient displays and context awareness techniques using sensors embedded in a environment can encourage users unnoticed to change behavior or attitude.

In this case, persuasion techniques used in the first stage and the second stage are same because there is no border between them.

3.5.2 Appropriate persuasion form

As I mentioned in Section 2.2, there are some drawbacks to applying social effects to applications while social effects are powerful to change receivers' behavior. Developers have to make sure of the applicability of social effects.

3.5.3 Attitude change

Life assist applications can be used in various scenes rather than existing persuasive applications. The framework classifies three types of life assist application in terms of the target behavior. First, this section describes common persuasion techniques that can be used every type, and then introduces the application types and persuasion techniques that can be used.

Common persuasion techniques using computers

As current persuasive applications have applied well-known persuasion techniques, there are many persuasion techniques that can be also applied to every life assist applications.

Feedback on receiver's condition According to goal setting theory mentioned in Section 2.1.2, being aware of receiver's own condition makes an effect for encouraging desirable behavior because s/he feels the impact of their own behavior and s/he confirms his/her behavior is correct. By using context awareness techniques, the applications are able to give feedback on receivers' condition to them.

Reduction, tunneling, and so on Fogg introduced some principles to change behavior in [33]. For example, reduction principle is that application should reduce bothersome and complex behavior into simple tasks such as simplified calorie counter using digital camera that promotes healthier eating [11].

Type A: Promoting desired behavior for public interest

When life assist applications are widely used and connected, there is a possibility that all of the users change their attitude together cohesively. However, usually receivers change their own behavior for their own sake. For example, a persuasion aiming to convince individuals to quit smoking persuades their behavior change by highlighting the benefits of good health. Most existing persuasive applications

have dealt with this type of target behavior. However, it is easily imagined that receivers are scarcely motivated for behavioral changes aiming at public benefits such as environmental protection. In this type, it is hard for persuasive applications to change receivers' behavior. One of the difficulties to change users behavior for this purpose is that it does not make any sense for a person to change his behavior if others do not act in concert. Generally resources shared by a number of unrelated persons tend to deteriorate quickly in a process, which is called the tragedy of the commons [40].

Use of social effects One of the current solutions of the tragedy of the commons is governmental regulation. For instance, introducing environmental tax is expected to reduce greenhouse gas emissions or waste of resources. Whatever the reason, developers of this type of life assist applications should adopt *dynamic social impact theory* and *social prool* mentioned in Section 2.1.3. In short, the developers have to form a virtual group that focuses on the target behavior.

As mentioned in Section 3.1.1, possible implementations are using networks for forming a virtual group and visualizing social effects to emphasize the effects.

Deterrent to bystander effect As I mentioned in Section 2.1.3, bystander effect is a side effect of social effect. If an application forms a virtual group where most people do not do the desired behavior, the receiver would not change their behavior or attitude. Thus the application has to prevent the bystander effect in the following ways for example.

- Visualizing pseudo receivers who do the desired behavior well. (see Social Facilitation mentioned in 2.1.3)
- Recalling the desired behavior by using display and so on at all times.
- Giving those receivers the competition by monitoring and sharing of the degree of attainment of the desired behavior. (see Social Comparison mentioned in 2.1.3)

Type B: Imparting knowledge about the target behavior

As elaboration likelihood model mentioned, the ability to think about the persuasion message or relevant knowledge needed to do the desired behavior is important for effective attitude change (Section 2.3.1). Many persuasive applications

encourage users to do relatively simple and obvious behavior such as exercise [54, 28, 36, 18, 16], and saving [45], which do not need to learn how to do the desired behavior.

On the contrary, there are other target behavior that the receivers do not know the effects and how to do the desired behavior before using the applications such as preventing global warming [35] and healthy eating [13]. In these cases, developers need to educate receivers somehow. For example, serious games [8] usually seek to effect behavior change by training, educating and altering the attitudes of players during game play. The assumption is that the altered state of mind translates to actual behavior after the game session is over. For instance, after playing ten 25-minute sessions of Squire's Quest at school, children reported increasing their fruit and vegetable consumption by one serving per day [5].

Educating There are many ways to impart knowledge. One of the simplest ways is that applications show the information. As mentioned above, serious games aim to change receivers' behavior and attitude by educating. Also there are some alternative ways.

- Even if applications cannot prepare enough information beforehand, the applications are able to enrich information by adopting the idea of *wisdom of crowds* [80].
- Even if applications cannot educate those users in proper manner, discloser of receivers' behavior creates an opportunity to advise each other on the desired behavior.

Type C: Promoting desired behavior unnoticed

One obstacle to frequent use of existing persuasions is botheration. Life assist applications using computers are able to encourage users to change behavior or attitude unnoticed. This makes is possible for users to receive persuasion messages in daily life.

Use of Context Awareness By applying context awareness techniques, a life assist application is able to run without any interaction with its receivers (Section 3.1.1). Moreover by using mobile devices, the application can run anytime and anywhere beside its users. In this case, the application is able to adopt operant

conditioning for attitude change with a minimum of fuss as mentioned in Section 2.1.2.

Weaving persuasion messages into other functions If applications need to interact with users, the applications have to assert themselves against the receivers. However the applications are still able to send persuasion messages by offering other functions to its users.

3.5.4 Continuous use of applications

This section discusses how to prevent setbacks and to sustain the desired behavior from three points of view, *Behaviorism*, *Motivational Theory*, and *heuristics derived from prior persuasive applications*.

Behaviorism

Habituation From behaviorism's point of view, *habituation* is a cause of the loss of interest in life assist applications. Habituation is a learning process to a decreased behavioral response to repeated stimuli [6]. There are factors that influence whether habituation occurs or not. According to Domjan [25], these factors are

- *Inter-stimulus interval* Amount of time that passes between one presentation of the stimulus and the next.
- *Stimulus duration* How long the stimulus lasts.

In order to prevent the habituation process, developers deliberate on following things.

- Applications should use many kinds of visualization and modals for a persuasion message.
- Applications should not send same persuasion message frequently.
- Applications should combine two or more stimuli.

Even if an application cannot prevent the habituation, the application should use reinforcers to encourage the target behavior as I mentioned in Section 2.1.2.

Motivational Theory

Mental satiation Mental satiation (psychical satiation) is a phenomena that a person loses intrinsic motivation during the repeated performance of an action [49]. One possible way to motivate changing behavior is adopting goal setting theory mentioned in Section 2.1.2. When an application defines an aggressive goal for its veteran users, those users would get a feeling of satisfaction after achieving the goal.

Heuristics

Needless to say, users have the power of life and death over life assist applications. Users can quit applications at any time they like.

Unobtrusiveness If an application's behavior is obtrusive for a user (e.g. asking him/her for inputting information too often, alarming noisy) , s/he may stop using the application immediately. Thus life assist applications should behave unobtrusively.

Customizability As I mentioned in Section 3.1.1, everyone has their own thing. If there is something a user does not like about an application, s/he may stop using the application. Thus life assist applications should have customizable functionality.

3.6 Overview of Case Studies

In Chapter 4 and Chapter 5, I will introduce two life assist application systems named *Ambient Lifestyle Feedback Systems* and *Social Effect Reflection Systems*. Ambient lifestyle feedback systems are "Type C", which encourage users to change behavior unnoticed. Social Effect Reflection Systems are systems that use social effects to change behavior. The six case studies are categorized as follows (Figure 3.5.)

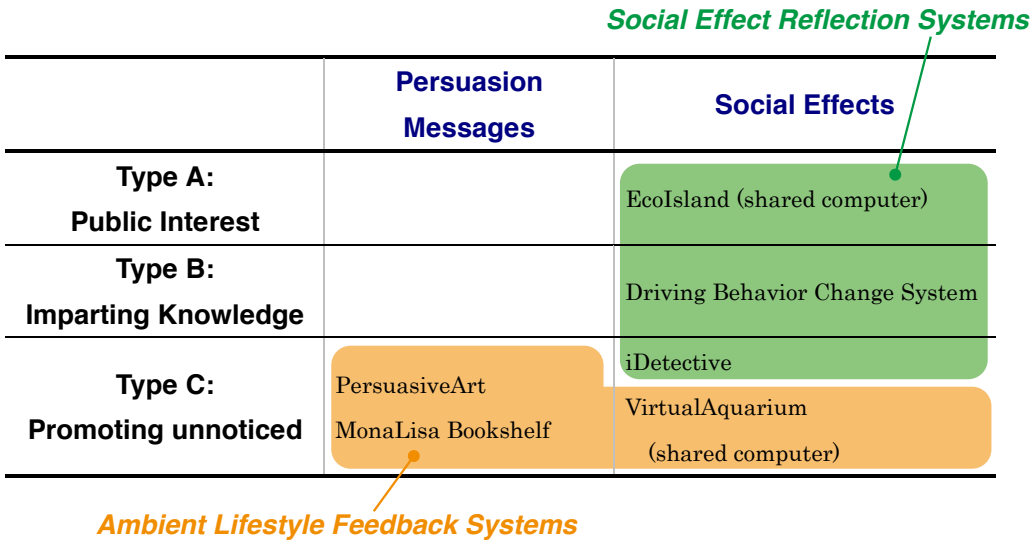

Figure 3.5: Categorization of six case studies

Chapter 4

Ambient Lifestyle Feedback Systems

Ambient lifestyle feedback systems aim to change behavior unbeknownst to those users (Section 3.5.3 Type C.) This chapter describes the concept and three case studies of *ambient lifestyle feedback systems*. These case studies are *Persuasive Art*, *Virtual Aquarium*, and *Mona Lisa Bookshelf*.

First, in this chapter, I describe the concept and design principles of the systems according to the framework. Then I introduce the three case studies. Each case study was designed to use different persuasion techniques in order to confirm the framework enhances the development of these applications.

4.1 Concept

Existing persuasive applications have been applied in many areas such as nutrition, health and energy consumption. However they suffer from drawbacks such as inaccurate self-reporting, burdens placed on the user. There are lot of things those applications request users to do for being persuaded such as inputting current physical situation, therefore those users cannot live daily lives without extreme caution in those applications.

Ambient lifestyle feedback systems are embedded computer systems designed to motivate changes in a person's lifestyle by reflecting an interpretation of targeted behavior back to the person. The systems acquire the person's current contexts by using context awareness techniques. The systems refers to elementary

behavioral psychology, operant conditioning mentioned in Section 2.1.2 to giving persuasion messages unnoticed. The systems change visualization on an ambient display responding to the person's behavior, which means that the systems generate the artificial consequences of the behavior. This concept is described as Figure 4.1.

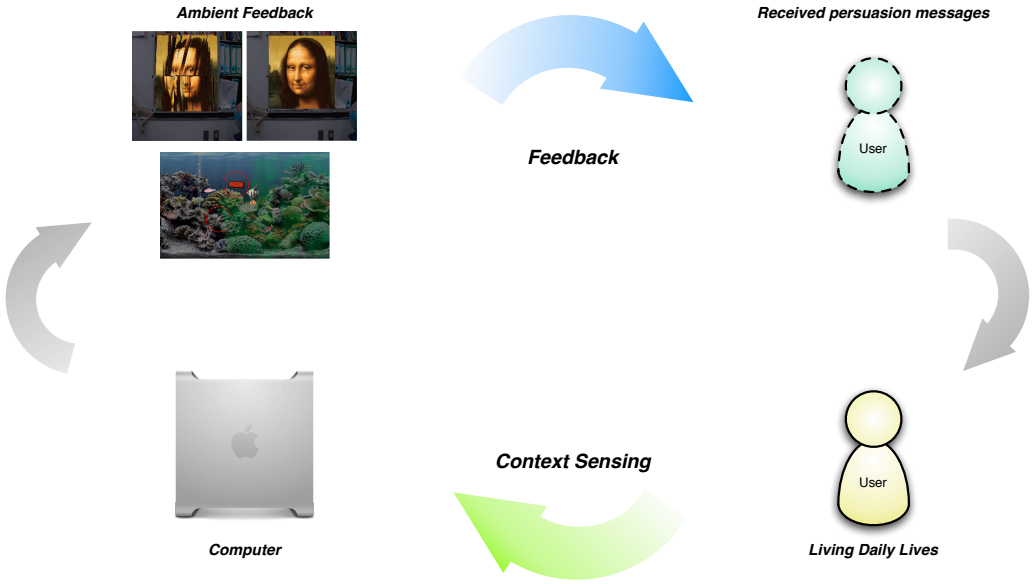

Figure 4.1: Ambient Lifestyle Feedback Systems Concept

4.1.1 Design principles

Passive observation

One of the key factors limiting the applicability of the earlier solutions to our intended purpose is that the various burdens they place on a user, either in the form of time use or effort. To avoid the burdens of self-reporting, the system should be able to passively observe the user's behavior.

To eliminate the need to set aside time or go to a special place for gaming sessions, the systems should be integrated with normal daily activities. Thus the first design principle is to use observations of the users' behavior as the system's input, as opposed to using keystrokes or some other proxy behavior. This also

facilitates the delivery immediate feedback, a key factor in the effectiveness of operant conditioning.

Emotional engagement

The fact that the feedback is delivered in a non-disruptive way must not mean that it ends up being irrelevant to the user. To effect a change in behavior in operant conditioning, we must be able to administer some sort of meaningful consequences to the user. We do not have means to effect changes in physical reality (such as delivering a sweet), so would it be possible to make the user care about changes in the internal state of a computer system? Computer games seem to be able to do this. Good games are able to provoke a range of emotional responses, from fun and satisfaction to guilt and discontent. By mimicking the techniques used in computer games, we should be able to build an emotionally engaging feedback system, allowing us to administer punishments and rewards without any physical resources. By "emotional engagement" we do not necessarily mean strong and deep emotional responses, but the simple kicks that make many games interesting and addictive.

Ambient feedback

To complete the integration of the system into the user's daily living environment, developers must also make sure that the output produced by the system is appropriate. The systems refer to Mark Weiser's concept of calm technology: technology that is able to leverage our peripheral perception to deliver information, as opposed to constantly demanding direct attention [84]. Ambient lifestyle feedback systems should be designed to blend into their environment and to be able to deliver information in the periphery. A loud or disruptive feedback system might even find itself thrown out of the house or workplace.

4.2 Persuasive Art: An Application that Encourages Users to Do Exercise

First case study is an application to encourage users to walk more. This application was designed for investigating how aesthetic expressions of ambient feedbacks encourage users to do more exercise. By introducing four different expres-

sion types, we recognized each characteristic.

Application type Needless to say, people know how to walk before using this application. Thus the application does not need to impart knowledge to walk. Also receivers are persuaded for their own sake. In this case, therefore, the *Type C: promoting desired behavior unnoticed* is chosen.

As suggested in Section 3.5.3, the application used context awareness techniques for attitude change.

Persuasion form Though we could adopt "using social effects" form, in order to investigate the effects of each expression, we adopted "persuasive messages" form.

4.2.1 Design

Decorating walls with pictures is common at home. Hanging a painting is a very important way to increase aesthetic feeling in our daily lives. Persuasive Art uses a painting to motivate a user to walk at least 8000 steps every day to keep his/her fit. The number of steps are monitored automatically and stored into a computer. The painting shows the feedback of the current status of the user's exercise in order to motivate him to maintain desirable habits.

Motivating people can be classified into two approaches. One is to make users aware of their current situation and the other is to enhance the user's willingness to change his habits. Motivating a change of habits can also be classified into two types. The positive expression style increases a user's positive emotion to motivate a change in the user's undesirable habits. The user feels happy when changing his/her undesirable habits even if the change is challenging and hard. Another type is the negative expression style. This promotes negative emotion to feel a sense of crisis that motivates to change the user's undesirable habits. For instance, if a user looks at him in a mirror and finds that he is significantly overweight, this may motivate him to do more exercise.

Persuasive Art offers the following four types of paintings as shown in Figure 4.2:

1. Landscape painting includes a tree that grows and withers.

2. Figure painting is the portrait of Mona Lisa.

3. Abstract painting has objects that change in size and complexity.

4. Still life painting contains a changing number and size of orbs in a bottle.

When using the landscape painting, growth of a tree in the painting is varied according to the users behavior. When the user maintains desirable habits, the tree will grow, but if he stops the desirable habits, the tree will get sick. The painting adopts the following metaphor. The increase of healthy activities makes the tree healthier, but the neglect of the exercise makes the tree sick. When using the figure painting, Mona Lisa gets older and younger according to the users behavior. The increase of healthy activities makes Mona Lisa younger, the neglect of the exercise makes Mona Lisa older. When using the abstract painting, the blue objects change in size and complexity according to users behavior. If the user maintains desirable habits, the objects "grow" significantly. When using the still life painting, the number and size of orbs in the bottle changes according to users behavior. Even if users do not maintain desirable habits enough, one orb is added into the bottle, but the size is small. If users do maintain desirable habits enough, one big orb is added. If users do not maintain at all, the bottle is cracked.

4.2.2 Implementation

Context Acquisition

In this application, the number of a user's steps was used as the operant behavior. The number of the steps were acquired by using a USB connected pedometer on the market manufactured by Omron (Figure 4.3.) Each participant wore the pedometer and was asked it to a computer every night. The computer imported the number of steps automatically and generated a visualization responding to the number.

Feedback

The four types of feedback images were generated responding to the number of steps by Adobe Flash.

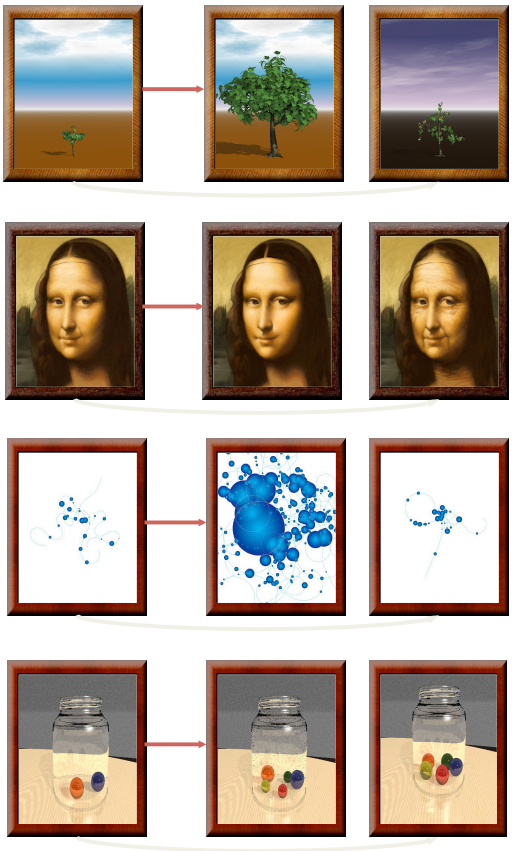

Figure 4.2: Four alternative virtual paintings

4.2.3 Experiments

Pilot study

To understand the effects of each painting, firstly we conducted a simple experiment. We hired 6 participants from our laboratory (age: 22 – 24) in 10 days. Participant's steps were counted by the system and they appraised those four types of paintings installed in the laboratory. In this experiment, any paintings did not increase users steps significantly though the participants became more conscious of their exercises (Figure 4.4.) It was striking that all participants claimed that they felt close to the tree expression. Most of them said this was because 1) they were connected emotionally to the tree and wanted to mature it, and 2) they were wracked by guilt when the tree died. Of course the Mona Lisa also represented empathetically, that lacked "unexpected" expression like growth of tree (Figure

Figure 4.3: Omrom's pedometer: Walking style HJ-710IT

4.5.) This could be explained by the effect of habituation mentioned in Section 3.5.4. From these impressions, important factor is applying empathetic expressions such as animate things.

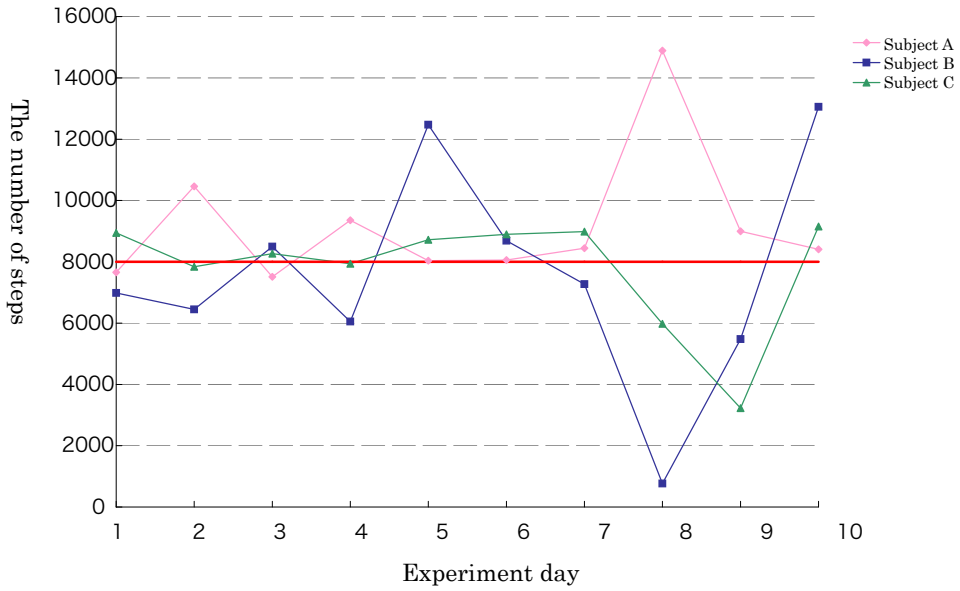

Figure 4.4: Result of pilot study

Experiment

Secondly, we conducted another experiment to investigate the effects of positive and negative expressions. We hired 8 participants (M:4, F:4, all are our university students not belonging to our laboratory) in 3 weeks. Just like the former experiment, each participant's steps were counted by the system. In this experiment,

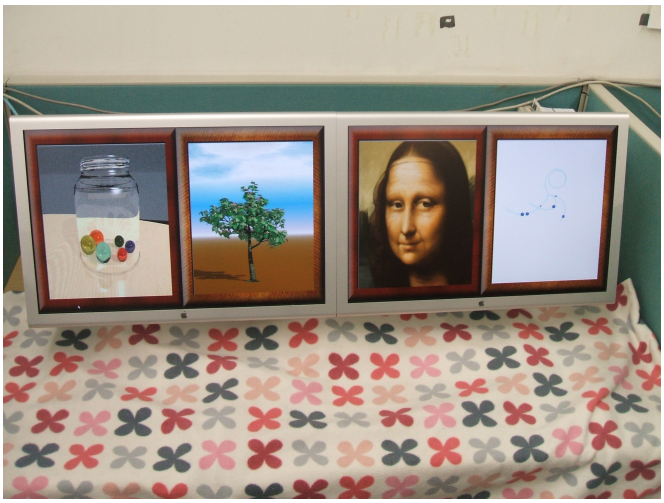

Figure 4.5: Experiment Setup

one half of the participants appraised positive expression without any negative expression, other half of the participants appraised positive and negative expressions. In the former case, the tree just grew when participants did well. In the latter case, the tree grew when participants did walk well and got morbid when participants did not walk well. In this experiment, there were no significant differences in numbers of steps.

4.2.4 Findings

When we interviewed the latter participants how they felt the negative expression, 5 out of 6 participants commented they felt that they must walk more. However the negative expression did not translate into the actual acts. The other 1 participant emphasized that the painted tree looked revolting and she failed to continue the experiment. This result shows that receivers may not only quit using such services, but also change their everyday behavior involuntarily to avoid the unpleasant experiences because it is quite hard for them to quit the services which are embedded or hidden in the environment if the responses are unpleasant for the users. Thus it is extremely important to choose proper expression carefully.

The pilot study showed that animate (= “live”) thing is an appropriate expressions for motivating users because users are connected emotionally to the thing. While any visual representation can be used to relay information, shapes that

come with pre-attached meanings (e.g. "a tree withering is a negative") are more capable of evoking emotional engagement. Tan and Cheok showed that a real creature is found to arouse more empathy than a visual creature in [12]. However, especially in Japan, people feel empathy also to virtual creatures. Fujinami presented that Japanese users feel empathy for even virtual creatures represented as abstract symbols in [36]. We sometimes assign different meanings to a real creature and a virtual creature because we know the differences between them. We need to investigate the effect of virtual creatures as a persuasive expressions in future case studies.

4.3 Virtual Aquarium: An Application that Encourages Users to Brushing Teeth Properly

Virtual Aquarium shown in Figure 4.6 has the objective of improving users dental hygiene by promoting correct toothbrushing practices.

Application type This application persuades users to brush their teeth not to skip. Thus application does not need to impart knowledge to brush. Also receivers are persuaded for their own sake. In this case, therefore, *Type C: promoting desired behavior unnoticed* is chosen.

Persuasion form If a family member notices that another member skip brushing, perhaps social facilitation (mentioned in Section 2.1.3) might come up to the surface. Thus we adopted "using social effects" form as well as "persuasion messages'" form.

This prototype uses 2 types of feedbacks: 1) dancing fish and a moving scrub as immediate feedbacks, and 2) death of fish and hatch of fish as accumulated feedbacks. This study was designed to investigate whether both these 2 types of feedbacks worked effectively.

4.3.1 Design

This application was set up in the lavatory where it turns a mirror into a simulated aquarium. Fish living in the aquarium are affected by the users toothbrushing

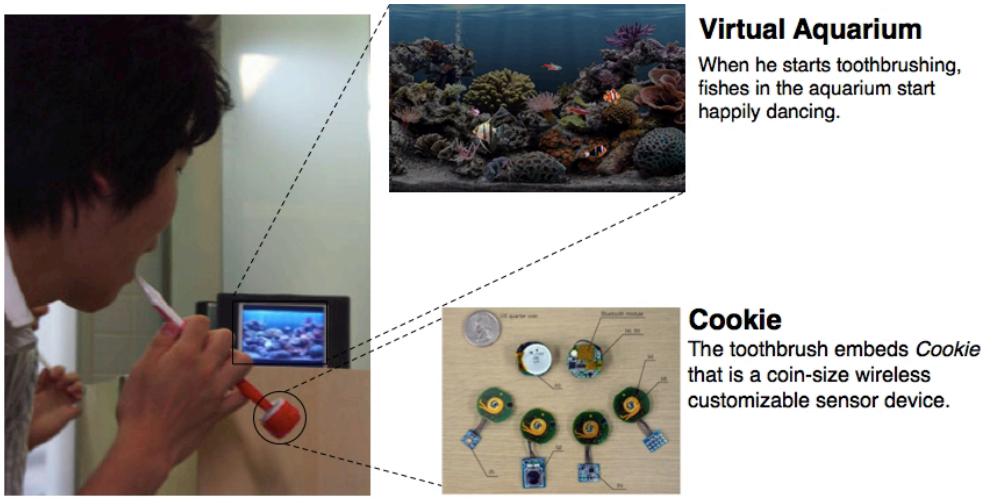

Figure 4.6: Virtual Aquarium System

activities. If users brush their teeth properly, the fish prosper and procreate. If not, they are weakened and may even perish.

In this prototype of the system, the ideal behavior was defined as follows:

1. Users should brush their teeth at least twice per day.
2. One session should involve at least three minutes of brushing.
3. Brushing should involve patterns that ensure the teeth are properly cleaned.

User behavior was compared to this ideal and translated to feedback as described below.

When a user begins to brush her teeth, a scrub inside the aquarium starts cleaning algae off the aquarium wall. At the same time, a set of fish associated with the user starts moving in the aquarium in a playful manner. When the user has brushed for a sufficient time, the scrub finishes cleaning and the fish-dance turns to a more elegant pattern. When the user finishes brushing, the fish end their dance and resume their normal activities. Both the activity of the fish and the movement of the scrub are designed in such a way as to give the user hints regarding the correct method of toothbrushing. The right picture in Figure 4.7 shows a scene from the aquarium during brushing. However, if a user does not brush his/her teeth sufficiently, the aquarium becomes dirty, and the fish in the aquarium become sick.

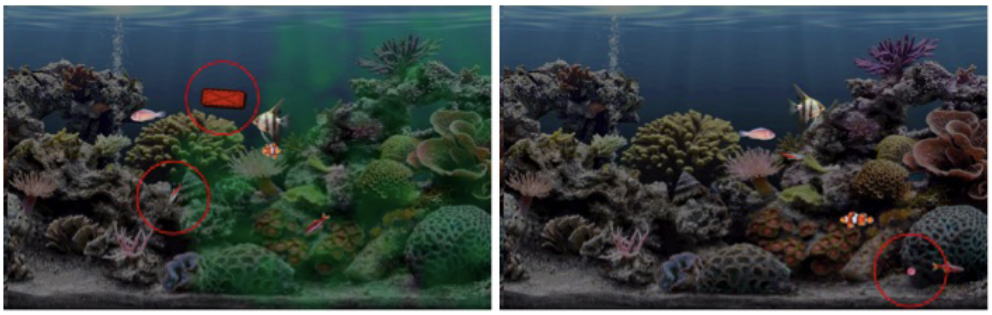

Figure 4.7: Images of Virtual Aquarium

The health of the fish is visibly affected by how clean the aquarium is. If a user neglects to brush her teeth, some fish fall ill and may even die. In contrast, faithful brushing may result in the fish laying eggs (The right picture in Figure 4.7). At first the eggs are not very likely to hatch. If the user continues to brush consistently for a number of days in a row, the incubation ratio increases. This way, the accumulated feedback gives clues to the correct behavior and attempts to maintain motivation over a period of time.

4.3.2 Implementation

Context Acquisition

In this application, the user's brushing activity was detected using *Cookie*, a wireless coin-size sensor module [51] (Figure 4.8). A cookie is attached with several kinds of sensors such as an acceleration sensor, a pressure sensor, geomagnetic sensor and so on. This application used an 3-axis acceleration sensor to detect the brushing activity.

Cookie was attached to each toothbrush in a household. Since toothbrushes are usually not shared and each Cookie has a unique identification number, we were able to infer which user was using the application at a given time. The Bluetooh connection, context acquisition and events notification mechanisms were managed by a context acquisition framework called Prottoy [50]. Toothbrushing patterns were recognized by analyzing the acceleration data.

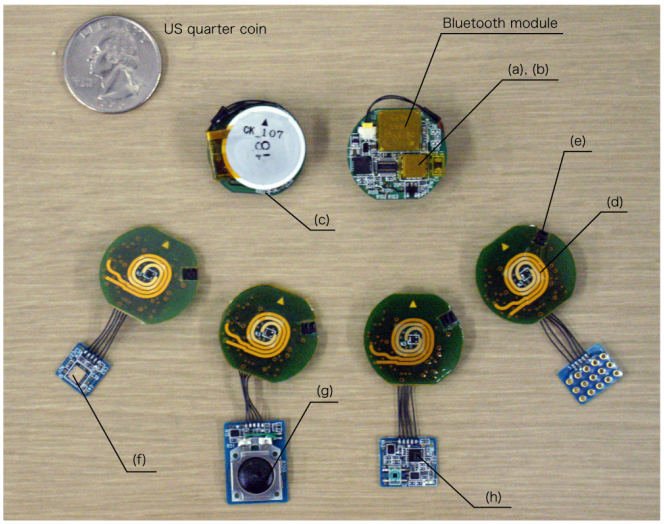

Figure 4.8: Wireless sensor module named Cookie

Feedback Visualization

The visualization of the virtual aquarium was written in ActionScript. The Flash application runs independently and listen a port to communicate with the Prottoy system. When a user's status is changed, Prottoy generates a xml document that contains the status of a couple of fish and sends it to the Flash application to render the aquarium.

4.3.3 Experiment and key results

In this experiment, we hired 7 adults (M:4, F:3, age: 22 – 50) in 3 weeks. In the first week, we measured usual brushing time of each participant using sensors without aquarium visualization. In the second week, aquarium visualization was introduced. In the last week, the visualization was removed and only brushing time was measured again.

While all participants did not brush well in the first week, after the visualization introduced we made sure that all participants did brushing at least 3 minutes. Noticeable point is that all participants still brushed longer than the initial level even in the third week. Besides, they did not neglect brushing any time in the second week. This means that moving scrub and dancing fish were totally effective to make users have habits of brushing in sufficient amount of times (Figure 4.9.)

From interviews after this experiment, more than half participants were enthralled by the unexpected behavior of fish, blowing eggs and so on. This means that accumulated feedbacks are effective for remaining interesting in the system.

4.4 Mona Lisa Bookshelf: An Application that Encourages Users to Keep a Shared Bookshelf Aligned

Mona Lisa Bookshelf has the objective to make users keep a shared bookshelf aligned.

Application type In the light of the framework, this application should be adopted "Type A" because the bookshelf was shared and the desired behavior was not receivers' own sake but we have designed the application as a "Type C".

Persuasion form The bookshelf is used by a large number of the general public. Thus we should have adopted "using social effects" form as well as "persuasion messages" form. However we could not properly utilize social effects as a result because we have designed the application as a "Type C".

4.4.1 Design

Resources shared by a number of people, such as a public toilet or a bookshelf in a research laboratory, tend to deteriorate quickly in a process called the tragedy of the commons. This happens because each individual derives a personal benefit from using the resource, while any costs are shared between all the users, leading to reckless use. Mona Lisa Bookshelf is aimed at keeping a bookshelf organized. It tries to encourage users to keep books in order and to return missing books, but also to take books out every now and then for reading. Each book in the shelf is linked with a piece of a digital image of the Mona Lisa. Like a picture puzzle, the image changes according to how the books are positioned. A high-quality flat display placed near the bookshelf shows the image to the users.

In this system, its feedback logic aims to encourage the following ideal behavior:

1. Books should be arranged correctly and aligned neatly

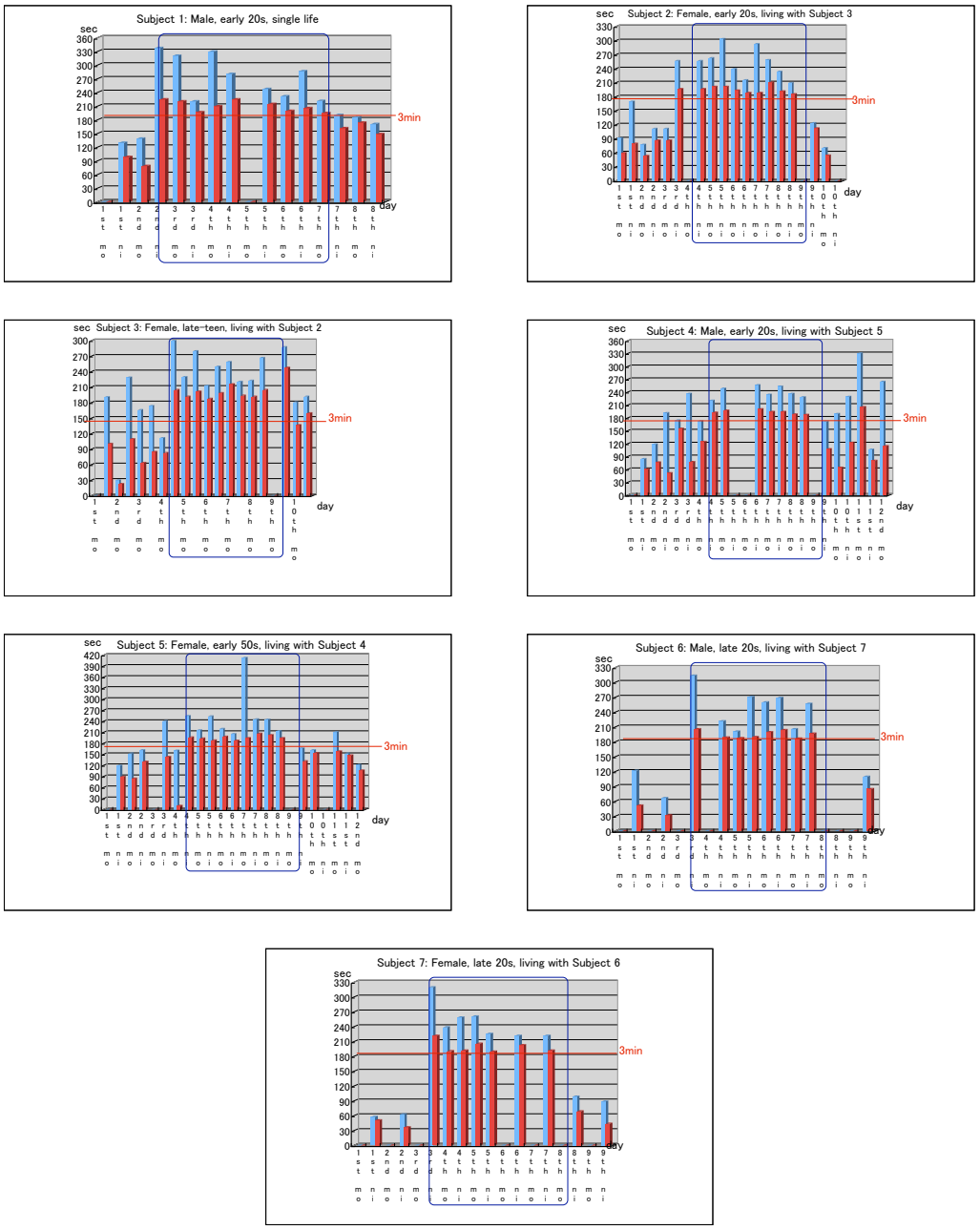

Figure 4.9: These charts show gradual changes of the recorded toothbrushing time for each participant. Horizontal axis is responsible for passage of time. 'mo' means morning of the day. 'ni' means night of the day. Blue bars indicate total brushing time of each toothbrushing time. Red bars indicate actual brushing time of each. The total brushing time means the time between the beginning and the end of toothbrushing. The actual brushing time means total seconds of sensed by the accelerometer.

2. At least one of the books should be read at least once per a week.

The correct arrangement of the books is pre-programmed, and could be e.g. alphabetical. User behavior is compared to this ideal, and translated to feedback as described below.

Mona Lisa Bookshelf also offers two expression styles to return feedback to a user to encourage cleaning his/her bookshelf or reading books in the following ways. When a book is removed from the shelf, the corresponding piece of the Mona Lisa image also disappears. If books are lying on their face or otherwise misaligned, the pieces of the image also become misaligned, distorting the picture. When the books are arranged neatly, Mona Lisa smiles contently. The assumption is that users are aware of how da Vinci's Mona Lisa is supposed to look like, and as when completing a picture puzzle, inherently prefer the correct solution to a distorted image. The feedback thus provides clues and motivation for keeping the bookshelf organized. The left picture in Figure 4.10 shows an example of a distorted image.

Figure 4.10: Screens of Mona Lisa Bookshelf

In addition to the immediate effect of the pieces of the image being moved around, there is an accumulated feedback mechanism that attempts to encourage users to read the books once in a while; if none of the books are removed from the shelf for over a week, Mona Lisa starts getting visibly older. The right picture in Figure 4.10 shows an example of an aged portrait. As soon as one of the books is removed from the shelf (hopefully to be read), she regains her youth.

4.4.2 Implementation

Context Acquisition

In this application, the absolute position of the books in a shelf was used as the operant behavior. Visual tags were attached to the spines of the books to facilitate their detection and identification. They were also attached to the corners of the shelf to determine its dimensions (Figure 4.11.) The detection system (Figure 4.12) comprised the following hardware: a digital video camera (iSight by Apple), a high-resolution digital camera (D50 by Nikon) and two infrared distance detectors (GP2D12 by SHARP). The distance sensors and the digital video camera were used to detect whether a user is manipulating books in the shelf. OpenCV, a real-time computer vision software library, is used to analyze the video signal. As soon as a user was seen leaving the shelf, the high-resolution still camera took a picture of it and all the books contained within it. Images captured by the still camera were analyzed by the VisualCodes [74] software library, which recognizes the visual tags attached to the books. Each visual code yielded data regarding its position, alignment and identity. This was then translated into context information that describes the bookshelf's width and height, which books were currently contained in shelf, and how they are aligned and ordered. This tracking mechanism observed how a user used her bookshelf passively without requesting extra actions.

Figure 4.11: Visual tags with blue circles that indicated the corners of the bookshelf

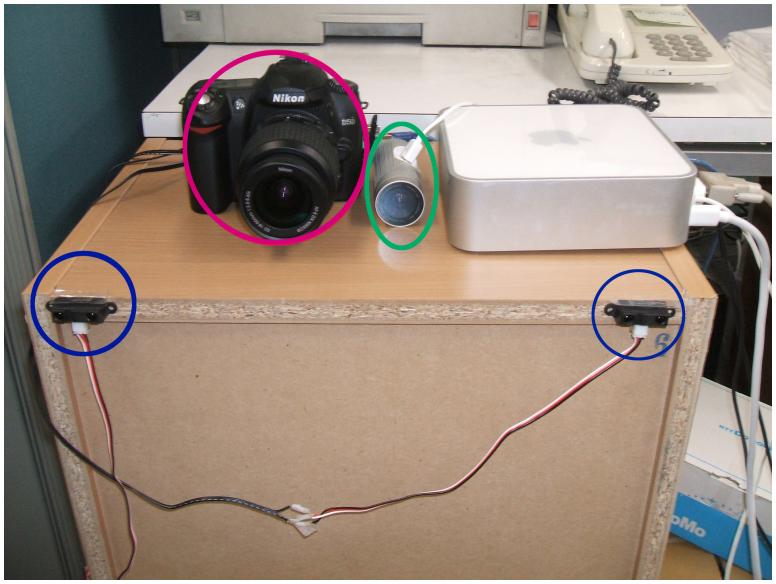

Figure 4.12: Bookshelf detection system setup

4.4.3 Experiment and key results

We conducted a simple experiment in our laboratory whether or not users change their behavior to deal with shared resources. One 61-inch plasma display showed the Mona Lisa related to one big bookshelf in the lab in 2 weeks. Unfortunately, this application was not effective at all. At first someone who noticed the relationship between the picture and books kept book organized. However, after few days, many of those researchers and students lost interest in the picture and the Mona Lisa was left apart. Besides, some participants commented that the apartness and missing were fun to see, so they changed the order of books intentionally.

This failure is because the presentation could not solve the tragedy of the commons. Even if the Mona Lisa was distorted, anyone could not find out who did not keep the bookshelf organized. Besides, the participants commented that they assumed somebody else read books when the Mona Lisa got older. This result was a kind of bystander effect mentioned in Section 2.1.3.

Improvements for this case study

As I mentioned, this case study should have designed as a “Type A” application. In order to prevent the bystander effect, one possible improvement is to visualize

who soils the bookshelf such as the color of the lacked piece of Mona Lisa is related to the borrowed person.

Chapter 5

Social Effect Reflection Systems

Social effect reflection systems aim to change behavior using social effects (Section 3.2.) This chapter describes the concept and three case studies of *social effect reflection systems*. These case studies are *EcoIsland, Driving Behavior Change System,* and *iDetective*.

First, in this chapter, I describe the concept and design principles of the systems according to the framework. Then I introduce the three case studies. Each case study was designed to use different persuasion techniques in order to confirm whether the framework works effective or not.

5.1 Concept

As I mentioned in Section 3.1.1, nowadays computers are able to make it possible for those users to interact with more than one person simultaneously by using networking technology. This means that computers are able to form virtual groups. Social Effect Reflection Systems aim to change users' behavior using social effects by forming virtual social groups, or by enrolling receivers in existing groups remotely (Figure 5.1.)

5.2 EcoIsland: An Application that Encourages Users to Reduce CO2 Emissions

Prior persuasive applications have motivated individuals to change behavior mostly for personal benefits. For example, a persuasive application aiming to convince in-

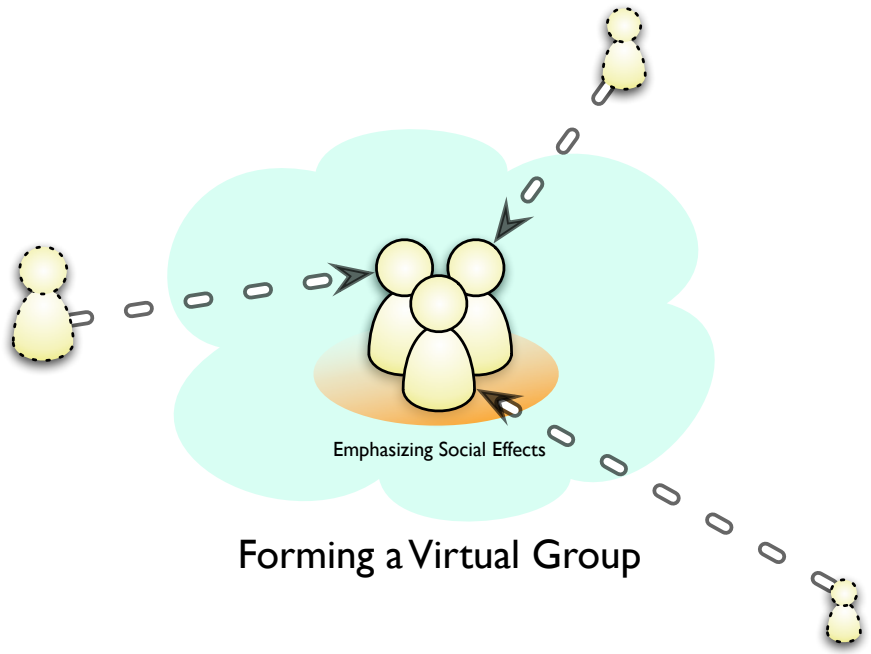

Figure 5.1: Social Effect Reflection Systems Concept

dividuals to quit smoking persuades their behavior change by highlighting the benefits of good health. Even though such a behavior change does not always take an immediate effect, users already know the importance of the behavior change. In other words, they understand that their sustained action will take effect ultimately. Thus, it is imperative for such persuasive applications to provide users with a sense of achievement by showing what s/he has done, how ahead s/he is of his/her competitors, and how close to his/her goal in order to keep him/her from getting discouraged [33]. However, it is easily imagined that people are scarcely motivated for behavioral changes aiming at public benefits such as environmental protection. One of the difficulties to change users behavior for this purpose is that it does not make any sense for a person to change his behavior if others do not act in concert. This dilemma is well known as the tragedy of the commons [40].

Application type Reducing CO2 emissions is a behavior for public interest. Thus in the light of the framework, the *Type A: Promoting desired behavior for public interest* must be chosen. In addition, the application needs to impart concrete knowledge to reduce CO2 emissions because we found that only a few people knew the proper way to reduce the emissions, which means the application includes the

Type B: Imparting knowledge about the target behavior.

Persuasion form Due to the restrictions on the Type A, the application must adopt "using social effects" form as well as "persuasion messages" form.

5.2.1 Attitude change for society

Hofstede mentioned in [42], individualist societies are the societies in which the ties between individuals are loose: everyone is expected to look after himself or herself and his or her immediate family only. He also referred that the United States ranked 1st (most individualistic country), the United Kingdom ranked 3rd, and France ranked 10th among 53 countries and regions in which IBM branch office were located. People in individualist societies are more self-centered and emphasize mostly on their individual goals. They tend to think only of themselves as individuals and as "I". They prefer clarity in their conversations to communicate each other more effectively. In contrast, collectivist societies are the societies in which people from birth onwards are integrated into strong cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty. Most of Asian countries are collectivist countries (Japan ranked 22nd, Singapore ranked 39th, South Korea ranked 43rd), and Hofstede added the remark that collectivist countries are more common in the world than individualist countries. Collectivistic cultures have a great emphasize on groups and think more in terms of "we". Harmony within a family or society is very important and should always be maintained, and confrontation should be avoided. Saying "no" means to destroy the harmony in the group. Triandis mentioned that it is important for people in a collectivist society to fulfill duties that have been built consensus in the society in order to accumulate virtues [81]. They have self-identities that are strongly linked to attributes of their group. It is discouraged to behave differently from each other.

5.2.2 Design

Persuasion for Promoting Public Interests in Collectivist Society

As we mentioned earlier, it is difficult to motivate person to change his/her behavior for public interests, such as environmental protection. Besides, it does not make any sense for a person to change behavior if other persons do not act in con-

cert. For example, if you find that many other persons litter a park with bottles and cans, you might neglect to keep the park clean.

When you think about the environmental protection, while technological solutions to reduce greenhouse gas emissions such as improving energy efficiency and developing clean energy sources are broadly applied, we still need dramatic changes in our human behavior to avoid the catastrophic climate change. World Wide Fund For Nature reported that the Ecological Footprint, which tracks the area of biologically productive land and water required to provide the renewable resources people use, and includes the space needed for infrastructure and vegetation to absorb waste carbon dioxide, exceeded the Earth's biocapacity. It takes 1.5 years for the Earth to generate the renewable resources used in 2007 [86]. Naturally, there are a lot of things that ordinary citizens can do. The resource recycling to realize a zero-waste society is a good example. Separating trash to some extent enhances the resource recycling and saves a lot of energy costs of the refuse incineration. Also many airline companies including All Nippon Airways, the second largest airline company in Japan, offer carbon offsetting programs to air travelers in order to neutralize the effects of their flights on the environment. Besides, Japan's Environment Ministry encourages every workers to wear light clothing such as short-sleeved shirts without ties, and to set air conditioners at 28 degrees Celsius (82 degrees Fahrenheit) or higher in their offices from June to September. Surprisingly, the last example works better than the second one in Japan. By referring the characteristics of collectivist society, this can be interpreted that a person cannot make sure that other people do the same in the former case. On the contrary, what made the latter case successful is that the behavior has been recognized as a good behavior in the society and a person understands others also do the same.

These examples reveal that we need to consider the characteristics of collectivist society for motivating collectivist people to change their behavior for personal benefits. From the characteristics, we have defined following five design strategies for persuasive applications that promote public interests in collectivist societies.

Organizing Groups If there is no group yet where the target behavior is recognized as a good behavior, the persuasive application must organize a virtual group where the target behavior is recognized as a good behavior. In other words, the

application convenes members who are interested in the target behavior but do not move into action yet because they do not want to stray from the current group they belong to. This makes a member feels that the target behavior is acceptable in the group, and it breaks his psychological barriers to act the target behavior.

Anonymity In a horizontally egalitarian society, there is a possibility that an application user antagonizes others who belong to the same "real" group (e.g. same society) because the target behavior is not widely accepted yet as recommended behavior. Not to make waves among the real group, it is advisable to provide users with anonymity on persuasive applications.

Mutual Surveillance

Monitored by Others As we mentioned, when someone else is watching, a person performs better at a task [87]. Moreover, the person will perform even better if the task has been recognized as recommended behavior in the group. The important point for the person is to make others aware that the person is now accumulating virtues for the group.

Watching Others A person in collectivist society tends to avoid isolation from the group. So watching others and confirming that other people do the same activities would lessen the person's feeling of isolation.

Comparing Others The feature of watching others reveals a person's contribution in the group. When the contribution is smaller than others, the person feels the pressure to contribute more. Of course if the person feels the pressure too much, s/he would give up to contribute and to use the persuasive application itself. Thus we suggest the necessity of "mutual aid" in order to subdue the effect.

Development of Mutual Aid When a person knows someone else in the same group is placed in predicament, s/he tries to help the person. Similarly, when a person knows another person in the same group cannot contribute enough in a persuasive application, s/he would try to contribute also for the person. The most important point for the people in collectivist society is to maintain the total degrees of contribution in the group.

Combine Use of Positive and Negative Feedback Fogg emphasized that positive punishment in operant conditioning should be avoided due to ethical reasons [33]. Consolvo et al. also pointed out that offering negative reinforcement or positive / negative punishment should be avoided in order to sustain the individual's interest without making her feel too bad or it runs the very real risk of being abandoned [17].

However, it is unavoidable for these kinds of feedback in persuasive applications for collectivist societies because users have negative feelings when they feel not like the others. We have no guideline to know what kinds of feedbacks strike users as "negative" feedbacks. When a user neglects to do desirable behavior, of course we could design that an application does not offer "negative" feedback ? for example, feedback unchanged. But the user still feels negative because s/he knows his/her neglect cause the feedback unchanged. Furthermore, giving negative feelings while training such as scolding is widely accepted in collectivist societies. Hofstede noted this is a typical characteristic of many collectivist countries [42]. In addition, Midden et al. reported that negative social feedback provided by an embodied agent, iCat, had the strongest persuasive effects[59] even though the experiments were conducted in an individualist country, Netherlands (ranked 4th).

Game Design

In order to confirm that our design strategies work effectively, we developed a persuasive application for encouraging users to reduce CO2 emissions. The target users were people living in Japan, a non-individualist country. There have been some existing persuasive applications to reduce ecological footprints. For example, Mankoff et al. designed a social networking site to motivate individuals to reduce ecological footprints [57]. However, this application was not explicitly designed for collectivist cultures even though it also used social incentives to motivate users.

EcoIsland is a game-like application intended to be used as a background activity by ecologically minded families in the course of their normal daily activities. The application was designed for being installed in the living room or another prominent place in a household.

Basic Concept Some experts say that greenhouse gas emissions, such as CO2, contribute significantly to global warming. They also believe if current trends con-

tinue, global sea levels will rise by a meter or more by the end of the century. Needless to say, the Japanese people understand that rising seas pose serious threat for their country because Japan is an island country. Therefore most Japanese know that we need to reduce quantities of the greenhouse gas that are released into the atmosphere. The application mimics this situation.

The objective of the application is to save virtual island from loss of land through rising sea levels by reducing the amount of greenhouse gas that each household emits. To give a responsibility to all users, we designed that each household owns one virtual island, and the family members are represented as avatars on the island (Figure 5.2). Each household sets the amount of greenhouse gas to be reduced, and the application tracks the approximate current amount of greenhouse gas by using self-reported data. If they fail to reduce the emissions enough, the sea level around the island rises corresponding to the excess of the emissions. Users can report their own green activities via their mobile phones or PC web browsers. On the phones or browsers, users have a list of activities that take to reduce the emissions: turning down the air heater by one degree, taking a train instead of a car, and so on. After reporting activities, the sea level reacts accordingly. Users can see nearby islands and activities as well as their own islands. Then they can list sell and buy offers for emission rights on a marketplace. Trading is conducted using a virtual currency EcoPoints earned by reporting green activities. The credits are also used to buy virtual items to decorate their islands. So successful sellers can afford to decorate their island more, while heavy emitters have to spend their allowance on emission rights.

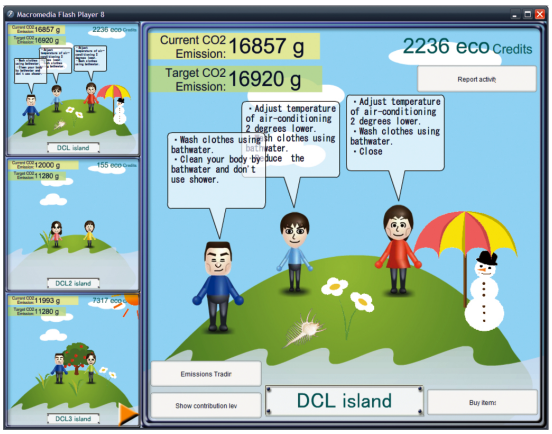

Figure 5.2: EcoIsland Main Screen

How Each Strategy Applied

Organizing Groups EcoIsland was designed for the families who were interested in environmental activities. We informed participants that other participants were also ecologically minded in our experiment. Moreover, this application brought a participant into line with other family members to save an island, which means they shared a common goal. Thus participants were able to report ecological actions at ease.

Anonymity Each household can name their island as they want, and the island name is shown on the display. Each family member in a household is represented on the island as an avatar. Even if the household behaves differently from others, others cannot identify them in real world.

Mutual Surveillance The application shows a number of islands owned by the families participating in the application. A family can observe the degree of ecological behavior of their neighbors through the visualization of the sea level of the neighbors' islands. Moreover, when a user reports several ecological behaviors, a speech bubble that describes what the user has done, appears over the corresponding avatar. Other family members as well as other households can read this speech bubble (Figure 5.2). Also, contribution of each family member is shown in a pie chart. The pie chart is concealed from other families (Figure 5.3). Also, the speech bubble inhibits users from cheating on the self-reporting. If a user reports many activities at once, other users will suspect the user of cheating because of the unnaturally expanded speech bubble. Then clicking on an avatar along the pie chart shows an activity history page as shown in Figure 5.4. This page shows each member's eco-friendly activities within a 24-hour period.

Development of Mutual Aid The mission in the application is to save the island by reducing the amount of greenhouse gas each that household emits, not a user emits. Even if one family member neglects reporting ecological actions for a few days due to a variety of reasons (e.g. catching a cold, travelling, and so on), remaining family members can maintain the island by reporting harder. Besides, the application prepares a remedy when none of the family members afford to report enough actions. The application offers the trading system, which is based

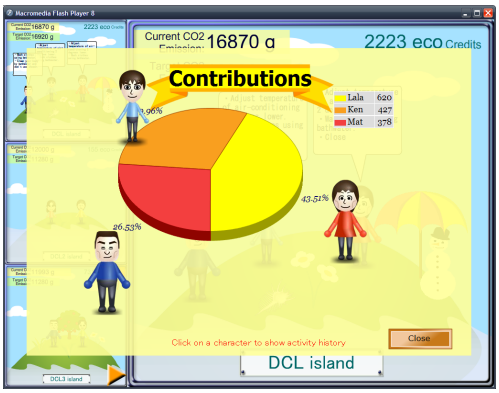

Figure 5.3: Family member's contribution

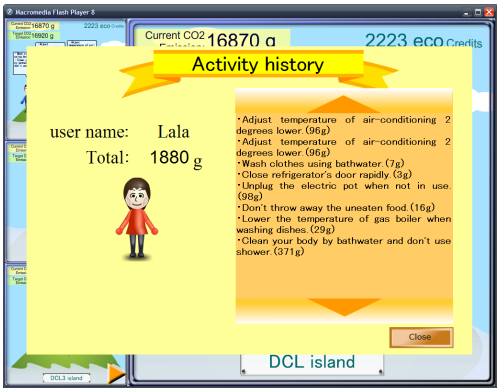

Figure 5.4: Family member's activity history

on the same principle as the industry level emissions trading systems. A household that finds it easy to make significant reductions can sell emissions rights to households that find it difficult to make reductions (Figure 5.4).

Figure 5.5: Emission trading system

Combine Use of Positive and Negative Feedback The water around island is the most symbolic feedback in the application. When the sea level is low, users feel it as positive feedback. On the contrary, users feel negative when the sea level gets higher. Moreover, the feedback is intended to evoke the importance of ecological behavior by using the metaphor of sea surface elevation (Figure 5.6). Furthermore, the island decoration is another positive feedback because the virtual items for decorating island are used as rewards (Figure 5.7.) However, this

may also effect as negative feedback when a household realizes that other islands are more decorated than the island. Again, we cannot avoid negative feedback from the application in collectivist societies until excluding mutual surveillance.

Figure 5.6: Sinking island

Figure 5.7: Purchasing virtual items

5.2.3 Implementation

Figure 5.8 presents the overall architecture and technologies that used in our EcoIsland system. The client computer that is installed in each household uses Adobe Flash to render visualization. The client offers feedback to users using data that is obtained from the EcoIsland web application running on J2EE server, which is implemented in Java. The mobile phone client uses a normal web browser to interact with the server to report ecological behavior. The system is the thin-client type: data are managed in a database on the server side, so that the client machine stores no data. Every interaction between users and the system in our experiment are recorded to be analyzed.

5.2.4 Experiment and results

In our first user study, we recruited six families known by our laboratory members, e.g. their acquaintance's families or relatives (20 persons, age 15 – 58, Male 12 and Female 8) who were interested in environmental issues and lived in a family. As the application was designed to be used in a group, all families had one or two children (age 15 – 24), five families had both parents, and one family had a single parent (age 47 – 58). They used their own mobile phones for reporting eco-friendly activities. The experiment lasted for four weeks. In the first week, we

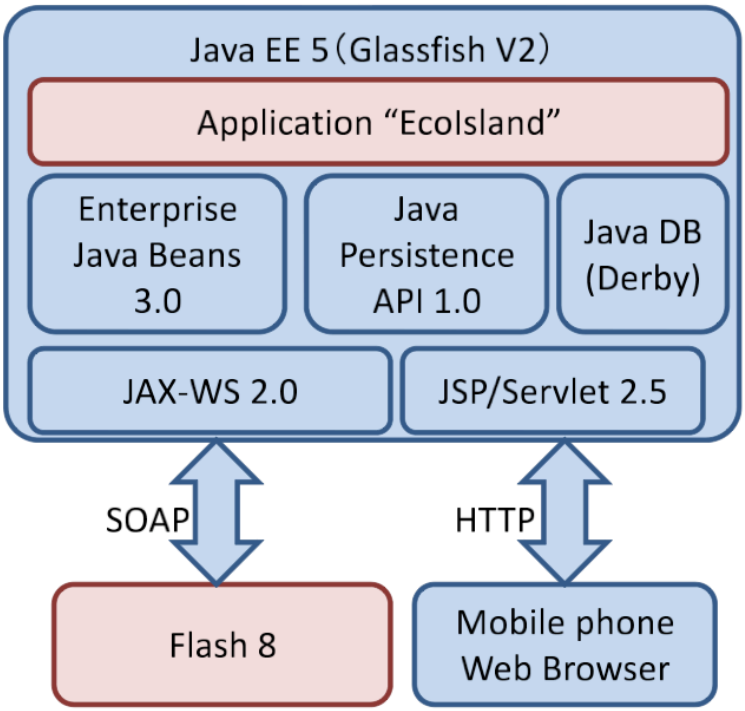

Figure 5.8: EcoIsland Architecture

equipped the participant's air heater with a simple electricity usage meter, Ecowatt. In the first week, participants did not use EcoIsland. We measured ordinary energy consumption before installing EcoIsland. In the second week, EcoIsland was installed and only one family member from each household was asked to use it. In the third week, all family members used EcoIsland. In the last week, all family members used EcoIsland that contains emission-trading system between families. After the experiment, we conducted a survey in the form of a questionnaire asking about the changes in the participants' attitudes. All participants took part in our experiment gratis.

Results

In the survey, 17 out of 20 participants said that they were more conscious of environmental ecology after the experiment than before.

From the air heater electricity usage data, there was no significant correlation with the reported activities (Figure 5.9). While this is an alarming result, it reflects that the experiment period was short to measure the day-to-day variance in an electricity usage. We ran the experiment at the end of December 2007 and the beginning of January 2008, and the period might also be non-optimal because it is a holiday season in Japan. Some families were away from home for long period (pink region in Figure 5.9).

Besides, we had to consider about changes of weather conditions in the experiment period. Needless to say, air heater electricity usage varies according to weather conditions and others. During the experiment period, the biggest daily mean air temperature difference was 7.3 degrees Celsius (Figure 5.10: 10.2 degrees Celsius on Jan. 9th, 2.9 degrees Celsius on Jan. 23rd.) Given these factors, we could not derive the correlation from statistical analysis.

Mutual Surveillance The eco-friendly activity log (Table 5.1) shows that participants reported eco-friendly activities more in the third week than in the second week ($p < .05$). According to the questionnaire, many participants answered that doing green activities with their family members contributed to change their environmental awareness. 14 out of 20 participants reported that they were asked to do eco-friendly behavior from their family members. 13 out of 20 participants felt they had to do eco-friendly behavior from watching their family members did eco-friendly actions. Moreover, 14 out of 20 participants reported that the application

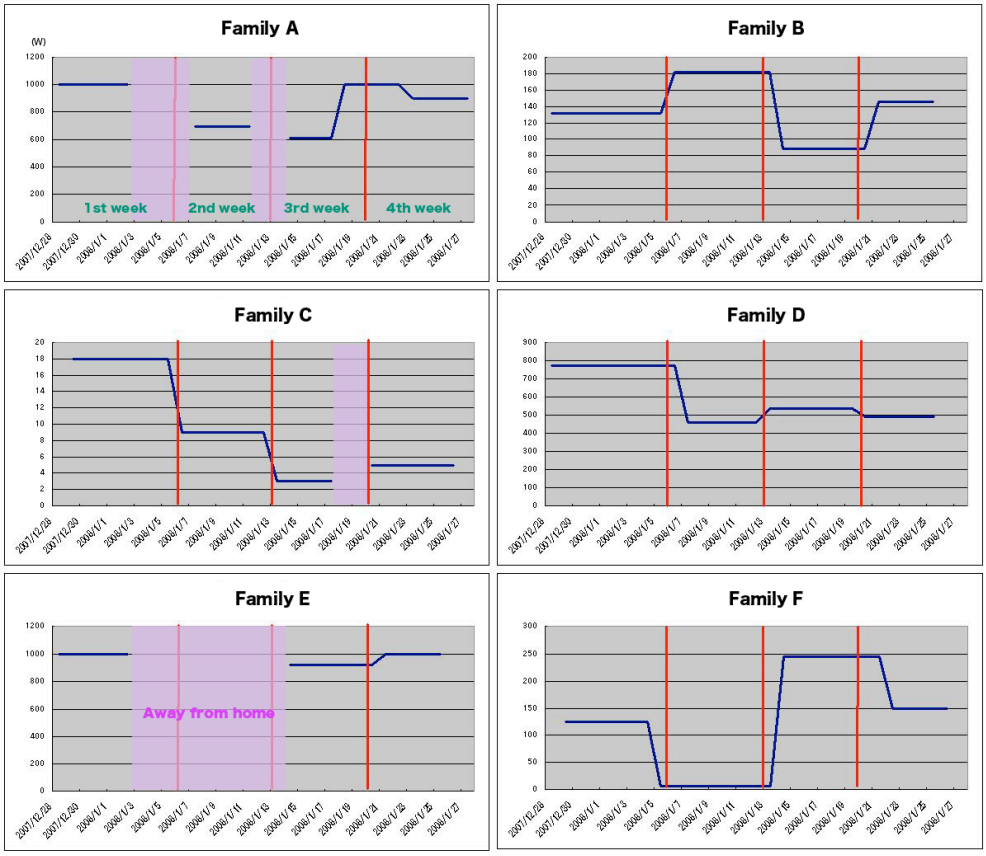

Figure 5.9: Air heater electricity usage

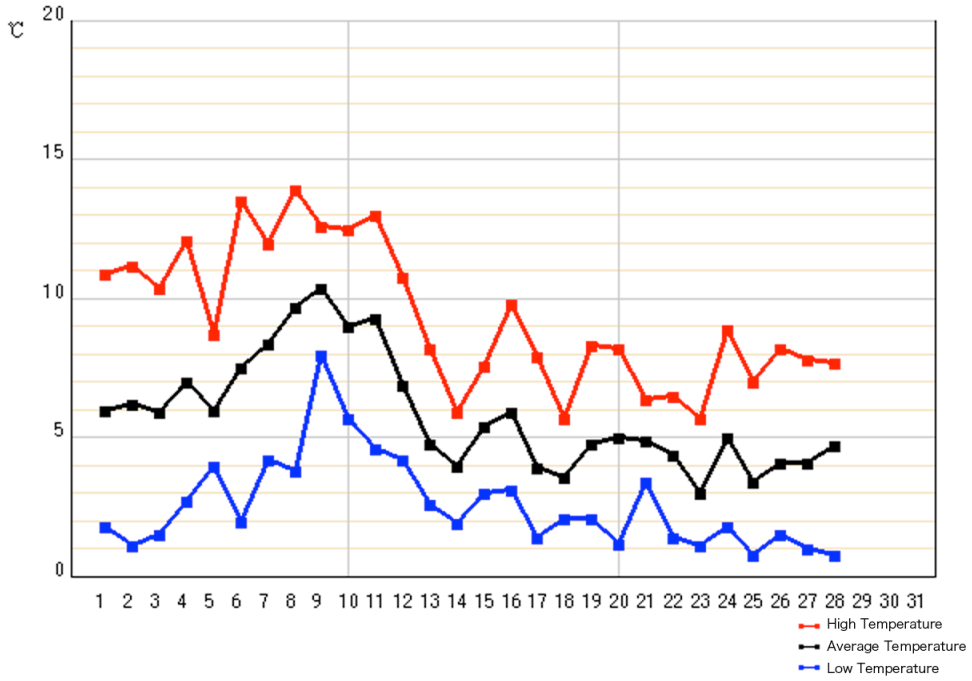

Figure 5.10: Temperature changes in Tokyo in January 2008

promoted the communication within their family. The fact supports that one of our strategies: "mutual surveillance" especially between family members could be used effectively. On the contrary, however, displaying users' activities in a speech bubble had a little impact in this experiment, because the font size of the bubble was too small to recognize in the current application, which was pointed out by four participants.

Table 5.1: The number of eco-friendly activities one participant in each household reports

Household	A	B	C	D	E	F
2nd week	99	46	21	11	26	97
3rd week	132	53	20	16	52	141

People tend to compare themselves to the others especially when they are looking at the same goal. 12 participants reported that they cared about the sea level of other islands. Some participants said that a user had a feeling of superiority

if another person's achievement was less than the user's achievement. This suggests, we think, mutual surveillance effects a promotion of competition with others even in collectivist societies.

Mutual Aid The target reduction of CO2 emissions was fixed to 6 % of the average Japanese CO2 emissions (Japanese government conducted a campaign against global warming aimed at cutting greenhouse gas emissions by 6 %). 10 participants expressed that the target was easy to be accomplished, but 5 said it was somewhat difficult. In this experiment, however, only 2 out of 6 household (this means only 1 pair) used the emissions trading system. Participants mentioned that it was confusing and not necessary. This was simply because the participants who achieved the target reduction without difficulty earned enough EcoPoints already. So most participants had no reason to use the trading system. The cause of the failure was that participants could not work other economic activities to earn EcoPoints in the application unlike real emission trading systems.

Combine Use of Positive and Negative Feedback 19 participants said that the feedback of sinking virtual island contributed to the change in their attitudes, which proved that even negative feedback made a satisfactory effect. However, the application could not encourage intrinsic motivation for eco-friendly activities, since some participants said that they felt motivated by explicit incentives, such as saving their sinking virtual islands (19 participants), purchasing virtual items (14 participants) and amassing EcoPoints (14 participants) rather than ecological reasons. Though this is an extrinsic reason, this must be an important motivation in getting started for continuous use of the application. 14 participants mentioned that earning EcoPoints by reporting eco-friendly activities contributed to behavior modification. They said that buying virtual items and decorating his/her island increases the motivation for acting eco-friendly activities. From interviewing, we found that some participants felt earning EcoPoints itself was an incentive while others felt collecting virtual items was an incentive.

5.2.5 Findings from the experiment

Cooperation, Competition, and Sense of Pride

In our experiment, we observed that our strategies promoted double-barreled effects. One is cooperation with other participants, and the other is competition

between participants. While the application showed other families' status as the sea level, pie chart, and speech bubbles in order to promote aiding others, at the same time, the situation may provide the other family with a sense of inferiority. However, interesting point here is that no participant felt a feeling of strangeness in the coexistence. No participant abandoned our experiment. On the contrary, from the results of our questionnaire, participants reported that sea levels of other islands as well as cooperation with family members motivated them to behave in more sustainable way.

Consolvo emphasized that offering negative reinforcement or punishing should be avoided in order to sustain the individual's interest without making her feel too bad or it runs the very real risk of being abandoned [17]. From our experiences, however, offering only such serene and fine feedback tends to get participants bored. Naturally, it takes long time for people to achieve the goal that persuasive application set (if not, persuasive application is not needed). If using a persuasive application ends up a routine work, the user would get bored with the application soon. Thus we believe that persuasive application must try various expedients to keep users from getting bored. Though promoting cooperation or competition itself is not the purpose of persuasive application, it is necessary feature for users to continue using application for long periods.

On the other hand, we should avoid excessive use of sense of pride in collectivist cultures. Mankoff et al. suggested a SNS web page design to show how a user reduces CO2 emission in his/her profile page. In fact, this may show the user stand out from the others, but this may not motivate others to do more. On the contrary, the user may be considered not to be in the same group.

Design for Feeling Closer to "Commons"

As we mentioned earlier, environment concern is one of the typical examples of the tragedy of the commons. To date, many solutions to the tragedy of the commons have been argued. One solution is to convert a common good into a private property, giving an incentive to the new owner to enforce its sustainability. Our approach used in the EcoIsland was similar to this solution. We introduced a virtual island shared by a household as an asset worth protecting. Participants were required to do ecological actions in exchange for decorating their islands.

What the notable point here is that participants were motivated even though

the asset was not real thing. Though it is difficult to choose the solution in real world unlike common meadow because it is impossible to slice CO2 emissions like a pizza, it seems useful to make the link between real action and virtual change.

Educating Proper Behavior

As we mentioned earlier, we adopted self-reporting style in the application (Figure 5.11). 4 participants mentioned that the self-reporting was somewhat burdensome because of the need to input activities manually every time. In fact this is true, and it is one of the issues that we need to make it to be improved. However, it does not simply lead that the sensor-based detection is the best way. Results in the experiment shows that presenting activities in a list was useful for teaching what kinds of activities were eco-friendly. Although we recruited the participants who were interested in ecology, 16 out of 20 participants did not act any activities that were not specified in the activity list. This means that it was necessary to show users eco-friendly activities in order to motivate behavior change. In addition to getting interested in environmental sustainability by using this application, the increase of the knowledge about sustainability is considered to come from the list shown directly to the users. It enabled users to educate the importance of the activities that they did not know before. 15 out of 20 participants expressed that their knowledge about green activities has increased, which could not be possible if the system uses the sensor-based detection. This was not explored well because most of the target behaviors that existing persuasive applications have been motivated are not so difficult to do without special knowledge.

5.3 Driving Behavior Change System

Driving Behavior Change System encourages drivers to change their habitual driving behavior by comparing with others.

It is difficult for vehicle drivers to change their own driving behavior because they do not know what the perfect driving is and they do not notice why their habitual behavior are not good for safety or efficiency. Even though some latest automobiles are equipped with ambient lights to encourage drivers to accelerate or brake more efficiently, automobiles cannot distinguish whether the acceleration or braking is necessary or not because it depends on the contexts. This section pro-

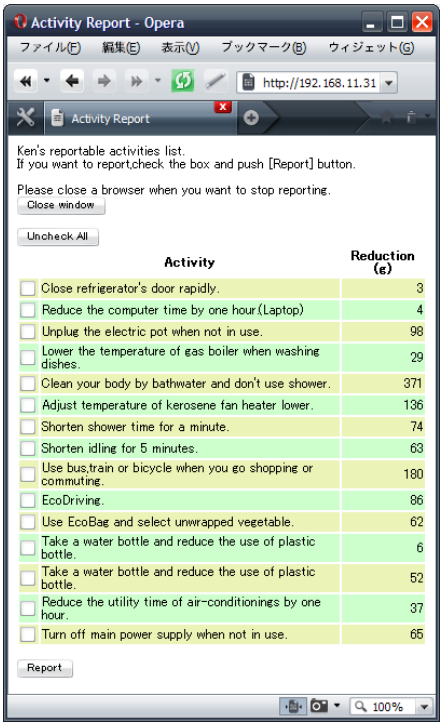

Figure 5.11: Activity report page

poses a novel application that teaches safe and comfortable driving and motivates users to change their driving behavior by comparing with other users who drive on the same road.

Application type Drivers cannot drive perfectly without any advice from others. Thus in the light of the framework, the *Type B: Imparting knowledge about the target behavior* must be chosen.

Persuasion form There is no golden rule for driving that could be applied in any cases. The perfect driving changes situation by situation and cannot be decided by computers in advance. Thus the application adopt "using social effects" form in order to compare with other drivers' behavior.

5.3.1 Background

Latest automobiles have various types of features in safety and economic efficiency. For example, anti-lock braking system (ABS) prevents wheels from locking

up while braking; airbag prevents passengers from striking interior objects like the window by inflating; engine stops idling silently while waiting at a red light or traffic congestion. In order to ensure these things, current automobiles are equipped with various types of sensors and computers. As well as engine speed and vehicle speed, computers in vehicle acquire information about steering column angle, each wheel speed, accel throttle position, braking position and so on. The computers silently decide how the vehicle should behave based on such information. This makes it possible for ordinary drivers to drive safely and efficiency without special techniques.

While such technological solutions are widely applied, drivers still need to change their driving behavior. For example, if drivers do not know how to drive efficiently, such technological solutions cannot persuade drivers not to press down the gas pedal more than necessary. To overcome the problem, latest cars including Toyota's Prius and Honda's Insight try to persuade drivers to drive more efficiently by using ambient lights for an efficient acceleration or braking. These lights are kinds of real time feedbacks. Such real time feedbacks change drivers' behavior just for the occasion because the feedbacks do not tell the reason why the lights are blinking, and they cannot apply the knowledge at different locations and different contexts. In order to change behavior and to acquire better habitual driving techniques, drivers have to notice their own driving behavior and analyze how to improve them.

5.3.2 Related work

Meschtscherjakov et al. compared five persuasive user interfaces to reduce fuel consumption in terms of technology acceptance [58]. However all these five user interfaces offered only real time feedbacks.

Ecker et al. proposed a game-like application to encourage drivers to reduce fuel consumption [27]. This application makes it possible for users to compare among drivers in real time. Also they pointed out that the usual boring and annoying character of an ecological driving style is overcome by using game-like visualization. As Mankoff et al. mentioned in [57], social comparison motivates people to change their behavior. However, Ecker et al. reported that some participants tended not to press the brake pedal properly in order to beat their opponents. These types of feedbacks that trigger the traffic accident should be avoided.

Figure 5.12: A playback screen which overlays vehicle information to recall driving

5.3.3 Design

Key idea of our application is to make drivers relive their own driving techniques and compare among other drivers after finishing drives. As we pointed above, real time feedback to compare with other drivers has one major drawback of enhancing unusual driving. In order to look back on driving in a calm manner, we adopted non real time feedbacks.

Users can see the differences between their own driving and optimized one / another users' one after finishing their drives. They can compete with each other in terms of energy consumption, stability, and so on. As they can compare with other driving data on the same road, they notice how to improve their habitual driving behavior (e.g. braking and shifting gear timing was slower than others). Users can also watch playbacks with overlaid vehicle information to review their own behavior (see Figure 5.12.)

5.3.4 Implementation

The application uses various types of vehicle information to produce minute visualization for reliving users' own driving techniques. As shown in Figure 5.13, we use four components to acquire vehicle information. CAN data sniffer gathers all data in in-vehicle data network. CAN is an abbreviation for Controller Area Network,

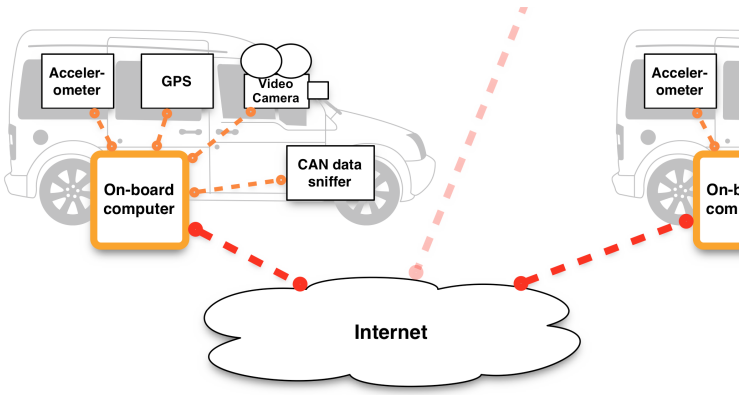

Figure 5.13: Real time in-vehicle data acquisition and transmitting to the Internet

which is a standard in-vehicle data bus to allow micro-computers and devices including many types of sensors in vehicle to communicate with each other. Many kinds of useful information for safety and efficient driving mentioned in Section I can be acquired by using this sniffer. Video camera records on-vehicle movie to recall visual image of their own driving. GPS acquires position data to locate the user on a road in order to compare with other drivers. Accelerometer acquires real time acceleration data to know how stable the vehicle is. An on-board computer in a vehicle stores these data and transmits them to the Internet. The application analyzes these data gathered from users and calculates optimized driving way on the road.

The prototype application was implemented in Java and Objective-C. CAN data were acquired by Lawicel's CANUSB device (Figure 5.14.) Phidgets accelerometers were used for detecting acceleration data. A Beagleboard was used for the on-board computer to gather and to transmit vehicle information.

5.3.5 Impressions from audiences at a international conference

Due to road traffic act, it is difficult to conduct the actual experiment of this application. Thus we gathered sensor log data ourselves and showed the application to the audiences at IoT 2010 conference held at Tokyo. In the application, two different logs appeared simultaneously. We have asked the audiences following questions.

1. Did the audiences receive the feedback? (Did the audiences understand the

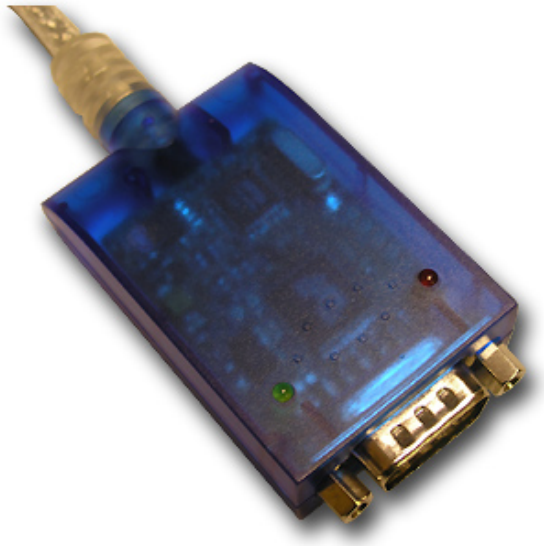

Figure 5.14: Lawicel's CANUSB

differences between a user's driving data and an opponent's data.)

2. Did the audiences notice how to improve their own driving behavior.

From our rough questionnaire, all audiences answered that they found the differences between two data. An audience advised that if the application hold a virtual contest such as "eco-run" by gathering data from internet, it might be fun. Another audience (male) suggested that the feedback was meaningful for him but he pointed out that his wife might not understand the feedback.

5.4 iDETECTIVE

iDetecive is an application that encourages users to walk more.Latest persuasive applications have used users' contexts acquired by several sensors for more effective persuasion. However most applications assume that those applications run with special devices that are equipped with sensors for acquiring contexts. The use of such special devices deters would-be users because they do not have a habit of getting on such devices. This study introduces a persuasive application that uses users' contexts acquired by mobile phone. Through the experiences in the application, this study clarifies whether current mobile phone is enough to persuade users or not.

Meanwhile, there have tons of mobile applications and it is a constant source of worry about how to maximize the exposure of the application to the users. In order to make users take the application at a mobile application market, we added an attractive feature to the application.

Application type This case study was designed to find how to make users start using life assist applications. Thus in the light of the framework, the *Type C: Promoting desired behavior unnoticed* was chosen. In this case, the persuasion message to walk more was designed to be weaved into a video game.

Persuasion form If a player notices that another player walks more, social facilitation (mentioned in Section 2.1.3) might come up to the surface. Thus we adopted "using social effects" form as well as "persuasion messages'" form.

5.4.1 Background

There have been many researches about context awareness using mobile devices for providing additional or personalized services. In order to acquire users contexts, most researches have used special mobile devices that are equipped with additional sensors. For example, SenSay, a context-aware mobile phone, detected the user's status by using a number of sensors which were mounted at various points on the body and the phone, and changed settings of the mobile phone dynamically such as turning the ringer off when the user is uninterruptible [77]. However, latest smart phones like Apple's iPhone which are equipped with some sensors including accelerometers, ambient light sensors, GPS and compass have been sold nowadays, and consequently these devices are able to acquire users contexts without any additional hardware.

These users contexts must be useful for making persuasive applications look more convincing. Often people do not realize all of their own physical and mental conditions. For example, people cannot realize their own weight or body temperature precisely without weight scale or thermometer. However, once s/he rides on a scale, s/he might want to lose his/her weight; once s/he sees his/her body temperature, s/he might decide to sleep earlier because s/he realize that s/he has a mild fever. By giving feedbacks applied users contexts to users, persuasive applications are able to persuade users effectively.

On the other hand, there are still few researches about persuasive applications

that are implemented using only mobile phone in the marketplace. In order to diffuse persuasive applications, it is indispensable to be running on usual mobile devices. Thus, we have designed and implemented a persuasive application using mobile phone in the market place for encouraging users to achieve healthy life. Through our experiences, we clarify whether current mobile phone is well equipped for persuading users or not.

5.4.2 Persuasion using mobile devices

As I mentioned in Section 3.1.1, persuasion using mobile devices has a number of advantages. However, there are also some drawbacks. First, battery-powered mobile devices work for only a limited time without electric charge. The more capabilities mobile devices have, the shorter those devices run without charge. Second one is size limitation. If a device is too large, its user cannot carry it. These two drawbacks mean that mobile device cannot be equipped with many peripheral equipments.

Tamagotchi is a handheld digital pet game sold by Bandai . The player is given the task of rearing the Tamagotchi. In order to keep the Tamagotchi's healthy life, the player has to feed it, to clean up its excrement and so on. The Tamagotchi urges the user to take care of itself by giving a sharp cry. As the player plays, the Tamagotchi will grow up based on the player's actions. Though no one may identify the game as a persuasive application, the behavior of the game is similar to mobile persuasive application as we mentioned above. Tamagotchi persuades its user to devote himself to the care of his virtual pet.

Foursquare is a location-based social networking service especially for latest mobile phones, which started out in 2009. Users can send their current location to the service by using GPS, and get some points that are awarded for "checking-in" at the venues. Users can earn many kinds of "badges" by checking into venues frequently. If a user is checked-in a certain venue more times than anyone else, the user will be "Mayer." Users can add some tips about venues for other users. In order to enrich the contents in Foursquare, the service persuades users to be checked-in more and more and to add more information by giving users the competition each other. As Shiraishi et al. pointed, people tend to compare themselves to the others especially when they are looking at the same goal. If another person's achievement is less than a user, the user has a feeling of superiority [76]. Social

comparison [31] is a powerful incentive to change behavior.

UbiGreen [35] is a mobile persuasive application that encourages those users to reduce CO2 emission by choosing better transportation method. The application running on a mobile phone uses a couple of sensors named MSP [14] to acquire user contexts. If users choose "green" transportation methods such as walking and bike, the feedback on the mobile display gets more positive (e.g. A tree yields an abundant harvest; An arctic sea ice where polar bears live grows.) Though this application does not have the capability to make users aware that the application is notifying, users choose green transportation methods voluntarily because they want to see the changes of the feedbacks. However, the authors reported that some participants wanted more variety in the visual rewards to maintain curiosity in the application. One of the most important things to design persuasive application is keeping users from getting bored.

From these examples, we decided to develop a persuasive application that includes following features.

1. The application uses a smart phone and attached sensors such as acceleration sensors and GPS
2. The application has an appeal for those users even though those users do not care about the desirable behavior
3. The application uses social comparison to encourage users to change their behavior
4. The application strives to keep users from getting bored.

5.4.3 Design

iDetective is like a "detective" game. Player's mission is to find the actual location on foot where some pictures given by his/her "client" are taken.

When a player is searching the place, the application shows the picture and some clues about the location (Figure 5.15.) The clues are different from request to request such as pointing toward the location, distance to the location, shooting direction of the pictures and so on. After the player finds out the location, s/he reports the location to his/her client with an evidence photograph for the sake of detective point. The amount of the point is depending on the difficulty of the

Figure 5.15: Searching mode on the application

location and how long the player walks. As the location is interesting for the player because it is winnowed carefully (e.g. magnificent scenery, unusual looking building, and so on,) the player is willing to search.

On the other hand, player can submit his/her favorite places to the application. Other players rate these places, and the player earns detective points corresponding to the popularity.

Player can look at his/her current status whenever s/he like such as how much s/he earn detective point (Figure 5.16.) As we mentioned earlier, this competitive feature intended players to play this application more. Other players can see how many requests the player comply, rank and his/her current title (e.g. master detective.)

One important feature of this application is that the players do not need to realize the purpose of the persuasion at the beginning. Some people are conscientious about protecting their own health and others are not. In particular, it is

Figure 5.16: Status screen

difficult to motivate the latter to walk more. Therefore this application hides the purpose and is designed like a location-based game.

However, human gets bored easily at changeless things. To prevent it, this application introduces a virtual agent to interact with users. As the agent asks questions about various topics which change depending on current user's activities, the application estimate how the user is concerned about his/her health and whether s/he contemplate walking or not. Virtual agent encourages the user to continue walking in a friendly manner (Figure 5.17.)

Persuasion techniques

iDetective adopted three psychological theories: goal-setting theory (Section 2.1.2), social comparison (Section 2.1.3), and transtheoretical model (Section 2.3.2).

Figure 5.17: Virtual agent

Goal-setting theory In iDetective, player chooses a request to find a location from the list. The list shows some requests with difficulty level, rough distance from the current user's location, and the location category (e.g. magnificent scenery, unusual looking building.)

Social comparison As we mentioned, if another person's achievement is less than a user, the user has a feeling of superiority. This application provides users with status mode to contend with other players for precedence (Figure 5.16).

Transtheoretical model iDetective estimates user's current stage by using contexts acquired by sensors and conversation with the virtual agent. The agent gives feedbacks depending on the stage. For example, 1) in pre-contemplation stage, the agent let the user know the current status; 2) in contemplation stage, the agent shows some advantages when the user behaves desirable actions; 3) in preparation stage, the agent motivates the user to walk; 4) in action stage, the agent praises

the user when the user behaves properly.

5.4.4 Implementation

We have implemented iDetective as a prototype system. We adopted Apple's iPhone as a mobile terminal of the application because it has 3G-network capability and is equipped with a GPS sensor, a compass, and a camera.

iDetective calculates player's walking speed and distance by measuring current location periodically. If the speed is too fast, the application assumes the player is somehow cheating (e.g. riding a bike.) Besides, the application confirms that player's evidence photograph by comparing with compass data and GPS data. Several information acquired by the sensors including walking distance and completion time are transmitted to the server to compare with other players.

5.4.5 Experiment

Method

To confirm our prototype application can acquire user's context by using Apple's iPhone, we have run the application outside and made the application continue to acquire sensor data. The iPhone was configured to acquire most accurate location data. First we created a pseudo request to go around in downtown Tokyo (estimated 370m distance) and asked a participant to take pictures at four points on the way. We asked the participant to do the trial four times. We prepared an iPhone 3GS 32GB (iOS 4.0.2 installed) for the experiment. The application could run even in the background.

Results

The results are shown in Figure 5.18. Blue line is actual route the participant walked (total distance: 370m), and the red line is given route using GPS information (total calculated distance: 1077m.) Blue arrows are actual shooting directions, and red arrows are given directions using compass information. The maximum error in position was 83 m at the beginning of the trial, and the maximum error in the shooting directions was 8 degrees. The application acquired 435 points data in a trial. It took 410 seconds to finish the trial (3.25 km/h.)

Figure 5.18: The results of the experiment

The application consumed 2.25 % of the internal battery life for one trial on average.

Through this experiment, we judged we cannot utilize the GPS module for measuring accurate distance in downtown Tokyo area because there are many high-rise buildings that obstruct radio wave used in GPS. However, especially in the early stages defined in the transtheoretical model, the application does not need to make players aware that the purpose of the application is to encourage them to walk more. As the detective point is not directly connected to walking distance, players might not doubt the score.

Oppositely, we found that the shooting directions were determined with considerable accuracy. By using both the location and the compass data, the application is able to judge whether the evidence photograph taken by a player is correct or not.

5.4.6 Discussion

Privacy issues

iDetective acquires location data every time to calculate estimated walking distance and detective point. To dispel the concern about the violation of users' privacy, the application deals with the calculations in stand-alone mode. The application transmits the results including estimated distance and detective points only to the server.

However, malicious players may guess the range of a player's activities by investigating his/her "complied requests" list. We need to adjust the information granularity to be disclosed to other players.

Consumer generated contents and those quality

To keep players absorbed in the application, one of the most important points is quality of the requests. Of course we need to prepare enough requests before the service is launched for public. However, it is indispensable to add requests gradually for keeping players from getting bored. To do so, we adopted a consumer generated contents approach. As we explained, each player can submit his/her favorite places to the application.

To ensure the quality of requests, our application encourages the players who complied with the requests to rate them. The players who offer high-quality requests earn the detective points, and the requests offered by senior players are recommended by the application.

5.4.7 Summary

In this case study, we proposed a game-like persuasive application using mobile phone, which is named iDetective. iDetective used three types of persuasive techniques to encourage users to walk more. Through our experiment, unfortunately, GPS module equipped with Apple's iPhone 3GS returned inaccurate values for measuring accurate walking distance, but by using both the location and the compass data, the application could judge whether the evidence photograph taken by a player is correct or not.

We are now preparing to conduct a large-scaled and long term user study. Originally this application was designed for the people who do not mind healthy behav-

ior, and for keeping players from getting bored. However, if we gather participants and ask them to use our application for a certain time, this must be an unignorable bias. Therefore we are going to submit our application to Apple's AppStore and deploy the application widely. We will observe how players behave and judge whether our mobile persuasive application is effective for motivating players to behave healthier life.

Chapter 6

Discussion

This chapter discusses general issues that are raised from six case studies described in Chapter 4 and Chapter 5.

6.1 Feasibility of Life Assist Applications

Although there have been proposed many persuasive applications, life assist applications that are used with sensors and are blended into a ubiquitous computing environment are totally different from them because life assist applications are intended for passive users. The six case studies indicated that life assist applications could be implemented with current information technologies including sensors, networks and so on though there are several drawbacks such as precision of context acquisition and packaging density. Many participants did not feel uncomfortable about the installation of life assist applications. This means that life assist applications are accepted in ordinary environments.

On the other hand, there were few reports of the statistical significance of attitude change. From next section, I will discuss the reason.

6.2 How The Framework Helped and Not Helped Developers

This section describes how the framework helped and not helped developers from experiences to design six case studies mentioned in Chapter 4 and Chapter 5.

6.2.1 Three stages of life assist applications to encourage users

The proposal of the three stages of life assist applications to encourage users makes developers aware that the role of life assist applications transits to the next stage according to users behavior. In particular, the first stage, *Making use of applications* stage, and the last stage, *Continuous use of applications* stage, are first suggested by this dissertation.

Making use of applications

Because the users of the six experimental case studies were asked to use them by us, it could not be said that the applications succeeded to encourage the participants to start using the applications voluntary. From their interviews, however, we found these case studies were endowed with attractive and with emotional attachment to those users.

In addition, we observed that ambient lifestyle feedback systems that promote desired behavior unnoticed were accepted in the second stage. As I mentioned in Section 3.5.1, there is no border between the first stage and the second stage in these "Type C" applications. Thus, if once receivers start using the applications, they carry to the second stage smoothly.

Continuous use of applications

Our six case studies were conducted in a short time. Besides, the participants were given the information when the experiments finished. In this condition, participants might feel the pressure to keep on using the applications even if the applications were not attractive for them. Therefore it could not be said that the applications succeeded to encourage the participants to continue using the applications voluntary. On the other hands, most participants of Virtual Aquarium and EcoIsland expressed that they wanted to keep using the applications.

In addition, a case in Persuasive Art that a female participant failed to continue the experiment indicates the importance of consideration on her tastes and of equipment for customization though the application could not cope effectively with her tastes.

6.2.2 Three types of life assist applications

The framework has defined three types of life assist applications, *Type A: Promoting desired behavior for public interest*, *Type B: Imparting knowledge about the target behavior*, and *Type C: Promoting desired behavior unnoticed*. Most existing persuasive applications including dieting [38]and reduction of electricity usage [4] use common persuasion techniques. Thus it could be said that the framework extends the area of attitude change using computers.

Although it is not guaranteed that the framework will cover all of life assist applications including what will appear in the distant future, we confirmed the six case studies were covered by the framework.

Overlap type

As EcoIsland applied two types of life assist applications, Type A and Type B, some life assist applications could apply multiple types. The case study showed that developers should consider whether or not each type could be applied to the planned application.

6.2.3 Limitations

This section describes some limitations and what the framework could not help developers.

Guideline for visualization of life assist applications

From six case studies, we have observed the power of visualization that designed intentionally or accidentally though our framework does not provide concrete guidelines about visualization of life assist applications except theories and heuristics that prevent setbacks and sustain the desired behavior mentioned in Section 3.5.4. This section gets implications for visualization in shape.

Attractive Visualization In Section 4.1.1, I introduced one of the design principles of ambient lifestyle feedback systems, *Emotional engagement*. In fact, we have learned animate ("living") subjects are appropriate expressions for motivating users because they are connected emotionally to the things. This could be explained by referring habituation theory. Attractive visualization has power to

keep users from getting bored and to prevent them from abandoning the application.

On the other hands, even though developers carefully apply theories and heuristics that prevent setbacks and sustain the desired behavior, users immediately stop using if they dislike the visualization. Unfortunately there is no guideline about attractive visualization, however, as Consolvo et al. mentioned, aesthetics can help with the technology's *surface credibility* [17].

Use of Metaphor We have introduced metaphor for visualization in many cases. In Virtual Aquarium case, for example, the green algae and the dirty aquarium were designed as a metaphor for unbrushed teeth. The action of fish means the beauty of oral hygiene. In EcoIsland case, the sea level means the threat of the global warming.

These visualizations are easily received by the users without bothersome prior explanation. Thus developers should utilize metaphor. However developer should avoid overuse of metaphor especially in "Multiple receivers" applications. These applications mostly adopt social comparison theory. The use of metaphor makes it difficult for users to compare each other. In fact, EcoIsland adopted numerical expressions partially such as EcoPoints and contribution of each member. Driving Behavior Change System also adopted numerical expressions such as fuel consumption.

Design for making receivers perceive social effects

As mentioned in Section 4.4, Mona Lisa Bookshelf did not work effectively because the application could not make receivers perceive social effects. This shows that It is not always true that social effects come up to the surface just by installing life assist applications in public.

Besides, the framework does not provide any clue of which social effect should be applied for a particular behavior although it says social effects should be used for the behavior for public interest and for imparting knowledge by comparing others.

Guideline for customization of life assist applications

As mentioned in Section 3.5.4, the framework has pointed out the importance of customization features. However the framework has not provide any clues to implement the features. Needless to say, there are tons of variables that are customizable in a life assist application. Developers want to know the order of priority of customization. In order to provide the order to them, we need to investigate the effects of interaction between users and applications in detail in terms of attitude change.

6.3 Reason to Prevent Attitude Change in Life Assist Applications

As mentioned in Section 2.1.2, there are many persuasion techniques that can be used for life assist applications. In particular, it was observed in the case studies that most classical techniques, *authority* and *liking*, hold prominent positions for attitude change. This does not mean that users are well persuaded if the applications use those techniques, but mean that users give up using the applications if the applications behave wrong and their trusts in the applications and sense of emotional attachment turn into disappointment.

Unlike existing applications including office suites, there is no reason for people to continue using life assist applications as mentioned in Chapter 1. Thus the behavior of life assist applications must be designed carefully rather than existing applications. The failure of context acquisition due to the poor grade of sensors and algorithms is one of the most frequent reasons to quit using the applications. Sometimes developers decide to adopt self reporting instead of automatic sensing like EcoIsland.

6.4 Ethical Concerns

Berdichevsky et al. discussed an ethics of persuasive technology and proposed eight ethical principles of persuasive technology design [7]. Generally the creators of a life assist application should comply these principles. However, some of them do not fit for life assist applications.

6.4.1 Incognizant persuasion

As I mentioned in Section 3.5.3, our framework assumes a type of life assist application that promotes desired behavior unnoticed. However the Berdichevsky's principles contain a golden rule of persuasion that is:

> *The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do.*

Ham et al. pointed out the effectiveness of subliminal feedback on a persuasive application [39]. In this paper, the authors acknowledged that there are potential ethical issues and informed consent for the receiver seems a crucial aspect of subliminal persuasion, they indicated that all persuasive applications in ambient intelligence environments have a tremendous amount of potential. Sophisticatedly blended systems into our environments in ambient intelligence era have this compelling question. Bohn et al. discussed the ethics in ambient intelligence and ubiquitous computing and suggested legal guidelines need to be drawn up in order to resolve who is ultimately responsible for behavior and functions of applications [9].

iDetective mentioned in Section 5.4 hided the purpose of the application but added a video-game flavor because passive people did not start using the application voluntarily. If no one runs an application from the sidelines, potential receivers cannot receive any persuasion messages. In order to get the existence in front of receivers, it is beneficial that applications have attractive exteriors or functions.

According to the principles, life assist applications that promote desired behavior unnoticed might violate this golden rule. Especially, life assist applications that weave persuasion messages into other functions seem to be violating the rule. Moreover, in the case of "Type C" applications, the target behavior was set by the developers of the applications and unnoticed to users.

At present, there is no sharp line between ethical persuasion and unethical persuasion. However, we need an ethical guideline for future life assist applications.

Chapter 7

Conclusion and Future Directions

This dissertation presents a framework for developing software always beside users. The last chapter concludes this research with summarization of this dissertation and describes the future directions of the research.

7.1 Conclusion

The rapid advancement of information technologies including sensors, algorithms, networks, packaging and so on, will change the interaction between users and applications. This dissertation proposed a new application area to be closely connected with human daily life, and is running every time and endeavor to enrich their quality of life by shepherding users to their goals, which was named *life assist applications*.

Even though there have been many researches about persuasive applications that are intended to change users' behavior, these applications do not suppose to use latest information technologies including sensors, networks and so on. In addition, there have been many theories to change attitude in the field of psychology, however, developers do not know how to apply those theories to the planned applications.

Due to the differences between life assist applications and existing applications, there was insufficient knowledge for development of life assist applications. In particular, users of life assist applications are rather passive or are not interested in those applications. Thus life assist applications need to make users start using them, to shepherd users to their goals, and to continue using them because

it takes much time to reach their goals. The proposed framework defined the three application stages and provided heuristics and guidelines for the first and the last stages. The framework defined three types of life assist applications and classified existing persuasion techniques and extended techniques by using computers into the three types. By selecting a type that is close to the planned application, developers are able to know useful persuasion techniques.

To confirm the effectiveness of the framework, six case study applications were developed and evaluated. From the six case studies, we found that the framework guided developers to design life assist applications though there were few reports of the statistical significance of attitude change. In addition, we have learnt knowledge and implications for practical issues for future life assist application development.

7.2 Future Directions

7.2.1 Simultaneous persuasion

When life assist applications become as common as current business applications, two or more life assist applications will be installed into users' own devices and those applications will run simultaneously. Under this circumstance, a user will receive two or more persuasion messages simultaneously.

Even if each visualization does not load heavy cognitive workload, a combination of different modality does load heavy cognitive load with users [43]. Besides, two or more applications might try to use a modality simultaneously. For further spread of life assist applications, we need to design a guideline for offering persuasion messages without collision against other messages.

7.2.2 Application to other areas for total optimization

Nowadays, there are a huge amount of computers that interact with people everywhere in the world. Those computers treat user input as incertitude data and they behave reactively. In these situations, the computers can only partially optimize the system that contains both people and those computers.

Latest computer systems get extremely large and serious in order to attend to every human need, and most of the systems are in vain. If the systems are able to

affect users' behavior for the sake of optimization, the systems could be compact and be economy. This could be applied to urban planning, physical distribution, and everything related to people.

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RESEARCH GRANT

1. 科学研究費補助金　若手研究 B: Persuasive Technology へのコンテクストアウェアネス技術の適用（研究代表者）　2009 年度 – 2010 年度　早稲田大学