Technology Reports

"petoco": A Home Communication Device

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Open Innovation

Design Ideas

Communication Devices

At NTT DOCOMO, we have been studying communication among families. As a result, we have identified problems in dual income families, where a child sometimes returns home while both parents are still out, and has fewer opportunities to talk with his or her parents. We developed petoco^{®*1} to provide these families with a means of communication that addresses the sorts of situations that can arise from the disjointed life rhythms of different family members. This is an innovative device that embodies the application and development of advanced technology based on concepts created using design thinking methods to solve issues from a human-centered design viewpoint.

1. Introduction

Based on our philosophy of creating a new world of communications culture [1], our aim at NTT DOCOMO is to resolve communication-related issues from the user's point of view. In line with this philosophy, we are focusing on the rapid changes that are taking place in family life, especially in Japan [2], and with families as our target users, we have begun a study of new services to address

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issues in family communication.

For this study, we have taken a new approach. Until now, many businesses have taken new technologies and market trends as their starting point, but it has been difficult to come up with new concepts that go beyond existing products and services, many of which have turned into standardized commodities [3]. In response to this situation, we have been considering more human-oriented approaches in order to identify new latent needs

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^{*1} petoco[®]: A registered trademark of NTT DOCOMO, Inc.

that users themselves may be unaware of, and to discover new markets based on these needs [4]. One such approach is that of design thinking [5]. As shown in **Figure 1**, the design thinking approach consists of a series of flows between the phases of "Inspiration" (careful observing and understanding the user), "Ideation" (creating ideas based on this inspiration), and "Rapid prototyping and verification" (where these ideas are quickly put into practice) [6].

In this article, we describe the sort of processes we considered for petoco as a concept device created through the use of design thinking to solve family communication issues [7], and we describe the technology that was used to implement it.

2. Application of Design Thinking to Concept Creation

Hereinafter, we describe how we applied the

design thinking method to the theme of family communication, and how we arrived at the final concept device through each phase of this process—(a) Inspiration, (b) Ideation and (c) Rapid prototyping and verification.

2.1 Inspiration

In creating this concept, we needed to recognize what sort of problems affect communication within families. To this end, we first sought to gain inspiration from family members who are the intended users of this system. In design thinking, "Inspiration" refers to the close observation and understanding of the user. To achieve this, we actually visited the homes of families with a range of different attributes, and we interviewed them regarding their use of communication. In particular, we focused on the communication issues of families categorized as Double Employed With KidS (DEWKS)—i.e., families with children where both



Figure 1 The design thinking process

parents go out to work. Recent surveys have shown that dual-income households are steadily increasing [8], and that further increases in DEWKS are expected in the future. From our interviews we found that DEWKS tend to exhibit characteristics such as the following:

- The lifestyle rhythms of parents and children tend to be highly independent (Figure 2)
- Parent-child contact time is very limited
- Since time is limited, they have a very strong desire to communicate with one another
- The lack of time gradually makes communication more troublesome and rarefied

Regarding these problems as a communication gap between parents and their children, we decided to study solutions for closing this gap. We also found that the above problems are more pronounced in DEWKS families with children of primary school age or younger who do not have any means of communication. We therefore conducted further interviews with these families as our target persona^{*2}. By interviewing these families at home, we were able to gather specific details on their lifestyle patterns such as the layout of their homes, the arrangement of their furniture and home appliances, and the paths people follow when moving around. From this, we were able to extract true insights^{*3} into the subconscious minds of users. As a result, we obtained the interview results and insights shown in **Table 1**.

With reference to these results, we defined our design principles by working towards "Ideation" based on our insights shown in **Table 2**.

Based on these insights obtained in the "Inspiration" phase, we studied device concepts in the



Figure 2 Typical communication gaps in a DEWKS household

	Table 1	Interview results	and the	insights	we obtained
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Interview results	Resulting insights
While parents continue to expect the same quantity and content of communication from their children, the chil- dren are less inclined to talk with their parents (especial- ly their fathers).	Family members find it difficult to talk because their life rhythms are disjointed and they spend little time together. However, they want to talk more about their real feelings.
The use of media such as sticky notes can convey thoughts and feelings that are difficult to express in digi- tal communication.	Even though communication is becoming more rarefied, people can still feel warmth and a sense of connection when communicating through media such as sticky notes and letters.

- *2 Persona: An imaginary stereotypical user of products and services
- *3 Insight: The user's intrinsic desires and intentions.

"Ideation" phase.

2.2 Ideation

In the "Ideation" phase, we held workshops and discussions with reference to the design principles extracted in the abovementioned "Inspiration" phase. This process generated a lot of ideas, which we organized and filtered down to refine the device concept through a combination of divergence and convergence. Based on these results, we created the original form of petoco with the product design described below. This included the major themes of a "tangible^{*4}" [9] experience and the role of a "hub" in the design principles obtained from the "Inspiration" phase. We also created use cases for this

design.

1) Product Design

Sketches of proposed product designs are shown in **Figure 3**. The features of these designs are presented below.

- An object in the living room or on an important pathway through which families pass
- A utilitarian design that is less susceptible to user preference
- Interactive character attributes with feelings and personality that encourage emotional attachment, particularly by children
- 2) Use Cases

Some examples of the use cases we came up with are described below.

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Insights	Design principles
Use devices to mediate and promote communication with- in families. Make the product appealing to encourage its use by children.	Provide a hub that can mediate communication between family members whose time is limited.
Design a tangible experience based on existing commu- nication metaphors.	Provide a tangible experience of existing modes of com- munication such as sticky notes and letters.



Figure 3 Product design proposal sketches

*4 Tangible: A word used in connection with real objects that

can actually be touched.

- When a parent is out somewhere and sends a message home, the message is printed out on a device in the home
- A smartphone can be used to monitor the interior of the home while out somewhere else
- When a child arrives home, it greets them and sends a notification to the parent's smartphone

2.3 Rapid Prototyping and Verification

At the "Rapid prototyping and verification" phase, we produced several simple mockups^{*5} with real textures and a number of functions and gimmicks. By using these mock-ups in the use cases obtained at the "Ideation" phase, we performed a more detailed user survey. Through this survey, we further refined and narrowed down the product design and use cases towards our final concept. 1) Product Design

The evaluation was performed using a mock-up in which a projector was used to create an image of a character on outside of the housing (Photo 1). We received a lot of positive feedback regarding the use of a curved product surface on which a character suddenly appears, particularly from children. The users also reported feeling a sense of unity and attachment with the product due to its

perceived cuteness, its changes in facial expressions, its responsive behavior, and other such attributes. 2) Use Cases

We decided on the functions of the final design concept after interviewing the users involved in a number of different use cases. Of these, the most positive response was obtained for the ability of this device to pass on messages sent by parents from outside the home. Working mothers were also highly appreciative of the function for monitoring the interior of the home. It was also pointed out that the ability to perform video calls was an attractive additional feature. We also found that ease of use and maintenance-free operation were also important points for prolonged use.

2.4 Final Concept

Through the "Rapid prototyping and verification" phase, we came up with petoco as our final concept. In this concept, we included the basic functions of text, voice and video messaging and video chat between petoco and family members with smartphones who are away from home, and between family members at home using petoco to pass on messages (Figure 4). In addition, the product design was made to blend in with the home interior, and attachment was stimulated by



Photo 1 The product undergoing evaluation

^{*5} Mockup: A model created for the purpose of prototyping and evaluating the appearance of a design.

projecting a character onto the outside of the product (**Photo 2**).

3. Functions Implemented by petoco

The final concept must be embodied as a commercial product and service using feasible technology. This section describes how we implemented the characteristic experience of petoco. The main specifications are shown in Table 3.

3.1 Video Output to a Smooth Curved Surface

In the evaluation mock-ups, we simply used an external projector to display images on the outside of the product, but for the final concept device, these images had to be produced completely by the product itself. We therefore adopted a rear



Figure 4 Basic function usage scenarios



Photo 2 Character display examples

Size	Approx. 16×13×13 cm (H×W×D)
Weight	Approx. 355 g
Camera	Mounted on front
Speakers	Mounted on bottom
Microphone	Dual microphone
Image projection	Internal rear projection system
Lighting function	Full color LED
Wireless LAN	IEEE 802.11b/n/g
Bluetooth [®] *1	Ver. 4.0
OS Android ^{™#2}	OS 5.1
Power supply	DC 12V/2A (AC adapter included)
Technical features	Face recognition, speech recognition, echo cancellation, noise reduction

Table 3 Main specifications

%1 Bluetooth®: A registered trademark of Bluetooth SIG, Inc. Used under license by NTT DOCOMO.

%2 Android™: A trademark or registered trademark of Google LLC.

projection system that projects images from inside petoco onto its smooth curved casing, which has a texture like frosted glass. To display uniform images on the product's curved surface, we used a focus-free*⁶ Laser Beam Scanning (LBS)*⁷ pico projector module*⁸ (Figure 5). To enlarge the drawing area displayed on the housing, we increased the projection distance by using a mirror mounted inside the housing. A secondary effect of using a mirror is that it allows video to be projected without having to correct the left-right mirroring of the rear-projected images that would have occurred if they had been projected directly onto the interior of the housing (Figure 6).

3.2 Simple Operation

1) Voice Input and Output

petoco is a device that is designed to be kept in

*6 Focus free: Focusing independently of the projection distance and angle, making focus adjustment unnecessary.

*8 Pico projector module: A module made with ultra-compact el-

the living room or dining room, and unlike handheld devices, it must always be capable of being operated from anywhere in the house. We must also assume it will be used by young children who may have difficulty inputting text. Based on these requirements, we decided to specialize petoco to operate only with voice input. This device uses a dual microphone to implement noise reduction*9 and echo cancellation^{*10} functions so that it can respond appropriately to voice input from users even in environments where there is background noise such as TV audio and other people talking. Furthermore, to provide feedback when voice input is received, the character responds in a way that corresponds to the function being performed so as to encourage feelings of attachment from children of lower elementary school grades at whom the product is targeted. During conversations with the device,

ements necessary for a projector such as an optical engine, driver and video processor.

*9 Noise reduction: Technology for suppressing noise. This is used in petoco to improve the accuracy of speech recognition in noisy environments.

^{*7} LBS: A system where a semiconductor laser beam is scanned by reflecting it from a MEMS mirror in order to project images.



Figure 5 Overview of the laser scanning projector



Figure 6 Using a mirror to perform back projection over a wider area

the character uses speech synthesis to generate different tones of voice.

2) Face Recognition

petoco must be able to recognize family members and provide each of them with the messages and other information they require. We implemented this capability by using a face recognition function. By registering the faces of family members the first time it is used, petoco can understand who is in front of it and can identify family members without any special operations.

Since this face recognition is always on, petoco can recognize family members at any time, say hello to them, congratulate them on their birthdays, and announce other pre-registered events such as anniversaries.

3.3 Communication Functions

1) Messaging

The messaging function received the most positive feedback from target users. It grew out of the existing idea of using sticky notes to pass messages between family members. A smartphone and petoco can exchange text, images and video, and petoco also has a function whereby people can leave messages by speaking directly to petoco itself. When

^{*10} Echo cancellation: A technique for removing echoes generated when a microphone picks up sound output by a device's speaker.

messages are received by petoco, face recognition is used to identify who the message should be sent to, and by having the character read out the messages, petoco performs the role of a family hub in relaying communication. Also, when sending a message from a smartphone, this can be done easily by using a familiar text chat interface (**Figure 7**).

2) Video Chat

To implement video chats between petoco and smartphones, we used a technology called Web Real-Time Communication (WebRTC) that enables Peer-to-Peer (P2P)^{*11} communication between browsers to facilitate real time communication such as video calling. In addition to use within web browsers, we are also working on the provision of Software Development Kits (SDKs)^{*12} for various development environments to facilitate the development of software that works with petoco.

3) Monitoring

We also implemented a function that uses face recognition to send notifications to smartphones when family members arrive home. However, in the interviews, many people expressed concerns about the security considerations of this sort of feature. We therefore took care to ensure that there was no way of using the product to covertly monitor the home remotely via a smartphone, or for sending pictures from inside the home automatically when notifying a smartphone that someone has just arrived home.

3.4 Light Function

The enclosure contains RGB color-changing LEDs that allow it to light up. During the initial setting, it is possible to set a different color for each registered member of the family. When information has been stored in petoco, it can attract the recipient's attention by blinking with the color corresponding to this individual (**Photo 3**). It can also be used as a table lamp.

3.5 Low-noise Design

It is assumed that petoco will be installed in living rooms and dining rooms where families spend most of their time. For this reason, one of our design policies was to avoid incorporating any sources of noise such as cooling fans into the



Figure 7 Transmitting and receiving messages

*11 P2P: A communication model where computers exchange information on an equal footing in contrast to the client-server model. In this article, exchanges of information between two mobile terminals and between a mobile terminal and petoco are all performed on an equal footing.

*12 SDK: A tool or set of tools used for software development.



Photo 3 Lighting example

product. Since this device uses a built-in projector to produce rear-projected images, our main concern was the dissipation of heat from the projector. Furthermore, we needed to ensure that the laser light from the projector could not escape and shine directly into people's eyes, and that the light from the LEDs inside the enclosure could not leak out from the enclosure, which made it difficult to ensure a large enough opening in the enclosure to allow heat dissipation. We decided to study the use of heat dissipation technology using carbon fiber^{*13}, which is not only more efficient than conventional technology based on aluminum or copper, but also performs better and is more reliable. After trying out various heat sinks, we confirmed that carbon fiber gave the best results, so we incorporated it into the device.

4. Conclusion

This article has described how we used design thinking to study concepts in the development of petoco, and how we embodied these concepts into a commercial product.

Although design thinking led us to an excellent concept, there are still many issues that must be resolved in terms of feasibility and cost in order to make this into a substantial device. We hope to continue this sort of new initiative in order to accumulate know-how and provide attractive new services.

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*13 Carbon fiber: A material consisting of carbon atoms bonded together in long chains.