A Study on Modality Adaptation Support for Migrating Services

Kiyotaka Takahashi
Nokia Research Center, Nokia Japan Co., Ltd.
Graduate School of Information Science and Engineering, Tokyo Institute of Technology
kiyotaka.takahashi@nokia.com

Tetsuo Yamabe
Nokia Research Center, Nokia Japan Co., Ltd.
Department of Computer Science, Waseda University
tetsuo.yamabe@nokia.com

Etsuya Shibayama
Graduate School of Information Science and Engineering, Tokyo Institute of Technology
etsuya@is.titech.ac.jp

Abstract

This paper presents our work on a service framework for supporting pervasive computing systems. In our vision, a novel mobile service based on pervasive computing requires to provide high accessibility regardless of computing platform and user context. From that point of view, user interface is one of key issues to achieve the vision. Therefore, we discuss technical challenge such as adaptation and context-awareness in terms of user interface. In this paper, we described the requirements and design for the service framework, and its application through explaining a possible scenario. Then we identified diverse modality as a technical challenge for achieving such mobile service and applied media conversion for adapting data representation to each particular modality. Besides, we carried out user trial using an experimental prototype. The results of the trial show the proposed approach for modality adaptation is beneficial to users in some aspect through usability and feasibility analyses.

1. Introduction

Recently, pervasive computing is quite hot research topic. In [1], M. Satyanarayanan described his vision on pervasive computing and identified the research challenges in that area. On the other hand, Rapid growth of computing hardware technology allows intelligence - which comprise of memory, processor, communicator, sensor and etc - to be pervasive in our daily lives. Services would be available in any scenes; and we could enjoy the benefits by interacting with various types of devices (e.g. mobile phones, PDAs, laptop PCs, and robots). In some senses, the hardware environment has been getting ready for achieving the pervasive computing.

On the other hand, the kind of hardware components that composes the device has become diversified due to a wide range of requirements and limitations (e.g. efficient energy consumption, shape for the portability). It leads to decrease the portability of services, since software (including operating systems and applications) is tightly coupled with their target hardware in many cases.

Consequently, the service portability with user interface (UI) would be an issue in this case. We assume that the service could be aware of the real world with support from the ambient intelligence; and could migrate among various devices to follow the user. Therefore, UI has to be adaptive to keep providing seamless user experience in the diversity of modalities. (Modality is "a sense through which human can perceive the output from computer" and "a sensor through which computer can receive the input from human". In this paper, we use the word, "Modality", for meaning Computer-Human interaction model)

A possible solution might be to provide a unified interface to access centralized service logic and data. For example, Google Inc. provides several kinds of services via web interface: web search, map search, mailer, and etc. However, required modality to the interface (input from keyboard and output to display) is still traditional PC based; and not enough adaptive to heterogeneous devices.

On the other hand, advanced devices (e.g. robots, ambient displays) have been emerging to support us. Such devices have quite different modalities in terms of user interaction. Also their target service domains are mutually isolated from each other. For example, PC and robot can not provide the same service to users in the same approach.

Even though they have quite different modalities and computational architectures, their objectives are essentially same - "Assist the daily life of the people". We believe that possibly they can collaborate and assist us transparently, according to user's situation and device's capability. Then, we consider a service framework for migrating services among such heterogeneous platforms.

When we consider the service framework, the main issue could be the diversity of modalities to keep providing seamless user experience. In this case, we anticipate that services could provide basically the same functionality, even though the service was migrated to a device which has different modality. In reality, nevertheless, it would be difficult to provide completely same functionality, because equipped capabilities of input and output are different among the devices. Therefore, we consider that point as the essential challenge in the paper: "How the service can keep providing semantically same service before-and-after the migration?"

1.1. Sample Scenarios

Figure 1 shows a sample scenario of service migration. In this scenario, we assume route navigation service is going to be used by a user. Also, three different types of devices could be found in the figure: Laptop PC, Mobile phone, and Robot.

There are four different scenes, which show possible situations that the navigation service is used:

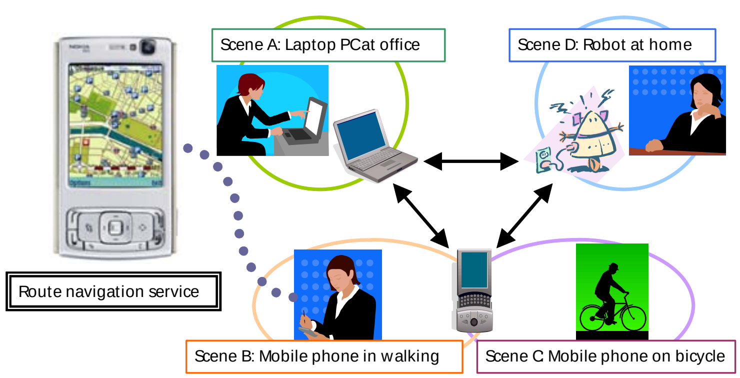


Figure 1. Service migration concept among heterogeneous devices

In Scene A, a user sets an objective point and searches the route to there by laptop PC at office. Laptop PC equips a large display and a big keyboard as an interface. Also, it is connected via a cable and has wide network bandwidth, which is enough to search the route interactively.

Then, in Scene B, the user migrates the navigation service to her mobile phone with keeping the result acquired in scene A. Mobile phone equips also a display and keyboard like laptop PCs, but the size of them are smaller and difficult to perform complex operations with the narrow bandwidth of wireless network. However, in this scenario, the user has already searched the route in Scene A; and no need to worry about that. On the mobile phone display, the map is adjusted to fit the small display; and automatically scrolls according the user's location, which is detected by GPS.

In Scene C, the user attaches the phone to her bicycle. The difference with scene B is the user's activity: walking and riding on a bicycle. The user can not use the keyboard anymore and hard to look the display carefully. At the moment, navigation service automatically switches its mode to allow voice interaction. This adaptation is supported by ambient intelligence: we assume that sensors are embedded into the surrounding environment and can detect user's activity from them. For example, the user wears sensor jacket and shoes; and they detect the user's posture and her leg motion.

In Scene D, the user finds the route in natural communication with a robot. Robot could be assumed that it has intelligence and can acquire the route without sequential operation from the user. In this sense, its modality is so similar with the human-to-human communication and different with ordinary PCs. Surely the navigation service itself could be migrated to other devices which appear in other scenes.

1.2. Analysis and Approach towards Adaptive UI

As seen in the scenario in the previous section, several situations could be considered to the advanced portable service. Based on the scenario, we figured out the important factors to design adaptive UI on the portable service in **Figure 2**. Mainly situations differ from the modality of device (a) and the service should change its interaction mode according to them.

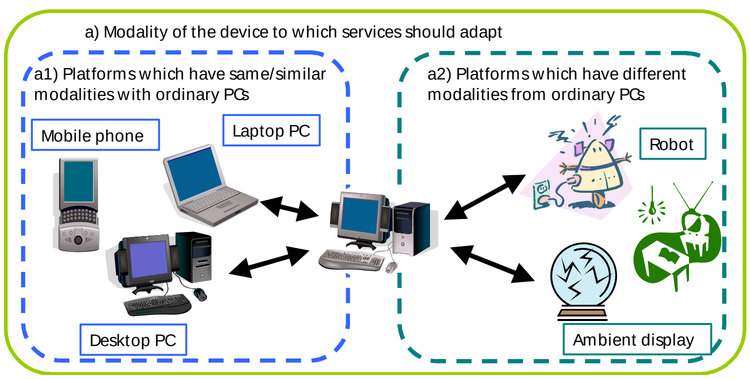


Figure 2. Important factors of adaptive UI design on portable services

Regarding a), possible cases could be categorized into two types: a1) adaptation among devices which have same/similar modalities with ordinary PCs (Scene A, B and C) and a2) adaptation among devices which have different modalities from ordinary PCs (Scene D).

2. Service Framework for Modality Adaptation

Based on the discussion in the previous section, we propose to carry out media conversion for adapting data representation to each particular modality at the task migration. This approach aims to keep accessibility to the semantically same service. The target conversion medium type has to be selected according to capability of target device.

2.1. Practical Scenario

Before jumping in discussion about advanced scenario like Scene D, we think that discussion about more practical scenario like **Figure 3** is quite important. Laptop PC has LCD, keyboard, and mouse. And Mobile phone has tiny LCD, speaker, and microphone. These devices have computational power, storage, and network connectivity in common. As a practical scenario, we assume that a web browsing application is migrated from PC to Mobile phone. PC allows users to read web pages by displaying them on its LCD. However, it seems Mobile phone does not provide the similar user experience with the same approach, because it does not have equivalent equipments to large LCD. Therefore, we attempt to apply media type conversion to this situation. As described above, Mobile phone can convey the contents of the web page to users by reading out instead of displaying to its LCD.

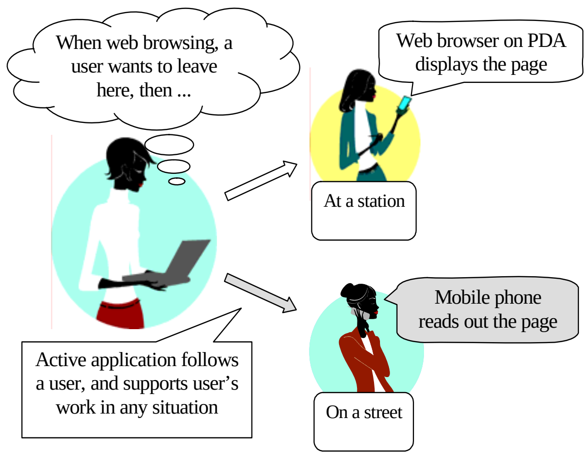


Figure 3. Practical scenario of the proposed concept

2.2. Requirements

Here explains the required mechanisms for keeping accessibility to the semantically same service. The followings are these required mechanisms:

- **Service migration trigger**: The service migration is triggered when user changes working environment from a device to another. To detect the trigger for the migration, each device has to have such capability.
- **Recognition of activated service for users**: This mechanism allows the service framework to recognize a service being used by user currently. After the recognition, the framework can transfer the service to destination. We think that we can consider current focused window as a service being used.
- **Media conversion**: In general, "Media conversion" means changing data formats (e.g. converting from .BMP to .JPG). However, we intend to use word "Media conversion" in the meaning of switching the category of data representation (e.g. text-to-speech, video-to-speech). We think that the media conversion is a key approach to make services available among the devices having diverse modalities.

- **Service migration**: This mechanism allows users to continue using the same service between source and destination devices.

3. Implementation

To demonstrate providing seamless user experience even though the service is migrated between heterogeneous devices, we implemented an experimental prototype of the service framework for modality adaptation. This section explains the implementation of the experimental prototype.

3.1. Approach

In this implementation, we especially focus on providing accessibility to the semantically same service. Then we assume the service migration is carried out from a device equipped LCD to not only a device equipped LCD, but also a device not equipped LCD. Therefore, we consider the following two service migration scenarios, Laptop PC to PDA and Laptop PC to Mobile phone.

We select the following approaches for the implementation:

1. **Service migration trigger**: Drag & drop operation.
2. **Recognition of activated service for users**: This functionality is not necessary in the prototype because a service is specified by drag and drop operation explicitly.
3. **Media conversion**: Use Text-To-Speech engine (The Festival Speech Synthesis System).
4. **Service migration**: Transfer only processing data from source device to destination device.

3.2. Design

The service framework is comprised of two sets of functions as source node and destination node. Each device plays role of source node, role of destination node, or both according to user's situation and device's capability.

3.2.1. Source node: The role of source node is to execute migration of data file indicated by users to destination node after applying appropriate media type conversion. Here summarizes each step of the migration procedure:

1. **Device detection**
   Detect a proximal device as possible destination using Phidget RFID Kit. And then, a popup window displays a corresponding image for the device.
2. **Drag and Drop**
   To trigger the migration, users drag a target file and drop it onto the popup window to indicate the target file for the migration.
3. **Media type conversion**
   Convert the target file into appropriate media type according to modality of destination node. Each node maintains some tables such as **Table 1** and **Table 2** for the conversion.
4. **Migration**
   Transmit the target file to destination node.

Table 1. An example of table of output device capabilities

Output device	Acceptable media type
LCD (VGA)	html, txt, avi
LCD (QVGA)	html, txt, avi
LCD (SQCIFF)	avi
Speaker	mp3, wav
LED	mp3, wav

Table 2. An example of table of device information

RFID tag	Device name	Image file	Available output devices
0x010238a67d	my_PDA	PDA.jpg	LCD (VGA), Speaker
0x0102387f87	my_phone	Phone.jpg	LCD (SQCIFF), Speaker

3.2.2. Destination node: The role of destination node is to provide accessibility to the semantically same service by invoking an appropriate application according to data file received from source node. Here summarizes each step of the procedure at destination node:

1. **Data receipt**
   Receive data from source node, and save it in a file.
2. **Application invocation**
   Invoke an appropriate application program according to type of received data

4. Evaluation

We intend to evaluate feasibility and usability of the proposed service framework for modality adaptation.

4.1. Experiment

To evaluate the framework, we prepared experiment composed of Task #1 and #2. Each task is composed three sets of sub-experiments. In each sub-experiment, a subject reads the first half of a web page on Laptop PC. And the subject continues to read (Task #1) or listen (Task #2) the second half of the same web page on a mobile terminal. Then the subject answers small quiz about the contents of the web page. One group of subjects starts task #1 and then task #2. The other group starts task #2 and then #1. After completion of both tasks, subjects answer questionnaire about the experiment.

- **Task #1:** A subject iterates the following steps for three web pages about entertainment, science, and sports:
  1. Read the first half of a web page on Laptop PC
  2. Migrate the second half the web page to PDA
  3. Read the second half of the web page on PDA
  4. Answer small quiz about the web page

- **Task #2:** Unfortunately, we don't have any actual programmable mobile phone. Therefore, we uses Nokia Internet tablet 770 as substitute for actual mobile phone. In Task #2, a subject iterates the following steps for web pages about entertainment, science, and sports:

  1. Read the first half of a web page on Laptop PC
  2. Migrate the second half the web page to Phone
  3. Listen the second half of the web page on Phone
  4. Answer small quiz about the web page

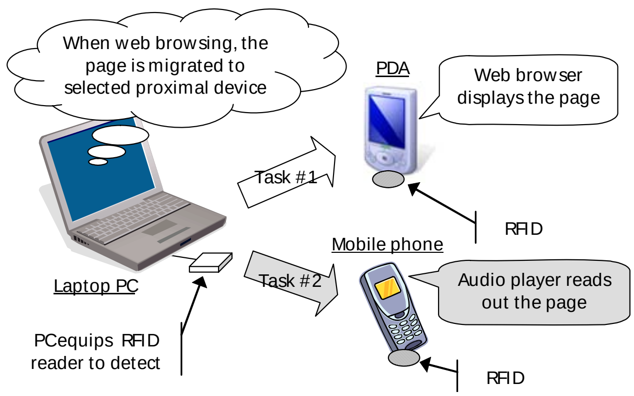


Figure 4. Experiment environment of the service migration

4.2. Discussion

We carried out the experiment with 6 subjects and evaluation of the results from the perspective of feasibility and usability. However, we could not produce statistically significant result due to the lack of number of subjects. We measured the degrees of achievement as feasibility, and measured the degrees of satisfaction and efficiency as usability. The questionnaire contains items on a 5 point scale ranging from "strongly agree" to "strongly disagree" for asking subjects' satisfaction and efficiency of the proposed approach. **Table 3** shows these questions. Q1, Q4, and Q7 are questions about Task #1. Q10, Q13, and Q16 are questions about Task #2. Q19 is question about overall aspects of the experiment. The others are asking subjects' comments.

Table 3. Questions in the questionnaire

No.	Question
Q1	I feel the simple task migration (i.e. Task #1) is useful
Q4	I feel readability of text information displayed on the PDA acceptable
Q7	I feel this operation is complicated for the purpose of browsing the web page continuously
Q10	I feel the task migration with media conversion from text to audio (i.e. Task #2) is useful
Q13	I feel listenability of audio information, which is read out by the phone, is acceptable
Q16	I feel this operation is complicated for the purpose of browsing the web page continuously
Q19	I feel the "Drag and Drop" operation is easy to trigger the migrations

4.2.1. Achievement: To measure the degree of achievement, we asked the subjects to answer small quiz in each Task. Each quiz is composed of four questions. First two questions are related to the contents of the first half of a web page. Last two questions are related to the contents of second half of the page. Therefore, we think that percentage of correct answers show their degree of achievement of Task.

Table 4 shows the detail of score of the quiz. It shows approximately the same mean values of score of PC cases in both Task #1 and #2. On the other hand, the mean value of score on PDA in Task #1 is the highest compared with the other mean values. As compared with PDA case, score of five subjects in Phone case dropped.

Table 4. Scores of quiz in each task

Subject	Task #1			Task #2			Total Score
	PC	PDA	Subtotal	PC	Phone	Subtotal	
A	2	5	7	6	5	11	18
B	5	6	11	5	3	8	19
C	5	6	11	4	5	9	20
D	6	6	12	5	2	7	19
E	6	5	11	4	4	8	19
F	5	6	11	5	4	9	20
Mean	4.83	5.67	10.50	4.83	3.83	8.67	19.17
SD	1.47	0.52	1.76	0.75	1.17	1.37	0.75

To analyze the trend of the degree of achievement among platforms, we carried out t-test for the sets introduced from the differences between the scores on each platform. For this calculation, we used a statistical analysis tool, SPSS. Table 5 shows the results of the statistical analysis. In this calculation, the degree of freedom is 5.

Table 5. Result of t-test for the scores of the quiz

Pair for the calculation	Mean	SD	t-value
PC in Task #1 – PDA	-0.833	1.329	-1.536
PC in Task #1 - PC in Task #2	0.000	2.098	0.000
PDA - Phone	1.833	1.472	3.051
PC in Task #2 - Phone	1.000	1.414	1.732

In the case of confidence range 95% and five degrees of freedom, we find the value, 2.571 in t-distribution table. In Table 5, the pair of PDA and Phone shows the significant difference. However, the other pairs don't show the significant difference. Therefore, it means that PDA is better than Phone to achieve these tasks in the experiment.

4.2.2. Satisfaction:

- **Migration from PC to PDA** The result of Q1 shows that many subjects have positive opinion of the proposed approach for the migration. The result of Q4 shows that the readability of text information on PDA is still insufficient level for some people.
- **Migration from PC to Phone** The result of Q10 shows that the subjects have approximately neutral impression on the proposed approach. However, the result Q13 shows that all subjects have slightly negative feeling of the listenability of voice synthesized by TTS. Perhaps the result of Q10 was caused by the insufficient listenability.

Overall, those results show a positive trend for the proposed concept and selected approaches to some extent, we think. In the questionnaire, some subjects mentioned the insufficient quality of voice synthesized by TTS. In that sense, the improvement of the quality can affect these results directly.

4.2.3. Efficiency: About the operation, the result of Q7 shows that the subjects have approximately neutral or positive impression. However, Q16 shows that some subjects have negative impression. One subject pointed out that the migration for Phone takes time too much. Therefore, the difference between the results of Q7 and Q16 might be caused by the quality of the current implementation. And the result of Q19 shows many subjects have positive feeling of "Drag and Drop" operation as service migration trigger.

Table 6. Scores of each question in the questionnaire

Subject	Q1	Q4	Q7	Q10	Q13	Q16	Q19
A	5	2	3	3	2	2	5
B	2	4	2	4	2	2	3
C	4	4	2	2	1	4	4
D	4	4	3	4	2	3	3
E	4	2	4	3	2	3	4
F	5	4	4	3	2	2	4
Mean	4.00	3.33	3.00	3.17	1.83	2.67	3.83
SD	1.10	1.03	0.89	0.75	0.41	0.82	0.75

5. Related Works

In pervasive computing area, there are quite many related works to our work. We think that the diversity of modalities as main topic in this paper has a strong connection with computer-human-interaction technology. Therefore, here we summarize related works such as multimodal markup language, direct manipulation, and multimodal interaction systems.

5.1. Multimodal Markup Language

Nowadays several parties are proposing many multimodal markup languages. The W3C are standardizing an XML based language called the Extensible MultiModal Annotation Language (EMMA) [2] to define syntax for interpreting a variety of inputs. It allows systems to semantically interpret the inputs such as speech, natural language text, and GUI. SALT forum is proposing Speech Application Language Tags (SALT) [3] for describing speech recognition and Text-To-Speech function in an HTML document. SALT lets Web developers describe speech interactions by embedding their dedicated tags for speech interaction in an HTML document. The XHTML+Voice profile [4] allows integration of voice interaction as additional modality by adding VoiceXML code into a header section in XHTML document.

These XML-based markup languages allow service providers to deliver Web contents with a variety of multimodal interactions. They provide powerful ability to describe an interaction for specific modality in the contents. In that sense, we think that they are useful to describe possible interaction for multiple modalities. However, it requires to be interpreted those contents by parser function like Web browser. This might be one potential restriction when our scenario described in this paper is realized, because the migration will be limited to some kind of services (e.g. Web service, service executed by dedicated software, which has a parser function for them).

5.2. Direct Manipulation

Direct manipulation is an approach for intuitive computer-human-interaction. In this research area, there are some related studies to our work. Pick-and-Drop [5] is an extended concept of the commonly used drag-and-drop in window system on PC. With this technique, a user picks up an object on one computer display with a stylus, and then drops it on a (possibly different) computer display. In terms of usability, many researches show the effectiveness of such direct manipulation; and it is also a quite potential approach for us to provide fine usability, even though we are currently using a normal drag-and-drop technique for triggering service migration in the prototype. MigriXML [6] is software architecture for allowing user to control the runtime migration of a graphical user interface from one computer to another one (e.g. from a desktop PC to PDA). It generates a virtual reality environment, which represents actual computing environment. In this environment, for example, user can move an application window from a desktop PC to PDA by drag-and-drop manner. This action invokes the migration of the program code of application in the real world. Besides, Donatien Grolaux, et al. [7] also proposes migratable user interface, which allows developers to provide a migratable UI and API based on QTk toolkit.

They have the sophisticated software architecture to realize such runtime migration of a data object or a graphical user interface. In that sense, they are a good reference for us. On the other hand, currently they only handle applications having common modality (i.e. conventional windows-icons-menus-pointers (WIMP) interface). It would be a serious limitation in our work, because our vision focuses on supporting diverse modalities (e.g. no display device like ambient display [8]).

5.1. Multimodal Interaction

Multimodal interaction system is one of the hottest research themes in computer science. In this theme, there are some related research topics to our work. One is to adapt user interface to user's ability or execution context of application. Patrick Roth, et al. [9] proposes an auditory browser, which provides accessibility for Web pages to visually impaired users. To deliver the contents of Web pages effectively, this browser analyzes not only spatial layout of Web page but also graphical objects. And Mario Bisignano, et al. [10] presents a software framework, which allows developers to realize fine usability by adapting execution context of application program. For example, the software framework selects the combination of playing visual contents on a device according to user preference and available network bandwidth at runtime.

The other one is to propose a design model for multimodal interaction system. ACICARE [11] and DynaMO-AID [12] are design models for multimodal interaction systems. ACICARE is dedicated to the design process for mobile multimodal interface in order to enable the rapid development. For this purpose, it provides a component-based platform for designing multimodal interface. And it also provides an analysis tool, which probe the used functionality on mobile device, for improving the interaction design. DynaMO-AID provides a design process for context-aware user interface and a design tool for visualizing the design. In this design process, they propose several design models to describe relationships between perceived contexts and internal states of multimodal interaction in their design process. It allows multimodal interaction designer to describe multimodal interactions by defining these relationships using the visualized design tool.

Those multimodal interaction systems handle a specific context or state transitions according to perceived context on a single computing device. In that sense, they present quite nice approaches for designing multimodal interaction. In our vision, however, we assume the use of a single service with diverse devices according to user context and situation. Therefore we need to consider a transition in not only user context but also diverse devices.

6. Conclusion

This paper presented our work on a service framework for supporting pervasive computing systems. We have described the requirements and design for the service framework, and its application through explaining a possible scenario. Also we have carried out a survey on the recent UI technologies in terms of the computer-human-interaction.

When we consider a way to provide high accessibility for services regardless of computing platform and user context, we have identified diverse modalities as a technical challenge. It prevents the provision of seamless user experience. Therefore, we applied media conversion for adapting data representation to each particular modality at the task migration. This approach aims to keep providing accessibility to the semantically same service on among heterogeneous devices with diverse modalities.

Besides, we implemented the experimental prototype of the proposed service framework. To evaluate the feasibility and usability of the framework, we have also carried out user trial (N=6) on this prototype, and analyzed the results in detail. According to the results, we found that the Phone platform in the prototype has some defects in the design and implementation (e.g. quality of synthesized voice, operability of the control function). However, about the migration from PC to Phone, we have got many positive comments on the usefulness as answers to the questionnaire. And generally the results also showed that the positive trends for the proposed service framework to some extent. In particular, the results show that the migration from PC to PDA would be acceptable from the perspective of the degrees of both achievement and satisfaction. Therefore, we believe that we have managed to propose the potential service framework for providing seamless user experience among heterogeneous devices with modality adaptation.

As a future work, we would like to improve the proposed concept and develop the sophisticated prototype for further evaluation with a large number of users.

7. References

[1] Satyanarayanan, M, "Pervasive Computing: Vision and Challenges", IEEE Personal Communication, August 2001, pp. 10-17.

[2] The W3C Multimodal Interaction working group, “EMMA: Extensible MultiModal Annotation markup language”, http://www.w3.org/TR/emma/

[3] SALT Forum, “Speech Application Language Tags (SALT)”, Technical White Paper

[4] VoiceXML Forum, “XHTML+Voice Profile 1.2”, http://www.voicexml.org/specs/multimodal/x+v/12/

[5] Jun Rekimoto, “Pick-and-Drop: A Direct Manipulation Technique for Multiple Computer Environments”, UIST 1997, pp. 31-39.

[6] Molina, J.P., Vanderdonckt, J., Gonzalez, P., “Direct Manipulation of User Interfaces for Migration”, IUI 2006, pp. 140-147.

[7] Grolaux Donatien, Van Roy Peter, Vanderdonckt Jean, “Migratable User Interface: Beyond Migratory Interfaces”, MobiQuitous 2004, pp. 422-430.

[8] Wisneski, C., et al., “Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information”, CoBuild 1998, February 1998, pp. 22-32.

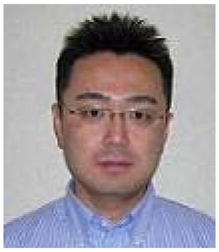
[9] Roth, P. Petrucci, L., Pun, T. and Assimacopoulos, A, “Auditory Browser for Blind and Visually Impaired Users”, CHI 1999, pp. 218–219.

[10] Mario Bisignano, et al, “Dynamic User Interface Adaptation for Mobile Computing Devices”, SAINT 2005 Workshops, pp. 158-161.

[11] Marcos Serrano, et al., “Multimodal interaction on mobile phones: development and evaluation using ACICARE”, MobileHCI 2006, pp. 129-136.

[12] Tim Clerckx, et al., “Tool support for designing context-sensitive user interfaces using a model-based approach”, TAMODIA 2005, pp. 11-18.

Authors



Kiyotaka Takahashi received a BSc degree in Information and Computer Sciences from Toyo University, Japan, in 1994. He worked for Soliton Systems K.K. and Lucent Technologies Japan Ltd. In 2000, he joined Nokia Japan Co., Ltd. He has been a Ph.D. student at the Graduate School of Information Science and Engineering, Tokyo Institute of Technology since 2004. His research interests include programming language and pervasive computing.

Tetsuo Yamabe received a BSc degree in Information and Computer Science from Waseda University, Japan, in 2003, and a MSc degree in Information and Computer Science from Waseda University, Japan, in 2005, and is currently pursuing a Ph.D. degree in Information and Computer Science at Waseda University, Japan. In 2005, he joined Nokia Research Center in Tokyo. His research interest includes mobile and pervasive computing.

Etsuya Shibayama received the BSc and MSc degrees in mathematical sciences from Kyoto University, Japan, in 1981 and 1983, respectively, and the DSc degree in information science from the University of Tokyo, Japan, in 1991. He has been a professor in the Department of Mathematical and Computing Sciences at Tokyo Institute of Technology since 2000. His research interests include textual and visual programming languages, user interface software, system software, and software security. He is a member of the ACM, the IEEE CS, and Usenix.