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Mobile & Wireless Communications

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Mobile Broadband Communication Systems  
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Mobile Convergence Trends  
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# An Extension of Executable UML for Modeling u-Home Network : Mapping HCI with SE

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## Abstract

*Exactly to develop the customer's needs with the new coming ubiquitous mechanism, it might need the new development method, which be focused on user centered analysis instead of system or developer centered development. Therefore, this paper attempts to graft SE(software engineering) into HCI(Human Computer Interface) for developing the future ubiquitous related systems to be needed new paradigm against the current existing system developments.*

*To do this, we suggest the user behavior analysis to develop products of new paradigm, and extend the standardized software modeling language, UML(Unified Modeling Language), to model based on the user centered behavioral analysis for the future systems on Ubiquitous environment.*

*To illustrate the proposed approach we use to a modeling example of u-Home Control System with our extended UML.*

## 1. Introduction

In near future's ubiquitous environment [1], it will be very important issue to estimate user demands and to develop a new product through modeling based on the user behavior analysis. Just even within one small domain, it will be happened a lot of diverse observable user data with which we be hard to analyze user behaviors. We cannot model with these behavior data. So, if just collect user behaviors with satisfying the particular goal, we get the user behaviors limited, but satisfied. To analyze behaviors which satisfy the user's particular goal on these data, it will protect to occur errors during developing new

ubiquitous paradigm's product [2]. Then it will be possible to model U-home control system with the goal oriented user behaviors. Also it may be applied with adding or improving new functions of new appliances.

To analyze and model user behavior data, it will be necessary to have the modeling language on the view of HCI. Also many researches are in progress to reduce a gap between SE(Software Engineering) and HCI(Human Computer Interaction).

So, it is necessary to unify a standardized common language to deal with comprehension of representation for these two fields [3]. There is more focused on modeling the system to represent the system structure in the view of SE, while it makes clues of the application to disclose the behaviors of the system in the view of HCI. Paula[4] suggests new modeling language to deal with HCI-SE model with Interaction modeling language. Kim[3,5,9] also suggests the user behavior analysis methodology to develop products of new paradigm at the coming ubiquitous age. Through this methodology, Kim[3,5,9] mentions to analyze the user behaviors to achieve the same purpose within a particular system (or an environment), then extracting common / uncommon behaviors, and identify objects on user behavior scenarios. With this information, Kim[3,5,9] may model the system of new paradigm which will come.

In this paper, section 2 describes related work. Section 3 suggests the extension of UML for modeling the user behavior: Mapping HCI and SE. Section 4 shows one example to model u-Home Control System with our proposed

approach. The last section mentions the conclusion.

## 2. Related Works

It tries to have the modeling language and tool on the view of HCI to analyze and model user behavior data. There is more focused on modeling the system to represent the system structure in view of SE, while it makes clues of the application to disclose the behaviors of the system in view of HCI. Especially the User Process Based Product Architecture (UPPA) is focused on evaluating to represent the functional relationship between the user and the system [11,14].

Also many researches are in progress to reduce a gap between SE(Software Engineering) and HCI(Human Computer Interaction).

So, it is necessary to unify a standardized common language to deal with comprehension of representation for these two fields.

Paula[4] suggests new modeling language to deal with HCI-SE model using Interaction modeling language.

### 2.1. The original UML (Unified Modeling Languages)

Booch and Rumbaugh combined the concepts from the OMT and the Booch method at Rational Software Corporation in 1994. Jacobson also joined to work together. Their jointed work was called the Unified Modeling Language (UML). The Unified Modeling Language (UML) is a general-purpose visual modeling language that is used to specify, visualize, construct, and document the artifacts of software system [6,7,8]. The UML [10,12,15] captures information about the static structure and dynamic behavior of a system. The static structure defines the kinds of objects important to its implementation and the relationships among the objects. The dynamic behavior defines the history of objects over times the communications among objects.

In this time, it is very popular modeling language UML on diverse fields, especially software engineering.

There are three prominent parts of a system's model:

- Functional Model
  - the functionality of the system from the user's point of view.
  - Includes Use case diagrams.

- Object Model
  - the structure and substructure of the system using objects, attributes, operations, and associations.
  - Includes class diagrams.
- Dynamic Model
  - the internal behavior of the system.
  - Includes sequence diagrams, activity diagrams and state machine diagrams.

## 3. Extension of UML for Modeling User Behavior: Mapping HCI with SE

We suggest extending UML for modeling the user behavior centered system. Extended UML [13] has the three extended diagrams, such as Class Diagram, Concurrent Message Diagram, and Concurrent State Diagram, for modeling the user behaviors.

**Table 1. Notation of Actor, Class, Object, Role, and Rule**

Element	Notation	Element	Notation
Actor		Object's Role (RCOT)	
Object		Object's Rule (RCA)	
Interface (Boundary) Object			
Control Object			
Entity (Service) Object			

### 3.1. Class Diagram (CD)

CD describes the static structure of a system with role and rule mechanism. Its basic class may have the template types of role such as recognizer, decision, communication, and transaction. Also rule concept in the class is followed by ECA (Event/Condition/Action) in table 1.

### 3.2. Concurrent Message Diagram (CMD)

We also extend the basic sequence diagram with concurrent mechanisms (such as fork-join, reverse fork-join, etc) for handling real things. Table 2 describes the CMD notations of Extended UML.

In Extended UML, the object in concurrent message diagram also is followed by Ivar Jacobson's stereotype such as interface, control, and service object. Interface object (or boundary object) just transfers a message to control object without any state. Control object makes a decision and mediates (or controls) between interface and service object. Service object transacts with data needed. Like class's role, its object may or may not have one or more roles of recognizer/ decision/ communication/ transaction.

Table 2. The CMD notation of the Extended UML

Element	Notation	Element	Notation
Event		Message	
Incoming		Outcoming	
Choice		Multiple Choice	
Fork/Join		Reverse Fork/Join	
Communication		Broad-casting	
Temporal Delay			

In other words, the object has role(s) based on which ERCDT (Event/ Recognition/ Communication/ Decision/ Transaction). Each object may or not have zero or more role(s). Also the object is included with ECA (Event/Condition/action) rule. For example, one object comes in an event, checks the condition, and then acts some service. Basically our approach is adopted synchronized message passing mechanism in CMD. And we include time delay that the message is received in time.

### 3.3. Concurrent State Diagram (CSD)

Still on our research, CSD will be basically followed by nested mechanism with OCL(Object Constraint Language). This diagram will contain some mechanisms for deterministic/stochastic system. Next time, we will extend automatically to check and convert from nondeterministic to deterministic state diagram.

## 4. Case Study

We shows one modeling example of "u-Home control System" with our extended UML.

### 4.1. Static Modeling using Class Diagram

Figure 1 shows the static modeling of u-Home Control System based on 'Fire prevention' use case scenario. In this class diagram, the system controller is important to control the u-Home environment. The Controller has the association relationship with Beeper, GasRange, PowerSupply, and Sensor class. The controller class controls all devices in the system.

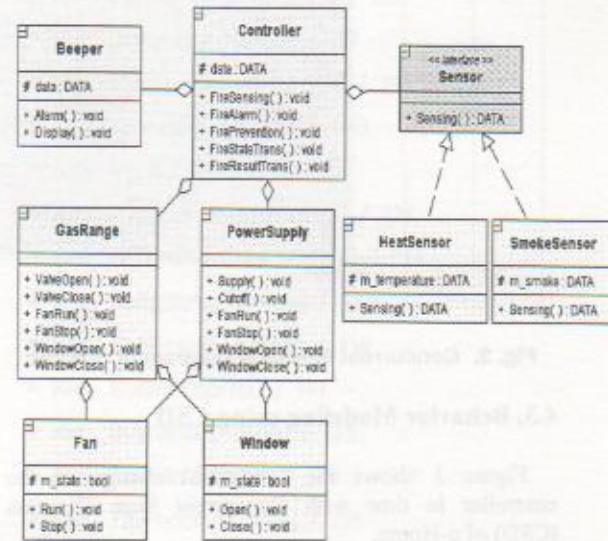


Fig. 1. Class diagram of u-Home

### 4.2. Behavior Modeling using CMD

Figure 2 shows the dynamic modeling of u-Home Control System based on 'Fire prevention' use case scenario. In this step, we use CMD (Concurrent Message Diagram). For example, when happen a fire in the u-Home, HeatSensor and/or SmokeSensor will sense the symptom of a fire, and then send this information to the controller. In figure 2, ① means to receive one message from either one sensor or other one, that is, the mechanism of OR gate. Then send this message to the controller. ② means that the controller makes a decision with message received, and sends the asynchronous broadcasting control messages, (such as alarm and display message) to the beeper. ③ and ④ means that the controller concurrently send messages to GasRange and PowerSupply for extinguishing the fire, that is, the mechanism of AND gate.

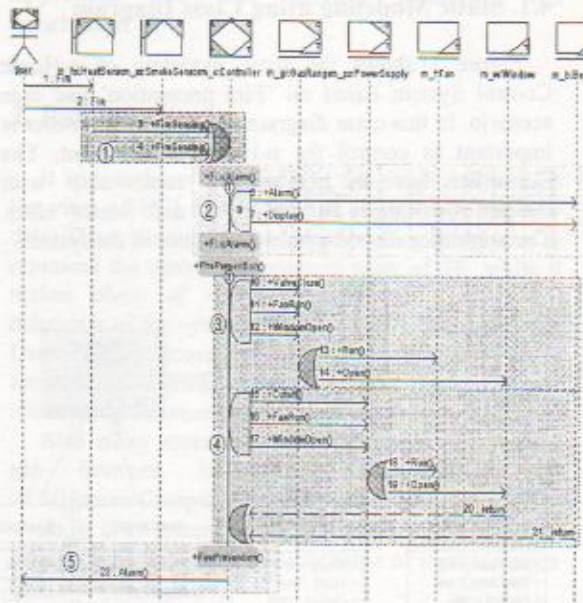


Fig. 2. Concurrent Message Diagram of u-Home

### 4.3. Behavior Modeling using CSD

Figure 3 shows the behavioral change of the controller in time with Concurrent State Diagram (CSD) of u-Home.

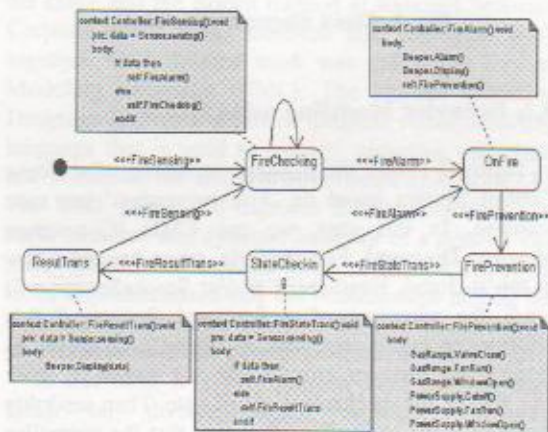


Fig. 3. Concurrent State Diagram of u-Home

### 6. Conclusion

This paper attempts to map SE (software engineering) with HCI (Human Computer Interface) for developing the future ubiquitous related systems to be needed new paradigm against the current existing

system developments. We also extend the standardized software modeling language, UML (Unified Modeling Language), to model based on the user behavioral analysis for the systems of the new coming Ubiquitous environment.

We model the 'Fire prevention' use case scenario of u-Home Control System with our extended UML. In near future, we will research about extracting the rules and/or the services based on the user behavior analysis.

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