Toward Uncertainty Handling Method in Smart Mobility Application Development

Hiromasa Inoki[1,a)] Kenji Hisazumi[1] Takahiro Ando[1] Tsuneno Nakanishi[1]
Akira Fukuda[1]

Abstract: In system development, specification changes are often made to improve or change service. The cause of the specification changes is uncertainty which can not be fixed until the practical use of the system gets started. The handling method of uncertainty has already been proposed, but detailed processes have yet to be defined for developing smart mobility applications. The paper propose a detailed process for applying the handling method of uncertainty to smart mobility applications, and also propose a method to facilitate to conduct the process employing Model-Driven Development technology. For continued development, we will also refer to how to use operational information to improve requirements and designs, and how to analyze impacts when requirements and design are added or changed. We conduct a case study to demonstrate our proposed method. For the case study, we use parking recommendation application.

Keywords: uncertainty, system development, smart mobility

1. Introduction

In recent years, large-scale, multi-functionalization and complication are serious in system development. In addition, social needs and circumstances change greatly, so specification changes are often made to improve or change service. The cause of the specification changes is uncertainty which can not be fixed until the practical use of the system gets started. Therefore, in order to respond smoothly to change of social needs and circumstances, a method focusing on the handling of uncertainty is necessary.

The handling method of uncertainty has already been proposed, but detailed processes have yet to be defined for developing smart mobility applications. The paper proposes a detailed process for applying this method to smart mobility applications. We also propose a method to facilitate to conduct the process employing Model-Driven Development technology. In the process, a life cycle of a development of an application is divided into three phases: a requirement analysis, design, and implementation phase, a simulation phase, and an operation phase. In the simulation phase, we resolve some types of uncertainties completely or partially using data from the simulation results. Rest of the uncertainties are fixed in the operation phase using data from actual operation.

For continued development, we will also refer to how to use operational information to improve requirements and designs, and how to analyze impacts when requirements and design are added or changed. We conduct a case study to demonstrate our proposed method. For the case study, we use parking recommendation application. To clarify the process, we classify each uncertainty according to when it is resolved.

The rest of paper is organized as follows: Section 2 describes scenarios that lead to security and privacy problems. In Section 3, according to the scenarios above, we propose some methods to the security and privacy issues. Section 4 concludes this paper and mentions future works.

2. Related Works

2.1 Definition of uncertainty

The paper[1] defined that uncertainty is the information which is necessary for system development, and which is recognized, defined, named and unresolved by developers.

In addition, the uncertainty must be defined so that it can clearly judge whether or not the expected information is obtained.

2.2 Assurance Case, GSN, D-Case[2]

Assurance Case is a document for discussing system safety and dependability based on evidence materials.First of all, the proposition that the system should satisfy is set as the top goal, and the top goal is divided and refined, and finally guaranteed by evidence.

GSN, a notation for goal-oriented analysis, is used to make a clear Assurance Case. Basically, the following five symbols are used in GSN.

- Goal: Proposition to discuss for the system

[1] Graduate School of Information Science and Electrical Engineering Kyushu University Fukuda,Hisazumi,and Ashir Lab, 744 Motooka Nishi-ku, Fukuoka 819-0395, Japan
[a)] publicity@f.ait.kyushu-u.ac.jp

- Strategy: Discussion strategies for dividing goals into subgoals
- Solution: Evidences finally guaranteeing that a refined goal has been achieved
- Context: Informations to be considered in discussing the goal
- Undeveloped Goal: Goals that are not given evidence and can not be further refined

D-Case is an extension of GSN by adding "Monitor". This notation makes it possible to discuss the entire life cycle of development including operation. Operational informations to be checked are described in Monitor, and a goal is guaranteed by using Monitor.

2.3 Development Process for Realizing Feedback of Operational Information to Request and Design

The paper[3] proposed a development method for realizing feedback of operation information to request and design. In this method, the uncertainties found at the request and design stage are focused on, and fix them by using the operation information. By modifying the model based on the fixed result of uncertainty, realize the change of request and design.

The procedure of the method consists of three steps.

STEP1: Making uncertainty table

The first step is making an uncertainty table based on the request specification. This table summarizes the options, influence ranges, dependency relationships, and fixed results on each uncertainty.

- Options: Solution candidates for each uncertainty
- Influence ranges: Parts of the model diagram that may change due to each uncertainty
- Dependency relationships: Dependence between uncertainties
- Fixed results: Name of fixed option(If it has not fixed, leave it blank)

STEP2: Analysis of operational information

Making model of uncertainty

At the beginning of STEP2, the model of uncertainty is made by using notation such as GSN or D-Case. The goal of it is properly resolving of each uncertainty. Some goals can be given "Solution" at design and development stage, but others cannot. Such a goal is given "Monitor", list of the operational informations which are necessary for achieve the goal.

Making table of operational informations

The operational informations, described as "Monitor", are summarized in this step. The table shows what the corresponding uncertainty is and whether the function of collecting operational informations is implemented.

STEP3: Improvement plan analysis

After starting operation of the system, uncertainties are traced using the obtained operation information and consider fixing them based on the table of operational informations. When an uncertainty is fixed, feedback is realized by changing the corresponding part of the request and design model based on the uncertainty table.

3. Proposed Method

The detailed applying process of the above method has not yet been clarified. Therefore, we propose a detailed process for applying this method to smart mobility applications. For clarification the detailed process, it is effective to arrange each uncertainty according to in which phases of the development life cycle it is solved. In the process, a life cycle of a development of an application is divided into three phases: a requirement analysis, design, and implementation phase, a simulation phase, and an operation phase. We resolve some types of uncertainties completely or partially using data from the simulation results in the simulation phase. Rest of the uncertainties are fixed in the operation phase using data from actual operation. In addition, for continued development, we organize how to use operational information to improve requirements and designs, and how to analyze impacts when requirements and design are added or changed.

We use D-Case for realizing feedback of operational information to request and design. The procedure is described below.

"The application operates properly" is set as the top "Goal" at first, and divided into detailed subgoals according to the "Strategy", which shows how to divide that goal. The prerequisite informations are connected with each goal as "Contexts" when describing the goal. When a goal that can not be divided any more is found, information that guarantees the goal is described as "Monitor" and connected with the goal. For a goal that does not have Monitor, add a mark indicating "Undeveloped". Monitors include uncertainties that are unknown at the requirement analysis, design, and implementation phase. They are divided according to which phase each uncertainty is resolved. In order to recognize the division, we classify each Monitors visually by assigning unique color it. This makes it easier for developers to know what information to note when simulating or operating.

4. Case Study

For the case study, we use parking recommendation application which is using a system named "Free Parking System (FPS)"[4]. This system is a parking recommendation system that targets a busy parking lot like a free curbside parking.

There are two remarkable features of this system. One feature is that it consists of an application and a server, and does not require a sensor. The driver requests the server to assign the parking lot through the application, and the server assigns the parking lot to the driver at the timing when the driver approaches the destination to some extent. The other feature is to assign a parking lot so that travel time of society as a whole is minimized, not individuals. For example, for the drivers A and B, consider the following two assignment methods.

(1) the travel time of A is 10 minutes, the travel time of B is 40 minutes
(2) the travel time of A is 20 minutes, the travel time of B is 20 minutes

The system chooses (2), because the sum of the travel times of A and B is shorter.

We apply uncertainty handling method to this system. The created D-Case model1 is shown in next page. "G" means Goal, "S" means Strategy, and "C" means Context in the figure. In applying, we set "The parking assignment application operates properly" as top goal at first, and divided it into subgoals according to Strategy "Divide by function". After repeat of this procedure, we connected Monitor to the goal which is judged that it cannot divide any further. If it doesn't need Monitor, a diamond mark which means "Undeveloped" has been attached. Each Monitor describes the information necessary to achieve the goal, and it is colored orange or purple. The informations described in orange Monitors can be confirmed at the simulation phase, and in purple Monitors can be confirmed at the operation phase.

FPS does not require a sensor, but we think that the accuracy of the parking assignment can be further improved by using several sensors. Therefore, "There is sufficient data from the sensor" exists in the subgoal to achieve the goal "The system grasps the vacancy information of the parking lot".

We will evaluate the uncertainty handling method by implementing the parking recommendation application based on this model, and clarify the detailed process for applying the method to smart mobility application.

5. Conclusion

This paper has organized the definition of uncertainty and the uncertainty handling method in system development and operation, and proposed the detailed process of applying existing uncertainty handling method to smart mobility application through a case study using parking recommendation application. In addition, we described how to make a model diagram using D-Case in the method. Each Monitors in the model describes the information necessary to achieve the goal, and it is color coded according to in which phases of the development life cycle it is confirmed. Such organization of Monitors contributes to the continuous development of the system.

We will evaluate the uncertainty handling method by implementing the parking recommendation application based on the model, and will more clarify the detailed process of applying the method to smart mobility application. In addition, we have created a D-Case on the uncertainties related to the realization of the system function, but we will create a D-Case that also takes into account the guarantee of the safety of the system in future.

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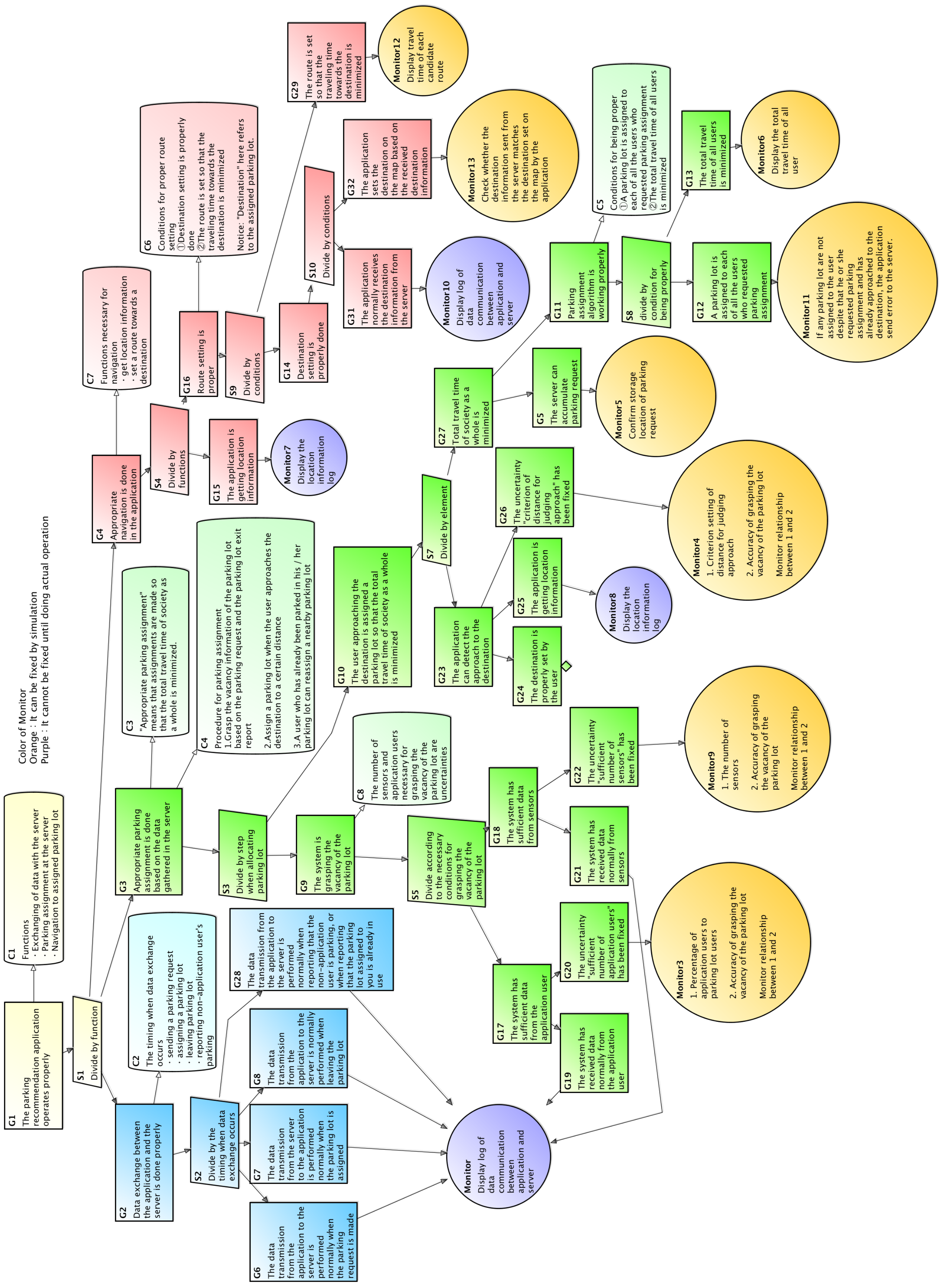

Fig. 1 D-Case model for parking assignment application