

Toward Sustainable Smart Mobility Information Infrastructure Platform

- Current Status -

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Abstract— Smart mobility systems, which include Intelligent Transportation Systems(ITS) and smart energy systems, become more important. There is, however, lack of its platform studies. We started a sustainable information infrastructure project for smart mobility systems. The project pursues issues that establish an information infrastructure architecture and seamless development method chain for it. The project has mainly two features; 1) applying life-cycle-oriented methods, which are a cycle from system development to operations, to a real world, and 2) dealing with an uncertainty in system design phase. This paper describes current status of the project.

Keywords—Smart Mobility, Life-Cycle-Oriented, Uncertainty, Real World, ITS, Smart Energy.

I. INTRODUCTION

Smart mobility systems including Intelligent Transportation Systems (ITS) have become increasingly important in recent years. So far, research on smart mobility has been studied from the viewpoints of vehicles such as cars, civil engineering, and urban planning. At present, the research for smart mobility focusing on not only transportation systems but also new fields have begun. Information communication technology has become its basic technology, and approaches from information engineering and information science are becoming more important. Although several approaches from the information communication field are also being done, many of them are based on research from individual element technologies such as various sensing technologies, acquisition and visualization ones for automobile data, etc. There are a lack of systematic fundamental researches including information platform design-development-construction technology for smart mobility. Also, these have been closed until system construction. Currently, rapid change including IoT(Internet of Things) has begun. This

means that life cycle oriented process from system development to operation is important.

On the other hand, the smart mobility society is currently undergoing new developments such as the emergence and utilization of new sensing technology for ITS and one of new services. This means that system requirements are often not decided in the system sign phase. At this point, it is important that the platform must be considered to be dynamic architecture rather than static one in the system design phase.

Considering the above background, we have started a project[1]. The purpose of this project is to build an information platform for sustainable smart mobility. This project aims as follows.

1) Establishment of research and development of information platform of lifecycle-oriented system process from design to operation and feedbacking from operation to design, and

2) Establishment of system development process incorporating uncertainty at the system design phase.

This paper describes current status of the project.

The structure of this paper is as follows.

Chapter 2 describes the smart mobility information infrastructure platform we are targeting, Chapter 3 outlines the features of this project, Chapter 4 presents the current research status of the project, and Chapter 5 describes related work, and finally, Chapter 6 let me summarize and discuss future issues.

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II. SMART MOBILITY INFORMATION INFRASTRUCTURE PLATFORM

The smart mobility information infrastructure platform is shown in Fig.1. It consists of three components; information collection into a platform, the platform, and information provision services.

1) The information collection component:

The information collection component gathers data from sensing physical world, which include new sensors, shop or tourist resort information, government one, original ITS one, various services by vendors, etc. That is IoT (Internet of Things). The data collected incomes into a data base as big data in the platform.

2) The platform component:

The platform component consists of the following.

- System documents and assets that include ones from system design to source code programs, etc.
- System contents that operate the smart mobility systems including big data. The platform allows us to provide new services to business companies.

3) The information provision service component:

By using the platform, business companies can provide various and innovative services to users. These services include normal or vulnerable road ones and smart mobility oriented novel ones.

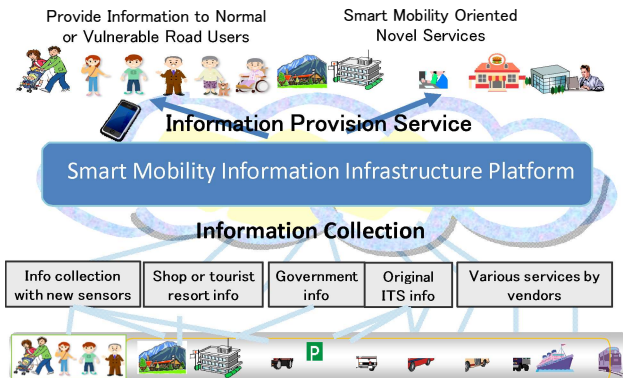


Fig. 1. Smart Mobility Information Infrastructure Platform

III. PROJECT OVERVIEW- FEATURES OF THE PROJECT-

Challenging issues of the project is shown in Fig.2. In addition, our project has the following features.

1) Real Life-Cycle Oriented Project

There are lots of researches and projects that deal with life-cycle system development. The most of these researches, however, have not applied to real world field. Our project is to apply methods proposed in the project to real world field. Target fields of the project are ITS and smart energy systems. In particular, an ITS company joining the project is the biggest

one in Japan. This promises that our project becomes successful.

2) Dealing with Uncertainty

The most important feature is that our project deals with uncertainty that is not decided in the system design phase. Recently, many systems become big and complicated. In addition, its requirements of users become ambiguous. In a system design phase, some parts of the system itself and operation ways are not decided, that is uncertainty. During operations after building the system, the uncertainty is decided. In particular, the smart mobility systems including ITS and smart energy systems are rapidly changing. Therefore, it is important to rapidly construct a system and to feedback to the system after operating of the system.

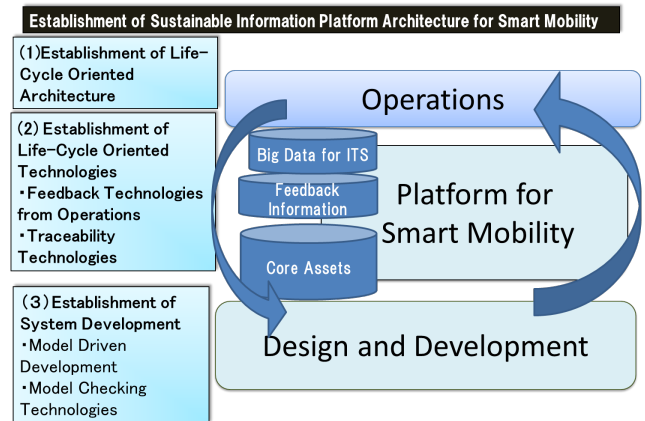


Fig. 2. Challenging Issues of the Project

IV. CURRENT RESEARCH STATUS

(1) Architecture for sustainable smart mobility [2]

As a concept where system design and development cooperate with operation, there is DevOps, which is a compound word of Development and Operation. This concept was proposed mainly by companies such as IBM. It is, however, a kind of paradigm, not concrete methodologies or engineering approaches. Our project aims to establish the methodologies for constructing smart mobility platform. Therefore, we decided to optimize the paradigm and element technologies of DevOps and to apply them for smart mobility. As a DevOps development-operation process for smart mobility, this project proposed a process called DSPL4DevOps that is a process combining Dynamic Software Product Line (DSPL) with a derived development paradigm. This process consists of the first cycle process and an improvement one after the first one. In addition, product evolution and changes predicted in advance at system design-development-execution phase is handled by a dynamic adaptation system defined in the first process and its operation one. The dynamic adaptation system is built by using DSPL paradigm. Product evolution and change that could not be predicted in advance are summarized as addition and change requests. These requests are coped by modifying the dynamic adaptation system that is carried out in

the improvement process and the operation one. In both development and operation processes, feature models, uncertainty models, and uncertainty impact -evaluation countermeasure tables are used as first class documents to manage the change.

As an architecture of the dynamic adaptation system, we decided to introduce a micro service architecture. The micro service architecture is an architecture that has been growing and systematized in the web related field and is an architecture that has been drawing attention rapidly in the past two or three years. The smart mobility system being a mixture of the conventional ITS system and the "smartphone-like" open one has both an open character and a closed one. Smart mobility is a market where stakeholders in the same industry and other businesses collaborate and compete in order to optimize the mobility of individuals with different demands, and each stakeholder carries out services and data in order to maximize its own profit. The micro service is a reasonable technical solution in the above a business environment.

We will apply the proposed architecture to service applications in the future and verify the effectiveness of this architecture.

(2) Life cycle oriented uncertainty resolution method based on actual operation [3], [4], [5].

Smart mobility services are always required to evolve. In addition, service provided environment changes as laws and circumstances change. In addition, these services are not provided as a single huge service, but are developed by combining various services. For this reason, it is impossible to consider all requirements and designs before starting the service, and it cannot be fixed. These mean that there are many uncertainties in system design phase. Therefore, this project proposed a lifecycle-oriented uncertainty solution method.

As a case study, we applied the proposed method to a service application called Patrash that is a service application supporting person mobility by bus to and from Kyushu Univ. Ito Campus. We got a result that the proposed method is useful. In addition, we are currently applying the method to large-scale applications in real world. This allows us to verify effectiveness of the method.

Furthermore, in order to support implementation of the proposed method, we developed a model-driven development tool called MetaIndex[6]. This tool has the following features. It is a light tool, and does not depend on a specific model and has versatility. This tool ensures traceability for realizing life cycle oriented system development.

(3) Safe and secure model checking technology [7], [8], [9], [10]

We developed a model checking technology that has an interface with state transition table. This interface is efficient and easy to introduce by enterprises. This tool is put into practical use from a certain company.

(4) Database construction technology [11]

A map database is important for developing smart ITS. There are three kinds of map data: image, geometry, and graph. This project has been working on research and development of

a map database system that can integrate and manage these types of maps. This project proposed an integrated map description method with giving numbers as edge order as attributes of two kinds of objects; line and area. By applying this description method to some examples, a map searching performance can be improved. For shortest path trees that have been conventionally used in graphical maps, this project proposed two kinds of information; one that follows the directed direction in the forward direction, and one that follows the directed direction in the opposite direction. These information is founded to be useful for route searching when there are stopover points and stopover-destination pair is not limited to one.

(5) Sensor, wireless network technology [12], [13]

In order to detect vehicles, pedestrians including in buildings, it is necessary to construct a sensor network with an enormous number of sensors. This project is developing technology to realize a low cost positioning system. In outdoors, the system has been realized by using GPS. However, in indoors, we cannot use GPS. Therefore, our target area is indoors. This project is developing a method to measure ZigBee sensor node location by using WiFi access points widely prevailing in indoor environment.

In order to carry out this technology, the following researches are necessary; i)to detect Wi-Fi signal with ZigBee sensor, ii) radio field intensity measurement using different radio communication, and iii) a sensor positioning system that utilizes information collected by the WiFi positioning system. Since Wi-Fi and ZigBee use the same 2.4 GHz band, it is possible to detect whether "there is radio waves" with each other. By using this, we clarified that communication between modules of different wireless communication systems is possible.

In the common sense of wireless communication so far, it has been considered to be impossible to communicate between wireless communication modules with different modulation method etc. However, in this research we got innovative knowledge to break this common sense.

(6) Low-cost vehicle detection technology [14]

As a low-cost vehicle detection technology, this project studies a method of detecting a vehicle by using stereo microphones. We developed a technology to detect vehicles by setting the two microphones parallel to the road and using the sound time difference from the vehicle to the microphones. This technology can reduce the cost to about one hundredth compared with existing technologies. In order to verify the feasibility of this method, the proposed method results that vehicle can be detected with high accuracy of F value 0.92 through experiments in Kyushu Univ. Ito Campus.

(7) ITS

The main target domain of the project is ITS.

1)Information sharing / recommendation system that supports mobile environment [15]

In this project, as a basis for building a person-centric recommendation engine rather than human-centric one, we established the information sharing recommendation infrastructure called Ito Can Life that supports the mobile

environment from and to Kyushu Univ. Ito Campus. This foundation enables offer of different services that are conscious of the difference between people who live in daily life in around the campus area and those who visit the area. Currently, in addition to presenting facility information on map by category, we provide route guidance associated with the location of the facility and presenting event information. All the facility information and event one are presented to users on the Ito Campus map.

2) Car sharing [16]

As a method to reduce the recovery cost of a one-way car sharing vehicle, this project is studying a method to change the behavior of potential users. In order to realize this method, the required technologies are as follows; i) prediction of next user action based on past behavior data (determination of potential users), ii) determination to collect vehicles for overall optimization, iii) request of next action to users by using prediction of the vehicle. So far, this project has been studied on ii) in particular. This project is analyzing which cars are located and where ones are placed to improve car occupancy rate by using car sharing data of Park24 Co., Ltd. and Toyota Motor Corp. performed in Tokyo with 100 bases and 100 vehicles. Its result by using simulation was that car utilization rate can be improved by about 40%. In addition, we revealed that about 15% of the car movement was wasted.

3) Privacy-aware user tracking technology [17]

Acquisition of user flow lines by using camera images and radio waves has been difficult to apply to real society due to privacy concerns. Therefore, we proposed a method identifying users by using user's shoe mark footprints obtained from the footprint pressure value at passing time of the users. This technology guarantees that anonymity can be maintained. Through experiments, we showed that the user can be identified with an accuracy of 83% by footprint including the center of gravity information.

4) Development of agent-based integrated simulation environment [18]

Analysis using simulation is often useful in order to confirm the effect and influence of the system on society. In simulation, it is costly to build a new model for service applications built in the real world for simulation. In order to reduce this cost, we built a simulation environment system, which has features of function connecting between an existing simulator and ITS service applications built in the real world, not simulation model. With this function, it is possible to omit the process of model mounting of ITS on the simulator, which leads to reduction in the cost of simulation implementation.

This system also has feature of the function of mutually connecting multiple simulators existed. This feature allows us to analyze ITS from the different viewpoints and the different regions that are mutually related.

(8) Smart energy

As one of smart mobility, in recent years, smart energy that is energy mobility is an important issue.

In this project, we started a smart energy project. From the technical view point, we propose a local VPP (Virtual Power Plant) that further stepped into VPP, which was proposed in

the past. Distributed management is also important for ledger management of energy systems. Therefore, we propose applying block chains to the management system. We have a plan to carry out this system in an apartment currently being completed

In addition, for this purpose, we plan to set up distributed energy resource sharing information infrastructure alliance.

V. RELATED WORK

(1) Uncertainty

In general describing, uncertainty seems to have been discussed much more in the field of management science rather than in the field of information engineering science. The term "uncertainty" has been used with confusion. Wynne classified meanings of the term "uncertainty" into the following seven category [19].

- 1) Risk: known damage and probabilities;
- 2) Uncertainty: known damage possibilities but no knowledge of probabilities;
- 3) Ignorance: unknown unknowns;
- 4) Indeterminacy: issue and conditions, hence knowledge-framing open; maybe salient behavioral processes also non-determinate;
- 5) Complexity : open behavioral systems, and multiplex, often non-linear processes so that extrapolation from robust data-points always problematic;
- 6) Disagreement : divergence over framing, observation methods or interpretation. Questions of competence of parties; and
- 7) Ambiguity : precise meanings (hence salient elements) not agreed, or unclear.

The uncertainty discussed in this paper corresponds to the risk and the uncertainty in the above Wynne's categories.

(2) DevOps (=Development+Operations)

Recently, DevOps, which means that collaboration between system development and its operations must be performed, has been discussed. However, its content is ambiguous. For example, Weiyi Shang proposed that gap between software developers and operators must be resolved by using logs [20]. This paper proposes its direction of DevOps.

VI. CONCLUSION

In this paper, the authors described current status of the project we started for smart mobility systems. The project will give an innovation research direction. There are still, however, many issues that should be investigated to accomplish our project successful. First, system evaluation performed by the project must provide useful information to information society. Second, the seamless tools must be provided to open-source ones for system developers and operators. Finally, our project must give a way to provide our project results for world.

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