

HAKONIWA

- Application Development Environment for Internet CAR system-

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ABSTRACT

Internet CAR system is a common ITS platform which connects a human, a road and a vehicle on the Internet. *Vehicle Environmental Applications* will have more importance in Internet CAR. Vehicle Environmental Applications can make use of environmental fluctuations of vehicles. With this feature, developments of Vehicle Environmental Applications are far more difficult. Application developers need environmental information during their development process. So far, no effective method is developed. This paper proposes the application development environment for Vehicle Environmental Applications. In this development environment, applications can virtually obtain environmental information and behave as it is in the real situations.

INTRODUCTION

In this paper, we propose Application Development Environment for Internet CAR system, which called HAKONIWA.

The Internet CAR Project [1] and Internet ITS Consortium[2], is working to connect roads, vehicles and humans by the Internet.

And their goal is creating the ITS platform which all vehicles were connected by the Internet. The main feature of the Internet is end-to-end communication on widely deployed network infrastructure on open platforms. By constructing road-vehicle-human network by the Internet, new application and services can be developed in open platform.

Deploying Internet devices in vehicles should make application development costs cheaper since these applications and devices would not only be developed for telematics. Any applications which exist on current internet can be applied for Internet CAR system. Existing internet applications, however, do not consider to behave in vehicle environment. Applications which can perform in vehicle environment will gain more importance in Internet CAR system. In this paper, these applications are called *Vehicle Environmental Applications*.

In this paper, we propose HAKONIWA, the application development environment for applications on the Internet CAR. In HAKONIWA applications can obtain environmental fluctuations virtually.

The following sections are organized as follows; we first outline in Section 2 the assumed environment for Internet CAR system, and requirements for HAKONIWA. Then, Section 3 details the system overview of HAKONIWA. Section 4 describes the evaluation of HAKONIWA.

VEHICLE ENVIRONMENTAL APPLICATIONS IN INTERNET CAR

This section illustrates the overview of vehicle environmental application and its development. We show the difficulty in developing the vehicle environmental applications.

Vehicle Environmental Applications

Currently about 120 sensors are equipped on vehicles in order to collect fluctuations of environment around vehicles(*e.g.*, GPS, Velocity sensor, Temperature sensor and so on). Moreover, network condition can be obtained from communication devices.

Vehicle Environmental Applications will make use of these fluctuations of environmental information. Vehicle Environmental Applications *obtain environmental information*, and *behave accordingly*. Vehicle Environmental Applications are categorized as follows.

- Observation Applications
Observation Applications will behave on the Internet side and observe the motion of vehicles. For example, the Probe Car system collect velocity information and geographical location, and then generate traffic information without any roadside devices.
- In-Vehicle Applications
In-Vehicle Applications will behave in the vehicle. Main purpose of In-Vehicle Applications is assistance of drivers and delighting the passengers. For example, video streaming application which dynamically adopt its quality according to the condition of communication network.

Figure 1 illustrates the abstract of Vehicle Environmental Applications. Any Vehicle Environmental Application, whether Observation one or In-Vehicle one, behave accordingly to the environmental information. Vehicle Environmental Applications can obtain

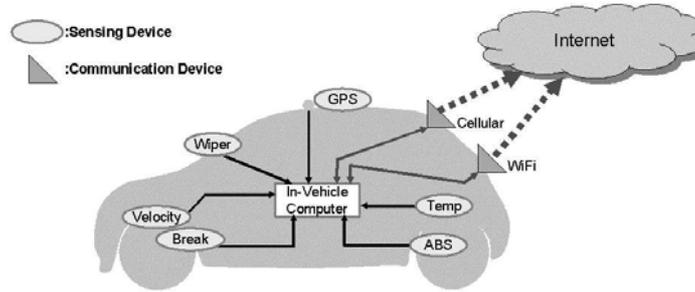


Figure 1: Vehicle Environmental Application

environmental information from sensing devices in the vehicle(Wiper, Break, GPS and so on) .

For example, the Probe Information systems[3], one of the Observation Vehicle Environmental Applications, collect information of vehicle environment from travelling vehicles and creates new information;traffic infomations weather information and so on.

Development Processes of Vehiclne Environmental Applications

In the developement process of Vehicle Environmental Applications, special development environment is indispensable to application developers.

For a development of any internet applications including Vechicle Environemtal Applications, application developers usually take 3 steps , 1)Design and Implementation, 2)Decision of Parameters, 3)Verification by Field Tests. In the first step, developers figure out the system overview and detailed application behaviors, and then implement these behavior accordingly. As the second step, they decide various parameters of its behavior. For example, initial data sending bit rate or limit wave strength for hand-over have to be decided. At the last step, an application behavior is tested in real but restricted situation.

Although these steps can be taken on the desk, development of Vehicle Environmental Applications 2nd and 3rd steps are more difficult than existing applications. Because behavior in Vehicle Environmental Application depends on vehicle environmental information. Thus, development environments for Vehicle Environmental Applications is required.

In the development environment, vehicle environments are simulated and application behavior is emulated. The development environment provides easier and more close-to-real testing environment for vehicle environemntal application developers.

CONCEPT OF HAKONIWA

In this section, we propose overview of HAKONIWA. HAKONIWA is our developemnt environment for Internet CAR system.

Overview of HAKONIWA

As mentioned earlier, development of Vehicle Environmental Application is more difficult than ordinary internet application. Thus, we propose development environment which is called “HAKONIWA”, meaning small boxed garden in Japanese.

In real situation, Vehicle Environmental Applications obtain environmental information from sensing devices equipped to the vehicle, and behave accordingly to these information. In the development environment, developing applications also require environmental information and should behave accordingly.

Figure 2 shows the relation between Vehicle Environmental Applications and Environmental Informations. In HAKONIWA, an environmental information can be obtained from simulation modules instead of sensing devices, so that applications can behave accordingly to the information.

With HAKONIWA, applications can be developed in the close-to-real situations, because vehicle situations are simulated and emulated in HAKONIWA.

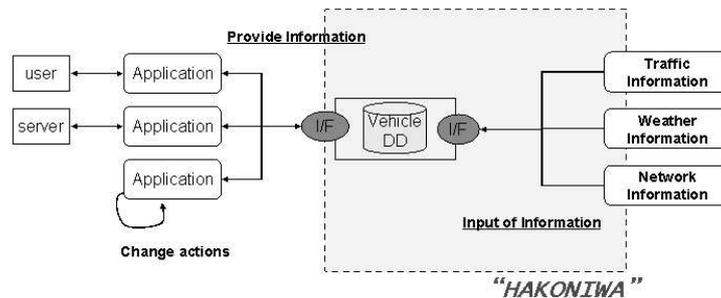


Figure 2: Vehicle Environmental Application and Environmental Information

In Figure 2, environmental information are stored in Vehicle Information Database. This is just a example of a interface between environmental information and applications. Other style of interface also could be applied. But interface should be stardarized in future for applications to access every vechiles equally.

Requirements

HAKONIWA must meet the following three requirements, “In-Vehicle Consistency”, “In-Traffic Consistency” and “Flexible Configuration”.

- *In-Vehicle Consistency*
The environmental information generated by simulation modules should be consistent in the vehicle. For example, when a velocity is 70km/h, geographic information must be changing by that velocity.
- *In-Traffic Consistency*
Environmental information of vehicles in the same traffic must not contradict each other. When one vehicle turn on its wiper for the rain, other vehicles in the same traffic must also turn on thier wiper. Otherwise wipers are assumed to be out of order.
- *Flexible Configuration*
In order to support any developments of Vehicle Environmental Application,

HAKONIWA should simulate any possible environments. There could be a various situation, for example, driving on a highway, or at a parking lot, or driving under heavy traffic jam.

If HAKONIWA does not meet these requirements, it is hard for developers to use HAKONIWA. Moreover applications which were developed in HAKONIWA will not behave as developers had expected.

DESIGN AND IMPLEMENTATION

This section describes system design of HAKONIWA and its implementation.

Design approach for HAKONIWA

There is two approach to facilitating the development of Virtual Environmental Applications. One approach is to setup the special device which can generate environmental information as a real vehicle. And second approach is to provide application running environment with environmental information.

Figure 3 illustrates the two approaches for HAKONIWA. In the first approach(in the right), an application connects to the special device and obtain environmental information from the device. The special device include some simulation modules. In the second approach(in the left), HAKONIWA is the development environment for vehicle environmental applications. Applications can behave on the environment. In this development environment, applications can behave like as real situation, because vehicle behaviors and environmental fluctuations are simulated and emulated.

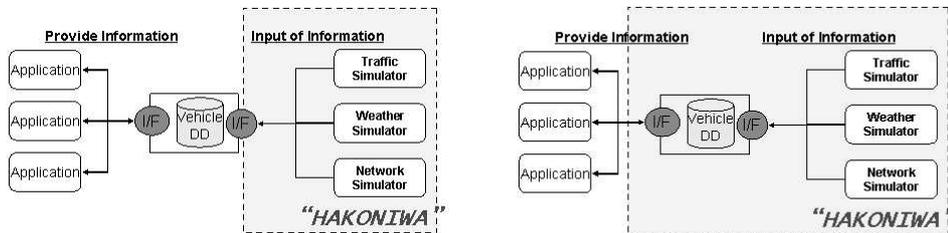


Figure 3: Two approaches for HAKONIWA

We compare these two approaches and, choose the second approach. The first approach require one PC for one application. When we develop system with many vehicles behaving simultaneously, we must setup many PCs. In development environment approach, we only need a PC. Currently, we cannot develop applications on different architecture at the same time.

Design

HAKONIWA consists of two modules. One is for simulating the vehicle environment, and another is for emulating the application behavior in the vehicle.

To meet requirements, we propose *Virtual Vehicle Model*. In Virtual Vehicle Model, the vehicles are abstracted as a Virtual Vehicle and vehicle surroundings are abstracted

as Environment Map. Virtual Vehicle represents a single vehicle in HAKONIWA. A developing application is installed to and running on the Virtual Vehicle and obtains vehicle environmental information through Virtual Vehicle. Environmental information of each Virtual Vehicle is simulated by Environmental Maps.

Development of Virtual Vehicle

Virtual Vehicle has 2 feature, first one is “Emulator of environmental information” and second one is “Running environment for application”.

Emulation

Environmental information of vehicles is generated by other simulation modules (detailed in later). In order for applications on the vehicle to obtain environmental information of the vehicle, all information belongs to the vehicle is identified by the Virtual Vehicle. And also, Virtual Vehicle offers the interface between applications and information. Applications obtain environmental information of its vehicle through the interface. Detail of the interface depends on the standard interface in a real situation.

Figure 4 shows the system structure of Virtual Vehicle. In the figure, some simulation modules generates the environment information. And applications obtain these information through Application Interface(API). Applications on the Virtual Vehicle sends and receives data through the virtual interfaces(I/F). Detail of the virtual interface is described in next part.

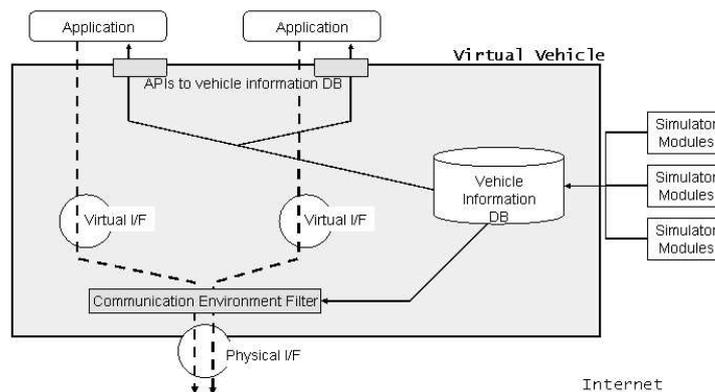


Figure 4: System Structure of Virtual Vehicle

Running Environment

In HAKONIWA, applications are installed to the Virtual Vehicle so that many vehicles could be simultaneously developed. Each vehicle have various applications, from streaming application to electric toll collection application. These applications must behave independently. In the implementation of this research, each Virtual Vehicle has its own Java VM(Virtual Machine) to enable these application behavior.

Moreover, running environment must provide communication network to the Internet. When applications on the Virtual Vehicle communicate via the Internet, a commu-

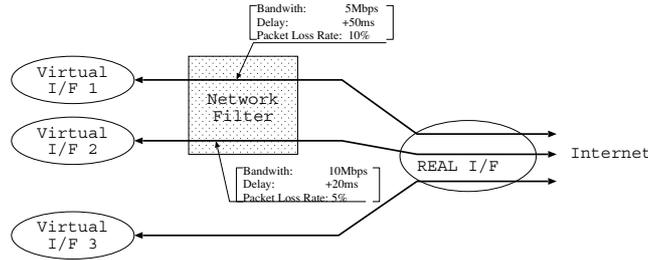


Figure 5: Communication Network Filter

nication network must be emulated as its environment. Emulation of a communication network is achieved by a communication network filter.

Virtual Vehicles have functions to sending and receiving application data via its virtual network interfaces. Because these virtual network interfaces are originally under constant condition, network condition also be emulated in HAKONIWA.

Figure 5 illustrate the Communicatin Network Filter. In this figure, some virtual network interface is attached to the real network interface and Network Filter stands between virtual interface 1, 2 and real interface. When Virtual Vehicle sends data to the Internet using virtual interface 1, Network Filter modifies communication quality. Concretely, data is queuing in the filter so that delay is modified or the amount of passing data is suppressed to the limited bandwidth. Kinds of items which can be modified in Network Filter are depending on the implementation of Network Filter.

In the implementaion, we use DUMMNET[4] as a network communication filter. In DUMMYNET, bandwidth, delay and data loss rate can be emulated.

Development of Simulation Modules

The vehicle environmental information are generated by simulation modules, such as traffic simulator or weather simulator, developed in their own research fields. Thus, accuracy of simulation in HAKONIWA is beyond our scope. If developer needs more accuracy in HAKONIWA, more accurate simulator is required.

Travel information of vehicles is simulated by traffic simulator. In this paper we use the traffic simulator based on SOUND(developed in University of Tokyo.). SOUND simulate the travel of each virtual vehicle. Travel information consists of Longitude, Latitude, Speed and Direction.

Communication Environment is simulated by the relation of position of vehicles and wireless access points. Communication Environment is consisted of 3 parameters, 1) Bandwidth, 2) Round Trip Time, 3) Packet Loss Rate.

Each simulation result is transferred to the map. Information can be identified by geographical position(Longitude, Latitude and Altitude). As for the weather simulation map, weather condition can be obtain at every geographical position. By transferring to the map, removing and adding of environmental information becomes far easier because all different simulator results can be treated by geographical position. Therefore configuration of HAKONIWA is easy and can be available at many situation.

EVALUATION

As an evaluation, a sample application is developed in HAKONIWA to evaluate the effectiveness. As a sample application, we have developed the primitive application,

just communicate to the server on the Internet. In this application, 100 vehicles and 15 Wi-Fi access points are configured as left side of Figure 6.

Then we have measured the fluctuation of round trip time between vehicles and the server. Right side of Figure 6 shows the fluctuation of round trip time, and this fluctuation indicates that the movements of virtual vehicles are simulated and emulated. Thus, application developers can develop application with these fluctuations. Again, accuracy of measured round trip time is beyond our research.

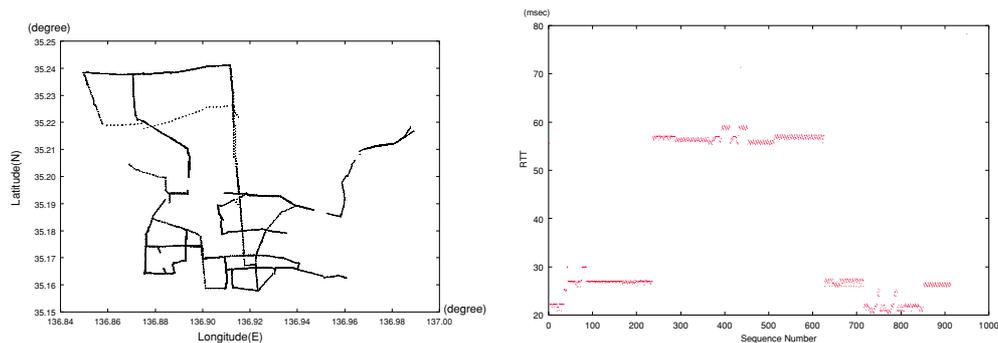


Figure 6: Configuration of Evaluation Environment and Evaluation Result

CONCLUSION

In this paper, we described the overview of HAKONIWA, application development environment for Internet CAR systems. We have seen the difficulty in developments of Vehicle Environmental Application in Internet CAR system, especially on testing process. To facilitating the development, we propose HAKONIWA which simulate and emulate the vehicle environment and offers the useful testing platform of application behaviors.

By HAKONIWA, developments of application in Internet CAR can be more effective, since applications can be tested and validated only with HAKONIWA without need for a real testbed nor special hardware.

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