A Development of Flexible Access Control System for Advanced ITS Networking

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Abstract: A combined use of the cellular and high-speed "hot-spot" communications can provide higher-rate and more convenient network access services to mobile users on-board vehicles. The authors developed an experimental flexible access control system so as to indicate the technical feasibility of such services. The system consists of a set of QoS monitor and mobile router that monitors and selects the optimum wireless access media among the PacketOne, Dedicated Short Range Communication (DSRC) and wireless LAN. It also consists of a pair of flexible access processing module and gateway that provides a seamless data stream to the applications. A series of field experiments has been conducted at KDDI Training Centre, Saitama, Japan, where the access points of DSRC and wireless LAN and other network equipment were placed for the experiment. The experimental results showed that the flexible access control works well for the optimum link selection and the flexible access buffer control provides a seamless streaming at the average throughput much higher than the cellular one.

Key words: Mobile Network, Wireless Access Network, Wireless Link QoS Control, Mobile Routing, Seamless Applications and Field Experiment

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The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35618-1_37

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1. INTRODUCTION

An enhancement of the advanced Intelligent Transport System (ITS) is expected to make it a major part of the information infrastructure for the network users on-board vehicles. A kind of high-speed wireless access media is expected to become available for the users so that they can access to the network in the same manner they do at their homes and offices using the broadband Ethernet. In addition to the conventional cellular networks having the wide coverage, there have been several high-transmission rate wireless access schemes developed. One example is the Dedicated Short Range Communication (DSRC)[1] which can act as a so-called "hot-Spot." Within its coverage, users can access to the network at a higher rate, compared with some conventional cellular ones. Along with such "hot-spot" deployments, an efficient use of the multiple media of high bit-rate wireless access is one of the key issues to achieve an optimum use of them. Meanwhile, some technique shall be applied so as to provide users seamless applications over the wireless media change with a short-period interruption. Following such discussions, we set two key issues to be developed as follows:

- automatic optimum wireless access media selection, and
- seamless application provisions over the media change.

The authors have developed an experimental flexible access control system so as to achieve those key issues and indicate the technical feasibility of the service to be provided over multiple number of wireless access media. In section 2, the flexible access control and experimental system are described. In section 3, the field experiment results are shown. And finally section 4 concludes the paper.

2. FLEXIBLE ACCESS CONTROL SYSTEM

For the system design, we assumed a use of the following wireless access media: PacketOne, DSRC and wireless LAN (IEEE802.11b.) The PacketOne represents a packet-switched cellular network with nation-wide coverage in Japan at a transmission rate of 64 kbit/s. As for the DSRC, it is expected that the number of road-side access points will be expanded to cover the places such as high-way service areas, petrol-stations, parking lots and shops. The wireless LAN will also be used at home-garages. Those can be regarded as promising media candidates for the advanced ITS use.

Figure 1 presents the system configuration developed. The QoS controller (QoS Cont.) monitors each of received signal level and packet throughput and choose the best medium at the time and place. The mobile router then establishes a network access path over the selected link, by updating the home agent (HA) registration with the link information. The mobile IP technology[2] is used for this selection. The pair of flexible access processing module (FAPM) on-board and flexible access gateway (FAGW) at the network side configures the middleware buffer and provides a seamless, continuous application service to the user. The FAPM is installed on one of the Car-PC though which an internet access from the other PC is also provided.

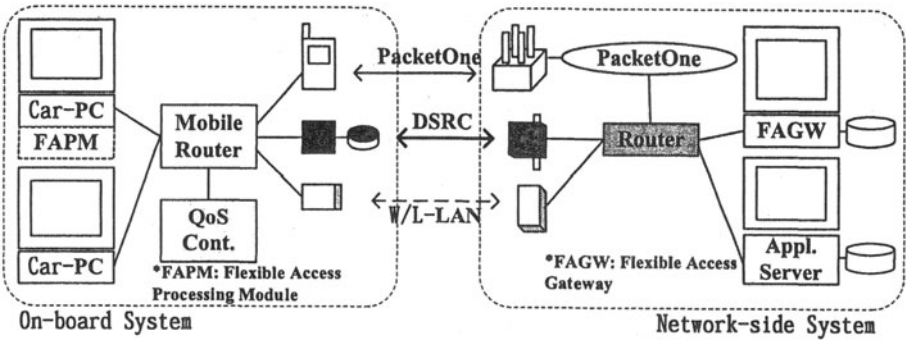

Figure 1. A flexible access control system configuration.

2.1 Wireless access media QoS Control

As explained in the previous section, the QoS Cont. monitors the received signal level and throughput of each wireless access medium. Figure 2 indicates the received signal level and throughput of each medium. The media control is achieved using those measured data. In the figure, the left-side column depicts the link-selection parameters. From the top, the parameters are as follows: The priority defines the media selection order. The switch interval defines the minimum link period during when the selected link is kept so as to avoid any media chattering at an unstable link condition. Each threshold value defines the medium "on" when the received signal level/throughput is above it. The media switch can be done either automatically or manually.

The figure shows a measured example of the automated media selection in which the received signal level is used as a criterion and each throughput

shows the actual data throughput sent over the link. At first, the W-LAN is used then along with the received level degadation, the link is switched to the PacketOne. Then along with the level recovery, the W-LAN is selected again. Finally, the DSRC is selected when its received level becomes "on."

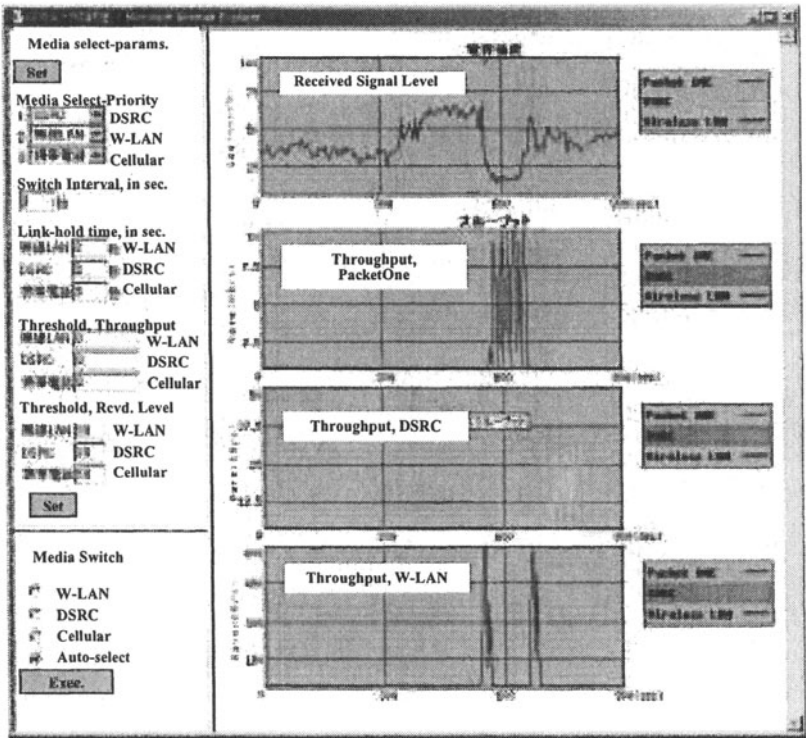

Figure 2.. A measured example of QoS monitor and media selection.

As shown in Fig. 2, the media selection has been correctly performed using the received signal level as a QoS measure among the three wireless media.

2.2 Flexible Access Buffer Control

The pair of FAPM and FAGW has been applied so as to provide a seamless application to the user even when the wireless link interruption is occurred during the media switching. Each of the FAPM and FAGW has some amount of middleware buffer memory allocated to each application.

Figure 3 shows an example of the FAPM buffer control for the video streaming to a mobile user. The link condition for the measurement is the same as the one shown in Fig. 2. At first, the amount of buffered data increases using the W-LAN, then decreases using the PacketOne, increases again using the recovered W-LAN and finally decreases using the DSRC. At last as shown in the middle, the data is reset, when the application is terminated. It is observed that an example of 500 kbit/s-video stream can be provided with no interruption over the three media switched time-to-time. It is also observed that the amount of buffered data at the FAPM varies according to the media throughputs and the application rates output from the buffer. Meantime, the data amount at the FAGW varies according to the wireless media throughputs, as the network throughput is fast enough compared to the wireless ones.

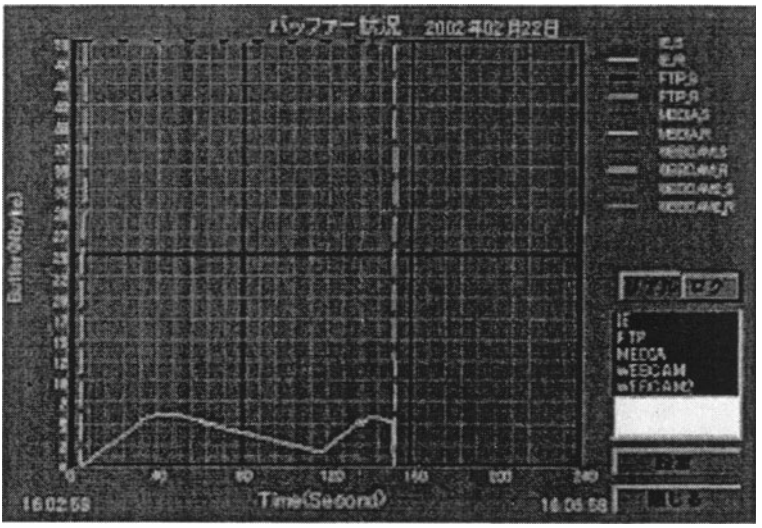

Figure 3. A measured example of flexible access buffer control at FAPM.

As shown in Fig. 3, the flexible access buffer control, placed as a middleware pair, has been used for the seamless application service provision.

3. FIELD EXPERIMENT

The experimental system shown in Figure 1 has been developed. In addition to the QoS Cont./Mobile Router and FAPM/FAGW pair, the system also consits of a pair of on-board and road-side 1-Mbit/s ASK DSRC modem,

an MPEG-4 encoder/decoder pair, Web-cameras, and so on. The on-board system has been placed on the experimental vehicle of Toyota Grand-High Ace, on which an UPS power generator and battery set has also been equipped. The car has space wide enough for the on-board system mount including the UPS set and the equipment rack.

The network-side system has been placed at the KDDI Training Center, Saitama, Japan where the network has been prepared. The venue has been built and run by the consortium members for the experiment of KDDI Labs., Toshiba, Panasonic and Toyota InfoTechnology Center. A series of field trials has been conducted there so as to examine the technical feasibility of the developed system and to conduct the quantitative link-performance evaluations.

Tables 1 and 2 indicates the switching period from one wireless media to the other, in a manner of manual and automatic switching, respectively. As shown in Table 1, the switching period from the W-LAN to DSRC is 3.0 second while the one to PacketOne is 15.5 second. The first one of 3 second represents the media switching period consumed for the mobile-IP control with a HA-update. Meantime, the one for the PacketOne further includes the switching over the public cellular network. The values shown in Table 2 varies, as each contains the link-status change detection of about 8 second. Referring to those results, a switching duration of several seconds shall be taken into account for the flexible access buffer sizing.

Table 1. Media switching period in sec., manual switching.

Wireless Access Media	→ W-LAN	→ DSRC	→ PacketOne
From W-LAN	*	3.0 ± 0.6	15.5 ± 4.5
DSRC	4.1 ± 0.5	*	16.1 ± 2.9
PacketOne	3.9 ± 0.8	3.4 ± 0.7	*

Table 2. Media switching period in sec., automatic switching.

Media, from → to	W-LAN → PacketOne	PacketOne → W-LAN	W-LAN → DSRC
Measured data	8.0 2↓9	5.3 ± 2.6	10.0 ± 0

Also, sets of vehicle-mounted 1-DIN sized PC with a touch-paned display and browser have been developed. The one has been mounted on the vehicle front panel for the driver use, so has been the other in the middle of the front-row sheets for the passengers use.

Photo 1. An external overview of the experimental vehicle.

Photo 1 shows an external overview of the experimental vehicle. Also Photo 2 depicts an on-board view taken during a field experiment.

Photo 2. An on-board view taken during the field trial.

4. CONCLUSION

A flexible access control system has been developed, which consists of the set of QoS controller and mobile router, the pair of FAPM and FAGW and several experimental equipment and measurement tool. A set of three promising wireless access media candidates of PacketOne, DSRC and W-LAN has been applied. A series of field experiments has been conducted so as to indicate the technical feasibility of such system and to evaluate the link performance quantitatively. The results showed that the pair of flexible wireless media selection and buffer control can provide a seamless application even over the link changes to the application for on-board customers. It is expected that those results are to be reflected for further studies with a variety of wireless media to be newly introduced such as cdma2000 1X-EVDO, IEEE802.11a, etc. It is also expected that the mobile-IPv6 technology, which is to be standardised at the IETF, will be taken into account for further mobile router configuration.

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