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# A Mobile Network that adapts characteristics of communication media

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The progress of communication media and the miniaturization of computer hardware realize mobile computing environment that we can access services and resources on computer networks without depending the time and the situation. We can use wired-LAN, wireless-LAN, ISDN, PHS and so on as a communication medium. And we can keep a connection to a network carrying portable computers and selecting a communication medium at the place where we are staying. However, even if we can keep a physical connection to the network, it is undesirable to interrupt our work and to must set up network configurations.

Many portable computers have suspend and resume functions. Using the functions we can restore the state before cutting the power supply. But the same medium before suspending can not always be used. And when we use wireless-LAN as a communication medium, we have to assume that a radio wave may not reached to our machines for some reason or other. In this situation if we do not want to suspend our work, we would like to keep a connection to a network with portable phone and so on. In these cases if communication media have changed running applications can not keep connections to their partners. Hence, when we switch communication media in existing systems, we always have to need to reconfigure network settings, to restart applications and to restore the state before disconnection. These situations are inconvenient for us.

On the other hand there is the systems that let hosts move keeping connections of network applications on the assumption of using a single communication medium. These systems are an implementation of IETF Mobile IP that constructs mobile computing environment on the network using TCP/IP, original protocols that can let hosts move seamlessly by making full use of the merit of wireless media, and so on. However, once

communication media has been multifarious, these systems that use a single communication medium are lack of flexibility. Hence we need the system that let hosts move switching communication media, can keep connections between network applications and can correspond to various characteristics of communication media.

The JAIST Mobile IP system satisfies these demands and provides the framework to realize more flexible mobile computing environment. The JAIST Mobile IP system can solve the following four problems.

- to let hosts move smoothly keeping connections between network applications.
- to switch to a suitable communication medium automatically
- to control timing of switching media
- to adapt various characteristics of communication media

Usual systems have corresponded to these problems one by one, but the JAIST Mobile IP system provides the framework to solve them totally. And the JAIST Mobile IP system is based on IETF Mobile IP, hence it can be built on the existing TCP/IP networks. It's a large advantage. In this paper, we focus on the fourth problem "to adapt various characteristics of communication media". And we discuss the design and implementation of the mechanism that can adapt the changes of characteristics (error-rate, band-width, delay, and so on) that switching media and hosts movement could cause.

Various optimizing methods suited to some characteristic of communication media have been studied for a long time. But if we use these fixed methods on the environment that let communication media switch, their performance can not be guaranteed. And using their methods may cause performance down depending on the situation. These optimizing methods specialized to one communication medium work entirely within usual systems that don't let media switch. But it is undesirable to insert usual fixed optimizing method within the JAIST Mobile IP system because it assumes that one communication medium switches dynamically to another different in its characteristics.

In this paper we propose the mechanism that changes existing optimizing methods depending on the situation. The mechanism contains modules specialized to characteristics of media. The modules can be changed dynamically as characteristics vary and can improve efficiency of packet forwarding to the full on the mobile computing environment. It is easy to add a new module and to modify modules because of common interfaces provided to modules. And usual methods have often had to change network composition entirely including protocols. But our mechanism does optimizing processes based on snooping packets to mobile hosts, and realizes performance improvement without affecting existing networks.

And to evaluate our mechanism we implement the JAIST Mobile IP system into the Real-Time Mach operating system. In evaluation we build a packets compressing module and a error recovery module as test cases of optimizing modules. A packets compressing module is selected to compress forwarding packets from and to mobile hosts when a narrow band-width medium is used. A error recovery module is selected to retransmit lost packets

locally when a high error rate medium is used. We show these modules behavior and effects, and demonstrate that our mechanism is effective to realize the mobile network that adapts characteristics of communication media.