A Context-aware Blogging and Learning Service in Mobile IPv6 Networks

Sheng-Cheng Yeh, *Member, IEEE*, Wu-Hsiao Hsu, Ching-Hui Chen, and Rung-Huei Liang

***Abstract*—Recently, the development of mobile services is becoming more popular. The mobile applications will not only take advantage of contextual information, such as location-awareness, to offer greater services to a mobile host (MH) but maintain existing transport-layer connections as the MH moves from one location to another. This paper exhausts our most recent work: the AcoustaNomad project. AcoustaNomad not only uses the mobile IPv6 to maintain the existing connections even if the MH changes locations and addresses, but utilizes location-aware technique to detect what kind of services the new location provides. In addition, AcoustaNomad shows two mature mobile applications: mobile learning and audio blogging. This paper proposes the architecture of AcoustaNomad and experimental results that demonstrate the ability of AcoustaNomad to enable location-aware services and applications.**

***Index Terms*—AcoustaNomad, m-Blogging, m-Learning, Context-awareness, Location-based Services.**

I. Introduction

WIRELESS and mobile networks become popular research issues in recent years. Since a mobile host (MH) can roam across different wireless networks, knowledge about locations is the necessity for the MH to detect what kind of services the current location provides. Therefore, the development of mobile applications should take advantage of contextual information, such as location, to offer greater services to the MH. In addition, the mobile IPv6 [1] should also be used to allow transparent routing of IP datagrams in order to maintain existing transport-layer connections as the MH moves from one location to another.

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Mobile technologies also provide an opportunity for a change in education. So, educators and technical developers are exploiting the capabilities and characteristics of mobile technologies to enable new and engaging forms of learning. In addition, Mobile technologies create challenges for the media industry. In Location33 [2], users equipped with a GPS enabled PDA or mobile phone walk around downtown Culver City, California and explore a new type of musical album by mixing together songs and stories based on their movement.

In this paper, we present our recent work: the AcoustaNomad project which is supported by IPv6 R&D division of National Information and Communications Initiative (NICI) in Taiwan. AcoustaNomad integrates mobile learning, mobile audio blogging, location-aware technology and mobile IPv6 technologies for any MHs. When a MH roams across multiple wireless networks, its IPv6 address may change in order to maintain connectivity. AcoustaNomad not only uses the mobile IPv6 to maintain the existing connections even if the MH changes locations and addresses, but utilizes location-aware technology to detect what kind of services the new location provides. At the current implementation, AcoustaNomad provides two mature mobile applications: mobile learning and mobile audio blogging. When a MH roams across multiple wireless networks, it will trigger the m-blogging service and allow the MH to upload its audio file that recorded the feelings or stories about a specific location to a remote server. Any MH can download the audio files when it roams to the same location. The system will also activate location specific learning contents in which language learners will be able to move around the physical space and retrieve location-specific content to act out the authentic conversations.

The remainder of this paper is organized as follows. Section II introduces the previous works related to mobile context-aware applications, mobile learning and audio blogging. The architecture of AcoustaNomad is explained in section III. Section IV describes the implementation results. Finally, Section V concludes the paper.

II. Related Work

Many research projects have developed the mobile context-aware applications in IP networks. Some related works are presented in the following subsections.

A. The context-aware IPv6 applications

In the research developped by Adrian Friday [3] proposes a novel wireless access point protocol designed to support the development of next generation mobile context-aware applications in their local environments. Once deployed, the architecture will allow ordinary citizens secure, accountable and convenient access to a set of tailored applications including location, multimedia and context based services, and public Internet. The developed architecture utilizes packet marking and network level packet filtering techniques within a modified mobile IPv6 protocol stack to perform access control over a range of wireless network technologies.

B. The location-aware services

The first locating system based on such an approach is called RADAR [4]. It operates by measuring and recording the signal strength (SS) of a number of sampled locations during the off-line phase, and infers the location of a MH based on the recorded SS database information in the real-time phase. RADAR is able to estimate a user's location to within a few meters of the MH's actual position. This suggests that a large class of location-aware services can be built over wireless LANs.

C. Immersive audio

S. Fisher [5] developed a model for authoring media content linked to physical space, which showed the concept of a virtual layer overlapped upon the physical space. Similar concept was found in Soundscape Composition [6] which provides pre-recorded audio content at specific locations. In the earlier works, these kinds of contents lack the relation of location and media, and thus they are against Salamensky's theory [7]. As a result, the recent works try to link multimedia with location using location-specific technology. SoundWalk [8] provides a tour experience with vocal and background sounds, however, the listening mode is linear.

Mobile technologies enable learners to interact simultaneously with both the physical world and the digital information. The Savannah study [9] explored the use of mobile devices to enable an interactive learning experience. Each student wore headphones for auditory experience and carried a PDA which could be tracked using GPS. The learners not only gained the knowledge of learning through experience, but also learned to help each other, to offer suggestions and ideas, and to try things out through practice.

III. Theoretical Model

As shown in Figure 1, the architecture of AcoustaNomad is divided into four components: m- Learning, m-Blogging, Locating Engine and mobile IPv6 technologies. More specifically, the components of m- Learning and m-Blogging are applications that must be based on the components of Locating Engine and mobile IPv6 technologies. When a MH changes its location, it uses the Locating Engine to detect and decide what kinds of services should be provided in the specific location. At the same time, the Locating Engine employs mobile IPv6 technology to maintain the existing connection. Afterward, the MH uses the services of m-Learning and m-Blogging via Sockets API. The functions provided by these components are described in following subsections.

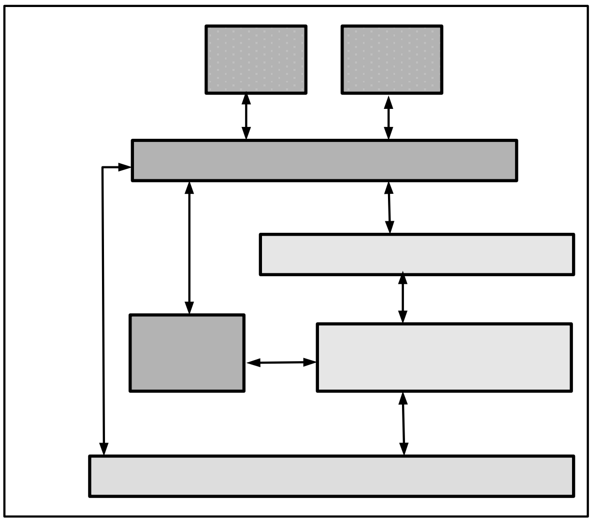

Fig. 1. The AcoustaNomad architecture with a m-Blogging and

A. Mobile IPv6

The main function of mobile IPv6 is to maintain an existing connection. That is, when an MH changes its location, it might also change its IPv6 address. In AcoustaNomad, the KAME [10] mobile IPv6 stack had been used since it works well and is regarded reference code.

B. Locating engine

A locating technique over wireless LANs can adopt the network-based or client-based deployment. For a network-based algorithm [11], a group of access points (APs) collect the RF signal measurements from a MH and send them to the central server for locating estimation. In AcoustaNomad, we propose a client-based locating engine as shown in Figure 2. Each MH's wireless adapter gathers real-time SS from multiple APs to match the fingerprinting of the signal strength database, which was established during the off-line phase. In the proposed locating algorithm, a MH's position is obtained by using the following Euclidean Distance method:

$$\text{Euclidean Distance} = \sqrt{\sum_{i=1}^{n} \left(SS_i - SS_i^n \right)^2} \qquad (1)$$

where n and i denote SS stored in the database during the off-line phase, the real-time accessed SS by the MH, the amount of AP and the APi, respectively.

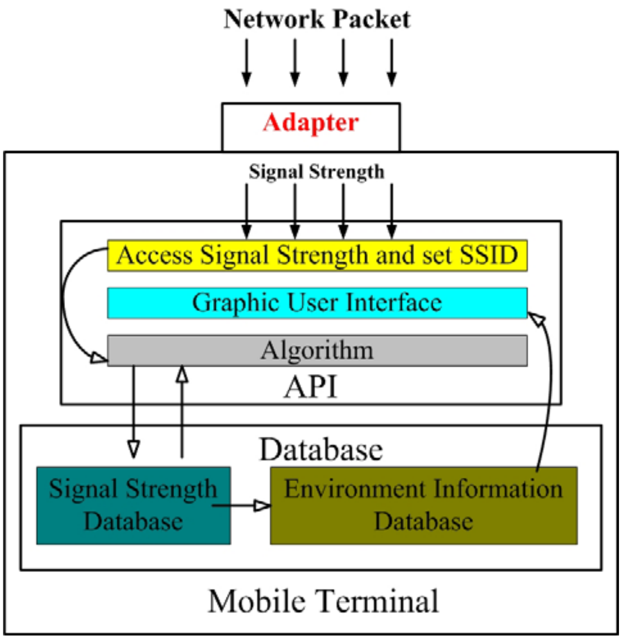

Fig. 2. The framework of locating engine based on a WiFi adapter

C. m-Learning

The purpose of m-Learning feature is to provide location-specific content to help the language learners to engage in the real world activities. Based on the characteristics of specific locations, the learning materials were designed to meet the needs of learners and were evaluated by an expert language teacher. Each dialogue was displayed in three formats; English, Chinese character and pin-yin, accompanied with correct pronunciations.

When a MH enters the zone of a specific location, the selection menu will pop up on the screen of the MH as shown in Figures 3 and 4. By clicking on the selected categories, specific dialogues will be presented and the MH can click on the play icon to listen to the pronunciations.

D. m-Blogging

The m-Blogging service aims at supporting locative audio interaction in urban living situation. Any MH can easily keep personal audio blogs in specific locations via our m-blogging authoring system. As shown in Figure 5, a MH can press recording button to start his/her voice recording and upload the audio file immediately right at the location. Our tools also support previous and next selection buttons to facilitate audio selection at the corresponding location. In addition, a playback button is made to support both audio previews before upload and audio listening after download.

The interface is designed according to a metaphor of portable mp3 player and recorder. Furthermore, this mp3-like system is context-aware enabled by our locating engine. Different blogs are kept by people in different places.

Fig. 3. The selection menu for a m-Learning service

Fig. 4. The illustration of a learning content

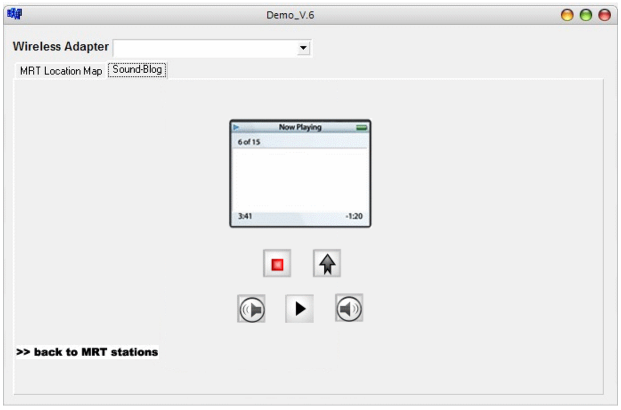

Fig. 5. The user interface for a m-Blogging service

IV. The System Implementation

The implementation of the proposed architecture is completed. Both MH and server run FreeBSD 5.4-SNAP operation system which includes KAME IPv6 reference implementation. The KAME project was a joint effort of six companies in Japan to provide a free stack of IPv6, IPsec, and Mobile IPv6 for FreeBSD variants. Therefore, it provides a lot of useful features of IPv6 such as Address autoconfiguration, anycast addresses, mandatory multicast addresses, mobile IPv6, and IPv6-to-IPv4 transition mechanisms.

A. The network topology and experimental testbed

The experimental testbed of AcoustaNomad is located on the 6th floor of our department building. The layout of the 6th floor is shown in Figure 7. This floor was divided into eight areas to represent eight Taipei Metro Rapid Transit stations. As shown in Figure 6, we place four 11 Mbps IEEE 802.11b compliant APs in the 6th floor. Each AP is connected to a CISCO 2811 router which is in turn connected to other CISCO 2811 routers in order to form a network topology. The operation system, called IOS in CISCO router 2811, is both mobile IPv6 and IPv6 capable router. Since there are eight networks in the network topology, each network must have a different IPv6 address. A dynamic routing protocol, such as RIPv6, is used between CISCO 2811 routers in order to route packets to different networks.

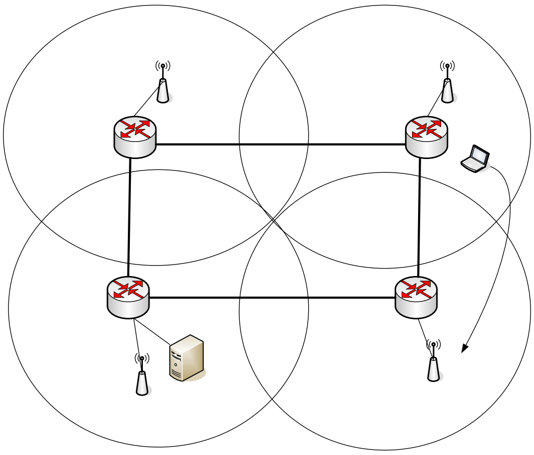

Fig. 6. The proposed network topology over a WiFi system with 4 APs

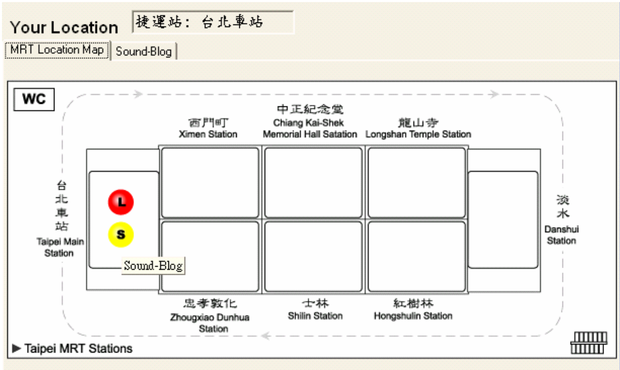

Fig. 7. A simulated station with m-blogging and m-learning service

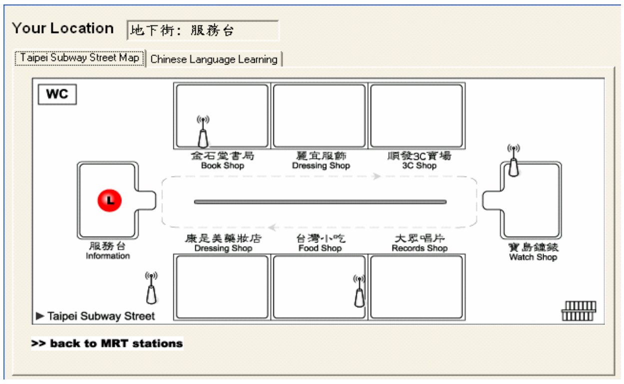

Fig. 8. A simulated station with m-learning service

B. The implementation results and discussion

As shown in Figure 7, when a MH stays in a simulated station, the location engine will estimate the MH's location and trigger the interactive menu for the specific location. As in Figure 7, the "S" and "L" icon indicates m-Blogging and m-Learning services, respectively. When the MH continues to roam to next simulated station, the location engine will estimate the MH's new location, maintain the existing connection and trigger the new interactive menu for the new location. When the new location only has m-Blogging service, the MH will see simply the "S" icon appeared on the MH. At this time, the MH can click on the icon to activate the menu shown in Figure 5. Figure 8 indicates that the location only has m-Learning service. Therefore, the MH can click on the red icon to activate the menu as shown in Figure 3 for a specific location.

Figure 9 shows another analysis result, the cumulative distribution function (CDF) of the error distance for the locating scheme, of our implementation. It is obvious that increasing the number of APs from 1 to 2 or more can provide a significant locating accuracy. However, the performance improvement is saturated when the total number of APs is increased from 3 to 4 [12]. It is worth noting from the experimental results that more than 80 percent of the estimated locations have error distance less than 5 m. As a result, many services can be predicted in advance accurately in a specific location when a MH roams to the specific location.

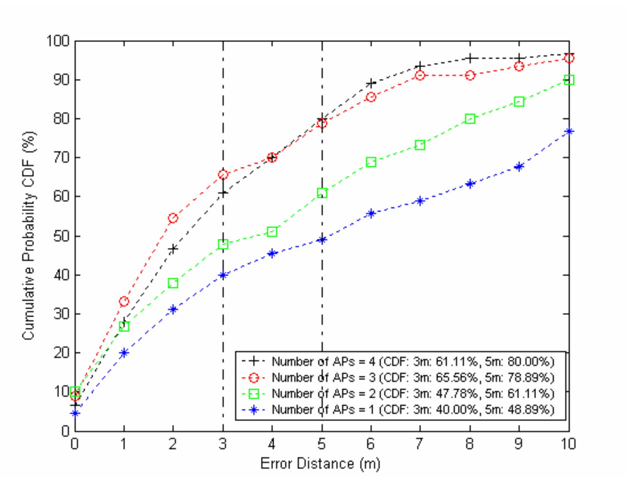

Fig. 9. The CDF of the error distance for the locating scheme

V. Conclusions

This paper has introduced AcoustaNomad, an implementation work for mobile learning and audio blogging applications. AcoustaNomad is based on locating engine which uses empirical signal strength measurements as well as mobile IPv6 which maintain the existing transport-layer connections. In addition, we also present the architecture of AcoustaNomad and the experimental testbed.

The analysis results indicate that more than 80 percent of the estimated locations have error distance less than 5 m. This means that the empirical method is superior and more accurate.

2001:3429:1:2::1/64
2001:3429:1:3::1/(
::2/64
2001:3429:1:1::1/64
2001:3429:1:4::2/64
2001:3429:1:2::2/64
2001:3429:1:6::2/64
Router
Learning and
Bloggin Server
2001:3429:1:6::1/64
2001:3429:1:8::1/64
2001:3429:1:7::2/64
2001:3429:1:8::2/64

As a result, any MH can detect the services easier when it moves to a new location. The results also revealed that subjects of the experiments had great interests in our system; they not only like the friendly user interfaces, but also satisfied with the services that the system could provide. It proves that emerging context-aware technology with the location-specific content is able to offer better opportunities for cultural explorations and social interactions. It also draws people from isolated environments together to our magic AcoustaNomad world. We believe that is our most significant contribution.

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