Interactive Bio-signal Transmission over the Test-Network of Next Generation Internet

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Abstract

We designed a telemedicine system operable in IPv6 protocol. The system consists of bio-signal transmission, video conferencing, and text communication. It was tested in IPv4-based local network of Yonsei Medical Center, using a tunneling method to bypass IPv6 data packets through existing IPv4 network. Two end systems supporting IPv6 successfully exchanged the information through the tunnel. We diversified the receiving terminal with a desktop PC, a notebook computer, and a tablet PC to demonstrate the system in both wired and wireless conditions. The test using wireless LAN verified the portability of the designed system. Showing the possibility of telemedicine system for future network environment, this system can lead us to the development of a new telemedicine system supporting other advanced features of IPv6.

***Keywords**:*
IPv6; tunneling; Next Generation Internet; telemedicine

Introduction

The lack of IP address is a serious problem on the current IPv4 (Internet Protocol Version 4) based Internet. IPv4, which uses a 32-bit address structure, is capable of providing about 4.2 billion address spaces ideally, but it is estimated that the number of available addresses will be much smaller than expected due to an indiscreet assignment of classes (A, B, and C) in the early days of the Internet. The current problem of insufficient address space can be solved by adopting IPv6 (Internet Protocol Version 6) which provides 3.4×10^{38} addresses by using a 64-bit address structure. Moreover IPv6 has many advanced features such as mobility, QoS (Quality of Service), built-in security, address auto-configuration, and plug-n-play.

Based on these new features of IPv6, different kinds of applications are being developed in various fields such as an aeronautical telecommunications network using IPv6 [1], a video conferencing over IPv6 on the Linux platform [2], and the cellular mobile IPv6 [3]. Likewise the development of the IPv6 has reached the level where it can be used in practical applications [4], and therefore the development of a telemedicine system supporting IPv6 is expected for the preparation of the next generation Internet. In this paper we introduce a telemedicine system composed of a bio-signal transmission, video conferencing, and the text communication, which is operable in IPv6 protocol. The operability of the system was tested in the IPv4 network using the tunneling technology. The data packet of the IPv6 end systems were successfully exchanged through the tunnel built in the IPv4 network.

Material & Method

1) Hardware Architecture

The system consists of two end terminals: patient's terminal and specialist's terminal (Fig 1). Pentium-IV with 512 Mbytes RAM and 2.4 GHz clock is used as the transmitting computer in the patient's terminal. The external units are interfaced to the computer through the PC add-on-boards and interface connectors; RS-232C, USB, and PCI. In specialist's terminal three different types of computers were used to receive the patient data: a desktop PC, a notebook computer, and a tablet PC.

In the patient's terminal the dedicated device (KTMED Co.), specially designed to acquire bio-signals from the patient monitor, transmits measured patient data to the terminal computer through RS-232 serial interface. It samples bio-signals (ECG, BP, respiration, and SpO_2) with 300 Hz and 12 bits resolution, and acquires the text string of other bio-data every 30 seconds: SpO_2 value, temperature, systolic pressure, diastolic pressure, and heart rate. The video conferencing camera (QuickCam Messenger: Logitech Inc.), interfaced with the PC by USB (Universal Serial Bus), captures video images with spatial resolution of 320×240 and temporal resolution of 30 frames/sec. The microphone interfaced through PCI (Peripheral Component Interconnect) by sound card captures PCM (Pulse Code Modulation) coded sound.

The LAN (Local Area Network) card (100 Mbps Ethernet) through PCI interface and the WLAN card (Samsung Co., 11Mbps) were used to make connection between the two end terminals. Two computers with FreeBSD 4.3 loaded were used as IPv6 PC routers in the connection between the IPv6 end hosts. Each PC-router had two NICs (Network Interface Card) in order to bridge IPv4/IPv6 networks.

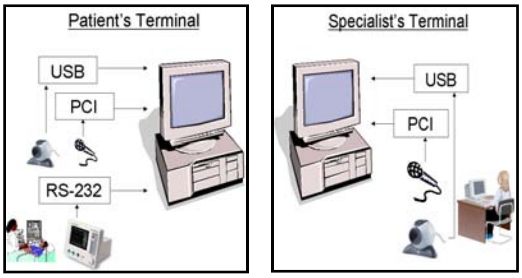


Fig 1. Hardware Architecture of the Patient's Terminal and the Specialist's Terminal

2) Software Architecture

The software configuration focuses on the exchange of patient data using IPv6 protocol. Windows Socket 2.2 is used to construct the API function of the socket communication for IPv6. The end systems for each the patient and the specialist terminal are equipped with the IPv6 Technology Preview for Windows 2000. The IPv6 Technology Preview for Windows 2000 is to help the Winsock developers who are developing network applications using Winsock programming interfaces [5]. Computers loaded with this IPv6 Technology Preview are able to use both of the Internet protocols: IPv4 and IPv6.

For the IPv6 PC routers, we used computers loaded with FreeBSD 4.3. It is dual-stacked so that it can encapsulate the arrived IPv6 packets using IPv4 carriers. Through tunneling, they encapsulate and decapsulate IPv6 packets using IPv4 carriers.

3) Test-bed Configuration

The predominant protocol of today's Internet is IPv4. To deliver IPv6 traffic over the existing IPv4 network, a transitioning technique called tunneling is used in this system. Tunneling is a method to bridge compatible networking nodes across incompatible networks [6]. The process can be described as the encapsulation of a payload using a carrier: an IPv6 payload with an IPv4 carrier or an IPv4 payload with an IPv6 carrier. Encapsulation and decapsulation of the payload are performed at the endpoints of the tunnel. Figure 2 illustrates tunneling mechanism of IPv6 packets in IPv4 carriers.

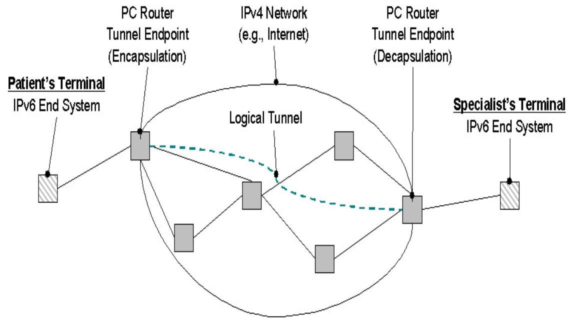


Fig 2. Tunneling Mechanism

The system was experimented using the LAN of Yonsei Medical Center, which is based on IPv4. The patient's terminal was set up in the Medical Engineering Laboratory and sent the acquired patient data to the specialist's terminal in Yonsei Medical Center. The IPv6 packets were encapsulated by the tunneling method and delivered to the other side of IPv4 network through the tunnel. The router in the specialist's terminal receives IPv6 packets in IPv4 carrier and decapsulates them to display on the screen. We used the prefix 2001:220:1000:0424::/64 for the tunneling interface and 2001:220:100a::/48 for the end terminal's IPv6 address. We assigned an IPv6 tunnel interface address and an IPv4 interface address on each router as shown in Fig 3. Using this IPv4/IPv6 transitioning method, we were able to deliver IPv6 packets through the conventional IPv4 network.

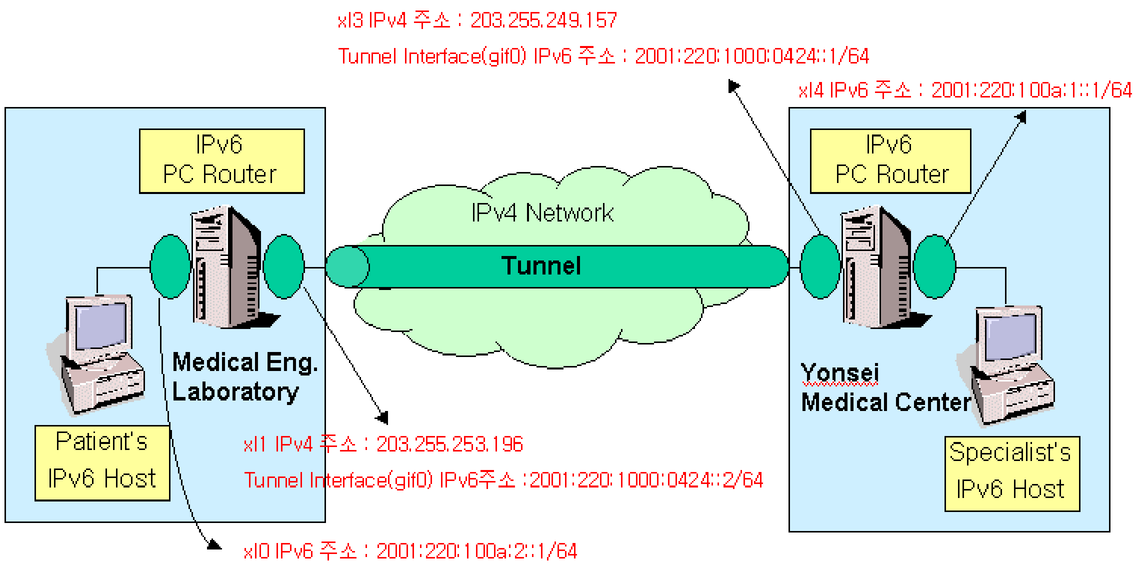


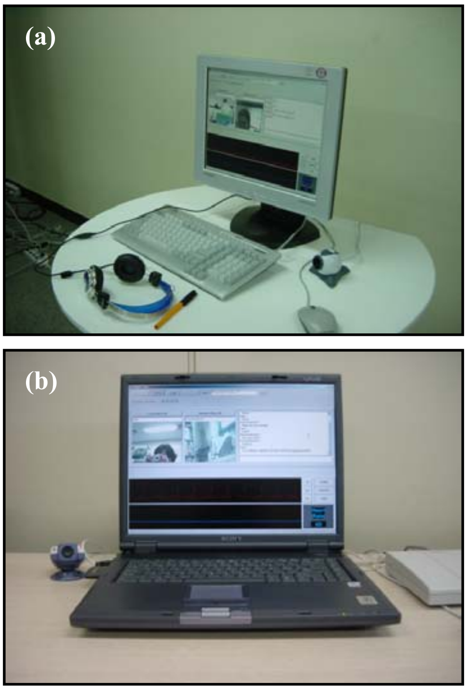
Fig 3. Test-bed Configuration of the System

Results & Conclusion

As illustrated in Fig 4, the patient's terminal displayed the acquired bio-signal of a patient and transmitted the data to the specialist's terminal at the same time. Three types of computers were used in the specialist's terminal (Fig 5).

Fig 4. Patient's Terminal

They successfully made connection with the patient's terminal and exchanged data using the video conferencing and the text communication. The notebook computer and the tablet PC made connections with the patient's terminal using 11Mbps wireless LAN card (Fig 5(b), (c)). By using a notebook computer and a tablet PC as specialist's terminals, we demonstrated the mobility of the designed system on IPv6 network. Using these devices, specialists can communicate with the patient while moving around in the hospital. With the abundant IP address that IPv6 offers, specialists in the hospital can always be online using any kind of communication devices with their unique, distinguishable IP addresses. This experiment with the notebook computer and a tablet PC demonstrated such possibility.



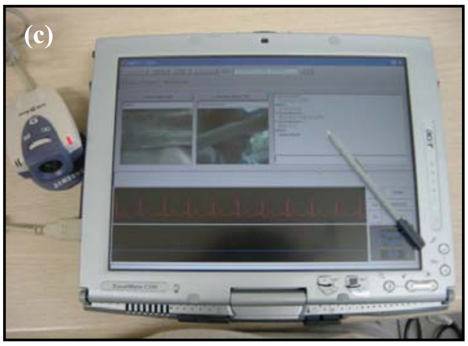


Fig 5. Specialist's Terminal: (a) Desktop PC, (b) Notebook Computer, (c) Tablet PC

In the future there will be numerous number of communication devices including the mobile and wired device, which need to be connected to the Internet ceaselessly. IPv6 is capable of allocating different IP addresses on every device while supporting other features that show an improved networking performance: guarantee in QoS, auto-configuration of end systems, standardized security, and an efficient header processing. It is expected to play a significant role in the future networking. However most of the current IPv4 infrastructures cannot handle IPv6 thus not being able to take advantage of its advanced functions. Therefore we used a transitioning technique called tunneling to enable the IPv6 support in an existing IPv4 infrastructure. Using this method, we implemented and tested an IPv6-supporting telemedicine system with a bio-signal transmission, video conferencing, and text communication.

The introduced system is the first telemedicine system designed to be operable in IPv6. Through this implementation, we confirmed a successful bypass of the multimedia bit-stream, produced as IPv6 packets, through the IPv4 Internet using tunneling technique. And the experimentation for tele-emergency care demonstrates the operability of the system over IPv6-based next generation Internet when the high data rates are required for future telemedicine. We can find the meaning of this experiment in demonstrating the application on the future networking environment.

Acknowledgments

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References

[1] Smith, P., Ipsky: IPv6 for the aeronautical telecommunications network, *Digital Avionics Systems, The 20th Conference*, Oct 14-18, 2001.

[2] Lee Ling Chuan, Jumari, K., Ismail, M. Implementation of video conferencing over IPv6 on the Linux platform, *SCOReD Student Conference*, July 16-17, 2002.

[3] Han-Chieh Chao, Yen-Ming Chu, Ma-Tai Lin. The cellular mobile IPv6 using low latency handoff algorithm for the packet-based cellular network. *ICCE 2000 Digest of Technical Papers*, 2000.

[4] Janos Mohacsi, Szabolcs Szigeti, Tamas Maray. Testing IPv6 implementations. *Computer Networks and ISDN Systems*, 1998.

[5] MSDN, URL: http://msdn.microsoft.com/downloads/sdks/platform/tpipv6/ReadMe.asp

[6] Daniel G. Waddington, Fangzhe Chang. Realizing the transition to IPv6. *IEEE Communications Magazine*, June 2002.

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