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의료센터의 애드혹망에서 뇌파전송 성능평가

Performance Evaluation of Transmitting Brainwave Signals in Ad-Hoc Network at Medical Center

조준모

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요약

삶의 질을 높이기 위하여 무선 애드혹망 기술은 컴퓨터과학과 건강관리 응용산업에서 가장 중요한 분야의 하나로 알려져 있다. 유비쿼터스 건강시스템은 또한 실시간으로 비상상태의 경고기능을 제공해준다. 이러한 기능은 봉사자들의 수를 줄여줄 뿐 아니라 만성적인 병자와 노인들을 살아갈 수 있도록 돕는다. 시스템의 응용을 위하여 효과적이며 적절한 네트워크 시스템은 필수적이다. 따라서, 본 논문에서는 환자노드가 지속적으로 뇌파를 측정하여 병원에 위치한 서버로 전송하는 다양한 네트워크 환경을 제안한다. 그리고, 이동노드들의 다양한 이동성과 토폴로지로 구성된 네트워크 시스템들을 옵넷 시뮬레이터로 시뮬레이션을 하고 평가할 것이다.

■ 중심어 : | 뇌파 | 애드혹 | 성능평가 | 의료 |

Abstract

To improve the quality of life, wireless ad-hoc network technologies are considered as one of the key research areas in computer science and healthcare application industries. The ubiquitous healthcare systems also provide alerting mechanisms against ill conditions in real time. This minimizes the need for care-givers and helps the chronically ill and elderly to survive. For the application of the system, supporting the efficient and proper network system is essential. So in this paper, I suggest some hospital network environments including patient mobile nodes continuously sending brainwaves to the server of the hospital area. Finally, the network systems are simulated by OPnet simulator and evaluate the performance among various mobility of the mobile nodes and topologies of the network for the efficient system.

■ keyword : | Brainwave | ad-hoc | Performance Evaluation | Medical |

I. Introduction

Recent advancements in wireless network technology and microelectronics accelerate the application of wireless networks in industry, as well as healthcare. During the last few years, the more flexible, wearable and mobile healthcare systems were proposed [1 - 4]. In Ref. [1], a ring with several sensors built-in and a wireless interface is used for constant monitoring of patients. An integrated mobile

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healthcare system is presented in Ref. [2]. Ref. [3] also presents a concept of wireless distributed sensor networks for patient monitoring and care. In Ref. [4], the wireless distributed data acquisition system for prolonged monitoring of patients is presented.

One of the major challenges of the world for the last decades has been the continuous elderly population increase in the developed countries. Population Bureau [5] forecasts that in the next 20 years, the 65-and-overpopulation in the developed countries will be nearly 20% of the overall population. Hence the need of delivering quality care to a rapidly growing population of elderly while reducing the healthcare costs is an important issue. One promising application in that area is the integration of sensing and consumer electronics technologies which would allow people to be constantly monitored [6].

On the basis of these studies, in this paper, some hospital network systems are presented, simulated and evaluated for the efficiency of the hospital network. The rest of this paper is organized as follows. Section 2 describes the general idea of a transmission of brain wave at medical center network. Then the general idea of brainwave is elaborated. In section 3, designing of brainwave network for a medical center will be explained. Then in section 4, the suggested networks are simulated in the Opnet simulator and reviewed the result of the performance. Finally, the whole paper is summarized in Sect. 5.

II. Transmission of Brainwave at Medical Center Network

2.1 Body Area Network at Medical Center

The rapid growth in physiological sensors, low power integrated circuits and wireless communication has enabled a new generation of wireless sensor networks. These wireless networks are used to monitor traffic, crops, infrastructure and health [7]. A number of intelligent physiological sensors can be integrated into a wireless body area network, which can be used for computer assisted rehabilitation or early detection of medical conditions. This area relies on the feasibility of implanting very small brainwave sensors inside the human body that are comfortable.

The implanted brainwave sensors in the human body will collect odd signal changes in order to monitor the patient's health status no matter their location. Not the selected signals but the whole detected brainwaves will be sent to the main server at the medical center. This device will instantly transmit all the vital information in real time to the doctors throughout the world. If an emergency is detected, the physicians will immediately inform the patient through the computer system by sending appropriate messages or alarms. Currently the level of information provided and energy resources capable of powering the sensors are limited [7]. So as the purpose of this paper, the efficient network is required. The collected data is transferred to remote stations with a multi-hopping technique using the medical gateway wireless boards. The gateway nodes connect the nodes to the local area network or the Internet. As such facilities are already available in medical centers; medical professions can access patients'physiological signals anywhere in the medical center. The data can also be accessed outside the medical center as they will be made available online. The Body Area Network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with realtime updates of medical records via Internet or various networks.

2.2 Concept of Brainwave

The electrical activity of the brain can be described in spatial scales from the currents within a single dendritic spine to the relatively gross potentials. Neurons, or nerve cells, are electrically active cells that are primarily responsible for carrying out the brain's functions. Neurons create action potentials, which are discrete electrical signals that travel down axons and cause the release of chemical neurotransmitters at the synapse, which is an area of near contact between two neurons. This neurotransmitter then activates a receptor in the dendrite or body of the neuron that is on the other side of the synapse, the post-synaptic neuron. The neurotransmitter, when combined with the receptor, typically causes an electrical current within the dendrite or body of the post-synaptic neuron. Thousands of post-synaptic currents from a single neuron's dendrites and body then sum up to cause the neuron to generate an action potential. This neuron then synapses on other neurons, and so on[8].

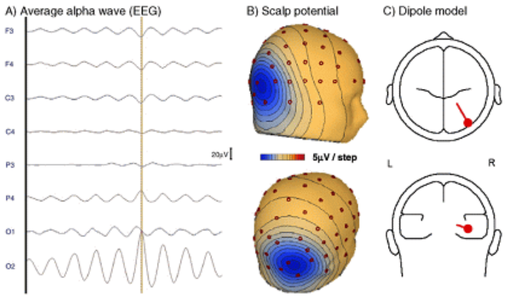


Fig. 1. EEG dipole

[Fig. 1] shows an example of average alpha wave peak using a software BESA.(A) shows that an event triggered average of the EEG signal centered on the negative peaks of alpha waves that exceeded a threshold of $-50\mu V$ in channel O2 for this typical subject and experiment. Generally, there are 63 channels but shows just 8 channels. (B) shows EEG scalp potential maps corresponding to the averaged alpha wave peak marked in (A). Picture (C) shows that fitting the model of a single current dipole (dot with arrow) to the EEG data.

III. Designing of Brainwave Network for Medical Center

3.1 Paradigm of Brainwave Network

The paradigm of brainwave network suggested in this paper is as follows. There are many patients moving inside or outside of hospital buildings. The patient is a mobile node, the mobile_node_0 for instance, in the Opnet simulator as shown in Fig. 2. However, there are 63 channels are specified for EEG device as mentioned earlier, generally only few channels are used for checking critical conditions for the patients. So I used 15 channel brainwave detector for a patient in the system. Ideally, each channel of the detector samples approximately 10,000bits of brainwave signal for a second. Then the mobile node tries to send to the server of the hospital. However, if the patient is out of the communication area from the server, the adjacent nodes could help to propagate the signal to the server. As soon as the server gets the signals from the node, it examines the brainwave for the odd symptoms in realtime. If the server detects the odd case then it alarms to the paramedics or emergency technicians, but just this part is omitted in this Opnet simulation.

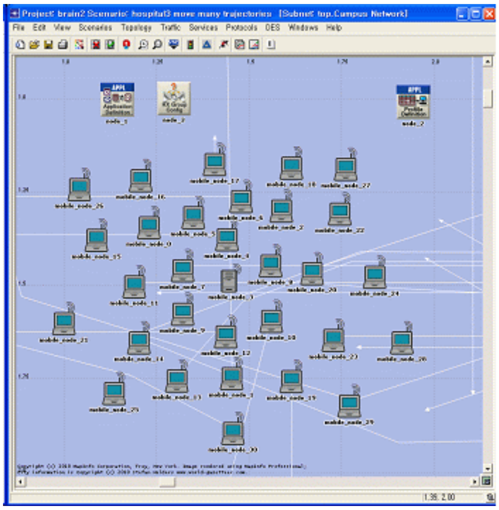


Fig. 2. Topology of the simulation network

3.2 Topology and Specification of Brainwave Network

A topology of the network is shown in [Fig. 2] The topology has many patient nodes around the server in the hospital.

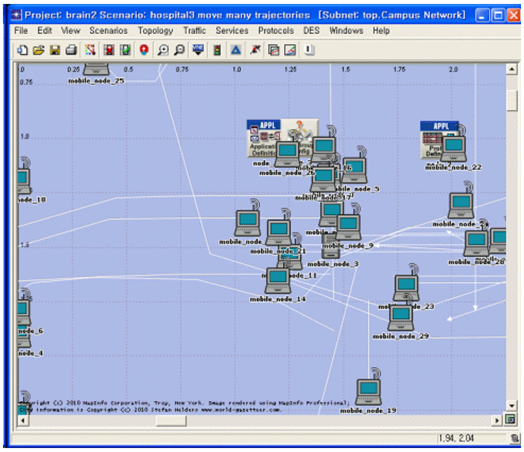


Fig. 3. The Mobility of the Nodes in the Network

The [Fig. 3] shows that the mobility of the mobile nodes in the network and each node has different mobility. The scope of the hospital network environment is about $1km^2$ square area. Each mobile node has 300m radius signal propagation capacity and each grid on the map is 250m.

IV. Performance Evaluation and Review

There are five types of simulation network is presented. A few-moderate movement-node network, few-excessive movement-node network, many-moderate movement-node network and few-excessive movement-node network. For instance, few-moderate movement-node network represents it is a network has few mobile nodes and moderate movement in the network. The many-excessive movement-node network means the network has many nodes with excessive movement network even some nodes leave out of the hospital area. The performance evaluation parameters are the traffic sent rate from the node and the receive rate at the server, the number of wireless LAN retransmission attempts. For additional simulation, the network set is the same as the last network except that the some nodes could leave out of the hospital area.

4.1 Few Numbers of Nodes Network

The network has few mobile nodes shown as the [Fig. 2] but, it has few nodes like three in the network. For the entire simulation environment, the mobile_3 node is the server and the rest of the nodes are patient nodes. The simulation result shown in Fig. 4. shows the traffic sent rate from the node and the receive rate at the server with three mobile nodes. The traffic sent rate of the three nodes are mostly in good condition and the received rate in the server is fairly good as well even though they are in motion.

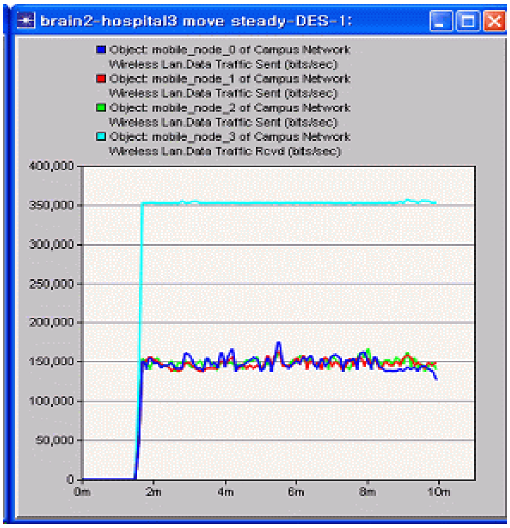
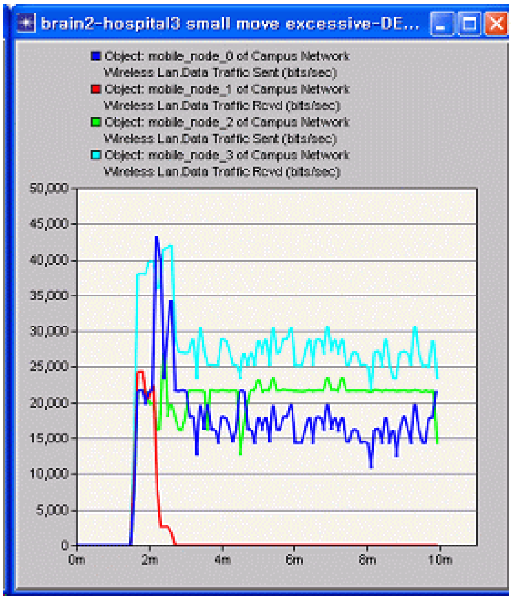
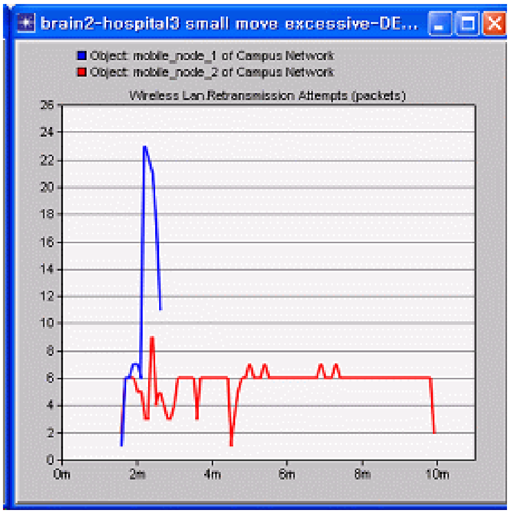


Fig. 4. Traffic Sent/Received Rate in Few-moderate movement-node Network

[Fig. 5] (a) is the simulation result of traffic sent and received rate of the few-excessive movement-node network. Even though there is few nodes, it does not shows the good performance at all. It was good at the beginning of the simulation time, but after 2 minutes, the sent rate of mobile_node_1 is degraded and eventually disconnected with both adjacent nodes and the server. We can also verify with the retransmission rate shown in [Fig. 5] (b). The retransmission rate of mobile_node_2 is continuously occurring but it manages to communicate. However, the mobile_node_1 is not even have chance to retransmit it due to the lack of the quantity and the excessive mobility.



(a) Traffic Sent/Received Rate



(b) Retransmission Attemps

Fig. 5. Performance Evaluation of Few-excessive movement-node network

4.2 Many Numbers of Nodes Network

The network has many mobile nodes is shown in [Fig. 2] There are 30 mobile nodes in the network numbering 0 to 30 except the number 3 the server. The simulation result shown in [Fig. 6] shows the traffic sent rate from the node and the receive rate at the server of the network with many nodes in moderate movement speed. The mobile_node_3, the upper part of the graph is the server's. Other graphs are node 1, 2, 24, and 30's. Most of the nodes' sent rates are about 1/3 of the performance shown in [Fig. 4] because of the many quantities of the nodes. Although they are in moderate movement in the network, we can see the quantities affects the great deal of the performance degradation.

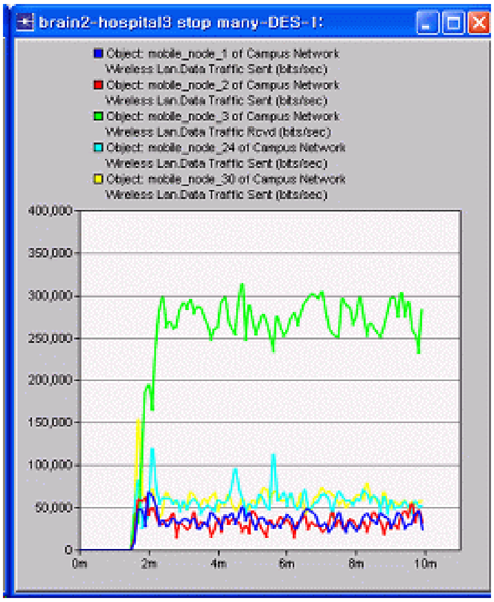


Fig. 6. Traffic Sent/Recieved Rate in Many-moderate movement-node Network

Secondly, the [Fig. 7] shows the traffic sent rate from the node and the receive rate at the server of the network with many nodes in excessive movement speed. I expected that the performance would be much worse than the moderate performance shown in Fig. 6. However, the simulation result does not show the worseness that I expected. The mobility in the certain limited area does not harm the performance of the entire network, since there the spread nodes in the area can propagate the adjacent nodes each other.

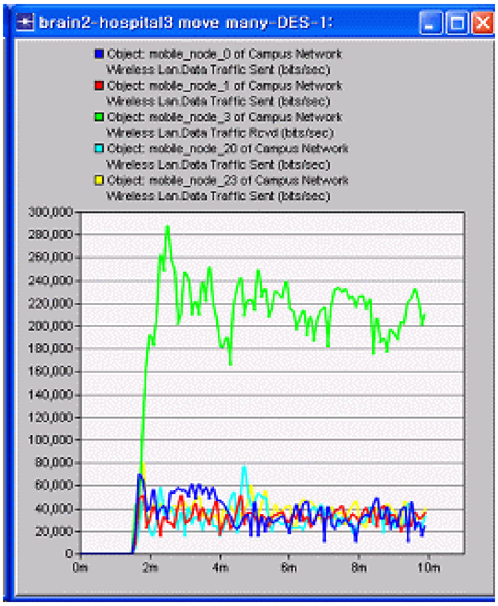


Fig. 7. Traffic Sent/Recieved Rate in Many-excessive movement-node Network

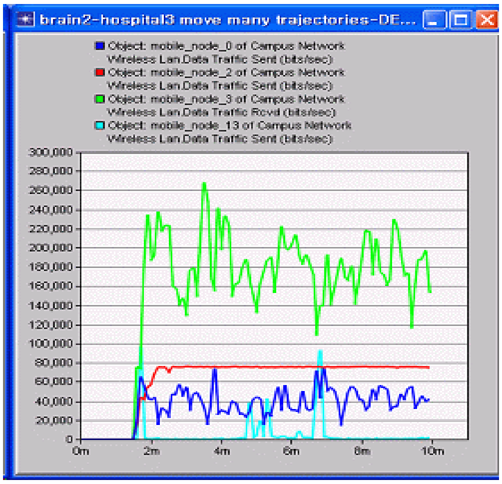


Fig. 8. Performance Result When Some nodes out of the Hospital Area

For the last simulation, many nodes with excessive movement and some nodes set to leave the hospital communication area after few minutes. The simulation result is shown in [Fig. 8] The graph of mobile_node_13, the lowest graph, and show that the transmission rate is extremely low since it leaves network and low connectivity. Such nodes leaving the network area degrades the performance of the entire network and does not help to propagate like did it in [Fig. 7].

With the simulation results, I conclude that the mobility could affect the performance degradation in the hospital network when there are few nodes in the region. However, even if there is excessive mobility in the network, it does not harm to the performance of the entire network since there the spread nodes in the area can propagate the adjacent nodes each other. For a small hospital network environment there might need to install more access points to preserve the quality of a network performance.

V. Conclusion

For monitoring patients in the hospital as an ad-hoc network, the efficient network topology and paradigm are required. So in this paper, various network topologies with network performance parameters are designed and simulated. With the simulation results, mostly, the mobility of the nodes can degrade the performance but in the limited communication area like in the hospital, does not affect the performance because of the many nodes' data propagations. For the further study, the network has many interconnected subnets consisting of many patient nodes for the bigger hospital or for a city area.

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