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의료센터의 다중로봇통신망을 이용한 뇌파전송망 프로토콜의 성능비교

Performance Comparison of Brain Wave Transmission Network Protocol using Multi-Robot Communication Network of Medical Center

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요약

병원과 같은 의료센터에서 이동하는 환자들의 상태를 효과적이며 실시간으로 감지하기 위해서는 다양한 무선통신망 프로토콜과 네트워크 상황을 고려해야 한다. 802.11a, 802.11g, direct sequence와 같은 무선통신 프로토콜들은 각각의 장단점이 있으며 모바일 노드의 개수나 전파도달 거리등 다양한 요소들이 망의 성능에 영향을 줄 수 있다. 특히, 환자들의 상태를 뇌파전송(EEG)을 통해 감지하기 때문에 이러한 데이터 특성도 고려하여 네트워크 토폴로지를 구성하였다. 따라서, 본 논문에서는 환자의 EEG 데이터를 효율적으로 전송할 수 있는 무선통신망을 설계하고 이를 Opnet 시뮬레이터를 이용하여 시뮬레이션한 뒤 그 결과를 이용하여 성능을 분석하였다. EEG를 전송하는 무선네트워크 환경에서는 전반적으로 802.11g의 성능이 우수한 것으로 나타났으며 토폴로지의 구성요소에 따라 결과의 특성에 다소 차이가 있었다.

■ 중심어 : | 뇌파(EEG) 전송 | 다중로봇 통신, 애드혹망 | 무선망 프로토콜 |

Abstract

To verify the condition of patients moving in the medical center like hospital needs to be consider the various wireless communication network protocols and network components. Wireless communication protocols such as the 802.11a, 802.11g, and direct sequence has their specific characteristics, and the various components such as the number of mobile nodes or the distance of transmission range could affects the performance of the network. Especially, the network topologies are considered the characteristic of the brain wave(EEG) since the condition of patient is detected from it. Therefore, in this paper, various wireless communication networks are designed and simulated with Opnet simulator, then evaluated the performance to verify the wireless network that transmits the patient's EEG data efficiently. Overall, the 802.11g had the best performance for the wireless network environment that transmits the EEG data. However, there were minor difference on the performance result depends on the components of the topologies.

■ keyword : | Brainwave(EEG) Transmission | Multi-robot Communication, Ad-hoc Network | Wireless Network Protocol |

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I. Introduction

Advances in wireless sensor networking have opened up new opportunities in health care systems. These sensors can improve the quality of health care for the world's increasingly aging population and patients[1]. Several EEG monitoring systems are emerging which offer off-line continuous data collection capabilities and can also signal a warning in real-time[2]. The target is to provide additional technological instruments to the medical personnel to improve their performances and workflow organization. To achieve the target, patient and hospital-centered systems are characterized by two different system architectures, involving different technological and communication issues[3].

Providing more efficient utilization of physicians and home-care professionals can contribute to reduce healthcare costs[4]. The ubiquitous healthcare system enables medical professionals to remotely perform real-time monitoring, early diagnosis, and treatment for potential risky disease. The current and emerging wireless technologies could improve the overall quality of service for patients in both cities and rural areas[5]. The ubiquitous healthcare system can provide a cheaper and smarter way to manage and care for patients suffering from age related chronic diseases with continuous, long-term monitoring[6].

Wireless communication protocols such as 802.11a, 802.11g, and direct sequence has their specific characteristics, and the various components such as the number of mobile nodes or the distance of transmission range could affects the performance of the network. So the various wireless communication networks are designed and simulated. In section 2, the basic issues related to the EEG and robot assisted mobile ad-hoc network are described. Then in section 3, the suggested robot assisted hospital network is described. Then the simulation results and evaluation is summarized in section 4. Finally, the conclusion is in section 5.

II. Transmission of EEG at Medical Center Network

2.1 Brain wave EEG

The human brain is obviously a complex system and exhibits rich spatio temporal dynamics. Among the non-invasive techniques for probing human brain dynamics, electroencephalography(EEG) provides a direct measure of cortical activity with millisecond temporal resolution. EEG is a record of the electrical potentials generated by the cerebral cortex nerve cells. The EEG provides a continuous graphic exhibition of the spatial distribution of the changing voltage fields over time[7].

[Fig. 1] shows an example of average alpha wave peak. (A) shows that an event triggered average of the EEG signal. 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[8].

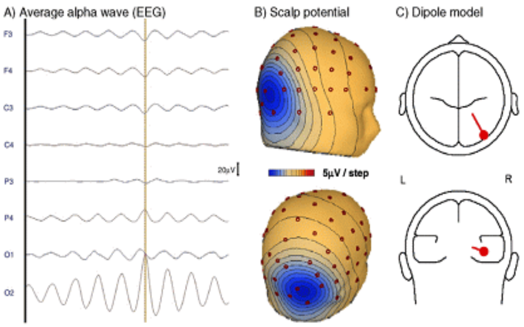

Fig. 1. EEG dipole

2.2 EEG Transmission MANET at Medical Center

In MANET, the nodes exchange and forward packets with the adjacent nodes as intermediate routers at the same time. The routing path of a packet in a MANET is formed by a series of mobile nodes and the packets are forwarded hop-by-hop fashion. If two nodes in a MANET are not directly connected, the connection between them would depend on other intermediate nodes. A broken link may destroy the entire path. This possibility of link breakage may split nodes into a number of components among which there exists no paths that interconnect them[4].

To enhance the reliability of MANETs, network partitioning should be prevented. The probability of network partitioning needs to be minimized or eliminated. One way is to control the speed, directions or mobility patterns of the nodes[9-11].

III. Robot assisted EEG Hospital Network

The suggested specification of EEG system and a robot assisted hospital network topologies are elaborated.

3.1 Specification of EEG System

To examine the brainwave for the medical purpose, I have considered it as using 10 channel EEG detector for a folk in the system. Ideally, each channel of the detector samples approximately 1,000bytes of EEG signal per second. Then the mobile node tries to send to the server of the hospital. As soon as the server gets the signals from the node, it examines the EEG for the odd symptoms in real time.

3.2 Specification and topology

The Hospital network suggested in this paper has some moving patients while they are either walking or sitting on a wheelchair with assisted robots at the hospital. The robot is equipped with communication device that transmits the patient's EEG data and the location to the server in real-time fashion. The multi-robot communication network is based on the ad-hoc network. Each robot has an ad-hoc network protocol such as the DSR in this simulation and performs the various functions as the ad-hoc network, which is data propagation through the adjacent nodes and so on. Moreover, the robots can support not only the functions of the ad-hoc network but also gives various functionalities of the robots. The server analyzes the received data for finding anomaly of brain wave such as braininfarct, epilepsy or heart attack.

The moving robots are programmed to follow the specific patient and the robots have mobile ad-hoc network using AODV routing protocol. Their destination of data is the server named node_0 shown in [Fig. 2] Each node is considered as a robot with a patient such as mobile_node_12. Furthermore, there are some fixed nodes such as node_10 transmit the EEG data from adjacent nodes to the next adjacent node or the server.

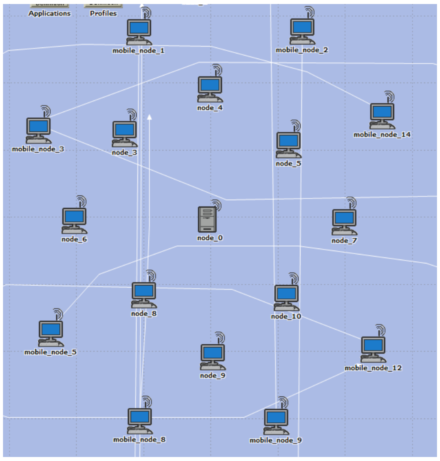

Fig. 2. Topology of Robot assisted Hospital Network

There is a 2km by 2km area of hospital that has various numbers of fixed and mobile ad-hoc nodes including a server. A node parameters of the wireless LAN are shown in the [Table 1].

Table 1. A node parameters of LAN

LAN parameters	Value
Packet power threshold	-95dBm
AP beacon interval	0.02
Buffer size	256000 bits
Distance Threshold	400m

IV. Simulation Results and Evaluation

Three wireless network protocols such as the 802.11a, 802.11g, and direct Sequence are adopted to the topology. There are some topologies under combination of the factors described on [Table 2]. So to speak, the topologies consist of 1 server, 8 fixed nodes, and various numbers of mobile nodes 4 or 8. The simulation is for obtaining best efficient network topology by examining many network parameters such as throughput, delay, network load, and so on. The simulation lasts for 20 minutes as well as the mobility of the mobile nodes.

Table 2. Topologies with various factors for the simulation

Wireless network protocol	# of fixed nodes	# of mobile nodes
802.11a	8	4
		8
802.11g		4
		8
Direct Sequence		4
		8

4.1 Simulation of Various Network Topology

In this section, I have applied small numbers of mobile nodes like 4 to the various wireless protocol environments. The TM2011-F8 M4 802-DES-1 shown on top of [Fig. 3]. shows the topology has 8 fixed nodes, 4 mobile nodes, and 1 server with 802.11a network protocol. The second line shows that the topology is the same specifications except that it uses 802.11g protocol. Finally, the third line is also the same as the above except it uses direct sequence protocol.

So, the [Fig. 3] shows the global load of each network protocols'. We can see that the 802.11g and the direct sequence has similar level of performance unlike the 802.11a. The highest value of global network load doesn't mean that the 802.11a has the best performance.

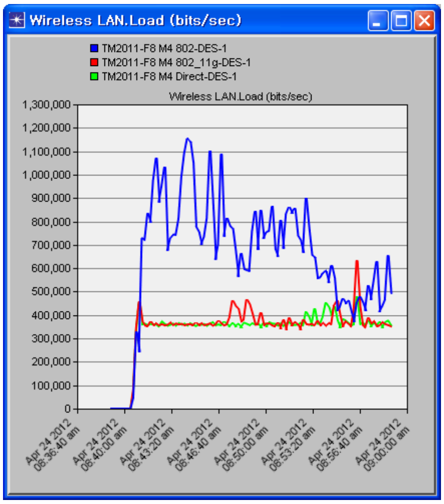

Fig. 3. Global network load of F8-M4

As shown in [Fig. 4] and [Fig. 5], the numbers of retransmission attempts and data dropped are also highest. The 802.11a protocol has trouble sending EEG data to the server. Basically, the 802.11a a character that has no interference from other protocols compare to the 802.11g. However, the 802.11a has shorter communication range than the

802.11g. This is the reason of the performance degradation.

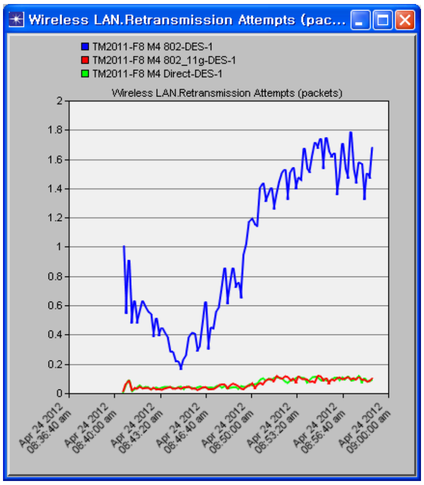

Fig. 4. Global network retransmission attempts of F8-M4

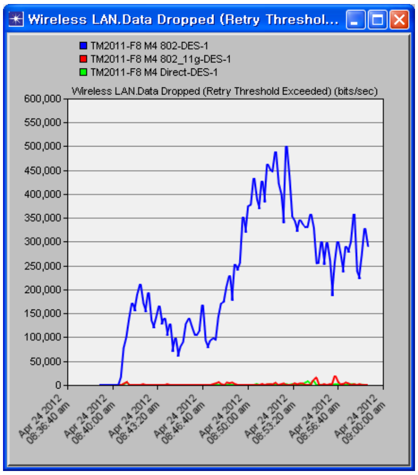

Fig. 5. Global network data dropped of F8-M4

At the view point of the server, the node_0, has similar results. As the simulation gets to the end, some mobile nodes are placed out of the network boundary. So the network communication environments getting worse in the topology. In [Fig. 6], the pictures shows that the data received of the server. The simulation starts at 8:40 and ends at 9:00 am. Around at 8:50 the performance of the 802.11a dropped rapidly because of the distance between nodes. The other two protocols such as 802.11g and direct sequence manages well compare to the 802.11a.

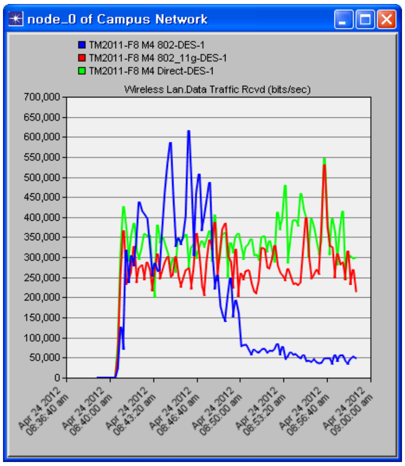

Fig. 6. Server traffic received of F8-M4

Similar result can be seen in the mobile nodes such as mobile_node_8. The great performance degradation is shown at 8:50 as shown in [Fig. 7]. Because of the severe degradation of the 802.11a, I decided to increase the number of the mobile nodes as patients at the hospital.

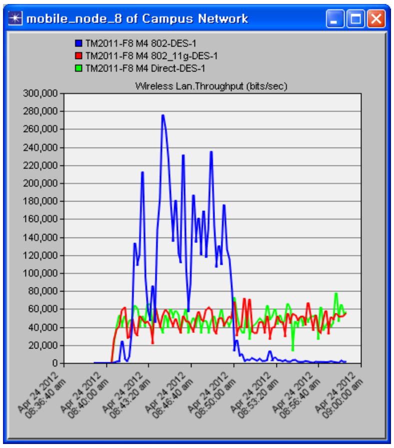

Fig. 7. Throughput of mobile node

4.2 Verifying the simulation results

In this section, I have applied more numbers of mobile nodes like 8 to the various wireless protocol environments and compare with the result of the preceding section.

The second line at the top in [Fig. 8], the TM2011-F8 M8 802-DES-1 means that the topology has 8 fixed nodes, 8 mobile nodes, and 1 server with 802.11a network protocol. So the two environments are the same topology but has different number of mobile nodes. The [Fig. 8] and [Fig. 9] shows the 802.11a with 8 numbers of mobile nodes has better performance than the other. The more the nodes, the more chances to propagate through them.

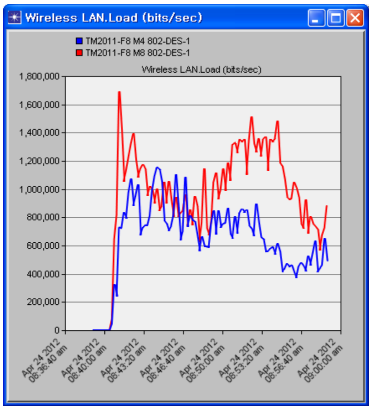

Fig. 8. Global network load

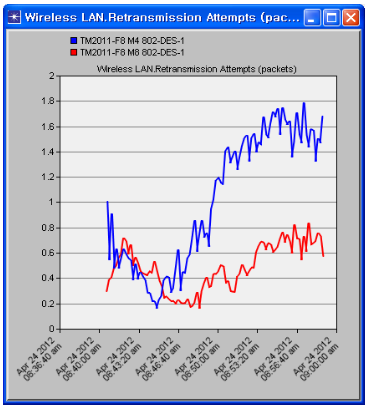

Fig. 9. Global retransmission attempts

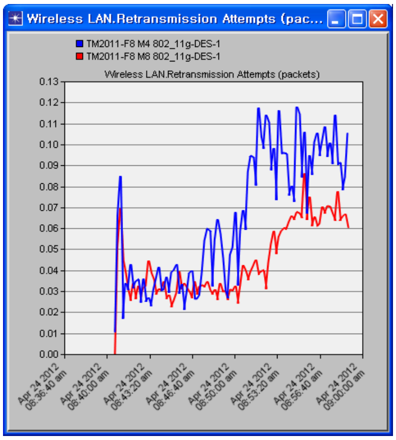

Fig. 10. Retransmission attempts in 802.11g

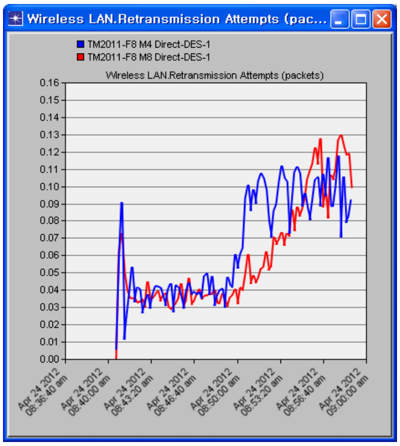

Fig. 11. Retransmission attempts in Direct Sequence

As increasing the number of the mobile nodes, the 802.11a still has less performance than the others. However, the performance between the direct sequence and the 802.11g has difference. There are important things to be focused on. The 802.11g performs better than the other protocol at this EEG transmission environment as shown in [Fig. 10] and [Fig. 11] Especially, the 802.11g with few more mobile nodes performs much better than I expected. Secondly, as the some mobile nodes going out of the network range at the end of the simulation time, the direct sequence even has more difficulties doing retransmission attempts as the mobile node grows. Therefore, in the direct sequence topology, too many mobile nodes and irregular bounce of the nodes could even affects the performance worse in the medical network.

V. Conclusion

For the fast response for the emergent situation of patients at the hospital, the robots equipped with wireless communication device could help the patient. The network system should be stable and efficient for the emergencies. For the stable and efficient network, various network topologies are designed and simulated. Especially, the 802.11a, 802.11g, and direct sequence has been deployed along with other network components. Mostly, the 802.11g and direct sequence protocols has better performance than the 802.11a. However, as the mobile node scatters each other, the 802.11g has slightly better performance than the direct sequence at the end of the simulation.

Using sensor devices in the medical center network will be an intriguing topic as a next topic.

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