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IT 융합 기술을 적용한 응급관리 정보 시스템의 신뢰성 향상 방안에 관한 연구

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Research on Enhancing Reliability of IT Convergence Technology Applied Emergency Management Information System

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요 약 응급 상황이 발생하면, 주어진 응급관리 정보 시스템(EMIS)에 의하여 응급차가 출동한다. 그러나 기존 EMIS의 문제점은 전문 의료인과 응급차 간의 신뢰성 높은 의사소통에 주안점을 두지 않아서 불필요한 사망자를 초래했다는 점이다. 본 논문에서는 이와 같은 단점을 해결하기 위해 고신뢰성 응급관리 정보 시스템인 HEMIS (Highly-reliable Emergency Management Information System)를 제시한다. 평가 결과, HEMIS는 기존의 EMIS에 비해 데이터 압축, 데이터 안전성 그리고 QoS면에서 우수하다는 것을 알 수 있었다. 그러므로 HEMIS는 응급차 내에서 의료 서비스 질을 높임과 동시에 응급차로 이동하면서 사망자 수를 줄일 것으로 기대된다.

주제어 : 응급차, EMIS, HEMIS, 의료 서비스, 사망자

Abstract In a situation of crisis, an ambulance is dispatched according to the given emergency management information system(EMIS). However, the problem of past EMIS is that they did not concentrate on the reliable communication between the ambulance and medical specialists, thereby causing some needless casualties. This paper presents HEMIS, a highly-reliable emergency management information system, to solve such flaws. The effects showed that HEMIS was superior in data packet size, data safety and quality of service(QoS) to that of typical EMIS. Therefore, HEMIS is expected to increase the quality of medical service in ambulances, thereby decreasing casualties of patients carried in ambulances.

Key Words : Ambulance, EMIS, HEMIS, Medical Service, Casualties

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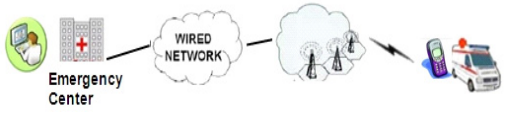
1. Introduction

When someone is in crisis and is in need for immediate medical help, normally an ambulance is dispatched according to the given emergency management information system(EMIS). Past studies have developed and designed architectures and methodologies to support this system in efforts to improve medical delivery speed, efficiency, and quality[1, 2]. They tend to keep a macroscopic-perspective, developing the system as a whole.

However, the greatest flaw of these studies is that they did not concentrate on the reliable communication between the ambulance and the doctor. As shown in Figure 1, in a typical EMIS ambulance paramedics usually use a cell phone to communicate with the emergency center. This poor communication network usually results in communication lagging due to phone call traffic. The problem is that if there is lack of communication, the patient in the ambulance is not cared at the adequate timing. One study showed that the response time of taking medical action in the ambulance had significant effect on health outcomes[3]. Not only that, first-aid malpractice due to lack of communication or no communication between the ambulance and the doctor were found as one of the main causes of patients' mortality[4].



[Figure 1] Common EMIS Communication Architecture

From these reasons, a highly reliable transmission method for EMIS is needed, so therefore our research is to propose HEMIS(Highly-reliable Emergency Management Information System) that secures highly reliable wireless network between physicians and ambulances. Such reliable link will allow medical specialists in the hospital to directly order high-quality medical service to the ambulance from afar, which is something the medical personnel in the ambulance cannot give. Hence, HEMIS is expected to enhance the quality of first-aid service that the patients are to get in ambulances, ultimately decreasing the patient mortality rates in ambulances and ensuring safe patient delivery.

2. Prior Studies

2.1 Basics of Ambulance Emergency System and Its Flaws

Functions like carrying a patient safely to a certain hospital is a common aspect of all ambulances, but the specialists staffed in the ambulance vary by situation. For instance in a 911 ambulance, the staff in the ambulance is not even a medical staff in technical terms, and is someone who can only take very basic first-aid procedures. On the other hand in a hospital ambulance, the staff in the ambulance is a medical staff, but is a paramedic or an ambulance medic.

The point is that either way they are not as credible or professional as medical specialists. These emergency medical technicians, paramedics or ambulance medics are non-professionals who are only trained to handle basic life support services such as administering oxygen and CPR(Cardiopulmonary Resuscitation). Of course, in cases of paramedics, they are trained to provide advanced life support services, such as heart monitoring and IV(Intravenous) therapy[5]. But still they highly rely on their past experience than deep clinical knowledge and are prone to many medical malpractices[6]. A study already criticized the flaw of their skills and proposed simulation training to be taken prior to their dispatch in the field[7].

2.2 Benefits and Risks in Wireless Networks

Wireless network in medical areas provide a variety of benefits. Once a wireless network is established it

allows options for real-time monitoring of ambulatory or mobile patients. It also allows medical staff to become mobile because information is easily accessed from anywhere within the coverage area, and also, it allows information to be pushed immediately to clinician(8).There have been many researches concerning wireless networks to be embedded in the EMIS, for one example, using 3G network to allow patients to interactively get the medical attention they and advice they need[8].

Contrarily, there are some risks following wireless networks. Especially in mobile wireless networks there are seamless transmission problems due to handover (handoff), data loss, fading, burst error etc. In handover (handoff) wireless networks, if proper transfer is not made, there will be a sudden stop in an ongoing data transmission. The reason this is a risk to consider is that in case of an ambulance, it travels distances which at least requires one or two cell tower handovers. Data loss is also a dangerous risk, since if the patient's health data is in some way corrupted due to data loss, it may critically affect the patient. Obtrusive environment such as in urban areas where a vast amount of buildings are affecting the signals could frequently cause fading. Also, it could interrupt the signal and cause burst errors so that there is no contiguous data transmission.

2.3 Emergency Management Information Systems

Recent trend to provide swift, accurate medical service in emergent situations include the effort of convergence of emergency systems and information system. Such efforts triggered the advent of quite a number of medical information systems, such as e-Health or u-Health[9-11]systems where physicians can provide medical services without time, space or any other constraints[12-14]. One of them is Emergency Management Information Systems, and its primary function is to allow at least basic primary medical services to be delivered to patients in emergency crisis at the right place at the right time. EMIS builds IT(Information Technology) as part of the emergency management to ensure that medical experts continue to provide medical service well, under the circumstance that they are supported by the technology and not be driven by it[15]. Our proposed system maintains the form of EMIS, while securing highly reliable wireless network between physician and ambulance, enabling rapid response. There is a significant benefit in using rapid response systems to prevent respiratory arrest. Prevention is far preferable to even expert resuscitation from cardiac arrest because the outcome of in-hospital pediatric cardiac arrest is poor[16].

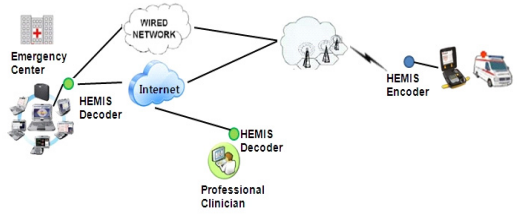
3. Proposed Model: HEMIS

3.1 Overall System Architecture

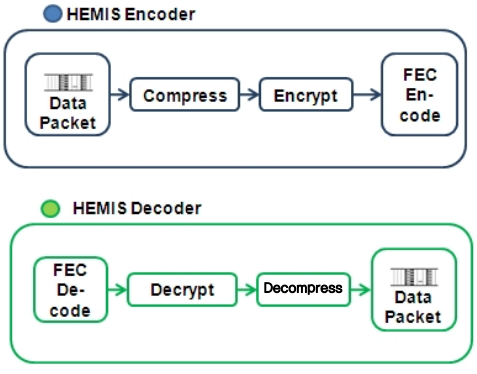
Our research focuses on the communication between the ambulance and the doctor to reduce any medical accidents taking place in ambulances. The point of our research is to not only propose a strong connection between the main clinician and the patient in the ambulance, but also to ensure a highly-reliable wireless network between them. This is achieved through our developed modules. These modules can be embedded as hardware, software or both, enabling encoding, compression, encryption and FEC(Forward Error Correction) of data packets sent between the wireless network. This way, the unstable QoS(Quality of Service) of wireless network becomes more safe and stable. HEMIS system architecture is shown in Figure 2.

First, in the ambulance, vital signs or any other parameters that represent the status of the patient is sensed or typed by the ambulance medic into data packets. For reliable data transmission the data packets are compressed and encrypted by the HEMIS encoder.

The converted data packets are then successfully sent to the cellular network. The second stage, which is the network transmission from the cellular network to a professional clinician, is also ensured due to FEC. Because of the HEMIS decoder embedded in either the clinician's personal computer or PDA(Personal Digital Assistants)[17, 18], the data packet is successfully received. HEMIS also allows features that provide decoders to be embedded in emergency centers in case it is needed. The display could be in 3D or in any other sophisticated ways(such as, including sound), including 2D animation display, for example, ECG (Electrocardiography) signals. A study proved that nevertheless, the sophistication and richness of 3D displays do not guarantee better decision making for all tasks; it is the contrary[19, 20]. The case of ECG decision making is such task, and in this case 2D displays are more useful than 3D. For the overall view of the encoding-decoding process, refer to Figure 3.



[Figure 2] HEMIS System Architecture



[Figure 3] HEMIS Encoding-Decoding Process

3.2 Compression and Encryption

Since the data transmitted to and fro between the ambulance and the physician in wireless communication, personal medical information becomes much more vulnerable to illicit or non-beneficial uses[21, 22]. Therefore, in the process of encoding of our proposed module, we included the compression and encryption process. We basically achieved compression through LZW(Lempel-Ziv Welch) compression method, although we've made some alternations in the algorithm to enhance effectiveness. Then we achieved encryption by minutely adjusting the compression algorithm, thereby not letting anyone extract the data unless they are aware of our unique algorithm.

3.3 Complementary Measures for Network Errors

In order to solve any network errors that may occur during any stage of the emergency data transmission (as discussed in 2.2), we use the FEC method. FEC is a method of reducing bit errors during data transmissions. Redundant bits, each usually a complex function of many bits from the input data stream, are added to the transmitted data and enable the receiving device to detect and correct a certain fraction of bit errors that occur during transmission[23].

4. Effects

Reducing the size of health data such as ECG is known to bring many benefits such as reducing the data bank in hospitals and allowing smaller processor devices to be used to manage and store health data[24]. That is exactly what HEMIS encoder does in its first step. ECG data is what HEMIS mainly handles. As a compression method, we use a modified version of LZW compression method. LZW is the most commonly used compression method application-wide, for example, in Al-zip. We modified the dictionary algorithm to our

taste, in order to modify the LZW compression method to be most effective to ECG data. A patient's abnormal ECG data would be reduced to almost 32% of its normal size according to our modified compression algorithm.

Also, HEMIS encrypts the data before it is transmitted wirelessly. We use symmetric-key encryption, so that only the authorized parties are capable of reading the secured messages. Say, for instance, some person of interest purposely attempted to snatch or attack the health data going across wireless network. Without encryption or any safety measures, the person's data is completely prone to the attack. The purpose of the HEMIS is to ensure the safety of the health data.

After compression and encryption, HEMIS uses FEC method to ensure highly reliable network QoS. HEMIS uses a triple redundancy code, which is one of the many methods of FEC. Each bit of the health data is transmitted 3 times. The received data of the 3 health data are averaged and therefore can be corrected if an error occurred. So HEMIS ensures three points; compression, encryption and reliability compared to the typical EMIS. The comparison is shown in Table 1.

〈Table 1〉 The Effects of HEMIS Compared to Typical EMIS

	Typical EMIS	HEMIS
Data Packet Size	Large	Small
Data Safety	Exposed	Protected
QoS Reliability	Low	High

5. Conclusion & Future Research

By embedding modules(HEMIS Encoder, HEMIS Decoder) that ensures highly-liable wireless network between the physician and the ambulance, our proposed system HEMIS is expected to improve the EMIS in three terms. First, the data packet size is reduced due to our LZW compression method. The main benefit of this is that the emergency response is reduced to a shorter period of time. In desperate situations, it is important to send the health data of the patient in the ambulance to the hospital as fast as possible owing to the fact that the patient's life is at stake. Since our system compresses the size of the total data packet as mentioned above, it is possible to send the data at a much faster rate.

HEMIS also decreased the rate of errors and allowed highly reliable wireless network. If the health data of the patient is big in size, it requires longer transmission speed and frequent transmission. But according to HEMIS, the size of the health data of the patient is small in size therefore requires less transmission speed and less frequent transmission. Not only that, HEMIS assures FEC method to recover data even if data loss happens.

Lastly, through encryption, the person's data is protected from any malignant attacks. By making sure that only the authorized parties have access to the network, HEMIS guarantees the safety of the patient's data. Therefore, HEMIS is expected to increase the quality of first-aid service that the patients are to get in ambulances, consequently decreasing needless casualties in ambulances and ensuring safe patient delivery.

The limitations of our research were that our compression method tended to be more efficient to data types that only include words or numbers. Though this may act as a strong advantage when transmitting vital signs of patients with cardiac disorders(their analog vital signs are transformed into digital numbers), our system may be inefficient when sending pictures or videos. Further research about sending more diverse health data than vital signs is needed. Also, HEMIS only concentrates on the reliable communication

between the ambulance, doctor and emergency center. More research is needed for HEMIS to be applied in more diverse and complex areas, for instance smartphones[25]. All in all, in hospital systems where much more parties are involved, HEMIS should be supplemented accordingly.

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