Disconnection Tolerant M-Emergency System

Sangwhan Cha and Weichang Du

***Abstract*—In emergency situations, a patient's information is hard to be shared between running ambulance and hospital even though the internet and telecommunication technologies have been rapidly grown because of unstable wireless access network. In order to share historical and current patient's information between an ambulance and a hospital efficiently in case of network disruption, there have to be some technologies. In this paper, we propose disconnection tolerant m-emergency systems that transparently perform required functionality to users. Such system provides disconnection tolerant mobile emergency services efficiently.**

***Index Terms*—Middleware, mobile application, context awareness, emergency.**

I. Introduction

Even though new medical technologies and equipments have been developed significantly, our public health system had continually struggled to combat ongoing and emerging public health threats and emergencies for over 30 years [1].

In emergency situations, a patient's information is hard to be shared between running ambulance and hospital even though the internet and telecommunication technologies have been rapidly grown because of unstable wireless access network [2].

However, there are some emergency cases patient's information has to be shared such as following examples.

A patient's medical information is usually kept in the server of hospital or medical information sharing center. Therefore, the previous patient's information has to be sent to emergency physicians in ambulance when the ambulance does not have medical equipment for accurate diagnosis.

Also, there is another important case that providing physicians in a hospital with a patient's current medical information in ambulance has to be done for emergency treatment and appropriate preparation on surgical operation when the ambulance arrives at the hospital.

In spite of the current wireless network technology, mobile emergency application services are prone to failures caused by the disruption of a wireless access network connection due to the movement of ambulance to the unavailable network areas or the blocking (shadowing) [3].

In order to share historical and current patient's information between an ambulance and a hospital efficiently in case of network disruption, there have to be some technologies such as

Technology for predicting network disruption

Technology for transmitting the patient's data efficiently in case of network disruption

Technology for making decision on the priority of the patient's data

Technology for extracting core meta data from the patient's multimedia data

In this paper, we propose disconnection tolerant m-emergency systems that transparently perform required functionality to users.

The rest of the paper is structured as follows. Section 2 discusses the related work. Section 3 discusses previous work. Section 4 introduces m-emergency systems and Section 5 discusses experiment and evaluation. Finally, Section 6 discusses concluding remark.

II. Related Work

There are some other different approaches for handling patient data in emergency situations.

Turcu et al. [1] propose an RFID-based system for emergency health care services in order to provide emergency physicians with a patient's accurate medical history such as allergic reactions, medication requirements, heart condition, etc. when the patient is unconscious. The patient has the RFID tag that contains all the vital information so that hospital or emergency staff can read and write depending on different levels of security implemented in data acquisition and writing system.

N. Huda et al. [4] propose privacy-aware access to patient-controlled personal health records in emergency situations for better and safer care with a novel privacy-aware protocol for handling access. In their proposed system, there are patient's health IC card and IC card reader with encrypted patient's data for the access from different healthcare centers.

J. Smalls et al. [5] propose health monitoring systems for massive emergency situations with monitoring device placed in injured victim to transmit the vital sign during an emergency. Their approach provides real time monitoring for victims so that the injury could not be worse because of delayed treatment.

E. Kyriacou et al. [6] propose an integrated system for the support of an emergency health care department with patient administration, patient record management, information exchange within the department and ambulance vehicles management. With respect to information exchange, telemedicine system has been used.

S. Pavlopoulos et al. [7] propose a mobile system for emergency health care provision via telematics support with a portable medical device that allows diagnosis and transmits vital bio signals and still images of the patient.

Although there have been many approaches for handling a patient's data in emergency situations, those approaches do not deal with efficient transmission on unstable wireless access network.

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The authors are with the faculty of computer science, University of New Brunswick (e-mail: scha@unb.ca, Sangwhan Cha).

III. System Overview

A. Middleware Solution

Our proposed middleware services [2] are application layer services to provide programming abstraction. They also can be considered as a set of services placed between mobile applications and device operating systems [8].

Network architecture for mobile application services is usually based on client-server architecture. Since there is a network disruption, the client-server architecture is not enough for providing mobile application services properly. Thus, we propose a mobile intelligent server (MIS) to provide disconnection tolerant mobile services. MIS consists of a service manager, a context handler, a resource manager, and a connection manager, for controlling mobile application services between mobile devices and mobile servers.

We propose three middleware solutions based on various network architectures for the mobile service disruption problem described in section 3. The first one is the MIS-based solution that needs to run the middleware on the mobile device and on the MIS. The second one is the mobile device-alone solution that only needs the middleware running on the mobile device and does not need MIS support. The third one is the server-based solution that needs the middleware running on the mobile device and being integrated into the application service provided by the server.

B. Context Aware Decisions

In order to make proper preparation for gradual network disconnection, we need two context aware decisions. With regard to the first context aware decision, we have to decide whether a device is getting out of coverage area and is going to be disconnected. We apply incremental method with signal strength. The decision only with signal strength is called simple decision. Table I shows context information for simple decision making.

TABLE I: Context Information for Simple Decision Making

Context	Dimension	Range	Abbreviation
Network	Signal strength	1~10	N_SS

The process of simple decision making is following.

If $N\_SS_i - N\_SS_{i-1} > 0$, let $K_i = 1$, where N_SS_i is network signal strength at time i.

else if $N\_SS_i - N\_SS_{i-1} < 0$, let $K_i = -1$

else $K_i = 0$.

For setting the starting point for decision making, let $inc(N\_SS_{t-n})$ be the sum of K_i for some period time (t-n) from the start time (n) of mobile application to current time (t). Then, the process of decision making starts when N_SS_t is less than and equal to handoff threshold and $inc(N\_SS_{t-n})$ is less than zero, where N_SS_t is network signal strength at the current time t.

For the process of decision making, let $inc(N\_SS_{T-t})$ be the sum of K_i for some period time (T-t) from the current time (t) to the running time (T). If $inc(N\_SS_{T-t})$ becomes less than 0, it induces that network signal strength is going to be downward. Therefore, we could predict that network disruption might occur.

Therefore,

Step 1. Finding $inc(N\_SS_{t-n})$ and $inc(N\_SS_{T-t})$

$inc(N\_SS_{t-n}) = \sum_{i=n}^{t} k_i$, where t= the current time (second) from the start time (n) of application.

$inc(N\_SS_{T-t}) = \sum_{i=t}^{T} k_i$, where T= the running time (second) from time (t).

Step 2. Making simple decision

Let ND be the network disruption.

When N_SS_t <=handoff threshold and $inc(N\_SS_{t-n}) < 0$,

$ND = inc(N\_SS_{T-t}) < 0$.

Step 3. Preparing network disruption

For mobile multimedia application services, the mobile device receives data until N_SS_t <= minimum acceptable signal strength.

With regard to the second context aware decision on mobile application services, we have to decide when the device should start to make preparation for gradual network disconnection based on network type, application bit rate, device type, device speed, and signal strength. The decision with above context information is called moderate decision. Since the coverage range is different between WiFi network and cellular network, network type has to be considered appropriately. For example, since WiFi network has shorter coverage range than cellular network, the device on movement in WiFi network needs earlier time than in cellular network for preparing network disconnection. Multimedia files are usually encoded at proper bit rate based on estimated/target network bandwidth or throughput for effective playback on mobile device. Therefore, application bit rate has to be considered appropriately. For example, applications with higher application bit rate need to prepare network disconnection earlier. Since each mobile device has different capacity for caching multimedia files, device type has to be considered appropriately. For example, mobile devices with high capacity need to prepare network disconnection earlier. Since the question how early the mobile device is getting out of coverage range is important fact for the second required decision, device speed has to be considered appropriately. For example, faster mobile device need to prepare network disconnection earlier. Table II shows context information for moderate decision making.

TABLE II: Other Context Information for Moderate Decision Making

Context	Dimension	Range	Abbreviation
Network	Signal strength	1~10	N_SS
	Type	WiFi=1, 3G=2	N_T
Application	Bit rate	Normal=1, Fast=2	A_BR
Device	Type	Normal=1, High=2	D_T
	Speed	Normal=1, Fast=2	D_S

Since N_T is directly proportional to the running time T, $T' = T \times N\_T$ should be applied, where T' is adjusted T with the value of contexts for the proper interval of comparison.

Since A_BR, D_T, and D_S are inversely proportional to the running time T, $T' = T \times (1/A\_BR) \times (1/D\_T) \times (1/D\_S)$ should be applied for the proper interval of comparison.

Therefore, $T' = T \times N\_T \times (1/A\_BR) * (1/D\_T) \times (1/D\_S)$.

IV. M-Emergency Systems

Fig. 1 illustrates the example of unreachable networks when ambulance vehicle runs from one network to another network.

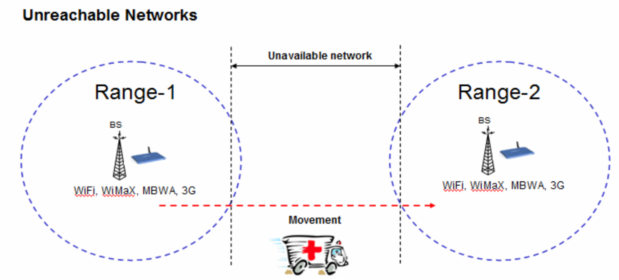

Fig. 1. The example of unreachable networks

As mentioned earlier, there are two cases to transmit a patient's information. The first case is transmitting a historical patient's information form the hospital to the ambulance. The second case is transmitting a current patient's information from the ambulance to the hospital. Since we apply our previous architecture, these two cases have to be handled differently. Fig. 2 illustrates the general model for m-emergency system. MIS is located in the fixed network and has reliable connections to the application servers.

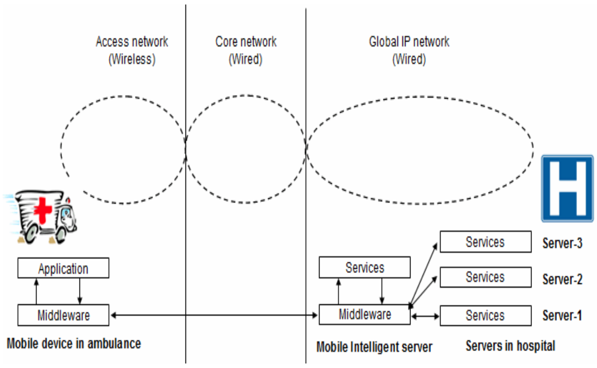

Fig. 2. A general model for m-Emergency systems

For the first case, the MIS still gets data from servers in hospital when the disruption in the wireless access network occurs in mobile medical device in ambulance. There could be four phases for disruption tolerant m-Emergency systems. Fig. 3 illustrates the architecture of middleware.

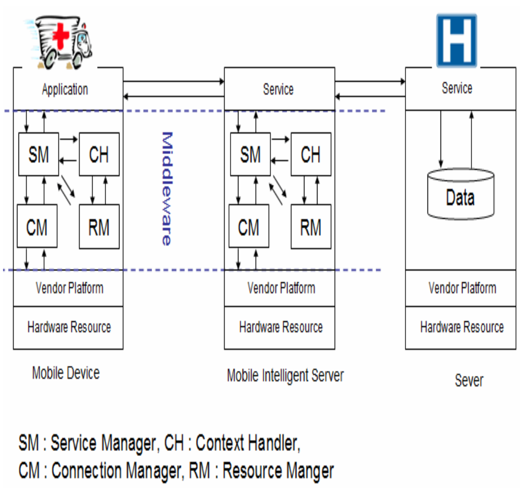

Fig. 3. The architecture of middleware system

1) The phase for predicting network disruption in the mobile device of the ambulance in figure 3:

With using the simple decision making in section 3, we could predict wireless network disruption so that the mobile medical device is able to prepare some more data before network disruption or extracted meta data from MIS.

2) The phase for transmitting the patient's data efficiently before network disruption

With using the moderate decision making in section 3, we could transmit the patient's data efficiently based on various context information before network disruption.

3) The phase for making decision on the priority of the patient's data

If there is the decision making on network disruption and are different set of data in MIS, the priority of data has to be set.

4) The phase for extracting core meta data from the patient's multimedia data

If there is the decision making on network disruption and meta data is good enough to handle the patient, extracted meta data will be sent to the mobile device in ambulance before network disruption.

The second case needs the phase for predicting network disruption, the phase for making decision on the priority of the patient's data, and the phase for extracting core meta data from the patient's multimedia data as well.

V. Experiment and Evaluation

In this paper, we only show the efficient data transmission in case of network disruption using context ware simple decision and moderate decision.

Our design and implementation incorporate with concerns of disconnection tolerant m-Emergency systems based on our previous work [9]. The mobile client in ambulance uses HTC Dev Phone and Samsung Galaxy S that run on Android platform version 1.6 and version 2.1-updatae. The MIS uses IBM ThinkPad (T43) that runs on Ubuntu 8.04(Hardy Heron). We use the hospital server for a patient's information on HP Compaq nx 6320 with Windows XP as the MIS. Fig. 4 illustrates the overview of experimental environment.

We design the prototype of disconnection tolerant m-Emergency systems for demonstrating the feasibility of applying our proposed techniques. We implemented the patient information transmitting using HTTP/TCP due to their widespread adoption for mobile device such as mobile handset and flexibility in implementation.

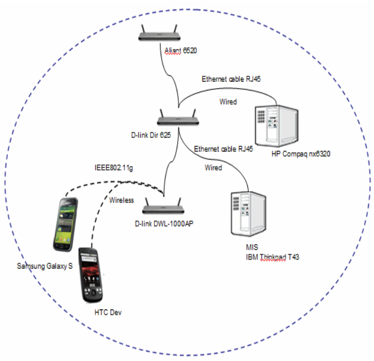

Fig. 4. Overview of experimental environment.

We analyze multimedia data (.mp4/11.3M) received without decision and with context aware simple decision in order to show how effectively and efficiently we could get data before network disconnection with higher sending rate.

Fig. 5 illustrates the comparison of total received data based on the change of sending rate using the simple decision from MIS.

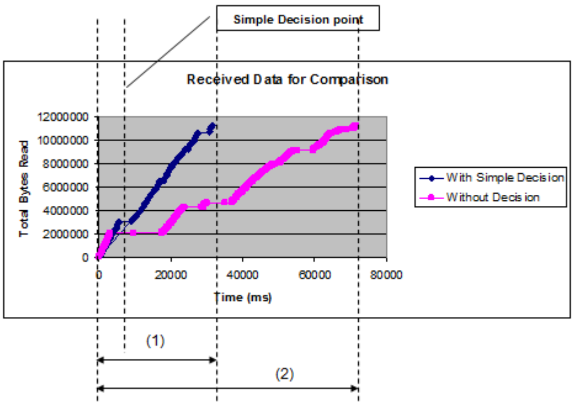

Fig. 5. Comparison of total received data using simple decision.

In Fig. 5, the process (1) illustrates the total received data without decision. The process (2) illustrates the total received data with simple decision, which causes sending rate to be changed from sending rate 1 (15,630 KB/sec) to sending rate 3 (62,520 KB/sec). If the sending rate is higher, the total duration of data receiving time is shorter as we expected. Therefore, we could reserve more data before network disconnection.

Fig. 6 illustrates the comparison of decision processing time for simple decision and moderate decision when device speed has been changed to 2 (fast). The decision processing time has been reduced with fast device speed.

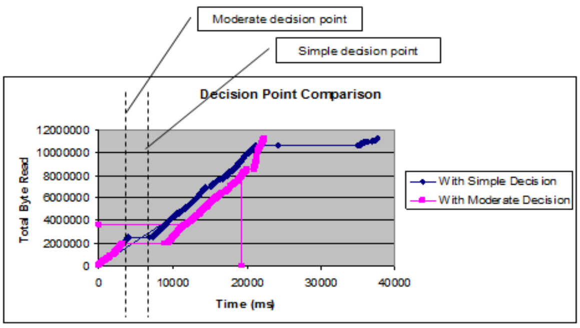

Fig. 6. The comparison of decision processing time.

As shown in above experiment, the proposed system provides disconnection tolerant mobile emergency services efficiently.

VI. Concluding Remarks

In this paper, we explore disconnection tolerant m-Emergency systems based on our previous proposed middleware architecture. This approach could play an important role of supporting mobile emergency systems.

For future work, we will further investigate on technologies for making decision on the priority of the patient's data and extracting core meta data from the patient's multimedia data

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Sangwhan Cha received his B.S. in computer science from University of New Brunswick, NB Canada, in 2000, the M.S. in software engineering from Korea University, Seoul Korea, in 2007 and the PhD degree in computer science from University of New Brunswick, NB Canada, in 2012. He is a Post Doc fellow at faculty of computer science, University of New Brunswick. His research interests are in the areas of software engineering, mobile computing and intelligent system.

Weichang Du is a professor at faculty of Computer Science, University of New Brunswick since 1991. He obtained his PhD degree in Computer Science from University of Victoria in 1991. His main research areas include mobile and wireless computing, internet computing, software engineering and knowledge engineering.