Smart MCI Tracking and Tracing System Based on Colored Active RFID TriageTags

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Abstract: *With regards of quick response, its importance can't be ingored during the mass-casualty incident (MCI) event. This paper focuses on the application of a mass-casualty incidents system in tracking and tracing with the use of the colored active Radio Frequency Identification (RFID) triage tag to make information of each vicim visual at the base of operations as soon as possible. Its main funtion mentioned in this paper is to traige the victims with the means of active colored tag. Meanwhile, the injuried information will be saved as data in PDA reader. In the process of the victim's arrival in the hospital emergency department and the treatment data sheet will be sent back by the hospital information system, so that this system will get the RFID triage tag ID. This system of tracing and tracking is called as a smart MCIs management system.*

Keywords: *mass-casualty incident; colored active RFID triage tag; tracking and tracing;*

1. Introduction

Normal patient care procedures for a single patient incident is relatively inefficient in terms of speed and resource confirmation. If these same procedures are used in a mass casualty event, it will take a long period of time to clear all patients from the scene. Therefore, a mass casualty incident requires the use of emergency procedures, such as START (Simple Triage and Rapid Treatment) triage, and also victims are grouped into four categories, depending on the urgency of their need for evacuation (Benson, M., et al., 1996). Any large number of casualties take place within a relatively short period of time, and they usually result from a such single incident as a military aircraft accident, hurricane, flood, earthquake, typhoon, or armed attack that exceeds local logistic support capabilities. To date, Mass-casualty incidents (MCIs) managemnet system has been viewed as an essentail issue; undoubtedly, its role is to save life sign of each injuried patient with four different colors (Black : Morgue, Red :Immediate, Yellow :Delayed, Green :Minor) by tradional paper triage tag whose ability of locating, identifying and triaging victims. Therefore, poor lighting affetced by numberous factors, such as different time of a daytime, variuos weathers, or power shortage, can lead to idtentify the locations of victims with difficulties (Gao, T. & White, D., 2006 ; Velasco, J. et al., 2006 ; Marti, R. et al., 2009). Hence, how to develop a smart MCI system applied on victims with a more sufficient way has indeed become a quite popualr issue to discuss.

2. Related work

2.1.RFID introduction

Radio Frequency Identification (RFID) technology was first introduced at World War II and used to distinguish where the enemy aircrafts are. Typically, RFID system has three basic components: tags, readers and the application system. In general, RFID tags are further defined into two categories: Passive model and Active model (Table 1). Passive RFID Tags do not contain a battery. Instead, they draw their power from the radio wave transmitted by the reader. The reader transmits a low power radio signal through its antenna to the tag, which in turn receives it through its own antenna to power the integrated circuit. The tag will briefly converse with the reader for verification and the exchange of data. As a result, passive tags can transmit information over shorter distances than active ones. They have a smaller memory capacity and are considerably lower in cost making them ideal for tracking lower cost items. Active RFID Tags are battery powered. They broadcast a signal to the reader and can transmit over the greatest distances. Typically they can cost $20 or more and are used to track high value goods or infectious patient in hospital in Taiwan, especially about student saftey management and elder man monitored are used (Holloway, S., 2006 ; Ching, H. & Wei, L., 2008)

2.2. Medical triage releated work

According to the previous researches, standards of initial triage with the category of victims are established based on the treatment urgency in the case of an explosive event or biological catastrophe (Benson, M. et al., 1996 ; Burkle, F., 2000 ; Romig, L., 2006). Due to an electronic tag used

rahter than a apper trige one, the electronic system is different from other three approaches. With the combination of the use of barcodes, tag readers, passive RFID tags, hand-held computers reallocation, and triage system , we are able to collect data in the mass casualty events (Bouman, J. et al., 2000 ; Chang, P. et al., 2004 ; Hamilton, J. 2003 ; Lauraent, C. & Beaucourt, L., 2005 ; Lenert, L. et al., 2005). There are many difficulties about the management of the injured soldier in the real pratice ; accordingly, ,many researches focus on electornic medical tag with a view to tracking the injured soldier with radio frequency identification. At the present time, Army had the pratice to manage injured solider by RFID electronic medical tag (Morris, T., 2006 ; Ping, L. et al., 2007, 2008, 2009 ; Qi, G. et al., 2007; Jian, H. et al., 2008 ; Chong W. et al., 2010). System of locations tracking has applied active RFID tags in hospitals ; however, it lacks of the embedded vital monitoring components (Dempsey, M., 2004). The use of the electronic triage system can provides simialr functions as other electronic triage tags (Lenert, L., et al., 2005 ; Morris, T., 2006 ; Velasco, J. et al., 2006 ; Vieira M. et al., 2006), but its function is more complete with its decentralization and characteistcs in Table 3.

2.3. Triage system

Simple triage is usually used in a scene of a mass-casualty incident (MCI), in order to classify patients into those who need critical attention and immediate transport to the hospital and those with less serious injuries. This step will start if the means of transportation is currently available. The categorization of patients based on the severity of their injuries can be aided with the use of paper triage tags or colored flagging (Table 2). Pre-hospital emergency triage generally consists of a immediate check for life-threatening concerns, usually lasting for no more than one minute on each patient. The START system (Simple Triage and Rapid Treatment) is considered as the most common and easiest one to use. In this system, three main things will be checked : breathe,

Active or passive	Other Classifications
Passive (no battery) Smaller, Lighter Shorter range (<3m) Smaller data storage Lower cost	Data storage (Programming) Read Only Write once Read/write
Active (with battery) Larger, Heavier Longer range (up to 100m) Larger data storage Higher cost	Frequencies Low –135 kHz VHF –13.5 MHz UHF –860MHz Microwave –2.4 GHz

Table 1. RFID Tags Types (Holloway, S., 2006)

circulation and consciousness. Depended on the medical responses of victims, the casualty will be classified to one of the four colored-triage levels and dispatch to hospital(Benson, M. et al., 1996 ; Burkle, F., 2000).

Color	Keyword	Description
RED	Immediate	patient requires immediate transport to a definitive care facility
YELLOW	Delayed	patient can wait unless their condition degrades to red tag level
GREEN	Minor	Little or no care needed, minor injuries can wait
BLACK	Morgue	patient is deceased or cannot be saved (death is imminent)

Table 2. Triage Tag Color Definition

Type / Characteristic	Traditional Paper Triage Tag	Passive Electronic RFID Triage Tag	Active Electronic RFID Triage Tag
Place Of Use	Hand or Leg	Hand	Hand or Leg
Unit Cost	NT$ 1~5	NT$ 15~30	NT 500~1000
Period of Use	Once	Once	Reuse
Identify Method	By Eye	By PDA	By Eye and PDA
Record Method	Write on Back Side	PDA keyin 3~5cm	PDA keyin 3~5m
Rainy Day	Bad	Good	Good
Night Day	Bad	Bad	Excellent(LED flashing)
Patient Count	Slow	Slow	Quick
Synchronize	Null	Null	Easy
Search to Identify	Null	Hard	Easy
Direct vision	Identify Color	Null	Identify Color
Digitalize Information	Read paper to keyin	PDA keyin and upload by PC	PAD keyin and upload by Wi-Fi/3G
Publish Information	Slow	Slow	Quick Upload by WEB
Change Triage Level	Only triage from light to heavy by hand	Only triage by PDA or PC	Triage by hand and change status anytime
Patient Track	No information after leaving	No information after leaving	Checking anytime
Dispatch Track	Talk by Radiophone or Cellphone	Talk by Radiophone or Cellphone	Track patient by GPS of Ambulance
Arrival Hospital Track	Passively waiting until arrival information notify	Passively waiting until arrival information notify	Actively Checking and confirming for arrival information

Table 3. Comparison of Traditional Paper Triage Tag and Electronic RFID Triage Tag

3. Smart MCI Tracking and Tracing System

Our paper aims to describe the solution to the unfitness of traditional paper triage tag by applying the smart MCI system., especially the happening of the MCI event under the uncontrolled circustmances such as the changeable weather and environemnts. With the use of this device, it is easy and aimmediate to assign hospital treatmenst within a shortest period of time. The goal of this research is to make each victim's inforamtion read by local managed officer in time and synchronize the information to the remote managed centers. Then each victim's infomation can be open to managers on web site and easily tracked and traced (Hamilton, J., 2003 ; Massey, T. et al., 2006).

3.1 Hardware componets
We set it up with the use of six devices to run the smart MCI system and collect the information of victims from disater sites to hospitals to confirm the function of track and trace. These devices are described as follows :

Device1: RFID Active Colored Triage TAG that has three colored LED lights, and each presents its triage tag status. We have to click the function button (+) twice to start the system. If EMTs want to alter the triage status, it works in the same procedure. In general, there are twenty triage tags in each emergency package. When the disaster evnet happens, EMTs will bring this package to disaster site for victim triage.

Device2: RFID PDA Reader receives every Active RFID Triage TAG ID and calculates the number of each color (Red, Yellow, Green, Black) when the software starts, if there are more than two PDA Readers, our system also synchronizes itself with both of them. It's not necessary for EMTs to worry about double strike. They will use the PDA to key in life sign of each victim at the same time.

Device3: Outdoor Wireless Bridge Stations connected with PDA by Wi-Fi are workable everywhere, and lets PDA synchronize itself data which are sent back to Back Edge Server database by cellphone 3G network.

Device4: Hospital Emergency Department (ED) Reader reads the Active RFID Triage TAG after the MCI event happens so that ED operator makes sure the victim's TAG ID with naked eyes and keyd in victim's personal ID into Hospital Information System

Device5: Front Edge Server acts as control center/station during the arrival of the EMTs and set the device workable to exchange information.

Device6: Back Edge Server acts as exchange center/station with the use of the internet anytime and anywhere. The disater manger can read the latest treatment information of victims on the web browser.
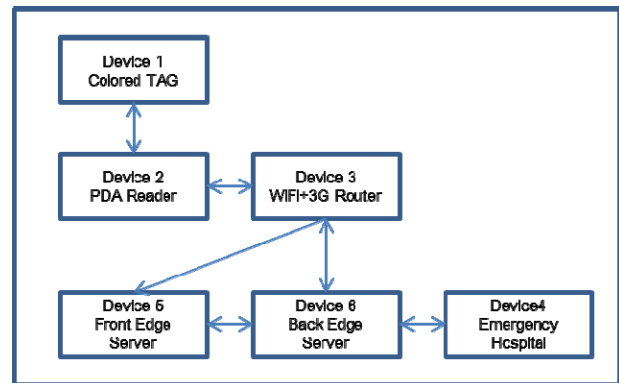

Fig. 1. Architecture of Smart MCI system

3.2 Software User Interfaces
We use Micorosoft VB and .NET programming tool to develop the fuctions of smart MCI system on PDA and at PC working space. Datatbase is a lso used by Microsoft SQL2008 to create and manage triage tag and information about victims. We develop the interfaces of five users with Smart MCI system, and the processes are described as follows :

UI_1 : RFID PDA Triage Tag Operation System. Receive each RFID triage TAG IDs and its color is saved. When emergency medical technicians (EMT) of local area arrive in the disaster site at the first time, the RFID colored triage tag must be operated to classify injuried status of victim. Then they use the PDA of smart MCI system, and count the number of triage and send the feedback to the manager of disaster event.

UI_2 : Local Data Synchronization Management System. Collect the RFID traige tag information to manage. This fuction of smart MCI system is to deliver the correct information just in time, and make it easy for the manager of disaster event to control and manage the situation.

UI_3 : Data Exchange System. Act as data center to exchange from disaster site to hospital. This fuction of smart MCI system is to collect complete information of victims in the disater event, so that Fire Bureau and Public Health Bureau are linked together to transfer victim's information within a short time.

UI_4 : Hospital Exchange Sytem. Receive the saved victims information from disaster site. This fuction of smart MCI system is to receive the disater event information when the dispatched victims arrive in the emergency department. And then the registrar keyins both the TAG ID and private personal ID into the hospital information system at the same time. Afterwards, our adopter program will automatically send the complete treatmnet information of victims back to the system.

UI_5 : WEB Publisher System. Show the correct disaster event informatiom. This fuction of smart MCI system is to show the correct information to the public rather than the delivery of false information.
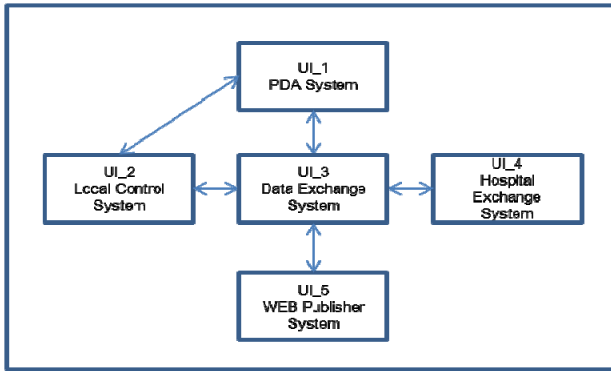
Fig. 2. Five Functions of Smart MCI system

4. System Implement

In the research period, we make 40 colored active RFID triage Tags (Fig. 3) to implement the MCI scenario which evaluate the tracking and tracing MCI information flow (Fig. 4) from disaster site to emergcy hospital. At the same time, we use WEB portal (Fig. 5) to show the final victims information. We also use three PDA Readers to triage these victims by RFID active colored triage Tag and its function shown by Fig. 6. Finally, we have three times in practical test of smart MCI system at Taipei, Taoyuan and Tainan of Taiwan to fix bugs and take the simulation process photos (Fig. 7) during 2008-2010..

4.1. Smart MCI system Operation Procedure
Our research of Smart MCI system is compatible with current existing MCI system because this system is designed to solve the past unsolved problem in the real practice. There are many outstanding charactertics about rainy day usage, searching victims at nights, counting traige number in real time, exchanging information from disaster site to hospital and publishing information on web site quickly. In general, standard operation process of smart MCI system is devided into four steps as follows :

A. TRIAGE : When 119 center receives the urgent call, EMTs will arrive in the disater site and take out the RFID active colored traige tag to setup its injuring color and put it on each victim. At the same time, front edge data server collects every colored TAG's information and counts the number of each color.

B. TREATMENT : EMTs use the PDA Reader to keyin each victims' life sign and save them into front edge server that synchronizes with each PDA Readers after the operation of every EMTs. Fig. 6 shows the interface of eight users with the use of PDA reader in smart MCI system that helps disater management with efficiency in the process.

C. TRANSPORTATION : Back edge server of Smart MCI system loads the number of local area hospital ED beds and dispatcahes the victims to different emergency hospitals by loading balanced principles. The assigned officer of EMTs keys in the assignment

of victims by PDA and synchronize the information with the use of front edge and back edge servers.

D. TRACK and TRACE : Emergency hospitals read the the signal of TAG ID about victims assigned from the diaster site and match the TAG ID with private personal ID into hospital registeration system and the installed adopter program of Smart MCI system transfers information to back edge server that starts web site to publish the victims' information on the openning public web address to track ervery victim's information flow from disaster site to the end in hospitals. It's easy to reivew how many victims in each hospital and where the RED traige tag of victims are with the use of smart MCI system.

4.2. Limitation of Smart MCI system
In this research, the application of the active RFID mode is installed and three different colors are used to present the four triage status. But there is no BLACK colored LED light, three colors are set to flicker at the same time, which presents as the BLACK triage status. There are four buttons of the colored tags and set its color by clicking (+) and colored buttons together, and then the flashing color works continously until pushing the RED button for five seconds to turn it off (Fig. 3). When a certain tag is turned off or switched to other colors, the smart MCI system reads the same TAG ID and saves different triage status in the database, which this situation will happen with high possibility in real practice. Another limitation of this research is about the acceptance of hospitals : why the regional responsibility of the hospital must install the RFID reader to read the RFID active colored triage tags? We share the benefits of using RFID triage tags with government managers and make them realize that hospitals just need to pay very low manpower to install our adaptor program of smart MCI system. In this situation, we have to show the automatic workflow of our smart MCI from data center to hospital information system, and tell the staff working in MIS of hospital how to install our adaptor program and how to modify two parts of hospital information system : (1) Registration system: when the colored triage tag arrives at at the emergency department (ED) of hospital, the registrar firstly operates the system to match TAG ID with personal ID into the registration system. (2) Feedback system: when the doctor of ED treats the patient of MCI completely and keys in the diagnosis into hospital information system, the feedback system will check the patient's personal ID to find out the treatment diagnosis from the smart MCI data server. However, difficulties of completing the treatment information of patients exist in this situation. Most emergency hospitals are glad to accept our suggestions and also make a plan to implement the use of the smart MCI system with policy promotion in the near future

5. Conclusion

So far, the application of electronic medical tag and electronic triage tag in various ways has been trendy, especially in the field of disater management and national army develpment. The purpose of this research is to find out the solution to the practical problems. Therefore, the RFID colored triage designed by active mode shows flashing light , and it also develops the smart MCI system for the staff in the Fire Bureau to implement. Meanwhile, its use has the same high satisfaction in digitalization of paper works and collects the correct information about disater management (Inoue S. et al., 2006 ; Marti, R. et al., 2009 ; Chong W. et al., 2010 ; Ching Hsiang, C., 2010). In a word, the use of the smart MCI system makes the information about victims more accessible for governmet managers with efficiency.

6. Acknowledgment
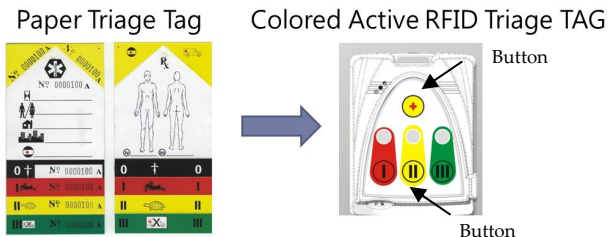
Fig. 3. Proof of Concept of Electronic Triage TAG
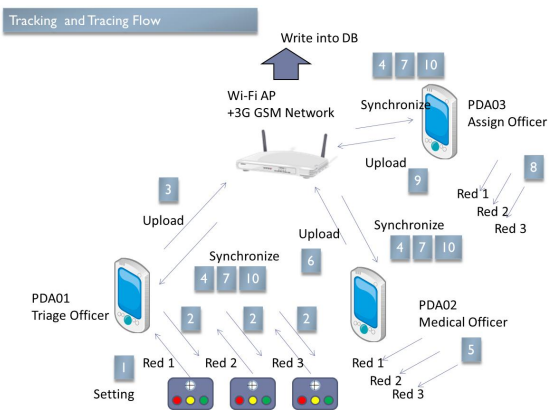
Fig. 4. Tracking and Tracing System Flow

Fig. 5. WEB Publisher System
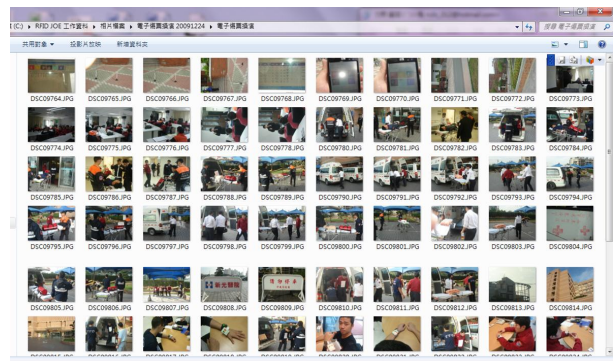

Fig. 6. PDA RFID Triage Tag Operation System

Fig. 7. Mass-casualty incidents Practice

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