The Concept of ICT to Support Ambulatory Application

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Abstract

Transmission of in-ambulance data without inconveniencing or undue effort on the part of the rescue crew—in other words, automation of in-ambulance activities (measurement/analysis, activity recording, message transmission)—is essential in implementing uniform medical control standards across the nation. One of key elements for this automation is information-communication technology (ICT). Its development is a must for emergency transportation for the near-future. High automation (automation of measurement, recording, analysis and transmission) of ambulance-borne devices is the goal of ICT. Emergency transportation for the near future is expected to enable data transmission from ambulances automatically, without inconvenience to rescue crews, resulting in high-quality services available uniformly across the nation.

Keywords: telemedicine, medical control, EMT

1. Objectives

Transmission of in-ambulance data without inconveniencing or undue effort on the part of the rescue crew—in other words, automation of in-ambulance activities (measurement/analysis, activity recording, message transmission)—is essential in implementing uniform medical control standards across the nation. One of key elements for this automation is information-communication technology (ICT). Its development is a must for emergency transportation for the near-future. Currently, no country has succeeded in supporting patients through ICT on board ambulances. As an ER doctor, I strongly believe the need to do so will grow in the near future. This paper describes various aspects I believe are crucial in these efforts.

2. Background

2.1 What is ICT?

The purpose of in-ambulance ICT is to improve emergency rescue quality by transmitting patient data and ambulance GPS data to the triage center automatically, with no inconvenience to or undue effort on the part of the crew. Ideally, ICT would connect the patient monitor online with TCP/IP and record crew activities automatically and electronically. In reality, time standards for the ambulance clock, cardiograph, and communication devices are not synchronized in Japan, and rescue crews must match these manually every morning. Synchronizing these devices would be a simple matter if the devices were linked via TCP/IP connections.

2.2 The third Generation (3G)-Mobile phone

Some believe communications with moving ambulances should be based on the 3G mobile phone network. Is this correct? Is the 3G mobile phone network good enough to ensure multi-path high-speed transmission from fast-moving ambulances? The answer is no, even in Japan, where a 3G network is established nationwide.

Multi-path communication:

This technology is not yet established. If the base station antenna is located very close to the mobile terminal and communication occurs in line-of-sight mode (Nakagami-Rice fading), communications will be reliable and stable and throughput close to nominal values. But in non-line-of-sight mode (Rayleigh fading), communication is not reliable under multi-path conditions, resulting in inadequate throughput. Maintaining a 384kbps connection rate (the FOMA uplink standard) during transmission from a moving car is quite difficult. None of the various studies involving transmissions from ambulances using the 3G network have led to introduction of a practical system.

Service area problems:

The number of base stations for the NTT DoCoMo 3G FOMA Service is now at around 3,200 in the Kanto-Koshinetsu area and 10,700 across the nation, with service areas expanding. The population coverage is about 98% nationwide as of the end of December 2007. This coverage, however, counts all city/village citizens when their local administration office exists in a service area. Undoubtedly, this approach counts mountainous areas and remote islands that are actually located outside service areas. Since mobile phone carriers follow profit-oriented market dynamics with the cream-skimming policy (shedding unprofitable areas), they will not invest money to construct base stations in these areas. Even with the advent of the 4G network, they will likely focus on urban areas while shortchanging rural populations.

2.3 Public wireless LANs

Are public wireless LANs useful? Wireless LANs are already in service at railway stations, airports, and main streets. If this system is deployed everywhere, broadband communications will be possible for public rescue vehicles such as patrol cars and ambulances. In an experiment, a Gifu (Japan) national road was equipped with a wireless LAN (Route-make terminals) by the Takayama National Road Office of the Land and Transportation Ministry. Since this assumes line-of-sight communications, transponders connected to NTT networks must be placed at every 0.5 to 1.0 km. Adopting this system for roads across the nation would involve exorbitant cost and infrastructure demands.

2.4 Geostationary satellites

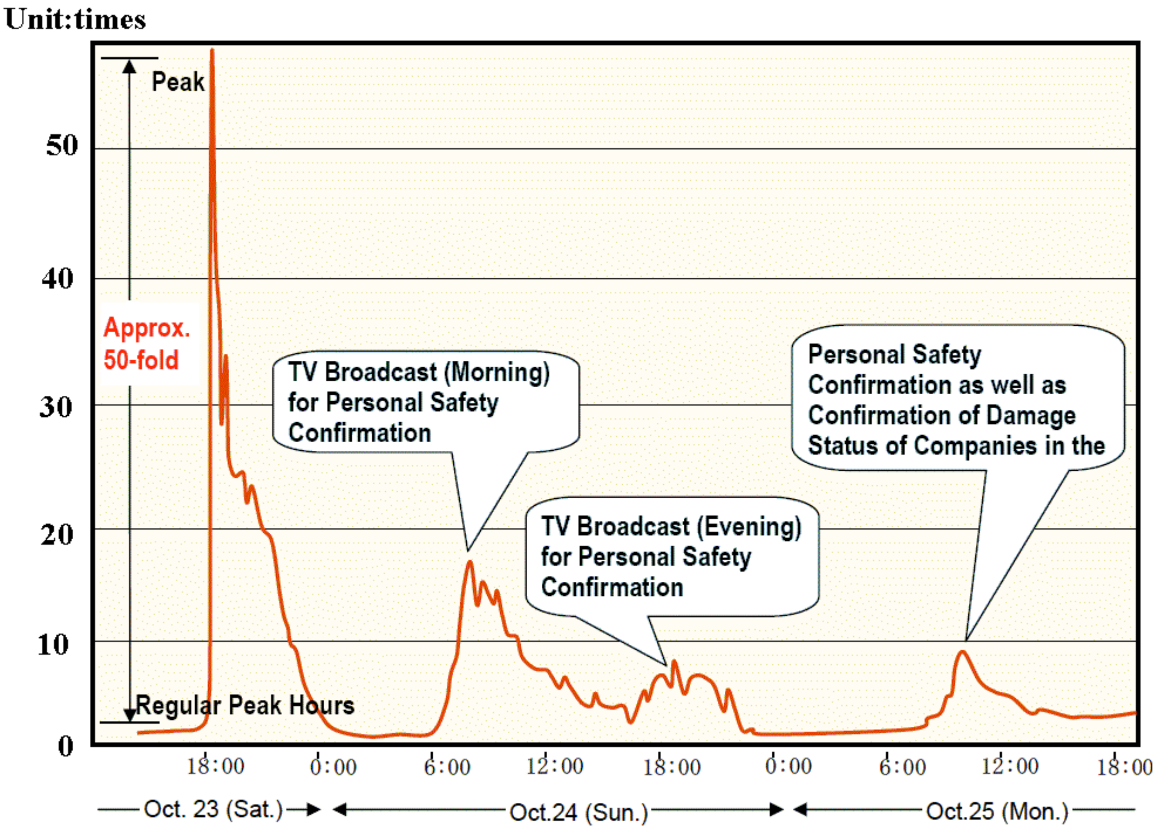
"Geostationary satellite" is the term for a communication/broadcasting satellite that remains at a certain orbital altitude above a specific point on the Earth at all times. They orbit in synchronization with the surface of the Earth at approximately 36,000 km above the equator. They are called geostationary because they appear fixed in the sky when viewed from the ground. One geostationary satellite can cover the whole nation. However, there are two technological issues posed by the limited transmission power of the ambulance and antenna gain when sending data at a high speed from a moving mobile terminal.

1) Blocking by buildings (communication interruptions)
2) Gain-to-noise temperature ratio (G/T) of the satellite receiver antenna

Problem 1 occurs because Japan is located at mid-latitude, not at the equator. G/T in 2) expresses sensitivity on the satellite side – a ratio of front gain G to overall noise temperature T on the receiver side. A common way to increase gain is to use higher frequencies and expandable antennas with fine mirrored surfaces.

2.5 Quasi-zenith satellite(HEOs)

As required by Kepler's second law, sweeps across equal areas of an ellipse take the same amount of time. If there are three satellites and each of them appears over Japan at zenith every 8 hours, this is the same as one satellite being present 24 hours. Such systems have already entered practical use in Russia and the USA. These satellites can avoid building-caused blocking and can be used efficiently when combined with a geostationary satellite that provides another sight angle. The successful development of a large expandable antenna also makes this system more feasible. This system is now expected to be used for disaster prevention and emergency rescue. Japan will launch GP-use quasi-zenith satellites incorporating KU-band transponders in 2012.



reported by NTT East Co.
http://www.aptsec.org/meetings/2005/apg07-2/APT_ITU_DIS2005/(10)NTTE-1.pdf

Figure 1 Calls to Niigata over the public phone network during the Niigata Earthquake from nationwide. October 2004, over 50 times higher than normal

2.6 Current status of the public phone network (immediately after a disaster)
Immediately after a disaster, the number of calls placed over the public phone network increases sharply. The resulting congestion can make connections highly unreliable. For example, immediately after the Niigata earthquake, as shown in the figure, the number of calls increased by a factor of 50. The Erlang-base call loss ratio (connection failure probability) rises to 0.99 or above. This means that even 100 calls will fail to ensure a single successful connection. In short, public networks are of limited use during times of disaster. A disaster/emergency rescue-dedicated network is needed, independent of the public network and capable of nationwide coverage.

2.7 Universal Service Fund
Carriers competing in the free market are free to shed services for emergency rescue, for the disadvantaged, and for people living in remote areas. A universal service fund which is possible in stable economies, aids in such situations. The International Telecommunication Union (ITU) recommends the deployment of this system in many countries, based on a WSIS (World Summit on the Information Society) action plan for resolving digital-divide issues.
In Japan, an extra charge of 7.35 yen/month has been imposed on each call across the board since March 2007. This fee is used to support services in high-cost remote areas in Japan; in other developed countries, a similar fee is used to fund communication applications related to medical care and education. In the United States, $50 million was paid out in 2007 for medical services for remote medicine to help those living in remote areas.
A 100% cash back or tax relief measure should be considered as part of a universal service policy to support wireless and satellite networks for emergency rescue-dedicated purposes.

3. Specific technologies
3.1 Emergency rescue activity record
Electronization is the key for quickly creating accurate activity records. Providing accurate information to the destination hospital is crucial, as is transmitting data back to a PC at the station automatically to minimize inconvenience. For this purpose, a system of handy PDA-like terminals must be provided to rescue crews, and a gateway system deployed to send PDA data to the network from the ambulance.
Voice recognition (particularly dispersion-type voice recognition) to eliminate the inconvenience of character input for busy rescue crews represents a challenge in innovation that Japan, as a leader in the development and international standardization, should be fully equal to. Other electronic tools will be needed to assist rescue crews improve their skills in providing medical treatment in an ambulance, as well in searching for hospitals. Additionally, electronic support is an essential element of a safe first-aid system capable of reliably identifying serious hidden symptoms.

3.2 Medical control
In Japan, the medical treatment of patients in the ambulance poses difficult issues because it falls under the purview of two different ministries – the Ministry of Public Management, Home Affairs, Posts and Telecommunications and the Ministry of Health, Labor and Welfare. Medical control based on a Notification by the Fire-Defense Agency Emergency Rescue Manager involves 1) early instructions to the rescue crew; 2) doctor's post-verification of the treatment provided; and 3) continuing education and training of rescue crew.

The restrictions imposed by Article 20 (which requires a face-to-face diagnosis) under Medical Law can be lifted when a reliable communication network is used, according to Notification No.1075 of the Health Policy Bureau, Ministry of Health, Labour and Welfare, issued December 24, 1997. A revised Notification further permits so-called remote medicine via networks for patients in ambulances.
In short, Japanese law permits medical control of rescue crews (for basic treatment and care) and higher-level treatment by the triage doctor located at the triage center. However, a high-quality communication path is the minimal condition necessary.

3.3 Specific diseases

Successful treatment of coronary clogging is known be highly likely if an acute heart attack patient receives medical treatment in the ambulance and a thrombolytic agent is administered within 60 minutes of identification of a vein route by the rescue crew. This treatment, however, may cause bleeding in the skull, making it necessary to monitor blood pressure constantly. An echocardiogram and a 12-lead electrocardiogram are essential for correct diagnosis of a heart attack, whereas the position of certain clots is easily detected by heart auscultation based on independent element analysis. This technology has been considered in certain countries where the patient must remain for relatively long periods in an ambulance, and related papers have been published by IEEE and APT.

If this technology is useful in 50% of acute heart attack cases, reducing hospital stays by one week per patient, hospital costs will be reduced by as much as 20 billion yen per year. The ICT-based medical control will be effective with various patients suffering from cardiac or respiratory arrest and external injuries, as well as acute heart attacks. While not a magic bullet, this technology will enter actual use in the near future. ICT offers high potential for improving prognoses and eventually reducing medical costs.

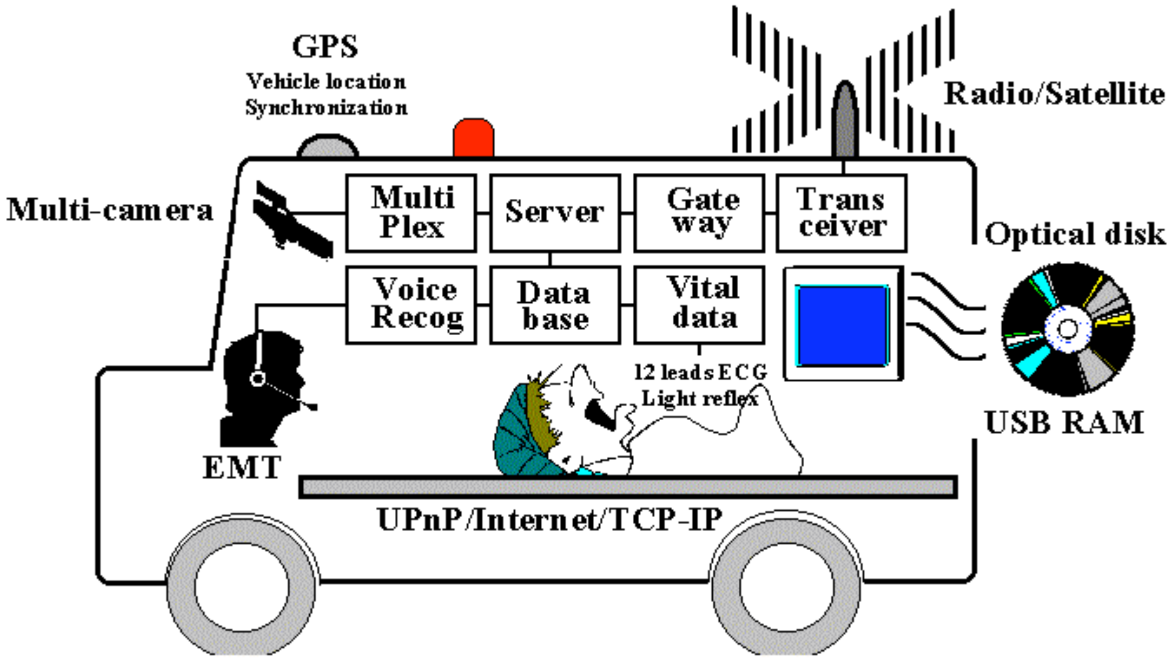


Figure 2 Telemedicine supported system

Real time clock on each device to synchronize the computer time setting with Universal Plug and Play

3.4 Networking in-ambulance devices

- Physiological measurements

At present, the measurement devices in ambulances are not connected to any networks. They are not even synchronized automatically. At present, the best solution appears to be to network them and to transmit data via a TCP/IP intranet on board the ambulance. Listed below are the parameters that must be identified.

A: Pharyngoscope

Monitors tubing via a CCD camera, records the process electronically, and transmits data; likely to enter wide use.

B: Light reflex image

Using a CCD camera, this measures size and contraction speed and records data electronically.

Based on this image, it should be possible to diagnose not just brainstem problems, but dementia and peripheral nerve disorders.

C: 12-lead electrocardiogram

Europe is the leader in this field, while in Japan Yokohama City has just introduced the technology. It provides information on ischemic heart disease during transportation and enables early aid for improved prognosis and reduced medical cost. This should prove useful if it can be automated and network connections made easier.

D: Automated ultrasonic measurements

The US military continues to issue academic reports on automated measurement of heart wall movements for acute heart attack patients and the absence/presence of chest/internal abdominal bleeding.

4. Discussion

4.1 Vision of medical controls for the near future

Emergency transport and medical care are intertwined. The extension of medical control is based on remote medicine and care by triage doctors located at medical control or triage centers. The ultimate goal is to improve prognoses and extend patient life expectancy. While ambulances are operated by the Fire Defense Agency, patients require prompt medical care. There is no question concerning the importance of pre-hospital care in reducing medical costs, which amount to 30 trillion yen annually in Japan.

Each prefecture currently operates a medical control center. However, assuming that the medical control center is only necessary for patients in serious condition (approximately 10%), one center should suffice for each Dou or Shu (state: 6–10 in total). Another important goal is nationwide equality in such services. The former, or prefectural-based medical control center service aims to provide a service based on local conditions, while the latter, or Dou/Shu-based medical center service, places the priority on economy and equality. In either case, there will be no progress in medical control without the development of ICT that can be effectively used in emergency transport.

4.2 Momentum for international standardization

ITU-T SG16 Q28 is currently boosting the standardization of remote medicine technologies. Tasks related to this standardization effort are currently underway in each member nation. Now is the time for member nations to propose PDA specifications for use by rescue crews and procedures for emergency rescue wireless communications.

5. Conclusions

High automation (automation of measurement, recording, analysis and transmission) of ambulance-borne devices is the goal of ICT. Emergency transportation for the near future is expected to enable data transmission from ambulances automatically, without inconvenience to rescue crews, resulting in high-quality services available uniformly across the nation.

As of December 2008, no country had succeeded in deploying a high quality communication path for mobile terminals, although this remains essential for the smooth implementation of medical controls. We are certain medical controls will be much improved in the near future both in quality and content as ICT integration proceeds, and that such ICT will significantly improve patient prognoses.

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