Proposal №: 00236

ACTS

March 1995

MOTEMES

Mobile Telecommunication for Medical Emergency Services

Prepared by the MOTEMES Consortium

Brief Technical Summary

Project Title:

MOTEMES - Mobile Telecommunication for Medical Emergency Services

Work Plan Area : Mobility and Personal Communication Networks

Work Plan Subarea : Mobile Services

Work Plan Task : Mobile Communication for Emergency Services and Temporary Applications

The background to the goals of the proposed project is that mobile radio technology provides various means to deploy communications networks which have many social uses such as emergency services at the scenes of an accident, fire, etc., or for other purposes such as multi-way/multi-feed real-time broadcast from events such as sports, political rallies, etc. The key feature of these type of mobile systems is to save lives, time and money, and report events as they happen. In addition, such systems must allow for temporary mobile services to be interconnected/integrated with other permanent networks or services at the technical and engineering levels to benefit from the full realisation of such application services. These types of systems must be able to provide multimedia services with appropriate performance, quality, safety and reliability as required by the application in question. The experimental use of mobile technology in various application areas is rapidly showing the potential and socio-economic benefits that can accrue from the use of this technology. The proposed project builds on this background to undertake advanced research as stated below.

The project will develop, build and demonstrate a mobile emergency information system from a set of the basic service components for the following situations:

- hospital base stations
- ambulance vehicles

The system can be taken to the accident location and be made operable immediately without the need of dedicated operating staff while suiting the specific situation and users.

The partners of the project will jointly develop a common system, which will be tested with minimal changes in four countries under real life conditions. All experiences will be integrated together in the design of efficient and practical emergency services.
Starting with GSM and then UMTS, at datarates up to 2 Mbit/s, will be used to achieve the following objectives:

- Definition of a generic set of telecommunication information services for use in the health care sector (e.g. ECG diagrams, data files, high quality voice, still image, real-time-video, etc.) built from reusable service components based on a Mobile OSA;
- Definition of a versatile, flexible and user-friendly data-base architecture for distributed multimedia (medical) information and ensuring that privacy and security aspects are catered for within this architecture;
- Specification, design (or adaptation) and implementation of the above GSM/DECT/UMTS (multimedia-) services including the need for management of these services and in particular their QoS, in a potentially hazardous and difficult environment;
- Integration of the data-base for distributed multimedia (medical) information into the mobile services architecture and ensuring that the whole system is sufficiently flexible to allow the upgrade and evolution of both the network infrastructure itself as well as any of the individual components;
- Testing of the system in an experimental environment and subsequent use and evaluation of the information system in a real environment with real users;

2. Project Plan

2.1. Technical Approach

2.1.1. Environment, Task and requirements

Emergency services rescue people in difficult physical situations. On the medical side a lot of techniques support the physician with his/her specialist knowledge such as instruments e.g. ECG-device etc. Hence, emergency services which are mobile, have to be fast and flexible and be usable in any physical location. There is an enormous potential for supporting emergency services by mobile communication media. Developments in cellular network infrastructures give the possibility of mobile communication services. On this basis the project is built with the goal of supporting the rescue of people.

The emergency service in towns differs completely from the rescue service on highways or outside the urban area. The following types of emergency cases have to be delt with:

20 % emergency cases requiring a surgeon and
80 % internal/neurological cases.

Emergency Cases

- bad injury
- shock
- hemorrhage
- sudden unconsciousness
- acute breast pain
- difficulty in breathing

EC Classification

— cardiological emergency
  - angina pectoris
  - myocardial infraction
  - heart insufficiency
  - heart rhythm disturbance

— neurological emergency
  - epilepsy
  - coma / intoxication (drugs)
  - paralytic strokes / cerebral hemorrhage
  - brain tumour

— pulmonary emergency
  - asthma
  - lung edema
  - aspiration,
  - foreign body in the respiratory tract

— other internal emergency
  - gastrointestinal hemorrhage

— surgical emergency
  - polytrauma, multiple injury

— obstetrics emergency

The main illnesses diagnosed are usually chronic diseases, mostly requiring treatment on-the-spot, using ECGs etc.. ECGs are therefore a good candidate for use in a demonstration.

The ambulance station is situated in towns, very often 15-25 km away from the city and the base hospital, where the patients can be properly treated. That means, before and during the ride, in the emergency car, the physician has to diagnose and to start the treatment. Communication media needs to support the physician during this diagnosis.

From this scenario very particular requirements are planced on the base in the hospital and on the equipment in the emergency car. These requirements are:

Base: Emergency Service Centre
- high quality picture and phone
- scanning of script data (handwritten notes)
- reproduction of image/voice information (VCR)
- networking facility with an ITS
- exclusion of negative interference effects (EMC) on the stationary telephone/pager systems of the hospital (cellular phones usually disturb the normal level of communication)
- simple technical care by non-technicians

Mobile Part: Ambulance Unit
- minimum size in the ambulance vehicle of equipment
- usage of available room/equipment in the ambulance without technical changes in the vehicle
- outdoor usage (outside the ambulance, low weight)
- high quality picture and phone
- scanning of script data (notes)
- usage during travel
- simple technical care by non-technicians

In the emergency car there are four highly skilled professionals: an emergency physician (anaesthetist), an internal organ specialist who is always available, as well as a skilled and highly qualified nurse team. All consultation personnel need short access times to information in order to make quick diagnosis. The emergency crew has a direct communication link with all operating theatres and intensive care utilities. All emergency physicians know about hospital logistics.

What can be achieved with the new communication media? Via an efficient communication system with a user interface, which is a simple to operate, the system can give practical assistance to the ambulance vehicle from the hospital; via fast access to hospital data base and to experts, utilising audio, video and data. It can help the pre-hospital care of the patient(s) by increasing the accuracy and speed of the diagnosis.

2.1.2. System Components and Structure

To fulfil the requirements above, a system is defined consisting of two main components: the base station in the hospital (MES) and the station in the emergency car or ambulance (MEIS).

The generic MES will contain the following service components:
- voice telephony,
- "short message" (duplex) along a separate device/connection,
- ECG -Data transmission,

- still/scanned image transfer;
- ECG/SmartCard data;
- video-telephony - optional.

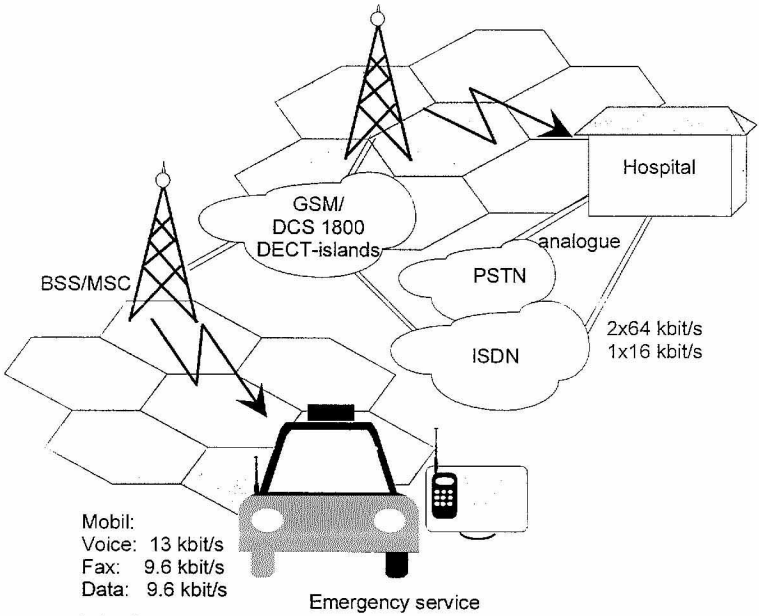

Figure 2.1: Configuration

The system shall be included in and co-ordinated with the existing hospital data processing systems.The hospital station shall have access to mobile **and** fixed network infrastructures. The mobile access allows a inexpensive connection with the emergency car during the trial and in the regular operation after the project. Hence, if there are capacity shortages in the mobile infrastructure of the hospital area, the connection can be built via the fixed network (see figure 2.1). Usually the access to the fixed network is available in hospitals.

The ambulance unit will have a doubled MEIS/MES equipment placed in standard aluminium emergency container boxes of the size (approx. 60 X 40 X 20) - see figure 2.2. Each box will contain a number of elements attached to a laptop PC as MES station appropriately configured for mobile telecommunication. The MES station will include SW/HW - I/O device interfaces and drivers, radio and telephone modems - PCMCIA cards - at least two slots (up to six) , codecs, protocols, etc. i.e.

- 2 cellular telephone units;

- power supply set (optional);
- SW/device for still image compression/decompression;
- SW/device for motion video compression/decompression (optional);
- video camera;
- scanner/printer device;
- ECG device;
- reader device for patient data chip SmartCard
- loudspeaker and microphone for free speaking.

The main components can be removed from the box.

With the box, the emergency crew can use a headset consisting of ear loudspeakers and a small microphone, connected to the box via an infrared link. This device allows the user free hands and easy operation even in a noisy environment.

The two transmission parts (cellular telephones) should enable the simultaneous use of two different services: e.g. voice and fax/message, or voice and video. The transmission of "short messages" is also possible within existing connections for GSM900/DCS1800; this can be used for the connectionless transfer of 160 ASCII characters of patient data (attention: security overhead!).

The initial experiment will configure a MES and improve it with the available transfer rates:

- voice: 13 kbps
- fax: 9.6 kbps
- data/video: 9.6 kbps

An additional study will investigate the performance improvement with respect to additional links and transfer rates.

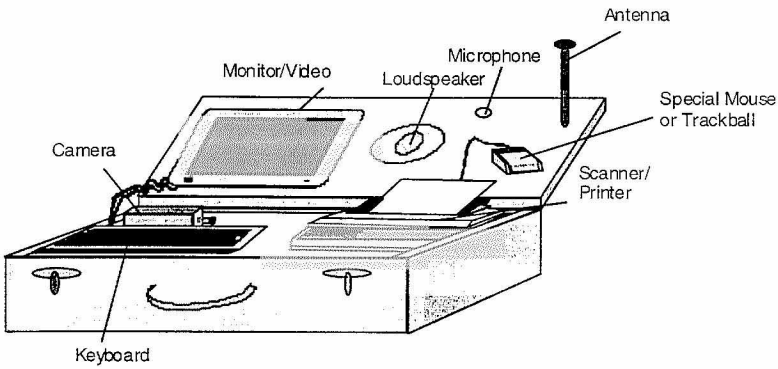

Figure 2.2: Components

In both systems the user will interact via a simple and transparent graphical user interface with touch screen / mouse / keyboard triggered routines and/or voice I/O routines. The systems will remain open and accessable for later extensions as technology advances. The MMI and device integration into a MES will be performed in successive steps to avoid gaps in technology and user ability to learn and adapt to the system.

The following usage scenarios can be shown.

MEIS/MES Usage in the car:

The MES container is connected via a multiple pin strip on the back side of the box with the car's power supply (220 V). The system contains high quality loudspeakers as well as an external microphone in the immediate working area of the ambulance crew. It is equipped with an external antenna, to avoid the electromagnetic screening effect of being inside the vehicle (figure 2.3). In the fixed system a power charge device for the box battery is included. For the pinstripe there are high mechanical requirements, due to the fact that the crew can not adjust the box. The mobile transmission part will manage the access to the available cellular network (GSM900/DCS1800 - double access!).

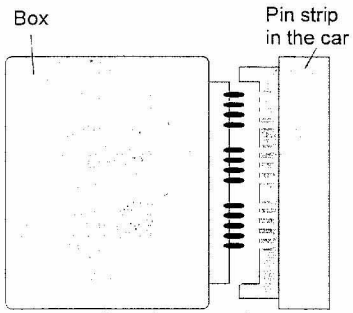

Figure 2.3: Fastening system in the car

MEIS/MES Usage outside of the car:
The box and its device works outside of the car with its own battery and antenna. For free speaking the crew uses the headset or a separate pair of loudspeaker and microphone in the box. The mobile transmission part manages the access to cellular and other mobile networks (GSM, DCS 1800, DECT, UMTS).

2.1.3. System concept

In a first step basis services shall be implemented using of existing technologies. Hence, the architecture of system and services shall allow an extension on further services and the transformation of future infrastructures (GSM -> DCS 1800 -> DECT -> UMTS). This requirement will be met, with the development of an approach to design and evaluation of a GSM/DECT/UMTS communications environment involving usage of formal methods for specification, verification and management. Following sub tasks are identified:

- Definition and design of specific application scenarios for emergency data transfer in a mobile environment;
- Definition and analysis of the communication requirements for specific mobile personal communication terminals (bit rates and traffic profiles, performance measures, services, etc.);
- Definition and analysis of possible configurations for the mobile emergency equipment, requirements on CPU performance, software, weight, memory and antenna;
- Definition and design of a reference model for the Mobile Open Service Architecture (MOSA) applied to the prototype service for medical application;
- Specification, design/configuration, implementation and evaluation of a prototype multimedia communication emergency service required for medical application in a mobile ambulance environment including aspects of QoS handling for audio/video communication;
- Application of a formal specification technique to generalise existing data stream languages capable of including compression algorithms (JPEG, MPEG, H.261) to include timing and synchronised data streams, to incorporate a sufficient degree of scalability (compare outline fonts to bitmap fonts) and to maximise the functional correctness of the service components and the GSM/DECT/UMTS service as a whole with respect to safety and life;
- Customisation of available and under development service components according to the user and API requirements including the specific QoS operation techniques;

- Definition and design/adaptation of terminal-to-user interconnection mechanisms, means and devices appropriate for performing the communication;
- Performance modelling and evaluation of prototype service components and other development and implementation of a specific technique to evaluate bandwidth requirements for telepointing, image and audio transfer to meet GSM/DECT/UMTS QoS requirements and establish the trade-offs between quality, compression and bandwidth in the design of teleservice components;
- Development/adaptation of data compression protocols and coding algorithms for audio/video transmission in the specialised GSM/DECT/UMTS application;
- Application of adequate measurement and monitoring techniques for result evaluation and verification against GSM/DECT/UMTS quality criteria regarding
  - traffic performance and control,
  - data access and availability;
- Experimentation with and result evaluation of the GSM/DECT/UMTS application in a real environment involving contributions to appropriate standardisation bodies.

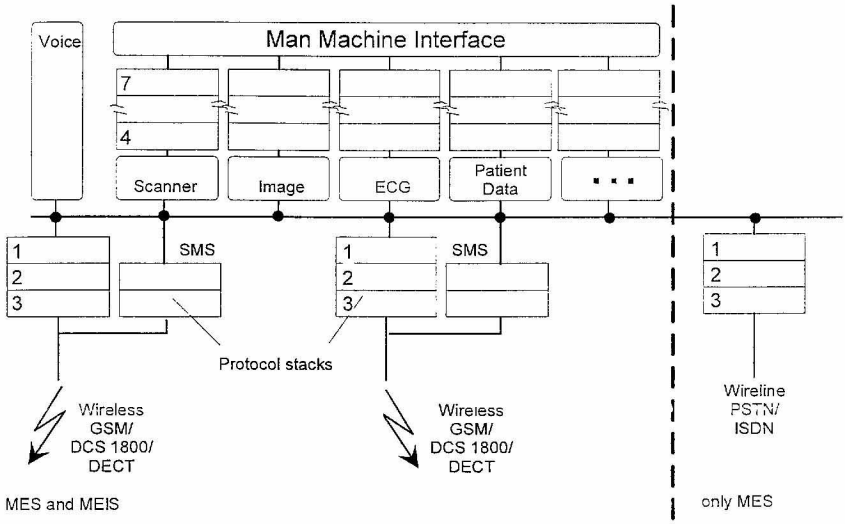

Figure 2.4: Logical structure

The system will include all components and integrate them into one unit. It provides a homogenous protocol structure and defined interfaces for extensions. The system and its access to the infrastructure has a modular design. That gives the possibility to port the system to other infrastructures and allows experimentation with the system in different countries with different infrastructures. The mobile station includes the access to mobile infrastructures only. The base station in the hospital has to allow the access to both, mobile and fixed infrastructures. Therefore the protocol structures include both.

2.1.4. Video components

The video part of the system to be developed will initially be based on H.261 coding. By setting the parameters for coding the video quality will be sufficient for the planned kind of use within the medical field. The video quality will be 0.5 ... 2 fps with 352 x 288 pixels CIF quality. The source video is coded in YUV - format, with 8 levels for each. In a later implementation within the time-frame of the project there might already be a possibility to use H.26P (H.268) or MPEG-4 video. Before that there will also be a possibility to use a pre-standard proprietary video coding implementation to be submitted to the standardisation body (-ies). That implementation might very likely be fully software based, also for the encoding part. The goal is then to achieve 5 ... 8 fps at 176 x 144 pixels QCIF quality. Using a CIF quality option will also be investigated.

The system will be able to exploit the available transport channels of various bandwidths to be used during the different project phases. Initially and for the field trial use, the focus will be for communication over the very narrow GSM data channels of 9.6 kbps. This will require a

separate GSM or other channel for audio communication. Audio remains the single most important media for communication also in this application field. Later the services of the Mobile National Host will be used to test and demonstrate the system in a DECT cordless communication environment. This will enable using a total channel of 64 kbps for video and audio over data, with a future possibility of even 128 kbps. This again will enable using G.728 (16 kbps, 3.1 kHz) standard audio and reasonable quality H.261 coded video.

The field trial experiment will be implemented using a step-wise approach, still enforcing rather high demands for the initial system. This is due to the danger of rejection if a prototype with insufficient service level is offered to soon.

The video coding and displaying hardware will require 2-4 slots in the field and base station's workstations. The field system hardware must be rather rugged. Special care for cooling and other practical issues will be necessary.

For the medical application field, the importance of sufficient resolution is greater than the requirements for response to movement of the target. So called talking-head video quality would immediately be rejected by the users doing remote assessment and remote decision support within the medical emergency field. The cost savings to be gained through the system, stem from being able to make the right decisions, based on sufficient information received about the case at hand from various information sources and tools. Video is one of the new information sources offered by the system, along with the other data oriented ones. The targeted cases are not those which require the highest level of emergency response. Of more interest are rather those which are urgent, but still enable receiving remote support from the medical officer at the base station, without disrupting the field personnel too much in their hectic work. The cost of reallocation or other correcive logistic measures due to mistakes in the hasty situations, is substantial. Hence, with remote support the right decision will be made and eliminate reallocations of patients, instead supporting "first-time-right" operations. Due to the importance of the logistics, also interconnection to the emergency station's logistic system will be investigated and taken into account in the design of the system.

2.1.5. Man machine interface and service integration

The human-machine interface is of key importance for interaction especially in adverse conditions like emergency cases. Ease of use is a major consideration. Touch-screen, mouse, keypad and voice output/input have to be evaluated for the special purposes necessary in this project. User scenarios have to be analysed carefully to find out the best combination of input/output devices in this special environment. Touch-screen technology for example allows direct access by the user to functions, offered by a self-explanatory presentation on the display. However, if there is some important information for a user who cannot look on the screen all the time, voice output is a very good media to provide the information immediately. To guaranty performance, the technologies to be used have to be evaluated carefully. New technologies might be introduced in a second step (e.g. voice recognition). This has to be considered in the definition phase to guarantee the seamless integration of this technology in a later step. The human machine interface to be defined has to be as similar as possible for the Ambulance units and the Emergency service Centre.

Finally there will be defined a multimodal, intuitive interface, offering simplicity in operation to the user, who is handling the multimedia terminal.