Collaborative R&D program:

Real time services for emergency medical monitoring and assistance in ambulance EMMAAS

1. Project Title:

Real time services for emergency medical monitoring and assistance in ambulance EMMAAS

2. Project summary:

The project aims to elaborate a system that improves the emergency medical services, through the development and implementation of a mobile acquiring, transmission and processing platform for video/audio/position and medical instrumentation data from the ambulance. The high quality of the video stream transmitted in real time to a central system with high processing power and data storage, the possibility of ambulance cameras remote control, and the possibility of video/audio data synchronization with the medical data, allow the making of medical assistance decisions during patient transport and the beforehand preparation of reception and treatment procedures in an emergency manner.

The main target of the project is to create a decentralized architecture to acquire, transfer and process in real time the information (video, audio, medical data) vital for the patients transported in the ambulance, by utilizing the most advanced technologies for wireless communication (4G HSUPA) and data processing (CELL) in order to provide specialized assistance to the ambulance personnel and to prepare in advance the emergency station in the hospital; so, mainly, the project aims to improve the Romanian emergency medical services.

The system is made up of three functional-constructive zones, the first and the last being decentralized:

I. **The mobile platform assembly**, each of them situated in a rescue vehicle.
II. **The central platform** (central system) for recording, processing and data storage supplied by the mobile platform (video, audio, position, medical data), command transfer to the mobile platforms (audio, remote control) and of decisions to the reception / operating emergency hospital stations.
III. **The user interface platform** assembly - medical frame (check points) in order to interpret the mobile platform information, associate it with external data

bases and taking decisions / providing assistance to the mobile platforms crew.

The fundamental and applicative research will allow the manufacturing and testing of the 3 platforms through:

1. The developing of the mobile platform through the developing and implementing the following modules: video acquisition, audio acquisition, medical data from the medical instruments acquisition, local storage, local processing and decision, GPS, power supply, as also through the development of procedures, algorithms and programs that allow data acquisition, platform auto ruling and managing of all ambulance equipment.
2. The configuring of the communication system based on 3G High Speed Upload Packet Access (HSUPA) technology and the developing of methods and algorithms for reducing the latency, improving the transfer rate and uniform the transmission, so that the medical, audio and video information to reach the hospital work points as clear and as uninterrupted as possible.
3. The development of the hardware architecture and central system program system to allow information receiving, processing and sending it to the check points in real time, as well as their adding into archive.
4. The integration of the special CELL processor in the central medical, audio and video information processing, analysis and interpretation system through the development of algorithms based on: (i) feature extraction; (ii) advanced search and association in data bases techniques; (iii) the exploitation of representation models for image texture and audio recordings, as well as signature analysis on signals from the medical equipment; (iv) the managing of recordings in time in conformity with the decisions from authorized medical staff and protocols specific to the medical emergency procedures.
5. The developing of the WEB system displaying application, allowing the configuration of the check points for selecting and information playback, cameras remote control and communication with the ambulance.
6. The development of the administration, security and monitoring system.

3. Relevance of the project

- **Project inclusion in program's 4 objectives and in research domains specific objectives**

The project is in the framework of the general objectives of the Fourth Program: “Growing the efficiency of the public health system”, aiming the following objectives specific to the research thematic (1) “Developing informatics systems for healthcare” (Research area 1.2 – Advanced informatics systems for e-services); (2) “Algorithms, methods/technologies and processing systems in the signals and information transmission systems (voice, audio, video/images, data, multimedia) for producing, processing, remote transport and delivery of informational content” (Research area 1.3 – Communication technologies, infrastructures and systems); (3) Real-time embedded systems (for automobiles, medical equipment, communications)” (Research area 1.6 – Technologies for distributed and embedded systems).

- **Intended target**

The project aims to develop a system for improving the emergency medical assistance, by designing and implementing of a mobile platform for collecting , transmitting and processing medical data and video/audio/location information from ambulances. The high quality video signal transmitted in real time to the central high computational power and data storage system placed in the emergency hospital dispatch, the possibility of remote controlling the video cameras in the ambulances and also the synchronization of the medical data with the video/audio data, confers the possibility of taking medical assistance decisions during the patients transport and preparing in advance the arrival and treatment of the emergency cases.

The main objective of this project consists in building the distributed infrastructure for data (video, audio, medical data) acquisition, transfer and processing in real time, by using the most advanced wireless communication technologies (4G HSUPA) and data processing (CELL) for speciality assistance of the medical personal being in the ambulances and advanced preparation of the emergency department of the hospital; so the project aims to improve the emergency medical services in Romania.

4. Project description from the technical and scientific point of view, including novelty degree and the possibility of applying research results

- **Brief presentation of S/T achievement status from domain, on national and international level, conclusive with project theme**

In the international community, it can be observed the constant preoccupation for maximizing the quality and efficiency of the emergency medical assistance, when the patient life is in danger.

Until 10 years ago, in order to increase the emergency medical assistance the ambulances have been equipped with life maintaining devices. In the same time, there have been developed a system for announcing and locating the emergency situation, this allowed the almost immediate intervention of the ambulances.

Due to the exponential development of the mobile communication systems, the quality of the emergency medical assistance service has increased by communicating with the medical personal and even with the patients. Until recently, there has been no technological mean for the medical personal in the hospital to help/guide/assist their colleagues in the ambulances based on real time images.

In Japan, the Central Hospital and the Fire Department of Tsukuba have developed a system that is transmitting photos of the patients in the ambulances. The photos are analysed by the medical specialists from the hospital and based on that they could transmit their recommendations/procedures that should be followed by the assistance personal in the ambulance. The major problem of this project was generated by the mobile communication technology that limited the data transfer. An important part of this project consisted in developing the compression algorithm specific to the transmitted photos. Functionality and technical details can be found at: http://www.aist.go.jp/aist_e/latest_research/2004/20041214/20041214.html.

Another approach implemented by a medical team from USA was to record the images from the ambulances (locally), store and analyse them as evidences in cases of mal praxis. In this project, no data was transmitted to the hospital in order to prepare the patient arrival.

As the mobile communication technologies evolved, it become possible the medical data transmission through SMS and MMS, especially data collected from heart monitoring equipment (EKG). Usually, this system is used for cardiac patients monitoring that are socially active and do not require hospitalization, just periodical control.

In Romania, there is a program of the Healthcare Ministry for providing to the emergency medical system modern ambulances, equipped with devices for monitoring the vital functions of the transported patients. According to this program, the present project proposes low-cost extensions of equipment, consisting in PTZ video cameras and local acquisition, storage and transmission system based on 3G HSUPA technology of various data to the headquarters of the emergency hospital.

- **Project contribution to the domain knowledge development, including novelty, originality and complexity of the proposed solutions**

The project proposes the use of top informational and communication technologies for various data (video, audio, location, and medical data) real-time transmission by means of the existent mobile cell infrastructure, thus developing a distributed system for information, assistance and preparation of the medical act in emergency situations for saving human lives.

In addition to the immediate support that the proposed system offers to the medical stuff in the ambulances, the video recordings of the actions at the emergency site or from the ambulances are of great use for later analysis, improvement of medical procedures and increasing the efficiency of the medical act. Also, the acquired, stored, processed and interpreted data can be disposed as a useful didactical material for preparation and training of the future medical stuff.

The proposed solution for the implementing of the distributed system is original due to the fusion of the sources of data of different types and representation formats (bidirectional audio, medical data from the medical equipment in the ambulances, position data, time) with the video data in a unique stream of information, available to the remote medical personal (in the hospital), allowing decision taking in full knowledge of the emergency situation.

The complexity of the proposed solution results from the acquisition mode in time of the data of different types unique streams with minimal data loss from multiple mobile platforms (ambulances) and from the difficulty of dynamic adjustment in real time of the information streams and synchronizing them. The three major components of the distributed system (mobile platform, central system and control point), although they are distinct entities, they must communicate in real-time and transmit information bi-directionally.

By utilizing in the central system a very powerful processor – CELL, built on a Power ecosystem – dedicated to processing of the information streams received in the central system, contributes to major extent to the knowledge development in the following domains:

i. Accelerated functions for: parallel and real-time processing, signal processing, image processing, digital filtering, audio re-sampling, video compression/decompression for multiple sources, security encryption/decryption.

ii. Developing target applications: processing/visualisation of medical images, data mining and analysis; feature extraction from static and dynamic images.

It is the first time that an application based on 4G HSUPA transmission technology and CELL real-time processing in a distributed system, is developed in Romania, thus contributing to establishing an ecosystem and developing adjacent tools specific to these classes of application: monitoring, debugging, analysers, utilities, search engines, databases, etc.

- **General and specific objectives of the project**

The fundamental and applied scientific research activities will be oriented towards the elaboration of a complete solution for developing a distributed system for real-time transmission and processing of the multiple various data (video, audio, position, time stamps, highly dynamic medical data) streams acquired from ambulances/accidents site for assisting and preparation of the emergency case medical act – therefore, the general objective is to maximize the efficiency of the public healthcare system by delivering critical information to the emergency medical system.

Thus, the project proposes a low-cost implementation solution of a class of mobile remote controlled (audio and remote-operation) platform, of collecting, fusion/synchronization and real-time processing of the video and medical data acquired from video cameras and medical equipment installed in the ambulances.

The simultaneously acquired information from a number of such mobile platforms are transferred in real-time to an operational central point, where by means of a software interface and access to the public healthcare system database these information are processed, analysed and interpreted in order to take an operational decision, elaboration/actualization of the patient electronic medical record and finally storing for case history.

Fig. 1 represents the architecture of this informational distributed system:

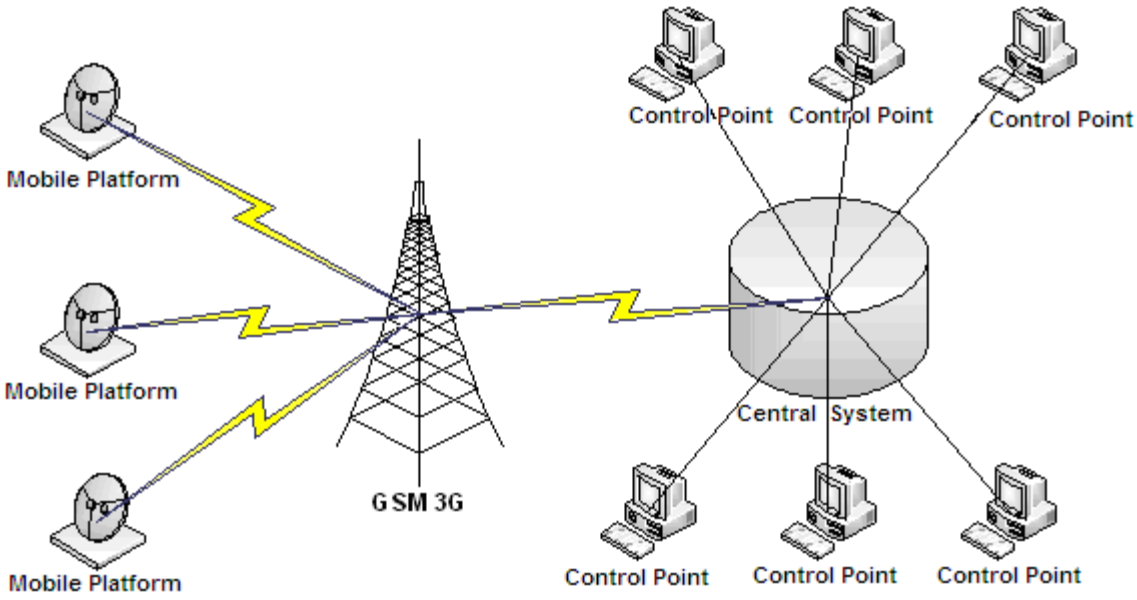

Fig. 1 – The architecture of the MASMED distributed system for collecting, transmission and processing of data streams for the emergency medical system.

The proposed system is composed of three functional constructive areas, the first and the last being also distributed:

IV. The **mobile platforms** ensemble, each one of them placed in an ambulance.

V. The **central platform** (central system) of recording, processing and storing of data (video, audio, position, time, medical data) received from the mobile platforms, commands transfer to the mobile platforms (audio, remote-operation) and decisions transfer to the reception blocks/operators from the emergency hospital.

VI. **User** (medical personal – control point) interface platforms ensemble for information from the mobile platforms interpreting, associating them with external databases and decisions taking/assistance supplying to the medical teams in mobile platforms.

The structure of the informational system MASMED being partitioned in physical modules specific to three functional areas, allows the design and implementation of the applications on the physical support, in parallel, the extension with new functionalities based on an object oriented approach like Rapid Deployment Automation and extremely easy integration.

The main objective of the project is decomposed in the following specific objectives:

1. The development of the mobile platform by designing and implementing the modules for acquisition of video, audio, medical data, local storing, local processing and decision making, GPS, electrical power, as well as the elaboration of procedures, algorithms and programs that permit data acquisition, platform self-govern ability and the administration of all the equipment in the ambulance.

2. Configuration of the communication system based on 4G High Speed Upload Packet Access technology (HSUPA) and development of methods and algorithms for reducing the latency, increasing transfer rate and transmission uniformity so that medical, audio and video information reach at work points from hospital as clear as they can and with interruptions as small as they can.

3. The development of the hardware architecture and the software system of the central system that allow the real-time receiving, processing and transferring to the control points, as well as the storing and archiving.

4. The integration of the CELL processor in the central system that processes, analysis and interprets the audio, video and medical data, by developing algorithms based on:
   - feature extraction;
   - advanced searching and association techniques for databases;
   - exploiting models of shape and textures representation in images, of audio records, and also of signature analysis of the signals from medical equipment
   - the records management in time according to the decisions of the authorised medical stuff and to the protocols specific to the emergency medical procedures, assuring to the medical specialist a complete information for taking operational decisions.

5. The developing of the displaying application in WEB system, allowing the control points configuration for the selection and displaying information, remote control of the video cameras and the communication with the medical teams from the ambulances.

6. The developing of the administration, security and audit system. This system will allow the controlled access to the application, the secured transmission of the information from one module to another and the recording of all the actions realised by the system, or the user to be permanent aware of the system state and actions.

– **Ethical aspects involved in projects development**

The mobile platform will record video images of the treated patients in the ambulances or in the adjacent area (for example in the area of the car accident). Considering the emergency aspect of the intervention, the personal data of the treated patients are confidential. The access to the private information is controlled at application level and guaranteed by the medical act.

– **Activities detail according with the proposed objectives**

The research activities derived from the specific proposed objectives will assure the full accomplishment of the functionalities from the emergency medical act point of view.

From this point of view, the distributed system that interconnects the mobile platforms will allow the medical team preparing in advance and also the set-up of the appropriate equipment in the emergency hospital due to the video surveillance of the patient in the ambulance. Additionally, during the transportation of the patient to the hospital, the medical team on the ambulance will be guided to perform procedures that will stabilize the patient or even save his life, due to the images obtained by remote control of the video cameras mounted in the vehicle.

Along with his capability of sending real time images, the system will also allow:

- the real-time dialogue with the medical stuff in the ambulance;
- patient monitoring by a medical specialist from the hospital during the transportation;
- the possibility of acquiring video images from outside the ambulance. This is very useful in the cases of car accidents. For this situations the video system should be able to acquire images also in night conditions;
- the capacity to send data acquired from the medical equipment in the ambulance, that associated with the video data will offer a complete set of data for the doctors in the hospital regarding the patient health condition.
- The possibility to record video and medical data for further analysis, in special for the improvement of medical services and/or mal praxis cases.

The data stream will assure that the central system and the control points are always active and functional. For the mobile platform are defined three states: off, on and not functional. The off state is used in case of damage or if the ambulance is not used for a long period. In the not functional state, the platform does not record images and do

not transmit data, and the majority of the components are shut down for not consuming energy. The platform can be switch on locally or remotely.

The platform being active, will record at high quality the video, audio and medical data in the local system (of limited capacity, organized as a circular buffer of temporary storing of recent data and information). The video information from the cameras are displayed also locally in the ambulance cabin to allow patient monitoring and to detect certain mal functionalities of the system. Also, if the connection to the central system is alive, the video, audio and medical data information are transferred in real-time.

Due to the technology used for the data transmission to the central system, the communication channel is not of constant bandwidth or latency. Thus, according to the available bandwidth at a moment the video information is MPEG compressed, and the resolution and frames/seconds are dynamically modified in time to be sent optimally to the central system. Due to the present technology limitation, it is possible only the transfer of a single video stream at one moment in time, particularly the one selected by the doctor through the user interface of the control point in the hospital. The information stored locally at maximum quality is then transferred to the central system through a more rapid transfer method, when the ambulances reach the headquarters.

The medical, audio and video information transferred in real-time to the system, are then routed also in real-time to the control points in the hospital to be processed by specific procedures and interpreted by the doctor.

The central system performs the following tasks, in parallel:

- The information received in real-time are recorded and stored for a long period (according to the specified storage capacity)
- The information received in real-time are catalogued and indexed according to the source ambulance, the announced case at the 112 emergency services and the necessary time for intervention. The same system will be developed further for the later use of the stored information.
- the record information in central system are compared with data flow received in real time at current time and completed so to result a unique complete flow to best quality
- All the information are prepared and packed as to be archived on external media

- The access to the stored or received information is protected by encrypting and authentication.

The control point, by means of the user interface, receives the data in real-time from the storage system. The video and audio data are processed directly, and the medical data is send to the medical equipment to be interpreted. The user will be able to activate and modify the parameters of the equipment existent in the ambulance (power on/off the system, picking the most appropriate camera view and control of its orientation, activating the audio system), to initiate data search in external databases (for example the family doctor database, the electronic form of the patient) according to criteria from the information received from the mobile platform, to configure procedures and functions for processing the static and dynamic recorded images for features extraction, comparing them with a priori learned patterns, to create case descriptions as evidence or for students/medical stuff training and to administrate the central system.

The first two of the defined specific objectives require the accomplishment of the designing the hardware structure and software system of the mobile platform (ambulance) for acquisition, processing, local storing and remote transfer of the video, audio, position and medical data, as for receiving the commands for camera remote control and of the audio stream from the control points in the hospital.

The **mobile platform** will be composed of the following modules: (i) video acquisition; (ii) audio acquisition; (iii) data acquisition from the medical equipment; (iv) local data flows storage; (v) data sending/receiving to/from the central storing and processing platform; (vi) GPS; (vii) power supply; (viii) self-diagnosis and maintenance. In the mobile platform a system will be design and manufactured in order to locally control, store temporarily and send/receive data flows and commands; this system will command and integrate all the eight modules of the mobile platform (Fig. 2).

This local command and control unit will be composed of processor and main memory, hard-drive storage system, hardware MPEG coding equipment and software data encryption module.

Because of the mode of exploitation (vibrations, shocks, humidity, presence of fluids, extreme temperatures), the local control system will be built in conformity with military

and aeronautical standards, having the guarantee of not influencing other life sustaining equipment in the ambulance.

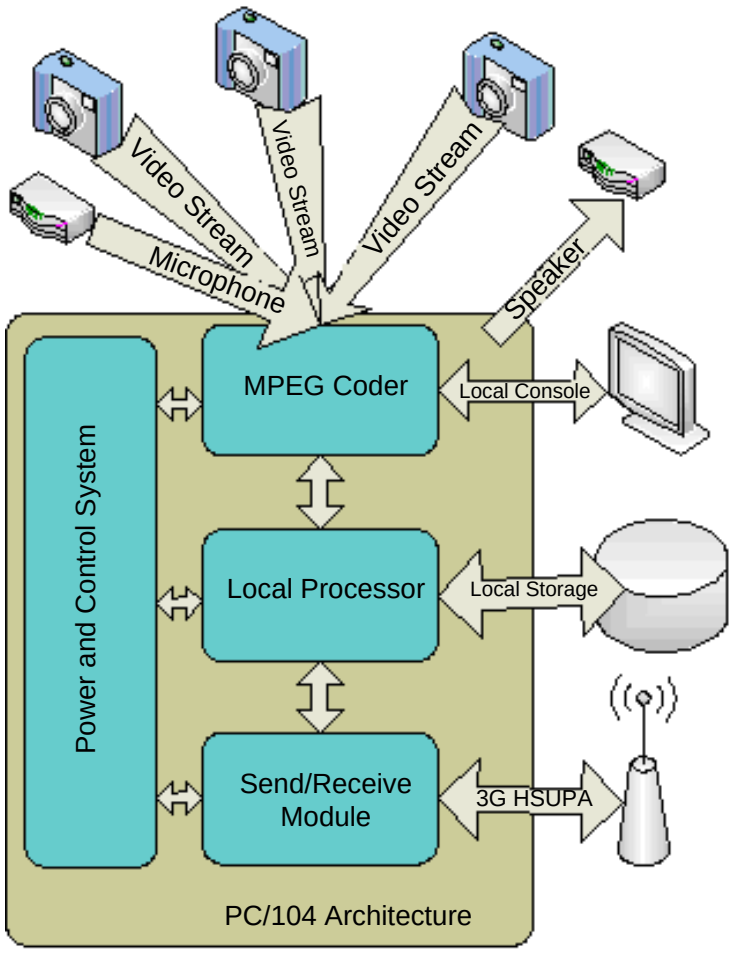

Fig. 2 - The structure of the system for control and command of the equipment of the mobile platform (ambulance)

The PC/104 technology will be used, which has the possibility to be powered from low voltages (24 Vcc) and passive cooling. The local processing unit will feature a display and voice command systems placed in the driver's cab in order to allow:

- monitoring of the patient by the medical staff from the hospital during transfer;
- control of the PTZ video cameras in order to gain necessary information in the event that this task cannot be completed remotely;
- diagnostic and displaying the error messages for the entire system in order to permit local intervention for their remedy.

The control unit will be hosted by a Linux operating system, which features serious advantages: open architecture allowing very easy later development; reduces developing costs by using the GPL license; integrates open standards that allow

integration with other applications and/or systems; assures high data security by using data encrypting systems without "back-doors"; very good scalability and stability for the operating system.

The video acquisition module is composed of: interior (pan-tilt-zoom, PTZ) cameras, exterior PTZ camera; two of the cameras are located inside the ambulance and one outside (Fig. 3):

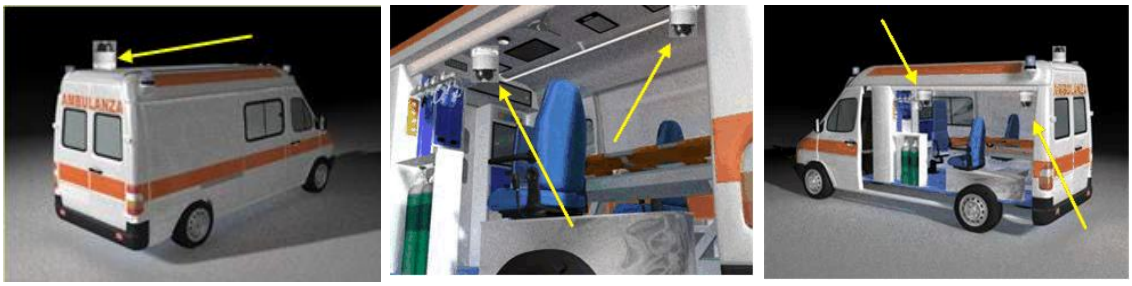

Fig. 3 – Location of video cameras on the mobile platform of MASMED system

The same type of camera will be used for these three points of observation, for simplification and interchanging the system's integration, following next technical characteristics: image stabilization (allows the attenuation of the effects of automobile generated vibrations from the image quality point of view) ; night mode working (the camera is able to record images despite the lack of adequate lighting); VISCA protocol support (allows camera motion control by using a RS232 interface); remote command of horizontal and vertical rotation (pan and tilt) from distance; minimum 16x optical zoom, controlled remotely; auto-focus; auto white-balance; analogue output; 12VDC power; 2-3 kg weight.

Cameras can be oriented from the control point of the hospital independent one of another. Although the camera coverage area is big, for the interior cameras a sub-area will be defined as usable and its limits will be configured by user; the orientation commands will be generated according to a selected vision sub area using remote operation:

- manual;
- automatic, according some continue scanning models that are predefined.

The vision field of the exterior camera, whose night mode will be automatic activated, won't be limited in dimensions and/or extreme positions.

When the ambulance is turned on, the acquisition module enters the monitoring state, meaning that data will not be recorder or transmitted and the cameras will be reset in order to acquire the largest possible area inside and outside of the ambulance. Using the motion detection system, a camera will begin to record only when motion is detected inside the ambulance, so storage local space is saved. Additionally, in an emergency, the ambulance operator is not obliged to start the recording, and so he can concern on the medical process.

The Audio Acquisition module enables two-ways real time communication between ambulances and headquarters. The audio system that can be used by all the ambulances needs less space than the driver. The microphone and speaker will be installed near the patient in order to allow dialog between the medic from the control point in hospital and the patient and also the ambulance personal. For easy utilization an echo cancelling protocol will be enabled in order to eliminate the echo that can occur when the microphone is used close to the speaker. An isolated system can also be used, so that the doctor is using a hands-free system that connects itself through blue-tooth. This system allows the doctor to move a short distance outside the ambulance.

Regardless of the acquisition method, the audio date is synchronized with the video data and saved locally or transmitted to the central system in the same way as the video ones, except the case that the bandwidth does not allow the transmission of all the information (medical, audio, video), the audio information has priority over the video one.

The Medical Data Acquisitioning module allows the recording and sending the information processed from by the medical gear from the ambulance to the central system using the same communication channel. Medical data are stored in central system for temporally correlation with audio and video flow and also interpreting, association initialization/ searching in database and taking decisions. The main purpose is to import medical information through serial systems or using Bluetooth technology (using Bluetooth technology, ambulance GPS data will also be acquire to identify the place of the accident and also to trace the current position of the ambulance).

Programs will be developed in order to permit the video, audio, position and medical data modules to impose over the raw information a time stamp in order to know the acquisition moment and the synchronization manner of different nature information.

All information acquired by the devices and gear of the mobile platform can be saved on a storage environment accessible to the local command and control processor in order to:

- To assure the continuity of the information in the event that communication with the central system cannot be established or is functioning with interruptions.
- To the automation and flexibility of the mobile platform operating manner, the acquisition modules being able to function without having direct real time with the central system and/or a control point intervention.
- To eliminate unauthorized access to the mobile platform information by saving the data in an encrypted manner.

The acquired data is formatted and written on an internal hard drive of the local control system. The storage capacity being limited, the data is written in a rotation system, so that the latest data is always storage. As soon as the ambulance reaches headquarters and the data is transferred in the central system, they are erased from the local hard drive of the mobile platform.

One of the main research activities focuses on developing, implementing and tuning the data sending/receiving system from/to the storage platform to the central system. This development represents the main project's pillar, because it permits the sending of information in real time from a moving platform to a fixed point.

For this purpose, 4G HSUPA (High Speed Upload Packet Access) technology is used, and it allows (up to the present time) transfer rates of information up to 5.76 Mb/s in the major cities. At the present time modems with 2 Mb/s speed can be used. The choosing of this technology was based on the following advantages:

- HSUPA protocol is already implemented, and the network is constantly evolving
- it allows high transfer rates, capable of transmitting real time TV resolution video images
- low network response time, can reach 2 ms, which allows using interactive systems

Additionally, for reaching the quality dictated performances of real-time transfer of video, audio, position and medical data flow, it is used an important number of characteristics of HSUPA technology (Fig. 4):

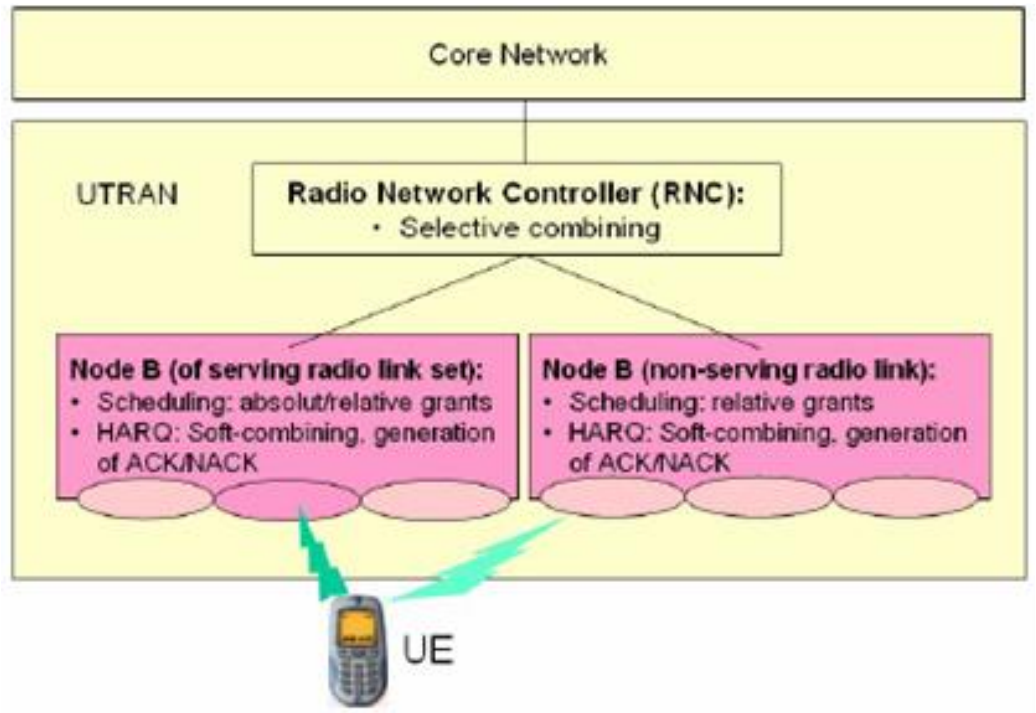

Fig. 4 – The programming mechanism and the HARQ protocol used by the HSUPA technology

1. The programming mechanism allows the resources to be dynamically allocated to the terminals, so that each has access as much as possible to the communication channel.

2. The HARQ retransmission protocol (Hybrid Automatic Repeat Request) (HARQ) does no discard erroneous packages but combines them in order to generate the correct package, so that the number of retransmission goes down considerably.

3. Transmission time has reduced from 10 ms to 2 ms, which permit a greater flexibility of terminals from MASMED distributed system.

4. The impact on the network is modified by the fact that the programming mechanism and the HARQ retransmission protocol move right in Node B (cell broadcaster) and by the fact that transmission can be made to several adjacent cells.

The development of the sending/receiving module is set to accomplish the connection only on demand and the possibility to initiate them from both parts, which leads to the efficient use of the communication channel. Depending on the bandwidth available at a given time (variable due to the field fluctuations), the sending/receiving module will chose the selective sending of the information. The medical data will be sent with priority, followed by the audio and last by the video.

In the event that the ambulance is not situated in the HSUPA coverage area, the next immediate technology will be chosen, of EDGE/GPRS type.

A GPS module will be incorporated in the mobile platform thru which the ambulance position can be known at the control point at any time. This allows on one hand the medic at the control point to recommend different treatments based on the ambulance travel time, and on the other hand, in emergency situations, an ambulance already in the field can be rerouted to a new destination, at least in order to stabilize the patient until the arrival of another ambulance.

The supplying with power of the local command and control system of the mobile platform will be made from a 12VDC or a 24VDC, which offers the following advantages: compatibility with the power system available in the ambulance; it considerably reduces the accidents risk due to the power supply system, practically it is impossible to get an electric shock from a damaged or malfunctioning component; greater mobility, even outside the ambulance.

Aside the hardware power supply a software component will be developed in the local module that permits the reduction of the power consumption of each component when it is not being used thus increasing the autonomy period when the ambulance is not operational (ignition on).

A software system will be developed in order to automatically diagnose and repair allowing the mobile platform to function even in the most unfavourable circumstances. This system involves developing the next functions and components:

1. Reset and automatic diagnose on all testable components on platform initialization.

2. Logging of all events in three functional zones: internally, local storage module and central system.

3. Preventive components monitoring system: periodically, based on a testing plan, the system automatically verifies each component. If following the verifications a component has answered slow or different from the standard mode (or then the response average), then the user will be advised.

4. Un-operational components identification and isolation system. In the event that a component cannot be used anymore it is isolated (turned off and/or deactivated) with a minimum impact on the other functions. For example in the situation that a camera cannot be used anymore, the other camera will be automatically commuted on, or if the transmission system is no longer operational, the local recording will automatically continue and the cameras will be set on a predefined position.

The central platform (central system) will be developed like a structure containing the modules: (i) sending-receiving with the mobile platforms and user interface (control point); (ii) central data storage and archive; (iii) information administration and display; data flow processing, static and dynamic image processing and multi-criteria analysis; (iv) automated control of ambulance cameras; (v) system operations log.

Central platform architecture and connections are represented in Fig. 5.

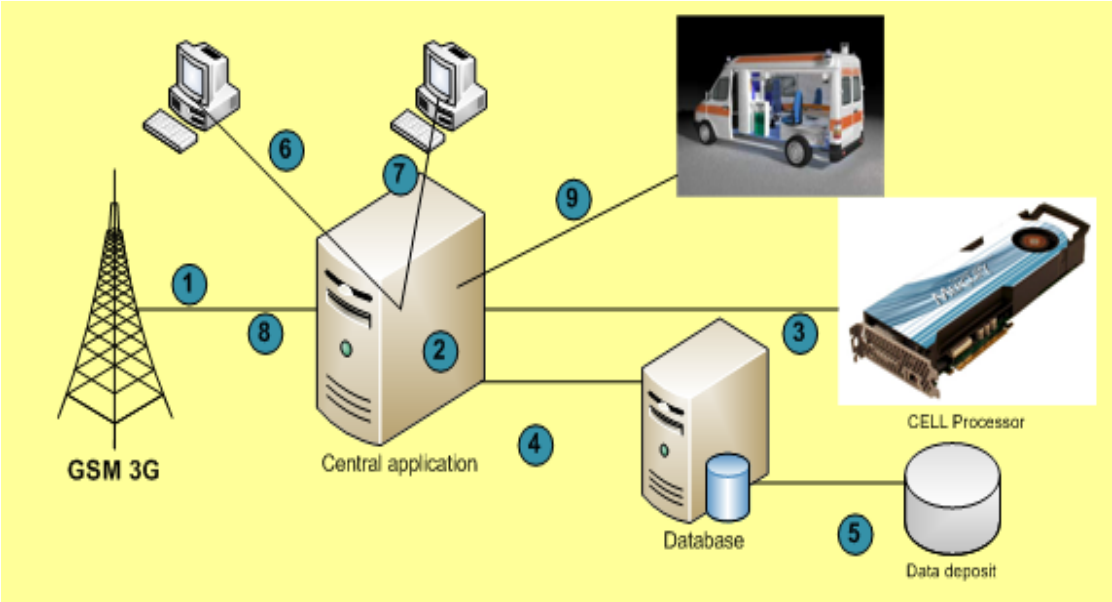

Fig. 5 - MASMED central system architecture and platform connections

The sending-receiving module with the mobile platforms and control point represents the communication interface between the two main components of the MASMED

distributed system. The information from the mobile platforms will circulate encrypted to the central system where they will be decrypted, processed and stored, and then re-cryptic and send to the control points. The connection module between the control points and the central system is free, so that the control point can use the existing connection systems.

Fig. 5 also describes the information flow. Data arrives from the mobile platforms through means of the HSUPA technology (1). The main application sorts the information flows (medical, audio, and video) from the control data (2). The flows are sent to the CELL processor for synchronization and analysis (3), after that together with the control they will be stored in the data base (4). From here the complete information is stored in the archive system (5) and sent to the control points (6). The control points have access through the central application and remote control to the video cameras in the mobile platform, (7) and (8). In the moment that the ambulance has reached the headquarters, it will download all the data locally stored to the central application using a high speed channel (9), that will finally reach the archive system (the data storage).

The data storage and archive module will allow the users to keep data (medical, audio and video) for analyse, control and demonstrate in medical purpose. The user has the possibility to access the information any time and exports them in a standard format, like DVD. The storage capacity will determinate the time of data storage. An estimative calculation show that for a video flowing of 400 kb/s at 15 frames/s average time of recording 3 hours per day, it results 540 MB per ambulance.

The Information Administration and Presentation Module will be developed as user interface. For flexibility and standardize we choose the use of a web client (thin client), with the following characteristics from the user point of view: possibility of commute between cameras and their control in two axes plus zoom in real time; possibility of reproduction the audio information in real time; possibility of superposition through the image of the medical information; access of the previous recordings; proceeding and rules definition concerning the system behavior in unnatural situations.

From the administrator point of view, the interface has the following characteristics: define new users or modify the existing one; define access rules; define ambulance policy and long term data storage; define access lists; modify video camera settings; apply modification and software improvement.

So, all the user interface functions are implemented al server web level, and they have the following advantages: computers that are in the hospital can be used; all modifications and improvements are done in one place, in web server; utilize standard crepitating methods.

The core of central platform MASMED is represented by the subsystem of real time processing of data flow (medical, video and audio), static and dynamic image processing and multi criteria analyse; software applications will be developed for the following functions:

- Medical, video, audio data synchronization.
- Restore medical/ audio/ video data flow. In the moment when the ambulance arrives at base it will transmit the local saved data at best quality, to the central system, where the data flow is restored using saved data. Also this function is used in the case in which the communication between the central system and mobile platform gets interrupted and it is necessary data flow resynchronization in real time, so at the control point data are presented synchronized and with interruptions as small as possible
- Superposition of medical information over video/ audio data flow for obtaining only one data format (DVD video format). This is necessary for eliminating the possibility of wrong data interpreting due to time differences between data flows; in the same time this system doesn't allow subsequent information deterioration by introducing or taking off information.
- GPS information processing received from the ambulance to be displayed to the user. Also, GSP technology is used for data flow synchronization (audio, video, medical).

In the off-line manner, there will be planned analysing and interpreting applications of medical, audio, video information by developing algorithms based on:

- feature extraction,
- advanced finding techniques and association in database,
- models exploitation of representing the forms and texture in images and audio recording, and also of signature analysing through the signals from medical gear,
- manage of recording in time according with the decisions of medical personal authorized and specific protocols with emergency medical procedures,

the results will assure the medical person a complete information, continue for taking operative decision and tracking the patients after the intervention.

All these information must be processed for every ambulance in real time. It will be used a special processor named CELL made by IBM, Toshiba and Sony for mathematic and professional graphics calculations (Fig. 6).

Because of its high performance architecture (1 Power Processor Element with 32k L1 caches, 512k L2 cache, 2 way SMT and 8 x Synergistic Processor Element wit instruction set SIMD of 128 bits, Register file – 128x128-bit, local memory of 256KB, MFC – Fig. 6), the processor will be used as Central Process Unit and also as Graphical Processing Unit, this will allow a very big flexibility from the application programming point of view. The eight parallel computing cores together with the Power Pc bits architecture allow impressing performances in real time: transfer high speed with memory (25.6 GB/sec), work at frequency greater than 3.2 GHz, high processing capacity (200 Giga Flops).

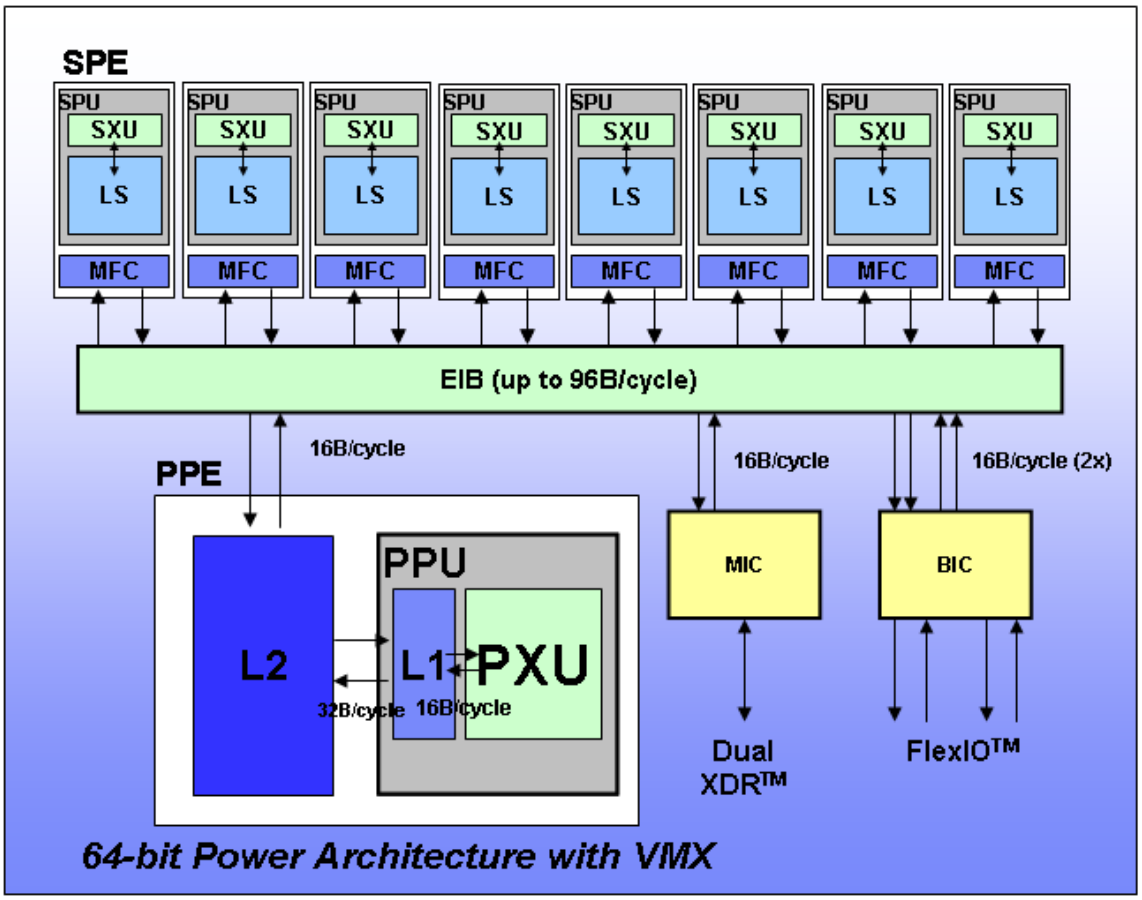

Fig. 6 – The intern architecture of CELL processor used in central system MASMED

While the central system accumulate information, using this per formant processor CELL the information can be analysed from the data base for generating the statistics about the ambulance utilization degree pertained cases gravity and generating the statistics about the intervention time pertained gravity and number of cases and also extraction and analyse of specific information from video flows.

The automatic control of cameras inside the ambulance is based on the functions defined at central level and at mobile platform level through which the cameras can be automatic oriented, if there is not o human intervention, in some predefined positions. This thing is necessary in the moment when the link with the mobile platform has been interrupted and the cameras are in an un-standard position that doesn't allow the automatic recording, or when an obstacle has interfered in the path of a camera and so the information can't be used. In this last case, it automatically commutes on the second camera.

It will be developed a recording module for the operations executed by the system that allows the recording of all the operations executed by the users and the decisions taken by the central system in order to enable whole system diagnose, analysis of executed commands and generation of statistical data.

The user interface platform (control point) is composed of the following modules: (i) the user login module; (ii) the information selection and display in the control point module; (iii) the audio module; (iv) the medical data from the ambulance transfer module.

The user login function allows the users to be defined with different tasks in order to limit access to certain areas of the system. There will usually be four user types with increasing rights:

1. User (U) - has read / observing rights
2. Editor (E) – in addition he has the rights to modify application level settings
3. Administrator (A) – in addition he has rights on all application commands and settings
4. Master (M) – he has total system access and control

The information selection and display module in the control point allows the information transmitted by the information managing and interpretation module to be interpreted and displayed in central system.

This module will function exclusively in Web system with encrypted access and transfer. For a quicker and easier use of the interface, the control point will be fitted with a dedicated camera control system so for all the common operations there will be no need for a mouse.

The audio module allows bidirectional dialogue between ambulance medical personnel and control point personnel. For an easier use an echo cancelling protocol can be implemented in order to cancel the echo that can appear when the microphone is used close to the speaker.

The medical data from the ambulance transfer module - allows the transmission of the medical data to specialized interpretation hardware.

Because the open architecture of the informatics' proposed system, series of activities searching-developing can be approached in a flexible manner in the three different zones - mobile, central and user - without rigidity forced by restrictions, conforming to the planned method object oriented RDA (Rapid Deployment Automation).

5. Presentation of estimated results

A synthesis of the S/T results is shown below:

R1. Complete control local system of acquiring, storage, temporary storage and transmissions/reception of data flow (audio, video, position, medical) and commands (audio, remote-operation of cameras) based on PC/104 technology, that integrates the eight hardware and software modules of the mobile platform from the ambulance: (i) video acquisition; (ii) audio acquisition; (iii) data acquisition from medical gear; (iv) local storage of data flow; (v) transmission/ reception of data to/ from central storage and processing platform; (vi) GPS; (vii) power supply; (viii) automatic diagnosis and auto repair.

R2. Algorithms and programs for selective remote-operation of the assembly of three video cameras from a mobile platform (ambulance) in manual and

automatic manner – according some continuous scanning models that are predefined.

R3. Solution and program for the over imposing to the raw video information, audio, position and medical data (import from serial interface and Bluetooth technology) of a time signature.

R4. Transmission and reception system of data in real time (including video flow with reduced latency, high quality of images and continuity in transmission) to/ from storage platform of central system, using 4G HSUPA technology.

R5. Software system of automatic diagnosis and auto repair of the control and command local system from mobile platform, with following functions: reset and automatic diagnosis of all testing components at the platform's initialization; event's login in three functional zones: intern, local storage manner and central system; components preventive monitoring of mobile platform; detection and isolation of un-operational components from the mobile platform.

R6. Central processing system, storage and transmission of data to/ from mobile platform and user interface platforms (control points in hospital), will be developed as a structure that integrates the following modules: (i) transmission/ reception with mobile platforms and user interface; (ii) central storage and data archive; (iii) information administration and representation; data flow processing, static and dynamic image processing and multi-criteria analysis ; (iv) automat control of cameras inside the ambulance; (v) operation audit performed by the system.

R7. Real time processing of data flow (medical, video and audio), static and dynamic processing image and multi-criteria analyse based on multi-core CELL technology with software applications: synchronization of medical data with the audio and video ones; retrieval of data flow medical/ audio. Video; over imposing of medical information over data flow video/audio in data unique format (video DVD); information GPS processing received from the ambulance.

R8. Software application set that are executed off-line on CELL processor for analysis and interpreting the medical, audio and video information through: extraction algorithms of characteristics from static and dynamic images;

advanced techniques for finding and associating in database; model exploitation for representing forms and texture in images and audio records; signature analyse through the signals from medical gear; manage of records in time according to the decisions of medical operators and protocols specific to emergency medical procedures.

R9. Complete system of programs executed on the user interface platform (control point from hospital) that has the following functions: (i) user's identification; (ii) selection and display of video information; (iii) audio communication with mobile platforms; (iv) medical data transfer from ambulances.

R10. Physical implementation, testing and validation of a distributed system of acquisition, transfer and process of video, audio, position and medical data flow including: (1) two mobile platforms – complete gear and control and communication fixed in two ambulances; (2) a central system completely equipped – connection at two mobile platforms and two user platforms: (3) two user platforms completely equipped, installed at Emergency Central Hospital Bucharest (SCUB).

6. Project's risks and viability

The informational real-time system for emergency medical monitoring and assistance will be realised in a distributed architecture, integrating acquisition, processing, local storing and transmission systems of data streams (video, audio, location and medical data) from each ambulance connected in the system. This type of architecture allows the simple monitoring of the equipment on each platform, automatic diagnosis and isolation in case of mal function, without influencing the functioning of the other mobile platforms.

For the data sending and receiving between the mobile platforms and the central system, it is used the most recent technology of wireless communication – 4G HSUPA (High Speed Upload Packet Access) which allows information transfer rates high enough in the perimeter of the large cities for performing TV resolution video data real-time transfers. The low latency of the network (up to 2 ms), allows its use in interactive systems from/to the storing platform of the central system. By choosing the HSUPA technology it is guaranteed the high performances of the real-time transfer of high quality video streams. Additionally, the HSUPA protocol is already

implemented and the network is continuously developing, which eliminates the risk of not accomplishing the transmission system in the specified quality parameters.

For the implementing of the local systems of acquisition, processing, storing and transmission of data streams from ambulances will be used the industrial technology PC/104, with low voltage power (12V cc), passive cooling and high viability components. The local control units will run under Linux operating system, which offers very important advantages: open architecture allowing easy further developing; low cost development by using the GPL licence; using open standards that allow the integration with other applications and/or systems; high security of the data by using encrypting methods without backdoors; high scalability and stability of the operating system.

In the central system of the distributed system will be used one of the most exiting high processor – CELL, built on Power ecosystem – dedicated to the processing of information streams received from the mobile platforms, the archiving of these information and the connection to the medical databases. The choice of the processing core was determined by the possibility of implementing accelerated functions for: parallel and real-time processing; signal processing; image processing, filtering; audio re-sampling; video compression/decompression for multiple sources; security encryption/decryption and developing of target applications that are high resources consuming: medical imaging/visualization; data mining and analysis; features extraction from static and dynamic images.

Due to its high performance architecture (1 PowerProcessorElement with 32k L1 caches, 512k L2 cache, 2 way SMT and 8x SynergisticProcessorElement with 128 bits SIMD instruction set, 128x128 bit Register file, local memory, MFC), the processor can be used in the same time as a Central Processing Unit and as an Image Processing Unit, which will allow a high flexibility for applications programming. The 8 cores of parallel computing together with the PowerPC 64bits architecture allow high real-time performances, with high memory transfer speed rates (25.6 GB/s), processing frequencies over 3.2 GHz, high computing power (200GigaFlops).

From the technical point of view, the system architecture, the communication technology, the computing and storage industrial systems and software developing tools used guarantee the successful implementation with high real-time performances. From the scientific point of view, the proposed solutions for the

system architecture and the decoupling in pipeline processing platforms are of high performance, viable and insure the success of the implementation.

From the costs point of view, the proposed research project is balanced in its budget elements; the total necessary cost of appreciatively 44 350 work hours, equivalent to 4 hours per day in average for 36 months, with a constant work team of 18 people. The research proposed period of 18 months is justified by the complexity of the project.

The expenses for basic research materials (computing equipment, communication, video cameras and software licenses), of 327 000 lei (i.e. 16.35% of the total cost) are necessary for full equipping of two mobile platforms on ambulances, a central transfer system, storing and processing data streams and connecting to the distributed area, and also for full equipping of two user (physician) interface platforms in the hospital control points.

7. Dissemination of results

For the mass dissemination of the research results, the following actions are scheduled:

- 15 participations to national and international conferences, in the areas of Emergency Medical Systems, Communication and Information Technology, Distributed Systems for data (video, audio, location, medical) acquisition, transfer, processing and storing, Databases and Image Processing;
- Publishing of 12 scientific articles and one monograph referring to “Distributed informational systems in the emergency medicine”;
- Registering two brevets for solution and product;
- Organizing two round tables – meeting with specialists and of two specialization

The costs for participating to scientific conferences are limited to 3.6 % from the total costs of the project. The total co-funding of the project from own resources (including the project coordinator which represents a UNIVERSITY) is of 449 200 lei which represents 22.46% from the total value from the budget of the project.

Additionally, there are contracted co-funding funds from the economic agent RMS, a known ICT company that has the interest in sustaining the development of the user platforms in the hospitals with computing equipment and to offer consultancy.

There is also the approval of XXXXXX – a communication service provider for asserting the project with Internet services, mobile services and necessary modems for using the 4G HSUPA technologies for which the company owns the licence. There is also the agreement of the IBM Linux Competency Centre for supplying technical consultancy and material support for the CELL Technology and storage systems necessary in the system's central point.

8. Partners:

UNIVERSITY: University Politehnica of Bucharest

HOSPITAL: Clinic Emergency Hospital, Bucharest

IT COMPANY: RMS