E-Health with Mobile Grids: The Akogrimo Heart Monitoring and Emergency Scenario

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Abstract

The patient is mobile and its health travels with him. Healthcare services should be available pervasively, integrated into the patient's environment. Mobile Grids form networks of mobile and stationary monitoring and diagnosis facilities around the patient, electronic health records, medical decision support, diagnosis and analysis services, as well as even mobile medical experts and physicians. Thus, Mobile Grids provide an infrastructure for an efficient development, provision and maintenance of complex e-health applications. The EU IST Integrated Project Akogrimo (www.mobilegrids.org) is specifying a Mobile Grid infrastructure and is prototyping the resulting framework in a testbed giving the base for the application of a Heart Monitoring and Emergency Management Scenario. Within the work of Akogrimo, this white paper gives an introduction into the usage of Mobile Grid technologies within this scenario and indicates enhanced business opportunities.

SIXTH FRAMEWORK PROGRAMME

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Grid for complex problem solving

1. Summary

Starting with a short introduction into current challenges and perspectives of the healthcare domain, this white paper motivates the use of Mobile Grid infrastructures within this domain supporting the patient's mobility requirements and the need for computation and data intensive applications. By means of the description of a Heart Monitoring and Emergency Management scenario the deployment and usage of the Akogrimo Mobile Grid platform is discussed and Mobile Grid specific capabilities are highlighted. The paper concludes with a description of changing value-creation processes influenced by (Mobile) Grids inducing new business opportunities for Network and Application Service Provides.

2. Healthcare Challenges Demanding Improved Infrastructures

The current situation in the healthcare domain is affected by the exciting fields of medical and technological improvement, increasing patient's requirements and the inversion of the age pyramid (leading to more chronic and degenerative diseases) as well as an increased cost pressure.

The medical progress is characterized by improved diagnosis and treatment methods. In particular, genetic engineering and in-depth imaging techniques (Computer Tomography, Magnetic Resonance Imaging) enables an individual anamnesis, diagnosis and treatment. Another important issue is the impact of technological development on medical equipment. The increasing trend in miniaturization and the mutual connection of medical devices allows a seamless and permanent monitoring of the patient. Early diagnosis and minimal invasive procedures are possible.

On the patient/customer site, a movement from pure treatment of diseases to wellness and a most effective exploitation of lifetime can be observed. Health services are used in order to underpin or improve the social situation (selection of partner, extended professionalism, continuous fitness etc.). The utilization of health services is going to be a regular service available everywhere and every time.

The patient is mobile and its health travels with him. Health care services should be available pervasively, integrated into the patient's environment. As already described, miniaturization is an important prerequisite. In the case of a disease or an emergency the patient expects support as fast as possible and tailored to its individual condition and physical properties.

All described challenges are already addressed in a vast number of research prototypes and proprietary commercial solutions. But, a transformation into real, continuous and integrated processes among all health service providers is still missing. Here, Mobile Grid solutions, forming network of mobile and stationary monitoring and diagnosis facilities around the patient, electronic health records, medical decision support, diagnosis and analysis services, as well as even mobile

medical experts and physicians can increase the influence on medical processes.

3. Mobile Grid Supported Healthcare Processes

How does it work? The Akogrimo Mobile Grid Framework supports the creation of multiple types of application starting from simple applications like patient monitoring to complex applications like complete emergency handling and disaster management. The Akogrimo Framework enables the integration of services provided by mobile resources, legacy applications, and data and computing intensive services within a Mobile Grid to offer applications to mobile, nomadic, and stationary users. In the e-Health environment the following types of mobile resources are of interest: medical devices for patient monitoring e.g. ECG devices and ultrasonic instruments, video and audio terminals supporting the interaction between patients, paramedics, and medical experts, as well as visualization facilities to display health records, vital data and diagnosis information. Particularly, the capability to adapt applications autonomously to changing contexts of mobile resources or mobile users and resulting varying qualities of service enables the efficient functioning of Mobile Grid based applications in volatile environments of emergency and rescue scenarios. The consequent advancement of security and identity management permits the deployment of the Akogrimo platform in mission critical business and even healthcare applications. The Heart Monitoring and Emergency Management scenario to be prototyped within an Akogrimo testbed is an example that will be explained in next chapter.

4. Heart Monitoring and Emergency Service (HMES) – The Akogrimo Mobile Grid Reference

Is there a real-world use case? As a starting point to validate the Akogrimo Mobile Grid platform and to realize a reference implementation of the platform a scenario combining patient monitoring, emergency detection and the subsequent rescue management was chosen due to the following reasons:

- Cross organizational service provisioning by ambulances, medical experts, hospitals, network operators, application services provider, and police services,
- Mobility of patient monitoring and diagnosis equipment,
- Mobile and stationary knowledge services provided by cardiologists and decision support systems, as well as
- Services to manage a high amount of historic and current patient data are required

The main objective of HMES service is the early recognition of heart attacks or apoplectic strokes and a proper treatment of patients as fast as possible. Two cases are considered: The application of a permanent monitoring service to observe the cardiac function that assures a more detailed diagnosis, a fast alert triggering, and a disease-specific response in the case of an

emergency. In the second case the patient receives a non-permanent monitoring device that is activated by the patient if he feels a problem in his cardiovascular system.

In the following the first case and the resulting emergency management process is described. The patient's ECG data are measured by the wearable ECG device, forwarded to the patient's mobile phone. The Mobile Grid based HMES recognizes the availability of the ECG data, automatically requests the data and calls an ECG analysis service to check for aberrations. Both the ECG data and the analysis results are stored in the HMES patient record. These data are made available to the attending doctor and in the case of an aberration to the emergency handling service.

When an aberration occurred, concurrently, the emergency handling service starts the following actions: determine the location of the patient, identify the responsible emergency dispatch centre and the general practitioner or cardiologist currently attending the patient, and a locally available emergency ambulance.

The supervision of the emergency service is carried out in the identified emergency dispatch centre. An emergency manager is informed about the possible emergency, contacts the patient and makes a decision where necessary. On the manager's workplace the following information are made available:

- reason for the emergency
- patient's administrative data
- patient's medical base record
- patient's emergency data
- location of the patient
- initial diagnosis of the ECG analysis service
- the attending doctors
- the available ambulance
- the locally available first responders

In addition, an audio link between the clerk and the patient is established. Depending on the patient's situation and considering the present information the manager talks to the patient to inform him about the suspect, to gather further symptoms, or to soothe him.

During the conversation the emergency manager is assisted by a diagnosis support service that analysis the available data, guides to the next question and suggests necessary decisions. In case of a suspected heart attack he alerts an ambulance that can reach the patient the fastest and the attending doctor or a cardiologic expert depending on their availability. The HMES patient record is extended to an emergency case-specific patient record, combining all information important to the emergency. The emergency handling service establishes an audio link to the paramedic and allows for a direct communication with the patient and the clerk. All relevant information is forwarded to the ambulance and is made available to the particular users. The dynamic navigation system receives the patient location and the timely shortest route to get there. A comprehensive patient history is compiled from the available patient records of the hospitals or practitioners the patient was under medical

treatment in the past years. A medical data analysis service prepares the data with respect to the current emergency and the visualization according to device terminal capabilities.

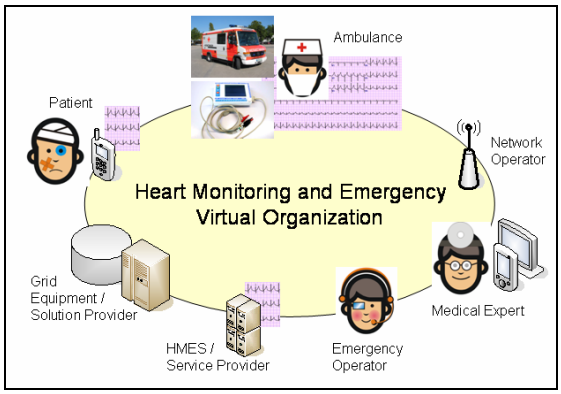

Figure 1 HMES Service and Resource Providers

Arrived on site of the emergency, additional diagnosis and monitoring equipment is used by paramedics. For example ambulance's diagnosis and monitoring devices are automatically detected as more effective resources able to provide a better ECG monitoring service. Consequently, the wearable ECG device of the patient can be seamlessly replaced. As soon as the new data source is available, the analysis service and the decision support service are informed and can integrate them in an improved diagnosis and decision support. In difficult or doubtful situations, a qualified physician can be involved in the diagnosis process. For that purpose he gets access to all available patient data and an audio link to the paramedics is established.

If a transport to a hospital is necessary a hospital finder service is called. This service is looking for an appropriate hospital and considers the patient's condition, the time to approach the hospital (traffic and distance) as well as the provisioning level, specialization and capacity of the hospital. The emergency room of the selected hospital is informed about the emergency. Thus, the admittance and emergency staff gets immediate access to all patient data. By calculating the arrival time the scheduling of the emergency staff and necessary resources (room, monitoring devices) can be optimized.

The charging of the HMES consists of several parts. For using the service the patient has to pay an annual flat rate to the HMES Provider. The data transferred over the network is charged by the network operator and is a part of the patient's monthly telephone bill. The services provided during the emergency handling process are paid by the patient's health insurance.

5. Profitable Development of Complex Applications on Mobile Grids

How to earn money with those non-generic, complex applications? Grid solutions allow the secure, reliable integration of services and resources provided by multiple organizations across administrative domains. The autonomy of the resource owner will be increased and transaction costs between the service providers will be reduced. These characteristic capabilities strongly support the ongoing process of ripping up traditional intra-enterprise value chains and the succeeding reconfiguration of single value-adding activities within inter-

enterprise value networks on the IT infrastructure level. Each partner in the new value network can focus on the highly efficient operation of the resources provided and gain economics of scale and scope. Thereby, particularly, the idea of domain or application specific service frameworks becomes important which is already addressed within the Akogrimo Business Modelling Framework distinguishing competitive strategies for services with different focuses. Applied to the HMES application, the development of the application will base on several frameworks comprising basic logistic services controlling the allocation of resources and information to be processed, generic health services accessing electronic health records and analyzing medical data, as well as frameworks of emergency management, traffic management, and disease specific services.

Mobile Grid Solutions further extend the business opportunities. Already existing mobile health telematics applications like tele-monitoring and tele-consultation can be combined and enriched by back-end services. Making existing data and computation intensive services available to mobile users is a second possibility. So the spectrum of applications becoming available is extended, particularly those orchestrating services and resources across organizations and domains.

On the strength of the flexible accounting capabilities, the support of service level and mobile dynamic virtual organisation management and the seamless integration of network resources into a Grid environment witch is provided by the Akogrimo platform, conventional business models of network operators, network service providers and application service providers can be easily extended with value added Grid operation and domain specific services.

6. References

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