Weird Project: E-Health Service Improvement Using WiMAX

Antonio Cimmino[1], Fulvio Casali[2], and Cinzia Mambretti[2]

[1] Alcatel-Lucent, Italy
antonio.cimmino@alcatel-lucent.it
[2] Socrate Medical, Italy
{fulvio,cinzia}@socratemedical.it

Abstract. Today the major obstacle to massive deployment of telemedicine applications are the security issues related to the exchange of real time information between different elements that are not at fixed locations. WiMAX, the new standard for wireless communications, is one of the most promising technologies for broadband access in a fixed and mobile environment and it is expected to overcome the above mentioned obstacle. The FP6-WEIRD [1] (WiMax Extension to Isolated Remote Data networks) project has: analysed how this technology can guarantee secure real time data transmission between mobile elements, built some successful demonstrations and paved the way to future commercial applications. This paper in particular describes: main promising e-health applications that WiMax would enable; the technological highlights and the main challenges that WiMax has to face in e-health applications such as accounting, privacy, security, data integrity; the way in which the WEIRD project 0 has studied the wireless access to medical communities and equipment in remote or impervious areas. 0 0; some envisaged implementations.

1 Introduction

Today the major limit to the deployment of telemedicine applications consists in the impossibility to exchange secure real time information between different elements that are not at fixed locations. Examples of advanced medical services that wireless data and images transmission would make it possible are:

- **Remote follow-up:** to avoid travels that patients are obliged to undertake today in order to reach far-away hospitals to be followed-up after therapies or chirurgical interventions.
- **Remote diagnosis:** to fulfil the need to transmit urgent data in order to make an immediate basic diagnosis, e.g., in occasion of street accidents, for people in special health conditions such as peace-maker bearers, pregnant women, etc. Two sub cases are envisaged: Data are collected in a fix place; Data are collected on a moving medium, e.g. an ambulance.

D. Weerasinghe (Ed.): eHealth 2008, LNICST 1, pp. 38–49, 2009.

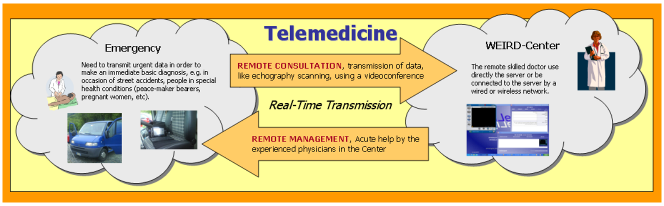

Fig. 1. WEIRD project European telemedicine application

- **Needs to intervene on non transportable patients** (e.g. accidents, childbirth at home): These cases may require off-air transmission of critical data or images (e.g. last echography, PET, real-time video).
- **Remote monitoring:** today elder people are remotely monitored only when at home, but not when travelling or simply walking in town or sitting in a park; remote monitoring will allow this too.
- **Remote assistance:** patients dismissed by hospitals often need to be reminded about therapies and medicines wherever they are (alarms, easy instructions).
- **Medical e-learning:** in order to allow doctors and caretakers to receive news, be trained, or just receive basic or advanced information directly to their premises or when travelling.

Today the use of these services is very limited, the main applications being in the educational field. Their take-off depends on the availability of the necessary wireless broadband access at acceptable costs and at acceptable security.

2 Service Framework

Hereafter few scenarios are described where the above mentioned services are offered to patients by using advanced transmission techniques, with the objective to identify the technical requirements that telemedicine sets to telecommunications.

Remote Follow-up

Patients affected by rare diseases or diseases for which highly expensive equipment are needed are treated in highly specialized medical structures and monitored once released.

Monitoring implies the periodic collection of medical data and images (echographies, ECG holter, spirometry holter, etc.) by a remote operator (in most cases the General Practitioner) and subsequent transmission to the specialized centre. Such data collection can take place either at a general practitioner consulting room or at patient's home.

The GP (General Practitioner) operator is equipped with portable equipment, such as ultrasound or ECG, and traditional tools, such as thermometer, stethoscope and digital pressure meter. He takes measures and images and transmits them to the specialized centre, adding verbal comments on patient's appearance or any other useful information.

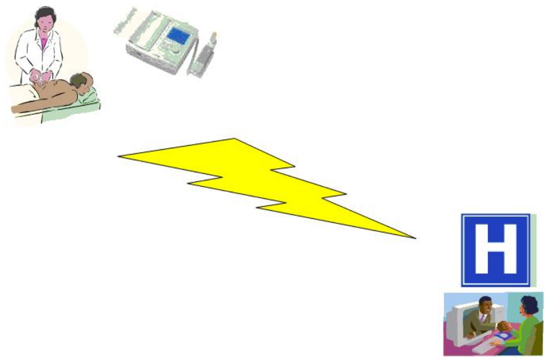

Fig. 2. Remote follow up: ECG exam in GP study

Remote Diagnosis

Remote Diagnosis is extremely useful when urgent interventions are to be prepared in the surgery of a hospital or specialized centre, e.g. in case a surgery has to be prepared to intervene on injured people or to cope with an urgent child delivery. The on-field operator is equipped with portable ultrasound equipment and traditional meters. Collection and transmission are as in the previous case (Remote follow-up). The wireless network must hold the session during roaming in the case that data are collected on a moving medium (e.g. an ambulance).

Today it is possible to perform basic remote diagnosis on ambulances which transmit data to their reference centres using satellite transmission and expensive end-user equipment: this prevents a broad adoption of these kinds of services.

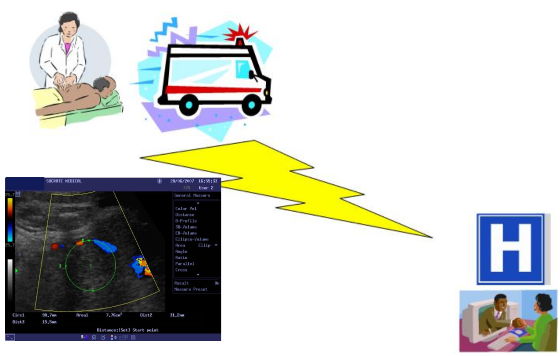

Fig. 3. Remote Diagnosis: examination taken during the travel to the hospital

Remote diagnosis in far-away and scarcely populated Areas

A different application of remote diagnosis is expected to expand rapidly in remote and scarcely populated areas (e.g. valleys on the Alps) where family doctors have to play broader roles and cannot send their patients to specialized centres as easily as in towns. In most of these cases the information exchange does not have real-time requirements, but the absence of wired broadband infrastructures may call for WiMAX capabilities.

Needs to intervene on non transportable patients

The need may arise either in urgency (e.g. an accident, a sudden disease) or not (e.g. a pregnant lady who decides to deliver at home). In both cases the on-field operator (the GP or first aid operator) may need the second opinion of an expert who can either be fixed (e.g. in hospital) or moving (e.g. travelling, on holidays). There can be the need for a technical discussion around an image simultaneously available at both ends. Even more, opening a videoconference session, the field operator has the possibility to show to the remote expert the data he is collecting (e.g. the moving echographic images), to ask for opinion and be followed while acting. This requires available bandwidth in the order of several Mb/s, VoIP and session holding when roaming.

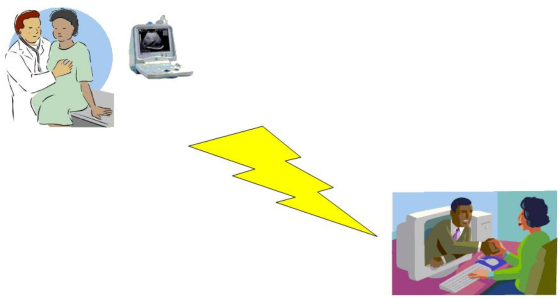

Fig. 4. Non transportable patient: caregiver at patient home supported by remote doctor

Remote Monitoring

Some people need to be full time real-time monitored (24 x 365) even if not hospitalized. These persons are equipped with an always-on equipment able to capture sounds, images and to perform simple measures (e.g., cardiac pulse). Collected information is transmitted to an operating centre In case something abnormal is evidenced, an operator gets in touch with the medical mobile centre nearest to the patient asking for intervention. This requires voice, video, and data transmission over the wireless network.

Remote assistance

This is a narrowband application consisting in sending alarms whenever the patient has to be reminded of making an exam or taking a medicine. Furthermore, the expert, that

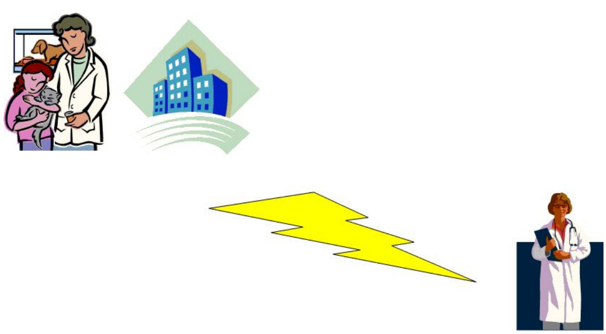

Fig. 5. Remote assistance: patient are reachable wherever they are

should be a doctor or another social assistant, should be easily reachable and able to support the patient at home with real-time or almost real-time opinions and instructions.

Medical E-learning

This is a standard e-learning platform that includes basic and advanced training courses and information for doctors. The most frequently asked questions and answers and other services that may improve the quality of the first medical service and reduce costs.

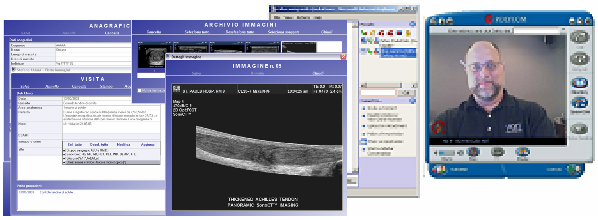

Fig. 6. Medical e-learning: expertise sharing

From a network requirements standpoint, the above services can be grouped in two classes: services requiring network session holding when roaming and services not requiring this feature. The following table summarizes the bandwidth wideness and service components that e-health applications require. It can be seen that all such requirements are expected to be fulfilled by the forthcoming WiMax technology.

Application	Patient data transfer	Patient medical images transfer	Patient medical streaming transfer	VoIp call	Video Conference
Bandwidth requirements	**64** Kbps	**128** Kbps	**512** Kbps	**64** Kbps	**256/512** kbps

3 Equipment and Network Evolution

Equipment wise, users can be assumed to have always portable end-user medical equipment. The progresses in both miniaturized technology and batteries let envisage that, in a near future, every-day-used portable medical devices will be equipped with wireless access (Wifi, UMTS, WiMax) in the same way smart phones are equipped today.

PC based ultrasounds able to collect echographic images and send it to a wireless network already exist, but their use is very seldom and limited to specific applications. Today these devices are used mainly for ergonomic reasons (are light and small) but they are hardly accepted by the medical operators. It is expected that the new generation of medical operators will show a different behaviour and overcome this psychological barrier. Furthermore the today geographically limited availability of broadband accesses will be overcome by WiMax.

4 Privacy and Data Integrity

Telemedicine deals with sensible personal data, therefore issues such as privacy, integrity, authentication, authorization are crucial in determining its viability. Data (including images) transmission for monitoring and diagnosis purposes must be authorized, authenticated and may be required to remain anonymous to some level of operators along the chain. Data storage is to be guaranteed for medical record tracking purposes. Data integrity needs to be guaranteed during manipulations and storing to avoid the risk of wrong prognosis caused by incomplete or mixed-up information. In urgent applications time is critical: to assure data transmission in real time priority has to be granted.

Designed by the IEEE 802.16 committee, WiMAX was developed after the security failures of early IEEE 802.11 networks. The 802.16 working groups designed several mechanisms to protect the service provider from theft of service, and to protect the customer from unauthorized information disclosure. A fundamental principle in these networks is that each subscriber station (SS) must have a X.509 certificate that will uniquely identify the subscriber. The use of X.509 certificates makes it difficult for an attacker to spoof the identity of legitimate subscribers, providing ample protection against theft of service and the 802.16e amendment added support for the Extensible Authentication Protocol (EAP) to WiMAX networks. Support for EAP protocols is currently optional for service providers. Also with the 802.16e amendment, support for the AES cipher is available, providing strong support for confidentiality of data traffic. Like the 802.11 specification, management frames are not encrypted, allowing an attacker to collect information about subscribers in the area and other potentially sensitive network characteristics.

5 Telecommunication Technology

The WEIRD project aims to exploit and enhance the WiMAX technology in a convergence layer heterogeneous network architecture, in order to cope with future needs of research user communities and to build testbeds allowing the European research backbone networks like GÈANT, GÈANT2 0 and relevant National Research and Education Networks (NRENs), to be reachable from isolated or remote areas. To build such a broadband access network infrastructure, and to improve the QoS and user experience, the WEIRD project workplan included the following technical challenges:

- Enhancements to the WiMAX technology
  - QoS support
  - Interoperability with mobility management 0 0
  - Radio-over-Fiber (RoF) techniques

- Enhancements to the IP network Control Plane
  - Advanced AAA
  - QoS support for real time critical applications,
  - Resource management to control bandwidth allocation
  - Roaming mechanism for connections of nomadic researcher stations to GÈANT
- Supporting studies and deployment recommendations
  - Simulations
  - Network planning,
  - Device configurations
  - Guidelines and best-practices for the permanent deployment of the WEIRD architecture in GÈANT and NRENs
  - Liaisons and project feedback with all sponsoring research organisations (GARR, ROEDUNET, RED.ES, FUNET).
- Liaisons with all projects relevant to WEIRD and progressing in FP6 and EUREKA programs.

6 Weird Applications Scenario

The scientific user communities that have participated into the project are the Fire Prevention Laboratory of University of Coimbra – Portugal, the Association OASI Maria SS - Italy, the Osservatiorio Vesuviano Volcano monitoring scientific site Italy and the Icelandic Meteorological office - Iceland. These communities have described their user scenarios that will drive the specification of system requirements and subsequent specifications.

The main scenarios in which the WEIRD system shall be able to operate are:

- WiMAX as a wireless access infrastructure for research networks in remote areas
- Broadband access for fixed remote research sites where wired solutions are not cost-effective
- Broadband mobile access for nomadic personnel and aggregation systems collecting data from sensor equipments in impervious areas (e.g., volcano)
- Broadband mobile access for fire monitoring and prevention
- Broadband mobile access for medical personnel requiring high resolution medical information in nomadic emergency situation
- Broadband mobile access for high resolution tele-hospitalization.

The technical solutions developed within the WEIRD project have been implemented, tested and validated in four testbeds deployed in Europe. The testbeds are located in Finland, Italy, Portugal and Romania, and the interconnection between testbeds is based on the pan-European GEANT2 research network (Figure 7).

The testbeds have different profiles and technology according to the aforementioned scenarios. Moreover, every testbed is specialized in order to highlight certain technical solutions. Thus, the WEIRD Project moves in a considerably large and rich domain for validating the developed solutions. This is considered as one of the most valuable and unique assets of the project. Even though not all of the application scenarios and technical enhancements are developed in every testbed, the project aims to provide the

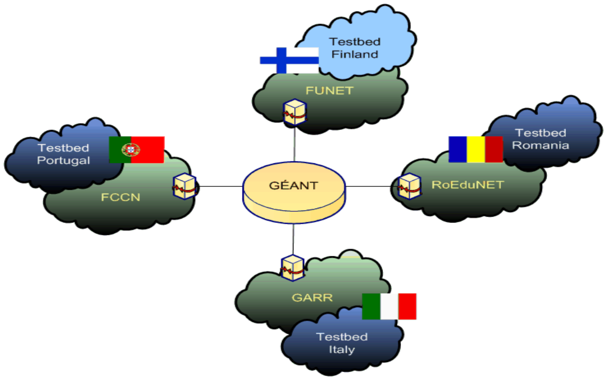

Fig. 7. WEIRD project European testbeds interconnection through GEANT research network

developed solutions for each testbed at the end of the project and to demonstrate some interworking of the selected applications in larger scale e.g. the Video over IP and VoIP transmission through the pan-European research network. The WEIRD architecture 0 has been designed to seamlessly integrate and support all the mentioned applications, including e-health. To achieve this aim, an API (WEIRD API) has been specified and implemented on the client side of the network. This API provides an interface between the e-health application and the QoS signaling protocol that has been chosen for the project – IETF NSIS 0. For the integration of the e-health application with the WEIRD API, it has been necessary to modify and adapt the application, allowing the required QoS parameters to be conveyed to the NSIS protocol. NSIS forwards the received QoS information to the network side QoS management entity, and the later will perform the resources allocation on the WiMAX link. This process guarantees that e-health applications will have the required bandwidth allocated on the WiMAX link in order to have a good performance without traffic disruption.

7 E-Health Demo Scenarios

Today the major E-health is one of the application areas more benefiting from WiMax Technology. The main object of telemedicine is to allow people in remote sites to exchange patient data, diagnostic images and video streaming generated by medical devices without any quality loss during the transmission. The required bandwidth depends on the application and should be increased or decreased on demand. In order to support emergency applications the data exchange should be done in fixed place as well as travelling. E-health applications can use voice and video over IP in order to support real-time communications in case of emergency. In addition, the same applications could support services such as remote assistance and patient's monitoring as well as distribution and collection of data. Scalable Collaborative platforms with web interfaces could be deployed by the medical authorities and easy administrated. As a result of the above presented scenarios, e-health applications represent excellent drivers for both broadband and mobility requirements. The need to have an always-on broadband link between the ambulance and the serving hospital is a strong requirement for both WiMAX and

3G-HDSPA/LTE architectures. The channel availability is an issue that cannot be solved with traditional 3G/GPRS deployment. WEIRD project has also analysed 0 0 the potential market for such telemedicine applications and drivers on based on the analysis made available by the WiMAX Forum (Figure 8).

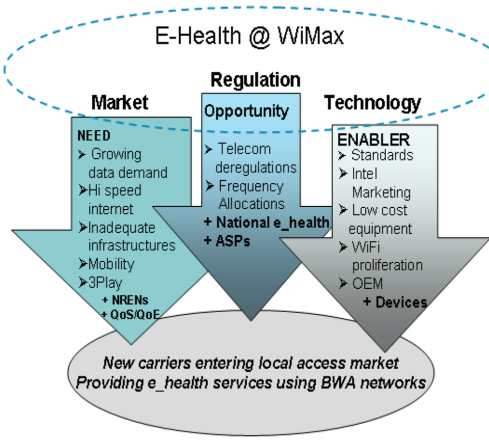

Fig. 8. WEIRD E-Health Market Drivers

Improving the efficiency of internal processes is one of the key business issues in the health and social sectors. Whereas the basic technical telecommunications and public infrastructure, including physical networks, generic interoperable services and adequate security, are in place in most Member States 0, a crucial layer comprising servers and services (ASPs) for sharing (regulation) both patient clinical and back-office information and thereby providing the missing connectivity is largely lacking, as is the upper layer of e-commerce applications to support patient care processes, the management of facilities and the (quality) control of health systems and thereby may be expected to become the economic drivers for e-business diffusion 0.

Another aspect is that the sector is a highly regulated national, often even regional market. Trends such as the expansion of private hospital chains and other private actors entering the market may change this over the years to come. Figure 8, shows and decouples market drivers for e-health applications using WiMAX technologies. On top of existing analysis of WiMAX Forum, new elements (+) have been added for the market, regulations and technologies.

8 Conclusion

Today the major Broadband Access Technologies like WiMAX are enabling factors for e-health solutions. WiMAX can yield additional benefits in term of availability of broadband communication channels, QoS, interworking with convergent networks and mobility of the subscribers.

Today a large number of activities are carried out with limited success, unnecessary costs and human difficulties because of the impossibility to exchange real time information between different elements of the chain that are not at fixed locations. The massive commercial availability of WiMax technology and WiMax based services will make these activities cost-effective and successful paving the way to the realization of an e-health environment. Here following are reported some real cases of today, costly and therefore limited applications, that the availability of WiMax will make cost-effective thus opening new opportunities for business and social development:

– Oasi is a Sicilian clinical research institute active in the field of mental disease. This institute provides diagnosis, care and rehabilitation for its patients when at home after hospitalization other than training and support to caregivers and patients' relatives. Today this implies a large number of travels to both patients and caregivers from/to hospital. Oasi is waiting for WiMax large scale availability both to avoid these unnecessary travels and related costs and to improve services and features.

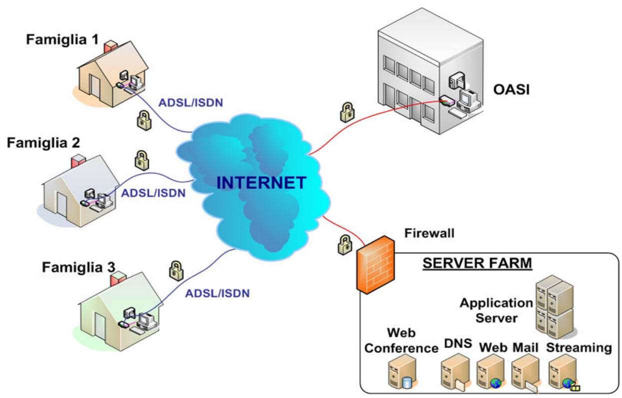

Fig. 9. OASIweb architecture

– SIMG is the most active organization of General Practitioners in Italy and plans to implement a web-based e-learning system with the objective to distribute to its associates new scientific and technology findings, thus keeping them constantly updated, organise courses on basic use of ultrasound systems as first opinion, and give full time on-line support. The present obstacle to the implementation of such business model is constituted by the mobility characteristics of GPs. A WiMax-based solution is under study to overcome this blocking factor.
– There are several similar cases of remote diagnosis in isolated far-away areas such as in Latin-America. An example is represented by the management of the so called Tele-salud centres which provide first level care in remote areas such as Amazonia and Andes. Today the clinical reporting and second opinion are provided using expensive and low efficient radio and satellite connections. WiMax will highly improve both operational costs and efficiency.

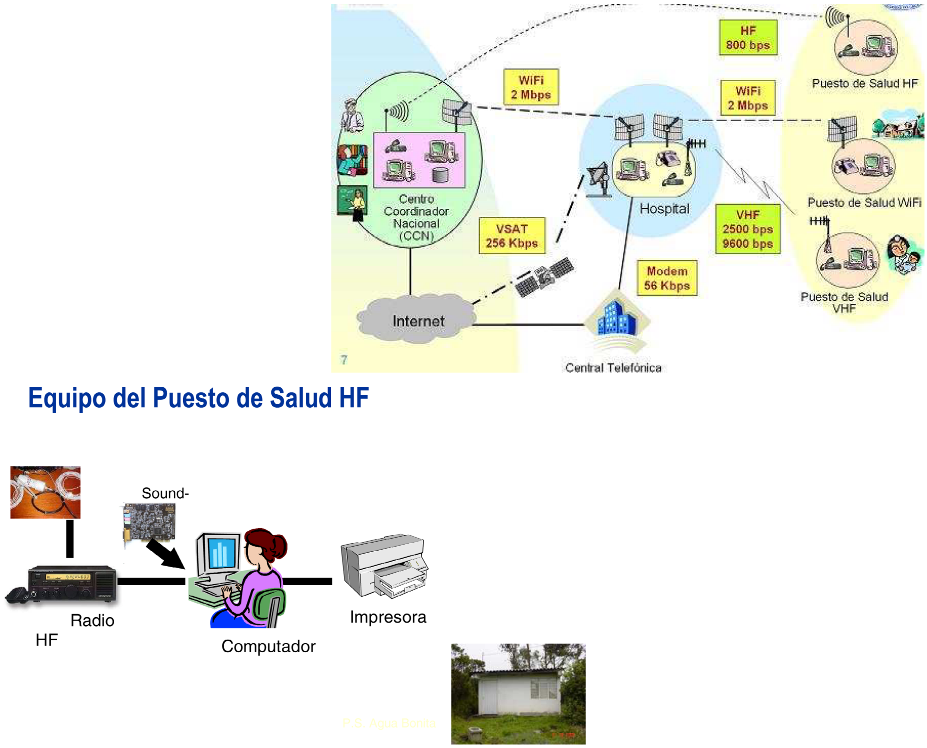

Fig. 10. Telesalud network and remote site

The Project FP6_WEIRD have studied these business models for social applications such as telemedicine and environmental monitoring (fire prevention, volcano monitoring) and the business case results are almost the same: R&D organizations have developed the needed technologies that industry is ready to bring into products and make available on large scale. The public sector is expected to trigger the process thus representing one of the major drivers for broadband mobile technologies.

Acknowledgements. This work is partially supported by European Project WEIRD (IST-034622-IP). Authors thank the partners of the WEIRD consortium for their valuable help.

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