Chapter 3

Flexible Intelligent Heterogeneous Systems for Enhancing Quality of Life

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1.1 INTRODUCTION

Looking-ahead to the 10-15 years mid-term, users (people and other entities) will require the access, as simple and natural as possible, to a multiplicity of services and available applications (ideally 'an universal service') provided and supported by a convergent and integrated system of technologies ('an integrated system of systems'). To this end ICT can provide a breakthrough by the integration of communication, localization and sensing functionalities made available to clouds of users by a self-consistent heterogeneous and flexible system.

Key features of this strategy are:
- the applicability to an as large as possible set of future services, having diversified and even divergent requirements
- system intelligence (sensing, learning, decision, action), reconfigurability, adaptability, energy efficiency and security
- context awareness (physical, environmental, situational localization)
- exploitation of the benefits of clouds of users
- highly efficient communication systems to deliver all the necessary information in due time, where needed, with required quality of service (QoS) and energy efficiency
- effective and synergistic cooperation among all the potentially available technologies.

Such features identify a system in line with the objective which have been explicitly defined by the European Initiative Horizon 2020, with a clear remind to the “Better Society” concept (i.e. “Longer and Healthier Lives” and “Inclusive Innovation and Secure Society”) [1].

All these key issues can be addressed by defining a reconfigurable heterogeneous telecommunication infrastructure (a platform) which can integrate localization and sensing capabilities, terrestrial and satellite communication subsystems and intelligent objects and networks with the ultimate goal of improving the quality of life of the citizens and users in several common scenarios, such as for example:
- people experiencing daily living difficulties at home (e.g. elderly people, chronic disease patients)
- people faced with a sudden emergency situation
- searching a Missing Person
- better user mobility in urban environment
- emergency and crisis management.

These innovative platforms must be highly reconfigurable in order to adapt to different application contexts and exploit the most recent intelligent distributed computing and social interaction technologies (i.e. software agents and cloud computing) by suitable middleware implementations: the objects establish autonomously social relationships of different kinds (e.g.: co-work, co-localization, co-ownership, transactional) and end up composing, maintaining and providing services and information to/from external apps and services. As an example, the system should be able to update the configuration parameter of a handheld device (e.g. an Android Smartphone) to provide the right information when and where needed (e.g., about a person entering a first aid, by providing the right information, such as “your relative is hospitalized in the orthopedic department”).

This Chapter is organized as follows. Section 1.2 is devoted to the description of the applications which can improve the quality of life: a particular emphasis is given to tele-health and emergency services. Section 1.3 describes the flexible heterogeneous architectures which can be used to enhance services for the quality of life, whereas Section 1.4 presents some results which have been already obtained in these fields. Finally, Section 1.5 provides conclusions and some future perspectives.

1.2 APPLICATIONS FOR QUALITY OF LIFE

Due to recent technological and societal changes it is clear that our society is moving towards a future in which telecommunication platforms will be integrated with heterogeneous systems of localization and sensing capabilities and in which intelligent objects will cooperate as in human social networks with the goal of providing services to the people at different level of complexity. To achieve such a visionary scenario, each component has to be designed (and often redesigned) taking into account a remarkable level of generality and universality that characterizes the new telecommunication entities and the new architectures and infrastructures have to be defined considering a plurality of services and applications with a low (ideally with no) reset effort. This platform can support applications in agreement to the objective defined by Horizon 2020.

1.2.1 Integrated Localization/Communications/Sensing (LOC/COM/SENS) Networks for Emergency Applications

The typical emergency scenario refers to a situation of public emergency (e.g., fire, earthquake, flood, explosion, big accident), where several rescuers, organized in teams, convene to the emergency area from different locations, possibly with different transportation means, likely equipped with tools for the intervention (e.g., water or stretchers). They belong to one or more emergency response organizations, e.g., police, fire service, and emergency medical services. A general emergency scenario and typical requirements for telecommunications systems are as follows.

1.2.1.1 Emergency Scenario

Every member of the rescue team of First Responders (FRs), as well as the Emergency Vehicles (EVs), is normally equipped with a portable radio transceiver, with advanced and integrated localization/communication (LOC/COM) capabilities. Localization capabilities are necessary to determine the terminal position (desired accuracy would be 1–2 m), using both Global Navigation Satellite System (GNSS) services and, in case of lack of a satellite radio link, terrestrial network-based positioning methods. In some cases, also the members of the same team or of other teams may need to know their reciprocal positions, for safety reasons.

The following elements could also be part of an emergency network:

- a communication facility which guarantees the connection (possibly through a satellite/High-Altitude-Platform-HAP) between the Emergency Control Center (ECC) and people operating in the emergency area. It is a temporary, mobile, or transportable station placed at the boundary of the emergency area and acting as a master node for the local network
- the HAP, moved on-demand above the emergency area to provide ad hoc and temporary communications capabilities. It can connect the Mobile Master Node (MMN) with the ECC and possibly the emergency vehicles (which have higher available power than the first responders' terminals) with the MMN
- the satellite, able to guarantee very long distance communications between the MMN and the ECC and the ECC and the emergency vehicle (EV).

1.2.1.2 Requirements for Emergency Systems

The requirements of radio communication systems for emergency rescue applications which have been issued by international standardization committees have been clearly identified and thoroughly described in [2]. Communication requirements for emergency services shall guarantee that the required information is available to the correct person or organization at the appropriate time. In essence, communications must be timely, relevant, accurate and secure for all actions that may be undertaken: particularly, the efficiency of the emergency operations is dependent upon the ability of the communication networks to deliver timely information among several authorized emergency teams.

The main requirements for providing efficient and effective emergency services can be summarized as follows:

- fast call setup: typical requirements for voice call establishment times are in the range 0.3–1 s, with 0.5 s often cited as the requirement for wide area operation. For voice-over-satellite connections to a remote ECC, such requirement shall be relaxed and call establishment times in the order of 1–2 s are customary
- instant access: the need for radio capacity is increasing during major incidents and accidents, so efforts have to be made to ensure, as much as possible, that adequate communication facilities be available
- quality of service: voice (or data transmission) quality should be adequate to guarantee the understanding (or correct reception) of the message
- seamless radio coverage: possibly throughout the whole served area availability of radio coverage should be guaranteed also under exceptional conditions (e.g., power supply outages, etc.)
- controlled network access: in order to guarantee controlled load of the network, under certain circumstances, priorities or restrictions should be assigned to specific users
- specific functionalities: advanced features, such as group communications and dispatching, security and encryption, and dynamic resource management, would be very useful.

The fulfillment of the above requirements normally remains under the responsibility of a variety of public authorities, such as national ministries responsible for emergency and security, international agencies, European and national police, civil protection agencies, coast guard, fire brigades, local authorities, etc.

1.2.1.3 An Integrated Approach for Emergency Situations

In emergency conditions, especially during the intervention and mitigation phases, the availability of LOC/COM/SENS devices lead to remarkable gains in terms of speed of response, completeness and effectiveness of intervention [3][4]. Because of the different networks in the considered scenario, these benefits can be completely exploited using reconfigurable and interoperable systems.

Efficient and complete emergency systems can be provided by the synergistic use of communication, positioning and global monitoring services: this trend is confirmed by the initiatives of security and safety agency, research institutions, standardization organizations and by the European Commission guidelines.

Therefore, an integrated communication, localization and sensing system is of tantamount interest for all of the emergency management phases. Particular attention should be given to the integration among the techniques, conceived as stand-alone and not necessarily oriented to multi-disciplinary applications.

To this aim, the following subjects have to be carefully considered:
- the methods of collection, analysis and integration of pre- and post-event GMES data, the data fusion techniques among the information coming from earth observation systems and the information collected by sensors deployed on site
- the context evaluation through cognitive approaches in order to identify the best transmission strategies, taking into account the scarcity of resources in an emergency context
- the advanced localization techniques which are based on the use of Global Navigation Satellite Systems (GNSS) assisted by available positioning information, which can be derived from both the communication and monitoring network.

In this framework, better performance can be achieved through the adoption of adaptive cooperative approach based on communication among users, communication network, emergency control and coordinator center and HAPs or mini-satellites.

The emergency systems which are based on the described approach are characterized by meshed heterogeneous architectures based on both satellite and terrestrial segments: in particular, the use of survived networks, i.e. networks which are involved in the disaster but still partially operating, and networks deployed after the critical event in the intervention area should be guaranteed. Alerting and control signaling are defined according to opportunistic, cognitive and cooperative paradigm. In the satellite and terrestrial components particular attention are given to the definition of terrestrial infrastructure and communication protocols for the transmission of the localization and sensing information, collected with frequency and reliability suitable for an emergency scenario.

The integration of sensors and terminals (even wearable) with other emergency networks represents another important issue: these devices, commonly seen as part of the object domain, can transmit biometric information, data, images also taking part in data fusion procedures on the involved area and through cooperative interactions among the devices themselves.

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1.2.2 Tele-Health Services

In the last few years the role of ICT (Information and Communication Technology) in the health system has been one of the main investigated research area [5], [6], [7]. In this context the design of an integrated interactive system for telemedicine services is required both for clinical studies and for self-care purposes: indeed the integration of distributed medical competence and clinical information contributes to the quality of medical care. Although prevention is in all Governments Agenda as the strategy to intervene on population life style and behaviour and to maintain as long as possible people in healthy conditions, nowadays there are very few population management programs that try to intervene on the lifestyle and behaviour modification. Indeed, the acute-desease people are about 20% of the population and represent the cause of the 80% of the healthcare expenditure, while the remaining population is responsible for about 20% of the healthcare expenditure.

In the following subsections the Tele-Health services are described, starting from an accurate analysis of both the state of art of the available services and applications and the user (patient and specialist) requirements. In particular both the Self-Care and the Assisted services are considered.

1.2.2.1 Self-Care Services

Primary prevention represents a big opportunity for interactive systems, with respect to the traditional information campaign, allowing to guide people in adopting correct and healthy life styles, by knowing patients feelings, concerns, habits and relationship with their illness.

The Self-Care Services offer a range of tools, functionalities and services supporting lifestyle improvement and wellness. This goal can be reached by means of tools able to convince the user about the value of this change of behaviour and with the capabilities of supporting him/her through an easy and attractive change process. The user-system interaction level can be decided by the user, who can only give essential information to the system or make some biometrics measurements to assess his health status or to be an active user by adhering to specific care plans.

1.2.2.2 Assisted Services

Considering prevention as a big opportunity for Healthcare system in order to reduce the impact of chronic disease on the population asks for a growing demand of technological solutions that can:

- support the increasing number of chronic diseases
- increase ICT integrated systems for easy fruition, exchange and management of clinical data, supporting the medical staff, providing easy access to health data
- reduce the number increase of medical errors and Adverse Drug Effects (ADE).

Two different services can support physicians and healthcare professional activities in this environments, aiming at answering these demands: e-clinical studies and tele-consultation services.

E-clinical studies services make easier and more efficient the work carried out by the experts in e-trials thanks to the continuous monitoring and management of incoming clinical data, which include the use of cryptography for privacy enforcement.

Tele-consultation services enable healthcare professionals to share patients data for early diagnosis and clinical cases discussion, allowing people to access periodical clinical check-up for prevention and avoiding medical institutions congestion.

1.2.2.3 The role of Patients/Citizens

The Health services should also be "accessed" through mobile phones, smartphone or PDA: in particular this feature could provide the opportunity to:
- access to portals that provide information about the health of citizens
- access to virtual communities and support groups and online support where people can share experiences and information but also specific data content in different EHs (Electronic Health Record)
- access to services for Homecare, even to receive "chronic disease management services" to run the care at home
- access to telemedicine and teleservices that enable collaboration among health professionals.

Therefore, in this context, the creation of personalized health networks, namely of networks that are focused on the concept of PHR (Personal Health Record) as a health personalized issue, is of great importance in the social network dedicated to health and diseases. This is also true in the case where the interface is with the ESF (Electronic Health records) in which a citizen, not just the doctor, inserts the data and personalized information on health. In this framework, the citizen becomes the focal point of the new health ecosystem and collaborates and shares information with not only health professionals but also with other citizens. This model is aimed not only to citizen patients but is open to all those who want to improve relations with their health, quicker and easier interaction with the social and health institutions.

1.3 FLEXIBLE HETEROGENEOUS ARCHITECTURE

The general network architecture to be adopted to provide services for enhanced quality of life is defined and two specific solutions for tele-health and emergency scenarios is presented.

1.3.1 Baseline architecture

The goal of a synergistic use of communications, localization and sensing services, provided by means of meshed heterogeneous architectures based on satellite and terrestrial segments, can be afforded by the use of the most recent cognitive, cooperative and context- and location-aware technologies, with deterministic and opportunistic radio access: a fully interoperable architecture is enabled by the distributed system intelligence and by suitable application programmable interfaces (API).

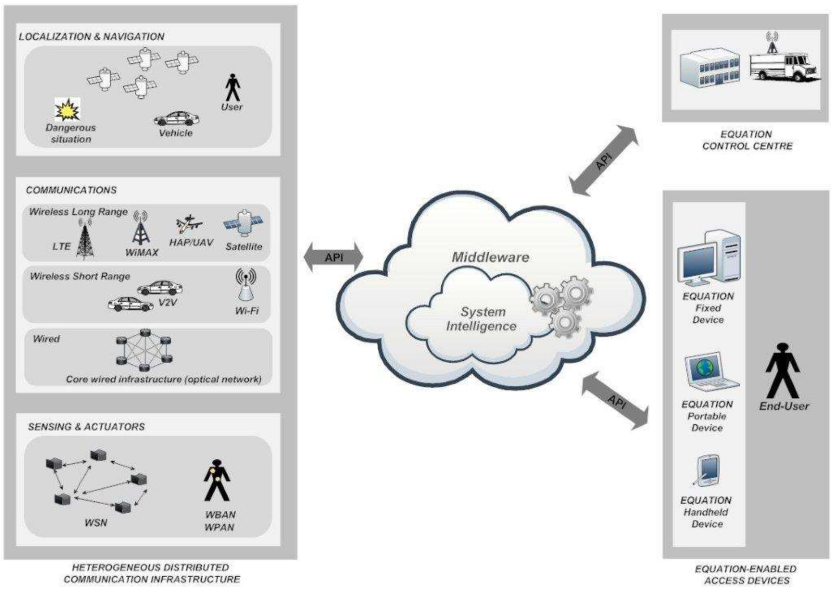

Figure 1: Baseline System Architecture.

The system baseline architecture in Figure 1 is as general as possible by assuming that the proposed platform can encompass interfaces to any kind of enabled devices (i.e., fixed, portable and handheld ones) and to suitable control centres and also to both wired and wireless public communication networks and to the most general localization and sensing systems. As a result, a key role in the baseline architecture is taken by the middleware, which is aimed at integrating all the heterogeneous components (coming from the separated domains, such as localization, communication, and sensing) in a common stratum that implements the basic functionalities for the discovery, management, composition, and activation of all the services provided by the distributed infrastructure. On top of the middleware the applications are executed, which provide the complex system intelligence functionalities.

The definition of the middleware architecture involves the usage of the newest distributed computing and social interaction technologies, in particular software agents and cloud computing. One issue that needs to be carefully addressed is the definition of an unambiguous description for objects and infrastructure components that "live" in the virtual world defined by Internet of Things (IoT). Another issue is the scalability in discovering and exploiting the services provided by the distributed components.

This architecture also allows the study and the design of advanced and assisted localization techniques based on the use of Global Navigation Satellite Systems (GNSS), like GPS and Galileo, jointly with additional information available by means of a cooperative approach among users. GNSS interference reduction techniques have also to be developed and analysed, taking into account the cooperative/distributed strategies in order to maximize the efficiency of the proposed solutions. The system intelligence supports the interoperability of the sensor networks with the communication systems, so allowing context aware capabilities of the system. In this general framework of reconfigurability, cognitive and cooperative paradigms are adopted, aiming at achieving the benefits which are guaranteed both at the transmission layer and at the network layer: specifically, the cognitive approach is focused on both distributed sensing and the definition of a cross layer solution, where QoS and energy-efficiency requirements are included. The use of the cooperative paradigm can act as a booster to provide general, ubiquitous, energy efficient services for quality of life improvement.

Main drawbacks of this distributed reconfigurable systems can be identified in energy consumption and security/privacy issues. Aiming at increasing the operating time of battery-powered systems, the devices and systems have to pursue the maximization of the energy efficiency with any possible strategies, such as link adaptation techniques, efficient resource management, cognitive/cooperative communications and distribution of heavy computing functionalities by mean of cloud computing.

Both cryptographic techniques to enforce key management procedures and network security protocols, such as IPsec, should be considered to create secure, authenticated, reliable communications over IP networks, providing a high efficiency security procedures to protect IP datagrams (IPv4 and IPv6).

1.3.2 Emergency Integrated Architecture

As anticipated, the future integrated emergency systems will be characterized by the utilization of meshed heterogeneous architectures, based on both satellite and terrestrial segments; the satellite and terrestrial components are defined with particular attention on the transmission of the localization and sensing information, even though for some services the satellite component may be not necessary, neither for communications nor for sensing.

In this architecture (Figure 2) the satellite infrastructure plays a lead role for its independence from the catastrophic event as well as for its ability of collecting information created by sensors deployed on the territory. This system covers the issues of sensing, security and safety information, through the collection of information via satellite and in-situ and the data harmonization capability.

The considered architecture enables an assisted localization, through the integration of GPS information and the information received from other in-situ terminals. The processing issues, required by the adoption of data fusion techniques for sensors and cooperative terminals in emergency scenarios, also play an important role particularly for data aggregation of sensors and terminals.

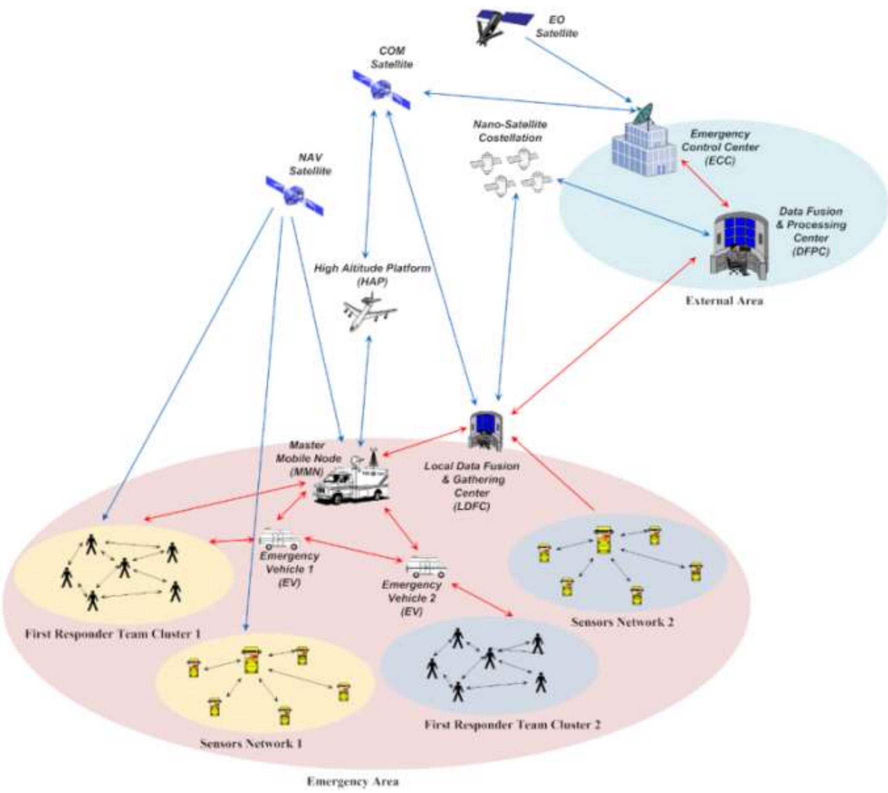

Figure 2: Emergency System Baseline Architecture

The sensors, terminals and interfaces used in this architecture aim to the acquisition and integration of biometric and geographic data from different places on the territory: they are highly re-configurable due to the large number of systems that could have be survived to the catastrophic event, include advanced localization functionalities and manage adaptive coding of source (video) and transport on multiple channel. The introduction of object domain deals with both sensors and teams as elements of the acquisition network. Assuming that pre-existent (to disaster) communication networks are totally or partially unavailable, by spectrum sensing techniques, spectral "holes" will be highlighted and opportunistically used for emergency communications.

1.3.3 System Architecture for e-Health Scenario

The definition of both the network architecture and the services platform solution for e-Health services derives from an accurate analysis of the user's needs. In order to perform the implementation of the overall e-Health infrastructure the following steps have to accomplished:
- definition and development of the services platform
- identification of the network requirements to support the defined services
- design of the network architecture satisfying the network constraints, exploiting different technologies characteristics and capabilities
- security and end-to-end QoS solution implementation.

1.3.3.1 Network Architecture

The provision of e-Health services through the implementation of an interactive service platform, including real-time audio and video interactions among patients, specialists and health service providers, requires the deployment of an interconnected system based on an integrated and interoperable telecommunication network, which consists of both terrestrial and satellite segments.

Figure 3 describes the overall network architecture to provide the quality of service required by the considered e-Health applications, optimizing and minimizing the offered service cost. As shown in Figure 3, both citizens and physicians can access the interactive Service Platform from different locations (e.g. Health Points, Hospitals, Home) regardless of the chosen access technology, either satellite or terrestrial.

1.3.3.2 Service Platform

The Service Platform (an example in Figure 4) aims at sharing health information among different applications and services (Self-Care and Assisted) and it is based on the Health Integration Engine (HIE). This module guarantees the information exchange among the e-Health subsystems (Personal Health Media (PHM), Electronic Health Record (EHR), Electronic Clinical Research Form (ECRF), Clinical Health record (CHR)), creating work-flows and rules to acquire, manage and route health data. HIE emulator implements SOA (Service Oriented Architecture) paradigm and deals with all messages to/from the HIE compliant with the HL7 (Health Level Seven).

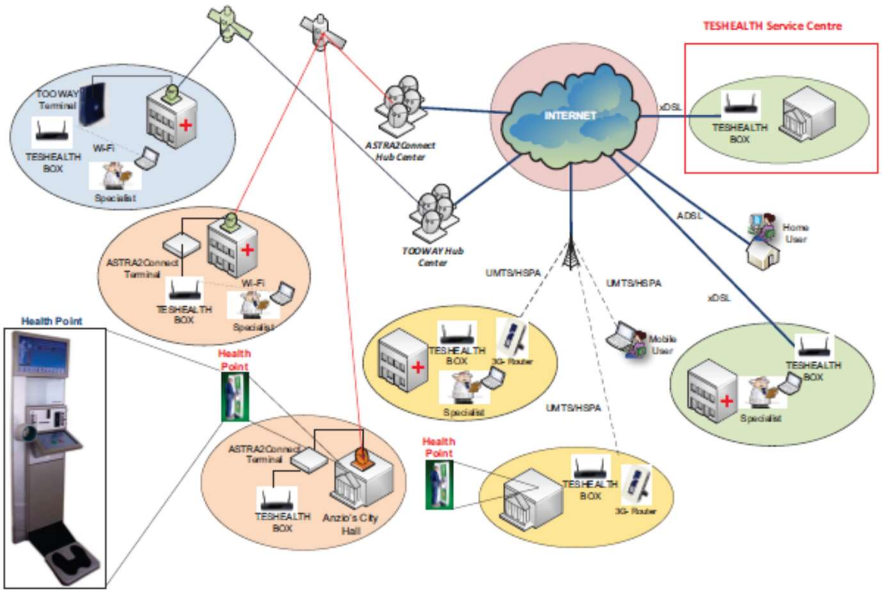

Figure 3: e-Health Network Architecture

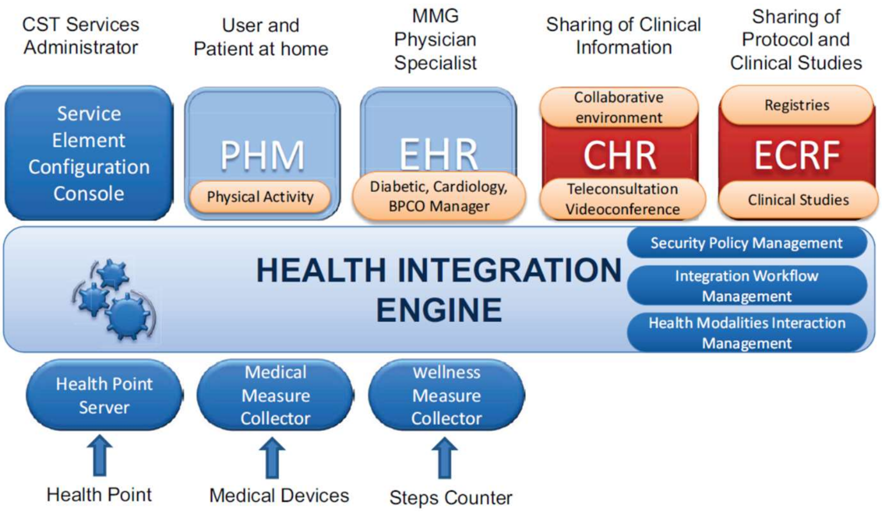

Figure 4: Service platform for e-Health Applications

1.4 SERVICES AND SYSTEMS FOR QUALITY OF LIFE

Some results are presented that have been already obtained in the field of Quality of Life improvement with specific reference to Emergency and e-Health applications.

1.4.1 Satellite-Assisted Localization and Communication for Emergency services

For the emergency systems it is worth mentioning the main results recently obtained in the framework of the Italian National Research Project SALICE (Satellite-Assisted Localization and Communication for Emergency services), funded by the Italian Ministry of University and Research [8]. SALICE aimed at studying the integration of different technologies for terrestrial and satellite communications and localization in a single infrastructure by means of a digital platform implementation based on Software Defined Radio (SDR) technology. Some of the main achievements of the SALICE project are reviewed [9].

1.4.1.1 Cooperative Relaying

Hybrid satellite/terrestrial cooperative relaying strategies are proposed for public emergency situations aiming at guaranteeing communication between the emergency area and the external areas [10]. As reported in [11], the combination of the hybrid satellite/terrestrial network, OFDM-based as proposed by the DVB-SH standard (SH-A Architecture), with the cooperative delay diversity (DD) relaying technique can be effective to overcome the performance loss in the non-line-of-sight environment. Moreover, cooperative relaying can be very effective in improving reliability and overall system performance: this could be especially important when the connectivity in a disaster area has to be restored and guaranteed.

In this cooperative scheme, the spatial diversity is mapped to frequency diversity to decrease the error rate: this feature achieves a remarkable performance improvement by the use of FEC codes. Both the satellite component (SC) and the complementary ground component (CGC) are included.

Results of computer simulations are presented in Figure 5, where the following working conditions have been selected: mode 1 K, signal bandwidth 5 MHz, OFDM sampling frequency 40/7 MHz, OFDM symbol duration 179.2 s, OFDM guard interval 44.8 s, QPSK modulation, turbo code (code rate 1/4). The channel propagation models are: Lutz model and TU6 model for the satellite and the terrestrial channel, respectively [12]. The one-relay and two-relay schemes are considered in an urban environment, which represents the worst case. The bit error rate (BER) performance is reported for different values of the delay in order to represent the impact of this value on the DD scheme; in addition in order to implement a more realistic case, a different power allocation between the SC and the CGC is assumed (unequal power): specifically, the copies of the signals coming from the CGCs (all types) are characterized by a higher power level with respect to the signal from the satellite.

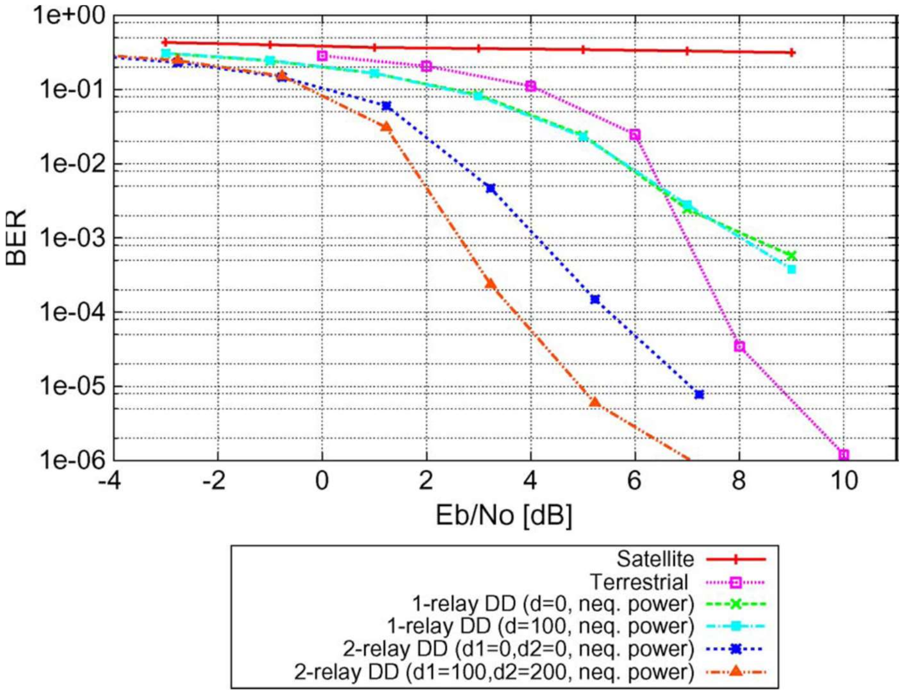

Figure 5: DVB-SH Performance comparison among: Satellite-only, terrestrial-only, one-relay cooperative DD and two-relay cooperative DD in city environment.

The presence of more than one relay, increasing the frequency selectivity of the channel transfer function, permits to achieve a significant BER performance improvement.

1.4.1.2 Cooperative Localization

The use of hybrid positioning systems can increase accuracy and reliability by combining the pseudorange measurements of both GNSS and terrestrial ranging systems [13]. In emergency scenarios, the use of these cooperative approaches is mandatory, as the environmental conditions where the users' terminals are likely to be used can be extremely hostile for a standard GPS-based navigation receiver (indoor environments, urban canyons, operations under foliage, etc.). Assisted-GNSS (A-GNNS) systems improve the standalone GNSS localization performance by using alternative networks to satellites (e.g., cellular network or the Internet) to provide the assistance data when and where no clear view of sky (e.g., light-indoor zones) is available. An innovative A-GNSS-like system, which does not rely on the existence of a prestructured communication infrastructure, is presented in [14]. It relies on a ”peer-based” cooperation architecture in which each user's device (the aiding user) acts as a server and sends its own estimated satellite localization data to the aided user. While rescuers are usually equipped with GPS-embedded terminals, victims may simply own a mobile phone or a smart phone.

1.4.2 Telemedicine Services for Health

As for the e-Health services and applications, some results achieved in the framework of the European Space Agency (ESA) project TElemedicine Services for HEALTH (TESHEALTH) [15], [16] are summarized: this project demonstrates a new opportunity in the marketplace, providing people unprecedented easy access to health and well-being related services. Specifically both the Self-Care and Assisted services are mentioned.

1.4.2.1 Self-Care Services

For Self-Care services the tools developed in the framework of the TESHEALTH are the the PHM and the Health Point.

The PHM is designed with the aim to help people to better know their body and adopt right life style. Acting as a tutor the PHM supports people in planning daily actions, thanks to an updated logbook dedicated to specific activities (e.g. check some parameters, make physical exercises, etc). In order to achieve the previous objectives the PHM includes a repository of care plans for primary prevention, which involves both the adoption of an alerting system (via SMS or email) for planned activities and a reporting system to make people aware of their results. In addition in order to allow people to share clinical information with the doctor, relatives and friends, it provides a documents and data storage. In detail, the PHM is a platform based on a three tiers architecture (Data layer, Back-End layer and Front-End layer). The Front-End layer represents the interface between user and the PHM system managing the graphical and textual messages. The Back-End layer hosts applications offering services to the Front-End layer. The Data layer is a database server used to store all data managed by the PHM application.

The Health Point is a remote device (a kiosk), that can be located in public buildings like pharmacies, allowing users to check autonomously some biometrics measurements. It permits to accurately measure: blood pressure, cardiac frequency, weight, body mass index and body fat. Consequently the cardiovascular risk evaluation can be estimated. These information are sent to the PHM in order to update the user health record.

1.4.2.2 Assisted Services

For e-clinical studies the application scenario of these services is based on ECRF platforms and encompasses a multi-centric study, which includes a core lab as study monitor and several peripheral clinical centres as contributors to the study. Specifically, it involves the exchange of data among ECRFs (through the HIE) of a patient monitored in a multi-centric study between two hospitals. As an example, this permits to perform a study of a group of patients with cardiac chronical problems, by gathering a broad set of homogeneous data in a specifically dedicated database, which includes data collected during standard clinical exams. Patients enrolled in the protocol are followed up with periodical exams in hospitals and periodical controls, performed by operators at home. Collected data are transferred to the ECRF to perform controls and verify the protocol.

The ECRF application has three logical tiers:
- presentation tier: it implements the User Interface (UI), communicating with the Application and Data tier through secured Web Services and UDP for interactive multimedia. It includes the ECRF Web framework and the integrated collaborative video client
- application and data tier: it represents the backend of the application, including the Web and the collaborative video servers and also implements the application business logic
- HIE tier: it provides the bi-directional exchange of data between the ECRF application and the other TESHEALTH subsystems.

Tele-consultation services enable healthcare professionals to share patients data for early diagnosis and clinical cases discussion, allowing people to access periodical clinical checkup for prevention and medical institutions congestion reduction. A teleconference module includes a set of functions as data storage and forwarding, collaborative working, virtual meetings, session scheduling, on-line video transmission and video-education.

Direct communication between users at different locations is provided. For example an expert could have a patient whose data need to be discussed with other centers. A virtual board enables all participants to exchange messages in a chat area and share images performing zoom actions and basic drawing as pointers, references, texts, highlighters.

1.5 CONCLUSIONS

The integration of communication, localization and sensing functionalities by means of heterogeneous and reconfigurable networks are a breakthrough step for the growth of distributed cloud computing and social interaction technologies and a giant leap towards the provision of a plurality of services and applications, ideally and in perspective a universal library of services seamlessly provided to users.

Such new services can improve the quality of life of the citizens in every-day life. The two described services related to the tele-health and emergency fields are exemplary applications, where the flexible, multi-service and cooperative heterogeneous architectures play a fundamental role.

The integration of communications/localization/sensing functionalities in a heterogeneous, flexible, cooperative system is far from being presently available: the design, implementation and deployment of this visionary scenario to provide better services to the third- millennium citizens is indeed one of the most challenging issue for the ICT scientific community.

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