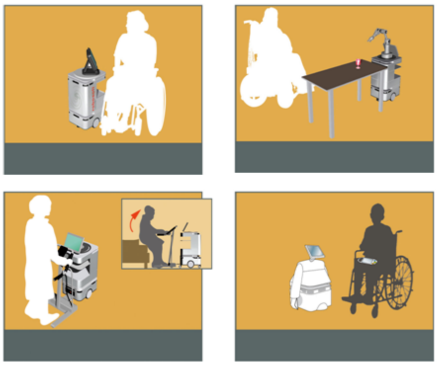

DOMEO Project

AAL-2008-1-159

D6.1 Telecommunication overall system description

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Summary

DOMEO project brings together patients, healthcare professionals and telemedicine contact centres' staff to improve healthcare follow-up and quality of life of the elderly. While patients live at home, healthcare professional work in their offices and telemedicine contact centres' staff manages calls in a third place, there is a need for secure and reliable network infrastructure to interconnect these actors.

D6.1 "telecommunication network architecture" provides a description of the DOMEO network facilities and technologies. D6.1 is the first deliverable of WP6 and will be then completed with D6.2 "Telecommunication connections integration report" and D6.3 "Data transmission validation and performance report".

Section 2 of the present document gives a description of the overall network architecture and of its actors and components.

Section 3 reviews the telecommunication technologies used in the frame of the DOMEO project, namely 3G, xDSL and Satellite DVB-RCS.

Section 4 introduces general considerations about network characterization which allows to identify networks parameters to be analysed before the deployment of new applications.

Finally, Section 5 describes more in detail the actors' facilities and various subsystems.

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List of acronyms

1G	1st Generation Mobile System
2G, 2.5G	2nd Generation Mobile System
3G	3rd Generation Mobile System
4CIF	4 × CIF : 704 × 576
ADSL	Asymmetric Digital Subscriber Line
ADSLF	ADSL Forum
AMPS	Advanced Mobile Phone Service
AVI	Audio Video Interleave
CDMA	Code Division Multiple Access
CIF	CIF 352 × 288
CO	telephone Central Office
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DVB-RCS	Digital Video Broadcasting – Return Channel via Satellite
DVB-S	Digital Video Broadcasting via Satellite
ECG	Electrocardiogram
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiplexing Access
FLV	Flash Video codec
FTP	File Transfer Protocol
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
HR	Heart Rate
HTTP	HyperText Transfer Protocol
IMT	International Mobile Communications
IP	Internet Protocol
IPTV	TV over IP
IR	Infra Red
ITU	International Telecommunications Union
LAN	Local Area Network
LDAP	Lightweight Directory Access Protocol
MAP	Mean Artery Pressure
MDD	Medical Device Directive
MF-TDMA	Multi-Frequency Time Division Multiple Access
MP3	Moving Picture Experts Group Layer-3 Audio file format
MPEG	Moving Picture Experts Group
NAT	Network Address Translation
OGG	open standard container format used to provide more efficient streaming and higher quality presentation
OSAS	Obstuctive Sleep Apnoe Syndrome
PCMCIA	Personal Computer Memory Card International Association
POTS	Plain Old Telephone Service

PSTN	Public Switched Telephone Network
QCIF	CIF/2 : 176 × 144
QoL	Quality of Life
QoS	Quality of Service
RADSL	Rate-Adaptive Digital Subscriber Line
RCST	Return Channel Satellite Terminal
RTCP	Real-time Transport Control Protocol
RTP	Real Time Transport Protocol
SDSL	Symmetric Digital Subscriber Line
SIM	Subscriber Identity Module
SIT	Satellite Interactive Terminal
SLAM	Simultaneous Localization And Mapping
Speex	Lossy audio codec optimized for speech
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VDSL	Very-high-data-rate Digital Subscriber Line
VOD	Video On Demand
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
WAV	Waveform Audio File Format
WIFI	IEEE 802.11b wireless networking
WMV	Windows Media Video
xLAW	Standard compression algorithms : (1) μ-law (2) A-law

1. Introduction

- Ageing population

Major changes occur in the body as age increases. As such changes may be related with sensorial organs, they also are related with vital organs such as the cardiovascular system, central nervous system and pulmonary system. Musculo-skeletal system diseases increase with age, thus leading to decline in the physical functions of elderly people. While there is no important change in learning and memory with the ageing process, degenerative neurological diseases increase around the age of 75 and cognitive impairment becomes an issue. Chronic diseases disturb the social life of elderly people. Functional disturbance, deficiencies and disability occur as a result of physical and mental illnesses and all of these disturb the QoL of the elderly. Many illnesses are not fatal, but can affect the activity and QoL of people over the short and long term. It is thought that QoL in later years may be diminished if illness, chronic conditions, or injuries limit the ability to care for oneself without assistance.

- Robots as companion for ageing population

Robots are being used in intelligent domestic environments, with the goal of creating a companion that assists people in their own home and helps them to be independent in their everyday lives. Amongst other aspects, this tool provides a control for management of daily tasks, social and health services support, for videosurveillance and videoconferencing with family members or professional carers as well as the remote control of the mobile robot by authorised persons. All the technologies of the environment-aware system will provide the wherewithal for the observation and monitoring of the elderly person and his or her activities within the domestic environment.

- Needs for proper telecommunication network

In order to transmit data from home to the telemedicine contact centre, the system needs reliable and secured telecommunication network. Transmitted data may be real time emergency alarms, daily physiological reports, environmental report and system status report.

2. Network Architecture Definition

Network architecture is the design of a communications network. It is the logical and structural layout of the network consisting of transmission equipment, software and communication protocols and infrastructure (wired or wireless) transmission of data and connectivity between components.
It is also a framework for the specification of a network's physical components and their functional organization and configuration, its operational principles and procedures, as well as data formats used in its operation. In telecommunication, the specification of a network architecture may also include a detailed description of rate and billing structures under which services are compensated.

Network architecture includes also Quality of Services (QoS) and network optimization mecanisms to manage delay, latency, jitter and packets loss which are the main network characteristics that impact data transmission.

The DOMEO network architecture is split in four parts: the patient's home, the telemedicine contact centre, the Healthcare professionnal office and the telecommunication network.

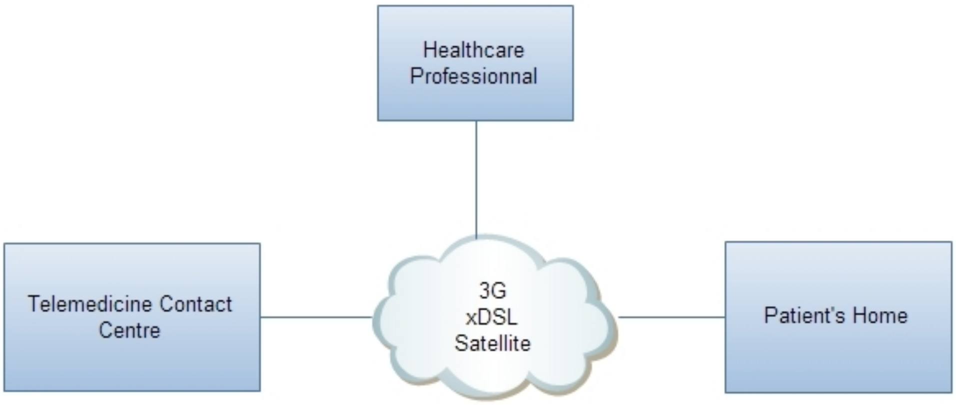

Figure 1 : Domeo overall architecture

2.1. Patient's Home

The patient's Home is the place where the robot and the modem are installed. The modem allows to connect the patient's home to the DOMEO network: it interfaces on one side with the robot and local area network to collect the patient and home data and on the other side with the wide area network to transmit those data to the telemedicine center.

2.2. Healthcare Professionnal office

The Healthcare Professionnal office is the place from which the specialist will provide its diagnosis : it will connect to the Telemedicine contact centre to access to patient's data as well as with the patient's home to hold videoconferencing.

2.3. **Telemedicine Contact Centre**

The telemedicine contact centre serves as the hub for medical parameters monitoring and disease management. Delivering patient support or medical information for healthcare professionals on the telephone requires the conduct and coordination of numerous tasks by telemedicine contact center operators (e.g. making and receiving calls, answering questions, entry of questionnaires, sending documentation). The answers must be given rapidly, whilst being personalized and adapted to the medical protocol of the program.

2.4. **Network**

The telecommunication network is the piece of the architecture which allows to link the end-points to the telemedicine contact center. It can be split also in two subsystems: the local area network inside the patient home, and the wide area network, outside the patient home. Basically the LAN is based on Ethernet, WIFI, Bluetooth, IR technologies while the WAN is based on mobile (3G), terrestrial (xDSL) or satellite (DVB-RCS) technologies.

3. Technologies

In the frame of DOMEO project, it has been agreed that medical and environmental data will be sent by the robot to the telemedicine contact centre either over a wireless 3G or satellite DVB-RCS or terrestrial xDSL link. Most of the cases in urban areas comply with xDSL or 3G technology while a proof of concept of satellite DVB-RCS transmission is achieved to comply with use in areas where there is no such infrastructure installed.

3.1. 3G wireless technology

3G refers to the third generation of mobile telephony (that is, cellular) technology. The third generation, as the name suggests, follows two earlier generations.
It comes with enhancements over previous wireless technologies, like high-speed transmission, advanced multimedia access and global roaming. 3G is mostly used with mobile phones and handsets as a means to connect the phone to the Internet or other IP networks in order to make voice and video calls, to download and upload data and to surf the net.

The first generation (1G) began in the early 80's with commercial deployment of Advanced Mobile Phone Service (AMPS) cellular networks. Early AMPS networks used Frequency Division Multiplexing Access (FDMA) to carry analog voice over channels in the 800 MHz frequency band.
The second generation (2G) emerged in the 90's when mobile operators deployed two competing digital voice standards. In North America, some operators adopted IS-95, which used Code Division Multiple Access (CDMA) to multiplex up to 64 calls per channel in the 800 MHz band. Across the world, many operators adopted the Global System for Mobile communication (GSM) standard, which used Time Division Multiple Access (TDMA) to multiplex up to 8 calls per channel in the 900 and 1800 MHz bands.
The International Telecommunications Union (ITU) defined the third generation (3G) of mobile telephony standards – IMT-2000 – to facilitate growth, increase bandwidth, and support more diverse applications. For example, GSM could deliver not only voice, but also circuit-switched data at speeds up to 14.4 Kbps. But to support mobile multimedia applications, 3G had to deliver packet-switched data with better spectral efficiency, at far greater speeds.

The transfer rate for 3G networks is between 128 and 144 kbps (kilobits per second) for devices that are moving fast and 384 kbps for slow ones (like for pedestrians). For fixed wireless LANs, the speed goes beyond 2 Mbps.

3G is a set of technologies and standards that include W-CDMA, WLAN and cellular radio, among others.

3G follows a pattern of G's that started in the early 1990's by the ITU. The pattern is actually a wireless initiative called the IMT-2000 (International Mobile Communications 2000). 3G therefore comes just after 2G and 2.5G, the second generation technologies. 2G technologies include, among others, the Global System for Mobile (GSM) - the famous mobile phone technology we use today. 2.5G brings standards that are midway between 2G and 3G, including the General Packet Radio Service (GPRS), Enhanced Data rates for GSM Evolution (EDGE), Universal Mobile Telecommunications System (UMTS) etc.

What is Required for Using 3G?:
The first thing required is a device (e.g. a mobile phone) that is 3G compatible. This is where the name 3G phone comes from - a phone that has 3G functionality; nothing to do with the number of cameras or the memory it has. An example is the iPhone 3G.

Unlike with WIFI which you can get for free in hotspots, you need to be subscribed to a service provider to get 3G network connectivity. The device is connected to the 3G network through its SIM card (in the case of a mobile phone) or its 3G data card (which can be of different types: USB, PCMCIA etc.), which are both generally provided/sold by the service provider. Through that, you get connected to the Internet whenever you are within a 3G network. Even if you are not in one, you can still use 2G or 2.5G services provided by the service provider.

3.2. **xDSL terrestrial technology**

DSL (Digital Subscriber Line) is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines. The fundamental work leading to Digital Subscriber Line (DSL) technology was done in the early 1980s by AT&T's Bell Labs. Later, after the AT&T divestiture, the work was assumed and brought to a practical level about 1989 by Bellcore. At present the main focus of xDSL development and marketing, other than within the microchip, equipment and telephone companies themselves, is the ADSL Forum (ADSLF), a group to which virtually everyone in the business belongs.

Without going into technical detail, xDSL encodes a stream of digital data so as to maximize the use of the available bandwidth and continuously monitors the transmission, even "cleaning it up" by detecting and correcting errors. This continuous encoding, sampling and adjusting of the data stream requires modern VLSI high-speed chip technology. Such features as equalization and echo cancellation are required to identify and correct errors that occur during transmission.

Several variations of xDSL technology are now commercially important. Early deployments to the residential market will be either ADSL or RADSL, as described below.

ADSL devotes a larger part of the bandwidth to downstream applications, since most residential Internet users will need it to download graphics-heavy images. The speed of the downstream channel can vary widely, up to about 6 Mbps, depending on the vendor and the specific service. The upstream bit rate is always less, hence the name asymmetric DSL. At the lower end of the spectrum is a 4 kHz channel devoted to voice, and functionally independent of the data stream. In fact, if the local electric-

utility power goes down, the voice channel will remain active, since it is still powered (as now) by 48 volt batteries, while the DSL channels will become disabled.
RADSL is a variation of ADSL in which the equipment can sense how high a bit rate the line can handle and adjust the speed downward accordingly. This "safe speed" can either be determined by testing the line during installation and locking it in at a set speed, or it can continuously adjust itself during operation.
HDSL has been used for several years in commercial applications, and typically transmits 1.5 megabits per second (Mbps) each way. Since it requires two wire pairs, it is not considered applicable to the residential market.
SDSL is a symmetrical form of xDSL, but at roughly half the speed of HDSL and using one wire pair instead of two.
VDSL is a high-speed version of xDSL, but only for short distances, perhaps a mile or less. For very short distances, speeds as high as 50 Mbps can be attained. A basic law of physics states that the shorter the distance the higher the speed that can be attained.

Main Features

Perhaps the biggest advantage of xDSL is its **speed**—typically from one to two orders of magnitude faster than dial-up modems. The apparent difference is fairly minor for the transmission of text, but for graphics is dramatic.
One primary advantage of xDSL technology is that it is **always on** for the customer—24 hours per day. There is no need to dial it up each time the user wants to log into the Internet or access the company network. Surprisingly, this is also an advantage for the phone company, since the xDSL signals passing through its central office bypass the switches used to connect phone calls, thus relieving congestion in the plain old telephone service (POTS) network, commonly known as the public switched telephone network, or PSTN. With dial-up modems, congestion is becoming a major problem for local phone companies, since typical Internet users stay connected for long periods of time.
Another advantage is that xDSL uses different parts of the available spectrum to carry **simultaneous voice and data**, and each can be used independent of the other. Thus, even though the computer is being used, phone calls can be made, and vice-versa.
For the phone companies, xDSL technology can be added incrementally. There is no need for a large investment in plant and equipment, since the main addition is a black box at each user's location and a larger one, known as a digital subscriber line access multiplexer (DSLAM) at the telephone central office (CO).

Applications

In the early days of xDSL technology, video-on-demand (VOD) was visualized to be the application that would drive the technology. Today VOD is all but forgotten as the Internet has emerged as the "killer app." xDSL represents a quantum leap forward in high-speed access to the Internet, where high-bandwidth graphics play an increasingly important role. Although many downstream (Internet-to-user) speeds are being deployed by various telephone companies, many are focusing on 1.5 megabits per second, which is 27 times as fast as a 56 kilobit per second modem.

Thus, a five minute download is reduced to 11 seconds, provided some other link in the Internet system doesn't slow down the transmission.

The second most common xDSL application is remote LAN connection. This enables telecommuters to talk to the office network at speeds essentially equal to what they would have available at the office itself. Video conferencing becomes possible if speeds higher than about 400 kbps are available. For the healthcare industry xDSL technology enables high-resolution images to be transmitted, perhaps for study and diagnosis by a specialist in real time. Educational applications will enable students to learn in a remote setting. Many other applications will be added as the technology becomes widely adopted.

3.3. **DVB-RCS Satellite technology**

While most television standards simply involve a one way transmission using a "one to many" concept, DVB-RCS uses a return channel to enable two way transmissions to be made. The standards for DVB-RCS are maintained by ETSI with the actual standard number: EN 301 790.

DVB-RCS defines a complete air interface specification for a two way satellite broadband scheme. It uses a VSAT (Very Small Aperture Terminal - an earth station, used for the reliable transmission of data, video, or voice via geo-stationary satellite, with a relatively small dish-antenna often around 1 to 2 metres in diameter). In effect DVB-RCS provides the user with a satellite based ADSL-style link without the need for the land based cables. This makes DVB-RCS ideal for use in many areas where there is no terrestrial infrastructure installed.

Depending on link budgets between the earth station and the satellite as well as other system parameters, DVB-RCS is able to provide up to 20 Mbit/s to each terminal on the outbound link, and up to 4 Mbit/s or more from each terminal on the inbound link.

The DVB-RCS technical specification is now approved as DVB-RCS+M. It provides support for a variety of types of terminal including mobile and nomadic terminals. In addition to this, it provides enhanced support for direct terminal-to-terminal, or mesh connectivity. DVB-RCS+M includes features such as live handovers between satellite spot-beams, spread-spectrum features to meet regulatory constraints for mobile terminals, and continuous-carrier transmission for terminals with high traffic aggregation. It also includes link-layer forward error correction based on Raptor or Reed-Solomon codes, used as a countermeasure against shadowing and blocking of the satellite link.

One of the major requirements for DVB-RCS is that the user terminals should be relatively small, easy to use, and be manufactured to a cost while remaining reliable. To achieve this the basic form of DVB-RCS provides what may be termed "hub-spoke" connectivity; i.e., all user terminals are connected to a central hub. This hub controls the system and it also acts as a traffic gateway between the users and the wider Internet. The DVB-RCS user terminal sometimes known as a Satellite

Interactive Terminal (SIT) or Return Channel Satellite Terminal (RCST) comprises a number of items:

* small indoor unit
* outdoor unit which includes a diplexer, low noise amplifier and a transmit RF amplifier
* antenna - size around 1 - 2 metres in diameter

The DVB-RCS satellite system provides the user with an interactive satellite service. Accordingly there are two elements to the system:

* Receive capability
* Transmit capability

The forward link is shared among a population of terminals using either DVB-S (EN 300 421) or the highly efficient DVB-S2 standard (EN 302 307). Adaptive transmission to overcome variations in channel characteristics (e.g., rain fade) can be implemented in both the forward and return links.

The DVB-RCS return link or uplink to the satellite utilises a multi-frequency Time Division Multiple Access (MF-TDMA) transmission scheme. This form of scheme enables the system to provide high bandwidth efficiency for multiple users. A key to the high efficiency of the system is the demand-assignment scheme which uses several capacity mechanisms to allow optimisation for different classes of applications, so that voice, video streaming, file transfers and web browsing can all be handled efficiently.

DVB-RCS supports several access schemes making the system much more responsive, and thus more efficient, than traditional demand-assigned satellite systems. These access schemes are combined with a flexible transmission scheme that includes turbo coding, several burst size options and efficient IP encapsulation options. These tools allow systems to be fine-tuned for the best use of the power and bandwidth satellite resources.

The user terminal offers an Ethernet interface that can be used for wired or wireless interactive IP connectivity for a local home or office network ranging from one to several users. In addition to providing interactive DVB services and IPTV, DVB-RCS systems can provide full IP connectivity anywhere there is suitable satellite coverage.

4. Network Architecture characterization

With the emergence of new applications on data networks, it is becoming increasingly important for customers to accurately predict the impact of new application rollouts. Not long ago, it was easy to allocate bandwidth to applications and let the applications adapt to the exploding nature of traffic flows through timeout and retransmission functions of the upper layer protocols. Now, however, new world applications, such as voice and video, are more susceptible to changes in the transmission characteristics of data networks. It is imperative to understand the traffic characteristics (packets loss, latency, delay, jitter) of the network before deployment of new world applications to ensure successful implementations and specially regarding satellite communication networks.

Packet loss: Packet loss occurs when one or more packets of data traveling across a computer network fail to reach their destination. Packet loss can be caused by a number of factors, including signal degradation over the network medium, oversaturated network links, corrupted packets rejected in-transit, faulty networking hardware, faulty network drivers or normal routing routines. When caused by network problems, lost or dropped packets can result in highly noticeable performance issues or jitter with streaming technologies, voice over IP, online gaming and videoconferencing, and will affect all other network applications to a degree. Some network transport protocols such as TCP provide for reliable delivery of packets. In the event of packet loss, the receiver asks for retransmission or the sender automatically resends any segments that have not been acknowledged. Although TCP can recover from packet loss, retransmitting missing packets causes the throughput of the connection to decrease. This drop in throughput is due to the sliding window protocols used for acknowledgment of received packets. In certain variants of TCP, if a transmitted packet is lost, it will be re-sent along with every packet that had been sent after it. This retransmission causes the overall throughput of the connection to drop.

Latency: Bandwidth is just one element of what a person perceives as the speed of a network. Latency is another element that contributes to network speed. The term latency refers to any of several kinds of delays typically incurred in processing of network data. A so-called *low latency* network connection is one that generally experiences small delay times, while a *high latency* connection generally suffers from long delays. Excessive latency creates bottlenecks that prevent data from filling the network pipe, thus decreasing effective bandwidth. The impact of latency on network bandwidth can be temporary (lasting a few seconds) or persistent (constant) depending on the source of the delays.
Latency may involve transmission delays (properties of the physical medium) and processing delays (such as passing through proxy servers or making network *hops* on the Internet). On DSL or cable Internet connections, latencies of less than 100 milliseconds (ms) are typical and less than 25 ms desired. Satellite Internet connections, on the other hand, average 500 ms or higher latency.

Delay: The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds. Delay may differ slightly, depending on the location of the specific pair of communicating nodes. Delay is usually reported in both the maximum and average delay, and includes:

* Processing delay - time routers take to process the packet header
* Queuing delay - time the packet spends in routing queues
* Transmission delay - time it takes to push the packet's bits onto the link
* Propagation delay - time for a signal to reach its destination

IP network delays can range from just a few milliseconds to several hundred milliseconds.

Jitter: Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. A jitter buffer can be used to handle jitter.

Such characterization will be performed as far as possible during the technical tests in laboratory. The tests should be conducted by Thales Alenia Space and with the technical team of CHU Toulouse which is hosting the Telemedicine contact centre and also testing the robots.

5. DOMEO Architecture

This section introduces the DOMEO architecture and provides a description of its main components.

- 3 patient's home equiped with Robots (RobuMate & RobuMaster)
- 2 telemedicine contact centers, one for France and one for both Austria and Hungary
- 3 Health care professionals

5.1. Patient's home

Patient's homes are located in Hungary, France and Austria and are equiped with robots (RobuWalker and RobuMate). Patient's home also include sensors to monitor and send back relevant information concerning the health status of the patient to the healthcare professionnal. Robot and home are equiped as well with videoconferencing and videosurveillance capabilities in order to set-up real time videocommunications between the patient and the healthcare professionnal either for telediagnosis or for well being and discussion.

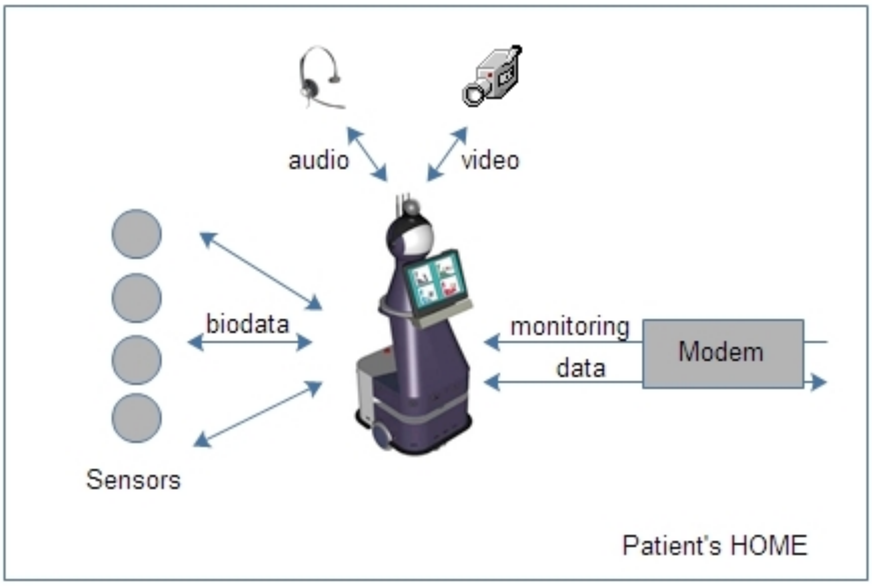

Figure 2 : Patient's Home architecture

5.1.1. RobuMate

RobuMate is a companion robot, which has verbal and visual interactions with the user. The RobuMate main objectives are :

- Human Robot Interaction (cognitive and memory assistance)
- Sending video flow to scene analysis in case of emergency alarm,
- Stimulation for doing physical exercises and watching user behaviour

The robot can bring assistance to the person in the very broad sens term:

- Reminders: prescriptions, schedules…
- Internet access: email, social networks, videoconferences…

- Day to day help to human

It comes with state of the art technologies:
- Autonomous navigation, based on SLAM (simultaneous localization and mapping), possibility to work out its own positionning chart
- Voice synthesis and recognition: the robot can speak and is able to recognize words and sentences
- Security systems like obstacle detection, automatic power shutdown on contact, real stability…
- Full internet access, like social networks nad othe tools (google mail, google share, calendar, web services…)

If the robot can be autonomous in its displacement, it can also be remotely controled using a web interface called Lokaria.
This remote control tool allows to get access to all robot information list and status. All the data to be exchanged on the network are exchanged between robot and the Lokarria web monitoring application developed by Robosoft to remotely control the robot.

5.1.2. **RobuWalker**

RobuWalker is a robotic walker, which has physical interaction with the user. The RobuWalker main features are:
- Physical Human Robot Interaction (assisting the sit-to-stand and walking)
- Supervising
- Monitoring the heart rate

The robuWalker robot runs as an autonommous system. It comes with the same security system than robumate for obstacle detection but does not embed the high level functionnalities like voice synthesis or reminders.
It runs an embedded application that uses force sensors to adapt the movement of the platform to the user needs. It helps elderly to stand up in a confortable way and can be used as a walk assistant.
The robot is equipped with sensors allowing the detection of physical fatigue.
The type of data to be exchanged on the network is similar to the robuMATE data.

5.1.3. **RobuMaster**

RobuMaster must be seen as functionality for centralizing and analyzing all the data coming either from RobuMate or RobuWalker. From this analysis it must be able to determine if there is some misbehavior or some alarm to be sent to the Lokaria monitoring platform.
In order to receiveanalyze/transmit such information, it must stay connected with robots while they are in use. It is able to request for additional information to each of the robots. It is, as well, continuously connected to cloud Internet to send health report and alarm.
Accordingly, RobuMaster is a piece of software that makes the link between both robots and remote medical centre, its implementation will be made on a dedicated

PC. In a later stage, the integration/duplication of RobuMaster's functionality is also envisaged within RobuMate.

5.1.4. **Audio/video communication**

Audio/video communication application integrated in RobuMate to achieve the DOMEO services is based on Thales Alenia Space Multimedia Telecommunication software which provides remote and widespread users with real time, multimedia and collaborative communication capabilities to allow:

- Virtual e-meeting
- Collaborative Work
- Interactive remote training
- Technical support
- Telemedicine
- Crisis management

The software is a Multi-Platform (Windows, Linux and Mac OSX) software, built on Client/Server architecture. It has got many advantages, compared to usual software on the Web, specially regarding networks layers' optimisation:

- Compliant with terrestrial (Internet, WAN, LAN), Mobile (3G or above), Satellite networks
- Network settings auto-negotiation is performed at connection time
- Selection of Unicast, Multicast or Hybrid mode
- Bandwidth from 128 Kbps to 4 Mbps is set up according to links' performances
- Transport layer protocol is adapted according to data flow: Session control (TCP), Audio & Video streaming (RTP/RTCP over UDP), Applications (TCP or UDP),
- QoS allows packet tagging per media
- NAT traversal is possible thanks to the uPnP protocol
- IPv6 compliant

The application supports Videoconferencing, i.e. one participants can talk to and see any of the other participants of the session

- Supported video codecs are H.264, H.263, FLV,
- Supported audio codecs are Speex, GSM, xLAW,
- Supported Audio/Video transport stream is RTP/RTCP over UDP (Unicast/Multicast/Hybrid).
- Supported video sizes are QCIF, CIF, 4CIF. Enable Full Screen.

The application supports Video streaming

- Streaming of video data flows from standard webcams or digital camera,
- Streaming of video data flows from IP camera (MJPEG / MPEG-4 or H.264)
- Streaming of video files (AVI, OGG, DIVX, MPEG, WMV ...),

as well as Audio streaming,

- Streaming of audio data flows from standard microphone
- Streaming of audio data flows from IP camera
- Streaming of audio files (MP3, OGG, WAV, …)

5.1.5. **Sensors**

According to the medical needs the following physiological parameters are planned to measure in DOMEO project:

- ⇨ blood pressure
- ⇨ ECG
- ⇨ body temperature
- ⇨ body weight
- ⇨ oxygen saturation

Expected parameters at blood pressure measurement

The most typical medical problem at the elderly population is the hypertension. The consequences can appeared at almost any part of the body. The measurement is very common, easy to do and accepted by physician.

The expected values are the systolic and diastolic blood pressure in [mmHg]. Also usual result is the pulse rate in [1/min], and the less frequent is the MAP {Mean Artery Pressure} in [mmHg].

The safety and performance requirement against a blood pressure meter/recorder device is available in international standards EN60601-2-30:2000. According to this standard, the device has been "CE" marked according to MDD {Medical Device Directive; 93/42/EEC-M5 - > 2007/47/EC}, and the dynamic accuracy (the blood pressure measurement accuracy) must be verified according one of the three methods referred {1, BHS protocol: Journal of Hypertension 1993, 11 (Suppl2): S43-S62;. 2, DIN58130:1995; 3, ANSI/AAMI SP10}.

The blood pressure measurement requires a cuff applied on the arm (or on the wrist) of the patient, which is applied only for the period of measurements, so it needs a patient action to apply the cuff and initiete the measurement.

Expected parameters at ECG recording

ECG recording is also a very common medical examination. There are many different reasons to make ECG recording, and there are different devices to do it. The most common ECG recording is the 'conventional' 12 lead resting ECG. Trained medical staff is required to apply the ECG electrodes on the expected position {the mis-positioning causes un-interpretable or mis-interpretable signals, and the acceptable difference depends on the lead, but it can be as small as 2-3 cm}. It also requires a resting {laying on back} body.

In case of DOMEO there is no way to ensure these circumstances. To provide as easy and simple measurement as it is possible is a must in case of elderly patient without supervision of medical staff. Therefore we selected a single channel ECG recording, and accepted its limitations: it can only be used to calculate HR {Heart Rate} and to identify the common arrhythmias.

There are several similar standards to define requirement s against the ECG recorders.

Meditech's choice is the EN 60601-2-47:2001 which is the specific standard for ambolatory ECG recorders. The ECG recording needs several ECG electrodes applied on the specific point on the body. Because of the very long measuring period the disposable electrodes are not acceptable, so we have to choose temporarily applied electrodes. We had to choose position insensible placements, therefore we had choosen two metallic electrodes which shall be touched by the hands. The electrodes can be built in to the RobuWalker or can be created as a separate ECG-pad.

Expected parameters at body temperature measurement

It is also a very common and easy to do measurement. There are different methods to measure the body termperature and different part of body where to measure. The expected result is a temperature in [°C] at a resolution of at least 0,1 °C {for special purposes 0,01°C can be the required resolution}.

According to the partners working in medical institute, the most accepted method is the infrared ear thermometry.

An off-the shelf product shall be shoosen, but unfortunately no thermometer with communication capability has been found. Accordingly, we suggest to select an aer thermometer and the result can be read out by using a camera, or entered by the patient.

Expected parameters at body weight measurements

The body weight is one of the most common measurements made by the people, and it is also an important parameter for physician. It is widely used to follow the progression of many different metabolic disturbancies including diabetes, different kind of obesity and also fluid retention.

The expected result is the body weight in [kg] with resolution of 0,1 kg or better.

The accuracy of 1% is usually enough, but the repeatability is more important to demonstrate and identify of changes in body weight wirthin several days period.

The body wheight scale can be placed in the flat, typically in the bathroom or it can be applied to the bed. For the simplicity we suggest to use the standard weight scale with communication capability.

Expected parameters at measuring oxygen saturation

The pulseoximeters can measure the actual oxygen saturation and the actual pulse rate of the patient. The measurement of oxygen saturation can be used to follow up the progression of several kind of illnesses. Nowadays it is widely used to identify apnoe e.g. OSAS {Obstuctive Sleep Apnoe Syndrome}. For this reason the pulseoximeter shall ba applied at night, while the patient is sleeping and the results of regular measurements shall be stored or transmitted immediately. The results can be stored and evaluated at the morning, which can be used for identification of the problem and for following up; or it can be evaluated immediately in which case an immediate alert can also be produced in case of critical oxygen saturation {usually the critical oxygen saturation is recovering when the patient awakens}.

The expected result is a pair of oxygen saturation in [%] and pulse rate in [1/min], or a series of it.

For daytime measurements it can be built into the RobuWalker, in which case it can be combined with the ECG recorder. Blood pressure measuring device based on the delay between the ECG signal and the pulseoxi signal can be developed in an experimental way.

For nighttime measurements a weareble sensor is needed, which shall be applied by the patient before going to the bed and shall be removed after awakening.

Communication and the data representation

As far as possible, the choice of the devices will comply with the Continua Health Alliance version 1 design guidelines which are based on proven connectivity standards and include Bluetooth for wireless and USB for wired device connection.
Products made under Continua Health Alliance guidelines should help to raise increased assurance of interoperability between devices, deliver healthcare in the home providing independence, empowering individuals and providing the opportunity for truly personalized health and wellness management, as expected within the DOMEO project.
Continua Health Alliance is working toward establishing systems of interoperable telehealth devices and services in three major categories: chronic disease management, aging independently, and health & physical fitness. This is line with the DOMEO project objectives.

Continua Alliance products make use of the ISO/IEEE_11073_Personal_Health_Data_(PHD)_Standards.
This standard includes a data representation for different kind of sensors, and we suggest to use this data representation in DOMEO project. The generally used data element is the AbsoluteTimeStamp, which contains <YYYYMMDDhhmmssss> in 6 bytes at BCD representation, where :

- ⇨ YYYY: the year in 4 digit;
- ⇨ MM: the month in 2 digit;
- ⇨ DD: the day in 2 digit;
- ⇨ hh: the hour in 2 digit;
- ⇨ mm: the minute in 2 digit
- ⇨ ssss: the second and hundreds of second in 4 digit.

Also a generally used data format is the SFLOAT, which is a float represented in 2 bytes with 4 bits signed exponent and 12 bits signed mantissa. The value repesented is: <mantissa>*10**<exponent>.

5.2. **Telemedicine contact centres**

The Telemedicine contact centre is the core of the DOMEO network architecture as it allows interconnection of the various DOMEO actors (patient/robot, healthcare professional, technology provider). Main components of the Telemedicine contact centre are :

5.2.1. **Call centre**

The call center is the place where inbound calls are received mainly from the patient's home and outbound calls are made mainly to the Healthcare professionnal.

5.2.2. **VPN server**

The VPN server allows to set-up a secure, private communication tunnel between two or more devices across a public network (like the Internet). These VPN devices can be either a computer running VPN software or a special device like a VPN enabled router. The VPN server allows to secure data travels across a public network like the Internet, because of very strong encryption. It is particularly well suited for transmission of medical data like in the DOMEO project. If anyone listens to the VPN communications, they will not understand it because all the data is encrypted. In addition, VPN’s monitor their traffic in very sophisticated ways that ensure packets never get altered while traveling across the public network.

5.2.3. **Users management**

To access the DOMEO services (Medical data storage and download, videoconferencing, robot monitoring, …), the user (Healthcar professionnal, patient/robor, telemedicine contact centre’s operator) first must authenticates itself to the service. That is, it must tell the LDAP server who is going to be accessing the data so that the server can decide what the client is allowed to see and do. If the client authenticates successfully to the LDAP server, then when the server subsequently receives a request from the client, it will check whether the client is allowed to perform the request. This process is called access control.

5.2.4. **Monitoring server, Lokarria**

The monitoring server allows accessing remotely the robot and its sensors. Thus it is possible to remotely monitor the status of the robot but also to remotely control it.
This is made through the use of a dedicated web application called Lokarria.

Lokarria is a set of services for controlling, monitoring and managing robots through the web:

- Manage all your robots through a single web interface,
- View the logs and alerts, configure logging from a web interface, activate several debug levels, check robots’ status,
- Check if the software running on robots is up to date, install securely the required or recommended updates without risks, a kind of “windows update” for the robots

It allows remote control of the robots from a web interface:

- Including real-time video, sensor feedbacks, console, etc.
- Multiple users supported at the same time (one is master, while other are spectators) from different locations.
- Performances are not downgraded thanks to ROBOSOFT servers that multiplex and cache video streams and data.
- Can be used from Smartphone web browser (modern ones)

Lokkaria services are also available through a REST API

- making possible the development of dedicated clients: native clients for mobile phones, custom viewers for monitoring several robots at the same time, visualizing them on a google map, etc
- Lokarria’s API requires keys for granting access,
- Very similar to popular web 2.0 APIs from Youtube, Flickr, Google, etc.

The data managed by Lokarria are described hereafter :

<u>Abbreviations:</u>

- R: Robot

- L: Lokarria
- MSRS: Microsoft Robotics Studio
- TBD: To Be Determined

Initiator:

The only case where the robot initiates communication with Lokarria is when sending log data to the system.

Directions:

Mostly from the robot to Lokarria. Data goes from Lokarria to robots when Lokarria is indicated as a source in the summary table. One exception is VideoConferencing for which data flow is bidirectional.

Formats:

They are almost all text-based over HTTP excepted for Video and Conference for which we have binary data streamed over custom protocols on top of HTTP / TCP.

Frequency:

Data retrieval from robots is not continuous for live data: self-scheduling threads engage into the retrieval process when at least one client is connected to the site and adapt their frequency accordingly. In the table, frequencies are given when robots are online and clients are connected.

Data definition Robosoft's side:

Laser Data	
Data Name	Type
Timestamp	Uint64
Pose	Pose3D
Echoes	Array of Echo (271 echo but configurable)

Pose3D	
Data Name	Type
Position	Vector3
Orientation	Quaternion

Vector3	
Data Name	Type
X	Double
Y	Double
Z	Double

Quaternion

Data Name	Type
X	Double
Y	Double
Z	Double
W	Double

Echo	
Data Name	Type
Distance	Double
Angle	Double
Overflow	Bool
Reflector	Bool

Localization	
Data Name	Type
Timestamp	Uint64
Pose	Pose3D
Accuracy	Enum
Localization	Localization
Accuracy, enum	
Data Name	Type
High	String
Medium	String
Low	String

PathManager	
Data Name	Type
Paths	Dictionary<String, Path>

Path	
Data Name	Type
Points	Array of Vector3
SpeedSteps	List of SpeedStep

SpeedStep	
Data Name	Type
Distance	Double
Speed	Double

Drive Monitoring	
Data Name	Type
Timestamp	Double
Command	Command
Feedback	Feedback
Properties	Properties

Command	
Data Name	Type
TargetLinearSpeed	Double
TargetAngularSpeed	Double

Feedback	
Data Name	Type
CurrentLinearSpeed	Double
CurrentAngularSpeed	Double
Enabled	bool

Properties	
Data Name	Type
MaxLinearSpeed	Double
MinLinearSpeed	Double
MaxAngularSpeed	Double
MinAngularSpeed	Double
MaxLinearAcceleration	Double
MaxLinearDeceleration	Double
MaxAngularAcceleration	Double
MaxAngularDeceleration	Double
Width	Double

Drive Control	
Data Name	Type
LinearSpeed	Double
AngularSpeed	Double

GoTo Control	
Data Name	Type

PointOfInterest	String

PointsOfInterest	
Data Name	Type
PointsOfInterest	Array of String

Map	
Data Name	Type
Map	Bitmap

Summary						
Data	Category	Protocol	Frequency	Source	Format	Output
Laser	Maintenance	HTTP GET	1 s.	MSRS	XML	JSON
Localization	Monitoring	HTTP GET	1 s.	MSRS	XML	JSON
PathManager	TBD	HTTP GET	1 s.	MSRS	XML	JSON
Drive Monitoring	Monitoring	HTTP GET	1 s.	MSRS	XML	JSON
Map	Monitoring	HTTP GET	Event-based	MSRS	XML	JSON
PointsOf Interest	Monitoring	HTTP GET	Event-based	MSRS	XML	JSON
Video	Monitoring	HTTP GET	0.04 s.	IP Cam	MJPG	JPG
Logs	Logs	HTTP POST	Event-based	Script	POST	DB
Conference	Videoconference	RTMP	Stream	Tablet PC	FLV	FLV
DriveControl	Control	HTTP POST	0.1 s.	Lokarria	POST	None
GotoControl	Control	HTTP POST	Event-based	Lokarria	POST	None
Cam control	VideoConference	HTTP	Event-based	Lokarria	GET	None

5.2.5. **Medical data server**

The sensors (tensiometer, oxymeter, weight scale, …) connected to the robot at patient's home deliver periodic medical data in order to check the health status of the patient. These medical data must be stored and made available to the Healthcare professionnal for analysis. They are collected by the robot and process for sending (FTP) to the telemedicine contact centre.
The database structure is currently under definition.

5.2.6. **Videoconferencing server**

Videocommunication between the patient and the Healthcare professionnal is one of the main features of the DOMEO service. Each of the actors connects to the videoconferencing server to have real time video and audio communication. The connection to the server is achieved via the client interface and through a SSL socket. At this stage, authentication is required (LDAP, Active Directory, ...). This connection can be fully automatic. The server system is running on LINUX platform while remote administration of the server is achieved via HTTPs. Once logged-in to the server, access to a list of predefined meeting rooms is allowed depending on user rights. Entering one of these rooms automatically set up convenient settings (bit rate, video and audio codecs, …) of the Client.

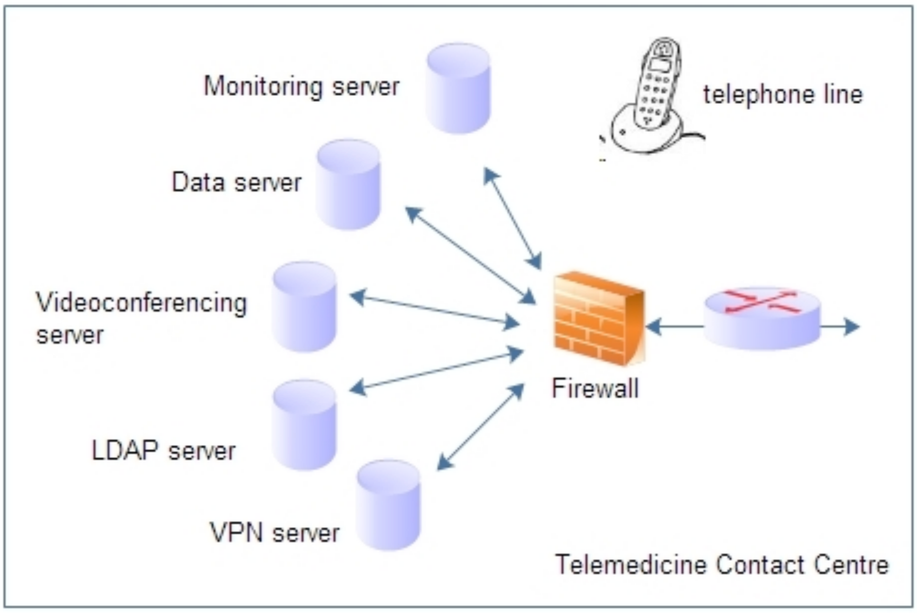

Figure 3 : Telemedicine Contact Centre Architecture

5.3. **Healthcare Professionnals**

On call healthcare professionnals located in their offices must answer to the request of the telemedicine contact centre operator. It is equiped with computer and videoconferencing capabilities including microphone, camera and videoconferencing client software as described in section 5.1.
The healthcare professionnal's office is linked to the telemedicine contact centre via its usual ADSL modem and Internet access. From his office, he can then connect to the medical data server to display patient's medical data and to the videoconferencing server to hold videoconference with the patient's home.

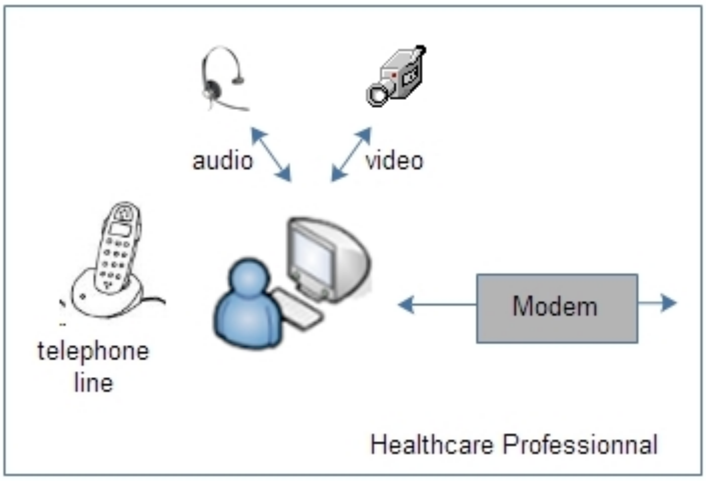

Figure 4 : Healthcare professional office architecture

6. Conclusion

Deliverable D6.1 “Telecommunications overall system description” introduces telecommunication and technology sub-systems which are required to conduct the DOMEO project’s technical tasks. The preliminary description of the patient and specialist environment as well as telemedicine contact centre provides a clear vision of the DOMEO system architecture.

Next step is to set up the network architecture and subsystem to proceed with trials between France, Hungary and Austria. Set up and validation will be described in next deliverable related to telecommunications D6.2 “Telecommunication connections integration report”. D6.2 will also include a description of the medical database structure required to store the medical data delivered by the robots.

End of document