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Homecare: A Telemedical Application

Jean-Pierre Dan and Jean Luprano
Centre Suisse d'Electronique et de Microtechnique SA, Neuchâtel, Switzerland

Telemedicine will shape medical developments in the coming years. A telemedicine scheme and a novel homecare device that relies on the public telecommunication network are presented.

Definition and drivers

The concept of telemedicine and the underlying future medical products to support it will pave the way to efficient, disease-specific modular devices and equipment. Health care for patients and for those who are professionally active but require medical follow-up to manage their health will be provided in the home. The patient is then the centre of focus of the system and not his/her sickness or the doctor.

Telemedicine is a general concept that applies communications techniques to the transfer of information that has a high medical content; this is often referred to as e-health. The basic concept is that the information (not the patient) is transferred to the specialist(s) who is (are) able to take the appropriate decision. Telemedicine includes tele-education, that is, e-learning, and teleinformation of the patient (Figure 1). The objectives of telemedicine are to increase the efficiency of the medical system. The basic assumption is that the cost of a medical act will be reduced while keeping at least the same level of quality. Because of the social impact of this concept, the European Community[1] and other countries[2] are establishing research programmes[3] for the development of supporting technologies and their implementation or dissemination.[4]

Segmentation and complexity

Figure 2 shows one telemedicine scheme and the positioning of each segment according to the maturity of the technologies. The technologies driving the development of telemedicine include microelectronics, microsystems, chip bonding/chip assembly, interconnection, advanced signal processing for portable devices, wireless communication for local communication and advanced energy sources. The speed of implementation and industrialisation of the end product is of course dependent on the level of maturity of the technology and the maturity of the supporting telecommunication technology.

Homecare devices aim to review and update patients' medical records, teleconsult them, monitor patient status (telediagnostics) and send alarms when needed. Telemonitoring, teleconsulting and telediagnostics are the main segments encountered in homecare applications. The backbone of any telemedicine application is the communication system.

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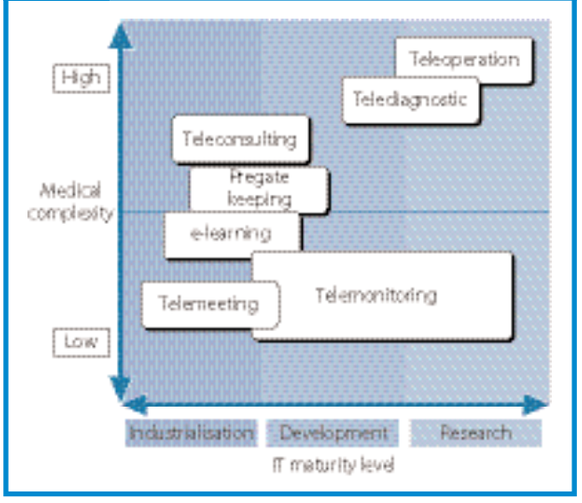
Figure 1: Scheme and positioning of telemedicine segments.



Telecom is the key

For homecare, indoor wireless local area networks (WLAN) are combined with the public switched telephone network/integrated service digital network, the Global System for Mobile communication/general packet radio service networks and future universal mobile telecommunication systems, which extend the area of coverage. Furthermore, the sensors on the patient's body are preferably wirelessly connected, making use of a wireless body-area network or wireless personal area network (WPAN). This combination ensures that the patient is always monitored with limited discomfort and within the reach of a medical call centre. In addition to technologies on the market such as Bluetooth and WLAN (802.11 based WLAN), novel techniques that rely on ultrawide band (UWB) technology will become available. In the example shown in Figure 2, which relies on UWB for the WPAN, a system should work at a centre frequency of between 3.1 and 10.6 GHz with a nominal bandwidth of 1 to 2 GHz.

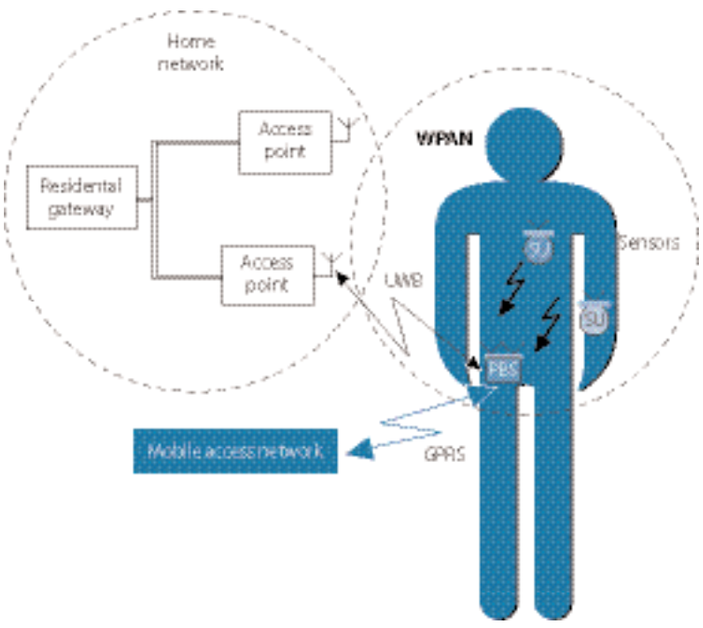
Homecare applications

The first products that were marketed in the homecare field were alarm systems, which still exist. They consist of a wearable alarm button that is wirelessly linked to a central system. The alarm signal is dispatched by pagers or by ordinary or portable telephone to a surveillance service. They have two drawbacks: the patient must self-determine that something is going wrong and must manually trigger the alarm, that is, be still awake or conscious.

In addition to these alarm systems, a variety of wearable devices for monitoring physiological parameters are commercially available. Most of these devices monitor single parameters such as blood pressure, temperature and pulse rate. They are not wirelessly linked to a local or a remote centre, and most of the time they are aimed at the sports market. These devices are not suitable for the medical monitoring of patients.

A higher level of detection is being achieved in next generation products. Increased use of more precise, sensitive and robust microsystems and the miniaturisation of nonportable existing systems combined with signal processing and wireless connection are helping to achieve the next step. New homecare devices are completely autonomous; they do not require user intervention and profit from elaborate and simplified user interface. They include sensors, microsystems, digital signal processors and power-management circuitry. The measurement is made in real time and false signals must be eliminated. Signal treatment is an important feature of the product because it must be robust and independent of the patient's age, size and gender. Solutions to this are found with the use of artificial neural algorithms. Many groups around the world are making developments on this new kind of device and products are close to being marketed.

Figure 2: Personal and local area networks, homecare application.



Advanced homecare

The next development step is aimed at novel systems that integrate a coherent set of interacting portable devices, while preserving mobility and independence and bringing optimum assistance to medical support. This integration includes the following features:

- automatic fall detection, considered by professionals as a major risk for elderly and disabled people
- automatic monitoring of vital medical physiological parameters such as electrocardiogram (ECG), oximetry, body temperature and heart rate
- communication of physiological parameters and voice between the user and external intervening parties such as medical doctors, medico-social institutions or monitoring centres.

The resulting system is modular and comprises miniaturised body-worn modules that provide continuous medical and behavioural monitoring (pulse rate, body temperature, ECG, oximetry, fall detection, activity and voice). The monitored parameters are wireless and transmitted to a base station that is connected to the public phone network. The base station processes and relays the received parameters and sends alarms to the external people such as socio-medical monitoring centres, neighbours and medical doctors, whoever is best suited to intervene depending on the type of alarm. When the link is established, the user may speak with healthcare professionals.

Systems the size of the one illustrated in Figure 3, which measures 40 × 20 × 70 mm, will integrate in one module functions such as fall detection, pulse rate and skin temperature moni-

toring, patient's voice acquisition and communication of physiological parameters and voice from the user to relatives, doctors and monitoring centres. The sensors and signal processing system in the device react without intervention by the wearer. For example, if the wearer falls, this will be detected by changes in pulse rate and in acceleration measurement received by the sensors. These signals will be processed (data fusion, classification and signal processing) and the result of that processing, the information, will be sent to the assigned recipient (relative, carer or medical professional). Data confidentiality and protection through encryption and authentication are important. Extensive tests have been made to quantify the efficacy and reliability of this monitoring system with respect to the physiological signals. The results obtained have confirmed the expected performance.

- Reliability and accuracy of parameter acquisition in working conditions conform to accepted medical requirements, specifications and standards.
- Signal processing such as noise reduction, parameter extraction and data fusion give sufficient information for decision making.
- Inhouse wireless communication is adequately reliable and the transmission range meets the expectations (from 10–200 m according to the application, for example, 20 m in the home, 200 m in the workplace). It complies with electromagnetic regulations. In addition, data security, confidentiality and authenticity are ensured by protocol, for example, Bluetooth.
- The overall power consumption that is necessary for the operation of accelerometers, signal processing and sensors in a small portable system has been achieved with the use of a novel power-management systems, which extend battery life to years.

The next steps for the device include clinical trials, registration, transfer to production and production process validation.

Summary

The advent of telecommunication and information technologies and the miniaturisation of technologies have enabled the evolution of telemonitoring systems. Early systems for hospitals and clinics, which usually required the patients to be wired to desktop devices, have evolved into homecare that requires devices to be lighter and simpler to use. In addition to miniaturisation and extended autonomy, further requirements for the telemonitoring system include local intelligence (that is, the system can take decisions without referring to external advice) and no moving parts to allow the patient to move freely during measurement periods.

Body and local communication networks can prolong the connection of the homecare patient with a monitoring centre through the public networks. Additional medical functions and processing have been added to homecare equipment for telemedicine and patient discomfort is decreasing because of miniaturisation, autonomy and increased versatility of new systems. The applications have evolved rapidly from manually triggered alarms and single physiological parameter monitors to autonomous telemedical monitoring tailored to complete needs. This will eventually make telemedicine beneficial to patients, doctors and society.

References

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Jean-Pierre Dan* is Senior Marketing Manager, Marketing and Sales, and

Jean Luprano is Section Head Application-Specific Electronics Centre, Systems Engineering at the Centre Suisse d'Electronique (CSEM) SA, 2007 Neuchâtel, Switzerland, tel. +41 32 720 5446, fax +41 32 720 5730, e-mail: jean-pierre.dan@csem.ch www.csem.ch

* To whom all correspondence should be addressed.

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Figure 3: Prototype of a complex portable medical device.