Remote Accessibility to Diabetes Management and Therapy in Operational Healthcare Networks

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Abstract	This draft version provides an overview of the existing OS, handheld devices, medical devices, application hosting devices , RPM systems and trends of these relevant to the REACTION project.
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0.9	Stefan Asanin	2010-08-27	First draft
1.0	Stefan Asanin	2010-08-31	First internal version
			Final version submitted to the European Commission

Internal review history

Reviewed by	Date	Comments made

1 Executive Summary

This draft version provides an overview of the existing technologies such as devices, platforms and systems including their trends relevant to the REACTION project and especially to the future exploitation of the project results.

2 Introduction

The technology watch task is part of the WP2 “User Centric Requirements Engineering and Validation”.

The aim of this workpackage is to maintain a continuous discovery and analysis of user centric requirements, needs and prospects, to be used in the design, development, implementation and validation of the REACTION platform and services. Moreover, the aim is to plan and manage user validation activities and to collect, analyse and document the results.

The work package will finally investigate all external drivers for service oriented remote health and home care environments and its deployment in European healthcare systems using a holistic approach to health status monitoring, assessment, improvement and maintenance.

The specific methodologies that will be used include evolutionary design and refinement re-engineering. Lessons Learned obtained during project progress will be used to arrive at adjustments to the initial requirements incorporating and inclusion of emergent requirements. The workpackage is responsible for continuously informing the workpackage partners of the requirement engineering process in order to enable the necessary and timely modification of design specifications and possible re-engineering of affected modules.

2.1 Purpose, Context and Scope of this Deliverable

This report is part of the task T2.3 – Evolutionary requirements refinement.

This subtask (i.e. deliverable 2.3 - Technology watch report) will maintain a continuous observation of existing and emerging technology developments with a view to assess their impact on the requirements. It will make available periodic reports to feed into the re-engineering refinement process. The Method of work is to follow up the technological developments in the field and revise each report version with changes or updates to existing features but also on futuristic development issues.

3 Standalone medical devices

3.1 Weighing scales

Weighing scales are designed to measure weight of the patient and store this data. Some models also send this data via a communication protocol (usually Bluetooth) to a application hosting device or directly to a web server from which the patient himself/herself or the clinician can access the gathered data.

3.1.1 Tanita BC-590

The BC-590 brings state-of-the-art technology to the health monitoring industry, as it is designed to transmit multiple readings, wirelessly, to a personal computer within seconds for an easy way to view and record fitness trends over time. The BC-590BT measures weight, body fat, body water, muscle mass, physique rating, daily caloric intake, metabolic age, bone mass, visceral fat, weight only button, all for 4 users, and was the first consumer scale to utilize Bluetooth technology (Tanita 2010).

3.1.2 LifeStar Scale Wireless Weight Scale

The LifeStar Scale is a digital weight scale enabling precise weight measurement, which can be utilized in many disease management programs or fitness regimes. An individual's weight is displayed clearly on the screen within seconds of stepping on the scale. After weighing in, the results are automatically transmitted via Bluetooth technology to the LifeStar PDA, where it can be viewed and saved. When convenient, the data can be transmitted to the LifeStar Network, where physicians may view patient data. Additional remote patient monitoring services are also available. The LifeStar Network provides privacy and data protection of patient information, and has the ability to track vital signs data over time (LifeStar 2010).

3.1.3 Cardiocom TELESCALE

The Cardiocom TELESCALE® is the industry telemedicine standard for CHF patient home monitoring management. TELESCALE® is an interactive home telemonitoring device integrated with a precision electronic scale. Each morning, patients use their

Cardiocom TELESCALE® at home to answer a series of questions about their current symptoms and to measure their weight. This is referred to as their "Health Check." The Health Check provides two-way communication between patients and health care providers and can be customized by a physician for a patient's telehomecare.

The Health Check data is automatically transmitted over the patient's telephone line directly to the OMNIVISOR® computer server in your office or to the CARDIO-PLAN nursing staff. OMNIVISOR® analyzes your patient's daily data and automatically identifies the patients in need of a follow-up call or care plan adjustment. Cardiocom's "management by exception" approach allows efficient and effective telemanagement of large patient populations (TeleScale 2010).

3.2 Blood pressure monitors

3.2.1 Bluetooth Blood Pressure Monitor Wrist Type (HPI-108)

Bluetooth mobile phone / PDA send command to blood pressure monitor to measure blood pressure (Systolic / Diastolic) and pulse from the wrist. The measured results can be transferred PDA / mobile phone through Bluetooth and PDA / mobile phone display the progress immediately. It is also possible to send a SMS to the programmed number (doctor or caregiver) automatically when the measure result is

over the setting value. Other features that comes with the blood pressure device is: statistical graph, fuzzy logic measurement system, high accuracy, up to 80 measurements with date/time for easy recording and reviewing, an average all records, and finally a completely automatic inflation and deflation provide home blood pressure monitoring convenience (HPI108 2010).

3.2.2 LifeStar BP Pro Wireless Blood Pressure Monitor

The LifeStar BP Pro wireless blood pressure and pulse rate monitor is an advanced device for measuring and assessing hypertension. The LifeStar BP Pro communicates with the LifeStar PDA and the LifeStar Network. After performing a test, the results are automatically transmitted via Bluetooth technology to the LifeStar handheld device, where it can be viewed and saved. When convenient, the data can be transmitted to the LifeStar Network, where physicians may view patient data. Additional remote patient monitoring services are also available. The LifeStar Network provides privacy and data protection of patient information, and has the ability to track vital signs data over time (LifeStar 2010).

3.2.3 Omron's HEM-790IT

Omron's HEM-790IT features Omron Health Management Software which will help track your progress to better blood pressure health. This monitor detects advanced diagnostics including Morning Hypertension and irregular heartbeat. Monitoring these important factors with Omron's software allows you to share valuable information with your physician.

The HEM-790IT has been tested, evaluated and proven to meet the rigorous safety and accuracy standards set by independent organizations (HEM790IT 2010).

3.2.4 Microlife 3AC1-PCCOS Upper Arm Blood Pressure Monitor

This Advanced Premium digital upper arm automatic blood pressure monitor features both patented Irregular Heartbeat Detection (IHD) and Microlife Average Mode (MAM) technology. IHD detects the appearance of an irregular heartbeat during measurement and gives a warning signal with your reading. An irregular heartbeat may indicate or cause cardiovascular disease. Leading cardiologists recommend taking three consecutive blood pressure measurements and averaging them for a more accurate result. This blood pressure monitor features MAM technology which enables a single or average mode measurement (Microlife 2010).

3.3 Pulse meters

3.3.1 LifeStar Oxy Pro Wireless Pulse Oximeter

The LifeStar Oxy Pro is an easy-to-use oximeter for measuring both oxygen saturation levels in the blood and pulse rate. It displays the medical data on the LifeStar PDA: oxygen saturation and pulse rate averages with the maximum and minimum measurements.

Throughout the test, the results are automatically transmitted via Bluetooth technology to the LifeStar handheld device, where it can be viewed and saved. When convenient, the data can be transmitted to the LifeStar Network, where physicians may view the data. Additional remote patient monitoring services are also available. The LifeStar Network provides privacy and data protection of patient information, and has the ability to track vital signs data over time (LifeStar 2010).

3.3.2 Alive Pulse Oximeter

The Alive Pulse Oximeter is a wearable medical device which uses wireless technology instead of inconvenient cables. It reads oxygen saturation data from a sensor on the finger or earlobe, and transmits the data via Bluetooth wireless technology to a mobile phone, PDA, laptop PC, or other Bluetooth-enabled device. The device can transmit the data in real-time or store the data for later download, as required.

The data received from the Alive Pulse Oximeter can be displayed locally, and for telemedicine applications it can also be transmitted in real-time to a central monitoring centre over the Internet. The device is well-suited to remote respiratory monitoring, e.g., for remotely monitoring patients receiving home oxygen therapy. The device is also suitable for home sleep apnoea screening, as the wireless technology provides a more comfortable environment for patients sleep (AlivePulseOximeter 2010).

3.3.3 Nonin Avant 4000 Bluetooth Wireless Pulse Oximeter

The Nonin Avant 4000 System with Bluetooth Wireless Technology provides freedom from wired connections while ensuring reliable and secure transfer of patient data — all in a small package. The lightweight wrist-worn patient module wirelessly sends data to a small tabletop display, improving patient mobility and reducing bedside clutter. Nonin — opening new horizons in connectivity (Avant4000 2010).

Nonin Avant 4000 Pulse Oximeter System Highlights:

- **Wireless** - Uses Bluetooth technology for ultimate patient freedom
- **Comfortable** - Lightweight wearable module fits a variety of patients

- **Unique** - The only monitor to give total freedom to the patient
- **Powerful** - 33.5 hour memory and a 10 meter signal radius
- **Easy to Use** - Clear colour-coded LED display & effortless connections
- **Alarms** - Customizable to meet unique needs
- **Suitable for Transport Use** - Comes with a 12v DC connector
- **Secure** - Data encryption feature to safeguard patient information
- **Efficient** - 120 Hours battery life for patient module, 18 hours battery life for oximeter (4 hour recharge)

3.3.4 PM-50 Pulse Oximeter

PM-50 is a miniature, lightweight device designed exclusively for spot-check monitoring of SpO2 and pulse rate. Weighing less than 200g, this device is easy to carry, easy to store, and equips you with just what you need to get the job done. Choose PM-50 and you will have the accuracy and efficiency you rely on when performing intermittent monitoring of a wide range of patients (PM50 2010).

In addition, this powerful device is easy to maintain, requiring just four AA batteries for up to 15 hours of run-time. More convenience and ease-of-use mean more time to focus on your patients. Take the worry out of your spot-check monitoring routine and choose PM-50: the simple choice.

- Suitable for adult, Paediatrics, and neonatal patients.
- Enables spot-check monitoring of SpO2 and pulse rate and automatically updates the data every second.
- Miniature design offers an impressive lightweight device making it easy to use on the go
- Backlit LCD prominently displays SpO2 and pulse rate readings accompanied by a pulse signal strength
- indicator
- Additional useful indicators shown on the LCD include patient ID, low power indicator, data storage indicator, error condition and standby mode
- Helpful prompts, including memory full, ID storage full, low battery and general error conditions, allow for simple and quick troubleshooting
- Memory supports storage of 200 data records for a maximum of 100 patient IDs

- Connect to a PC using a standard communication cable for downloading and printing trend data
- 4 AA alkaline or rechargeable batteries provide 15 hours of run-time
- Automatic standby and shutdown modes assist in conserving battery power
- Power-off button features a 2-second delay to prevent accidental shutdown

3.4 ECG meters

3.4.1 LifeStar ECG Wireless Cardiac Event Monitor

The LifeStar ECG is a lightweight and easy to use personal 1 Lead ECG event monitor intended for monitoring symptoms that may suggest abnormal heart rhythms. The LifeStar ECG communicates with the LifeStar PDA and the LifeStar Network. After performing a test, the results are automatically transmitted via Bluetooth technology to the LifeStar handheld device, where it can be viewed and saved. When convenient, the data can be transmitted to the LifeStar Network, where physicians may view patient data. Additional remote patient monitoring services are also available. The LifeStar Network provides privacy and data protection of patient information, and has the ability to track vital signs data over time (LifeStar 2010).

3.5 Combo devices

3.5.1 MDKeeper

Effortless, uninterrupted vital signs monitoring anytime and anywhere. That´s the key sign to Aerotel's MDKeeper which is an innovative remote wireless monitoring solution for mobile-health and home-care applications. With MDKeeper, the elderly or chronically ill can maintain a normal active lifestyle without being confined to their homes or making frequent visits to their doctor. MDKeeper integrates unique, powerful biosensors into a lightweight wearable device. It monitors multiple vital signs (such as pulse rate, 1-lead ECG and blood oxygen saturation level) without discomforting its users, even when they are on the move. Using its proprietary integrated expert system, MDKeeper stores and analyzes patient data. The data is

transmitted, either immediately or on a timed basis, to a remote medical center for further analysis and care, via its built-in Siemens Wireless Module. MDKeeper can communicate with remote hospital information systems, integrating its data into existing and emerging telehealth applications, electronic patient records (EPR) and other online data analysis and clinical decision support systems (MDKeeper 2010).

3.5.2 Fitbit

The Fitbit accurately tracks your calories burned, steps taken, distance travelled and sleep quality. The Fitbit contains a 3D motion sensor like the one found in the Nintendo Wii. The Fitbit tracks your motion in three dimensions and converts this into useful information about your daily activities.

The Fitbit can record detailed daily data (minute by minute calorie burn and sleep data) for 7 days and summarized daily data (daily steps, calories and distance) for 30 days. Once the Fitbit is within range, it will automatically upload any stored data that it has recorded. Walk within 15ft of the provided base station and your data will be automatically uploaded to the Fitbit website (FitBit 2010).

3.5.3 Intelesens VS100

The Intelesens VS100, patch based Bluetooth Vital Signs Monitor has achieved CE regulatory approval and began shipping in December 2009. Intelesens is an internationally recognised, leading innovator in targeted non-invasive wireless vital sign monitor development who has developed the world's first intelligent, wearable, non-invasive, wireless vital signs monitoring device for use primarily in remote patient monitoring and personal telehealth applications. Intelesens is a spin out from the University of Ulster where there is a strong long term relationship with three leading academics thus ensuring the continued identification and design of world beating innovative products. Intelesens is developing a portfolio of products which will deliver improved quality-of-care to patients and significantly reduce healthcare costs by reducing the need for hospitalizations and outpatient visits. Intelesens develops and manufactures its own products and also products for other original equipment manufacturers (OEMs) (Intelesens 2010).

3.5.4 BioHarness

BioHarness BT couples the pioneering Smart Fabric sensor technology of the comfortable and unobtrusive BioHarness garment with the power and ubiquity of Bluetooth®. BioHarness BT enables the capture and transmission of comprehensive physiological data on the wearer via mobile and fixed data networks – enabling genuine remote monitoring of human performance and condition in the real world.

Product Capabilities:

- SDK available
- Monitors heart rate, R-R
- Monitors breathing rate and relative depth
- IR skin temperature measurement
- Activity measurement via 3D accelerometer
- Posture analysis
- Fabric-based, dry contacts
- Wireless connectivity
- Enables local display of summary data on a Bluetooth / Java device
- Remotely configurable thresholds
- Streaming, Sample or Threshold data transmission modes over the cellular data network

Software Development Kit, SDK is available on request. The kit is an excellent way to integrate the BioHarness into other third party software (BioHarness 2010).

3.6 Continua compliant devices

Already devices are available for many physiological measurements. lists devices available as of 16 May 2010 (taken from www.continuaalliance.org) that are certified as Continua compliant. lists other devices and devices certified as fulfilling a manager role. Finally, and deal with more programmable and developmental tools and systems.

Device	Manufacturer	Model	Transport
Blood pressure	A&D	UA-767PBT-C	Bluetooth
	Cypak	CPX186 Continua convertor cable	USB
	Omron	Home blood pressure	Bluetooth
Glucose meter	Roche	Accu-Check Smart Pix	USB
Pedometer	Omron	Pedometer with Bluetooth docking	Bluetooth
Pulse oximeter	Nonin	PalmSAT 2500	Bluetooth
	Nonin	Onyx II 9560 Fingertip	Bluetooth
Weighing scales	A&D	UC-321PBT-C	Bluetooth
	Cypak	CPX186 Continua convertor cable	USB
	Omron	Weighing scales with body composition	Bluetooth
USB agent platform	Texas Instruments	Generic USB platform	USB

Available Continua agents.
(AND Medical 2010), (Cypak 2010), (Omron 2010), (Nonin 2010).

4 Application Hosting Devices

4.1 CoroNet – Telemetry

The telemetric function is equivalent to the Bedside monitor function both with respect to functionality and quality. Current patient surveillance with monitors and telemetric systems are often done using two separate systems. CoroNet unites these two into one system.

The unit that is used to monitor ECG and SpO2, is also used as a telemetric broadcast device. If contact with the bedside monitor is lost when the patient is up and moving, the measuring unit is automatically reconfigured to simultaneously broadcast to the Bedside monitor via access points. This information is also routed to the Central station and archive. When the Bedside monitor is no longer needed, measurement data is routed to a telemetry server. This way the monitoring process remains uninterrupted, and all data is stored in the same file.

Desired areas can be covered by installing an adequate number of access points. CoroNet Telemetry enables monitoring of active and moving patients with diagnostic grade MIDA technique. Bluetooth based telemetry ensures sufficient bandwidth while keeping the power supply at an acceptable level. Bluetooth access points are connected to and receive their power supply through the LAN (CoroNet Telemetry 2010).

4.2 Microtel ecgAnywhere

The Microtel ecgAnywhere has redesigned the standard 12-lead ECG in order to take advantage of extraordinary gains in compatibility and remote medicine ECG technology. The entire unit fits into the palm of a hand, and is especially useful for healthcare professionals where manoeuvrability is essential. The ecgAnywhere also excels in terms of connectivity; it has the capacity to store up to 40 reads, and at any time the stored data can be transmitted analogically through a phone line, or digitally through a USB port or a Bluetooth interface. The unit can use these technologies to transmit data in both local and remote environments, relieving many physical constraints associated with ECGs today. And unlike many current ECG units where the screen depicts what is merely a representative rhythm strip with no actual data, the ecgAnywhere is able to portray the results in real-time on its high-resolution LCD screen for those situations where an immediate analysis is critical (Microtel ecgAnywhere 2010).

ecgAnywhere features these options:

- ECG Memory
- Possibility to store up to 40 ECG in SCP-ECG format in its internal memory.
- Any ECG report can include patient's data.
- PC Archiving
- Digital transmission of ECG reports to a local PC via USB cable.
- Wireless transmission
- Digital wireless transmission of ECG reports to a local PC via Bluetooth connection.

4.3 Vena Platform

The Vena platform embeds the IEEE Personal Health Data standard, along with *Bluetooth* Health Device Profile onto a single chip. Vena can be used to deliver a complete user interface including display driver. All that needs to be added is your chosen sensor. The reference design includes development hardware, which can be used to rapidly prototype and test your product, as well as xIDE for Interface Express, a complete software development environment for high-performance 2.1/2.1+EDR Bluetooth applications development. Through a complete single chip approach Vena brings a new cost point to connected health devices, with a module cost as low as $10 in appropriate volumes. The Vena platform implements the full version one device connectivity standards defined by the Continua Health Alliance.

Vena is the first product to achieve Bluetooth Health Device Profile (HDP) Qualification, providing reliable wireless connectivity. The Vena platform contains all of the elements required to produce a complete device. For a medical device the platform can support a chosen sensor using the built in ADC. The Vena platform can be used as the main processor for a device manager application, or can interface to a host processor for integration into an existing design. In both configurations Vena can simultaneously monitor multiple devices. Cambridge Consultants exceptional radio system design capability has been applied to minimise the power requirements of the device. For periodic measurements this approach allows longer battery lifetimes and maximises product usability. Vena can be used to provide connectivity

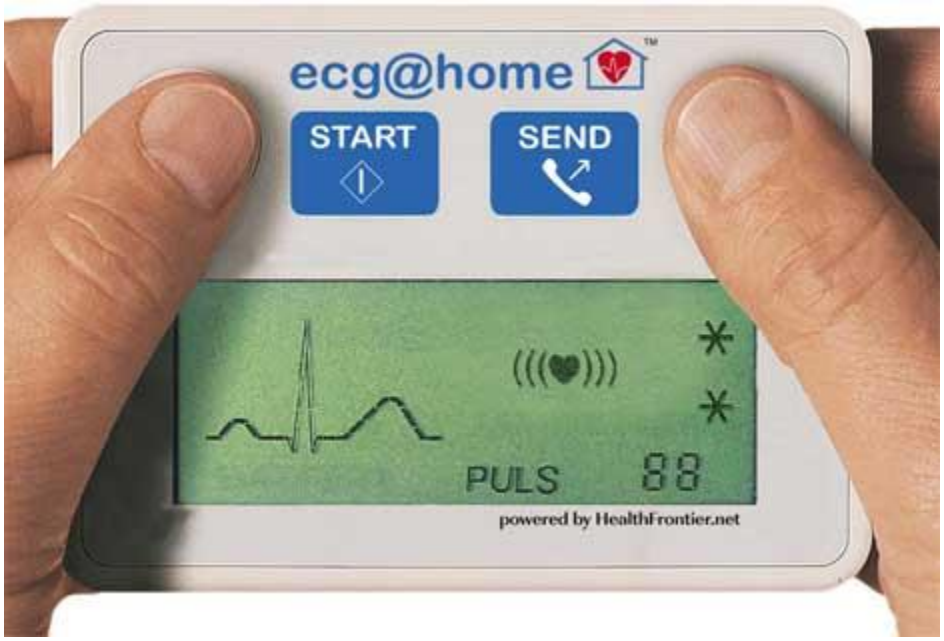
to existing devices. It can be customised to work alongside your existing platform to provide the addition of a compatible communications interface. In addition to Bluetooth wireless technology the Vena platform offers software support for a range of other connections. Standard wired connections can also be added via UART or USB. The on-chip 24-bit DSP can be used for sensor input processing, additional security, or compression algorithms. The user interface can also be modified to suit desired application (Vena Platform 2010).

4.4 Cholestech LDX System

The Cholestech LDX System places the power of prevention in the hands of the healthcare professional. Using just a small drop of blood, the CLIA-waived system delivers rapid, lab-accurate results for lipids, glucose, liver enzymes, and high sensitivity C-reactive protein (hs-CRP) at the point-of-care. The broad test menu makes the Cholestech LDX an invaluable tool in the prevention and management of conditions ranging from heart disease to diabetes to metabolic syndrome. It's the shortest route from risk assessment to treatment options and counselling. The accuracy, speed and broad menu of tests available for the Cholestech LDX make it an invaluable tool in the fight against heart disease, diabetes and metabolic syndrome. Best of all, the rapid results allow for immediate testing, counselling and treatment decisions. *RS-232 Adapter Kit a*llows interface between LDX System and PC-compatible computer for patient result download (Cholestech LDX System 2010).

4.5 HealthFrontier ecg@home

The ecg@home is HealthFrontier's newest innovation in web-enabled electrocardiogram (ECG) technology. It is small enough to fit in the palm of a hand and supports numerous connectivity features, including data transmission through USB, Bluetooth, or trans-telephonically. In conjunction with the RHMS, the ecg@home is a powerful EKG solution for any healthcare environment. The ecg@home is a single lead ECG event recorder. It can record, and store an ECG tracing using the patented built-in electrodes. It also records important ECG parameters. ECG Parameters measured are heart rate, deviation of the ST segment of the wave, duration of the QRS complex, and abnormalities of the T-wave, T-Neg, Arrhythmia.



The ecg@home acquires 10 seconds of Lead (I) using two thumbs, or Lead (II) using one thumb and an external lead placed on the left leg, or any peripheral Lead, such as V5, using the thumb and the optional external electrode. The ecg@home is powered by an IT backbone known as the Remote health Monitoring System (RHMS). HealthFrontier's RHMS is a web-enabled software application that automatically receives, stores and forwards incoming ECG scans to a patient's Electronic Medical Record, thus eliminating the need for paper printouts (HealthFrontier ecg@home 2010).

4.6 TeleStation

The TeleStation is the center of Philips Remote Patient Monitoring, enabling secure, two-way flow of information between remote caregivers and chronically ill patients.

It's a hub for the transmission of vital signs data (automatically collected from the wireless measurement devices or manually entered) and it's also a medium for interactive communication between care providers and patients at home.

The TeleStation prompts patients to answer health assessment survey questions - which can be customized to manage any disease - and will automatically send an Autochek survey to follow up on out-of-limit readings. Clinicians can tailor patients'

daily interactions to help reinforce specific topics: signs and symptoms, medication and side effects, diet and lifestyle, and compliance with care protocols (Philips TeleStation 2010).

4.7 Health Buddy

The Health Buddy system connects patients in their homes to their care providers. What sets the Health Buddy system apart is its ability not only to communicate historical patient information for patients with chronic conditions, but also to facilitate patient education and encourage medication and lifestyle compliance.

The Health Buddy Appliance is the ultimate in simplicity. Key features include:

- Easy-to-use, patient centric design
- Simple, intuitive four button operation
- Large, high-resolution colour screen
- Support for multiple languages, including English, Spanish and Dutch
- Multiple medical device ports
- Wireless Bluetooth and Infrared Support
- Friendly tutorial preloaded on each appliance
- Uses remote configuration for patient customization

With more than 30 health management programs to choose from, the Health Buddy system can address a broad range of chronic health issues (Health Buddy 2010).

4.8 Commander

The Commander Home Monitor is an interactive home monitoring device for disease states such as CHF, Diabetes, COPD, Asthma and Hypertension. The modular design allows you to select the Cardiocom peripheral devices that provide the most appropriate and cost-effective care for your patients. Each day your patients use their Commander Home Monitor to obtain objective biometric data such as: weight, blood pressure, blood glucose, peak flow, and oxygen saturation. Patients also answer a series of questions about their current symptoms. Questions are both displayed in large font and spoken. The data is transmitted over the patient's telephone line directly to the Commander Data Management System at your facility (Commander 2010).

commander

4.9 Genesis DM

Genesis DM is seamlessly integrated into the innovative new Honeywell HomMed LifeStream telehealth platform, providing web-enabled, on-demand access to disease-specific symptom management (DSSM), customizable by diagnosis and symptoms (Genesis DM 2010).

This telehealth device measures heart rate, blood pressure, and weight, and provides customizable subjective disease-related queries for a more complete picture of an individual's health. Automated set up and automatic patient engagement with a friendly voice and easy-to-use interface guide the patient at every step.

With breakthrough ease of deployment and use, Genesis DM delivers dependable vital sign and symptom pattern acquisition from the start, using clear auditory and visual user cues. Voice-enabled DSSM modules, available on-demand through the LifeStream portal, provide symptom-specific assessment and patient information by diagnosis or disease state on managing hypertension, COPD, CHF, and diabetes.

4.10 RTX3370 Telehealth Monitor

The RTX3370 Telehealth Monitor is a wireless gateway, which serves as the central device for seamless and secure collection of data from chronically ill patients. The RTX3370 Telehealth Monitor collects data from a range of standard external vital sign monitoring devices such as scales, blood pressure monitors, blood glucose monitors and peak flow meters and transmits the data to a HTTPs server on the Internet.

The device is specially designed for home use by the patient and contains a number of unique features, designed for the 60+ target group with simplicity and usability as important targets, as for example a large easy-to-read display and large buttons. Furthermore, besides collecting vital sign data, the device has the ability to serve as a communicator between the care provider and the patient, since the RTX3370

Telehealth Monitor can be configured to ask symptomatic questions and also for patient reminders.

The RTX3370 Telehealth Monitor can also be configured to verbalize what is on the screen using compressed audio files. The files can be replaced to match language and text for each specific text that needs to be spoken. Moreover, due to the fact that it incorporates a very flexible JavaScript interpreter, the RTX3370 Telehealth monitor is easily adapted to the Health Service Providers specific handling of different diseases. The handling of data and selection of what to display is defined in these scripts (RTX3370 2010).

4.11 DayLink Monitor

The monitor is a biometric measurement device that records a participant's weight and answers to pre-programmed questions regarding symptoms of the chronic condition or co-morbidities that Alere may be monitoring. The participant's health information is then sent daily via a phone line to Alere's clinicians, which allows them to provide immediate guidance and/or alert the participant's physician if the symptoms require immediate attention (Alere 2010).

4.12 LifeStar PDA

The LifeStar Remote Monitoring System runs on the LifeStar PDA (Cingular 8525), that contains all of tools required to safely and efficiently monitor the following: 1 lead ECG, non-invasive Blood Pressure, Weight and a Pulse Oximetry.

During or after performing a test on any LifeStar monitor, the results are automatically transmitted via Bluetooth technology to the LifeStar handheld device, where it can be viewed and saved. When convenient, the data can be transmitted to the LifeStar Network, where the data is stored. The LifeStar Network provides privacy and data protection of patient information, and has the ability to track vital signs data over time (LifeStar 2010).

5 Remote Patient Monitoring systems

5.1 CardioBelt ECG Acquisition System

The CardioBelt ECG Acquisition System is easy to use and provides the accuracy and reliability that physicians have come to expect from high-end devices. Combined with Monebo's patented ECGAnalyzer Software, CardioBelt allows patients to take their own ECG and wirelessly transmit the results to their health care provider. The ability to do this without the aid of a health care professional on-site opens up opportunity for the home monitoring of heart patients using a critical and widely understood test, the ECG. This yields improved health care, convenience for the patient and more efficient healthcare delivery.

In operation, CardioBelt transmits ECG data to a local home appliance, cell phone, or any other communication device. The device then transfers the ECG data to a remote care provider's station where the data is displayed and interpreted. The software system may store the ECG data, generate reports, and allow retrieval of archived records (Monebo 2010).

5.2 MHM100 Personal Heart Reporting Service

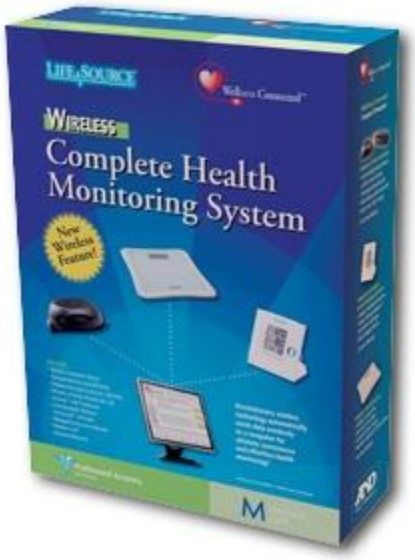
The Medick Personal Heart Reporting Service gives the user a level of control over heart health previously unavailable outside the doctor’s consulting room or hospital. Most changes in the health of the heart should be spotted at an early stage so that appropriate treatment can be given if it is required. The MHM 100 uses intelligent neural network technology to assess the heart. This means that the MHM 100 has a level of accuracy that compares with the standard ECG (electrocardiogram) monitors used by doctors. We must point out, however, that no ECG monitoring device can claim to detect all heart irregularities. However, the MHM 100 is as good as current technology allows. The MHM 100 is a personal ECG testing device that monitors the heart on a beat by beat basis to detect any irregularities. It does this over a period of up to 8 hours and automatically generates a report of the heart rhythm and the patient can use the Medick Explorer software to send the ECG results for expert interpretation (MHM100 2010).

5.3 Tele-CliniQ

This system deals with streamlined medical management of home-based chronically ill patients. Tele-CliniQ significantly eases the burden of monitoring medical parameters of chronically ill patients, while enhancing their quality of life. An easy-to-use multi-parameter communicator, it can simultaneously transmit data from up to four medical devices to the MPM Receiving Center. Once measurements have been recorded into each connected instrument, the user simply presses the “Start” button to activate parameter reading and transmission. Equipped with an internal memory and real-time clock, its automatic data transfer is reliable and minimizes human error. Tele-CliniQ streamlines medical management because it is both time and cost effective (Aerotel Medical Systems (Tele-CliniQ 2010).

5.4 CP-1THW - Wireless Complete Health Monitoring System

This combo pack contains the tools you need to get you moving towards better health at any stage of life. Including a Wireless Activity Monitor, Wireless Automatic Blood Pressure Monitor, Wireless Precision Scale, and ActiLink USB Transceiver.



Information is the key to long-term wellness maintenance and improvement. Through daily tracking of blood pressure, weight, and physical activity, individuals can become aware of their personal progress and take a proactive approach to caring for their health. The Wellness Connected system helps you do just that, keeping you motivated to reach your health goals whether they're losing weight, lowering blood pressure, or keeping a daily activity regimen.

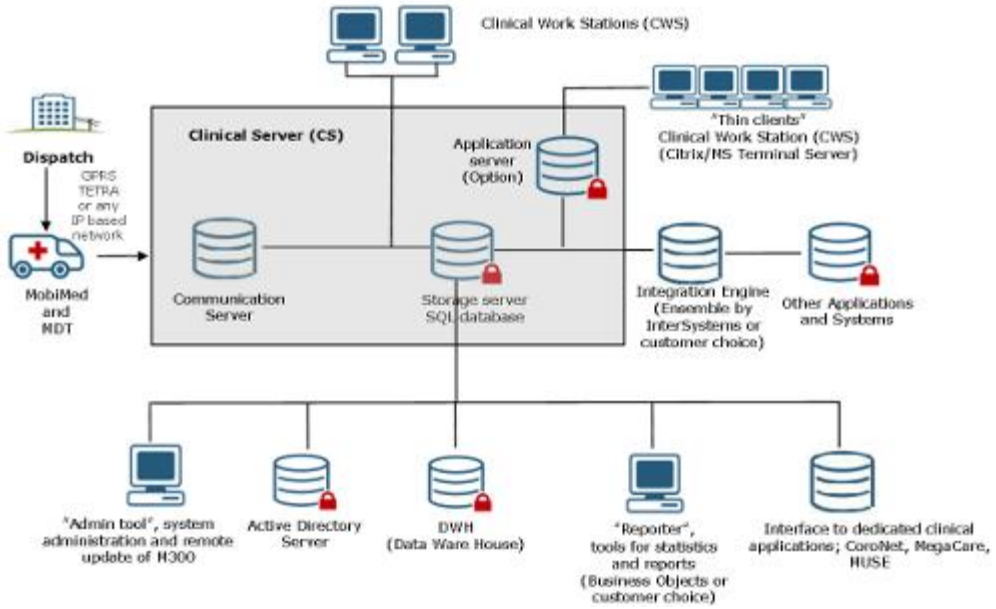
The Wellness Connected software application automatically receives your measurements and graphs it in a colourful, user-friendly interface. Or, take your wellness tracking to the next level by subscribing to the ActiHealth Online service. With ActiHealth, you can view your wellness data from any Internet-enabled computer and even remotely track the progress of family and friends such as an elderly parent or weight loss partner. Wherever you want to go with your health, Wellness Connected will help you get there. The only downside is there is a USB stick that has to be connected to computer in order to transfer data gathered from the sensors (CP-1THW 2010).

5.5 MobiMed

The ultimate eHealth solution for Pre-hospital Clinical and Operational Process Development. MobiMed is a toolbox that brings the pre-hospital scope into the hospital and vice versa. The MobiMed platform is a powerful tool to build pre-hospital eHealth processes. MobiMed is modular, flexible, scalable, configurable and integrateable and prepared for future demands. MobiMed has solutions and benefits

for all stakeholders involved in the pre-hospital care. The MobiMed toolbox contains SW components for decision support, monitoring, documentation (EPR), communication, integration with other systems, and statistics.

The MobiMed toolbox is based on modern IT components in order to meet all the normal IT requirements such as Single-Sign-On, Security requirements, Audit trail, LDAP connection, Automatic failover, Remote updates, Thin clients, Virus protection, etc (MobiMed 2010).



Showing a possible architecture with involvement of MobiMed.

5.6 MyGlucoHealth Meter

The first FDA cleared integrated Bluetooth enabled diabetic care product. The Bluetooth capability allows for short range communication over secure wireless connection between devices, such as personal computers and cell phones. This feature gives the user the luxury of digitally transmitting their daily readings to be better evaluated through a real time online data collection network. Physicians can then be automatically updated on their patients and may intervene if the results require physician action (MyGlucoHealth Meter 2010).

Figure showing MyGlucoHealth Meter communication

Recorded results are automatically sent to MyGlucoHealth over a secure connection where you can track and chart your results, data, and send information to your physician. The easy strip ejector minimizes time spent gathering a blood sample so that you can access your daily results more rapidly. Testing results are available in as little as three seconds or less and requires an even smaller blood sample size (.3µL) than other meters. With automatic coding of the test strips, the MyGlucoHealth meter is a more comprehensive diabetic testing system that gives the user the most control over the care of their diabetes and allows for enhanced communication between patient and doctor. Aside from the simple operation and innovative

functions, MyGlucoHealth meter allows you to alternate testing sites for no more sore fingers. This technology is easy to use and easy to learn.

5.7 Home-CliniQ

Home-CliniQ is a PC application software installed at the user's location. Home-CliniQ allows the monitoring of various parameters. It communicates with vital sign monitoring devices via a wireless, Bluetooth interface. Home-CliniQ monitors incoming wireless connections. Once a wireless connection is detected, it establishes a communication protocol with the transmitting device. Home-CliniQ's window will then display the status of the communication.

Upon completion of a successful data transfer, the received data will be stored on the PC's hard disk and sent via the Internet to Aerotel's MPM or HRS systems. Mobile-CliniQ is a Symbian-based mobile phone application software. Mobile-CliniQ allows the monitoring of various parameters and communicates with vital sign monitoring devices via a Bluetooth interface. Data is sent via GPRS to a medical monitoring center. With Mobile-CliniQ, personal health service becomes a reality for today's mobile lifestyle (Aerotel Medical Systems (Home-CliniQ 2010).

5.8 Alive Diabetes Management System

The Alive Diabetes Management System provides wireless transmission of blood glucose readings to a central web-based database, allowing an accurate diary to be kept. This can be easily reviewed by the patient and his physician, with two way wireless messaging providing insulin schedules, advice and reminders. Expert systems on the server analyse the data and provide immediate feedback to the patient and his doctor. The system facilitates better diabetes management, reducing the long term complications of diabetes.

The Alive Diabetes Management System utilises the latest advances in technology to provide an affordable solution which meets the need for improved disease management and care planning. The system uses Bluetooth and mobile phone networks (Alive 2010).

5.9 Continua compliant tools for developing RPM systems

Dev Tool	Manufacturer	Feature
Manager Development	Lamprey Networks Inc (LNI)	OXPlib implements the details of the ISO/IEEE 11073-20601 optimized exchange protocol and provides a simple, high level interface for application development, without compromising application control. The OXP stack uses the CESL Transport Provider Interface (TPI) to transport layer shims. Shims for USB and Bluetooth are provided. A development shim for TCP is also included. The OXP stack supports simultaneous operation with multiple ISO/IEEE 11073-20601 agents.
CPATS	LNI	Continua PAN Agent Test Suite. Uses ISO/IEEE 11073-20601 Test Association in conjunction with test object to implement fully automated regression testing
HealthLink	LNI	Enables Continua devices to deliver data to eHRs using open industry standards. HealthLink includes a complete implementation of an ISO/IEEE 11073-20601 manager, an xHR interface and a simple monitoring application for configuration and control.

Available Continua related systems, development tools with features.
(Lamprey Networks 2010)

6 Handheld devices

Wearable sensors will be connected through a patient centric Body Area Network (BAN). Decentralised decision support at the point-of-delivery (the patient) will be achieved with active nodes/gateways (e.g. PDA, Smart Phone operating personalised software bundles in an OSGi framework or Apples iPhone OS 3.0). Communication will be based on standards where possible. For optimum patient comfort and usability, ePatches and BAN need to have the following properties:

- They are wearable for up to one week in the course of normal human activity
- They are easy to wear and mount without being visible or attracting undue attention
- They do not disturb normal daily activities or cause discomfort
- They consume very little power and can run on a small battery for a week
- They can cope with transmission black-outs and different communication networks
- They may be disposable and may be manufactured in mass production processes at low costs and with environmental materials and substances

A Personal Area Network (PAN) will connect the patient to loosely coupled ambient sensors. Communication protocols with built-in reflective properties (such as Bluetooth and ZigBee) will be preferred, but other communication protocols will be supported. The PAN node will be used for data fusion and inference. Data will be combined with descriptive context data such as GPS data, ambient temperature, human activity indicators, etc. and fused to Data Management.

6.1 Mobile phones

A mobile phone (also called mobile, cellular phone or cell phone) is an electronic device used for full duplex two-way radio telecommunications over a cellular network of base stations known as cell sites. As the majority of available mobile phones are outnumbering and the fact that more and more mobile phones fall into the category of Smartphones, this subchapter is left empty for further review.

6.2 PDA and Smartphones

A personal digital assistant (PDA), also known as a palmtop computer, is a mobile device that functions as a personal information manager. Current PDAs often have the ability to connect to the Internet. A PDA has an electronic visual display, enabling it to include a web browser, but some newer models also have audio capabilities, enabling them to be used as mobile phones or portable media players. Many PDAs can access the Internet, intranets or extranets via Wi-Fi or Wireless Wide Area Networks. Many PDAs employ touch screen technology.

A Smartphone is a mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature phone'. Smartphones and feature phones may be thought of as handheld computers integrated within a mobile telephone, but while most feature phones are able to run applications based on platforms such as Java ME or BREW, a Smartphone allows the user to install and

run more advanced applications based on a specific platform. Smartphones run complete operating system software providing a platform for application developers.

6.3 Tablet PC / Mini laptops

6.3.1 Apple Ipad

6.3.2 Apple Iphone

6.3.3 Panasonic Toughbook 08

6.3.4 Samsung Q1

..and more to come.

6.4 Operative systems

6.4.1 Symbian OS

6.4.2 Apple iOS

6.4.3 Android

6.4.4 Windows Mobile

6.4.5 Palm OS

6.4.6 Mobile Linux

6.4.7 RIM BlackBerry OS

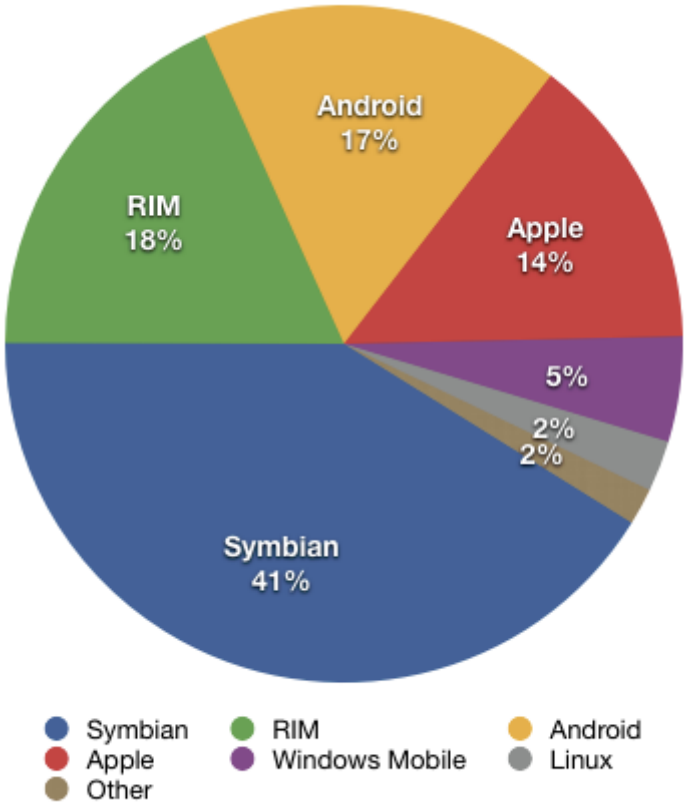


Figure 1 http://www.gartner.com/it/page.jsp?id=1421013

7 Wireless sensing - context and environmental data

7.1 OS/Platforms

Operative Systems (OS) for embedded computers or sensors are very like ordinary OS but with aimed performance. Here, OS is a software that runs on sensor devices in order to manage its computer hardware and to provide for application services.

7.1.1 Contiki

Contiki is an open source, highly portable, multi-tasking operating system for memory-efficient networked embedded systems and wireless sensor networks. Contiki has been used is a variety of projects, such as road tunnel fire monitoring, intrusion detection, water monitoring in the Baltic Sea, and in surveillance networks. Contiki is designed for microcontrollers with small amounts of memory. A typical Contiki configuration is 2 kilobytes of RAM and 40 kilobytes of ROM. Contiki offers a low-power radio communication with full IP networking, network interaction by Unix-like command shell interface, power-efficiency with the help of a software-based power profiling mechanism that monitor each sensor node, on-node storage through Contiki's Coffee File System, simulators, and the programming model (C language) has an event-driven kernel suitable for the REACTION platform *push* data transfer model. Contiki is developed by the Swedish Institute for Computer Science (SICS) and provide access (hardware, software, knowledge) if so required by the REACTION project (Contiki 2010).

7.1.2 TinyOS

TinyOS is an open-source operating system designed for wireless embedded sensor networks. It features a component-based architecture which enables rapid innovation and implementation while minimizing code size as required by the severe memory constraints inherent in sensor networks (TinyOS 2010).

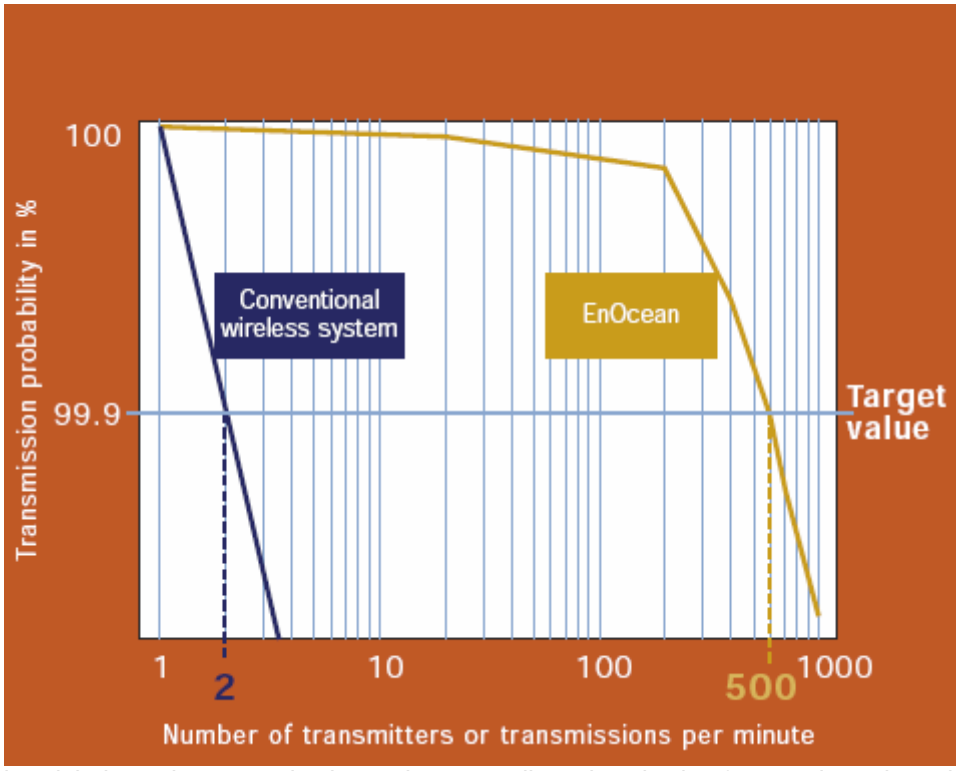
7.1.3 Nano-RK

Nano-RK is a fully pre-emptive reservation-based real-time operating system (RTOS) from Carnegie Mellon University with multi-hop networking support for use in wireless sensor networks. Nano-RK currently runs on the FireFly Sensor Networking Platform as well as the MicaZ motes. It includes a light-weight embedded resource kernel (RK) with rich functionality and timing support using less than 2KB of RAM and 18KB of ROM. Nano-RK supports fixed-priority pre-emptive multitasking for ensuring that task deadlines are met, along with support for CPU, network, as well as, sensor and actuator reservations (Nano-RK 2010).

7.2 EnOcean

EnOcean technology was developed to detect sensor data without the need for batteries or an external supply of current, and to transmit them wirelessly. The wireless range is up to 30 meters in buildings, and up to 300 meters in the open.

Minimal amounts of energy from the environment – some 50 micro joules per action – suffice to send a wireless telegram. Similar to the dynamo principle of generating energy for a bicycle light, a tiny electrodynamics transducer produces an electric voltage from finger pressure. The wireless telegram accompanying this is transmitted by the EnOcean wireless switch when the button is pressed or released. A KNX gateway receives the wireless signal and generates the appropriate KNX telegrams on the bus to switch something on and off, to dim or to adjust blinds.



Low collision risk through extremely short telegrams allows hundreds of transmitters in a single radio cell[1].

Sensors intended to monitor their surroundings in cycles can be powered by a miniature solar cell. A small energy storage mechanism (Goldcap 0.1 F) charged during the day (minimum approx. 50 lx) serves to maintain functionality in the night time. In a typical scenario the sensor is waked every 10 seconds for about 5 milliseconds to meter something. Any change in the metered value is transmitted. A so called presence signal is sent after maximally 15 minutes. For 99.95 percent of the time a sensor is in a sleep state – with minimum current drain of its ultra-low-power timer, whose typical requirement of 100 nA dominates the energy balance. But EnOcean also uses other energy sources from our surroundings – difference in heat for example – to generate voltage. Two degrees are sufficient for a thermal converter, currently being developed, to send a signal. That is less than the temperature difference between the air in a room and the surface of warm radiators or machine parts.

- Secure wireless transmission – even in systems with hundreds of sensors
- Little risk of collision through extremely short wireless telegrams
- Ecological – no battery disposal and less radiation load than conventional light switches (EnOcean 2010).

[1] http://www.enocean.com/fileadmin/redaktion/pdf/white_paper/wp_energyforfree_en.pdf

7.3 Continua compliant communication ?

Device	Manufacturer	Transport
Bluetooth stack	Toshiba	Bluetooth
Toughbook H1	Panasonic	Bluetooth/USB

Available Continua Bluetooth stack and tablet PCs.
(BluetoothManager 2010), (Panasonic 2010)

Tool	Manufacturer	Transport
CPK082 *(Compliance connection)*	Cypak	RFID transceiver support

Available Continua programmable Application Specific Integrated Circuit (ASIC).
(CPK082 2010)

8 Appendix of communication protocols

8.1 ZigBee

ZigBee is a WPAN standard for a suite of high level communication protocols using small, low-power digital devices with short range radios. Typically used for industrial automation and domestic light control applications, ZigBee is governed by the ZigBee Alliance, a group of companies which maintain and publish the standard.

8.2 Bluetooth

Bluetooth is an open wireless technology standard for exchanging data over short distances from fixed and mobile devices, by using short length radio waves and creating personal area networks (PANs). Bluetooth was initially created by telecoms vendor Ericsson in 1994, and today is managed by the Bluetooth Special Interest Group. Although it was originally conceived as a cable replacement technology, a wireless alternative to RS-232 data cables, in its current specification it can connect several devices, forming small short range networks.

8.3 USB

The Universal Serial Bus (USB) is a wired point to point connection technology that is capable of high throughput (480Mbit/s for USB 2.0 and 4800Mbit/s for USB 3.0). The USB signals are transmitted through a twisted-pair data (channels) cable and prior to USB 3.0 these commonly used half-duplex differential signalling to reduce the electromagnetic noise effects in long lines. The USB 3.0 uses far more complex by introducing two additional pairs of shielded twisted wires and interoperable contacts. These data channels permit a higher data rate as well as full duplex operation. A USB connection is always between a host (or a hub, e.g. PDA) at the connector end and a device (or hub's upstream port, e.g. a biosensor's transport gate) at the other end.

8.4 WiFi

A wireless fidelity (Wi-Fi) network is used to connect computers to each other, to the Internet, and also to wired networks. Current Wi-Fi networks operate in the ISM bands (2.4GHz, 5GHz), offer speeds up to 54Mbps and support quality of service (QoS) with managed levels for data, voice as well as video applications. Their medium access is based on the carrier sense multiple access/collision avoidance (CSMA/CA) principle.

8.5 IPv6

The Internet Protocol version 4 (IPv4) is today suffering from an acute shortage of available address space for allocation (with what is the standard of 32 bits). The reason behind it is the exponentially increasing network devices that are connected both in the wired and the wireless domain. Therefore, there exists a 6^{th} version, IPv6 (with what is to be the new standard address space of 128 bits) that has become the successor protocol to the currently exhausted IPv4. Although communication technologies such as the IEEE 802.15.4 (IPv4 (and v6)) has been developed in a rapid pace the applications that make use of smart objects have not and this due to proprietary or half-closed systems with partial or non-interoperable systems, i.e.

computers communicating with their own protocols via complex multi-protocol gateways. This has been a technological discomfort so far but as these networks today more and more operate on fully E2E IP-based architectures one could assume the problem would be dissolved. But when it comes to sensor architectures that do not rely on an IP-basis and instead deploy a protocol-translation gateway model they thereby re-energize the problem of complexity in design, management and deployment of multi-protocol gateways. The complexity lies within the non-efficient network fragmentation due to inconsistent routing, QoS, transport and network recovery techniques. Although there indeed exist systems that use a network architecture with a protocol-translation gateway, E2E IP architectures are widespread acknowledged to be the only alternative to design a scalable and efficient network that use a vast number of communicating smart objects.

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