Biomedical sensors in patient monitoring

Dag Ausen, SINTEF ICT, Norway, dag.ausen@sintef.no
Content

Patient monitoring

Biomedical sensors

2 examples
Wireless hospital scenario

Triage
Surgery
Bedside monitoring
Wireless patients

Data collection 24/7
Alarm levels
Data collection

Out of hospital scenarios…
Care monitoring
Self management
Motivation
Care monitoring - rehabilitation

Michael is recently diagnosed with Congestive Heart Failure. He was treated in hospital for two weeks, and is now enrolled in the rehabilitation program for CHF patients. Objective for monitoring Michael: He needs to watch his weight because general circulation problems and he needs to do moderate exercise, i.e. walks.

Nurse Jane Millner going about her daily routine of checking up on her patients. They all suffer from some chronic disease, and are equipped with different kinds of sensors according to their needs. Her job is to detect disease exacerbations at the earliest stage possible, to be able to intervene and avoid e.g. a trip to the hospital. Regular and frequent monitoring of vital signs is central in the care process of a chronically ill person.
Diagnostic monitoring
Heart patients
Point-of-care diagnostics
Scenario—Coping well
John has just turned 80. Some years ago he started to forget things; obvious little things like the week day, how to get home from the local shop and the names of his grandchildren. Eventually he was diagnosed with Alzheimer. The municipality took them through a “needs test” and helped them set up the required technology support. Now the smart calendar on the wall in the kitchen and the duplicate beside the front door and on his TV helps him cope. The system stops him in doing dangerous things like walking out the door in the middle of the night; by playing off a video message of his wife telling him to go back to bed triggered by him opening the door. John has also got his portable personal assistant. It can answer simple questions. It tells the day and time and what special things he needs to do that day. The assistant also helps him find the way on his daily walks.
Scenario – Care for me

Every day after lunch, Pat the nurse sits down at her computer to check out her “little flock”. She is responsible for the health care follow-up of 28 patients living close by. Many suffer from chronic diseases, like diabetes, Congestive Heart Failure or COPD. They are provided with different physiological sensors according to their health follow-up needs. Some have sensors placed in the toilet or in the undergarments, for automatic urine sampling. Many have their own sensor measurements kit for once-a-day measurements. The system helps her sort out who to pay special attention to. She sees that Ben is in the “red”, due to out of range weight and spirometer readings. She also sees he has forgotten to take his medication last night, and that his next appointment with his GP is due in a week. She calls him on the videophone, has a nice chat and then decides to inform both his GP and consult with the COPD specialist, via their shared “Care at home collaboration service”.

pHealth 2010 – D.Ausen, SINTEF
Scenario - Safety at home

Ann, 66, has started to recover from a hip fracture. When she was discharged from the hospital, fall-sensors were installed in her house, as part of the “Home safety kit” offered by the municipality care services. The kit includes sensors for detection of open/closed windows, for light and heat control, for vital signs and activity monitoring plus a exercise program fitted to her needs. Sensors will detect her movement and gait patterns, and if she falls; the care service she is signed up for will be alerted, providing them with video and sound access to her house. The kit makes Ann feel safe, especially at night time when she is often dizzy.

The technology allows her to live safely at home, hopefully for many years still to come.
High risk workers

Cold climate
Firemen

Vital sign monitoring

Photo: Statoil
Or just you and me?

Feeling well, but you never know…

Photo: Swix Sport AS
## Ten targets for wireless medicine

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. affected</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alzheimer’s</td>
<td>5 M</td>
<td>Vital signs, location, activity, balance</td>
</tr>
<tr>
<td>Asthma</td>
<td>23 M</td>
<td>RR, FEV1, Air quality, oximetry, pollen count</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>3 M</td>
<td>Ultrasound examination</td>
</tr>
<tr>
<td>COPD</td>
<td>10 M</td>
<td>RR, FEV1, Air quality, oximetry</td>
</tr>
<tr>
<td>Depression</td>
<td>21 M</td>
<td>Med. compliance, activity, communication</td>
</tr>
<tr>
<td>Diabetes</td>
<td>24 M</td>
<td>Glucose, Hemoglobin A1C, activity</td>
</tr>
<tr>
<td>Heart failure</td>
<td>5 M</td>
<td>Cardiac pressures, weight, BP, fluid status</td>
</tr>
<tr>
<td>Hypertension</td>
<td>74 M</td>
<td>Continous BP, Med. compliance</td>
</tr>
<tr>
<td>Obesity</td>
<td>80 M</td>
<td>Smart scales, glucose, caloric in/out, activity</td>
</tr>
<tr>
<td>Sleep disorder</td>
<td>40 M</td>
<td>Sleep phases / quality, vital signs</td>
</tr>
</tbody>
</table>

Source: TEDMED March 2010
Biomedical sensors

Vital sign monitoring (physiological parameters)

Hand-held ultrasound

Diabetes monitoring system

Sleep disorder

ePatch platform
ePatch platform

Continuously monitoring
Robust & reliable
“wear & forget”
Intelligent signal processing
ePatch for diabetics in closed loop system

- acceleration sensor
- MHz sensor
- sweat & moisture sensor
- optical sensor
- GHz sensor
- temperature and humidity sensors

FP7-project REACTION
Examples

ESUMS - Mobile Home Health Monitoring

BWSN – Biomedical Wireless Sensor Network
Wires everywhere...

Dual chambre Ext. temporary pacemaker
Patient monitor
CCD monitor
Ventilator
Oxymeter
Infusion pump
Syringe pumps
Pressure sensors
IABP: intra aortic balloon pump
LVA/RVAD Left and right ventricular assist devices
The BWNS-project at a glance

Care for patients in advanced intra-hospital clinical environments as operating rooms and critical care environments like dedicated intensive care units, requires use of an increasing number of point-of-care medical devices with sensors attached to the patient to monitor and generate information for clinical decision making to support vital processes.

Monitoring implies automated detection impending life-threatening situations, imminent danger or diagnostic entities by collection of, and serial evaluation of time-stamped data.

The BWSN project developed, implemented and tested a multi sensor, vendor independent biomedical sensor network for the future wireless hospital.

The sensors came from six different Scandinavian sensor developers. All sensors were implemented on a commercial software platform existing at some Norwegian hospitals and were tested in a hospital environment.
The Biomedical Wireless Sensor Network

Memscap - Wireless non-invasive Blood Pressure
Millicore - DigiVent Pulmonary Air Leakage
Novosense - CardioPatch ECG sensor
Novelda - Medical UWB-IR radar (wireless heart rythm)
VTT - Heart Monitoring Accelerometer (heart movement)
SINTEF - SpO2 & Temperature sensors

Bringing the data to the doctor
‘Online’ patient data
Historical database
Decision support SW

pHealth 2010 – D.Ausen, SINTEF
Live demo
A video from the clinical test performed at the Interventional Centre is available on www.bwsn.net or directly at YouTube (www.youtube.com/watch?v=hIHTt7JMSE).
Hospital scenarios

Data collection (24/7)
Decision support at the bedside

Real time ECG in a wireless web portal (© Imatis AS)
Patient care visibility system

View of inpatient and outpatient’s status and progress of care

Monitoring of hospital key performance indicators.
Mobile Home Health monitoring

Michael is recently diagnosed with Congestive Heart Failure. He was treated in hospital for two weeks, and is now enrolled in the rehabilitation program for CHF patients. Objective for monitoring Michael: He needs to watch his weight because general circulation problems and he needs to do moderate exercise, i.e. walks.

Nurse Jane Millner going about her daily routine of checking up on her patients. They all suffer from some chronic disease, and are equipped with different kinds of sensors according to their needs. Her job is to detect disease exacerbations at the earliest stage possible, to be able to intervene and avoid e.g. a trip to the hospital. Regular and frequent monitoring of vital signs is central in the care process of a chronically ill person.
ESUMS motivation

Make physical rehabilitation care better and less expensive

**Empower the patient:** Take charge of own care – in home environments
Take advantage of development progress of handheld technology and connectivity

**Break down some monopolies:**
- Allow integration of 3. party state-of-the-art sensors
- Open source and modular SW architecture

Enable the monitoring nurse **decision support** for active and frequent follow-up of patients

ESUMS augments current work processes for point measurements with continuous measurements of heart rate and activity.

Provides easy overview of patients at risk

Focused research area: How can activity and posture data be used in combination with heart rate and other vital signs to improve patient follow-up?
Mobile Home Health Monitoring

ESUMS server providing database- and web services

INTERNET

Patient Sensor Device capturing Temperature, Activity level, Posture, and Heart Rate

3G/WiFi

Handheld application showing live data (in parallel with normal phone functionality)

Desktop application for remote monitoring of patient data

COTS devices employing standards based wireless communication

pHealth 2010 – D.Ausen, SINTEF
Desktop application
ESUMS approach

**Modular handheld platform**
- Easy integration of 3rd party sensors (COTS)
- Enables the monitoring nurse decision support for active and frequent follow-up of patients
- Open source, modular middelware and application software
- Standards based interfaces and communication
- Focus on improved vital signs sensor algorithms
- Multiparameter analysis for enhanced decision support
- Service Oriented Architecture
- Based on MPOWER Open platform for flexible integration of new sensor components and software services. (UniversAAL – follow up project).
Challenges

Intelligent systems for the analysis of multi-parametric data.
Personal Health Systems used for prevention or remote management.

Accurate alerting
Signalling of risk
Supporting healthcare professionals in their decision making.

Correlate the multi-parametric data with established biomedical knowledge to derive clinically relevant indicators

Identify new indicators for predicting or diagnosing the worsening of conditions at early stages and for prompting early intervention.

ICT WP 2011-2012, call 8
Messages

• Understand the patient and his needs
• Understand the people around the patient (health professionals, relatives, etc)
• Identify the benefits that (personal health) technology (including biomedical sensors) can bring to the patient and the people around him

• Biomedical sensors exists – the challenge is how to use them
• Personal Health Systems needs to create value for the user
Thanks for your attention!

Dag Ausen, SINTEF ICT, Norway, dag.ausen@sintef.no