Mobile Health Monitoring Systems

WINTER SCHOOL: HOT TOPICS IN SECURE AND DEPENDABLE COMPUTING FOR CRITICAL INFRASTRUCTURES

CORTINA – JANUARY 17, 2012

Roadmap

- Introduction
- m-Health: Opportunities, Outcomes and Open Issues
- m-Health Application: Heart Monitoring
- Knowledge Representation
- Software Architecture
- Results

Introduction

- e-Health:

  "is the application of information and communications technologies (ICT) across the whole range of functions that affect healthcare, from diagnosis to follow-up"

D. Silber- "The Case for eHealth"
European Commission's Conference on eHealth

Introduction

- eHealth offers a number of opportunities:
  - Everyday healthcare:
    - home monitoring and care for elderly and housebound;
    - personalization of healthcare services
    - individual healthcare management;
  - Enhanced and life-long health education of both citizens and medical staff;
  - Prevention and management of chronic diseases;
  - Management of emergency situations and disasters results of human activity (globalization and migration, bio-terrorism, climate changes, natural disasters etc.).

m-Health

- Mobile eHealth or mHealth:
  - "use of mobile devices to improve health care":
    - Mobile phones;
    - PDAs;
    - Monitoring devices;
    - Any other wireless devices to support healthcare.

- Main functionalities of mhealth devices :
  - Collect patient data;
  - Transfer clinical data;
  - Monitor patients through suitable applications

m-Health Application fields

- Education and awareness
- Helpline
- Diagnostic and treatment support
- Communication and training for healthcare workers
- Disease and epidemic outbreak tracking
- **Clinical care and remote patient monitoring**
- Remote data collection

m-Health Outcomes

- Data Capture
- Data Transfer and Access
  - e.g. Electronic Health Record
- Data Analysis
  - Alarming or warning systems for doctors or patients
  - “Intelligent” processing for Medical aims or healthy LifeStyle

m-Health Open Issues

- **Technology:**
  - Memory size;
  - Computing power;
  - Battery Life;
- **Interoperability:**
  - AD HOC systems;
  - Needing standards;
- **Reliability in communications:**
  - Energy Expenditures;
  - Interferences;
- **Security:**
  - Privacy;
  - Data integrity;

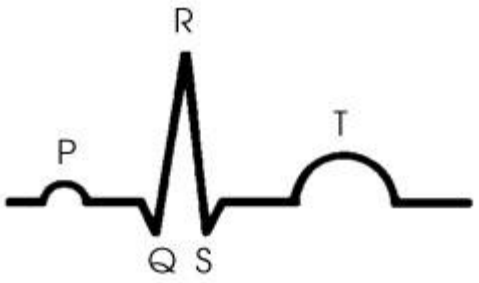
m-Health Application: Heart Monitoring

- The importance of heart monitoring:
  - Could help to prevent heart attacks
  - Supports the detection of potential anomalies
  - Supports the health assessment of chronic diseases

- mHealth systems available on the market for heart monitoring usually:
  - Collect data coming from a wearable ECG device
  - Transmit these data to the patient's smart phone or PDA for processing.
  - Detect heart rate (HR) and heart rate variability (HRV) on the basis of statistical and geometric methods, and ***do not take additional context information into account***

m-Health Application: Heart Monitoring

- Suppose a system that monitors parameters like
  - Heart rate (HR)
  - Heart rate variability (HRV)



- Suppose we want to generate alarms in case of persistent tachycardia

- If the patient is walking fast?
  - Problem of "False Positive" alarms

m-Health Application: Heart Monitoring

- One solution:
  - To correlate biomedical parameters with patient's context-aware information:
    - Biomedical information:
      - HR, HRV, etc..
    - Physical activity:
      - Posture, Movements, etc..
  - To use knowledge technologies to build proper applications (ex. Decision Support Systems)

Knowledge Representation

- Production rules form:
  - IF condition THEN action

- A rule which uses context information

IF *(RHRmax < HR <= HRmax) AND (LYING=true)*
AND (TIME_INTERVAL > TSD)
THEN *generate_alarm*

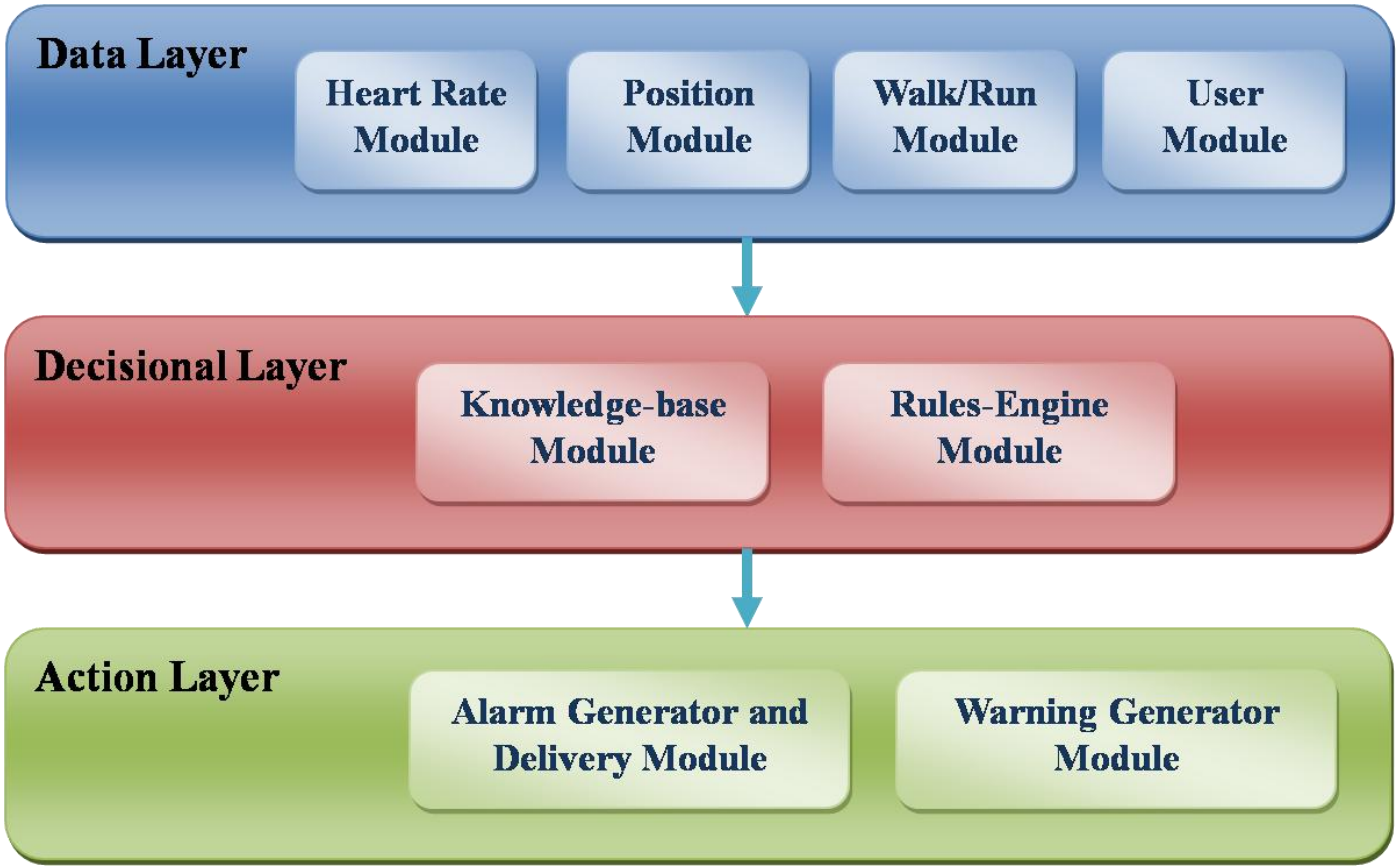
Knowledge Representation: Parameters Considered

- **Heart Monitoring Information**
  - *measuredHeartRate* is the heart rate measurement acquired by the patient;
  - *restingHeartRate* (RHR) is the patient's resting heart rate;
  - *HRmax* is the maximum patient's heart rate calculated by using Karvonen formula;
  - ***SDANN* is the standard deviation of R-R interval calculated every 5 min**;
  - *elapsedTimeInteval* is the time window elapsed between two abnormal heart rates measured;
  - *timeThreshold* is a time threshold usually set to 10 sec.

- **Physical Activity Information**
  - *walking* is a boolean datatype property indicating if the patient is walking or not;
  - *running* is a boolean datatype property indicating if the patient is running or not;

- **Posture Information**
  - *standingUp* is a boolean datatype property indicating if the patient is standing up or not;
  - *lying* is a boolean datatype property indicating if the patient is lying or not;

Software Architecture



Data Layer

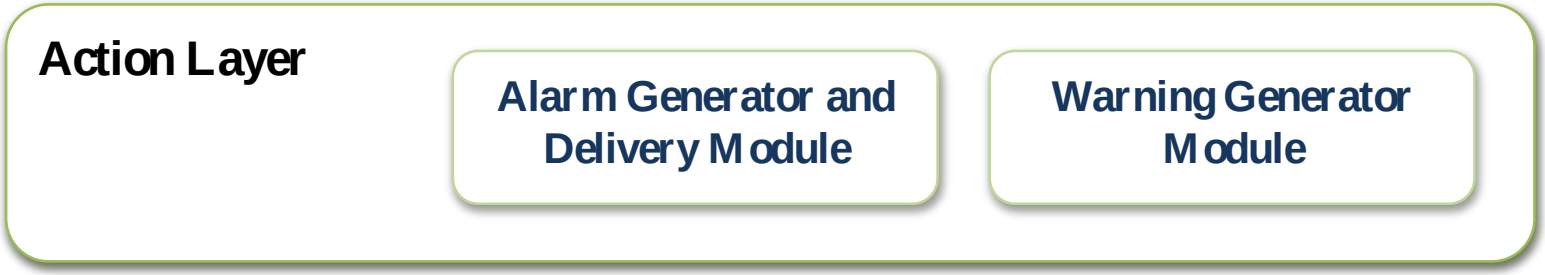
- User Module
  - name, age, gender, and the Resting Heart Rate (RHR)
- Heart Rate Module
  - QRS Complex Detection;
  - Heart Rate;
  - SDANN;
- Posture Module
  - Staying up;
  - Lying;
- Walk/Run Module
  - Recognize the patient's movement.

Decisional Layer

- Knowledge-base module
  - Concepts;
  - Relationships;
  - Rules;

- Rules-Engine module
  - Execute the rules;

Action Layer



- Alarm Generator and Delivery Module
  - Generate alarms to doctor.

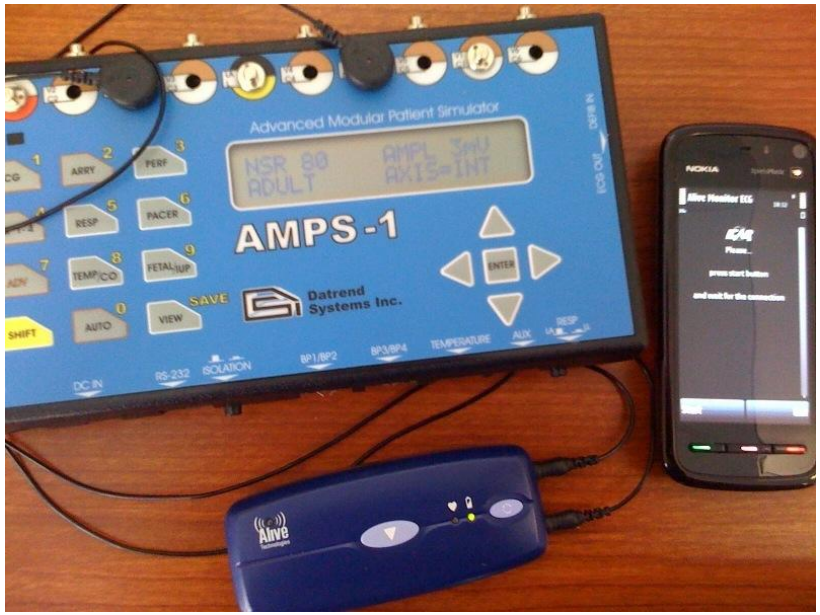
- Warning Generator Module
  - Generate audio and textual warnings to the patient.

Hardware Devices

- DATREND AMPS-1
  (Advanced Modular Patient Simulator)
  - 12 lead ECG
  - 52 Arrhythmia selections

- Alive Monitor HM13
  - Wearable ECG
  - Small
  - Bluetooth

- Nokia 5800 Xpress Music
  - Symbian OS
  - Java
  - WiFi
  - Bluetooth



Results

- Test performed on data from 15 healthy people:
  - 80% men
  - 20% women
  - Age from 25 to 48

- 50% of dangerous situations simulated

- Red highlighted lines of Table represent false positive alarms avoided

Age	HR max	RHR	Posture	Physical Activity	HR Measured	SDANN	Elapsed Time Interval	Alert Type
25	195	85	Lying	None	126	<50	<10	Alarm
30	190	85	Lying	None	120	>50	>10	Alarm
31	189	85	Lying	None	132	<50	>10	Alarm
32	188	85	Standing-up	Running	120	>50	>10	None
34	186	85	Standing-up	Running	63	<50	>10	Alarm
37	183	85	Standing-up	Walking	106	>50	>10	None
38	182	85	Standing-up	Walking	52	>50	>10	Alarm
41	179	85	Standing-up	None	100	>50	>10	Alarm
43	177	85	Standing-up	Running	181	>50	<10	Warning
45	175	85	Lying	None	55	>50	>10	None
48	172	85	Standing-up	Walking	180	>50	>10	Alarm

Thank You

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