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Institute for High Performance Computing
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An Effective Mobile Monitoring for Patients at Risk of Fainting

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Road Map

- Goal
- Motivation
- Micro-Mobile knowledge-based Decision Support System
- Lazy Pattern Matching Algorithm
- System Architecture
- Conclusion

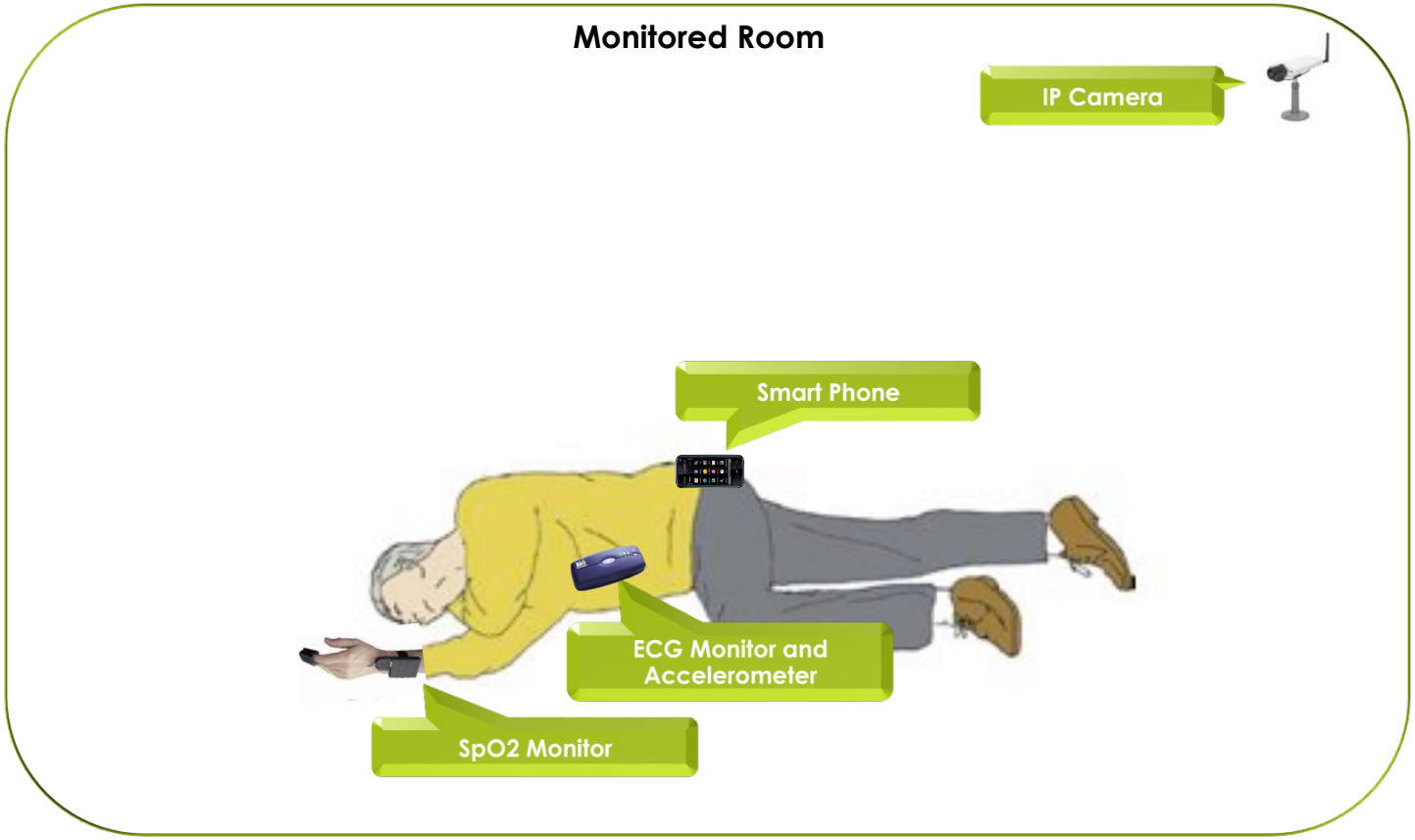
Goal

- We present a **Mobile Monitoring System** able to:
  - Monitor automatically some vital parameters such as Heart Rate and Oxygen saturation and also information about posture and movements
  - Process collected information through a rule-based Decision Support System (DSS), implemented on a mobile device
  - Generate automatically alarms if a dangerous situation occurs.

Motivation

- A lot of patients with heart disease in a Nuclear Medicine Department every day are examined under stress by using a particular injection which can cause:
  - High Heart Rate Variability
  - Body Temperature Alteration
  - **Frequent Fainting**
    - Fainting is due to a sudden temporary severe reduction in blood flow to the head, and causes rapid onset of hypoxia of all organs and tissues in the head, resulting ultimately in loss of consciousness.

Mobile Monitoring System



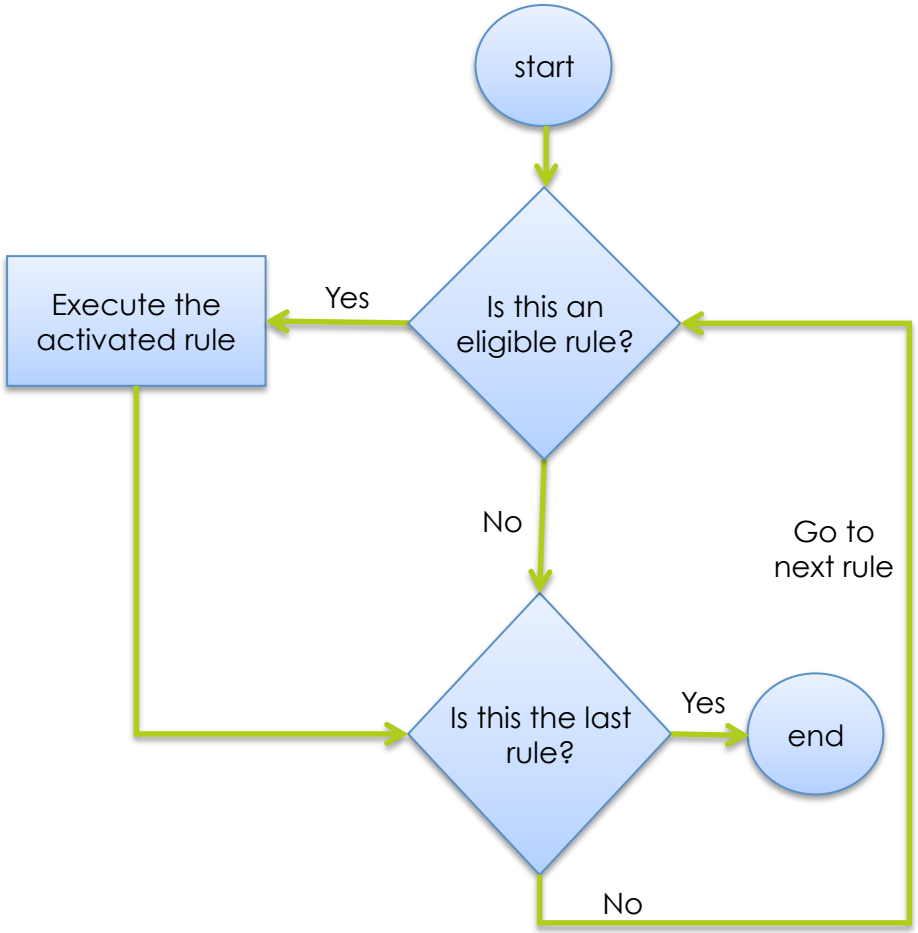
Micro-Mobile knowledge-based Decision Support Systems

- The designed and implemented micro-mobile DSS is able to:
  - model the experts' know-how about a specific domain
  - reproduce the process followed by the experts to face decision problems
  - provide alarms, suggestions, and explanations
  - receive and/or use information anywhere for supporting users in their tasks
  - process data there where they are needed
  - provide support also with no connection

Micro-Mobile knowledge-based Decision Support Systems

- Micro-Mobile reasoning system to build knowledge-based DSSs:
  - standard and expressive formalisms to model the domain knowledge
    - RDFS/OWL descriptions
  - mechanisms to define, update and retract the formalized knowledge
  - rule-based reasoning for simulating the process followed by experts
    - simple IF-THEN structure
  - Lazy Pattern Matching Algorithm to execute the eligible rules as soon as they are identified

Lazy Pattern Matching Algorithm




```
if [ (SpO2 < 80)  AND
        (elapsedTimeInterval > timeThreshold) ]
then
   alertType = Alarm;


if [  (HR > HRmax)
     AND  (lying = true)
     AND  (elapsedTimeInterval > timeThreshold)]
then
     alertType = Warning;


if [  (SDANN < 50) ]
then
   alertType = Alarm;
```

Knowledge Representation: Parameters Considered

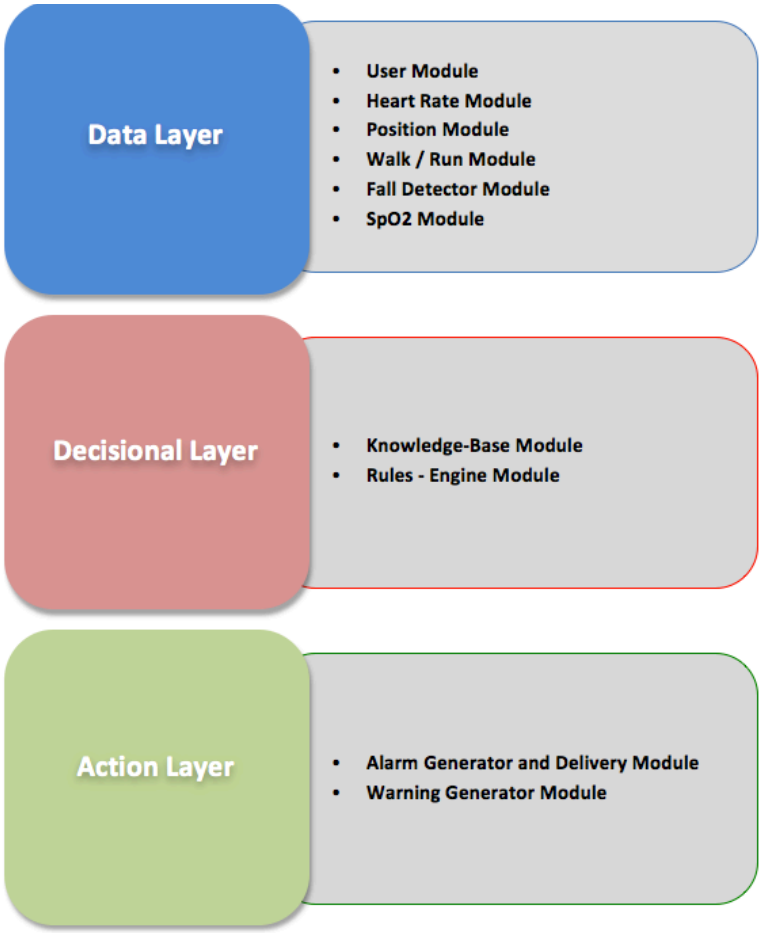
- Vital Monitoring Information
  - *measuredHeartRate* is the heart rate measurement acquired by the patient;
  - *restingHeartRate* (RHR) is the patient's resting heart rate;
  - *RHRmax* is equal to RHR+10;
  - *RHRmin* is equal to RHR-10;
  - *HRmax* is the maximum patient's heart rate calculated by using Karvonen formula;
  - *SDANN* is the standard deviation of R-R interval calculated every 5 min;
  - *SpO2* is the oxigen saturation;
  - *elapsedTimeInterval* 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;

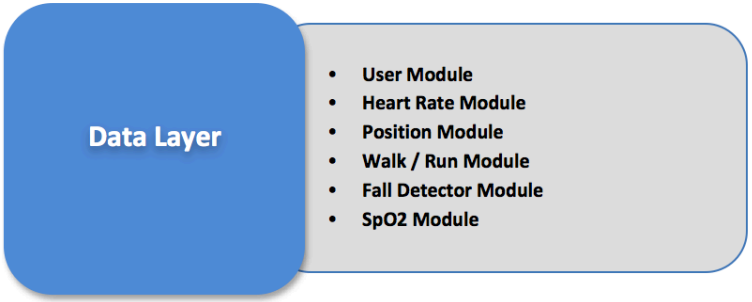
- Posture Information
  - *standingUp* is a boolean datatype property indicating if the patient is standing up or not;
  - *lying* is a boolean datatype property indicating if the patient is lying or not;

- Alert Information
  - *alertExplanation* indicates an explanation of the abnormal situation to be reported to the clinicians;
  - *alertType* indicates the severity of the alert, i.e. if it is a warning or an alarm.

System Architecture

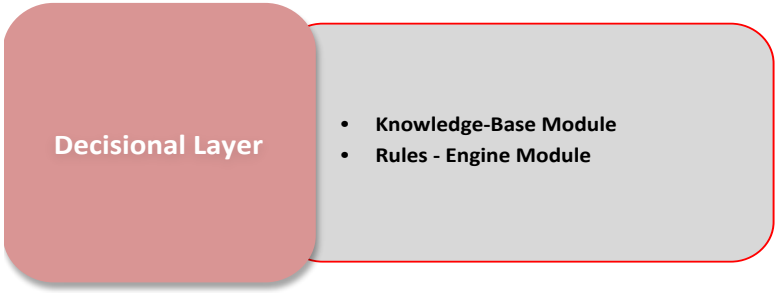


Data Layer



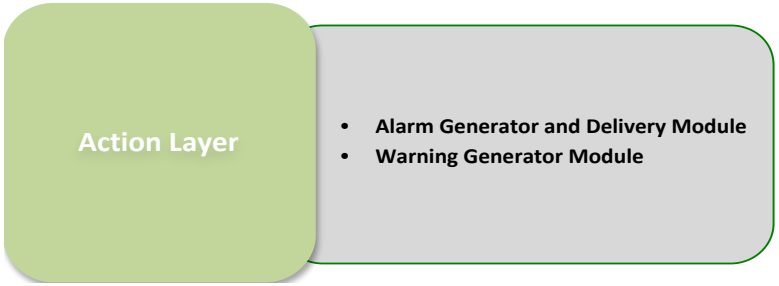
- User Module
  - name, age, gender, and the Resting Heart Rate (RHR)
- Heart Rate Module
  - QRS Complex Detection;
  - Heart Rate;
  - SDANN;
- SpO2 Module
  - SpO2 Oxygen Saturation;
- Position Module
  - Staying up;
  - Lying;
- Walk/Run Module
  - Recognize the patient's movement;
- Camera IP Module
  - Connect to camera on specific URL;
- Fall Detector Module
  - Patient falls;

Decisional Layer



- Knowledge-base module
  - Concepts;
  - Relationships;
  - Rules;
- Rules-Engine module
  - Execute the rules;

Action Layer



- Alarm Generator and Delivery Module
  - Generates SMS alarm.
- Warning Generator Module
  - Generates audio and textual warnings to the patient.

Some Experimentals Results

- Case of study
  - Hospital Monitoring System for a Nuclear Medicine Department
  - Home Care Health System to monitor some vital parameters:: patient's oxygen saturation, patient's heart rate, estimated SDANN, patient's posture and his/her physical activity
- Results
  - the system has been deployed and tested on two mobile (Java-enabled) smart phones with comparable hardware (Nokia N8 and HTC Legend)
    - the response time for the first firing rule is more or less equal to 30 ms
    - the overall reasoning time is approximately equal to 56 ms
  - The realized prototype relying on a rule-based DSS for the analysis of data was tested on a group of 15 healthy patients in different motion conditions and equipped with several sensors. The tests have shown the superiority of the proposed system in terms of:
    - Decrease in false positives;
    - Detection of possible risk situations not detected by classic systems missing either DSS or context-awareness.

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Thank You

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