Recommendation Service for Smart Space-based Personalized Healthcare System

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Personalized healthcare system

System targets people with high risk of cardiovascular decease

- Mobile sensors provide vital signs measurements
- Mobile device processes and transmits data to the HIS
- In case of emergency HIS sends ambulance and volunteers to aid the patient
- Regular monitoring using questionaries
Recommendations for m-health system

Application areas for recommendations

- Life style management
- Increase adherence to the treatment

Requirements for recommendations

Patients are the target audience for recommendations

- System must not provide any medical suggestions (drugs, procedures or modification of prescribed treatment)
- Recommendations should be accessible
- They should correspond to the current state of health
- They should be regular, but not annoying
- Recommendation set should be expandable by the doctor
Recommendations reference scenario

- **Patient**
- **Sensor**
- **Mobile device**
- **HIS**

**[automatic readings]**
- Send latest measurements

**[manual input]**
- Regularly notify patient to input measurements
- Input latest measurements

**Send measurements**
**Send recommendations**

**Show current recommendations on defined schedule**

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The architecture of the system

Smart space

End-user elements
- Patient KP
- Ambulance KP
- Volunteer KP

Services
- Electronic Health Record KP
- Dispatcher KP
- Authentication KP
Updated architecture with recommendation KP

Smart space

End-user elements
- Patient KP
- Ambulance KP
- Volunteer KP

Services
- New component
  - Recommendation KP
  - Dispatcher KP
- Electronic Health Record KP
- Authentication KP

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Electronic health record documents taxonomy

- HISDocument
- DemographicData
- DoctorExamination
- LaboratoryAnalysis
- Measurement
  - BloodPressureMeasurement
  - WeightMeasurement
  - PhysicalActivityMeasurement
Smart space integration module allows to get data from EHR
Rule engine processes data according to the rules
Recommendations are then published in the smart space

In our prototype we used Drools rule execution engine
Rules for recommendation KP

Recommendation rules were formed according to JNC 7

- Negative trend in blood pressure and prehypertension → Lifestyle management required
- Negative trend in blood pressure and hypertension → Consult the doctor to improve blood pressure management
- ...

Preprocessing data for rule engine

Document preprocessing is required to ease rule development

- Methods for calculating average / total value for recent period
- Methods for checking availability of certain types of documents
- Similar methods for values of certain parameters
Example of a rule

```java
rule "weight management (physical activity)"
when
    SimpleFact(name="Lifestyle management required")
    EHR(
        averageValueForRecentPeriod("WeightMeasurement", "BMI", 30) > 25 &&
        totalValueForRecentPeriod("PhysicalActivity", "moderateActivityMinutes", 7) < 150
    )
then
    patient.addRecommendation("Exercise more")
end
```
Results and future work

Results
- A prototype solution of recommendation service is created
- Recommendation rules according to JNC 7 were formed and tested using a set of real-world blood pressure records

Future work
- Integration with real-time measurements
- Simplification of recommendation rules syntax
- Support for treatment adherence recommendations