Smart usage of context information for the analysis, design and generation of power-aware polices for mobile sensing apps

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Introduction

- There is a massive adoption of mobile devices by society in almost any daily activity [1].
    - Any-where, any-time connectivity
    - Possibility of installing new mobile applications
    - Increasing computing, memory, and sensing capabilities
- Sensing capabilities of smartphones improve interaction with user, turning mobile devices into *omni-sensors* able to *know* about their surrounding environment.

Introduction

- Hence, mobile devices have achieved a considerable degree of sensitivity that tries to mimic the sense of humans.
- In this way these devices have become *context-aware*, which is translated to an increasing level of understanding about user's activity.
- *Context* refers to a four-dimensional space composed of *computing context*, *physical context*, *time context*, and *user context* [2].

Motivation

- Despite the increasing computing, storage and memory capabilities of smartphones, battery is not evolving at the same pace [3].
- Each new generation of smartphones keeps improving and including new hardware embedded components, which imposes a higher energy demand.
- This limitation is highlighted when a continuous access to sensors data is needed, which is the core requirement of **mobile sensing applications**.
- Then it is mandatory for any mobile sensing application development to consider the energy constraint and implement mechanisms or strategies to optimize battery duration.

Motivation

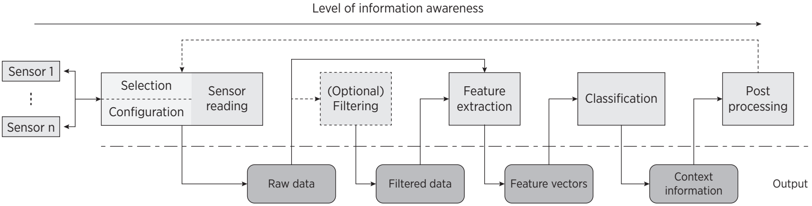


Figure: Stages of mobile sensing applications

- There is a tradeoff between the accuracy of context information retrieved and the associated energy consumption [4, 5].

Hypothesis

Hypothesis

Intelligent policies produced through context information built from sensors data can be employed to reduce the energy consumption in a mobile device when performing continuous sensor readings.

- An intelligent policy is a special rule that defines how sensors should be accessed in order to reduce the energy consumption and achieve the requirements of a mobile app. It is intelligent in terms of self-adaptness to changes detected in context information.
- This research work aims to employ data coming from GPS and inertial sensors (accelerometer) in order to obtain context information about user mobility that helps to adapt the usage of sensors and reduce energy consumption.

Problem statement

Problem statement: Mobility pattern identification

Given a set $V = \{v_1, v_2, \ldots, v_n\}$ of data values read from sensor S in the time interval $T \in [t_1, t_2]$, identify the current mobility pattern p_S that represents the activity of user.

$$\text{PatternIdentifier}(V) \longrightarrow p_S \in \mathit{Patterns} \tag{1}$$

Where *Patterns* is a set of patterns that represent an interesting state in user mobility, specifically the set $\{\mathit{no\_movement}, \mathit{walking}, \mathit{running}, \mathit{vehicle\_transportation}\}$.

Problem statement

Problem statement: Policy generation

Given the set of detected mobility patterns $\mathcal{P} = \{p_{S_1}, p_{S_2}, \ldots, p_{S_n}\}$ in data from sensors $\mathcal{S} = \{S_1, S_2, \ldots, S_n\}$, parameters for assigning weight to energy e and accuracy a, and physical constraints status c of a mobile device, find a policy that select the proper set of sensors $\mathcal{S}_{new}$ and its associated configuration $\mathcal{S}_{new_{conf}}$ while meeting application requirements.

$$\text{PolicyGeneration}(\mathcal{P}_{\mathcal{S}}, e, a, c) \longrightarrow \mathcal{S}_{new}, \mathcal{S}_{new_{conf}} \quad (2)$$

The $\mathcal{S}_{new_{conf}}$ configuration is referred as the *duty cycle* of associated sensor.

Objectives

Main objective

To reduce energy consumption in the mobile sensing apps, which perform continuous sensor readings, through power-aware policies generated from context information obtained from sensors data.

Objectives

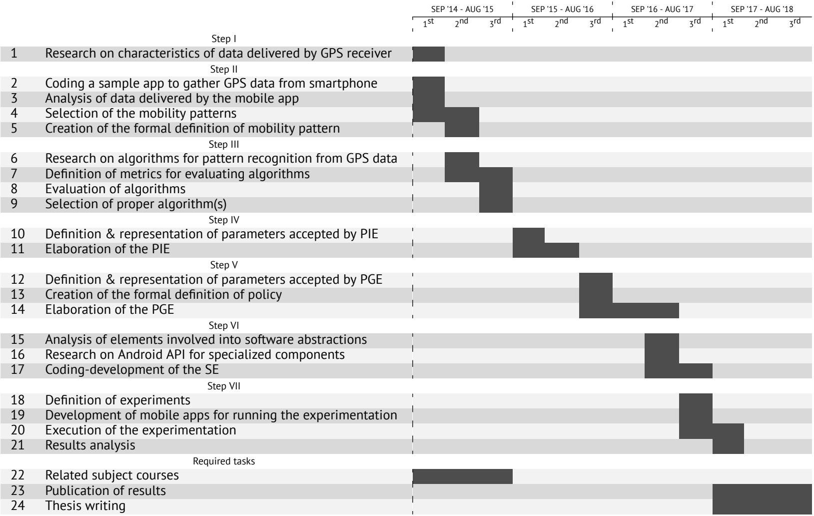
Particular objectives

- To identify mobility patterns from context information obtained from an inertial sensor (accelerometer) and location providers (GPS, WPS).
- To generate policies for a smart sensors' usage from identified mobility patterns, accuracy and energy requirements of mobile application, and status of mobile device's constraints.
- To ease the development of mobile sensing applications that require user location tracking, i.e., LBS, by means of a middleware that isolates the complexity of sensors' access and the associated efficient energy management.

Methodology

1. Research on the characteristics of data delivered by sensors, (GPS and accelerometer).
2. Definition and selection of mobility patterns to be identified.
3. Research and selection of algorithms to detect mobility patterns of user based on data delivered by GPS and accelerometer.
4. Creation of the pattern identifier element (PIE).
5. Creation of the policy generator element (PGE).
6. Development of a software element (SE) that integrates both PIE and PGE.
7. Experimentation.

Schedule


SEP '14 - AUG '15
SEP '15 - AUG '16
SEP '16 - AUG '17
SEP '17 - AUG '18
1st 2nd 3rd
Step I
1 Research on characteristics of data delivered by GPS receiver
Step II
2 Coding a sample app to gather GPS data from smartphone
3 Analysis of data delivered by the mobile app
4 Selection of the mobility patterns
5 Creation of the formal definition of mobility pattern
Step III
6 Research on algorithms for pattern recognition from GPS data
7 Definition of metrics for evaluating algorithms
8 Evaluation of algorithms
9 Selection of proper algorithm(s)
Step IV
10 Definition & representation of parameters accepted by PIE
11 Elaboration of the PIE
Step V
12 Definition & representation of parameters accepted by PGE
13 Creation of the formal definition of policy
14 Elaboration of the PGE
Step VI
15 Analysis of elements involved into software abstractions
16 Research on Android API for specialized components
17 Coding-development of the SE
Step VII
18 Definition of experiments
19 Development of mobile apps for running the experimentation
20 Execution of the experimentation
21 Results analysis
Required tasks
22 Related subject courses
23 Publication of results
24 Thesis writing

Contributions

- A mechanism for detecting mobility patterns from the data read by sensors of mobile devices (especifically GPS and accelerometer).
- A mechanism for generating policies for accessing sensors. The produced policies will allow to perform an intelligent usage of smartphone's sensing infrastructure in continuous sensor readings, reducing the energy consumption.
- A middleware implementing the previous mechanisms, easing the development of mobile sensing applications.

Brief state of art revision

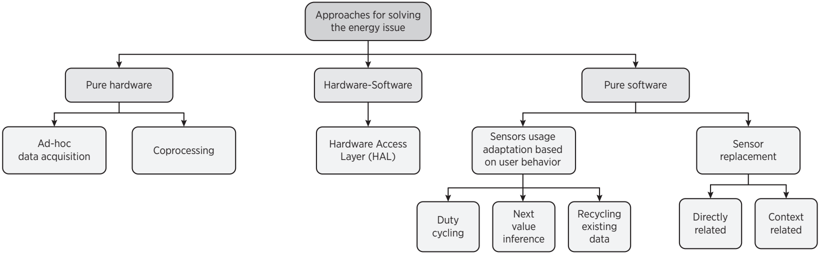


Figure: Taxonomy of solutions

Brief state of art revision

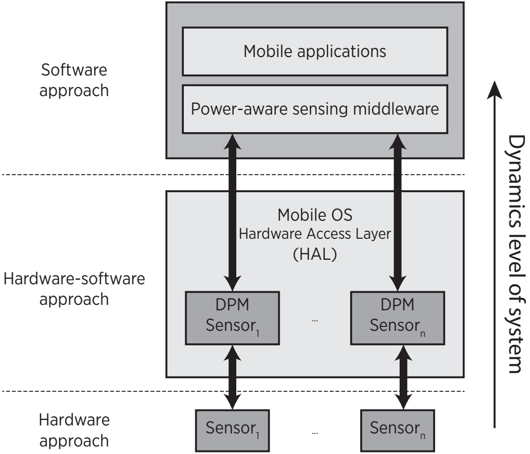


Figure: Distribution of approaches across mobile platform's layers

Basic scenario

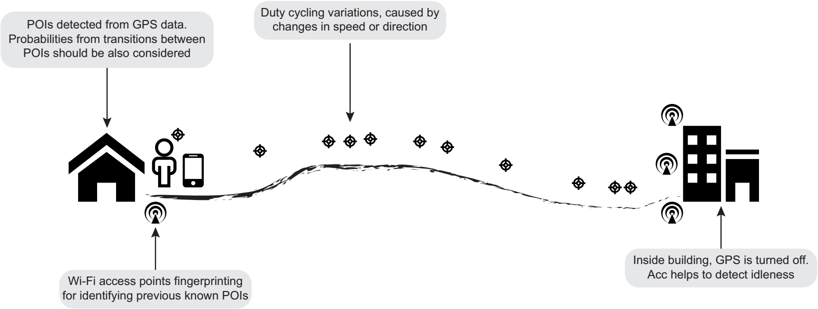


Figure: Basic scenario

Proposed solution

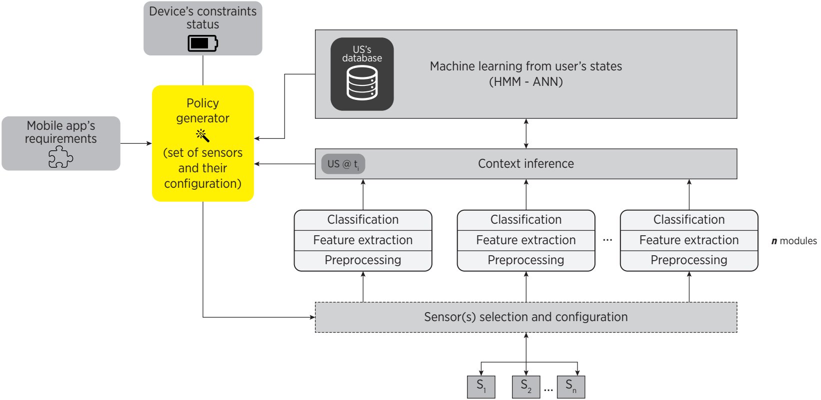


Figure: Overview of current solution

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