



# 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 [2].
  - 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 and environment.
- *Context* refers to a four-dimensional space composed of *computing context*, *physical context*, *time context*, and *user context* [1].

# Motivation

- Despite the increasing computing, storage and memory capabilities of smartphones, battery is not evolving at the same pace [3], growing only 5% each year [4].
- Each new generation of smartphones keeps improving and including new hardware embedded components, which imposes a higher energy demand.
- This resource constraint becomes more critical when 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

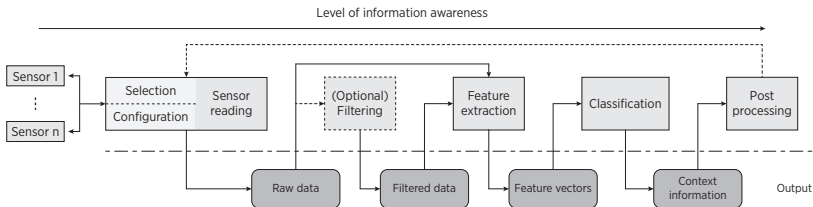
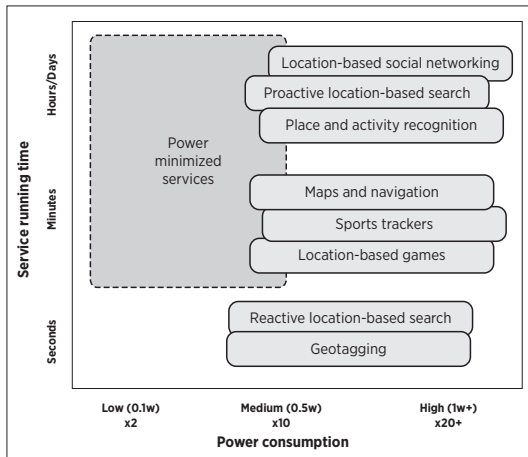


Figure: Stages of mobile sensing applications

- There is a tradeoff between the accuracy of context information retrieved and the associated energy consumption [6, 5].

# Motivation



**Figure:** Location based services categorization based on running time and power consumption, as proposed by Kjærgaard [3]

## Basic scenario

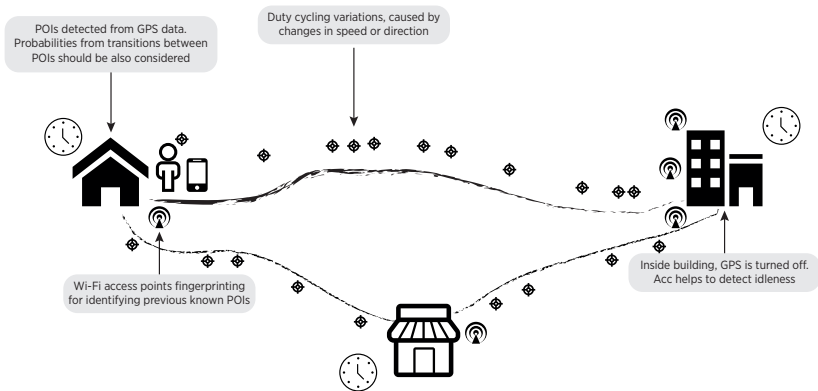


Figure: Basic scenario



# 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 in the shape of user mobility that helps to adapt the usage of sensors and reduce energy consumption.

# Problem statement

## Problem statement: Mobility pattern identification

Given a set  $V = \{v_1, v_2, \dots, v_n\}$  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.

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

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

# Problem statement

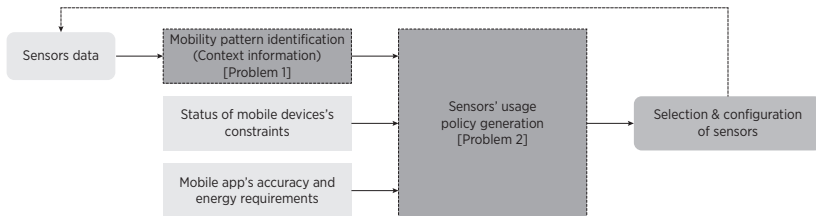
## Problem statement: Policy generation

Given the set of detected mobility patterns  $\mathcal{P} = \{p_{S_1}, p_{S_2}, \dots, p_{S_n}\}$  in data from sensors  $\mathcal{S} = \{S_1, S_2, \dots, S_n\}$ , 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.

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

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

# Interaction between problems



**Figure:** Interaction between the thesis work's problems

# Objectives

## Main objective

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

# Objectives

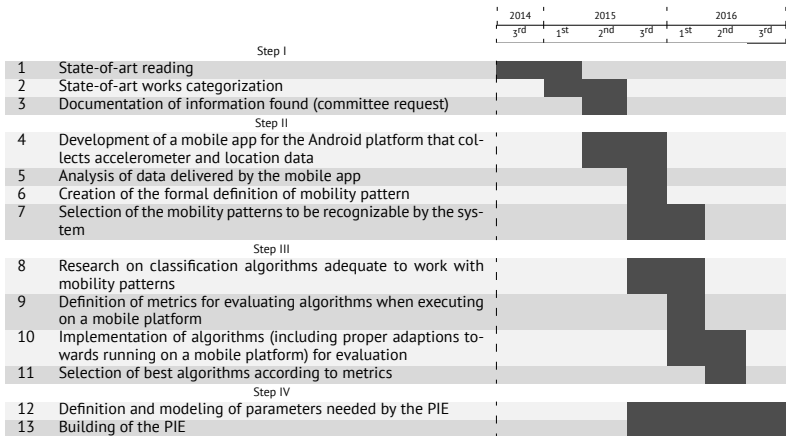
## Particular objectives

- To identify mobility patterns from context information obtained from an inertial sensor (accelerometer) and location providers (GPS, WPS).
- To generate policies for a self-adapting 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, isolating the complexity of sensors' access and the associated efficient energy management.

# Methodology

1. Familiarization with state-of-art power-aware sensing related techniques
2. Formal definition and selection of mobility patterns to be identified
3. Research on pattern recognition algorithms focused on mobility patterns identification
4. Design of the Pattern Identification Element (PIE)
5. Research on and proposition of adaptive policies for energy efficient usage of sensors
6. Design of the Policy Generation Element (PGE)
7. Development of a middleware involving the PIE and PGE for the Android platform
8. Experimentation in terms of accuracy and energy efficiency

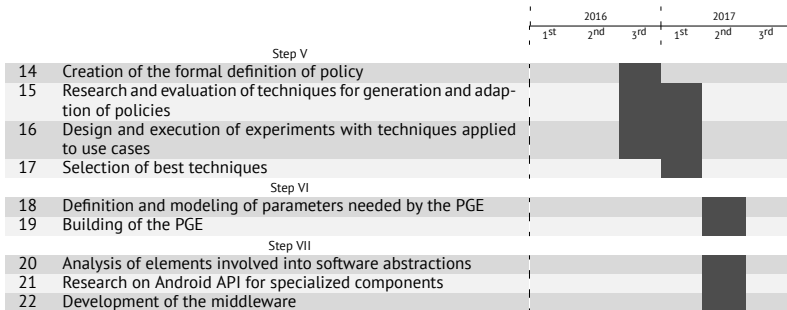
# Schedule



**Table:** Schedule of activities (each column represents a four months period)

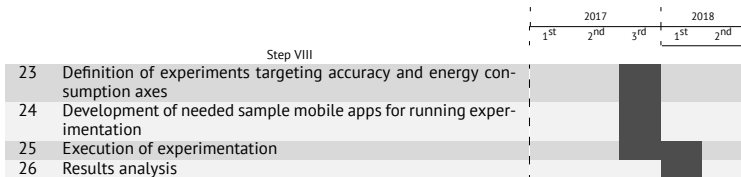


## Schedule



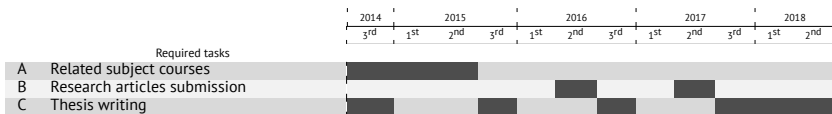
**Table:** Schedule of activities (each column represents a four months period)

# Schedule



**Table:** Schedule of activities (each column represents a four months period)

# Schedule



**Table:** Schedule of required activities

## Contributions

- A mechanism for detecting mobility patterns from the data read by sensors of mobile devices (specifically 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 power-aware mechanisms for easing the development of location based services.

# Conclusions

In this talk:

- An introduction to the energy consumption issue in mobile sensing apps and its relevance has been presented.
- A description of the important components of our thesis work has been also given.
- An overview of the proposed methodology for solving the energy consumption issue has been provided.

Thank You  
for your attention!

- [1] Guanling Chen and David Kotz. A Survey of Context-Aware Mobile Computing Research. Technical report, 2000.
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- [3] Mikkel Kjaergaard. Location-based services on mobile phones: Minimizing power consumption. *IEEE Pervasive Computing*, 11:67–73, 2012.
- [4] Xiao Ma, Yong Cui, and Ivan Stojmenovic. Energy efficiency on location based applications in mobile cloud computing: A survey. In *Procedia Computer Science*, volume 10, pages 577–584, 2012.
- [5] Kiran K Rachuri, Cecilia Mascolo, and Mirco Musolesi. *Mobile Context Awareness*. Springer London, London, 2012.
- [6] Jaemun Sim, Yonnim Lee, and Ohbyung Kwon. Context-aware enhancement of personalization services: A method of power optimization. *Expert Systems with Applications*, 41(13):5702–5709, 2014.

## Brief state of art revision

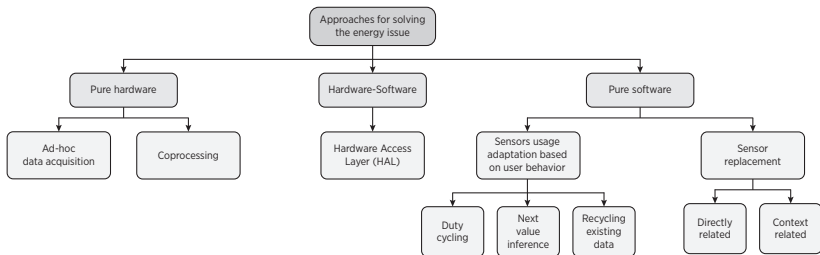
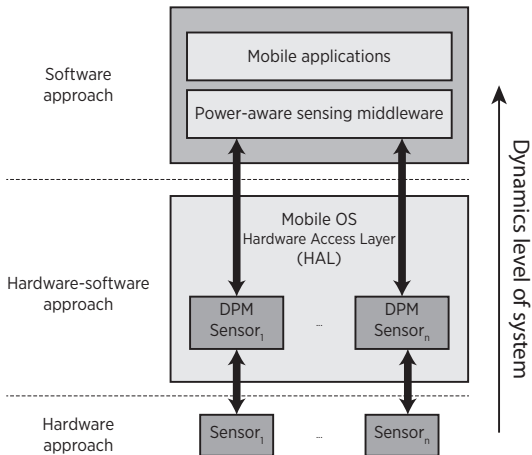


Figure: Taxonomy of solutions



## Brief state of art revision



**Figure:** Distribution of approaches across mobile platform's layers

## Proposed solution

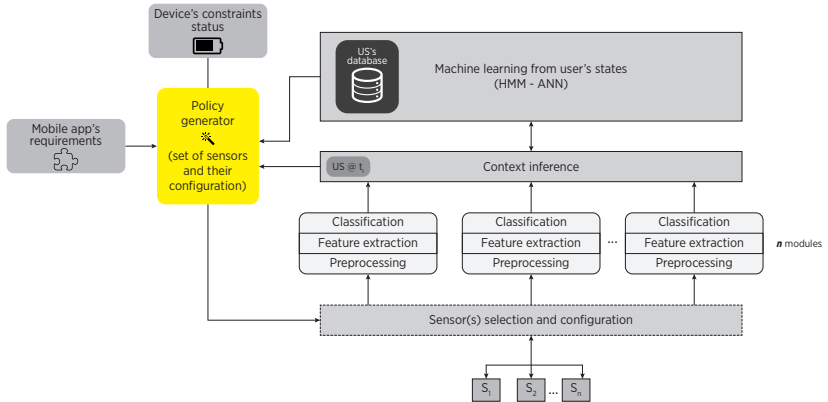


Figure: Overview of current solution