Microdistribution of freight. On-board sensor units

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Motivation

- Urban logistics vehicles have a significant contribution to the daily traffic.
  - In Barcelona, 15% of city traffic and 23% of connecting trips
- There is the need for more efficient and effective freight transportation systems that not only address costs but also fully tackle environmental issues such as air pollution, noise and visual intrusion.
- Measures considered to optimize urban logistics:
  - Access control, limiting the access to vehicles in certain areas.
  - Urban Consolidation Centers (UCC), to consolidate flows outside the urban area.
  - Green vehicles, reduce emissions and energy consumption.

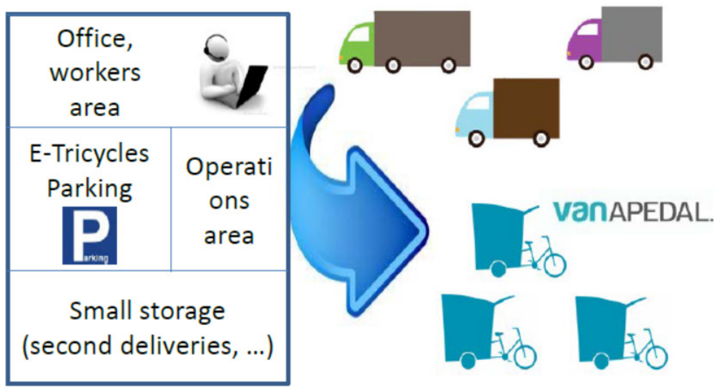
The GrowSmarter Project

- H2020 initiative. Lighthouse Project
  - Cities of Barcelona, Cologne and Stockholm
- GrowSmarter aims to:
  - Improve the quality of life for European citizens.
  - **Reduce the environmental impact by reducing the GHG emission.**
  - Create sustainable economic development within the framework of smart solutions
- Urban challenges/measures:
  - Renewal of existing buildings
  - Integrated infrastructures (e. g. ICT, street lightning, etc)
  - **Sustainable urban mobility thus reducing local air quality emissions**
- i2CAT is developing a technology that will allow to equip the electrical vehicles used for microdistribution purposes with pollution sensors.
  - Used to evaluate the effectiveness of the measures that the project will implement in the city of Barcelona.

Objectives

- More efficient and effective freight transport systems. The measure consist in implementing a UCC and limiting the access to vehicles in certain areas:
  - During some hours of the day
  - To some type of vehicles -> Electric bikes (**freight distribution**)

- Quantify environmental benefits. The contribution of i2CAT to this measure will provide:
  - A location and tracking system for knowing the location of the bikes
  - A mechanism to measure the benefits of closing the general traffic, in terms of environmental parameters and noise

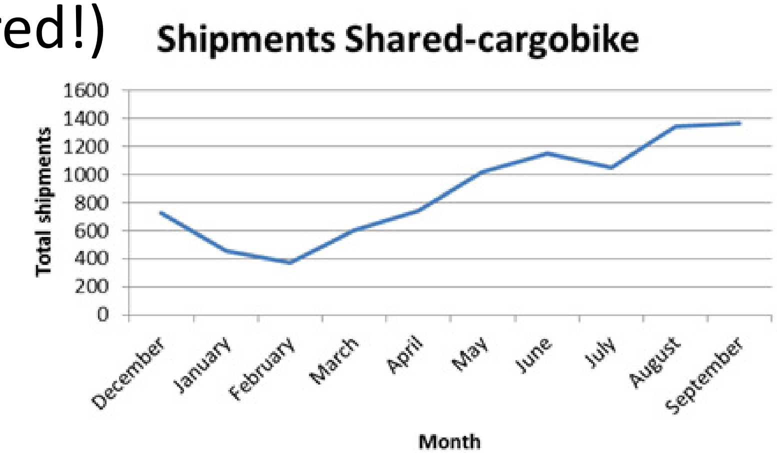


Microdistribution platform (I)

- Freight distribution in the restricted area will be done by vanapedal (Solucions Última Milla S.L.).
- Vanapedal is an eco-logistics company funded on 2010, that provides efficient solutions for urban logistics in the last mile.
- Previous pilots:
  - 2011. Pilot test for Home Deliveries for a supermarket (Barcelona)
  - 2012. Second pilot with TNT operator
  - 2013. Microplatform pilot (7 workers, 6 e-bikes). SEUR, ASM
  - 2014. **Smile project**, Valencia
  - 2015. 14 workers, 8 e-bikes (Barcelona), 3 tricycles (Valencia)

Microdistribution platform (II)

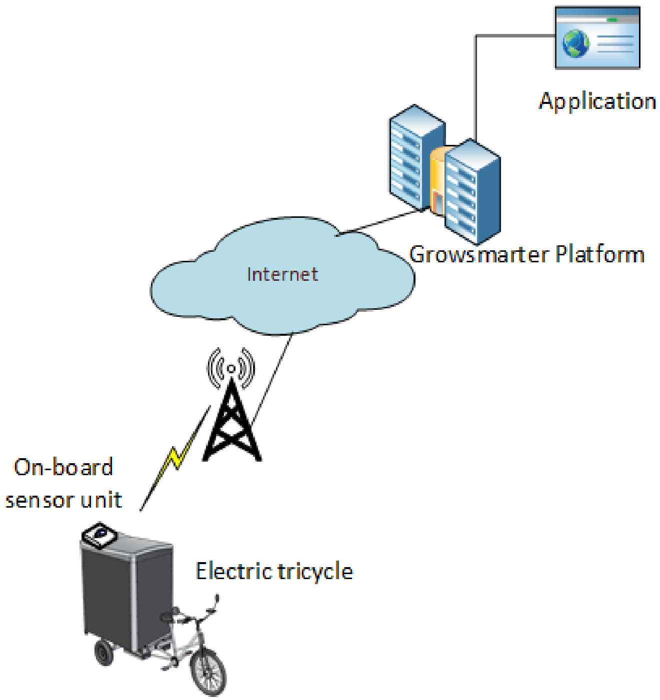
- SMILE project experience: Smart green Innovative urban Logistics for Energy efficient mediterranean cities.
- Objective: Define, plan, test, share and promote public policies, strategies and measures for intelligent urban freight solutions.
- Estimated savings (but not measured!)
  - 5,840 km traveled by van or truck
  - 1.7 Tn of CO_2



Sensing system. Overview

Growsmarter project: last-mile deliveries with green vehicles (e-tricycles) and transshipment terminal.

- On-board sensor unit installed in the e-tricycle used for the microdistribution
- The position and different environmental parameters are measured while the tricycles are moving.
- The information collected is transmitted to the remote platform.



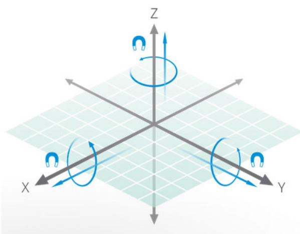
On-board Sensor Units. Environmental monitoring

- Sensors intended to show the **variation** of the environmental parameters
- Installing in the bikes
  - Sound level
  - Temperature
  - Atmospheric pressure
  - Relative humidity on the air
  - Particles (PM10, PM2.5)
  - Gases
    - CO
    - NO_2
    - O_3
    - SO_2
- Mobile low-cost sensors vs. fix air quality stations
  - Precision ↓
  - Affordability ↑
  - Scalability ↑

As the interesting aspect is the improvement on certain parameters compared to the ones measured where no action has been done, no absolute precision is needed. The precision requirement of the absolute measurements is relaxed

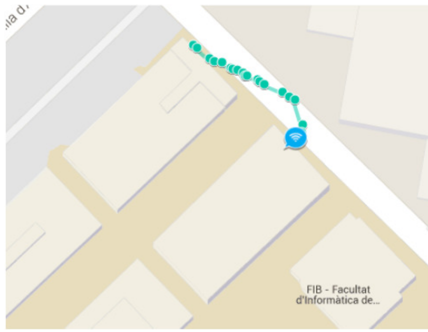
On-board Sensor Units : Features (I)

- Edison Main Board
  - Linux OS
  - Python, C programming
  - Low size and weight
  - Low voltage and power consumption (<1W)
  - Integrates communication interfaces (WLAN, Bluetooth)
  - Improves other platforms features
    - Chosen before Raspberry Pi 3 was released
- Location and tracking
  - GPS
  - WiFi scan
  - Accelerometer
  - Gyroscope
  - Magnetometer
- Support for several peripherals
  - I2C, UART multiplexing, ADC
  - Flexibility to integrate additional sensors



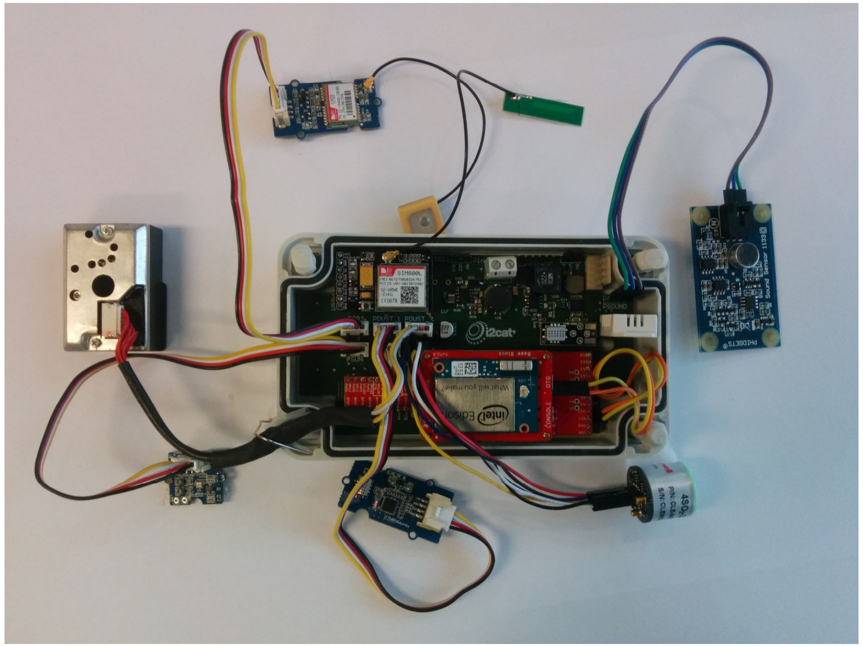
Raspberry Pi vs. Edison Feature Comparison

	Raspberry Pi B+	Intel Edison
Price	$35.95	$74.95*
Video	HDMI, Direct LCD, Composite	None
Audio	Stereo output	I2S Out
Flash	microSD socket	SDIO interface; 4GB onboard flash
RAM	512MB	1GB
Processor	700MHz ARM1176JZF-S	500MHz Dual-core Atom processor; 100MHz Quark MCU
GPIO	27 pins on 0.1" headers	70 pins on 0.4mm mezzanine header
Ethernet	10/100 onboard	None
WiFi	None	Dual-band 802.11 (a/b/g/n)
Bluetooth	None	Bluetooth 2.1/4.0
USB	4 ports	1 USB-OTG
Other interfaces	SPI, UART, I2C	SPI, UART, I2C, PWM
Power Consumption	5V * 600mA (~3W)	3.3V - 4.5V @ <1W
Dimensions	85mm x 56mm x 19.5mm	60mm x 29mm x 8mm*



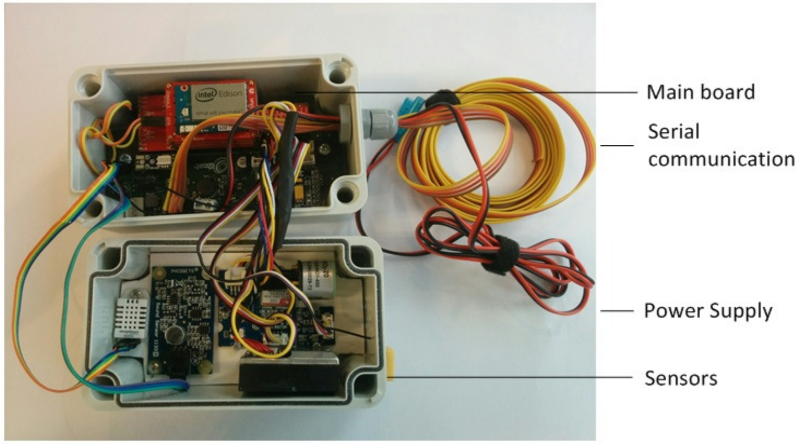
On-Board Sensor Units: Features (II)

- Support for multiple battery supplies
  - Electrical vehicle battery (24- 48V)
  - USB (5V)
- Supported sensors:
  - GP2Y1010AU0F
  - MICS 2614
  - MICS 6814
  - CLE 0421 400
  - 1133
  - Si1145
  - DHT22
  - Flexibility to integrate additional sensors



On-Board Sensor units: Prototype

- Development phases:
  - Phase I: Software implementation and sensor connectivity validation. Use of a development board. Validation in the laboratory premises.
  - Phase II: WLAN and GPRS communication and integration of additional sensors. First mobility tests.
- Phase III: Final prototype
  - Design of an integrated circuit board
  - Modular
  - Integrated
  - Portable
  - Support for multiple power supplies and sensors



Prototype: Cost

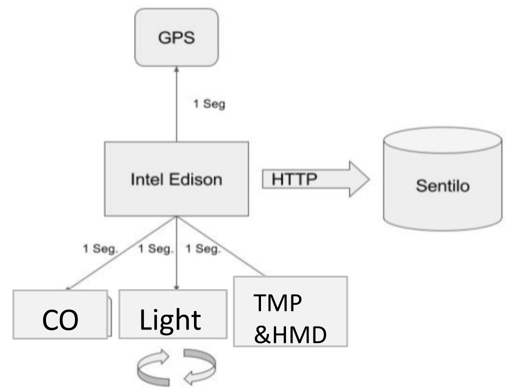
Module	Cost
Edison board (CPU, WLAN, Bluetooth)	63 €
Peripheral modules (ADC, I2C,UART,...)	100 €
9-axis sensor (accel, gyros, magnet.)	31 €
GPS	27 €
GPRS	14 €
Temperature & Humidity sensor	13.5 €
CO sensor	6 €

Module	Cost
Light sensor	4.5 €
Barometic pressure sensor	12.5€
O3 sensor	20 €
SO2 sensor	170 €
PM10 sensor	12 €
Noise sensor	6 €
IP65 encapsulation	20 €

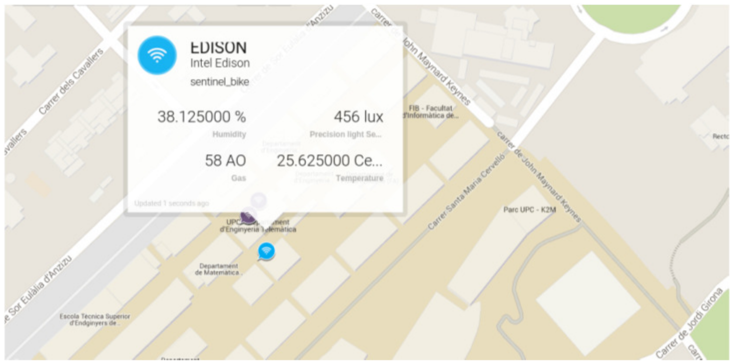
- Prototype design
  - Prioritizes flexibility and modularity, not cost
  - Cost can be optimized (peripheral modules, sensors, MCU integration, ...)

Data Publication (I)

- Publication on a centralized platform for data processing, analysis and visualization
  - HTTP communication
  - Mobile component
    - Bicycle
  - Environmental and air quality sensors
  - Tracking information

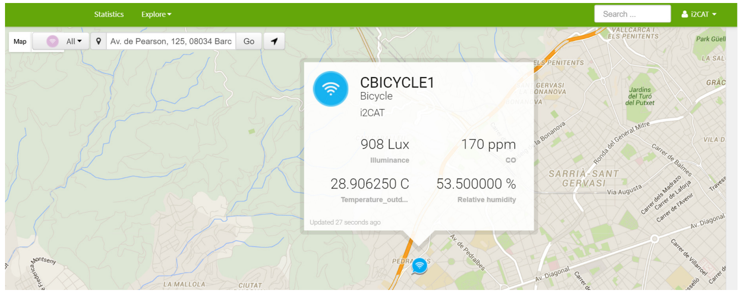


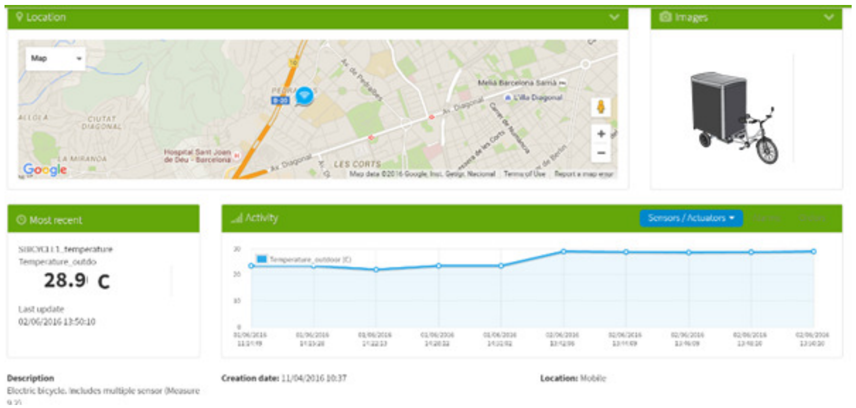

```
PUT /data/sentinel_bike/EDISONLIGHT HTTP/1.1
Host:
IDENTITY_KEY: 4786ce9fcae8204c1e5222cb64abeebcf765b7b9eb63612238505bf434ac658e
Content-Length: 68
Content-Type: application/json

{"observations":[{"value":"361","location":"41.325697 002.016925"}]}

Establishing socket connection...
 Socket connection Established!
 HTTP/1.1 200 OK
Content-Type: application/json
Date: Wed, 20 Jan 2016 15:30:12 GMT
Server: "SentiloServer/1.0"
Content-Length: 0


Socket connection closed!
```



Data Publication (II)

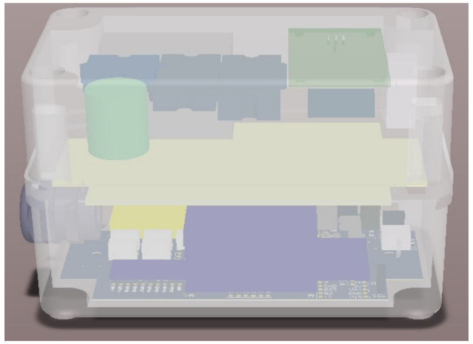
- Data platform
  - Based on Sentilo open source platform
  - Interface between the sensors and services/applications
  - Stored data can be analyzed and used to:
    - Track and evaluate the performance of the microdistribution service
    - Study mechanisms and alternatives to optimize the service
    - Measure environmental impact

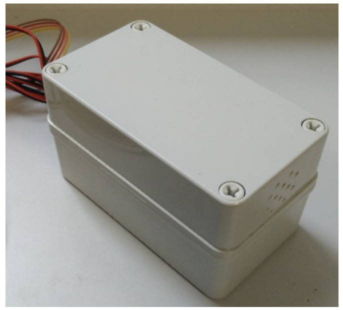




Current Status

- Work in progress
  - Prototype platform integration and validation
    - Performance evaluation
    - Robustness tests
    - Mobility tests
  - Calibration





Next steps

- Integration with the electric vehicle
  - Parameters
    - Battery level
    - Force
  - Choice of the model of electric vehicle to be used for the pilot
    - The fleet is compounded by three different models of green vehicles
    - Analysis of the controllers: interface, available parameters and available number of vehicles of each model.
- Pilot deployment and evaluation phase
  - Three e-bikes with on-board units
  - To begin in Q1 2017
  - Two years duration

Questions?

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