
1

iscte TECNOLOGIAS E ARQUITETURA

## Project Motivation

**Sustainability**

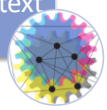
- Shared spaces > diffusion of responsibility > no feedback > high consumption
- Change behaviors
- Engage the different types of users in the development and implementation of the project

**Different approach**

- Integrate multi-disciplinary knowledge
- Computer Science, Architecture and Psychosocial science team

**Technological context**

- Creation of IoT laboratory at ISCTE
- Mobile device interaction
- BIM capacity at ISCTE
- Challenge of integrating a technical solution in a psychosocial approach to change behaviors



2

# Project Goals


*Real-time collection of sensor data and its analysis on the IoT platform to identify patterns and behaviours and 3D building modelling*

Done!

*Diagnosis of community perception based on surveys of the target population. Feedback received allows to identify the main requirements and approximations of our platform*

Done!

*Calculation of the Ecological Footprint (consumptions) by individual, room, department, building and estimate reduction goals*

Partially done


*Knowing which strategies (incentives, feedback,..) will motivate more each user to reduce energy consumption at ISCTE, notably through the implementation of behavioural economics tools and gamification strategies*

Partially done

3



# Project Team

João C. Ferreira

Ricardo P. Resende

Vasco Rato

Sílvia Luís

Rita Moura

**PhD Students**

- Bruno Mataloto

**Master Students**

- Diogo Santos
- Daniel Calé
- Catarina Santos

4

# 1st Year Expenses

**Fellowship**

- Bruno Mataloto 9M ~ 7K€
- Rita Moura 9M ~ 9K€
- Daniel Cale 4M ~ 4K€

**Hardware**

- IoT Sensors and Transmission boards ~ 5K€
- Equipment to performs sensing in 10 places

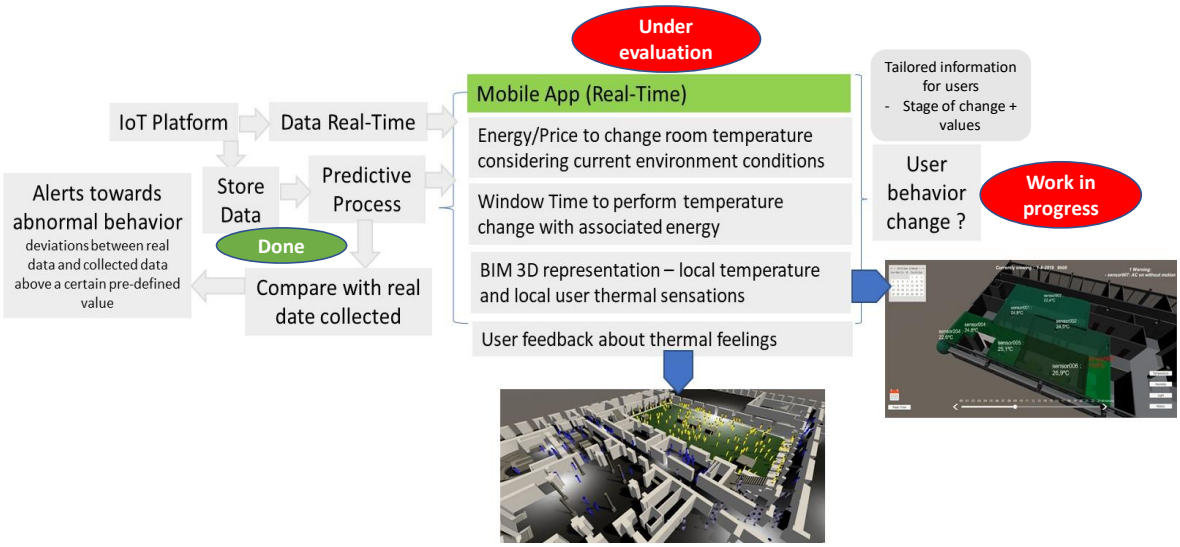
**Dissemination**

- Conference (registration and travel costs) ~ 3K€
- Open access publication ~ 2K€

5

5

# Overview




6

6

# Developed Solution and Installation @ISCTE

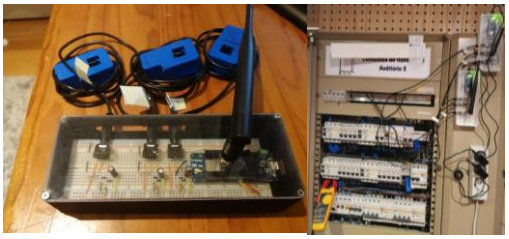
**Developed Solution**

**Auditório Silva Leal**

**Auditório C103**

**Academic Services**

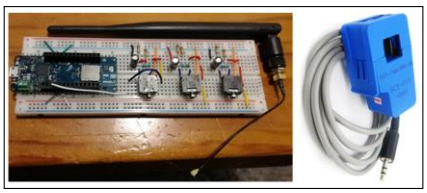
**Data Centre**

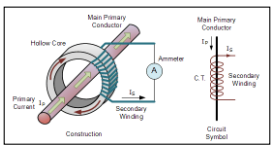


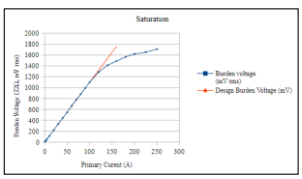
7

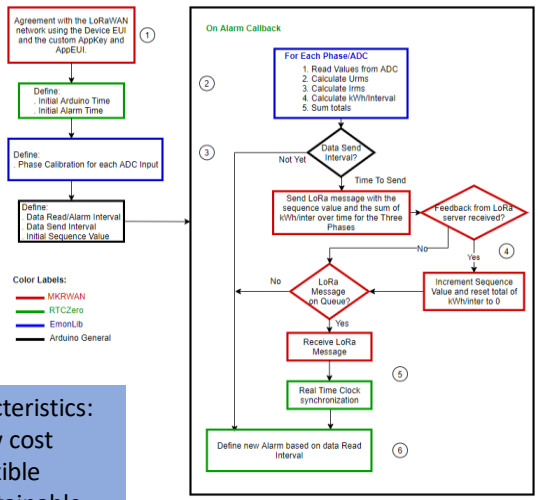


# Developed Energy Monitoring Sensor





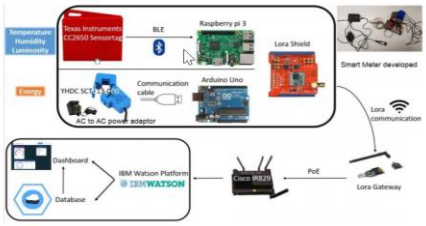



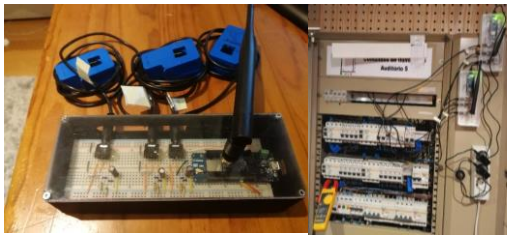

Characteristics:
- ✓ Low cost
- ✓ Flexible
- ✓ Sustainable

8

# Energy Management Platform for Public Buildings

- Local development: energy and environment measurements – temperature (in/out), humidity, luminosity, noise, air quality – Lora data transmission – Data visualization
- Saving actions: alerts interaction with heating/cooling system, providing tailored information
- Patterns identification: model behavior
- Data representation on BIM models
- Understand room temperature gradients

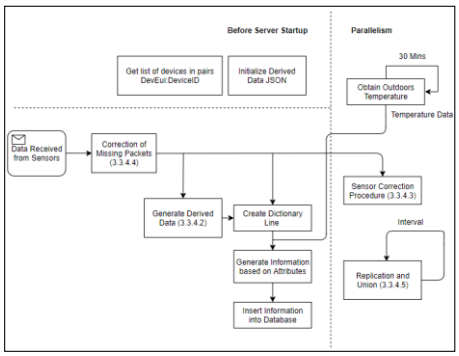




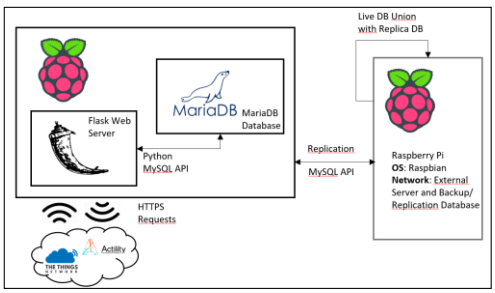
9

# Data Storage Developed Solution




***Flask***

- No "*bloat*"
  - Resource saving
- No pre-defined database
- Easy to extend libraries



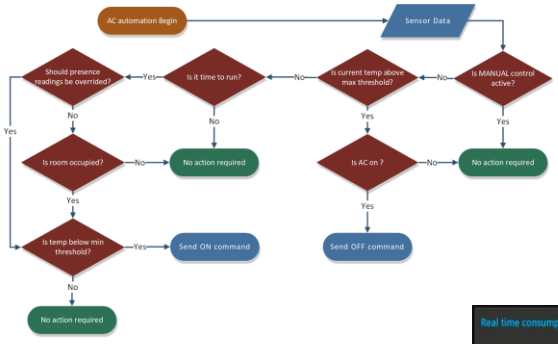

**RaspberryPi**

- Low consumption
- Open-Source OS
- Portable Hardware and Software
- Acceptable specifications
- Secure
- Low cost
- Easy to use



10

# Data Visualization in Dashboards




What is done in computer science
Automatic Saving Actions based on data


Data visualization in mobile devices
Data analytics
Pattern identification

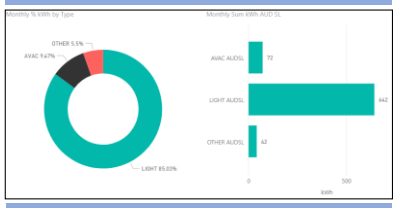




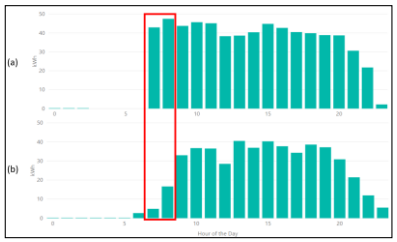
# Results: Data from Auditório Silva Leal (SL)

**Period May 2019**

**Identified Consumption**




**Differences from Auditório SL (a) and C103 (b)**

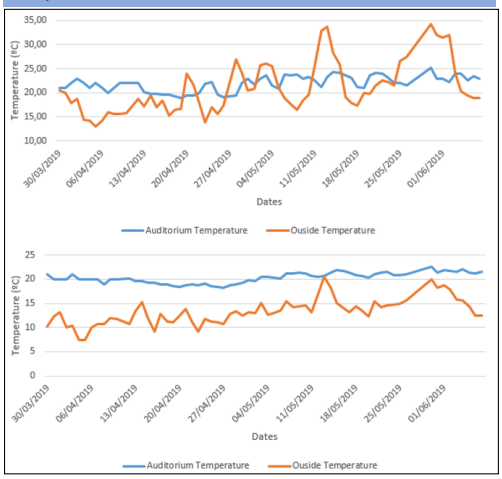


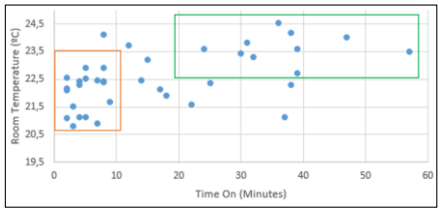

**Daily differences and identified waste on Auditório SL and C103**


- Identified waste of 38%
  - 248kWh in May 2019
- Huge differences from Auditório SL and C103
- **Reason**: lights at SL are controlled centrally

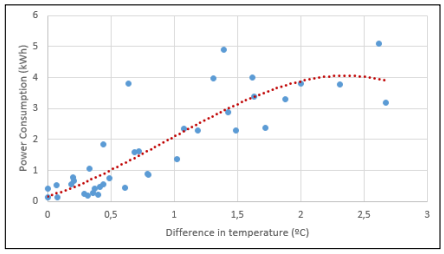
# Results: Data Centre Monitor Process Outputs

**Temperature value inside and outside**




Time of AC running in minutes *vs.* temperature




Power used to change inside temperature

- Results shows good thermal behaviour
- Change of 1ºC in temperature needs 1kWh

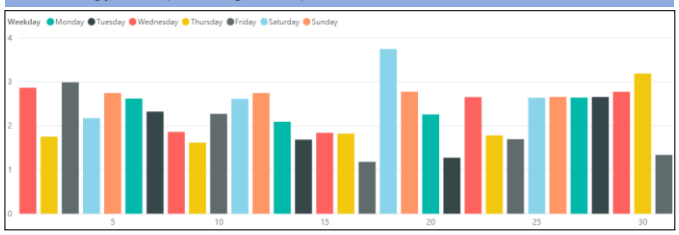
13

13

# Results: Data from Auditório C103

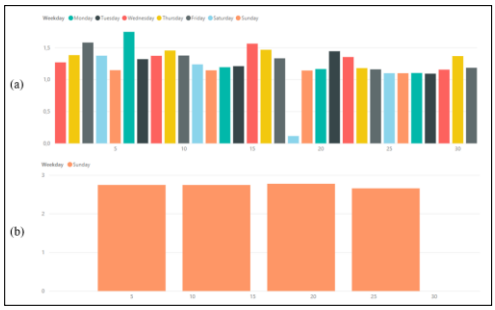
**Period: May 2019**

**Total energy waste (including classes)**




- Waste of 71.37kWh in May due to always being on computer
- Lights without

**Energy waste during off-hours (23h-08h) (a) and Sundays (b)**



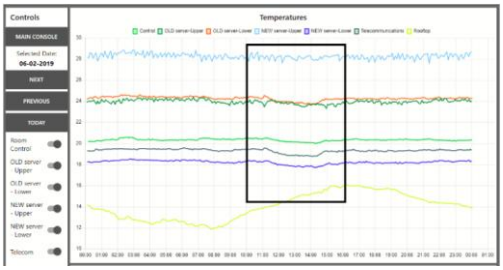

14

14

# Results: Data from Auditório Silva Leal (SL) - Current Reality Perception

**Findings**

- Anomaly detected on temperatures of all the sensors regularly
  - Points to an Air Conditioning Response since it affects all the measurements



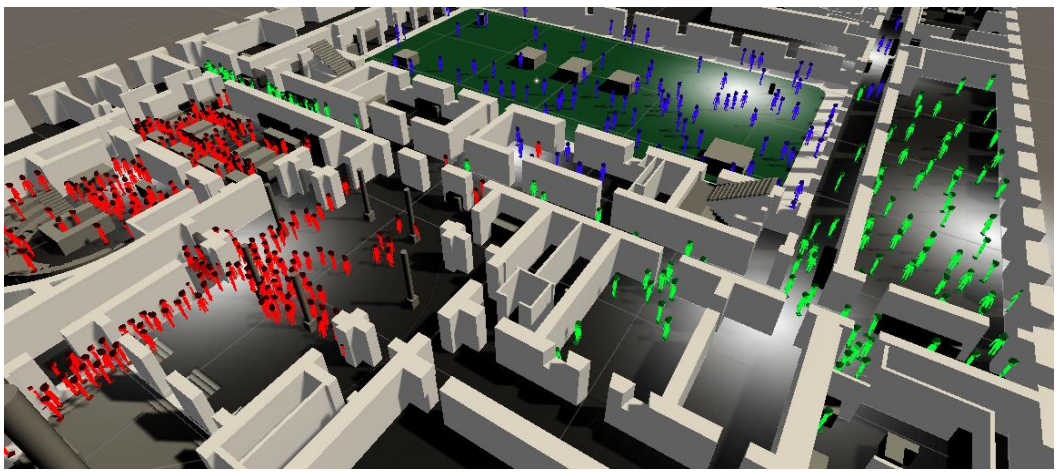

**Humidity**

- No visible correlation between the humidity outside the building (rooftop), and inside the data centre


15

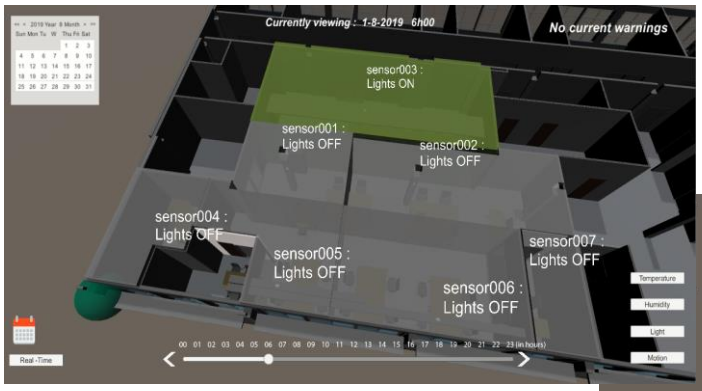


# Results: User Interaction and Thermal Feeling Representation



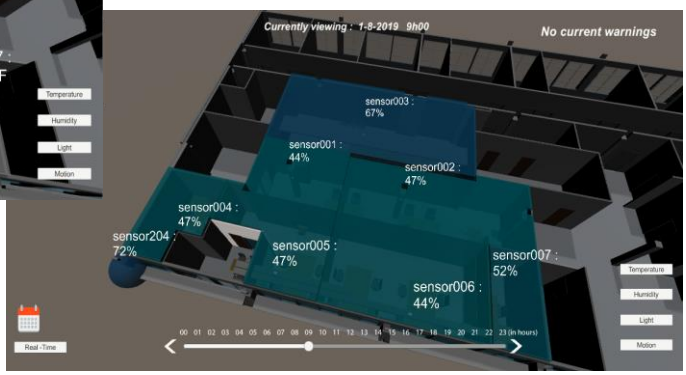
16

# Results: IoT BIM Data Representation




**Goal:**

- Improve user environmental perception

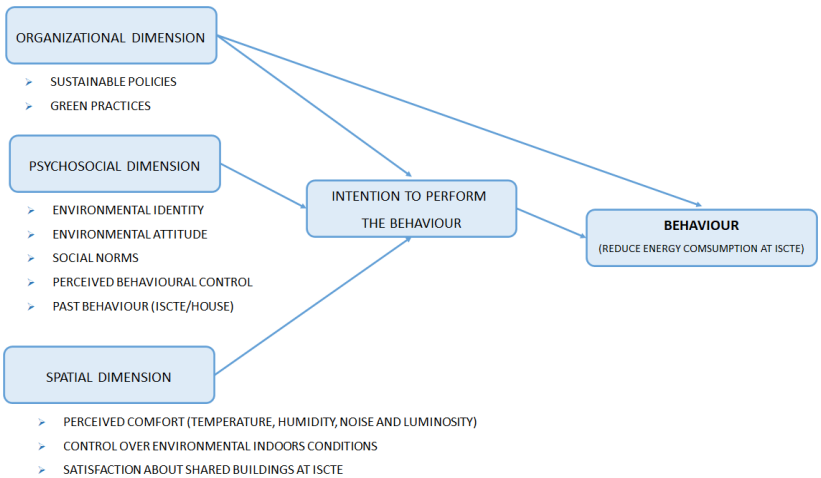



17



# Environmental Behaviour Assessment

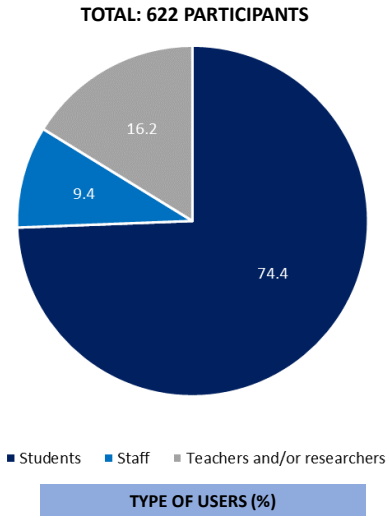
- Surveys (PT and ENG) to assess community's perception on environmental sustainability and willingness to change current energy consumption behavior at ISCTE
- Different types of users: students, teachers and/or researchers, and staff




**Behaviour change diagnostic model for ISCTE's community assessment**

18

# Results: Environmental Behaviour at ISCTE




**Findings**

- **Organizational:** Most users state that ISCTE has a sustainable policy, but on average only seem to agree slightly that ISCTE strives to implement green practices in its shared buildings
- **Psychosocial:** On average, ISCTE's community has a positive attitude towards sustainability and believe that they have enough capacity and autonomy to adopt more sustainable behaviours at ISCTE. Users also present high levels of intention to be environmentally conscious and already perform actions to reduce energy consumption (for example, turn off the lights) at ISCTE. However, users only agree slightly that their peers engage in these behaviours at ISCTE's shared buildings
- **Spatial:** Users think that, on average, they are neither comfortable nor uncomfortable at ISCTE, but are still slightly satisfied with its' buildings overall

19

19

# Findings: Environmental Behaviour at ISCTE

Results show that ISCTE and its' community have a great potential to successfully engage in behavioural change interventions in the future to motivate the reduction of energy consumption at ISCTE, in accordance to the project's goals.

| Organizational | Psychosocial | Spatial |
|---|---|---|
| • Make ISCTE's sustainability policies and practices more visible and prominent for users | • Explore with greater detail the effects of social norms on sustainability among different users | • Increase levels of comfort at ISCTE's shared buildings without compromising energy consumption levels |

20

20

# Next Steps

**Savings actions on user side**

- How to interact using real environment data to create savings actions?
- Mobile device interaction will play an important role (validation process under way)
- Tailored approach: information (incentives, norms,…) provided in accordance with the type of user (students, teachers…) and usage (classroom, services,…)

**Understand user preferences and behavior**

- Additional studies to explore the variables that motivate sustainable behaviour using different techniques (real-time information, focus group….)

**Experimental**

- Test whether different types of information (text vs. IoT BIM data representation) about the indoors environmental conditions (for example, temperature) of shared spaces influences the intention and adoption of more sustainable behaviours at ISCTE

**Real-time information**

- Explore over the time the role of social norms in the adoption of sustainable behaviours, based on real-time information about the indoors environmental conditions of shared spaces at ISCTE, using the IoT BIM data representation

**Focus group / Interviews**

- Explore users' in-depth opinion about ISCTE's role in the implementation and maintenance of sustainability in its' shared buildings

21

21

# Project's Outputs

- **Smart Cities Summer School in June/July 2019 and Winter School in February 2020**
- **Six masters' thesis and one PhD dissertation**
- **Publications in journals**
  - **LoBEMS—IoT for Building and Energy Management Systems** at electronics journal of MDPI (ISSN 2079-9292, Quartile one) . Information available at https://www.mdpi.com/2079-9292/8/7/763/htm
  - **IoT Power Monitoring System for Smart Environments** at sustainability journal of MDPI (ISSN 2071-1050, Quartile two). Information available at https://www.mdpi.com/2071-1050/11/19/5355/htm
- **Publication at conferences in book chapters**
  - CCIOT(August 2019, Japan), "Data Centre Environment Monitoring System". Proceedings of the 2019 4th International Conference on Cloud Computing and Internet of Things September 2019 Pages 75–81https://doi.org/10.1145/3361821.3361824
  - Sustainable Energy for Smart Cities, Braga December 2019, "Smart Auditorium: Development and Analysis of a Power and Environment Monitoring Platform", published in Sustainable Energy for Smart Cities, Springer International Publishing, 2021, https://doi.org/10.1007/978-3-030-45694-8
- **Workshops participation**
  - 1ª Conferência Campus Sustentável Social (CCS2019) "Social IoT Platform" – presented by Vasco Rato, ISCTE-IUL - Porto October 2019
  - SRA - E - Iberian Chapter International Conference – presented by Sílvia Luís and Rita Moura – Coimbra September 2019

22

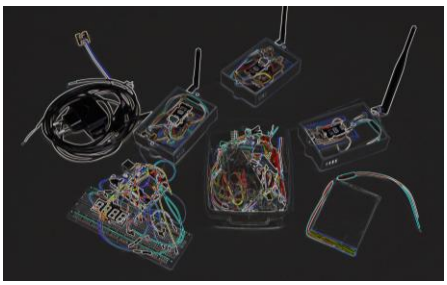
22

# Workshop @ISCTE


23

23

# Workshop @ISCTE



Organization

**ISTAR-IUL Software System Group**

and

**MSIAD**

(Mestrado em Sistemas Integrados de Apoio à Decisão, ISCTE-IUL)

18th October 2019
18h00 – 20h15

Auditório 2
Building 1, 2nd floor
ISCTE-IUL

With support of

FUNDAÇÃO CALOUSTE GULBENKIAN
ISCTE IUL
Instituto Universitário de Lisboa
MSIAD
ISTAR IUL

**WORKSHOP ON INTELLIGENT SYSTEMS**

18h00 "University Community Engagement in Technologies for Sustainability: a Social Architecture" Project status – João Ferreira

18h30 IOT*(AMBISENSE) – Smart environment monitoring using LoRa – Bruno Mataloto

18h45 EnerMon: IoT Power Monitoring System for Smart Environments – Diogo Santos

19h00 Parking Guiding System with Occupation Prediction – Gonçalo Alface

19h15 Age and Gender Classification – A Proposed System – David Silva

19h30 IoT System for EV Charging at Shared Spaces – José Pedro Martins

19h45 Discovery of sensitive data with Natural Language Processing – Mariana Dias

20h00 Low-Cost, Lightweight IoT Platform with Custom LPWAN LoRa Integration – André Santos

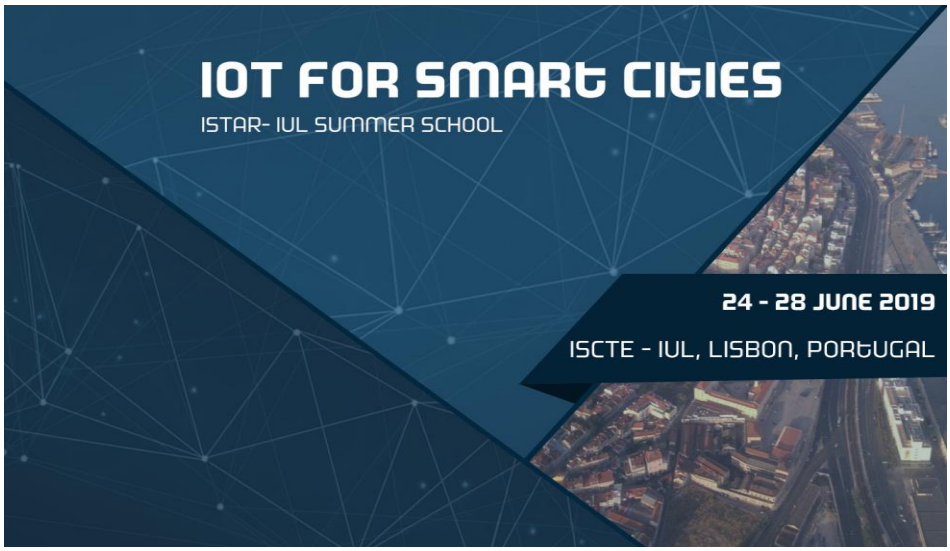
24

24

# Summer School 2019

**Talk: Combining behaviour change tools with IoT to promote sustainability**
Sílvia Luís ISCTE-IUL, CIS-IUL

The efficacy of programs that promote sustainable behavior is highly dependent on contextual and motivational characteristics. IoT can support the development of applications that gather large amounts of data from the environment and use them in accordance with the individual's motivational stage in order to provide the most adequate behavior change tool




25

25

# International Panel



26

26

# Winter School 2020

**Talk: Gulbenkian project main results - University Community Engagement in Technologies for Sustainability: a Social/Architecture and IOT Approach**
Joao C Ferreira, ISCTE-IUL, ISTAR

We developed an IoT solution to measure temperature, humidity, luminosity to provide real-time user environment information to local users. This data is stored and later processed to identify patterns and visualisation tools, which allows us to understand and have environmental perception. In this project, we implement a different approach based on the development of a 3D visualisation tool that presents the system collected data and warnings in an interactive model of the building. This data representation allows users to gain a perception of the environment and introduces a new approach for user interaction to achieve savings in shared space like public buildings


27

27

# Project's Outputs II

- **Submitted to journals (in review process)**
  - Personalized context energy forecast to change energy behaviour in shared spaces submitted to MDPI Sensors (Q1 Journal)
  - IoT Data 3D Representation for User Environment Perception to MDPI Sensors special issue of BIM Models and IoT for Sustainable and Smart Cities Sensing Approaches (Q1 Journal)

- **Conference Participation**
  - Project presentation at the International People Association Studies (IAPS) 2020 in Quebec City, Canada (Virtual Conference, June 21-26)

28

28

# Conclusions

## Project running for 12 months

- Perception of current situation with IoT sensing information performed
- Identification of current problems
- Advice performed based on data collection analyses
- Good psychosocial foundation for successful behavioural change intervention in the future

## Next steps

- User interaction to change behaviour – Pilots @ISCTE to collect more data – 2nd round of studies (experimental studies, real-time information studies and focus group/interview studies with different type of users

29

29


30