UCD Earth Institute

Better understand today's world.
Inform solutions for tomorrow.

Transparent Living: The Challenge of Delivering Ambient Assisted

AMBIENT 2016 , Oct. 10th 2016

Professor Gregory O'Hare,
School of Computer Science
&
Director of the Earth Institute

Transparency

A window on to our lives

"Why, sometimes I've believed as many as six impossible things before breakfast."

Lewis Carroll

Key Enablers for Ubiquitous Sensing Systems

- Capacity to sense and gather a rich context
- Embraces totality of Data Sources
- Tolerant of contradictory, real-time, lossy, quality-variable data
- Ability to correlate disparate data streams and uplift raw data through inference
- Adaptivity and Personalisation of Feedback

Key Enabler: Sensing & Connectivity

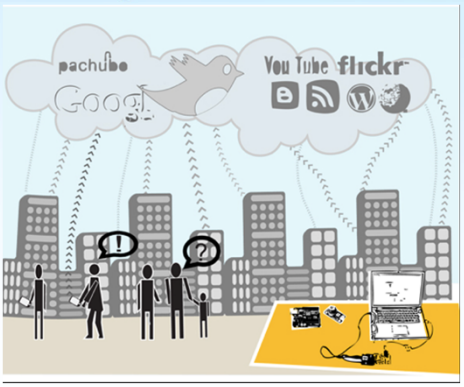
Harvesting the Context

Sensing Intelligently is Very Difficult

Very often we think of sensing as a relatively straightforward process of data capture given an appropriate sensing infrastructure.

Blind gathering of data is an overly simplistic view. It naively fails to consider the use to which the data will be put, and the power envelope within which it must be assembled.

Data gathering should also be moderated by feedback resulting from its very usage.



Ubiquitous Sensing

- Opportunistic Collaboration

  Recognition that no single sensor operates in isolation but rather as a part of a collective

- Distributed Reasoning

  Recognition that in-network intelligence is fundamental

- Utility-based Reasoning

  Recognition that deliberation comes at a cost namely power consumption;

RUBICON (Robotic UBIquitous COgnitive Network)

FP7 STREP Call 6

Symbiotic Robot-WSN integration for cooperative activity recognition.

UCD [Ireland] Coordinator
OREBRO [Sweden]
Ulster University [UK]
CNR [Italy]
University of Pisa [Italy]
Tecnalia [Spain]
ROBOTNIK Ltd [Spain]

Robot Control and Robot/WSN Integration

COGNITION

Agent-based Sensing & Acting Layer

Learning Network – Core Learning Service

Networking Infrastructure

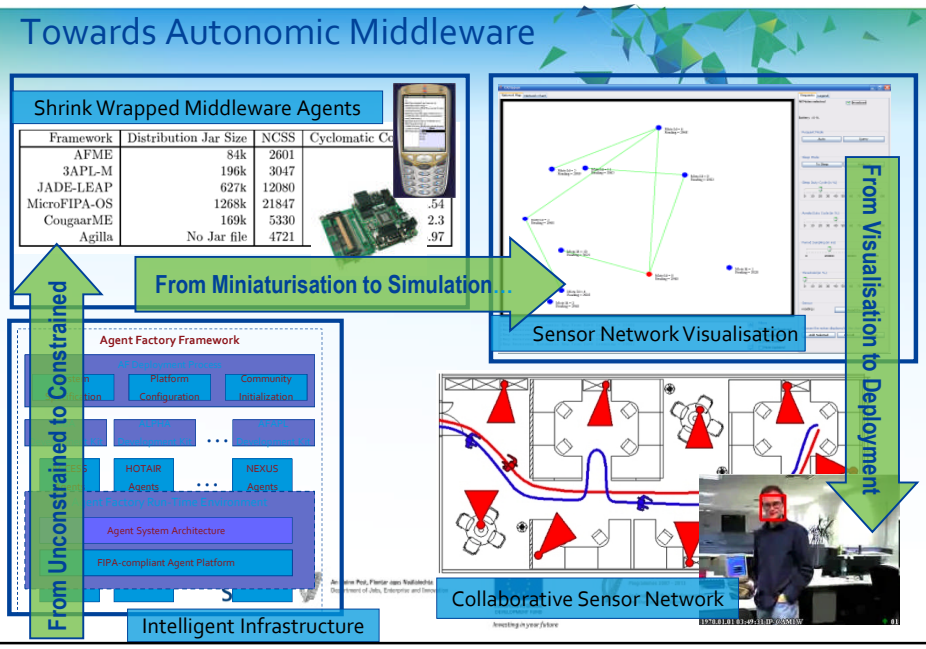
Participatory Sensing/Crowdsourcing

- 700 million new smartphones sold in 2012[1]
  - Increase of 42.7% over 2011.
- Sensing platform in people's pockets:
  - Proximity Sensor
  - Ambient Light Sensor
  - Accelerometer
  - Magnetometer (compass)
  - Gyroscopic Sensor
  - GPS Receiver
- Data transfer mechanisms:
  - WiFi, 3G, Bluetooth

Citizens Observatory WEB

COBWEB is funded by the European Union FP7 ENV.2012.6.5.1

Towards Autonomic Middleware



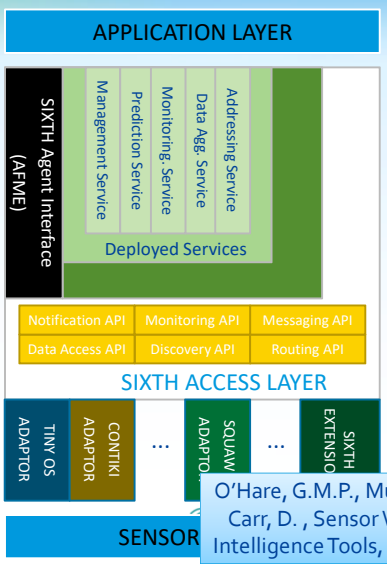
SIXTH Features

- Portability and Extensibility:
  - SIXTH works with any hardware that run Tinyos 2.x
- Adaptability:
  Choice of the protocol of communication during the compilation process
- Usability:
  - Interactive tool to enable user and researcher to have an accurate insight as to the state of the network
  - Message Requests to one, many, or all the motes of the network Data saved in a file for future treatment
  - Simple sliders allow to change node duty cycle or sampling rate

Angove, P., O'Grady, M.J., Hayes, J., O'Flynn, B., O'Hare, G.M.P., & Diamond, D. A., Mobile Gateway for Remote Interaction with Wireless Sensor Networks, *IEEE Sensors Journal*, Volume: 11 , Issue: 12, Page(s): 3309 - 3310 (2011),

O'Hare, G.M.P., Diamond D., Lau, K.T., Hayes, J., Muldoon, C., O'Grady, M.J., Tynan, R., Rancourt, G., Kolar H.R. & McCarthy R., The Adaptive Environment : Delivering the Vision of In situ Real-Time Environmental Monitoring, IBM Journal of Research and Development, Vol 53, No: 3, 2009

SIXTH Overview



Features:

1. Modularity – components can be reconfigured at run-time and possibly automatically
2. Flexibility – components can be added and removed at run-time and possibly automatically
3. Reusability – components must be reusable
4. Open – use open standards for interoperability
5. Extendible – allow other users to hook into our work
6. Universal - exists in some form on all nodes
7. Hides complexity

BASIC (1)	Data Access / Discovery / Routing
EXTENDED (2)	Messaging / Monitoring / Notification

O'Hare, G.M.P., Muldoon, C., O'Grady, M.J, Collier, R.W., Murdoch, O., Carr, D. , Sensor Web Interaction. International Journal on Artificial Intelligence Tools, Vol. 21, No. 2 April 2012, World Scientific Publishing

Demo: Tasmanian Bushfire Monitoring

- SIXTH middleware enables the use of multiple diverse sources within a single monitoring system
- Cyber sensors encapsulate and abstract diverse information from multiple sources, all providing additional context relating to the bushfires in Tasmania
  - Twitter provides real time access to local and global reports
  - Cosm provides real time access to IoT sensors
  - fire.tas.gov.au provides real time bush fire alerts
  - Yahoo! Weather provides real time access to weather data

Tasmania Fire Service

twitter

cosm

YAHOO!

- Blue Circles = Twitter User Sensors
- Orange Squares = COSM IoT Sensors
- Red Triangle = Tasmania Bushfire Alert Sensors
- Green Triangles = Yahoo Weather Sensors

Key Enabler: Interpreting Context

Interpreting & Making Inferences upon the Context

Delivering Intelligence

Agent Factory Micro Edition (AFME) is a is a *minimized footprint* reflective agent platform that has been designed specifically for use with resource constrained mobile devices.

It provides:

- Intelligent Scheduling
- Reduce computational overhead enabling agents to modify the frequency of execution of control algorithm
- Agent Migration: Transfer of agent state and movement of agents between devices;
- Resource bounded reasoning

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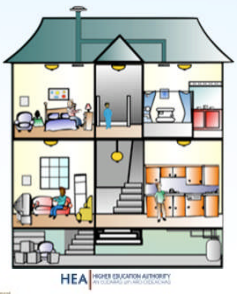
Domestic Sensor Distribution

Sensor Type	Location	Reason
Infra Red	Key / frequent locations	Detect presence of patient
Microphones	Key / frequent locations	Detect ambient sounds of patient
Light, temperature and humidity	Key / frequent locations	Monitor environment / presence
Contact / pressure sensors	Bed / chairs / windows / doors	Detect presence of patient / state of doors and windows
SenseCam	Patient	Monitor surroundings and events of patients daily life
Energy and Water Monitors	Plugs / Pipes / Taps	Monitor use of electricity / water in case of emergency



Managing Wandering

60% of Alzheimer's Patients will wander.

Managing wandering and providing comfort and alerts to stakeholders is of paramount importance.

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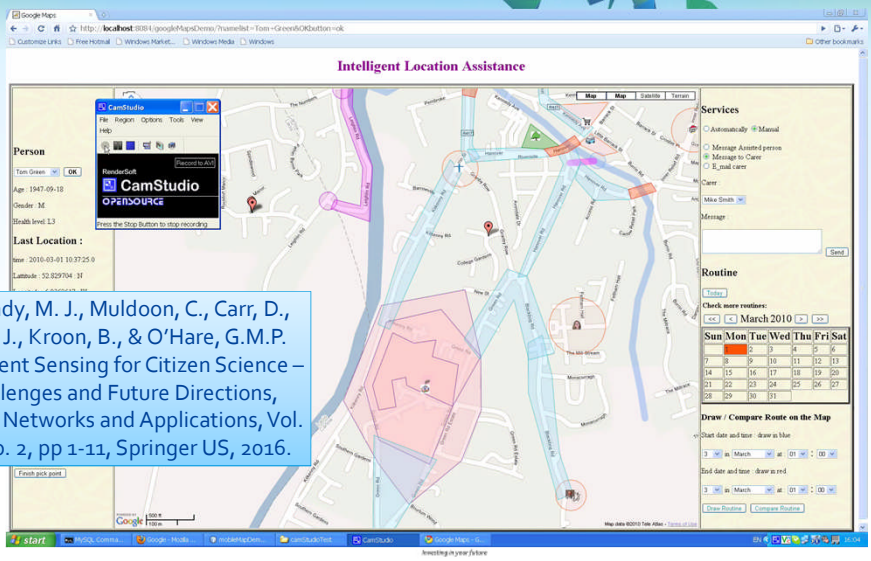
Wanderhelp



O'Grady, M. J., Muldoon, C., Carr, D., Wan, J., Kroon, B., & O'Hare, G.M.P. Intelligent Sensing for Citizen Science – Challenges and Future Directions, Mobile Networks and Applications, Vol. 21, No. 2, pp 1-11, Springer US, 2016.

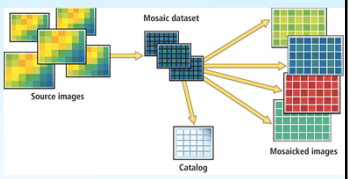
RUBICON AAL Sensing

Amato, G., Bacciu, D., Chessa, S., Dragone, M. Gallicchio, C., Gennaro, C., Lozano, H., Micheli, A, O'Hare, G.M.P, Renteria, A. et al, A Benchmark Dataset for Human Activity Recognition and Ambient Assisted Living, In Proceedings of 7th International Symposium on Ambient Intelligence (ISAmI 2016) Ambient Intelligence-Software and Applications, pp 1-9, 2016}, 1st-3rd June , 2016, Seville, Spain, Springer International Publishing.

Dataset Quality

Finding datasets that are:

- Sufficiently. large;
- Comparable to the situation being monitored;
- Suitably annotated;



Is inherently difficult.

Amato, G., Bacciu, D., Chessa, S., Dragone, M. Gallicchio, C., Gennaro, C., Lozano, H., Micheli, A, O'Hare, G.M.P, Renteria, A. et al, A Benchmark Dataset for Human Activity Recognition and Ambient Assisted Living, In Proceedings of 7th International Symposium on Ambient Intelligence (ISAmI 2016) Ambient Intelligence-Software and Applications, pp 1-9, 2016}, 1st-3rd June , 2016, Seville, Spain, Springer International Publishing.

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Ambient Approaches

1. Data Collection

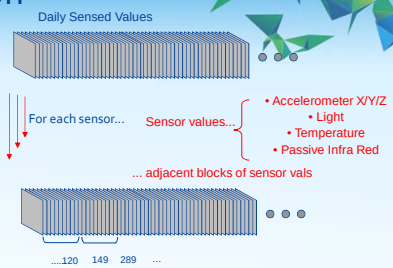
Passive Information Gathering via sensors in the environment and wearable devices

2. Conveying Information

Using assistive visualizations in the patients environment to aid memory, and other devices in care-giver's location to inform status of patient

Event Segmentation

Raw Data

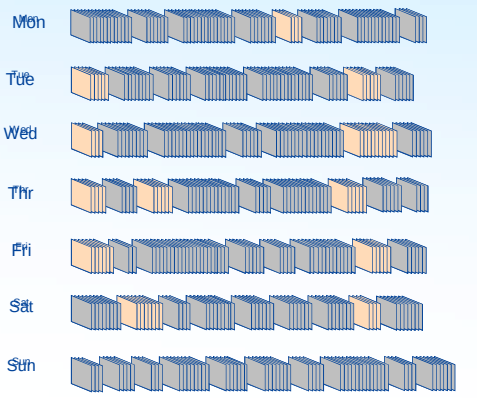


Similarity Matching

Normalisation & Data Fusion

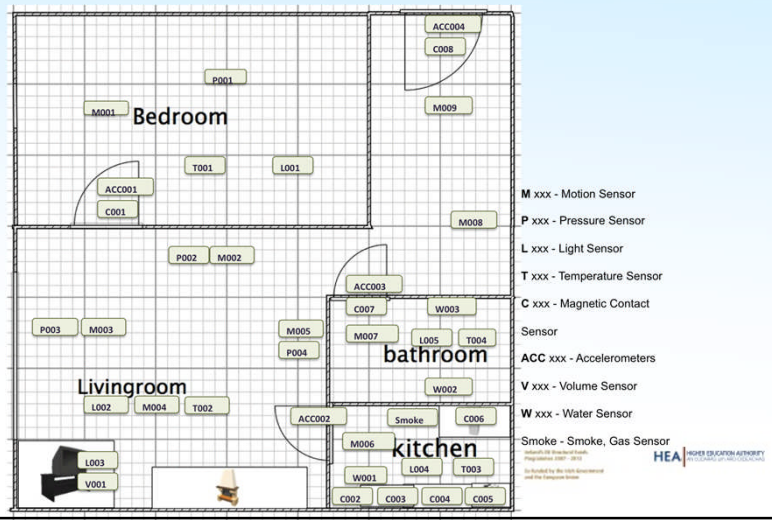
Thresholding

Finding Similar Events

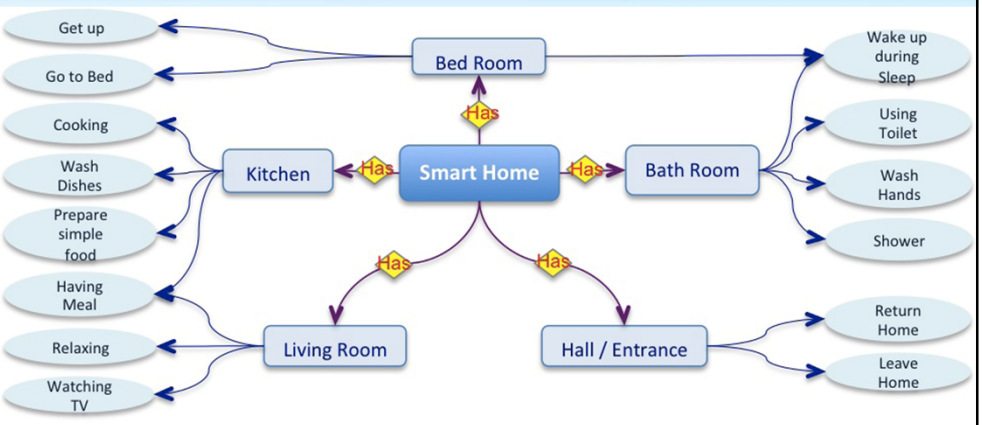


Storing by Association

AAL Instrumented Space



Activities of Daily Living



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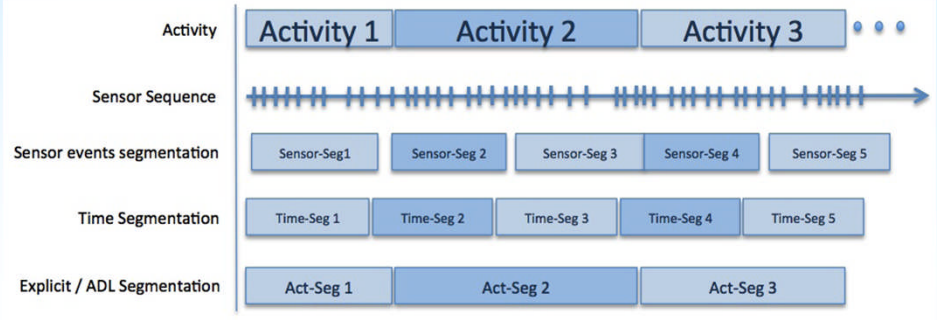
Activities of Daily Living



Wan, J, O'Grady, M.J, & O'Hare, G.M.P., Dynamic sensor event segmentation for real-time activity recognition in a smart home Context, Personal & Ubiquitous Computing Journal, Vol. 18, Springer, 2014

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Recognising Activities of Daily Living

Activity	Naïve Bayes	Bayesian Network	J48	Naïve Bayes Tree
Cooking	0.962	0.953	0.519	0.972
Get up	0.990	0.981	0.981	1.000
Go to bed	0.936	0.957	0.979	0.936
Having Breakfast	0.962	0.962	0.827	1.000
Having Coffee / Tea	0.328	0.603	0.776	1.000
Having Dinner	0.947	0.930	0.825	0.947
Having Lunch	0.000	0.000	0.583	0.583
Leave Home	0.988	0.988	0.988	1.000
Making a Tea / Coffee	0.978	0.968	0.753	1.000
Return Home	1.000	1.000	0.989	0.989
Shower	0.038	0.564	0.654	1.000
Use toilet	0.994	0.965	0.894	1.000
Visit Kitchen	0.920	0.931	0.793	0.943
wake up during sleep	0.633	0.810	0.886	1.000
Washing dishes	0.976	0.969	0.724	0.969
Watching TV	1.000	1.000	0.834	0.995
Average	0.791	0.849	0.813	0.958

Home Area Networks

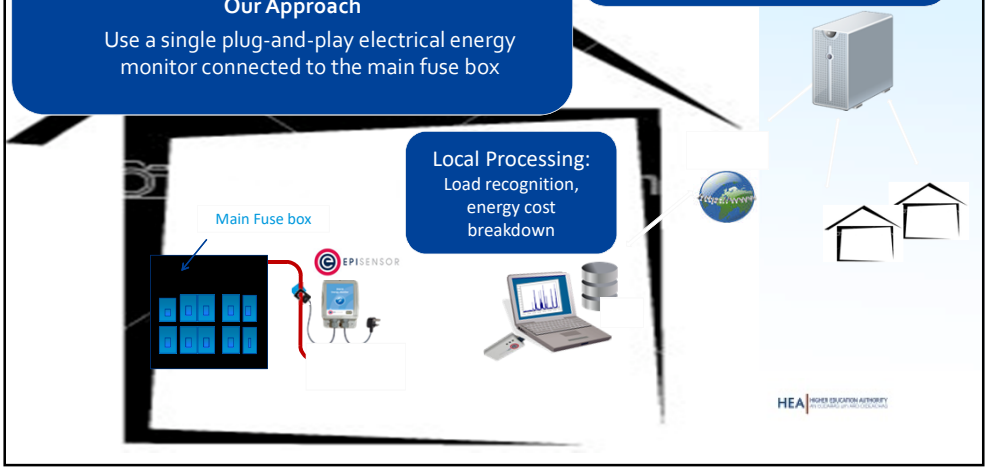
Traditional Approach

Retrofit building with intelligent sockets

Our Approach

Use a single plug-and-play electrical energy monitor connected to the main fuse box

Load descriptor database and Remote processing



Appliance Signatures

A blend of derived parameters constitute the *Unique Appliance Signature*

1. Real Power *P*

2. Power Factor *Pf*

3. And so forth…

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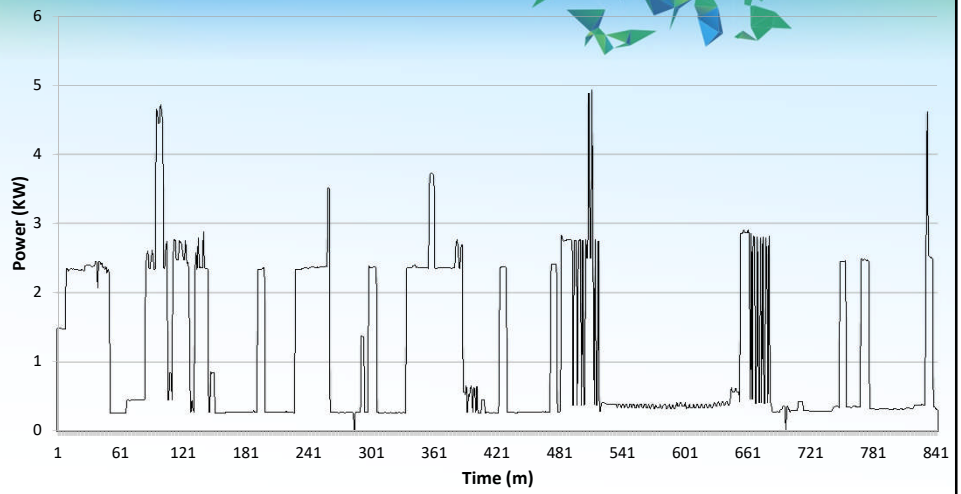
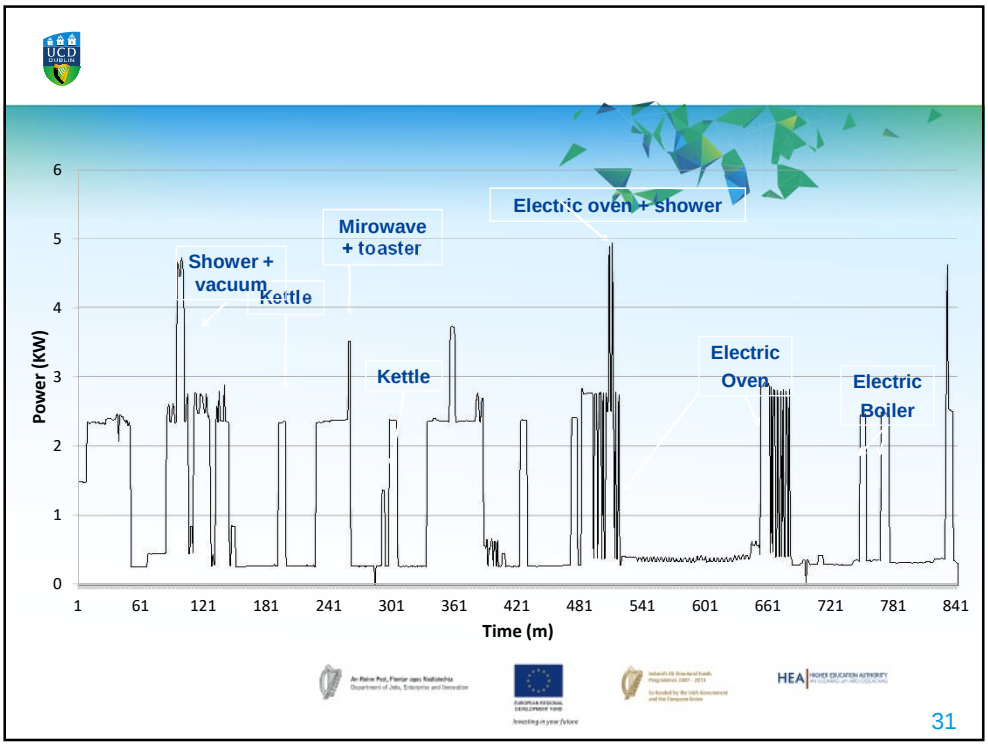
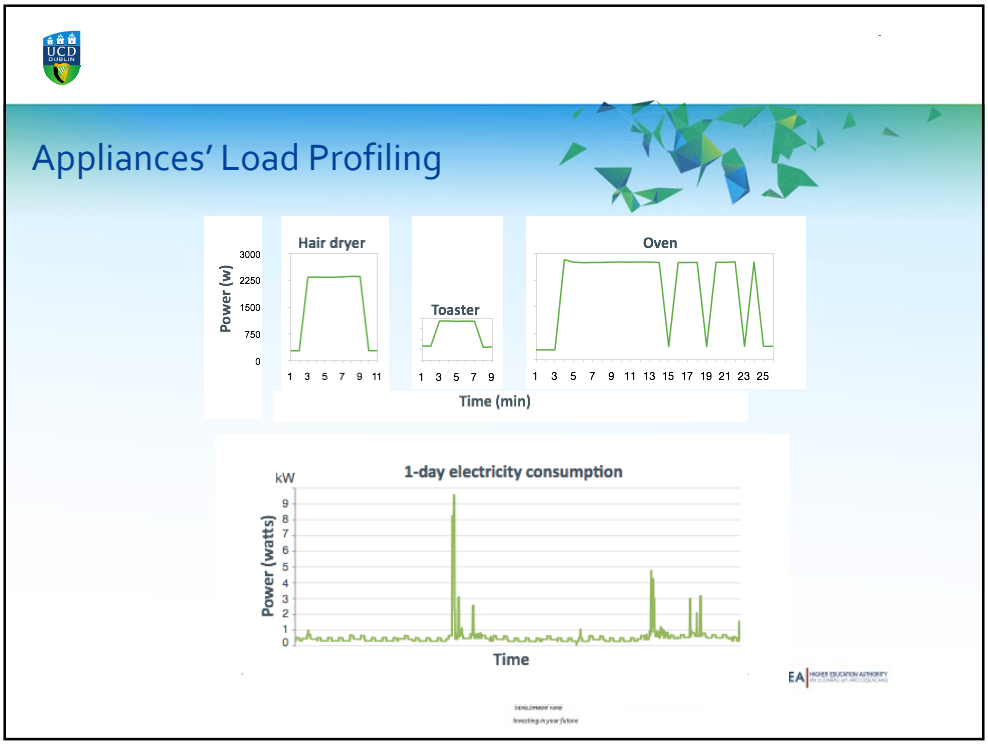
Deployment




Power (KW)
Time (m)
Shower + vacuum
Kettle
Mirowave + toaster
Kettle
Electric oven + shower
Electric Oven
Electric Boiler
0
1
2
3
4
5
6
1
61
121
181
241
301
361
421
481
541
601
661
721
781
841
31


Appliances' Load Profiling
Power (w)
Hair dryer
Toaster
Oven
Time (min)
1-day electricity consumption
kW
Power (watts)
Time

Spin Out Company

CLARITY EU - EnPROVE

The Consortium

Experts on information and Communication Technologies: UNINOVA, UCD DUBLIN, PHILIPS sense and simplicity

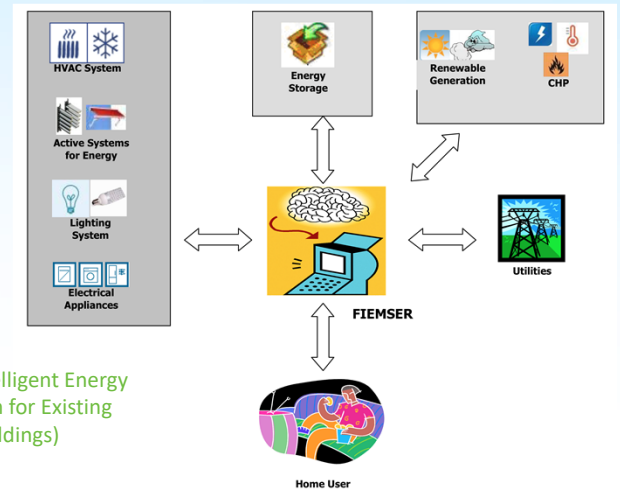
Experts on Energy in Buildings and Architectural Tools: CSTB le futur en construction, labein tecnalia, GEM Team Solutions

Final Users: Mostostal, ACTIS 3D

EnPROVE: Maximising return of investment (ROI) when investing on energy saving solution

CLARITY - FIEMSER

- CSTB
- THALES
- TECNALIA Labein
- Fraunhofer
- Philips
- Acciona
- TENESOL



FIEMSER (Friendly Intelligent Energy Management System for Existing Residential Buildings)

CLARITY - HOBNET

- RACTI
- Ericsson
- Mandat International
- Sensimode

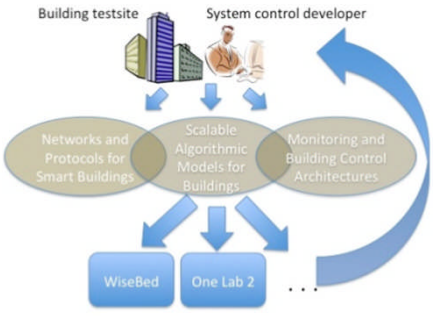
University College Dublin

University of Geneva

University of Edinburgh

HOBNET

HOlistic Platform Design for Smart Buildings of the Future InterNET



Key Enabler: Personalisation & Adaptivity of Feedback

Delivering Feedback that is Personalised and Contextualised to the Stakeholder Needs

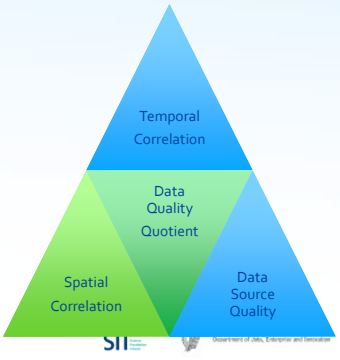
AuRA: Augmented Reality Interfaces

Conflating Data is Difficult

- What if data is contradictory?
- What if large volumes of inexact/inaccurate data saturates smaller volumes of accurate data?
- How do you know which data is good quality and which is poor quality?
- How do we ensure that the integrity of the data warehouse is not compromised with low fidelity data?
- How can we achieve this in real-time and in a computationally efficient manner?

Developing a Data Quality Quotient

- We need to be able to identify a Data Quality Quotient
- What are the dimensions upon which we should correlate data



More Data

Less Quality

Conclusion: To Dream by Day

"All people dream, but not equally. Those who dream by night in the dusty recesses of their mind, wake in the morning to find that it was vanity.

But the dreamers of the day are dangerous people, for they dream their dreams with open eyes, and make them come true."

D.H. Lawrence