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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


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Key Enabler: Sensing & Connectivity




Harvesting the Context


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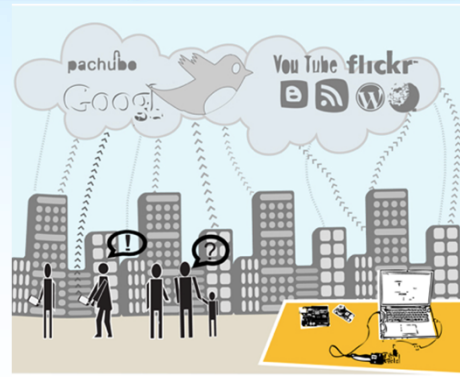


Sensing Intelligently is Very Difficult

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.



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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;



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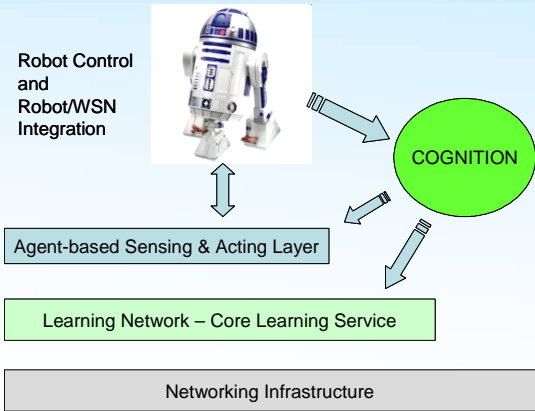
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 **RUBICON (Robotic Ubiquitous COgnitive Network)**

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 2012¹
 - 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
Citizen Observatory Web

<http://cobwebproject.eu>

COBWEB: Citizen Observatory WEB is a project which is creating a platform to enable citizens within UNESCO Biosphere Reserves to collect environmental data using mobile devices.

- COBWEB is working with researchers, policy makers, enterprise and local citizens and communities. This collaboration helps us to make sure tools and approaches we develop suit their needs and goals, and benefit their communities.
- COBWEB is working with the UNESCO World Network of Biosphere Reserves: Dyfi (Wales); Samaria, Mount Olympus (Greece); and Wadden Sea and Hallig Islands (Germany).
- The project uses open technologies and standards. We want to make sure data are collected so that they can be compared to authoritative data and re-used by other projects.



COBWEB is funded by the European Union Under the FP7 ENV.2012.6.5-1 funding scheme, EU Grant

Follow us: @CobwebFP7







COBWEB is funded by the European Union FP7 ENV.2012.6.5-1






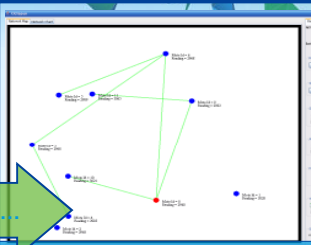


Towards Autonomic Middleware

Shrink Wrapped Middleware Agents

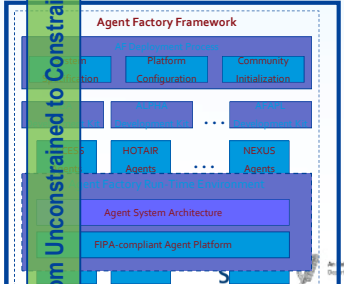
Framework	Distribution Jar Size	NCSS	Cyclomatic Co
AFME	84k	2601	
3APL-M	196k	3047	
JADE-LEAP	627k	12080	
MicroFIPA-OS	1268k	21847	.54
CongaarME	169k	5330	2.3
Agilla	No Jar file	4721	.97



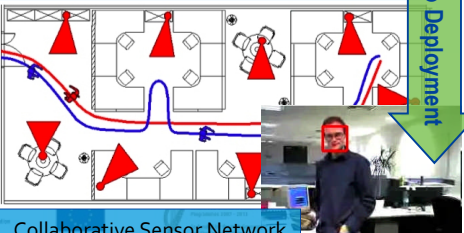


Sensor Network Visualisation

Agent Factory Framework



Intelligent Infrastructure




Collaborative Sensor Network

From Unconstrained to Constrained

From Miniaturisation to Simulation...

From Visualisation to Deployment









SIXTH Features

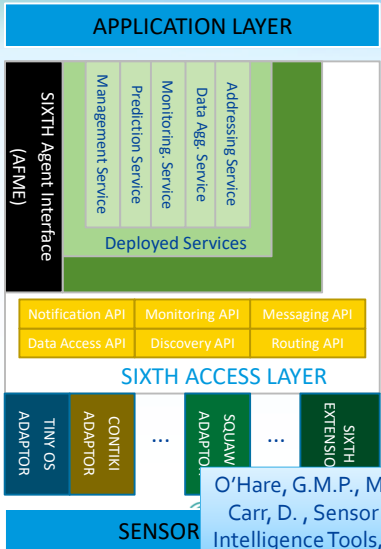
- Portability and Extensibility:
 - SIXTH works with any hardware that run Tinyos 2.x
- Adaptability:
 - Choice of the protocol of communication during the compilation process
- Usability:
 - Interactive tool to enable user and researcher to have an accurate insight as to the state of the network
 - Message Requests to one, many, or all the nodes 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



APPLICATION LAYER

- SIXTH Agent Interface (AFME)
- Deployed Services:
 - Addressing Service
 - Data Agg. Service
 - Monitoring Service
 - Prediction Service
 - Management Service

SIXTH ACCESS LAYER

Notification API	Monitoring API	Messaging API
Data Access API	Discovery API	Routing API

SENSOR LAYER


- ADAPTOR
- TINY OS
- ADAPTOR
- CONITIKI
- ...
- ADAPTOR
- SQUAW
- ...
- SIXTH EXTENSIO

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.Extensible – 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

- 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 *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



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Managing Wandering

60% of Alzheimer's Patients will wander.

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



Wanderhelp


The screenshot shows the 'Wanderhelp' application interface. At the top, it says 'Intelligent Location Assistance'. The main area is a map with various colored overlays and markers. On the left, there is a 'Person' profile for 'Tom Green' with details like age (1947-09-18) and health level (L3). Below that, it shows 'Last Location' with a timestamp and coordinates. On the right, there are sections for 'Services' (Automatically Manual, Message Attended person, Message to Care, R-mail care), 'Routine' (Check more routines, March 2010 calendar), and 'Draw / Compare Route on the Map' with options to draw routes in blue or red. A 'CamStudio' watermark is visible over the map area.

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.

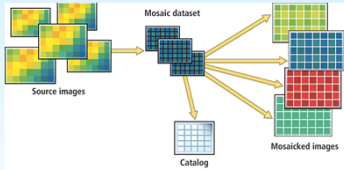
    

 **Dataset Quality**


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.

 20




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

Daily Sensed Values



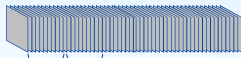
For each sensor...

Sensor values...

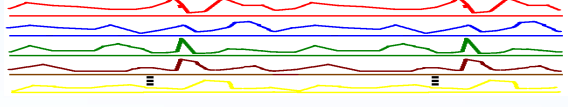
- Accelerometer X/Y/Z
- Light
- Temperature
- Passive Infra Red

... adjacent blocks of sensor vals


Similarity Matching




Normalisation & Data Fusion







Thresholding



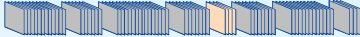



Daily Segmented Events

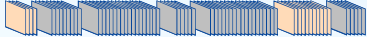








Finding Similar Events


Mön 


Tüë 


Web 

Thr 





Fri 


Sät 

Sün 

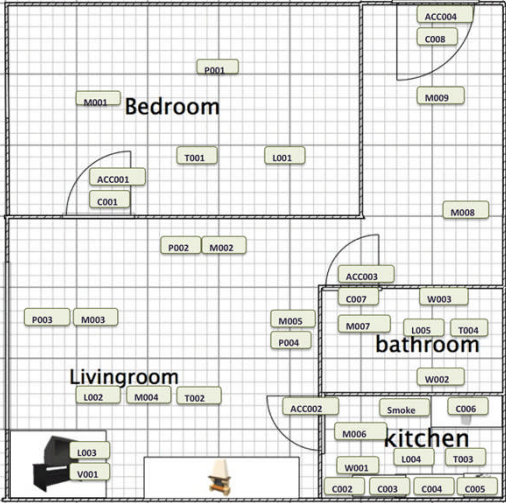
Similar Events 

Storing by Association










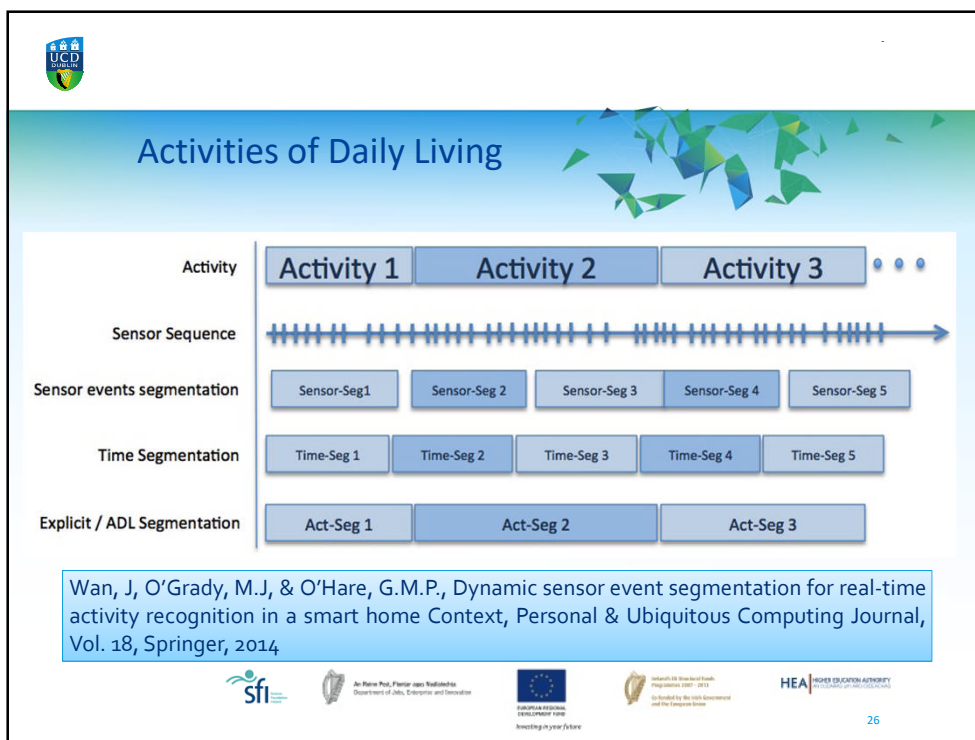
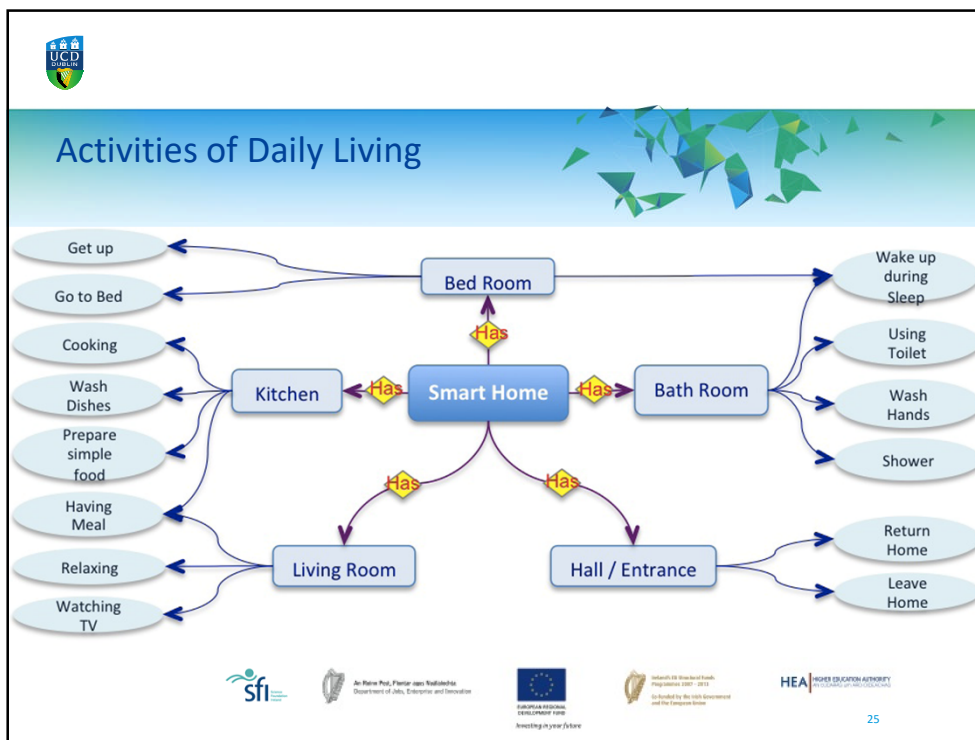


AAL Instrumented Space



- M xxx - Motion Sensor
- P xxx - Pressure Sensor
- L xxx - Light Sensor
- T xxx - Temperature Sensor
- C xxx - Magnetic Contact
- Sensor
- ACC xxx - Accelerometers
- V xxx - Volume Sensor
- W xxx - Water Sensor
- Smoke - Smoke, Gas Sensor





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






Local Processing:
Load recognition,
energy cost
breakdown



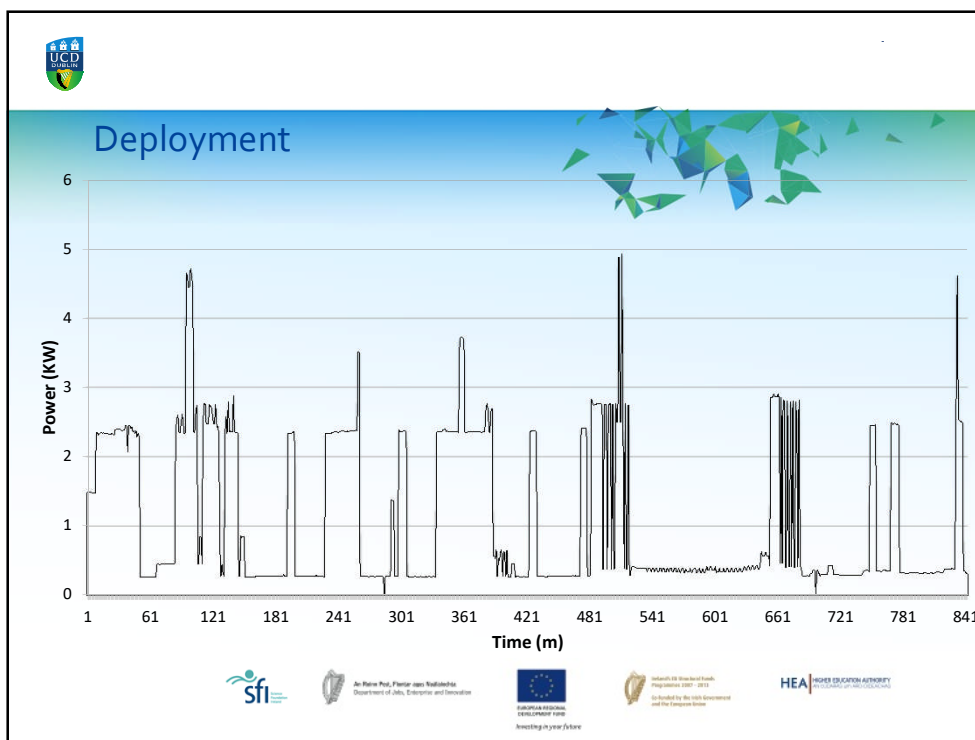
 **Appliance Signatures**

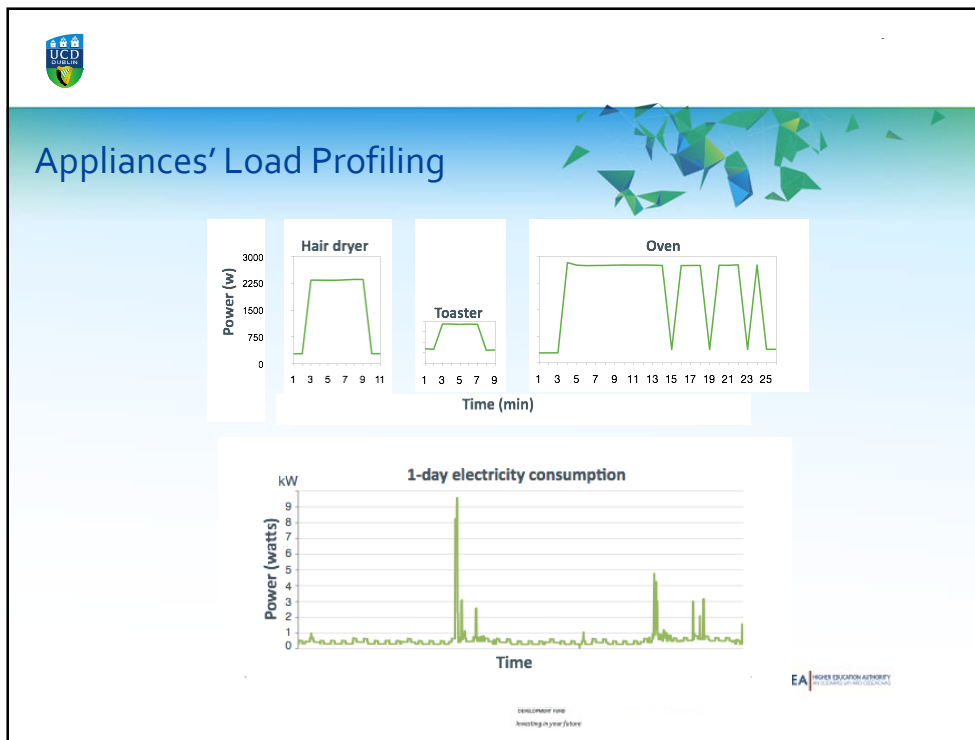
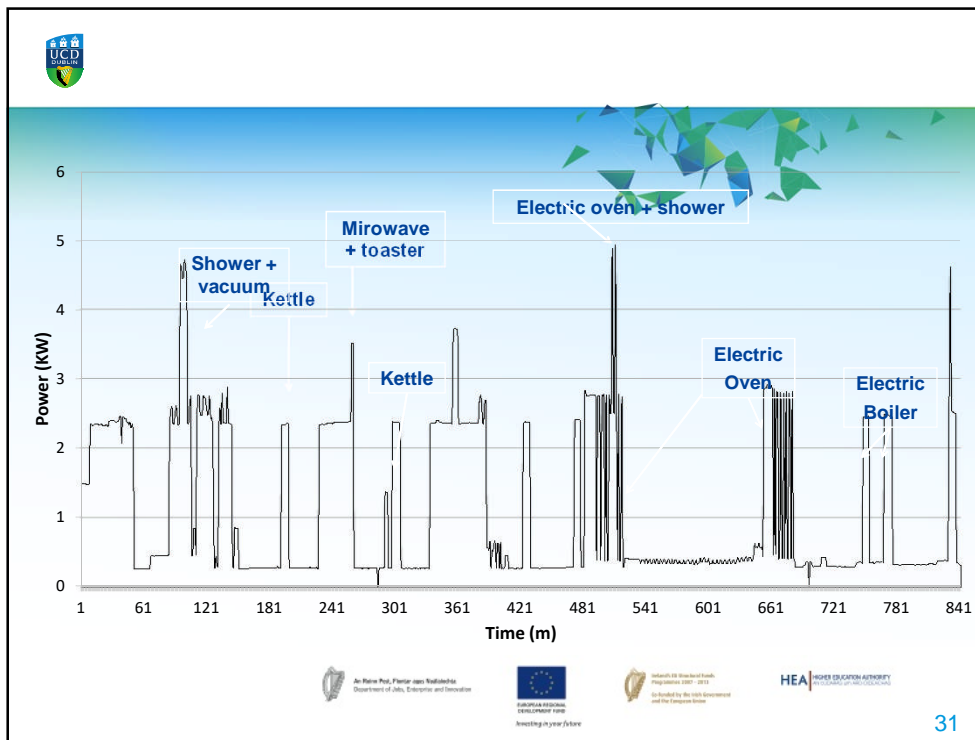
A blend of derived parameters constitute the *Unique Appliance Signature*

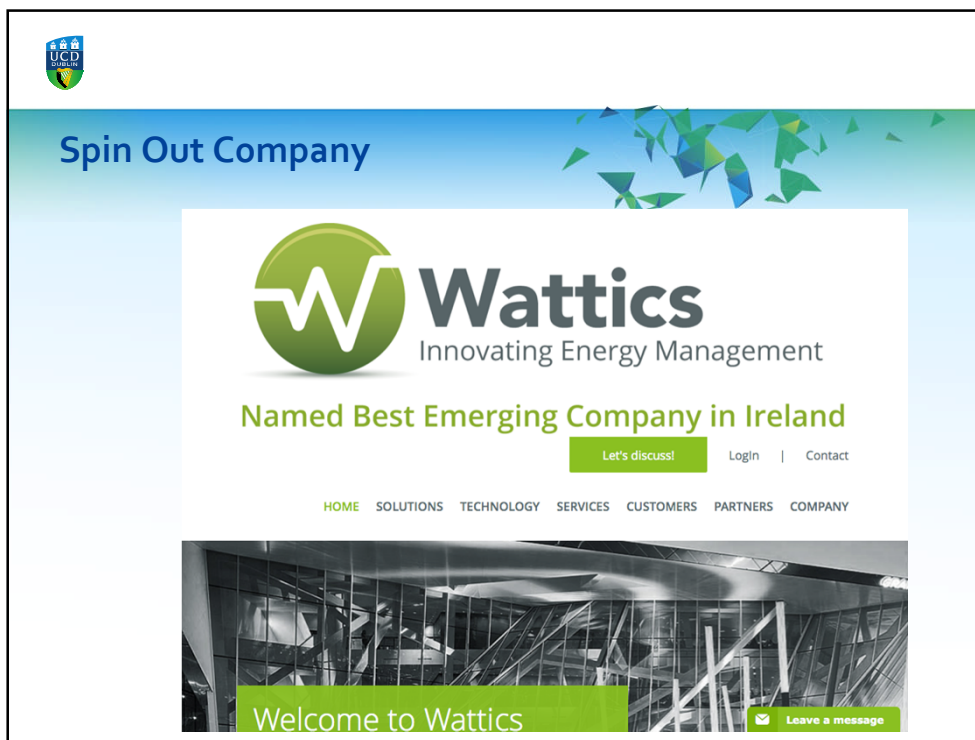
1. Real Power P 
2. Power Factor Pf 
3. And so forth... 

29








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Wattics

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Leave a message



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PHILIPS

Experts on Energy in Buildings and Architectural Tools

CSTB

labein

GEM

The Consortium

Final Users

Mostostal

ACTUS 3D



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

EnPROVE: modeling, prediction and decision support

- decision-maker criteria and restrictions
- available market solutions
- recommendation for best available solution
- demonstrated expected benefits
- installation plans

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- Acciona
- TENESOL

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

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- University of Geneva
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HOBNET
HOlistic Platform Design for Smart Buildings of the Future Inter.NET

Building testsite System control developer

Networks and Protocols for Smart Buildings Scalable Algorithmic Models for Buildings Monitoring and Building Control Architectures

WiseBed One Lab 2 ...

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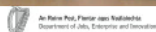
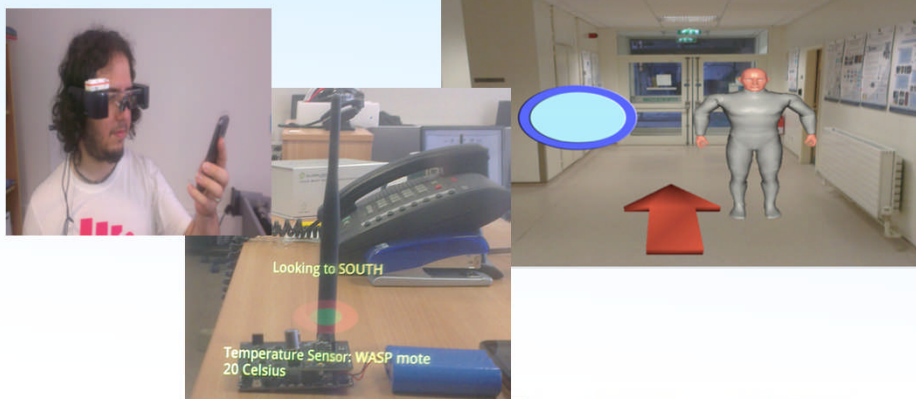
Key Enabler: Personalisation & Adaptivity of Feedback



Delivering Feedback that is Personalised and Contextualised to the Stakeholder Needs



AuRA: Augmented Reality Interfaces





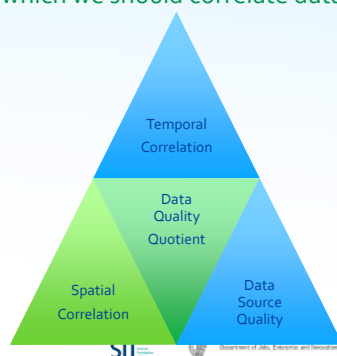
Conflating Data is Difficult

- 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





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

