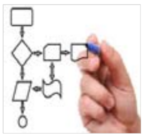
INNOVATION THROUGH INTEGRATION

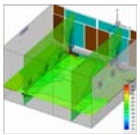


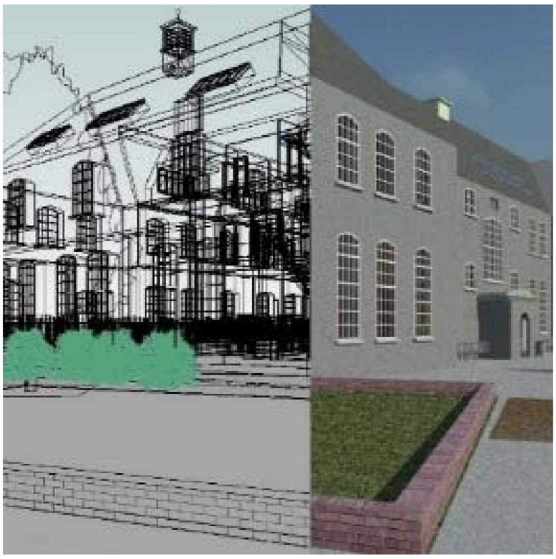
IRUSE

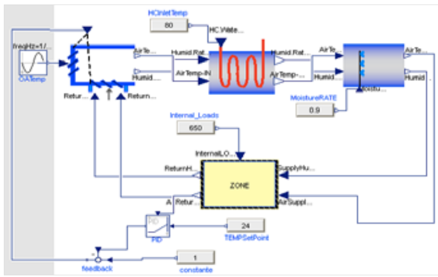
Informatics Research Unit for Sustainable Engineering

RESEARCH PORTFOLIO



BIM and Lean Management

Energy Facilities People

Smart Buildings and Big Data


UCC University College Cork, Ireland
Coláiste na hOllscoile Corcaigh
School of Engineering

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RESEARCH AREAS AND ACHIEVEMENTS AT A GLANCE

Research Areas

IRUSE – the Informatics Research Unit for Sustainable Engineering – bundles and manages research projects acquired by the Chair Information Technology in Architecture, Engineering, and Construction.

Research areas cover topics such as Information Modelling and Analysis, Facilities and Energy Management, and Business (Process) Modelling.

Primarily, our research focuses on the integrated, consistent and coherent modelling, management and analysis of product and process data. The area of Building Information Modelling (BIM) deals with static or slowly changing data, whereas the area of building performance monitoring deals with dynamic, bulk data compiled from monitoring devices. Both data types are required to predict or simulate the building behaviour. Those predictions are required on different scales and levels of detail (multi-dimensionality).

The availability of multi-dimensional data is a pre-requisite for the optimisation of building operation processes. Depending on the applicable business model the performance of buildings needs to be monitored, and analysed on either system, sub-system or component level. The advanced performance analytics and diagnostics methods developed as part of our research will enable FM-providers to optimise their business processes and to extend their business models with additional service bundles.

Achievements

Since 2008 IRUSE participated in 12 research projects with a total budget of approximately € 35 million. The groups funding totalled up to approximately Euro 5.2 million.

Key projects were the Strategic Research Cluster ITOBO (Lead), the EU-FP7 project CAMPUS21 (Coordinator) and the EU-FP7 Strategic Action REEB which was a direct feeder for the EU-FP7 and HORIZON2020 European Research Roadmaps in the area of energy in buildings.

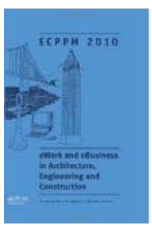
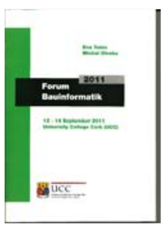
The group has published more than 120 publications, amongst them:

2 edited conference proceedings,
17 scientific research reports (evaluated by independent reviewers nominated by the European Commission),
10 journal papers, and
92 papers at international, peer-reviewed conferences.

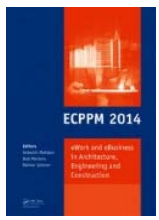
Outreach

IRUSE hosted two international conferences and organised three national and three international workshops which resulted in editing two conference proceedings; one of them was published by Balkema publishers (CRC-Press).

Two international workshops were organised in conjunction with international conferences, i.e. the workshop papers were published as part of the conference proceedings, again with CRC-press.





Alumni

Seven Postgraduate students completed their PG research (6 PhD, 1 MEngSc). IRUSE graduates progressed into academia and industry; or they established their own businesses. Career paths include:

- **Assistant Professor**, University of Nottingham, Campus Ningbo, China.
- **Lecturer,** Derby Business School, U.K.
- **Director of Information Systems**, Office of Inspector General, City of Chicago, USA.
- **IT Specialist**, Fota Island Resort, Ireland.
- **Co-Founder** EOS-Energy Solutions, Hannover, Germany.
- **BIM Coordinator,** RPS Built & Natural Environment, Cork, Ireland.

IRUSE had employed an average of eleven staff and PG students per annum since 2008.

The employment track-record of former IRUSE staff and students includes:

- **Lecturers,** Civil Engineering Dept., Markere University, Uganda; and Mathematics Dept., Waterford Institute of Technology, IRL.
- **Innovation Coordinator,** NIMBUS Centre, Cork, Ireland.
- **Data Scientist,** Texuna Technologies, London, UK.
- **Database Expert,** MifPay, China.
- **Programmer,** DB-Matters, Ireland.
- **Senior Quantitative Analyst,** Bord Gais Energy, Ireland.

UCC School of Engineering

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RESEARCH STRATEGY

IRUSE
Informatics Research Unit for Sustainable Engineering

University Strategy

IRUSE is a member of UCC's Environmental Research Institute. Our research activities are embedded in UCC's research strategy as part of **Thematic Area 3 '*Physical Sciences, Engineering and Mathematics (including ICT)'*** with an emphasis on categories (5) High Performance Computing, (6) Artificial Intelligence, and – most importantly – (7) Smart Buildings.

National Research Strategy

The following priority areas - specified by the Irish policy advisory board for enterprise, trade, science, technology and innovation (Forfas, 2014) – guide our work:

Priority Area B - Data Analytics, Management, Security and Privacy
Work in this area (i) enables building owners (e.g. governmental agencies) and building operators (e.g. indigenous Irish SME) to discover the needs for performance monitoring, expose variability in contracting and improve the performance of building services systems. (ii) It provides a higher transparency in novel business models, such as ESCO or PPP; and (iii) It becomes an enabler to replace or support human decision making with (semi)automated algorithms during the design and operation of buildings and infrastructural systems.

Priority Area C - Digital Platforms, Content and Applications
Work in this area focuses on the knowledge transfer from research into teaching, strengthening Ireland's position as leading player in the eLearning sector. With the development of Living Laboratories in UCC's ERI-building and CEE-building we contribute to the strategic goal to built up a solid base in digital content, development of linked data (product and process data) and e-readiness of Academic Institutions. The collaboration with European and indigenous firms has been successful in eLearning, the establishment of wireless infrastructures and middleware.

Priority Area K - Smart Grids and Smart Cities
In this area our work focuses on the exploitation of the availability of sensors, communication and analytical technologies for the further development of design and management solutions for urban infrastructure systems, with an emphasis on district heating and load balancing between groups of public buildings. We deploy ICT technologies to exchange information using standardised formats and monitor and control various building systems.

Priority Area N - Innovation in Services and Business Processes
Our research focuses on business model innovation by embedding new data analysis and performance monitoring technologies in new business and procurement models for the Construction and Facilities Management sector. The need for innovation around new business models is illustrated by the potential use of data networking as a communication channel between building owners, operators and building users.

Finally, our applied research for the construction sector is guide by the strategic development plan entitled: "**Ireland's Construction Sector – Outlook and Strategic Plan to 2015**" published by Forfas in 2013. The document highlights the need for Building Information Modelling and the further development of expertise and skills related to the exploitation of digital models for planning, process and quality management.

Important Documents

UCC: **Strategic Plan: Sustaining Excellence 2013 – 2017**: University College Cork: 2013.

UCC-R: **UCC's Thematic Research Areas, Associated Research Priorities:** UCC - **Research Support Services. http://www.ucc.ie/en/research/overview/strengths/** (last accessed January 2016).

Forfas: **Research Prioritisation Exercise**: Irish policy advisory board for enterprise, trade, science, technology and innovation (Forfas): Dublin: 2012.

DoJEI: **National Research Prioritisation Exercise: First Progress Report**: Department of Jobs, Enterprise and Innovation (DoJEI): Dublin: June 2014.

SFI: **Agenda 2020**: Science Foundation Ireland, Dublin, 2013.

Forfas: **Ireland's Construction Sector – Outlook and Strategic Plan to 2015**: Irish policy advisory board for enterprise, trade, science, technology and innovation (Forfas), Wilton Park House, Wilton Place, Dublin 2: July 2013.

ECTP: **Energy-efficient buildings PPP: Multi-Annual Roadmap and Longer Term Strategy**: European Construction Technology Platform (ECTP) and European Commission: Brussels, 2010.

EU: **Energy-Efficient Buildings – Multi-Annual Roadmap for the Contractual PPP Under HORIZON 2020**: European Union (EU), 2013 (ISBN 978-92-79-31239-7, doi: 10.2777/29993).

Research Partners

IRUSE has collaborated with a total of 44 research partners since 2008. The tables below provide breakdowns (a) per country, (b) per sector, and (c) per area of expertise (or discipline).

IRL UK	AUS CZ	GER	FR/ NL	ES	SLO IT/GR	FIN SWE	Total
16	3	5	6	6	5	3	44
36%	7%	11%	14%	14%	11%	7%	

Univer-sity	Res. Instit.	Industry	SME	Govern-ment	Total
18	9	12	4	1	44
41%	20.5%	27%	9%	2.5%	

Architecture	Civil Eng. Construction	Computer Science	Electrical Engineering	Energy Eng.	Facility Mgmt. Infrastructure	Government	Management	Mechanical Engineering	Total
3	13	8	3	3	3	1	1	9	44
7%	29%	18%	7%	7%	7%	2.5%	2.5%	20%	

United Technologies Research Center · Honeywell · ARUP · bam · CARTIF · NEC · sirus · IBM · BILFINGER · TU WIEN Technische Universität Wien · TNO · CSTB · SINTEF · VTT

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University College Cork, Ireland
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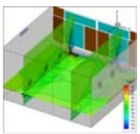
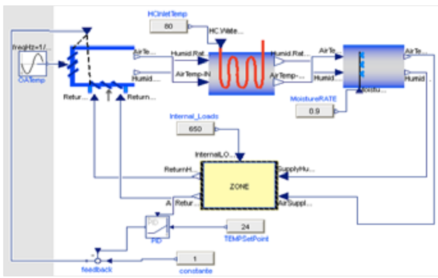
RESEARCH PORTFOLIO

CAMPUS 21

Control and Automation Management for Buildings and Public Spaces in the 21st Century




This certificate was presented to
Karsten Menzel
Recognising leadership of a project in the Seventh EU Framework Programme for Research at "Ireland's Champions of EU Research 2012"
attended by
President of Ireland, Michael D. Higgins



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PROJECT PARTNER

University College of Cork

University College Cork (UCC) is a member of the National University of Ireland (NUIC). UCC is Ireland 's leading research institute (3,000 employees, incl. more than 800 faculty). UCC is involved in the project through the Informatics Research Unit for Sustainable Engineering (IRUSE) and the Cork Constraint Computation Centre (4C).

IRUSE is a research unit at UCC and was one of the founding members of UCC's Environmental Research Institute (ERI). It is committed to research and development of Sustainable Built Infrastructure Systems and Technologies.
4C was established in 2001. The major research expertise of 4C lies in constraint programming and advances in artificial intelligence (AI) to make constraint programming easier to use.

HSG Zander

As a reliable partner of the real-estate industry, HSG Zander has been working in the entire spectrum of facility management for many years. Long-term experience, expertise and readiness for innovation of the group are available for all possible services. The company portfolio includes facility management activities, technical, infrastructural and commercial FM – with integrated packages that combine all facility services, HSG Zander can offer the complete range of possible services.

HSG Zander does also successfully launch PFI- and contracting-projects and operates real estate portfolios for key account customers via operating companies - with the Commerzbank Arena as a typical example.

Technische Universität Wien

As a centre for advanced studies, the overall mission of the Department of Building Physics and Building Ecology, Vienna University of Technology (TU Wien) is to promote, develop, and disseminate scientific and technical knowledge, methods, tools, and skills toward enhancing the sustainability and habitability of the built environment.

NEC Laboratories Europe

NEC Laboratories Europe (NLE) is the corporate research facility of NEC Europe Ltd, a wholly-owned subsidiary of NEC Corporation, a leading provider of telecommunication infrastructures, service platforms, service enablers, cloud platforms, and IT solutions. The laboratories are located in Heidelberg, Germany and Acton, UK.

Work focuses on software oriented research and development for the Future Internet. NLE has been a key partner in projects of the European Commission's Information and Communication Technologies Programme. The Department has a sustained and successful track record in conducting nationally and internationally funded research projects especially in the areas of building physics, building diagnostics, and building automation.

Fundación Cartif

Fundación CARTIF is a leading Spanish Applied Research Centre created in 1994. CARTIF is formed up by 9 technical divisions and 200 researchers specialised in several areas such as Energy, Environment, Food and Chemicals, Biomedical, Robotics, etc.

Moreover, CARTIF is the Spanish National Liaison Point of the European E2BA (Energy Efficient Buildings Association). Cartif works in close collaboration with the AYUNTAMIENTO DE VALLADOLID. CARTIF has expertise in measurement and verification of energy savings (IPMV by www.evo.org), ICT development and dissemination.

Electricity Supply Board (ESB)

ESB is the largest Electricity Utility in Ireland. It is vertically integrated with generation, distribution and retail. Its retail area is being expanded from electricity to include gas, energy efficiency and renewable offerings to customers. ESB is involved in exploring the potential of smart meter systems and electric vehicles.

It has more than 75 years experience of energy generation, supply and engineering expertise. ESB has many years experience of a variety of procurement, business and operational models and a thorough understanding of the practical impact of energy efficiency and renewable energy design in buildings, and the difficulty of balancing and integrating multiple technologies.

United Technologies Research Centre

UTC is the multi-national parent corporation of such companies as Carrier, UTC Fire & Security, Otis, Pratt & Whitney, etc. It has significant expertise in product offerings such as building management solutions, HVAC systems, fuel cells, gas turbine systems, combined heat and power systems, and on-site energy generation solutions.

UTRC-I is the recently established European leg of United Technologies Corporation's (UTC's) central research organization, the United Technologies Research Center (UTRC). UTRC has a proven track record of successfully partnering to develop new concepts and commercialise them through the UTC business units.

Royal BAM Group nv (bam)

Royal BAM Group nv is a successful European construction group and unites operating companies in five home markets with the administrative centre in the Netherlands and listed at Euronext Amsterdam.

BAM is active in the sectors of construction, property, civil engineering, public private partnerships, mechanical and electrical contracting, consultancy & engineering, and facilities management. The Group ranks among the largest companies in Europe.

Temperature Ltd (SIRUS)

Sirus Engineering Systems (SES) was established in 1988 to provide Building Control Solutions to clients. Sirus is UCC-NUIC's major subcontractor for HVAC maintenance including the control, operation, and energy management of approximately 50% of all Campus buildings.

SES works in partnership with Siemens Building Technologies, Honeywell, Cylon, and KIMO in the application of their systems in all types of building environments.

Through strategic mergers, Sirus Engineering Systems became the Irish agents for the largest controls companies in the world.

Ayuntamiento de Valladolid

The participation of the Valladolid Municipal Council is going to be carried out through its Energy Department (Agencia Energética Municipal de Valladolid – AEMVA). It is a managing and operation unit that works in the framework of the council, whose main purpose is the optimisation and rationalization of the energy consumption and by extension of the public services offered by the Council. It was created in 1992 with the determination of treating the municipal energy optimization as a whole.

PROJECT OVERVIEW

Objectives

Campus 21 addresses the need for integration strategies of ICT in building and neighbourhood energy management systems.

Campus 21 aims to achieve optimised and holistic operation of Energy-, Security-, Safety and other Facilities Services.

Campus 21 aims to optimise the energy usage and operational cost and to reduce the overall CO_2 emission of buildings and public spaces.

Campus 21 develops an integration strategy which addresses four key areas:

1. Technical Integration Strategy,
2. Integrated Business and Procurement Models,
3. A Holistic Validation Concept, and
4. An Integrated Standardisation Concept.

The following Scientific and Technological Objectives (STO) have been identified in order to achieve the objectives:

- STO 1: Creation of concepts for new Business Models
- STO 2: Development & Performance Evaluation of Buildings & Public Spaces
- STO 3: Development of an Integrated Energy Systems Management Concept
- STO 4: Development and Deployment of an ICT Service Platform for Energy Systems Management
- STO 5: Development of predictive systems control, and load balancing
- STO 6: Determination of a “Performance Baseline” and evaluation of “Advanced control tools
- STO 7: Development of a Procurement Schema and widespread dissemination
- STO 8: Development of a Standardisation Plan

Approach

The key technological innovations of CAMPUS 21 are:

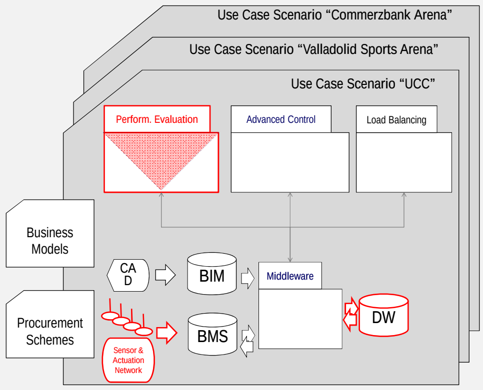
1. Integration concepts for energy management systems including the related middleware components,
2. Methodologies for intelligent, optimised control of building services systems,
3. Algorithms and tools to support load-balancing between renewable micro-generation, storage systems, and energy consuming devices in buildings and public spaces.

This is complemented by the development of key business elements, including:

1. New business models for integrated energy management and the underpinning novel procurements schemes.
2. Performance Metrics and a holistic Evaluation Concept for Systems Integration.

Work Packages

No.	WP Title
WP 1	Business Models and Procurement Schemes
WP 2	Evaluation and Monitoring Concept
WP 3	Use Cases & Guidelines for Integrated Energy Systems Management
WP 4	Integration Concept and Middleware Components
WP 5	Algorithms & Tools for Control of Micro Generation and Energy Storage Components
WP 6	Load Balancing for BMS and Local Energy Distribution Grids
WP 7	Dissemination and Standardisation



Demonstration Sites





Campus University College Cork (incl. District Heating), Ireland   Commerzbank Arena, Germany   Sports Complex, Spain

Partner

University College of Cork
http://www.ucc.ie

Electricity Supply Board (ESB)
http://www.esb.ie

HSG Zander
http://www.hsgzander.com

United Technologies Research Centre, Ireland
http://www.utrc.utc.com

Technische Universität Wien
http://www.tuwien.ac.at

Royal BAM Group nv (BAM)
http://www.bam.eu

NEC Laboratories Europe
http://www.neclab.eu

Temperature Ltd (SIRUS)
http://www.sirus.ie

Fundación Cartif
http://www.cartif.es

Ayuntamiento de Valladolid
http://www.valladolid.es

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MONITORING and EVALUATION CONCEPT

Objectives

This research focuses on the development of concepts for monitoring and validation of building performance. The emphasis is on instruments to produce the evidence for energy savings and reduced total cost of operation. Work includes:

1. The definition of information and subsequent **evaluation requirements** for building performance evaluation.
2. The development of a **modular, hierarchical, block based monitoring concept** including a corresponding data acquisition schema.
3. The development of a Performance Evaluation Metrics which supports the integrated, holistic analysis of performance criteria.

Approach

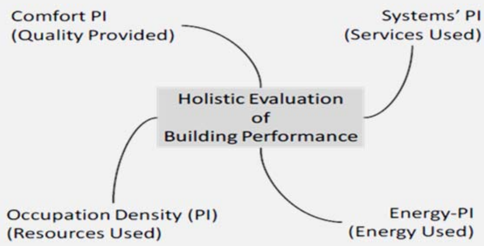

Figure 1: Evaluation Criteria

WHAT to evaluate?

COMFORT PERFORMANCE INDICATORS (PI)
This set of PI ensures that buildings are operated in compliance with technical or legislative requirements for

OPERATIONS PERFORMANCE INDICATORS (PI)
This set of PI ensures that all building services are operated in an integrated way.

ENERGY PERFORMANCE INDICATORS (PI)
This set of PI ensures that the energy consumption of systems is monitored and optimised.

USE EFFICIENCY PERFORMANCE INDICATORS (PI)
This set of PI ensures that spaces are neither 'under utilised' (i.e. booked and not used) or 'over utilised.

WHERE to monitor?

The monitoring concept supports building opera-tors to determine required points and components to be monitored.

BLOCK BASED concept

This means a 'group' of components delivering a specific functionality is always considered.

HIERARCHICAL concept

This means users are supported to identify links between monitoring and actuation.

MODULAR concept

This means different sub-systems can be integrated on different 'spatial zone levels'.

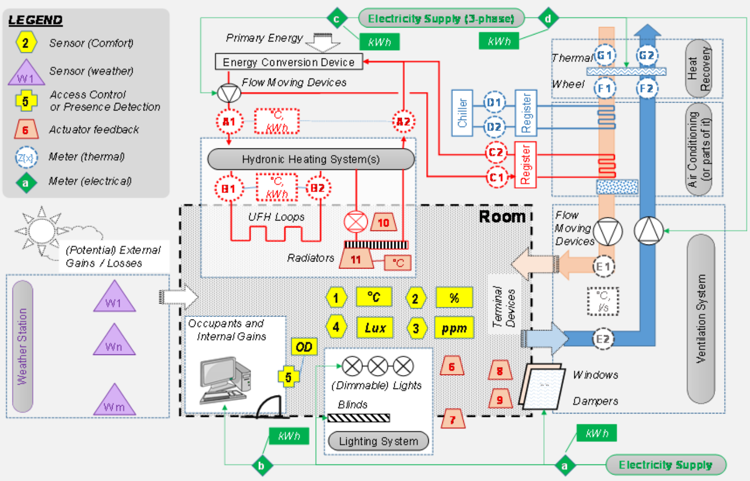

Figure 2: Block-base, hierarchical, modular monitoring concept

Primary Stakeholder	User		Operator		Owner		all
Level of Detail	USER COMFORT		OPERATIONS PERFORM.		USAGE EFFICIENCY		ENERGY EFF.
CAMPUS	n.a.	Aggreg. Upx	$UI_{absolut}$	$UI_{relative}$			Metered Wx
BUILDING/ SYSTEM		Aggreg. Upx	$UI_{absolut}$	$UI_{relative}$	O_{real}	Aggreg. OD	Metered Wx
CIRCUIT	n.a.	n.a.	$UI_{absolut}$	$UI_{relative}$	n.a.	n.a.	Submetered Wx
ROOM	Temp, RH PMV CO2 Lux	UPx	$UI_{absolut}$	$UI_{relative}$	O_{real}	OD	Submetered or estimated Wx
		Aggregation		Aggregation		Aggregation	

Figure 3: Evaluation Metrics and Aggregation

AGGREGATION:
Since all relative values are available on a scale from 0 to 100% PI can be aggregated into KPI

HOW to evaluate?

UNDER PERFORMANCE (UP) Performance Indicators:
UP-PI are measured on space and floor level and determine user comfort. Absolute values are converted into relative values (0 to 100%).

USE INTENSITY (UI) Indicators:
UI-PI are measured on component or (sub)system level and are used to characterise the operations performance. Absolute values are converted into "relative ranges" (i.e. 70% < high UI <= 100 %).

USE EFFICIENCY (OD) Indicators:
OD-PI are compiled fr, access-control systems. Absolute head-counts are compared to the maximum occupation density for a space (0 to 100%).

ENERGY CONSUMPTION Indicators:
Absolute values are compiled from (sub)meters. A conversion into relative values is possible by comparison against an agreed "baseline", e.g. the normalised, metered energy consumption before a retrofit.

Contact

IRUSE Researchers:
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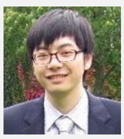
Andriy Hryshchenko, MEngSc.



Collaborators:
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School of Engineering

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OCCUPANCY MONITORING USING RFID TECHNOLOGY

Objectives

A challenge in accommodating efficient energy usage in buildings is how to service building spaces with optimum energy while the relevant spaces experience varied levels of occupancy.

Normally building spaces are serviced with a standard level of heating, ventilation and air conditioning throughout normal business hours. This creates the scenario where there is needless usage of energy when building spaces are unoccupied.

By using the real-time occupancy data captured from the monitoring system, better building control algorithms can be provided to specify the necessity to supply a relevant building space with constant levels of building services (lighting, heating, ventilation, and air conditioning).

Radio Frequency Identification (RFID) is one method of analyzing occupancy activities in buildings.

This research transferred the experience gained from an experimental set-up of a RFID gate demonstrator deployed in the IRUSE-Labs to four room control systems in the Civil & Environmental Engineering (CEE) building in UCC. Installations were combined with a commercial room access control system, to provide a comparison of monitored results.

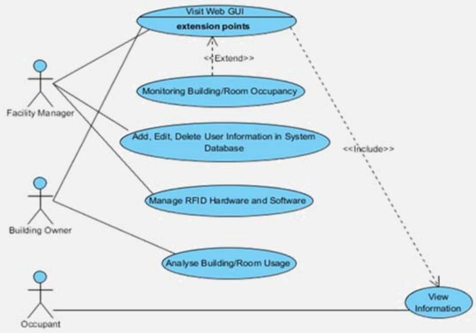

Figure 1: Use Case Diagram

The Use Case Diagram technique (see **Figure 1**) was used to identify main users of the system, which includes the building owner, facility manager and occupants. All of these users should be able to visit the client-side web GUI (Graphical User Interface). For all occupants, they should be able to view their information such as personal profile, RFID tag tracking record etc.

Approach

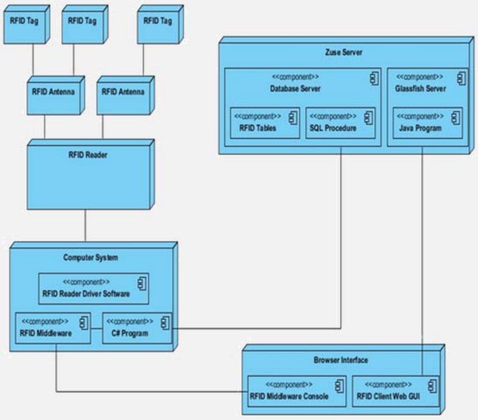

Figure 2: RFID System Deployment Diagram

Figure 2 (left) provides a UML-Deployment Diagram for the installed RFID gate reader system.

A Computer System is used to compile readings from different gate readers. It comprises of the RFID Reader Driver Software, the RFID Middleware, and C# Programs.

The RFID middleware allows users to configure, deploy, and send commands directly to readers through a common interface. Additionally, it can be used for checking for errors and duplicated values.

The C# Program element can be customised to adjust the RFID gate reader system to specific use cases and different database systems.

Data is stored on a database server abd can be accessed through web interfaces (Glassfish Server).

Figure 3: Installation at CEE 1.09 Computer Lab

Figure 4 (below) provides an example for calculated values to determine the occupation density using both the RFID and the commercial access control system (TDS).

The first column is the timestamp calculated on a hourly basis. The second column displays the number of readings compiled from the TDS system. The third column displays the number of readings compiled from the RFID system.

TIMESTAMP	TDS_READS	RFID_READS
19-FEB-13 21	8	8
19-FEB-13 20	9	7
19-FEB-13 19	8	7
19-FEB-13 18	10	11
19-FEB-13 17	18	12
19-FEB-13 16	22	13
19-FEB-13 15	30	23
19-FEB-13 14	20	10
19-FEB-13 13	35	23
19-FEB-13 12	29	39
19-FEB-13 11	28	28
19-FEB-13 10	20	15
19-FEB-13 09	5	7
19-FEB-13 08	7	7

Figure 4: Calculated result for RFID and TDS System

Figure 3 (above) is a picture of RFID gateway antennas and TDS access control system deployed in Room CEE 1.09 – a Computer Lab with 42 seats.

This room, another computer lab and the drawing office are equipped with a heat re-distribution system, using the computer labs as "energy source" (excess heat) and the drawing office as "sink" (north-east facing with 5.00m ceiling height).

For the installation and implementation an Alien RFID system was used, comprising of: Alien ALR-9900+ EMA readers and ALR-8696-C antennas operating at the European frequency band of 866MHz.

Contact

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STRATEGIES FOR CONTINUOUS COMMISSIONING OF INTELLIGENT BUILDINGS

Objectives

Continuous building monitoring techniques are used to provide the best possible level of detail for the analysis of building energy performance.

Maintaining Building Management Systems (BMS) can require significant efforts for the building management team. The performance of a BMS can be substantially reduced due to improper/incompatible equipment installation, degradation and failures, or even inappropriate settings of operational sequences.

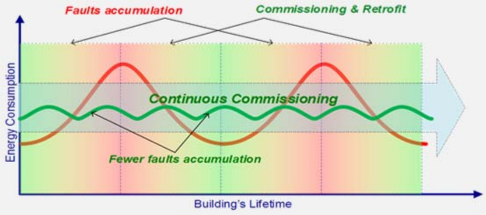

Figure 1: “Ad hoc” VS “Continual Commissioning”

This research aims:

- o to develop algorithms for continuous monitoring outside of the trademarked CC® description, cf. fig. 1;
- o to develop identification methods for faulty operation scenarios in building services system through data analysis;
- o to establish an understanding of the relationship between sensor density, sensing accuracy for single physical parameters at a spatial and temporal level;
- o to outline potential energy savings resulting from Continuous Commissioning.

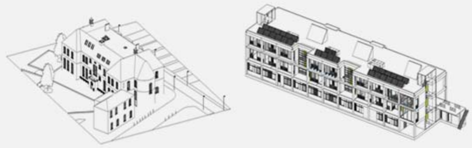

Figure 2: ERI and CEE buildings used as case study

Approach

Continuous commissioning is an ongoing process used for performance analysis, BMS optimisation, and energy benchmarking. It includes the analysis of BMS alarms and information about missing data or interrupted monitoring streams.

Figure 3 represents the data-related steps of ongoing BMS commissioning.

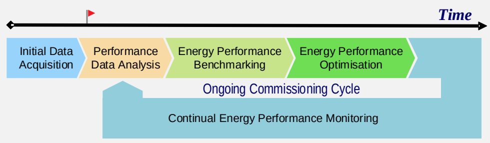

Figure 3: Data-related steps for CC of BMS

Building performance benchmarking requires the development of Key Performance Indicators (KPIs), which also can be called Energy Performance Indicators (EnPI). Additionally, reliable methodologies and techniques for raw data analysis are required (cf. fig. 4).

Closely and continually working with incoming data will:

- o provide energy managers with information about the current status of systems' operations,
- o Lead to knowledge how to adjust these systems,
- o Provide maintenance costs savings.

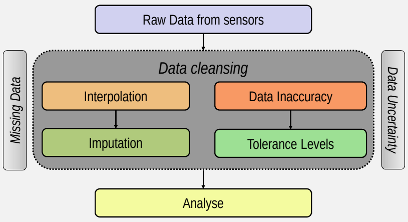

Figure 4: Data Value Generation Techniques

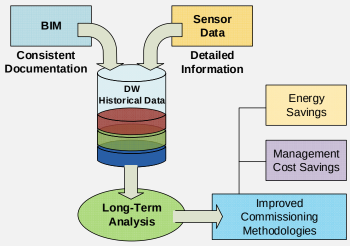

Figure 5: Continual Commissioning strategies

Achievements

Displayed (cf. fig 6 right) are the 2012 temperature data trends used for the analysis of thermal comfort (gathered from integrated wireless sensors in CEE building). The ‘comfort band’ is depicted in green.

Figure 7 (below) highlights the identified in-appropriate use of BMS scheduling for the preparation of Domestic Hot Water (DHW) in the ERI building. Since the gas boiler is used in the mornings to prepare DHW (blue line) the solar gains are insufficiently used for DHW generation (red line)

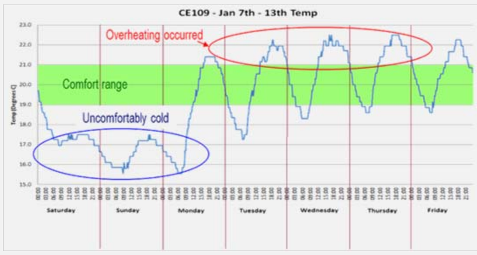

Figure 6: Example for thermal comfort analysis

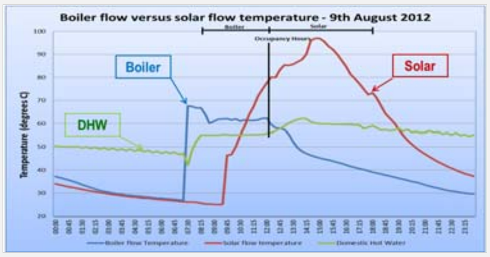

Figure 7: Example f. in-apropriate use of BMS scheduling

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RESEARCH PORTFOLIO



BaaS

The Building as a Service

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PROJECT PARTNERS

Fundación Cartif

Fundación CARTIF is a leading Spanish Applied Research Centre in terms of R&D and technology transfer activities created in 1994. CARTIF is formed up by 9 technical divisions and 200 researchers specialised in several areas such as Energy, Environment, Food and Chemicals, Biomedical, Robotics, etc. In 2010 CARTIF carried out over 100 R&D and innovation projects, with a turnover of approximately 12M€.

Information and Communications Technologies (ICT) and Energy are two of the main research areas of CARTIF. Both together have created a multidisciplinary group focused on the application of ICT in the field of Energy, in particular Energy Efficiency, Energy Saving integration of Renewable Energy Systems, Electricity Market, Demand Response, Smart Grid, etc.

NEC Laboratories Europe

NEC is a leading supplier for telecommunication and IT systems for many industry sectors including utilities, power grid operators, construction and transport sector. NEC Laboratories Europe (NLE) is the corporate research facility of NEC Europe Ltd, a wholly-owned subsidiary of NEC Corporation, a leading world-wide provider of telecommunication infrastructures, service platforms, service enablers, cloud platforms, and IT solutions.

Today, the laboratories are located in Heidelberg, Germany and Acton, UK. Research and development functions are integrated into the same organization to shorten the time to market of cutting-edge ICT technologies.

Honeywell Prague Laboratory

Honeywell is a diversified technology and manufacturing leader, serving customers worldwide with aerospace products and services, control technologies for buildings, homes and industry, automotive products, turbochargers, and specialty materials. Advanced control products and energy management services for homes and buildings represent an important part of Honeywell Automation and Control Solutions (ACS).

Honeywell customers range from individual homeowners to larger commercial and governmental buildings, health care facilities, airports, schools, and military bases. Honeywell Prague Laboratory – part of Honeywell spol. s r.o. – is an R&D organization involved in development of new solutions for the process industries, homes and buildings, as well as in the fields of video surveillance and security.

Fraunhofer IBP

The Fraunhofer Institute for Building Physics (IBP) deals with research, development, testing, demonstration and consulting in the fields of building physics. This includes noise control, sound insulation measures in buildings, optimization of audibility conditions in audiences, energy saving measures, lighting technology, questions of indoor climate as well as aspects of moisture and weathering protection, the preservation of building structures and of historical monuments.

The fields of research that the Fraunhofer Institute cover include: research, development, testing, demonstration, and consultancy in the field of building physics: acoustics, sound insulation, lighting, energy conservation, indoor climate, durability, hygrothermics, building chemistry and building biology.

Technical University of Crete

The Technical University of Crete TUC is a research-oriented university with activities encompassing a number of engineering disciplines. The mission of TUC is to contribute to the advancement of the state-of-the-art in pertinent technological fields while establishing and maintaining close cooperation with the industrial- and production-sectors in Greece and abroad.

The TUC research group has significant experience in the area of ICT for Energy Efficiency. A non-exhaustive list of research activities in pertinent to the BaaS project research areas include: development of cloud-based building monitoring and control systems; integration technologies; development of building simulation software; development of algorithms to facilitate intelligent building operation. The TUC research group has significant experience in the area of ICT for Energy Efficiency and a computer cluster to support computational activities. In addition, a building on TUC campus has been fitted with an extensive sensing infrastructure and a web-based monitoring and control ICT system has been developed–this building will act as a test-bed for algorithm testing and ICT tool development in the BaaS Project.

University College of Cork

UCC is a state-owned University structured into four Colleges. UCC wil be involved in the project through IRUSE (Informatics Research unit for Sustainable Engineering) as UCC-IRU. UCC-IRU is committed to the research and development of Sustainable Built Infrastructure, Systems and Technologies. Current research areas are Information Technology in Architecture, Engineering, and Construction as well as Building Energy Systems, Buildings Operation and Facilities Management. UCC-IRU is member of the European Construction Technology Platform (ECTP-FA7), CITA (Irish Construction Information Technology Alliance).

UCC-IRU has extensive experience in the area of ICT for Energy Efficiency. UCC-IRU research agenda addresses the need for integration concepts, holistic monitoring and analysis methodologies, lifecycle oriented decision support and sophisticated control strategies through the seamless integration of people, IT devices and computational resources. UCC-IRU have already developed a data warehouse system for its ongoing national projects that will be subsequently customised to match the requirements of various application domains and deployed in BaaS project. The motivation of UCC-IRU in BaaS is to collect, consolidate and analyse data and standardise data models.

Dalkia Energía y Servicios

A subsidiary of Veolia Environment and EDF, Dalkia optimizes the technical, financial and environmental performance of the facilities it manages on the behalf of local authorities and businesses.

From design and engineering to energy procurement and facility operation and maintenance, all of Dalkia's services are performed with a focus on sustainable development. Its goal is to leverage local resources and minimize each facility's impact on the environment, while reducing both fossil fuel consumption and greenhouse gas emissions. Dalkia provides cost-effective, eco-friendly energy efficiency services that include performance guarantees for the public-and private-sector customers around the world.

PROJECT OVERVIEW

Objectives

The BaaS system aims to optimize energy performance in the application domain of non-residential buildings in operational stage. In the building operational life-cycle three significant tasks have to be continuously performed:

collect information and assess the buildings current state; predict the effect that various decisions will have to Key Performance Indicators (KPIs) optimization.

A generic ICT-enabled system will be developed to provide integrated assess, predict, optimize services that guarantee harmonious and parsimonious use of available resources.

This major objective is also pursued within BaaS via a number of multifaceted actions and Scientific & Technological Objectives:

Scientific Objectives SO1

Development of building modelling and simulation for energy performance estimation and control design.

Scientific Objectives SO2

Development of integrated Automation and Control Services.

Technological Objective TO1

Development of data Management: Working on existing initiatives and ongoing projects results, integrating State of the Art of extended BIM, EEB Ontologies and Standards.

Technological Objective TO2

Development of middleware Platform: System Integration, Interoperability And Standards

Approach

The **BaaS system** comprises four components:

A **data management** component to collect, organize, store and aggregate data from various in- and out-of-building sources. An (IFC-based) BIM will act as a central repository for all static building data, and a data warehouse will be used for dynamic data.

A **service middleware platform** to abstract the building physical devices, support high level services on the cloud and facilitate secure two-way communication between the physical and ICT layers (building) with high level services (cloud).

Energy models for performance estimation and for control services, looking for a trade-off between prediction accuracy (performance estimation) and computational complexity (fast-model for control design).

Assessment, Prediction and Optimization Service such as:

- **Assessment and prediction services:** simulation models, acting as surrogates of the real building, incorporating sensor dynamic data, will be used to assess performance and comprehensively estimate the values of relevant KPIs as well as help perform sensitivity analyses;
- **Optimization service,** automatically will generate holistic nearly-optimal control strategies with the goal of achieving operational efficiencies as measured through relevant KPIs and will be imbued with adaptive and re-configurability properties to respond to faults and atypical scenarios.

Upon verification of component interoperability, and development of a measurement and verification plan, the BaaS system will be demonstrated in two buildings and will be validated as an Energy Conservation Measure with Energy-Services Companies as the end-user.

End-user acceptance will be accomplished by analyzing the replication potential in tandem with the results of a sensibility study

Work Packages

No.	WP Title
WP 1	Theoretical Case Studies and End-user Acceptance
WP 2	Building Data: Interoperability and Standardization
WP 3	Middleware Platform
WP 4	Building Energy Modelling & Simulations for Performance Estimation and Control
WP 5	Advanced Automation and Control Services for Performance Optimization of Building Operation
WP 6	Demonstration of the BaaS System
WP 7	Exploitation, Dissemination, Standardization

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IFC-COMPATIBLE DATA WAREHOUSE PLATFORM FOR BUILDING PERFORMANCE ANALYSIS

BaaS

Objectives

Efficiency is essential when handling and managing large volumes of buildings' performance data. Current data management strategies over utilize a single table concept to store diverse categories of data.

It is out of sync with peripheral applications such as support for BIM data, leading to inefficiencies in extracting a specific piece of information.

Furthermore, adding new devices to, and retrieving relevant data from data warehouses (DW) requires a certain level of manual interaction within existing DW schema.

The motivation of this research is to address these deficits and produce an unified database schema that can be used to share performance data in a structured way amongst different software applications.

Approach

A new concept of a scalable schema for a data warehouse focusing on Building Performance Analysis is being proposed. Its aim is:

- to improve the compatibility between repositories in Building Management Systems (BMS) and Building Information Modelling (BIM) applications.
- to improve the scalability of the DW to efficiently accommodate the exponentially increasing quantity of data and
- to provide flexible mechanisms for multi-dimensional data analysis on different levels of granularity.

A standardized BIM provides an integrated data repository which supports the documentation of building elements, buildings services components and their grouping. Furthermore, BIM supports the modelling and documentation of building processes, such as operation, maintenance, or inspection.

This descriptive BIM data can be used to classify, categorise and group raw data compiled from Building Management and Monitoring Systems.

Therefore, an integrated DW-environment is based on an open, transparent, and shared meta-data model such as the IFC-standard (ISO PAS 16739) which supports common modelling language, communication protocols and standards.

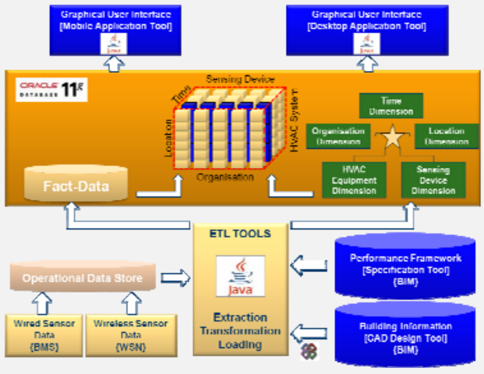

Figure 1: The Data Integration Principle

Achievements

The major elements of the newly proposed data warehouse schema follow the specifications given in the open IFC-standard (IFC4).

This meta model offers a rich body of semantic information covering most engineering disciplines such as architecture, structural engineering, building services engineering, building automation, construction management, and facilities management.

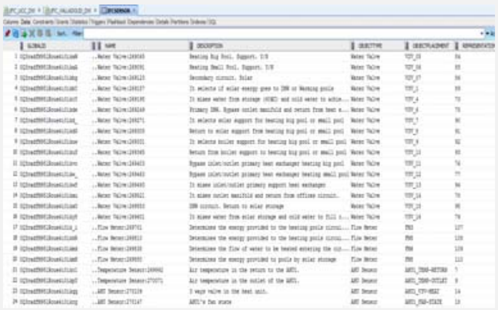

Figure 3: Output of DWH

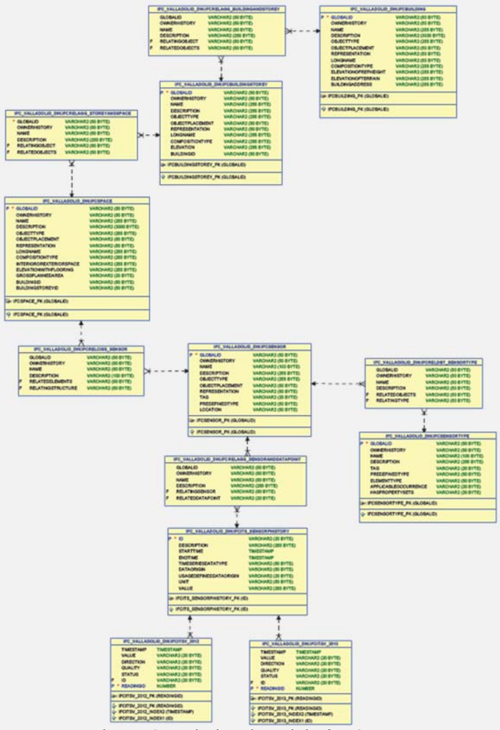

Figure 2: Relational Model of IFC DWH

By using IFC 4 we improve the efficiency of data exchange between BMS, CAFM, design software and the newly introduced DW-platform.

The proposed DW-application is used to support the management of “bulk data” compiled from monitoring systems and seamlessly extends existing BIM-platforms.

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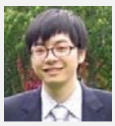

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DYNAMIC ENERGY SIMULATION FOR ADVANCED BUILDING CONTROL

Objective

In general, current Building Energy Simulation Tools are used for pre-construction design and comparison of designs rather than a full exact varying representation of reality.

They are designed for comparison of potential designs. Because of the difficulty in predicting occupant behaviour, very often the predicted results do not correlate with the real actual performance when buildings are in operation.

Questions arise in relation to occupant comfort when a building space is serviced with a constant level of heating and ventilation.

Live instantaneous simulation can provide benefit from tuning BMS, building certification, energy profiles and design performance review. In addition, a cost saving could be realised if intelligent systems know to what level should a building space be heated or cooled.

This study describes a methodology being developed to combine building energy simulation results with accurate and real sensor and meter data with the purpose of better understanding the relationship between energy simulation and real building operation for better occupant comfort and to guide efficient operation.

The study focuses on the ERI and CEE buildings located on the campus of University College Cork, Ireland.

Figure 1. CEE building used as case study

Approach

The proposed method for validation of building simulation results initially involves a comparison of data from building simulation and respective measured sensor readings.

From this comparison, value is added from correction of simulation results, and/or input to simulation parameters. Further worth can also be provided by gaining knowledge for creation of simulation profiles which are difficult to predict before construction and operation.

Additional value can also be derived from identifying conditions of poor results and other relevant input factors which can be corrected.

Simulation data and actual data is available from various campus buildings of University College Cork, Ireland.

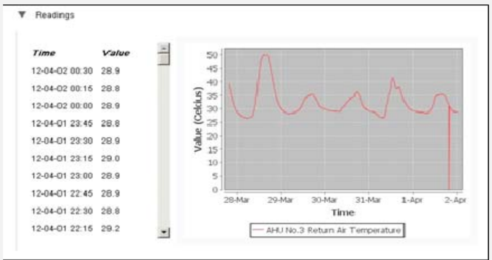

Figure 3: Temperature sensor information interface

One weakness of building control systems is the ability to capture the precise quantity of human occupation.

Typically, human-sensing is defined as the process of extracting any information on people in an environment

For dynamic building energy simulations this is also one of the most difficult parameters to determine and quantify. As a method of overcoming this deficit a hardware-software platform has been developed at UCC.

Real life measured occupancy data from four building spaces in UCC's Civil Engineering Building have been recorded using a novel occupancy system to develop relevant indicators concerning occupancy levels.

Two technologies are used to detect occupancy, proximity card access and RFID detection.

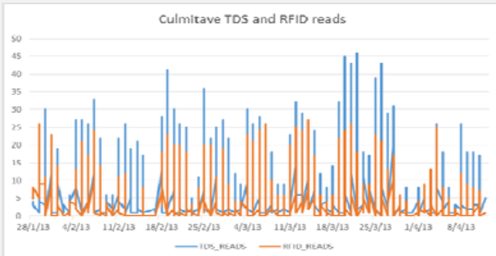

Figure 4: Example of raw occupancy data before correction

Achievements

The results to be derived from this method can give an indication of quality of simulated data results and provide feedback. If the difference between simulated and real data is too large, steps to improve results will be suggested. In future it is envisioned that automated adjustments may be performed to simulation inputs to correct results.

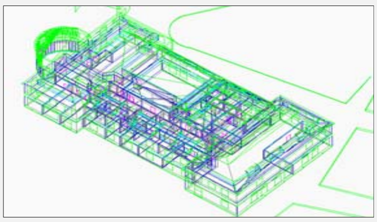

Figure 2: Simulation Model

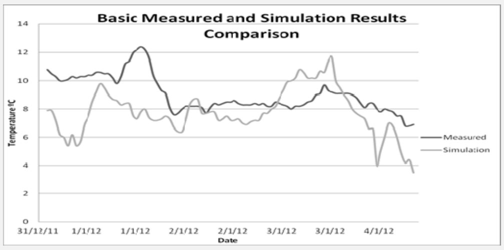

Figure 5: Measured versus "pre-defined" weather data

Related achievements of the CAMPUS21 and BaaS research include; occupancy evaluation, simulation validation, building energy data analysis etc. This is performed with the research participants: BILFINGER (HSG Zander GmbH), TU Wien, TU Crete, Honeywell, NEC Laboratories Europe, CARTIF.

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RESEARCH PORTFOLIO

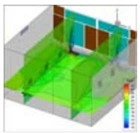
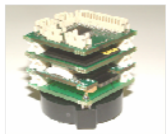


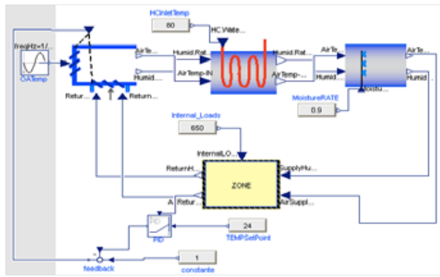


PRTLI 5

Programme for Research in Third-Level Institutions





BIM and Lean Management

Energy Facilities People

Smart Buildings and Big Data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http://zuse.ucc.ie/grep

NEW BUSINESS MODELS FOR SUSTAINABLE BUILDING OPERATION

Objectives

The issue of reducing primary energy demand in buildings remains a critical issue for achieving reduced carbon emissions and security of energy supply worldwide.

To date energy efficiency measures have focused on short term returns without a strategy for the buildings lifecycle.

Therefore, typical consumption (of buildings in Ireland) remains still at 220-300kWh/m2 per year compared to the target of less than 80kWh/m2

80% of buildings in Ireland predate 1991 and 75% of current stock will be in use in 2050. Besides improved insulation, the installation of advanced monitoring and control systems is one recommended retrofit action.

Therefore, this research proposes that improved integration of building services and control systems can improve building performance and especially energy performance.

Underpinning the integration approach with specially developed business models and procurement systems will achieve regular renovation cycles and develop the process of reducing energy demand in buildings.

Approach

The critical path for reducing energy consumption is through developing a culture and a framework for shorter building energy renovation cycles.

However the core problem currently is cost. This research proposes that ICT developments offer opportunities to enrich and improve building performance data for analysis and management through its lifecycle.

When coupled with a systematic process like 5D-BIM then this can improve the design construction and maintenance planning and therefore impact positively on cost control and investment returns.

With this we can confidently examine a range of renovation possibilities for the demonstrator buildings.

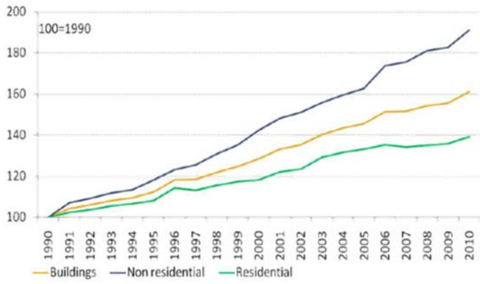

Figure 1: Electricity Trends in the Building Sector (Eurostat)

It is proposed to underpin all of the above with new business models to involve all the stakeholders for building energy management from supply and demand control to end use including maintenance and operations contractors.

New business models are needed to stimulate building stakeholders to make informed decisions and commit to sustainable building management.

For this research we will use Osterwalder's framework for business modelling.

Work on business models is complemented by a critical analysis of current procurement models. The emphasis of the analysis is on the possibility for early involvement of all stakeholders, including operators of energy and building services systems.

A second emphasis of the procurement model analysis focuses on the need for continuity in the operation, maintenance and upgrade of control and monitoring systems.

Pillar	Block	Description
Product	Value Proposition	Gives an overall view of a company's bundle of services and products
Customer Interface	Target Customer	Describes the segment of customers the company wants to offer value to
	Distribution Channel	Describes the various means of the company to get in touch with its customers
	Relationship	Explains the kind of links a company establishes between itself and its different customer segments
Infrastructure Management	Value Configuration	Describes the arrangement of activities and resources
	Core Competency	Outlines the competencies necessary to execute the company's infrastructure business model
	Partner Network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialise value
Financial Aspects	Cost Structure	Sums up the monetary consequences of the means employed in the business model
	Revenue Model	Describes the way a company makes money through a variety of revenue flows

Figure 2: Osterwalder's Business Model Framework

Achievements To Date

The work carried out includes the specification and deployment of a hardware and software platform for the integrated operation of building services systems.

This is complemented by related business and procurement models, which emphasis on the provision of integrated operational, maintenance, inspection, and upgrade services. In some publications this is also called "Energy Service Provision".

Using this methodology, demonstration systems were installed and operated for a limited time period on these demonstration sites.

Lessons learned were gathered from the procurement and deployment activities of these integrated energy systems.

Currently, the second iteration of the development cycle for the above methodology is in progress. It is aimed that the final models are applicable for industry to utilise for a range of building types.

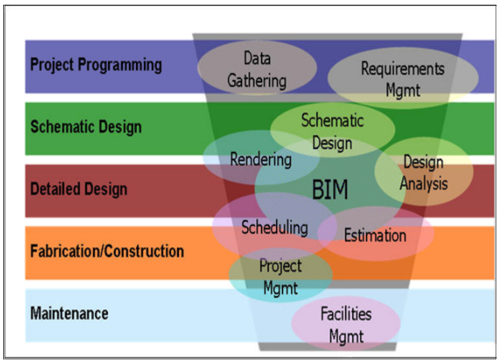

Figure 3: An Integrated Planning and Procurement Platform

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BUILDING PERFORMANCE MODELLING

Abstract

For Facility Management (FM) companies, Information Technology (IT) is becoming important. Clients demand that their buildings perform more efficiently and desirable FM contracts are awarded to FM companies who fulfil these requests. IT equipment is being used to monitor energy consumption within a building.

This allows a Facility Manager to analyse the data, benchmark it against similar buildings and offer the client modernisation procedures for the appropriate systems. Initial projections estimate, that for a FM company that is operating 1000 buildings, the amount of data collected after 5 years will be around 2.5 billion datasets.

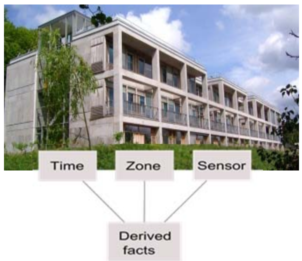


Figure 1: Dimensions Derived from BIM

Objective

This research aims to deliver a standardized method to acquire the performance data of a building. It discusses the infrastructure needed to harvest data from the buildings and store it in a centralised, efficient Data Warehouse (DW) system.

The main focus will be on analysis functions that are running on top of the DW. Their objective is to support the Facility Manager with clear and understandable visualisations and process the huge amount of information for him in a convenient and non-time intensive way.

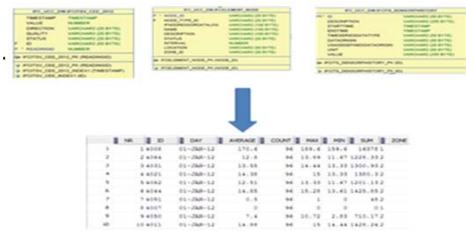


Figure 2: Amalgamating BIM and Monitoring Data

Approach

CONSOLOIDATION OF INFORMATION:

- Information is usually spread across multiple tables
- A Materialized View (MV) consolidates data
- MV's can be modelled for individual data representations
- Unneeded data gets ignored in the MV
- MV's allow to pre-calculate data for quick access

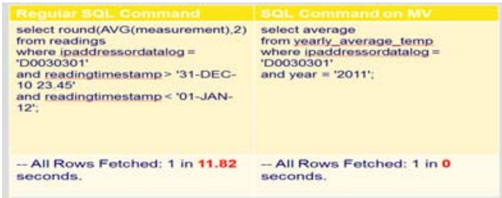


Figure 3: Simplification of Queries and Fast Response Times

Materialized Views & Cubes

The Data Warehouse (DW) is used to pre-calculates Performance Indicators (PI) in Materialized Views.

The performance gain for using DW-technology compared to regular SQL commands is huge (cf. figure 3)

Results

Creating a Data Warehouse Cubes

- A cube consists of a fact table (w. measured data) and
- Dimensional data, e.g. time, zone, system (cf. figure 1)

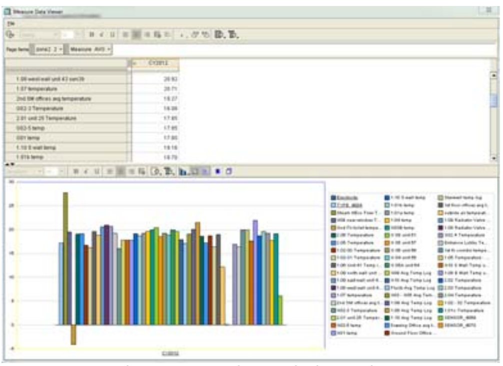
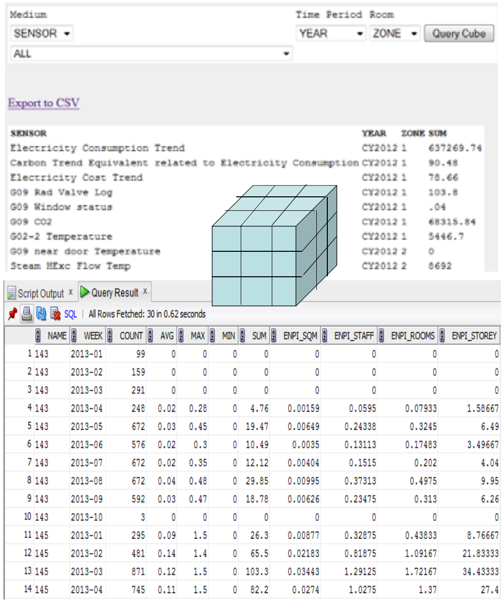


Figure 5: Complex Analysis Results
(UnderPerformance Indicator – UP_{temp} for one floor)



SENSOR	YEAR	ZONE	SUM
Electricity Consumption Trend	CY2012	1	637269.74
Carbon Trend Equivalent related to Electricity Consumption	CY2012	1	90.48
Electricity Cost Trend	CY2012	1	78.66
G09 Rad Valve Log	CY2012	1	103.8
G09 Window status	CY2012	1	.04
G09 CO2	CY2012	1	68315.84
G02-2 Temperature	CY2012	1	5446.7
G09 near door Temperature	CY2012	2	0
Steam HExc Flow Temp	CY2012	2	8692

	NAME	WEEK	COUNT	AVG	MAX	MIN	SUM	ENPI_SQM	ENPI_STAFF	ENPI_ROOMS	ENPI_STOREY
1	143	2013-01	99	0	0	0	0	0	0	0	0
2	143	2013-02	159	0	0	0	0	0	0	0	0
3	143	2013-03	291	0	0	0	0	0	0	0	0
4	143	2013-04	248	0.02	0.28	0	4.76	0.00159	0.0595	0.07933	1.58667
5	143	2013-05	672	0.03	0.45	0	19.47	0.00649	0.24338	0.3245	6.49
6	143	2013-06	576	0.02	0.3	0	10.49	0.0035	0.13113	0.17483	3.49667
7	143	2013-07	672	0.02	0.35	0	12.12	0.00404	0.1515	0.202	4.04
8	143	2013-08	672	0.04	0.48	0	29.85	0.00995	0.37313	0.4975	9.95
9	143	2013-09	592	0.03	0.47	0	18.78	0.00626	0.23475	0.313	6.26
10	143	2013-10	3	0	0	0	0	0	0	0	0
11	145	2013-01	295	0.09	1.5	0	26.3	0.00877	0.32875	0.43833	8.76667
12	145	2013-02	481	0.14	1.4	0	65.5	0.02183	0.81875	1.09167	21.83333
13	145	2013-03	871	0.12	1.5	0	103.3	0.03443	1.29125	1.72167	34.43333
14	145	2013-04	745	0.11	1.5	0	82.2	0.0274	1.0275	1.37	27.4

Figure 4: Example for Using Cubes
(Energy Performance Indicators for one building)

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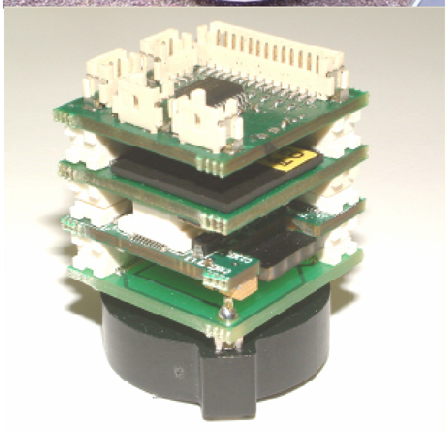

COMPLETED PROJECTS

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INFORMATION TECHNOLOGY FOR OPTIMISED BUILDING OPERATION

Abstract

ITOBO brings together a full spectrum of academic and industry partners to collaborate in the development of embedded systems addressing the 21st-century needs for the energy-efficient operation and sustainable maintenance of new and existing buildings.

We keep the "human in the loop" with flexible, reconfigurable wireless systems that help occupants optimise their environment rather than imposing an environment upon them.

We enable employers in the ICT and construction sector to create sustainable jobs in the knowledge society by delivering a paradigm shift in new business models for collaborative work.

Objectives

ITOBO will contribute to improved asset management in Ireland and abroad while supplementing efforts to fulfil the Kyoto Protocol requirements. Our detailed work-plan culminates in field testing of operational systems.

These operational objectives for managing the built environment will in turn drive the development of enabling technology and basic ICT science. We expect that the fundamental science developed and the experience obtained in the domain of energy efficient building operation can be transferred and adapted to other sectors.

Approach

ITOBO will make specific research contributions to ICT in:

Ubiquitous sensing infrastructures: by supporting seamless and dynamic end-to-end network composition and service operation through sensor and RFID hardware.

Disruptive networking paradigms: by enhancing the management of large-scale, complex networks, services, and mobile users through introducing new network and management approaches.

Decision support systems: the development of novel constraint-based preference models and optimisation algorithms that support the configuration, adaptation, and servicing of smart buildings and the networks that manage them.

Dynamic, re-configurable service architectures: by designing a system architecture that will support scale-free composition of service coalitions with managed operation across several administrative (e.g. tenant, owner, building-operator) and business domains (e.g. suppliers, network operators, facility managers).

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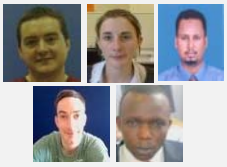

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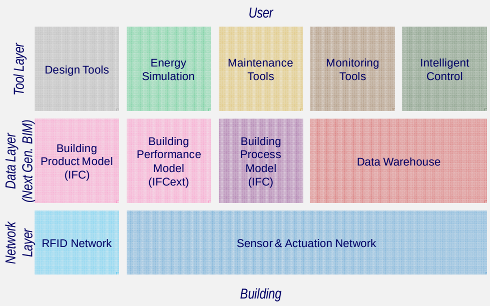
ITOBO ACHIEVEMENTS

Modular Platform

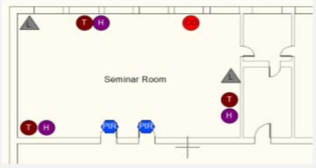


ITOBO has developed a modular Hardwar-Software-Platform which supports the installation of a holistic "end-to-end" building performance analysis solution; comprising of

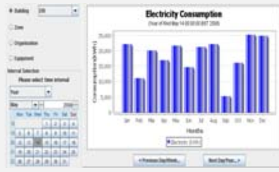
(1) Web-based data representation and analysis
(2) A powerful Data-Management platform supporting BIM and Performance Monitoring in a holistic way
(3) Wireless sensors of "indefinite lifetime" and a gateway box for wireless data transmission within and between buildings.

Web-based Monitoring

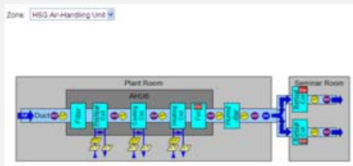
User Comfort,e.g. temperature, CO_2 humidity, etc.) can be transparently monitored.



Data Aggregation & other mathematical functions are available for analysis.



Energy Demand & Performance can be monitored on component level.

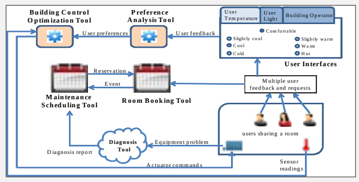


Performance Analysis

User Preferences and weather data is analysed to inform Intelligent Building Control.

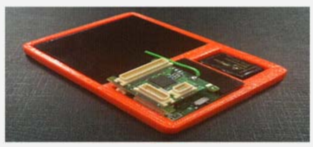
A Performance Metrics delivers detailed information how single components should perform optimally.

Model-based Control & Diagnostics takes the user preferences, weather data, and component-based performance specifications into consideration.

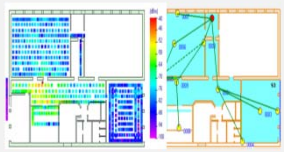


Wireless Data Acquisition

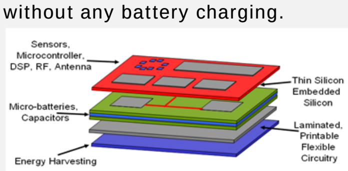
Building Energy Mote (BEM) compiles up to 6 different data streams which can be (de)acti-vated using software commands.



The Design Support Tool assists technical staff in the generation of layouts using existing floor plans.



Energy Harvesting in combi-natiion with intelligent embedded software ensures indefinite sensor life-time and 58 hours operation without any battery charging.



Living Labs


ERI


CEE


CYLON HQ


HSGzander Training Center and Hotel

The Building of the Environmental Research Institute (2006) is - due to its multiple micro co-generation capacities - a so called "Green Building" representing the ITOBO living laboratory.
Demonstration focuses on:

- Understanding performance of integrated systems.
- Maximum installation density.
- Test integration concepts.

The building of the **Dept. of Civil & Environ-mental Engineering (1910)** is used as demon-strator for intelligent renovation strategies.

Demonstration focuses on:

- a strategy how to holistically document, monitor/, analyse, and upgrade in order to achieve intelligent control in combintion with existing older systems.

The building of **CYLON Controls Ltd (~1990)** represented the ITOBO National Demonstrator.
Work focused on Lighting Concepts

- To maximise performance of existing lighting systems.
- Develop novel control scenarios for "lighting on demand scenarios" considering presence detection , scheduling, and workflow analysis.

The HSGzander Hotel & Training Center, represents the ITOBO International Demonstrator.
Work focuses on mechanically operated HVAC.

- Advanced monitoring & performance analysis.
- Minimum installation density for sensing and metering.
- Data Analysis and Data Mining.

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Decentralized, RFID-based Information Management for Facility Management Scenarios

Abstract

This research was part of the *Network Embedded Systems* (NEMBES) research project, funded by the Higher Education Authority (HEA).

NEMBES was an inter-institutional and multi-disciplinary research programme that investigated a "whole system" approach to the design of networked embedded systems, marrying expertise in hardware, software and networking with the design and management of built environments.

Networked Embedded Systems enable precision sensing, monitoring, control and information gathering/delivery in science, engineering, manufacturing, energy, environment/ecology, daily living, healthcare, agriculture, traffic, security and many other applications.

The application of RFID technology supports improved tracking and tracing of components and tools at an "item level". RFID-technology is more robust and reliable than other tracking and tracing technologies.

Therefore, this research studies the potential of RFID-applications in Facilities Management scenarios. The emphasis of this research is on the usage of RFID-tags for decentralised information management in buildings.

Decentralized Information Management can dramatically improve the efficiency of outsourced inspection and maintenance scenarios, making a positive contribution to new management scenarios in buildings' operations.

Objectives

This research aimed to develop methods for Decentralised Information Management in FM using RFID-Technology, including:

(1) The development of a web-based system supporting facility managers.

(2) The integration of RFID technology with Mobile Technology, such as PDA, to increase the efficiency of facility inspections and maintenance data collection.

(3) The provision of wireless communication between offices and field locations.

Information/data is stored on active RFID tags, such as:

- RFID Tag ID: unique ID associated with each RFID tag.
- Inventory ID: the ID of the relevant item to which the RFID tag is attached. The combination of inventory ID and tag ID provides the link to further information stored in CAFM systems.
- Inventory Name: the name of the relevant item to which the RFID tag is attached.
- Type/Specification: specific item specification data.
- Installation Time: Time item was installed in the bldg.

Approach

Stakeholder Scenarios

Three potential user groups have been identified; including:

Office User: detects facility failures. Reports are generated (using Java enabled interfaces) to inform facility management departments.

Facility Manager: manages the generated tasks/tickets, distributes workload and assigns tasks to work crew members for renovation, repair and inspection.

Work Crew: receives task details through mobile devices and uses embedded RFID readers to retrieve information from RFID tags attached to building items.

The information contains relevant facility/item data, and allows a crew member to make timely decisions, and report back to facility management with updates.

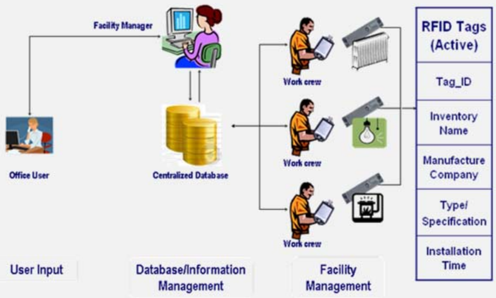

Figure 1: typical Scenarios in Facility Management

In the scenario shown in Figure 3, active and passive UHF tags were adopted for different purposes.

Active UHF tags with integrated temperature sensors are attached to the radiators to provide technical information. Additionally room temperature is recorded to support local diagnostics.

Passive UHF tags are used in all lighting systems. From the unique tag IDs and a central database, a complete set of parametric information can be retrieved.

Approximate Positioning:

- In additional to the above, while maintenance crews walk through the building RFID-tags from inventory items are identified.
- Using a set read-range zone, the approximate location of the crew member can be calculated using a digital floor plan.
- This allows maintenance activities to be monitored in real-time.

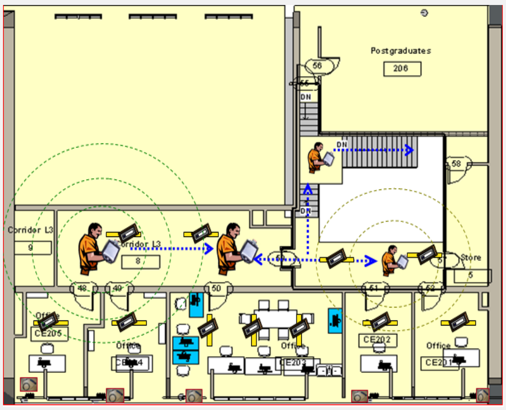

Figure 2: RFID Location Tracking

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NEMBES

Location Based Sensing In Facility Management Scenarios Using RFID Technology

Abstract

Technological advancements have made RFID one of the most robust methods for people and inventory identification, localisation, and tracking for indoor environments. This is very crucial in the facility management sector as management of continuous and timely changes is important.

The aim of the research project 'NEMBES' is to address Networked Embedded Systems R&D from an application focus to the whole system viewpoint.

The research, alongside location based sensing, needs to incorporate identification as well as tracking of personnel and inventory items.

Our current research focuses on tracking occupants and inventories within a building facility using RFID.

This research challenges RFID as a more comprehensive alternative to existing positioning techniques in terms of accuracy, cost, and computational complexity.

Objectives

The main objective of our research is to develop a methodology for heterogeneous location-based sensing in FM scenarios for indoor environments. This can only be done by first analysing different location-based technologies currently used and/or researched, as state-of-the-art. Therefore, analysing core techniques, advantages, and loopholes.

As part of the research, we are currently working on tracking occupants and inventory items within a building space using RFID. The objective is to find out whether a person or item is within a building space (a predefined read-zone) at a given time and how the space used over a specific period of time, and hence, conclude the behaviour of occupants within a specific zone/building

Approach

Facility management of a building includes its operations and maintenance tasks.

Occupant Density, Occupancy Patterns, and Inventory control management are important data inputs for many applications.

These parameters are important for building operations such as fire safety and evacuation procedures, Heating, Ventilation, and Air-Conditioning (HVAC) control, space planning, people/staff management.

Therefore, this research analyses occupants' 'usage behaviour' aiming to allow improved specification, determination and complete documentation of usage 'patterns'.

RFID technology can efficiently support localisation and identification methods of components on an 'item level' (including people) with limited overheads. Therefore, this research analyses different RFID-based localisation techniques to identify their potential to accurately locate targets – if required in combination with data fusion.

Occupant Density *gives the number of people present in a building space at a particular time.* Figure 1 shows a concept of how occupants are counted, to measure density when entering or exiting a building space based on direction of motion. In this project, RFID technology is used to achieve this.

Occupancy Patterns *represent the use of a building space over a specific period of time.* It gives an estimate of the behaviour of occupants towards a building space.

Based on this, energy consumption requirements can be found and efficient use can be assured. This occupancy data is necessary to take out building management decisions based on user comforts.

The HVAC system of a building can be automatically controlled from the BMS, partially based on these parameters. Similarly, other sensor values of temperature, lighting, humidity, and CO_2 levels can also be monitored and controlled from these parametric values.

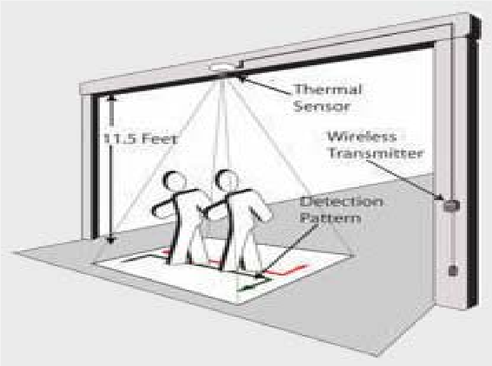

Figure 1: Conceptual Portal Doorway

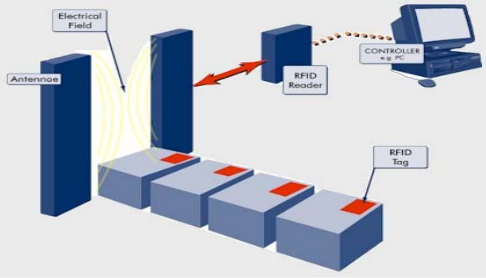

Figure 2: Monitoring of Inventory using RFID

Inventory Item control and monitoring is another part of this research project. A facility manager needs to know the location and status of an item, so as to find out about its misplacement, malfunctioning, required replacements, expiry information, inspection, or any other status update.

Figure 2 shows a sequential tag scanning process of inventories using RFID. This type of a process is normally found in production warehouses or in Supply Chain Management (SCM) where each item is tagged with specific information to be read at different stages of the SCM process. Our project focuses on similar and continuous monitoring of items in a fixed read-zone.

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INTELLIGENT FACADE SYSTEMS

- A CONCEPT STUDY -

Objectives

This project aimed to develop a concept and a prototype of a facade system suitable for renovation under occupation. The developed facade system should be applicable to a number of different types of building structures.

The design concept considered four main parts: Architecture, Structure, Energy and Control.

The concept was designed to be applicable for three main renovation scenarios:

- o Complete replacement of facade,
- o Additional skin added to façade incl. 'window interface'.

Approach

Key elements of the concept:

(1) Modular and Autonomous.

- o Single zone approach w. decentralised zone control.

(2) Compact and Integrated:

- o Integrated control features.
- o Integrated harvesting and storage of (renewable) energy.

(3) Prefabricated.

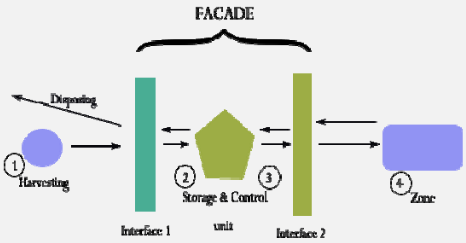
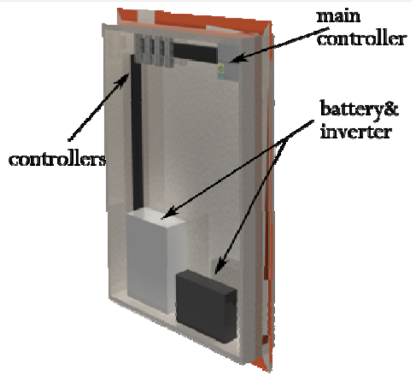


Figure 1: General design concept.



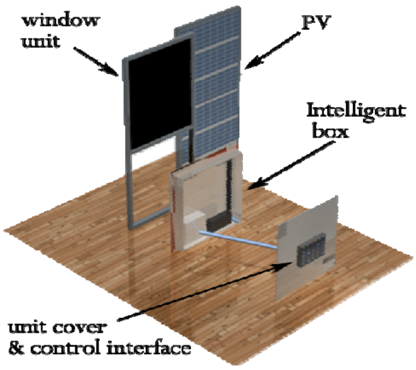


Figure 2: Panel with storage and control unit.

Figure 3: Panel combination w. alternative functionalities.

Case Study

Details of the case study:

- o CEE-building (inaugurated in 1910)
- o South facing computer lab selected as case study
- o Photovoltaic modules deployed on the south facade connected to the building through window interface.
- o New lab layout to allow better energy usage and reduce maintenance cost in this zone,
- o Existing lighting replaced with LED lighting.

The following parameters were studied:

- o Room occupancy,
- o Lighting conditions,
- o Estimated solar radiation levels,
- o Estimated energy generation from the PV panels,

Simulation results prove that:

- o Five solar panels are sufficient to provide electricity to offset the power demand for lighting in the lab, i.e. power generated by PV-panels will be sufficient to cover LED lighting demand (except f. weeks 1-9 & 42 – 52).

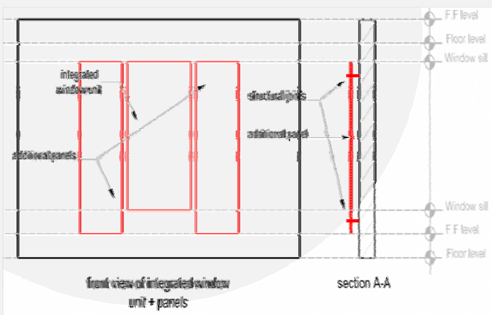


Figure 4: Elevation & section view after panel installation

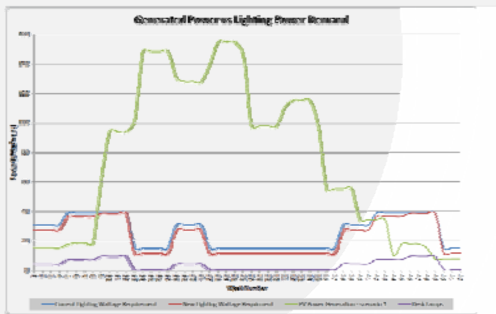


Figure 6 Electricity demand and supply for room CE108

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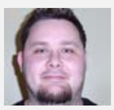

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Decision Support for for Sustainable Renovation Strategies Aiming at Energy-Efficiency Gains

Abstract

Restoring and retrofitting existing building stock supports excellent opportunities to improve the energy efficiency of buildings and reduce their CO_2 emissions by making smart energy-saving choices. Furthermore, it is necessary that buildings work efficiently and provide the best working environment for occupants.

However, most old buildings exhibit energy wastage because of unsuitable control systems and malfunctioning building elements. In order to attain cost savings and make occupants comfortable in the long term, technical renovation is promoted as a potential solution to these issues.

Computerised tools are capable of gathering and organising information which can provide the kind of overview required. Building Information Modelling (BIM) is a suitable technology enabling storage and management of building data during its life cycle that can be used to analyse Building Performance.

The purpose of this research is to develop an energy simulation model for buildings in need of renovation. Additionally, real-time data from wireless sensors and Building Performance Monitoring Data of the Building Management System will be used for the calibration of the energy simulation model.

Approach

The 3D Geometry and Topology, Material Specifications, Inventory Items etc. were modelled and stored in a dedicated tool for Building Information modelling. Model data for the HVAC and lighting system were added. An integrated plug-in for Energy Simulation was used to simulate the energy consumption and define a certain level of thermal comfort.

Data retrieved from Building Management Systems was used to support data analysis which generated a clear picture about how a building is performing. This data was used to support two research aspects:

(1) To provide decision support for the planning of renovation activities through the usage of calibrated energy simulation models

(2) To provide decision support for the prioritisation of maintenance tasks.

Figure 1: ERI-Building Used for Case Study 2

Case Study 1

The building of the Department of Civil and Environmental Engineering and the building of the Environmental Research Institute, both on the UCC campus, were used as case studies.

The Civil Engineering building is a three storeys structure with 550mm thick, red brick wall covered externally with roughcast, old single glazed windows and very spacious timber roof with two skylights in the middle section.

The ventilation system consists of ventilation shafts running within brick walls reaching the roof where three mechanical ventilation fans were mounted in metal turrets.

Currently, these fans are not operational. The first part of the carbon neutral research is focused on renovation aspects from a structure and materials point of view.

Figure 2: CEE-building

Four scenarios of renovation are taken into consideration:

(1) Renovation of walls by adding an additional layer of external insulation,

(2) Insulation of the roof and attic,

(3) Replacement of old windows with high quality double glazed windows, and

(4) Combining all mentioned scenarios.

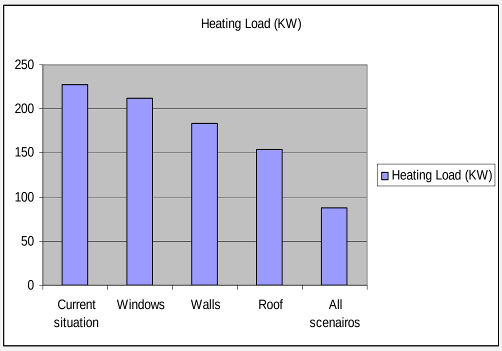

Figure 3: Simulation Results

Case Study 2

The ERI-building is a 3 storey research, It is equipped with a BMS to track various parameters, such as Temperature, Humidity, CO_2, Heat Consumption, Position of Bypass Valves and Position of Under Floor Heating Valves. Real-time data collected from sensors are compared with the simulation results. Results provided by simulation and BMS are quite similar. (3% difference).

Researchers have developed a platform to support facility management activities. Building performance data is monitored, building information can be extracted from BIM. Additional occupancy details are available from an RFID system. An ARIS server is used to supply process information relating to maintenance activities.

To automate the FM tasks, Fault Detection and Diagnosis modules need to detect if or when a failure event is about to occur and to find the solution to solve the event. The Scheduling component can then calculate a schedule according to the preferences, standards, resources and set maintenance tasks collected by the Maintenance Management System. Finally, Building Engineers will be presented with a set of tasks and information describing the renovation and maintenance tasks required

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NDP National Development Plan 2007 - 2013

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh School of Engineering

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European Research Roadmap for ICT Enabled Energy-Efficiency in Buildings and Constructions

Abstract

Energy Efficiency (EE) as a whole is a key challenge for our world today and in the future. When considering current climatic changes, carbon emissions, decreasing fossil fuel resources, and ever increasing energy costs.

In Europe between 40% and 50% of energy generated provides heating and power to buildings, while accounting for approximately 30% of carbon emissions. There is an urgent need to improve energy management from construction, through occupancy, and through demolition/re-use.

Objective

As part of the EU's efforts to improve Buildings' Efficiency REEB provides a contribution to the coordination of high value research,

The industrial sector targeted by REEB is *Building Construction*: houses, residential buildings, large infrastructures. There is no specific classification of building type.

REEB examines new, used, renovated, residential, tertiary and industrial buildings. REEB focuses on the use of ICT (Information and Communication Technology) to support and develop *"Building Automation", and* improve EE, leading to, what is termed, "*smart-buildings*" of tomorrow. Smart-buildings provide optimal management of a building's energy.

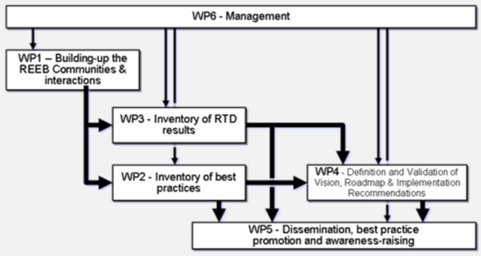

Figure 1 REEB Work Packages

Approach

The main objectives of the REEB include:

- The establishment of an European-led community dedicated to the innovative use of ICT supporting energy-efficiency (EE) in construction.
- The identification of a set of well founded best practices for usage of ICT applications and tools for Energy Efficiency in Europe and world-wide, as well as most representative ongoing standardization initiatives and development regulations;
- The drawing up of a cartography of current and emerging projects and international research initiatives related to the ICT support to EE in the built environment.
- The development of a Vision, a Roadmap and a set of recommendations for implementations of ICT – supported EE technologies in Construction.

REEB will focus of the following key areas:

- ICT methods and tools supporting optimal design of products and services with respect to energy consumption and the related environmental impact.
- Integrated ICT-based systems enabling eco-efficient production, conservation and distribution of energy.
- New ICT-based control and monitoring systems applicable to industrial processes, office buildings, living environments in order to optimise energy consumption and to reduce environmental impact.
- Design, simulation and strategy adaptation of energy use profiles, especially in terms of in-house/in-building consumption management, with a focus on energy-neutral new or renovated home and working environments, supported by innovative business models and platforms for energy efficiency service provision.

Achievements

The “Cartography of EE-Research” highlighted strengths and deficits in current EU and international research.

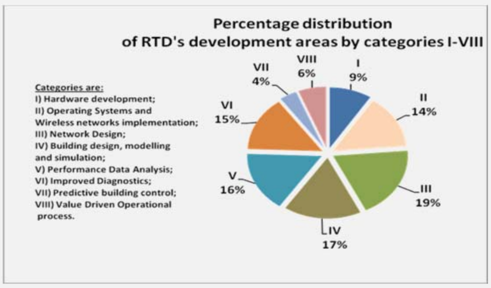

Figure 2: Cartography of EE-Research

The results developed in REEB were used by the European Commission and the European Construction Technology Platform to develop the “*Multi-Annual Research Roadmap*” for the Energy-Efficient Buildings PPP-Initiative of the European Commission in FP7 and HORIZON 2020 (see right).

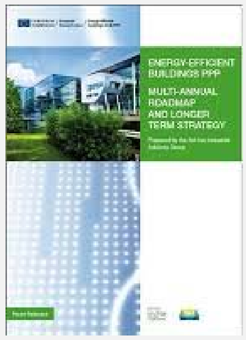

Figure 3: Multi-Annual Roadmap

Project Partner

Project Coordinator:
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Project Partner
Valtion Teknillinen Tutkimuskeskus
VTT Technical Research Centre of Finland

Fundación LABEIN
Spain

Commissariat a l'Energie Atomique
France

Acciona Infraestructuras
Spain

ARUP
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Intelligent Use of Building Energy

Abstract

Recent European Legislation (Directive 2006/32/EC) requires present and future Facility and/or Building Managers to reduce building energy consumption and operational costs.

Also, buildings are recognised as leading contributors to the climate change problem contributing in excess of 30% of global CO_2 emissions. Therefore, conducting performance based assessments of building operation is of utmost importance.

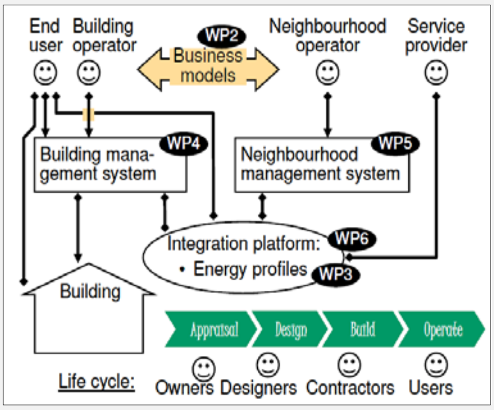

Figure 1: Overall Project and WP Summary

Objective

The objective of the IntUBE project is to develop a system for utilising Building Information to save energy, particularly in existing buildings.

The IntUBE was developed to achieve increased life-cycle energy efficiency of the buildings without compromising the comfort or performance of the buildings:

- by integrating the latest developments in the ICT-field into Intelligent Building and Neighbourhood Management Systems (IBMS and NMS) and
- by presenting new ICT-enabled business models for energy-information related service provision.

Approach

Work in IRUSE (UCC) focused on the development of concepts for new business models to provide services for efficient and intelligent use of buildings' energy information.

Business Models developed by IRUSE in intube include:.

- Business Models for Heat Trade Business
- Business Models for Energy Service Provision
- Business Models for Total Facilities Management
- Business models for Energy Profiling
- Revised and Initial Demonstration Scenarios

Work on Business Models also included:

(1) Development of distinguished "Energy Profiles" supporting the (standardised) exchange of 'Energy Information' amongst the stakeholders

(2) Specification of alternative distribution channels and related core resources.

(3) Characterisation of new stakeholder profiles f. business models emphasizing on Energy Service Provision.

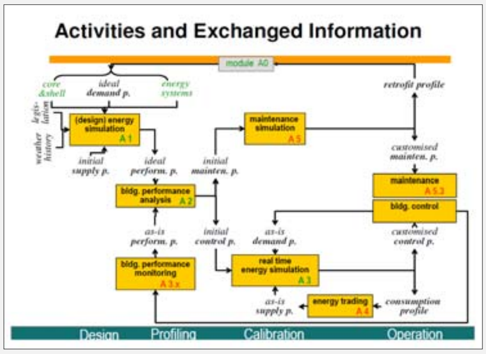

Figure 2: Processes and Exchanged Information (IDEF)

Achievements

The intelligent energy information management concepts and the new tools and business models developed by IntUBE help owners, operators, and tenants of buildings to use the existing building stock more efficiently.

IRUSE contributed to the following work packages:

WP2	Business Models (Work Package Leader)
WP3	Energy Simulation: D3.2, D3.3 & D3.4
WP6	Service Platform
WP7	Integration and Validation
WP8	Dissemination and Exploitation

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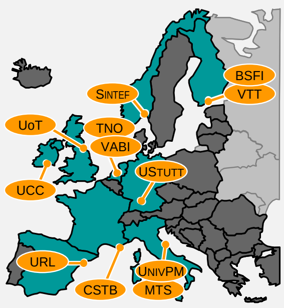

School of Engineering

http://zuse.ucc.ie/intube

Advanced Building Monitoring Using Wireless Sensors

Abstract

Lowering the world energy consumption is one of the major challenges of present day and future generations. The combined energy amount used for buildings (residential and services) in kilo tonnes of oil equivalent (ktoe) comprises over 40% of Ireland's total energy consumption. This amounts to a monetary value of €3.5 billion for the year 2004.
It should be also noted that this 40% energy consumption by buildings also translates into over of 30% of Ireland's total CO_2 emissions which may have a direct monetary value in the context of an emerging carbon tax-scheme under consideration by government at present.
Recent European Legislation (Directive 2006/32/EC) requires present and future Facility and/or Building Managers to reduce building energy consumption and operational costs. Therefore, conducting performance based assessments of building operation is of outmost importance.

Objective

The objective of this project is to specify, design, and validate a data management technology platform that supports integrated energy and environmental mgmt. in buildings utilising a combination of wireless sensor network technologies, an integrated data model and data mining methods and technologies.
Principally targeted at the operational life cycle of large public and private buildings, it is envisaged that the Build-Wise platform will provide a dramatic improvement over existing disparate hardware and software technologies currently utilised in the management of energy in buildings, leading to increased energy efficiencies in buildings in the range of 15-20%.

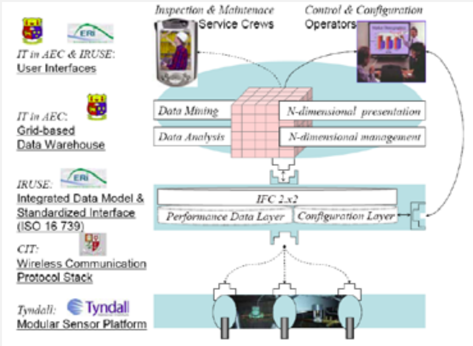

Figure 1: buildWISE-Platform

Approach

In addressing these objectives, the project developed a wireless sensor platform using a backend mgmt. and control system based on standards compliant to suitable Building Information Models. This technology platform, is based on the combination of:

- A Performance Framework Tool (PFT) to support the documentation and specification of building performance requirements (cf. figure 1);
- A Performance Monitoring Platform to provide access to classified and categorised Building Performance Data through context-sensitive web-based user interfaces (cf. figures 4,5).
- A Wireless Systems Network Design tool to allow the design of power efficient and reliable indoor wireless sensor networks for use in Building Management Systems. This tool also simplifies the installation of such networks determining the optimum positions of sensor nodes (cf. figure 3).

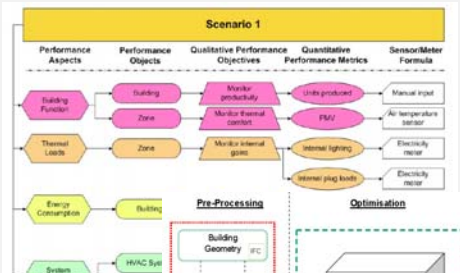

Figure 2: PFT, NUI Galway

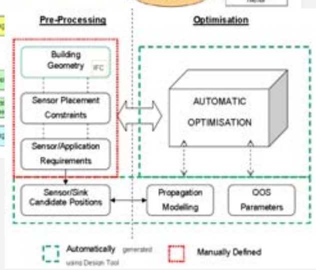

Figure 3: WSN Design Process, CIT

Achievements

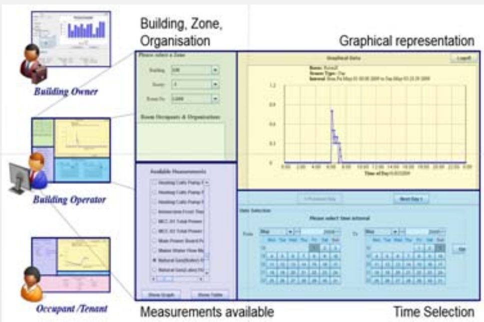

Figure 4: Web-based User Interface (IRUSE)

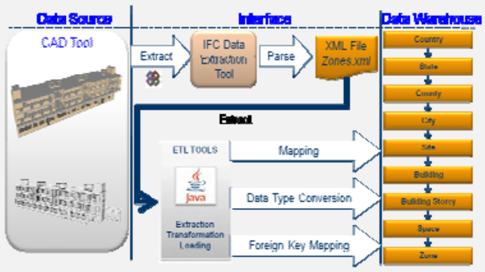

Figure 5: Data Categorisation (IRUSE)

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http://zuse.ucc.ie/buildwise