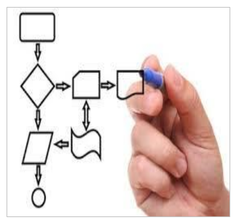
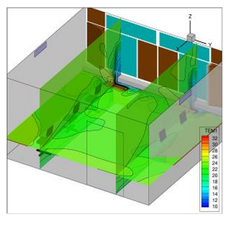
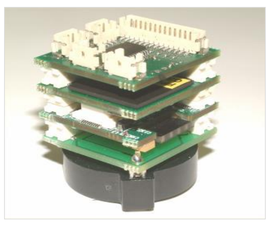
RESEARCH PORTFOLIO



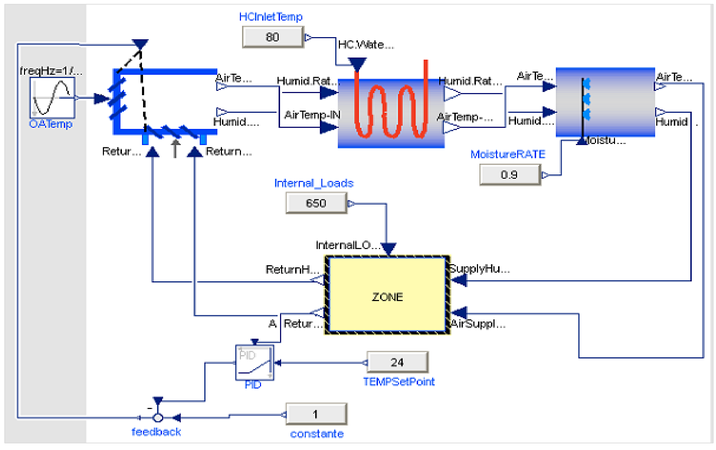
BaaS

The Building as a Service







BIM and Lean Management

Energy Facilities People

Smart Buildings and Big Data


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

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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.

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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

Contact

Project Coordinator:

Fundación Cartif
Web: http://www.cartif.es

Other Participants:

NEC Laboratories Europef
Web: http://www.neclab.eu

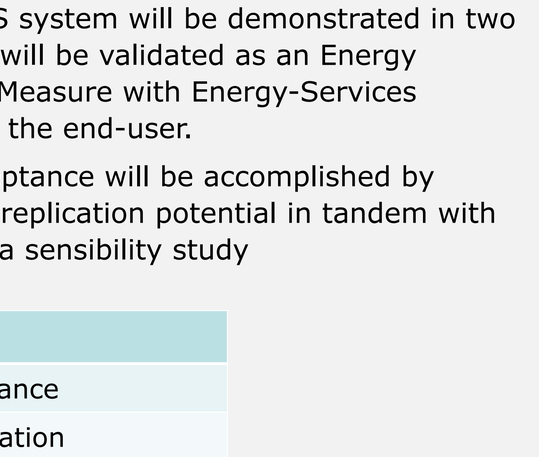
Honeywell Prague Laboratory
Web: http://honeywell.com

Dalkia Energía y Servicios
Web: http://www.dalkia.es/

Fraunhofer IBP
Web: http://www.ibp.fraunhofer.de

Technical University of Crete
Web: http://en.tuc.gr/

University College of Cork – IRUSE
Web:http://zuse.ucc.ie



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IFC-COMPATIBLE DATA WAREHOUSE PLATFORM FOR BUILDING PERFORMANCE ANALYSIS

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.

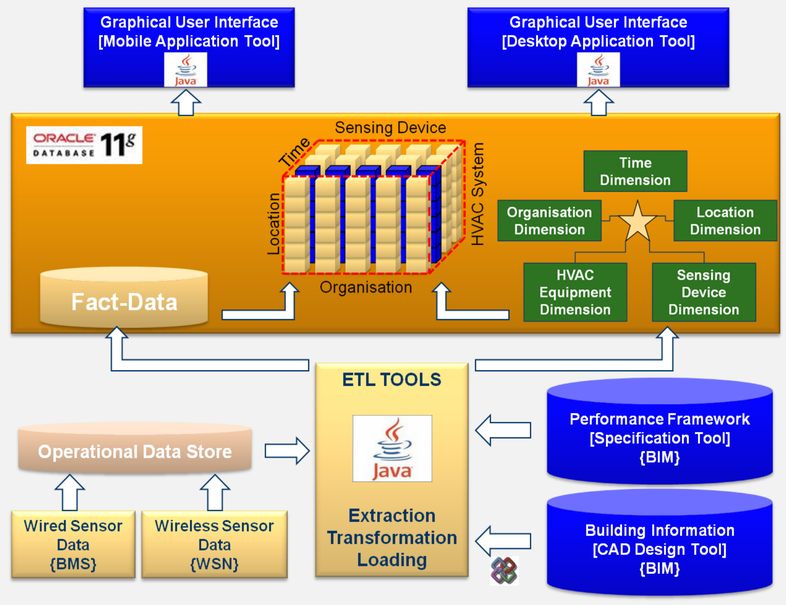


Figure 1: The Data Integration Principle

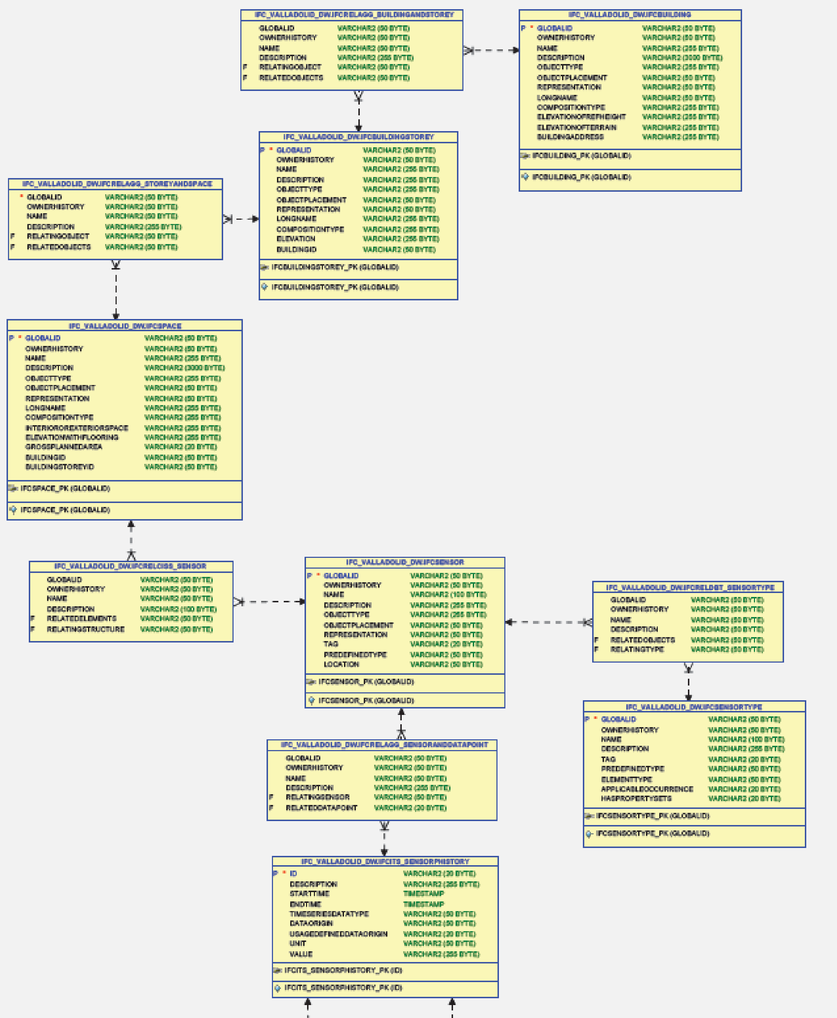
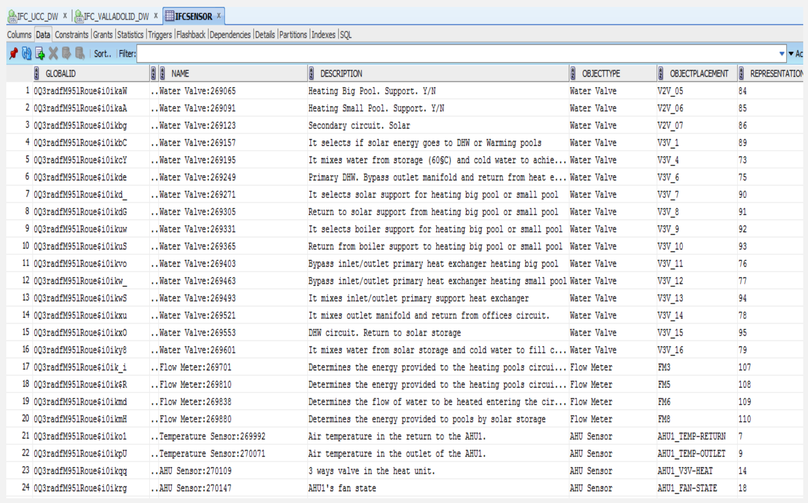


Figure 2: Relational Model of IFC DWH

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.



IFC_UCC_DW | IFC_VALLADOLID_DW | IFCSENSOR

Columns | Data | Constraints | Grants | Statistics | Triggers | Flashback | Dependencies | Details | Partitions | Indexes | SQL

Sort.. Filter:

	GLOBALID	NAME	DESCRIPTION	OBJECTTYPE	OBJECTPLACEMENT	REPRESENTATION
1	0Q3radfM951Roue$10ikaW	..Water Valve:269065	Heating Big Pool. Support. Y/N	Water Valve	V2V_05	84
2	0Q3radfM951Roue$10ikaA	..Water Valve:269091	Heating Small Pool. Support. Y/N	Water Valve	V2V_06	85
3	0Q3radfM951Roue$10ikbg	..Water Valve:269123	Secondary circuit. Solar	Water Valve	V2V_07	86
4	0Q3radfM951Roue$10ikbC	..Water Valve:269157	It selects if solar energy goes to DHW or Warming pools	Water Valve	V3V_1	89
5	0Q3radfM951Roue$10ikcY	..Water Valve:269195	It mixes water from storage (60$C) and cold water to achie...	Water Valve	V3V_4	73
6	0Q3radfM951Roue$10ikde	..Water Valve:269249	Primary DHW. Bypass outlet manifold and return from heat e...	Water Valve	V3V_6	75
7	0Q3radfM951Roue$10ikd_	..Water Valve:269271	It selects solar support for heating big pool or small pool	Water Valve	V3V_7	90
8	0Q3radfM951Roue$10ikdG	..Water Valve:269305	Return to solar support from heating big pool or small pool	Water Valve	V3V_8	91
9	0Q3radfM951Roue$10ikuw	..Water Valve:269331	It selects boiler support for heating big pool or small pool	Water Valve	V3V_9	92
10	0Q3radfM951Roue$10iku5	..Water Valve:269365	Return from boiler support to heating big pool or small pool	Water Valve	V3V_10	93
11	0Q3radfM951Roue$10ikvo	..Water Valve:269403	Bypass inlet/outlet primary heat exchanger heating big pool	Water Valve	V3V_11	76
12	0Q3radfM951Roue$10ikw_	..Water Valve:269463	Bypass inlet/outlet primary heat exchanger heating small pool	Water Valve	V3V_12	77
13	0Q3radfM951Roue$10ikwS	..Water Valve:269493	It mixes inlet/outlet primary support heat exchanger	Water Valve	V3V_13	94
14	0Q3radfM951Roue$10ikxu	..Water Valve:269521	It mixes outlet manifold and return from offices circuit.	Water Valve	V3V_14	78
15	0Q3radfM951Roue$10ikxO	..Water Valve:269553	DHW circuit. Return to solar storage	Water Valve	V3V_15	95
16	0Q3radfM951Roue$10iky8	..Water Valve:269601	It mixes water from solar storage and cold water to fill c...	Water Valve	V3V_16	79
17	0Q3radfM951Roue$10ik_i	..Flow Meter:269701	Determines the energy provided to the heating pools circui...	Flow Meter	FM3	107
18	0Q3radfM951Roue$10ik4R	..Flow Meter:269810	Determines the energy provided to the heating pools circui...	Flow Meter	FM5	108
19	0Q3radfM951Roue$10ikmd	..Flow Meter:269838	Determines the flow of water to be heated entering the cir...	Flow Meter	FM6	109
20	0Q3radfM951Roue$10ikmR	..Flow Meter:269880	Determines the energy provided to pools by solar storage	Flow Meter	FM8	110
21	0Q3radfM951Roue$10iko1	..Temperature Sensor:269992	Air temperature in the return to the AHU1.	AHU Sensor	AHU1_TEMP-RETURN	7
22	0Q3radfM951Roue$10ikpU	..Temperature Sensor:270071	Air temperature in the outlet of the AHU1.	AHU Sensor	AHU1_TEMP-OUTLET	9
23	0Q3radfM951Roue$10ikqq	..AHU Sensor:270109	3 ways valve in the heat unit.	AHU Sensor	AHU1_V3V-HEAT	14
24	0Q3radfM951Roue$10ikrg	..AHU Sensor:270147	AHU1's fan state	AHU Sensor	AHU1_FAN-STATE	18

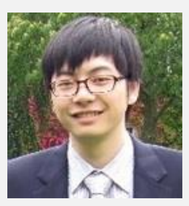
Figure 3: Output of DWH

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.

Contact

IRUSE Researchers:
Kai Mo, MEngSc.
Andriy Hryshchenko, MEngSc.
a,hryshchenko@ucc.ie



WP Leader: Prof. Karsten Menzel
University College Cork
Informatics Research Unit for Sustainable Engineering
CORK, Ireland
k.menzel@ucc.ie

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University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

http://www.baas-project.eu

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.

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.

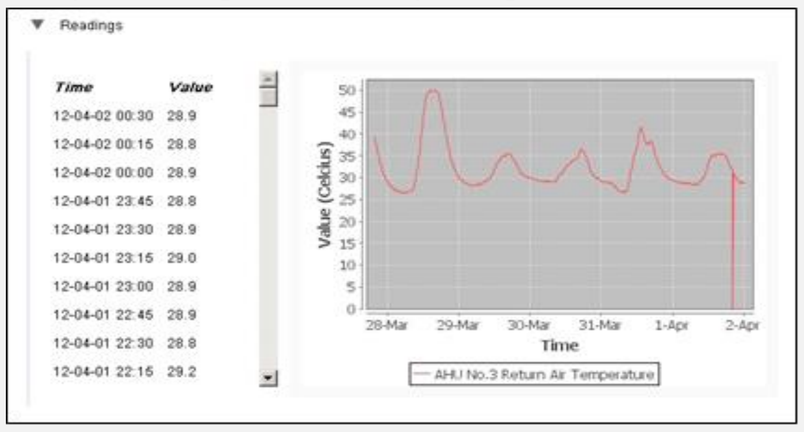

Figure 3: Temperature sensor information interface

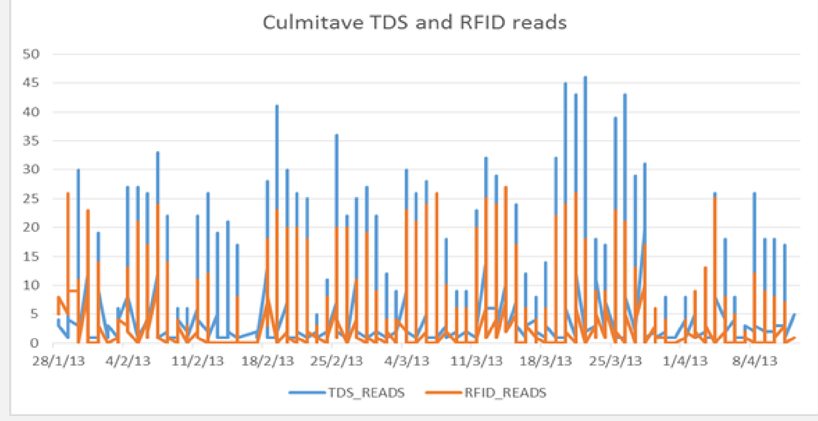

Figure 4: Example of raw occupancy data before correction

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.

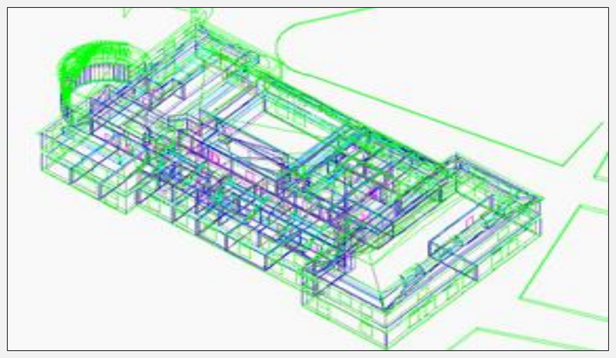

Figure 2: Simulation Model

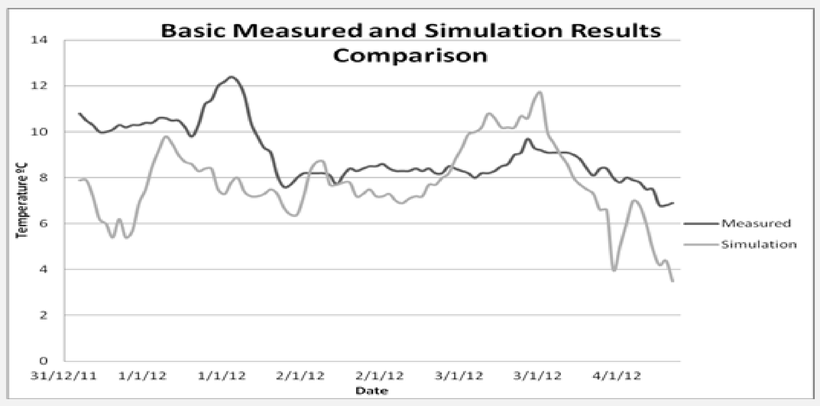

Figure 5: Measured versus "pre-defined" weather data

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.

Contact

IRUSE Researchers:
Donal Browne, MEngSc.
Andriy Hryshchenko, MEngSc.
a,hryshchenko@ucc.ie

WP Leader: Prof. Karsten Menzel
University College Cork
Informatics Research Unit for
Sustainable Engineering
CORK, Ireland
k.menzel@ucc.ie

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