NUI Galway
OÉ Gaillimh

IRUSE

BERKELEY LAB

Linked Data Workshop

Ghent
28/29 March 2012

IRCSET
Investing in People and Ideas
Irish Research Council for Science, Engineering and Technology

DERI

Overview

- Introduction
  - ☐ IRUSE (Built Environment)
  - ☐ DERI (Semantic Web/Linked Data)
- Cross-domain Data for Building Management
  - ☐ Enhanced Decision Support with Scenario Modelling
  - ☐ Challenges
- Linked Building Data
  - ☐ DERI Building Use Case

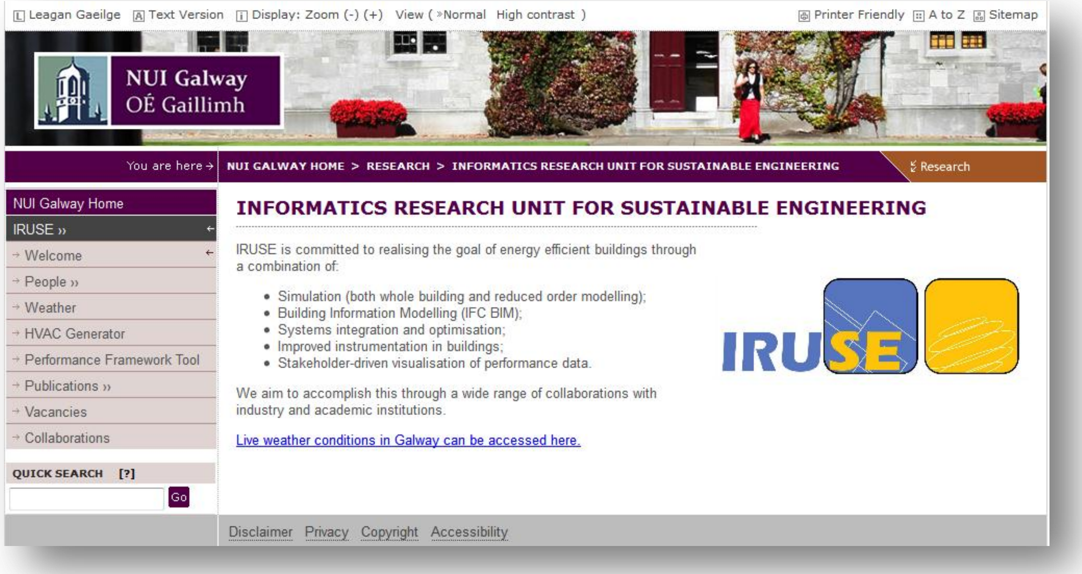
Who are IRUSE?

Based at National University of Ireland, Galway

Research Group of Civil/Mechanical Engineers

5 post-docs & 7 PhDs

Fish & Chips
Mc Donagh's
BARNACLES


Leagan Gaeilge
Text Version
Display: Zoom (-) (+)
View (»Normal High contrast)
Printer Friendly
A to Z
Sitemap
NUI Galway
OÉ Gaillimh
You are here →
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Research
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IRUSE »
Welcome
People »
Weather
HVAC Generator
Performance Framework Tool
Publications »
Vacancies
Collaborations
QUICK SEARCH [?]
Go
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INFORMATICS RESEARCH UNIT FOR SUSTAINABLE ENGINEERING

IRUSE is committed to realising the goal of energy efficient buildings through a combination of:

- Simulation (both whole building and reduced order modelling);
- Building Information Modelling (IFC BIM);
- Systems integration and optimisation;
- Improved instrumentation in buildings;
- Stakeholder-driven visualisation of performance data.

We aim to accomplish this through a wide range of collaborations with industry and academic institutions.

Live weather conditions in Galway can be accessed here.

IRUSE interested in Building Optimisation during Operational Phase

HVAC systems integration and Optimisation

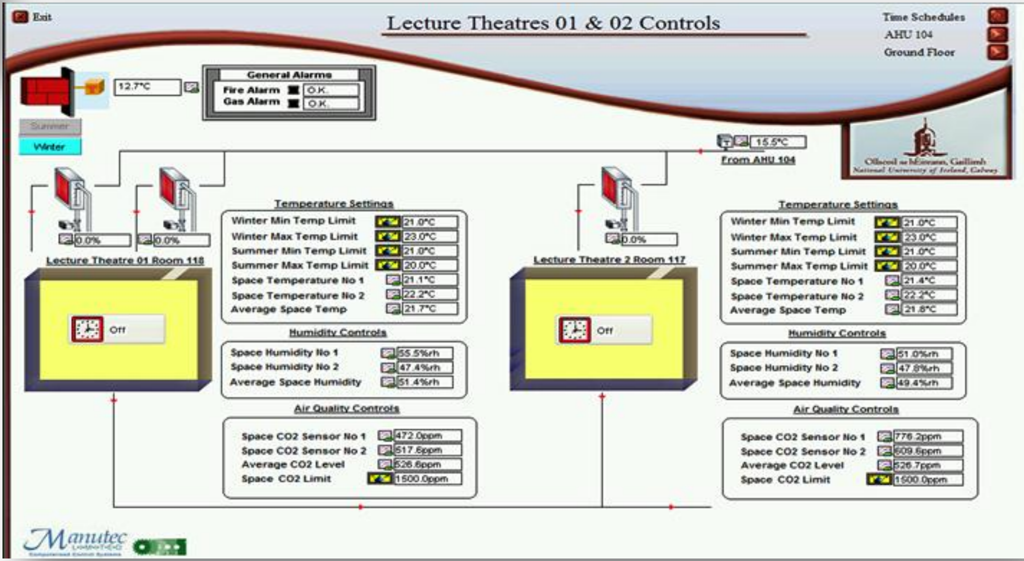
Information driven building operation

Stakeholders specific performance data

Energy Simulation

Building Information Models

Calibration of simulation models


Exit
Lecture Theatres 01 & 02 Controls
Time Schedules
AHU 104
Ground Floor
Summer
Winter
Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway
Manutec Limited
Computerised Control Systems

12.7°C

General Alarms	
Fire Alarm	O.K.
Gas Alarm	O.K.

15.5°C From AHU 104

Lecture Theatre 01 Room 118

0.0% 0.0%

Off

Temperature Settings	
Winter Min Temp Limit	21.0°C
Winter Max Temp Limit	23.0°C
Summer Min Temp Limit	21.0°C
Summer Max Temp Limit	20.0°C
Space Temperature No 1	21.1°C
Space Temperature No 2	22.2°C
Average Space Temp	21.7°C

Humidity Controls	
Space Humidity No 1	55.5%rh
Space Humidity No 2	47.4%rh
Average Space Humidity	51.4%rh

Air Quality Controls	
Space CO2 Sensor No 1	472.0ppm
Space CO2 Sensor No 2	517.6ppm
Average CO2 Level	526.6ppm
Space CO2 Limit	1500.0ppm

Lecture Theatre 2 Room 117

0.0%

Off

Temperature Settings	
Winter Min Temp Limit	21.0°C
Winter Max Temp Limit	23.0°C
Summer Min Temp Limit	21.0°C
Summer Max Temp Limit	20.0°C
Space Temperature No 1	21.4°C
Space Temperature No 2	22.2°C
Average Space Temp	21.8°C

Humidity Controls	
Space Humidity No 1	51.0%rh
Space Humidity No 2	47.8%rh
Average Space Humidity	49.4%rh

Air Quality Controls	
Space CO2 Sensor No 1	776.2ppm
Space CO2 Sensor No 2	609.6ppm
Average CO2 Level	526.7ppm
Space CO2 Limit	1500.0ppm

About DERI

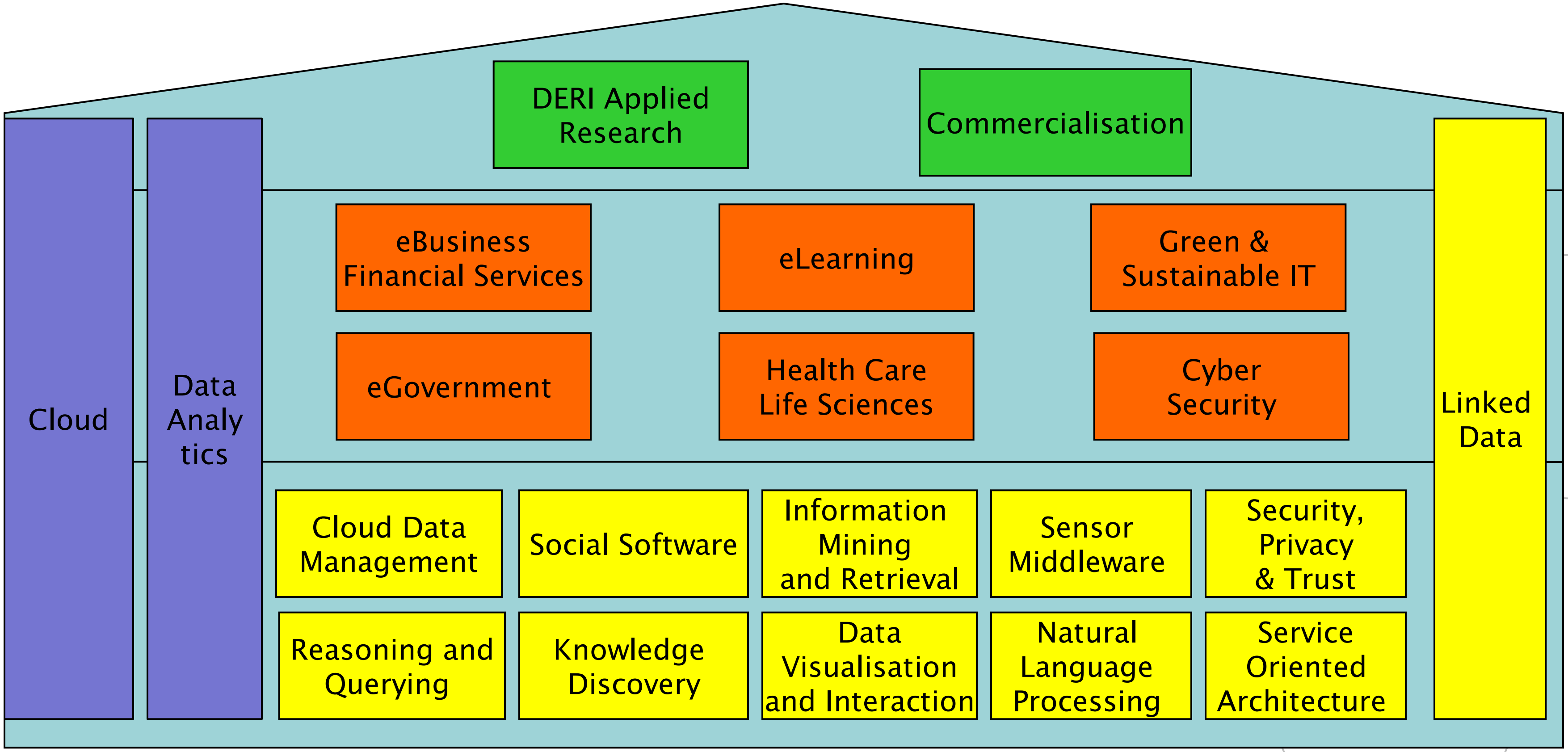
- **Founded June 2003 as a CSET (Centre for Science, Engineering and Technology).**
  - ☐ Link scientists and engineers / academia and industry
  - ☐ Fundamental research
  - ☐ Development of Irish-based technology companies
  - ☐ Attract industry
  - ☐ Education & outreach
- **DERI Institute**
  - ☐ CSET
  - ☐ Commercialization, DAI
  - ☐ EU, EI, direct industry, IRCSET
- **DERI strategic plan responds to priorities**
  - ☐ Local: University focus on Informatics, Physical & Computational Sciences
  - ☐ National: SMART Economy, Program for Government
  - ☐ International: EU Digital Agenda

CISCO
AVAYA
ERICSSON
TAKING YOU FORWARD
Alcatel·Lucent
FONDAZIONE BRUNO KESSLER
celtrak
OPENLINK
storm technology

About DERI

- **Number one in its core space**
  - Research Publications > 950
  - Participate in 17 standardisation groups (W3C, OASIS)
  - Approx 140 members from 30 nations
  - 57 PhD's /Masters
  - 42 completed PhDs/Masters
- **Core Industrial Partners:**
  - MNC's: Cisco, Avaya, Bel-Labs, Ericsson…
  - SME's: Storm, Celtrak, OpenLink……
  - Research: FBK
- **Total Research Grants: >€60 million**
  - SFI, EU Framework, Enterprise Ireland, Industry

The 2012 DERI House



Cloud

Data Analytics

DERI Applied Research

Commercialisation

eBusiness Financial Services

eLearning

Green & Sustainable IT

eGovernment

Health Care Life Sciences

Cyber Security

Cloud Data Management

Social Software

Information Mining and Retrieval

Sensor Middleware

Security, Privacy & Trust

Reasoning and Querying

Knowledge Discovery

Data Visualisation and Interaction

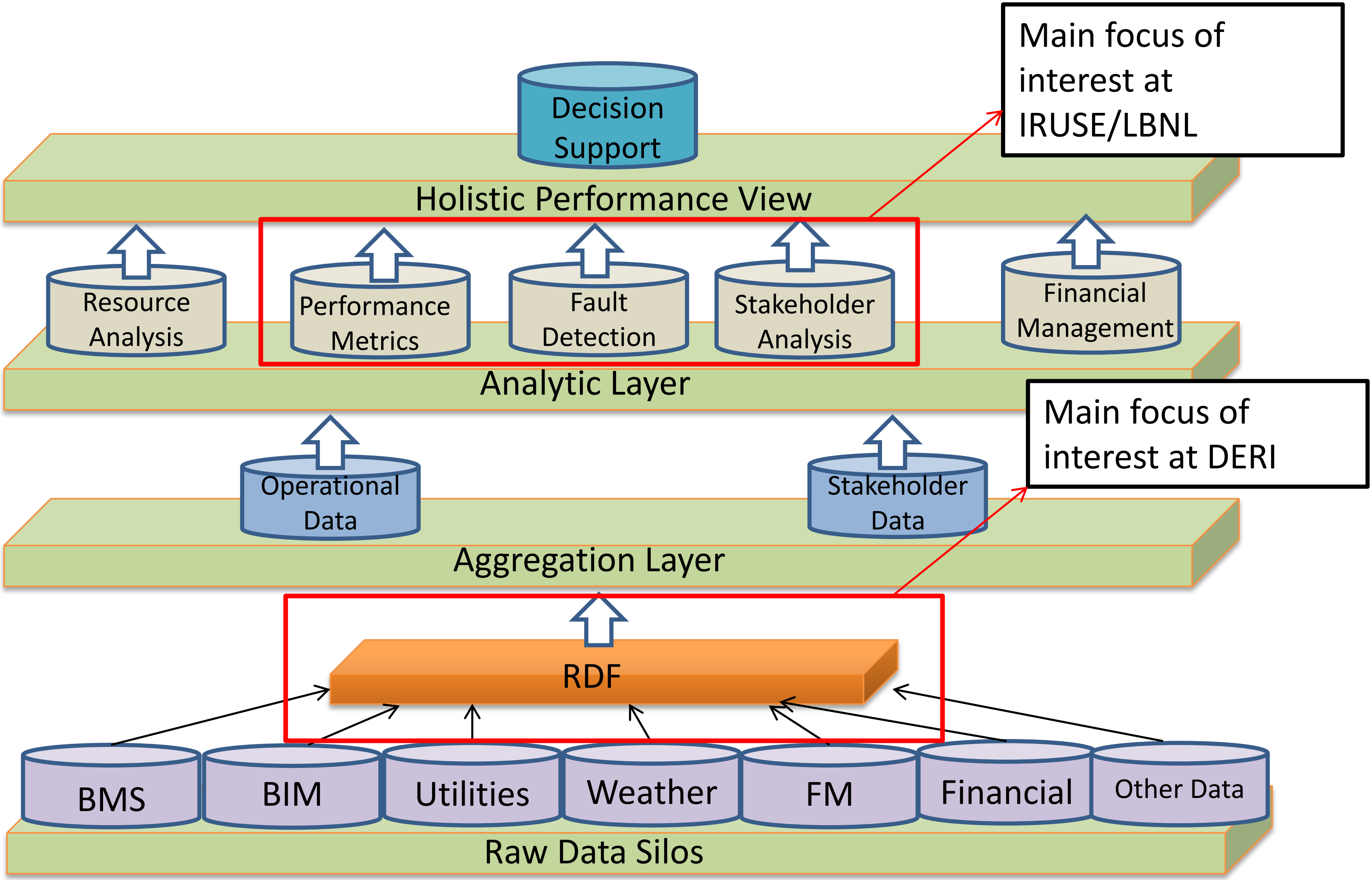
Natural Language Processing

Service Oriented Architecture

Linked Data

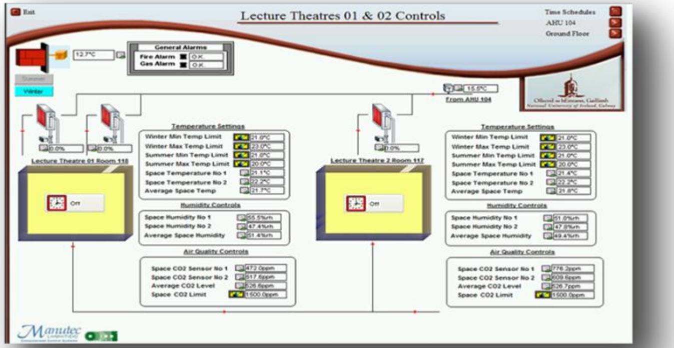
DERI is designed to provide an integrated solution

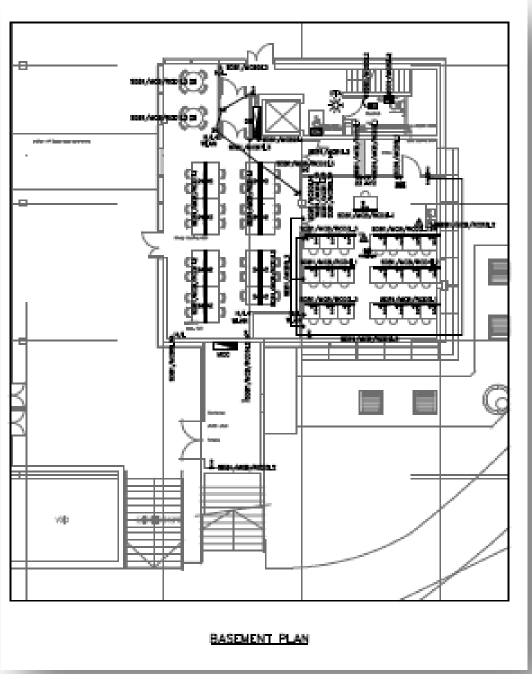
IRUSE, LBNL, and DERI have Complementary Research Interests


Main focus of interest at IRUSE/LBNL
Decision Support
Holistic Performance View
Resource Analysis
Performance Metrics
Fault Detection
Stakeholder Analysis
Financial Management
Analytic Layer
Main focus of interest at DERI
Operational Data
Stakeholder Data
Aggregation Layer
RDF
BMS
BIM
Utilities
Weather
FM
Financial
Other Data
Raw Data Silos

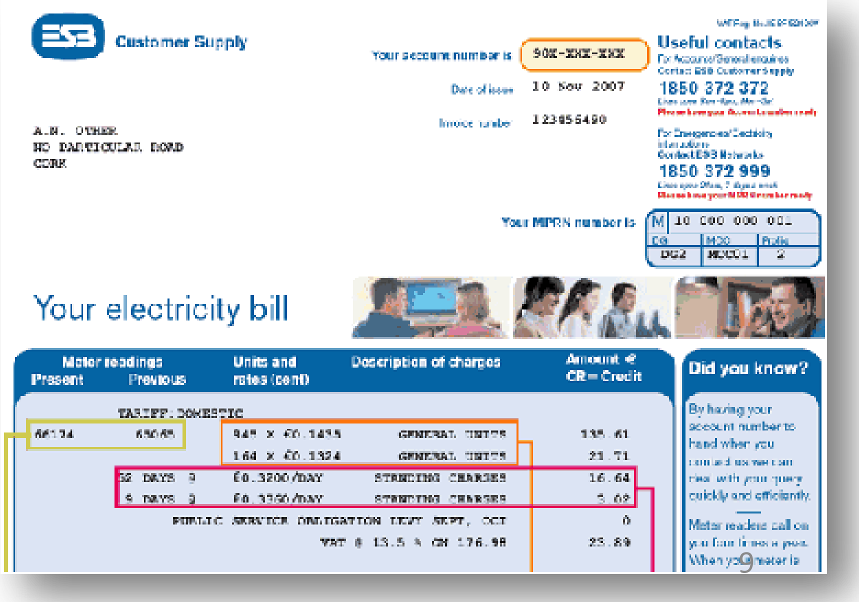
Organisations incur substantial costs as a result of data mismanagement

Confusion
No Interoperability
Cost Overruns
Higher Costs
Inefficiencies


Lecture Theatres 01 & 02 Controls
Time Schedules
AHU 104
Ground Floor
General Alarms
Fire Alarm
Gas Alarm
O.K
Summer
Winter
Lecture Theatre 01 Room 118
Lecture Theatre 2 Room 117
From AHU 104
Temperature Settings
Humidity Controls
Air Quality Controls
Manutec


BASEMENT PLAN

Building Manager



Customer Supply

Your account number is 90X-XXX-XXX

Date of issue 10 Nov 2007

Invoice number 1234554 90

A.N. OTHER
NO PARTICULAR ROAD
CORK

Useful contacts

1850 372 372

1850 372 999

Your MPRN number is M 10 000 000 001

DG	MCC	Profile
DG2	MCC01	2

Your electricity bill

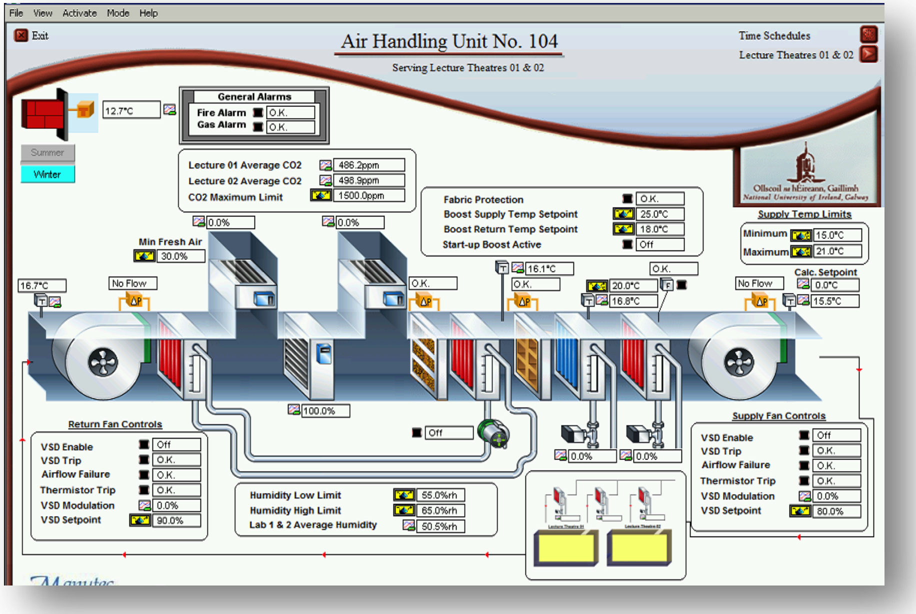
Meter readings Present	Previous	Units and rates (cent)	Description of charges	Amount € CR = Credit
		TARIFF: DOMESTIC		
66124	65065	945 x €0.1435	GENERAL UNITS	135.61
		164 x €0.1324	GENERAL UNITS	21.71
	52 DAYS 9	€0.3200/DAY	STANDING CHARGES	16.64
	5 DAYS 9	€0.3350/DAY	STANDING CHARGES	3.62
			PUBLIC SERVICE OBLIGATION LEVY SEPT, OCT	0
			VAT @ 13.5 % ON 176.98	23.89

Did you know?

By having your account number to hand when you contact us we can deal with your query quickly and efficiently.

Meter readers call on you four times a year. When your meter is

Research Motivation - a concrete example



File
View
Activate
Mode
Help
Exit
Time Schedules
Lecture Theatres 01 & 02
Summer
Winter
12.7°C
16.7°C
No Flow
0.0%
0.0%
O.K.
16.1°C
O.K.
O.K.
20.0°C
16.8°C
No Flow
100.0%
Off
0.0%
0.0%
Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway
Manutec

Air Handling Unit No. 104

Serving Lecture Theatres 01 & 02

General Alarms
Fire Alarm O.K.
Gas Alarm O.K.

Lecture 01 Average CO2 486.2ppm
Lecture 02 Average CO2 498.9ppm
CO2 Maximum Limit 1500.0ppm

Min Fresh Air 30.0%

Fabric Protection O.K.
Boost Supply Temp Setpoint 25.0°C
Boost Return Temp Setpoint 18.0°C
Start-up Boost Active Off

Supply Temp Limits
Minimum 15.0°C
Maximum 21.0°C

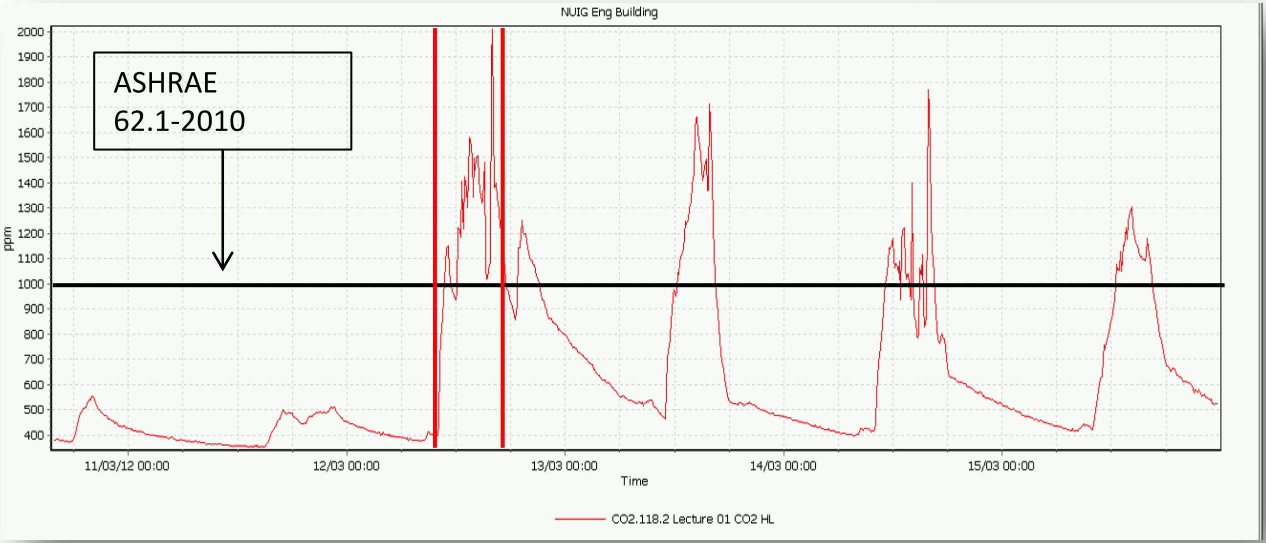
Calc. Setpoint 0.0°C 15.5°C

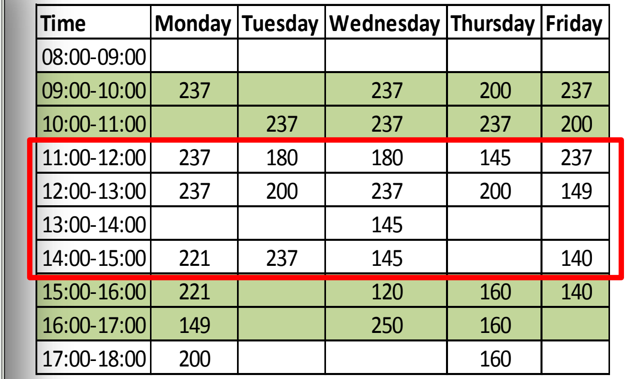
Return Fan Controls
VSD Enable Off
VSD Trip O.K.
Airflow Failure O.K.
Thermistor Trip O.K.
VSD Modulation 0.0%
VSD Setpoint 90.0%

Humidity Low Limit 55.0%rh
Humidity High Limit 65.0%rh
Lab 1 & 2 Average Humidity 50.5%rh

Supply Fan Controls
VSD Enable Off
VSD Trip O.K.
Airflow Failure O.K.
Thermistor Trip O.K.
VSD Modulation 0.0%
VSD Setpoint 80.0%

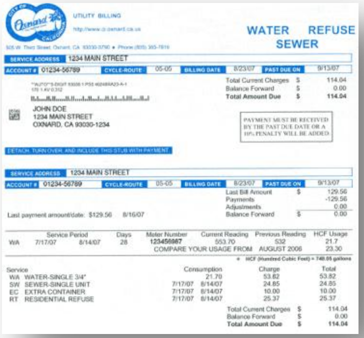
CO2 levels





Time	Monday	Tuesday	Wednesday	Thursday	Friday
08:00-09:00					
09:00-10:00	237		237	200	237
10:00-11:00		237	237	237	200
11:00-12:00	237	180	180	145	237
12:00-13:00	237	200	237	200	149
13:00-14:00			145		
14:00-15:00	221	237	145		140
15:00-16:00	221		120	160	140
16:00-17:00	149		250	160	
17:00-18:00	200			160	

These are the types of data that we wish to leverage



UTILITY BILLING

http://www.ci.oxnard.ca.us

305 W. Third Street, Oxnard, CA 93030-5790 • Phone (805) 385-7816

WATER REFUSE SEWER

SERVICE ADDRESS	1234 MAIN STREET						
ACCOUNT #	01234-56789	CYCLE-ROUTE	05-05	BILLING DATE	8/23/07	PAST DUE ON	9/13/07

Total Current Charges $ 114.04
Balance Forward $ 0.00
Total Amount Due $ 114.04

JOHN DOE
1234 MAIN STREET
OXNARD, CA 93030-1234

PAYMENT MUST BE RECEIVED BY THE PAST DUE DATE OR A 10% PENALTY WILL BE ADDED.

DETACH, TURN OVER, AND INCLUDE THIS STUB WITH PAYMENT.

SERVICE ADDRESS	1234 MAIN STREET						
ACCOUNT #	01234-56789	CYCLE-ROUTE	05-05	BILLING DATE	8/23/07	PAST DUE ON	9/13/07

Last Bill Amount $ 129.56
Payments -129.56
Adjustments 0.00
Balance Forward $ 0.00

Last payment amount/date: $129.56 8/16/07

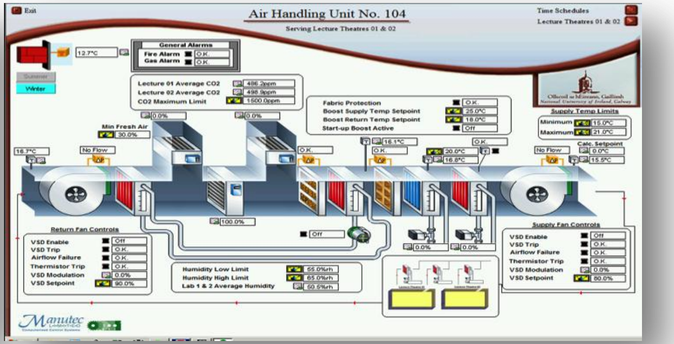
	Service Period		Days	Meter Number	Current Reading	Previous Reading	HCF Usage
WA	7/17/07	8/14/07	28	123456987	553.70	532	21.7
				COMPARE YOUR USAGE FROM		AUGUST 2006	23.30

* HCF (Hundred Cubic Feet) = 748.05 gallons

Service		Consumption		Charge	Total
WA	WATER-SINGLE 3/4"		21.70	53.82	53.82
SW	SEWER-SINGLE UNIT	7/17/07	8/14/07	24.85	24.85
EC	EXTRA CONTAINER	7/17/07	8/14/07	10.00	10.00
RT	RESIDENTIAL REFUSE	7/17/07	8/14/07	25.37	25.37

Total Current Charges $ 114.04
Balance Forward $ 0.00
Total Amount Due $ 114.04

Utility Bills



Air Handling Unit No. 104
Serving Lecture Theatres 01 & 02

General Alarms
Fire Alarm O.K.
Gas Alarm O.K.

Lecture 01 Average CO2 486.2ppm
Lecture 02 Average CO2 498.9ppm
CO2 Maximum Limit 1500.0ppm

Fabric Protection O.K.
Boost Supply Temp Setpoint 25.0°C
Boost Return Temp Setpoint 18.0°C
Start-up Boost Active Off

Min Fresh Air 30.0%

Supply Temp Limits
Minimum 15.0°C
Maximum 21.0°C

Calc. Setpoint 0.0°C

Return Fan Controls
VSD Enable Off
VSD Trip O.K.
Airflow Failure O.K.
Thermistor Trip O.K.
VSD Modulation 0.0%
VSD Setpoint 90.0%

Humidity Low Limit 55.0%rh
Humidity High Limit 65.0%rh
Lab 1 & 2 Average Humidity 50.5%rh

Supply Fan Controls
VSD Enable Off
VSD Trip O.K.
Airflow Failure O.K.
Thermistor Trip O.K.
VSD Modulation 0.0%
VSD Setpoint 80.0%

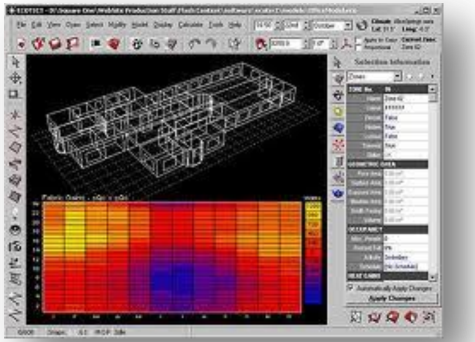
Exit
Time Schedules
Lecture Theatres 01 & 02
Summer
Winter
12.7°C
16.7°C
No Flow
0.0%
0.0%
O.K.
100.0%
Off
16.1°C
O.K.
O.K.
20.0°C
16.8°C
O.K.
No Flow
15.5°C
0.0%
0.0%
Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway
Manutec Limited
Computerised Control Systems

BMS

2000
PPM CO2
acme
CO2-2000

Sensor & Meter Data

Weather Data



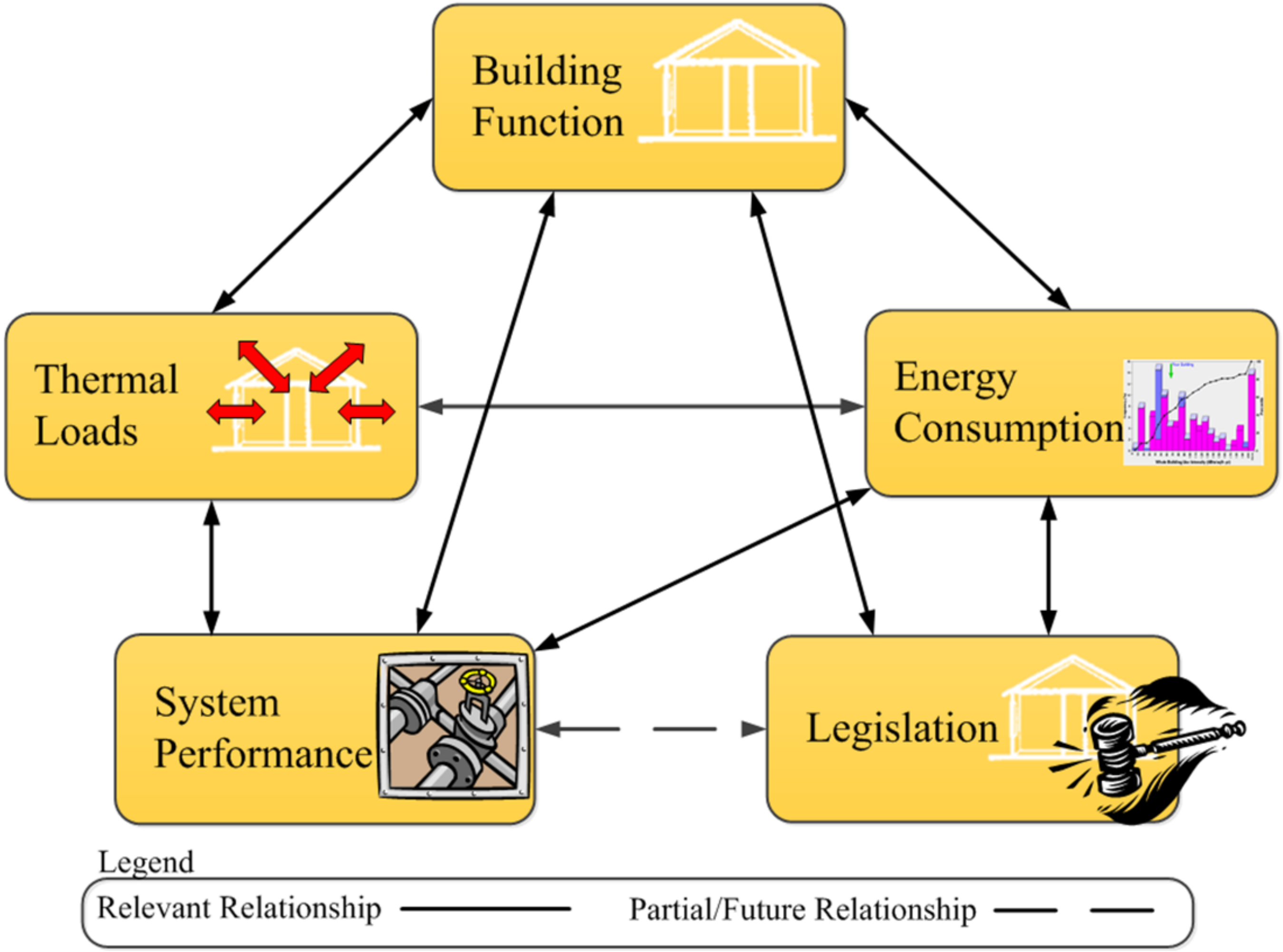
Simulation Models Output

Building Models

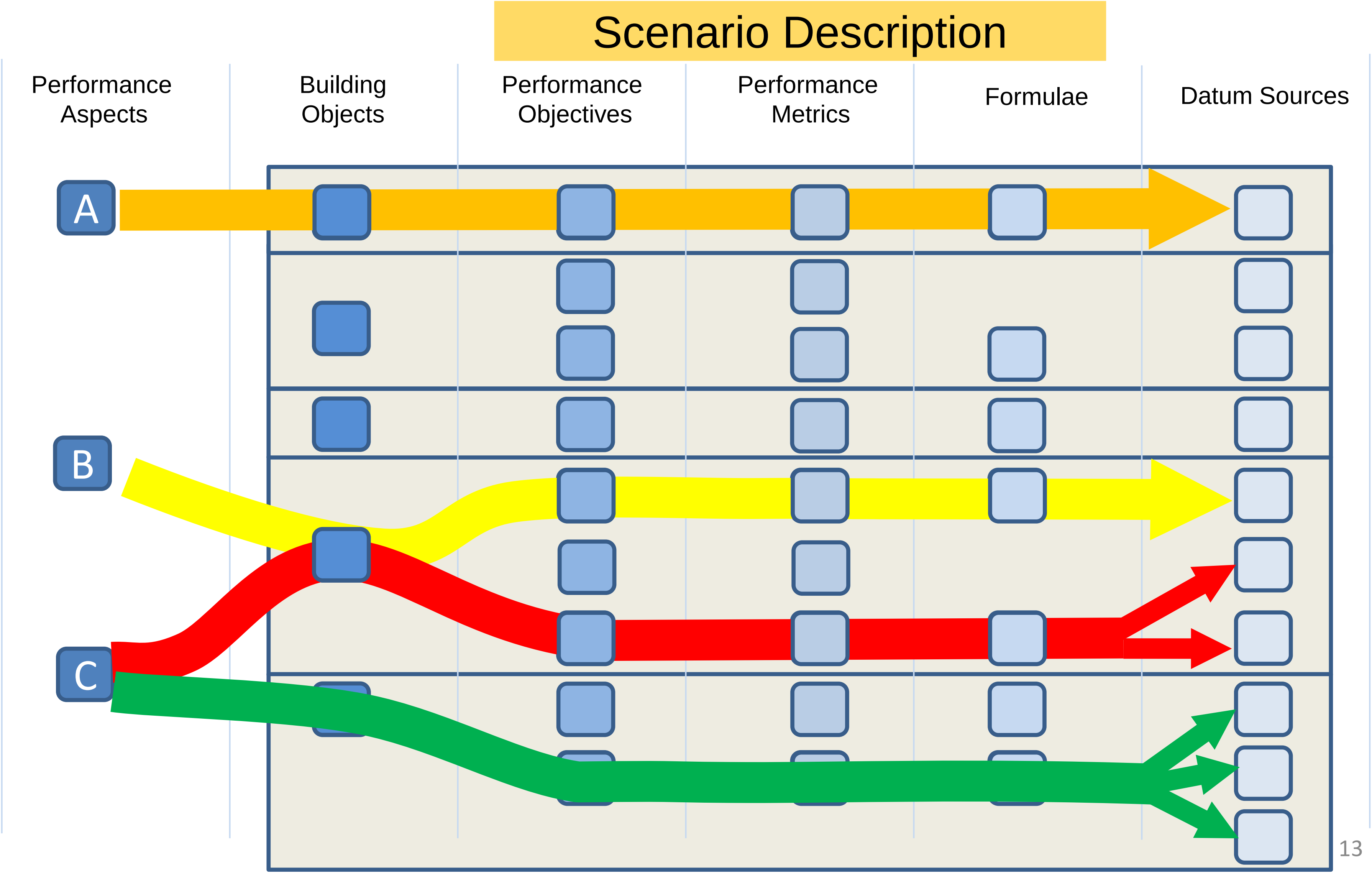
HR
Occupancy
Security
Fire

Other Data

Scenario Modelling provides a holistic interpretation of building performance

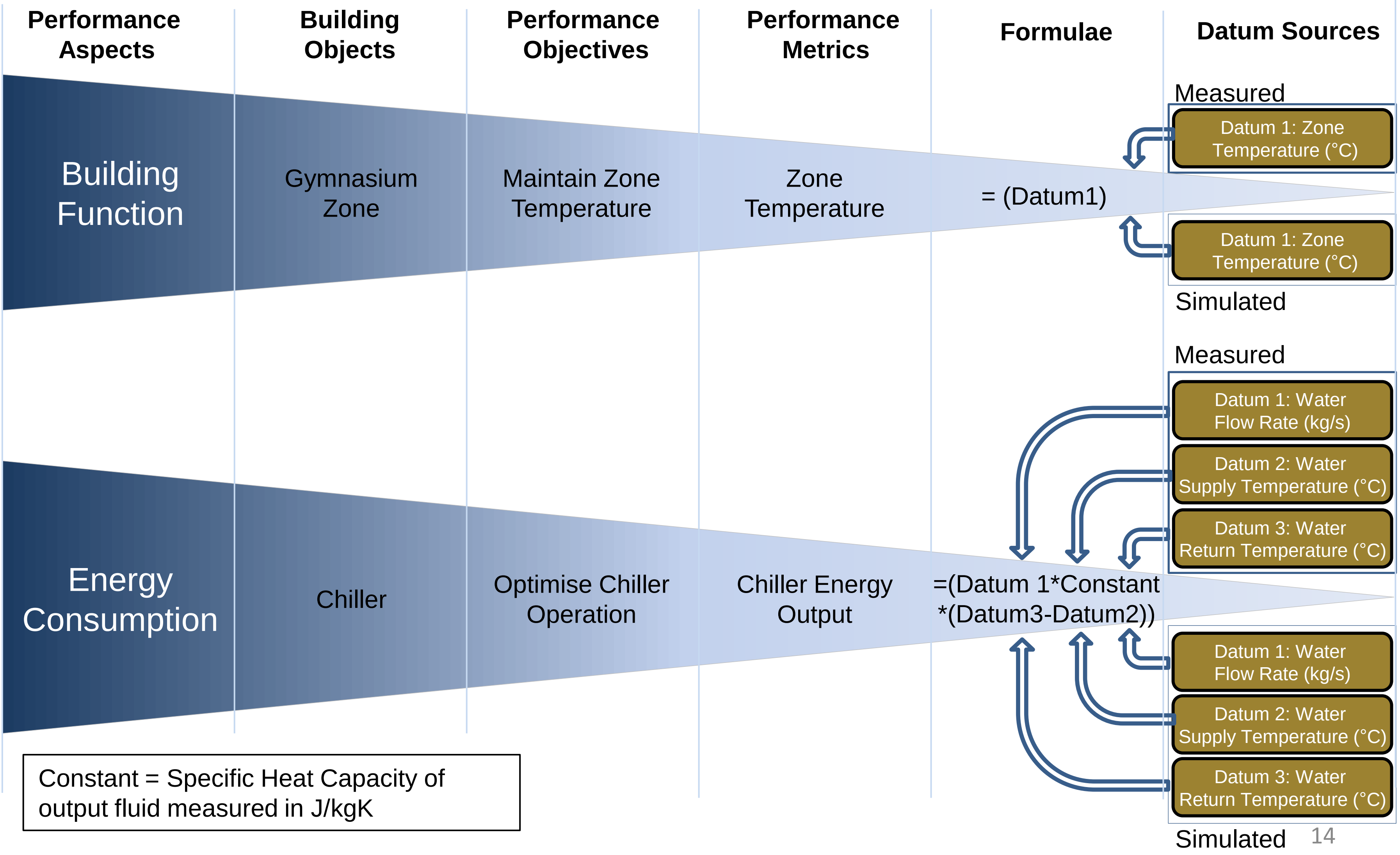

Building Function
Thermal Loads
Energy Consumption
System Performance
Legislation
Legend
Relevant Relationship
Partial/Future Relationship

Define information required by stakeholder and related data


Scenario Description
Performance Aspects
Building Objects
Performance Objectives
Performance Metrics
Formulae
Datum Sources
A
B
C

A building manager would like to analyse comfort and energy consumption

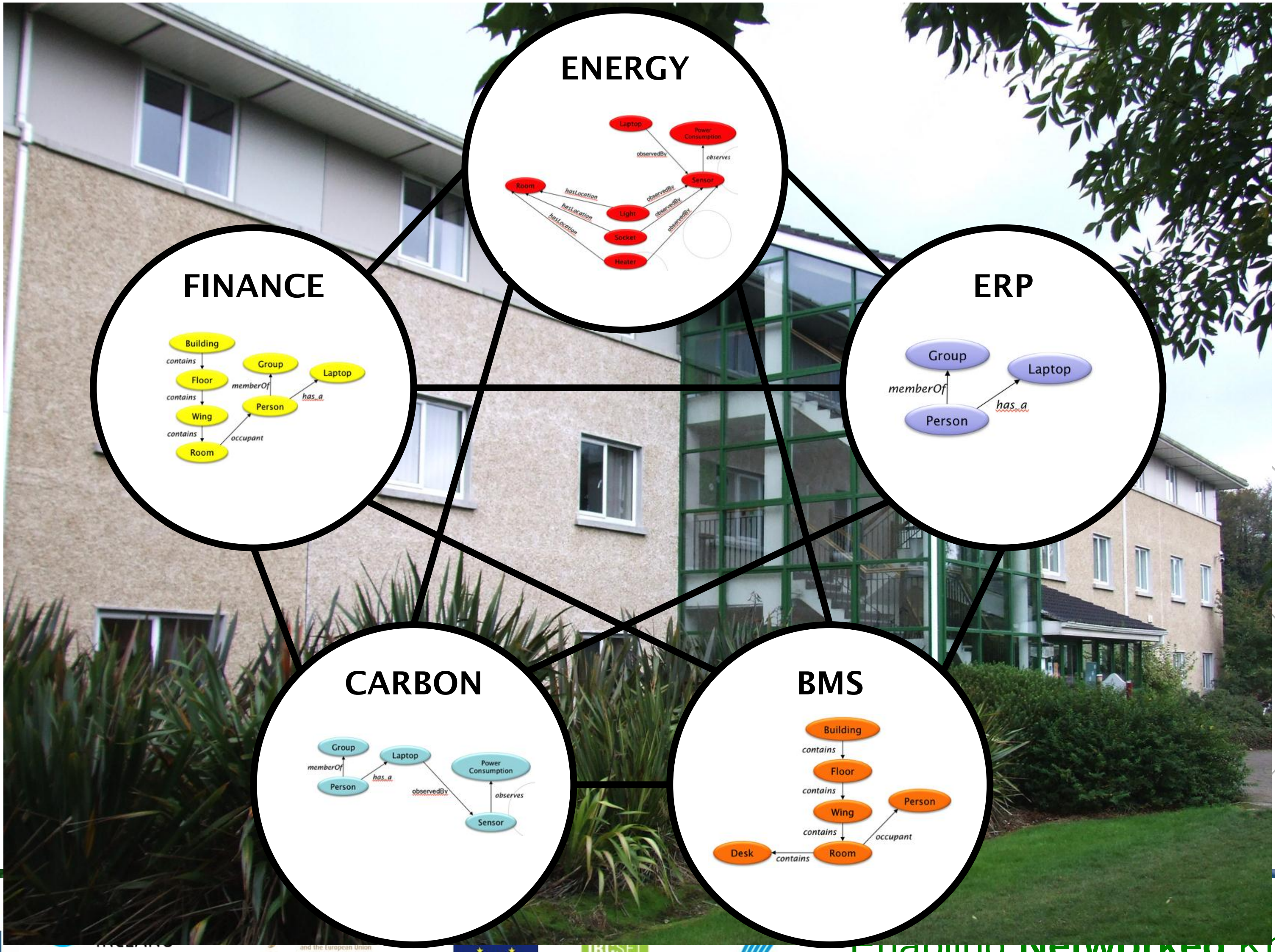
Scenario: Compare Comfort & Energy Consumption



Performance Aspects	Building Objects	Performance Objectives	Performance Metrics	Formulae	Datum Sources
Building Function	Gymnasium Zone	Maintain Zone Temperature	Zone Temperature	= (Datum1)	Measured Datum 1: Zone Temperature (°C) Simulated Datum 1: Zone Temperature (°C)
Energy Consumption	Chiller	Optimise Chiller Operation	Chiller Energy Output	=(Datum 1*Constant *(Datum3-Datum2))	Measured Datum 1: Water Flow Rate (kg/s) Datum 2: Water Supply Temperature (°C) Datum 3: Water Return Temperature (°C) Simulated Datum 1: Water Flow Rate (kg/s) Datum 2: Water Supply Temperature (°C) Datum 3: Water Return Temperature (°C)

Constant = Specific Heat Capacity of output fluid measured in J/kgK

Cross-Domain Perspective


ENERGY
Laptop
Power Consumption
observedBy
observes
Sensor
Room
hasLocation
hasLocation
hasLocation
observedBy
observedBy
observedBy
Light
Socket
Heater
FINANCE
Building
contains
Floor
contains
Wing
contains
Room
Group
memberOf
Person
Laptop
has_a
occupant
ERP
Group
Laptop
memberOf
has_a
Person
CARBON
Group
memberOf
Person
Laptop
has_a
observedBy
Power Consumption
observes
Sensor
BMS
Building
contains
Floor
contains
Wing
contains
Room
Person
occupant
Desk
contains

Key Challenges

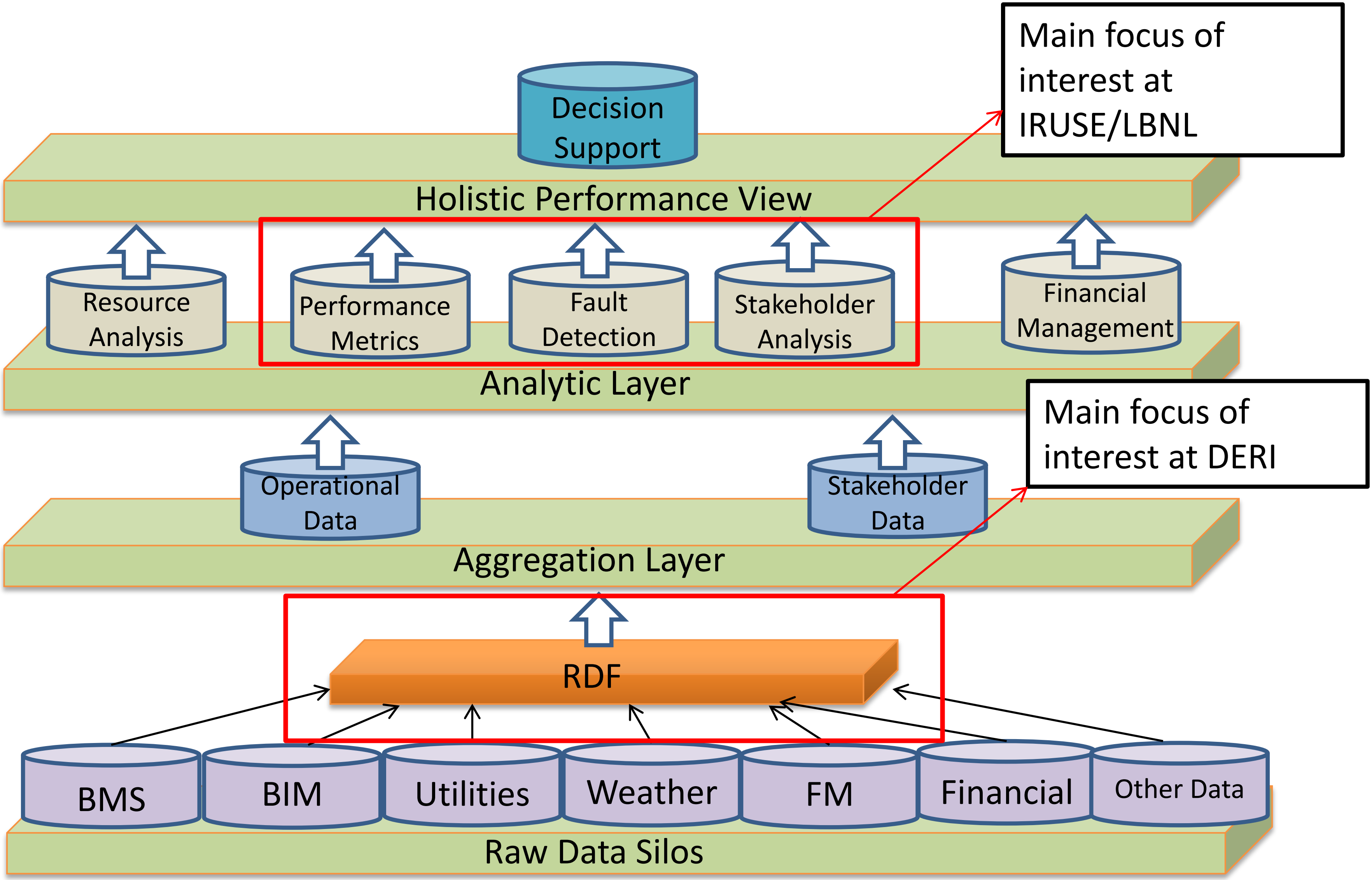
- Initially developed a Performance Framework Tool
    - IFC based
    - Encountered significant roadblocks with BIM
    - Originally felt BIM was central pillar of performance assessment
    - Recognise BIM is one of many pillars

- Technology and Data Interoperability
    - Data scattered among different information systems
    - Multiple incompatible technologies make it difficult to use
    - Dynamic data, sensors, ERP, BMS, assets databases, …

Linked Building Data

- Linking building data builds context between systems
  - Relevant information can linked together to build holistic views of the building
  - Broader context can be used in decision making
- Maintains loose coupling between systems
  - Allows domain systems to focus on their expertise
  - Allows systems to develop independently

IRUSE, LBNL, and DERI have Complementary Research Interests


Main focus of interest at IRUSE/LBNL
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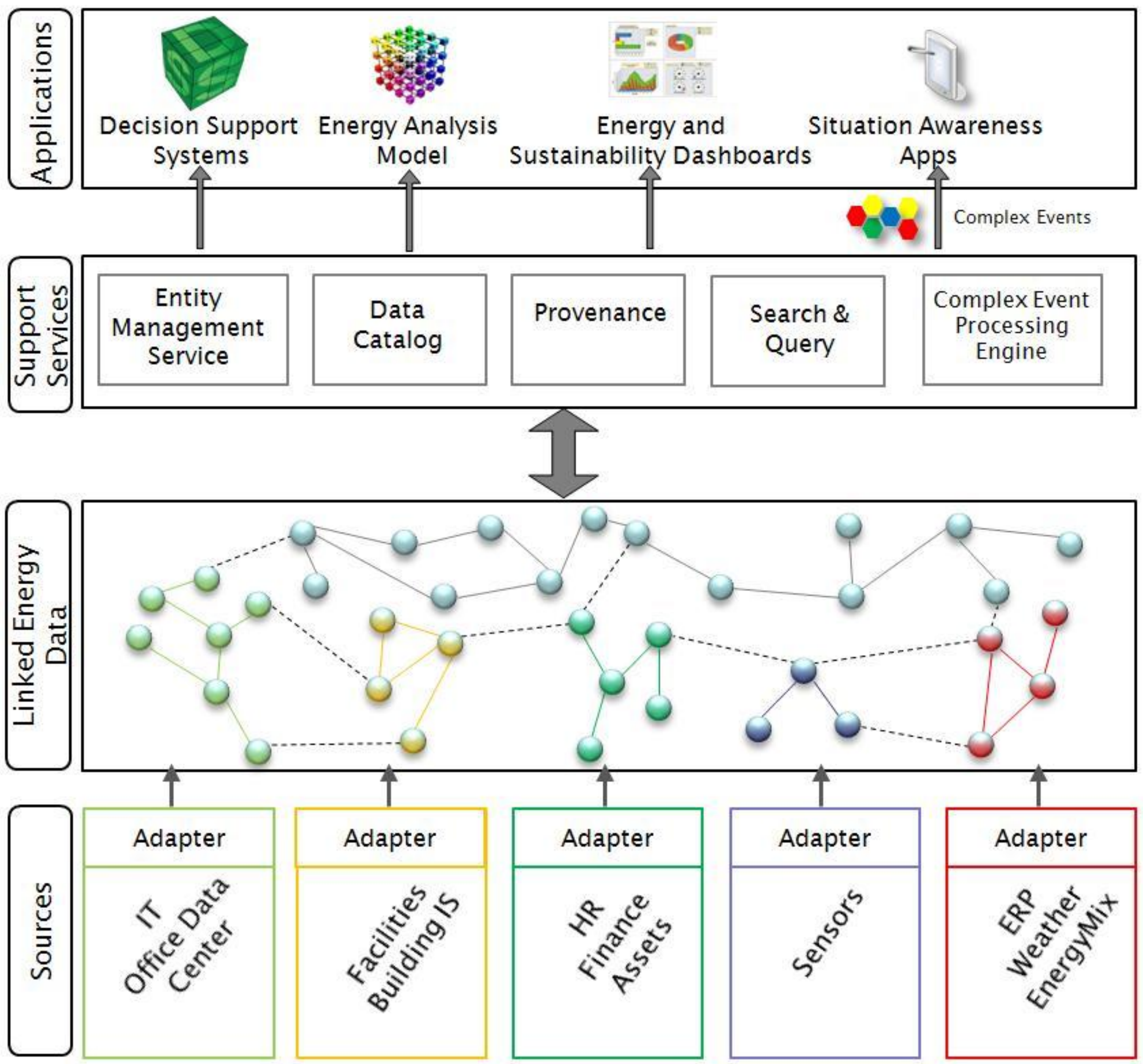
Resource Analysis
Performance Metrics
Fault Detection
Stakeholder Analysis
Financial Management
Analytic Layer
Main focus of interest at DERI
Operational Data
Stakeholder Data
Aggregation Layer
RDF
BMS
BIM
Utilities
Weather
FM
Financial
Other Data
Raw Data Silos

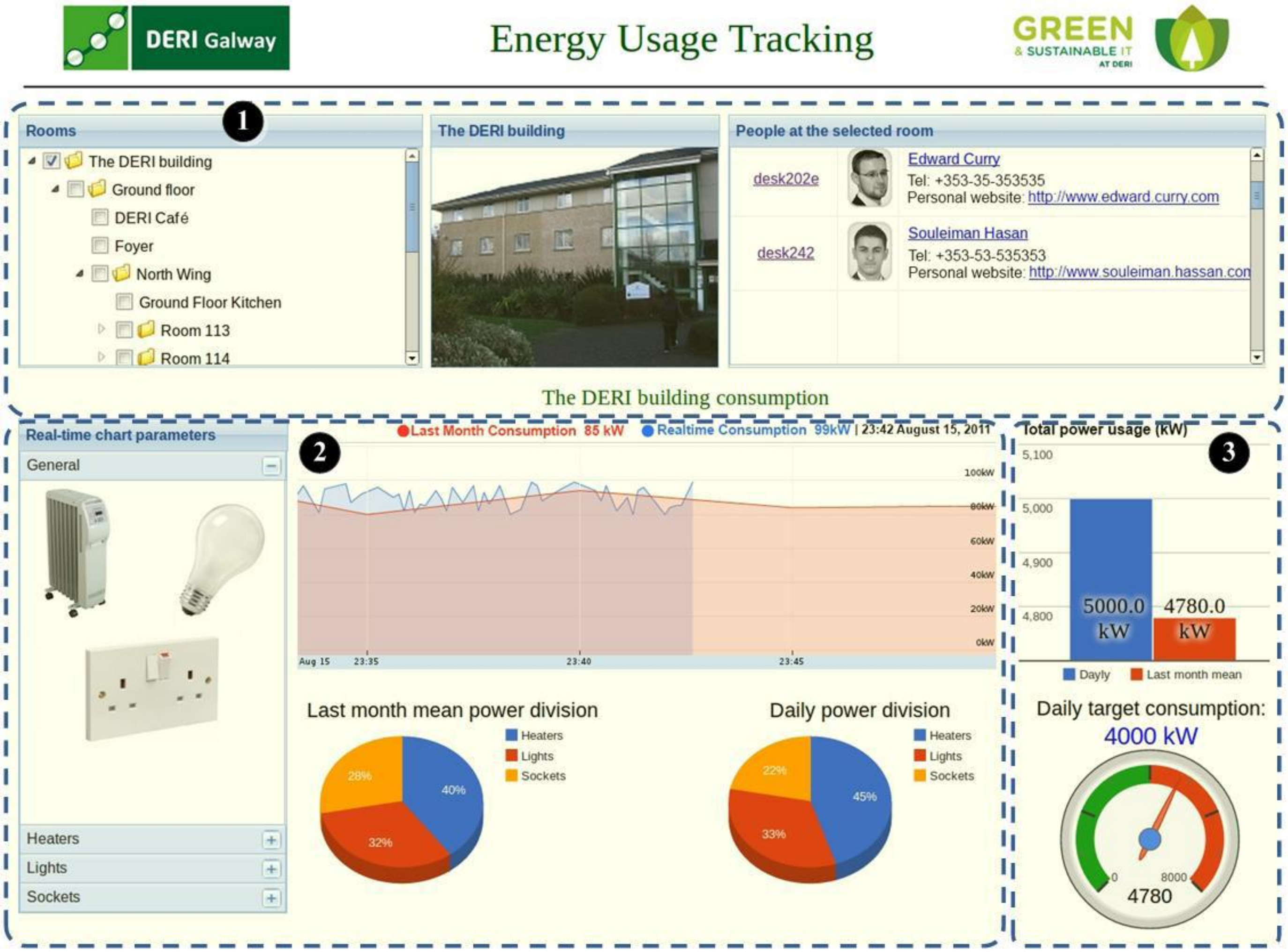
Case Study: DERI Building

- DERI Building
  - ☐ No BMS or BEMS
  - ☐ 160 person Office space
  - ☐ Café
  - ☐ Data centre
  - ☐ 3 Kitchens
  - ☐ 80 person Conference room
  - ☐ 4 Meeting rooms
  - ☐ Computing museum
  - ☐ Sensor Lab

DERI Dataspace


Applications
Decision Support Systems
Energy Analysis Model
Energy and Sustainability Dashboards
Situation Awareness Apps
Complex Events
Support Services
Entity Management Service
Data Catalog
Provenance
Search & Query
Complex Event Processing Engine
Linked Energy Data
Sources
Adapter
IT
Office Data Center
Adapter
Facilities
Building IS
Adapter
HR
Finance
Assets
Adapter
Sensors
Adapter
ERP
Weather
EnergyMix

Building Energy


DERI Galway
Energy Usage Tracking
GREEN & SUSTAINABLE IT AT DERI
1
Rooms
The DERI building
Ground floor
DERI Café
Foyer
North Wing
Ground Floor Kitchen
Room 113
Room 114
The DERI building
People at the selected room
The DERI building consumption
Real-time chart parameters
General
Heaters
Lights
Sockets
2
Last Month Consumption 85 kW
Realtime Consumption 99kW | 23:42 August 15, 2011
100kW
80kW
60kW
40kW
20kW
0kW
Aug 15
23:35
23:40
23:45
Last month mean power division
Heaters
Lights
Sockets
28%
40%
32%
Daily power division
Heaters
Lights
Sockets
22%
45%
33%
Total power usage (kW)
3
5,100
5,000
4,900
4,800
5000.0 kW
4780.0 kW
Dayly
Last month mean
Daily target consumption:
4000 kW
0
8000
4780

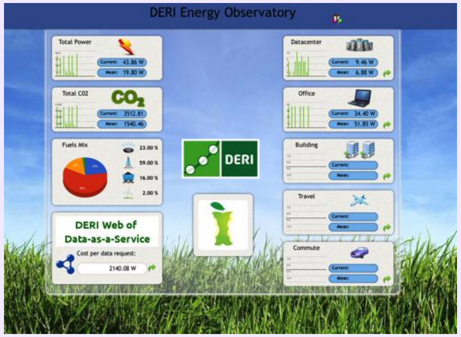
☑ The DERI building

desk202e	Edward Curry	Tel: +353-35-353535 Personal website: http://www.edward.curry.com
desk242	Souleiman Hasan	Tel: +353-53-535353 Personal website: http://www.souleiman.hassan.com

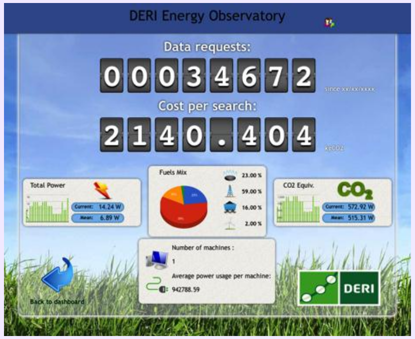
1. Data from Enterprise Linked Data Cloud
2. Sensor Data
3. Building Energy Situation Awareness

DERI Energy Observatory

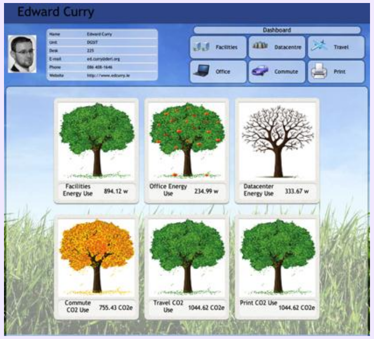
Enterprise Energy Observatory


DERI Energy Observatory
Total Power
Current: 43.86 W
Mean: 19.80 W
Total C02
CO2
Current: 3512.81
Mean: 1540.46
Fuels Mix
23.00 %
59.00 %
16.00 %
2.00 %
DERI Web of Data-as-a-Service
Cost per data request:
2140.08 W
DERI
Datacenter
Current: 9.46 W
Mean: 6.88 W
Office
Current: 34.40 W
Mean: 51.85 W
Building
Current:
Mean:
Travel
Current:
Mean:
Commute
Current:
Mean:

Organisation


DERI Energy Observatory
Data requests:
00034672
since xx/xx/xxxx
Cost per search:
2140.404
Total Power
Current: 14.24 W
Mean: 6.89 W
Fuels Mix
23.00 %
59.00 %
16.00 %
2.00 %
CO2 Equiv.
CO2
Current: 572.92 W
Mean: 515.31 W
Number of machines :
1
Average power usage per machine:
942788.59
Back to dashboard
DERI

Business Process


Edward Curry

Name Edward Curry
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Website http://www.edcurry.ie

Dashboard
Facilities
Datacentre
Travel
Office
Commute
Print
Facilities Energy Use 894.12 w
Office Energy Use 234.99 w
Datacenter Energy Use 333.67 w
Commute CO2 Use 755.43 CO2e
Travel CO2 Use 1044.62 CO2e
Print CO2 Use 1044.62 CO2e

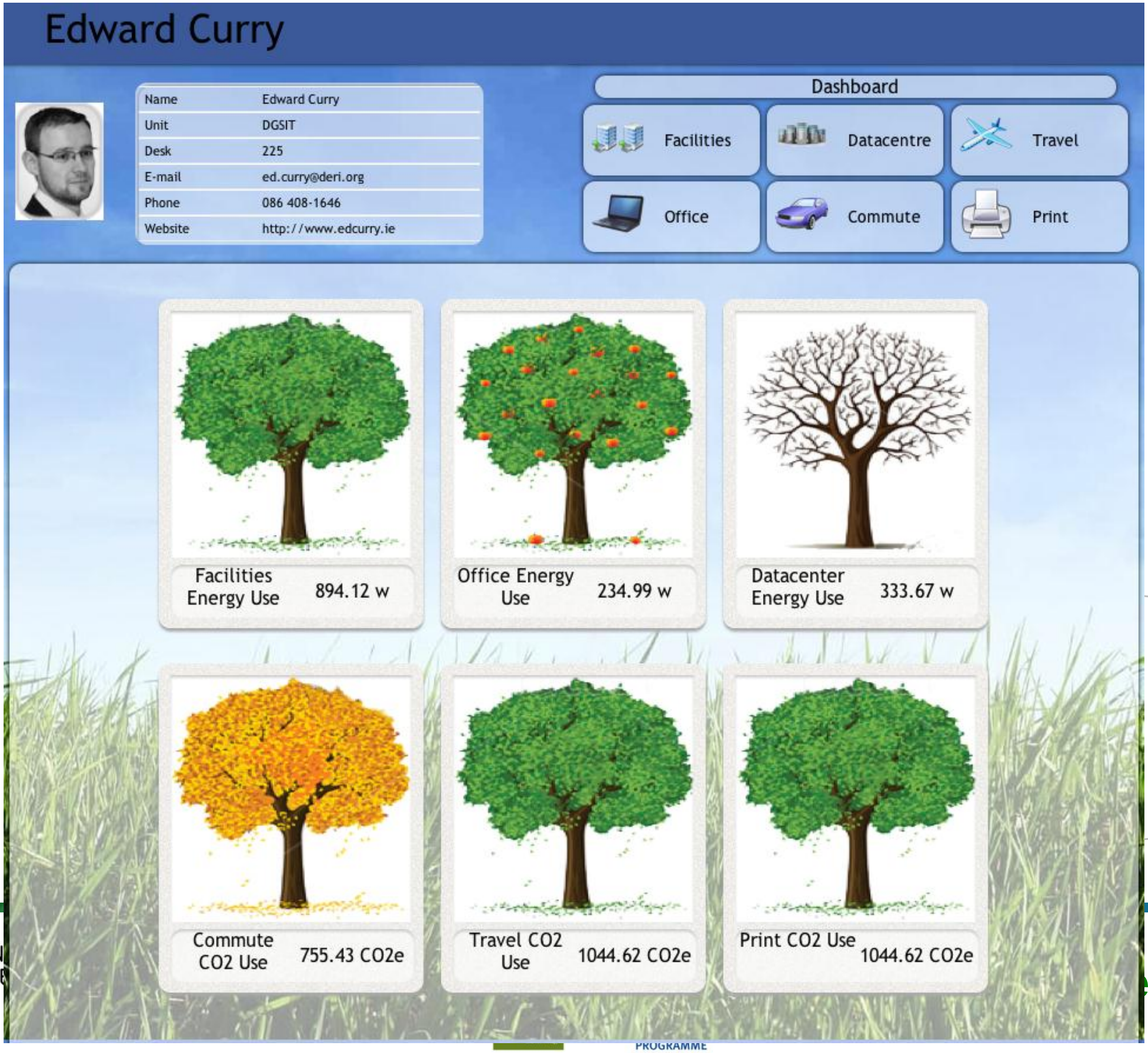
Personal

Open Energy Intelligence Platform

(Linked Data, Semantic Web, Semantic Sensor Networks)

sfi
Fondúireacht Eolaíochta Éireann
Science Foundation Ireland
ENTERPRISE IRELAND
Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union
EUROPEAN REGIONAL DEVELOPMENT FUND
IRCSET
Investing in People and Ideas
Irish Research Council for Science, Engineering and Technology
SEVENTH FRAMEWORK PROGRAMME

iEnergy – Personal



Edward Curry

Name	Edward Curry
Unit	DGSIT
Desk	225
E-mail	ed.curry@deri.org
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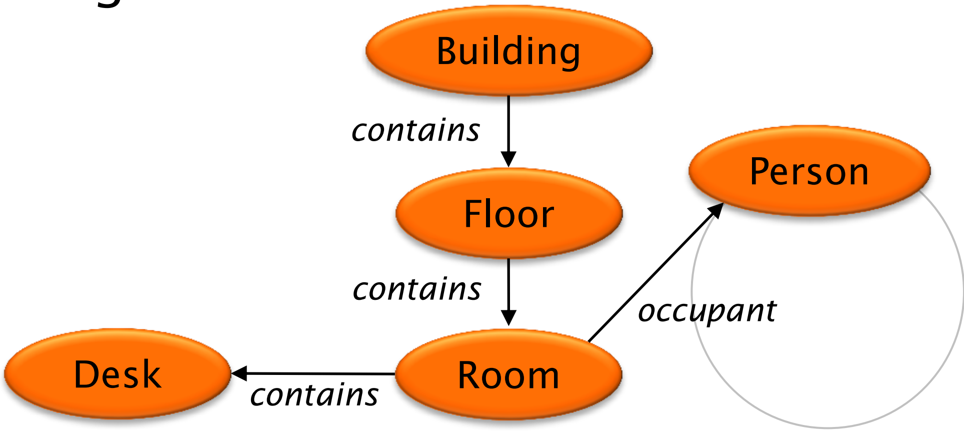
Website	http://www.edcurry.ie

Dashboard
Facilities
Datacentre
Travel
Office
Commute
Print

Facilities Energy Use	894.12 w
Office Energy Use	234.99 w
Datacenter Energy Use	333.67 w
Commute CO2 Use	755.43 CO2e
Travel CO2 Use	1044.62 CO2e
Print CO2 Use	1044.62 CO2e

Vocabulary Used

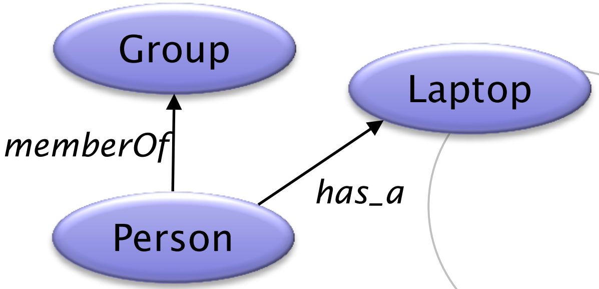
- Buildings and Rooms
  - ☐ Simple vocabulary for describing the rooms in a building
  - ☐ http://vocab.deri.ie/rooms



- Queries
  - ☐ How many floors are in the Building?
  - ☐ How many desk on are the first floor?
  - ☐ Who is the occupant of room 202e?
  - ☐ Where does Edward Curry sit?

Vocabulary Used

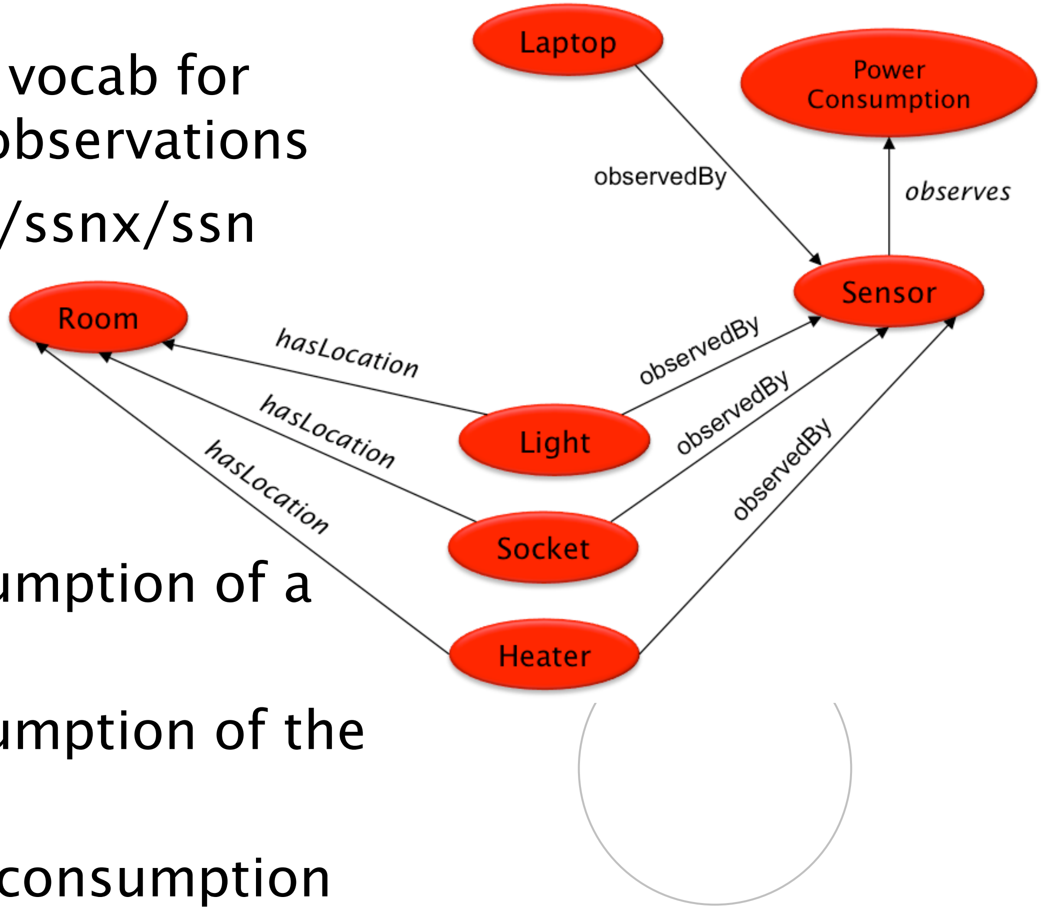
- People, Groups and Devices
  - FOAF: Simple vocabulary for describing peoples and groups.
  - DERI Energy: Devices and Laptops



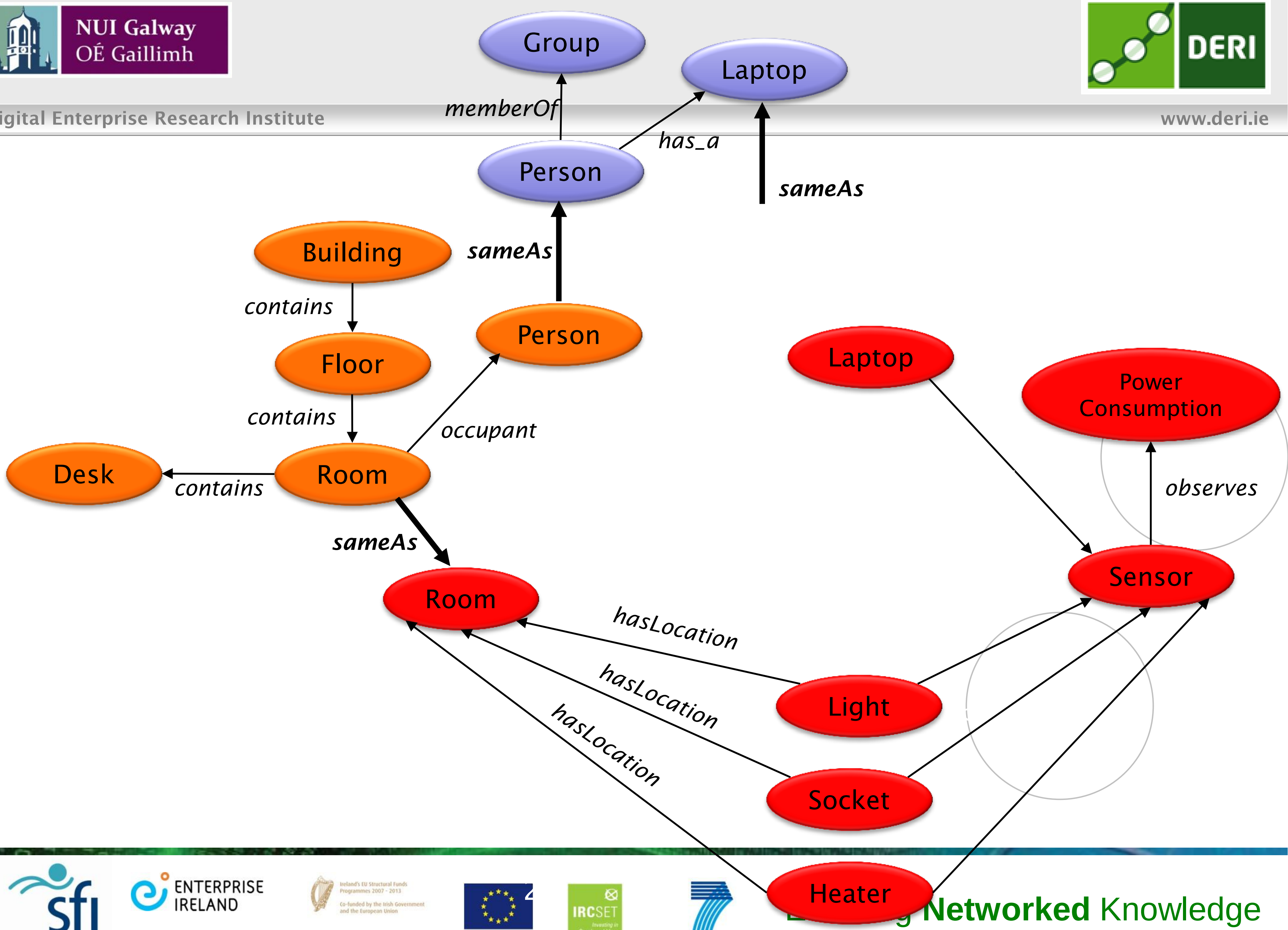
- Queries
  - Who are the members of the Green IT group?
  - What laptop does Edward have?
  - What laptops are used by the Green IT group??
  - Who is using a MacBook Pro?

Vocabulary Used

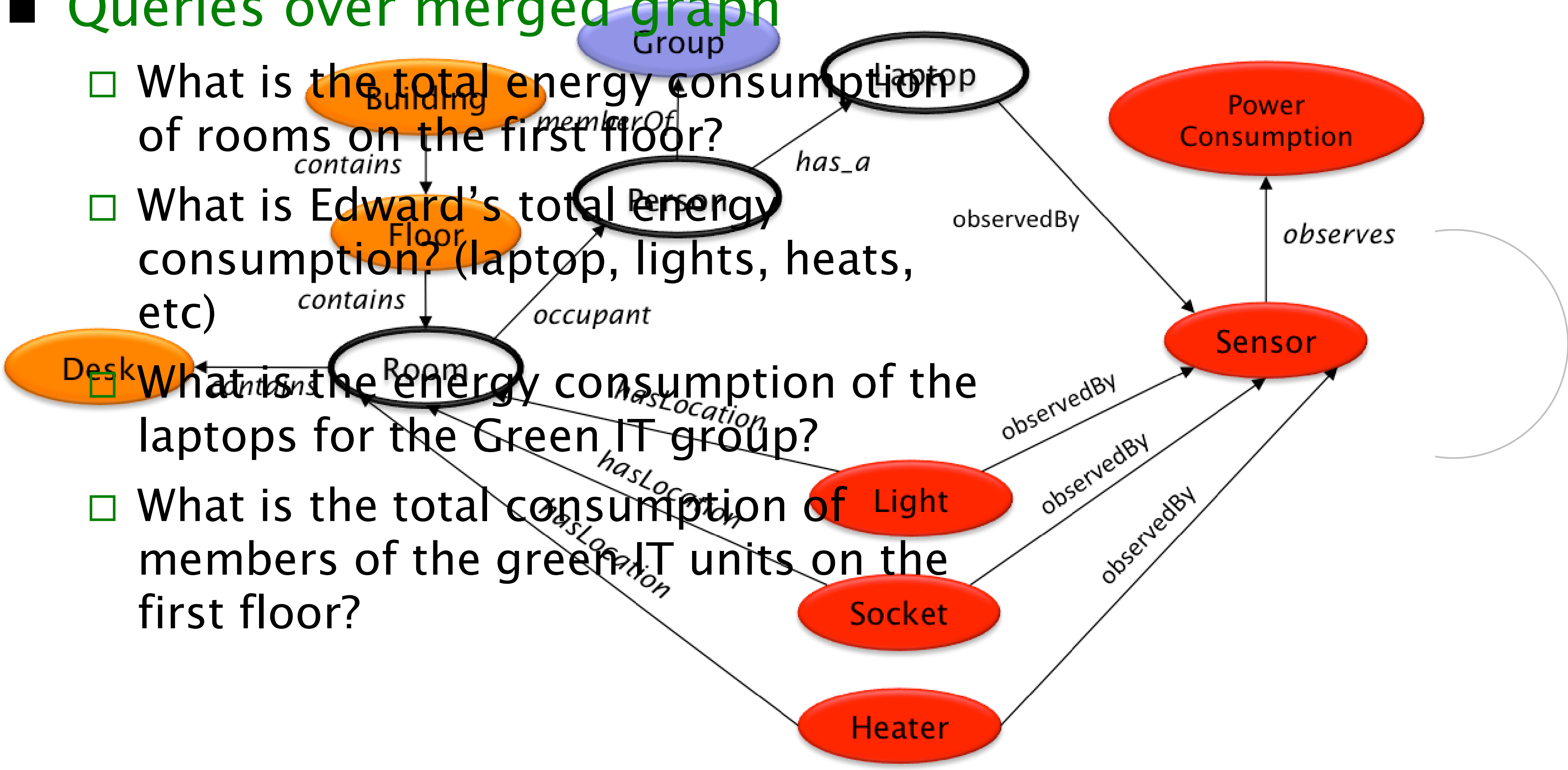
- Energy Sensor Network
  - Semantic Senor Network vocab for describing sensors and observations
  - http://purl.oclc.org/NET/ssnx/ssn


Laptop
Power Consumption
observedBy
observes
Sensor
Room
hasLocation
observedBy
hasLocation
observedBy
Light
hasLocation
observedBy
Socket
Heater

- Queries
  - What is the energy consumption of a laptop?
  - What is the energy consumption of the lights in room 202e?
  - What is the total energy consumption of room 202e?


Group
Laptop
memberOf
has_a
Person
sameAs
Building
sameAs
contains
Person
Floor
Laptop
Power Consumption
contains
occupant
Desk
Room
contains
observes
sameAs
Sensor
Room
hasLocation
hasLocation
Light
hasLocation
Socket
Heater

Linked Data


Group
Laptop
Building
memberOf
Power Consumption
has_a
contains
Person
Floor
observedBy
observes
contains
occupant
Sensor
Desk
Room
contains
hasLocation
observedBy
Light
hasLocation
observedBy
hasLocation
observedBy
Socket
Heater

- Queries over merged graph
  - ☐ What is the total energy consumption of rooms on the first floor?
  - ☐ What is Edward’s total energy consumption? (laptop, lights, heats, etc)
  - ☐ What is the energy consumption of the laptops for the Green IT group?
  - ☐ What is the total consumption of members of the green IT units on the first floor?

Selected References

- Curry, E., et al . (2011). An Entity-Centric Approach To Green Information Systems. 19th European Conference on Information Systems (ECIS 2011).
- Hasan, S. et al. (2011). Toward Situation Awareness for the Semantic Sensor Web: Complex Event Processing with Dynamic Linked Data Enrichment. 4th International Workshop on Semantic Sensor Networks
- Curry, E., & Donnellan, B. (2012). Green and Sustainable Informatics. In, Harnessing Green IT: Principles and Practices (in press). John Wiley & Sons
- Curry, E. et al, Using Multi-Domain Data to Optimize Building Operational Performance: A Linked Data Approach to Interoperability. Advanced Engineering Informatics. (Under Review)
- White, M. et al. An Energy Efficiency Metric to Report the Cost of Data Centre Services to Consumers in Real-Time. DCEE 2012, (Under Review)
- Curry, E. et al. Towards an Open Platform for Holistic Real-time Enterprise Energy Intelligence: A Linked Data Approach, e-Energy 2012, (Under Review)
- Curry. E. et al. Intel and IT Sustainability, MISQE, (Under Review)