Intelligent IoT Platforms for Smart Environments – A Smart Home Example

Information Technologies Instititute (CERTH/ITI)

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Information Technologies Institute

Smart Home

OUTLINE

- Introduction
- CERTH/ITI IoT Platform
- The SmartHome example
- Closing Remarks

Why IoT Platforms

- There are plenty of hardware manufacturers that are creating new connected devices, new applications and new business processes
  - More & more commercial solutions require their own user interface(s)
  - Customer expectations are harder to meet
- Big Data Handling
  - Huge amount of information exchange, storage and process
- Cyber attacks have shifted towards IoT devices due to their connected nature
- Privacy

CERTH/ITI IoT Platform I

- **Protocol Agnostic**
  - Wi-Fi, ZigBee, EnOcean, Lora, Modbus, BACnet, Bluetooth, NB-IoT, Z-Wave
  - Rest Api, Mqtt
- **Domain Agnostic**
  - Energy, Water, Gas, Health, HuBA, Environment, Agriculture, etc.
- **OEM Platform**
  - Different types of users (5 Roles)
  - Custom Interface, Device Groups, Dashboards, Rules, etc.
  - Plenty Variety of widgets
- **User friendly** environment for handling various assets (sites, devices, sensors, etc.)
- **Real-time data monitoring** via web sockets

CERTH/ITI IoT Platform II

- Easy integration of third party software
  - Python, Java, Angular js, PHP, Tick Script

Data Storage –Data retrieval

- **Mongo DB** stores object information data
  - Clients
  - Users
  - Sites, Portfolios
  - Assets, Devices, Device Groups
  - Dashboards
  - Rules

- **Influx DB** stores time series data
  - Measurements from sensors
  - Data produced by the IoT Platform (prediction, costs, alerts, …)

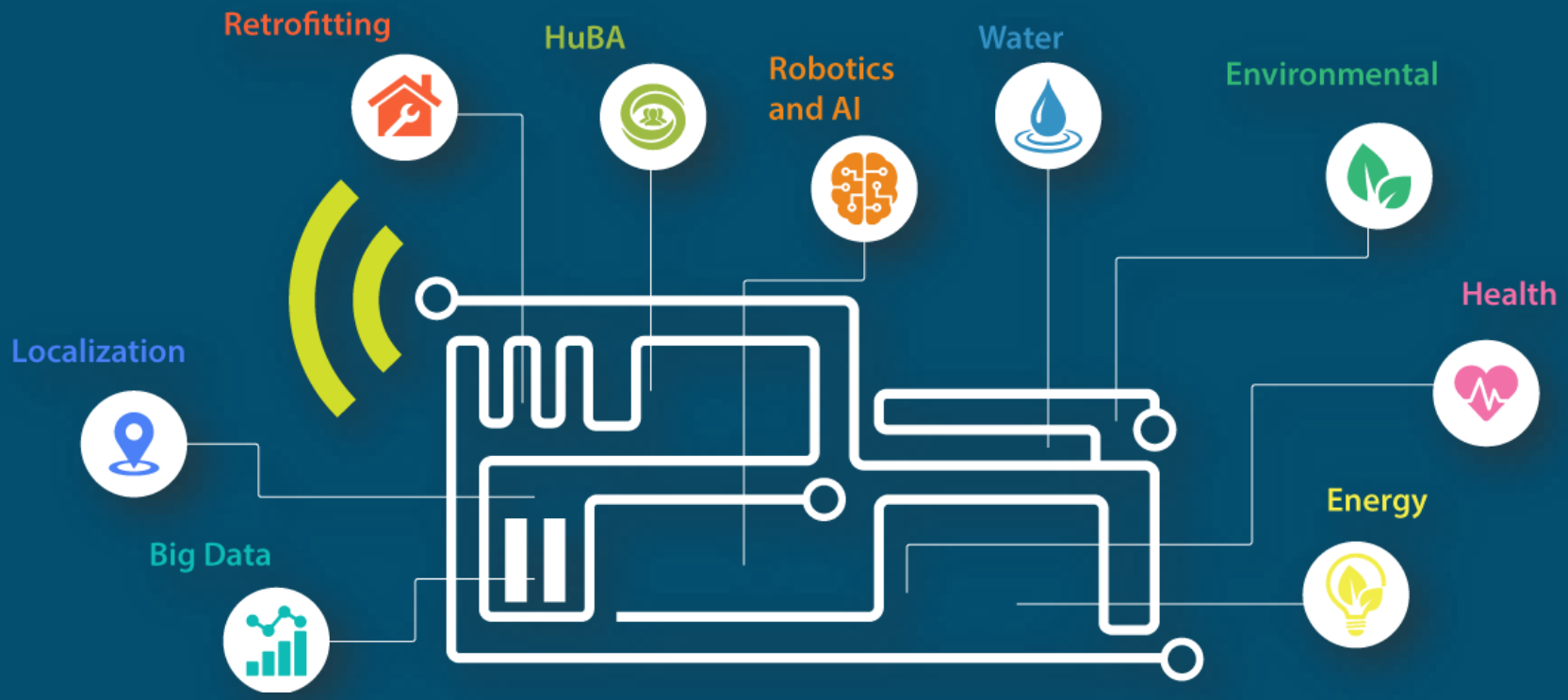
CERTH/ITI IoT Platform III

Cyber Security and Data Privacy

- Successfully passed penetration testing
- Separate database for each client
  - Only Authenticated users can access each clients data
- Secured via SSL certificate
  - Communication via https, tls, wss
- Basic Authentication required for every information exchange
- Proxy Server
  - All ports are closed except https port (443)
- Authorized Access to databases only via Rest Services
- Server 24/7 Up due to docker infrustructure
- GDPR Compatible
  - No private data is stored on the IoT Platform

ITI nZEB Smart Home ecosystem

A rapid prototyping & novel technologies demonstration infrastructure resembling a real domestic building where occupants can experience actual living scenarios while exploring various innovating smart IoT-based technologies.



Existing Infrastructure I

As the first Smart near-Zero Energy Building in Greece, it combines enhanced construction materials and intelligent ICT solutions creating a future-proof, sustainable and active testing, validating and evaluating ecosystem.

- SoA Construction concept
  - Cutting-edge insulation materials
  - Triple glasses for windows with low Ug
  - Modern Design
  - >300m² - Main House and Supporting Areas (Demo Room, Control Rooms)
- Smart and Fully controllable **LOADs**
  - Dimming & On/Off Lighting – Indoor and Outdoor
  - HVAC (complete monitoring and control of a VRV installation)
  - Smart Home Appliances (WiFi enabled appliances)

Existing Infrastructure II

- Energy Generation & Storage

A highly flexible and adaptable installation that includes:

- 9,57 kWp Thin Film PVs with a 10 kW Inverter (Modbus enabled)
- 4,68 kWh Lithium Ion Batteries distributed to 3 single phase 3kW Inverters (Modbus enabled).
- Islanding capability of basic *House* Loads.

- Health

- Variety of Wireless Medical Devices (oxygen, blood pressure, glucose, body temperature, etc.)
- High Resolution Occupancy Detection Devices (i.e. Bluetooth beacons)
- Smart Watches & Wristbands for biometrics

Existing Infrastructure – III

- **WiFi**
  - Smart Appliances
  - Energy Meters
  - Smart Door Locking and Parking Systems Control Unit
  - People Counter: Occupancy
- **ZigBee**
  - Smart Plugs/Lamps (On/Off Actuation / Consumption)
  - Temperature, Humidity, Motion Sensors
- **EnOcean**
  - Lights Dimming
  - CO_2 / Temperature Luminance Sensors
- **Z-Wave**
  - Motion, Temperature, CO_2, Luminance Sensors
  - Door/Window/Cupboard Sensors

Existing Infrastructure – IV

- **Bluetooth**
  - Blood Pressure / Glucose Sensors
  - Body Temperature
  - Oxygen Level
  - Beacon: Occupancy
- **LoRA**
  - Events: Motion, Water leakage, Horizontal Liquid Level
  - Parking: Presence/Absence
  - Gases: CO, NO_2, CH_4, $CH\text{-}CH_3$, H_2, $CH_3\text{-}CH_2\text{-}OH$, NH_3, H_2S, $CH_3\text{-}CH_2\text{-}OH$, $C_6H_5CH_3$)
  - Smart Water: pH & Temperature
  - Agriculture: Temperature, Humidity, pressure, Luminosity, Leaf Wetness, Soil Moisture, Weather Station (wind speed, wind direction, rain volume, …), Soil/Water Temperature, Solar radiation
  - Water Meters
- **NB-IoT**
  - End to end NB-IoT Test Bed

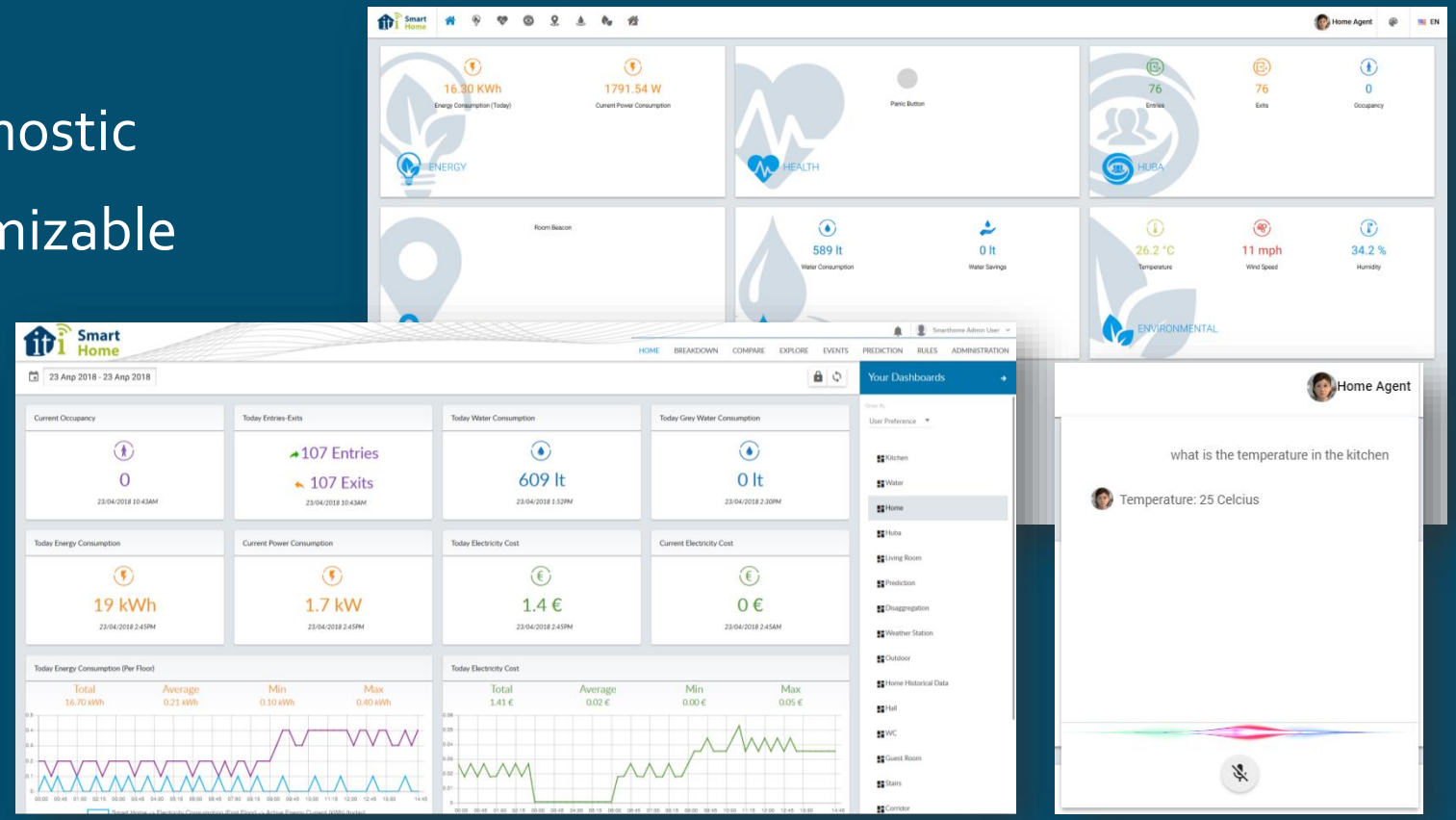
Existing Infrastructure – V

- **BACnet**
  - HVAC: complete monitoring and control

- **Modbus**
  - Energy, Power, Voltage, Amperage, PF, …
  - Access to PV Generation
  - Access to Battery Inverters – Islanding coordination
  - Access to Battery Shunt Information.

Multi-Layer Monitoring & Control Interface

- Interoperable voice activated IoT Platform(s) for monitoring & control
  - Device/domain/protocol agnostic
  - User friendly / Highly customizable
  - Multi-Layer Users Support
  - Increased Security,
  - and more…



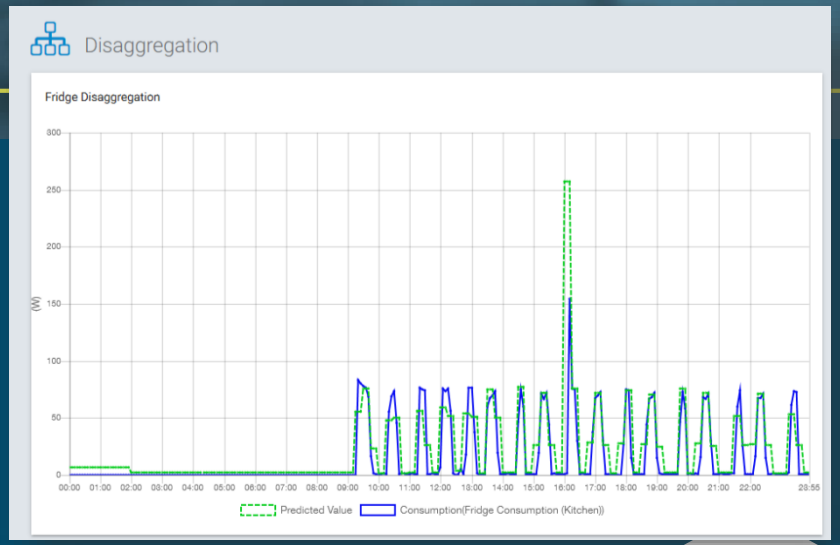
DIH Energy

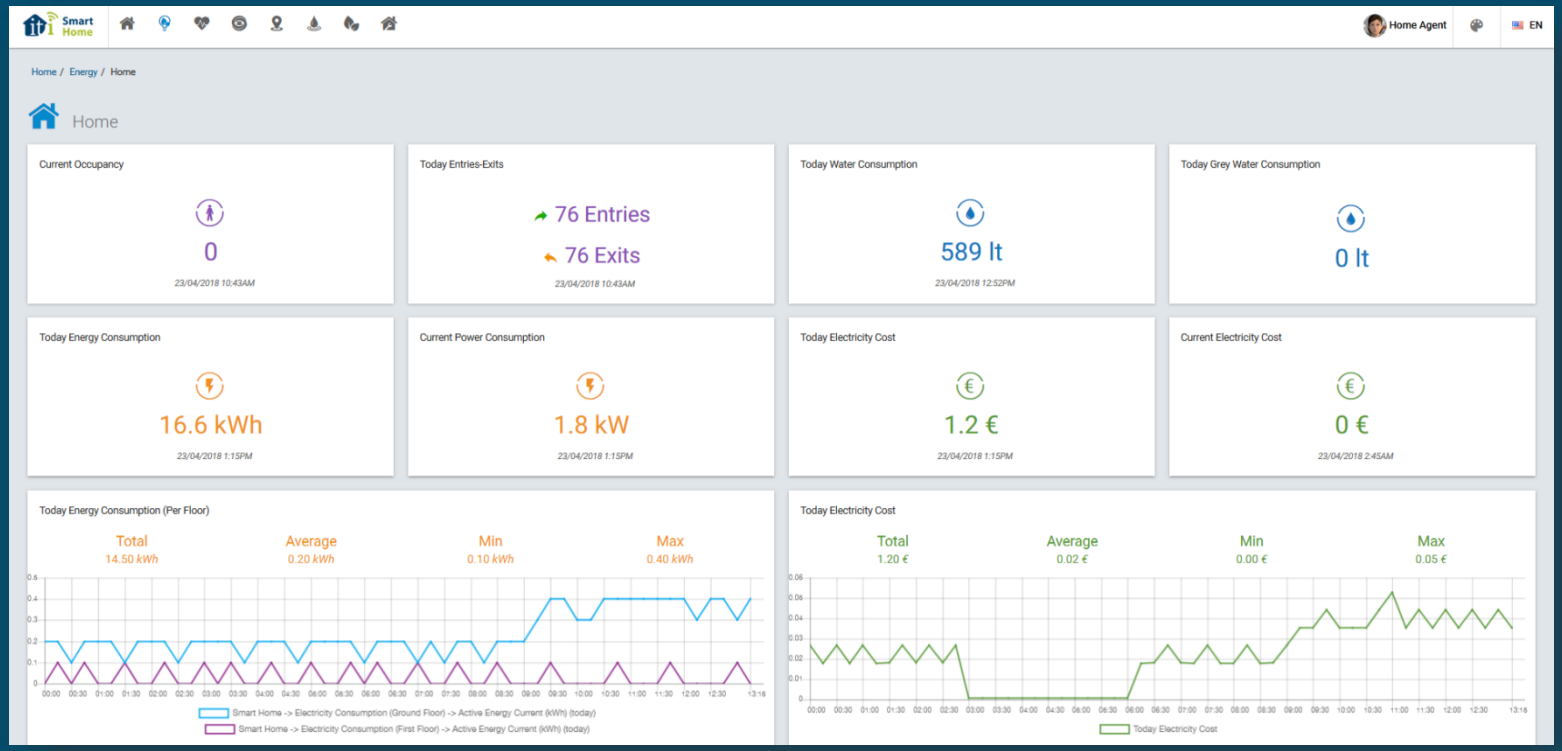
Holistic Building Energy Management :

- Complete monitoring & control of electrical assets
- Integration with Smart Appliances
- Economic Analysis of Energy Use
- Energy Consumption & Generation Prediction/Forecasting
- Energy Consumption Disaggregation
- Voice Activated Intelligent Agent for HMI Interaction
- Occupant-based Building Automation
- Islanding capability through PV and ESS complete integration

DIH Energy

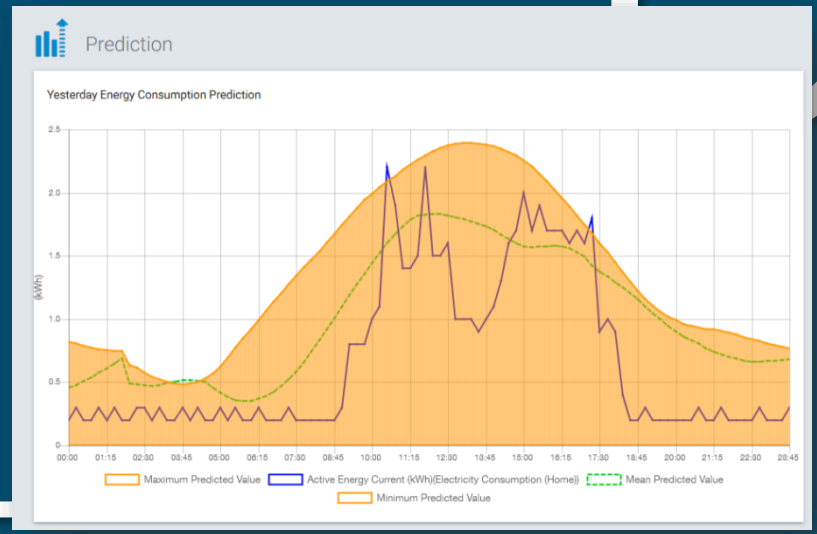
- Disaggregation





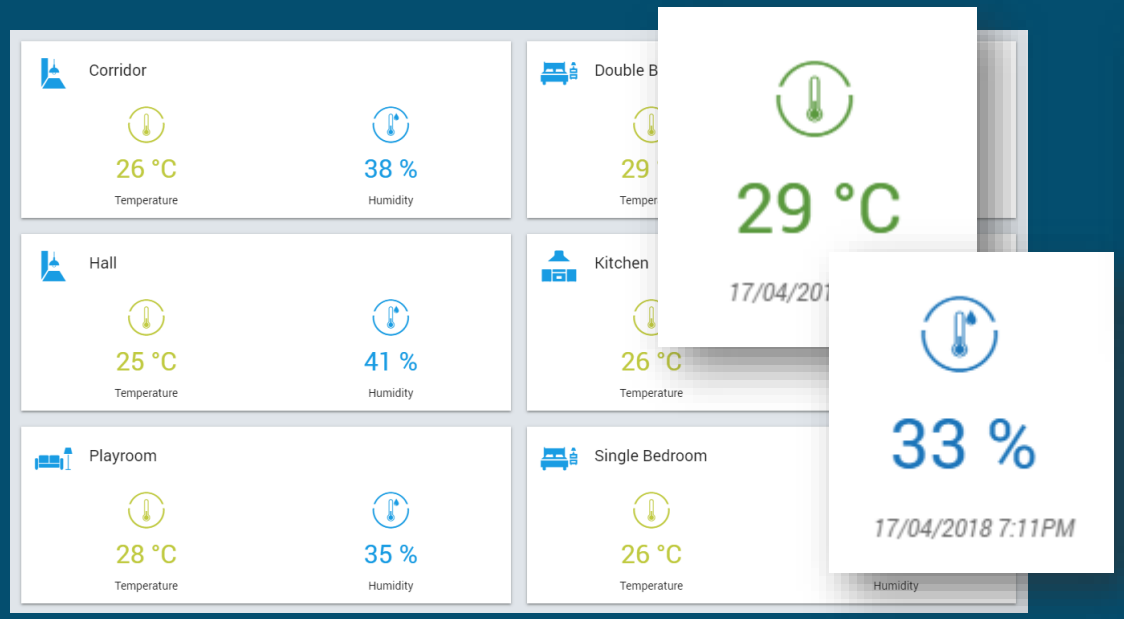
- Real-time Access per Building / Room / Device

- Prediction

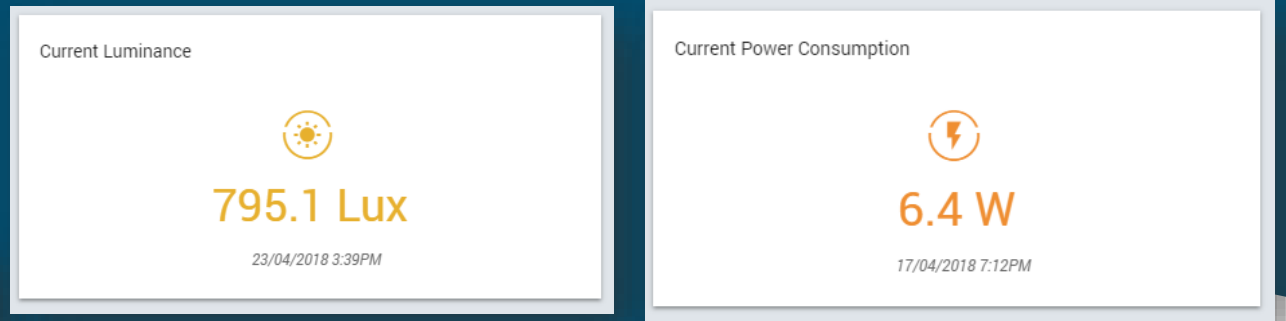


Real-time detailed spatial monitoring

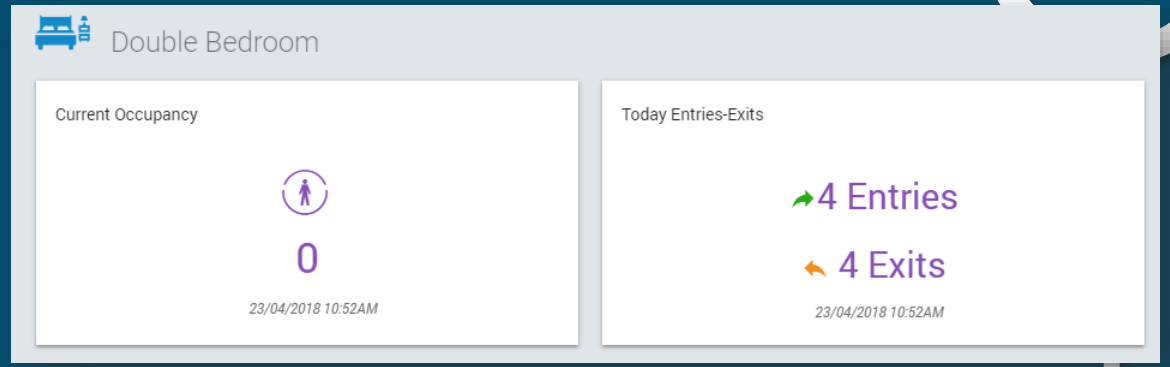
Monitoring Temperature & Humidity per space



Monitoring Luminance & Energy consumption



Occupancy & Entries/exits



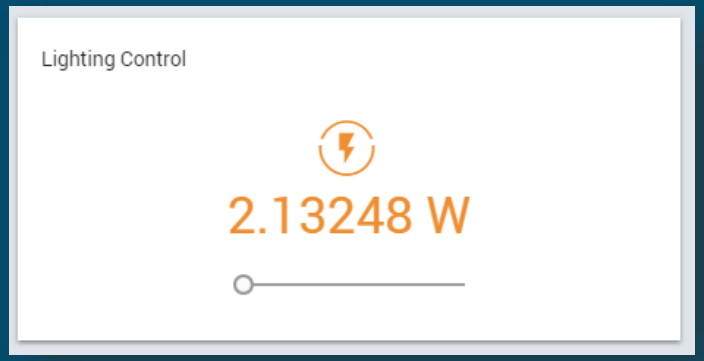
Monitoring CO_2 level

Control actions

Control lights

On/off

Dimming



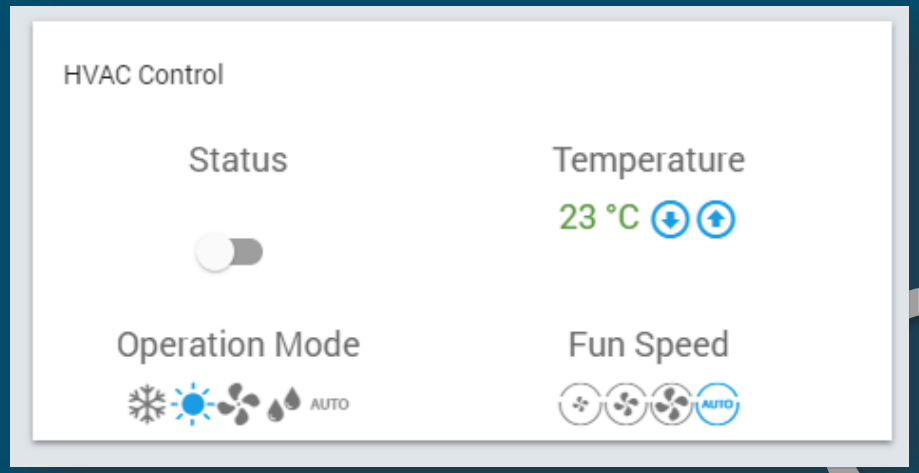
HVAC Control

On/off

Set temperature

Control mode

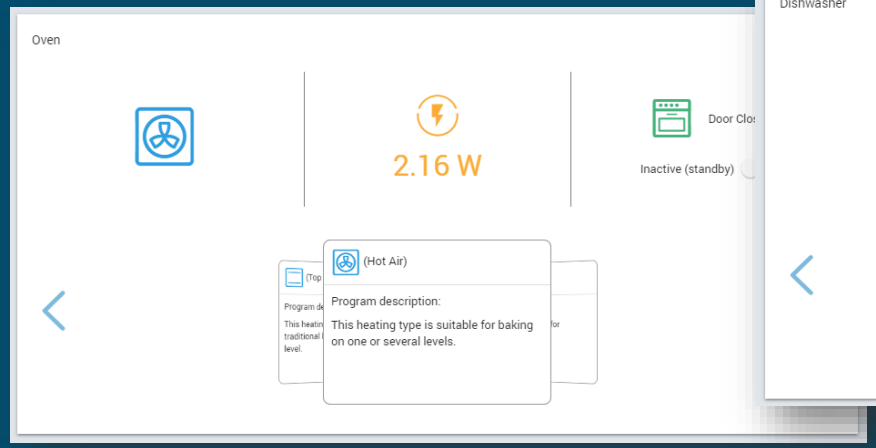
Control fun speed



Control TV & other devices

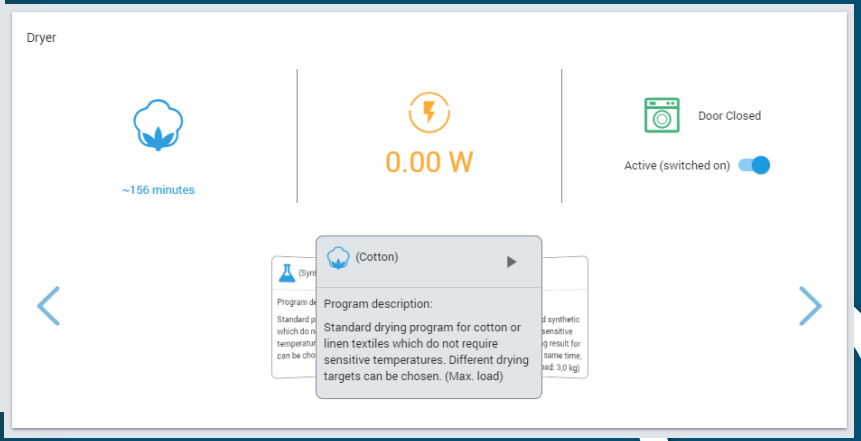
SMART APPLIANCES MONITORING & CONTROL

Oven



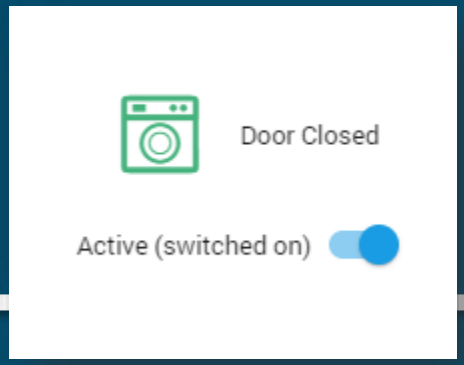
Dishwasher

Dryer

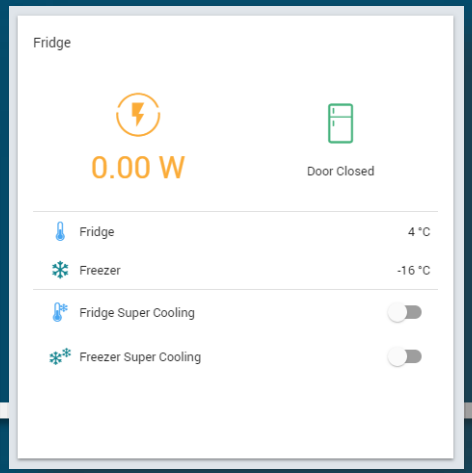


Program progress

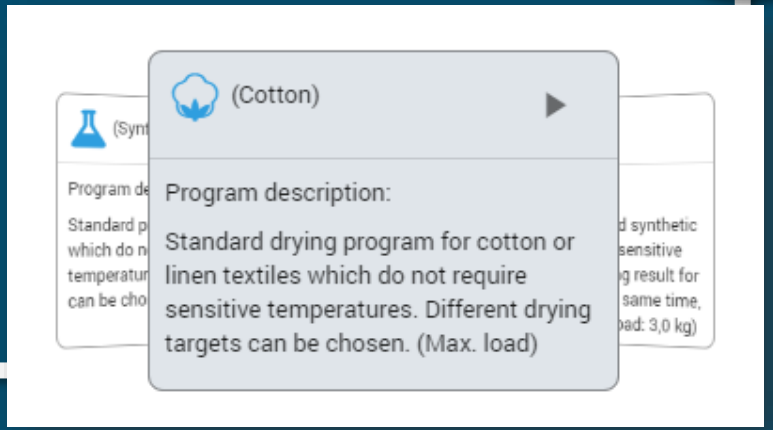
Door status & control device (on/off)



Fridge



Select & start a program

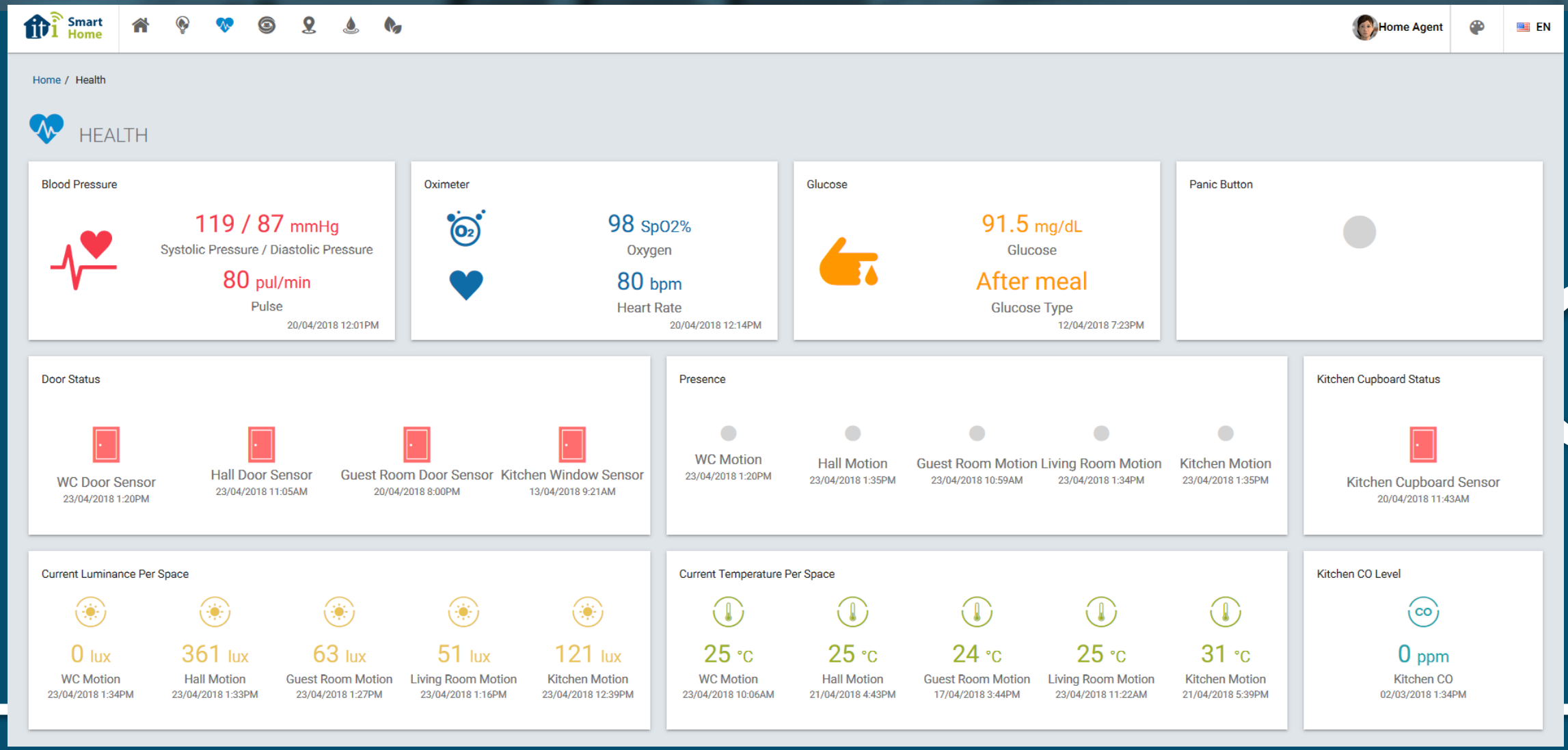


DIH Health

Assistive Living and Health Monitoring

- Continuous, Connected Care Patient Monitoring through Various Medical & Alarm Devices
- Real-time Predictive Analytics
- Treatment adherence
- Behavioural monitoring and peace of mind
- Wellness and quality of life integrated services, along with AI-driven Conversational Agent (Virtual Assistant) for Self-management of chronic diseases.

DIH HEALTH


Smart Home
Home Agent
EN
Home / Health
HEALTH
Blood Pressure
119 / 87 mmHg
Systolic Pressure / Diastolic Pressure
80 pul/min
Pulse
20/04/2018 12:01PM
Oximeter
98 SpO2%
Oxygen
80 bpm
Heart Rate
20/04/2018 12:14PM
Glucose
91.5 mg/dL
Glucose
After meal
Glucose Type
12/04/2018 7:23PM
Panic Button
Door Status
WC Door Sensor
23/04/2018 1:20PM
Hall Door Sensor
23/04/2018 11:05AM
Guest Room Door Sensor
20/04/2018 8:00PM
Kitchen Window Sensor
13/04/2018 9:21AM
Presence
WC Motion
23/04/2018 1:20PM
Hall Motion
23/04/2018 1:35PM
Guest Room Motion
23/04/2018 10:59AM
Living Room Motion
23/04/2018 1:34PM
Kitchen Motion
23/04/2018 1:35PM
Kitchen Cupboard Status
Kitchen Cupboard Sensor
20/04/2018 11:43AM
Current Luminance Per Space
0 lux
WC Motion
23/04/2018 1:34PM
361 lux
Hall Motion
23/04/2018 1:33PM
63 lux
Guest Room Motion
23/04/2018 1:27PM
51 lux
Living Room Motion
23/04/2018 1:16PM
121 lux
Kitchen Motion
23/04/2018 12:39PM
Current Temperature Per Space
25 °C
WC Motion
23/04/2018 10:06AM
25 °C
Hall Motion
21/04/2018 4:43PM
24 °C
Guest Room Motion
17/04/2018 3:44PM
25 °C
Living Room Motion
23/04/2018 11:22AM
31 °C
Kitchen Motion
21/04/2018 5:39PM
Kitchen CO Level
0 ppm
Kitchen CO
02/03/2018 1:34PM

Occupant Health Status

Blood Pressure

119 / 87 mmHg

Systolic Pressure / Diastolic Pressure

80 pul/min

Pulse

20/04/2018 12:01PM

Oximeter

98 SpO2%

Oxygen

80 bpm

Heart Rate

20/04/2018 12:14PM

Glucose

91.5 mg/dL

Glucose

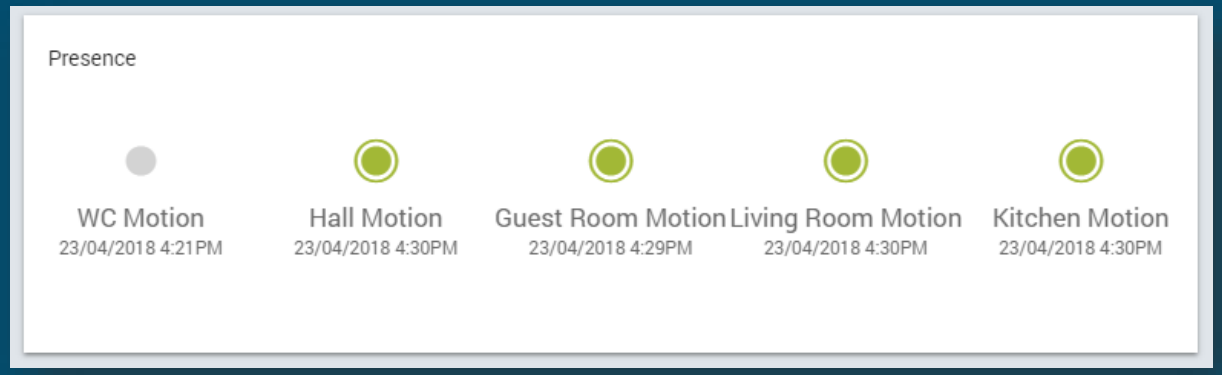
After meal

Glucose Type

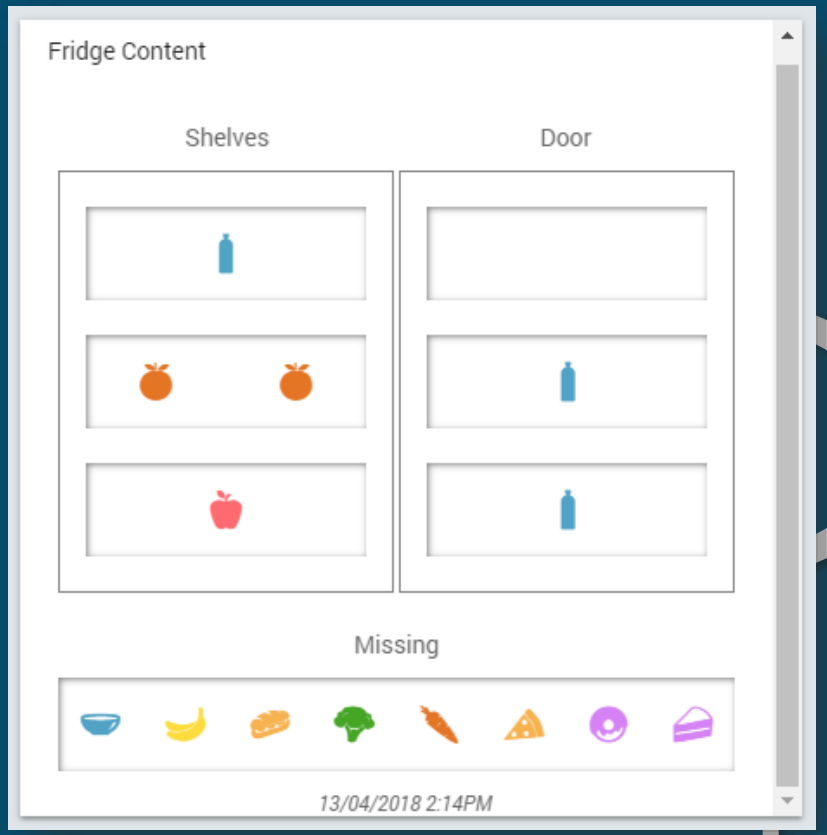
12/04/2018 7:23PM

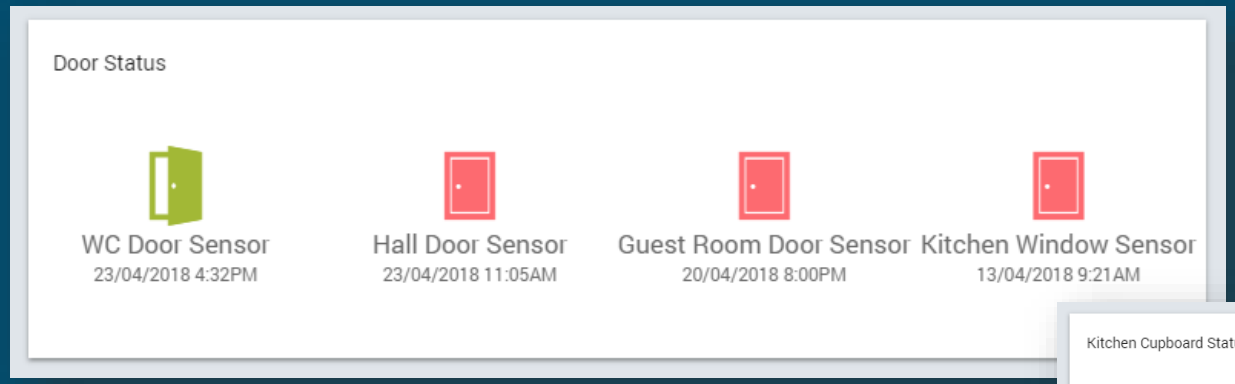
Panic Button

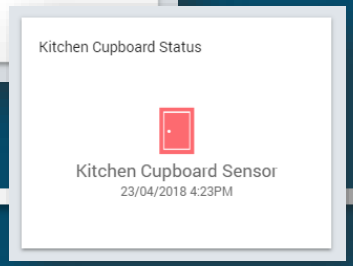
Occupant behavioral analysis



Computer vision driven support







LIVING CONDITIONS TRACKING

Current Luminance Per Space

28 lux	68 lux	42 lux	24 lux	116 lux
WC Motion	Hall Motion	Guest Room Motion	Living Room Motion	Kitchen Motion
23/04/2018 4:35PM	23/04/2018 4:37PM	23/04/2018 4:31PM	23/04/2018 4:34PM	23/04/2018 4:34PM

Kitchen CO Level

0 ppm

Kitchen CO

02/03/2018 1:34PM

Current Temperature Per Space

27 °C	28 °C	27 °C	30 °C	29 °C
WC Motion	Hall Motion	Guest Room Motion	Living Room Motion	Kitchen Motion
23/04/2018 4:35PM	23/04/2018 4:37PM	23/04/2018 4:31PM	23/04/2018 4:34PM	23/04/2018 4:34PM

DIH HUMAN BEHAVIOUR ANALYSIS

Multiple low cost and/or high accuracy solutions:

- High Accuracy (>95%) privacy-preserved depth cameras with great resolution (~cm)
- Medium Cost People Counting Active Infrared Beams
- Low Cost BLE Enabled Beacons – Smart Watch / Wristband / Phone / Device

Occupancy extraction analysis for pattern / flow / activity detection

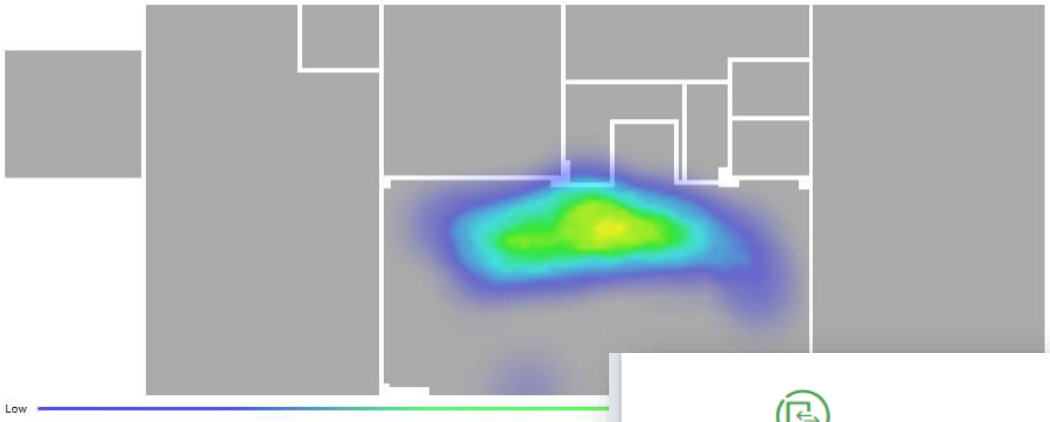
DIH HUMAN BEHAVIOR ANALYSIS

LOCALIZATION

Room Last Value (Floor Plan)

HUBA

Heatmap (Last Hour)



Room Beacon

Kitchen Fridge

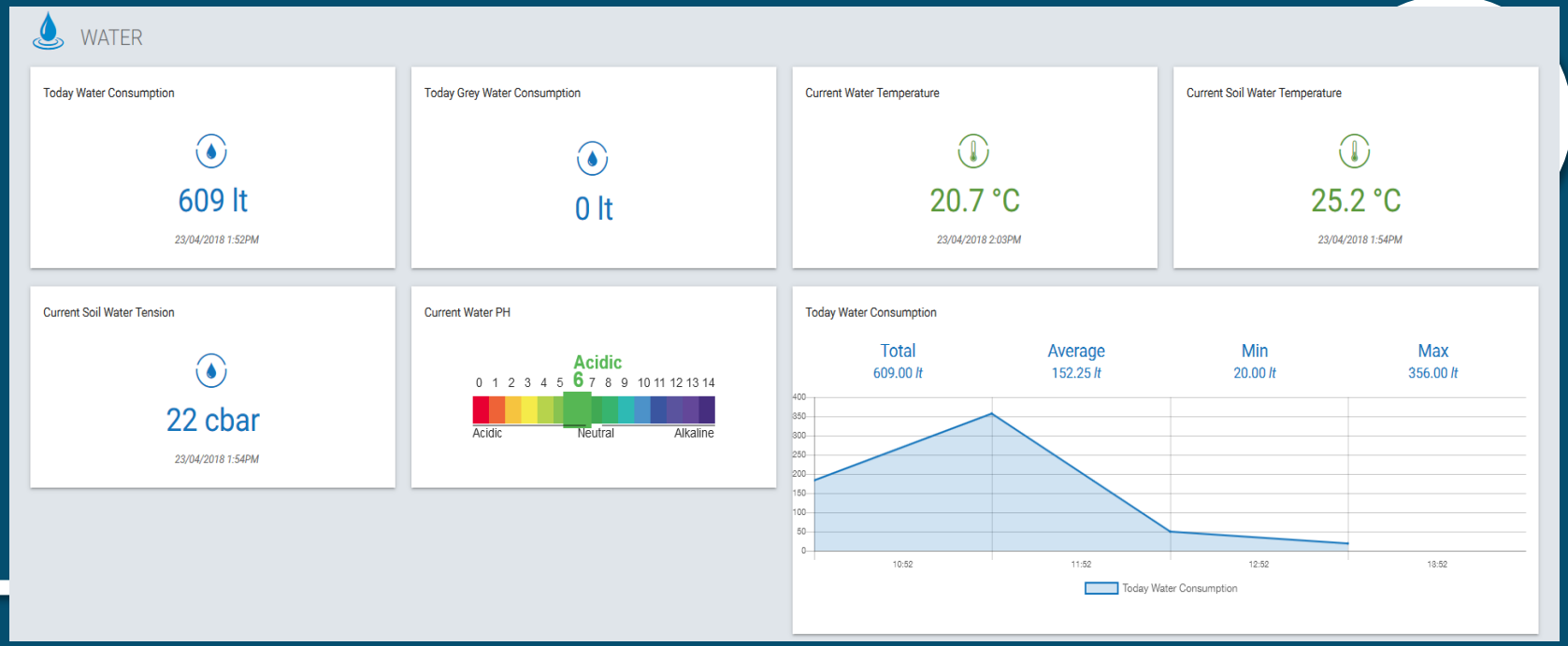
100	100	0
Entries	Exits	Occupancy

HUBA

Smart Water Analysis

Access to Water Consumption/Distribution

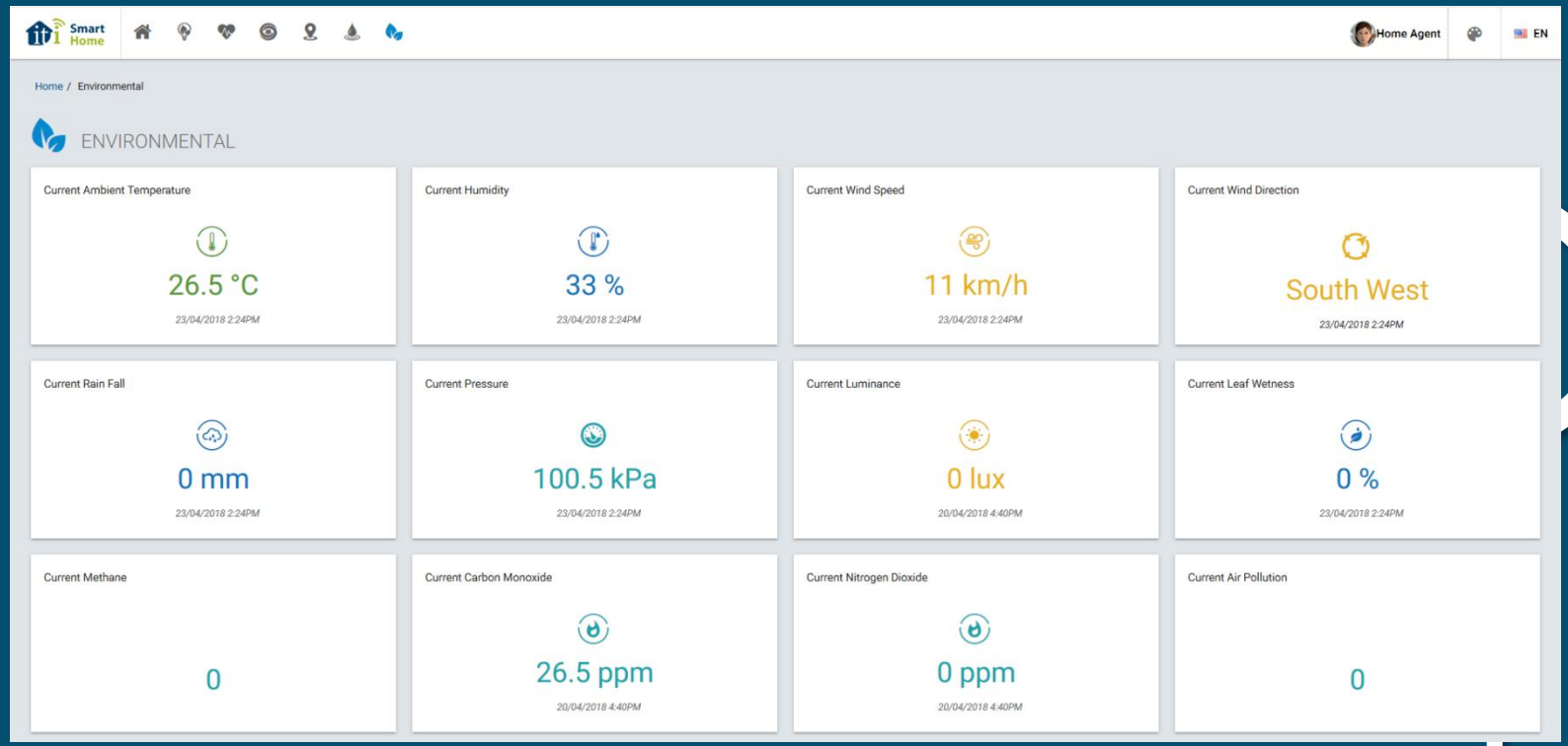
- Grey waters Utilization
- Agriculture related data
- Distribution Handling



ENVIRONMENTAL

Multi-level Indoor/Outdoor Environmental Conditions

- Temperature
- Humidity
- Pressure
- Wind Speed/Direction
- Rain
- Pollutants (NOX, COX, …)
- etc.



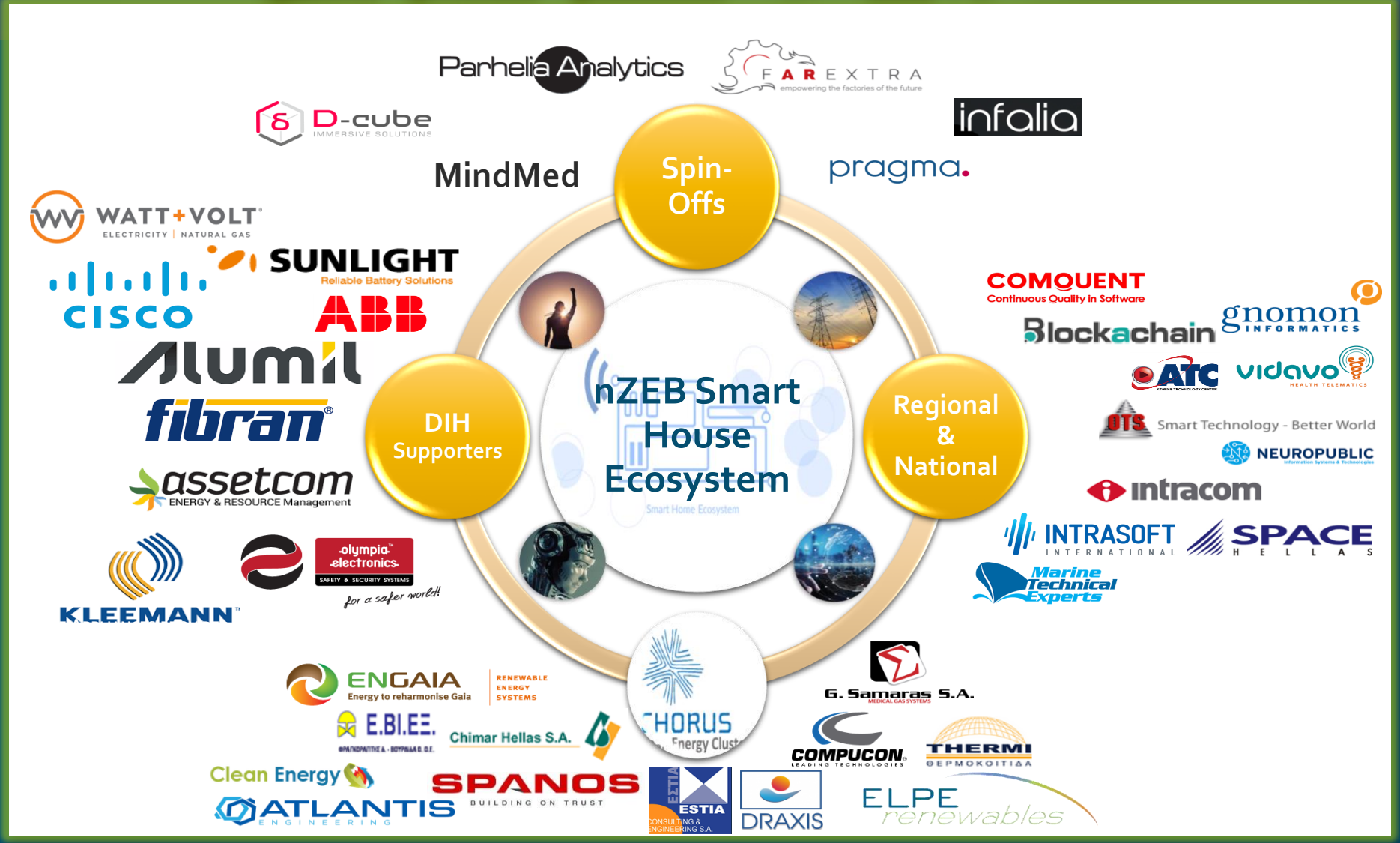
ONGOING R&D

Over 10 ongoing EU & National R&D Projects on Energy Sector

...including retrofitting related projects

As well as ***SPEAR & SIT4Energy***, ...

DIH Ecosystem



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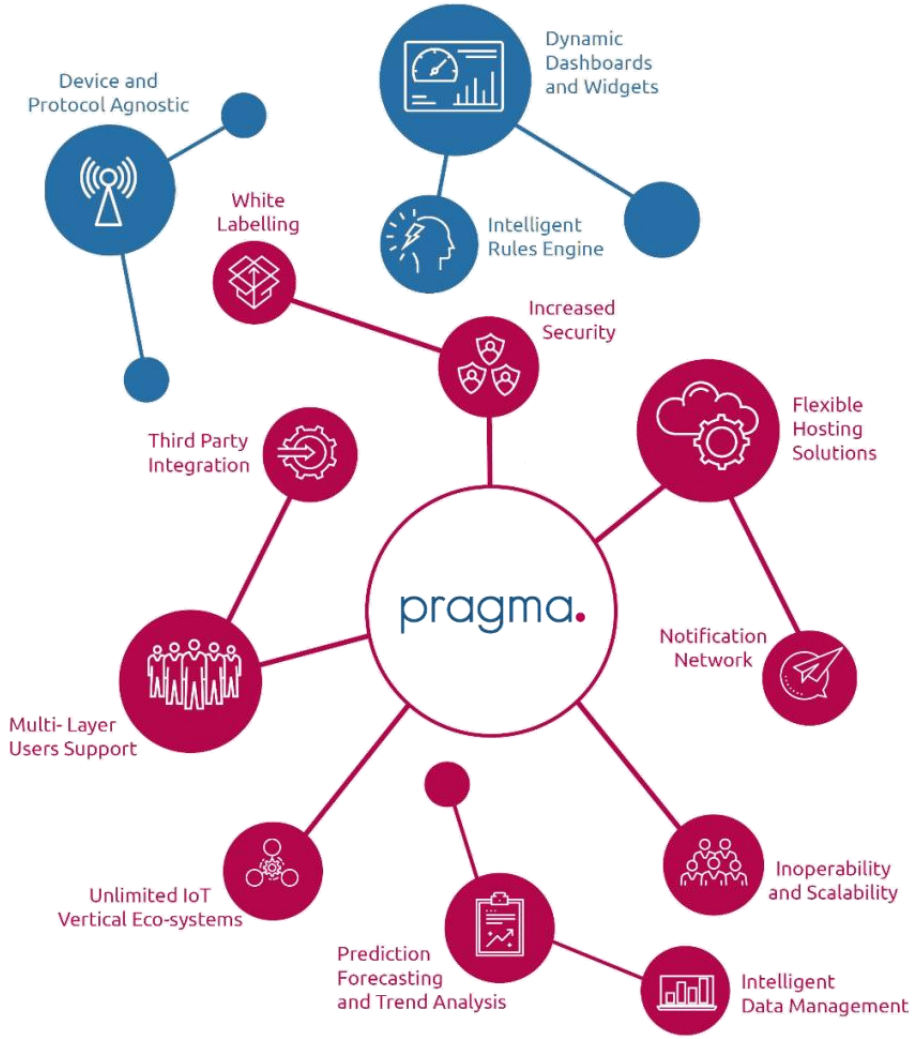
Home Appliances provided by Siemens

pragma.

Holistic IoT Solution

- **Mission:**
  - Create an **OEM IOT** Platform with **multi-user** stakeholder support**, agnostic** of **domain, sensor, gateway** with full support for **customization** & **adaptation**
- **Vision:**
  - Bring about **innovation** and **revolutionize** the IoT **domain**



THANK YOU!

Any Questions?

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