COSMOS

Cultivate resilient smart Objects for Sustainable city application

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D7.1.1 Use Cases Scenarios Definition and Design

WP7 Use cases Adaptation, Integration and Experimentation

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1 Introduction

Smart City applications are wide ranging and have many practical implications for deployment. IoT has been shown to be an effective technology for higher quality, more efficient and new city services despite some of the implementation challenges. The typical risk management strategy for Smart City applications has been to limit the scope of a business case and therefore a focused work plan can be executed with direct, measurable cost/benefit analysis.

From a city perspective, COSMOS has the goal of improving the utility of IoT systems across multiple applications, reuse existing instrumentation, provide tools for creating new applications in this integrated paradigm and demonstrate new financial benefits.

These goals are not without challenges and much work will go into technology behind the scenes. It is our approach that Work Package 7 will present use cases in a progressive fashion, with a first iteration prioritising ease of implementation and foundation over complexity while developing two further iterations Deliverables 7.1.2 and 7.1.3 progressing both the sophistication and, by virtue of the our integrated approach, the impact.

Three cities are participating in the trial Madrid, transport, London energy, Taipei future integration and assistance in understanding the situation.

In this Work Package deliverable we will

- provide the background material describing the current situation and available resources in each of the cities
- show the use cases that will be trialled within the first iteration of the project
- describe the work that is being carried out to prepare systems for use within COSMOS
- provide operational plans on data flows and communications from the city partners
- articulate some of the challenges that were discovered and any anticipated challenges ahead

The outcome of this deliverable is to inform the project, but also give future Smart City projects some working models for delivery of projects.

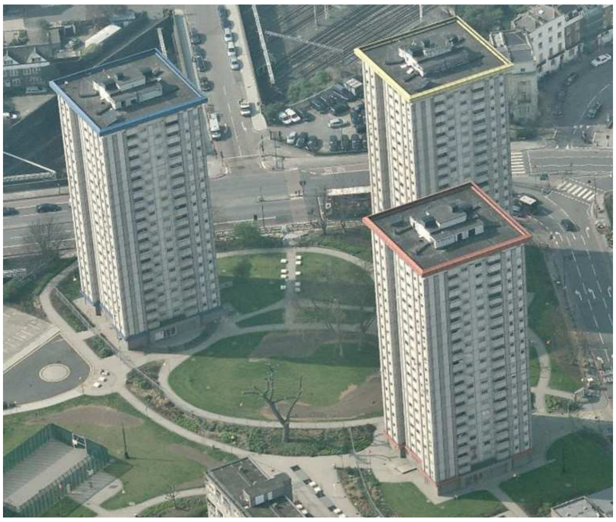
2 Description of Living Lab Cities

2.1 London Borough of Camden

The London Borough of Camden is one of the 32 principal subdivisions of the area of Greater London which is governed by a council system. It is one of the Inner Boroughs with the majority of the area classified as urban or in some cases dense urban. There are approximately 220,000 residents within an area of 21.8 square kilometres that are from a wide range of ethnicities.

The COSMOS Living Lab is being directed by the Housing Sustainability team within the Council that is in turn works with both the Housing Group and the Corporate Sustainability Team to deliver energy efficiency programmes to council tenants and leaseholders within the Camden owned housing stock.

Within the boundaries of the London Borough of Camden, the Ampthill square estate will be used to demonstrate an interconnected IoT-based system for smart energy management. The Ampthill estate is a social housing estate that comprises of three 21-storey tower blocks; Dalehead, Gillfoot and Oxenholme.



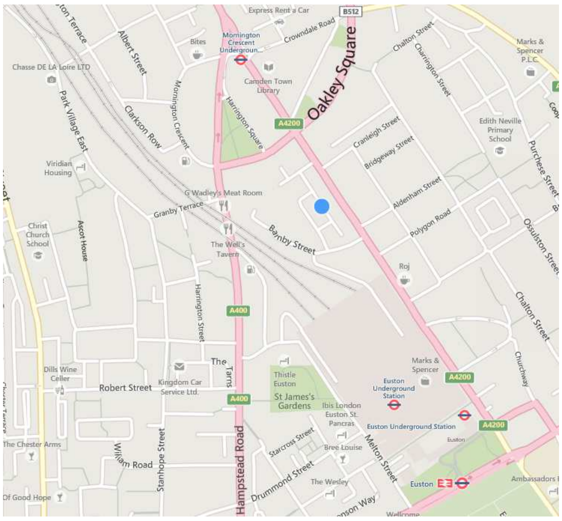


Figure 1 The Ampthill Square Estate in LBC, marked in blue on map. London NW1

The Ampthill estate is a moments' walk away from Camden High Street, and has good transport links with Euston Underground station and Mornington Crescent nearby. There are two gas fired Combined Heat and Power (CHP) systems on the roof of each building, along with Solar Thermal panels for heating water (visible in Figure 1). Combined with an on-site boiler, the components form a complete District Heating system that can provide higher efficiency and better pollution control than an ordinary system.

There are approximately 800 residents living in the Ampthill estate with a mix of cultural and socioeconomic circumstances. Ampthill reflects the cross section of urban London and its rich mix of citizens. Typical household sizes are 1 or 2 bedrooms with 1-4 occupants.

Goals and objectives of Camden are to improve the lives of citizens in a sustainable way. The area of focus for this project is through the housing sustainability team with peripheral benefits in householder finance and health.

2.2 Madrid

Madrid is the third largest city in Europe with a metropolitan area of over 600 square kilometres and a metro population of about 6.5 million. Madrid is a mix of historic neighbourhoods with small streets and squares in the centre and large boulevards and highways connecting out to the suburban areas.

Public transportation in Madrid is owned by the city and operated by subsidiary organisations. The Metro de Madrid has 283 kilometres on 13 lines with 300 stations. It has an annual ridership of approximately 650 million and connects with a large commuter rail network called Cercanias and strategic interconnections with the bus system.

Empresa Municipal de Transportes (EMT) is the bus company serving Madrid and also the partner organisation within the COSMOS project where we will implement transport scenarios. EMT carries over 400 million passengers per year in a fleet of 2,000 buses on 217 lines. The 93 million kilometres that are driven each year is controlled from one main centre with six additional operations centres in support. Also EMT is responsible for the 5,000 bus stops where in some cases there is digital information, connectivity and assistance for impaired passengers.

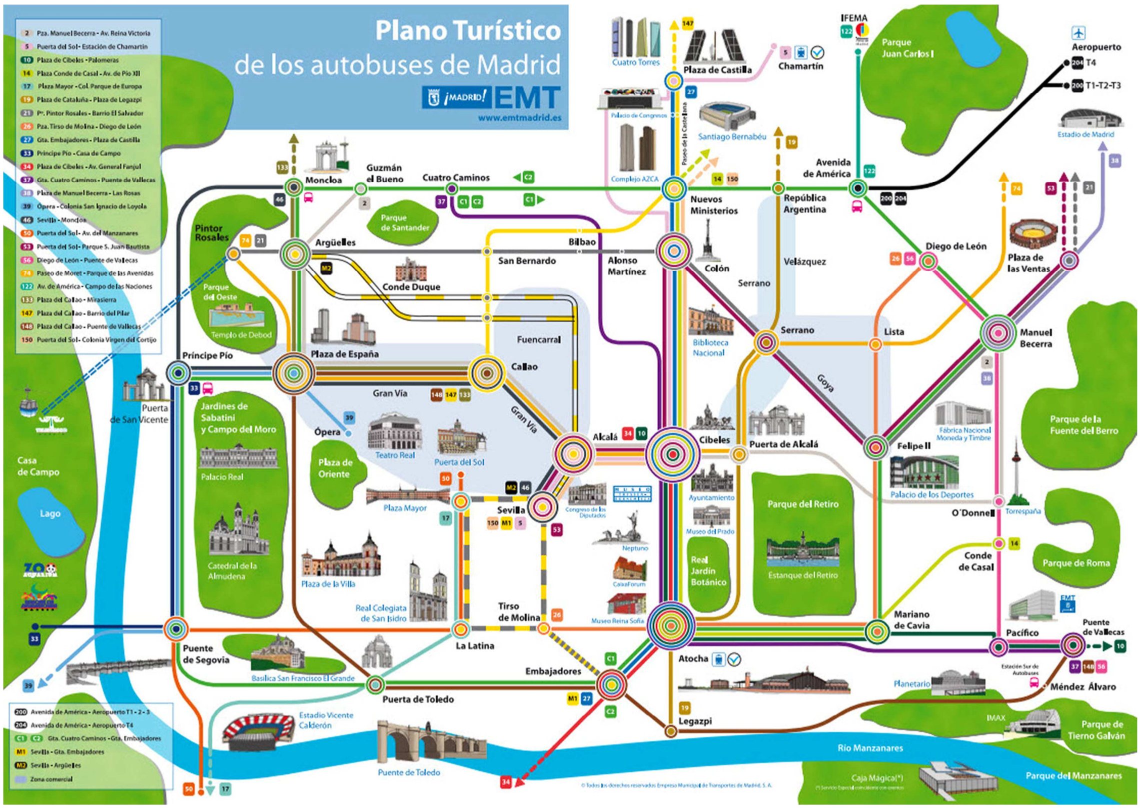


Figure 2 Although a tourist map of the Madrid bus routes, this map illustrates the density of buses within the centre, the intersecting routes and some of the major lines within the city.

Overarching goals of EMT are to make sure that buses carry passengers safely, buses are on schedule and there is access for the quantity and needs of the various passenger types. Special needs can include space for wheelchairs, assistance with sight/hearing impaired, children, elderly and the like.

Operationally this translates to good communication with passengers, drivers and control staff to keep buses spaced out evenly on lines, anticipate problems, implement special protocols (e.g. diversions, extra buses, bus priority,) and inform passengers of arrival/departure status for their journey. Information collected by EMT from the buses is vital, but equally as important is the coordination with the city’s traffic management centre.

The COSMOS project will specifically look at new services that can be offered to passengers that will help the quality of their journey, extend services to new passenger groups and offer flexibility in use of bus services.

2.3 Taipei

Taipei (literally means "North of Taiwan"), officially known as **Taipei City**, is the capital city and a special municipality of Taiwan. Minsheng community is the first American model community in Taipei, Taiwan. The current population of the community is over 80,000. In 1967, Taipei City Mayor Mr. Kao carried out an urban developing plan for land consolidation and joint development, to develop the city towards the east end. This project transforms the suburb area of 110 hectares into a modern residential area accommodating 45,000 people.

Both the living standard and the level of education of the community residents are higher than the average. The community administrative district includes 10 villages, and there are currently 20,300 households in the Minsheng Community. The community is well-equipped with public facilities, such as post offices, banks, swimming pools, tennis courts, baseball fields, parking lots and the first sewage treatment plant in Taiwan since 1970. Minsheng Community Development Association Taipei (MCDAT) was initiated by residents in 1993. The association organizes diverse activities, and they actively advance environment protection, open innovation in a live environment with the cooperation of the municipal government, research Institutes etc.

Figure 3 The city of Taipei and the study area of Minsheng

Smart Network System Institute (SNSI), a research institute of III, has worked with Ministry of Economic Affairs, developed a solution named In-Snergy, which is Taiwan 's first home energy management suite and cloud management platform for smart home energy management, with open integrated software, hardware and services, forming a safe, convenient and comfortable home environment for users.

In-Snergy caters to various needs and hardware equipment that allows consumers to monitor home appliances anytime, anywhere. Consumer can use the mobile phone app to control appliances such as thermos, air conditioners and other electronic products, help people monitor the power usage status of every appliance, and improve home energy efficiency.

While the In-Snergy service is working together with other IoT research projects in an integrated approach on the context of smart city, it also promotes the open innovation in a live environment of Minsheng community. In-Snergy service involves real uses of power meter in 2,000 households since 2012, and it deployed already to over 3,400 homes and more than 10,000 nodes.

Today each household is feeding information in such a way that data can be collected and analyzed to a decision model. The model includes factors of age, gender, demand shift, user habits etc., hence value-added data bank is incrementally built. In-Snergy efficiency scheme can be programmed and improved, advices and suggestion is presented which benefits the community/city as a whole.

Through the COSMOS work, there will be dissemination of ideas, new applications to other cities and areas which are specialising in smart mobility, telematics and smart cities, while showing scenarios enacted for smart energy and others. Detailed plans are to be set in future COSMOS work package, and new financial benefits can be demonstrated.

3 Systems Description in Living Labs

3.1 London Borough of Camden Heat Network

District heating systems involve the centralised generation and transmission of heat, usually for homes, offices and factories in urban and suburban areas with a relatively high population density. By centralising the production of heat they utilise energy more efficiently than conventional (distributed) heating systems, such as with electricity or by the combustion of oil or gas in individual domestic or industrial installations. Further, their large scale allows district heating systems to adopt better measures for reducing particulate and greenhouse-gas emissions to the atmosphere.

3.1.1. District heating: a brief history

The idea of centralised heating is not new. Under-floor or hypocaustum heating had been developed by the Romans by the 1st century BC (McParland *et al.*, 2009). When the Summer Palace in St Petersburg, Russia, was built in the early 18th century, it was warmed through the circulation of centrally-heated water from solid-fuel burning boilers, a significant innovation at the time. By the early 20th century, Icelanders had begun using geothermally heated water extracted from wells to heat their homes and villages, perhaps pioneering the idea of heating entire districts from a single source of energy (Björnsson, 2013).

The centralised generation of electricity in large power plants in the course of the 20th century offered opportunities to widen the scale of centralised heating systems to the district level. The thermal efficiency of such plants is typically about 35% for coal and oil-fired plants, up to 60% LHV (lower heating value) in combined-cycle gas-fired generators (Farmer, 2006). The 'waste' heat from such plants, previously usually released into the environment, e.g. through cooling towers or other heat exchangers, is now often utilised for district-heating schemes.

While the incentive for power companies to sell their waste heat to local consumers was purely economic in the early stages (especially following the sharp increase in fossil-fuel prices in the 1970s), increasing awareness of the need to address the causes of global warming, combined with economic incentives to reduce greenhouse-gas emissions, have in recent years provided a powerful rationale for the development of district heating schemes. Such schemes connect multiple heat sinks (e.g., homes, offices and factories) through an underground piping network and distribution substations to a variety of heat sources (e.g. combined heat-and-power plants): see Figure 1.

Today, depending on the locality, district heating systems utilise energy from sources that include industrial waste heat from cogeneration or CHP (combined heat and power) plants, in addition to heat derived from biomass (e.g., wood pellets, straw), geothermal water, methane (e.g., from sewage), solid 'municipal' waste, renewable sources, and just about any low-cost combustible material (Lindenberger *et al.* 2000; Lund *et al.* 2010; Martin & Spence 2010). While the incineration of municipal waste is approximately CO2 neutral (except for the plastics component in the waste), district-level heat production plants combusting fossil fuels emit 40-50% less CO2 than gas or oil-fuelled domestic central-heating systems (Elsman 2009), underlining once again the rationale for their widespread adoption.

The reach of district heating systems too, has been growing steadily in the temperate countries of the northern hemisphere, with a majority of the citizens of several, including Denmark, Estonia, Finland, Latvia, Lithuania and Poland, now benefiting from district heating schemes, while in Iceland almost every home, office and factory is connected to a district heating grid (Euro Heat & Power 2013). Today, cities such as Copenhagen (population 500,000), receive as much as 98% of their heating demand from district heating systems, with waste incineration accounting for as much as 30% of heat generated (Elsman 2009).

3.1.2. Factors that affect thermal load

While such centralisation offers substantial economies of scale and higher operating efficiencies, it also places great responsibility on the managers of district heating schemes to anticipate demand and ensure it is met. Demand for heating is affected by factors operating at various temporal scales, such as:

- Time of day (e.g., factories and offices have their greatest demand during working hours on weekdays, whereas homes have their greatest demand in the evenings and early mornings).
- Weekday or holiday (industrial demand is low on holidays, while domestic demand may be higher).
- Season (heat demand is usually less during summer than during winter, with demand fluctuating significantly during the shoulder-periods of these seasons)
- Ambient temperature (colder weather increases heat demand).
- Wind speed (high winds cause convective cooling and may increase heat demand).
- Insolation: clear skies may result in warmer days and radiative solar heating of buildings, but also colder nights, as a result of radiative cooling. Conversely, cloudy skies may result in cooler days but warmer nights.
- The quality of insulation of buildings.
- Social and behavioural factors.

The Heat Metering System Portal component of the Camden heat metering scheme aims to engage customers with their energy consumption and to gain an understanding of what is effective in realising energy efficiency in the home. The goal is to deliver benefits to both the customer and the Council.

Customer benefits will be delivered by technologies that increase their awareness of their own energy usage, providing them with vital information to manage and reduce their energy footprint. These technologies will include real time data and a prepayment/pay-as-you-go billing method.

The first phase of this programme was to introduce the Physical Metering and Communications infrastructure, whereby data is flowing from the meters, being gathered in an implementation of the Heat Metering System and presented back to tablets. Ad hoc reporting was available via API calls that are run by system teams at Hildebrand. These APIs will be used to present data to the Customer Access Programme, the Back Office System and the Payments gateway.

In this final phase of system delivery, Payment and Back Office functionality will be introduced along with API methods exposed to allow the Camden Customer Access Program to provide views of energy consumption and financial transactions.

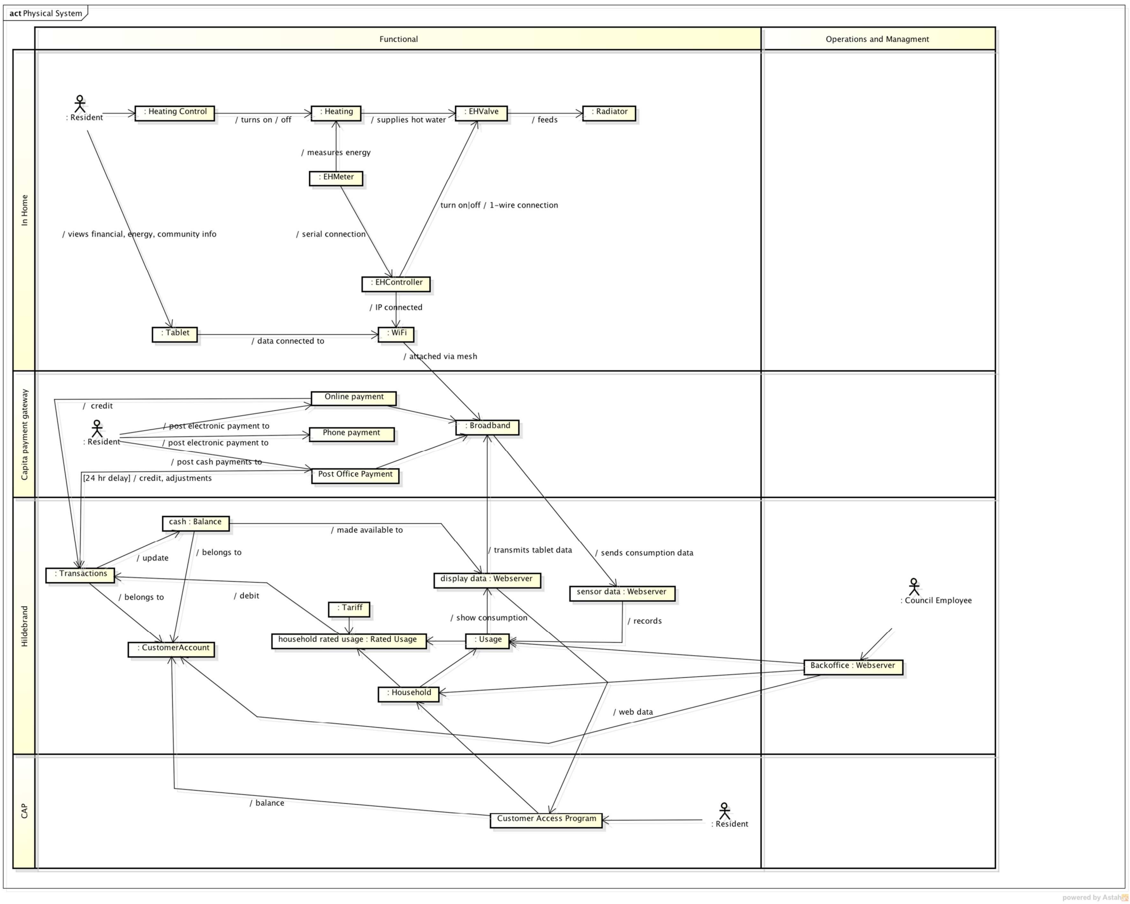


Figure 4 Overall heat metering system

The In Home Components describe the physical metering, communications and tablets. They have local configurations and operate within a private local area IP network or are direct serial communications device from device. The Core Heat Metering System manages the associations of these devices and manages the flow of data. The Back Office system has some ability to manage those physical assets and monitor their availability. One of the most important aspects of the In Home Components is the accurate metering of the heat delivery.

Outside of installation and commissioning processes, the tablet is the end user use case of interest. The installation and commissioning is handled at unit assembly so it will not be discussed within these application scenarios.

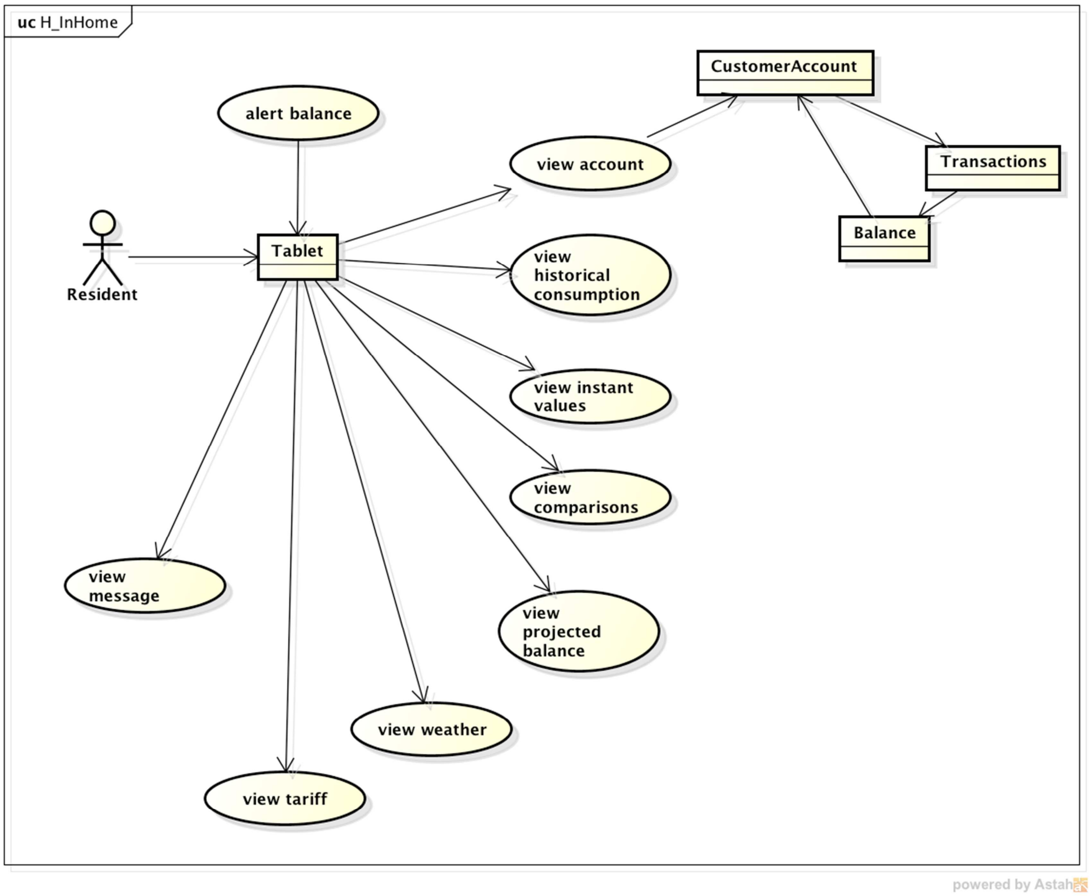


Figure 5 The tablet functionality that makes up the in-home display

3.1.3. Back Office Components

The Backoffice is the view and management control into the system for people that must operate the system. This is generally speaking, Camden Council employees that need to look at the data generated from the system, make adjustments to account balances, look at transaction histories and monitor/manage the physical assets in the system.

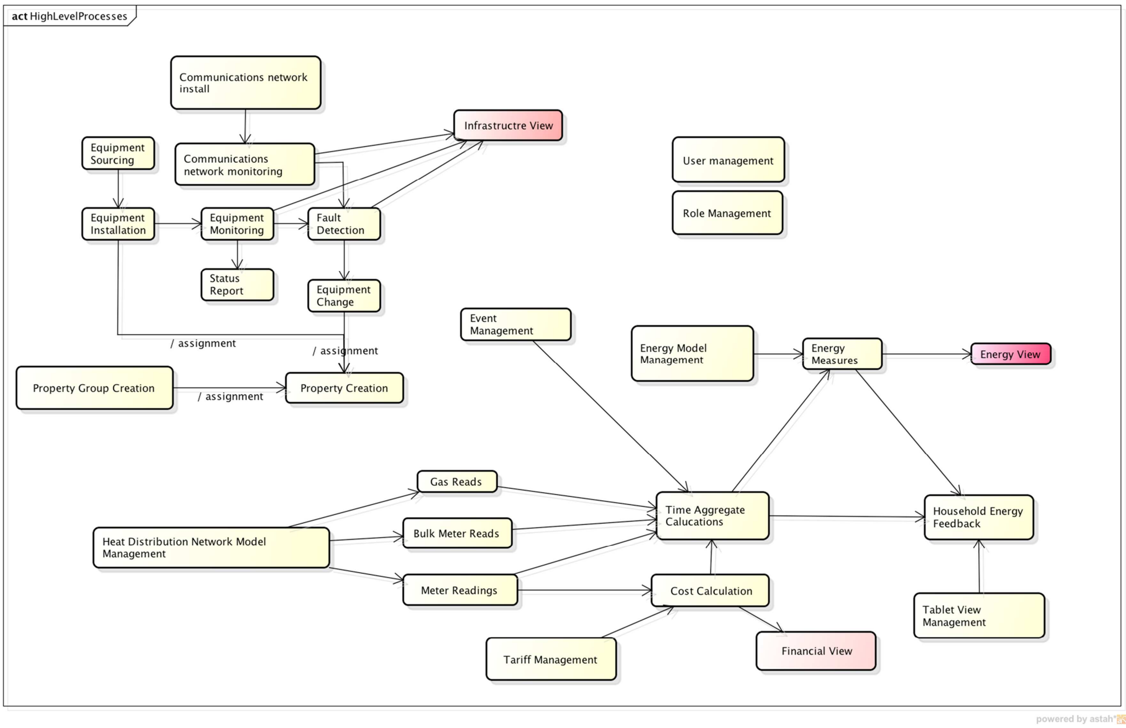


Figure 6 Logical diagram of the Back Office components to control the heat metering system

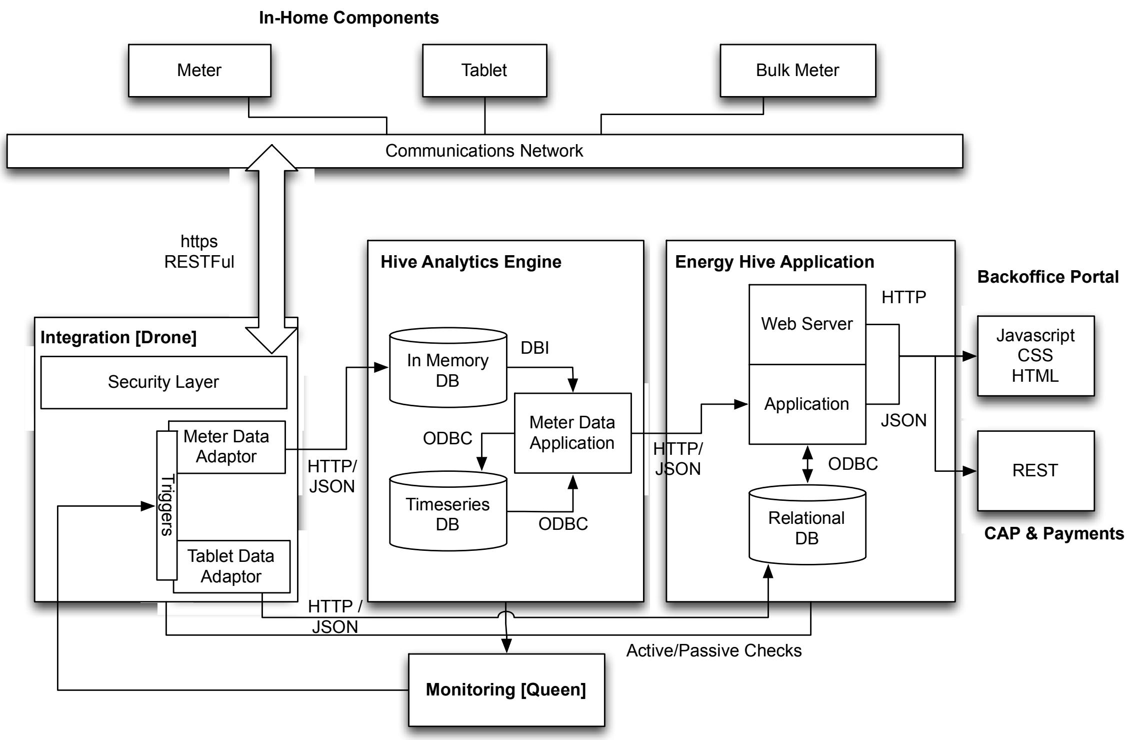


Figure 7 Physical diagram of the ICT enacting the heat metering system

3.1.4. Energy Management

To demonstrate an interconnected IoT-based system, information fed back from the Physical Metering and Communications infrastructure will be used to automatically manage the operation of each on-site CHP and Boiler. This requires an understanding of the factors that affect the Energy Balance for the system. The system consists of thermal energy supply (for all hot water demand) and electricity supply. The thermal energy supply for the estate is split between boiler, CHP and Solar Thermal contributions.

$$\boldsymbol{Q_{supply} = Q_{s,boiler} + Q_{s,CHP} + Q_{s,solar}}$$

The heat demand falls into two main categories; heating and appliance use. In this case appliance usage refers to hot water use by baths, showers, dish washers etc.

$$\boldsymbol{Q_{demand} = Q_{d,heating} + Q_{d,app}}$$

Similarly, a balance is also required for common electricity supply and demand. The individual resident electricity demand is monitored and supplied separate to the system, and is not within the scope of the project. The electricity supply for the estate is split between on-site CHP contributions and the supply from the National Grid. The electricity supply from the CHP is mostly dependent on the thermal load on the district heating system.

$$\boldsymbol{E_{supply} = E_{s,CHP} + E_{s,grid}}$$

Electricity demand falls into two main categories; heat pumps and utility usage. The district heating system requires hot water to be pumped through the building from each component, and this requires a considerable amount of electricity. The utility usage includes lighting, lifts and other utilities provided by the estate.

$$\boldsymbol{E_{demand} = E_{d,pump} + E_{d,utility}}$$

A program is to run that allocates a fixed gas flow to the CHPs and boilers at half hourly intervals, based on the predicted thermal load. This requires the Solar Thermal supply contribution to be predicted and accounted for. The program must also balance the electricity taken from the National Grid and the expected electricity output from the CHP. The complete IoT-based system will consist of a control system that seeks to supply heat energy and electricity to meet the demand as accurately as possible ($\boldsymbol{Q_{supply} = Q_{demand}}$, $\boldsymbol{E_{supply} = E_{demand}}$)

3.2 Madrid Bus Systems

Over the last few years the mass adoption of smart phone technology has significantly increased the utility of open information and the dissemination of real-time status of buses. Application developers have been able to collect, analyse and visualise bus information in a way that supports real-time journey planning and provides an engagement mechanism for passengers to report on the quality of their journey. This has given the Customer Information and the Information Analysing functions a very rich dataset to manage, both proactive and reactive, service delivery.

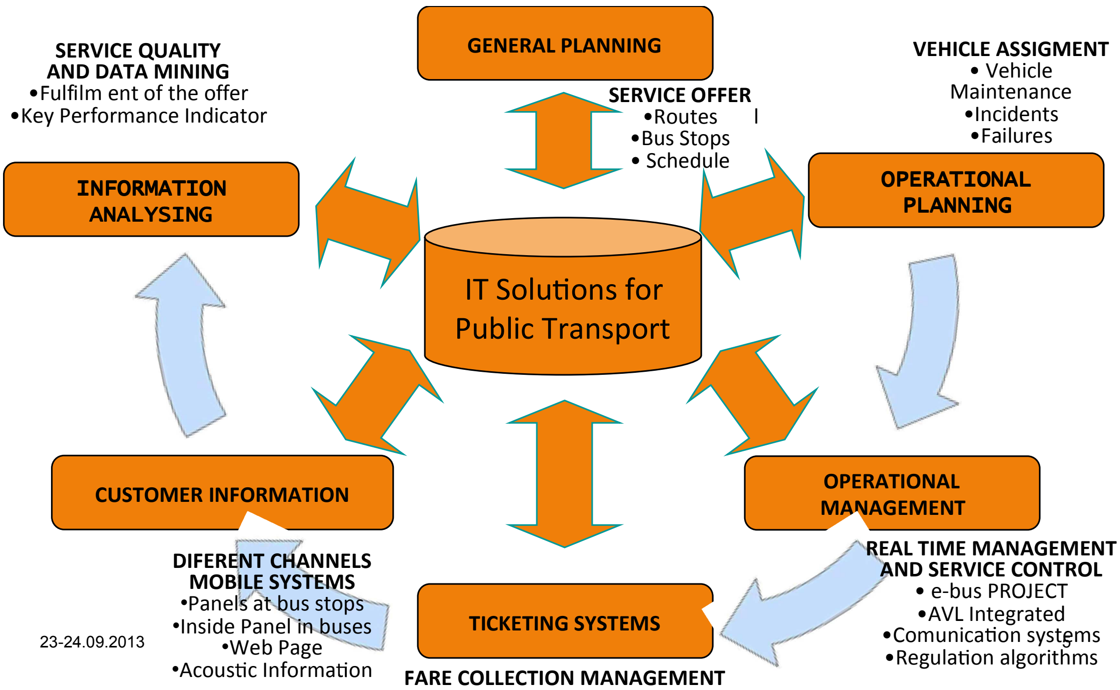


Figure 8 Information technology macro-system showing the functional areas of EMT

Some current limitations to take this digital innovation further are around data exchange with other city services, notably traffic management and to engage more widely with citizens where information protocols are richer and bidirectional.

As open data has shown that services can be revolutionised, it is anticipated that a protocol that is standardised (city wide,) publically available and provides this integration of wider functions will likewise create a new wave of opportunities for application developers both internally and externally to the city.

3.2.1. On board systems within the bus

With a fleet of 2,000 buses that are constantly on the move, not only is sensing and control of the bus itself important, but using the bus as a sensor itself to inform other city services also provides new opportunities. The following figure shows the sensing systems that are found on every bus.

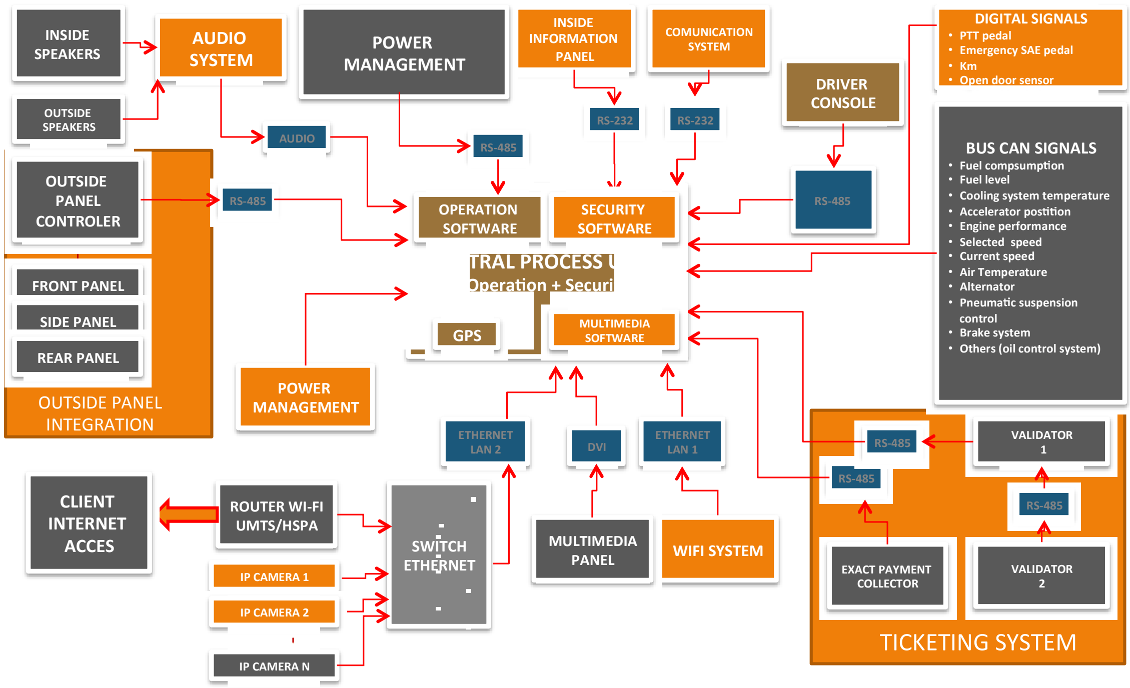


Figure 9 Systems on board all of the Madrid buses, all communicating through a mobile network back to EMT central ICT

The major systems can be shown as:

Central Process Unit (CPU) – the main control unit that coordinates the peripheral systems within the bus. Also located in this area is global positioning (GPS) that tracks the location of the bus.

Digital Signals – there are sensors hooked up to some of the mechanical systems on the bus that are not covered under the engine and drive train systems. These include things like the doors, emergency switches, etc. This is a generic digital signal acquisition facility.

CAN Signals – controller area network (CAN) is a vehicle standard with a message oriented protocol. The engine and drive train of the bus are instrumented with sensors that then communicate via this standard protocol. It is a physical layer protocol and is acquired by the Central Processing Unit to be forwarded via TCP/IP to be analysed.

Ticketing System – the ticketing system is composed of two types of ticketing, firstly a payment collection system for cash and tokens and secondly a modern RFID card reader linked to a prepaid balance on a passenger account. The first ticketing system is anonymous, whereas the second can be attributed to an individual passenger.

Multimedia Panel – the multimedia panel shows information and advertising to passengers on the bus. It is driven from the CPU's video hardware whereby content is processed for display from the CPU to the TFT multimedia panel. There are also segmented display panels that show destination and stop information.

Outside Panels – the outside panels are segmented displays primarily showing the line, destination and stop information.

Public Wifi – EMT has equipped all buses with free publicly accessible Wifi. This allows for connectivity to the Internet from passenger's devices.

Driver Console – the driver is in communication with central control where information is updated regularly to the driver console. This is information about the buses on the line, timing and any ad hoc notifications.

Driver Communication – an audio system for the driver to be able to communicate with central control is a two way private channel. Central control and call the driver through the audio system to warn of diversions or get updates on a local situation from the driver.

IP Cameras – 3 to 4 video cameras are located in passenger areas of the buses relaying feeds to central control. The feeds are used for passenger safety and recorded for investigating crime or other incidence that might occur on the bus.

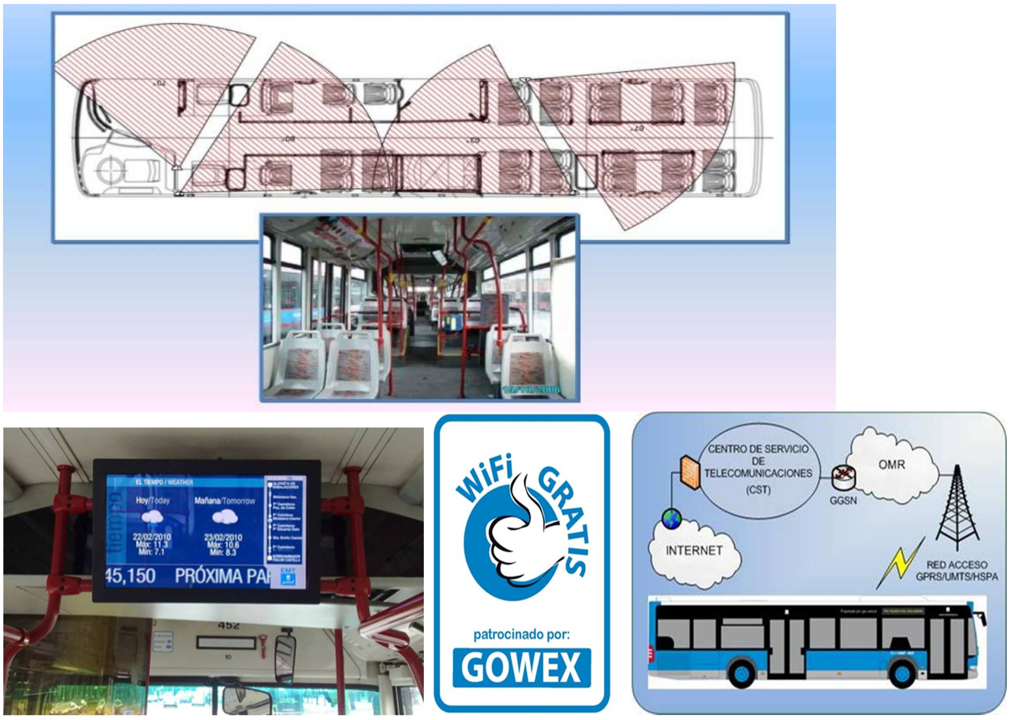


Figure 10 Various photos of systems on board EMT buses, note the CCTV camera views

3.2.2. Systems at the bus stop

There are approximately 5,000 bus stops with many having electronic signage and the ability for audio communication via an intercom system. There are accessibility technologies to assist the visual and hearing impaired with information.

Figure 11 Electronic signage available at bus stops, notice the audio systems as well

Most of the data that is displayed on the digital signage is available via the open data sources published by EMT.

3.2.3. Open data and applications

EMT has an extensive set of open data hosted at (http://opendata.emtmadrid.es) . Broadly speaking there are two categories of data that EMT publishes:

1) Static data – this is descriptive data about lines and stops, it is available as XML or Excel spreadsheets. This is reference data that provides geolocations of fixed infrastructure within the EMT bus system.
2) Dynamic data – as buses move and traffic conditions change, there are updates to arrival times and locations of buses that are continuously updating. This dynamic data is time dependent and has a geospatial component as well. This data is accessible via web services pull in XML or JSON formats, it requires an API key to integrate.

The COSMOS project will be creating new sources of open data and will work towards new protocols for data exchange as well as new data types.

3.2.4. Applications

There are a number of official and un-official bus applications that assist passengers with route planning and updates on arrivals and departures. The applications typically use the public data sources as an information source and use mapping tools to visualise data onto mobile and web applications. A complete list of applications can be found at (http://opendata.emtmadrid.es/Aplicaciones).

3.3 Journey Planning and Management

The purpose of a bus is to transport passengers and to do so in a safe and timely manner. In COSMOS planning many interesting opportunities emerged in the ability to coordinate passengers and to introduce some new actors, namely carers/parents that may not be considered a passenger, but an active participant in someone else's journey.

The transport model that EMT has implemented is one that is User Optimised in the classical sense. This is where the cost function of the system is minimised for the utilisation of passengers given a set of mobility resources.

A journey is defined as a passenger traveling from a “start point” to a “destination”. This may be planned in advance or done in an ad hoc fashion. There is a “start time” of the journey defined by the arrival time of the bus at the start point. Also there is an “end time” of the journey defined by the arrival time of the bus at the destination. The “duration” of the journey is the end time minus the start time. A couple of notes here, both the start time and the end time are continuously updated estimates due to the changing position of the buses and for most people the journey is beyond just using the bus, they must walk or take other modes of transport to get to their actual start point and destination. This means there might be a range of possible start points, destinations and associated timings.

There are a few structural elements that define a transport network, specifically “lines” and “stops”. The stops are nodes or vertices in a network that are of primary interest as they are where passengers board and alight. A line is a series of stops and in graph terms these are edges. Also, this can be modelled as a directed graph in that buses travel in a particular direction. Although obvious, the line can be travelled in both directions, but not so obviously the line is represented by two directed graphs with slightly different nodes (for instance on the other side of the street) and edges. The edges are constrained by the road network.

In certain situations the structure of the network changes, such as a diversion with temporary stops. This means that any models constructed may have to be recalculated based on those changes. It could also be an opportunity to find new structures that make the user experience better.

Of course there are vehicles that operate on top of the transport network and have finite capacity. The capacity is limited by the number of vehicles on the line and the size of the buses (number of passengers) operating. In some models the capacity of the road network is considered, however we will treat it as a dynamic property of the system with the upper bound being conditions of little or no other traffic and a lower bound that is at least positive. Capacity in a dynamic system is expressed as a number of passengers over a unit of time just like bandwidth in an electronic network.

The mathematical model of a general network $G = [N, L]$ is a set of nodes N and a set of directed edges L. Keep in mind that lines intersect and passengers can transfer at certain nodes to navigate through the network. Paths are traversals of the network that can be expressed as a series of edges with a start and end node. Journeys are formally the same as a path, just that it is a specific path taken by a passenger.

If w is a pair of nodes for example (1,4) representing a start point and end point, the path is a set of named edges { a, b, c } will be denoted as $P_w = \{ a, b, c \}$. The direction of the path is implied by the order of the nodes and edges and in a graphic direction is shown with arrows.

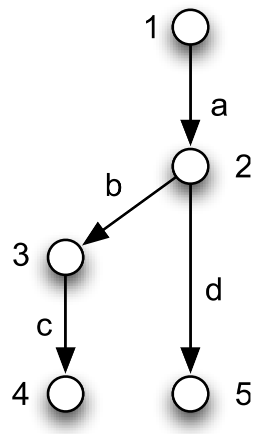


Figure 12 Example of a transport network with nodes labelled with numbers and edges labelled with letters.

Important concepts on the utilisation of this network are demand denoted by d, which is the same the journeys described above summed for all passengers and capacity as above denoted by c, again summed for all buses working on a line. Demand best expressed as demand for a journey or d_w where w describes a start and end point as a coordinate. Capacity on the other hand, is capacity on an edge and carries the subscript of the edge it is describing, for instance c_d is the capacity on the edge d between nodes (2,5). Flows on an edge are represented by f which indicates the current state on an edge in terms of passengers being carried and again is subscripted using the edge of interest.

All of the aforementioned parameters are dynamic in nature and have units of measure as rates, specifically passengers per unit of time. They are also treated as linear systems whereby the sum of a set of edges for a path is equal to the total flow or capacity from two nodes. There is good background material in Nagurney (http://supernet.isenberg.umass.edu/articles/EOLSS.pdf) that shows various equilibriums and forms of equations around optimisation.

So far we have described deterministic models and for the purposes of cycle 1 of COSMOS we believe this to be the most relevant approach. Whereas stochastic models may be able to describe a system better as a whole for simulation and planning, in operation we are observing and calculating based on real data collected from the system.

To further discuss the differences to the classical techniques and the approach in using IoT for transport modelling, you can see a basic difference in how measurements would be made. In a classical technique, induction loops would be used to count vehicles passing at nodes and that traffic turned into model parameters. In the IoT space, we are able to use GPS and active feedback from the bus systems to continuously update a model.

In most literature there is a description of microscopic modelling and macroscopic modelling. We think IoT goes even further to add dynamic geospatial elements to a microscopic model and essentially use data fitting techniques found in machine learning disciplines and/or physical models based on velocity, position and tracking estimators.

An example model using dynamic geospatial techniques constrained by a classical network configuration will be shown in section 6. The model is limited to the application scenario found in section 4.

3.4 Taipei Smart Home Management System

Consumer electronics, office equipment and other plug loads consume 15% to 20% of total residential and commercial electricity while not in primary mode. Moreover, we need to find out where most of the power resources consumed. One reasonable way is to use a smart home management system to form a safe, convenient and efficient home.

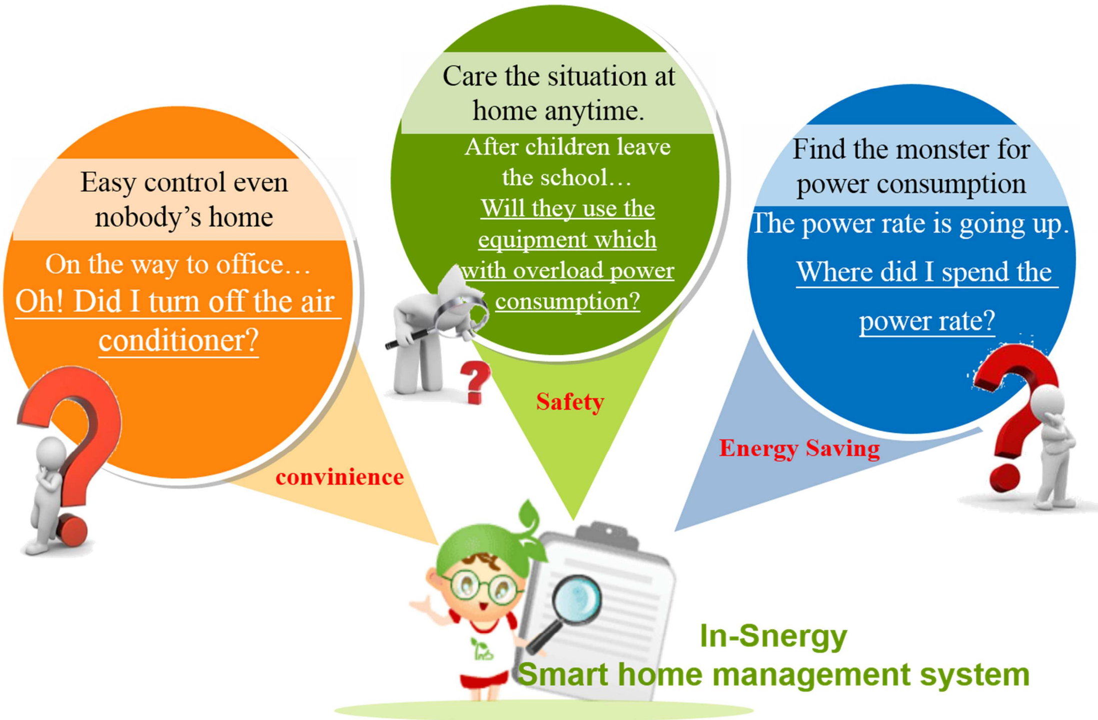


Figure 13 In-Snergy motivations and end user benefits

The current idea is to provide an easy proactive and reactive way to care about what is happening on power consumption no matter at home or remote, the other point is to figure out the spectrum of the power consumption.

3.4.1. In-Snergy Smart Home Management System

In-Snergy "Smart Home Management System" project is to develop a system such that it will be capable to keep track of every appliance in the home, and the user will be able to acquire all appliance energy consumption parameters. Along with this, the energy consumption parameters of each individual appliance will be sent to gateway where an intelligent algorithm will be running to manage all the appliances as per user requirements. The user can monitor the energy parameters of each individual load using mobile phone which will also work as a data setter to set various user programmable parameters like high/low cut-off voltage, etc.

By automatically turning off loads when not in use, the system can provide energy savings in homes and offices. Applications for this system include workstations, home offices, and home appliances, home entertainment systems.

In-Snergy have huge scope of approval, we constantly collect user data and feedback for improvement. The solution goes through the repeatable cycle of trial, analysis, product improvement & system adjustment. This solution is highly reliable, stable and scalable.

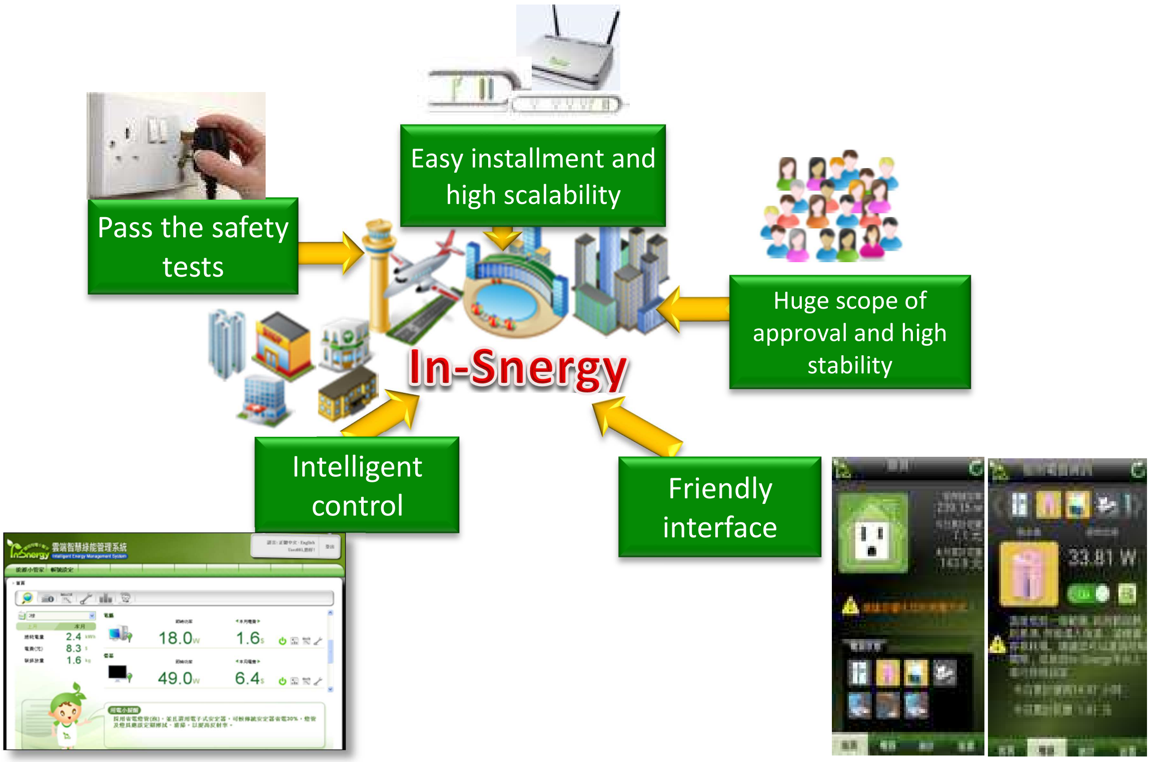


Figure 14 Characteristics of In-Snergy with wide scope of approval

3.4.2. System Function

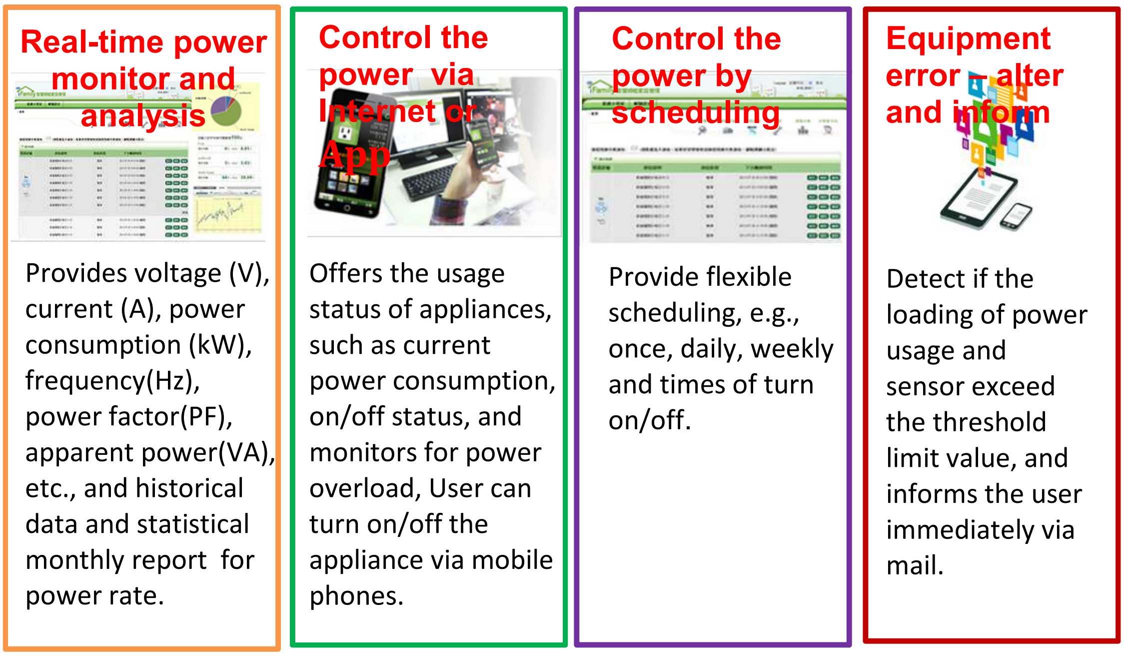


Figure 15 System Functions of In-Synergy

Real-Time Power Monitor and Analysis - To monitor the real-time power use of your home appliances. The power output, capacity, power factor, apparent power and accumulate power consumption will be provided, as well as the historical records of power use and the monthly reports of the electricity bills.

Remote Energy Controller - To display the current status of your home appliances, including the real-time power consumption of electrical appliances as well as power shut-down, safety use and overloads, so that you may easily control or shut down your electrical appliances remotely while you are away abroad with your smart phones.

Scheduling - With more flexible settings than ordinary timers, such as the settings of power on/off for a single time, daily base or weekly base; you no longer limited to the constraints of the settings.

Notice and Warning for Abnormality Detection - For detecting if any electric overloads exceeding the critical capacity, then notifying the users promptly via e-mail.

3.4.3. Smart Home Management Solutions

The In-Snergy provides flexible and comprehensive smart-home management solutions, catering to various needs and hardware equipment, there are 8 most frequent used sensors planned to deploy, 7 of them are available for trial, Gas Emergency Shut Valve is the one yet to deploy. Besides the above mentioned sensors, there are other extendable sensors can be added into the solutions.

Real-time information on home appliances is available through network connection, achieving smart-home applications and forming a safe, convenient, and comfortable home environment for users. It supports 3 different levels of usage, the light package, basic package and supreme package.

The light package can be immediately operational with Wi-Fi connection, but generally with low expandability. The basic and supreme package can be connected up to 10 and 40 sensors respectively via cloud green gateway using ZigBee communication technology. It's a perfect design for smart home, smart community and small and medium enterprises.

1. Intelligent cloud power meter
2. CT meter
3. Cloud CO2 sensor
4. Cloud thermo-hygrometer
5. Cloud CO sensor
6. IR controller
7. Gas Emergency Shut Valve
8. Green gateway
9. Other extendable sensors

Figure 16 In-Snergy home management system

3.4.4. Background of In-Snergy field trial in Minsheng Community

After the introduction of 3.4.1 through 3.4.3, we can understand that the In-Snergy smart home management solutions provide a diverse products and capabilities with great potential expandability. Yet, it is physically not possible to conduct field trial on all products. After the SNSI team had several meetings with the leaders of Mingsheng Community (MCDAT) and head of villages, together they decided to promote and conduct the field trial in a most pleasant way.

For trial event promotion, SNSI performed 20 recruiting seminars for trial volunteers (family based), 9 sessions of demonstration on products with community events, 80 plus community store visits, connected and collaborating with 33 head of village to build up the bulletin board for field trial promotion.

For Home Management Solutions field trial, SNSI provided most common used products including, cloud based IOT appliance platform (for data store/analysis etc.)、smart Green Gateway and cloud based smart sockets。 The components for trial are introduced in detail later this chapter. The trial aims to properly monitor each household's power usage¸ spectrum of the power usage, and learn the total power consumption for energy efficiency purpose.

In order to properly conduct the field trial for future further deployments and benefits, the safety and convenience factors of the solutions are the other two big factors for the research solutions on trial, that will help SNSI build up a reasonable home energy management model and value added data bank through data feedback、analysis 、product improvement & system adjustment cycle.

For longer run, the goal of the field trial in Minsheng Community for future product development is as follows, Based on the feedback data and analysis to improve the cloud based IOT appliance platform and perform the equipment adjustments：

a. Improvements on In-Snergy system interface： a lower technical barrier, and a more friendly installation and operation for usage.
b. Improvements on equipment design： Equipment adjustment to current household environment and usage scenario for better look and easier installation.
c. Mobile device interface deployment： facilitate the mobile device control scenario.
d. build up home appliance feature (Eigenvalue) data bank： collect feature data for power consumption via smart meter feedback information, to build up value added data bank for future analysis and innovation development.

A. Build up a living lab for cloud base smart energy management system：

a. Promote and field trial In-Synergy solutions around Minsheng Community, demonstrate energy saving ideas and scenarios through community events.
b. Deploy up to 10,000 network appliance nodes.
c. Build up Taiwanese family energy usage behaviour model and data bank, thus for future study on the main factors of power consumption and innovation benefit.

3.4.5. In-Snergy field trial in Minsheng Community

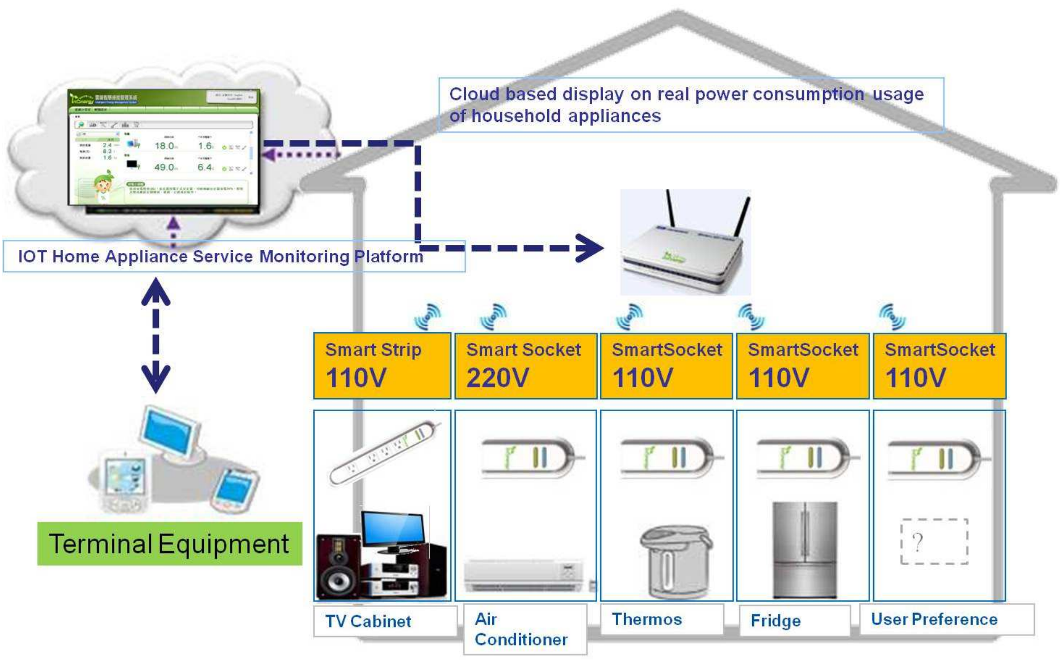


Figure 17 In-Synergy home management solution field trial for Minsheng Community household

Home Management Solutions Field trial components

For Home Management Solutions field trial, SNSI provided most common used products including, cloud based IOT appliance platform (for data store/analysis etc.)、smart Green Gateway and cloud based smart sockets, details as follows :

3.4.5.1. Green Gateway

Green Gateway (The iGateway) is an all-in-one router, designed for users to enjoy continuous two-way communication, it collects real time data regarding appliance power usage etc. and warning message from the meters, it also supports receiving command from the user to turn on/off of the meter simultaneously. It supports real-time power management and secures wireless Internet access, keeps you always-on-line.

In order to keep the efficiency and stability of the meter operation, plus the system robustness, Green Gateway has the capability of auto recovery on the internet access、6 hours offline data auto recovery, to cope with the norm situation of family internet interruption.

The following devices then communicate with the gateway for sensing and actuation:

110V Smart Extension Cord (4 plugs Extension Cord)Green Gateway	
110V Smart Socket	
220V Smart Socket	
Smart Thermo-hygrometer	

4 Application Use Cases

4.1 Capital Planning

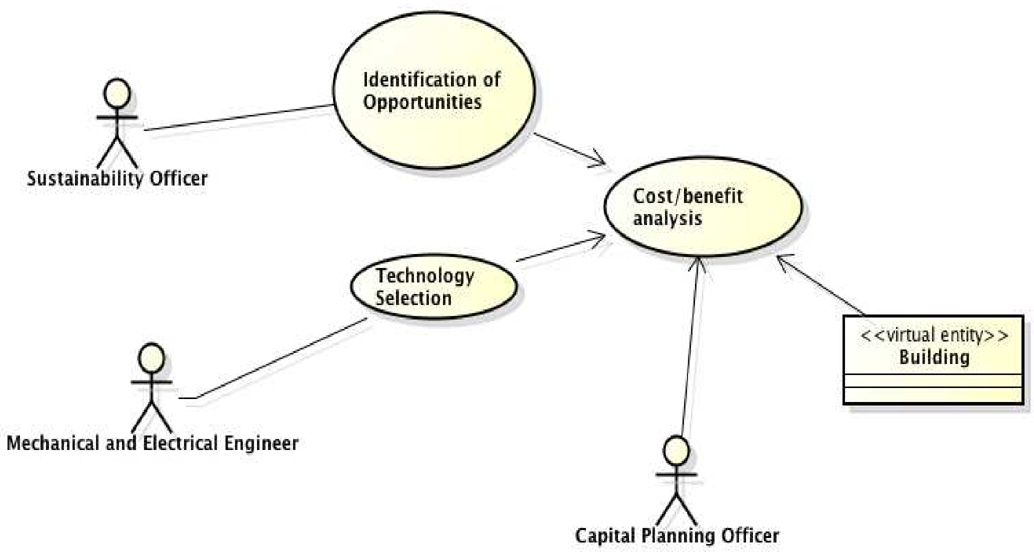


Figure 18 Use case diagram for Capital Planning

Use case : Capital Planning
ID: 1
Brief Description: The EnergyHive system in each building enables Capital Planning officers to perform a more rigorous cost/benefit analysis of suggested programs or technology installations. The system provides accurate information as to the carbon/monetary saving of an implementation.
Primary Actors: Capital Planning Officer
Secondary actors: Mechanical & Electrical Engineer, Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate
Main Flow: 1) Sustainability Officer identify an opportunity for environmental improvement of system 2) Engineer select appropriate technology for instalment 3) EnergyHive system provides detailed information as to the effect of the change in the system 4) Capital Planning officer uses EnergyHive information to assist in cost/benefit analysis
Postconditions: The Capital Planning officer decides whether to rollout the proposal

4.2 Minimising Carbon

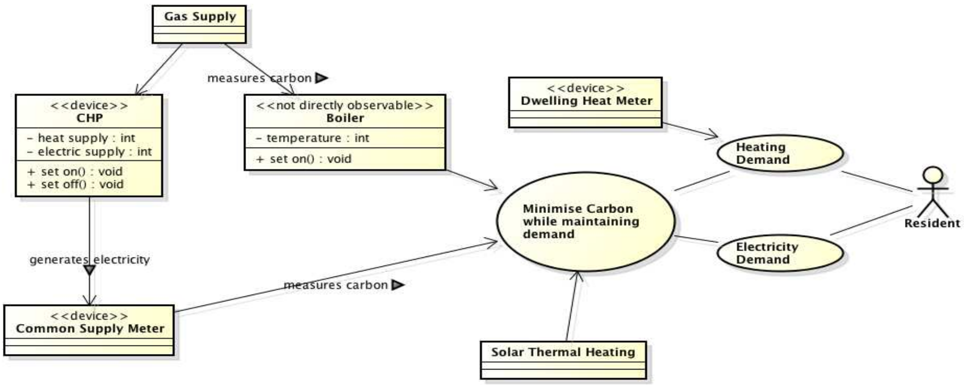


Figure 19 Use case diagram for Minimising Carbon

Use case : Minimising Carbon
ID: 2
Brief Description: An effective way to minimise carbon is to give more weighting to processes with lower carbon production levels, whilst maintaining the demand. The interconnected IoT-based system using an energy platform will make possible effective management of the energy supply in order to minimise carbon production. With minimal input by the resident or site staff, the system will predict the estate's heat and electricity consumption in half hourly intervals and manage the CHP and boiler accordingly.
Primary Actors: Resident
Preconditions: Specialised Instalments 1) Gas Flow meter to CHP from boiler to regulate the Gas supply 2) Control system with temperature sensor on boiler 3) Flow meter/temperature sensor on Solar Thermal 4) Heat meter in each dwelling 5) Communication infrastructure between sensors and hub
Main Flow: 1) System predicts the estate's heat and electricity demand for a half hour period 2) System calculates required gas supply and distributes to CHP and boiler accordingly 3) Carbon produced is measured 4) Individual resident heat consumption is monitored
Postconditions: 1) The resident is charged for their personal heat consumption 2) Prediction errors are logged to improve system on later iterations

4.3 Minimising Demand

Use case : Minimising Demand
ID: 3
Brief Description: Another method of reducing carbon production is to minimise the demand for Heat energy

production. This is possible through the current IoT platform, namely EnergyHive (designed by Hildebrand). The EnergyHive system will use smart meters to report real-time energy consumption information automatically and remotely. The system assists the user in setting a heating schedule with accordance to their budget.
Primary Actors: Resident
Preconditions: 1) EnergyHive system implemented in each dwelling 2) Valve up/ down control system to the radiator
Main Flow: 1) Resident accesses their customer account to view balance 2) Resident can set a heating schedule 3) Resident is given tariff and projected balance for a given schedule
Postconditions: 1) User can optimise their schedule to minimise their consumption

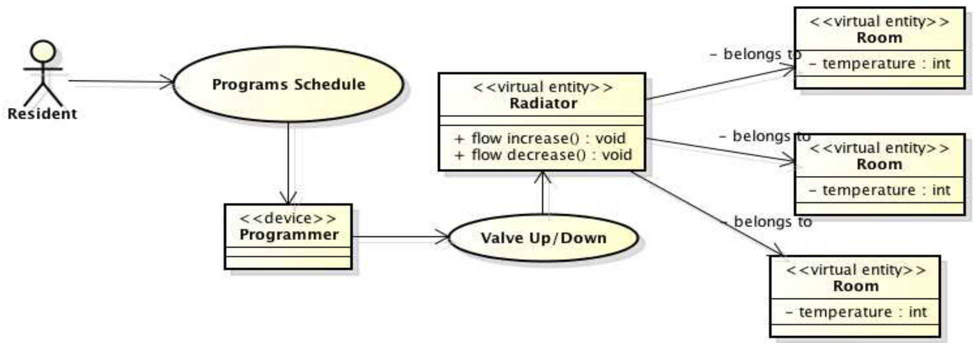


Figure 20 Use case diagram for Minimising Demand

4.4 Special Needs Passenger with Carer Assistance

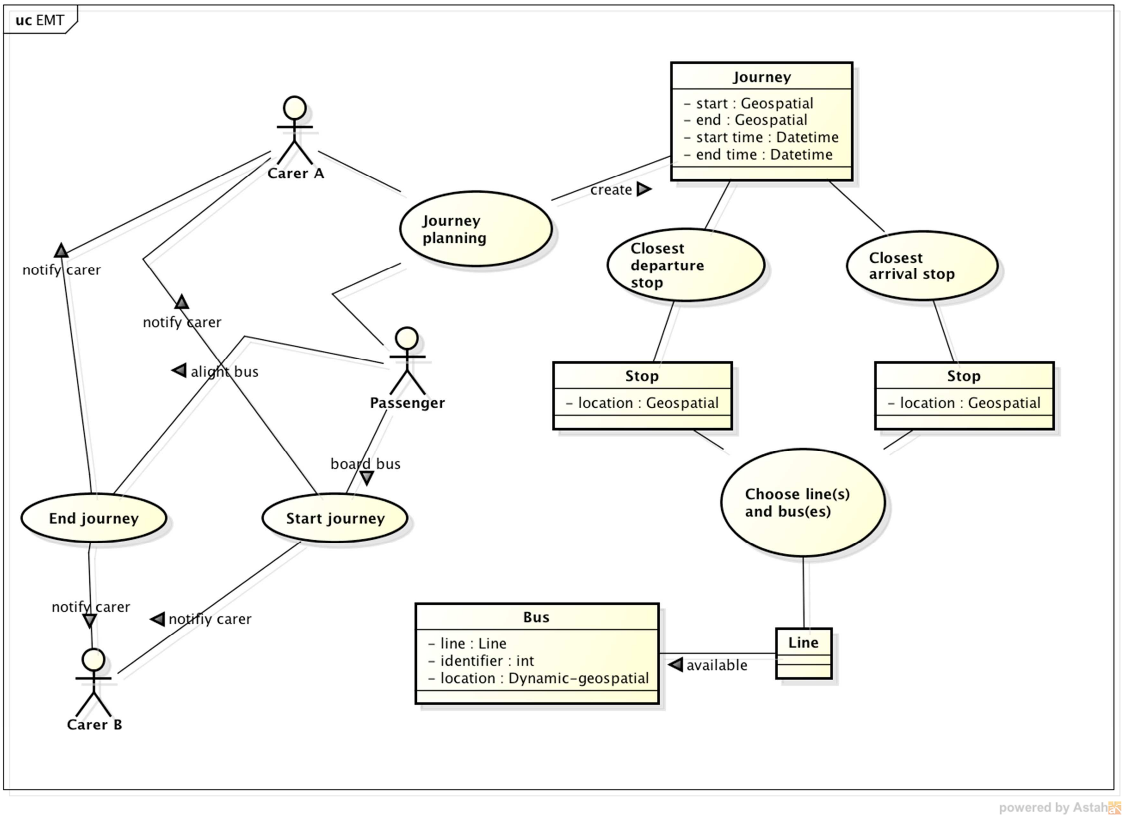


Figure 21 Special needs passenger traveling on the bus system with assistance from two Carers

Use case : Special needs passenger journey
ID: 4
Brief Description: Passengers that have special needs such as children, elderly, disabled and the like, may choose to use the bus system if they can get assistance on the beginning and end of their journey. Assistance would come in the form of a carer who might help the passenger plan their journey, track the passenger's progress and then hand off to a new carer that would be waiting at the destination.
Primary Actors: Passenger, Carer A and Carer B
Preconditions: Journey requirement 1) Passenger, Carer A and Carer B know of each other 2) Carer A is with the passenger at the beginning of the journey
Main Flow: 5) Carer A and the Passenger configures a new journey 6) System finds the closest departure stop 7) System finds the closest arrival stop 8) Lines are selected such that the Passenger boards a bus that will travel from departure to arrival 9) Carer A and B are notified that the Passenger boarded a specific bus 10) Carer A and B are updated with progress of the bus including estimated time of arrival 11) Carer A and B are updated when the Passenger has finished the journey
Postconditions: 12) The Passenger has arrived at the destination 13) Carer A knows that the Passenger arrived safely

14) Carer B knows if the Passenger has not arrived when expected

5 IoTA Model

5.1 IoTA Model for the Energy Scenarios

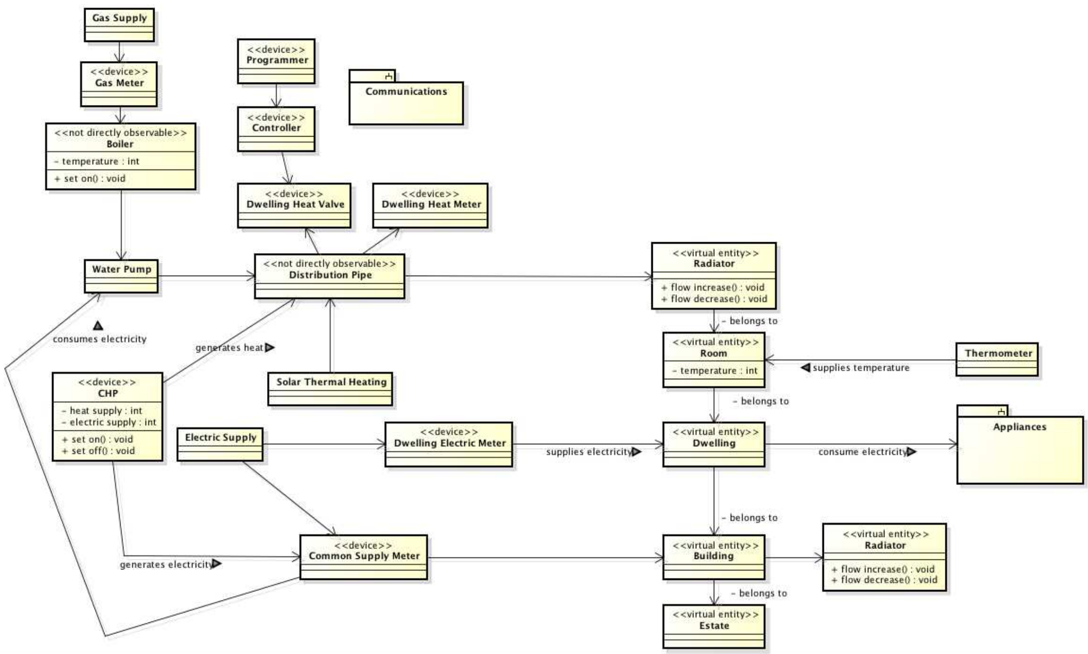


Figure 22 Model for the IoT system with adjoining description of components for the energy scenarios

Component	**Description**
Gas Supply	Natural Gas supplied to the Ampthill Estate. Consumed by the boiler and the CHP
Electric Supply (National Grid)	Electricity supplied to the Ampthill Estate from the National Grid. Electricity consumption from individual residents is taken from this supply. The National Grid also contributes to the common supply for building and estate utilities.
Boiler	Natural Gas fuelled boiler. Contributes hot water on resident, building and estate level. The boiler is not directly observable, therefore it is monitored and controlled by the Gas meter
Solar Thermal Heating	Multiple solar thermal panels installed on the roof of each building. Contributes hot water on resident, building and estate level.
Combined Heat & Power (CHP) Engine	Natural Gas fired Gas turbine engine. Contributes hot water on resident, building and estate level. Also contributes electricity to the common supply for building and estate utilities.
Water Pump / Distribution Pipe	A system of water pumps transport hot water from each source through the distribution pipe. Consumes electricity from the National Grid and the CHP. The distribution pipe supplies water to each individual resident, along with utilities in the building and on the estate.
Gas Meter	Monitors the flow and temperature of gas through the boiler to indirectly regulate and control boiler. Also monitors flow to the CHP, to indirectly measure electricity and heat energy from the CHP.
Common Supply Meter	Measures the total electricity supply on a building and estate level (excluding individual resident supply).
Dwelling Electric Meter	Measures electricity to individual resident dwellings. Electricity is only supplied by the National Grid.

Dwelling Heat Meter & Valve	Measures heat energy consumption for each resident dwelling. The valve is controlled by the programmed schedule
Programmer/Controller	Receives/sets schedules for heating and operates the hot water valve accordingly

5.2 IoTA Model for Bus Scenarios

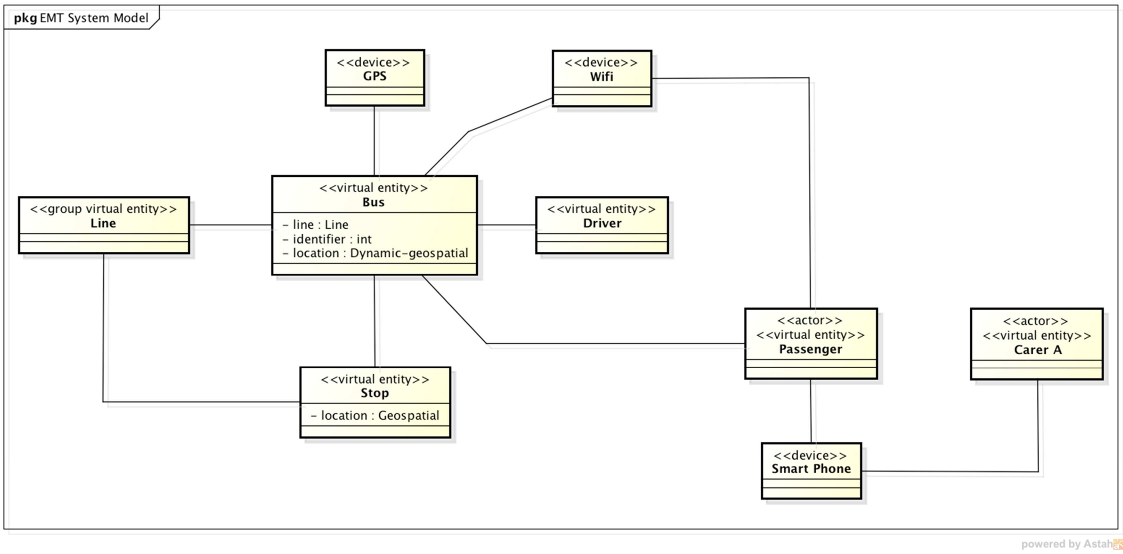


Figure 23 Model for the IoT system within the EMT transport scenarios

Component	Description
Line	A line is a group virtual entity that is composed of the buses and stops that operate on a given line. In real terms the line is uniquely identified to bus users with a line name and color.
Bus	The bus is the vehicle that operates on a line. It is flexible in that one day a particular bus may be operating on one line and another day it has been redeployed. The identifier that goes along with the bus will uniquely identify the bus for its lifetime. The bus is a virtual entity as it describes the moving space tracked by the devices on board.
GPS	GPS is a device that tracks the location of a bus and maintains the bus virtual entity position sensing over time. It is a sensor type device.
Wifi	The Wifi is a device that is a resource to passengers for gaining access to the Internet. It also acts as a sensor in that if someone is within radio contact to the Wifi then they are within proximity of the bus. There is an implication that if the duration of radio contact is long enough, then the smart phone giving off a Wifi signal is onboard the bus. Otherwise if the duration is small, the bus may have driven past the smart phone. Note, the smart phone is also a proxy for a person which is carrying the phone.
Driver	The driver is in control of the bus and can indicate various statuses of the bus. The driver takes on the position of the bus and could be used as an extra “sensor” in future scenarios.
Stop	A stop is a place that has a position in geospatial terms. It will have a unique identifier and be a part of one or more lines. Stops that are a part of multiple lines are of special interest as passengers may change at these locations to get on to different parts of the bus network.
Passenger	A passenger is a virtual entity that will assume characteristics of the bus once they are on board. It is also assumed that a passenger will have a mobile phone that will act as a sensor as well. Typically a passenger is a primary actor in a bus scenario and may need various foreign identifiers to be useful for an applications.
Smart Phone	A smart phone is available to human actors in the system. The smart phone can be considered a sensor as well as a actuator within an IoT context. The actuator functionality is usually informational.

Carer	A Carer is a special actor that is observing an IoT process. They can contribute information to the system via a smart phone or web application.

5.3 IoTA Model for Smart Home Scenarios (Taipei)

The formal IoTA model for Taipei will be constructed in the Year 2 activity.

6 Data Sources and Structures

6.1 Heating System Data Feeds

The complete set of data feeds required for the IoT system is described in Figure 24. The data feeds that are necessary for prediction will need to be logged over a trial period, to provide training data for the system.

Data Feed	Source	Purpose
Luminosity	EnergyHive multi-sensor	Thermal Load Prediction. Solar Thermal Supply Prediction
Weather (Historic/Real-time /Forecast)	MetOffice	Thermal Load Prediction Electricity Demand Prediction
Temperature (indoor/outdoor)	EnergyHive multi-sensor	Thermal Load Prediction
Electricity Consumption data	Common/Dwelling Electric Meter (Hildebrand)	Total Electricity Supply Calculation Electricity Demand Prediction Post-Prediction Error Calculation
Thermal Load data	Common/Dwelling Heat Meters (Hildebrand)	Total Thermal Energy Supply Calculation Thermal Load Prediction Post-Prediction Error calculation
Solar Thermal Energy supply	Solar Heat Meter (Hildebrand)	Total Thermal Energy Supply Calculation Post-Prediction Error calculation
Gas flow/temperature	Heat Meter	Boiler/CHP Control System

Figure 24 Data feeds described by their source and purpose in the system

6.2 Heating System Data Flow Model

An example model of the IoT system, built in SciLab, is shown in figure 10.

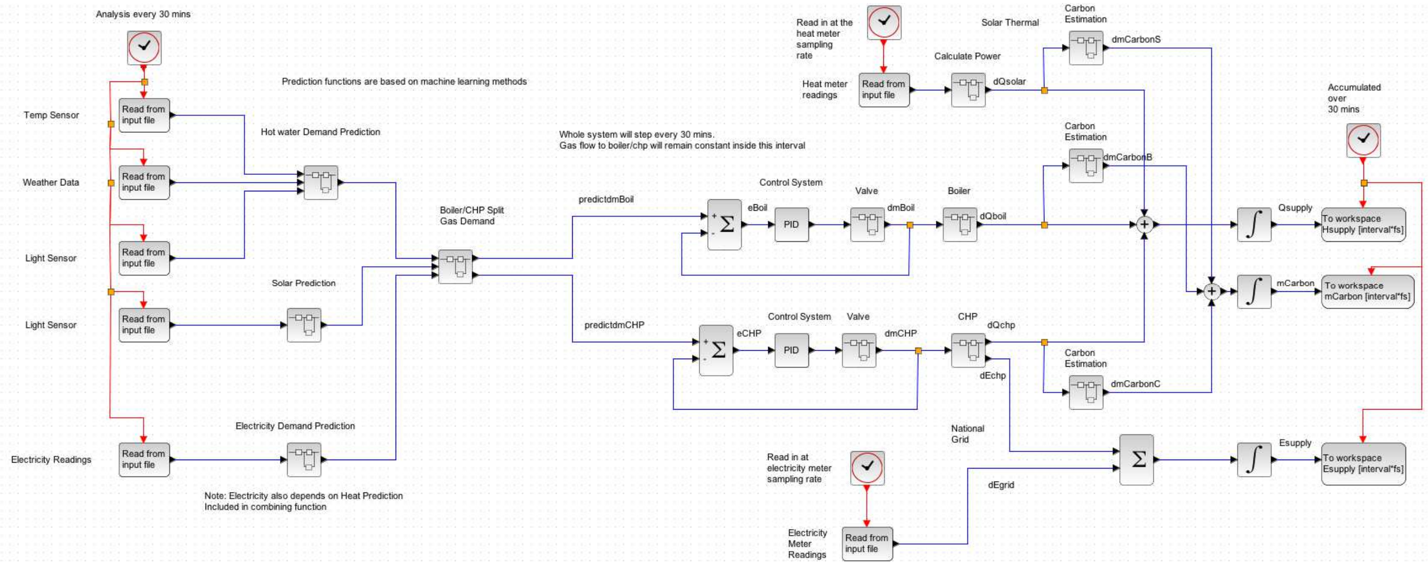


Figure 10: SciLab model of the system

The diagram provides an overview of the processing of data from the input feeds. These input feeds are processed using a statistical prediction model, which outputs the expected thermal load, electricity usage and solar thermal input for the next half hour period. Another calculation step is necessary to determine the optimum gas supply allocation to the CHP and boiler for the predicted conditions.

The SciLab model represents the gas supply to the Boiler and CHP through a control system with a PID controller, which controls a valve to reach the desired mass flow rate of gas. The expected output from the Boiler and CHP is calculated using a set of thermodynamic equations. The final electricity and thermal energy supply is stored in (kWh), along with an estimation for the total mass of carbon produced in the half hour period.

6.3 EMT Bus System Data

Data from the buses is available in a variety of formats via the EMT Open Data portal (http://opendata.emtmadrid.es/) , but specifically we will use the Google Transit formats for cycle 1 as they serve as a defacto standard to integrate other cities within the COSMOS framework. The following table describes those sources and how they will be used within the project.

The data sources can be found at: http://servicios.emtmadrid.es:8080/GTFS/transitEMT.zip and a more detailed description at https://developers.google.com/transit/gtfs/ Within the table, the source column describes the file within the zip archive that will supply the data.

Data Feed	Source	Purpose
Lines	routes.txt	Lines and identifiers that are used for keys into other data sources

		Links to status URLs that show the line
Weather	Norwegian Meteorological Institute (http://www.yr.no/)	Predicting disruption Predicting demand
Stops	stops.txt	Position of the stops within the bus network, including a unique key and lat/lng coordinates
Incidents	http://servicios.emtmadrid.es:8080/rss/emtrss.xml	RSS feed of disruptions, both planned and unplanned
Stop Times	stop_times.txt	The planned schedule for buses to arrive and depart at particular stops Initialising the model and tracking performance against this schedule
GetEstimatesIncident	https://openbus.emtmadrid.es:9443/emt-proxy-server/last/media/GetEstimatesIncident.php	Latest information for a stop/line combination. Includes GPS data of the buses and estimated time of arrival to the stop.

Real time return from the EMT GetEstimatesIncident API:


```
{
  "errorCode": "000",
  "description": "La recuperación de ServiceMedia ha sido correcta.",
  "stop": {
    "label": "1",
    "description": "AV.VALDEMARIN-ALTAIR",
    "direction": "Av. de Valdemarin, 88",
    "stopLines": {
      "data": {
        "label": "161",
        "description": "MONCLOA - ESTACION ARAVACA"
      }
    }
  },
  "arrives": {
    "arriveEstimationList": {
      "arrive": [
        {
          "stopId": 1,
          "lineId": "161",
          "isHead": "False",
          "destination": "ESTACION ARAVACA",
          "busId": "4650",
          "busTimeLeft": 711,
          "busDistance": 7129,
```

```
          "longitude": -3.7398198974758,
          "latitude": 40.43554589658,
          "busPositionType": 1
        },
        {
          "stopId": 1,
          "lineId": "161",
          "isHead": "False",
          "destination": "ESTACION ARAVACA",
          "busId": "4638",
          "busTimeLeft": 999999,
          "busDistance": 9568,
          "longitude": -3.730715139771,
          "latitude": 40.434996699893,
          "busPositionType": 1
        }
      ]
    }
  },
  "incident": {
    "lastBuildDate": "24 Nov 2014 16:16:05 GMT"
  }
}
```


6.4 Bus System Data Flow Model

The data flow model for the bus system has two main models that need to execute within COSMOS for IoT data, firstly presence of a passenger and secondly prediction/estimation of arrival of the bus.

For the presence detection, a MAC address will be used as the method to identify a passenger via Wifi sensing. Only MAC address that are registered will be considered.

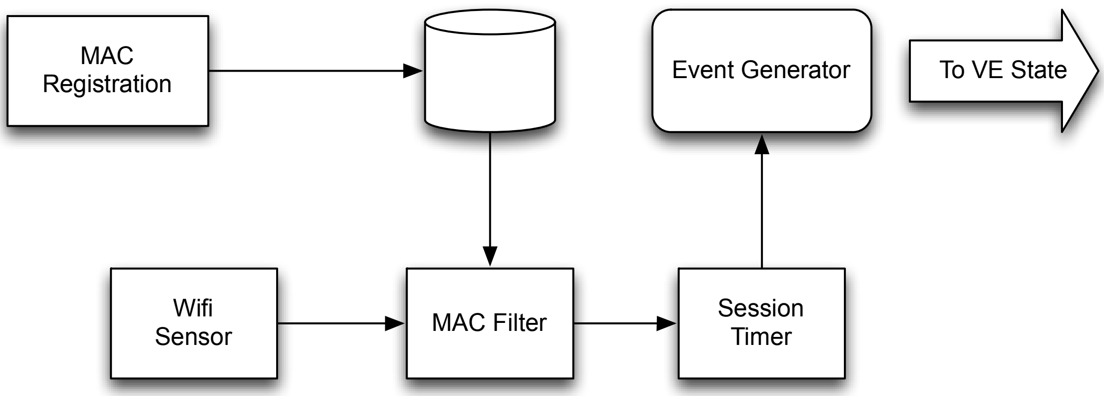


Figure 25 Presence detection using a MAC address registered to a virtual entity

The update to predict a bus arrival will be done on a cascading estimator that will be recomputed at every cycle. A cache will be maintained to reduce load on the system.

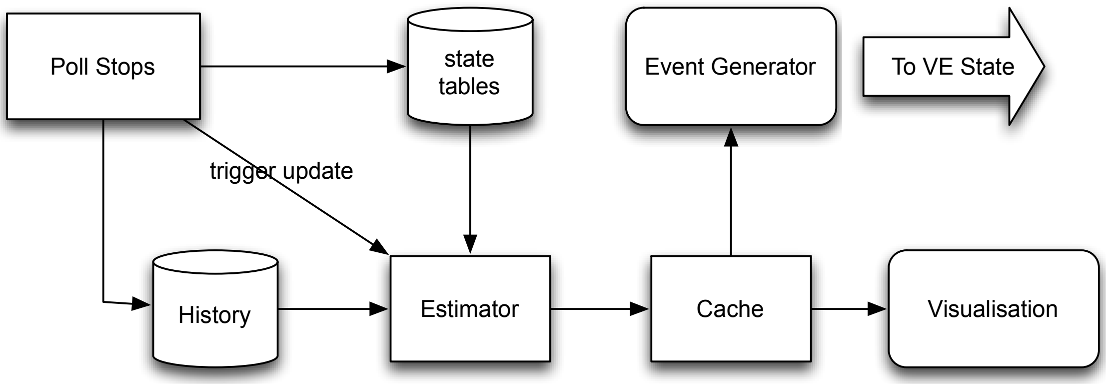


Figure 26 Estimation of position and arrival time of buses, will also map to virtual entities that are on board a bus

The estimator will look at the previous journey times on the segments of interest and apply those to near future predictions. In the case of predictions further out, history of journeys based on average travel time and variance will be used alongside time of day (within a 30 min window) as a classifier. A naïve Bayes classifier will use that history as trained input and it will be run for day of the week, holiday days and 30 minute time window on each route.

6.5 Taipei Smart Home Management System Data

In-Snergy API uses the HTTP protocol to transfer data, including information queries, device control and other functions. In-Snergy receives HTTP Request command, and will return HTTP Response. For the Content-Type, HTTP Response supports JSON and XML format. If return format not specified, the default format returned will be JSON data. All API URL begins with http://api.insnergy.com/api/.

For example, the query API for the basic user data is user / info.

The complete URL is http://api.insnergy.com/api/user/info.

6.5.1. Request Format

Request format uses the following format:

<api_method>[.format][?format=format_value][&param_name=param_value]

.format can be .json or.xml, format_value can be json or xml, returned in JSON format and XML format.Ex:

* user/info
* user/info?user_id=myuserid
* user/info.json?user_id=myuserid
* user/info.xml?user_id=myuserid
* user/info?user_id=myuserid&format=json
* user/info?user_id=myuserid&format=xml

6.5.1 API directory

The following lists the detailed usage of API.

Function	Method name	Authentication	Parameters
auth/login	Authenticate the user account password	Permissions verification must be done	* auth (required) Verification code: connect user_id and user_pass colon with ":", and then perform Base64 to encode string together.
device/control	The specified device control	Permissions verification must be done	dev_type (required) Device Type * 02 = Socket-110V * 06 = Multicircuit Socket * 07 = Socket-220V *dev_id (required) Device ID * action (required) Device Action * on = Device ON * off = Device OFF
appliance/user	Query according to the user account for appliances account information	Permissions verification must be done	cust_id (required) User Account

* Example requests

http://api.insnergy.com/api/appliance/cust_id?myuserid

6.6 Taipei Smart home management System Data Flow Model

The following diagram describes the Taipei Smart home management System's data flow used for Minsheng Community household trial. The flow is, the sensors uploads data to the management system, and through the server, the information will distribute data to Rule engine and database, Rule engine performs database auto services including firing alarm and auto control of the on/off switches, and VEE will base on database setting performing the data checking and adjustments.

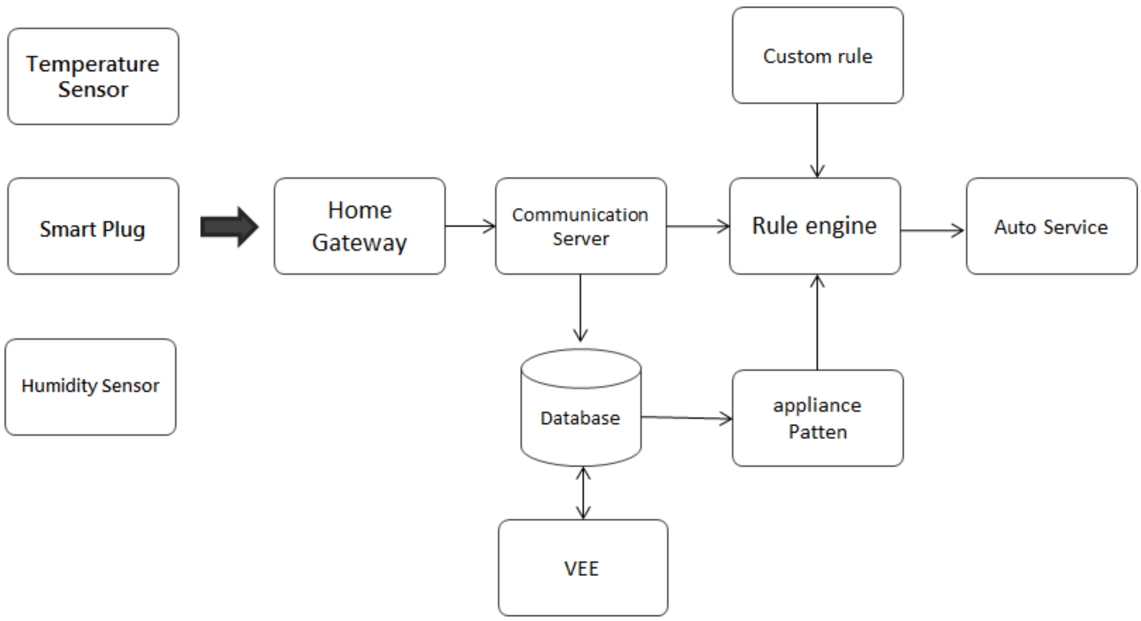


Figure 27 In-Synergy data flow

7 Scenario Implementations

Each of the Use Cases above will be implemented through the realisation of an application. The application is where specific end user requirements are addressed, rather than in the core COSMOS system. Therefore the application approach for the various Use Cases will be shown in this section.

The application developer requirements and requirements for the city to support COSMOS has been the main focus of Year 1 and will span into Year 2 with more depth and breadth.

7.1 Camden Heat Metering Application

7.1.1. Integration with COSMOS

The heat metering application implements the Camden Heat Metering System with integration to COSMOS technologies to supply intelligence to the system and end user.

This section provides a high level design of the Heat Meter Application which forms the core of functionality of an end to end system to measure, bill, collect revenue and manage Camden Heat Meters. Because the overall Camden Heat Meter Programme has many aspects, the delivery is broken down into four packages that are structured in a way that simplifies the communication, functionality and management.

1. Physical Heat Meters and Communications equipment – incorporating all of the physical assets and software found within the residential premises.
2. Heat Metering System – the system that manages the metering and communication assets, manages data from the meters, enables the reporting of the consumption information back to end users and back office staff. Used principally by Hildebrand for the operation of the Heat Metering System, all functionality that is exposed to COSMOS via virtual entity APIs.
3. Back Office System – the system that reports data back to back office staff through web views and exports, allows for different roles within Camden to perform their tasks (such as Finance, M&E, IT, etc.)
4. Payment Interface – this is the interface such that payments collected via other systems can be posted as credits into the Heat Metering System.
5. Resident Interfaces – this is the user interface for the resident to manage their interactions with the Heat Metering System, including a tablet and web site used for support.

This section will show how the Heat Meter System is intended to be used at a process level from the Back Office Portal for management/operation of the:

- physical assets – heat supply, metering, communications and feedback technology
- energy performance management – building and household energy consumption and efficiency through reporting and consumption data export
- accounting and financial elements – prepaid billing system for heat, payment into a prepayment account, management of prepayment accounts, rate setting and tariff management

Also this section will show how Payments will be received from the Capita payments system and be credited to prepayment accounts held inside the Heat Metering System. This is done through an application-programming interface (API) that allows the Capita Payments System to securely communicate with the Heat Metering System. The specification of the Payment interfaces are in that project's detailed documentation, however this document acts as the high level design document to show system level interactions.

This section will show the interfaces that will be exposed to the Camden Customer Access Programme such that dashboards can be presented to Camden residents. These are system level API interfaces and interactions, not graphical user interfaces. Those GUI specifications will be covered in a yet to be decided project in cooperation with the Camden Customer Access Programme.

In addition to the Camden Customer Access integration, the tablet interface will be shown. The requirements have been specified Camden Council on behalf of the residential end users as there are specific regulatory and operational process requirements that need to be met in the first instance of this application.

Finally, this section will show the system level interactions with the Physical Metering and Communications devices and systems. The detailed internal workings of the meters and communications devices will not be covered within this document.

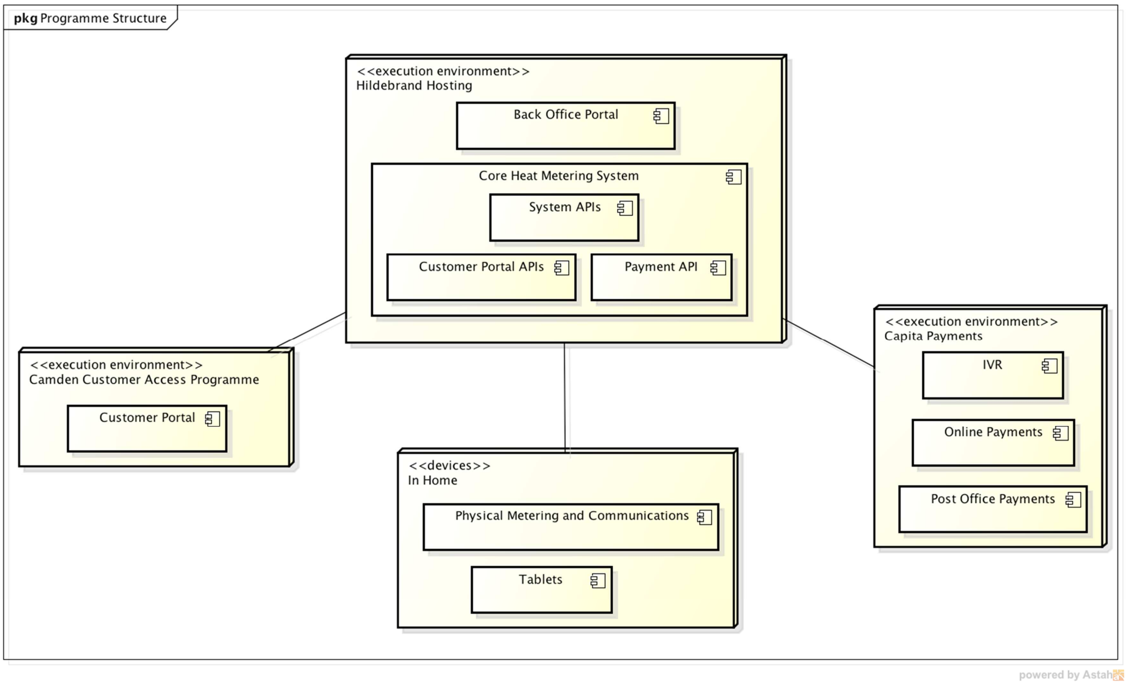


Figure 28 Component and deployment diagram showing all of the physical locations, scope of responsibility and systems associated with the Camden Heat Metering Programme. Note the Core Heat Metering System is at the centre of the Hildebrand responsibility.

7.1.2. Heat Metering System Core

Taking into consideration the very specific area of the Core Heat Metering System as show above in Figure 1, it has a few high level objectives:

- safe and robust operation of the assets in the field, including the ability to bring new properties onto the scheme, maintain the working condition of those assets and signal faults that may have wider impact

- measurement of energy (specifically heat in this case) consumption per household with the generation of a real-time bill and account balances that can be used in a “pay as you go” scheme
- a system for controlling and managing the feedback to householders and energy consumers to include them in consumption, economic, environmental and financial planning decisions
- robust operation of payments and balances, including management of exceptions, overrides and credits

COSMOS interfaces with the Core Heat Metering System and works with the local tablets to enact offline services and social sharing.

Requirements

7.1.3. In-home Components

The in-home components are largely managed by the Tablet that is found in the home. The Tablet is set up to work with a meter and in turn the meter is assigned to a property. Therefore the assignment of the Tablet to a Property is through this chain of associations.

A Customer Account that holds prepaid balance is assigned to a Property. This allows for meter assets to be replaced without disrupting the account balance for a Customer Account. Transactions (credit/debit/adjustments) contain a log entry of the Property that they were made against. Transactions are created with the information that is the current association of Customer Account to Property. If that assignment is changed, history will not be changed, but any future transactions will have the new association of Customer Account to Property.

Section details the design of the In-home components and the tablet, including the User Interface elements where appropriate. The following table is the high level description of the interactions that are required.

ID	Name	Description
SI-1	Alert balance	A visual alert on the tablet which is triggered by the CHMS indicating there is problem with the account balance linked to the meter that the tablet is paired with.
SI-2	View message	Messages can be sent to a tablet with the view message function being able to display a message to the resident. Messages originate from the CHMS or can be put into the CHMS by Backoffice Portal functionality.
SI-3	View tariff	The tariff that is assigned to the Customer Account
SI-4	View weather	Current and forecast weather for the nearest relevant location that the Property that the meter is assigned to.
SI-5	View projected balance	Based on weather forecast and historical usage there will be several views into a projected balance. The first is in terms of projecting a projected “Day to Top Up” and the second as a forecast of spend today, this week and this month.
SI-6	View comparisons	Using usage across similar households, display how your household compares in terms of energy use

SI-7	View instant values	Display of the power (in kilowatts) being used at current time. This is a dynamic reading based on how hot water and heating are being used and will have some lag while the system transmits that reading, however it will be considered “real-time”
SI-8	View historical consumption	Display of energy (in kilowatt hours) that has been used over previous days, weeks, months as a summary and as navigable timeseries graphs
SI-9	View account	Ability to display the Customer Account number on screen with near real-time Balance and the last 5 credits and last 5 debits, including any adjustments that have been made, also the status of the account and the meter/property information that the tablet is configured against.
SI-10	Pair tablet with meter	In order for the tablet to be able to display the above information, it needs to be able to be paired with a meter. The meter, property and customer account associations will then link back through a chain of associations to the tablet. This process will enable the association of the tablet with the meter.

7.1.4. Customer Access Portal System Interactions

The Customer Access Portal is provided by Camden with a link to the information stored within the Core Heat Metering System. The link must be set up by securely associating the CAP identifier with the Property identifier in the CHMS.

If the resident moves or ceases tenancy, the CAP must direct the unlinking and linking processes provided by the CHMS. The CAP may need to validate tenancy agreements, address confirmation, proof of residency to make those links.

The following requirements have been identified for the initial customer access portal:

Unique ID	Requirement
CHM.CAP.101.	CAP must have the ability for a user to change their password
CHM.CAP.102.	CAP will assign or let the user choose a user name
CHM.CAP.103.	User must have the ability to securely associate their CAP account with their CHM Customer Account
CHM.CAP.104.	User must be able to view the status of their account
CHM.CAP.105.	User should be able to turn off their heat and ensure that no money will be taken from their Customer Account (suspend account) if they are gone for a long period
CHM.CAP.106.	User should be able to see their instant power usage in Watts
CHM.CAP.107.	User should be able to see their rate of use in monetary terms, £ per hour usage calculated over a rolling 15 minute window
CHM.CAP.108.	User should be able to see the total amount of energy in kWh used by periods
CHM.CAP.109.	Periods will be defined as day (last 24 hours), week (last 7 days), month (last 30 days) and last year (last 365 days)
CHM.CAP.110.	Historical usage should be shown graphically as a bar chart showing the daily usage for a selectable periods

CHM.CAP.111.	User should be able to see the total amount of usage (cummulative in kWh) from 1 April 2013
CHM.CAP.112.	User should be able to view comparisons with flats of the same size (number of bedrooms) within the Block that it is located in for Periods as defined. This is shown in kWh
CHM.CAP.113.	User should be able to view energy use for the previous year for the same Periods as defined. For example, same week last year or same month last year.
CHM.CAP.114.	User should be able to see the account number and barcode of their Customer Account. There is no difference in Prepaid to Credit customers in this case
CHM.CAP.115.	User should be able to see their Balance that is on the Customer Account
CHM.CAP.116.	User should be able to see the cost of energy for the same Periods as defined
CHM.CAP.117.	The User should be shown an estimated top up date based on a forecast of energy usage
CHM.CAP.118.	User should be able to see their tariff with unit costs displayed
CHM.CAP.119.	User should get a strong indicator on the User Interface that they are running low on credit
CHM.CAP.120.	User should get a very strong indicator when they credit has run out and they are to be or have been disconnected from supply
CHM.CAP.121.	User should have access to the transaction log of financial transactions against their account, this will include a rolling balance on a daily basis, i.e. at least one transaction per day showing the consumption and balance at the end of that day
CHM.CAP.122.	User should have access to the history log of state changes against their account
CHM.CAP.123.	Messages and message history must be able to be delivered to the user, they will be limited to 100 characters
CHM.CAP.124.	Communication outages should be handled
CHM.CAP.125.	Estimated performance and loads should be handled
CHM.CAP.126.	The solution should be able to look up all information based on the Customer Account number
CHM.CAP.127.	The solution will use secure HTTPS as the application data protocol with a Restful design
CHM.CAP.128.	Data encoding will be via JSON notation
CHM.CAP.129.	The solution will only accept calls from known IP addresses
CHM.CAP.130.	The solution will use HMAC tokens to secure the integrity of API requests
CHM.CAP.131.	The solution should achieve an up time of better than 99.8% excluding scheduled outages
CHM.CAP.132.	User should have the ability to change their billing preference from Paypaid to Credit if they are a vulerable tenant

Following the requirements that have been captured, a set of system interactions have been designed to meet those requirements.

ID	Name	Description

SI-11	Alert balance	A visual alert on the tablet that is triggered by the CHMS indicating there is problem with the account balance linked to the meter that the tablet is paired with.
SI-12	View messages	A list of all of the messages that have been sent to the user account.
SI-13	View tariff	The tariff that is assigned to the Customer Account showing the structure and values assigned.
SI-14	View weather	Current and forecast weather for the nearest relevant location that the Property that the meter is assigned to.
SI-15	View projected balance	Based on weather forecast and historical usage there will be several views into a projected balance. The first is in terms of projecting a projected “Day to Top Up” and the second as a forecast of spend today, this week and this month.
SI-16	View comparisons	Using usage across similar households, display how your household compares in terms of energy use
SI-17	View instant values	Display of the power (in kilowatts) being used at current time. This is a dynamic reading based on how hot water and heating are being used and will have some lag while the system transmits that reading, however it will be considered “real-time”
SI-18	View historical consumption	Display of energy (in kilowatt hours) that has been used over previous days, weeks, months as a summary and as navigable timeseries graphs
SI-19	View account	Ability to display the Customer Account number on screen with near real-time Balance and all transactions including credits, debits and any adjustments that have been made, also the status of the account and the meter/property information that the CAP account is configured against.
SI-20	Create Customer Account	The ability for a CAP user to create a heat metering Customer Account, this will then provide the CAP user with the ability to make payments against that Account, view the data from the linked meter, etc.

7.1.5. Backoffice Portal

The Backoffice Portal has systems interactions that are used by staff to manage various aspects of the overall system. This includes physical assets, residential end users and financial accounts belonging to residents.

The following requirements for the Backoffice were identified by Camden staff:

Unique ID	Requirement
CHM.BO.101.	Account information must be able to be found through a search by block and flat information, showing the PRN that the account is currently assigned to
CHM.BO.102.	The Customer Account can be of either type prepayment or payment on account (extending credit)

CHM.BO.103.	Within the solution when showing details of the Property and Account, the Customer Account number should be shown
CHM.BO.104.	Within the solution when showing details of the Account, the full bar code number that also contains the Customer Account number should be shown
CHM.BO.105.	The solution should show the account status of which there is Active/Ceased/Suspended - there are other inferred states on the Account as well, Disconnected and Unlinked/Linked
CHM.BO.106.	The system should record the time and date that the Customer Account was created and by what method
CHM.BO.107.	The system should record the time and date that the Customer Account was ceased and by what method
CHM.BO.108.	The system should record the time and date that the Customer Account was suspended and by what method
CHM.BO.109.	The system should record the time and date that the Customer Account was ceased and by what method
CHM.BO.110.	The system should record the time and date that the Customer Account was Linked and by what method
CHM.BO.111.	The system should record the time and date that the Customer Account was Unlinked and by what method
CHM.BO.112.	The system should have a time and date that the suspension should resume to Normal state for the Customer Account
CHM.BO.113.	A Customer Account should contain a vulnerability indicator (true/false) to be used for do not disconnect
CHM.BO.114.	The Customer Account must contain an indicator to show that it is either a Tenant or a Leaseholder account, an additional type should be added which is internal
CHM.BO.115.	The system should provide a listing of the Account details for a specified period per Property, Block or Type (status, do not disconnect, tenant/leaseholder)
CHM.BO.116.	The system will be able to show the energy consumption at a Property level, organised by Block and also aggregated by Block (total consumption and average consumption)
CHM.BO.117.	The system will be able to show the consumption by Block recorded by the Bulk meter if one has been installed
CHM.BO.118.	The system will be able to show the comparison for the total consumption as the sum of all of the Blocks to the Bulk meter
CHM.BO.119.	The system will be able to show the average consumption of the Block and the averages for Properties within that Block that are of the same number of bedrooms (as provided in a reference). The comparison will be shown between the individual flat and the average for the group that it belongs to (all and number of bedrooms)
CHM.BO.120.	The system will be able to show the energy consumption per property for a date range and the reads (actual meter readings). If the Property has 2 meters, consumption will be summed and reads will be indicated as to which meter they came from
CHM.BO.121.	Bulk meter reads will be presented as consumption (for the Periods) and the reads (actual meter readings) for a date range
CHM.BO.122.	Properties with two meters will have an extended report showing the two meters separated out from the total. This includes both consumption and reads
CHM.BO.123.	The system will offer a prediction/forecast of consumption for a 12 month period

CHM.BO.124.	The solution will be able to show ranked order of energy consumers (based on meter and links back to Property/Customer Account) and be filtered based on Status (Active/Ceased/Suspended, Type (Tenant, Leaseholder, Prepaid, Postpay),
CHM.BO.125.	The solution should be able to produce an energy report which is a CSV file downloadable with Property identifiers and reads on a daily basis.
CHM.BO.126.	The solution will be allow for a financial manager to be able to create new rates for charging consumption. The rate in pence per kilowatt hour can be combined with a standing charge to form a Tariff. Tariffs will be able to be managed at an individual or block level
CHM.BO.127.	A standing charge can be a part of the Tariff. It will be expressed as pence per day and when used in the balance calculation will be charged by the minute. The standing charge will work within a Tariff structure and be configured along with a rate.
CHM.BO.128.	Payments can be manually entered into the system with credit going to an account. The source of that payment will be from the Back Office system
CHM.BO.129.	Adjustments (credit/debit) will be able to be made against an account at anytime.
CHM.BO.130.	Disconnection must be able to be restricted based on time and date. This will mean that disconnections are not allowed at those times by the system.
CHM.BO.131.	A vulnerability indicator will be recorded against an account that indicates this Customer Account will not be disconnected.
CHM.BO.132.	The system will be able to override the disconnection and turn the heat back on. This will be an administrative function performed by a sustainability officer
CHM.BO.133.	The system should show the Customer Account balance
CHM.BO.134.	The system will show the rolling balance of the Customer Account on a daily transaction log whereby for any given day the transactions for credits and debits with the corresponding resulting balance will be visible
CHM.BO.135.	The system will show the current Customer Account balances by Block and Property
CHM.BO.136.	While looking at a Customer Account, a historical log of activity should show disconnection and reconnection events with a time and date
CHM.BO.137.	Should be able to list closed accounts and unlinked accounts and the current Balance of those Accounts. Rejected income will be reported by the Payment system supplied outside of this system
CHM.BO.138.	System will send an alert for vulnerable Accounts going into emergency credit
CHM.BO.139.	System will send an alert for Account that is has been disconnected
CHM.BO.140.	System will produce a CSV export on a per Account basis that shows their transaction history. This will include credits/debits/adjustments with daily debits reflecting the consumption costs for that day. A date range can be selected for the export (to/from date)
CHM.BO.141.	System will produce a CSV export of the financial activity for a Block with individual Property and Accounts listed for a given date range.
CHM.BO.142.	System will show a list of meters that are not making contact with the server infrastructure. This will be shown as an ordered list by age of last contact
CHM.BO.143.	System will show a list of broadband lines that are down
CHM.BO.144.	System will show a list of screens that have not made contact with the server. This will be shown as an ordered list by age of last contact
CHM.BO.145.	The system will have a facility to generate energy statements on a Property by Property basis

As a part of the design process the system interactions have been designed to meet the requirements above.

ID	Name	Description
SI-21	Property Group creation	The ability to create property groups based on Estate and Block hierarchies. The Groups will be used for filtering, sorting and aggregating Properties.
SI-22	Property creation	The ability to create Properties that contain a unique reference number and are used in assignment to Customer Accounts, Meters and other in-home equipment. They should also be associated with any Groups that are relevant. This is considered a key link to Camden systems for reporting and assignment.
SI-23	Equipment sourcing	This is the process of batch numbering equipment that will be placed in the residential system so that any pre-configured associations between Tablet, Meter, PCB and Router can be made prior to installation. Intended to be used by installers and assembly partners. Should also contain serial numbers or unique identifiers and asset tags of interest to the process.
SI-24	Equipment installation	This is the process of assigning a batch of equipment to a Property at the time of installation and carrying out any quality checks on the installation, validating the associations of equipment and leaving the equipment in proper working order. Should also record the date and time of installation for reference.
SI-25	Equipment monitoring	The process that actively checks the equipment in the home and its functional parameters. It will send those parameters to the Fault Detection system to either trigger an alert, escalate, ignore or take some control of the equipment.
SI-26	Status report	A report that shows the status of the equipment, what its current readings the ability to sort and filter.
SI-27	Communications network install	The process of installing the broadband and mesh network elements, including any security settings and placement within the management tool.
SI-28	Communications network monitoring	The process that actively monitors the communications network operational performance including data connectivity, throughput, mesh routes, clients attached, etc.
SI-29	Fault detection	The central process the view monitoring data and generates a fault based applying rules on the data that is coming in to the Fault Detection system. Some basic alerting functionality will be provided, but alerts that are generated may need to be tracked and escalated within other operational systems outside of the CHMS.
SI-30	Equipment change	Equipment will be maintained and replaced over time and this process allows for the management of those changes. It will support the creation of new Equipment elements and the assignment of those elements to the various Property references and communications network elements.

SI-31	Infrastructure view	This is a general export and reporting area that provides access to the equipment that is providing CHM services. That includes the assignments and relationships between equipment and properties.
SI-32	User management	The Backoffice Portal will have users that will be given credentials to log in and use functionality. A system administrator will be allowed access to manage users, such as creation, deactivation, password changes and permissions/role assignment. Individual users will have some user management functionality that will allow them to change their password and contact details.
SI-33	Role management	The Backoffice Portal will restrict functionality based on Roles. Role management is the ability to create those Roles and enable the permissions on to functionality. For instance a Role may be Sustainability Manager that only has access to Energy related, not financial data on Properties.
SI-34	Heat distribution model management	This is the functionality that allows for central boilers to be created with size, type and other descriptive information can be held for analysis purposes. Also Properties will be able to be modelled against which generation and distribution system they are a part of.
SI-35	Gas reads	This is the process that generates Gas readings. This the input gas that is metered for some of the Boiler inputs. It may come from a file or be entered by hand from gas meter readings. This represents the raw energy input into the entire heating system. The reads will be in the same units across the entire system (kWh) and need caloric values to be applied before they are put into the system.
SI-36	Bulk meter reads	This is the process that generates Bulk meter readings. Bulk meters are reading the hot water energy that has been generated within the Boiler plant. The difference between the Gas input energy and the Bulk meter read is the boiler’s efficiency in converting gas into hot water. The Bulk meter read may have energy, power, temperature, flow rate and other parameters that must be captured.
SI-37	Meter readings	This is the process that generates meter readings. The meter readings are at an individual residential level with the difference between the Bulk reads and the Meter reads being the efficiency of the distribution system (i.e. losses in the pipework). The Customer Account will be billed against the kWh energy of the Meter readings. The other readings such as power, temperature and flow will be transmitted and used as input into analysis and presentation for Customer and Backoffice facing functionality.
SI-38	Tariff management	This is the process of maintaining the tariffs or unit rates that will be applied to the Customer Account and/or the consumption of energy. The tariff is the price to the Resident. This may be a combination of standing charge and rate per kWh consumed. The Balance of the Customer Account will be debited at the rate specified by the Tariff that is assigned to their account. Note: there can be multiple Tariffs in the system however only one Tariff can be assigned to a Customer Account at any one time.
SI-39	Event management	Events are a general term used to capture something that has happened at a particular time. This functionality is a general facility for capturing and managing Events that might be used for future

		analysis. This might be a record of a system outage or fault that needs to be recorded.
SI-40	Time aggregate calculations	This is the process that calculates energy and usage statistics over various time periods. These are the aggregates that are used for reporting, billing and general analysis. They are at the heart of the Core Heat Metering System. An example would be the number of kilowatt hours consumed by a Customer Account from the 1 Feb to the 28 Feb or the day by day amount consumed across that period. More advanced to that, would be the average amount of energy consumed by a Block, Estate or other group for a time period. This function makes extensive use of the data that has been recorded in the CHMS database.
SI-41	Cost calculation	This is the process that takes the Tariff and Customer Account (including consumption from the Account) and calculates the cost. This is a real-time running process that will debit the Customer Account Balance.
SI-42	Financial view	This is a general process description of the export and reporting functionality that is required for the financial aspects of the Core Heat Metering System. This includes reports/exports of Balances by Property, spend per Property for various time periods, etc. Also there is the ability to view transactions by Customer Account, credits, debits and adjustments.
SI-43	Financial adjustments	Financial adjustments are administrative credits and debits that are entered to Payments API. For instance a credit may be given.
SI-44	Customer Account Edit	This is the ability to edit the Customer Account details and change the status or assignments of the Customer Account. This is meant to be a super user type function that allows deep edits within the CHMS data structures. In particular attributes like, Do Not Disconnect (DND) can be toggled within this area. Customer Account Creation has been captured in the CAP components description in **¡Error! No se encuentra el origen de la referencia.**.
SI-45	Energy model management	Although this may not be readily clear, it is meant to reflect the capture of an energy model. For example, you may want to actively record the Bulk meter reads subtracting all of the Meter reads that are downstream from it. This model might write data into a new timeseries that can be displayed as an ongoing efficiency measure. Also, internal to the Core Heat Metering System, things like comparisons and benchmarks are stored as models. This functionality may be reserved for internal Hildebrand staff.
SI-46	Energy measures	This is the process of reading and naming the output from the Energy Models. It is a report or export of energy measurements derived from the readings and data/algorithms from the Model.
SI-47	Energy view	This is the overall reporting/export function of all of the energy Measures, including the meter reads.
SI-48	Household energy feedback	This is the area that allows for the communication of messages and the assignment of a Customer Account into a comparative group. The Feedback are the measures (statistical or direct readings)

		provided to the Tablets and the CAP, plus any messages that might get sent to the Customer Account. The messages are managed and originated from this functionality.
SI-49	Tablet view management	This is the functionality that manages the view of the Tablets.

From the system interactions, a navigation framework has been constructed.

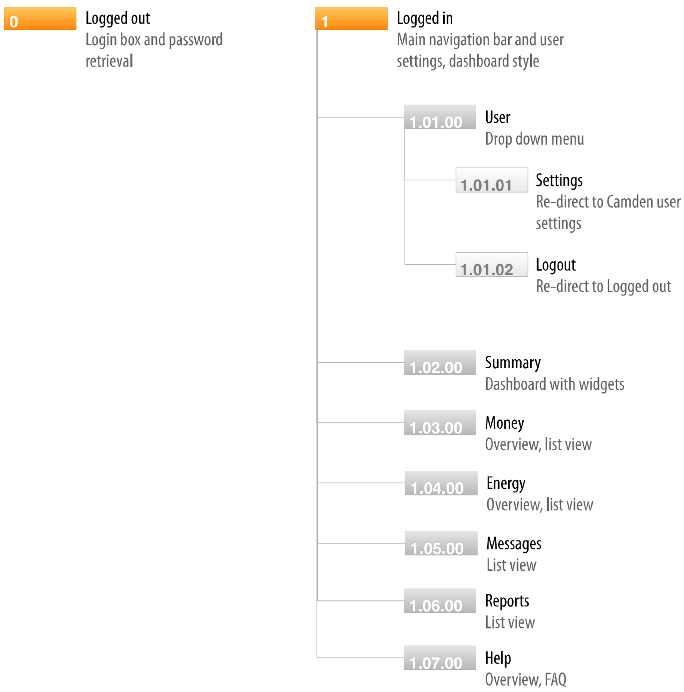


Figure 29 Backoffice navigation structure

The following is a short synopsis of the intention of each of the areas that corresponds to the navigation element.

- **Login** (logged out Home) – this represents that page that will ask for a username and password in order to authenticate users. There is a function to send a password to recall the password. This is the default view when navigating to the Backoffice portal URL.
- **Home** – this the page just after login, which will be like a dashboard showing the main navigation that is allowed for the role that is logged in. Messages and alerts should be shown on this page.
- **Property** – most of the management of the system will be from an index of a property. This allows for users of the Backoffice portal to find information about the state of the heating system at a particular property and the Customer Account information linked that that Property. There is cross navigation to Accounts such that Account functions are performed at that detailed level.
- **Account** – this give the BO portal user the ability to find information about the Customer Account regardless of what Property it is linked to (or in some cases the

Account might not yet be linked), transactions against the Account and the ability to make adjustments to the Account will be in this area.

- **Energy** – group level (estate and block) energy consumption, plus the ability to compare groups of flats (for instance of similar size) will be the primary view of this area. Individual Property consumption information can be viewed and the generation of things like Energy reports will be provided in this area.
- **Finance** – accounting functions to view transactions across the whole heat payment scheme will be the focus of this area. Financial controllers should be able to see the total credit and debit accounting logs. This is also the area that tariffs will be managed, however they can be assigned At the Account level as well.
- **Operations** – mostly pertaining to the safe and efficient operation of the metering and in-home assets, plus the communications network that brings data back to the main cloud service.
- **Reports** – a log of the reports that have been run in various export functions, plus any system generated reports that are scheduled or triggered from the backend.
- **User Settings** – individual management of passwords and any self service user settings. This is not to be confused with the accounts that are for residents which are held in the CAP. This is only the users that have access to the Backoffice portal.
- **Role Management** – roles define the entitlement/rights to perform functions within the Backoffice portal, for instance a generic Manager role can create new Officers.
- **User Management** – ability to see all of the users of the Backoffice system, it will be restricted to Superuser and Manager level permissions.
- **Signout** – this will redirect to the Login page

7.1.6. Payments System

The payment system provides the interface to credit funds on to the Customer Account Balance. It also provides some management interfaces to the Customer Account, notably creation of the Customer Account and the ability to change the status of Customer Accounts. By design, this system is quite independent from the CHMS and has the ability to de-couple from the Property and Meter aspects of the system.

The motivation for this separation is for ease of implementation of security, adaptability to other payment mechanisms and portability of Account Balances between Properties.

ID	Name	Description
SI-50	Cease account	A Customer Account may be ceased if the Customer Account is no longer required. This means the Account no longer accepts payments, but the identifier of the Account is not reused and historical transactions can still be reported. A ceased state is the only one that Balances can be zeroed and cash returned to the Customer Account.
SI-51	Un-cease account	This is a change of Account status to take it back into normal operation.

SI-52	Freeze account	A Customer Account might need to be frozen and reject credits and debits, however this may be while the Customer is changing Properties or has an administrative issue. For this reason adjustments can be posted to a frozen account.
SI-53	Unfreeze account	Ability to reverse the state of frozen and take an account back to normal operation.
SI-54	Disconnect account	This turns on and off the flag that allows for the heat to be disconnected as a result of payment rules. If the disconnect flag is false, then the heat can not be disconnected. This function will set the disconnect flag to true, which is the default state.
SI-55	Un-disconnect account	This reverses the disconnect flag and sets it to false.
SI-56	Unlink Property	This unlinks the Property from a Customer Account. Credits and adjustments can still be made, by there is no consumption recorded against the Customer Account, so no debits will practically be transacted.
SI-57	Link Property	Provides a function for the linkage of a Customer Account to a Property. No validation is done within this system, so any validation/authorisation must be implemented before this function is called.
SI-58	Create Account	An account must be created and as a result an Account number will be generated and returned. The Customer Account can then be used to credit and link to a Property.
SI-59	View Account	A Customer Account has various attributes, states, associations and transaction records against it. The view Account functionality provides a view/export of that information.

7.2 Madrid Application

7.2.1. Integration with COSMOS

The Madrid EMT application is at a conceptual level for Year 1 and would be implemented as a mobile native application in order to make use of mobile operating system's communication and location services. Figure 30 shows the local data structures that will be relied on for application development with the Application Data being used for virtual entity data to power the application.

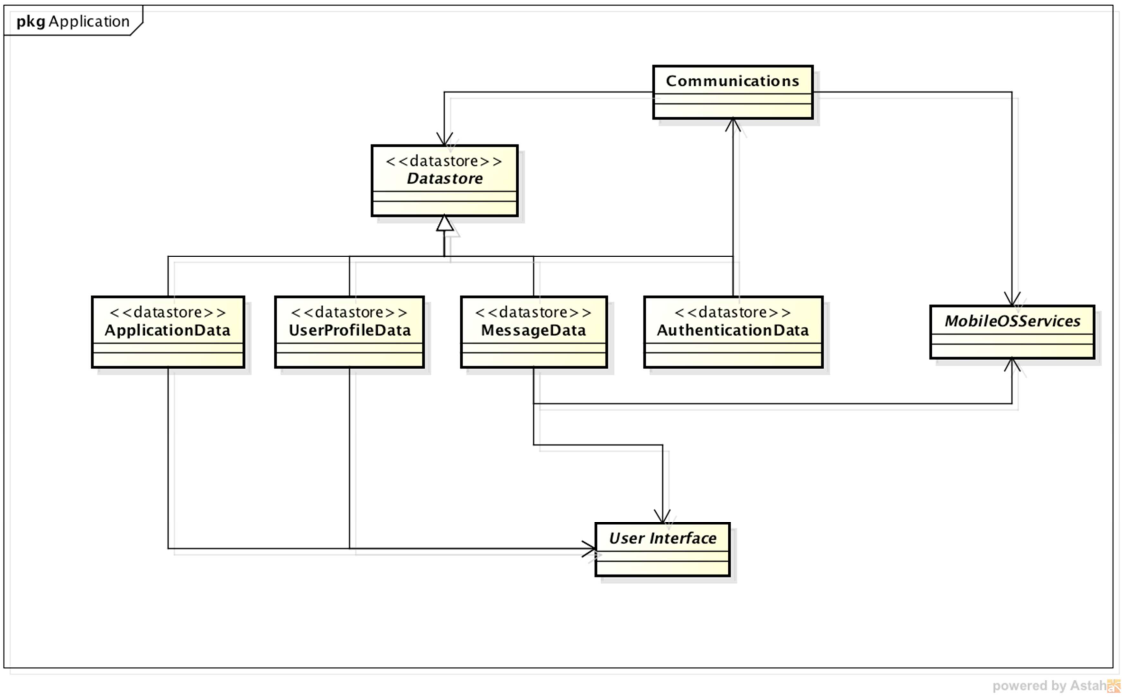


Figure 30 Mobile application architecture implemented on a handset through native OS services. This is for both Android and IOS

User Profile and Message Data are the responsibility of the application developer, including any support for creation of users and addressability of the messages.

The Application Data representing the virtual entity will be delivered through the Reactive Box framework which will be brokered via the COSMOS platform. Reactive Box will be described in more detail in Year 2.

8 Conclusions

This document has shown the Use Cases, domain specific background information and application design for the three test bed cities for COSMOS. The physical systems and input data represented as virtual entities (VEs) will be used in conjunction with COSMOS to deliver applications that are socially aware.

The implementation strategy is to make the data sources available to the other work packages while trying to think through the practical limitations of the city as a target user of the COSMOS system. Many of the advanced technologies and concepts in COSMOS will be difficult for city ICT and city business unit managers to understand, therefore WP7 must also provide a user experience that works to deliver services.

The Camden application is being constructed in Year 2 with Madrid focusing on a robust provision of their virtual entities for external application developers. The Madrid use case provides a reference for the type of citywide virtual entities that would be required by any large public transport service.

Within Year 2, there will be an emphasis on generalising the COSMOS services and framework though a test COSMOS platform that will be operated by Hildebrand. This should further supply requirements for application developer support and other generalised services that will be necessary for them to develop for city customers.

Also within Year 2 a detailed description of the Taipei Use Case will be given with a design as to how the existing energy feedback application can use COSMOS services that will be available on the Year 2 platform.