COSMOS

Cultivate resilient smart Objects for Sustainable city application

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1 Introduction

This document is an update to the initial Use Case Scenarios Definition and Design document published in Year 3 of the COSMOS project. It further develops the use cases for COSMOS, as well as showing how those use cases have been tested with end user input. We go further in showing three areas of focus for COSMOS application partners:

1. how the IoTA reference architecture can be realised into a platform that offers the adaptability and scalability for smart cities; this effort is demonstrated through UrbisAPIs a prototypical smart city instance of COSMOS;
2. leveraging the peer to peer and low resource device goals of COSMOS as social objects through an open source radio level communications protocol named OpenThings and then integrating that with UrbisAPIs; and
3. the creation of a scalable system for converting pull-based public information into published events through work on VEPROT which will be further disseminated through Madrid's Mobility Lab.

The goal of including UrbisAPIs is to have a COSMOS legacy where a COSMOS platform instance is provided for end users to participate in the innovation cycle. Year 3 is the launch of UrbisAPIs to the public and, similarly, the Mobility Labs instance of the VEPROT and COSMOS work will be made public on Madrid's transport data sources.

Let us re-iterate key issues from Year 1. Smart City applications are wide-ranging, and have many practical implications for deployment:

- IoT promises to be an effective technology for higher quality, more efficient and new city services despite some of the implementation challenges.
- To limit project risk, cities that are using IoT are still doing so with "island" implementations, that is to say business functions are not integrated using IoT and IoT infrastructure is not being leveraged between business functions.

From a city perspective, COSMOS has a mission of:

- improving the utility of IoT systems across multiple applications;
- reusing existing instrumentation;
- providing tools for creating new applications in this integrated paradigm; and
- demonstrating new financial benefits in the applications deployed.

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 a further iteration in Deliverables 7.1.3 progressing both the sophistication and, by virtue of our integrated approach, the impact.

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

In this Work Package deliverable, we will:

- describe UrbisAPIs and show the functional design and features of the platform;
- introduce new Use Cases from Camden and Taipei test beds;
- show general features of city management and organisation;
- present a framework for usability and user interactions;
- update background material describing the current situation and available resources in each of the cities;
- present plans for new survey material and end user research carried out by Camden;
- show the Use Cases and how they are enacted and modelled within UrbisAPIs;
- describe the work that has been carried out in making devices that are COSMOS enabled, including work on the OpenThings protocol and how those are compatible with UrbisAPIs; and
- articulate some of the challenges that were discovered and any anticipated challenges ahead.

The value of this deliverable should be to show the challenges and user issues around COSMOS technology and, specifically, implement city solutions with COSMOS as city management and application developers, with UrbisAPIs and Mobility Labs as two facilities to carry that work forward.

The outcome of this deliverable is not only to inform the project, but also to give future Smart City projects some working models for the delivery of projects.

2 UrbisAPIs

As the name implies, UrbisAPIs is a platform focused on APIs for city services, and represents an instance of the COSMOS platform. From the perspectives of the city test beds, this is where COSMOS can be used and managed for VE developers and application developers. It provides an ease of use for infrastructure owners and operators (both the city- and citizen-owned assets), virtual entity creators/maintainers and application developers.

This section is an initial product specification that shows the end user perspective of features and functions that can be used once they are registered. The scope for UrbisAPIs is multicity, in that, as a user, you will be able to use services from multiple city infrastructures and model virtual entities that span cities.

Implementation of UrbisAPIs will continue through Years 3 and beyond of the COMOS project, and some functionality is currently available to Camden developers. A product roadmap will be shown with staging of features. However, an iterative development methodology is being used.

UrbisAPIs can be found at http://www.urbisapis.com.

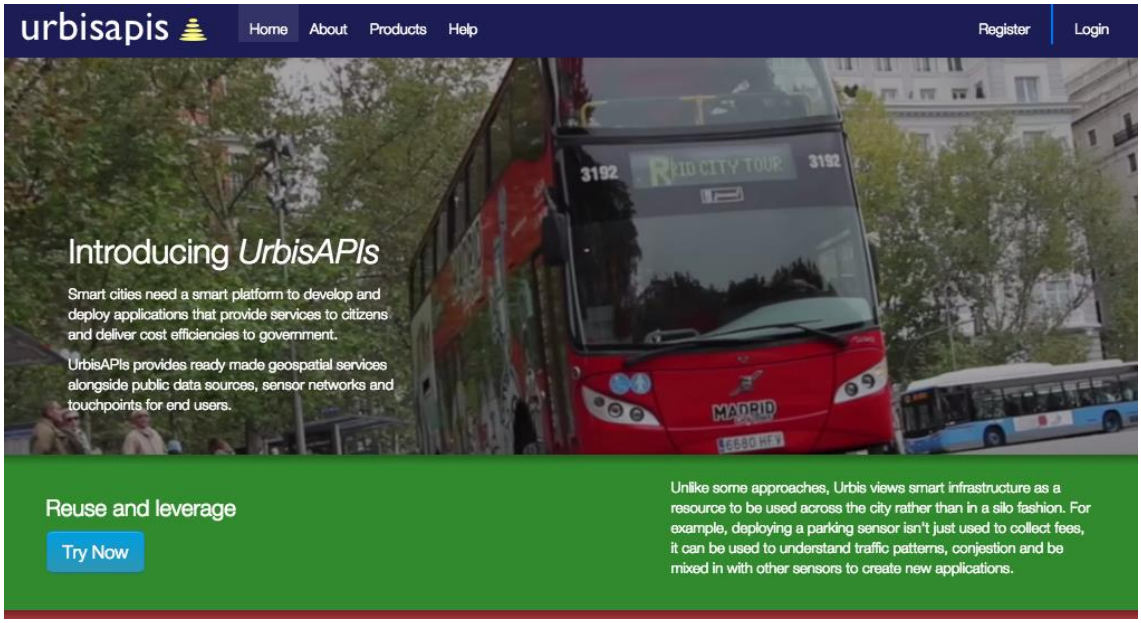


Figure 1: UrbisAPIs Homepage

2.1 Purpose

This section provides a design of the UrbisAPIs platform that forms an exemplar instance of the COSMOS project. The UrbisAPIs website provides a user interface for end-to-end functionality relating to COSMOS, with unique functionality of coordination/integration of COSMOS subsystems, higher-layer IoT functions, billing, revenue collection, operational management of services below the application layer and distribution assistance for applications.

To show the deployment of the system, the description of the overall system is broken into four deployment locations:

1. **Field assets** – incorporating all of the physical assets that are sensing, actuating and bridging communications; some field assets may have local control and peer level communication – examples will be shown in Section 8, where field asset capabilities are shown for UrbisAPIs; an important and complex field asset is one that is mobile (changing physical location of the asset), or may even be virtually mobile (a process representing a virtual entity may move to different field assets).
2. **Customer facing** – essentially these are applications. However, there are special provisions for end users to participate in feedback and interaction with virtual entities, security implications, accessibility, timeliness and the ability to model end users as virtual entities makes them important to model within UrbisAPIs.
3. **Hildebrand hosted** – composed of subsystems, this area is the "cloud" for COSMOS and the core of the UrbisAPIs platform; the UrbisAPIs Portal is the user interaction that is detailed in this section.
4. **Payment systems** – this is the interface such that payments collected via other systems can be posted as credits into UrbisAPIs.

This document will show the UrbisAPIs Portal functionality and how it is used for the creation, management and operation of virtual entities and applications.

Further to that, roles and user types will be shown with mappings to functionality that the UrbisAPIs system will provide. The creation and management of those roles will be shown.

Finally, this document will show the query and reporting interactions with the devices and device management systems. The detailed internal workings of the sensing, actuating and communications devices will not be covered within this section.

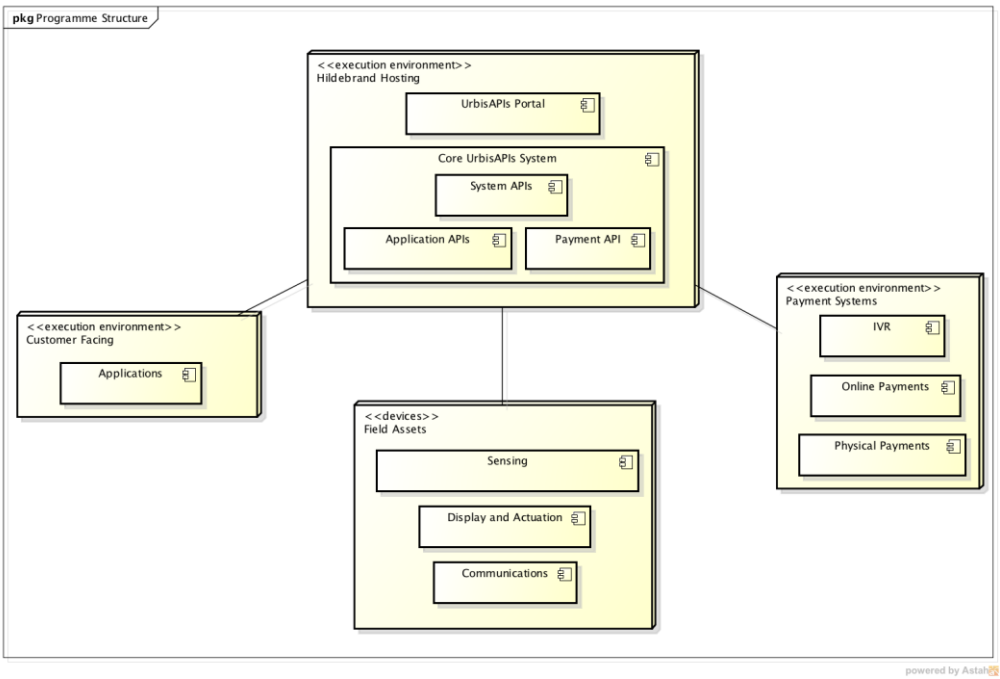


Figure 2: Deployment diagram of UrbisAPIs

2.2 Core UrbisAPIs System

Taking into consideration the very specific area of the Core UrbisAPIs System, as shown above in Figure 2, there are a few high-level objectives for any application implemented within UrbisAPIs:

- safe and robust operation of the assets in the field, including the ability to bring new field assets into the system, maintain the working condition of those assets and signal faults that may have wider impact;
- representation of a virtual entity within a context of an application;
- a system for controlling and managing the feedback to and from the application, to support the application with data and events; and
- robust management of payments and balances where required, including management of exceptions, overrides and credits.

The UrbisAPIs Portal provides the management and control via a web-based user interface that is hosted by Hildebrand. A concept of a Super User has the capability to configure new users of the UrbisAPIs Portal. The user interfaces described in this document are wireframes to convey the basic functionality presented on a screen. Textual descriptions will compliment and complete the wireframe diagrams and should be read carefully, as they may contain more information the diagrams themselves.

A logical architecture is a model that is used to express concepts and label functional process of a system. We are using a technique known as the unified modelling language or UML to document components. Please refer to external resources for explanations of UML.

2.3 Design Overview

The design approach is user-focused, with the goal of providing value to the users of the UrbisAPIs system through reuse, sharing and ease of use. When interviewed, possible users of UrbisAPIs were:

- not ICT experts;
- have limited ability to manage software development and software systems implementations;
- viewed integration as a major advantage, but had struggled previously in integrating current software systems;
- had limited ability to procure a software system that required internal ICT support, but also struggled with security and privacy concerns in outsourcing through software as a service (SaaS).

Our chosen deployment model is SaaS, which means that the high-level design considerations can be addressed within the boundaries of SaaS. Security and privacy pose challenges in a cloud environment, especially one where the application layer is outside the control of the city. Where the system design can alleviate concerns with privacy and control choices will be shown as design constraints.

2.3.1. Overview of Users and Roles

From the analysis taken from Section 3, where city operational structures are shown, the following system roles are represented within UrbisAPIs:

- **Super User** – creates and manages all users; has access to all functions.
- **Manager** – a role that can be appended to any operational role, such that a manager can administer users under the hierarchy. For instance, a Customer Services Manager can manage all Customer Service users, and has the functional rights that the user group has access.
- **Customer Services** – view permission on virtual entitles that are within an application entitlement scope.
- **Application Management** – view and management of applications that are entitled by a developer; can assign Customer Services entitlements.
- **Finance** – view and management of accounting features for virtual entities and API access; can set prices and make financial adjustments to account.
- **Technical Operations** – view permissions on system performance indicators, like load and number of requests.
- **Application Developer** – creates an application and assigns Application Management user entitlement; ability to manage the application and construct new virtual entities; can assign entitlement to technical operations.
- **Data Provider / Maintainer** – ability to create new data source and virtual entities and assign permission levels to those sources.

3 City Operational Structures

Whereas Smart City policy research has developed models for themes, issues and actions in developing a Smart City, very little research has been aimed at an operational level. In this section, we develop models that can be used for the implementation of IoT within a Smart City context.

3.1 Background

A thematic approach is the most common way to show the potential benefits of the application of IoT and, therefore, a Smart City approach. This mimics how the city organises budgets and management structure, and how citizens would view their various needs from government services.

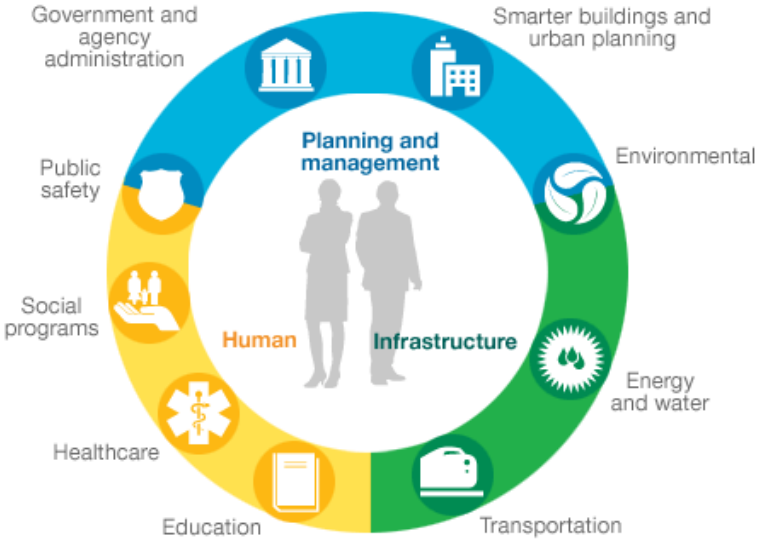


Figure 3: Smart City thematic model (IBM Smarter Cities, 2014)

Many of the research projects within Smart Cities, for instance, Zenn, R2Cities, Pitagoras, Celsius, Insmart, Steep, Eu-Gugle, Step Up, Pleec and Transform, are energy system-lead, with innovation coming from citizens or private business working on the fringe of city operations. The technology deployment model is largely driven by the way a service is procured or how it is financed through risk-sharing with systems vendors or community interest groups. This is further a practical consideration, as many cities do not own energy infrastructure and merely set policy or policy environments that promote the city's interests.

Other research projects in the smart transport area for cities look at integrating transport for efficiencies, better energy efficiency in public transportation systems, traffic management and emergency services provisions. Here there is more of a direct ownership model of transport assets (roads, buses, track, trains, etc.), large operating budgets and specific technical knowledge required to make these systems function.

The other areas shown in the thematic model exhibit similar affinity towards IoT and ability for the city to directly control influence. Figure 4 shows the relative scale of city government themes' ability to implement IoT solutions for Smart City applications.

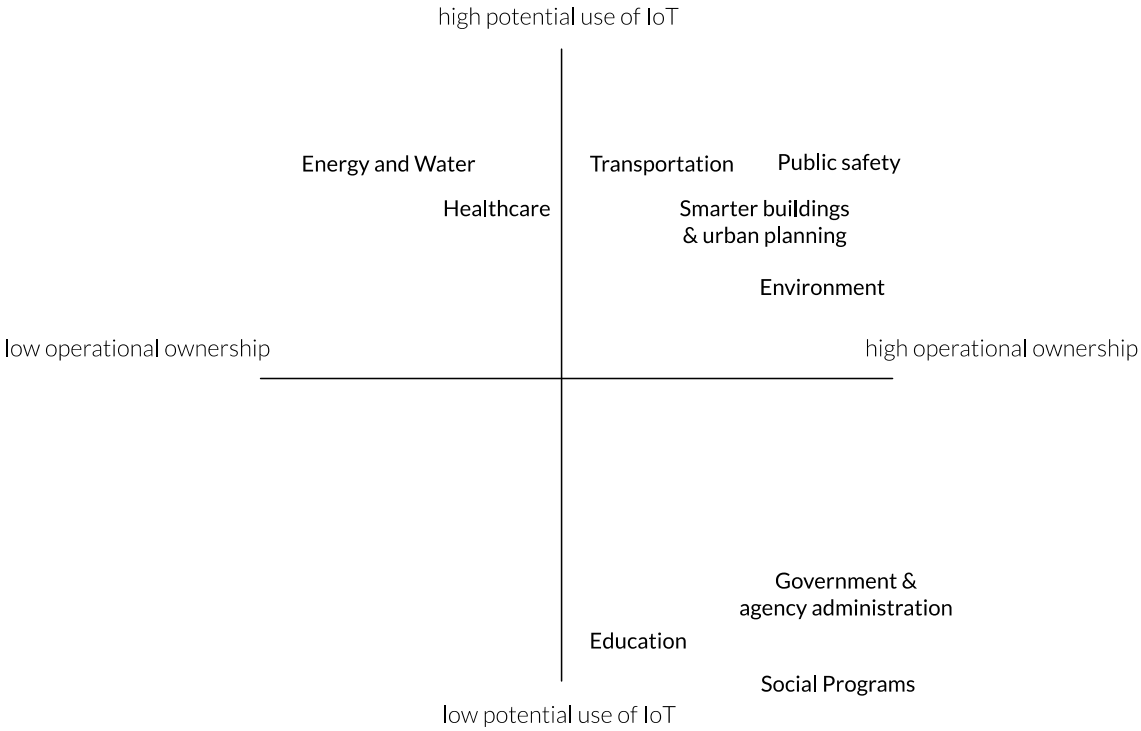


Figure 4: Integration and infrastructure reuse within government organisations are dictated by level of operational influence and use of IoT

3.2 IoT Operational Model for Cities

Our approach has been to show a more operational model of a city, like a value chain that would describe the flow of materials and processes to create end user value. This operational model must be generalised enough to be applied to many different city political and administrative systems, yet still offer some specific guidance on the implementation of IoT within a city.

Figure 5 shows the relationship between the political, administrative, operational and citizen influence. In democratic systems the loop is closed, but sometimes slow-moving.

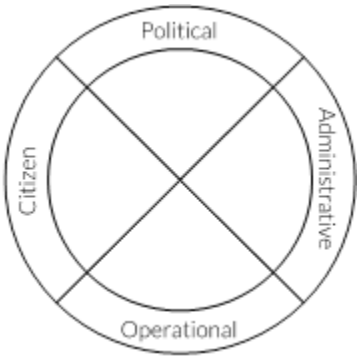


Figure 5: Engagement model for IoT with main city actors effecting service delivery

Taking into consideration the actors in the engagement model, the following IoT implications can be described:

- **Political** – the ability to verify policy and budgets with measurable output from IoT systems; the ability to discover the root cause of citizen issues and use data to campaign for new policy; understanding of the inner-dependencies of programmes and assess risk in creating new policy and spending; functions are reporting, simulation and systems reuse.
- **Administrative** – taking the policy and programme agenda from elected politicians and turn those into delivery programmes through the use of IoT; verification and budget control as delivery is occurring; ability to procure systems and delivery based on accurate data; new financial models where risk is shared with operator of service (performance contracts) both internally and externally; functions are reporting, cost control, revenue collection and high level management.
- **Operational** – service delivery is at an operational level; Figure 6 shows the areas of Inbound Logistics to Service where traditionally a specialist department will create or source a solution that is delivered out to citizens, visitors or businesses within the city; this is the area that will most benefit from reuse and efficiencies the IoT can provide; functions are device management, service creation, application management, user management and integration.
- **Citizen** – the citizen has the most to gain from successful use of IoT and, like today where citizens may bring their own smart phone to use city services, they may increase their impact on a Smart City by choosing which cars to purchase (traditional, smart, electric), what energy to use (grid, renewable, community generated), lending their data for analysis of services, etc.; while citizens may not directly force the choice of IoT technology into a city, the demand for efficiency and integration indirectly puts pressure on politicians and administrators to consider IoT as a possible solution; functions that citizens require are mainly application-related, however there could be a future where citizen-owned IoT devices are a part of the city's scope for the Smart City.

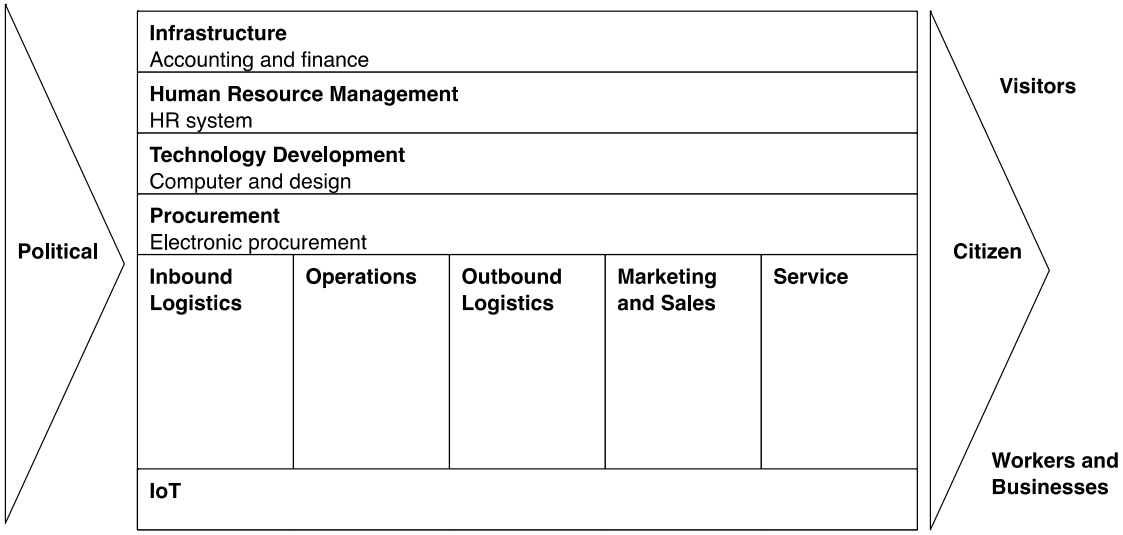


Figure 6 Value chain for Smart Cities showing where city services operation is situated and where IoT can cut across multiple services to be an integrated, centrally managed component of the Smart City

The opportunity that we believe can create the efficiencies, reuse and improved quality is shown as a lateral service offering that can be used by all of the participants within a city value chain.

3.3 City IoT Operational Functions

A set of IoT functional categories are proposed that begin to show where integration between departments logically takes place for deployed sensors, actuators and where a citizen would play a major role in the IoT system's function.

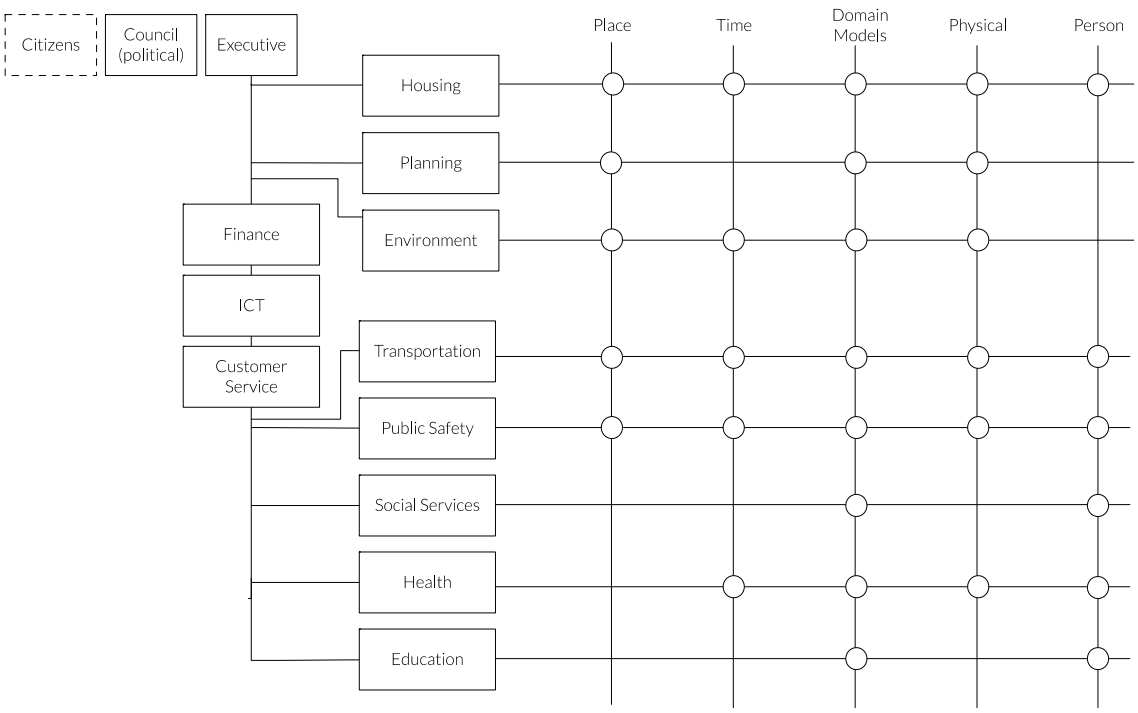


Figure 7 Dimensions of IoT functionality mapped to the operational departments found within a typical city

- **Place** – requiring knowledge of a space that is either build or natural environment; includes management of those places.
- **Time** – where timeliness matters within the system; near real-time processes are the ones of main interest in this IoT model.
- **Domain Models** – all areas have specific models that can be contributed by a department; example might be a traffic prediction model that would impact environment or planning functions.
- **Physical** – the need to measure a physical parameter; in health this might be patient vitals or treatment parameters, for housing it could be an energy sensor; usually will be provided by a sensor and might be controlled by an actuator.
- **Person** – in some cases the person is a critical component to the system; the person may be acting as a sensor, making choices or influencing other parts of the system directly.

4 Usability Framework

4.1 Relation to COSMOS

In this section, we develop a usability framework that is being researched as a part of the user view of the COSMOS project. Surveys and pilot implementations are being deployed that require guidelines for usability and user experience which are typically viewed as non-functional requirements. It is not only important to inform the technology partners, but usability in itself is an interesting area of research that has not been well developed in the IoT arena.

In Year 3, this framework will be further developed and researched for effectiveness within the design and user engagement processes. A companion methodology for design called Proposition Design that will be described in Deliverable 7.4.3 incorporates elements of this framework.

For the avoidance of doubt, this framework has been developed solely as a part of the COSMOS funding, and has not been used in any other context, funded by any other agency or been used in a commercial setting. It has been developed by Hildebrand Technology Limited and Camden Council.

4.2 Framework Preface

The Internet of Things (IoT) is a self-styled term to describe objects that are able to communicate via the Internet. Objects range from sensor inputs to actuators that control physical objects with new interactions requiring advances in machine and human interfaces.

While much has been done in the area of machine to machine interfaces in the way of protocols and interoperability, the human interface has had relatively less focus.

It is probably useful to set a context with a definition of IoT provided by Haller et al. [1]

> *A world where physical objects are seamlessly integrated into the information network, and where they, the physical objects, can become active participants in business processes. Services are available to interact with these 'smart objects' over the Internet, query their state and any information associated with them, taking into account security and privacy issues.*

This framework highlights and explores the different concepts to consider when designing products for IoT. The number of issues to take into consideration when designing a product increases significantly when it is meant to be connected to other things - this increases further when this connected thing can significantly affect an aspect, or multiple aspects, of a person's life. Presented are the different elements that designers should take into account, ranging from large cultural interpretations of products to more specific accessibility issues surrounding products.

4.3 State of the Art

Product design methodologies have more recently put humans first in their approach. Human-Centred Design (HCD) and now a growing area of service-oriented design are formal design methodologies that not only consider the utility of a product or service, but also usability aspects in a multi-device, mobile environment.

Problem-solving approaches require the user to recognise the existence of an issue, concern or problem. Surveys and analysis are used to identify common problems and collect requirements for solutions.

Vision proposal approaches take into consideration people's lifestyle or work activities that sees a future need or actively creating demand for a new product or service.

Another area that emerges in IoT is the concept of inter-usability, which is multifaceted but brings up new important user expectations:

- **Knowledge continuity** – based on the retrieval and adaptation of knowledge constructed from the use of one or more devices, e.g. what I do in one place should be recognised by the system as a whole for future interactions.
- **Task continuity** – based on the memory of the last operations performed with the service independently from the device used, and the belief that this memory is shared with the system, e.g. if I switch locations or devices, the system should be able to understand where I am within the steps of performing a task.
- **Consistency** – when there are different devices and user interfaces, how do they maintain consistency in terminology, cognitive models and user expectations
- **Composition** – based on the design time decision of what device provides user-facing functionalities or, in some cases, which software provides functionalities

Usability, as defined by ISO9241-11, is the degree of effectiveness, efficiency and user satisfaction achieved when a product is used. Traditional usability has specialist areas dealing with accessibility, aesthetic, patterns and task analysis, to help designers be aware of design trade-offs as well as making better designs.

A more complete model of IoT design facets is offered by Rowland et al. in "*Designing Connected Products, UX for the Consumer Internet of Things*". In addition to traditional usability issues, technical issues around communication failure, time lag and expectations of immediacy in the physical world begin to feature as design considerations. Specifically, IoT is largely asynchronous by technical design, with different information being displayed on different devices, breaking one of Neilsen's key heuristics of 'visibility of system status.'

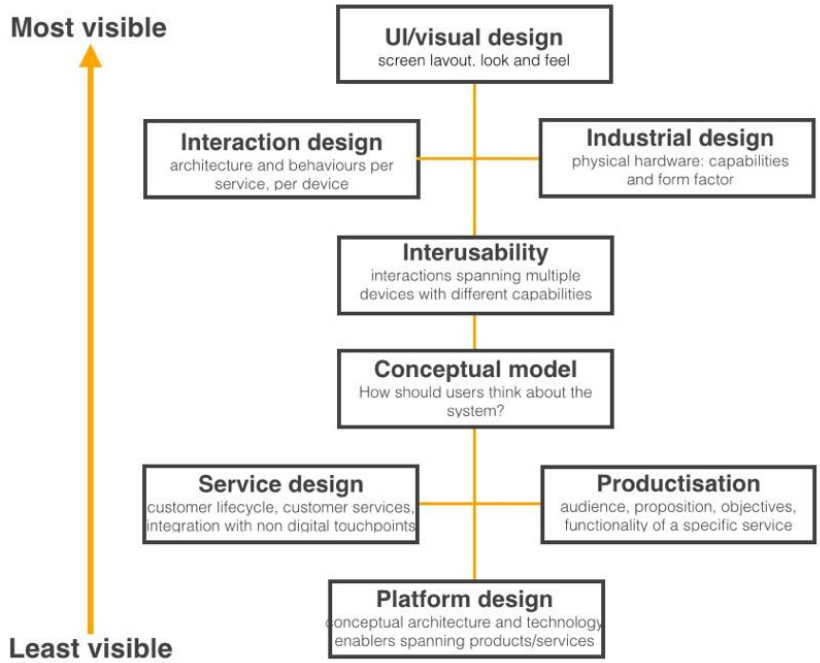


Figure 8: IoT design facets, Rowland et al. 2015

The vision of IoT supported by the COSMOS project is one of high reuse at a device level and virtual entity semantics, to be able to share experiences and leverage deployed assets. Inherently, this can create consistency issues and contention in the purpose of a sensor, actuator or enabling infrastructure. Therefore, usability must be treated as dynamic problem different from traditional manufactured products. Service design, especially around the inclusion of legacy systems and processes, has long had this problem, yet no universal method has emerged to resolve the complexity issue.

4.4 COSMOS Usability Framework

COSMOS has considered the current challenges in IoT design, and has found that the following key usability areas are important factors to consider when assessing solutions, as well as constructing requirements:

Safety

Is it safe for humans and the environment? Are there fail-safes in place to allow for any issue that may occur that can have an impact or affect on the user? What if a heating controller malfunctions? Does the device have the potential to harm the user in any way, even if it is auxiliary? Is it accessible to young children or those with learning difficulties? What could be the risk to them?

Privacy

Does the device use private data? Does it have data pertaining to the user? How is it

handled? If you are using an energy monitor that shares data, it is possible to tell when the user is not at home? How are privacy issues handled, especially in the context of current discourses surrounding privacy and technology?

Inclusivity

Are you alienating certain groups of people because of certain design choices? If a service requires the user to use a social network, for example, many people may refuse to use it. Phone app vs. Web app: some users may not want to use a certain platform because it is not useful to them. Also, as a fundamental, not everyone has internet access nor a mobile/smart phone.

Accessibility

Being able to physically use something. Does it need to be moved? Does a button need to be pressed? Is it, or something it is interacting with, in a hard-to-reach place? Does it require a level of knowledge to use? Is the UI inclusive of people with certain physical or mental conditions?

Cultural Sensitivity

Have you considered how the things you are doing may be interpreted by different cultures? Disjuncture between signifier/signified - red doesn't necessarily mean danger to everyone.

Affordability

How expensive is the product/service? Does it require a lot of money to run? Do you need something expensive to enable you to use it, i.e. an iPhone or a certain spec of computer? Does this encourage elitism?

User Conflict

Does this device have the potential to create conflict between users? If multiple users can control one device, how is this handled? It might be more of an impediment than a benefit.

Following the framework does not necessarily mean that the system is then engineered to satisfy all of the issues raised in the usability area. Using the framework shows the constraints and suitability of a solution and, where designers wish to engage with a particular market or end user, shortcomings can be determined using the framework.

For example, a product or service may only be targeted to a geographical market that has high cultural affinity, and for an application area that is very specific. Therefore, the service may not be usable out of that geography due to language, etc. it still meets requirements.

In addition, some conditions may be temporary, such as an illness or incapacity, that might affect accessibility for a short period of time. A situation such as a broken hand might make a devices unusable that would normally work for a user.

4.5 Safety

Health and safety are fundamental to all applications, devices and measures endorsed by the EU, and every country's own health and safety requirements. It would be unethical and potentially illegal to overlook safety issues on a national or EU perspective. RAMS (Risk Assessment Method Statements) are, therefore, crucial to any measure on both a device application level, and as an overarching implementation basis.

Individual devices will require certification marks such as CE and UL which, in traditional electronics and telecommunication equipment, would require BS EN 60950. However, each IoT device, especially in the case of actuators, will require specific device safety testing using the applicable standards. Safety requirements are usually rooted in reducing the risk of fire, electric shock and injury for both the operator and laymen that might come into contact with the system. In some cases, further health and safety testing and standards may apply, including asbestos or hazardous waste substances awareness, or for small objects like sensors that might pose swallowing danger to children.

Besides the necessity of acquiring certification marks and adhering to specific quality standards, and in addition to complying to industry health and safety legislation, designers of connected products need to ensure:

- that the hardware is safe, i.e. the user is not going to get electrocuted or mistake the device for another device;
- that the product is made out of non-hazardous materials;
- that software or manual overrides are in place to ensure that it cannot:
    i. do anything to harm the user (such as a malfunctioning smart thermostat, which could leave users in unreasonably cold/damp homes because this would put them in potentially life-threatening situations, such as suffering from cardiovascular conditions or respiratory health issues); or
    ii. pose undue danger if security is compromised.

Designers have to be aware of these issues and their potential damage, and must put in place contingency plans for failures that may occur.

Safety is also crucial in the disposal of IoT equipment, such that materials do not cause environmental hazards after use and, as far as possible, recyclable. The WEE and ROHS directives in Europe cover such issues.

Finally, and most importantly, feedback loops and “bad data” are likely to occur if unchecked in even a moderately simple IoT system. If actuation is taking a signal from these inputs, then malfunctions or delays in communication of a sensor may risk safety.

4.6 Privacy and Information Security

In the digital, connected realm, privacy has become a massive issue to people. Areas of concern usually stem from the risk of misuse of private information to bring harm to a person. That harm can be in the form of discrimination, financial loss, criminal activity or at the extreme in warfare.

Given that IoT aims to connect our physical world, information privacy and security takes on the new dimension of a possible physical threat that can be targeted or scaled. Hacking GPS traffic congestion sensors might cause traffic to falsely re-route to purposefully pose public danger. Communication failure may make information inconsistent, whereby the system may make harmful decisions once communication is restored. Knowing a person's travel patterns from IoT sensing may make them an easy target for identity theft or robbery.

The EU's new General Data Protection Regulation (GDPR) is scheduled for adoption in mid-2016, whereby privacy and data protection regulation will become more harmonized across Europe. The GDPR extends to foreign companies and agencies that process the data of EU citizens. The principles are important to put into the context of IoT:

- **Scope** – Interpretation of who and what is covered can be difficult in an IoT system, especially an IoT system that is deployed as infrastructure and is reused at an application layer. For instance, identification of individuals may be entrusted to an operator and, through the joining of data sets, direct or inferred personal data may be obtained by an application utilizing that infrastructure.
- **Privacy by Design** – IoT designs can be complex, and may involve many partners that are layered through communication and physical space (through shared use assets). This part of the regulation can easily come into conflict with design for cost, safety of the commons and security requirements. In a lot of cases, there may not be a single design authority for the entirety of the system.
- **Consent** – Data subjects (users) must be able to understand their consent to the use of data. This consent must be kept up to date and not be overly broad. IoT has many use cases that are casual, and may have user interfaces that are passive, with no ability to inform and collect consent. It may also be hard for designers to articulate the functionality of the IoT system when reuse is an objective.
- **Right to be Forgotten** – Data subjects must be able to request the deletion of personal data relating to them by the data controller. In certain situations, however, the data controller may be obliged to keep data, even if the subject has asked for it to be deleted, i.e. in the case of financial transactions that involve tax records.
- **Data Portability** – Data subjects must be able to transfer their personal data from one electronic processing system to and into another, without being prevented from doing so by the data controller. Additionally, the data must be provided by the controller in a structured and commonly-used electronic format.

4.7 Inclusivity

Another key usability area to consider when creating an IoT product is the inclusivity of the design. Every design decision has the potential to include or exclude users. Inclusive design emphasises the contribution that understanding user diversity makes to informing these decisions, and thus to including as many people as possible, i.e. considering whether a design is accommodating of all people, regardless of their age, gender, mobility, ethnicity or circumstances, and avoiding the unnecessarily alienation or exclusion potential users by including or excluding particular features or specifications. This could be on the level of the language used – is it too technical? – or the usability requirements – does it require the user to have a social media account in order to participate?

4.8 Accessibility

An important facet of inclusivity is the accessibility of a product by its end user. If accessibility is viewed as the ability both to access and benefit from a product, then accessible design must seek to maximise the universality of a product's application – making sure that a design does not exclude a specific group of potential users because their particular needs or conditions of use have not been considered. Accessibility in this sense is strongly related to universal design, which is the process of creating products that are usable by people with the widest possible range of abilities, operating within the widest possible range of situations.

The concept of accessible design focuses on enabling, as far as possible, both:

- direct access, i.e. a user's unassisted use of a product; and
- indirect access, i.e. the product's compatibility with a user's assistive technology.

If the product itself cannot be designed so that it may be directly accessed by all users, then an alternative approach for increasing its inclusivity is to ensure that it can support built-in accessibility features that might assist a user to mitigate their special needs; for example, by creating an app that supports a braille display, so that blind or visually impaired users, who might otherwise be excluded, can interact with and benefit from it.

4.9 Cultural Sensitivity

When considering the inclusivity of a design for IoT, it is also important to take into account the cultural awareness and sensitivity of a product. Today, the internet is a global platform that reaches into the homes, businesses and lives of most people on every continent. The design process of any product that looks to connect different cultures, particularly on a globalised scale, must be aware not only of cultural variances, religious practices, social mores, local customs and etiquette, but also of how certain language, concepts, symbols, motifs, colours and the placement of text and elements might be interpreted by different users.

4.10 Affordability

In order to maximise the inclusivity of IoT design still further, the affordability of a product for its end users must also be considered. The price of a product or service, especially one that is financed continuously, will affect who and how many people will be able to use it, and for how long. Additionally, if, for example, a high-specification computer or phone is required in order to support the product, access will be duly limited to an elite group of users. Other considerations include servicing, maintenance and replacement costs and requirements. In order to maintain a broad user base, it is therefore necessary to balance, as far as possible, the

price of a product and its reliance on additional (costly) requirements with its efficiency, capability, profitability, etc.

4.11 User Conflict

The design of IoT products should also consider the way(s) in which these products affect users, and enable users to interact with the people around them. Many IoT devices operate in public or shared spaces, and have the capacity to be operated by multiple users. This creates the opportunity for conflict to occur between users. It is important to consider how a product might mitigate any potential for conflict, perhaps by allowing a hierarchy between users, or by granting a single user administrative privileges.

In addition, the IoT, like the Internet of People, will cause different reactions in different citizens. Some citizens will believe more in their government, local government, health service or charitable organisation. Others may well prefer their local supermarket, energy company, Facebook, Twitter or Google provider over not-for-profit organisations.

5 Survey Research

In the case of the Camden Scenario, the potential end users of the COSMOS platform are social housing residents who come from a diverse community with differing levels of understanding and/or acceptance of smart technology.

In order to inform the COSMOS project as a whole, but particularly to provide a local context for the two Camden Scenario Use Cases that are being implemented in Year 3, Camden Council and Hildebrand will host a series of questionnaire and engagement workshops with local Camden residents. The aim is to gain a better understanding of different attitudes towards technology and, particularly, smart heating systems. In addition, it will provide knowledge and awareness of residents' use of – and relationship to – their built home environment, and their understanding of existing heating controls and how this may affect their health or welfare, in so far as it will elucidate any personal areas of concern that they may have when it comes to heating their homes.

After responses to the questionnaires have been collected, the MINDSPACE framework will be applied to analyse and classify participants into categories. This will dictate how further interventions could be managed, and how positive behavioural change may successfully be achieved.

The knowledge that results from this survey research will be used, where suitable, to inform the design of appropriate user interface tools, structured to directly satisfy the preferences of the end user. These will also provide a basis and a framework for Camden Council to better advise their residents on reducing their energy bills and increasing their levels of health and welfare.

5.1 Recruitment of Participants

Camden Council will send letters to local residents, mount a publicity campaign around council housing blocks and engage with TRA (local Tenant and Resident Association) representatives and local ward councillors in order to encourage volunteers to participate. In order to engage with the most financially deprived residents, compensation incentives in the form of local shopping vouchers will also offered.

The workshops will be hosted locally to the council residences to attract as many respondents as possible, and a combination of mid-afternoon and evening slots will be provided, in order to maximise attendance and reach as great a demographic as possible.

5.2 Survey Documents

Camden and Hildebrand have developed a set of documents that will be used for the questionnaire workshops. These include:

- Participant Information Sheet
- Informed Consent Form
- Participant Profile Questionnaire
- Smart Heating Explanation Script
- Home Heating Questionnaire

See Appendix A for complete versions of these tools.

5.3 Upcoming Events

Tables 1 and 2 (below) detail upcoming events that Camden Council and Hildebrand have planned to conduct survey research and engage with local residents.

Table 1: Upcoming survey research events

Activity	Date	Duration	Number of Attendees	Notes
Questionnaire Workshop	01/02/2016	1.5 hours	7 residents	Questionnaires designed to find out residents' opinions on smart heating. Written information will also be provided about COSMOS, as well as a verbal explanation of smart heating.
Questionnaire Workshop	02/02/2016	1.5 hours	9 residents	
Questionnaire Workshop	03/02/2016	1.5 hours	7 residents	
Questionnaire Workshop	25/02/2016	1.5 hours	22 residents	
Technology Event for Social Carers	23/02/2016	3 hours	Approx. 65 social carers (children and adult)	Answering questions about the COSMOS project and, specifically, the Camden Scenario.

Table 2: Upcoming resident engagement events

Activity	Date	Notes
Further Workshops	March	Engagement with residents.
Pilot Installation: Phase 1	March	Installation of sensors in 2 flats.
Intervention Plan Development	March/April	Camden and Hildebrand develop intervention strategies after applying the MINDSPACE framework.
Pilot Installation: Phase 2	March/April	Installation of sensors in a further 13 flats.
Questionnaire Workshop for Sheltered Residents	April	Workshop with residents and care staff to better understand how smart heating would be received by the elderly.
Resident Engagement	April - June	Present Use Case objectives to residents and get feedback via open discussion. The meetings will provide

		Camden Council and Hildebrand with information on any impairments/accessibility or safety issues.
Measuring and Verification	April - August	Management/follow-up of the intervention plan, including interaction/engagement with residents (letters, phone calls, etc.).
Video Production	April - August	Production of a short film illustrating the project and its engagement with local residents.
Feedback Sessions	May - August	Two feedback sessions conducted in the middle and towards the end of the research period (March to August for the first 2 residents; April to August for the further 13 residents) to show them monitoring results linked to their heating consumption and humidity levels.

6 Application Use Cases

This deliverable provides an update to the scenarios from Years 1 and 2, with a final review of the Use Cases in order to make a full and operational system.

6.1 Camden Scenario

6.1.1. Capital Planning / Energy Performance

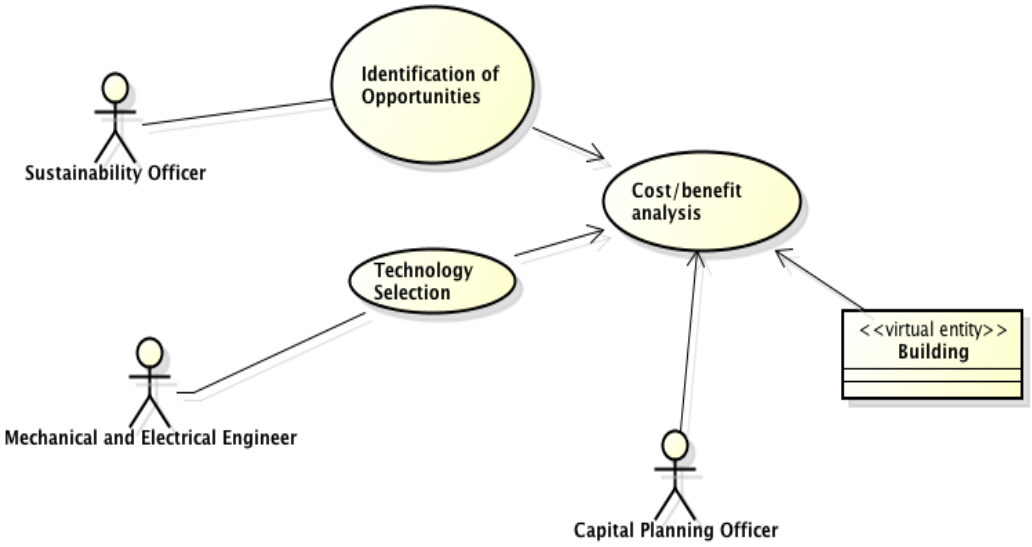


Figure 9: Use Case diagram for Capital Planning/Energy Performance

Use Case: Capital Planning/Energy Performance and Commissioning and Quality Assurance
ID: 1
Brief Description: The EnergyHive system in each building enables Capital Planning/Senior Energy Performance Officer 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 Actor(s): Senior Energy Performance Officer; Design and Compliance Manager
Secondary Actor(s): Mechanical and Electrical Engineer; Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate, as well as boiler controls and verification systems.
Main Flow: 1. Temperature readings are collected at distribution level within Camden heat networks.

2. The energy balance model will be run against the Trend readings, and the temperature/electricity readings showing performance indicators (degree hour per kWh) against a network model for the delivery.
3. Normalisation for seasons and weather conditions should be applied (subtract degree hours inside versus degree hours from weather).
4. Sensors will be installed wherever suitable on the district heat network to manage distribution losses.

Postconditions: Ranked performance of the buildings' heat networks is reported to enable interventions to improve network inefficiencies.

6.1.2. Minimising CO2 Emissions

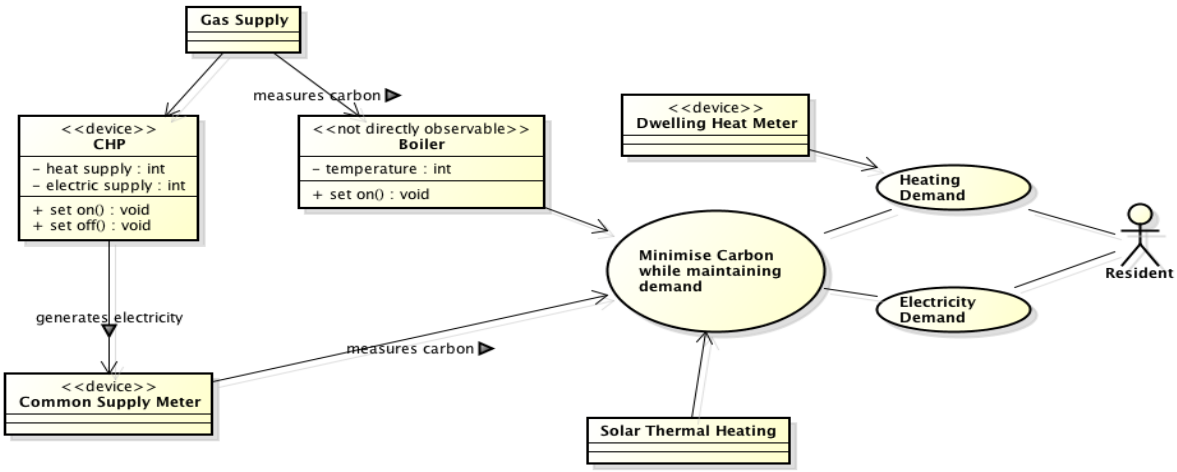


Figure 10: Use Case diagram for minimising C02 emissions

Use Case: Minimising $C0_2$ Emissions
ID: 2
Brief Description: An effective way to minimise carbon is to give more weighting to processes with lower $C0_2$ 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 $C0_2$ emissions. With minimal input by the resident or site staff, the system will predict the estate's heat in half-hourly intervals and manage the CHP and boiler accordingly.
Primary Actor(s): 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. $C0_2$ emissions are 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.

6.1.3. Minimising Demand

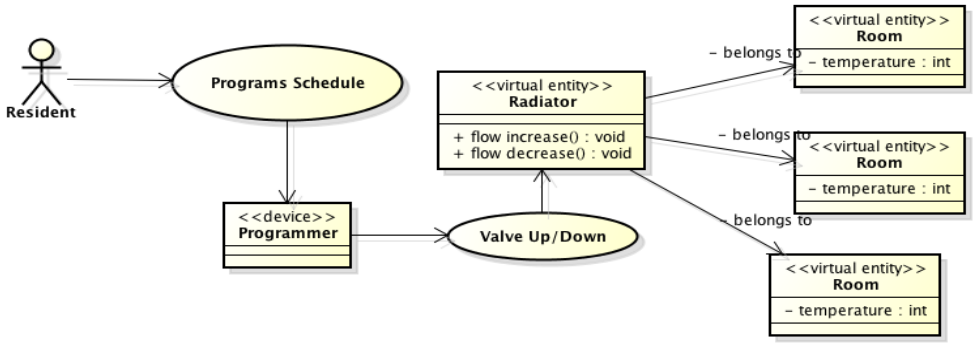


Figure 11: Use Case diagram for minimising demand

Use Case: Minimising Demand

ID: 3

Brief Description: Another method of reducing C02 emissions is to minimise the demand for Heat Energy. 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, both automatically and remotely. The system, with support from a council Sustainability Officer, assists the user in setting a heating schedule in accordance with their budget. The purpose is to make users aware of the cost of heating, with the Sustainability Officer being able to identify and support users who are particularly high consumers and, therefore, at risk of fuel debt. Similarly, Council Officers will be able to identify particularly low

use, which may indicate a health risk or non-occupancy.
Primary Actor(s): Sustainability Officer; Energy Performance Officer; 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: User can optimise their schedule to minimise their consumption.

6.1.4. Heating Control

Use Case: Heating Control
ID: 5
Brief Description: The EnergyHive system is measuring the temperature of the properties where it is installed and has the ability to control the delivery of heat through a valve. A new tablet has been deployed within the property that allows for a set point and schedule to be entered. Feedback from users has been that they would like the system to automatically help them set a programme and manage efficiencies on an ongoing basis, for instance: detection of whether or not they are at home; using the weather forecast to help with program and supply-side management when the solar thermal is available for use. The tablet is a COSMOS-compatible device and it can act locally to run case-based reasoning in an efficient manner.
Primary Actor(s): Resident
Secondary Actor(s): Mechanical and Electrical Engineer; Sustainability Officer
Preconditions: EnergyHive system must be installed within a resident's premises.
Main Flow: 1. Resident will select an autopilot function on their tablet. 2. Autopilot will determine a recommended set point for the temperature in the house. 3. Set point can be overridden by the resident. 4. The system will learn the patterns of occupation and adjust the run programme to turn off the system based on un-occupied property; the resident can override. 5. Savings should be quantified over using a normal time-based programmer.

Postconditions: An improvement to the efficiency of the heating system should be reported.

6.1.5. Building Performance Management

Use Case: Building Performance Management
ID: 6
Brief Description: The boiler systems within buildings have master programmers and temperature settings that are controlled by a Trend boiler control system. There are also verification instruments installed within buildings to measure the effects of the boiler control; they can provide feedback to inform the run-time commands to the boiler control as well. A more granular view of the energy demand, including trade-offs with electricity usage, is desired so that individual residential premises are getting higher comfort while balancing the energy input.
Primary Actor(s): Mechanical and Electrical Engineer; Energy Performance Officer
Secondary Actor(s): Resident; Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate, as well as boiler controls and verification systems.
Main Flow: 1. Temperature readings are collected at distribution level within Camden heat networks. 2. The energy balance model will be run against the Trend readings, and the temperature/electricity readings showing performance indicators (degree hour per kWh) against a network model for the delivery. 3. Normalisation for seasons and weather conditions should be applied (subtract degree hours inside versus degree hours from weather). 4. Sensors will be installed wherever suitable on the district heat network to manage distribution losses. These losses may be within the energy centre (boiler room), pipework laterals and risers and/or dwelling cylinders.
Postconditions: Ranked performance of the buildings' heat networks is reported to enable interventions to improve network inefficiencies.

6.1.6. Identification of Opportunities

Using machine learning, identify where energy savings opportunities exist. This will help Sustainability Officers to identify projects with sound business cases, with both $C0_2$ emissions savings and energy reduction benefits, which can then be submitted for formal approval.

Use Case: Identification of Opportunities
ID: 7
Brief Description: The EnergyHive system running in planning mode can use machine learning to suggest opportunities for efficiency. This is largely an unsupervised learning exercise where cause and effect models can be run with comparisons to other like buildings or similar conditions that have been observed.
Primary Actor(s): Sustainability Officer; Energy Performance Officer
Secondary Actor(s): Budget holders; Rent and Billing Services; Air Quality Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate.
Main Flow: 1. Sustainability Officer creates model constraints for parameters to optimise (i.e. cost or carbon savings desired with physical systems). 2. Model runs within system bringing up bands of savings that can be made from changes in input parameters. 3. System provides control ranges that would have to be implemented in order to make potential savings.
Postconditions: A quantified opportunity for efficiency within the energy system is presented for evaluation.

6.1.7. Damp/Condensation Monitoring

Use Case: Damp/Condensation Monitoring
ID: 8
Brief Description: The aim is to help residents to identify and reduce/eliminate damp, where it exists: humidity sensors monitor condensation levels and identify where damp is best detected; temperature sensors measure how the temperature of the properties affects damp; and window open/close sensors demonstrate the extent to which the residents are ventilating their properties.
Primary Actor(s): Resident

Secondary Actor(s): Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each dwelling, including humidity, temperature and window sensors in rooms that are concerned.
Main Flow: 1. Log readings from humidity, temperature and window sensors against rooms where they are installed. 2. Obtain feedback from resident if damp is present, on the basis that they are told to report damp when detected. 3. Create a learning model to understand the causes of damp (supervised learning with the report of damp as the training of the machine learning algorithm). 4. Continuously calculate a prediction for damp from the machine learning model, and alert the Sustainability Officer if damp looks likely. 5. Alert resident of the likelihood of damp through some feedback mechanism. 6. Help the resident to use the “damp kit” (cleaning and drying equipment supplied by Camden Council) to eliminate any damp detected. 7. Continue to learn the conditions that prevent damp, and use feedback and control to re-enforce good conditions in humidity, temperature and ventilation.
Postconditions: Damp model using sensor input and feedback from resident; damp alerts based on prediction of damp; maintenance of dry conditions.

6.2 Madrid Scenario

Within Y3 working plan, and always focusing in Madrid Use Case, the main objective is to keep balancing the commitment between usefulness and opportunity. That means, that the final solution provides added value for Madrid Smart Mobility environment. Therefore, Y3 plans to develop a complete system, based in Y2 prototype, with the following characteristics.

6.2.1. Special Needs Passenger with Carer Assistance

The overall use case shows several characteristics that could be considered as (sub)use cases, each one of them capable to manage or analyze different COSMOS behaviors. However, due to the holistic approach it is homogenously planned as a whole.

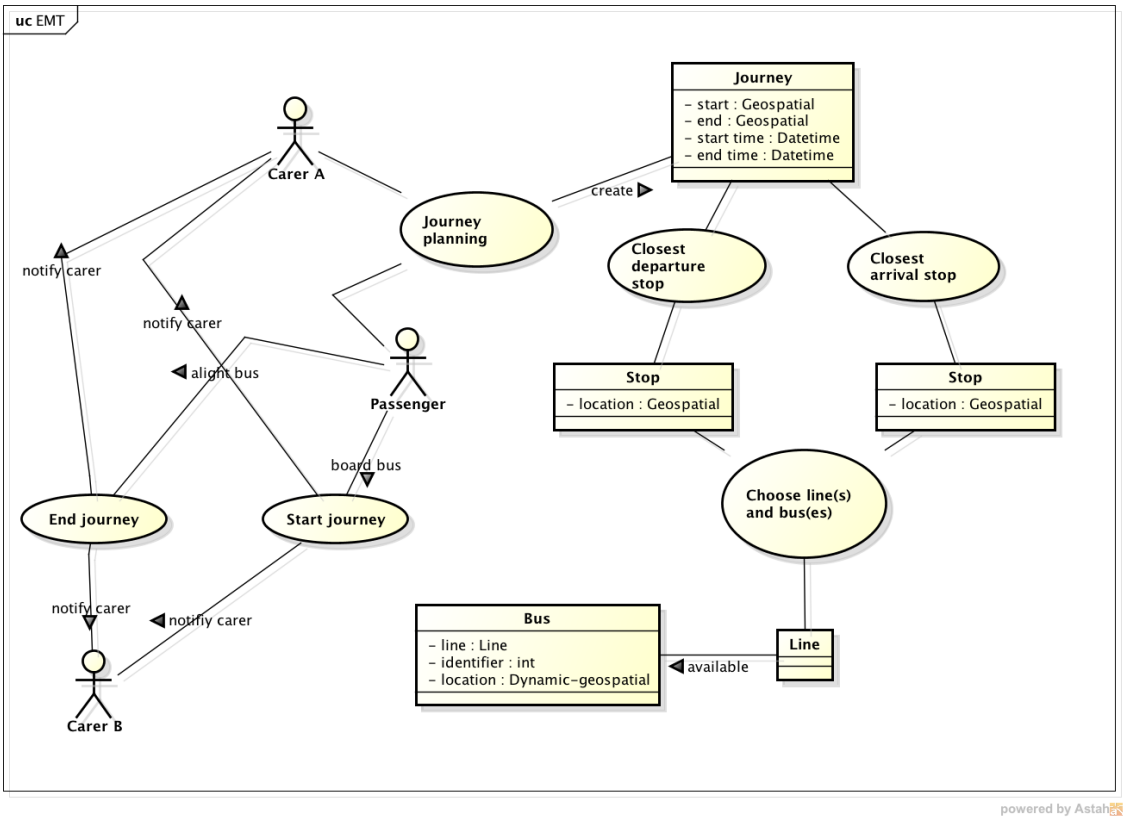


Figure 12: Special needs passenger traveling on the bus system with assistance from two Carers

As indicated in D.7.1.2, Madrid UC considers not only the real need of a user in order to travel around the city, but the safety that provides the supervision of a caregiver. According to the characteristics of the service introduced in the previous deliverable, we may conclude that the design fundaments and specifications were right.

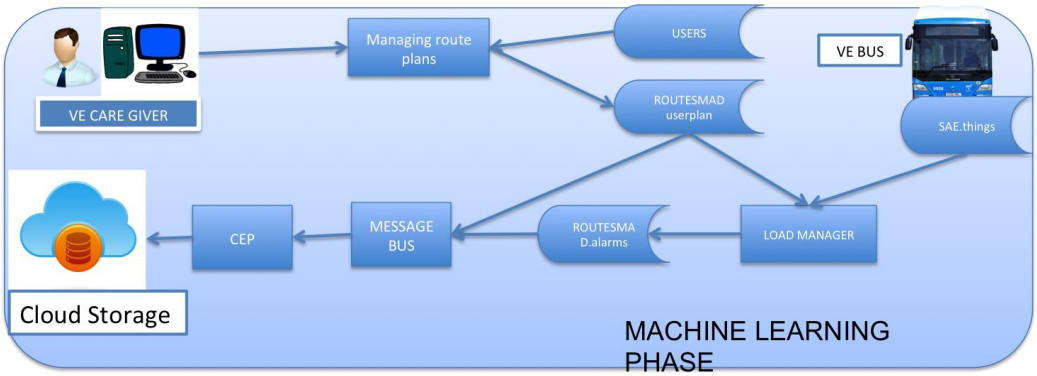
Use case : Special needs passenger journey

ID: 10

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 caregiver 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.

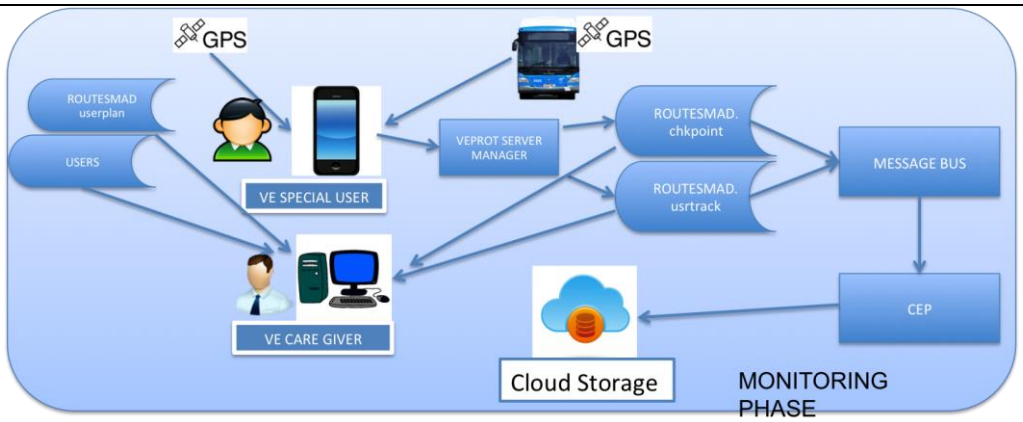
Route Planner Flow

1) Person with special needs and Caregiver know of each other.
2) Profile of person with special needs and relationships are stored into security storage system.
3) Caregiver can design routes for those to take care of.
4) Caregiver has access to the trip supervision and to the needs of the person to take care of.
5) Person with special needs has an integrated Smartphone app within COSMOS to be used during the trip
6) Information about users, routes and bus service must be stored in the normalized VE included in the structured collections to be converted into messages or events.
7) COSMOS Machine Learning System has enough information to know, for the different trip segments included into the trip and for the specified days, the trip time and other normalized parameters to be used for detecting deviation or anomalies.
8) COSMOS Machine Learning System can include, in real time, events such as the pass by of buses at a certain bus stop, traffic information, and other values.
9) COSMOS Machine Learning System must know at any time the position of buses of the bus lines that are generally used by the person with special needs event if it is not making a trip
10) Caregiver configures the route plan according to schedules and planning of the person he looks after.



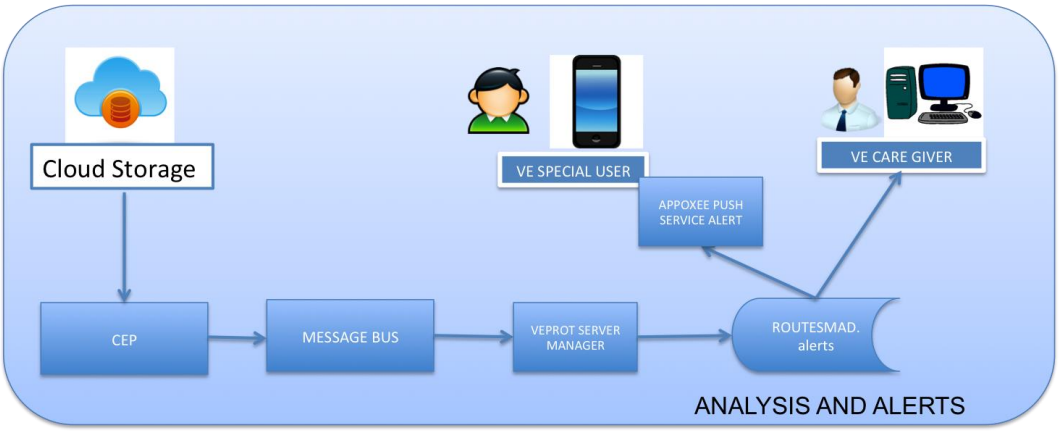
On Route Flow (normal mode):

1) The person with special needs starts a route using the integrated COSMOS app.
2) The caregiver receives an alert indicating that the users has started a trip.
3) The user app sends trip tracks every few seconds, and those are analyzed by COSMOS through Reactive Box by using events observation in real time.
4) COSMOS system knows if the trip is being done on foot, or by bus, combining and analyzing the different VEs.



On Route Flow (alarm mode)

1) COSMOS-CEP analyzes events that are happening during the trip and compares those with the stored historical activity and deviance patterns.
2) COSMOS-CEP analyzes and detects real time events coming from different sources, such as traffic data or metheorology.
3) COSMOS-CEP generates warnings or alerts towards Reactive Box system, which are received in real time by the caregiver and, thereafter, if needed, by the user Smartphone app.
4) The caregiver can launch also alerts towards COSMOS-CEP or towards the user Smartphone app.



7 IoTA Model

7.1 IoTA Model for Energy Scenarios

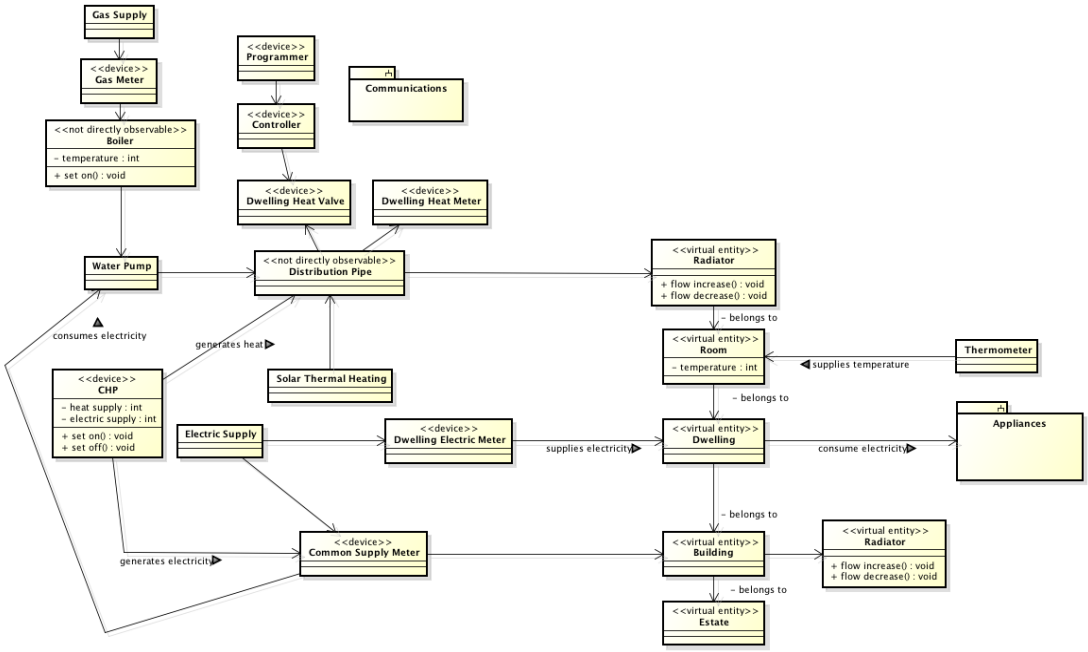


Figure 13: Model for the IoT system with adjoining description of components for the Energy Scenarios

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 and 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	A system of water pumps transport hot water from each source through the distribution pipe. Consumes electricity from the

Pipe	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 and 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

7.2 IoTA Model for Bus Scenarios

In the conceptual mode originally designed, the different relationships between VEs were generally indicated according to the following figure:

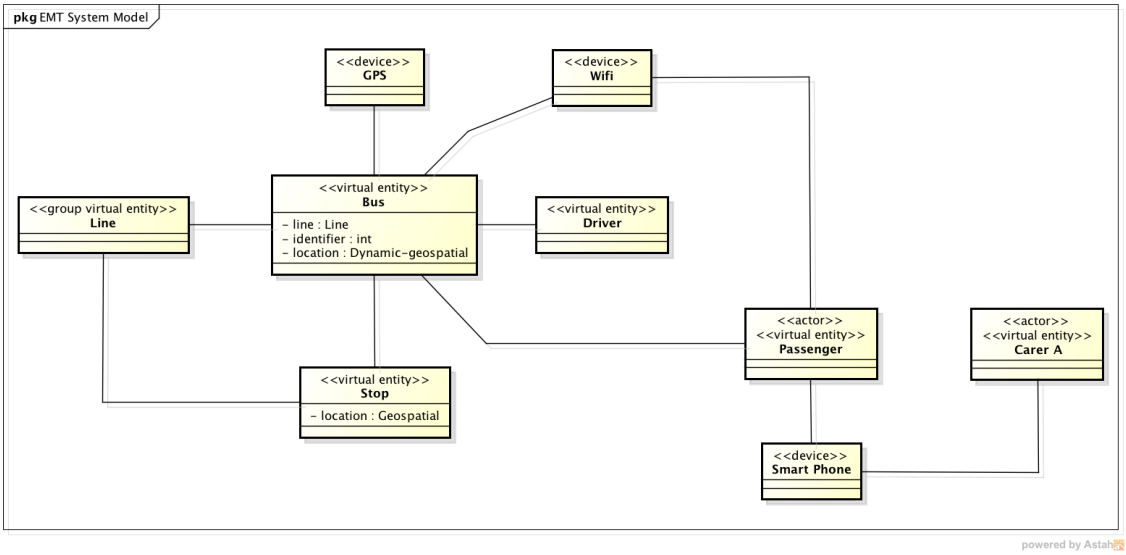


Figure 14 Model for the IoT system within the EMT transport scenarios

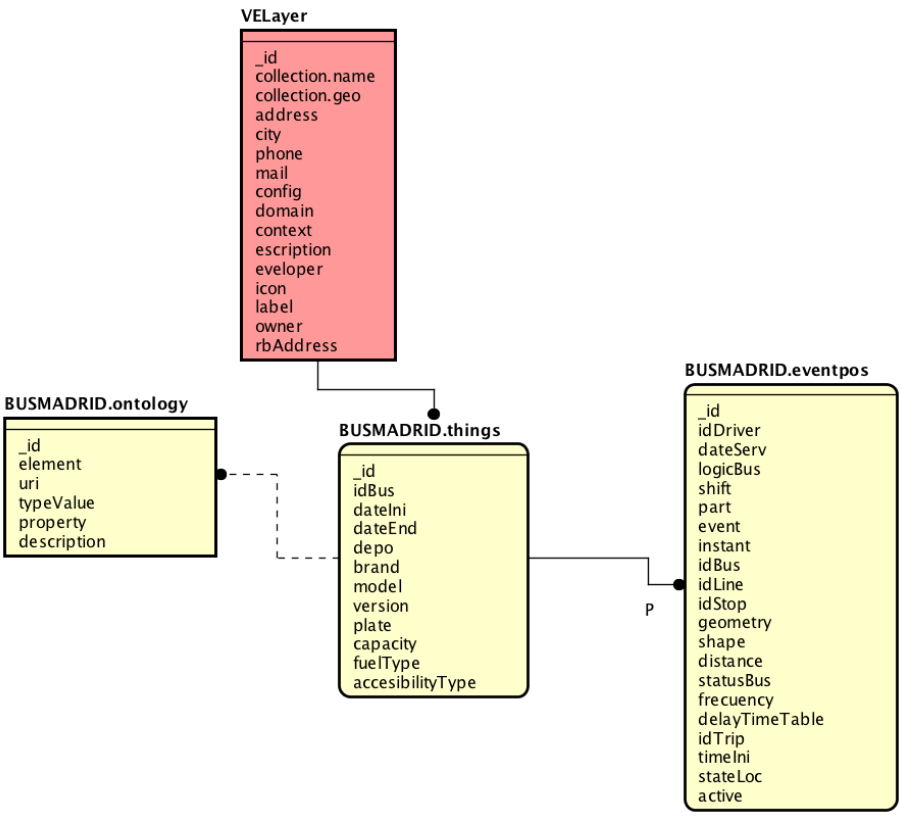
In the aforementioned figure the primary VE model was defined in order to make the conceptual design for the Use Case:

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 colour.
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.
Wi-Fi	The Wi-Fi 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 Wi-Fi 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 Wi-Fi signal is on board 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 an 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.

The conceptual model has evolved, reaching a model which is reflected within the architecture of the system allowing the deployment of an IoT architecture designed for the Smart Mobility integrated within COSMOS ecosystem.

The relationship schema among different VEs has also been evolving, dividing itself into different specialized sub models:

7.2.1. VE sub model for the location of buses in the bus lines



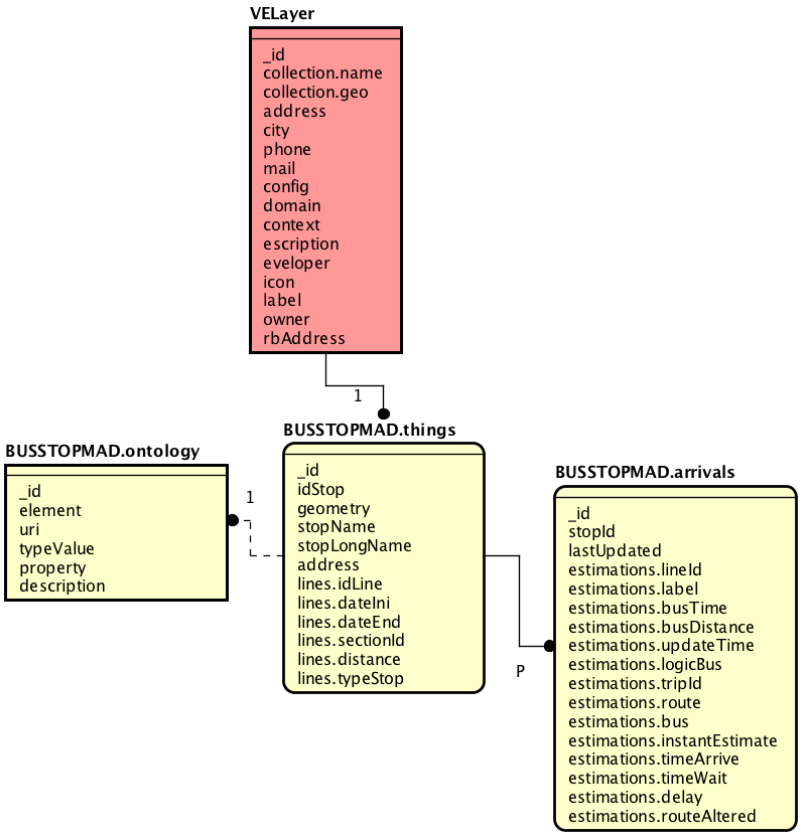
Attribute	Value	Property	URI	Description
layer	**BUSMADRID. things**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#busmadrid	Kind of layer into RB. Layer ontology describes data domain Reactive Box and other elements of this entity
idbus	[id of bus]	schemas:Number	https://schemas.org/Number	Unique identifier of bus into EMT Company
DateIni	[date ini]	Dcterms:date	xsd:dateTime	Begin date of current information
DateEnd	[date end]	Dcterms:valid	xsd:dateTime	End date of current information
Depo	[id depo]	mobilitymadrid:depo	http://mobilitylab.emtmadrid.es/def/transport#Depo	Deposit which it belongs
Brand	[name of brand]	mobilitymadrid:brand	http://mobilitylab.emtmadrid.es/def/transport#Brand	Brand of bus
Model	[name of model]	mobilitymadrid:model	http://mobilitylab.emtmadrid.es/def/transport#Model	Model which belongs into Brand

Version	[num]	schemas:Number	https://schema.org/Number	Number of version into a specific model
Plate	[id plate]	schemas:Text	https://schemas.org/Text	Plate id of bus
capacity	[num]	schemas:Number	https://schemas.org/Number	Max capacity of passengers
fuelType	[type of fuel]	Mobilitymadrid:fuelType	http://mobilitylab.emtmadrid.es/def/transport#fueltype	Type of fuel (gas electricity etc)
Accesibility Type	[type of accesibility]	Mobilitymadrid:accessibilitytype	http://mobilitylab.emtmadrid.es/def/transport#accesibilitytype	Type of accesibility

Attribute	Value	Property	URI	Description
layer	**BUSMADRID .eventpos**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#busEventMad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
idBus	[_id]	Schema:text	http://schema.org/Text	Unique id of bus into system
dateServ	[date value]	dcterms:date	xsd:datetime	Date of line-service (can be distinct of instant of current event)
idLine	[idLine]	Schema:text	http://schema.org/Text	Line which the service is working
logicBus	[value]	schema:text	http://schema.org/Text	Number of a bus logic (this is not an idBus)
idStop	[idStop]	Schema:text	http://schema.org/Text	Next or current stop where bus is passthru
instant	[date time value]	dcterms:date	xsd:datetime	Instant of the current event
geometry	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of current position of event
private	array of		-	Next items are for internal use only
private.idDriver	[idDriver]	Schema:text	http://schema.org/Text	Driver id who is working in the service bus
private.shift	[value]	schemas:Number	https://schemas.org/Number	Shift of driver
private.part	[value]	schemas:Number	https://schemas.org/Number	Part of shift of driver
private.stateLoc	[value]	schemas:Number	https://schemas.org/Number	Status of location of bus
private.event	[value]	mobilitymadrid:eventtype	http://mobilitylab.emtmadrid.es/def/transport#eventtype	Class or kind of event
distance	[value]	schemas:Number	https://schemas.org/Number	Distance in meters from begining of itinerary
statusbus	[value]	mobilitymadrid:statuscodebus	http://mobilitylab.emtmadrid.es/def/transport#statuscode	Status of the bus service
frequency	[value]	schemas:Number	https://schemas.org/Number	Frequency on seconds from the bus inmediately before

delaytimetable	[value]	schemas:Number	https://schemas.org/Number	delay on seconds from the theoretical timetable
idTrip	[value]	schemas:Number	https://schemas.org/Number	Number of trip
timeIni	[date time value]	dcterms:date	xsd:datetime	Theoretical time of start of trip
active	[value]	dcterms:boolean	xsd:boolean	Bus active True/False

7.2.2. VE sub model for the definition the bus stops and estimated arrival time of buses

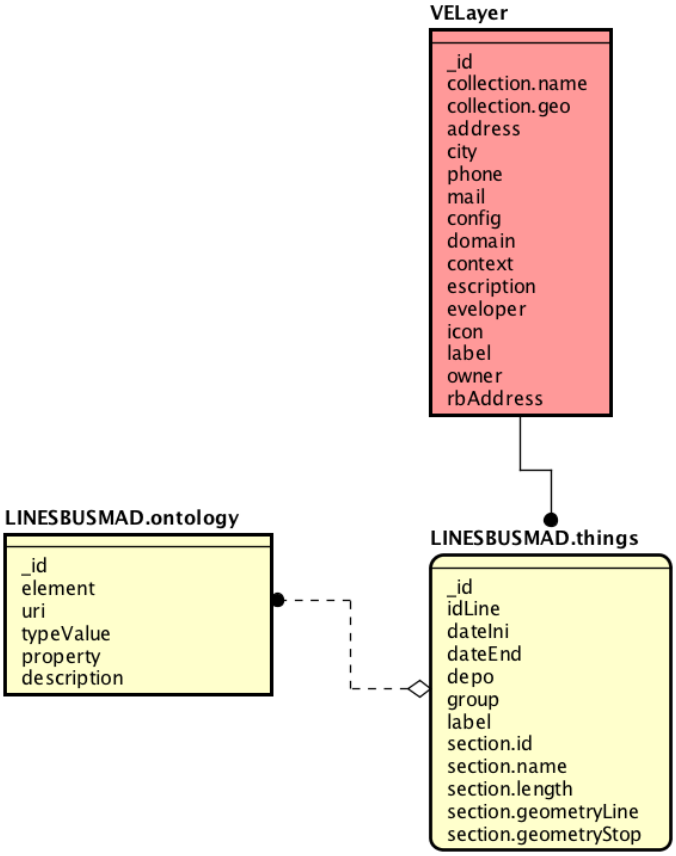


Attribute	Value	Property	URI	Description
layer	**BUSSTOPMAD.things**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#busstopmad	Kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
idStop	[id of stop]	schemas:Number	https://schemas.org/Number	Unique identifier of stop into Company
geometryStop	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of stop
stopName	[name of stop]	schemas:Text	https://schemas.org/Text	Public Name of Stop
stopLongName	[alternatename of stop]	Schema:alternateName	http://schema.org/Text	Long Name (full) of Stop
address	[Stop Address]	Schema:PostalAddress	http://schema.org/PostalAddress	Address of stop

ARRAY	ARRAY	ARRAY	ARRAY	Structure of line objects
idLine	[id of line]	schemas:Number	https://schemas.org/Number	Unique identifier of line into EMT Company
dateIni	[date ini]	Dcterms:date	xsd:dateTime	Begin date of current information
dateEnd	[date end]	Dcterms:valid	xsd:dateTime	End date of current information
sectionId	[id section]	schemas:Number	https://schemas.org/Number	Itineraty 1 2 etc
distance	[value]	schemas:Number	https://schemas.org/Number	Distance in meters from start of Itinerary
typeStop	[id type]	mobilitymadrid:typestop	http://mobilitylab.emtmadrid.es/def/transport#typestop	One stop can be (in respect of stop) header - intermediate stop - etc

Attribute	Value	Property	URI	Description
layer	**BUSSTOPMAD.arrivals**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#busEventMad	Kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
stopid	[_id]	Schema:text	http://schema.org/Text	Unique id of stop
lastUpdated	[date value]	dcterms:date	xsd:datetime	Datetime of current data
estimations	array of			Array of time of arrivals
estimations.lineId	[value]	schema:text	http://schema.org/Text	Number of EMT line
estimations.label	[value]	schema:text	http://schema.org/Text	Public label (current no used)
estimacions.destination	[value]	schema:text	http://schema.org/Text	Name of destination
estimations.busTime	[value]	schemas:Number	https://schemas.org/Number	Time of bus
estimations.busDistance	[value]	schemas:Number	https://schemas.org/Number	Distance from bus at stop
estimations.updateTime	[date time value]	dcterms:date	xsd:datetime	Datetime of current data
estimations.logicBus	[value]	schemas:Number	https://schemas.org/Number	Number of logic bus
estimations.tripId	[value]	schemas:Number	https://schemas.org/Number	Number of trip
estimations.route	[value]	schemas:Number	https://schemas.org/Number	Number of route
estimations.bus	[value]	schemas:Number	https://schemas.org/Number	Number of bus
estimations.instantEstimate	[date time value]	dcterms:date	xsd:datetime	Datetime of calc estimate
estimations.timeArrive	[value]	schemas:Number	https://schemas.org/Number	Time of arrive to stop
estimations.timeWait	[value]	schemas:Number	https://schemas.org/Number	Time of wait on stop
estimations.delay	[value]	schemas:Number	https://schemas.org/Number	Delay in stop
estimations.routeAltered	[value]	schemas:Number	https://schemas.org/Number	Route altered true false

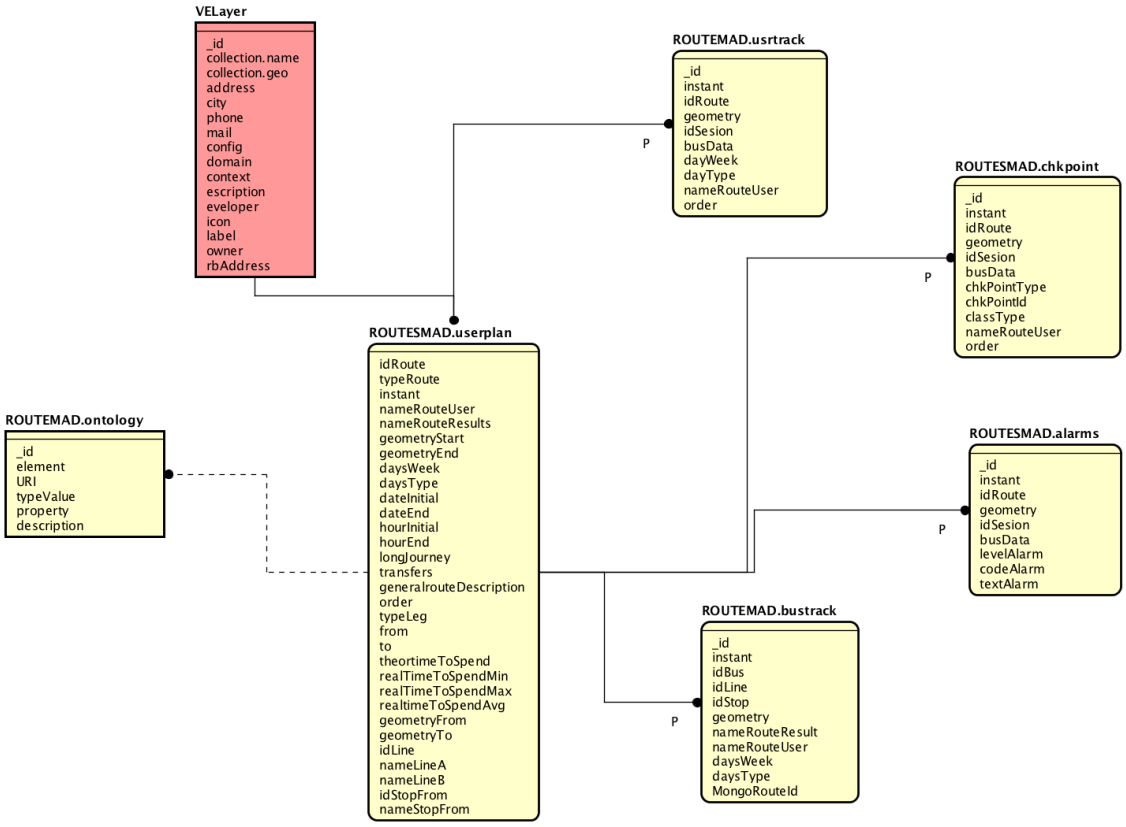
7.2.3. VE sub model for the definition of bus lines and their itineraries



Attribute	Value	Property	URI	Description
layer	**LINEBUSMAD.things**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#linebusmad	kind of layer into RB. Layer ontology describes data domain Reactive Box and other elements of this entity
idLine	[id of line]	schemas:Number	https://schemas.org/Number	Unique identifier of line into EMT Company
dateIni	[date ini]	Dcterms:date	xsd:dateTime	Begin date of current information
dateEnd	[date end]	Dcterms:valid	xsd:dateTime	End date of current information
depo	[id depo]	mobilitymadrid:depo	http://mobilitylab.emtmadrid.es/def/transport#Depo	Deposit which it belongs
group	[cod group]	mobilitymadrid:group	http://mobilitylab.emtmadrid.es/def/transport#group	Each line belongs to subgroup of lines (ej. Nightly Universitary…)
label	[id label]	schemas:AlernateName	https://schemas.org/AlternateName	Public identifier of the line
sections	Array	Array	Array	Array of sections (each itinerary) ¿JSON-LD?
section.sectionId	[id section]	schemas:Number	https://schemas.org/Number	Itineraty 1 2 etc

section.name	[name sect]	schemas:Text	https://schemas.org/Text	Public Name of section
section.length	[value]	schemas:Number	https://schemas.org/Number	Distance in meters of current section
section.geometryLine	GEOJSON	multiline object	http://geojson.org/geojson-spec.html#id6	Representation of vials on itinerary of section
section.geometryStops	GEOJSON	multiline object	http://geojson.org/geojson-spec.html#id6	Representation of stops on itinerary of section

7.2.4. VE sub model for planning trips, user tracks, checkpoints and alarms



Attribute	Value	Property	URI	Description
layer	**ROUTESMAD.userplan**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#usereventmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
idRoute	[_id]	Schema:text	http://schema.org/Text	Unique id of route plan

typeRoute	[type of routes]	Mobilitymadrid:routestype	http://mobilitylab.emtmadrid.es/def/transport#routestype	Type of route (example: carespaceialperson)
instant	[date time value]	dcterms:date	xsd:datetime	Instant of the create this calc
nameRouteUser	[value]	Schema:text	http://schema.org/Text	ID of user of route plan
nameRouteResults	[value]	Schema:text	http://schema.org/Text	Name of current into the Transport System
geometryStart	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of start of Route
geometryEnd	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of end of Route
daysWeek	[type or week days]	Mobilitymadrid:weekDays	http://mobilitylab.emtmadrid.es/def/transport#weekdays	Days of week which this route is used from the user
daysType	[type or service days]	Mobilitymadrid:daystype	http://mobilitylab.emtmadrid.es/def/transport#daystype	kind of day which user uses the route (ej: LA = Working day SA.- Saturday FE.- Festive
dateInitial	[date ini]	Dcterms:date	xsd:dateTime	Begin date of the route is used from user
dateEnd	[date end]	Dcterms:valid	xsd:dateTime	end date of the route is used from user
hourInitial	xsd_time	Dcterms:time	xsd:Time	hour Begin for using de route
hourEnd	xsd_time	Dcterms:time	xsd:Time	hour End for using de route
longJourney	[value]	schemas:Number	https://schemas.org/Number	Full time calculated in the trip (including walking and bus trips)
transfers	[value]	schemas:Number	https://schemas.org/Number	Qty of transfers (one or more bus lines)
generalRouteDescription	ARRAY	ARRAY	ARRAY	Current array represented de routes description grouping and sourting with Order of route
route.order	[value]	schemas:Number	https://schemas.org/Number	Leg or fragment of trip (order into the array)
route.typeLeg	[value]	Schema:text	http://schema.org/Text	Kind of segment of trip (W=walking B=Bus)
route.from	[value]	Schema:text	http://schema.org/Text	Name from of current segment
route.to	[value]	Schema:text	http://schema.org/Text	Name to of current segment
route.theorTimeToSpend	[value]	schemas:Number	https://schemas.org/Number	Theoretical Time of this part of trip
route.realTimeToSpendMin	[value]	schemas:Number	https://schemas.org/Number	Minimal Real Time of this part of trip
route.realTimeToSpendMax	[value]	schemas:Number	https://schemas.org/Number	Maximal Real Time of this part of trip
route.realTimeToSpendAvg	[value]	schemas:Number	https://schemas.org/Number	Average Real Time of this part of trip

route.geometryFrom	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of start of current segment
route.geometryTo	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Representation of geo-point of end of current segment
route.descriptionLeg	[value]	Schema:text	http://schema.org/Text	description of current route segment
route.idLine	[id of line]	schemas:Number	https://schemas.org/Number	Unique identifier of line into EMT Company
route.nameLineA	[name sect]	schemas:Text	https://schemas.org/Text	Public Name of section of Line FROM
route.nameLineB	[name sect]	schemas:Text	https://schemas.org/Text	Public Name of section of Line TO
route.idStopFrom	[id of stop]	schemas:Number	https://schemas.org/Number	identifier of stop which this segment of bus route starting
route.nameStopFrom	[name of stop]	schemas:Text	https://schemas.org/Text	Public Name of source Stop
route.idStopTo	[id of stop]	schemas:Number	https://schemas.org/Number	identifier of stop which this segment of bus route ending
route.nameStopTo	[name of stop]	schemas:Text	https://schemas.org/Text	Public Name of target Stop
route.detailRouteDescripcion	ARRAY	ARRAY	ARRAY	This ARRAY contains de multiline details of routes
route.routePoints	GEOJSON	multilineObject	http://geojson.org/geojson-spec.html#id6	Multilinestring of checkPoints of Route where the systems check de route
route.stopPoints	GEOJSON	multipointobjetc	http://geojson.org/geojson-spec.html#id5	Multipoint of Stops of this segment of trip
checkPointsRoute	GEOJSON	multipointobjetc	http://geojson.org/geojson-spec.html#id6	Multilinestring of checkPoints of Route where the systems check de route
typeCheck	[value]	schemas:Text	http://mobilitylab.emtmadrid.es/def/transport#chkpointtype	Type of check point
timeCheckPointsRoute	[objectvalue]		https://schemas.org/Text	Array of objetcs. one position per multiline string of checkPointsRoute with (theoretical time minimal time maximal time average time)
checkPointsStops	GEOJSON	multipointobjetc	http://geojson.org/geojson-spec.html#id6	Multipoint of checkPoints of Route where the systems check de route
numberStop	[value]	schemas:Number	https://schemas.org/Number	Number Stop of check point
nameStop	[value]	schemas:Text	https://schemas.org/Text	Name of stop in check point
timeCheckPointsStops	[objectvalue]	Objetc	https://schemas.org/Text	Array of objetcs. one position per multiline string of checkPointStops with (theoretical time minimal time maximal time average time)

Attribute	Value	Property	URI	Description
layer	**ROUTESMAD .usrtrack**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#usereventmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
_id	[_id]	Schema:text	http://schema.org/Text	Unique id of item
instant	[date time value]	dcterms:date	xsd:datetime	Instant of data generation
idRoute	[value]	Schema:text	http://schema.org/Text	Unique id of route plan
geometry	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Geo-point of current position of user
idSesion	[value]	Schema:text	http://schema.org/Text	Current session of user track
busData	[value]	JSON structure	JSON structure	data of bus when the user device is linked to
dayWeek	[type or week days]	Mobilitymadrid:weekDays	http://mobilitylab.emtmadrid.es/def/transport#weekdays	Day of week of current track
dayType	[type or service days]	Mobilitymadrid:daystype	http://mobilitylab.emtmadrid.es/def/transport#daystype	kind of day which user track is produced
nameRoute User	[value]	Schema:text	http://schema.org/Text	ID of user of route plan
order	[value]	schemas:Number	https://schemas.org/Number	Leg or fragment of trip (order into the general route in userplan)

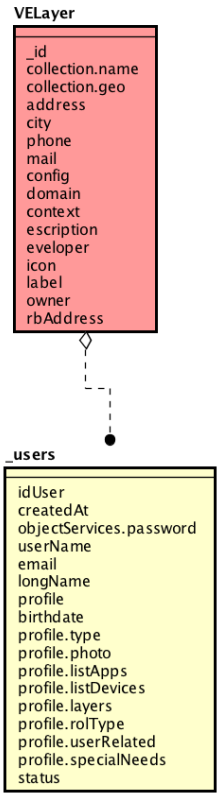
Attribute	Value	Property	URI	Description
layer	**ROUTESMAD.chkpoint**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#usereventmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
_id	[_id]	Schema:text	http://schema.org/Text	Unique id of item
idRoute	[value]	Schema:text	http://schema.org/Text	Unique id of route plan
instant	[date time value]	dcterms:date	xsd:datetime	Instant of data generation
geometry	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Geo-point of current position of user
idSesion	[value]	Schema:text	http://schema.org/Text	Current session of user track
busData	[value]	JSON structure	JSON structure	data of bus when the user device is linked to
chkPointType	[value]	schemas:Text	http://mobilitylab.emtmadrid.es/def/transport#chkpointtype	Type of check point (stop or any)
chkPointId	[value]	Schema:text	https://schemas.org/Text	Id of check point defined in userplan

classType	[value]	Schema:text	http://mobilitylab.emtmadrid.es/def/transport#typecheckpoint	Class of check Point
nameRoute User	[value]	Schema:text	http://schema.org/Text	ID of user of route plan
order	[value]	schemas:Number	https://schemas.org/Number	Leg or fragment of trip (order into the general route in userplan)

Attribute	Value	Property	URI	Description
layer	**ROUTESMAD.bustrack**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#usereventmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
_id	[_id]	Schema:text	http://schema.org/Text	Unique id of item
idLine	[id of line]	schemas:Number	https://schemas.org/Number	Unique identifier of line into EMT Company
idbus	[id of bus]	schemas:Number	https://schemas.org/Number	Unique identifier of bus into EMT Company
idStop	[id of stop]	schemas:Number	https://schemas.org/Number	Unique identifier of stop into Company
instant	[date time value]	dcterms:date	xsd:datetime	Instant of data generation
geometry	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Geo-point of current position of user
nameRoute Results	[value]	Schema:text	http://schema.org/Text	Name of current into the Transport System
nameRoute User	[value]	Schema:text	http://schema.org/Text	ID of user of route plan
dayWeek	[type or week days]	Mobilitymadrid:weekDays	http://mobilitylab.emtmadrid.es/def/transport#weekdays	Day of week of current track
dayType	[type or service days]	Mobilitymadrid:daystype	http://mobilitylab.emtmadrid.es/def/transport#daystype	kind of day which user track is produced
idSesion	[value]	Schema:text	http://schema.org/Text	Current session of user track
busData	[value]	JSON structure	JSON structure	data of bus when the user device is linked to
chkPointType	[value]	schemas:Text	http://mobilitylab.emtmadrid.es/def/transport#chkpointtype	Type of check point (stop or any)
chkPointId	[value]	Schema:text	https://schemas.org/Text	Id of check point defined in userplan
classType	[value]	Schema:text	http://mobilitylab.emtmadrid.es/def/transport#typecheckpoint	Class of check Point
order	[value]	schemas:Number	https://schemas.org/Number	Leg or fragment of trip (order into the general route in userplan)
idRoute	[value]	Schema:text	http://schema.org/Text	Unique id of item in ROUTESMAD.userplan

Attribute	Value	Property	URI	Description
layer	**ROUTESMAD.alarms**	mobilitymadrid:layers	http://mobilitylab.emtmadrid.es/def/layers#usereventmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
_id	[_id]	Schema:text	http://schema.org/Text	Unique id of item
instant	[date time value]	dcterms:date	xsd:datetime	Instant of data generation
geometry	GEOJSON	point object	http://geojson.org/geojson-spec.html#id2	Geo-point of current position of user
idRoute	[_id]	Schema:text	http://schema.org/Text	Unique id of route plan
idSesion	[value]	Schema:text	http://schema.org/Text	Current session of user track
busData	[value]	JSON structure	JSON structure	data of bus when the user device is linked to
levelAlarm	[level of alarm]	Mobilitymadrid:levelalarms	http://mobilitylab.emtmadrid.es/def/transport#levelalarms	level of alarm (Info Warn Fatal)
codeAlarm	[code of alarm]	Mobilitymadrid:codealarm	http://mobilitylab.emtmadrid.es/def/transport#codealarm	code of alarm
textAlarm	[value]	Schema:text	http://schema.org/Text	Description of current alarm

7.2.5. VE sub model for user definition, profiles and roles



Attribute	Value	Property	URI	Description
layer	**USERBUSMAD**	mobility madrid:layers	http://mobilitylab.emtmadrid.es/def/layers#travellerbusmad	kind of layer into RB or Mobility Servers. Layer ontology describes data domain Reactive Box and other elements of this entity
idUser	[_id]	Schema: text	http://schema.org/Text	Unique id of traveller or user into system
createdAt	[date ini]	Dcterms: date	xsd:dateTime	Date of user Creation
objectServices				Contains the crypto password
objectServices.password	[value]	Schema: text	https://schema.org/accessCode	Password
userName	[value]	Schema: name	http://schema.org/Name	user id of person
email	[value]	Schema: email	https://schema.org/email	email of person
longName	[value]	Schema: name	http://schema.org/Name	name of person
profile	Array	Array	Array	Array of user profile
birthdate	[date value]	Schema: birthdate	http://schema.org/Birthdate	Birthday
profile	[value]	Schema: text	http://schema.org/Text	objetct with values (Address phone email etc)
profile.type	[value]	Schema: text	http://schema.org/Text	Class of user id (IE: human, dog, application…)
profile.photo	[url]	Schema: url	http://schema.org/turl	URL of Photo of Traveller
profile.listApps	Array	Array	Array	Array of application allowed for this user
profile.listDevices	Array	Array	Array	Array of device id allowed for this user
profile.layers	Array	Array	Array	Array of collecions of data and privilegees for access for this user
profile.rolType	[value]	Schema: text	http://schema.org/Text	Rol of user into the system (example: "caregiver","superuser","user")
profile.userRelated	Array	Array	Array	Array of user who this user are related
profile.specialNeeds	Array	Array	Array	Array of special needs of user (IE: "visionReduced","mobilityReduced"…)
status	[yes/no]	Schema: boolean	http://schema.org/boolean	Status active/no active of current user

8 Data Sources and Structures

8.1 Camden Scenario

8.1.1. Heating System Data Feeds

The complete set of data feeds required for the IoT system is described in Table 3 (below)

Data Feed	Source	Purpose
Luminosity	EnergyHive multi-sensor	Thermal Load Prediction Solar Thermal Supply Prediction
Weather (Historic/Real-time /Forecast)	Met Office	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
Window open/closed	EnergyHive window sensor	Detecting if the window is open while heat is being generated
Humidity	EnergyHive humidity sensor	Detecting the dampness within the air for damp prediction

The data feeds that are necessary for prediction will need to be logged over a trial period, to provide training data for the system.

Table 3: Data feeds described by their source and purpose in the system

Data Feed	Source	Purpose
Luminosity	EnergyHive multi-sensor	Thermal Load Prediction Solar Thermal Supply Prediction
Weather (Historic/Real-time /Forecast)	Met Office	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
Window open/closed	EnergyHive window sensor	Detecting if the window is open while heat is being generated
Humidity	EnergyHive humidity sensor	Detecting the dampness within the air for damp prediction

8.1.2. Heating System Data Flow Model

An example model of the IoT system, built in SciLab, is shown in Figure 15 (below).

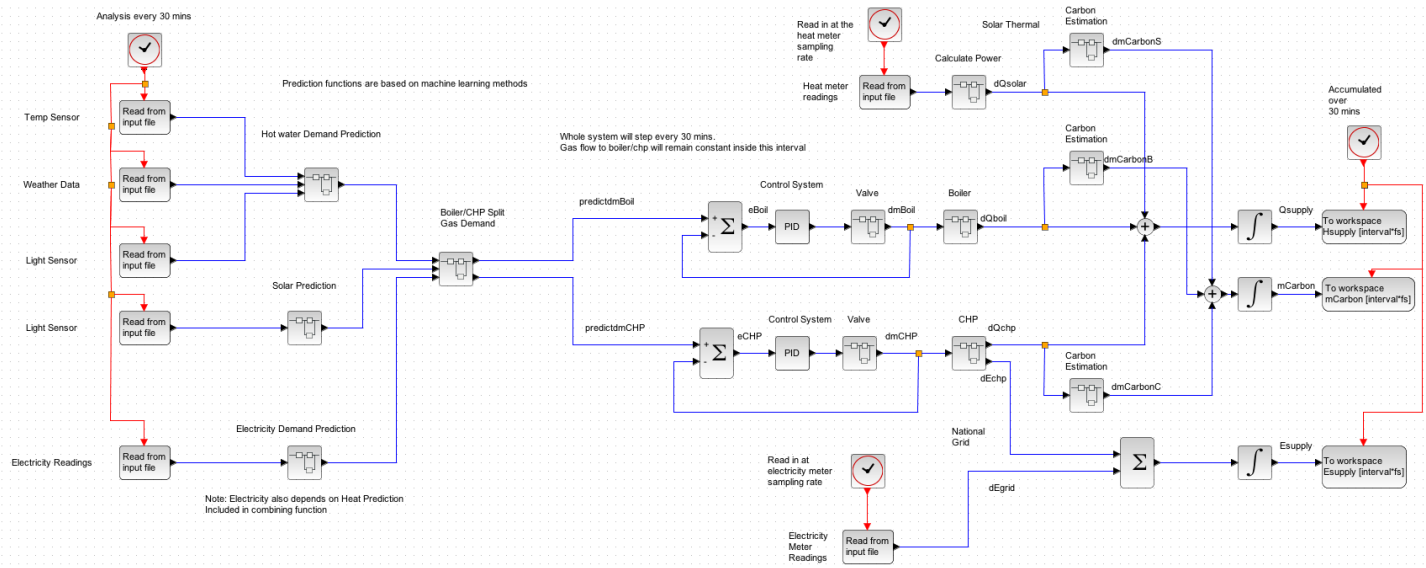


Figure 15: SciLab model of the system

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.

8.2 Madrid Scenario

8.2.1. EMT Bus System Data

The set of data feeds required for the IoT system in Madrid use case is described in Table 4. The data feeds that are necessary for prediction will need to be logged over a trial period, to provide training data for the system.

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.

Table 4: Data feeds described by their source and purpose in the system

Data Feed	Source	Purpose
Lines	https://openbus.emtmadrid.es:9443/emt-proxy-server/last/geo/GetRoutesLine.php	Lines and identifiers that are used for keys into other data sources Links to status URLs that show the line
Weather	Wind and humidity (Madrid City Council Service) http://www.mambiente.munimadrid.es/opendata/horario.txt Weather forecast (National Service) http://www.aemet.es/xml/municipios/localidad_28079.xml	Predicting disruption Predicting demand
Stops	https://openbus.emtmadrid.es:9443/emt-proxy-server/last/bus/GetNodesLines.php	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 Special Alerts from COSMOS CEP and other sources	RSS feed of disruptions, both planned and unplanned. Real Time incidents ingested from COSMOS and other data sources, including Caregiver messages and User messages.
Stop Times	https://openbus.emtmadrid.es:9443/emt-proxy-server/last/bus/GetTimeTableLines.php	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"
  }
}
```

8.3 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 addresses that are registered will be considered.

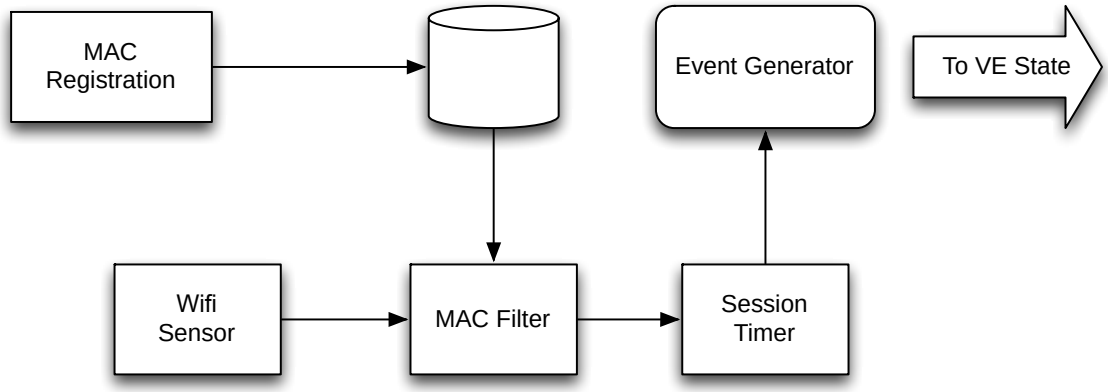


Figure 16: Presence detection using a MAC address registered to a virtual entity

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.

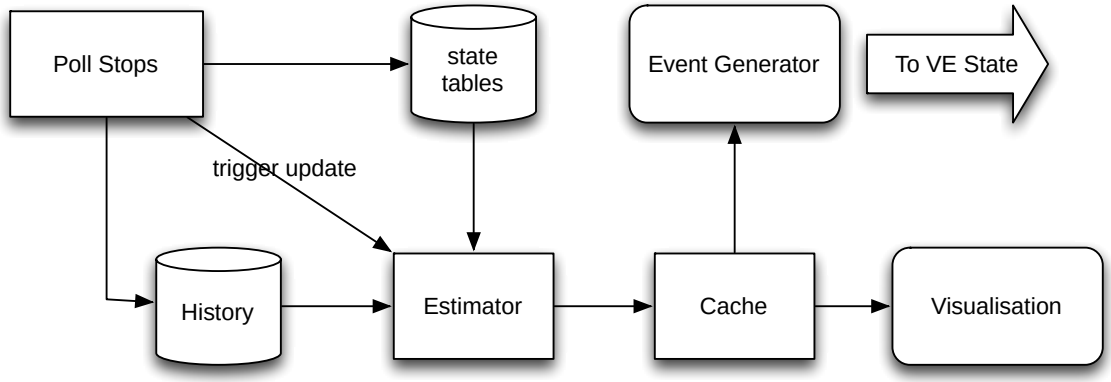


Figure 17: Estimation of position and arrival time of buses, will also map to virtual entities that are on board a bus

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.

8.4 Taipei Scenario

8.4.1. 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.

8.4.2. 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. Example:

```
* 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
```

8.4.3. 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

8.4.4. 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.

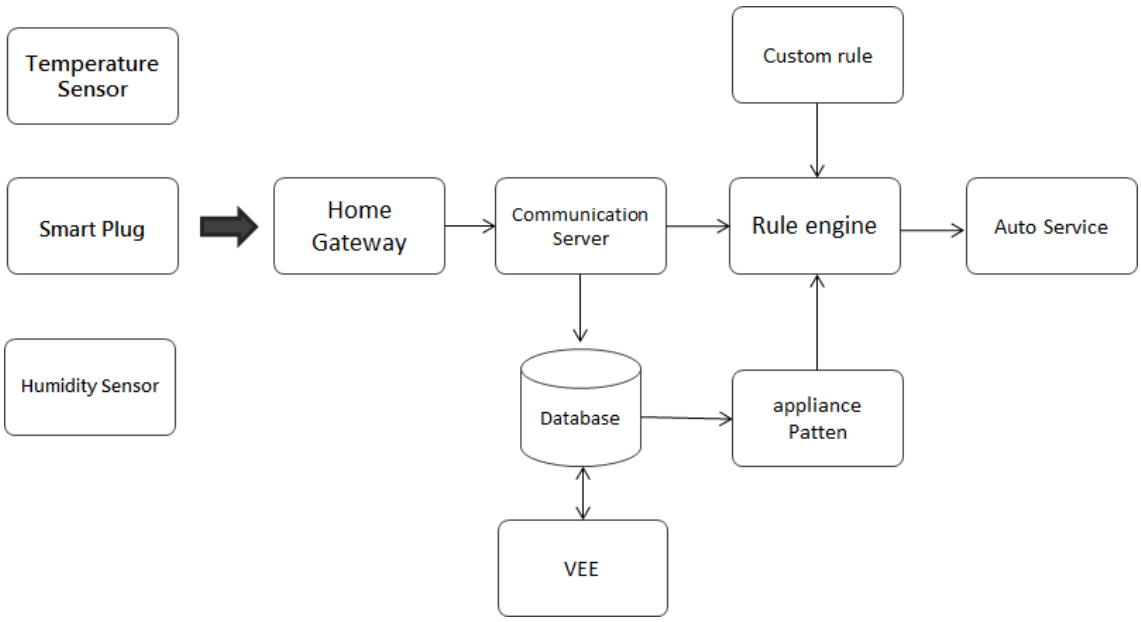


Figure 18: In-Synergy data flow

9 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.

9.1 Camden Heat Metering Application

9.1.1. 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 is 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.

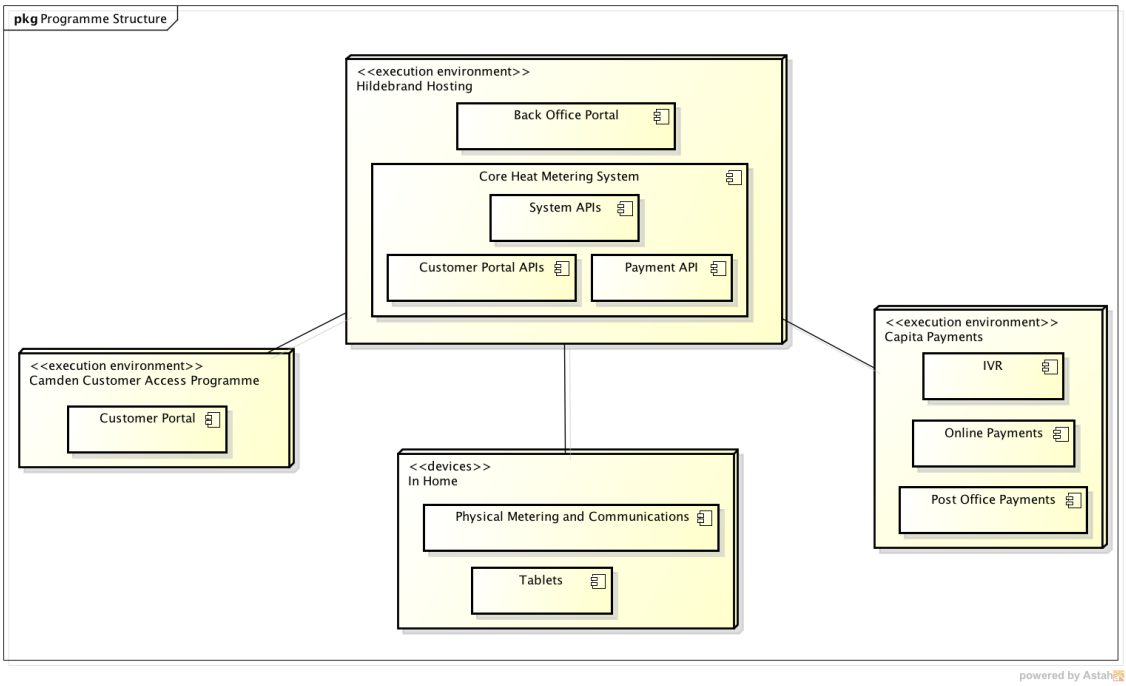


Figure 19: Component and deployment diagram showing all of the physical locations, scope of responsibility and systems associated with the Camden Heat Metering Programme. Note the Core Heat Metering System is at the centre of the Hildebrand responsibility.

9.1.2. Heat Metering System Core

Taking into consideration the very specific area of the Core Heat Metering System as show above in Figure 19, 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; and
- 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.

9.1.3. 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.

9.1.4. 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.

9.1.5. 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.
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.

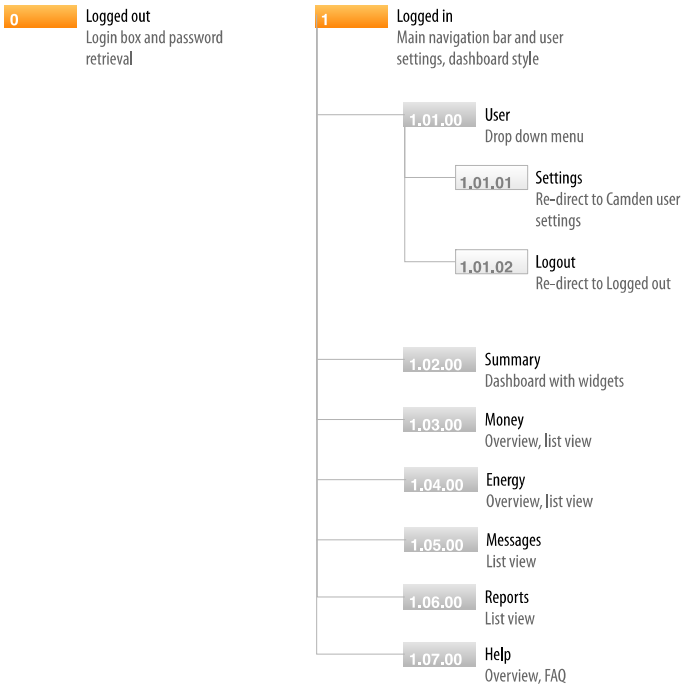


Figure 20: Backoffice navigation structure

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

9.1.6. 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.

9.2 Madrid Application

9.2.1. Integration with COSMOS

INLIFE H2020 is a Project related to accessibility topics which aim is to provide assisted help to users with special needs. The need of building an accessible app implies a great opportunity to establish an active cooperation among both INLIFE and COSMOS. On this regard, COSMOS capacity to manage predictive models based in Machine Learning could help INLIFE system, which app could include track user systems for caregivers and could also be useful to control not only the user position but also to avoid unexpected events once on route.

The special needs person application implements the Madrid UC providing the interface that will be used by the person with special needs in order to benefit from COSMOS technologies and services.

According to Madrid UC end user profile, the design of the app takes into account the user's reduced physical or cognitive capabilities, making the app a reliable ally on their daily mobility needs. COSMOS is providing knowledge for the building of the INLIFE H2020 assisted trips monitoring subsystem. Within the ongoing works, COSMOS team is actively cooperating in the design of an accessible app thinking in users with special needs, as well as in the complete integration of the monitoring and alarms system, using as an intermediate backend element the Madrid Reactive Box.

Next figure shows the current outlook of the app according to the ongoing works.

Figure 21: Outlook of the app for Madrid UC supporting INLIFE H2020 project

Regarding Caregiver's managing system, the development consists in a web portal which contains several design characteristics specific for route planning. To achieve this, a complete system is being designed to operate in real time at current management systems and totally integrated within COSMOS. This development is being generically conceived for the Mobility Labs environment, including other multiple uses.

All future developments in Y3 will be based on users' needs, which will include, among others, the following tasks:

9.2.1.1. Starting Session System

In order to allow a dynamic communication among the user with special needs and the caregiver when starting a session, a specific architecture has been developed so COSMOS can know about the relationship among them. This starting session system has been developed within the Madrid Mobility Labs system, in order to build a system more open and adaptable to future requirements or testing models. The aim is that this architecture could be potentially used by other developers to build other mobility oriented systems.

Mobility Labs starting session system is based in Meteor. Therefore, both the user with special needs and caregiver can use it to get connected to the system and to be in contact between them.

The storage of the starting session data is made in a NoSQL DDBB controlled by the Reactive Box (RB) Server which specifies the users and access rights (for reading or writing/reading). For each user connected, the Reactive Box indicates which layers can be accessed and which privileges or rights are provided (superuser). In addition to that, hierarchy of data collection included within the DDBB that contains layers allows to establish element groups in "private" or "public" mode, so each item of each layer can show or hide part of its content independently and according to the security role of the user which is connected to the Reactive Box. COSMOS connects to the RB through this starting session process.

9.2.1.2. Route Planning Portal

A new portal integrated with COSMOS is being developed for the planning, design and management of the routes that will be used by the user with special needs and its caregiver, with following characteristics:

9.2.1.2.1. Starting a session

For starting a session a user name and a password are required. Same user name applies for the caregiver and person with special needs, changing only the role.

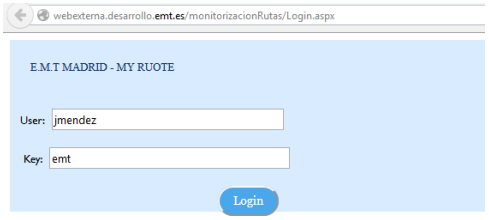


Figure 22: Access portal

9.2.1.2.2. Monitoring interface

Once the Access is granted, the interface shows the available options: adding a forecasted route, delete it, visualize it and monitoring the user with special needs once making the trip

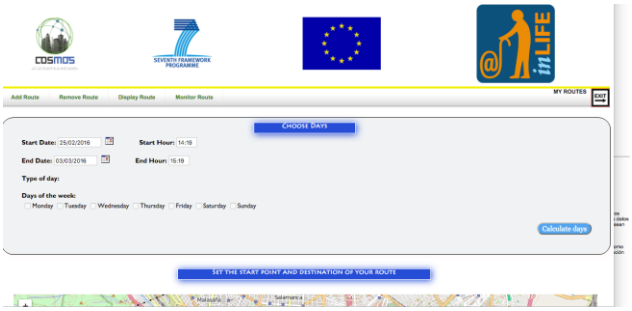


Figure 23: General monitoring interface

Within this portal it will be possible to define trip preferences and the different checkpoints that will be used by COSMOS during trip monitoring.

Figure 24: Screenshot of checkpoints along a route

This monitoring functionality allows real time visualization of the user with special needs and its location, as well as the different warnings or alerts that may happen if the user doesn't follow the route. Therefore, during this process, information is consumed both from the tracking provided by the accessible smartphone interface and COSMOS alerts and warnings thanks to the integration CEP-Reactive Box.

10 User Engagement

10.1 Madrid Scenario

There are two main objectives in relation to the user management strategy, in order to ensure user involvement:

1. To involve groups of developers and researchers in the use of data mobility through MobilityLabs Madrid and, by extension, to promote the knowledge of COSMOS system. Regarding this first objective:
    a. Currently, EMT continues working on building the information portal OpenLab Mobility
    b. The aim is to reach a multidisciplinary new space for research ideas related to the Smart Mobility
    c. Developing and sharing source code from third party
    d. Publishing white papers in the context of IoT and Smart Mobility
    e. … and, of course, promoting COSMOS as one of main features within this infrastructure, as indicated in Figure 25.

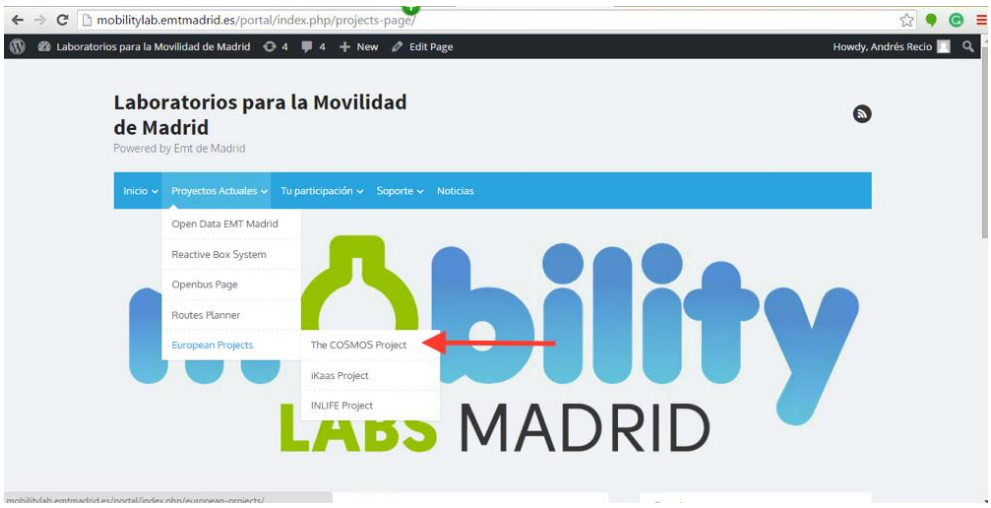


Figure 25: Mobility Lab website screenshot

2. To establish developing strategies to facilitate the use of public transport for user groups with special needs:
    a. To analyze needs of the aforementioned groups of users
    b. Work on usability & accessibility standards (EMT & CRTM are preparing the first meeting with special users -elderly & cognitive disabled people- in order to collect requirements)
    c. Bring on the autonomy for people with special needs
    d. Support solutions for accessibility at Public Transportation

    Regarding this second objective, an end-user survey/questionnaire, specially oriented to caregivers, has been developed to be circulated among a wide range of

Madrid citizens in order to get enough input about Madrid COSMOS solution and scenario.

The draft questionnaire, which will be shortly circulated, can be accessed at:

https://docs.google.com/forms/d/1_lA_ImZr5QSviFoMi1UnI2XTvZ5dNcX01oiHx39FxN4/viewform

In addition to that, and according to the aim of the European Commission about fostering synergies among different EU funded projects and initiatives, Madrid City Council and EMT Madrid have contacted with the Consorcio Regional de Transportes de Madrid, CRTM (Madrid Regional Transport Authority), as the CRTM is currently working in the development of a user interface on accessibility under the framework of the H2020 EU project called INLIFE. The CRTM will circulate COSMOS survey among their stakeholders and end users as well, mutually enriching the process of user involvement among both ongoing projects.

The results of the survey will be provided in future deliverables.

11 COSMOS Devices – OpenThings

OpenThings is a lightweight messaging protocol for sending reports (e.g. temperature measurement, power reading) and commands (e.g. turn on socket, set dimmer level) between small sensors and connected devices. The protocol is intended for use in simple applications with point-to-point or star network topologies. In both cases one device is a master and remaining devices are slaves.

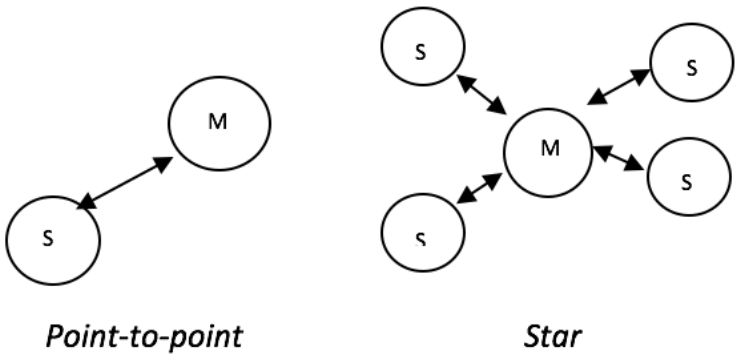
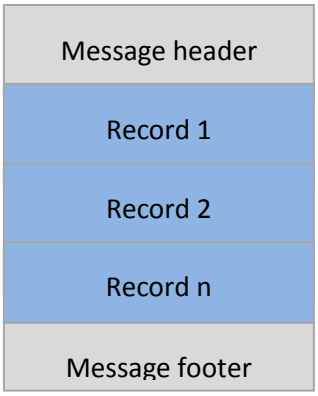


Figure 26: OpenThings network topologies

The protocol provides basic message structuring and data validation (CRC). Messages are transmitted in one direction at a time without acknowledgement. The protocol does not contain any encryption, quality of service, anti-collision or network routing elements. These can be implemented in additional network layers if required; the goal of this protocol is only to define a universal message structure and framework for how data is described, represented and sent. The protocol is hardware agnostic; it can be used with any suitable transport means, for example, a 433MHz radio or serial bus connection.

11.1 Transmissions

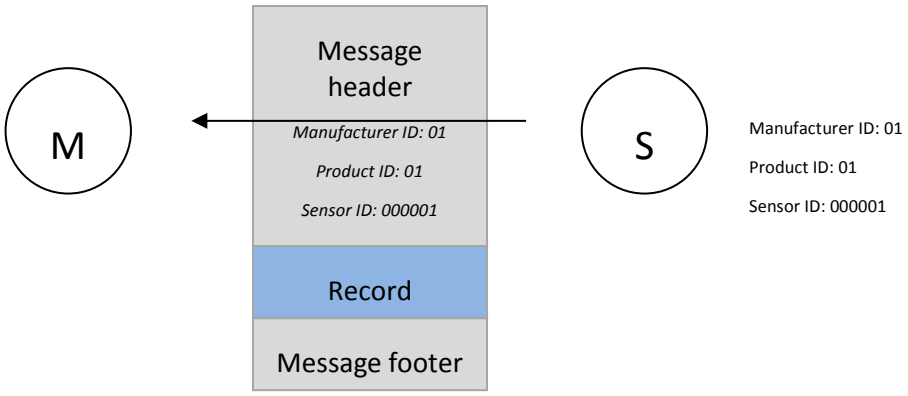
Each transmission has a defined messaging structure containing one or more records. Each record contains a parameter identifier (e.g. temperature, light level, voltage) and type description (e.g. integer, float, character) of the data value to be sent. In this way the protocol is extensible and allows new categories of data to be described and sent without any changes to the underlying protocol.



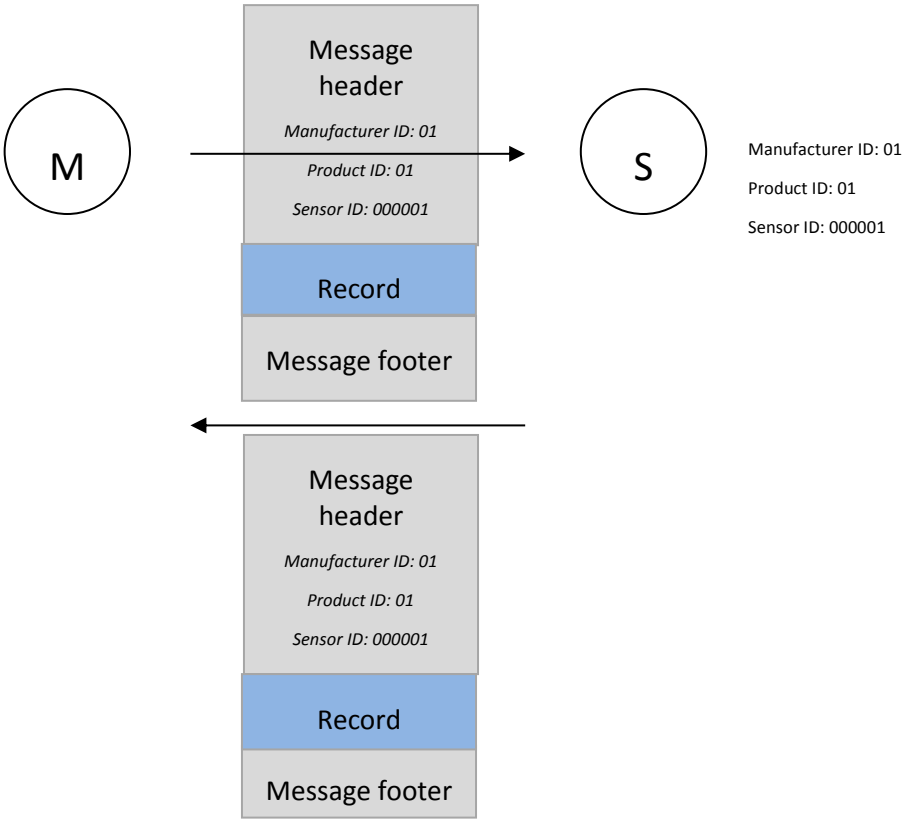
11.2 Addressing

In OpenThings network topologies only slave devices have addresses. An address is the combination of the Manufacturer ID, Product ID and Sensor ID and must be unique. Slave devices will only act on messages sent containing their address and only originate messages with their address. Master devices listen to all messages sent on the network (other than messages they have sent themselves) and originate messages with the address of the slave they want to send the message to. The protocol does not allow broadcasting; all messages must be individually addressed.

This example shows the exchange of messages and addressing when a slave device reports a parameter:



This example shows the exchange of messages and addressing when a master commands a parameter on a slave device and the slave device is expected to respond.



11.3 Default Dictionary of Parameter Identifiers

Table 5 (below) lists the parameters that can be reported and commanded as part of the default parameter identifier dictionary. Manufacturers may extend (but not modify) this to meet their requirements.

Table 5: Default dictionary

Parameter	Char	Hex (Report)	Hex (Command)	Units
Alarm	!	0x21	0xA1	*See "Alarms"*
Debug Output	-	0x2D		*Reserved for debug*
Identify	?	0x3F	0xBF	*See "Identify"*
Source Selector	@		0xC0	*See "Multiple Commands"*
Water (Flood) Detector	A	0x41	0xC1	1 = flooded, 0 = dry. *See "Binary Parameters"*
Glass Breakage	B	0x42	0xC2	1 = broken, 0 = intact. *See "Binary Parameters"*
Closures	C	0x43	0xC3	Curtains/blinds; 1 = open, 0 = closed. See *"Binary Parameters"*
Door Bell	D	0x44	0xC4	1 = pressed, 0 = released. See *"Binary Parameters"*
Energy	E	0x45	0xC5	kWh
Fall Sensor	F	0x46	0xC6	1 = fall, 0 = no fall. *See "Binary Parameters"*
Gas Volume	G	0x47	0xC7	m^3
Air Pressure	H	0x48	0xC8	mbar (millibar)
Illuminance	I	0x49	0xC9	Lux. *See "Illuminance/Light Level"*
Level	L	0x4C	0xCC	*See "Generic Level"*
Rainfall	M	0x4D	0xCD	mm
Apparent power	P	0x50	0xD0	VA
Power factor	Q	0x51	0xD1	
Report Period	R	0x52	0xD2	s (seconds). See *"Sensor Report Frequency"*
Smoke Detector	S	0x53	0xD3	1 = smoke detected, 0 = no smoke. *See "Binary Parameters"*
Time and Date	T	0x54	0xD4	Seconds since Epoch (1 Jan 1970)
Vibration	V	0x56	0xD6	1 = vibration detected, 0 = no vibration. *See "Binary Parameters"*
Water Volume	W	0x57	0xD7	l (litres)
Wind Speed	X	0x58	0xD8	m/s
Gas Pressure	a	0x61	0xE1	Pa
Battery Level	b	0x62	0xE2	V
CO Detector	c	0x63	0xE3	1 = gas detected, 0 = no gas detected. *See "Binary Parameters"*
Door Sensor	d	0x64	0xE4	1 = open, 0 = closed. *See "Binary Parameters"*

Emergency (Panic Button)	e	0x65	0xE5	1 = emergency, 0 = no emergency. *See "Binary Parameters"*
Frequency	f	0x66	0xE6	Hz
Gas Flow Rate	g	0x67	0xE7	m^3/hr
Relative Humidity	h	0x68	0xE8	%
Current	i	0x69	0xE9	A
Join	j	0x6A	0xEA	No data. See *"Joining"*
Light Level	l	0x6C	0xEC	Unsigned int, 0 = off, max = full on. *See "Illuminance/Light Level"*
Motion Detector	m	0x6D	0xED	1 = motion, 0 = no motion. *See "Binary Parameters"*
Occupancy	o	0x6F	0xEF	1 = room occupied, 0 = room not occupied. See "*Binary Parameters"*
Real Power	p	0x70	0xF0	W
Reactive Power	q	0x71	0xF1	VAR
Rotation Speed	r	0x72	0xF2	RPM
Switch State	s	0x73	0xF3	1 = on, 0 = off. *See "Binary Parameters"*
Temperature	t	0x74	0xF4	Celsius
Voltage	v	0x76	0xF6	V
Water Flow Rate	w	0x77	0xF7	l/hr (litres/hour)
Water Pressure	x	0x78	0xF8	Pa
Case (Control Knowledge)	+	0x90	0x90F	Unitless vector as a string
Trust	++	0x91	0xA0	Unitless vector as a string

Devices are not required to support all parameters and the dictionary does not in general define the type of parameters (see Table 11); whether Energy is reported as a 32-bit unsigned integer, 48.16-bit fixed point or even as an unhelpful character string is up to the manufacturer, as long as it is reported in kWh.

Some parameters can also be set as a command by a master device or very occasionally by a slave; this is signalled by setting the top bit of the parameter identifier (i.e. adding 0x80 to the hex number). Thus a smart plug might report that its switch was off with parameter identifier report "0x73", and a gateway might command it to turn the switch on with the parameter identifier command "0xF3".

11.4 Joining

The default joining protocol is simply a device announcement. The slave device sends a Join command (parameter identifier "j" command, 0xEA) and waits for a listening gateway to send it a Join report (parameter identifier 'j' report, 0x6A). Neither join record carries any data, so should have a type of 0x00 (see Table 11).

11.5 Keep-Alive

The default parameter identifier dictionary does not define any heartbeat or keep-alive record identifier. In the interests of brevity, devices wishing to send a keep-alive message that have nothing else to send can simply send a message with no records in it; in other words, they just send bytes 0 to 7 and x to x+2 from Table 9.

11.6 Identify

The “Identify” parameter (parameter identifier “?” report, 0x3F) may be used to report version numbers or model names. More usefully, as a command (0xBF) it requests the receiver to identify itself, for example by flashing an LED or beeping for a few seconds.

11.7 Sensor Report Frequency

Some sensors make periodic reports of their data. The “Report Period” parameter (parameter identifier “R”) allows the device to announce how often these reports will be made, and may allow a master device to command the time between reports if the slave device allows. By convention, a report period of zero indicates that a sensor will or should report parameter values when they change rather than at fixed intervals.

11.8 Multiple Reports

Some devices may have multiple sources of information. Consider monitoring three-phase mains, for example; the device would need to report the voltage, current and power for each phase. This is done by sending multiple records with the same identifier in the same message. So to report three-phase real power, for example, a device would send a message containing a ‘p’ record containing the power on phase 1, another ‘p’ record containing the power on phase 2, and a final ‘p’ record containing the power on phase 3.

11.9 Multiple Commands

If a slave device has more than one commandable parameter, a master device may need to command only one parameter out of a set; for example, to set the light level of one dimmer switch of a pair, or turn on one switch out of a multiswitch gang. To avoid any race conditions, it must send a record containing the source selection parameter (parameter identifier “@” command) with a bit field of the indices of the parameter to command immediately before the part of the record setting the parameter.

For example, to turn on the first (bit 0) and third (bit 2) switch of a multiswitch gang the master should send the following record (see Record Structure section for details of the elements):

Table 6: Example record to turn on first and third switch of a multiswitch gang

Byte sequence	Value	Note
1	0xC0	Parameter identifier “@” command
2	0x01	Unsigned normal integer, data length 1
3	0x05	Bitfield, bits 0 and 2 set
4	0xF3	Parameter identifier “s” command
5	0x01	Unsigned normal integer, data length 1
6	0x01	Command switch on

However, to turn on the first switch and turn off the third switch a single source selection parameter cannot be used. Instead two source selection parameters commands must be sent in the same record:

Table 7: Example record to turn on the first switch and turn off the third switch of a multiswitch gang

Byte sequence	Value	Note
1	0xC0	Parameter identifier “@” command
2	0x01	Unsigned normal integer, data length 1
3	0x01	Bitfield, bit 0 set
4	0xF3	Parameter identifier “s” command
5	0x01	Unsigned normal integer, data length 1
6	0x01	Command switch on
7	0xC0	Parameter identifier “@” command
8	0x01	Unsigned normal integer, data length 1
9	0x04	Bitfield, bit 2 set
10	0xF3	Parameter identifier “s” command
11	0x01	Unsigned normal integer, data length 1
12	0x00	Command switch off

11.10 Alarms

The "Alarm" parameter (parameter identifier "!" report) is intended for conditions internal to the device that may need to be reported urgently. There is no obligation on a device to report these conditions. The parameter value is one or more characters defining the alarm conditions, as follows:

Table 8: Default alarm values

Condition	Char (set)	Hex (set)	Char (clear)	Hex (clear)	Comments
Low Battery	B	0x42	b	0x62	The device's battery is failing and must be replaced soon.
Power Fail	P	0x50	p	0x70	A mains-powered device is currently running off its battery backup.
Over Temperature	T	0x54	t	0x74	The device is running unexpectedly hot and needs attention.
Tamper	Z	0x5A	z	0x7A	The device's anti-tamper mechanism has been triggered.

The device may report that an alarm condition no longer applies by sending an alarm with the lower case version of the condition character in its parameter value. For example, a device whose ventilation has been fixed might send the record "0x21 0x71 0x74" to indicate that its temperature is back within normal operating parameters.

Alarms can be cancelled from a master device by sending an alarm parameter identifier "!" command.

11.11Generic Level

"Generic Level" is intended for reporting and controlling generic devices; its value is an unsigned integer where zero indicates fully off, and the maximum value as defined by the type indicates fully on.

11.12Illuminance/Light Level

"Illuminance" is intended for reports from light sensors, and gives the amount of illumination in Lux. "Light Level" is intended for reporting and controlling dimmer switch settings; its value is an unsigned integer where zero indicates that the switch is fully off, and the maximum value as defined by the type indicates that the switch is fully on.

11.13Binary Parameters

A number of the parameters describe binary states, such as a switch being on or off. All these parameters are "active high", i.e. they report their active state ("the switch is on") with a value of 1 and their inactive condition with a value of 0.

Some slave devices may have multiple sources for the same binary parameter, such as individually controllable switches on a multiswitch gang. A slave may compress the different instances of the binary parameter into a single bitfield, with each bit reporting a different instance. So for example a strip of six switches could report that switches 0 and 3 were on and all the others off with a data value of 0x09 (binary 00001001). Binary parameters cannot be commanded using this shorthand; to avoid race conditions, master devices must use the "Source selection" parameter as described above.

11.14Message Structure

Each transmission is sent according to the following message structure:

Table 9: Message structure

	Byte Num.	Data Name	Remark
Message header	0	Remaining length [7:0]	Number of bytes in whole message excluding this byte(x+1) – *see Note 1*
	1	Reserved bit [7]	Must be zero – see *Note 2*
		Manufacturer ID [6:0]	Manufacturer identifier – see *Note 3*
	2	Product ID [7:0]	Product identifier – see *Note 4*
	3	Reserved [15:8]	Reserved, default 0x0000 – see *Note 5*
	4	Reserved [7:0]	
	5	Sensor ID [23:16]	Unique Sensor ID to allow differentiation between end devices – see *Note 6*
	6	Sensor ID [15:8]	
	7	Sensor ID [7:0]	
Records	ˆ		
	Bytes 8 to x-1 contain one or more Records as shown in Table 8.		
	ˇ		
Message footer	x	End of data [7:0]	NULL (0x00) to indicate end of data
	x+1	CRC [15:8]	CRC-16-CCITT – see *Note 7*
	x+2	CRC [7:0]	

The message header and footer are mandatory for each message transmission. Each message may contain one or more records, up to a maximum message length of 256 bytes. Bit numbers are shown in square brackets "[ ]".

Note 1: This byte can be used by the receiver to determine the length of the message to be received. Some radio chipsets with a packet handler can use this byte to automatically receive variable length messages.

Note 2: This reserved bit will always be zero in this version of the protocol.

Note 3: The Manufacturer ID is a globally unique number from 0 to 127 inclusive. It is allocated on request and published on the OpenThings' website.

Note 4: The Product ID should be used to identify the type/model of the product (e.g. smart plug, temperature sensor, PIR sensor, etc.). There is no reservation on Product IDs and manufacturers are expected to allocate their own; however, devices with Product IDs from 0 to 127 inclusive are expected to use a subset of the default parameter dictionary detailed above.

Note 5: These bytes are reserved for application/manufacturer specific functions. For example, they could be used for an encryption seed. If not used the default is NULL (0x0000).

Note 6: The Sensor ID must be unique to each end device of a given Product ID within the same radio network. To ensure this is the case it is recommended that the Sensor ID should be incremented (+1) sequentially in production for a given Product ID by the manufacturer.

Note 7: See Appendix A for more details on the cyclic redundancy check ("CRC") validation. The CRC is calculated from byte number 5 to byte number x inclusive, i.e. over the Sensor ID, the message body and the end of data marker. If the message is encrypted, the CRC should be performed over the unencrypted data.

11.15Record Structure

Each record has the following structure:

Table 10: Record structure

Byte Num.	Data Name	Remark
1	Parameter identifier [7:0]	The identifier of the data being sent – see *Note 8*
2	Type description [7:0]	The type of the data being sent including its length z – see *Note 9*
ˆ		
Bytes 3 to 3+(z-1) contain the data value for the parameter		
ˇ		

Note 8: The parameter identifier indicates the physical measurement or control being communicated (e.g. power, frequency, switch state). Devices with Product IDs between 0 and 127 inclusive are expected to use parameter identifiers from the default parameter identifier dictionary, otherwise manufacturers are expected to define their own dictionary of parameter identifiers for each product.

The parameter identifier "j" (0xEA as a command, 0x6A as a report) has been reserved as a special parameter to allow slave devices to request to join/pair to a master device (typically a display or gateway) and must be included in each dictionary. If manufacturer products have a joining/pairing process it should be implemented around this command and response pair.

The parameter identifier of value 0x00 is forbidden.

Note 9: The first 4 bits of a record type description byte define the type of the data value being sent (e.g. integer, float). The last 4 bits define the length of the data value being sent (in bytes):

Table 11: Type description byte

7	6	5	4	3	2	1	0
Type				Length			

Table 12: Type definition within type description byte

7	6	5	4	Type	Decimal point
0	0	0	0	Unsigned integer	x.0 normal integer
0	0	0	1		x.4 fixed point integer
0	0	1	0		x.8
0	0	1	1		x.12
0	1	0	0		x.16
0	1	0	1		x.20
0	1	1	0		x.24
0	1	1	1	Characters	
1	0	0	0	Signed integer	x.0 normal integer
1	0	0	1		x.8 fixed point integer
1	0	1	0		x.16
1	0	1	1		x.24
1	1	0	0	Reserved	
1	1	0	1	Reserved	
1	1	1	0	Reserved	
1	1	1	1	Floating point	IEEE 754-2008

It is entirely legal for any record to have a zero length data value, like the example “join” record below. Any type may be used, but a type description of 0x00 (unsigned unshifted integer) is conventional. Multi-byte numerical data values are sent big-endian, i.e. with the most significant byte first; see the example “power” record below.

11.16Example Records

Table 13: Example "join" command record

Byte num.	7	6	5	4	3	2	1	0	Note
1	1	1	1	0	1	0	1	0	Parameter identifier "j" command
2	0	0	0	0	0	0	0	0	Unsigned normal integer, data length 0

Table 14: Example "power" report record

Byte num.	7	6	5	4	3	2	1	0	Note
1	0	1	1	1	0	0	0	0	Parameter identifier "p" report
2	1	0	0	0	0	0	1	0	Signed normal integer, data length 2 bytes
3	x	x	x	x	x	x	x	x	Power [15:8]
4	x	x	x	x	x	x	x	x	Power [7:0]

Table 15: Example "smoke detector" report record

Byte num.	7	6	5	4	3	2	1	0	Note
1	0	1	0	1	0	0	1	1	Parameter identifier "S" report
2	0	0	0	0	0	0	0	1	Unsigned normal integer, data length 1
3	0	0	0	0	0	0	0	x	State [0]: 1 = smoke detected, 0 = no smoke.

11.17CRC Validation

The CRC can be used by the application layer to check the validity of a message. The CRC-16-CCITT checksum is implemented using the divisor polynomial of 0x1021 or (x16 + x12 + x5 + 1). The crc function will calculate the 16 bit CRC for an array of message bytes using a code space efficient algorithm. Other algorithms are available optimised for speed but considering the low data rate, this algorithm is preferable.

```
int16_t crc(uint8_t const mes[], size_t siz)
{
	uint16_t rem = 0;
	size_t byte, bit;

	for (byte = 0; byte < siz; ++byte)
	{
		rem ^= (mes[byte] << 8);
		for (bit = 8; bit > 0; --bit)
		{
			rem = ((rem & (1 << 15)) ? ((rem << 1) ^ 0x1021) : (rem << 
1));
		}
	}
	return rem;
}
```

11.18Example Radio Settings

These are the radio settings used as default by Hildebrand's tablet reference designs.

Table 16: Radio physical settings

Transmission frequency	434.300 MHz
Deviation	± 30kHz
Radio FSK data rate	2400 baud Manchester (encoded at 4800 bits/s)
Message transmission interval	10s
Preamble	3 bytes (0xAA , 0xAA, 0xAA)
Sync bytes	2 bytes (0x2D , 0xD4)

For radio applications it is it is recommended that the total message length is less than 64 bytes.

12 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.

New details of communications protocols and device specifications have been added, such that COSMOS developers can work within the platforms that will be deployed within test beds.

A platform called UrbisAPIs has been the implementation during Year 2, with infrastructure that enables the deployment of UrbisAPIs. There is further work to be done in Year 3 for the complete functionality to be available on public data sources.

Hence, at this stage it is of great importance to take into account final users and to think about system's functionalities as a benefit for cities and, therefore, for citizens. On this regard, it is essential to go beyond prototypes and conceptual models, implementing real systems that will last beyond the project's life.

According to that idea, any effort should be devoted to finalise the system beyond the use cases, and framed either as a final user app or a service that will allow to reduce costs, reduce mobility needs, improve accessibility, save energy or any other benefit according to the use of it. COSMOS can be a very important factor for the Smart Cities development, but it will depend on the maturity obtained at this final phase and on the knowledge that other integrators may have about the developed system.

In this scenario, fostering hackathons or any other social events may be of great help to disseminate and foster COSMOS capabilities.

13 Appendix A

13.1 Participant Information Sheet

What is this research for?

The purpose of this research is to understand how you currently use your heating, and how technology might be used to improve the way that you manage your heating, so that your heating bill is reduced.

The research is being conducted on behalf of COSMOS, a European funded project in which Camden collaborates with nine other European partners, including universities, IT companies and public sector entities.

Stella Doukianou, PhD student in Computer Science and Behavioural Economics at the University of Coventry, will help Camden with the research.

What will I do as part of this research?

You will fill out two questionnaires. In the first, you will be asked questions about yourself. In the second, you will be asked for your opinion on technology and heating controls. Both questionnaires will be anonymous.

Why have I been chosen?

The groups of people taking part in this research have been randomly selected, and are all volunteers.

How long will this take?

Both questionnaires should take no more than 20 minutes to complete in total, but you are free to spend as much time as you like answering the questions.

What will be done with the data?

We will analyse the data and draw conclusions from your answers. These will be used to help make improvements to your existing heating controls.

Results may be published in academic journals or presented at conferences. However, you will not be personally identified in any publication or presentation.

What are the benefits of taking part in this research?

You are contributing to the improvement of the way that data, involving probability, is presented. You will also have the opportunity to experience being part of a behavioural study and a research project.

Is the research confidential?
Your responses will be kept strictly confidential, and will only be used for the purpose of this study. The information that you provide will not be made available to anyone who is not directly involved in the study.

Contact Information
If you have any questions regarding the research, please contact Stella Doukianou at

doukians@uni.coventry.ac.uk or Susana Espino at susana.espino@camden.gov.uk.

13.2 Informed Consent Form

Ref _____

In order to collect data for this research, we need to have your consent. By writing your initials in the boxes below, you are agreeing with the following statements:

	Please initial
1. I have read and understood the Participant Information Sheet for the above study, and have had the opportunity to ask questions.	☐
2. I understand that that my participation is voluntary, and that I am free to withdraw at any time without giving a reason.	☐
3. I understand that all the information that I provide will be treated in confidence.	☐
4. I understand that I have the right to change my mind about participating in this study.	☐
5. I am over 18 years old.	☐
6. I understand that the data is being collected for research purposes.	☐
7. I agree to be filmed during this workshop (optional).	☐
8. I agree to take part in this research project.	☐

Date: …….

Name of Participant: ……

Signature of Participant: ……

13.3 Participant Profile Questionnaire

Ref _____

Ethnicity: What is your ethnic group? (Please tick one box)		
White	English/Welsh/Scottish/Northern Irish/British	
	Irish	
	Gypsy or Irish Traveller	
	Any other White background (please specify)	
Asian or Asian British	Indian	
	Pakistani	
	Bangladeshi	
	Chinese	
	Any other Asian background (please specify)	
Black or Black British	Caribbean	
	African	
	Any other Black/African/Caribbean background (please specify)	

Mixed/multiple ethnic groups	White and Black Caribbean	
	White and Black African	
	White and Asian	
	Any other mixed/multiple ethnic background (please specify)	
Other ethnic group	Arab	
	Any other ethnic group (please specify)	

Age: What is your age? (Please tick one box)									
0-15		16-24		25-34		35-44		45-54	
55-64		65-74		75-84		85+			

Gender: What is your gender? (Please circle the answer)			
Male	Yes/No	Is your gender identity different to the sex you were assumed to be at birth?	Yes/No
Female	Yes/No		

Highest level of education gained: (Please tick one box)				
School		University		Other (please specify)
College		None		

Family status: (Please tick one box)			
Live alone		Live with children	
Live with partner		Live with partner and children	
Live with extended family (please specify)			

13.4 Smart Heating Explanation Script

In a moment, we will give you a questionnaire that will ask you about how comfortable you feel using technology, and what you think about Smart Heating systems.

A Smart Heating system is a type of heating system that learns how you like your heating, and uses what it has learned to control the heating in your home on its own.

So, for example, in the winter, if you don't want your house to be colder than a certain temperature, a smart heating system will automatically turn the heating on if the weather gets too cold. And, in the summer, if you don't want to heat your home unless it gets cold, a smart heating system will only turn the heating on if it gets to a certain temperature which you can set.

The idea is that you only use as much heating as you actually want, so you don't end up paying for more.

A smart heating system can also be controlled remotely from your mobile phone or tablet. This means that even if you are out of the house, you can control the temperature in your home.

13.5 Home Heating Questionnaire

Ref _____

1. **How comfortable do you feel using technology? (Please tick one answer)**

Not at all		Comfortable		Very comfortable		Don't know	

2. **Please rate (1-5) how important each statement is to you when heating your home.**

(1 – Extremely important, 2 – Important, 3 – Don't know, 4 – Not important, 5 – Extremely unimportant)

I want to keep my heating within my budget.	
I want to keep my home warm and comfortable.	
I want to control my heating from a mobile/computer.	
I don't want to interact with my heating controls (I prefer fully automated controls).	
I want to keep my home healthy.	
I want my heating system to operate correctly.	

3. **When you are cold in your home, what do you do first? (Please tick one answer)**

I wear more layers.		I turn the heating on or up.	
I use additional heaters (e.g. electric heaters).		Other (please specify)	

4. **Would you like to have a smarter heating system in your house? For example, a system that can manage the heating on its own after learning your heating preferences. (Please circle one answer)**

Yes / No / Don't know

5. **Would you like to have a remote control for your heating system? For example, so you can warm your home before arriving using a mobile phone, etc. (Please circle one answer)**

Yes / No / Don't know

6. **Would you like to the temperature of your home to be automatically adjusted according to outside weather conditions? (Please circle one answer)**

Yes / No / Don't know

7. **Please rank (1-3) the following statements in terms of what is most important to you, with 1 being the most important.**

Having a smarter heating system that learns from my heating preference.	
Having a remote control for my heating system.	
Having the temperature of my home automatically adjusted according to weather conditions.	

8. **What information do you find most useful on your heat meter? (Please circle one answer)**

Instantaneous energy consumption	Historical energy consumption	Weather	None

9. **What additional information would you like to see on your heat meter? (Please specify if 'none' or 'don't know')**

10. **Do you think that your heat meter helps you to save energy? (Please circle one answer)**

Yes /No / Don't know

If you answered 'yes' or 'no', please explain why.

11. **What is your ideal heating control? For example, fully automated, manual only, etc.**

END OF THE QUESTIONNAIRE

14 Appendix B

14.1 Privacy Statement

As a local authority, Camden collects, holds and processes a considerable amount of information, including personal information about the people it serves. It does this in order to provide its services in the most effective and efficient way that it can.

The Council recognises that it has a duty to those whose information it holds to treat that information responsibly, keep it safe and secure and process it correctly and proportionally.

The Council has many functions and legal responsibilities and holds data for all of these areas. Amongst the most significant areas are for example its roles in education and in providing schools, providing care and support for the vulnerable and looking after and improving the environment. If you would like to know more about the Councils functions and duties please see the Council's web site at www.camden.gov.uk. Camden will systematically review this statement.

The Council's Borough Solicitor has overall corporate responsibility for Data Protection in Camden. Our aim is to comply with Data Protection Law at all times, but if you do have any concerns over how information is being handled in Camden or have any questions, please do not hesitate to contact the corporate information access team.

If you would like more information about Data Protection, the law and good practice, please see the Information Commissioner's website who are (the statutory governing body for England and Wales) www.ico.org.uk.

14.1.1. What personal information do we collect and what do we do with it?

We will collect information from you in order to undertake our functions as a local authority. In some areas, we may ask you to register your name, email address and relevant personal details when you seek to use our services. We will also collect information from you if you complete any other forms on our site, or if you contact us with comments or specific requests. Camden will use your personal data for a limited number of purposes, and at all times within the rules set out in the Data Protection Act 1998.

We will process personal data for the following purposes:

- For the purpose to which you provided the information, e.g. processing information given on a benefit claim form for the purpose of processing your benefit claim, and to monitor the Council's performance in responding to your request;
- To allow the Council to be able to communicate and provide services appropriate to your needs, e.g. to be able to arrange suitable access arrangements where you have mobility difficulties;
- To ensure that the Council meets its legal requirements, including obligations imposed under the Equality and Health and Safety Acts;
- Where necessary, for the Council's Law Enforcement functions, e.g. licensing, planning enforcement, trading standards, food safety, etc. where the Council is legally obliged to undertake such processing;

- Where the processing is necessary for Camden to comply with its legal obligations, e.g. the prevention and/or detection of crime;
- To process financial transactions, including grants, payments and benefits involving the Council, or where the Council is acting on behalf of other government bodies, e.g. Department for Works and Pensions;
- Where you have consented to the processing;
- Where necessary to protect individuals from harm or injury; or
- Where otherwise permitted under the Data Protection Act 1998, e.g. disclosure to comply with legal obligations. For further information on the Data Protection Act refer to the Information Commissioner's website.

Camden Council may also use your personal data, after it has been anonymised, for statistical analysis of data to allow the Council to effectively target and plan the provision of services. In deciding what personal data to collect, hold and use, the Council is committed to ensuring that it will:

- Recognise that any personal data handled by Camden is held on behalf of that person, and respect that responsibility;
- Adopt and maintain high standards in respect of the handling and use of that personal data;
- Only collect, hold and use personal data where it is necessary and proportionate to do so;
- Securely delete any personal data when no longer needed;
- Keep your personal data secure and safe;
- Not unnecessarily and without good reason infringe the privacy of those on whose behalf we hold data;
- Consider and address the privacy risks first when planning to use or hold personal information in new ways, such as when introducing new systems;
- Be open with individuals about how we use their information and who we give it to;
- Make it easy for individuals to access and correct their personal information;
- Ensure that there are effective safeguards and systems in place to make sure that personal information is kept securely and does not fall into the wrong hands;
- Provide training to staff who handle personal information and treat it as a disciplinary matter if they misuse or don't look after personal information properly;
- Put appropriate financial and human resources into looking after personal information to make sure that we can live up to our promises; and
- Regularly check that we are living up to our promises and report on how we are doing.

The Council may disclose personal data to third parties, but only where it is necessary, either to comply with a legal obligation, or where permitted under the Data Protection Act, e.g. where the disclosure is necessary for the purposes of the prevention and/or detection of crime, or where it is necessary to allow a third party working for or on behalf of the Council.

The Council will strive to ensure that any personal data in its care will be kept safe, and that where your information is disclosed to a third party, the Council will seek to ensure that the

third party has sufficient systems and procedures in place to prevent the loss of personal data. Where the Council seeks to disclose sensitive personal data, such as medical details, to third parties, we will do so only with your prior express consent or where we are legally required to do.

If you choose to complete any of our online forms, Camden Council will not use the personal information you provide us with for marketing purposes without first gaining your consent. We may pass your details on to third party service providers who are contracted to Camden Council in the course of dealing with your request. These third parties are obliged to keep your details securely, will use them only to fulfil the request and will dispose of the information at the appropriate time.

No personal information that you have given us will be passed on to third parties for commercial purposes. Our policy is that all information will be shared among officers and other agencies where the legal framework allows it, if this will help to improve the service you receive and to develop other services.

Whilst the Council tries to ensure that any personal data it holds about you is correct, there may be situations where the information it holds is no longer accurate. If this is the case, please contact the department holding the information or the Corporate Information Access Team so that any errors can be investigated and corrected.

If you do not wish certain information about you to be exchanged within the Council, you can request that this does not happen. You can write to, or email us, quoting Section 10 of the Data Protection Act, and we will consider your request and respond to you.

14.1.2. Families with Complex Needs

Camden Council is part of the Government's initiative for families with complex needs. This aims to support families who are facing multiple challenges.

Camden is committed to improving outcomes for families, and is participating in a national initiative which seeks to do this via integrated and family-focused working. The Council will be identifying those families with the most pressing and complex needs. This will involve some sharing of information between council departments and with other organisations. Any such sharing will be done proportionately and lawfully for the purpose of identifying those families who most need this support. Sharing will be done to ensure that services are better coordinated and focused for those families.

Families may be approached by organisations that are involved in this project or that have previously been working with the family and, if so, consent for data protection purposes will be established at this point.

If your family is assessed as eligible to receive support from the Council and/or its partner agencies for the purposes of this initiative, and whether or not you agree to take part in the initiative, we will share your personal information (including your name and date of birth) for the purposes of local and national evaluation and research of services provided. We will share your information with the Office for National Statistics (ONS) (data protection/registration number: Z1404686), acting as data processor on behalf for the Department for Communities and Local Government (DCLG) for these purposes. Your information will not be used by the ONS for any other purposes, and will be destroyed on completion of the study. Your information will be anonymised and handled in accordance with the law. It will not affect your benefits, services or treatments that you get.

For more information, or to opt out, please contact Information and Records Management Services.

Further information on the Government's Troubled Families Programme can be found on the www.gov.uk website.

14.1.3. Collecting Information Automatically

We collect statistics about your visit to our website. We use this information to track user activity which in turn helps us to improve the website. These statistics do not contain personal data and cannot be traced back to an individual.

We use 'cookies' to collect this statistical information. However, the cookies themselves do not store personal information.

14.1.4. Equalities

The Council is under legal duties to have regard to the impact of its policies and operation upon various groups based on factors such as age, sex, ethnic origin, race, sexual orientation. Gathering and analysing statistics on these factors allows the Council to ensure it implements and designs its policies in as fair a way as it can. It regularly prepares equality impact assessments on particular polices to ensure that those policies do not unfairly impact upon any groups and it also uses them to ensure that it complies with its duty to promote relations between different groups. Such statistical data does not allow for the individual identification of any specific person and it will not impact upon any individual's particular entitlement to services and or facilities.

14.1.5. Detection and Prevention of Crime

Camden Council is required by law to protect the public funds it administers. We process and share the information provided to us for the following purposes:

- Council employee Payroll
- Council employee Pensions
- Electoral Register
- Student Loans
- Housing
- Supported Care (Home Residents and Care Home Residents)
- Transport passes, including residents' parking blue badges
- Insurance Claimants
- Housing and Council Tax Benefits
- Licenses, e.g. market trader/ operator, and (new) personal licenses to supply alcohol
- Council Tax
- Leisure
- Property (Planning, Business Rates)
- Libraries
- School admissions

To prevent and/or detect potential fraud and crime, by both conducting our own Data Matching as well as sharing this information with other public bodies, such as; the Audit

Commission, the Department for Work and Pensions, other Local Authorities Revenues and Customs and the Police under Sections 29 and 35 of the Data Protection Act 1998.

The Councils approach to the prevention and detection of fraud is detailed in the Councils Anti Fraud and Corruption Strategy, specifically section 4 “Managing and Preventing the Risk of Fraud and Corruption”.

14.1.6. Contact Camden

As part of the Councils drive towards increasing customer satisfaction with its services it seeks to route customer contact via Contact Camden. When you telephone Camden (particularly for the first time) you will go to one of our Contact Camden officers. They will seek information from you which will be shared within the Council in order for us to deliver services for you.

You may also be asked to give consent to the use of the information for wider purposes but if this is the case we will explain why we want that information, what we will use it for and we will stick to the parameters of your agreement.

14.1.7. Data Matching

Computerised data matching and analytics allows potentially fraudulent claims, transactions, applications and payments to be identified. Where a match is found and two or more records have contradictory or conflicting information, the inconsistency will require further investigation. No assumption can be made as to whether there is fraud, error or other explanation until an investigation is carried out. Regardless, the data matching process is a proven way of helping to ensure that records are up to date and accurate.

14.1.8. The National Fraud Initiate (NFI)

The Audit Commission is appointed as the Councils external auditor to audit the accounts of Camden Council and also conducts its own data matching exercise, the NFI.

In addition to our exercises the Audit Commission requires local authorities to participate in a data matching exercise to assist in the prevention and/or detection of fraud. We are legally required to provide particular sets of Data to the Audit Commission for matching for each exercise, and these are set out in the Audit Commission’s guidance.

The use of data by the Audit Commission in a data matching exercise is carried out with statutory authority under its powers in Part 2A of the Audit Commission Act 1998. It does not require the consent of the individuals concerned under the Data Protection Act 1998.

Data matching by the Audit Commission is subject to a Code of Practice. This may be found on the Audit Commission website. As a participant in the NFI, the Council has a nominated a contact responsible for ensuring the Council complies with the NFI Code of Data Matching Practice.

For further information on the Audit Commission’s legal powers and the reasons why it matches particular information, refer to the Audit Commission website.

For further information about data matching at Camden Council please contact the Corporate Information Access Team.

14.1.9. Confidentiality/Security

We give you the option of using a secure transmission method to send us the following types of personal data:

- Primary personal data (such as name and contact details)
- Identifiers (such as credit card details, website password) The two tools that are available to Camden Officers are Egress and CJSM.

These tools will be used to securely share your personal information with you. Egress is free software and is available to use by all organisations and individuals. Further details on Egress and CJSM are available from the council by email dpa@camden.gov.uk.

All our employees and data processors with access to, and associated with the processing of, personal data are obliged to respect the confidentiality of our visitors' personal data. We ensure that your personal data will not be disclosed to government institutions and authorities except if required by law or other regulation.

14.1.10. Email Messages

You may receive occasional email messages from Camden Council on matters that we consider may be of interest to you, if you have provided your email address to us for this purpose. If you sign up to subscribe to My Camden news you will receive a weekly e-newsletter. You can change your subscription preferences or unsubscribe from My Camden news at any time.

If you sign up for any service update email alerts, such as local parking suspension alerts, you will receive the alerts as and when they are created. You can unsubscribe, or change which service update email alerts you receive, at any time.

14.1.11. Email Monitoring

The use of Camden Council's email system may be monitored and communications read in order to secure effective operation of the system and for other lawful purposes.

14.1.12. External links

www.camden.gov.uk contains links to other websites. This privacy policy applies only to the London Borough of Camden's website. When you are transferring to another site you should read their privacy statement for their policy on the use of personal information.

14.1.13. Changes

If this privacy statement changes in any way, we will place an updated version on this page. By regularly reviewing this page you will ensure that you are always aware of what information we collect, how we use it and under what circumstances, if any, we will share it with others. We are under a duty to share data within the council services for effective service provision. Your information will be shared with relevant services as stipulated in our Data Protection Notification with the ICO under the Data Protection Act 1998. We will endeavour to ensure your personal data will be processed in accordance with the Principles and Rights of the Data Protection Act 1998 and any disclosure(s) made will be in accordance with our Notification, which can be viewed at www.ico.org.uk. A copy of the Notification is also available on request from the Council.

For more information, please contact the Corporate Information Access team.

14.1.14. Google Analytics

This website uses Google Analytics, a web analytics service provided by Google, Inc. ("Google"). Google Analytics uses "cookies", which are text files placed on your computer, to help the website analyse how users use the site.

The information generated by the cookie about your use of the website (including your IP address) will be transmitted to and stored by Google on servers in the United States. Google will use this information for the purpose of evaluating your use of the website, compiling reports on website activity for website operators and providing other services relating to website activity and internet usage. Google may also transfer this information to third parties where required to do so by law, or where such third parties process the information on Google's behalf. Google will not associate your IP address with any other data held by Google. You may refuse the use of cookies by selecting the appropriate settings on your browser, however please note that if you do this you may not be able to use the full functionality of this website.

By using this website, you consent to the processing of data about you by Google in the manner and for the purposes set out above.

14.1.15. The Future

The Council has recently agreed a significant new policy the “Camden Plan”. As part of this, and in recognition of the important of having, where appropriate sharing accurate data, the Council is running a number of projects both to check the accuracy of its data and how it can be best used to assist those upon whose behalf it is held. For these projects, the Council will undertake privacy impact assessments when appropriate and will comply with Data Protection legislation with the aim being that its data is accurate, only held when necessary and shared in order to improve the quality of the services it provides.

The Council’s Fair Processing Notice details how we use your information. Over time we aim to have one master record (Golden Record) which will contain your basic details and records of all your transactions with the council.

14.2 Data Protection Act 1998

Camden Council will process all information in accordance with the requirements of the Data Protection Act 1998. The Council will use the information that you have provided to check the validity of your request for a service from us.

We are required by law to protect the public funds we administer. We may share/check the information provided with other bodies responsible for auditing or administering public funds, in order to prevent and detect fraud. These bodies include: other council departments, other public authorities and Government Departments, e.g. HMRC (Inland Revenue & Customs & Excise - VAT), DWP (for Benefit claims) and the Home Office (for nationality). We may also obtain information from the above organisations or share your information with them to ensure that the information is accurate.

14.3 Audit Commission Code of Data Matching Practice 2008

This authority is under a duty to protect the public funds it administers, and to this end may use the information you have provided to the Council when applying for Services for the prevention and detection of fraud. It may also share this information with other bodies responsible for auditing or administering public funds for these purposes.

For further information, please see the Audit Commission website or the contact the anti-fraud and investigation team.

The Audit Commission appoints the auditor to audit the accounts of this authority, It is also responsible for carrying out data matching exercises.

Data matching involves comparing computer records held by one body against other computer records held by the same or another body. This is usually personal information. Computerised data matching allows potentially fraudulent claims and payments to be identified. Where a match is found it indicates that there is an inconsistency which requires further investigation. No assumption can be made as to whether there is fraud, error or other explanation until an investigation is carried out.

The Audit Commission currently requires us to participate in a data matching exercise to assist in the prevention and detection of fraud. We are required to provide particular sets of data to the Audit Commission for matching for each exercise, and these are set out in the Audit Commission's handbooks, which can be found at www.audit-commission.gov.uk/nfi, an extract of which is below:

The mandatory datasets are not collected from a single source, are creditors' (payment history and standing data), housing rents, payroll and pensions payroll. The other two mandatory datasets, ie, housing benefits and students eligible for a loan will be collected from the DWP and SLC respectively. Each local government body should submit whichever of these are relevant to its functions, that is:

- London Boroughs and Unitary councils - creditors, payroll, pensions payroll and housing rents (where housing stock remains with the authority or where it has been transferred to an arm's length management organisation (ALMO)).
- County councils - creditors, payroll and pensions payroll.
- District councils - creditors, payroll and housing rents (where housing stock remains with the authority or where it has been transferred to an ALMO).
- Pension authority (local government) - pensions payroll.
- Police and Fire - creditors, payroll and pensions payroll.
- Probation and Passenger Transport - payroll (creditors is not mandatory).

The use of data by the Audit Commission in a data matching exercise is carried out with statutory authority under its powers in Part 2A of the Audit Commission Act 1998. It does not require the consent of the individuals concerned under the Data Protection Act 1998.

14.4 How We Use Your Information

14.4.1. Why does Camden collect and store personal data?

Camden, as a Local Authority, collects holds and processes a considerable amount of information, including personal information about the people it serves.

Personal data covers basic details such as name, address, telephone number, and date of birth. We also collect some sensitive information such as ethnicity, religious beliefs but only where it is required to provide a service. We will always explain to you why and how this information will be used. We do this in order to provide services in the most effective and efficient way.

For some of our services we need to collect information from you so we can contact you or provide the service. We always try to make sure the information we collect is correct. The information that you provide will be logged on our database for future reference and this information may be accessed by other departments within the Council.

Our aim is to provide you with a service that does not require you to repeat basic information each time you contact Camden.

The information you provide us may be shared with other Local Authorities, Department of Work and Pensions (DWP), HMRC and the Home Office. There will be times that the information will be disclosed to our partner organisations that provide services on behalf of Camden. Once they have provided the service your details will be deleted securely.

Departments in Camden that have personal and sensitive information on you will only allow designated officers to access or process this information. If an external agency asks us to provide any information that is sensitive and personal to you, we will only disclose it once we have your specific consent to do so or where we are legally required to do so.

14.4.2. Using Your Personal Data

We will use the information you provide for the following purposes:

- To ensure the Council meets its legal obligations, including those related to diversity and equal opportunity
- Where you have agreed for the purpose of consulting, informing and assessing your opinion about our products and services
- Regulatory, Licensing and Enforcement functions, which the Council is obliged to undertake
- All financial transactions to and from the Council, including payments, grants and benefits where monies are due or outstanding.
- Camden reserves the right to use all information provided to all the Council's departments to protect public funds.

14.4.3. Use of Your Information

The Council will collect, store and use the information you provide in line with the Data Protection Act 1998. We will only collect enough information to provide you with services. We will try to keep your information accurate and up to date, and to only keep it to provide you with a service.

The Council may disclose personal data to third parties, but only where it is necessary:

- To comply with a legal obligation
- For the prevention or detection of crime,
- To allow a partner organisation to act on behalf of the Council.

The Council (and our partner organisations) will keep your personal data secure using all of the required technical and organisational security measures.

The council has strict policies around who can access, store or disclose your information to other departments or external organisations. Further details are available in our Privacy Statement

Under Part IIA of the Audit Commission Act 1998 we participate in the National Fraud Initiative data matching exercise. The Council may share this information where necessary with other organisations, including (but not limited to) where it is appropriate to protect public funds and/or prevent fraud in line with the National Fraud Initiative guidelines. The data held by Camden Council will be used for cross-system and cross authority comparison for the prevention and detection of fraud.

14.4.4. Sharing Basic Details across Council Services

Camden Council in carrying out its duties aims to provide you with efficient and timely services and to do so we need to co-ordinate our services. To achieve this, your information will be stored on a central computer system using information from all the Council's computer systems. This central system will record any change to your details, so that once you have told one Council department you do not have to repeat this information.

Our long-term aim is to have one master record (Golden Record) for each customer that will contain your basic details (name, address, date of birth and gender, together with some information which can be used to confirm your identity) and details of the services you receive from the Council so that we could tailor our services to meet your specific needs. However, we will only access this information to respond to your queries or to provide you with a service or to carry out our duties.

The Golden Record will not contain extensive details of the services you have received. However, this record will also act as an index to other council databases and will be able to feed information into a number of council systems, including:

- Customer transactions and complaints
- Housing
- Council Tax and Benefits
- Electoral Register
- Adult and Children's Social Services
- Schools and pupil information
- Parking Control/enforcement & permits, accessible transport
- Young people's information
- Libraries

The Golden Record will also allow the council to respond to any queries you may have in respect of the provision of services more quickly and efficiently. By linking into a number of Council systems, any query or issue can be investigated more quickly. However, any access to such Council systems will only take place in response to any query or instruction received by yourself, and only where such access is necessary to answer or respond to the query or issue raised by yourself.

The Council will not normally create or hold Single Customer Records in relation to children (individuals under the age of 18) without the consent of the child's parent/guardian.

14.4.5. Further Information and Complaints

If you need any further information, clarification or have a complaint regarding your personal information please contact the corporate information access team.