Cities in the Cloud

A Living PlanIT Introduction to Future City Technologies



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Preface

The world of government is changing amid increasing pressure to deliver solutions to citizens that are not only economically sound but environmentally and socially responsible. On the other hand, the emergence of Internet services and an 'always-on' culture has simultaneously raised expectations – particularly amongst younger citizens – and prompted delivery alternatives that can help relieve some of this pressure. The cloud provides the means to cost-effectively deliver software, computing power, and innovative, integrated solutions to meet these expectations. In addition, substantial demand worldwide for urbanization creates pressure on existing cities and creates demand for new ones. All of this calls for coherent approaches to resolving this equation, to enable governments to successfully evolve to a 'Government 2.0' model, and to meet the demand for urban settlement and economic growth worldwide.

This paper extends that discussion within the context of future cities. Future Cities have gained significant momentum in the past few years as a solution to the increased demand for urban living worldwide, meeting that demand while maintaining and improving the economic, social, and environmental performance of the city. The main tool used to achieve these goals is the application of technology, but as with any technology-rich project, having a well-planned coherent approach to implementation that addresses and reconciles both business and technology goals is critical. The failure of some early entrants into this market has been defined by the lack of such an approach. Many experts and commentators cite Living PlanIT – whose approach is based on the application of Cisco and Microsoft network, server and cloud technologies – as being the leading contender in providing more considered solutions to the problem of smart urbanization.

Living PlanIT's methodology transforms the entire lifecycle of development, from conception to appropriate funding models, to construction techniques to the role of the property developer. Living PlanIT's model perhaps more importantly then optimizes city operations through a combination of deep sensing, distributed control and cloud-based data acquisition and analytics.

Living PlanIT's Urban Operating System (UOS™) provides essential middleware – built on Cisco infrastructure and Microsoft Cloud platforms – that enables networked sensors and actuators to be deployed at scale, coordinated through a unified and secure real-time control layer which also shares and collects data across the entire urban landscape. This data can be analyzed and mined for insight, allowing for the continual delivery of incremental efficiencies.

The UOS™ also provides a set of data and application services that facilitates the leveraging of building and city facilities and information by applications known as PlaceApps because they are location- and context-aware. This enables the application developer community to quickly and simply build applications in that urban context for delivery to citizens, governments, service providers, and real estate developers and operators alike.

The data collected also enables a new style of integrated reporting for cities, One Urban Report™, in which all stakeholders can receive accurate information on financial and nonfinancial (environmental, social, and governance) performance and the relationships between them. Through integrated reporting and PlaceApps using this information, the city and its citizens can make better decisions about their use of financial, natural and human resources, thereby creating a more sustainable city. In addition, One Urban Report™ and its associated PlaceApps will also dramatically improve the level of engagement a city has with its citizens.

This approach therefore takes empowerment of connected Government, transparency in reporting, and provision of resident, worker, and visitor services to the next level, providing both the information pool and the platform for development and deployment. For this reason, both Cisco & Microsoft have selected Living PlanIT SA to be a strategic partner in the development and delivery of future cities. Accordingly, this paper discusses the first fruits of these partnerships, demonstrating how a coherent future city platform such as the UOS™ helps resolve the multiple needs of cities, their citizens, and their governments.

New Business Model for Cities

Living PlanIT has developed new business models, technology, and partner channels to respond to the following key trends and market opportunities:

Urbanization of cities

- The population of the planet is increasingly moving to cities, hoping to improve their quality of life. This has been especially felt in the developing world, including China, India, and parts of Africa. Today cities contain 50% of the globe's citizens, a number projected to grow to 70% (some 5.6 billion people) by 2050.[1]
- Cities are ill equipped to deal with the shift in population and lack the necessary scale of infrastructure required to support it. Today cities already represent 60-80% of the world's annual energy usage.[2]
- Construction and infrastructure projects are notoriously expensive and inefficient. Valorization is poor, fraud is prevalent and, despite the best intentions, construction projects often result in tactical decisions that frequently exacerbate environmental impact.
- The cost of urban sprawl far outweighs investment in 'clean sheet' implementations. New technologies coupled with environmentally conscious buildings and infrastructure planning and design consistently outperform urban augmentation.
- Insufficient thought has gone into economic and social development and long-term sustainability.

The above frequently result in large communities of state-dependent residents and dramatic destabilization of industries that drive GDP.

Rural Urbanization

- There is a need to improve the quality of life in rural and regional settings to stabilize population movement, strengthen key industries, close the gap between rich and poor, and curb socio-political unrest.
- Initiatives must drive mechanization and automation of traditional industries whilst providing education and re-training of the subsequent population of surplus labour.
- In making the delivery of education and healthcare more efficient, all relevant parties must develop a labour pool of skills to allow for high production values and competitive products and services.
- Municipalities must reduce the load on centralized energy, waste, and water treatment systems – the scale, cost, and time to deliver a centralized network is not practical in the medium term.

Knowledge Economies

- Major stakeholders must expedite the creation of Knowledge Economies, as global competition is cannibalizing traditional staple industries. Furthermore, labour-price advantages erode all too quickly.
- Nations have to develop strategies to increase the sophistication of their populations to service and attract advanced industries.
- Changing the status quo must emphasize educational development, tax and fiscal incentives that inspire job creation, financing and venture-funding ecosystems, and partnerships with global institutions and commercial concerns.
- Small- and medium-sized businesses are the powerhouse of any economy – necessary for conditions that promote the formation and success of entrepreneurial businesses.

[1] http://esa.un.org/unpd/wup/index.htm, accessed April 2011

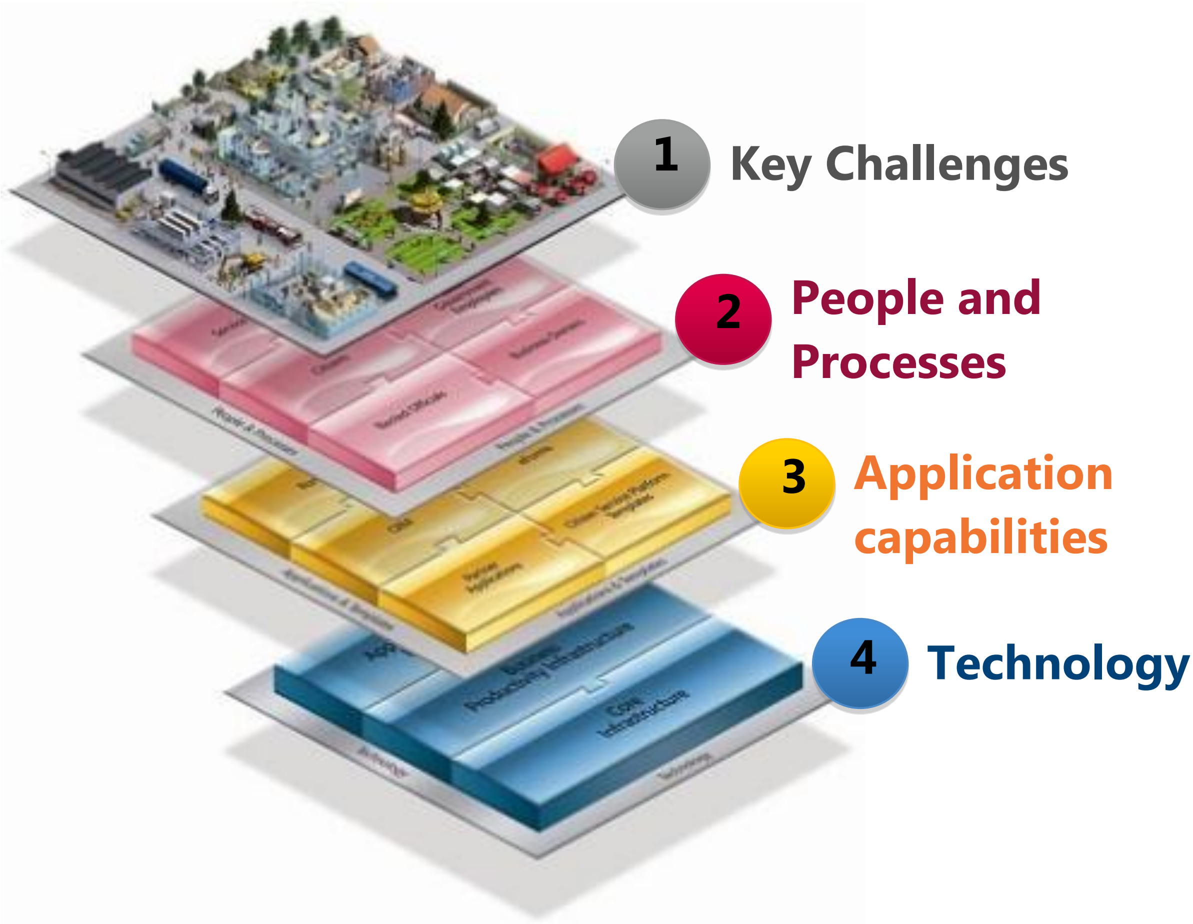
[2] McKinsey Global Institute. *Preparing for China's Urban Billion*. March 2009.

- G8 and trade blocks (such as the EU through the Lisbon Strategy, the Digital Agenda and European Innovation Scoreboard) drive global innovation and competitiveness and can be harnessed to improve socioeconomic conditions.

Future city Requirements, Architecture, and Technology

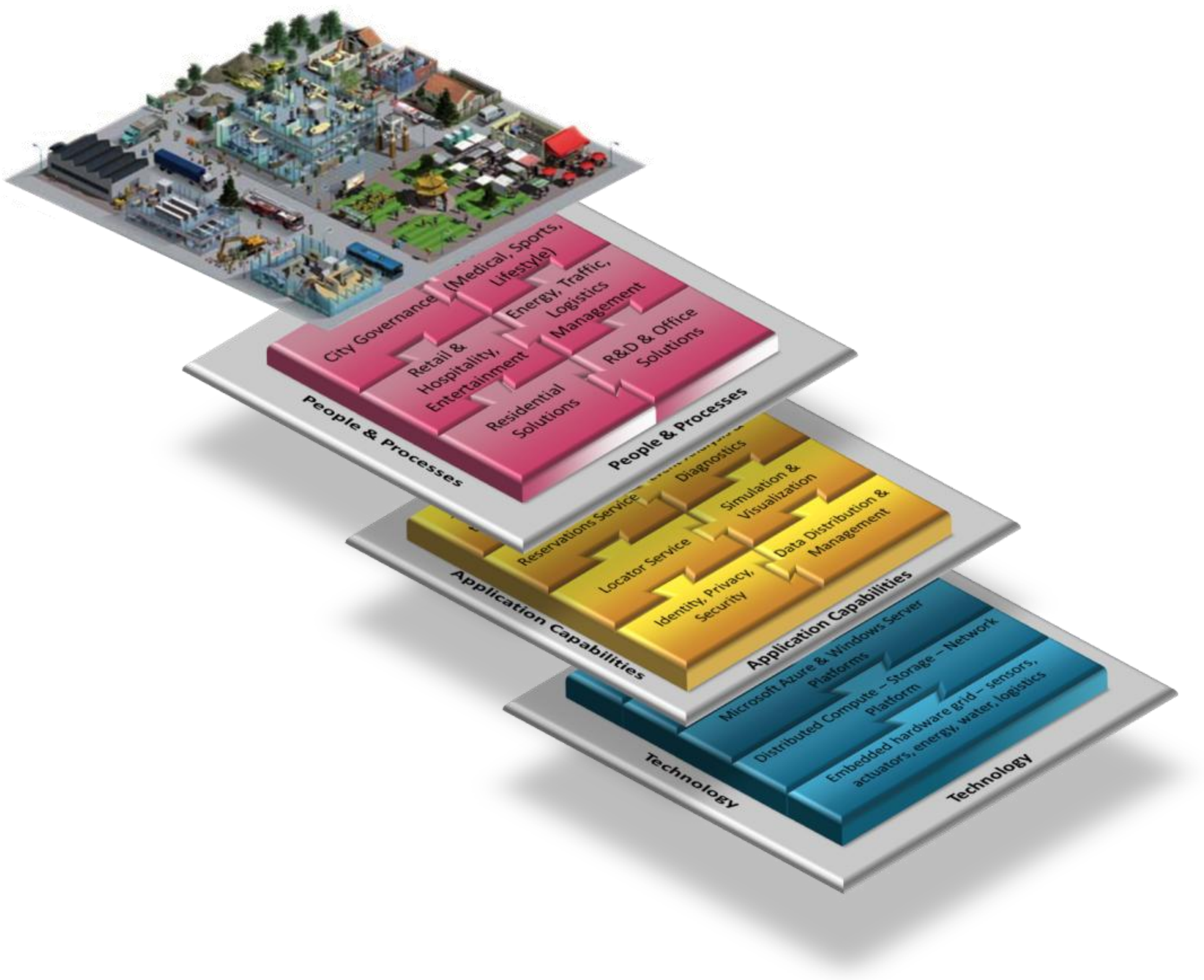
The following diagram has been developed by Microsoft Corporation to illustrate their Connected Government Framework four-layer model, designed to illustrate how current government business challenges map to technology solutions that can help address them. We include this as we find it a very helpful model to illustrate the architecture – in technical terms – of a future city.

Figure 1. The four-layer Connected Government Framework model



In the future city environment as conceived by Living PlanIT, this model is enabled by the Living PlanIT Urban Operating System (UOS™). The following image shows how the UOS™ enables this model:

Figure 2. Model as Implemented in a Future City

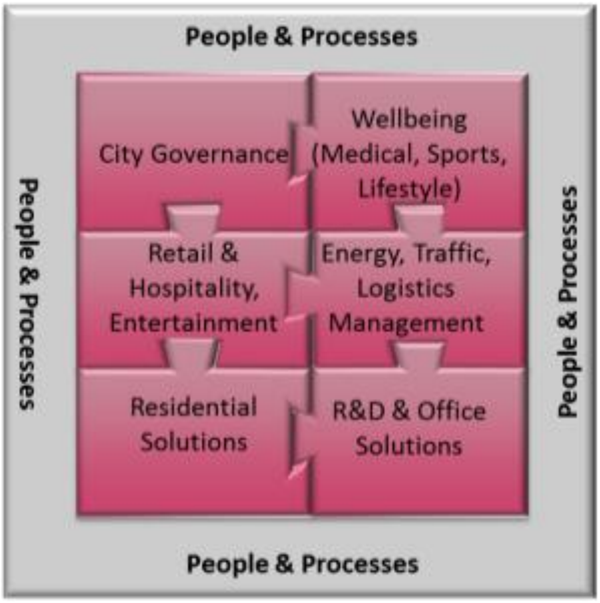


It is important to note that the processes and capabilities shown in the above diagram are examples only; i.e., this is a non-exhaustive list. The actual range being implemented is far greater, and beyond the scope of this document.

The prior section of this document has already described the need for future cities and the key challenges that their builders, operators, residents, and governments face – layer 1 in the model above. The following three sections correspond with layers 2-4, and will describe how the Living PlanIT approach to future cities and the Urban Operating System can be applied to address these challenges and successfully implement future cities..

People and Processes

Figure 3. Sample Future City Processes enabled by the UOS™



People

We may reasonably take as a premise that cities are a collection of buildings and associated infrastructure, and that buildings are 'machines for living'. The goal of the future city is to make those machines more effective, using cutting-edge approaches for incorporating technology.

We may also look at the city as an organism in its own right, with both mechanical and human elements interoperating within it.

Whichever view we take, the human element is critical for cities to succeed in becoming prosperous, socially beneficial, and environmentally sensitive places to work, share and live in. Despite manifold increases in the level and intelligence of automation being applied in well-architected future cities, ultimately every service and every activity comes back to the involvement of, and impact on, people. That has to be the lens through which city design and operation is optimized.

It is also worth noting that people who spend time in the city do so in the context of non-exclusive roles, which will influence how they interact with the city itself and each other:

- Resident
- Worker based in the city
- Visitor / tourist
- Government employee
- City operator / building operator employee
- Student
- Etc.

PlaceApps

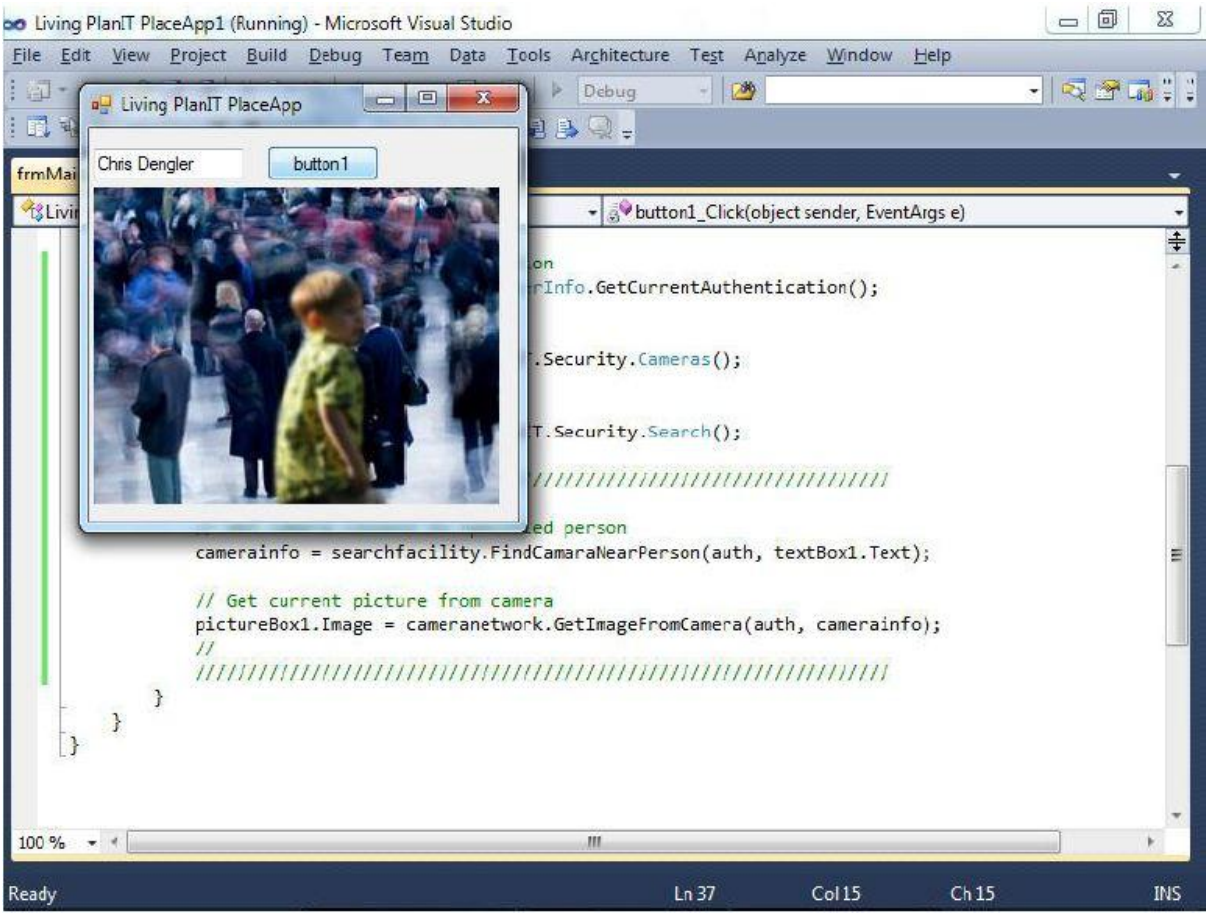
Given this context, how can we most effectively integrate people into this environment, so that they can interact with the city, its buildings and infrastructure, its technology, and its services in the most effective way, irrespective of but sensitive to the role they perform?

PEOPLE AND PROCESSES

The Living PlanIT and Microsoft answer to this question is PlaceApps. A PlaceApp:

- Performs one or multiple vertical functions for a given role or roles
- Is context- and location-aware
- Enables context and session state to flow from one interaction to the next (via the cloud) until complete
- Can be experienced through multiple devices, even within the same 'transaction'
- Takes advantage of the cloud and large amounts of information collected in the city through the UOS™
- Is built on the extensive application services portfolio exposed by the UOS™
- Takes advantage of device capability but is mostly based in the cloud (UOS™) in order to simplify deployment and management of applications on devices and ensure currency
- Can in most cases be quickly and easily downloaded and installed on a device (if not already present)
- Provides security and privacy guarantees based on user preferences.

Figure 4 – 'Find My Child' PlaceApp running in Microsoft Visual Studio Development Environment



This is clearly an extension of the smartphone 'app' concept to the future city. However, the experience of these apps is not limited to any particular device (or make of device) but can be enabled via many interfaces including voice-only interaction through Automated Speech Recognition (ASR) and Text to Speech (TTS), browsers, smartphones, desktops, laptops, netbooks, tablets, Smart Surfaces and Walls, kiosks, TVs, head units in vehicles, etc. While not all methods are necessarily meaningful or appropriate for every application, the experience can adapt for different languages spoken, or to accommodate those with particular accessibility needs using techniques such as audio cues and gesture-based sign-language recognition.

PlaceApps allow citizens and other city occupants to take advantage of the intelligence constantly gathered around them, and also to be able to take charge of their own lives and their own information. They empower residents and workers to interact with city infrastructure and capabilities in innovative and meaningful ways, encouraging their use and helping to make people feel comfortable and safe in a high-tech environment that safeguards their rights.

The Role of PlaceApps in Business Processes

Relatively simple business processes, or even relatively complex, long-running processes, can be enabled via a single PlaceApp, provided that the context is comparatively simple.

However, in more complicated scenarios, a PlaceApp – or potentially many such apps used by one or several people - will interact with a continually running process that manages one or more elements of the city. This is where the distributed Real-Time Control and PlaceApp enabling aspects of the UOS™ meet. Careful modeling and composition of processes will help to ensure that the various elements of a process interoperate successfully. Both large-scale and microscopic simulation is used extensively by Living PlanIT and its partners in the development of both real-time control models and PlaceApps in order to ensure successful implementation and deployment.

Examples of these more complex spanning processes follow in this paper (see in particular Appendix 1).

Processes

While a few examples of processes or classes of processes are listed in figure 3 above, there is not enough space in this paper to describe each of these exhaustively. A worked example of a complex process involving many PlaceApps, people, and mechanical interactions, including Energy, Transportation, and Logistics management is covered in some detail in Appendix 1. Brief descriptions of each of the sample processes/classes follow.

City Governance

This class of processes covers how governments at multiple levels manage and conduct their responsibilities in the future city. Processes extend from the management of contracts, by which services are outsourced or delegated to operators, through Citizen Relationship Management, through Reporting and Compliance procedures, through granular activities supported by PlaceApps that enable the efficient functioning of government-run entities which provide services in the city (for example, inspection or emergency services).

To illustrate with some examples:

Integrated Urban Reporting

The UOS™ provides extensive reporting facilities with as much transparency as is desirable while protecting privacy and complying with legal constraints. Given the pressure on cities and enterprises to provide timely, full and transparent reporting, this represents a significant opportunity to do it better, easier and faster.

Combined Reporting

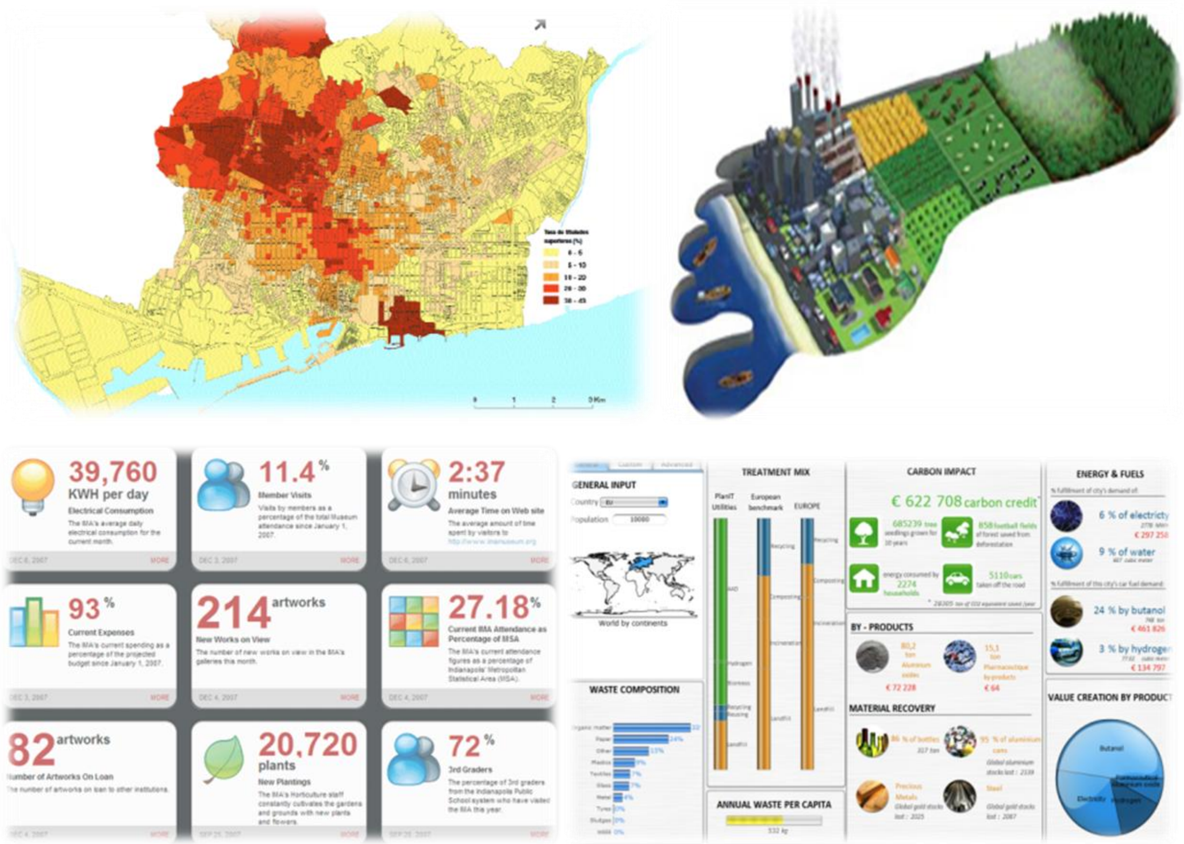
Governments today produce many reports, which often can be classified as social, environmental, or financial in nature (discrete enquiries into events often make up the balance). However these are mostly produced in silos, often by different departments and in different standards and styles.

Not only is this hugely wasteful, it makes reconciliation of the data extremely difficult. This in turn has a negative impact on transparency and causes more waste as interested parties attempt to align and correlate the data, flooding government agencies with enquiries in the process. It is clearly beneficial if reports are created from a common base, aligned, and accessible by interested parties. The UOS™ is well positioned to fulfill this need, if necessary in conjunction with more traditional records management services.

Urban Indicators

As a starting point to such an endeavor, Living PlanIT has identified 1200 'urban indicators' that traverse these three categories and which can, in many cases, be derived purely from UOS™ collected data. It is believed that these indicators would form a strong foundation for such a report. Living PlanIT is working with leading researchers and academics in this space and is prepared to develop partnerships with interested parties to drive de-facto standards in this area.

Figure 5 – Sample Urban Indicators



Emergency Services Support

(Note: a Living PlanIT – Microsoft demo showing solutions in this area is on permanent display at the Microsoft Executive Briefing Center in Brussels)

A number of PlaceApps will support specific aspects of emergency response, coordinating not only with each other but also with large-scale processes such as water management and traffic control.

An example might be a screen mounted in a fire truck for use by the captain. En route, the captain can verify from this screen that traffic lights are being adjusted and that traffic is being routed away from his route to expedite their arrival. In addition, he can determine – with automated recommendations – where his engine should pull up near the incident on arrival. He can inspect and remotely unlock fire hydrants, and observe that water pressure is automatically increased so as to meet requirements.

A map of the internal structure of the affected building is shown, together with the location of the fire and any victims needing rescue, with recommended routes to reach both. He can verify that certain doors and windows will be automatically unlocked so as to enable entry. A rescue plan can be established and communicated to his men while en route, freeing valuable time at the scene and thus helping to save lives.

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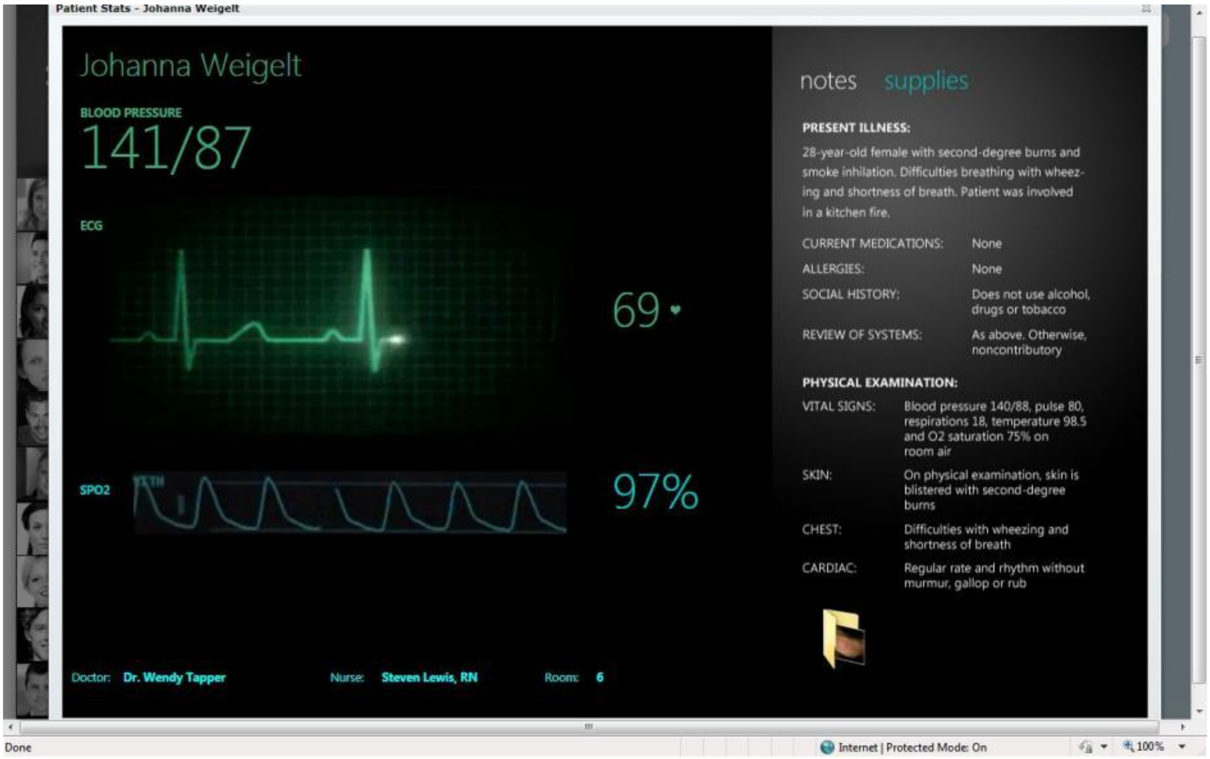
Figure 6 – Fire Truck Captain's Display with Heat Map of Incident Location

Well-Being (Medical, Sports, LifeStyle)

This class of processes enables the provision of medical care, sports facilities, and lifestyle choices for city residents, workers, and visitors. Coordination and resource management processes work hand in hand with a series of PlaceApps, handling micro-scale interfacing with the broader process.

This could take the form of a display for a triage nurse in an ER, allocating patients in priority order to treatment rooms with full information being made available in real time to all authorized medical personnel. It could also take the form of a display in a treatment room that displays patient vital signs and other salient information.

Figure 7 – 'Smart Wall' Medical Monitor App



Those who undergo medical care may have their vital signs monitored remotely – a Living PlanIT partner, BioDevices, has developed smart clothing solutions for this specific purpose. The replenishment and transport of critical resources can be quickly and seamlessly handled by the Living PlanIT Logistics system (see below) even if supplies or laboratories are on another site.

Sports facilities can be electronically monitored to extend the reach of coaches and supervisors, who can ensure that individuals putting themselves in harm's way or running the risk of damaging themselves through overexertion or incorrect use of equipment receive counsel. Individuals can also automatically capture information on their performance levels and fitness achievements for a permanent record that they can analyze themselves, or share – if they wish – with their friends, trainer or physician.

Retail & Hospitality, Entertainment

This class of processes pertains to the management and support of retail and hospitality operations in the future city, and the provision of electronic and physical forms of entertainment.

Examples include extensive support for retail, from customer tracking and analysis through to smart walls enabling selection of clothing or other commodities, adaptive advertising solutions (screens which switch context according to the collective demographic profile of those looking at them), e-personal shoppers, and the integration of online and on-premise shopping.

For entertainment, a large portfolio of current and historic content from cultures around the world can be made available on multiple devices without the need to convey physical media, thus ensuring that all cultures and nationalities are equally served irrespective of location.

Energy, Traffic, Logistics Management

These three core processes are essential to the effective operation of the future city. They are covered in more detail in Appendix 1.

Residential Solutions

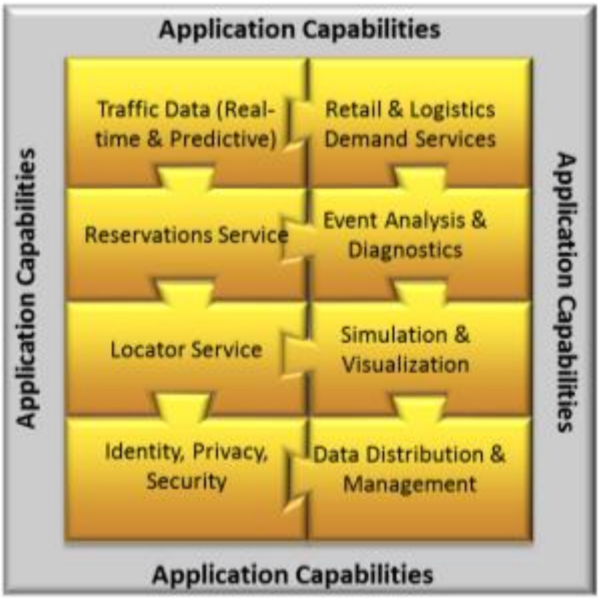
This class of processes aggregates a large number of solutions that support residences and their renters/owners/operators in a future city. These range from maintenance request and fulfillment management, to home security and entertainment solutions, managing the process of selling / renting homes, to providing automated 'move-in' processes that coordinate the handling of legal, financial, informational and logistical requirements to dramatically ease and simplify moving.

R&D and Office Solutions

This class of processes covers a wide range of solutions for corporate entities of all sizes that occupy space in R&D and other offices. Some processes are similar to those covered for residential above – but with a somewhat different context, typically – others might handle requests to customize or refit space, to provide incremental services such as additional network bandwidth, processing power or storage, to address the need for special protection for certain assets, or to make available specialized materials including materials requiring certain classes of handling or confinement.

Building Blocks: Application Capabilities

Figure 8. Sample Application Capabilities enabled by the UOS™



Application Capabilities

The UOS™ exposes many application capabilities to processes and PlaceApps with its services framework.

PlaceApps Services Framework

The UOS™ is populated over time with an increasingly rich set of data that describes all aspects of the city as an organism. This will include inputs, outputs, performance against objectives, and the behavior of both mechanized and human elements of the system. The question remains, what can we do with all this information?

The Concept of PlaceApps

As mentioned previously, PlaceApps are to a city what apps in an appstore are to a smartphone. PlaceApps may run on a number of devices – from voice interfaces through smartphones, to 'PCs', vehicles, smart walls and kiosks – with user interfaces that are semantically consistent, but adapted to the particular characteristics of the device.

PlaceApps are intended to be relatively thin layers of local code – they may run in a browser or similar container, or some sandbox on the device – with most of the work being performed in the cloud, leveraging an extensive set of data and application services exposed by the UOS™.

Partner Development

The vast majority of PlaceApps will be developed by Living PlanIT, Cisco, and Microsoft partners. Developing such a partner ecosystem means a richer, more effective environment for all, due to the sheer nature of scale of the applications that can and need to exist. These applications will require the domain expertise held by many partners, many of which are already experienced and effective in specific areas.

Many partners will simply need to adapt their existing applications to the UOS™ context, which usually means stripping out lower level code, as the services layer will provide most of the infrastructural requirements.

In some cases partners will build *services* as part of their own application that would be reusable by others, in other words would-be candidates for incorporation into the UOS™ services layer. A commercial process will shortly exist to manage this while ensuring that partners are compensated accordingly and their rights protected. This will also help in quickly building out the services layer.

Services

The vast majority of developers will access the UOS™ service tiers as interoperable web services, built to industry standards and profiles. For partner developers using Microsoft tooling, this will be facilitated by integration with Visual Studio via UOS™ templates. For developers in other environments, it is likely that Living PlanIT partners will produce supporting constructs. The services are tiered into four layers, from ‘top’ to ‘bottom’:

- **Vertical services**

Services that constitute a significant element of an application, bound to a specific domain or context (eg. transportation, medical, retail)

- **Business services**

Services that operate within a business (as opposed to technical) context – technical complexity is abstracted away into a business function (eg. find resource, play media, reserve capacity)

- **Meta services**

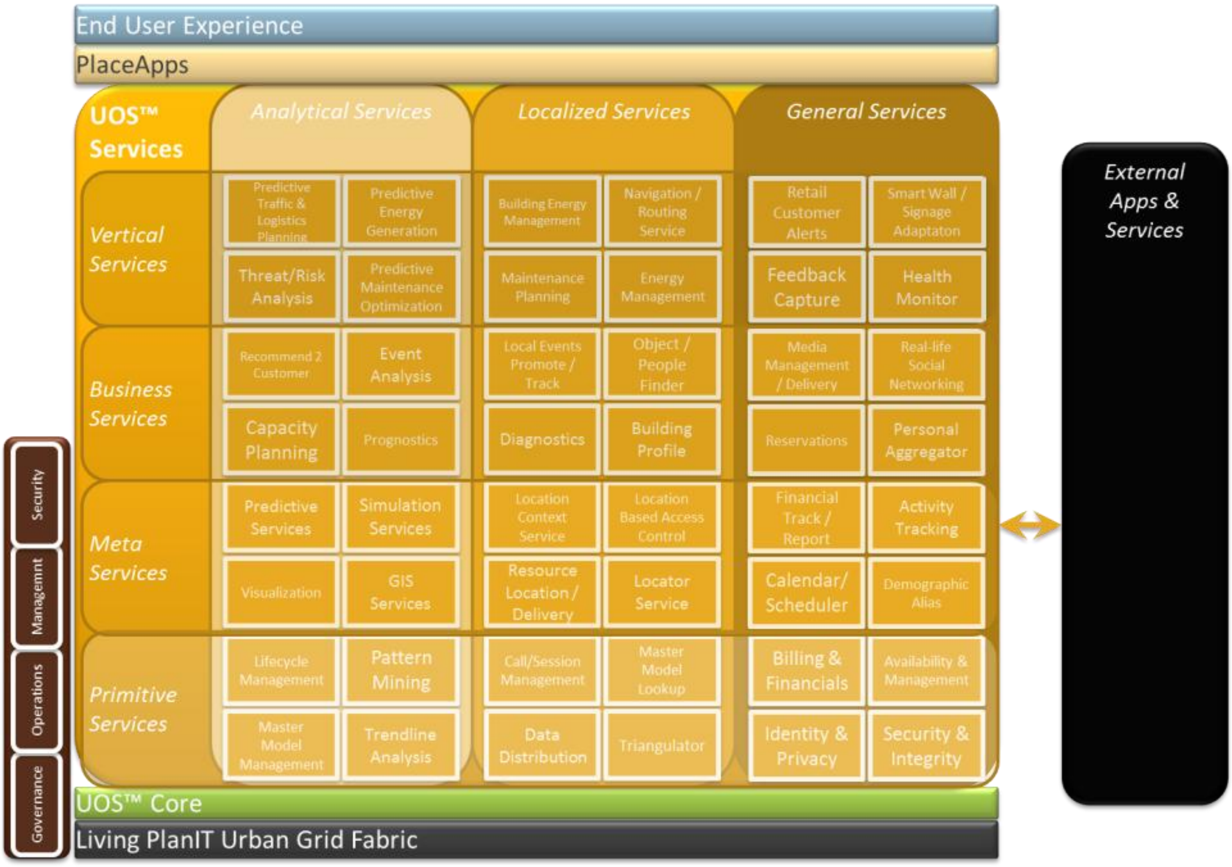
Services that provide useful aggregations of function but are unlikely to be exposed directly to a consuming process (eg. locator service, GIS enabling services, visualization services)

- **Primitive services**

Low-level technical services that enable the building of applications and higher-order services (eg. identity service, data distribution service, pattern analysis service)

A limited selection of services are shown in the picture below which illustrates this service tiering:

Figure 9. Non-exhaustive list of UOS™ Services



Sample UOS™ Services

Figure 4 shows a sample list of application capabilities implemented via UOS™ services, and available to PlaceApps and complex high level control processes. The following sections summarize each of these services – space does not permit an exhaustive treatment of each.

Traffic Data (real-time and predictive)

This service is to some extent described in Appendix 1, in the context of the transportation management process, which it nonexclusively serves. Vehicles in a Living PlanIT-enabled future city will be equipped with a Living PlanIT-developed 'black box' known as a UOS Automotive Appliance, which serves the dual purpose of providing access to vehicle sensor networks and hosting PlaceApps in an in-car environment, such that they can be used safely by a driver.

This enables vehicle position and speed to be sampled as frequently as necessary (the risk of someone misusing this data to track an individual inappropriately is mitigated by many levels of safeguard we will deal with elsewhere – many of them are mentioned in this paper). This allows vehicles to be mapped to the road system and a complete picture for all roads built up of traffic movement, without the need for static sensors and cameras (which can nonetheless be used to augment the information available).

This real-time traffic information is used to provide advisory services to travelers, to run the city traffic system, to provide data on road system performance and traffic congestion to city managers, and to help schedule bus and taxi movements so that timetables to meet customer demand. Access to vehicle sensors can also help in building a picture of local weather and road conditions, produce composite camera views of the city, and help increase coverage for locating a missing resource or person.

Retail and Logistics Demand Services

These two services bracketed together both measure demand and are closely associated. These services provide a continually updated forecast of retail and logistics demand by commodity and location. The service is fed by a combination of historic data about buying patterns and correlations by real-time data received from retailers, logistics operations, and by trendline analysis. This historic data is coupled with explicit knowledge of any current, forthcoming, or predicted events known to impact demand for commodities (a simple example might be raincoats or umbrellas when it is raining). Services are used to drive reordering and fulfillment to ensure that the UOS™-coordinated supply chain pipeline is appropriately maintained, and customers optimally served without undue wastage or inbound logistics movement of unwanted goods.

Reservations Service

This service aggregates together multiple services and datasets to provide a reservation service that can be used for multiple different types of resource across the city. Based on authorization, this can be used to reserve anything from a bicycle, to a table at a restaurant, a hotel room, a doctor's appointment, or a music lesson. Many processes and PlaceApps use this service in many different contexts, as do higher level processes through service composition.

Event Analysis & Diagnostics

In the general sense this set of services might be known as 'analytics'. It takes on more specific characteristics because of the data sets available to inspect – diagnostics being the observation of patterns in a particular set of data that describes performance of a system in some way (whether the target is a machine or a human being). These services provide access to several means of accessing and deriving insight from the UOS™.

The UOS™ supports multiple ways of accessing the large amounts of near-real time and historic information for the development of insight and optimization of operations. Techniques used in the UOS™ include but are not limited to:

- *Complex Event Processing* - detecting patterns in series of events being processed through the UOS™ bus, in order to infer situation and context which requires a response
- *User-Driven Queries* - self- service reporting, empowering citizens, partners, service providers, governments and their employees, building and city operators and entrepreneurs to find information relevant to them, within the context of authority and privacy protection. Generally unless there is a reason (such as privacy or security risk) to restrict read-only access to information it will not be significantly restricted. Levels of access can be dynamically changed in the event of an emergent security concern.
- *Published Reports* - reports designed for a particular audience / requirement that are run and disseminated regularly, or on the occurrence of an event or set of events
- *Data Mining* – mechanized analysis of historic data to find patterns and correlations not necessarily visible via human inspection of information.
- *Predictive Analytics* – use of historic data to forecast future events or behavior. This is a key factor in several use cases for the UOS™ including energy and traffic management.

Locator Service

Much as with the reservations service, multiple lower level services and sources of data are aggregated here into a single interface to locate many different resources within the city, leveraging information available in real-time and near-real-time to the UOS™.

The object located could be a vehicle (either private, or an allocated pool vehicle), a retail outlet or set of outlets, a book in a library, a missing wallet, or a person, based on authorization level for the resource concerned. For example, a law enforcement officer with an arrest warrant would have access to all means to track down a suspect. A person would be able to track his/her wallet if believed missing, but not one belonging to someone else (unless they are his/her under-age of majority child). This service is used by many different processes and PlaceApps in the future city and is called by higher level processes as part of service composition.

Simulation & Visualization

This class of services supports multiple processes in the future city throughout its lifecycle.

Simulation

The Living PlanIT Urban Lifecycle Methodology makes heavy use of simulation throughout the process of designing, manufacturing, constructing, operating, maintaining, and decommissioning buildings and urban infrastructure. Simulation drives the configuration of the sensor-actuator networks, and is also key to the continued development of the UOS™ itself, in particular vertical services that enable classes of applications and the generation of PlaceApps.

Simulation in the Design Process

Developments using the Living PlanIT approach are developed according to a highly design-centric philosophy. The entire development is fully modeled and detailed in 3-D, making use of a UOS™ service known as the Urban Development Wizard, which makes modular construction elements available in the design surface, along with metadata such as their cost, leadtime, and real-world performance. Simulation is used to ensure that the building design meets requirements ranging from structural and energy performance to how people move around the structures, the predicted performance of sensors and actuators, and what normalization needs to be applied to data transmitted.

Simulation in Manufacturing

Building and infrastructure models are decomposed into their component parts as defined in the supply chain, and a complete build sequence for assembly is generated. This is used to create the plan for manufacture, delivery, and on-site installation of all components - which is used to coordinate the entire supply chain and logistics operations. Simulation extends to on-site plant and heavy component movements, ensuring that these operations can be achieved safely.

Simulation in Maintenance

Since all building and infrastructure models are maintained accurately during the assembly process and beyond, they are used throughout the lifetime of the building. Maintenance operations can therefore be planned using simulation to provide optimum access paths, minimize damage, and ensure that no maintenance subjects the building to stresses beyond that it was designed to accommodate. The same techniques can be used to ensure safe handling and installation of heavy equipment.

Simulation for Sensor Configuration & Real Time Control

The UOS™ Sensor Network is driven by model of buildings and their surrounding infrastructure. Simulation helps develop suitable real-time control algorithms, as well as how to position, interpret, and read information from the deployed sensors. This information is compiled into code that runs in the Urban Network Controller and the UOS™.

Open Simulation for PlaceApp development and RTC improvements

Simulation models of sample Living PlanIT developments – starting with our pilot development PlanIT Valley, near Paredes in Portugal – will be made available on the web. These models provide a 'virtual city' environment in order to support the development and optimization of PlaceApps, which will run as they would in the real city. The same models can be used by developers to develop and offer improved real-time control algorithms, which can be monetized if they represent an improvement over existing solutions. The models are provided as 3-D walkthrough models in order that they can be experienced by test users and designers during their development.

Hardware-in-loop Testing

The next logical stage for many of these simulations is hardware-in-loop testing, where a purely virtual simulation is replaced in part with real hardware subjected to model loads. This enables verification of processing chains before solutions are deployed in a real building, and ensures that technical infrastructure is appropriately scaled and configured for the demand that will be placed on it, even in exceptional circumstances.

Visualization

This is often closely coupled to simulation, with the results of simulation often being at least in part represented by visualizing results for human interpretation and checking. However this technique can also be used directly on other UOS™ derived data sets. Two common techniques are:

- Dashboards – near-real time display of information derived from inbound data to the UOS™. In most cases these will be task-specific, will support drill-down into underlying detail, and will be supported by controls which allow the human operator to interact with or direct the behavior of the system within defined constraints.
- Complex Data Visualization – graphical representation of data in such a way that the ability of the human brain to see non-obvious patterns is enhanced, or to optimize speed of response to inbound information in mission critical scenarios.

Less common approaches may include augmented reality applications that allow operators and citizens to add one or more layers of data to their field of vision as they move through the future city using special glasses or other portable devices.

Identity, Privacy, Security

This class of services is fundamental to the success of the future city, and represents a topic of such complexity that it is beyond the scope of this paper to cover in detail. As an illustration, let us explore the design of identity services for the future city – which is required to maintain privacy while maintaining security.

The integration of the identity of the citizen across multiple agencies and the ability to provide a joined-up response to life events needs to be achieved without compromising privacy. It must also not compromise our goal of allowing the citizen to manage their own identity and what information is released about them to who or when, while anonymous, aggregate data is made more widely available.

Identity management is therefore a key enabler for future cities. A unified identity system – albeit one that can integrate with multiple identity providers and different forms of authentication – is needed to handle the extensively 'wired' nature of the city and the density of data transactions and applications provided. The UOS™ identity metasystem follows principles and technologies recommended by Cisco and Microsoft, with a strong focus on 'partial' identities.

Specifically, every citizen will have a number of 'identities', each of which is composed of a number of attributes which are either exposed, or used to validate a claim without exposing the information. The use of multiple identities limits exposure of truly important credentials, minimizing risk of abuse and identity theft, while allowing for the exposure of less critical information that is helpful for participants in the city ecosystem such as retailers, building operators, service providers, and governments.

Not only will citizens be in charge of their identities, the information that constitutes them, and when this information is exposed, but they will also have the rights to inspect and – where legal – purge records of even relatively insensitive information that has been captured about them. This is intended to build a trusting relationship between the city, the government, and citizens, allowing for the acquisition and flow of information that is helpful to all participants without compromising their identity.

For example, a 'demographic' identity may merely provide someone's age range, gender, and certain lifestyle information, and will uniquely identify that individual over multiple transactions –but cannot be linked back to the true identity of the individual concerned. In the case of skewed or small populations, data masking approaches can be taken in order to avoid abuse by back-solving into a true identity.

Data Distribution & Management

As has previously been mentioned, the UOS™ implements a sensor network and real-time control at multiple levels, as well as enabling simulation for multiple purposes through the urban development lifecycle. The core functions of the UOS™ mostly revolve around data marshaling and management in order to support higher-level real-time control, PlaceApps, and analytics. As well as providing key infrastructure capabilities for the UOS™, these mechanisms are also made available to other processes and services as services in their own right.

Event Bus / ESB

The UOS™ event bus is a tiered, distributed implementation of an Enterprise Service Bus. The most important capability here is to be able to marshal events at scale from producers to consumers in near-real time. This is mostly achieved using publish-subscribe (pub-sub) techniques, although these are modified somewhat in order to cope with the needs of urban scale, and the concatenation of multiple network streams carried out for network and processing efficiency.

One key principle in fulfilling these contracts is to ensure that the management of this information is optimized across the network. In the general case this means processing subscriptions at the most local level possible, although in some cases (for efficiency) a multicast/broadcast type approach might call for processing at a higher level of aggregation.

The second major function is to allow the invocation of services independently of location of data, processing, or endpoint. This is accomplished using standard ESB / Cloud / Virtualization techniques.

The event bus also serves as a platform for higher-level coordination of events and services. This includes such capabilities as orchestration / workflow and the use of business rules.

Data Lifecycling & Storage

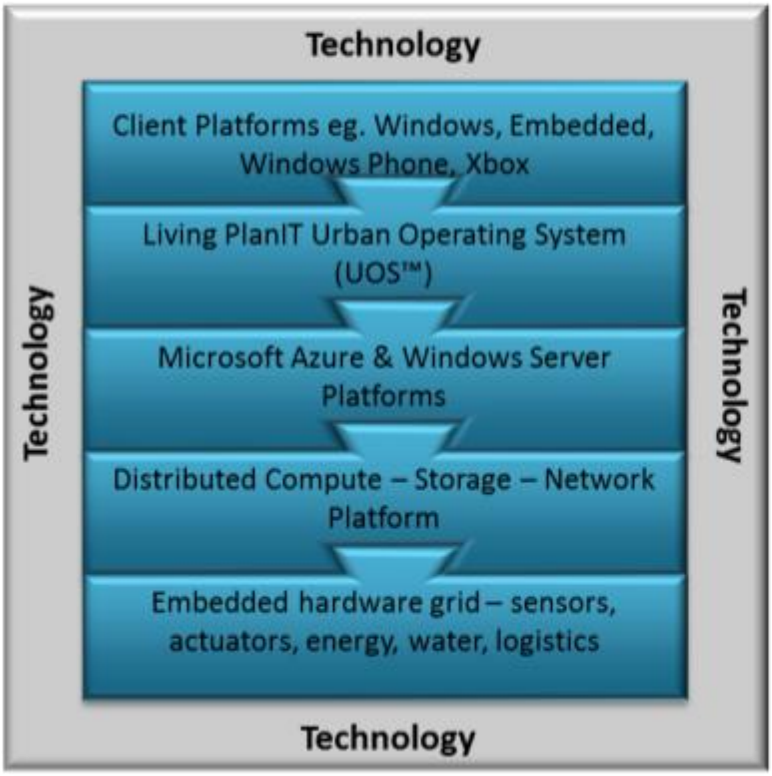
The UOS™ represents a very large multidimensional data store of mostly time series information. There is a clear need to manage this data over its lifecycle – keeping full resolution data indefinitely represents a risk to an individual's privacy as well as an expensive burden with marginal gain. Full resolution data will be kept for some period of time – depending on a set of rules which can be changed – mostly for forensic and legal purposes. From that point onwards data will be systematically aggregated and in most cases made anonymous.

Some data has clear local affinity – for example state data that is pertinent to a building. Leveraging the distributed nature of the compute platform, one copy of that data will reside locally in a building's compute node. This not only allows for performant data fetches, it also enables redundant operation in the event of major systems failure elsewhere in the network. The existence of multiple copies of data distributed around the campus allows redundancy and resilience to be achieved throughout performance, with a minimum of waste.

Marshaling of data to storage locations on the network is largely via a process of automated self-optimization based upon demands placed on it. Internal metrics will allow storage algorithms to be optimized over time, however in some cases applications may choose to explicitly request the provision of a subset of data at a given storage location (in effect an intelligent pre-fetch of a cached copy of the data).

Building Blocks: Technology Infrastructure

Figure 10. Technology Infrastructure for Future cities



Technology Infrastructure

The generic optimization of technology infrastructure is more than adequately covered in multiple Cisco & Microsoft documents and processes.

This section will focus on the specific technology infrastructure required to enable a UOS™-managed future city, and what elements and designs Living PlanIT, Microsoft, and their partners can bring to facilitate and simplify implementation.

The above graphic shows five major categories of technology available to and leveraged by the future city. The remaining sections will describe each of these in turn.

Embedded Hardware Grid

Key to the Living PlanIT approach to future cities is the embedding of technology into structures, with this mostly being achieved through design and assembly into modular building components prior to their delivery to site for installation. This has multiple advantages over a 'build and then retrofit' model:

- Overall cost to implement technology is lower (no rework, less 'craft')
- Implementation quality and reliability is greater (less room for error, less damage done during 'fit')
- Sensors, actuators, compute, network, energy and resource systems can be optimally located in the building design without being able to readily access their location from the finished construction
- Technology is standardized and commoditized as opposed to every tenant / owner selecting their own, incompatible, non-shared solutions
- Implemented services can be innovated in ways that are simply not feasible in retrofit models (eg. deep sensing with high sensor densities, underground logistics system, or rooftop water collection with energy recovery)

- Economic models for funding construction and technology fit can be changed:
    - Technology is funded with the building, not separately;
    - Richer building functionality drives up building value which helps funding;
    - Developer achieves faster Return On Investment (ROI) because of the ability to monetize services provided by the technology platform (as opposed to having no stake in that business)

The hardware platform is designed to work using Cisco technologies and is deployed primarily in the form of two classes of appliance:

- Urban Network Appliance (UNA) – this appliance constitutes a Cisco Integrated Services Router (ISR) equipped with Living PlanIT Real Time Control software – derived from ECU software developed by McLaren Electronics in Formula 1 racing. This software turns the router into a unified, integrated and manageable control systems platform capable of receiving large amounts of sensor data and implementing real time control at the edge of the network.
- Urban Cloud Appliance (UCA) – this appliance deploys the Living PlanIT Urban Operating System (UOS™) on a highly optimized Cisco Unified Computing System (UCS) platform, which can be preintegrated into a modular building component much as with a modular data center.

Space does not permit a full treatment of every element embedded, however most elements are discussed at least in brief somewhere in this paper. It is deemed relevant to take a deeper look into sensor deployment, as this drives so much of the value proposition.

Deep Sensing

A future city is dependent on the provision of a sufficient density of real-time and near-real time information in order to operate the city appropriately, depending on prevailing conditions and occupant needs. This continual optimization of resources allows us to meet economic, social, and environmental goals. The Living PlanIT approach is to achieve this via the embedding of sensors and actuators into the fabric of buildings, in most cases this being achieved via integration into modular building components.

Sensor Densities, Types, and Uses

In Living PlanIT developments sensor densities average 1 sensor per square foot, depending on what type of usage the space is designed for. Many sensors send data only infrequently or on an event – this is particularly true of structural sensors at steady state – but others may sample on a relatively frequent basis, such as medical sensors, pressure sensors in retail environments, and cameras. Living PlanIT partners produce over 100 different sensor heads, with the most commonly used sensors targeting environmental conditions, structural state, resource flow (people, materials, traffic, water, energy) and security / identity.

Deploying Sensors

Many current sensors used today are current-sensing devices that need to be connected to an A-D input and a DC power supply. Living PlanIT favors sensors that talk to a network directly, and therefore contain their own A-D, scaling/filtering, and network stack. Wireless sensors with the ability to receive remotely or ‘scavenge’ power are even more valuable, and the overall trend is to integrate sensor heads directly onto a silicon substrate with other components. An alternative approach to sensing is based on gratings etched into the surface of a glass fiber which interact with the environment and influence the reflectivity of tuned laser light, providing the means to distribute sensors without distributing any electronics. In general, battery-powered devices are not favored due to high maintenance requirements.

Managing and Collecting Data

Living PlanIT UOS™ Sensor Network solutions allow sensor data collection and real-time control reacting to incoming sensor data to be placed at the edge of the network, minimizing latency and filtering information and events that only need to be consumed locally. At the same time, events that need to be propagated can be easily passed through the tiers of the UOS™ for processing in macro-scale real-time control or retention as part of history data.

Living PlanIT UOS™ data formats and distributed compression mechanisms allow a large and highly variant sensor network load to be quickly and efficiently passed through the network between processing nodes and cloud computing environments.

Distributed Compute – Storage – Network Platform

Another element of the embedded hardware grid is the distributed compute, storage, and network platform. The concept here is that "The City is the Data Center". Each building obviously needs at least a distribution network, but Living PlanIT goes beyond that to distribute computational capacity and storage to each building also.

In many cases, the building compute cluster is installed as a single modular component pre-filled with technology and support equipment (power supplies, thermal management) much like containerized data center designs which are currently popular. Ultimately it is intended that these clusters will be certified and sold as Azure appliances, with each building cluster constituting a private cloud within a private cloud.

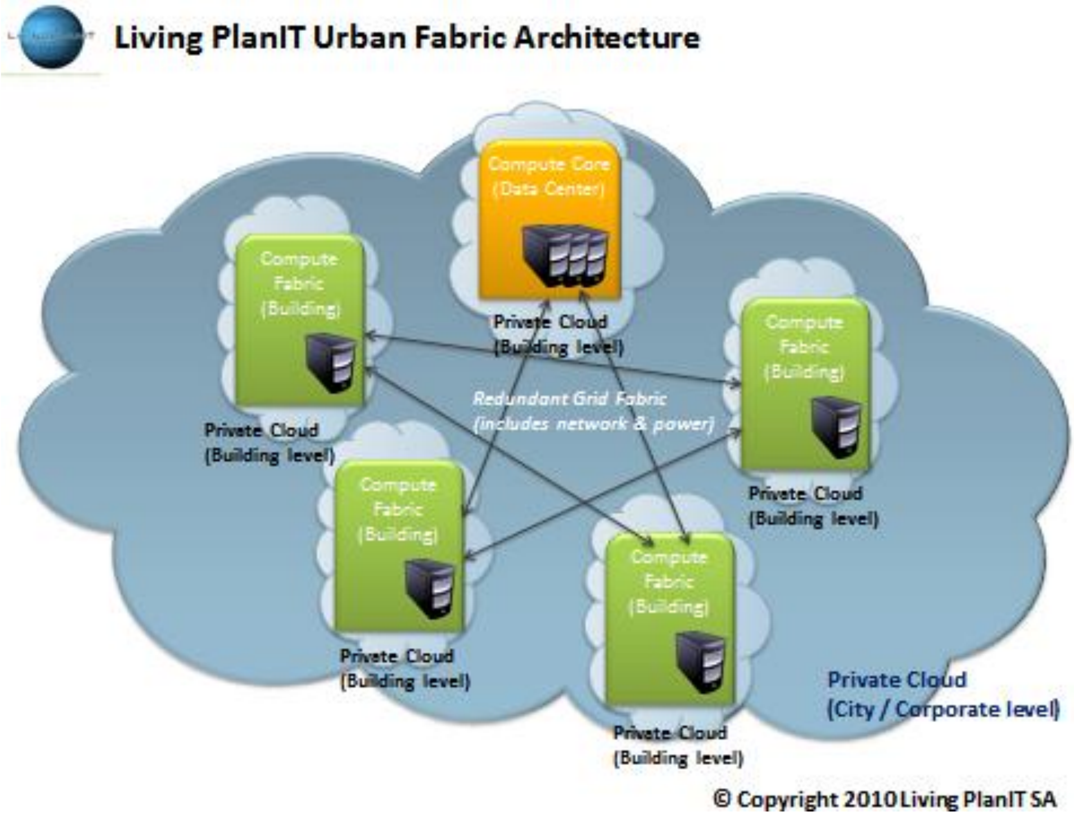
This approach has many benefits in terms of redundancy. In most cases in the event of a major system or network failure outside a particular building, the building systems can run autonomously until reconnected. As a corollary, additional capacity in each building – provided not only for redundancy but also to support 'roving' high-workload tasks that can be distributed wherever capacity exists (such as simulation and analytics) – can be used to support other buildings if their compute clusters fail.

Additionally, latency can be reduced by keeping at least one copy of local data in local storage, leveraging affinity between the tasks that go on in a building, and the data that supports them.

The redundancy of processing and storage that usually requires multiple data centers is achieved here through distributing capacity, while needing no more – and probably less – equipment. A metaphor here is the difference between RAID 1 and RAID 5 (or 6) disk arrays.

Distribution of core and storage networks allows many cities and most large urban developments to have their urban compute platform managed as a single entity.

Figure 11. Clouds-within-Clouds – Distributed Platform



Living PlanIT Urban Operating System (UOS™)

The Living PlanIT Urban Operating System (UOS™) is a unified, distributed, real-time control platform that converges cloud computing, deep sensing, simulation, analytics and application services with the fabric of buildings and infrastructure.

Living PlanIT's UOS™ middleware is embedded in the fabric of buildings and infrastructure and abstracts underlying city hardware, such as energy, water, waste, transportation and logistics systems, to provide an integrated urban control platform. This platform surfaces data and application services to "PlaceApps".

The UOS™ enables future cities to be created, optimized and monitored. The sustainability of urban environments is achieved through applying intelligence to buildings and urban spaces and closely optimizing their performance through a comprehensive set of networks, sensors, urban infrastructure, and computing technologies both on premise and in the cloud.

How the UOS™ Works

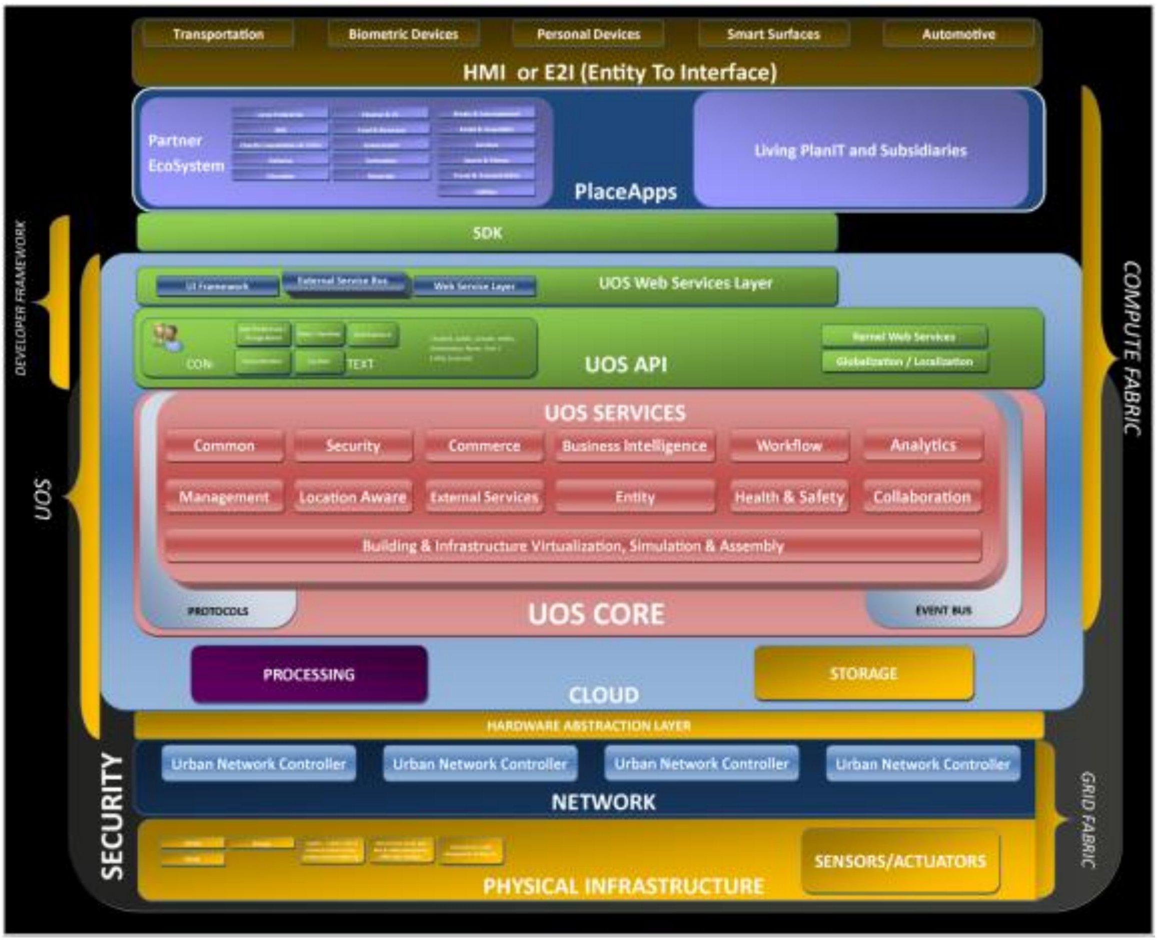
The UOS™ is fed information from an integrated sensor network, which is embedded into every part and function of the urban environment. Data is combined and aggregated, analysed and inspected to derive knowledge and insight into the functionality and dynamics of urban environments. This combination of **distributed sensing and processing** with **central command and control** allows for efficient city management and optimized operations.

The UOS™ allows Living PlanIT to collect data about everything going on in an urban environment and retain this information as long as it is useful. Not only does this help the city to react in real time to various situations, but it also enables the continuous optimization of all city functions, giving the UOS™ the ability to predict the outcomes of certain events. Examples include traffic control, climate and energy management, and home automation.

The consistent architecture of information in the UOS™ allows new applications and features to be added inexpensively and conveniently through PlaceApps. Extending the management of cities and service offerings to residents and visitors, these new applications leverage the information provided from sensors, mobile devices, and people interacting with systems in the city. This unlocks the creativity of developers in our Partner Ecosystem, and provides for new revenue streams and business models to be generated on an ongoing basis.

UOS™ Architecture

Figure 12: Overview of Living PlanIT Urban Architecture



Many of the detailed functions of the UOS™ have already been described in this paper. It seems appropriate, however, to delve further into how the UOS™ supports real time control as a key enabler for future cities and a critical function for the UOS™ that has not been covered elsewhere.

Distributed, unified, Real Time Control

The UOS™ enables real time control for all building and infrastructure functions to be achieved using a common layer of sensing, actuation, network, and computation. The network and computation is shared further with other network and computational loads, maximizing the overall efficiency of the system and avoiding waste.

Local Real Time Control

Living PlanIT UOS™ Sensor Networks distribute the first level of real-time control to the edge of the network by running it in a modified router known as an Urban Network Controller (UNC). The UNC is able to carry out real-time control with very low latency and isolate this load as needed from the rest of the system. The programming of control algorithms is derived from the physical building or system model in the first instance, although it may vary from this over time as analysis of historic data allows more efficient algorithms to be developed. The UNC also concatenates many sensor streams into a single stream for efficient transport to the UOS™.

Distributed Real Time Control

The UOS™ - along with the compute platform upon which it depends – is also highly distributed and location-aware. Processing of data is tiered from building tier up to urban tiers and beyond, with the number of tiers being variant to suit different levels of scale in development. The compute platform and the UOS™ is managed as a single entity – in fact it is probably accurate to say that "The City Is The Data Center".

Macro-level Real Time Control

Not all real-time control is isolated to the local level, although in general this is where the most immediate response to input is provided. Local responses however may be parameterized and therefore dependent on input from a broader domain. These higher level coordination functions are implemented in the UOS, on top of its event bus (Enterprise Service Bus).

As a simple example – an airflap (actuator) is controlled by a UNC, in this instance providing warmer air to a room based on user requirements and thermal load. The system does not use a crude thermostat approach with its commensurate overshoot/hysteresis characteristics, but achieves the desired temperature following a critically damped curve. However, calculating this curve depends on the temperature of the warm air in the duct as this will impact rise rates.

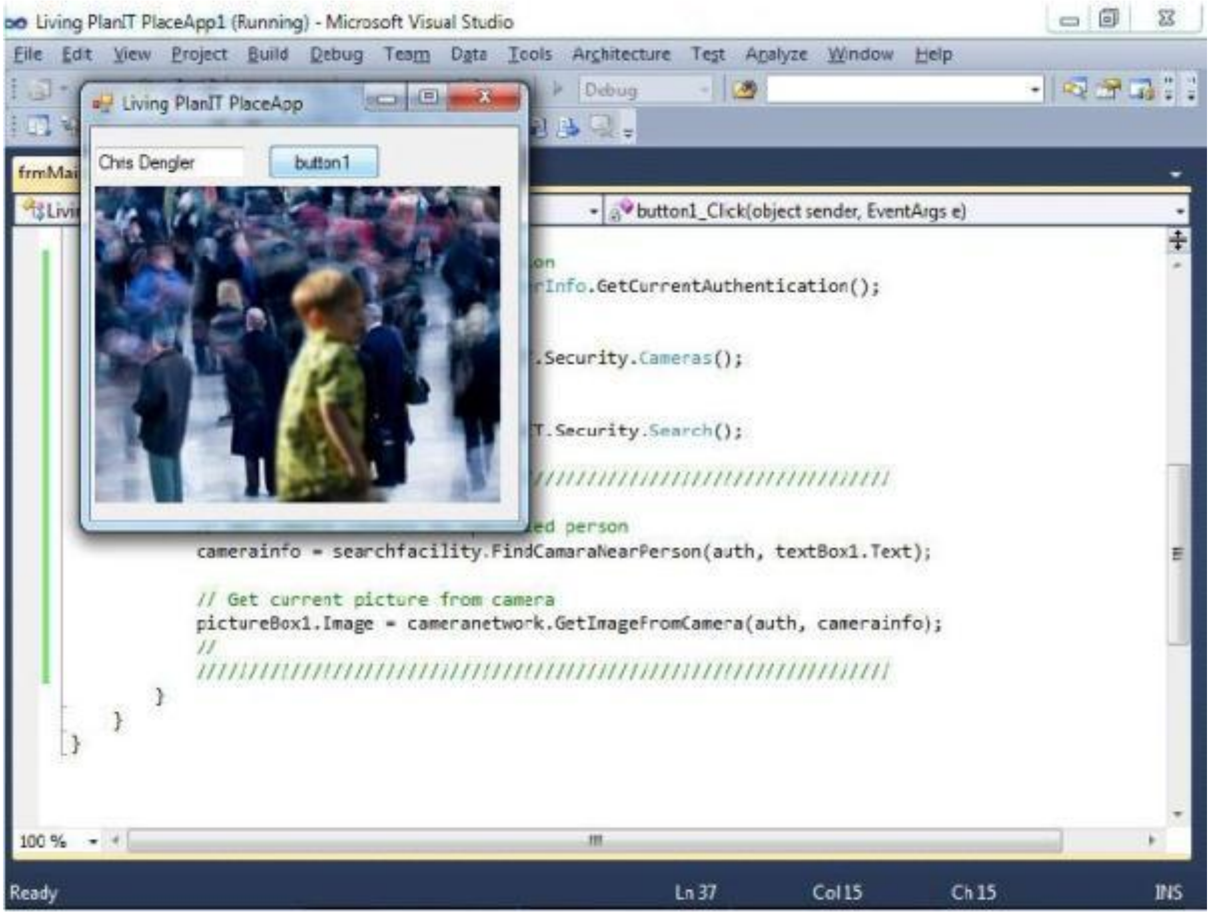
Another system controls the temperature of the air in the duct based upon building- and/or regional-level requirements, but that temperature is constantly conveyed to the UNC so that it can use the correct value in its calculations. The UOS™ event bus coordinates the update of one UNC by another.

Intelligent Real Time Control

The integrated, unified nature of the real time control system makes sophisticated behavior by the building systems easy to integrate. As a simple example within the realm of home automation or domotics, taps can be network controlled primarily to avoid the accidental release of water (overflowing sinks/baths). However, once the taps are controlled by the network, it becomes a simple matter to automate filling a bath. And this behavior does not have to be programmed, just observed. Once a pattern is established and associated with an individual user profile, this can be offered as a standard preset that becomes effective whenever needed.

The same capabilities are what present so much power to PlaceApps. PlaceApps not only have a very large and well organized data set to draw upon (via UOS™ Services APIs) but can also interact with the real time control system of the building / region / city with appropriate authorization. For example, in the general case a citizen probably should not be able to direct observation cameras in a public place (they would be able to browse a joined-up view of the last images taken as the camera executes a scan pattern, using Microsoft GeoSynth technology). A law enforcement officer *would* be able to direct cameras in real time. In specific circumstances, however – such as looking for a child – an application might enable a citizen indirectly to take control of those cameras, in order that the child's current location and activity can be shown.

Figure 13 – Find My Child Application (running in Visual Studio)

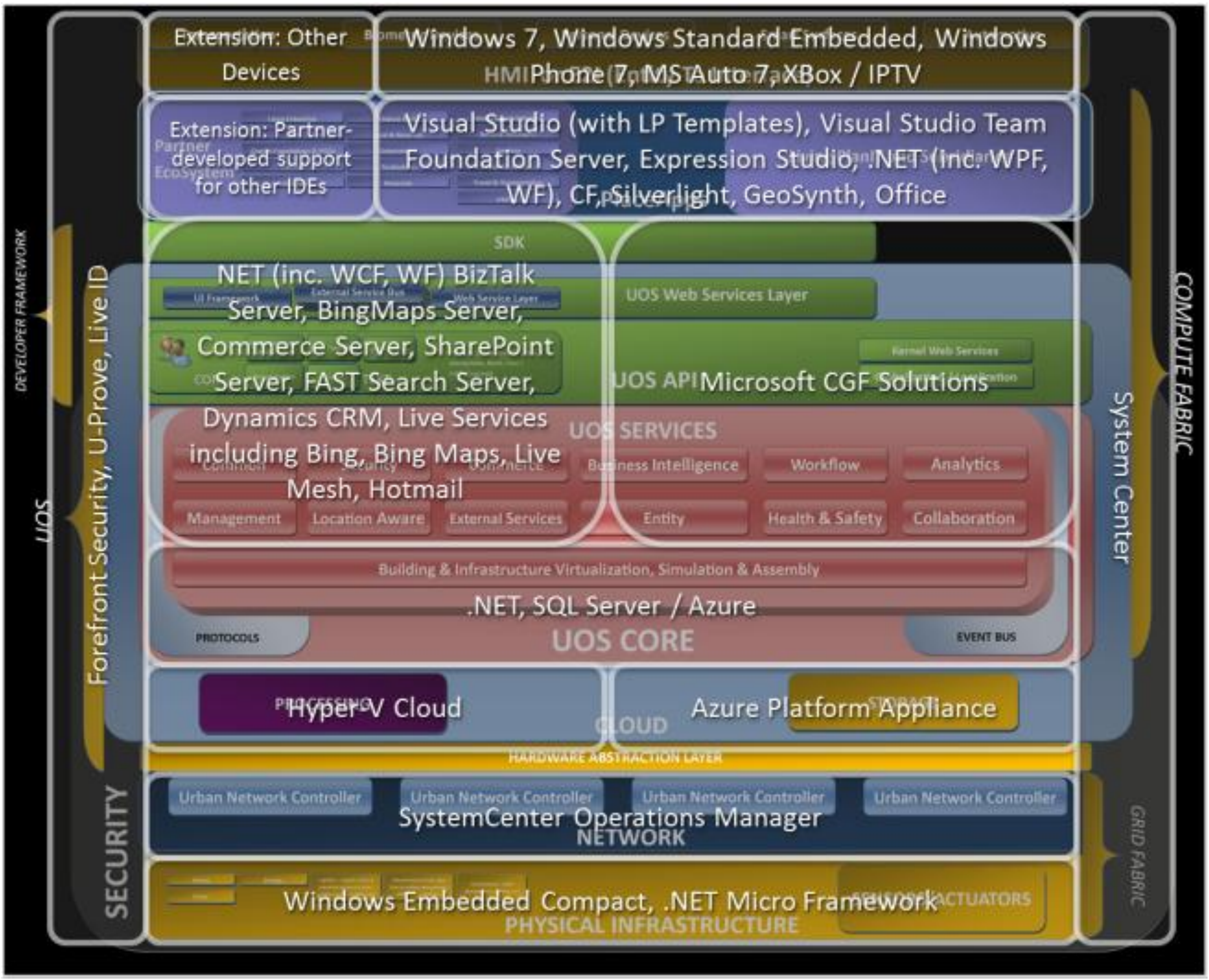


Microsoft Azure & Windows Server Platforms

The UOS™ leverages multiple Microsoft platforms in its design and architecture. As a private cloud implementation, the strategic direction for the UOS™ is to run where possible on Microsoft Azure. The nature of the UOS™ however abstracts users and developers from the products it is built on – therefore the migration from Hyper-V cloud to Azure can be achieved without visibility or disruption.

The following graphic details Microsoft products used in the Living PlanIT architecture:

Figure 14: Microsoft Products Overlaid on Urban Architecture



Client Platforms

A number of client platforms need to be supported in the future city if PlaceApps are to be universally available to citizens, city workers, and visitors. This includes popular non-Microsoft platforms – such as Apple iPhones and iPads and Android and Blackberry devices - as well as the core platforms available from Microsoft:

- Windows 7
- Windows Phone 7
- Windows Embedded Standard and Compact 7
- Microsoft Auto 7
- Microsoft Surface
- Xbox

In addition, for functions such as user-driven queries and task-focused workflow processes, Office will be used as a host for connected self-service applications, leveraging solutions such as SQL Server Power Pivot for Excel 2010.

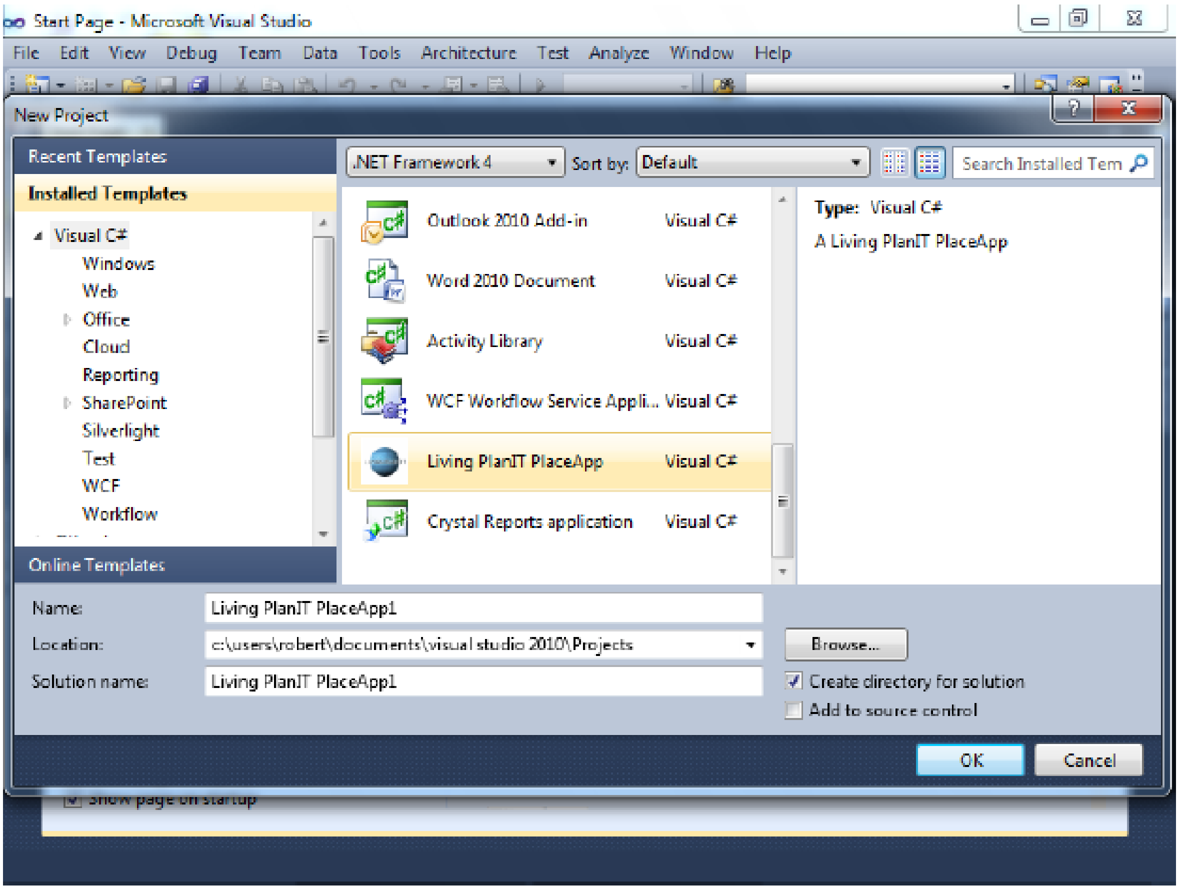
Certain clients need to be embedded in city infrastructure. These include:

- Smart Walls
- Kiosks
- In-vehicle solutions
- In-wall control panels (replacing light switches and their like)

Living PlanIT solutions in these areas are built on Windows Embedded platforms listed above.

The following picture shows how using Microsoft Visual Studio and a Living PlanIT-supplied template, a PlaceApp can be easily started, and then completed using a small number of lines of code calling rich UOS™ application services.

Figure 15 – Using a PlaceApp template from within Visual Studio



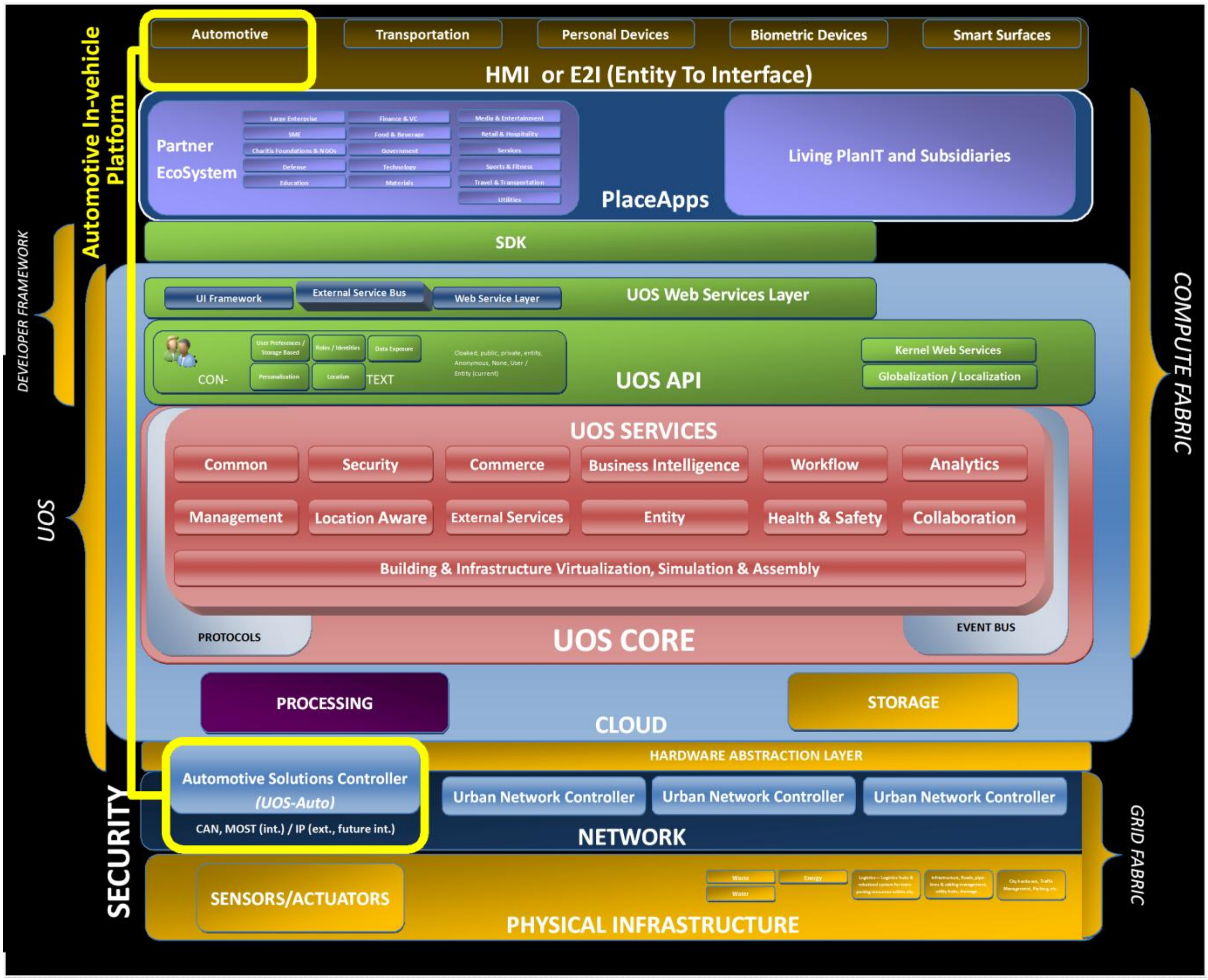
Appendix 1
Living PlanIT & Partner Solutions Extending the UOS™

Living PlanIT's Automotive & Mobility Platform – UOS Automotive Appliance

Given the importance of smart transportation to the future city environment, it should perhaps come as no surprise that Living PlanIT's first solution offering outside the building and infrastructure environment is a platform designed to extend the UOS™ into the vehicular environment. The UOS Automotive Appliance is a leading-edge hardware and software solution that provides a bridge for vehicle sensor and actuator buses to be reliably linked to the UOS™ in the cloud, while simultaneously providing a first-class host solution for in-vehicle PlaceApps along with more conventional vehicle infotainment functionality. The same solution also lends itself to being used for static Mobility solutions, such as Smart Walls and Kiosks located in the city environment.

Extending the Architecture

The current state-of-the-art in vehicle engineering uses many different electronic control units (ECUs) and mechatronic systems, tied together by one or more network buses, which differ somewhat from those to be found in generalized computing environments. While it is expected that this situation will change, the mission-critical nature of many of the supported functions and corresponding legislation is slowing the rate of such change, making it necessary to provide adapters for these environments to communicate effectively with the rest of the city and global environment.



Conceptual Architecture for Vehicle Integration

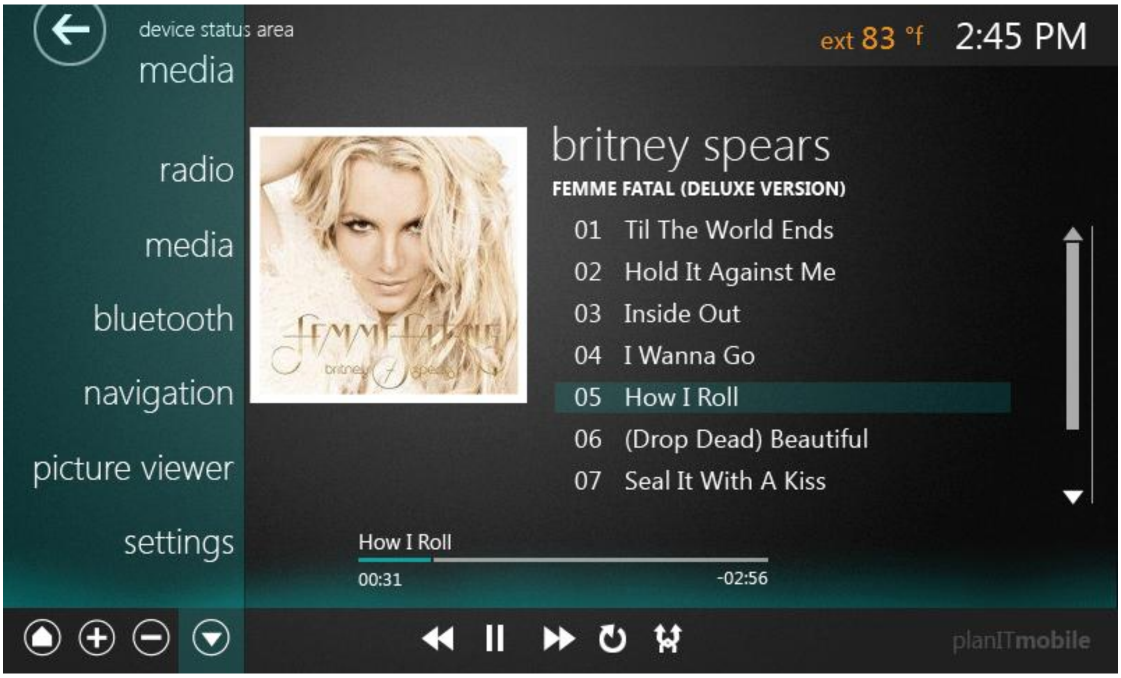
Fortunately a natural platform exists in the form of the 'head unit'. While there is no one clear specification or architecture for these devices, some centralized cluster of compute capability to run secondary (and sometimes primary) display screens, auxiliary vehicle functions, and support technology-based features such as entertainment, navigation, and any connected services present has become a de facto standard in recent years, replacing in many cases the conventional radio stack.

De facto software platforms for these units do exist, with a very notable example – assessed by adoption by OEMs as a differentiator - being the Microsoft Auto platform, now at version 7. Microsoft Auto extends Windows Embedded Compact with essential features such as audio and Bluetooth-based telephony in an extensible software platform that simplifies integration, support, and ongoing feature delivery for the automaker and their supply base.

Introducing UOS Automotive Appliance

As with much of the rest of the UOS™, Living PlanIT has built upon these Microsoft technologies to provide the platform for the Smart Urban vehicle. The UOS Automotive Appliance platform supports three major functions consistent with the philosophy outlined above:

- First-class traditional Head Unit functionality – to fulfill the role expected of it, the UOS Automotive Appliance head unit provides excellent support for entertainment, telephony, networking, communications, navigation, and access to the world wide web. This is fully customizable and also extensible with automaker-specific applications as needed, leveraging both Microsoft tooling and extended capabilities available as part of the UOS-Auto™ platform.
- UOS™ Sensor Network – UOS Automotive Appliance has extensive support for interfacing with existing vehicle buses and extracting data as needed for diagnostics, prognostics, servicing, and application support. Information gathered is filtered and passed to the UOS™ much as the Urban Network Controller does in buildings.
- PlaceApps host – the UOS Automotive Appliance platform provides an ideal platform for the delivery of PlaceApps to drivers – who have particular requirements in terms of interfaces that do not distract and present a minimal cognitive load – and passengers alike. PlaceApps will provide the means both for integrating vehicles into a Smart Transportation system and making their function optimally efficient in an urban context, as well as rendering the time in the vehicle maximally productive and pleasant for its occupants.



Sample User Interface for UOS-Auto Implementation

Power and Flexibility

The state-of-the-art in providing computing platforms in vehicles also lags behind other parts of the industry. While attempts have been made to bring consumer platforms into the vehicle, they lack the robustness, reliability, and power management required for a truly vehicle-compliant platform. Similarly, traditional vehicle head unit platforms lack power, flexibility, and the ability to innovate quickly and match consumer electronics delivery cycles, slowing the deployment of advanced features into vehicles.

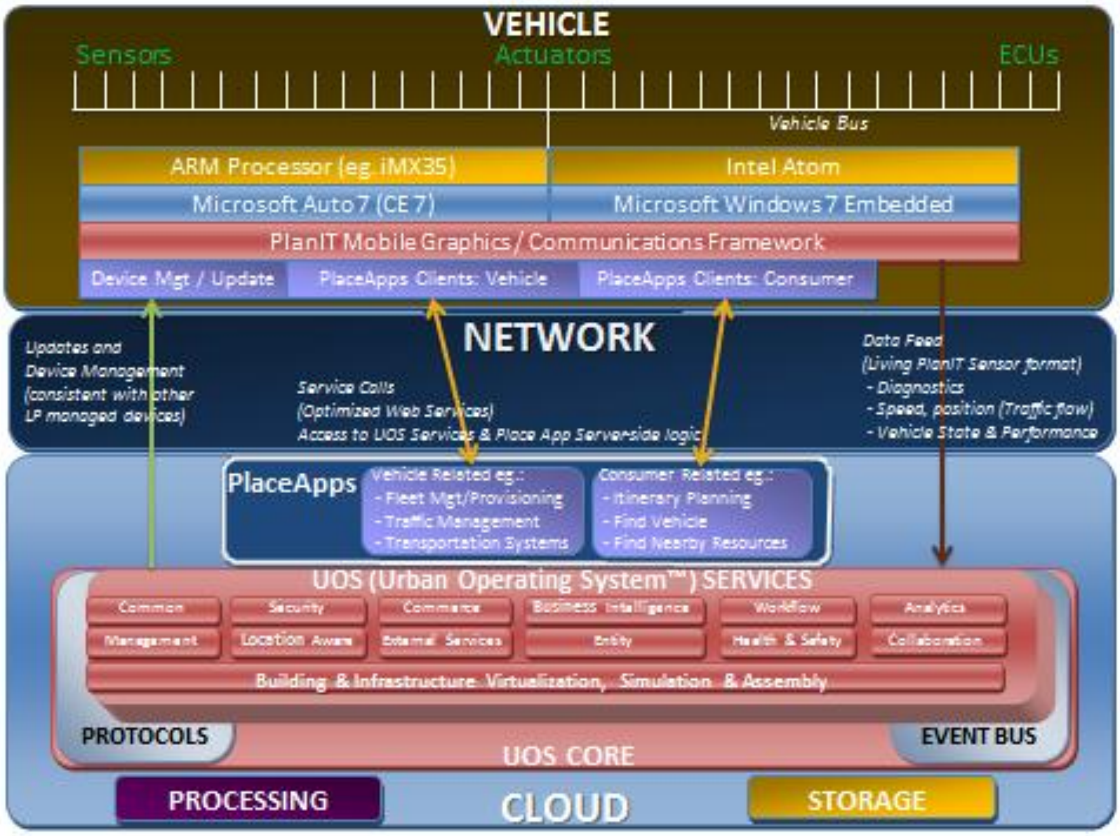
Living PlanIT's platform bridges this gap by providing:

- A modular hardware platform that can be specified with different levels of processing power – or upgraded during a production run or in-field – to meet requirements of the automaker, customizer, or fleet operator
- A modular hardware platform with a range of daughter cards to add / tailor facilities (such as wireless networks or different tuner types) and/or adapt to different vehicle bus configurations
- The modular hardware platform also allows a wide range of price points to be served from a single chassis design, optimizing economies of scale for all componentry
- The ability to seamlessly run in parallel two processors with different architectures and operating systems:
    - A traditional 'embedded' environment with ARM core and Windows Embedded Compact, providing reliability, fast start-up, and low power consumption;
    - A more consumer-orientated layer with Intel processor and Windows Embedded Standard, providing power, flexibility, and strong orientation to the consumer electronics / computing ecosystem and the cloud.
- The ability to present a common graphical environment that allows functionality from both platforms to be seamlessly combined and switched transparently to the user.
- The means to have one environment supervise the other – in a vehicle the ARM/CE solution typically acts as the 'master' and runs the Intel/Windows solution under its control. However, for static urban use (eg. Smart Wall) the scenario may well be a little different, with the ARM solution acting more as a backup device to the Intel environment. The UOS Automotive Appliance platform provides high flexibility in this regard.

The dual platform environment means that while the CE environment is relatively 'locked down' and predictable, automakers or installers can allow the Windows solution to have more flexibility than a typical embedded device, permitting controls and applications to be installed by the customer or user. In the event of a problem the Windows environment can be quickly restaged – even in motion – back to a known good state, providing a reliable, predictable experience with power and flexibility.

Integration with the UOS™ Sensor Network

The UOS Automotive Appliance solution provides hardware/firmware level integration with most widely used bus solutions including low- and high-speed CAN and MOST. In addition, software solutions simplify the extraction of diagnostics and state information from bus-enabled ECUs, and the concatenation of this information into a compact stream sent to the UOS™, leveraging much the same wire protocols as the rest of the UOS™. This allows vehicles in an urban environment to continually pass useful information such as velocity, position, road and weather conditions, accident information, battery state, and driver itinerary to the UOS™ as part of an integrated transportation system (see Appendix 3 for more details). In a more conventional example, remote diagnostics and vehicle fleet monitoring can be extremely well served using precisely the same infrastructure and independent of the region in which the vehicle is used (subject to some connectivity being available on some network somewhere at some time!).



UOS-Auto Architecture & Communications with UOS™

Available Now

The UOS Automotive Appliance platform is available for integration by vehicle manufacturers as original equipment and also installers for aftermarket use in fleet and other scenarios, and has already been exhaustively tested in conjunction with two OEMs for future vehicle products. The UOS Automotive Appliance platform will provide the foundation for vehicle connectivity in PlanIT Valley irrespective of platform manufacturer. A broad set of software libraries provides ready access to conventional and connected features that are ready to ship.

Living PlanIT Intelligent EV Dashboard Display

Coming Soon

In addition to full integration into a local UOS™ environment in PlanIT Valley, the UOS Automotive Appliance platform will also be extended with capabilities being researched today with Living PlanIT partners. This includes vehicle-to-vehicle 'mesh' networks, driver condition monitoring, traffic information, fleet support, and driver aids such as 'see-through' capabilities (see Appendix 3 for more information).

Visualization Solutions by Screampoint

Visualization Layer - 5D Future city™

The purpose of a visualization layer is to provide insight, not just pictures. People become more engaged when they can filter information that is presented visually and make discoveries on their own. In order to have all users of the UOS™ experience an intuitive, immersive environment for how they live, work and play, Screampoint's 5D Future city™ is being utilized as the front end, visualization solution. Developed by the former lead developer of Keyhole/Google Earth, 5D Future city allows people see their world in 3D and interact with their data and documents as historical reference, in real time or in future context. This intersection of 3D, time and data enable UOS™ users to connect people, places and things in ways they have never had the ability to do before.

Nicknamed "Spacebook", 5D Future city™ is designed to sit on top of the UOS™, PlaceApps™ and any other existing software applications and allow an average user to see expert system information in easy to use environment. Leveraging the power of Microsoft's Windows 7, the client application is connected via the Internet to a Cloud-based server that hosts the 5D Future city™ environment that is customized for each user through a subscription basis.

People and businesses that use 5D Future city™ will enjoy its mashup of Gaming, Geospatial, Architecture, Engineering and Financial software, providing an individualized, dashboard-style view to their data. A prime use of 5D Future city™ is to bring together previously disconnected operational programs and data, that allows for coordinated, efficient and sustainable urban policies and strategies across neighborhoods, businesses, and the entire social fabric of an urban area. 5D Future city™ allows people and businesses to collect, connect and communicate complex data sets like never before.

Being Cloud-based, 5D Future city™ can be used with a Windows 7 computer and mobile devices, such as a Windows Phone 7. The Location-based services that the mobile version of 5D Future city™ provides enhances the present and future uses of the UOS™ while leveraging the power of Windows Phone 7. People are placed geospatially in real time 3D in the 5D Future city Mobile™ environment. Using the Windows Phone 7 platform, a series of 5D SMART Apps are used to interface with PlaceApps™, city government data, mass transit information, 3rd party applications and a host of data captured over time in the 5D Future city™ environment.

LIVING PLANIT & PARTNER SOLUTIONS EXTENDING THE UOS™

The aggregated data that is captured by 5D Future city™ can be used by organizations for more accurate and better analysis, decision making and response. Some organizations that will benefit from a 5D Future city™ implementation include Market Research, Advertising, Asset Management, Financial Rating Agencies, Investment Organizations, Industry Information Companies, Real Estate Brokers, Real Estate Developers, Government Agencies and Publically Traded Companies.

Integrated Reporting: One Urban Report™

The ultimate realization of the application capabilities and technology infrastructure building blocks, combined with PlaceApps and information collected by the city government itself, is an integrated report on the city's performance. Living PlanIT's Urban Operating System™ together with Microsoft's Connected Government Framework make it possible to produce "One Urban Report™" (OUR™). The new management concept of integrated reporting, which is starting to be practiced by leading companies all over the world, can also be applied to cities for the same and even greater benefits. The number of people living in cities and the financial and natural resources they consume vastly exceeds the number of people employed by companies and the resources they consume. Thus integrated reporting by both companies *and* cities will make a major contribution to a sustainable society. Living PlanIT and Microsoft, in partnership with Glenelg Partners, have developed in the Azure cloud the ability for cities to produce One Urban Report™ in order to improve decisions regarding resource allocations at both the city and individual level and to dramatically improve a city's dialogue and engagement with its citizens.

The Concept of Integrated Reporting

Within the past few years a growing number of companies in different industries and different countries have adopted the practice of "integrated reporting." In its simplest terms, integrated reporting means combining a company's financial report (required of all listed companies) with its (usually) voluntary corporate social responsibility or sustainability report on its nonfinancial or environmental, social and governance (ESG) performance. This report is *not* intended to be a lengthy document reporting on every possible financial and nonfinancial performance metric. Rather, it is a report about the key or material financial and nonfinancial performance metrics and, equally importantly but rare, the relationships between them. It shows how the company is using financial, natural and human resources to create value for shareholders and other stakeholders.[3]

Financial and Nonfinancial Performance

More and more companies today are making sweeping claims about how "attention to ESG issues is good for shareholders" without being specific about the cause-and-effect relationships, supported by data. For example, how is greater energy efficiency, with lower carbon emissions, reducing costs? And the same for recycling programs? Are the growth rates, profit margins, and customer loyalty on "green" products greater than for traditional ones? How is diversity in the work force leading to more innovation? Is the company's commitment to sustainability enabling it to attract and keep more talented people, particularly younger ones? And is it enhancing the company's brand? How is better governance and risk management reducing reputational risk from compliance failures or corruption in the company and its supply chain? A truly integrated report provides answers to questions like these, with the particular questions obviously being a function of the company's industry and business strategy.

Leveraging the Internet

One Report doesn't mean *only* One Report. Integrated reporting also involves leveraging the Internet to provide more detailed information of interest to particular stakeholders such as shareholders, employees, customers, and NGOs. This information can be accompanied with tools for analyzing it

[3] For a detailed discussion of the concept of integrated reporting see One Report: Integrated Reporting for a Sustainable Strategy by Robert G. Eccles and Michael P. Krzus. New York, John Wiley & Sons, 2010. See also The Landscape of Integrated Reporting: Reflections and Next Steps edited by Robert G. Eccles, Beiting Cheng and Daniela Saltzman, Boston: Harvard Business School, 2010 which is available as a free EBook on here: http://www.smashwords.com/books/view/30930.

and also pulling in data from other sources and augmenting these tools with those developed by the user and accessed from other sources. Cloud-based computing using Azure is a quick and cost-effective way for companies to do this and, more generally, it enables them to start practicing integrated reporting almost as soon as they make the decision to do so.[4]

Stakeholder Engagement

Finally, integrated reporting is as much about "listening" as it is "talking." Again, the Internet can be leveraged to substantially improve the level of dialogue and engagement a company has with all of its stakeholders. The company can solicit feedback on its current reporting practices and how they can be improved in terms of both content and format. It can also engage with stakeholders in order to determine their expectations and degree of satisfaction with how these expectations are being met. Since it is impossible for a company to optimize across all expectations, it can also use engagement as a way of creating a "common conversation" amongst all stakeholders to educate them and increase their appreciation of how their expectations need to be balanced against the expectations of others.

Integrated Reporting Applied to Cities

Cities, just like companies, need to manage both financial and nonfinancial performance. The city government's responsibility is to create an environment where companies can create jobs for citizens and products and services for citizens and other consumers—city GDP is analogous to a company's revenues. Cities, in cooperation with government at other levels, also need to provide education, other social services, utilities, healthcare (to varying degrees), and a healthy and safe environment. The best cities enable and support culturally interesting and diverse experiences for their citizens. Finally, cities need to engage with their citizens, through the electoral process and in many other ways, to ascertain their desires and how well the city is meeting them. In fulfilling its responsibilities, a city utilizes financial (operating costs and capital investments funded by taxpayers), natural (energy, water and raw materials), and human resources (employees on the city payroll).

Two Levels of Performance Measurement

While formally similar, measuring city performance is more complex than it is for companies since it involves two levels of performance. The first is performance for which the city is directly responsible, e.g., the quality of education and the price of utilities and paid-for social services. The second is for the performance of the city *as a whole* which includes financial (e.g., GDP) and nonfinancial outcomes (e.g., carbon emissions, crime rates, corruption and life expectancy) for all public and private sector activity taking place in the city. Nevertheless, both of these levels can be incorporated into a city's One Urban Report™ when properly structured and the elements of integrated reporting by cities are the same as they are for companies.

Focus on Material Metrics

One Urban Report™ is not simply a vast compendium of all available information. Instead, it provides information on the truly material dimensions of financial and nonfinancial performance of the city. In a company, materiality is defined in terms of performance measures that are critical to the company's strategy. In a city, they are a function of the city's policies, based on the electoral mandate received by those currently in office, which in turn is implemented by its civil servants.

Identify Key Relationships

The key relationships between financial and nonfinancial performance must be shown. For example, what is the high school graduation rate and scores on standardized tests as a function of money spent

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[4] "Integrated Reporting in the Cloud," by Robert G. Eccles and Kyle Armbrester, IESE *Insight*, First Quarter 2011 Issue 8, pp. 13-20.

on education? Have road improvements reduced average commuting time? Is an expanded police force making the city safer? Have tax incentives attracted companies—and how many jobs have been created as a result? Utilizing cloud-based operating systems such as Microsoft Azure, state and local governments can easily interact with various departments and help measure and compare their performance from a centralized and standardized location. Since all cities have a disparate set of often incompatible legacy systems, the Azure cloud approach is an elegant way to solve this problem. The use of analytical tools that provide benchmarking and comparative analysis and the transparent reporting of performance, including to citizens, enables data-driven performance management and improvement.

More Detailed Information

Citizens are especially interested in particular performance metrics depending on their demographic characteristics, role and interests. The Internet can be leveraged to provide the detailed information of interest in a way that is easy to find and use by locating it in an organized fashion on the city's One Urban Report™ website. Parents with children will want to know about the performance of schools. The elderly will want to know about the response time of emergency services. Women will want to know what parts of the city are dangerous at night. Landscape designers will want to know what homes have been recently purchased. PlaceApps can be developed to deliver that information of particular interest to citizens in their various roles.

Customized Reports on Multiple Devices

Living PlanIT's Urban Operating System™ (UOS™), and PlaceApps developed by the partner community will leverage the Internet to provide integrated reporting on many different types of devices and locations. For example, citizens can access city performance information on their mobile phones and it can be provided on screens in public places, such as bus stops and kiosks in public parks. "Views" of the One Urban Report™ can be customized according to a user's preference and use, and evolve over time as the user's sophistication increases and interests change.

Citizen Engagement

Finally, engagement with a city's citizens is as important or even more important than a company's engagement with its stakeholders. In its most fundamental sense, a city *is* its citizens who are paying the elected officials and civil servants, as well as covering the costs for infrastructure, while expecting an environment in which they can live, work, and play. Town hall meetings, open forums, neighbourhood visits, attendance at fairs, and athletic events are all essential. But these physical interactions need to be supplemented by leveraging the Internet to dramatically increase the level of dialogue and engagement in order to ensure that the city and its citizens are in touch with each other. Fundamentally, this is about making sure the citizens are in touch with themselves. The stronger this citizen engagement, the stronger the city will be. By taking a data-centric view which provides standardized information in a single cloud location and through the use of PlaceApps based on this information, the city can dramatically improve its level of engagement with its citizens.

Better Decisions

Through integrated reporting, city officials and their citizens will make better decisions about how they are using financial, natural and human resources. PlaceApps can be developed which enable citizens to have their own One Urban Report or My Urban Report™ (MUR™) that shows how they and their families are creating value through the resources they consume. Integrated reporting applied by both the city itself and its citizens will improve both financial and nonfinancial performance. Not only will this make the city a more sustainable and enjoyable urban environment, it will also make the city a positive contributor to rather than a detractor from the creation of a truly sustainable society.

Appendix 2
Energy, Traffic, and Logistics Management

Integrated Energy Management

While integrated energy management is, in effect, an application that runs on the UOS™, its role is so critical to the successful operation of a future city and to the effective integration of Living PlanIT and partner energy solutions, that we deem it worthy of being classified as an application *capability*. Many other real-time control scenarios and applications will integrate with the energy management subsystem to the extent that it can be considered fundamental.

"Smart Grid 2.0"

Some might ask 'why isn't this just a smart grid'? Conceptually, this is a fair question, but in terms of what current generation smart grids represent, this is something quite different. Smart grids today attempt to bring some notion of distribution and collaboration to the guessing games utilities have been playing for a number of years –often with a fairly high degree of success. Utilities and grid operators use external factors like weather forecasts, successful TV shows or sporting events to predict the variable demands on their infrastructure. To a large degree, they are able to satisfy demand using these techniques, but not necessarily in the leanest or greenest way.

The Smarter Grid

In Living PlanIT energy solutions, a number of clean energy sources (wind, solar, waste-to-energy-and resources) are combined with energy redistribution capabilities (water and air buses) and energy storage (pumped water, battery, ice, thermal sinks) to provide a multi-variant way of meeting demand. Outside grid energy can also be used – if for nothing else than as a backup – but also to be able to return excess power to the grid where appropriate. However, the effective management of this complex provisioning system requires a high degree of real-time control with a huge span of control from micro-events (managing a bioreactor in real time) through to macro-events (weather patterns and time of day and the impact on the availability of solar and wind power).

Marrying Supply and Demand

But that is just the supply side of the equation. The demand side is more sophisticated also, with real-time controls being applied again at multiple levels, from room heating / cooling all the way up to city-wide energy consumption and distribution.

It is helpful to work through a simple example. We described earlier a scenario in which a UNC is operating a simple airflap in an apartment room, based on data about air duct temperature provided by another process running on another UNC. What this really means is that while controlling actuators to manage the heat or cooling flow in an individual room, the needs of the apartment, the building, and the region/city are continually aggregated and the energy management strategy seamlessly updated city-wide in order to meet demand in the most efficient and sustainable way.

Energy management entails the redistribution of thermal energy from where it is not needed to where it is, as well as the addition or subtraction of such energy from the entire system to where it can be stored or put to good use in other ways, and then the provision of energy entails multiple generation and storage sources each with their own characteristics, so it can rapidly be seen that this is an extremely sophisticated way of managing energy.

Managing Demand

But even this level of sophistication assumes that demand for energy 'is what it is'. This needn't necessarily be so. Living PlanIT building systems look to mitigate power usage for elements such as heating, ventilation and air conditioning (HVAC) through careful use of building physics tuned to local climate considerations, and the exploitation of integrated systems and parasitic losses. But demand can be influenced at the urban behavioral scale, also.

To start with, there is not necessarily a need to heat or cool an empty room or office. Necessarily? It depends how long it will be empty for, and whether maintaining a steady state is more effective than allowing the room to cool / heat up and then get it back to desired temperature again.

If you know, or can predict when a room will be used, these are practical considerations. Occupancy sensors and the analysis of historic data will allow significant efficiencies to be exploited. The same applies to other facilities such as lighting, computers, and entertainment equipment. Smart appliances and smart sockets will provide the fine grained control to manage power utilization and make residents and workers aware of what they are unwittingly responsible for. They are then provided with the controls to manage this, whether via the application of patterns and business rules, or explicit remote control.

Options exist here too. Computers that are idling can be used for useful computational tasks in a parallel processing grid, with task loads tuned to optimize getting the job done with the net lowest energy utilization across the entire city.

Transportation Management

Transportation and Logistics have a huge impact on a city in terms of living conditions and the economic, social, and environmental performance. Careful consideration of these fundamental systems and how they connect to the rest of the urban organism is therefore considered critical, and worthy of description here.

Future city Transport Policy

Future cities around the world have adopted different solutions for 'solving' the transport problem. Some have outlawed the private car from the inner part of the city, mandating the use of public transport with its classical flaws in terms of determinism of journey time, sparsity in certain areas, weaknesses at connections, and challenges to meet large swings in demand. Often while banning the car, the city continues to grant unrestricted access by delivery trucks and buses to meet its needs for different supplies. In many cases, this type of access is loosely regulated from an efficiency and emissions perspective.

Living PlanIT's pilot city – PlanIT Valley in Portugal – aims to take a more integrated approach. The intent is to ring-fence the use of emissions-producing vehicles to the edges of the site. External connectivity is well served with two major roadway links and a railway station, and transit centers at these locations facilitate the interconnection to intra-city transport. The transit centers are collocated with logistics hubs which perform the same function for inbound and outbound logistics.

Transport within the City

Transport within the city is mixed mode, including strong provisions for walking and cycling, taxis, shared-use pool vehicles, trams/buses, city operator / government utility vehicles, and private cars. All vehicles within the city are electrically operated. Some of these vehicles depend on battery storage, which is enabled by a significant provision of charging stations, with inductive charging being investigated as an option for some locales. Battery storage is viewed as part of the energy pool of the city, and where appropriate can be tapped (as part of Integrated Energy Management – see above) to supply energy to meet city requirements.

That 'where appropriate' statement above hides a lot of complexity. Whether it makes sense to pull data from batteries is in the first instance a factor of the city's energy strategy. How much power can be pulled from which vehicles is also maintained as part of that strategy. This is determined by knowing the charge state of every battery, when it is likely to be next charged (itself a function of energy strategy to some extent) and what likely duty cycles are expected until that time. For pool vehicles, a more collective sense can be taken – based on likely demand, certain vehicles can be taken out of commission and their batteries tapped for energy. The UOS™ can manage all of these calculations and the implementation of business rules, with operator oversight and override as appropriate.

How this is managed is also a policy decision for city operators and governments. The most effective generalized solution is an energy market, but this is likely to depend on the friendliness of local legislation. In many areas, the future city is dependent on smart legislation. Smart legislation can be accelerated through application of citizen enabling concepts available from partners.

Measuring the Immeasurable

But how, with a private vehicle, would you know what use is likely to be made of the car until its next charge? With a fully integrated vehicle management system. In effect, this amounts to extending the UOS™ into the vehicle with an 'adaptor platform' that provides the dual function of extending the UOS™ sensor network into the vehicle data network, and providing a host device for various PlaceApps. Living PlanIT has already created this platform and sells it today as an advanced head unit to vehicle manufacturers (based on Microsoft embedded software platforms).

Living PlanIT Intelligent EV Dashboard Secondary Display

With such a system interoperating with the rest of the UOS™ and customer consent and participation, calendar information can be used to determine likely journeys; traffic and weather information can be exploited to predict likely energy consumption; and energy strategy and customer destination information taken into consideration to provide most likely next charge time. In an energy market scenario, the city then makes the customer an offer to purchase this 'calculated surplus' energy from his or her battery – the price of that offer will in general terms exceed the cost of recharging the battery later when energy is less in demand. The customer can configure the system to automatically accept the offer based on rules, or to refer it to him/her under defined circumstances (which could be all the time).

This sophisticated management and coordination of vehicles extends to a few other things besides. For example, battery condition – a concern with early generation electric vehicles is constantly monitored, along with other critical functions, to provide a sophisticated remote diagnostics capability, and also to prevent the battery being damaged by things it cannot handle. If fast charging is causing internal temperature to climb too high, charge rates will be reduced in order to compensate for this effect. And the likelihood of this happening can be calculated based on historic general and specific unit performance, ambient temperature, and other factors, and taken into account in the itinerary and charge management functions described above.

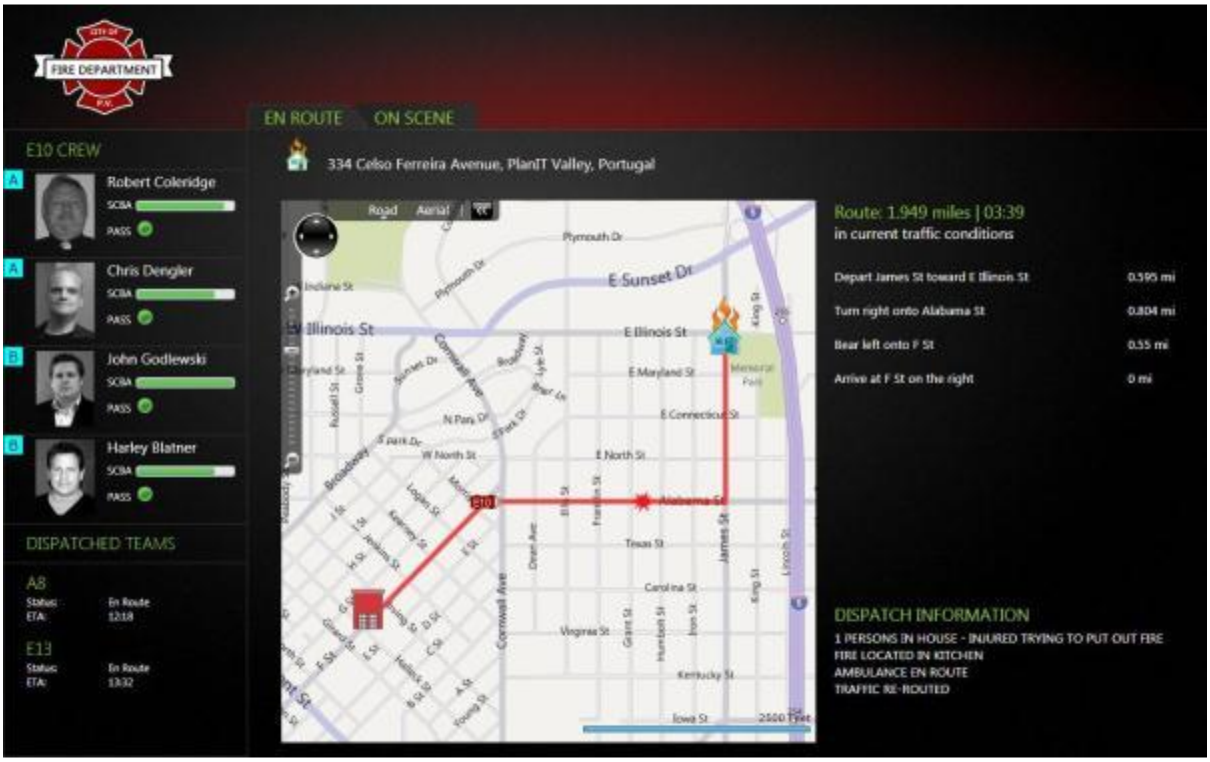
Vehicle routing does not only take into account traffic density, destination, driver preferences – it also takes into account vehicle performance characteristics, load, topography, type of road surface etc. That way, if a driver is concerned about the greenest rather than the quickest route, or if preserving battery range is critical, an EV might be routed around a hill rather than up-and-over it, depending on topography and other conditions.

Vehicle and Traffic Management

The UOS Automotive Appliance solution doesn't just help with battery management. It's also the platform for provisioning, metering, customization, and billing for shared-use vehicles. Any citizen can either pre-book or just pick up an available vehicle from wherever it is, and drive it to wherever they need to go within the city, and leave it there. And every vehicle / driver is monitored continually, with help only a pushbutton or voice command away. Additionally, all vehicles are provisioned with an extensive range of PlaceApps delivered from the cloud to both make the time in the vehicle more enjoyable and productive for all vehicle users, and to make the vehicle usage maximally efficient. Vertical applications specialized for dispatch, routing, timetable, and passenger management are used with the same platform to support buses, taxis, and trams, and their drivers and passengers.

Given that all of these vehicles are instrumented, traffic management receives a huge boost, in the continuous availability of high quality data on traffic flow and conditions obtained from every vehicle. This means that the availability of high quality near-real time traffic information becomes a reality not only for traffic control, but for every driver in the city. With traditional in-car navigation techniques this would be a problem, because every navigation engine would make the same recommendation for routes, causing congestion wherever they were sent. In PlanIT Valley, the traffic control system works in conjunction with the navigation engines to route drivers through multiple routes through the city, load balancing traffic and giving all drivers an acceptable experience and journey times. These techniques are being piloted by Living PlanIT research partners at Instituto de Telecomunicações in Porto today.

This same technique allows for real-time manipulation of traffic in emergency circumstances. The way can be cleared for a fire truck or ambulance not just by coordinating traffic lights (if they exist) to turn green, but also by thinning traffic in that area ahead of the vehicle by sending other traffic to alternative routes. This may require regulation changes in order to present instructions as opposed to advice via the navigation system – this is under consideration for implementation in PlanIT Valley.



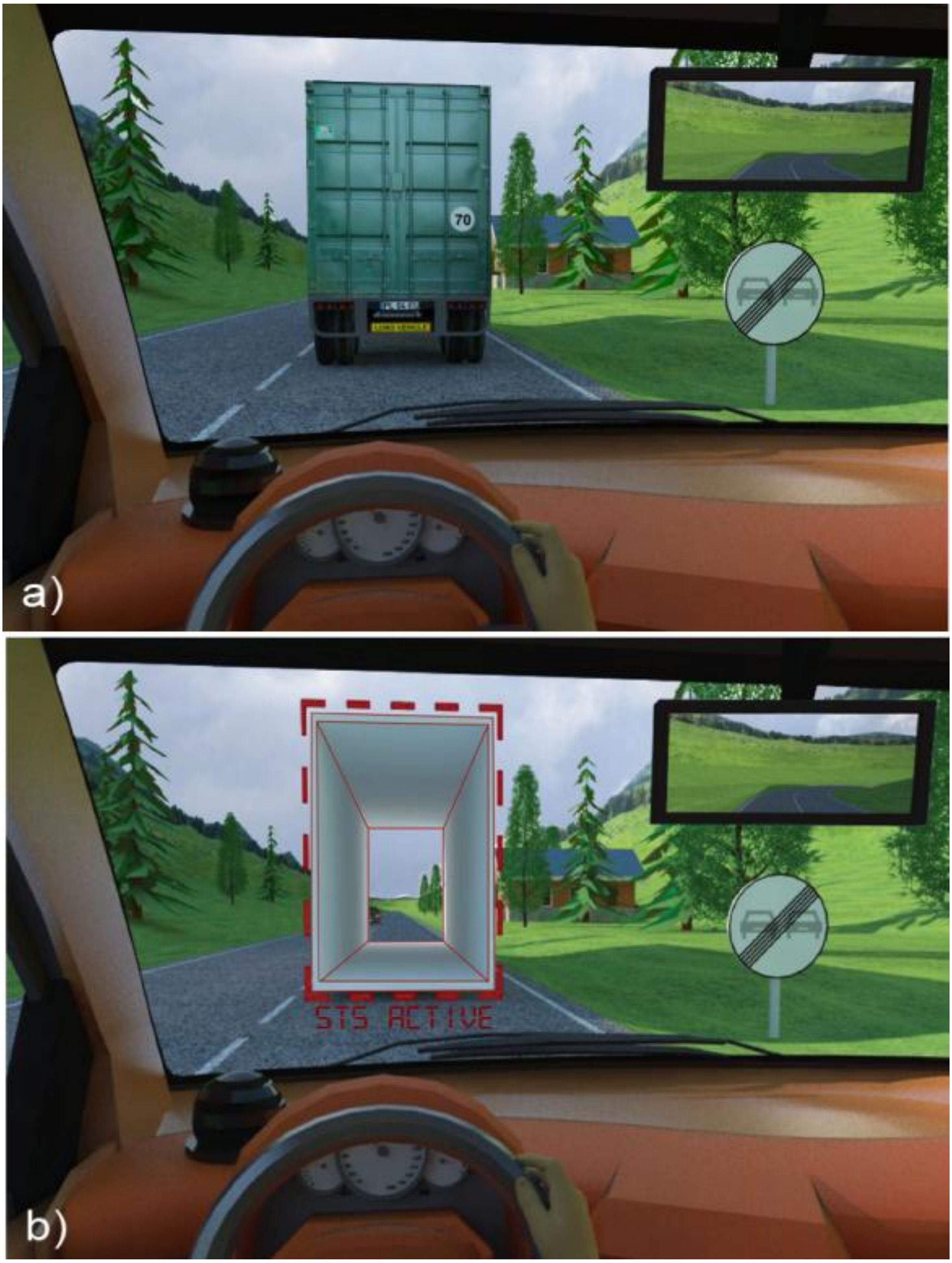
Fire Truck view of traffic clearance ahead of route

A significant waste and cause of congestion today is vehicles cruising around looking for parking spaces. With sensor technology it is possible to guide vehicles directly to available – and individual – spaces, with reservation being a monetizable option. If a user has special requirements (eg. mobility issues) this will be known and a suitable parking space allocated.

Smart vehicle and traffic management can have other benefits too. The next picture illustrates an experimental development by a Living PlanIT research partner again at the University of Porto where camera images are coordinated to provide a view 'through' a high sided vehicle ahead of the driver. With the use of multiple cameras - both vehicle mounted and static – and Microsoft GeoSynth technology it's likely that most blindspots could be effectively filled.

' Looking through' an obstacle ahead via cameras and head-up displays

Joined Up Transportation



Finally, the integration of transportation with the UOS™ allows for the deployment of truly joined-up transportation systems. A PlanIT Valley PlaceApp not only allows you to figure out where you want to go but also presents the best way to get there, with the user choosing to optimize by environmental impact, speed, cost, or some combination of these and other factors (such as numbers of people travelling, whether heavy loads are being carried, etc.). Once a route has been selected, the coordination of what is likely to be a multi-mode journey can be continued via a range of interfaces, all of which pick up on the journey context as soon as the user is recognized.

This enables fine-grained scheduling and coordination to take place. For example, if a train is 10 minutes late, it makes little sense to have a large number of private citizens, taxis, and shared-use pool cars at the station causing congestion for those 10 minutes. Far better to inform individuals and operators ahead of time so that schedules can be adjusted and congestion avoided. If a bus is coordinated to service that train, the impact on the rest of the network can be calculated of rescheduling that bus, with other prospective travelers being instantly informed. Or two smaller buses could be run if available – one at the original time to service other customers, the other meeting the train. The total cost of providing that differentiated service can also be calculated – in economic, environmental, and social terms – helping the operator make an informed decision.

As another example, if a passenger plans to get off a bus and pick up a shared-use bicycle, there is little point doing that if there is no bicycle available, or if there will not be one there at the appointed time. The system can either flag the need for a bicycle to be marshaled there if economic, or the passenger can be directed to a different stop where there is a bicycle available, even if this means a slightly longer ride. Or such legs of a journey might be planned to take contour into account – a passenger could be dropped off uphill of his destination, and in the morning ride downhill again to be picked up by a different bus.

Logistics Management

It was noted earlier that PlanIT Valley is designed with two large logistics hubs near its vehicular entry points. These are designed to provide a large scale I/O capability, with a substantial automated material handling and common warehousing facility. Retail, food and drink, and maintenance materials can all be commonly stored and replenished here, and used as needed. The distribution of materials where feasible is directed away from city streets and achieved via underground distribution systems that leverage the modular conduit systems already installed to carry pipework and cable-based services through the city. The logistics hubs are operated with joint venture partners with existing large-scale distribution systems, with the intention that material needs can be serviced from these networks with great efficiency and speed.

These logistics capabilities open up increased opportunities for PlaceApps, where the opportunities to fully blend online and on-premise retail and food and drink ordering can be exploited. For example, what starts as an on-premise transaction might transition to one that looks like online, because a customer simply does not want to carry their shopping home. Or a clothes shop does not have the exact combination of color and size that a customer seeks – this is no major issue. If it is in the common warehouse, it can be delivered to the store within minutes. If not, it will be fulfilled via the logistics partner network and delivered to the customers home later – perhaps even on the same day.

Living PlanIT UOS™ Demonstration at Cisco C-span, July 2011

At C-span we will be showing sample applications running on a compact version of the entire UOS™ architecture covering the following scenarios:

- Building Monitoring & Escape
- Remote Biometric Sensing
- Traffic Management
- Water Control

These demos all run on an entry-level Living PlanIT Urban Cloud Appliance built on a Cisco 2951 ISR.

Discussing each briefly in turn:

Building Monitoring & Escape

In this scenario, a virtual building is monitored for temperature and structural strain, represented in the demo by fiber-optic based sensors supplied by Fibersensing. As we warm the sensor, the ambient temperature in the location represented by the sensor increases rapidly. The pattern and degree of heat increase – together with other sensor inputs not represented in the demo such as cameras, smoke and chemical detectors – causes the UOS™ to forward information to safety and security applications together with alerts to the city monitoring center. An automated evacuation alert is triggered at a critical temperature. At this point, directional sirens sound in the building, and the smart LED light boxes – which normally provide the correct level and color temperature of illumination based on conditions – switch to evacuation mode, running if necessary off battery backup power. In evacuation mode the lights show occupants in every part of the building the safest escape route, taking into account the location of the hazard and the numbers of people using each route.

We reset the system to show how the UOS™ responds to another issue. This time, a structural member in the building is showing strain levels greater than nominal. This sends an alert to an engineer in the city monitoring center to have someone look into what is going on. However, once the level of strain exceeds a critical threshold an evacuation is again triggered. The light box in this case shows a different route due to the problem being differently located, and indicates a different class of problem through color. It should be noted that in general most buildings are not continuously monitored for strain and therefore often structural failure occurs before inhabitants can be warned.

Remote Biometric Sensing

This demonstration shows how the UOS™ can obtain information about the medical condition of individuals who may be considered at risk for a number of reasons – patients in medical facilities, those needing assisted living, or those away from home who have a higher than usual risk. The provision of such monitoring can be simplified by the UOS™ infrastructure, with multiple different information sources integrated continually to build up the most comprehensive picture of the state of the individual concerned. Monitoring can be provided continually independent of location and without requiring specialized equipment in the rooms where monitoring occurs.

To emphasize this point, one of our presenters is wearing a Biodevices Vitaljacket which wirelessly communicates EKG readings to the UOS. The EKG readings can be seen to vary when the presenter exerts himself. This data is continually logged, analysed, and can be reviewed by a physician remotely at any time. The Biodevices jacket also records the orientation of the individual via a miniature gyrosensor – this can be used to help interpret the EKG readings and also to detect when, for example, an elderly person has fallen or lost consciousness in his or her home.

Traffic Management

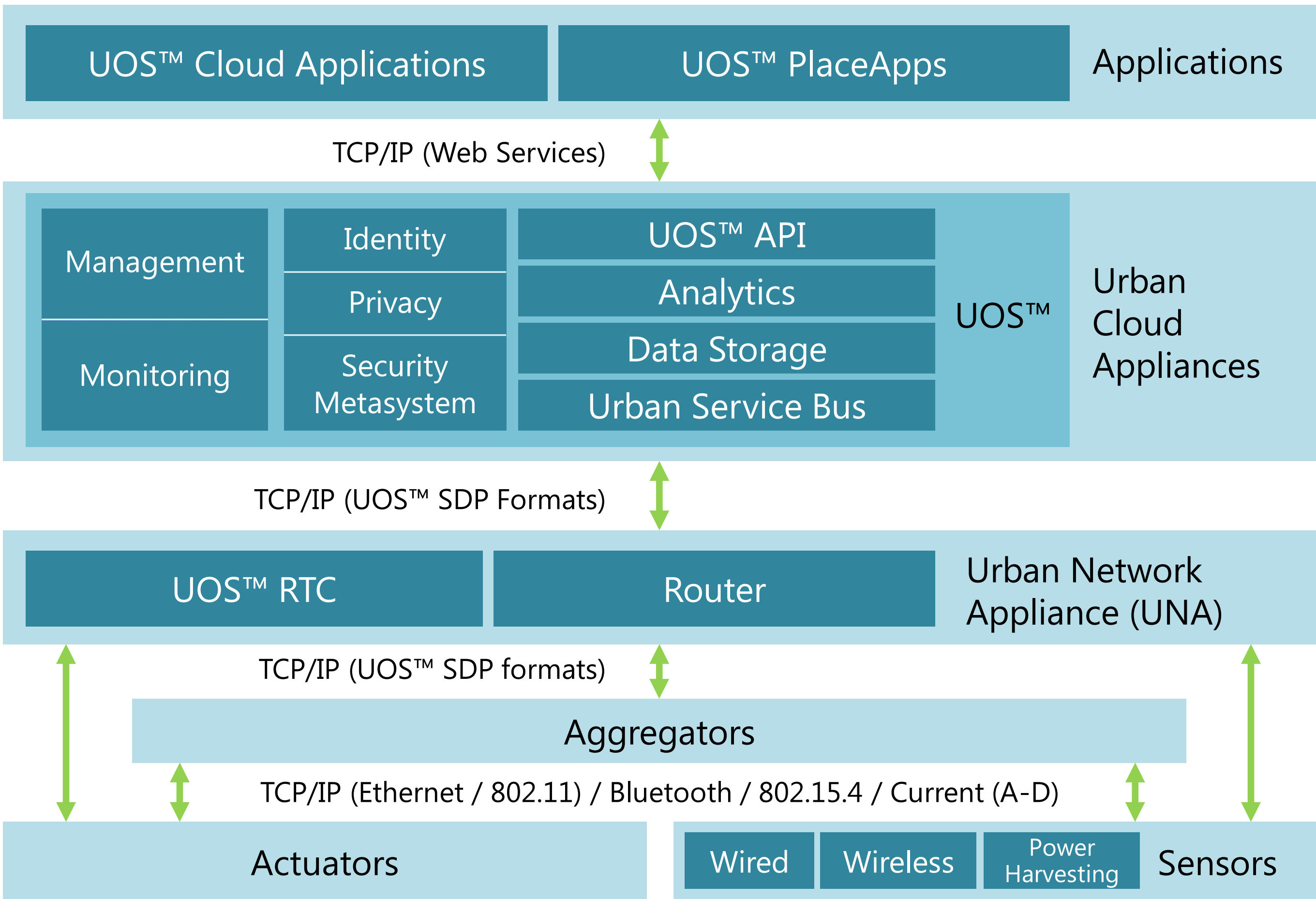
This shows how traffic can be managed in a future city. Individual vehicles all report their location, speed, and where known, intention (for example from navigation systems or driver regular patterns) to each other and to the city traffic management systems. This allows the flow of traffic to be optimized – load balanced if you like – across the entire city. In this instance a smart traffic management solution is implemented using the UOS™ in conjunction with a distributed traffic solution developed by Geolink and Virtual Traffic Lights (and based on earlier work by the University of Porto and Instituto de Telecommunicacoes). In this solution, traffic lights are eliminated with instructions being given to individual vehicles continually by the UOS™ and by interactions with other vehicles. Since we can't mess with real traffic, the demonstration shows an advanced simulation of real traffic behavior in the city of Porto obtained by monitoring real-world traffic over an extended period of time – and incidentally shows improved traffic flow compared to traditional systems. Due to an accident, the UOS™ needs to clear an expedited path for an emergency vehicle responding to the scene. Once the instruction is sent, a window in time and space is cleared for the emergency vehicle, which therefore can provide aid in the minimum amount of time. Other traffic is routed away from this window, which has a short term impact on the other traffic, but in most cases this is minimal. The demonstration shows the advanced coordination capable in a fully instrumented and integrated city.

Water Control

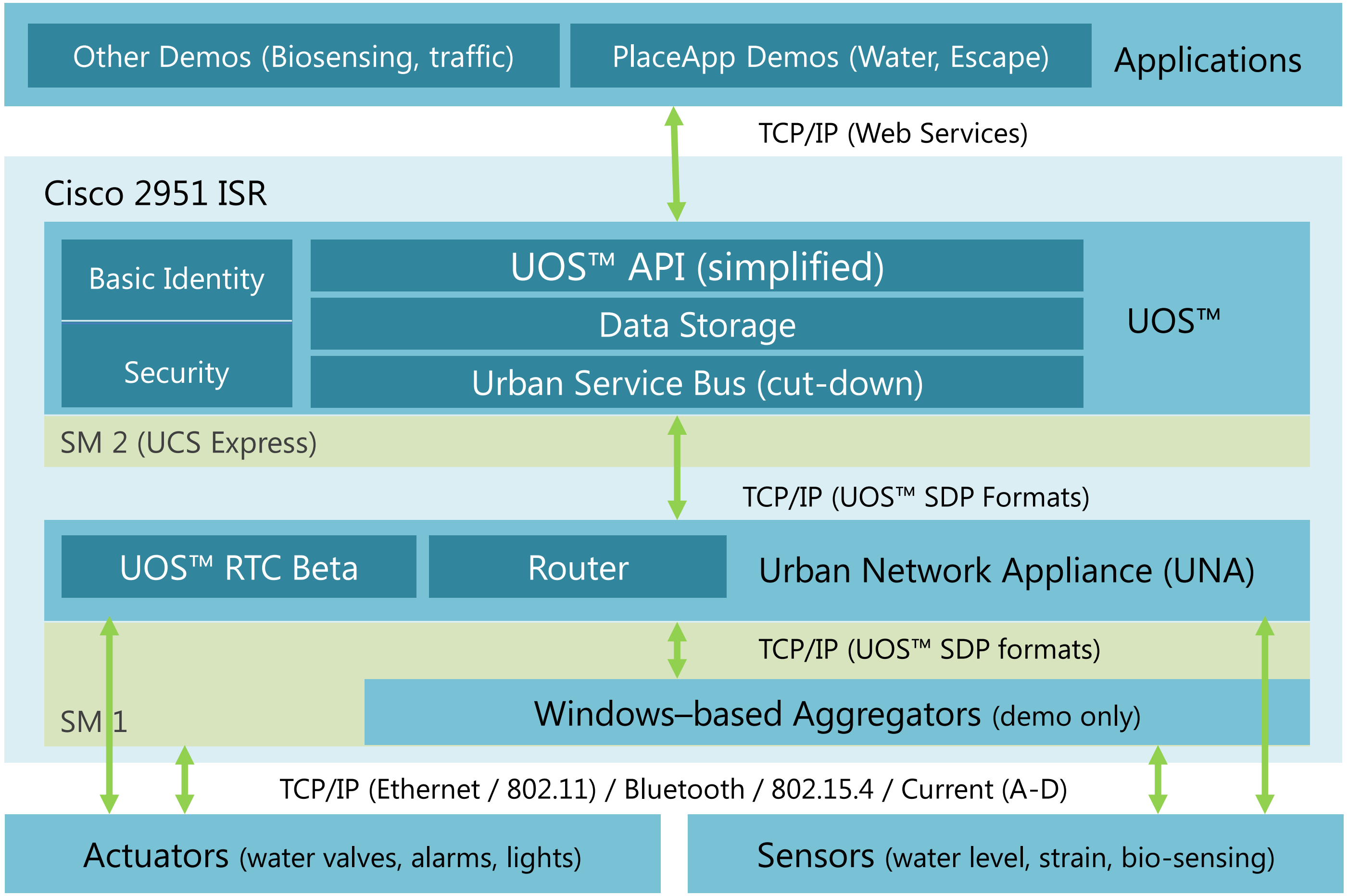
This demonstration shows the benefits of automating even simple functions such as controlling taps and waste in a bathtub or basin. Firstly, this provides resident convenience, as perfect baths to individual's requirements can be poured easily from a number of interfaces including wall panels and iPhones. Secondly, this minimizes wasted heat and water and therefore is a significant contribution to sustainability as pre-warming of the water by running the tap can mostly be avoided. Thirdly, this is a safety feature – children and the elderly can be badly injured by hot water, here, cold water is always poured first to virtually eliminate this risk. Finally, this also helps protect the building, as neither leaving taps on nor unintended displacement can cause water to escape onto the floor, with consequent clean up and damage remediation costs.

The demo stand provides a miniature emulation of a bath. It can be seen that the bath can be filled by profile to different requirements from both a wall-mounted screen and an iPhone app. The profiles differ with a child's bath being notably shallower and cooler than that for an adult. Additionally, additional displacement is countered by the waste rapidly opening and purging excess water.

UOS™ high-level architecture



Architecture of UOS™ demonstration



Ecosystem Partners involved in Demonstration

LIVING PLANIT

CISCO

Microsoft

McLaren ELECTRONIC SYSTEMS

PHILIPS
sense and simplicity

FiberSensing
bringing light to measurement

libelium
comunicaciones inalámbricas distribuidas

GEOlink

VIRTUAL TRAFFIC LIGHTS

biodevices

U.PORTO

it instituto de telecomunicações

ieeta

universidade de aveiro
theoria poiesis praxis

optimus

Partner Technologies Featured

- Cisco 2951 Router and Service Modules supplied by Cisco
- Windows Azure and Visual Studio 2010 supplied by Microsoft
- UOS RTC based on content developed by McLaren Electronics
- Light Box supplied by Philips Lighting Systems (The Netherlands / US)
- Fiber Optic Sensors supplied by Fibersensing SA (Portugal)
- Zigbee Sensors supplied by Libellium (Spain)
- Vitaljacket supplied by Biodevices SA (Portugal)
- Traffic simulation based on content developed by:
  - Geolink (Portugal)
  - Virtual Traffic Lights (Portugal / US)
  - Universidade do Porto (Portugal)
  - Instituto de Telecomunicações (Portugal)
- Thanks to all our partners shown above, and also to:
  - IEETA / Universidade de Aveiro (Portugal)
  - Optimus (Portugal)