Alliance for Internet of Things Innovation

Smart City Replication Guidelines Part 1: Cross-Domain/Application Use Cases

Version 1.0

AIOTI WG08 – Smart Cities

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CONTENTS

Glossary of Terms

ACTIVAGE	ACTivating InnoVative IoT smart living environments for AGEing well
AIOTI	Alliance for Internet of Things Innovation
BSI	British Standards Institute
CEDUS	City Enabler for Digital Urban Services
CIM	Context Information Management
CityKEYS	H2020 CityKEYS R&D project
CREATE-IoT	Cross Fertilisation through AlignmenT, Synchronisation and Exchanges for IoT
EIP	European Innovation Partnership
EIT	European Institute of Innovation and Technology
ETSI	European Telecommunications Standards Institute
FG-DPM	(ITU) Focus Group on Data Processing and Management
FP7	EU Framework Programme 7 project
GHG	Greenhouse Gas
GIS	Geographic Information System
H2020	EU Horizon 2020 Collaborative R&D Programme
IEC	International Electrotechnical Commission
IRIS	Integrated and Replicable Solutions for Co-Creation in Sustainable Cities
ISG	(ETSI) Industry Specification Group
ISO	International Organization for Standardization
ITU	International Telecommunications Union
KPI	Key Performance Indicator
LED	Light Emitting Diode
LSP	(H2020) Large Scale Pilot
MAtchUP	MAximizing the UPscaling and replication potential of high level urban transformation strategies
MONICA	Management Of Networked IoT Wearables – Very Large Scale Demonstration of Cultural Societal
NGES	Next Generation Emergency Services
NO_2	Nitrogen dioxide
ODI	Outcome Driven Innovation
PAS	Publicly Available Specification
PM_{10}	Particles of the order of 10 micrometers in size
$PM_{2.5}$	Particles of the order of 2.5 micrometers in size
PSAP	Public Safety Answering Point
REMOURBAN	REgeneration MOdel for accelerating the smart URBAN transformation
REPLICATE	REnaissance of Places with Innovative Citizenship and TEchnolgy
RUGGEDISED	Designing Smart and Resilient Cities for All
SCC	Smart Cities and Communities
SO_2	Sulphur dioxide
Stardust	Holistic and Integrated Urban Model for Smart Cities
symbIoTe	Symbiosis of smart objects across IoT environments
SynchroniCity	Delivering an IoT enabled Digital Single Market for Europe and Beyond
Triangulum	The Three Point Project / Demonstrate. Disseminate. Replicate.
UNE	Spanish National Technical Committee on Standardization
VICINITY	Open virtual neighbourhood network to connect intelligent buildings and smart objects

1. Introduction

The Alliance for Internet of Things Innovation (AIOTI) was launched in 2015 by the European Commission and several relevant stakeholders (mainly industry) in the IoT domain to create a dynamic European ecosystem that can boost the market in its multiple application domains.

AITOI WG08 is devoted to the study of smart cities, providing relevant guidance and paving the way for a widespread consensus at European level that can be used as reference for interoperability and replication. In 2015, WG08 published its first deliverable "Smart City LSP Recommendations Report" [1]. This provided guidance for the H2020 Large Scale Pilots (LSP) 2016-2017 programme, in which one LSP was devoted to Smart Cities (Pilot 4: Reference zones in EU cities, awarded to Synchronicity project). The AIOTI Smart Cities Working Group gathered inputs from its partners, identifying four main areas of action, existing development gaps and the related technological requirements needed for LSP deployment. This input constitutes the perfect starting point for next steps. This document provides an overview of the requirements for replication of smart city solutions, focusing on cross-domain use cases that are applicable to smart cities.

This new report follows this up by developing replication requirements and guidelines for smart city solutions. It introduces the subject of how smart city solutions can be replicated, identifies the importance of cross-domain use cases to aid in this process. It provides examples of cross-domain use cases and how these are used.

Finally requirements are derived for communication between platforms and the exchange of data. Note that oneM2M also has a federated approach but only when both platforms are oneM2M compliant.

Part 2[1]: "Guidelines and blueprints for IoT enabled smart cities" [2] addresses the topics of technology guidelines and blueprints, data interoperability, KPIs and reference architectures.

The objective of these two deliverables (and the work of AIOTI WG08 as a whole) is to build a case for a future-proof horizontal approach that brings value to cities and citizens and derive related requirements. This deliverable will provide the evidence for a large number of commercially viable, cross-domain use cases that will drive future work on horizontal platform requirements and guidelines.

At the National level, British Standards Institute (BSI) and the Spanish National Technical Committee on Standardization (UNE) have been highly active in the development of standards for Smart Cities. BSI have developed the following range of standards for Smart Cities:

- PAS 180 Smart cities. Vocabulary.
- PAS 181 Smart city framework – Guide to establishing strategies for smart cities and communities [3].
- PAS 182 Smart city concept model - Guide to establishing a model for data interoperability [4].
- PAS 183 Smart cities – Guide to establishing a decision-making framework for sharing data and information services.
- PAS 184 Smart cities – Guide to developing project proposals for delivering smart city solutions.

[1] Work in progress

- PAS 212 Hypercat: Automatic resource discovery for the Internet of Things – Specification.

Work is ongoing in many countries on implementing cross-domain Smart City solutions. The Spanish National Plan for Smart Cities was launched in 2015 and updated at the end of 2017 with the extended "National Plan for Smart Territories, 2017-2020". This strategy constitutes one of the main pillars of the Digital Agenda for Spain and has a budget of €170m. At the beginning of 2017, Spain had an extensive portfolio of smart city initiatives including:

- 28 "Red.es" projects (http://www.red.es/redes/actuaciones/administracion-en-linea/plan-ciudades-inteligentes), within three calls: Smart City I (2014, €15m, 11 projects, 24 local entities), Smart City II (2015, €63m, 14 projects, 17 local entities) and Smart Islands (2015, €30m, 3 projects, 3 local entities). At the end of 2017 two new calls were launched: Smart Tourist Destinations (€60m) and Smart Buildings (€30m for cities managing at least 150 buildings).
- 123 DUSI (Integrated and Sustainable Urban Development) strategies running, from two calls and €1.013m (http://edusi.es/): first EDUSI call (83 cities), second EDUSI call (40 cities). A third call has been closed at the end of 2017 (with €353,4m).
- Two active city networks: RECI – Red Española de Ciudades Inteligentes (82) and Red INNPULSO (62 cities).
- One inter-platform cross-domain initiative: GICI – Grupo Interplataforma de Ciudades Inteligentes (21 platforms) with the objective of providing the Spanish vision on smart cities until 2030.

2. Replication techniques for Smart City solutions

The following techniques can be considered tools to help replicate smart city solutions:

- Best Practices,
- Common (Cross-Domain) Use Cases,
- Capability Models,
- Benchmarking / KPIs,
- Interoperability,
- Platform Approach,
- Standards (vertical and horizontal),
- Profiling.

From the list above, this deliverable focuses on commercially viable Smart City use cases, especially those which are cross-domain or cross-application, together with the essential KPIs and standardisation requirements that are needed for these. It proposes a set of criteria for both what is cross-domain and what is commercial viability. It identifies sources of commercially viable cross-domain use cases and also some research and development projects which may be a source of further (more speculative) cross-domain use cases. It proposes a standardised template for documenting cross-domain use cases containing the essential elements.

3. What does Cross-Domain mean?

A cross-domain (or cross-cutting) use case is one which, to be realised effectively, requires access to information normally contained in different (possibly legacy) silos or data-sets. Smart Cities, because of their wealth of different domains, provide some of the best examples of cross-domain use cases. Examples of some of the principle Smart City domains are shown in Figure 1 [5].

Figure 1: Possible Domains in a Smart City.

An alternative view, focusing on applications rather than domains, is provided in Figure 2.

Figure 2: IoT Applications in a Smart City [6].

Figure 3 [7] illustrates that each of us could be interacting with a Smart City application every waking hour of our lives (and probably while we are asleep as well although we may not realise it). Waking up in a smart home, then moving to a smart transport system and on to a smart office, finally going smart shopping and interacting with smart healthcare or wellness after work. There is a huge amount of communications bandwidth required here as well as a lot of other functionality that needs to be provided to enable these seamless and transparent transitions.

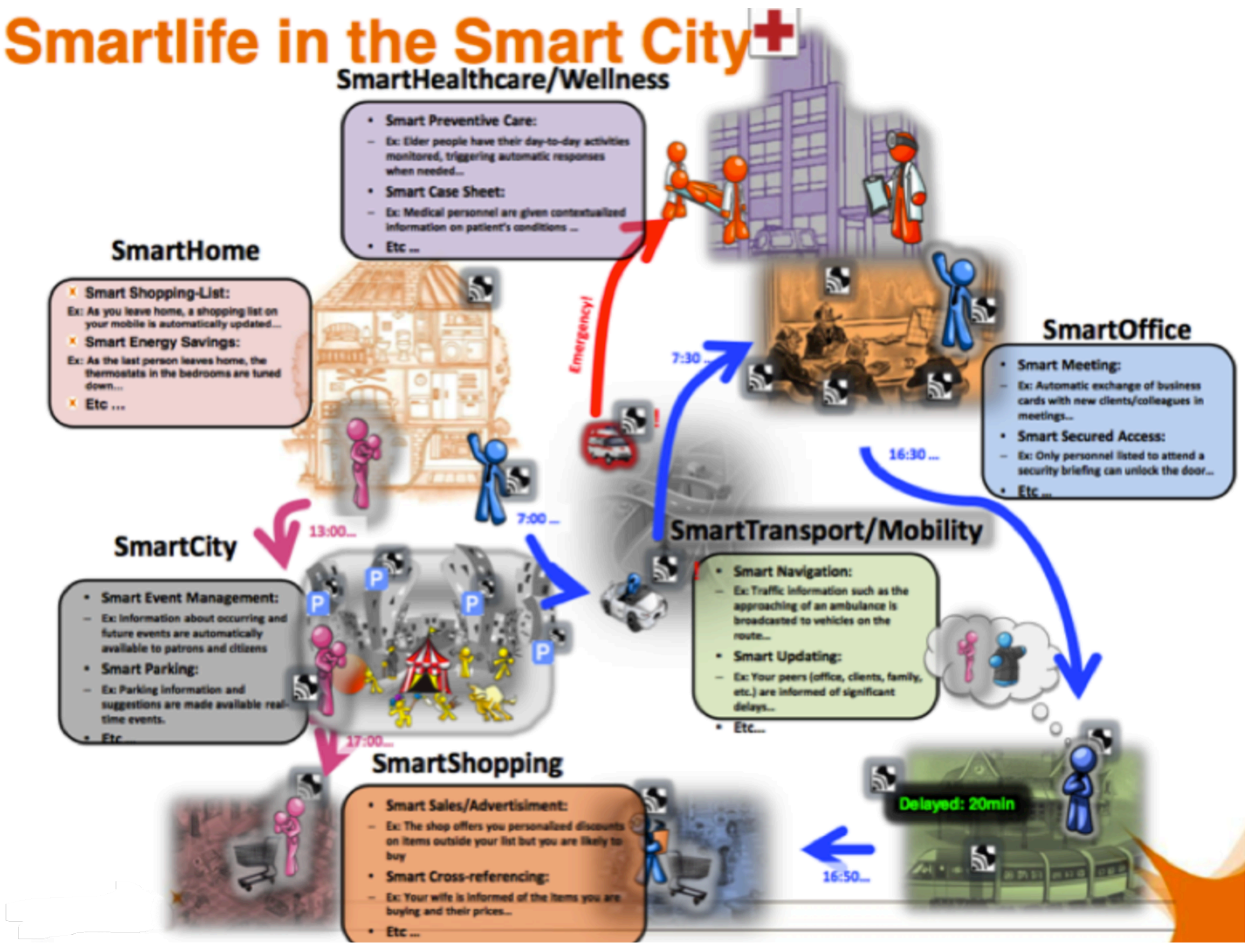


Figure 3: Smart Life in the Smart City [7].

Smart City Domains

A Smart City is often considered as a single large domain. There are other domains, such as Smart Agriculture and Smart Manufacturing, that also provide good examples of cross-domain use cases. However, for the purposes of this document, a Smart City is considered to contain a number of domains, such as Mobility and Energy, as shown in Figure 4 [3].

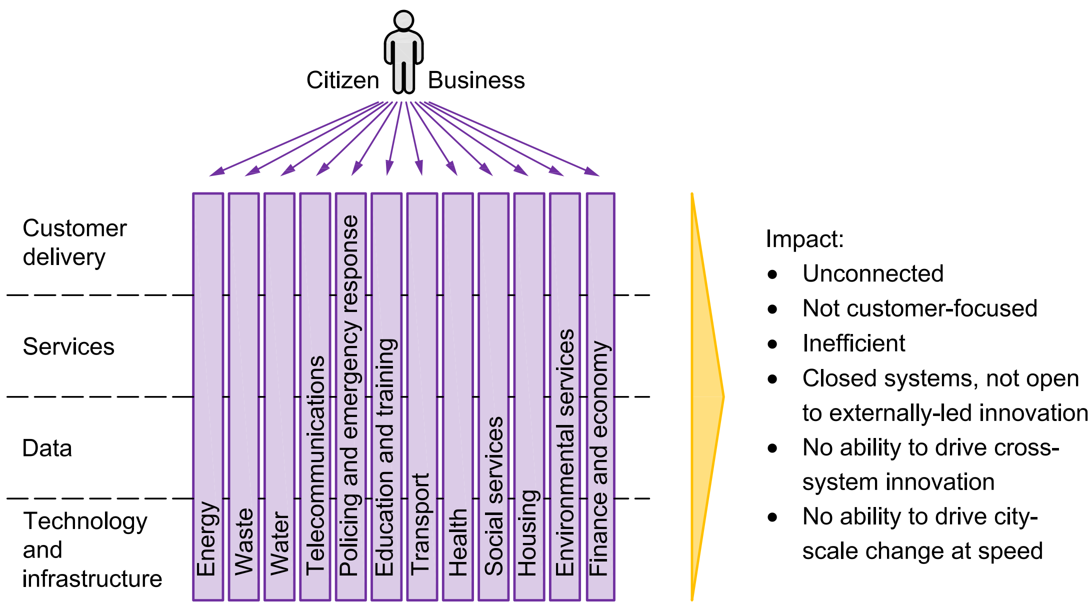


Figure 4: Vertical Domains (Silos) in a City.

EC DG Internal Policies proposes the six Smart City domains listed below along with their component parts [8]:

1. Smart Governance
   - Digital administration
   - Transparency
   - Participation
   - Geographical information

2. Smart Economy
   - Tourism
   - eCommerce
   - Employment and entrepreneurship
   - Innovation ecosystem

3. Smart Mobility
   - Access
   - Road infrastructure
   - Traffic and transport
   - ICT connectivity
   - Parking

4. Smart Environment
   - Urban environment
   - Waste management
   - Energy
   - Water

5. Smart People
   - Citizen participation
   - Digital inclusion

6. Smart Living
   - Health
   - Education
   - Culture, leisure, recreation
   - Social affairs
   - Security and emergency response
   - Urbanism and shelter
   - Public infrastructures and urban equipment

For the purpose of this document, cross-application use cases within the same domain are also considered relevant. Therefore, applications within the Smart Economy domain such as Tourism and eCommerce would be considered to be cross-application use cases.

The traditional operating model for a city has been based around functionally-oriented service providers that operate as unconnected vertical silos as shown in Figure 4. Smart cities need to develop new operating models that drive innovation and collaboration across these vertical silos as shown in Figure 5 [3].

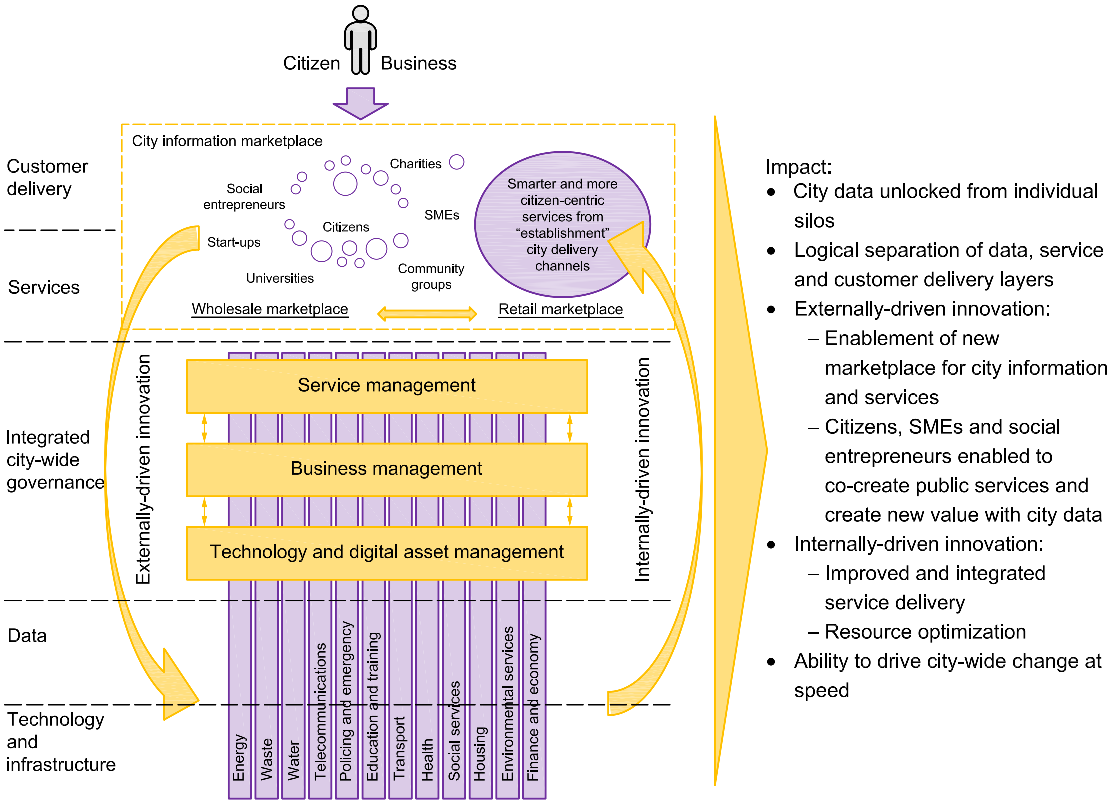


Figure 5: New integrated operating model for Smart Cities.

Hence it is the cross-domain aspects which are important and the ability to share and re-use data from the different domains simultaneously. For example, deploying dedicated devices, tied to a particular app and network, is very inefficient and it would be much more cost-effective if sensors could multitask and generate data for different use cases. It would be much better if a temperature sensor positioned close to the street could be used, not only as a tool for checking road conditions, but also a weather status/forecast tool. Single sensors reduce deployment costs and cut expenditure on communications [9].

In order to replicate a Smart City solution, it is necessary to examine the common elements of a number of Smart City use cases in order to identify those parts that can be replicated intact (unchanged) and those parts that need to be tailored (configured/customised) when applied to other cities.

4. What is commercial viability or economic sustainability?

The following are proposed as criteria for the commercial viability of a smart city use case/solution:

- Is there a real city-driven need for the solution defined by the use case?
- Is the solution deployed in a city (or preferably more than one city) today?
- Does the solution have real users (rather than test users)? Roughly how many are there? Are they paying to use the solution?
- Is the solution economically sustainable? Who is providing the funding (what type of stakeholder) to maintain the service and how is the revenue shared?
- Does the solution reduce the consumption and cost of energy?
- What is the value proposition? Could it be funded from a mixture of private and public funding? Is there a regulation that provides the need for this use case?
- What is impact on the CAPEX/OPEX of the stakeholders in a smart city?
- What is the commercial complexity, in terms of the different suppliers and service providers, that need to come together to offer the solution?
- Who are the actors providing data necessary to offer the solution?
- Is the solution future-proof (e.g. does it rely on a network solution that is due to be phased out) and is it sustainable?

When considering the economic viability or sustainability of implementing any particular solution, it is important to consider the overall benefits to a range of stakeholders (as described in Section 5). Funding may need to come from other sources which benefit from the availability of the solution which may not traditionally fund these sorts of activities.

5. Smart City Capability Model

A capability model describes 'what' an organisation or ecosystem needs to do instead of looking at processes - 'how' things are accomplished. This is simpler because capabilities change little whereas processes and mechanisms change a great deal. Therefore, it may be useful to focus on capabilities, desirables, undesirables and KPIs first to avoid premature discussions on 'how' where commercial needs have more of a disruptive impact on collaborative outcomes. Once the capabilities have been defined it will be easier to define useful KPIs.

A typical Smart City capability framework is shown in Figure 6 [10]. The domains are listed on the right hand side.

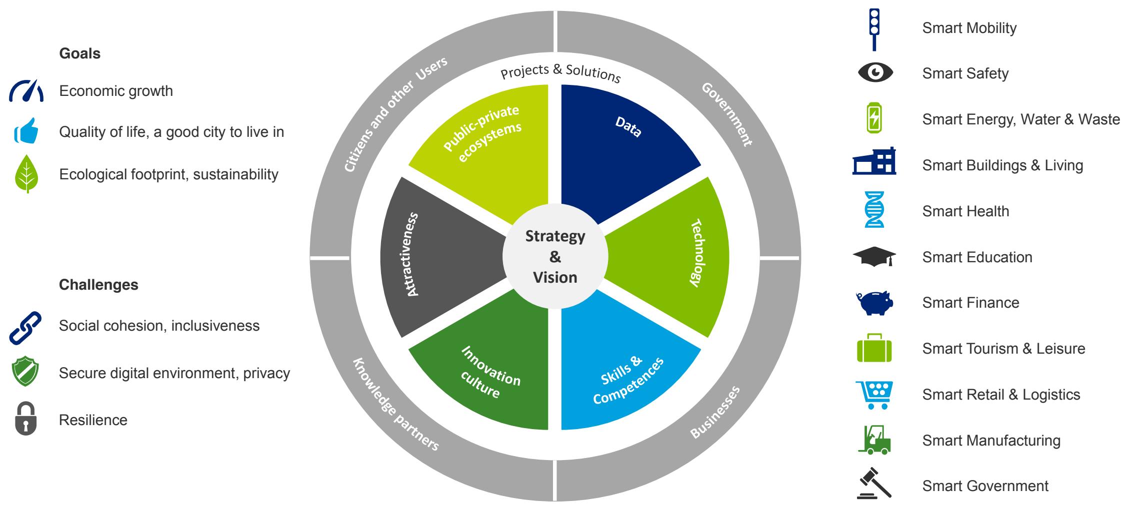


Figure 6: Smart City Capability Framework.

The following questions should be answered in the context of a particular smart city domain or application:

- Who are the actors?
- What are they providing and what benefits do they receive?
- What are the outcomes - sometimes referred to as Outcome Driven Innovation (ODI)?
- What will drive the change?
- What is the mechanism that will drive change?
- Who will benefit?

For example, looking at the Air Quality use case described in Section 7:

- The motivation for the implementation should be the EU Air Quality Directive [11]. However, this has not been sufficient in itself to improve air quality in cities such as London, Barcelona and Madrid.
- Other (more motivational) reasons for change could be the number of premature deaths occurring in these cities that can be linked in some way to poor air quality.
- Which stakeholders are incurring the extra costs of these premature illnesses and deaths?
- Is there a way to improve air quality that would reduce the costs to these stakeholders?
- What mechanisms could be used to reduce pollution and improve air quality? For example:
  - reducing emissions from vehicles overall,
  - moving vehicles (especially high polluting vehicles) to use different routes.
- Which actor (or combination of actors) might fund (or part fund) the solution?
- Could a case be made for funding from public or private health services to implement an effective solution?

6. Sources of Smart City Cross-Domain Use Cases

The EU Horizon 2020 Lighthouse projects are exploring techniques for replication of Smart City solutions. There are currently twelve smart city lighthouse projects, receiving a combined total funding of €263.84m [12]. They are looking at issues ranging from retrofitting of buildings to make them energy efficient to smart transport in order to reduce congestion and greenhouse gas (GHG) emissions. All new lighthouse cities must have a energy action plan validated by the EC Joint Research Centre (JRC) to be eligible for funding.

The complete set of lighthouse projects are shown in Figure 7. These started between 2014 and 2017. Some of these projects have finished and others still have 2-3 years left to run.

Figure 7: Current EC Horizon 2020 Lighthouse Projects

These are led by the following 28 lighthouse cities:

- GrowSmarter: Stockholm, Cologne, Barcelona [13]
- IRIS: Göteborg, Utrecht, Nice [14]
- MAtchUP: Valencia, Antalya, Dresden [15]
- mySMARTLife: Nantes, Helsinki, Hamburg [16]
- REMOURBAN: Valladolid, Nottingham, Tepebasi/Eskisehir [17]
- REPLICATE: Bristol, San Sebastian, Firenze [18]
- RUGGEDISED: Umeå, Rotterdam, Glasgow [19]
- Sharing Cities: London (Greenwich), Lisbon, Milan [20]
- SmartEnCity: Vitoria-Gasteiz, Sonderborg, Tartu [21]
- SMARTER TOGETHER: Wien, Lyon, München [22]
- Stardust: Pamplona, Tampere, Trento [23]
- Triangulum: Manchester, Eindhoven, Stavanger [24]

These projects are providing best practises for the replication of Smart City solutions. Each lighthouse project also includes at least 3 'follower' cities which are deploying solutions based on those established in the lead cities. There are currently 24 follower cities.

In addition, there are five EU Horizon 2020 Large Scale Pilots as shown in Figure 8.

- Management of Networked IoT Wearables – Very Large Scale Demonstration of Cultural and Security Applications – www.monica-project.eu
- ACTivating InnoVative IoT smart living environments for AGEing well - www.activageproject.eu
- AUTOmated driving Progressed by Internet Of Things – www.autopilot-project.eu
- Internet of Food and Farm 2020 - www.iof2020.eu
- Delivering an IoT enabled Digital Single Market for Europe and Beyond – www.synchronicity-iot.eu

Figure 8: Current H2020 Large Scale Pilots [25]

These projects started in early 2017 and will also provide opportunities to apply best practises. In total these have produced over 50 use cases and several of these are cross-domain. In particular, the SYNCHRONICITY project [26] is aimed at delivering urban IoT services on a large scale within cities. The ACTIVAGE LSP is also implementing several cross domain use cases as described in Annex D. A new LSP on Smart Energy will start later in 2018.

The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) is a collaboration of 5 DGs (including DG Energy, DG Move and DG Connect) and has a range of projects looking at use cases for Smart Cities [27].

Commercially proven projects include the EIT Digital (European Institute of Innovation and Technology) projects. 9 smart city projects are addressing real (commercially focussed) solutions [28], including CEDUS, the City Enabler for Digital Urban Services [29].

A range of specifically cross-domain use cases has also been identified by the Green Digital Charter in its collection of case studies [30].

7. Examples of Smart City Cross-Domain Use Cases

The draft ETSI ISG CIM Group Report on Use Cases [31] has identified a number of cross domain use cases that are relevant to Smart Cities. These are included (with others) in the following list:

- Smart lighting so that street lighting is only provided when needed.
- Air quality monitoring, traffic routing and road pricing.
- Monitoring assisted persons outside the home.
- Smart Parking and assisted living to ensure that parking spaces are available for health professionals when required [32].
- Smart Street Lighting, Air Quality Monitoring and Pedestrian Safety.
- Mobility inside the City.
- Next Generation Emergency Services (NGES) Crowd Control and Emergency Response.
- Mobility as a Service.

The NGES use case is an example of a cross-domain use case which spans several of the vertical domains, including smart buildings, environmental pollution monitoring and eHealth services, as shown in Figure 9.

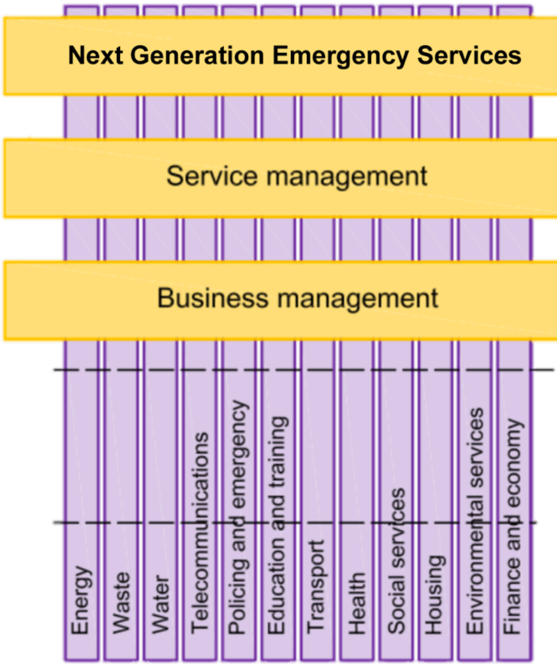


Figure 9: NGES service using information from many of the verticals.

A template for a Smart City use case including cross-domain and commercial viability aspects is shown in Annex A.

A more detailed template for Smart City use cases has been developed by the ITU-T SG20 Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities (FG-DPM) [33].

Another template for IoT use cases has been developed by ISO/IEC JTC 1/WG 10 Internet of Things [34].

The following smart city use cases follow the template provided in Annex A. They are typically pilot projects or trials and have not yet been proven to be commercially viable, although some (such as the Smart Lighting use case) have been deployed on a commercial scale.

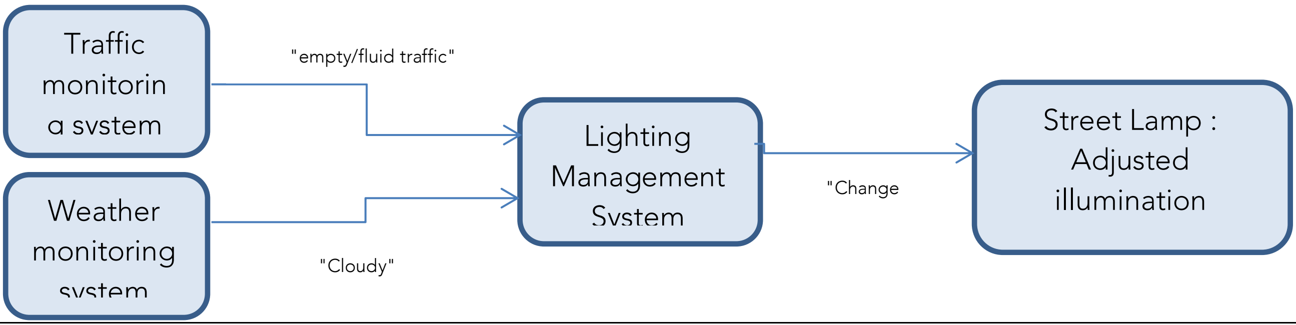
Smart City Cross-Domain Use Case

Smart Street Lighting

City need: Street lighting accounts for 3% of the world's total electricity consumption. Cities such as London, New York, Hong Kong, Toronto and Sydney are studying ways to reduce the costs of street lighting as it consumes a large proportion of their budget.

Description: If street lighting is used only when required, such as when traffic is flowing during adverse weather or low light, then much of the energy used by street lighting could be saved. For this use case, a means to detect the presence or absence of traffic (motor vehicles, cyclists and pedestrians) is required.
A potential drawback of this service is that lights cycling on-and-off may disturb residents, so the use case should provide tools to control cycling (e.g. to make it not too frequent, to use gradual transitions, etc.).

Information exchange:



Relevant Agents:

Agent	Type	Description	Technology
Traffic Monitoring System	System providing information about current street occupancy levels.	Sensor installed in the roadway to indicate road occupancy.	Inductive loop vehicle detectors. Camera with vehicle/pedestrian detection and tracking software.
Weather Monitoring System	System to measure weather conditions by monitoring sensors.	Sensors placed in various locations within a city.	Including apps on smartphones
Lighting Management System	System to manage and control IoT enabled street lights.	Light detector User smartphone	Management application

Data Sources:

- Street monitoring sensors to monitor traffic.
- Weather monitoring sensors to measure light levels, rainfall levels, air pollution or fog monitoring.
- Lighting management systems communicating with LED street lamps equipped with communication and control devices.

Why is it cross-domain? It requires access to information that is normally held in separate silos: specifically, weather data, traffic data and lighting data.

Why is it commercially viable? This use case is deployed in Cambridge, Massachusetts where it has saved a further 30% of energy after the 50% saving through moving to LED lighting has been taken in to account. The city of Eeniend in the Netherlands uses a system which dims LEDs to 20% power when no one is in the area. When a sensor detects movement, the lights switch to full power and alert other lights in the person's path to brighten as well [35]. The city of Bordeaux has also deployed a smart street lighting system covering 220 lampposts (see Section 10).

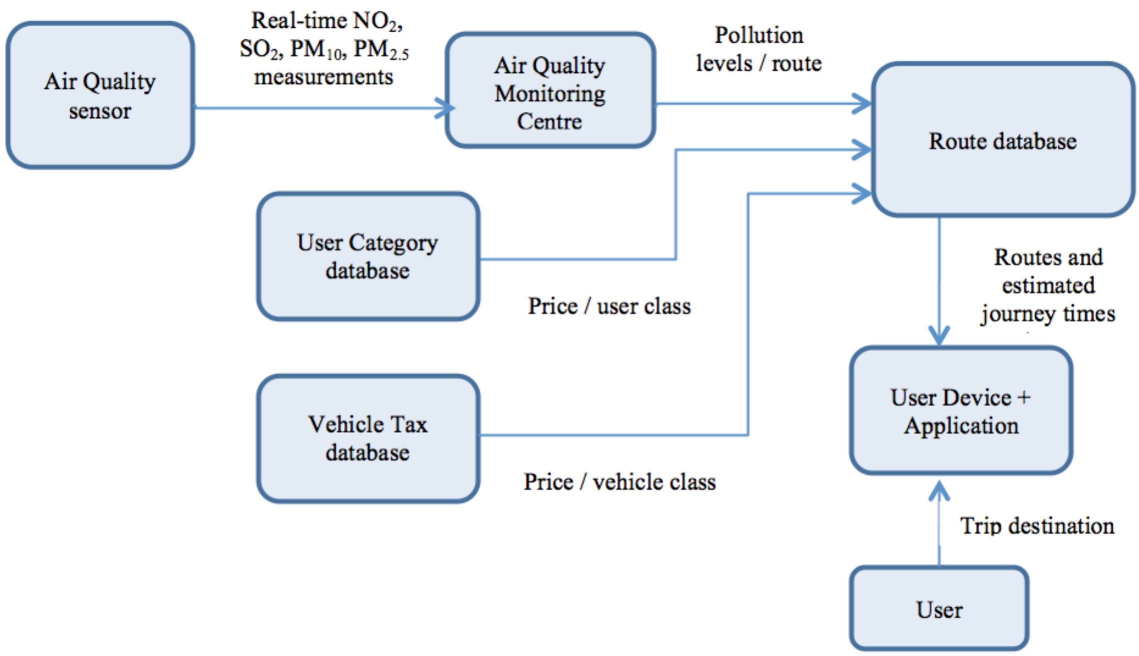
Smart City Cross-Domain Use Case

Air Quality Monitoring, Traffic Routing and Road Pricing (modified VICINITY)

City need: Cities such as London and Barcelona have a problem with air quality (especially NO_2, SO_2 and PM_{10} and $PM_{2.5}$ particulates) and ways are being considered to reduce levels of these in order to meet EU air quality directives [11].

Description: A dense network of air quality sensors would make it possible to differentiate between traffic routes for individual vehicles based on air pollution levels. It would then be possible to route traffic over less polluted routes thus reducing peak pollution levels. This could be implemented using an option on a vehicle SatNav which provided air quality-based routing in addition to lowest time or shortest distance routing. It might also be possible to link the charging data to the class of vehicle and its CO_2/NO_2/particulates emission levels, so that higher polluting (higher banded) vehicles were charged more to use a route with poorer air quality. An option would be to allow particular categories of users, e.g. doctors or health visitors to travel freely on any route.

Information exchange:



Relevant Agents:

Agent	Agent Type	Agent Description	Technology
Smartphone user	End User	People who download an app to allow their Smartphone to send air quality readings to a database, perhaps with some kind of payment	App on smartphone attached to an air quality sensor
Fixed sensor	End User	Fixed infrastructure	
Vehicle driver	End User	SatNav user	Adapted SatNav or Smartphone app
Route Database	Service provider	SatNav route provider	Data Centre
Air Quality Monitoring Centre	Independent Authority / Service provider	Collector of air quality data such as www.londonair.org.uk Provider of air quality data to users and route databases	Data Centre

Vehicle Tax / Road Pricing Database	Central Government Authority	Government sponsored authority on vehicle tax data – e.g. www.gov.uk/vehicle-tax or www.service-public.fr/particuliers/vosdroits/F19211	Data Centre
User Class database	Central Government Authority		Data Centre

Data Sources:

- A smartphone with a built in air quality sensor so that NO_2, SO_2, PM10 and PM25 can measured and sent in real-time to air quality monitoring centres such as www.londonair.org.uk.
- An in-vehicle SatNav adapted to offer routes based on air quality as well as shortest time or distance to destination. This could be made to work with air quality routing databases such as [36] and [37]
- Information from Vehicle Excise Centre.
  Government sponsored authority on vehicle excise data – e.g. www.gov.uk/vehicle-tax or www.service-public.fr/particuliers/vosdroits/F19211

Why is it cross-domain? It requires a link between the air quality monitoring data and the vehicle excise duty data in order to determine the appropriate rate for a vehicle to use a specific route.

Why is it commercially viable? Air Quality problems are one of the most pressing city needs as poor air quality is contributing to the deaths of 30,000 people per year in cities such as London [38]. Pilots are on-going in London, Barcelona and Cambridge. In Cambridge the option of allowing different categories of user to travel different routes is also being trialled. The question is does the reduction in cost for other sectors (e.g. the health service) exceed the cost of deployment of the infrastructure and who pays for it to be deployed?

Smart City Cross-Domain Use Case

Monitoring assisted persons outside the home (ACTIVAGE)

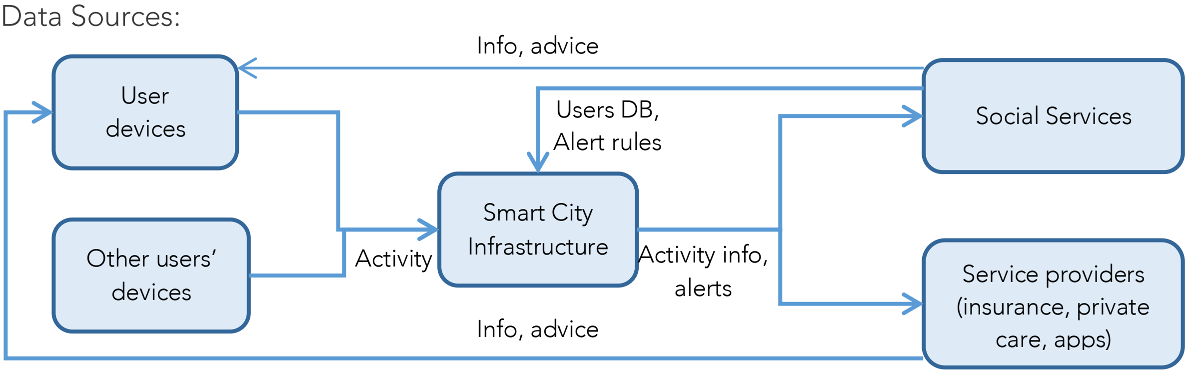
City need: Improved care to citizens, better quality of life (Quality of Life dimension)

Description:

The use case has two sub-cases:

1. A public service offered by municipalities to individuals
2. A private service offered by insurance companies and/or subscribers

Data Sources:



Relevant Agents:

For sub-case 1:

- Service Providers such as municipalities that open their Smart City infrastructure to be used by public/private initiatives delivering services to individual citizens.
- Technology providers: App developers, Smart City infrastructure vendors, IoT solution providers.

For sub-case 2:

- Service Providers: Insurance companies, private care companies, who can benefit from the available smart city infrastructure (for free or under a payment scheme).
- Technology providers: same as sub-case 1.

Information to be exchanged:

- Detection of an elderly person leaving the home.
- Information about their physical activity: measuring steps, distance walked and other physical activity outdoors.
- Monitoring the user's social activities such as going out, chatting with friends, communication with other users (e.g. through phone line), etc.
- Information that contributes to detecting cognitive impairment and pathologies (e.g. repetitive visits to the bank), or nutrition habits based on diversity of places where the elderly person goes.
- Detection of other elderly people in the same situation and doing the same thing, and alerting them.
- Control of the assisted elderly person within a security perimeter or route outdoors.
- Location of assisted elderly person outdoors and informing caregivers

Why is it cross-domain? In sub-case 1, linking the Economic dimension (ICT infrastructure of the city such as Hot Spots) with the Quality of Life dimension.

Why is it commercially viable?

Sub-case 1: provided as a public service offered to individuals: municipality owns a Smart City infrastructure; it gives value to their citizens and promotes local innovation and investment by spreading its use.

Sub-case 2: Private service offered by insurance companies and/or subscribers: for individual users, fee to insurance companies, or subscription to care providers; for insurance and private care companies, fund equipment for the delivery of the services.

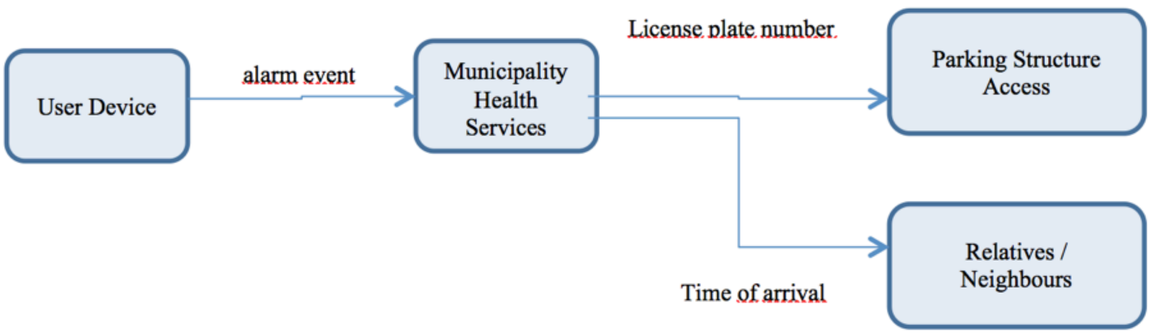
Smart City Cross-Domain Use Case

Smart Parking and Assisted Living (VICINITY)

City need: To enable health professionals and emergency services to get to residential homes more quickly.

Description: The Municipality of Pilea-Hortiatis (Greece) operates an eHealth at home pilot supporting around 50 registered homes in the municipality area. When one of the devices triggers an alarm, health care personnel are notified, a parking space is assigned, the license plate of the approaching car is white-listed and an estimated time of arrival is provided.

Information exchange:



Relevant Agents:

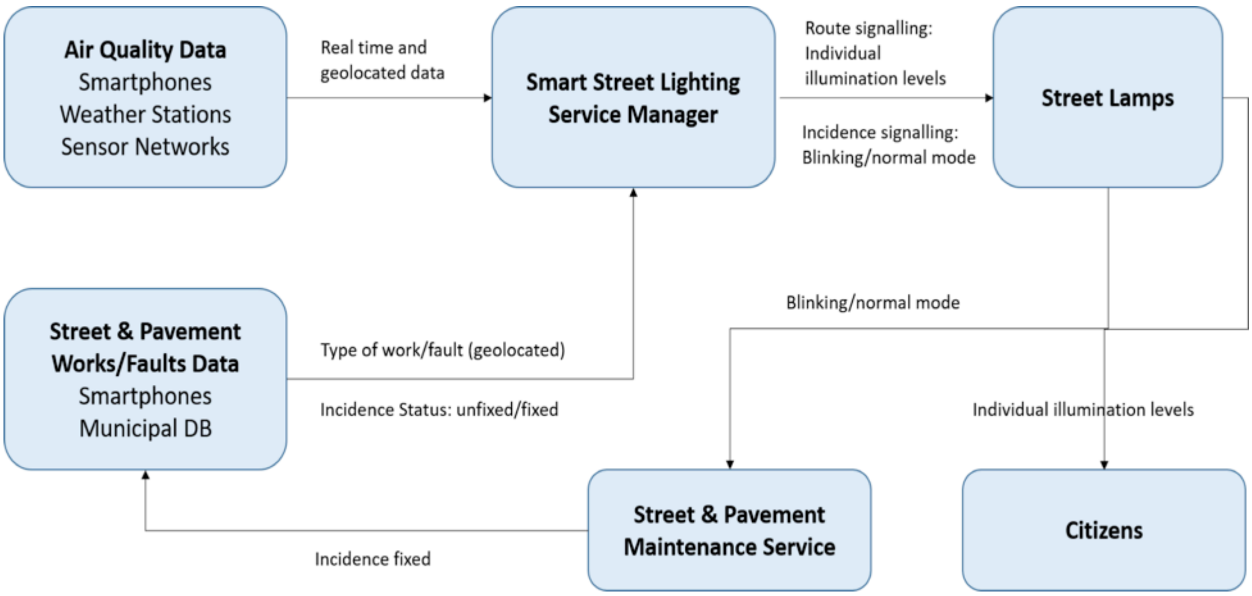
Agent	Agent Type	Agent Description	Technology
Elderly people	End Users	People living alone, in need for assisted living services provided by municipality health services personnel	
People with long term needs	End Users	People with specific needs (such as people with hypertensive, dementia, obesity etc.), living either alone or with daily assistance/ monitoring	
Relatives / Neighbours	Addressed Users	People related with the assisted living end users, who will be contacted if needed to interact or check on the condition of the end users (e.g. following a call from the Call Centre)	mobile apps for communication purposes
Doctors	Stakeholders	Doctors treating the people in need for assisted living, monitoring their medication and everyday health status and progress	mobile apps or dedicated applications providing full monitoring capabilities
Call Centre Personnel	Stakeholders	Specialised personnel working for the 24/7 call centre, being responsible for answering calls and responding to signals received by assisted living homes. Automatically reception of signals from home devices, including identification parameters, sensor values, GPS position	dedicated web-applications for remote monitoring and support upon triggering of alerts from end-user' devices
Health service providers	Stakeholders	To be either automatically contacted by call-centres or directly by the home communication infrastructure to immediately dispatch ambulance to people asking for help (e.g. in the case of a fall-detection)	

Data Sources: • A communication device, installed in-line with the user's regular telephone device, providing automated dialling to the 24-hour call centre at the user's request (through a remote wearable button) or when triggered by attached actuators. It also allows people to communicate from nearly everywhere in the apartment utilizing a high quality long-range microphone and speakerphone. • A pressure monitoring device (able to measure systolic/diastolic pressure and heart rate levels) and a weight monitoring device (measuring weight, mass index, resting metabolism, visceral fat level, skeletal muscle, body aging) allowing collection of a series of important health parameters (for example for people with hypertension). The measurements are scheduled to be taken once a day, requiring the patient to make use of the device placed within their apartment, and are then communicated on a daily basis to the municipality's secure data warehouse for future reference. • A wearable "panic button", the call centre to be contacted with a single tap at any time of day, so that the owner does not feel unsafe when being alone at home. It further allows phone calls to be answered from everywhere within the apartment, without the need to run to the phone device to answer risking an accident. Many accidents are caused this way. In case of emergency, and if the person wearing the necklace falls down, the 24 hours support service is automatically alerted in order to promptly provide first aid (send an ambulance or inform a relative to help). • A wearable GPS Positioning device for elderly people with dementia, allowing their relatives to be informed of their exact coordinates in case they move outside of a pre-defined area.
Why is it cross-domain? It requires a link between the municipality health services database and the parking structure database in order to allocate a specific parking slot to a defined vehicle.
Why is it commercially viable? Active and Healthy Aging is one of the largest budgetary expenditures to cities and it would save cities a lot of money if people could be kept living in their own homes for longer. Pilots are on-going in Pilea-Hortiatis (Greece) and other municipalities in the H2020 VICINITY and ACTIVAGE projects.

Smart City Cross-Domain Use Case

Smart Street Lighting, Air Quality Monitoring and Pedestrian Safety (Madrid)
City need: Pollution in the City of Madrid has become a serious issue, particularly for the citizens´ health (respiratory and cardiovascular diseases, allergies, cancer, etc.). The City Council is working on a hardening of the measures to be taken, to achieve healthy air quality levels and in accordance with the legislation; especially the ones related to traffic management - limiting the speed of vehicles or prohibiting to park- since it's responsible of most of the total emissions. On the other hand, it is also desirable to reduce the number of accidents caused to pedestrians due to maintenance works and faults in the streets. Focused in these two aspects, CeDInt-UPM has deployed a pilot in the International Excellence Campus that UPM has in Montegancedo as Testbed for the city of Madrid (https://www.cedint.upm.es/en/project/living-lab-illumination)
Description: In order to mitigate air pollution effect on citizens, this application aims to guide/recommend pedestrian alternative routes (at nights) according to pollution levels in the area and considering the existence of street & pavement works/faults. The Smart Street Lighting Service Manager (SSLSM) gathers air quality parameters based on static (weather stations, sensor municipal and collaborative networks) and mobile (smart phone users) sources. Besides, it collects street & pavement works/faults data from municipal sources and citizens involvement (smartphones). The SSLSM indicates the alternative routes by regulating the illumination level of each street lamp (e.g. the best route will present the highest light intensity), and signals the street & pavement works/faults setting the nearest street lamp on blinking mode, preventing accidents and helping the maintenance service to locate the incidence.

Information exchange:



Relevant Agents:

Agent	Type	Description	Technology
Pedestrians	End Users	Citizens walking in the city streets during night time.	-
Smart Street Lighting Service Manager	Service Provider	Company managing of the Smart Street Lighting infrastructure.	Management application
Road/street/pavement Maintenance Service	Service Provider	Company in charge of the street works.	-
Citizens with smartphone	Data Provider	Citizens providing air quality and works/faults data using their smartphones.	Apps on smartphone

Municipal Environment, Civil Works and Health Councils	Stakeholder / Data Provider	Public authority benefiting from improving citizens' health and preventing incidents. Collectors of air quality and road/street works data.	Data Centre

Data Sources:

- Weather stations capable of monitoring, among others, air quality parameters such as CO_2 or NO_2.
- Air Quality wireless sensors equipped with ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrous oxide sensors.
- Smartphones with two different applications: a) to continuously monitor and send air quality data; b) to register and send works/faults at streets and pavement.
- LED street lamps equipped with communication and control devices.

Why is it cross-domain? It requires access to information that is normally held in separate silos: Smart Street Lighting, Air Quality Monitoring and Pedestrian Safety.

Why is it commercially viable? The effect that pollution has on people is devastating, even leading to death. The cost that this implies for Health Services is very high. Minor, but also relevant, the costs associated with accidents caused to pedestrians due to works on the streets. The technological investment required to implement the proposed solution in a City is derisory compared to all these expenses. Besides, the solution can be easily replicated in other cities and is scalable and incremental, since the technology can also be used by additional domains.

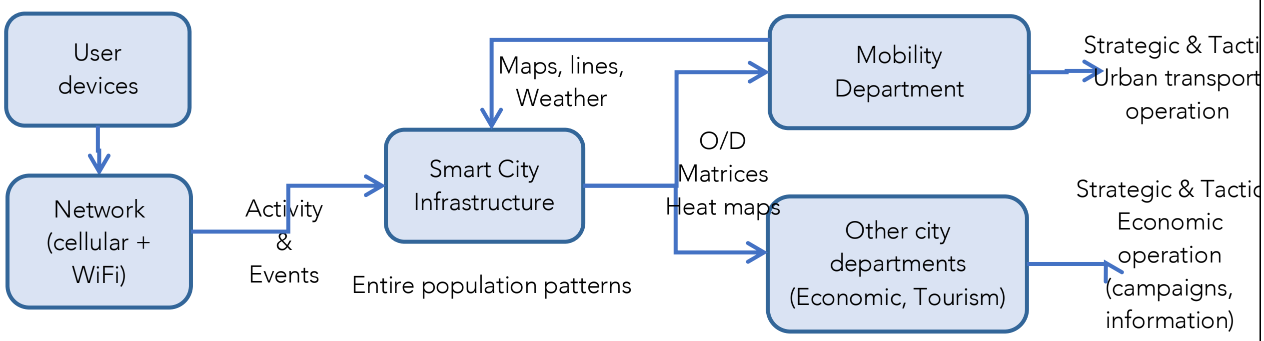
Smart City Cross-Domain Use Case

Mobility inside the city (REPLICATE)

City need: To have a better understanding of mobility behaviour of vehicles and pedestrians (Mobility dimension), with application for mobility (e.g., transport modes) and other applications (economic, tourism). Improve the support for decision making. Improve knowledge of the mobility in the city. This knowledge implies improving the quality of the data and its cross exploitation.

Description: The collection of telecom traces and events (handovers in cellular networks, connections at wifi hotspots) to be used by the mobility department to create origin-destination matrix in near-real time, to gradually advance towards real time in the future. Specific treatment of key aspects: security/privacy of information, data governance, quality of service and standardization / interoperability.

Information exchange:



- Network events: CDR (Call Detail Record) or Call Forwarding. Regular and frequent exchanges between mobile devices and antennas. Constant localization of the mobile device. Events: network-triggered location (initial connection, handover, LA change, pulling) and event-triggered location (calls, SMS, internet connection, checks). Data connectivity to the local WIFI system and location data from the base stations and routers. All this information is provided aggregated and anonymized.
  - O/D matrix (system generated).
  - Aggregated mobility diagrams (modal sharing, heat traffic maps).
  - Traffic info (road, parking).
  - Pattern for the entire population.
  - Other info: maps, public lines, weather.

Currently the different municipal departments manage their own information, with occasional and manual coordination. The cross-matching possibilities between different sources are not exploited and there is high dependence towards ICT solution providers.

Relevant Agents:
- Telecom operator: it provides trace sets about network usage through network events (handovers, network monitoring events, user-generated events, wifi events).
- Mobility department of the municipality.
- Other city departments (e.g., tourism, economic activities) to exploit the data for other purposes.

Why is it cross-domain? Mobility dimension + Information and Communication dimension + Others (economic, tourism).

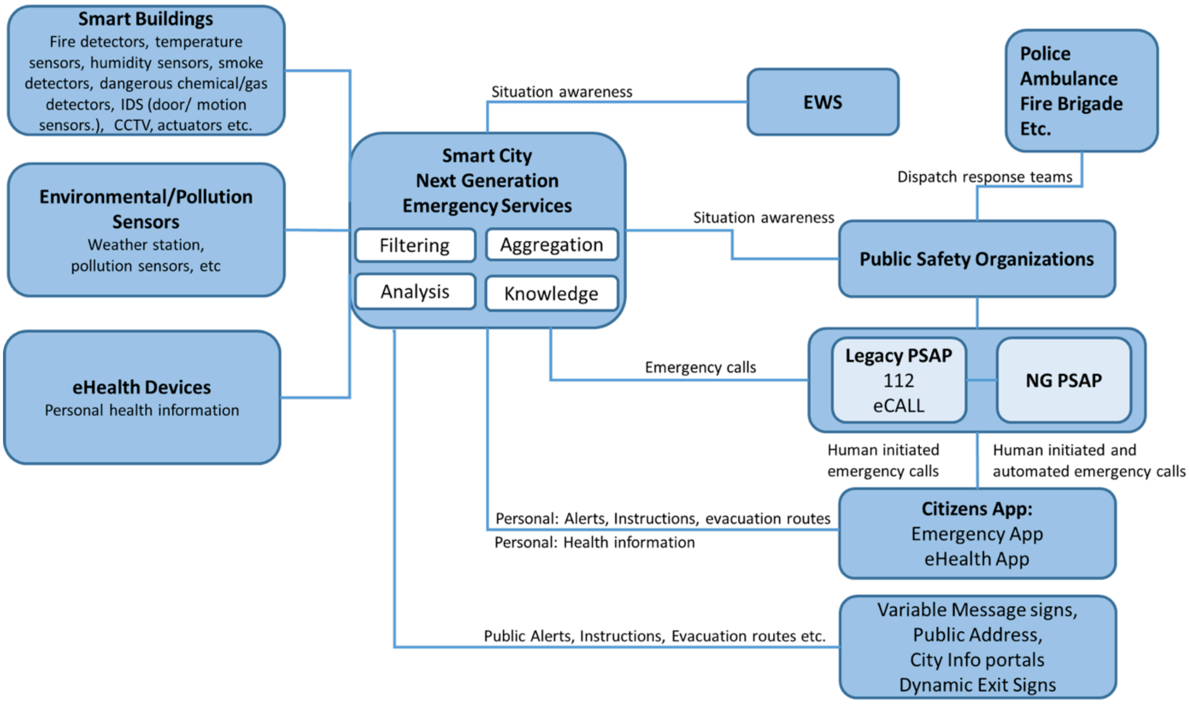
Why is it commercially viable? The approach contributes to the implementation of a more efficient management of urban resources, offering a better offer of services to different users (pedestrians, commuters, visitors):
- Asses the impact of specific measures and respond to incidents in a reasonable time.
- Centralization, processing and exploitation of mobility data with tools, in order planners, operators and transport authorities to have a real view of the current state of mobility both at urban level and in its surrounding territory.
- Mobility Indicator Control Panel that compiles, analyzes and displays the state and evolution of the city's main KPIs: heat maps, O/D matrices and modal distribution.

Currently, an annual data consolidation is carried out, with insufficient frequency to assist in the operation. The information is not exploited in a coordinated way, data sources are not merged, they are treated separately, so it is even difficult to assess whether the information that is already available is sufficient or not.

Smart City Cross-Domain Use Case

Next Generation Emergency Services (NGES)
City need: Improve situation awareness and response capabilities to crisis situations and improve citizens' safety by utilizing smart buildings, citizens' eHealth services and environmental sensors. In case of a crisis situation in private and public smart buildings (e.g. fire, bomb attack, gas leakage etc.), and/or crisis situations initiated by natural disasters, Smart Cities NGES can interact with public safety agencies and citizens for enhanced situation awareness and emergency response. Smart cities NGES will be able to manage tasks such as data aggregation, filtering and analysis of emergency events taking into account the dynamics of a crisis event and interact with (a) the citizens and (b) with public safety agencies (c) with smart city objects/devices. Examples of EU R&D projects partially addressing the use case are NEXES [39] and eVACUATE [40]
Description: The use case has the following sub-cases. 1. A smart building (private and/or public) equipped with smart sensors (temperature, smoke detectors, humidity sensors, gas detectors etc.) monitor parameters of interest 2. Smart environmental sensors that measure environmental parameters of interest (e.g. weather stations, pollution sensors etc.) 3. eHealth devices and/or eHealth apps that can share citizen health information The functionalities of the Smart Cities NGES are: a. Trigger automated emergency calls to PSAP, initiated by smart buildings, by smart environmental sensors, by eHealth applications and send real time information to PSAP for enhanced situation awareness of critical parameters b. Control (automatic or semi-automatic) actuators to minimize the spread of an incident c. Send information/instructions to the public/citizens within the vicinity of the incidents (inside a building, vicinity of a building, in critical area etc.) through various means (mobile apps, city information points, public address, variable message signs etc.), supporting evacuations (e.g. dynamic exit signs). d. Dispatch information to disaster response teams e. Receive information by citizens f. Interoperate with Early Warning Systems

Information exchange:



Relevant Actors:

Agent	Type	Description	Technology
Smart Cities NGES	Service provider/Smart City NGES operator	The service is dedicated to emergency management and response and acts as an intelligence, integration and interoperability layer with public safety services, citizens, smart objects/devices	Smart Cities IoT platform. Filtering, aggregation, analysis, knowledge extraction
Public Safety Answering Points (PSAP) – Legacy PSAS & NG PSAP	Public Authority/PSAP operator	24 hours PSAP operation that receives traditional 112 calls, human originated NG emergency call and automated emergency calls originated by smart cities NGES	Legacy PSAP, Next Generation (NG) PSAP (SIP based calls), GIS based emergency platforms, first responders' devices (text, voice and multimedia devices)
Smart Building infrastructure	Private and public smart building infrastructure (e.g. residential buildings, airports, schools, hospitals, municipality buildings etc.)	Smart buildings providing information about fire detection, temperature, humidity, smoke, chemicals/gas, intrusion detections, CCTV, actuators	Smart sensors and actuators, IoT smart building aggregation nodes, IoT hubs, communication and control devices
Smart City environmental sensors and/or external environmental data sensor providers	Smart City environmental sensor infrastructure and external or commercial data providers	Environmental sensors and external environmental data providers that are connected to the Smart Cities NGES providing information about parameters such as wind speed, temperature, humidity, rain fall, ice, pollution, air quality, water levels etc.	Environmental sensors and pollution detectors, sensor aggregation nodes and gateways
Smartphone apps	Data consumer (personalized and/or broadcast) and data producer. eHealth devices and eHealth apps. 112 Emergency app etc.	Citizens providing health data via eHealth devices, manual entry data, voice etc. Citizens can initiate 112 and NG 112 call, Citizens can receive instructions	Mobile apps, eHealth devices, PSAP gateway
Variable message signs, public address (or similar), dynamic exit signs, EWS, citizens app etc.	Data Consumer (public or private owned)	Consumes and disseminates emergency data from smart buildings, smart environmental sensors, citizens app to citizens	Dynamic signage gateways (signage, text, voice and multimedia), EWS gateway
Public safety organizations	Data consumers/data providers. Emergency centres and emergency response teams (e.g. fire brigade, police, civil	Public safety organizations are able to consume emergency data, receive PSAP calls and dispatch	Public safety data centres and infrastructure

	protection, ambulance etc.)	information to emergency teams	
Early Warning System	Data consumer, public or private owned service	Existing EWS can consume NGES events, alerts etc. to improve situation awareness	EWS data centres, interface to NGES platform

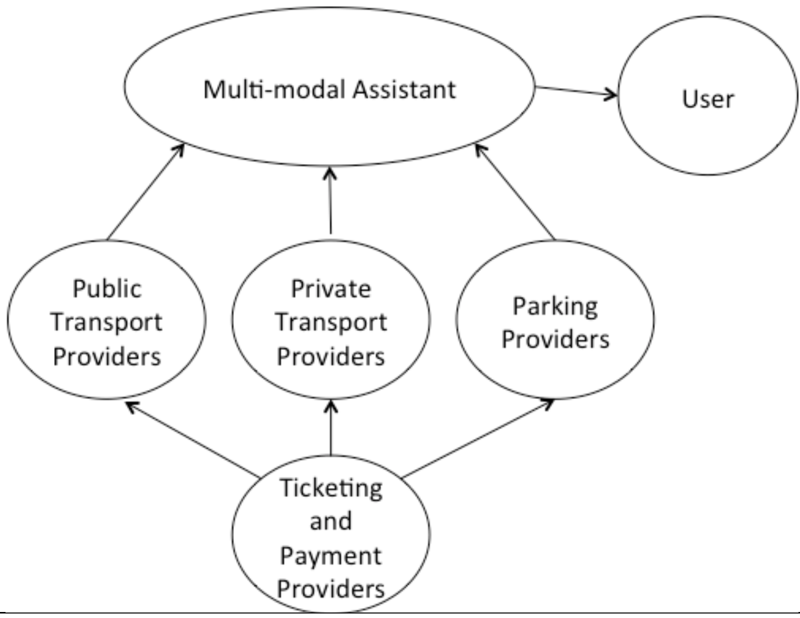
Data Sources:

- Smart buildings: Fire/smoke detectors, temperature sensors, humidity sensors, chemicals/gas detectors, intrusion detection systems, CCTV, actuators etc.
- Environmental and pollution detection: wind speed, temperature, humidity, rain fall, ice, pollution, air quality, water levels etc.
- eHealth devices: Personal health information
- Citizens Apps: Information from emergency area, personalised information

Why is it cross-domain? It requires access to information that is normally held in separate silos. It requires interworking and data exchange among heterogeneous devices, sensors, applications, public safety organizations and citizens.

Why is it commercially viable? Effective emergency response operations can save lives of citizens, improve public safety response and resource allocation, avoid spreading of disasters, and thus reduce cost of damage. Investment in smart buildings, environmental/pollution detection infrastructure, external data source providers, smartphone application development, ICT infrastructure for smart signage will be fostered while smart cities will increase business continuity and attract investment of new businesses. The NGES can be easily replicated in other cities, the concept can be implemented in an incremental and modular way adding additional smart city domains. In terms of rollout investment strategy, the realisation of such cross-domain use case heavily depends on a mixture of public and private funding. Especially for the former, the regulatory regime should be in place (as an example eCall [41] is mandatory since 31st March 2018), acting as a facilitator for wide deployment and relevant civil protection infrastructure (i.e. PSAP, C2s) modernisation. For the private sector an investment strategy should include both the individual consumer and the public/city authorities in the loop, maximising their business cases spanning from add on security services to conventional users of IoT applications to specialised services that address civil protection/public safety users and relevant city authorities.

Smart City Cross-Domain Use Case

Mobility as a Service (SynchroniCity)
City need: Cities need to both reduce traffic congestion and the air pollution from vehicles in order to improve the heath and quality of life for their citizens, while also increasing competiveness of the businesses located there.
Description: A multi-modal travel assistant gathers information from a range of IoT devices (e.g. traffic intensity, parking sensors, etc.) and the city context data in order to help users achieve goals such as: • Obtaining accurate and optimized travel itineraries based on real-time and updated mobility data, user's preferences and requirements. • Access to wider and complementary offers of transportation modes. • Easier combination of public and private (owned or shared) transportation modes. • Easier location of free parking spaces. • Avoidance of infringements and fines. • Better understanding of the total cost of transportation and ticket validity. • Using travelling time more efficiently. • Use of a single ticket covering all modes of transport. • Access to a seamless and flexible payment system.
Information to be exchanged: 
Relevant Agents: • Multi-modal Travel Agent. • Transport providers. • Parking providers. • User device.

Data Sources: • Traffic sensors must at least provide their GPS location and the traffic flow intensity. • Parking sensors must at least provide their GPS location and their status. • Vehicle sensors must at least provide vehicle/transportation line info, speed and their GPS location. • Environmental sensors must at least provide humidity, air quality, noise and wind speed. • User devices must at least provide their GPS location. • Ticketing devices must at least provide user information, transport mean and their GPS location. • Bike docking stations must at least provide user information, bike info, status and their GPS location. • Mobility premises must at least provide humidity, Air quality, noise and wind speed.
Why is it cross-domain? It requires access to the information held in databases of many different transport and parking providers.
Why is it commercially viable? There is a city need and customer demand but services (such as MaaS) are only just getting off the ground.

8. KPIs for Cross-Domain Interoperability

There are many standard sets of KPIs which are relevant to Smart Cities including:

- BSI [3]
- ISO [42]
- ISO/IEC [43]
- ITU-T SG20 [44]
- CITIkeys [45]
- ETSI Standard TS 103 463 V1.1.1 (2017-07) [46]

However, what is specifically needed for this study are KPIs which focus on the ability to compare and exchange data between domains, and none of the above frameworks focus specifically on this. For example [46] contains the following indicators for ICT services:

Indicator title	Indicator unit	Definition
Access to public transport	% of people	Share of population with access to a public transport stop within 500 m
Access to vehicle sharing solutions for city travel	#/100 000	Number of vehicles available for sharing per 100 000 inhabitants
Length of bike route network	% in km	% of bicycle paths and lanes in relation to the length of streets (excluding motorways)
Access to public amenities	% of people	Share of population with access to at least one type of public amenity within 500 m
Access to commercial amenities	% of people	Share of population with access to at least six types of commercial amenities providing goods for daily use within 500 m
Access to high speed internet	#	Fixed (wired)-broadband subscriptions per 100 inhabitants
Access to public free WiFi	% of m2	Public space Wi-Fi coverage
Flexibility in delivery services	Likert	The extent to which there is flexibility in delivery services

These relate to outcomes but don't relate specifically to the ease with which cross-domain data can be used to facilitate the outcomes.

In order to foster the uptake of cross-domain smart city deployments, interoperability indicators should be defined addressing the following indicative aspects:

- Cross-domain technology and infrastructure (i.e. interoperability across domain specific technologies and infrastructures; new as well as legacy)
- Cross-domain data access and data sharing (i.e. availability of data and interoperable data exchange; data translation of domain specific context across different domains; mechanism to seamless share data across different domains)
- Cross-domain services (i.e. provision and sharing of services across different domains)
- Cross-domain applications (i.e. application layer interoperability across different domains)
- Cross-domain big data and analytics framework (i.e. big data and analytics frameworks across different domains; analytics as a service, cross-domain reasoning)
- Cross-domain IoT systems and platforms interworking capabilities (i.e. interoperability over IoT platforms and systems across different domains)

- Cross-domain trustworthy data access, sharing, aggregation and distribution (i.e. security and privacy across different domains; security assurance framework)

BSI PAS 182 [4] provides a framework that can normalize and classify information from many sources so that data sets can be discovered and combined to gain a better picture of the needs and behaviours of a city's citizens (residents and businesses).

9. Requirements for Standards

Standards provide:
- Interoperability between services / subsystems / components / devices
- Regulatory compliance
- Cheaper products (due to commoditization)
- Avoidance of vendor lock-in
- The ability to introduce new business models

Standards help enable interoperability, avoid "vendor lock-in" improve economies of scale and cost savings create a common market, improve global market access disseminate awareness and knowledge foster progress, cross-education and innovation. Standardization is voluntary/dynamic, not from regulators 'Self regulation' by the market and best practice benchmark. Governments/Citizens need to reference them for Protection of health and the environment, ensuring safety. Compatibility and interoperability of public services. Standards help all stakeholders including: industry at large, small and medium-size enterprises public authorities and regulators, academia and the research community consumers, etc.

Examples of where standards are important to Cross-Domain interoperability include:
- Data interoperability
- Device interoperability

For example, a standardised way to freely expose subsets of city data to app developers, such as weather, maps and transport information, is an important platform feature. In the hands of innovative app developers, combining different datasets of this sort can lead to new apps and create extra value [9].

Standards are required for communication between federated platforms so that data can be exchanged seamlessly and transparently. Such an architecture is described in [47].

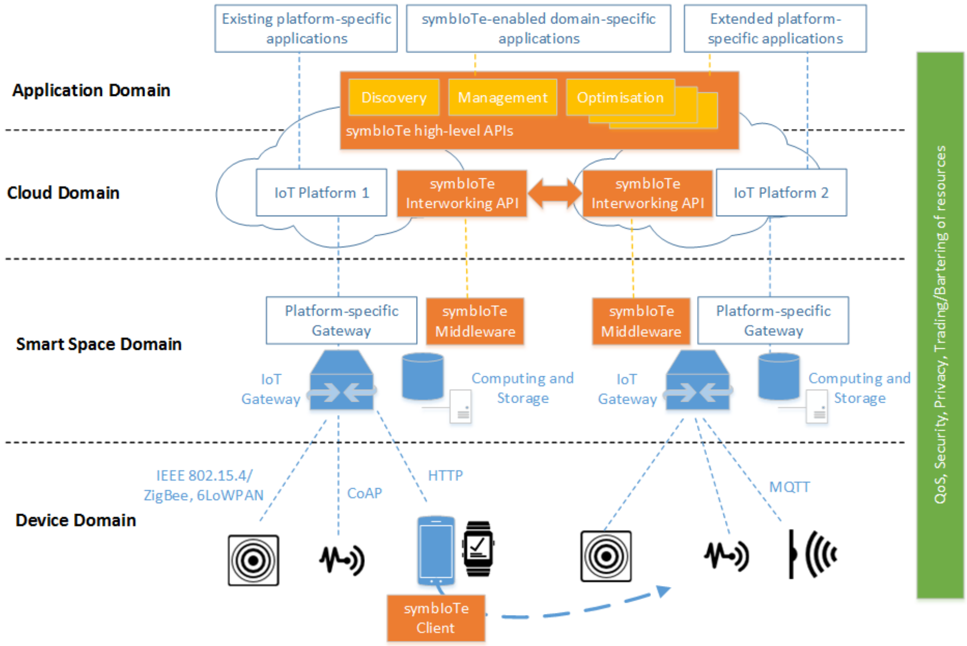


Figure 10. Example of a federated architecture from symbIoTe.

As it can be seen in Figure 10, symbIoTe [48] proposes a novel approach for connecting platforms, being those federated or not, in order to allow the development of applications using resources from third parties' platforms. In order to be part of the symbIoTe ecosystem, and thus interoperable within it, all platforms must be symbIoTe compliant. symbIoTe builds a virtual IoT environment through an abstraction layer, where virtual representations of sensors and actuators are exposed. Then, using high-level APIs, or either enablers, all members of the ecosystem are able to search, discover and use others' resources. Federation is the second step on interoperability, offering trust and negotiation mechanisms for allowing the creation of new business models on top of it. More details at domain level:

- At Application Domain, symbIoTe offers a high-level API for managing virtual IoT environments, enabling the creation and management of cross-platform environments discovering, optimizing and managing resources and data. In addition to this, a set of enablers (similar concept as the one offered by FIWARE) is provided in order to ease the development of domain-specific applications.
- The Cloud Domain provides an interworking API for the exchange of information between two collaborating IoT platforms, following standards like the one conducted by oneM2M. It exposes a directory of open resources.
- For the Smart Space Domain, symbIoTe exposes a standardized API for resource discovery and configuration allowing a simplified integration of sensors and platforms within the smart space.
- Through device specific clients, smart objects from the Device Domain, are integrated into the smart spaces preventing vendor lock-in.

Note that oneM2M has a federated approach but only when both platforms are oneM2M compliant. When either or both platforms are non oneM2M compliant, they should both use a RESTful API to exchange data successfully. This is an API that uses HTTP requests to GET, PUT, POST and DELETE data or a RESTful web service which is based on representational state transfer (REST) technology.

For interworking with the non-oneM2M platforms and systems, oneM2M specification defined the interworking proxy entity (IPE). IPEs provide non-oneM2M reference points and remapping the related data model into the oneM2M-defined data model, which are eventually exposed to other oneM2M platforms and/or applications. The IPE abstracts and maps the non-oneM2M data model to the oneM2M resources. It enables bidirectional communication between the oneM2M system, non-oneM2M platforms and systems and supports seamless interaction between applications and devices using the oneM2M RESTful API.

The ISO/IEC JTC 1 IoT Reference Architecture is provided in [49].

10. A platform route to IoT enabled smart cities: City of Bordeaux case study

In 2017, the public lighting services of Bordeaux Métropole and the City of Bordeaux had the opportunity to benefit from public funding to deploy an IoT 'experiment' in a city district. 220 smart lampposts were installed in a district in the north of Bordeaux which hosts public facilities that are only used occasionally during events. These facilities include the exhibition center, the convention center, the MATMUT Atlantic stadium used for soccer games and concerts, the velodrome, etc. As this district does not need to be lit on a permanent basis, if street lights are only switched-on when there is an event or when street sensors detect vehicles or pedestrians, then significant energy and financial savings can be made.

The experiment was perceived to be a success, and other city departments then expressed interest in connecting other management services using the IoT model. The use cases for these included:

- Supervision of boilers for a group of schools and sports facilities.
- Provision of electric vehicle charging stations.
- Access control gates.
- Water, electricity and gas meters.
- Points for collection of voluntary contributions of goods.
- Garbage collection bins.

To pilot all these sensors / actuators, the Digital Department carried out a study of the IoT network to be deployed and the use that could be made of it given the volume and diversity of the management services to be connected. Very quickly, it became clear that the range of management services used different connectivity and data connectivity technologies and they reached a key conclusion: Building IoT in siloes will not scale and that an abstraction model to bridge the gap between operational technologies and the digital world was needed, otherwise it will be impossible to master the total cost of ownership. The city concluded that a standard such as the oneM2M data platform provides a unique value proposition to providing management services in an open manner, therefore avoiding lock-in to specific provider.

As a result, a special technical clause was included in all new calls for tender stating: "The holder shall propose a connection method that is based on the oneM2M Release 2 standard published in September 2016 and available under www.oneM2M.org".

11. Conclusions and Recommendations

Proliferation of IoT use cases in Smart Cities is inevitable. Cities often need to make trade-offs between a) time to market/deployment, which may provide a preference for turnkey solutions, and b) sustainability and reusability, which may incur an initial deployment delay but is the best way to master the total cost of ownership and to fuel innovation over a longer period of time.

To date, operational deployments of IoT-enabled Smart Cities have usually favoured the first (turnkey) approach because of: organisational barriers, short term cost advantages and the learning curve needed to embrace IoT at large scale. However, cities often favour a horizontal approach (not necessarily using a single network or platform) which is perceived as the long term profitable strategy as IoT use cases within cities develop and flourish. When it comes to sourcing operational solutions, often-times addressing operational objectives has so far outweighed the longer term benefits of an horizontal approach. These issues have been highlighted recently by ETSI ISG CDP in a white paper targeted at city mayors and chief executives [50].

The main driver for a change in city strategy will be the emergence of market-driven use cases which provide mechanisms to support key city priorities as drivers for change, in many cases backed up by legislation. However, in order to drive these forward it many be necessary to set up a City Governance Council with the responsibility, accountability and budget to accomplish this overarching objective.

Many of these use cases are cross-application or cross-domain by their very nature and will naturally favour the horizontal approach to IoT-enabled Smart Cities. This report has identified a set of commercially viable and economically sustainable cross-domain use cases which are either cross-application or cross-domain. These use cases will provide market drivers for horizontal integration, changing procurement processes in such a way that component re-usability will be integral to such processes.

Based on these conclusions, AIOTI makes the following recommendations:

1. Cities need to think horizontally during procurement, only then can they master the total cost of ownership for IoT use cases that are increasingly cross-application and cross-domain.
2. Proving a clear business case can be challenging for new innovations for which little historic evidence is available. As a consequence, replication and experience sharing among cities are key to overcome the long learning curves needed to understand the cost/benefits of such use cases.
3. Ultimately a horizontal approach is about building a robust data infrastructure which provides the necessary conditions for a wide range of applications to be deployed and to create value to the city in many ways.

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Triangulum
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References:

1 AIOTI WG08 "Smart City LSP Recommendations Report", November 2015.

2 AIOTI WG08 "Guidelines and blueprints for IoT enabled smart cities", 2017.

3 BSI PAS 181:2014 "Smart city framework – Guide to establishing strategies for smart cities and communities".

4 BSI PAS 182 "Smart city concept model – Guide to establishing a model for data interoperability".

5 ETSI TR 103 290 V1.1.1 (2015-04) "Machine-to-Machine communications (M2M); Impact of Smart City Activity on IoT Environment": https://portal.etsi.org/webapp/ewp/copy_file.asp?Action_type=&Action_nb=&Wki_Id=42454

6 Telit: IoT Applications in a Smart City - www.telit.com

7 Francois Ennesser, Gemalto, "Preserving Privacy and enabling Trust in the Smart City: The key to widespread service deployment?", ETSI Smart City Workshop, 3-4 June 2013, Sophia Antipolis

8 EC Directorate General for Internal Policies, Policy Department A: Economic And Scientific Policy, *Mapping Smart Cities in the EU*, 2014.

9 oneM2M White Paper "Smart Cities done Smarter", February 2017.

10 Deloitte: Smart City Capability Framework.

11 EU Directive 2008/50/EC - http://ec.europa.eu/environment/air/quality/directive.htm

12 List of H2020 Smart City Lighthouse projects: http://www.smartcities-infosystem.eu/scc-lighthouse-projects.

13 H2020 GrowSmarter project: http://www.smartcities-infosystem.eu/sites-projects/projects/growsmarter

14 H2020 IRIS project: https://www.smartcities-infosystem.eu/sites-projects/projects/iris

15 H2020 MAtchUP project: https://www.smartcities-infosystem.eu/sites-projects/projects/matchup

16 H2020 mySMARTLife project: http://www.smartcities-infosystem.eu/sites-projects/projects/mysmartlife

17 H2020 REMOURBAN project: http://www.smartcities-infosystem.eu/sites-projects/projects/remourban

18 H2020 REPLICATE project: http://www.smartcities-infosystem.eu/sites-projects/projects/replicate

19 H2020 RUGGEDISED project: http://www.smartcities-infosystem.eu/sites-projects/projects/ruggedised

20 H2020 Sharing Cities project: http://www.smartcities-infosystem.eu/sites-projects/projects/sharing-cities

21 H2020 SmartEnCity project: http://www.smartcities-infosystem.eu/sites-projects/projects/smartencity

22 H2020 SMARTER TOGETHER project: http://www.smartcities-infosystem.eu/sites-projects/projects/smarter-together

23 Stardust: https://www.smartcities-infosystem.eu/sites-projects/projects/stardust

24 Triangulum: http://www.smartcities-infosystem.eu/sites-projects/projects/triangulum

25 IoT European Large Scale Pilots programme: www.european-iot-pilots.eu

26 Delivering an IoT enabled Digital Single Market for Europe and Beyond: www.synchronicity-iot.eu

27 The Marketplace of the European Innovation Partnership on Smart Cities and Communities: https://eu-smartcities.eu/

28 EIT Digital Cities projects: https://www.eitdigital.eu/newsroom/digital-cities/

29 CEDUS City Enabler for Digital Urban Services: http://cedus.eu/index.html

30 Green Digital Charter, Collection of Case Studies, European Smart Cities using ICT: http://www.greendigitalcharter.eu/

31 ETSI GR CIM 002 Context Information Management (CIM): Use Cases (UC).

32 VICINITY D1.3 "Report on Pilot Sites and Operational Requirements"

33 FG-DPM D1.1 unified use case template https://www.itu.int/en/ITU-T/focusgroups/dpm/Pages/default.aspx

34 ISO/IEC JTC1/WG10 N417 Draft TR on IoT Use cases.

35 IoTUK "The Future of Street Lighting - The potential for new service development", Future Cities Catapult, 2017 - https://iotuk.org.uk/wp-content/uploads/2017/04/The-Future-of-Street-Lighting.pdf

36 NHS Plan a lower pollution travel route: http://www.breathelondon.org/plan-lower-pollution-travel-route

37 Clean Air Route Finder, Mayor of London, London Assembly - https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/clean-air-route-finder

38 Health risks of air pollution in Europe – HRAPIE project. New emerging risks to health from air pollution – results from the survey of experts - http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/health-risks-of-air-pollution-in-europe-hrapie-project.-new-emerging-risks-to-health-from-air-pollution-results-from-the-survey-of-experts

39 H2020 NEXES project: https://cordis.europa.eu/project/rcn/194850_en.html

40 EU FP7 eVACUATE project: https://cordis.europa.eu/project/rcn/108077_en.html

41 eCall Service: https://ec.europa.eu/transport/themes/its/road/action_plan/ecall_en

42 ISO 37120:2014: Sustainable development of communities. Indicators for city services and quality of life: https://www.iso.org/standard/62436.html

43 BS ISO/IEC 30182:2017 "Smart city concept model. Guidance for establishing a model for data interoperability".

44 Recommendation ITU-T Y.4900/L.1600 gives general guidance to cities and provides an overview of key performance indicators (KPIs) in the context of smart sustainable cities (SSCs).

45 CITYkeys KPIs: http://www.citykeys-project.eu/

46 ETSI Standard TS 103 463 V1.1.1 (2017-07) "Access, Terminals, Transmission and Multiplexing (ATTM); Key Performance Indicators for Sustainable Digital Multiservice Cities".

47 ITU-T FG-DPM-O-052 "Framework to support data interoperability in IoT environments" - Draft for input to ITU-T SG20

48 H2020 symbIoTe project: https://www.symbiote-h2020.eu/

49 ISO/IEC CD 30141 ISO/IEC JTC 1/WG 10 "Information technology – Internet of Things Reference Architecture (IoT RA)"

50 ETSI White Paper 26 "The 4th Industrial Revolution and the Municipal CEO", ETSI ISG CDP, April 2018 – available from http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp26_city_digital_profile.pdf

Annex A Template for a Smart City Cross-Domain Use Case

Title:
City need:
Description:
Information to be exchanged:
Relevant Agents:
Data Sources:
Why is it cross-domain?
Why is it commercially viable?

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