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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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1 Scope

The present document would undertake compilation and review of activities taking place in the area of Smart City. It will analyse the relevance of Smart City applications, and possible underlying network architecture. The present document will describe use case descriptions for Smart City applications in context of but not limited to IoT communications.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Toward a framework for Smart Cities: A Comparison of Seoul, San Francisco & Amsterdam.

NOTE: Available at http://iis-db.stanford.edu/evnts/7239/Jung_Hoon_Lee_final.pdf

[i.2] Gordon Falconer Shane Mitchell: "Smart City Framework A Systematic Process for Enabling Smart+Connected Communities".

NOTE: Available at https://www.cisco.com/web/about/ac79/docs/ps/motm/Smart-City-Framework.pdf

[i.3] The Role of Standards in Smart Cities Issue 1.

[i.4] http://www.gartner.com/technolog.

[i.5] http://www.idc.com.

[i.6] CleanTechnica: "Predictive Energy Optimization: Smart Buildings, Smart Grids, Smart Cities".

NOTE: Available at http://cleantechnica.com/2014/02/12/predictive-energy-optimization-smart-buildings-smart-grids-smart-cities/#OkeRr1jvH9JBiACL.99

[i.7] IBM: "Smarter Buildings".

NOTE: http://www.ibm.com/smarterplanet/us/en/green_buildings/overview/

[i.8] http://www.smartsantander.eu/.

[i.9] SmartSantanderRA: "Santander Augmented Reality Application".

NOTE: Available at http://www.smartsantander.eu/index.php/blog/item/174-smartsantanderra-santander-augmented-reality-application.

[i.10] Ojo et al.: "Designing next generation smart city initiatives - Harnessing findings and lessons from a study of ten smart city programs".

NOTE: Available at http://ecis2014.eu/E-poster/files/0575-file1.pdf.

[i.11] CEN/CENELEC: "Smart cities".

NOTE: Available at http://www.cencenelec.eu/standards/Sectors/SmartLiving/smartcities/Pages/default.aspx

[i.12] "A vision of a smarter city".

NOTE: Available at www.foresightfordevelopment.org/sobipro/download-file/46-155/54.

[i.13] "Smart cities in Europe".

NOTE: Available at http://www.smartcitiesineurope.com/category/best-practices/?orderby=title&order=ASC.

[i.14] ANSSC: "Directory of Smart and Sustainable Cities Standardization Initiatives and Related Activities".

NOTE: Available at http://bit.ly/1hVCr1Y.

[i.15] ETSI TS 103 264: "SmartM2M Smart Appliances Common Ontology and SmartM2M/oneM2M mapping".

[i.16] ETSI TS 103 267: "SmartM2M Smart Appliances Application of ETSI M2M Communication Framework".

[i.17] Smart Grid Task Force EG2 deliverable: "Proposal for a list of Security Measures for Smart Grids (EnisaSG)".

[i.18] ETSI TS 118 102: "Requirements".

[i.19] ETSI TS 118 101: "Functional Architecture".

[i.20] ETSI TS 102 689: "Machine-to-Machine communications (M2M); M2M Service Requirements".

[i.21] ETSI TS 102 690: "Machine-to-Machine communications (M2M); Functional architecture".

[i.22] European Parliament: "Mapping Smart Cities in the EU".

NOTE: Available at http://issuu.com/aie_eur_electrical_contractors/docs/ipol-itre_et_2014_507480_en/1.

[i.23] BS 25999-1: "Business continuity management -Part 1: Code of practice".

[i.24] ISO 22301: "Business Continuity Management System Self Assessment Questionaire".

[i.25] Hatzelhoffer, L. et al.: "Smart City in Practice". Jovis Verlag, Berlin, 2012.

[i.26] CEN-CENELEC-ETSI Smart Grid Coordination Group: "SG-CG/M490/F-Overview of SG-CG Methodologies", Version 3.0, November 2014 (Annex 5 to CENELEC BT149/DG9624/DV).

[i.27] ISO/IEC 27001: "Information technology -- Security techniques -- Information security management systems -- Requirements".

[i.28] ISO/IEC 29100: "Information technology -- Security techniques -- Privacy framework".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADSL	Asymmetric digital subscriber line
AKA	Also Known As
API	Application Programming Interface
APTS	Advanced Public Transportation Systems
ATIS	Advanced Traveller Information Systems
ATMS	Advanced Traffic Management Systems
BCM	Business Continuity Management
BSI	British Standards Institute
BUTLER	uBiquitous secUre inTernet_of_things with Location and contEx-awaReness
COSEM	Companion Specification for Energy Metering
CSE	Common Services Entity
DSL	Digital Subscriber Line
EC	European Commission
ENISA	European Network and Information Security Agency
EnisaSG	European Network and Information Security Agency Security Group
GPRS	General packet radio service
HSDPA	High Speed Downlink Packet Access
IBM	International Business Machines
ICT	Information and Communication Technology
IDC	International Data Corporation
IEC	International Electrotechnical Commission
IP	Internet protocol
ISO	International Organisation for Standards
ITS	Intelligent Transport Systems
LTE	Long Term Evolution
M2M	Machine-to-Machine
M-bus	Meter - Bus
NFC	Near Field Communication
NGN	Next Generation Network
NGO	Non Governmental Organisation
NRW	Non - Revenue Water
PLT	Power Line Telecommunication
POI	Points Of Interest
QoE	Quality of Experience
QoS	Quality of Service
SAP	Smart Appliances
SAR	Special Administration Region
SCADA	Supervisory Control and Data Acquisition
SCL	Service Capability Layer
SGAM	Smart Grid Architecture Model
URI	Universal Resource Identifier
VDSL	Very high speed Digital Subscriber Line
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network

4 Definition of Smart City

A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance. Figure 1 shows the elements involved in making a City Smart.

Figure 1

Some other definitions of Smart cities are the following:

"A smart city is based on intelligent exchanges of information that flow between its many different Subsystems. This flow of information is analysed and translated into citizen and commercial services.

The city will act on this information flow to make its wider ecosystem more resource-efficient and Sustainable. The information exchange is based on a smart governance operating framework Designed for cities sustainable." (Gartner, 2011 [i.4]*)*

"Smart city" [refers to] a local entity - a district, city, region or small country - which takes a Holistic approach to employ[ing] information technologies with real-time analysis that encourages Sustainable economic development." (IDC, 2011 [i.5]*)*

Smart city is about connecting users and data across multiple domains to share information. It can be described as a City described by the many technologies see figure 2 (from [i.1]) this shows the main domain covered in Smart city:

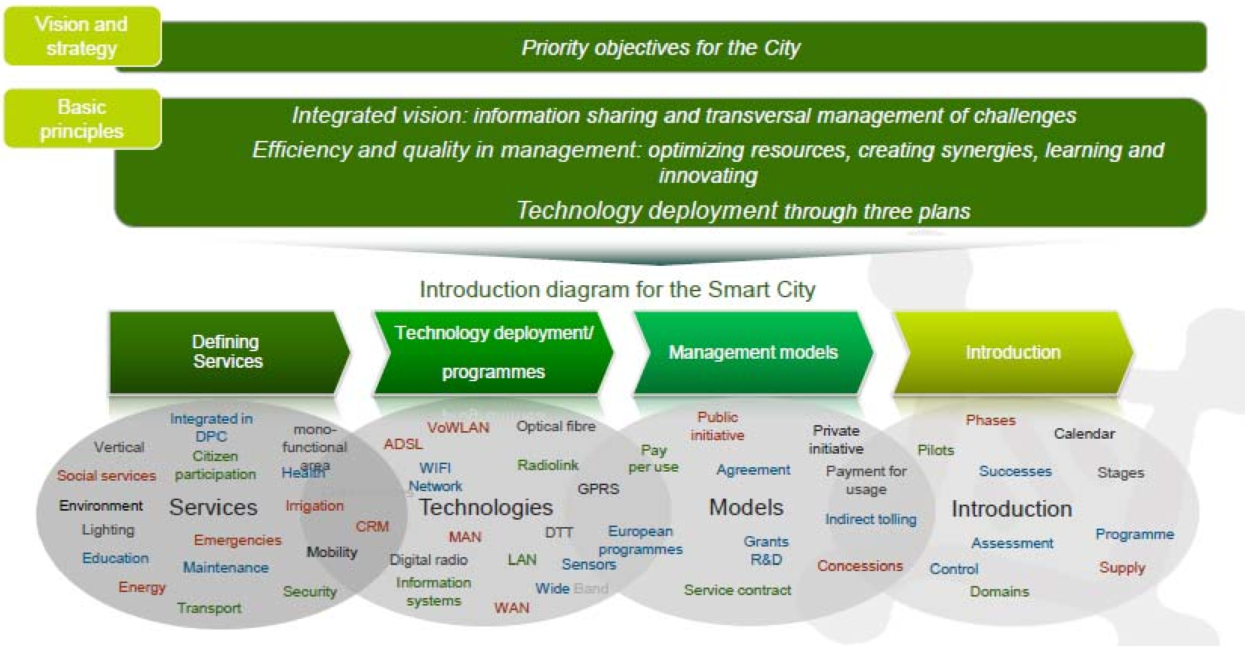

Figure 2

5 Stakeholders involved in Smart City

There are many interpretation of a Smart city Framework, however the key stakeholders that should be covered in any framework should be according to the following list [i.2]:

- ***Government or City authorities*:** should support the initiative of smart city for it to work. The government will be able to bring multiple groups together to establish common language for Smart Cites. For example in the UK the British Standards Institution backed by the government is developing standards for Smart Cities [i.3].
- ***Private Sector*:** the private sector need to be educated on "how"-policies and business models necessary for implementing Smart City solutions works, without the private sector the whole community does not get a buy in.
- ***Public Sector:*** Smart cities are not likely to develop without initiative and involvement from the local public authorities to federate all actors (water, energy, waste utilities; Healthcare and emergency services; Public transport and traffic regulation; and telecommunication service providers), whether they are public or privately operated.
- ***Service providers:*** Smart cities need to accommodate the involvement of multiple service providers, as it is likely that the multiple sectors to aggregate will not accommodate a universal choice, especially if services are to be offered to citizens on their own devices. Furthermore, to support a viable ecosystem, the diversity of services involved in the aggregation, which are each of significant complexity, can potentially be operated by specialized actors: Telecommunication, M2M data dissemination, Analytics, Security and Trust, etc.
- ***Academics and NGOs*:** are stakeholders that focusing on the "how" rather than on the "why". Both, of course, are important, but focusing too much on the "why" will hinder quick adoption of solutions and initiatives.
- ***Residents of the city:*** this group of stakeholder are the recipient of Smart city services.

6 Use case examples of communities that have created Smart Cities in the following areas

6.1 Transport

With the boom in motorization, urbanization and population growth over the last century, transport has played a fundamental role in the development of the economy and society, and as a direct consequence has shaped daily life. However, transport supply has often been unable to fulfil the rapidly increasing demand for it, and has itself contributed to a number of problems including congestion and pollution. Solving these problems by suppressing demand or expanding supply is not realistic as in either case there are constraints in place. However, the rapid development of information and communication technology in the last few decades provides new opportunities to manage and perhaps alleviate such problems. Intelligent transport systems (ITS) in which knowledge of transport patterns, preferences of the transport users, the status of the transport infrastructure and other factors are brought together may help in better managing the factors that cause these problems. The beneficial impacts are expected to be centred on more efficient use of the available transport infrastructure on behalf of its users with additional benefits in improved safety, and reduced vehicle wear, improved journey transportation times, and reductions in the overall energy consumption of the transport infrastructure.

Intelligent Transport Systems (ITS) are a specialized subset of machine-to-machine communications in a software driven and all-connected world. There are a number of dimensions of ITS as indicated in the following list:

- Advanced Traveller Information Systems (ATIS);
- Advanced Traffic Management Systems (ATMS);
- ITS-Enabled Transportation Pricing Systems;
- Advanced Public Transportation Systems (APTS);
- Vehicle-to-Infrastructure Integration (VII); and
- Vehicle-to-Vehicle Integration (V2V).

Supporting each of these capabilities both separately and together is a crucial aspect of Smart City. Integration of ITS to Smart City can be viewed from a number of perspectives: Data integration; Communication integration. In practical use data integration (syntactic and semantic) enables the sharing of data from multiple sources and is key to the development of new economic models in Smart City through the merging of data - this may be seen in ITS services such as multi-modal routing and multi-modal congestion monitoring.

6.2 Smart Cites, Smart Water

One of a city's most important pieces of critical infrastructure is its water system. With populations in cities growing, it is inevitable that water consumption will grow as well. The term "smart water" points to water and wastewater infrastructure that ensures this precious resource - and the energy used to transport it - is managed effectively. A smart water system is designed to gather meaningful and actionable data about the flow, pressure and distribution of a city's water. Further, it is critical that that the consumption and forecasting of water use is accurate.

A city's water distribution and management system has to be sound and viable in the long term to maintain its growth and should be equipped with the capacity to be monitored and networked with other critical systems to obtain more sophisticated and granular information on how they are performing and affecting each other. Additional efficiencies are gained when departments are able to share relevant, actionable information. One example is that the watershed management team can automatically share storm water modelling information which indicates probable flooding zones and times based on predictive precipitation intelligence. The transportation department can then reroute traffic accordingly and pre-emptively alert the population using mass notification.

Incorporating smart water technologies allows water providers to minimize non-revenue water (NRW) by finding leaks quickly and even predicatively using real-time SCADA data and comparing that to model network simulations. Reducing NRW also allows municipalities to recover costs incurred in treatment and pumping - this can be significant.

6.3 Building Management (Residential and Commercial)

This example was taken from the Smart building project [i.6]. It describes how a building can be aware of what is about to happen. It describes how without no prompting or programming, the building knew how to be more aggressive during an overnight purge; the fans and maybe part of the plant would work harder, which could mean the prices could be adjusted to suit the consumer. Also if we imagine a building knew that on Fridays it is OK to re-set static pressure a bit earlier than the rest of the days because most tenants are out. Maybe it also knows that a gradual decrease in the discharge air temperature is the way to avoid a morning spike on some days, but not others. Perhaps it also knows how to curtail usage in the plant and fans on one of those dreadful peak demand days. Finally imagine a building that could automatically communicate with the utility company to become more responsive to the grid. During demand response events, the building automatically curtails non-critical building loads or turns on back-up energy sources. Through automated demand response and predictive controls, the energy consumption is continuously adjusted to reduce demand at critical times of the day in response to hourly pricing signals from the grid. For this, you receive compensation from the utility provider. So all of a sudden your building is not only using less energy and decreasing your energy bill, but it is actually making money for you.

These examples are current example of Smart buildings and the NV-energy company in Las Vegas are one of the first utility providers to integrate predictive energy optimization. In 2013, the Las Vegas' utility provider launched a new energy management program, called mPowered, which is helping its largest customers - including Las Vegas' famous casinos and resorts - become smart buildings.

Las Vegas is an example of what the future world of Smart Cities will look like - fully connected infrastructures that utilize big data, analytics, cloud-based predictive energy optimization technology to proactively manage our most valuable resources, protecting our earth and creating a healthy environment for future generations [i.7].

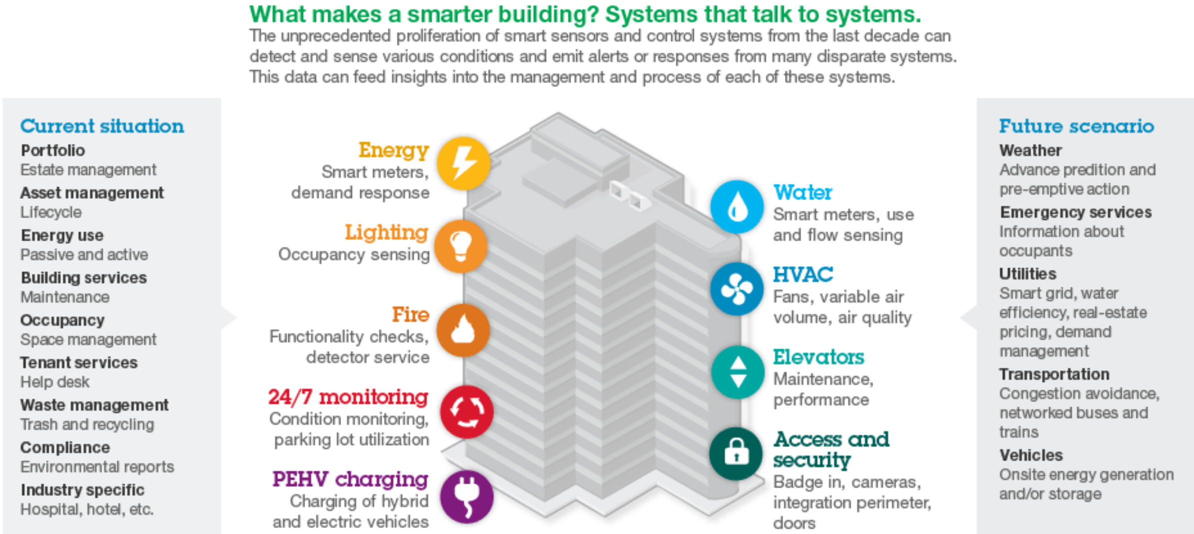

Figure 3

6.4 Culture & tourism

Sandanter is one of the first truly smart cities, showing how digital technology can be used to make cities a better place to live. Transforming Santander into a smart city was no easy task. Around 180 000 people live in the city with its beaches, leisure facilities, casinos and history, Santander is as much a tourist destination as it is a modern European city.

The project team was to install more than 12 000 sensors around the city, around an area of approximately 35 kmsq, or 13,4 square miles. The work commenced in September 2010 and the installation was completed in October 2013. A large proportion of the sensors were hidden inside white boxes and attached to street infrastructure such as street lamps, buildings and utility poles, while others were buried into the actual pavement. Not all of the sensors were static; some were placed on the city's public transport network, including buses, taxis and police cars. By downloading an app to their smartphones even the residents of Santander could become moving sensors in their own right.

These sensors measure a variety of variables, from light and pressure to humidity and temperature. Vehicles broadcast their positions in real time while other sensors measure air quality levels, for example. The sensor infrastructure deployed across the streets of Santander is wirelessly connected through the backbone network to the Telefónica M2M service platform (IDAS/DCA, AKA, Smart Business Control platform). This technology enables the network of sensors to transmit data back to the project hub as often as every two minutes. Once there Telefónica's big data platform extracts intelligence, allowing the enormous amounts of big data to be analysed and observed in real time by the Council employees.

Some of the advantages are that the municipals officials have a real time view of key city metrics, which enables them to make better decisions and engage in a more cost effective planning. Also resources can be planned and allocated faster and more effectively while cost savings can be realized more effectively. Also the project allows the council to operate in a more transparent manner. It can publish data and information on its digital properties to allow Santandarians to make more informed choices about their city. Local issues are escalated faster and can be tracked online by the public and media alike, meaning the council is more accountable than ever [i.8].

Santander Augmented Reality Application (SmartSantanderRA) is an application that was developed as part of the Smart city project. The (Application i.e. App includes information about 2 700 places in the city of Santander divided in different categories: beaches, park and gardens, monuments, Points Of Interest (POI), tourism offices, shops, art galleries, museums, libraries, culture events agenda, shops, public buses, taxis, bikes, parking places, etc. The App works by allowing real time access to traffic and beaches cameras, weather reports and forecast, public buses information and bike-rental service, generating a unique ecosystem for citizens and visitors when walking around the city. On starting the Augmented Reality view, the App creates on a smartphone screen, an overlay over the camera with nearby POIs. If a particular POI is selected, further information (title, short description, photo and distance to the POI) is displayed. Apart from that, the App allows creating the route to that place or playing digital content related to the POI (e.g. videos) if it is available [i.9].

6.5 Governance & administration

The complexity in smart city initiatives lies in the integration and linking of different policy domains. The challenge is largely managed through different forms of governance. In the context of Smart Cities, intelligent governance aims at citizen participation in providing the overall direction for developing transportation, health, education and other sectors through coherent cross-sector policies and strategies as well as delivery of integrated services to citizens, business and other stakeholders.

Intelligent governance of smart cities requires at least four types of governance mechanisms:

1) Coordination and integration;

2) Service integration;

3) Participation and co-production; and

4) Policy and regulations.

Based on the outcomes of the recently concluded "Intelligent Governance of Smart Cities - Foundations" project [i.10] which determined the state of play in research and practice of Smart Cities, and assessed the emerging divide between practice and research in the domain, this project will investigate governance requirements for smart city initiatives. Specifically, it will select policy domains of interest to Macao SAR and develop a governance framework (Smart Governance Framework) to support the integration of these domains.

The project aims to develop a governance framework consisting of models and techniques for implementing four governance mechanisms in the context of smart cities:

1) Policy coordination and integration;

2) Service and process integration across agencies;

3) Participation and co-production by citizens and other stakeholders; and

A set of up to three policy domains for instance Environment, Transportation, Energy, ICT Infrastructure, Economy and Manpower, and others; will be selected as case studies based on the preferences of Macao SAR Government. In addition to the Intelligent Governance Framework, a toolkit prescribing processes for implementing governance actions will also be developed.

The deliverables produced by the project will serve as the basis for developing the capabilities of government agencies in understanding governance mechanisms required to support smart city or cross-sector integration initiatives. The toolkit in particular will provide concrete instruments for agencies to develop an appropriate smart governance framework to support their concrete smart city integration needs.

6.6 Smart City Communities Use cases

6.6.1 Developed Cities

The use cases under this clause is to cover Smart Cities in developed countries which are countries that in themselves have good infrastructure but evolved to have better cities by using concepts that allows smart innovation can now call themselves "Smart Cities". The examples cited in the present document are mainly for Europe and there are many examples are available in the enclosed reference "Smart Cities for Europe" website [i.11]. The report "Mapping Smart Cities in the EU" [i.22] - published in January 2014 is available - was commissioned by ITRE, the European Parliament's Industry Research and Energy Committee, inter alia to provide context for the European Innovation Partnership on Smart Cities and Communities.

6.6.2 Developing Cities

Studies have been carried out on having Smart Cities in Developing countries and what will be required to enable the concept. One of such research was carried out by IBM study on Nairobi Kenya as part of the Global Utility Consumer study. The drive for Smart cites in this area is as a result of Demographic change and challenges that goes with it. Kenya according to this study [i.12] will have a large workforce which will be able to create economies of scale that can lead to an increase in the quality and efficiencies of services. The infrastructure that was considered to be able to sustain these change include change to transport system to try to resolve traffic congestion. This will require traffic infrastructure to be smarter supported with good education and regulation/enforcement to work.

Also needed to be considered for Smart Cites is affordable and reliable energy. Nairobi's energy source at the heart of this should not only rely on hydroelectric power sources but should also consider alternative sources such as solar and wind power generation.

The study also considered having a secure safe environment which meant that security of personnel as part of having a "smart city". To have this the study showed what was needed was shared information amongst Private and Public security forces in Nairobi. The infrastructure to realize this will be to consider a centralized information database that will allow both Private and Public enforcement to have access. So needed will be a digitization, centralization and better management of records.

6.6.3 Green field

The use case examples here is focusing on communities' purpose built for Smart Cities, the example taken here is from Masdar city [i.13].

Masdar City is an arcology project in Abu Dhabi, in the United Arab Emirates. Its core is a planned city, which is being built by Masdar, a subsidiary of Mubadala Development Company, the city relies on solar energy and other renewable energy sources. Masdar City is being constructed 17 kilometres (11 mi) east-south-east of the city of Abu Dhabi, beside Abu Dhabi International Airport.

Masdar City has terracotta walls decorated with arabesque patterns. From a distance, the city looks like a cube. The temperature in the streets is generally 15 to 20 °C cooler than the surrounding desert. The temperature difference is due to Masdar's unique construction. A 45-meter high wind tower modelled on traditional Arab designs sucks air from above and pushes a cooling breeze through Masdar's streets. The site is raised above the surrounding land to create a slight cooling effect. Buildings are clustered close together to create streets and walkways shielded from the sun. Masdar is powered by a 22-hectare field of 87 777 solar panels with additional panels on roofs. There are no light switches or water taps in the city; movement sensors control lighting and water to cut electricity and water consumption by 51 and 55 % respectively.

Water management has been planned in an environmentally sound manner as well. Approximately 80 % of the water used will be recycled and waste water will be reused "as many times as possible", with this greywater being used for crop irrigation and other purposes.

The exterior wood used throughout the city is Palmwood, a sustainable hardwood-substitute developed by Pacific Green using plantation coconut palms that no longer bear fruit. Palmwood features include the entrance gates, screens and doors.

7 Framework required to build a Smart City

7.0 General

One possible framework for Smart City considers collecting enormous amount of information data from all connected devices and analysing the results of the data. ICT provides the connectivity needed to have a Smart City however to build a Smart City requires more than simply using ICT to link and manage social infrastructure its providing new value and services that residents truly need.

To make an ICT framework based project realistic, requires a centralized approach that relies on blind "brute force" of data collection from all users which in some way is unrealistic, besides this would infringe on privacy regulations. Instead, intelligence at the edge (such as processors in M2M devices and smart phones) has to be relied upon to filter appropriate data and trigger relevant actions, resulting in a distributed information system approach.

Generating the knowledge to arrive at solutions is by filtering, collecting and analysing enormous amount of data relevant information from smartphones, various sensors, meters, and other devices. Data portrays the activities and conditions of people and society in real time. Even with a distributed system approach relying on intelligence at the edge, analysing these enormous volumes of data involved to optimize flows of people and resources in smart cities requires powerful computing resources. An example of Smart city framework based on ICT is shown below:

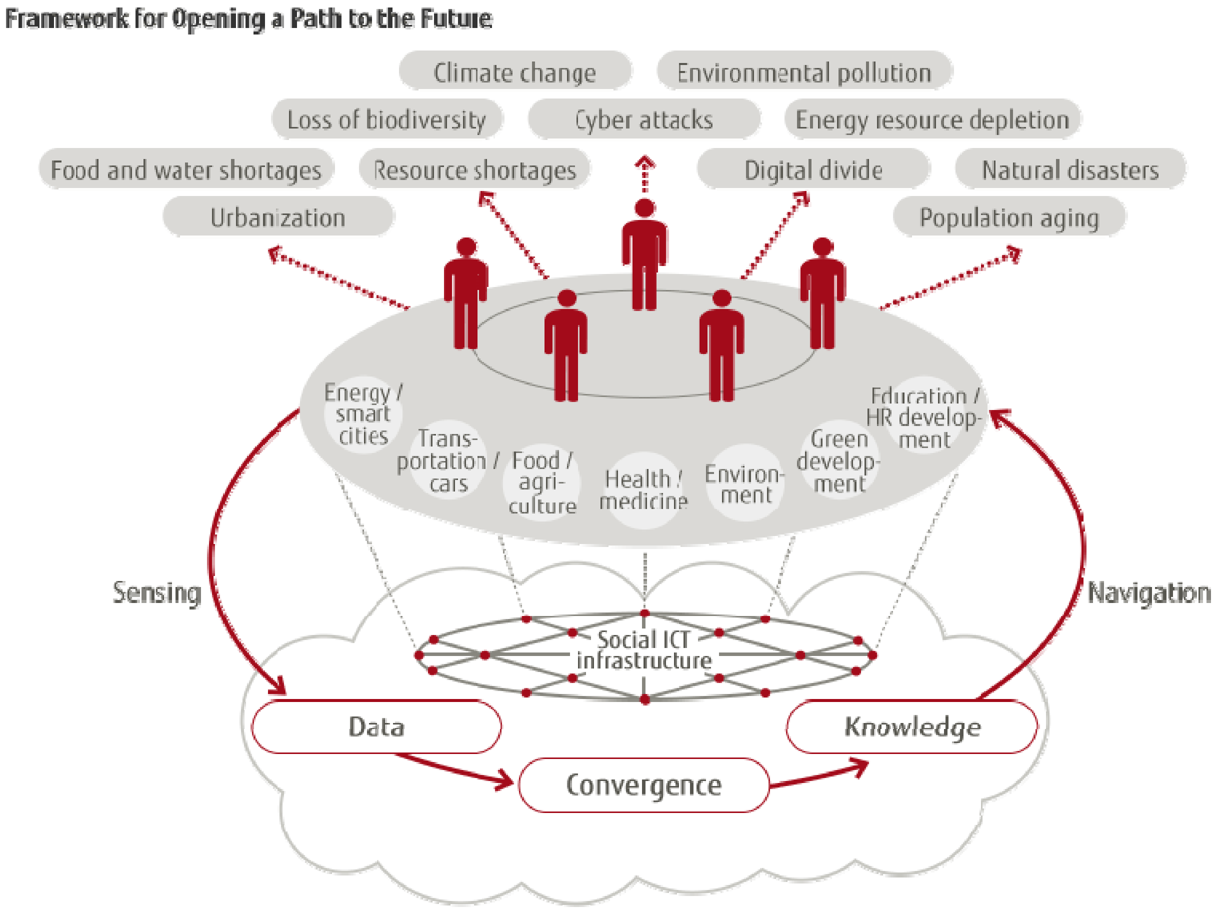

Figure 4

7.1 IoT Infrastructure for Smart Cities

This clause identifies the role of enabling technologies in realizing Smart Cities, these include:

- Fixed:
  ADSL, Fibre, PLT, NGN, co-axial (cable)
- Wireless:
  Wi-Fi, Digital Radio, Wide band, narrow band, LTE, GPRS, satellite, NFC
- Horizontals:
  Security/privacy, Energy efficiency, Machine to Machine, QoS/QoE, Interconnect & Interop, Smart Card, data management, semantics, User/Human

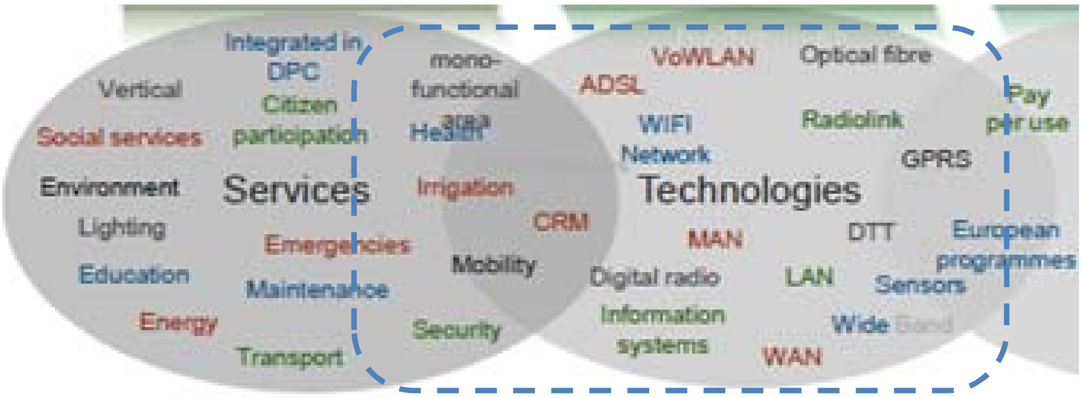

Figure 5

7.2 Machine to Machine Communication

Horizontal Platform concept is an enabler for multi-domains Interworking and the M2M standards are key assets.

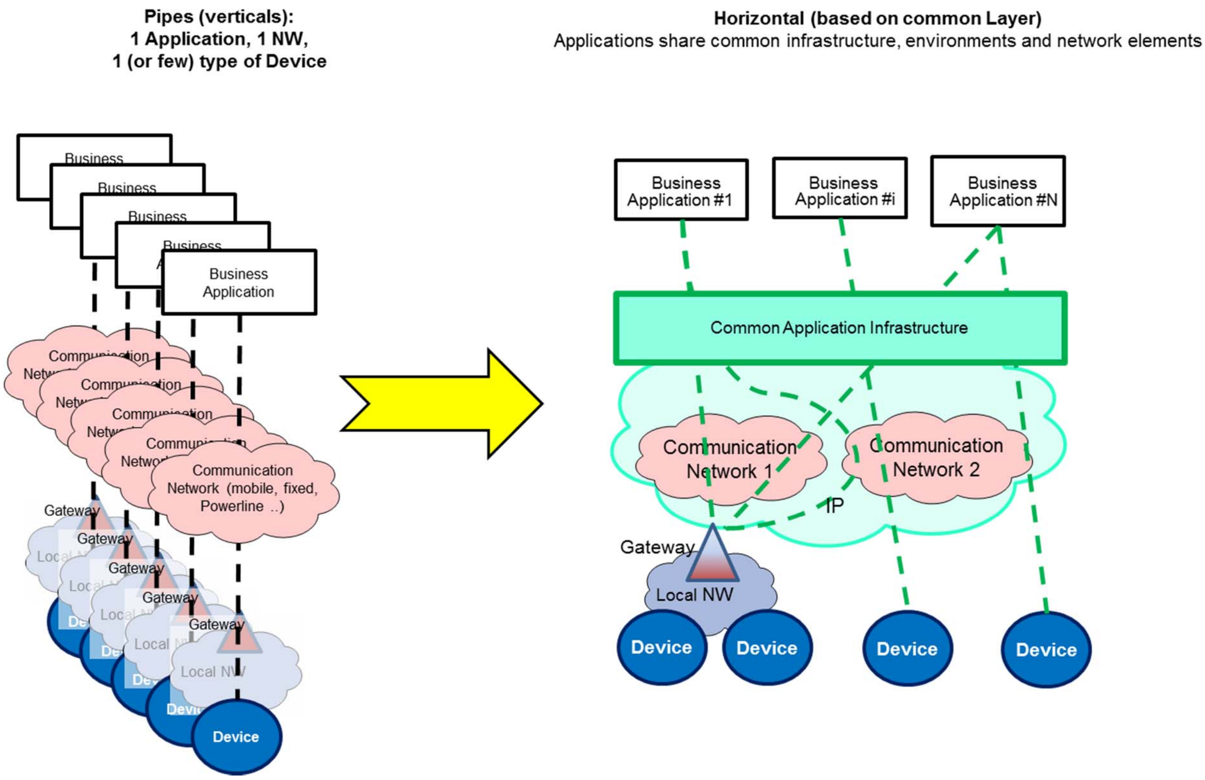

Figure 6

The M2M Standard was designed specially to give a simplified & unified layer as a service to various partners aiming at sharing their respective information: a common Platform to share data among various Application domains initially having different data models.

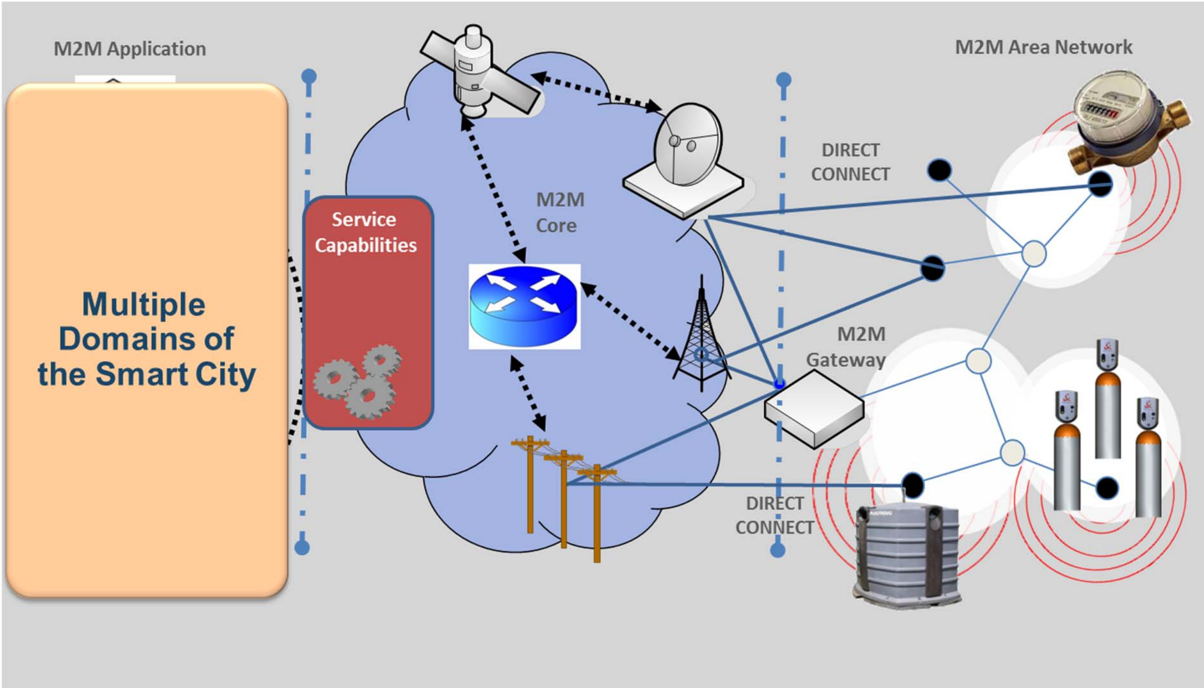

Figure 7

Overview of the importance of the underlying ICT in the Smart City is a simplified M2M architecture to enable data sharing among various applications. The above diagram shows a simplified M2M Architecture, on top of the different possible physical connections and how it applies to Smart City.

Key M2M standards assets:

- Unified access to data from any application domain.
- Management of Privacy (Access Rights) and security levels adapted to the Application needs.
- Suited for IP networks, yet agnostic to underlying communication technologies.

7.3 Smart Cities Service integration

From the context and the considerations elaborated in clause 6, the most impacting characteristic of Smart Cities on the service platform and the communication framework is that a Smart City is de facto a composition of group of services. As an example, a relatively frequent event like a car accident can already involve a big mass of services and actors:

- traffic detection and control
- police services
- fire-fighters
- medical and ambulance
- telemedicine onsite consultation
- hospital identification and navigation Traffic lights control to give priority to the ambulance
- online information about the accident and for the relative of the involved people
- car removal

Each service can be self-standing, but in most of the cases each service is made as a combination of the information coming from other services, and the same information may be reused by different services. E.g. a traffic sensor information is used a lot of different service.

Assuming that a realistic deployment is made a set of different applications based on different technologies, there are three major implications on the communication framework that support the smart cities.

The first is that the communication framework needs to support the sharing of information among service application, with simple and light dynamic means to authorize other application to access to the provided information, still respecting all the implication for privacy and security.

The second is that the communication framework needs to support the communication interworking among all the different protocols used by the sensor networks. The most probable common denominator is the reuse of IP as main communication means and the use of URI as identification, but the efficiency required on the sensor side is leading to deploy a lot of optimized technologies in the area networks.

The third is the support of means for semantic interworking that according to current solution trends will be probably obtained by a combination of mechanisms ranging from real semantic interworking, to native adoption of common semantics, to mechanism to publish objects with the related ontology and methods via formal languages.

Here follows a description of the mechanism for the communication framework, using as example the solution provided by the ETSI M2M and by oneM2M specifications that are de facto functionally and architecturally identical. For more details refer to ETSI M2M and oneM2M specifications [i.18], [i.19], [i.20] and [i.21].

The mechanism is based on the use of standard API (Mca/Mcc/mId/dIa/mIa in the picture) towards specialized Interworking Application Entities exchanging information on a distributed service platform (CSE/SCL in the picture). Such Interworking Application Entities are able to remap the specific technology (or proprietary data model) to the standardized resources exposed by the platform of the standard communication framework. This is typically supported via a full semantic inter-working of the data model used by the specific technology and a related protocol inter-working logic, and, depending on the complexity of the specific technology considered, it can imply the definition of a complex set of resources built via the basic ETSI M2M/oneM2M ones, or a simple direct mapping of the communication via the containers.

The approach enables a unique solution for enabling communications among different protocols, catering for different level of inter-working including protocol inter-working, semantic information exchange and data sharing among the different solution and deployments.

Here follows two examples of use of such interworking framework, the first dealing with full protocol and semantic interworking, the second one focalizing only on protocol interworking.

The first example is depicted in the following picture and shows a typical scenarios where different technologies (Zigbee® with telco Profile, Mbus with COSEM, other) are enabled to communicate one each other. The picture also shows where the common data model and the specific data model awareness are supported.

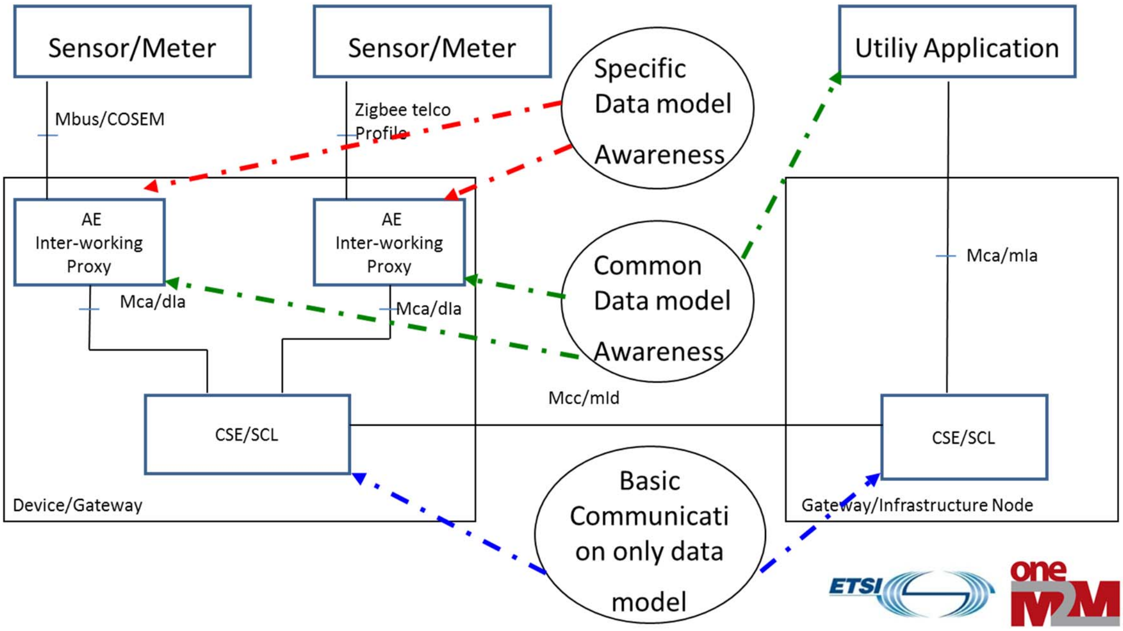

Figure 8

With this level of interworking an M2M Application can access non-oneM2M solutions without the need to know the specific protocol encoding for these solutions. A drawback is that the Interworking Proxy Application Entity also potentially needs to interwork between a non-oneM2M security solution and oneM2M security. E.g. it needs to be the termination point of any non-oneM2M specific encryption.

The second example is depicted in the next picture and shows the case when a common data model is shared among application, so de facto only a protocol translation and basic communication mapping is needed.

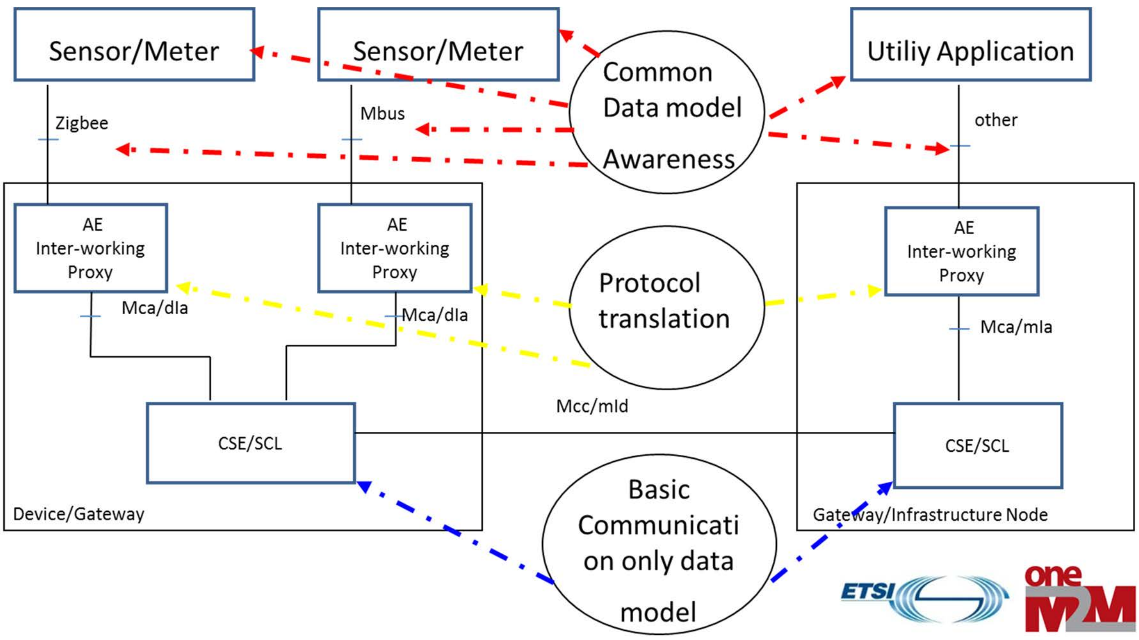

Figure 9

In this variant data and commands are transparently packed by the Inter-working Proxy Application and transported and shared via the service platform. The Interworking Proxy Application Entity made the protocol translation and the mapping on the basic communication data model of ETSI M2M/oneM2M, assuming that a common semantic data model is defined and shared by the applications.

8 Role of Information Security for Smart Cities

Optimization of flows of people and resources in smart cities implies collecting information related to the whereabouts of its inhabitants and processing them in almost real time.

As illustrated in European projects such as BUTLER, such data necessarily involve privacy sensitive information such as determining whether a citizen just stays home or is travelling within or outside of a city.

Furthermore, smart cities obviously require means to act on the involved flows, which constitute critical infrastructures and as such need to be strongly protected from potential attackers, whether local or remote. Such infrastructures (equipment, people and process) obviously need to comply with stringent security requirements assessed by appropriate certification schemes (see e.g. ENISA security recommendations for Smart Grids [i.17]).

Privacy is best addressed through "Privacy by Design", whose underlying principle is data minimization. Hence, blind data collection and centralized information processing have to be excluded in profit of distributed processing systems relying on intelligence at the edge to extract relevant information and trigger appropriate actions.

The main security challenge of smart cities, however, may come from the need to establish trust among the multiple actors involved, who tend to be part of distinctive trust ecosystems. For example Telecommunication Network operators tend to form a circle of trust, but may not be trusted by electric utilities or water management companies supposed to rely on their service to transfer private data on which they hold responsibility. And some telecommunication operators may not accept liabilities for data which, if compromised, could result in failure of a critical energy plant.

The traditional model to ensure information security in systems involving multiple actors results in hop-by-hop security (figure 10): each actor in the ecosystem is protecting information (in terms of authentication, confidentiality and integrity as needed) with its own credentials, which are not exchanged with other actors. As data are then exchanged with other actors, they need to be decrypted and re-encrypted at the boundary between systems, using credentials provided by the other actor. This results in potential exposure of sensitive information at the boundary, which is not advisable in such critical infrastructures. Furthermore, each actor in such a system becomes fully liable for potential alteration of data while protected with its own credentials. Accepting such liability would require integrating a risk assessment process which depends from another actor, potentially in a different business, which is not easily achievable in practice.

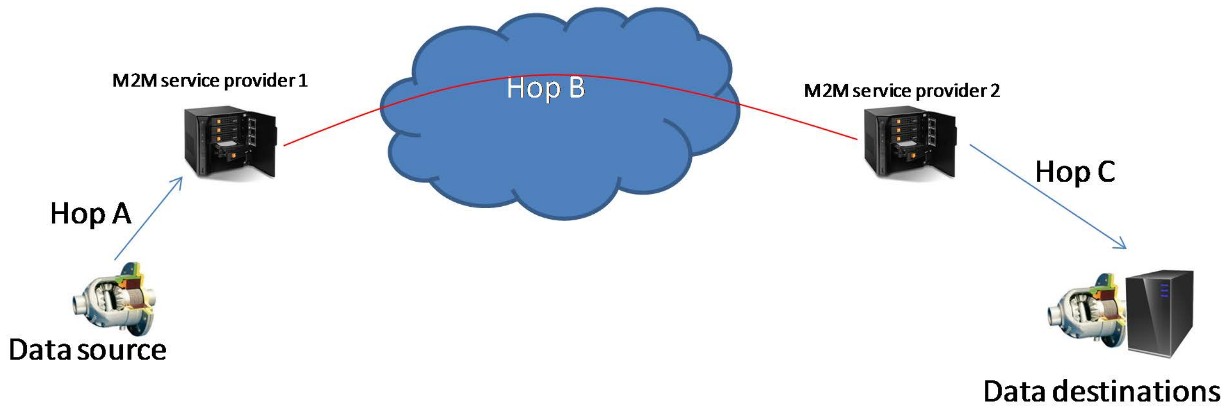

Figure 10: Hop-by-hop security scenario

Liability may be limited if sensitive data are encrypted end-to-end with specific credentials, which are not known from intermediate third party involved in the data transmission. The challenge here is that both endpoints are generally not controlled by a common party who could perform a holistic risk assessment process and accept the resulting liabilities.

To overcome this challenge, the most realistic approach is to enable in the ecosystem the dissociation of the trust establishment role (and attached liabilities resulting from security risks), from the other services involved. This is similar to moving from the concept of moving from a closed approach where insurance for product operation is always provided by the product manufacturers, to more open approach where consumers can choose the insurer they trust the most. In a smart city ecosystem, it can be expected that local public authorities hold the necessary trust from other involved actors to play this role of trust enabler, which may also be subcontracted to third parties. This results in an end-to-end security model as illustrated in figure 11.

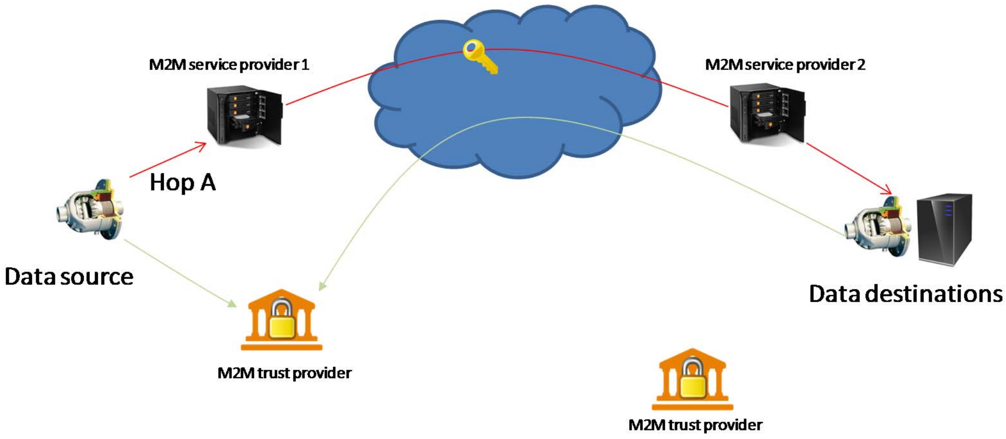

Figure 11: End-to-end security assisted by trust provider

The role of the trust provider involves the following tasks:

- Authenticating data sources and data destination entities.
- Ensuring that proper authorization to access information from the source has been obtained by its destinations. The trust provider acts as a policy decision point for authorization, while access control enforcement remains performed by the other stakeholders.
- Enable end to end protection of data using group credentials. This requires global distribution of group credentials to data sources and destinations controlled by different stakeholders. The group key delivered to a data source is used to cipher transmitted data and ensure confidential delivery to all authorized destinations.

Security: Standards are needed based on the enormous data being captured, stored, transferred and destroyed. Such data contain personal information. Possible areas for standardization include data protection: in the UK, there are already established standards for information security management and data protection. The ISO 27000 series of standards embrace best practice in information security. It includes ISO/IEC 27001 [i.27] which is a specification for an information security management system (ISMS) which aims to ensure that information security management is established and maintained through continual improvement.

The newly-published ISO/IEC 29100 [i.28] approaches privacy risk management issues from a framework-level perspective. Such initiatives require an ongoing and close collaboration between standards makers and policy makers, of increasing importance in the context of the new EU Privacy regulation and the growing use of identity management technologies (such as biometrics).

The trend is that while Security Risk Assessment schemes are now recognized as a common necessary practice to determine the necessary investments to protect an application or system, they will need to be completed by a Data Protection Impact Assessment process to ensure that privacy sensitive information are only collected where required for a legitimate purpose and adequately protected from unintended use.

Resilience: Existing standards can also be applied to improve the resilience of Smart Cities. Business Continuity Management (BCM) is a process that helps manage risks to the smooth running of an organization or delivery of a service or services, ensuring continuity of critical functions in the event of a disruption, and effective recovery afterwards. In the UK examples of these standards include Business continuity management - Part 1: Code of practice [i.23] a code of practice which establishes BCM process, principles and terminology to assist with furthering the understanding and implementation of business continuity within an organization, and Business Continuity Management System Self Assessment Questionaire [i.24] which specifies how to design and build an effective (and auditable) business continuity management system to meet regulatory, customer and business requirements, thereby enhancing confidence.

There may also be a need for a new standard setting requirements for resilience of the systems of the Smart City that will need to be complied with to ensure the continued functioning of the City under all but the most extreme circumstances, e.g. no electricity anywhere for longer than a week.

Smart Cities can be seen as a combination of critical infrastructures (transportation, healthcare, information, food and water, energy and wastes) which are each subject to specific resilience requirements. The people, process and equipment involved in such infrastructures need to be subject to appropriate accreditation schemes to ensure resilience in the advent of unpredictable events.

9 Potential standards available

9.0 General

A system-oriented approach to standardization is needed for the development of smart cities technologies and processes that will result in commercially scalable and replicable solutions with a high market potential and uptake in different sectors. The integration, harmonization, sustainability, interoperability, cost reduction and market uptake of those identified solutions can be achieved through standardization. A comprehensive collection of worldwide activities on Smart Cities "ANSSC Directory Smart and Sustainable Cities Initiatives" was prepared by ANSI [i.14].

9.1 Data communication within white goods and its relevance to Smart Cities

The data communication work being carried out within Smart Appliances (SAP) will study and identify common data semantics and communication which can be used in Smart Cities. The result of the output will be useful as it suggests potential protocols for communication between appliances which will play a part in achieving smart cities. The ETSI work under study includes the following:

- SAP semantic/ontology [i.15]:
    - Common ontology derived from the EC Study on Semantic Assets for Smart Appliances Interoperability.
    - Mapping of common ontology on the elementary ETSI M2M/oneM2M resources and services.
- SAP communication solution and interworking [i.16]:
    - General informative description of the ETSI M2M/oneM2M framework.
    - Normative description of the interworking framework with normative reference to ETSI M2M/oneM2M specification.

9.2 Information Management in SGAM

The Smart grid information layer of the Smart Grid Architecture Model (SGAM) mentions various data models and standards that allow for communication, this also needs to be considered as an enabler to Smart Cities [i.26].

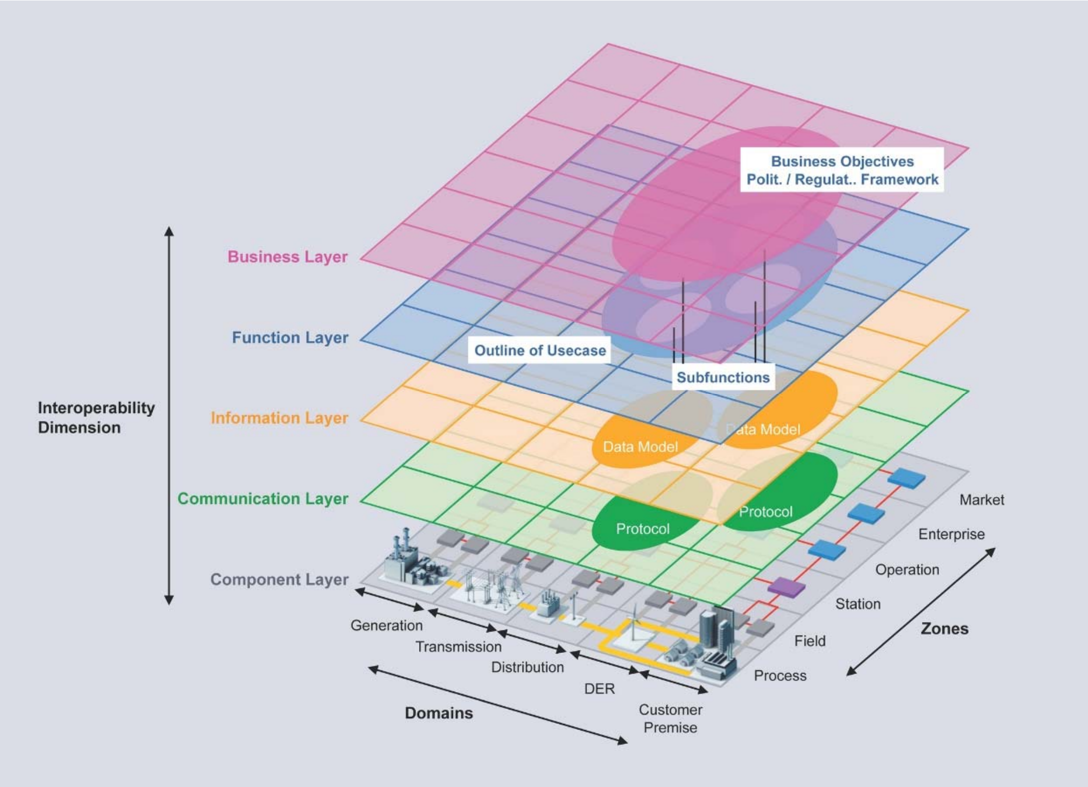

Figure 12

10 Conclusion

The need for common communications

According the BSI report [i.3] a defining feature of Smart Cities is the ability of the component systems to interoperate. The optimal use of resources across a complex urban environment depends on the interaction between different city services and systems. To identify the most effective use of resources therefore requires communication between the different component systems (e.g. energy use monitored by Smart Metering combined with external temperature monitoring on the building to reduce the energy consumption of a family).

It is likely that over the next few years, Cities will have to install communications infrastructure (owned and managed by multiple vendors) that will allow information to be gathered in real time and in intervals. There will need to be strategies for optimized data collection and assimilation and documented good practice in this area would help in the creation of these strategies. In many cases the format of the information - and often the media and protocols on which it is carried - will be different and the communications environment will be highly heterogeneous.

As Smart solutions are developed in different sectors, there will be a need for information captured in various infrastructure elements to be shared between service delivery channels. The information will need to be normalized (and perhaps translated), classified and stored.

Standards implications

The findings of the gap analysis in the standards strategy are that there are plenty of standards covering interoperability within the context of particular service delivery systems, but there is a lack of overall interoperability framework standards that work across systems.

Annex A: T- CITY

This annex describes the Smart City project called T-City performed by Deutsche Telekom and the city of Friedrichshafen in Germany since 2007.

In 2006, Deutsche Telekom initiated a city contest among all German cities of the size of 25 000 to 100 000 inhabitants. The city with the most innovative and viable overall concept for improving people's urban quality of life by using information and communication technology (ICT) was selected in February 2007. The winner was the city of Friedrichshafen at Lake Constance with 60 000 inhabitants. In August 2007, Deutsche Telekom started the project called T-City in a public private partnership with the city of Friedrichshafen scheduled over a period of five years. The project budget was in the high double-digit M€ range.

In 2007, Deutsche Telekom upgraded the broadband infrastructure in the city of Friedrichshafen. Fibre optical cables and street cabinets were installed. Further fourteen HSDPA base stations were installed. 37 WLAN hotspots were installed all over the town. 98 % of all households are covered by VDSL access. 82 base stations cover the whole city except the northern municipal area.

More than 40 individual sub-projects out of the following six project fields were carried out during different time frames within the whole five-year T-City project:

- Education and research;
- Mobility and transport;
- Tourism and culture;
- Citizen, city, and state;
- Business and work;
- Healthcare and medical assistance.

As an example six sub-projects are briefly described:

- Mobile Clinic:
  - Monitoring data, e.g. blood pressure and weight, of patients with chronic heart conditions are regularly transmitted from home to the hospital or doctor in charge. The data is transmitted via the Internet or mobile phone.
- Tumour Conference:
  - Doctors in hospitals or in private practices exchange digital clinical pictures to cooperate on diagnosis and treatment.
- Independent Living (Ambient Assisted Living):
  - For people with restricted mobility, the use of delivery services such as pharmacy, shopping and meals are facilitated by a service portal.
- Edunex:
  - Edunex is a web-based educational platform for schools. Pupils and teachers have access to learning material via the Internet.
- Kindergarten Online:
  - The project is based on an Internet portal, where parents can get information about 37 kindergartens. Parents can register their children online for a kindergarten place giving preferences. The kindergartens can plan faster and easier.

- Smart Metering:
  - 1 600 private households in Friedrichshafen were equipped with Smart Meters. The measured data is transmitted via mobile phone or DSL connection to the municipal utilities. End-users can monitor their own individual energy consumption at quarter-hourly intervals via a personalized Internet portal.

Deutsche Telekom tested products in Friedrichshafen, which have been rolled-out nationwide afterwards, e.g. Smart Meters or the secure and authoritative De-Mail.

For Friedrichshafen, the benefits of the T-City project were the modernization of the municipal administration, the introduction of the standard public administration hotline number 115, and the boost of the municipal economy.

The overall T-City project was successful and worthwhile although some projects failed. The realization of education project was difficult because education is governed by the federal states. Healthcare projects were impacted by strong rules of health insurances.

The T-City project was accompanied by a scientific study [i.25] on e.g. the people acceptance of the project. A survey in 2012 resulted in the following figures:

- 36 % agree with the statement that the quality of life in Friedrichshafen will be enhanced.
- 28 % think that they will benefit personally from T-City in future.
- 54 % are concerned that the protection of their personal data is not taken into account sufficiently.

The following advices to make Smart Cities successful arose from the survey:

- ICT should be presented as a simple tool that can be used easily and that facilitates the daily life.
- The concerns that using ICT is a waste of time and tends to be addictive and leads to less physical exercise and to fewer social contacts should be taken into consideration.

The T-City project with Friedrichshafen is extended by three years from 2012 to 2015. Some sub-projects have been continued, some new sub-projects have been started. The project focuses on the areas energy, health, and transport. The targets are, respectively:

- saving energy costs and improving the security of energy supply;
- making health care more attractive, secure, and cost-efficient; and
- protecting the environment by advanced mobility systems.

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History

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