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**Access, Terminals, Transmission and Multiplexing (ATTM);
Broadband Deployment and Energy Management;
Part 7: Digital multiservice cities;
Sub-part 1: Multiservice Street Furnitures**

Reference

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 7, sub-part 1, of a multi-part deliverable covering "Broadband deployment and energy management", as identified below:

ETSI TS 105 174-1: "Overview, common and generic aspects";

ETSI TS 105 174-2: "Network sites";

ETSI TS 105 174-3: "Core, regional metropolitan networks";

ETSI TS 105 174-4: "Access networks";

ETSI TS 105 174-5: "Customer network infrastructures";

ETSI TR 105 174-6: "Cable Access Networks";

ETSI TS 105 174-7: "Digital multiservice cities":

Sub-part 1: "Multiservice street furnitures".

Modal verbs terminology

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Executive summary

The main objectives of cities are to improve citizens' lives, local economy dynamics and to attract new residents and enterprises to establish locally. Strong evolutions in the fixed and mobile Internet connectivity have impacted the expectations and behaviours of the people and the enterprises they are working in.

Digital services have become an important part of the daily life, crossing many activities within the day from personalized morning news, thru latest updates on the transportation schedule (bus, train, road traffic), the operations at work or schools even up to shopping at the supermarket. This digital revolution has also entered the area of services and operations delivered by public services such as the city. To adopt this evolution, the Information Communication Technology (ICT) platforms of the city services should be rethought and changed from the silo strategy to an integrated approach. To achieve this goal, the ICT of the city should rely on a unified digital multi services infrastructure that combines cable-based and wireless networks.

This digital multi services infrastructure is supposed to be economic, safe, multi purposes and future proof to enable the sustainability of the city in regards to its digital services strategy and roadmap.

Up till now silo and vertical ICT have been mainly taken into consideration to deploy services. Since a few years, various smart city efforts and initiatives suggest to strongly adopt a transversal approach in which services share a common Internet Protocol (IP) network, co-operate between each other and furthermore enable third parties to leverage the value offered by the power of data mining and big data processing.

A common and shared multi services architecture for the city's digital services is therefore needed to achieve the city's goals and ambitions at reasonable cost of ownership and of operation while strongly taking into consideration the eco efficiency of the different elements of the ICT deployments.

Introduction

Today digital life is leading major evolutions in the expectations that peoples and enterprises have towards the public administrations. As the local representative and interface, the municipality is in front line. The boom of the mobile Internet economy has created many new types of services which requires the city to evolve and adapt to such new behaviours from their target audiences.

City parking or tourism attractiveness are two simple examples of such digital revolution. In both cases, one expect to have access to digital services which respectively facilitate the discovery of an available parking place or to the accessibility of local public transportation facility such as bus, tram and even city bikes.

These digital services have increased the requirements of the ICT infrastructures of the city and amplified the need for a more sustainable information Technology (IT) design. Smart digital city parking service requires sensors to be deployed within the field, that their real time status (busy of available parking place) are transmitted thru a data network and that a digital service leverage this information to be made available to the driver but also to the financial department in case of the parking usage has to be charged.

Today many city applications are to be seen as island or silo application and have their own network, own software platform and as a results different operations and maintenances. A common architecture will reduce this multiplication of networks and software solutions while improving the economical and energy efficiently costs.

The present document will contain information which covers topics such as physical network installation, network transmission implementation, digital services deployments thru an energy efficiency Next Generation Network (NGN).

1 Scope

The present document details measures which may be taken to ease the deployment of smart new services and their multiservice street furnitures of digital multiservice city within the IP network of a single city or an association of cities administratively clustered. Furthermore, the suggested measures will enable to engineer a reliable common networking infrastructure which can improve the Total Cost of Ownership (TCO) for the public administration while improving the energy efficiency of the overall deployment.

The present document also lists the requirements which have led to this common architecture.

Clause 4 identifies and presents a general overview of a city from small entity to significantly large municipality clustering several cities and villages.

Clause 5 presents the pursued objectives behind the concept of smart city.

Clause 6 describes the general theoretical pillars which bears the engineering requirements to deploy a digital multi service city.

Clause 7 identifies the general needs from the cities.

Clause 8 of the present document present a suggestion of an engineered digital multiservice city.

This will enable the proper introduction and implementation of a new service, application or content within the city digital portfolio on a unified energy efficient network, though it is not the goal of the present document to provide detailed standardized solutions for network architecture.

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 referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] CENELEC EN 50173-2: "Information technology - Generic cabling systems - Part 2: Office premises".

[2] CENELEC EN 50173-4: "Information technology - Generic cabling systems - Part 4: Homes".

[3] CENELEC EN 50174-1: "Information technology - Cabling installation - Part 1: Installation specification and quality assurance".

[4] CENELEC EN 50174-2: "Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings".

[5] CENELEC EN 50174-3: "Information technology - Cabling installation - Part 3: Installation planning and practices outside buildings".

2.2 Informative 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 referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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] ETSI TS 105 174-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Energy Management; Part 1: Overview, common and generic aspects".

[i.2] ETSI TR 105 174-4: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment - Energy Efficiency and Key Performance Indicators; Part 4: Access networks".

[i.3] ETSI TS 105 174-4-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Energy Management; Part 4: Access Networks; Sub-part 1: Fixed access networks (excluding cable)".

[i.4] ETSI TS 105 174-5-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Energy Management; Part 5: Customer network infrastructures; Sub-part 1: Homes (single-tenant)".

[i.5] ETSI TS 105 174-5-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Energy Management; Part 5: Customer network infrastructures; Sub-part 2: Office premises (single-tenant)".

[i.6] ETSI TS 105 174-5-4: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment - Energy Efficiency and Key Performance Indicators; Part 5: Customer network infrastructures; Sub-part 4: Data centres (customer)".

[i.7] ETSI TR 105 174-2-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment - Energy Efficiency and Key Performance Indicators; Part 2: Network sites; Sub-part 1: Operator sites".

[i.8] ETSI TS 102 973: "Access Terminals, Transmission and Multiplexing (ATTM); Network Termination (NT) in Next Generation Network architectures".

[i.9] ETSI TR 103 290: " Machine-to-Machine communications (M2M); Impact of Smart City Activity on IoT Environment (Impact of Smart City activity on IoT Environment)".

[i.10] ETSI TR 102 898: "Machine to Machine communications (M2M); Use cases of Automotive Applications in M2M capable networks".

[i.11] ETSI TR 102 935: "Machine-to-Machine communications (M2M); Applicability of M2M architecture to Smart Grid Networks; Impact of Smart Grids on M2M platform".

[i.12] ETSI TR 102 857: "Machine-to-Machine communications (M2M); Use Cases of M2M applications for Connected Consumer".

[i.13] ETSI TR 103 375: "SmartM2M IoT Standards landscape and future evolutions".

[i.14] AIOTI Recommendations for future collaborative work in the context of the Internet of Things Focus Area in Horizon 2020.

NOTE: Available at https://ec.europa.eu/digital-single-market/en/news/aioti-recommendations-future-collaborative-work-context-internet-things-focus-area-horizon-2020.

[i.15] Wikipedia definition of street furniture's.

NOTE: Available at https://en.wikipedia.org/wiki/Street_furniture.

[i.16] European Innovation Partnership on Smart Cities and Communities "Operational Implementation Plan".

NOTE: Available at http://ec.europa.eu/eip/smartcities/files/operational-implementation-plan-oip-v2_en.pdf.

[i.17] European Innovation Partnership on Smart Cities and Communities "Strategic Implementation Plan".

NOTE: Available at http://ec.europa.eu/eip/smartcities/files/sip_final_en.pdf.

[i.18] European Innovation Partnership on Smart Cities and Communities "Humble Lamppost".

NOTE: Available at https://eu-smartcities.eu/commitment/6670.

[i.19] ETSI GS OEU 009: "Operational energy Efficiency for Users (OEU); Global KPI Modelling for Green Smart Cities".

[i.20] ETSI GS OEU 019: "OEU KPIs for Smart Cities".

[i.21] Light Fidelity TED Talk "Wireless data from every light bulb".

NOTE: Available at http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb.

[i.22] IEEE 802.11TM: "Wireless LAN; 802.11-2012 -- IEEE Standard for Information technology -- Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[i.23] IEEE 802.11sTM: "Wireless Mesh Networking; 802.11s-2011 -- IEEE Standard for Information Technology -- Telecommunications and information exchange between systems--Local and metropolitan area networks--Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 10: Mesh Networking".

[i.24] VLC Visible Light Communications IEEE 802.15.

[i.25] IEEE 802.15.4TM: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (WPANs)".

[i.26] IEEE 802.11ahTM: "WiFi HaLow; P802.11ah -- IEEE Draft Standard for Information Technology -- Telecommunications and Information Exchange Between Systems-Local and Metropolitan Area Networks-Specific Requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Amendment 2: Sub 1 GHz License Exempt Operation".

[i.27] IETF RFC 3031: "Multiprotocol Label Switching Architecture".

[i.28] IETF RFC 4761: "Virtual Private LAN Service Using Label Distribution Protocol (LDP) Signaling".

[i.29] IETF RFC 4762: "Virtual Private LAN Service Using BGP for Auto-Discovery and Signaling".

[i.30] IEEE 802.3TM: "Ethernet".

[i.31] IEEE 802.3azTM: "Energy Efficient Ethernet; IEEE 802.3az-2010 -- IEEE Standard for Information technology -- Local and metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications -- Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet".

[i.32] IEEE 802.3abTM: "Ethernet over Twisted Pair at 1 Gbit/s; 802.3ab-1999 -- IEEE Standard for Information Technology -- Telecommunications and information exchange between systems -- Local and Metropolitan Area Networks -- Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications -- Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T".

[i.33] IEEE 802.3u™: "Fast Ethernet over Twisted Pair; 802.3u-1995 -- IEEE Standards for Local and Metropolitan Area Networks-Supplement -- Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30)".

[i.34] IEEE 802.3z™: "Ethernet over Fiber Optic at 1 Gbit/s; 802.3z-1998 -- Media Access Control Parameters, Physical Layers, Repeater and Management Parameters for 1,000 Mb/s Operation, Supplement to Information Technology -- Local and Metropolitan Area Networks -- Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".

[i.35] IEEE 802.3af™: "Power Over Ethernet; 802.3af-2003 -- IEEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems -- Local and Metropolitan Area Networks - Specific Requirements -- Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications -- Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)".

[i.36] IEEE 802.3at™: "Power Over Ethernet; 802.3at-2009 -- IEEE Standard for Information technology -- Local and metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications -- Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements".

[i.37] IEEE 802.1q™: "Ethernet Virtual LAN ; 802.1q-2014 - IEEE Standard for Local and metropolitan area networks--Bridges and Bridged Networks".

[i.38] Market Place of the European Innovation Partnership on Smart Cities and Communities.

NOTE: Available at http://eu-smartcities.eu.

[i.39] Guide Pratique - Deploiement de la Boucle Locale Optique Mutualisee sur support aerien.

NOTE: Available at http://www.fieec.fr/iso_album/20151126085028_121115_guide_pratique_blom_basse_def.pdf.

[i.40] IETF RFC 1034: "Domain Names - Concepts and Facilities".

[i.41] IETF RFC 1035: "Domain Names - Implementation and Specification".

[i.42] UEFI Forum ACPI specification.

NOTE: Available at http://www.uefi.org/specifications.

[i.43] IETF RFC 2474: "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers".

[i.44] IETF RFC 2475: "An Architecture for Differentiated Services".

[i.45] European Innovation Partnership on Smart Cities and Communities "s[m2]art".

NOTE: Available at https://eu-smartcities.eu/commitment/7434.

[i.46] Recommendation ITU-T G.9959: "Short range narrow-band digital radiocommunication transceivers - PHY, MAC, SAR and LLC layer specifications".

[i.47] IEEE 802.1p™: "Traffic Class Expediting and Dynamic Multicast Filtering; 802.1D-2004 - IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges".

[i.48] IEEE 802.11e™: "Wireless Multi Media; 802.11e-2005 -- IEEE Standard for Information technology -- Local and metropolitan area networks -- Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications -- Amendment 8: Medium Access Control (MAC) Quality of Service Enhancements".

[i.49] IEEE 802.11ad™: "WiFi WiGig; 802.11ad-2012 -- IEEE Standard for Information technology -- Telecommunications and information exchange between systems--Local and metropolitan area networks--Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications -- Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band".

[i.50] IEEE 802.11ac™: "WiFi ac ; 802.11ac-2013 - IEEE Standard for Information technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks -- Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications -- Amendment 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz".

[i.51] IEEE 802.3bv™: "Gigabit Ethernet Over Plastic Optical Fiber ; P802.3bv - IEEE Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber".

[i.52] 3GPP: http://www.3gpp.org/specifications/specifications.

[i.53] Recommendation ITU-T Y.4900: "Overview of key performance indicators in smart sustainable cities".

[i.54] Recommendation ITU-T Y.4901: "Key performance indicators related to the use of information and communication technology in smart sustainable cities".

[i.55] Recommendation ITU-T Y.4902: "Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities".

[i.56] Recommendation ITU-T Y.4903: "Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals"

[i.57] ISO 37120:2014: "Sustainable development of communities -- Indicators for city services and quality of life".

[i.58] Recommendation ITU-T SG5: "Environment, climate change and circular economy".

[i.59] ISO/TC 268: "Sustainable cities and communities".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions and the following apply:

digital multiservice cities: cities using digital infrastructure which consist of a single unified high speed networking infrastructure that allows the ICT systems of the complete city services departments to interconnect seamlessly and securely to each other

street furniture: collective term for objects and pieces of equipment installed on city streets, city roads, and public areas under responsibility of the city for various purposes

NOTE: These objects and equipments belong to the wider terminology of the urban assets as named by cities.

urban asset: collective term to qualify the physical assets which belong to a city and which are located across its territory, in streets, roads, public parks and associated urban constructions

3.2 Abbreviations

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

ACPI	Advance Configuration and Power Interface
AIOTI	Alliance for the Internet of Things Innovation and in particular AIOTI WG3 on IoT Standardization
AP	Access Point
API	Application Programming Interface
ATTM	Access, Terminals, Transmission and Multiplexing
BTS	Base Transceiver Station
CCTV	Closed-circuit TeleVision
DNS	Domain Name Service
EIP	European Innovation Partnership
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
EM	Electromagnetic Communication
ENTI	External Network Test Interface
FIEEC	Federation des Industries Electriques, Electroniques et de Communication
Gbit/s	Giga bits per second
GOF	Glass Optical Fiber
GPS	Global Positioning System
GS	Group Specification
HMI	Human Machine Interface
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IIC	Industrial Internet Consortium
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISG	Industrial Specification Group
ISM	Industrial, Scientific, and Medical
ISO	International Organization for Standardization
ISP	Internet Service Provider
IT	Information Technology
ITS	Intelligent Transportation Systems
ITU	International Telecommunication Union
JTC	Joint Technical Committee
Kbit/s	Kilo bits per second
KPI	Key Performance Indicator
LAN	Local Area Network
LP-LAN	Low-Power Local-Area Network
LP-WAN	Low-Power Wide-Area Network
LR-WPAN	Low-Rate Wireless Personal Area Networks
LSP	Label Switch Path
M2M	Machine to Machine
MAC	Media Access Control
MAN	Metropolitan Area Network
MPLS	Multiprotocol Label Switching
NFC	Near Field Communication
NGN	Next Generation Network
NT	Network Termination
OASIS	Organization for the Advancement of Structured Information Standards
OCF	Open Connectivity Foundation
OCF	Open Connectivity Foundation
OEU	Operational energy Efficiency for Users
oneM2M	Partnership Project oneM2M launched by a number of SSOs including ETSI
ONVIF	Open Network Video Interface Forum
OS	Operating System

PoE	Power over Ethernet
POF	Plastic Optical Fiber
PSIA	Physical Security Interoperability Alliance
PSTN	Public Switched Telephone Network
QoS	Quality of Services
RF	Radio Frequency
RFC	Request For Comments
SLA	Service Level Agreement
SME	Small and Medium Enterprise
SOHO	Small Hoffice Home Office
SP	Service Provider
SSID	Service Set IDentifiers
STF	Special Task Force
TC	Technical Committe
TCO	Total Cost of Ownership
TR	Technical Report
TxRx	Transceiver equipment
UEFI	Unified Extensible Firmware Interface
UHD	Ultra High Definition
UTP	Universal Twister Pair
VLAN	Virtual Local Area Network
VLC	Visible Light Communications
VPLS	Virtual Private LAN Service
W3C	World Wide Web Consortium
WAN	Wide Area Network
Wi-Fi	Wireless Fidelity
WiGig	Wireless Gigabit
WLAN	Wireless LAN
WMM	Wi-Fi Multimedia
WSN	Wireless Sensor Network

4 General overview of a city

4.1 Reaching sustainability thru digital multiservice city networks

Municipality facilities range from a single premise to multiple buildings located across the city territory. Single premise municipality come from the origin of this administrative facility: "the city house" were the mayor was living and were all government administrative duties were performed.

Thru the centuries, the mayor has been supported by more and more complementary staff creating by purposes respective services departments. Along this employment grow, city properties availabilities or acquisitions, services offices started to span either across several physical building facilities within the city area either across larger geographical area when the administrative entity span on multiple contiguous cities or villages.

Municipalities nowadays have also undertaken several other responsibilities such as safety, education, waste management and recycling, healthcare, water and electricity distribution, public transportation and potentially many more.

Most of today municipalities are supported by Information and Communications Technologies to help the city staff to perform the daily work, communicate with each other and with the higher authorities. In that concern, municipalities operations should be considered as an enterprise ranging from a Small Office Home Office (SOHO), a Small and Medium Enterprise (SME) up to large enterprise. According to the respective type of enterprise the city can be matched to, technical recommendations which applies to homes and offices ICT deployments such as ETSI TS 105 174-5-1 [i.4], ETSI TS 105 174-5-2 [i.5] and ETSI TS 105 174-5-4 [i.6] or to telecommunication services providers such as ETSI TR 105 174-2-1 [i.7] should be considered to improve the energy management of the city ICT deployment.

Indeed, from a networking perspective municipalities have various challenges to face to.

4.2 Inside-building connectivity cabling infrastructure

Regularly the buildings which host the municipal staff are not contemporary and have not been designed with IT in mind. Furthermore, in important cities, those buildings are often classified heritage buildings and construction works are heavily constrained.

The result is that network cabling is regularly of a concern. It is common to see physical deployments where rooms are not correctly equipped with appropriate network access socket, that network cables are inappropriately installed, that technical facilities such as cable patch panel are imperfectly installed or simply missing, etc. Finally, poor cross-domains vision leads often to the installation of several independent physical network cabling setups such as:

- Network cablings for analog/digital telephony services.
- Network cablings for emergency (e.g. alarms, elevators) services.
- Network cabling for IT data networking service.
- Network cabling for IP telephony service.
- Network cabling for analog/digital video surveillance service.
- Network cabling for IP video surveillance service.

There is a clear need to unify these ICT independents infrastructures thru a common multi-services physical engineering architecture.

Requirements, specifications and best practices for the deployment of these physical cabling infrastructures are covered by various norms such as CENELEC EN 50173-2 [1], CENELEC EN 50173-4 [2], CENELEC EN 50174-1 [3] and CENELEC EN 50174-2 [4].

4.3 Inter-buildings connectivity cabling infrastructure

Nowadays, in many cases municipalities facilities are spread across many buildings which may or may not be near to each other's. Besides the constrain of classified heritage buildings, distances between facilities may be large. With that regards and according to the capabilities, municipalities either opt to deploy their own inter-building cablings either opt for contracting external service provider(s).

Similarly to the local cabling, poor cross-domains vision regularly leads to the installation of several independent physical network cabling setups or to establish multiple service contracts with service providers.

There is a clear need to improve the engineering architecture which interconnects the various facilities spread across the territory.

Requirements, specifications and best practices for the deployment of these physical cabling infrastructures are covered by various norms such as CENELEC EN 50174-1 [3] and CENELEC EN 50174-3 [5].

4.4 Digital services availability

IP networking technology leverage numerous IT services such as data transfer, digital telephony, video surveillance, IoT operation and monitoring, etc. IT staff availability within the municipality shall be taking into account and due to financial constrains regularly missing (Small cities, villages) or outsourced to external services provider. The consequence is that there is limited or missing engineering view on the deployment of the digital services. It is a common situation where the IP data network is unfortunately fragmented into multiple independent IP networks isolated from each other and even requiring to pass thru externals service providers for internal communications.

By example, when migrating from analog/digital telephony or video security to IP telephony or video security, lack of technical engineering and poor global networking views often lead to mirror traditional POTS (Plain Old Telephone Service) or situation. Municipalities often deploy independent and isolated IP networks per service and per site (even per building) whereas technically engineered design would suggest to architecture the deployment as a single unified IP voice or video platform leveraging a multi service network spanning across the building facilities.

The engineering of a multi-services network would also open the way to innovative IT solution such as voice and video convergences while also enabling communication between such as:

- physical IP phones and softphone running on municipal employee's computer:
- access to IP camera video streams from authorized computer within the network.

4.5 Network access coherence

Local or inter-buildings physical networking connectivity has constrained the municipal authorities to fragment their local IP networks into isolated networking areas. Access to the Internet, or specific national network resources, with such engineering implies to install a dedicated physical connection to a network service provider (e.g. ISP) within each local network. Unfortunately, it is also common to have cities where Internet connections are even physically linked to single agent computers therefore removing the capability to share the service provider access with the agent department.

The engineering of a multi-services network would also improve the accessibility to the Internet as well as to other specific external services (e.g. national citizen or enterprises registries) such as those provided by higher authorities of the government.

5 General considerations about digital multiservice city

Renowned technology organizations such as the ITU-T describes the concept of the sustainable city with following terms:

"*A smart sustainable city is an innovative city that uses ICT and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.*"

This definition has been developed based on the work carried out by FG-SSC and UNECE in Recommendation ITU-T SG5 [i.58].

The point of view of internationally recognized analysts share a strong position that technology organizations emphasis: the importance of a transversal approach across the various services which build the organization of a city:

"*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 enterprises 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)

An increasing number of everyday machines and objects are now embedded with sensors or actuators and have the ability to communicate over the Internet. Collectively they make up the Internet of Things (IoT).

With the development of the IoT, more and more of the information systems present in the city are now offered technologies which enable real-time data harvesting and almost real-time data processing and sharing.

Within the ETSI, the SmartM2M Technical Committee (TC) is focusing on the specifications and requirements to enable end to end interoperability between Machine-to-Machine (M2M) communications.

The scope of the following documents covers topics such as smart grids, connected car, home automation and smart cities. The working program includes:

- to develop and maintain an end-to-end overall telecommunication high level architecture for M2M;
- to identify gaps where existing standards and provide specifications to fill these gaps.

TC SmartM2M has initiated several development of standards for communication between Smart Appliances. The standards are based upon ETSI's functional architecture for Machine to Machine communications, and includes a common data model and the identification of communication protocols for several use cases such as transport, water management, building management, culture & tourism, described in ETSI TR 103 290 [i.9], ETSI TR 102 898 [i.10], ETSI TR 102 935 [i.11] and ETSI TR 102 857 [i.12].

To be sustainable in servicing or introducing new digital services, the city needs to have an ICT infrastructure which enable seamless end to end communications at the lowest possible cost of installation, energy consumption and operation. By enabling a common infrastructure, structural expenses can be shared amongst the variety of services that the ICT of a digital city has to cover.

6 Theoretical pillars for a digital multiservice city

6.1 Convergence path

From villages to megacities, across urban cities, all of these living places can be qualified by some 'smart' attributes within the different delivered services: energy (electricity, gas) delivery, water management (distribution, recycling), waste (organic, plastic, generic) management, transportation (bus, metro, train), education, healthcare, public security and mobility (road, traffic light). The daily operations of the administration, which could be considered as the enterprise behind the scene, are also areas were smart process and smart management, smart building, etc. could be realized.

It is now clear that with the maturity of various ICT technologies, most of these public order services could benefit of the data era to improve their efficiency, sustainability and increase the level of quality for the resident citizen, the municipal workforces or the enterprises commuters.

From data collection (e.g. consumption metering, traffic flow, air/water quality monitoring) to data analytics, all the process may benefit of the road to the sustainable city qualification. Nevertheless, before any specific ICT terminology this road has to be first defined in terms of functional aims which are presented in figure 1.

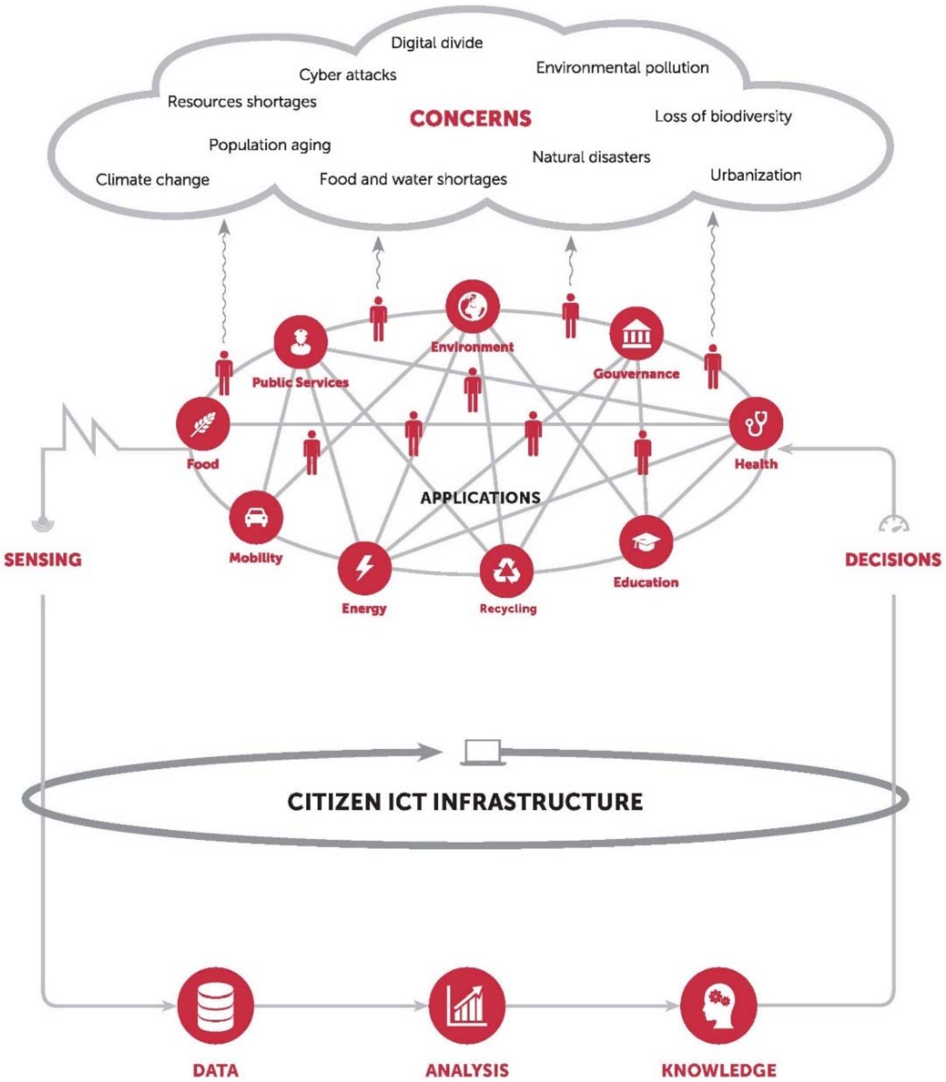

Figure 1: Functional aims of a digital multiservice city

6.2 Cross domain

The municipal services provided to residents, in return of their local taxes, depends on numerous factors: size of the territory, amount of inhabitants, history, geographical location, etc. Basis services expected by the city authorities ranges from water delivery, sanitation sewer, sanitation refuse & waste, street/parking/public transport (bus, metro, etc.) and lighting for mobility, schools and public libraries for education, police and fire departments for security, hospitals and ambulances for healthcare, etc. Since ages, these services have been the concern of several different municipal employees who often belong to separated and independent departments. This underlying administrative structure, bigger the city is bigger is the gap, has leaded the cities to adopt an operational model which inducts the silos mentality.

Silos Mentality is a mindset present when certain departments or sectors are unable or do not wish to share information with others in the same organization. Such low working relationships and lack of cooperation have also impacted the way ICT technologies have been introduced into the operational engine of the cities. In most cases IT applications have been designed and developed to answer specific services needs independently from each other. It is also likewise that these applications evolve independently of each other. Consequences of such behavior reduce the efficiency in the overall operation but also do not contribute to improvement of the productivity.

The presence of these silos has numerous impacts such as:

- information fragmentation:
  - in the presence of different and non-interworking applications and systems, the data tends to remain isolated whereas specific exchanges cross domains would be beneficial. For example, crossing real-time household data on water consumption with the water pumping station operational network would probably reduce the leakage in delivery in some under provisioned areas at critical moments of the day.
- inability to think of the economy of scale:
  - existing silo-based model leads to multiple procurements for similar infrastructures or applications. For example, installing outdoor IEEE 802.11 [i.22] WLAN (Wi-Fi) networks for public Internet access, deploying another for the video security purposes while also setting up separated backbone networks would imply both costs increases in procurements, management and support but also constrains on technical aspects such as radio frequency interferences, physical assets limitations and urbanistic headaches.
- lack of uniform technical specifications:
  - independent applications or network infrastructures design, non-coordinated procurements result in heterogeneous technological platforms, which are more difficult and costly to manage, maintain and evolve. For example, area-wide villages or municipalities have often their employees and workers spread across several building situated in different locations. The local IT networking infrastructures are commonly independent from each other leading regularly to situation were both network cannot talk to each other and most probably have their standalone Internet access. Such an unplanned situation would seriously impact the setup and Total Cost of Ownership of an IP telephony platform.

It is therefore clear that cross domain thinking shall be applied when possible. The various levels were this specific exercise should be realized are:

- services business logics on both functional and operational levels;
- network (wired & wireless) architecture on both Local Area Network, Metropolitan Area Network and Wide Area Network;
- applications data structure, semantic and correspondences;
- data access methods;
- applications software architecture.

By embracing cross domain mentality versus silos mentality, serious operational improvements could be achieved thus strengthening the adoption of the smart city. As an example, real time crossing data of city parking availabilities, city traffic status, and street traffic lights might enable both free parking locations suggestion to driver while making traffic more fluid thru the avoidance of congestion areas where many drivers will converge. Furthermore, this fluidity in the traffic could be reflected by influencing the traffic light in a positive manner.

6.3 Data Culture & Open Data governance

For ages, municipalities have been servicing public interests and citizen needs generating numerous information of different kinds not shared with any party outside the city. Even in the presence of ICT technologies, these data have been locked within the specific business applications in which there are processed.

One key feature of digital multiservice city is the adoption of the cross domain approach. When ICT technologies are designed with this mentality many innovations may emerge.

To remain competitive and achieve sustainable growth, cities shall embrace the Data Culture philosophy. By changing the way government officials look at and use data we can enable the ICT ecosystem to be creative and this out of the box. Indeed, rather than limiting the usage of specific set of data within a city department to its specific business processing, sharing this set with other departments but also with third party outside the city sphere could benefit to the overall community.

For example, it is the water department which usually manages the fire hydrants locations as they belong to the water infrastructure city assets. However, the primary beneficiaries of this locations data set are entities like the fire department and the public safety. The water department has traditionally the responsibility for disseminating this information to those that need it. By embracing the Data Culture, instead of keeping these locations records and the associated operational status (operational valve, water flow, water pressure, etc.) closed and communicating these once a while, sharing dynamically theses precious data with the outside could be of a great benefit and even can save lives.

Opening Data outside the traditional scope of single or multiple city departments often faces technological of political barriers. Indeed, many city data are decades old, and extracting information to release as Open Data can be time consuming and difficult. Furthermore, some fear that releasing information could be used by outside parties to evaluate their performances.

Open Data does not mean providing access to anyone or in any way. When adopting this practice, data governance should be associated. Indeed, data should be structured in understandable formats, with defined semantics, open access should be presented according to their respective scope and usages should be logged. Furthermore, Open Data does not mean Free Data. Data Culture of a municipality is therefore also the ability to both operate as a free public service but also as an enterprise minded organization.

6.4 Availability, Interoperability, Scalability and Resilience

When it comes to IT, there are important inequalities between the cities. According to the size of the area, the number of inhabitants, the variability in the publicly provided services, the specificities (industrial, vacation, port, university, etc.) or the status (village, capital, etc.), the obligations and the finances (thru regional/governmental subsidy or local taxes) are different. These differences have an impact on the level of use of IT and therefore on the service level and service quality which could be achieved thru the digital infrastructure within reasonable limits.

Nevertheless, whatever city, critical services shall be treated with the same importance. ICT infrastructures and applications related to the critical domains (e.g. police, fire department, alerting system) shall be seriously analysed and associated with particular service levels such as:

- availability;
- interoperability;
- scalability;
- resilience.

Beside critical conditions were all these service levels shall be simultaneously associated, independent concerns should be applied in ICT fields such as to:

- avoid vendor lock-in and proprietary technologies;
- enable common information and meta-data semantic across vertical domains;
- enable open data interfaces/API between applications;
- enable infrastructures/platforms monitoring and proactive supervision.

By introducing these service level requirements, it is possible to embrace the concept of a digital multiservice city. As an illustration there are numerous city departments which may have valuable information serviceable to address the question of the unoccupied dwellings:

- the revenue department view the notion of vacant property thru their records which keep track of those that do pay property taxes and those that do not;
- the water and electricity departments view the notion of vacant property thru their records which keep track of those that have an active account and effective consumption and those that do not;
- the sanitation refuse and waste department view the notion of vacant property thru their records which keep track of the collection passages and the weight of waste collected.

As there is not a department in charge of keeping track of vacant properties, there is not an appropriate view on this question. Several departments have some data on the problem of vacancy, but their interpretation of the question is approached through the lens of the service they deliver.

However, if these data sets are made available, in a digital and interoperable format, crossing them would give a better view and help to reduce the vacancy rate. This will be of added value for the citizen (vacant properties negatively impact housing values), the real estate business (increase value proposition), the city (population grow) and even the police (vacant units are more likely to be vandalized or squatted).

6.5 Digital Equity

In the road to digital, cities are taking important decisions which impact the operation and delivery of their public services. From data scanning to e-Government, gradually the delivery model is modernized with digital assets and offering. While Municipal Service Counters are complemented with digital counterpart, some are simply replaced by their digital counterpart.

Digital Service Counters are of a great benefit to the population or the businesses/commerce. Residents who have mobility issues, poor health, the elderly and those living in geographically remote areas can take advantage of this delivery method. Local trader is no longer forced to close shop to get to the administration offices neither business employee to take break during work. Digital services provide also facilities for the administration to communicate with the population, alerting systems are in the first line for such improvement.

To illustrate these, it can be mentioned:

- alerting the inhabitant of a specific geographical zone in case of water contamination, fire and air pollution;
- notifying the inhabitants of a neighbourhood before the waste truck round;
- soliciting the citizen for the electoral duty;
- invoicing the inhabitant for the various city taxes;
- etc.

Public libraries, municipal schools, social services.

It seems obvious that these multi service facilities are permitted through the Internet. However, even if every day the penetration of the broadband access in increasing, there is still a large percentage of the population without Internet access or who do not have access at all. Literature refers this inequality as the Digital Divide.

It is therefore essential that the digital multi service city does everything in its power to reduce and defeat this Digital Divide. Cities have some answers to fulfil the Digital Equity:

- Digital Public Space in some of the city property (e.g. city house, library house, library truck).
- In such place where anyone who wishes (children, adults, all social classes, all ages) can come to connect the available computers and access the Internet for all types research.
- Public Wi-Fi in some of the city property or areas (e.g. city house, city green park, city places).
- Facilitating (e.g. building permit, taxes incentives) Service Provider in their Broadband deployment (wired or wireless) within the city administrative scope.
- Specific education courses within the children schools or recycling courses for elderly.

6.6 Pledge of confidence

Municipalities collect and own numerous information about their inhabitants, companies established in the territory and commuters. On one side, they have immediate access to data such as electricity or water consumptions, the amount of produced waste, the financial income, the properties ownership, the various contacts information (addresses, phones numbers, etc.), the family status and composition, etc. On another side, when fostering smart city, thru various deployed digital technologies, they may have access to people locations (e.g. Bluetooth kiosk on bus stops, Wi-Fi in hotspot, video security camera, Location Based App, etc.), to consuming habit (e.g. traffic thru the public internet access), etc.

Many smart cities platforms collect, analyse and share the data about the citizen or produced by them. This extraordinary amounts of information, combined with Big Data processing can really impact the privacy of the citizen. It is important that cities take action to analyse and define framework in field such as data ownership, data privacy, data access transparency and also offer a way for the citizen to control these subjects.

Numerous studies have established that personal data are valuable. In the business data broker industry, personal data monetisation is common: one get finance free access to a service but in exchange do accept to trade the data generated by the service usage. It is commonly known that an individual worth around one euro. The market leads to multi-billion euro when broker has access to abundant number of individual profiles.

Cities have often budget difficulties, particularly when it deals with ICT. It is important that city authorities are not attracted by such kind of monetization and that they comply with the regulatory framework.

Beside their role of ensuring data privacy of the people, cities shall also ensure the confidentiality of these data. It is important to apply this constraint to both data transfer and data storage.

6.7 Digital Infrastructure

Some of the services delivered by cities are associated with physical networks assets such as delivery (e.g. water, electricity, gas, lightning), collection (e.g. sewage), mobility (e.g. metro, tram) and telecommunication (e.g. data, voice, IoT sensors, traffic light, video security).

Similarly to behaviour that can be observed in the data silos generated by the independence of service departments, cities often suffer from important separations in the various networks.

To reach a correct level of sustainability, cities should rationalize and unify networks when possible. Telecommunication networks are appropriated for such operational merging thru infrastructure sharing. Synergies are also possible with the other network assets:

- Fiber backbone and access can be deployed in aerial thru the lamp pole infrastructure or underground thru the sewage infrastructure.
- IoT sensors or Wi-Fi hotspot can be deployed thru urban assets such as bus stops, public dustbin, or tourist information kiosk.

6.8 Metric and KPI

In order to measure the improvements that ICT technologies bring to the city services and the quality of life of its citizen and enterprises commuters, it is crucial to define Key Performance Indicators (KPI) which are clear, understandable and realistic to determine.

These KPI enable both the city to calculate the smart enhancements in the provided services but also to position itself into the regional, national and international scene. Thru these indicators, the municipal authorities and their stakeholders should have a common understanding of the "smartness level" of the various field of involvement of the city.

7 General needs from the cities

7.1 ICT users' position

Energy efficiency of data centre buildings, transmission node building, computer rooms, networks and IT systems is of high importance for the ICT Customers who are users of ICT System Installations e.g. Car manufacturers, Banks, Insurance Companies, Network Operators, Airplane Companies and Governmental Ministries.

Independently from the ICT systems integrators, service providers, producers and manufacturers of ICT system installations, in the perspective of EU Digital Agenda mechanism and law enforcements, these Users are proposing commonly agreed, proofed KPIs and framework of implementation.

Such energy management KPIs will help Users of Operational Architecture to easily identify, compare and scale the effective energy efficiency of their ICT installations internally and with the other Users.

The following Position Papers from the Industrial Specification Group Operational energy Efficiency for Users (ISG OEU), focusing on smart cities, will be provided in order to complement the present ETSI standards:

- ETSI GS OEU 009 [i.19] : Global KPI Modelling for Green Smart Cities
  "Definition of Global KPI Modelling for Green Smart Cities. This modelling will cover ICT domain including residential and office areas".
- ETSI GS OEU 019 [i.20] : OEU KPIs for Smart Cities
  "The deliverable will define indicators (KPI) for Smart Cities expressing city level in terms of People, Planet, Prosperity, Governance and Propagation".

The following recommendation from the ITU-T Study Group 20, focusing on smart sustainable cities, gives a general guidance to cities and provides an overview of key performance indicators in the context of smart sustainable cities:

- Recommendation ITU-T Y.4900 [i.53]: "Overview of key performance indicators in smart sustainable cities".

It belongs to a series of recommendations and supplements about KPI definitions which also includes:

- Recommendation ITU-T Y.4901 [i.54]: "Key performance indicators related to the use of information and communication technology in smart sustainable cities".
  This recommendation lists the KPIs focusing on ICT use in smart sustainable cities.
- Recommendation ITU-T Y.4902 [i.55]: "Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities".
  This recommendation lists the KPIs used for ICT impact on sustainability.
- Recommendation ITU-T Y.4903 [i.56]: "Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals".
  This supplement provides information regarding KPIs and evaluation index systems of smart cities, KPIs of sustainable cities, etc.

The following recommendation from the ISO/TC 268 [i.59] technical committee, focusing on sustainable cities and communities, defines and establishes methodologies for a set of indicators to steer and measure the performance of city services and quality of life.

- ISO 37120:2014 [i.57]: "Sustainable development of communities -- Indicators for city services and quality of life".

Figure 2: ICT users' digital domains of interest

8 Multiservice digital infrastructure

8.1 A shared digital infrastructure as core foundation

The core foundation for a digital multiservice city is strongly tighten to the ability that the components of its ICT systems have to interoperate. To achieve this goals, city should install a shared communications infrastructure that will allow the ICT systems of the complete services departments to interconnect seamlessly and securely to each other.

8.2 Management of the various network cabling infrastructures of the city

Performant ICT requires the access to a high speed network. To achieve the goal of a ubiquitous digital access the city network backbone should span across the entire territory. When seen thru the silos approach, the deployment of such a broadband network architecture, mainly composed of optical fibre and most probably high speed wireless point to point links, on a large geographical scale is a complex and expensive civil engineering challenge. However, when seen thru the cross-domain approach, evidence demonstrate the benefit of sharing passive infrastructure amongst different city departments of city partners such as utilities.

Numerous city network infrastructures can be leveraged to achieve this strategy:

- Access to electrical power distribution infrastructure.
- Access to ducts, trenches.
- Access to lighting infrastructure.
- Access to water distribution infrastructure.
- Access to gas distribution infrastructure.

- Access to sewer collecting infrastructure.

Furthermore, other passive city assets such as real estate properties (technical room facility), conduits, manholes, cabinets, lamppost, poles, masts, antenna, towers and other supporting constructions could also play an important role in the design of the digital multiservice city infrastructure.

Best practices in network architectures organize the infrastructure topology into a multi layers structure which spans across the geographical area to deserve at city scale or urban metropolis scale.

- Layer 1: Digital multiservice city core network:
    - The core network provides high-speed and redundant forwarding services to move the data packet between the distribution nodes which span across the city area. The core nodes (usually routers) are commonly the most powerful, in terms of forwarding power; they define the Wide Area Network (WAN). When city communication networks interconnect to each other, some of these nodes also acts as Metropolitan Area Network (MAN) inter-exchanges nodes. Current appropriated bandwidth are high speed links such as Gigabit and 10 Gigabits.
- Layer 2: Digital multiservice city distribution Network:
    - The distribution network is often referred as the multiservice delivery level which offer several smart layers' functionalities for the various policies related to data packet routing, data packet filtering and Quality of Services (QoS). The distribution nodes (usually routers and switches) are mainly dedicated to connect the network sites (LAN) to each other; their links to the network sites are often referred as last mile connections. Appropriate dispersal of these network nodes across the city geographical area makes them also an appropriate place to connect special delivery network elements, such as the municipality urban assets. Current appropriated bandwidth are high speed links such as Gigabit (and potentially 10 Gigabits).
- Layer 3: Digital multiservice city access Network:
    - The access network is often referred to the desktop layer. The access nodes (usually switches) have the main concern to connect the end hosts (workstation, server, enterprise devices: wireless access point (AP), printer, scanner, IP phone/camera, etc) to the city network infrastructure. The proximity of these nodes to the end devices makes them also an appropriate place to deliver secured electricity power (Power over Ethernet, PoE IEEE 802.3af [i.35] or IEEE 802.3at [i.36]) to low consumption devices (Wi-Fi AP, IP phone/camera, IoT gateway, etc). Current appropriated bandwidth are high speed Gigabit connections.

When reaching the network site layer, the hierarchy of the infrastructure topology can be further organized in stratums to fit the actual architectural structure of the local area (single or multi floors house/building, a multi constructions administrative district/campus) to deserve. Typical network topology for LAN access includes star, mesh, tree, and clusters.

The digital multiservice delivery across the city wide area implies to cope with multiple distances ranges. Core node links can deal with long distances which ranges from km to tens of km whereas distribution nodes links deal with distances from hundreds of metres to a km.

Off course, the transmission capability to achieve such distances depends of the physical communication medium: optical fiber is nowadays the preferred media to succeed in the delivery of multi (tens/hundreds) gigabits in long distances (core/distribution) links thru optical transmissions. However, in various cases electrical transmissions over copper (twisted pair or coax) or wireless links can still be delivering acceptable high speed data rate for distribution network links.

ETSI TR 105 174-4 [i.2] and ETSI TS 105 174-4-1 [i.3] detail measures which may be taken to improve the energy management of access networks for broadband deployment.

To the extent possible the city should do everything in order to have total control over its digital multiservice city infrastructure. In other words, it is valuable and advantageous for the city to deploy its own physical networking fiber connectivity links when technically feasible. When considered in a mid (3 years) to long term (10 years) strategic vision, having the ownership of the networking links is a smarter than having contractual access to a service provider (SP) infrastructure.

Beside such economical consideration, there are various technical reasons which drive the city to deploy its own physical fiber network infrastructure or to contract, from a carrier, for dark (unlit) fibre links:

- Freedom of the optical transmission standard: network bandwidth depends of the fibre transceivers which are bound at the extremities of the fibre link and the length of this one. According to the link needs, the municipality can lit the fibre with the most appropriate transceiver (from a single wavelength to wavelength-division multiplexing, from gigabit to multigigabits). Should a link speed need to increase, the municipality has the freedom to upgrade the transceivers.

- Freedom of the digital transmission standard: digital data transmissions can be operated by various technologies such as Ethernet, MPLS, etc. According to the engineering of the digital services and the requirement for network resilience one can be more suitable than the other. Network size, number of digital services, security concerns, multi-homing requirement, etc. are concerns which drives the choice of the optimal transmission standard.

- Ease of introduction of new digital services: to leverage a single physical network infrastructure sharing while delivering to each digital service within its own controlled environment, the municipality can either chose to introduce a new IP service by the mean of a complementary VLAN in Ethernet, a complementary LSP in MPLS, or even by the assignment of a specific light wavelength which virtualizes the link at the optical level.

- Freedom of the choice of ISP: Different Internet access might be required to be served by different service providers. While public administration agents require access to specific Internet service provider with specified technical SLA (redundancy, low latency, security, etc.), schools, libraries, police, citizen free public Internet, IoT sensors, etc. may use other service providers.

ETSI TS 105 174-1 [i.1] focuses on the best practice for cabling and installations and transmission implementation independently from the ownership of these infrastructures. ETSI TS 102 973 [i.8] describes a proposal of requirements for a Network Termination (NT) device in Next Generation Access Networks.

Deploying networking links includes planning and routing, obtaining permissions, creating ducts and channels for the cables, and finally installation and connection. When the situation permits, aerial links installation have to be preferred instead of digging the streets or sidewalks. In that concern, Objectif Fibre organization from the Federation des Industries Electriques, Electroniques et de Communication (FIEEC) has published a practical guide to deploy shared local optical infrastructure over aerial support [i.39].

However, there are various situations in which completely following such strategy it is simply unfeasible. In such cases, when contracting with an SP, passive network links (e.g. dark fibres) have to be preferred over active network links (e.g. leased line).

Digital service end points are usually distant from their access nodes in range from a few metres to a few hundred metres. As for the other communication layers, speed, achieved distance and access flexibility depend on the physical medium in use. Cable free connectivity offered by wireless technologies such as Wi-Fi (Electromagnetic Communication, EM) or Li-Fi [i.21] (an improvement of Visible Light Communication, IEEE VLC [i.24]) deliver suitable speeds, to the user desktop. From hundreds of gigabits over a few metres with LiFi (under certain conditions) up to multi-gigabits over hundreds of meters for existing contemporary IEEE Wi-Fi standards (e.g. IEEE 802.11ac [i.50]: 1 Gbit/s, IEEE 802.11ad [i.49]/WiGig [i.26]: 4 Gbit/s).

Current trends raised by the fields of IoT and M2M give to low speed (few kbit/s or hundred kbit/s) wireless communication technologies a significant role to play into the digital multiservice city infrastructure. Connectivity in this low speed and low power wireless network access can be categorized into two main viewpoints: short distance (LR-WPAN, LP-LAN) and long distance (LP-WAN).

In the former viewpoint, connected objects join the IoT wireless (mainly in unlicensed RF ISM band) gateway hooked to the city infrastructure at the Access Network layer whereas in the later viewpoint the connected objects join the IoT Base Transceiver Station (BTS) of a mobile operator network infrastructure (using his licenced RF band). ETSI TR 103 375 [i.13] provides a complete landscape view on these IoT technologies for Smart Cities.

Regarding the data transport technology, it is clear that IP (v4 and v6) and Ethernet [i.30] are the most suitable addressing and data transmission protocols to be deployed for the digital multiservice city infrastructure layers. Appropriate addressing plan, network hierarchy, security policies such as packet filtering and firewalling rules as well as and related QoS support have to be well engineered to achieve the design of a digital multiservice city delivery infrastructure.

Furthermore, although Ethernet has been proven to be a good transport technology for WAN, large city core network may need to consider other types of carrier class transport technologies such as Multiprotocol Label Switching (MPLS, IETF RFC 3031 [i.27]) or Virtual Private LAN Service (VPLS, IETF RFC 4761 [i.28] and IETF RFC 4762 [i.29]).

However, these considerations as well as engineering details on optical network architectures are outside the scope of the present document.

8.3 Digital services delivery thru the urban assets

8.3.1 Leveraging street furniture with digital technologies

Street furniture [i.15] is a collective term for objects and pieces of equipment installed on city streets and city roads for various purposes. These urban assets include the objects listed in the following clauses. Many of these city urban assets can be leveraged to either contribute as:

- network access nodes within the multilayer mesh which constitute the unified digital communication infrastructure;
- an service distribution and wireless AP node towards end users or connected objects (sensors, actuators) of the IoT world.

8.3.2 Usages of billboard, streetlamp, bollard and various poles, bench and picnic table

Most of these urban assets can play a role in the enhancement of the sustainability of the city. These assets can be promoted to a role which provides additional services beyond the native one.

For instance, these urban assets can be the operation points for:

- Communications as transmitter/receiver points for data communications thru Li-Fi.
- Provide public Wi-Fi services as a new city infrastructure.
- Public security, through use of CCTVs (IP video security) on posts.
- Control of light attenuation levels.
- Environmental sensing (air quality, noise pollution monitoring).
- Environmental management through CCTVs.
- Traffic control through thru CCTVs or radar.
- Parking (monitoring) availability and access through sensors and actuators.
- Smart meters reading.
- Sound level monitoring thru sensors.
- Movement activity monitoring thru motion sensors of CCTVs.
- Image sensing (proximity, pedestrian counter).
- Digital signage (way finding, traffic direction, civic information).
- Water level/flood monitoring.
- Etc.

Thru these various data sources, intelligent cross domain analyses and processing (most probably thru Big Data platform) can be leveraged to offer useful services to the city and it audiences. Typical example includes the adaptation of the streetlamp illumination level according to environmental parameters such as lighting condition, proximity of a user, detection of an abnormal incident. Offering to the citizen a better quality of life could be a simple as sharing the harvested information related to the quality of the air of the presence of high level of flower pollens in rest areas, green parks and other child park.

Beside data harvesting functions, these urban assets can be considered as information delivery points, to the proximity users, either thru local display mechanism (e.g. info kiosk, interactive or not) either thru digital service delivery pushing the contextualized information directly into the user mobile terminal (e.g. smartphone, tablet) via locally generated wireless access point (e.g. Wi-Fi, Bluetooth, Near Field Communication/NFC) or thru voice and data communication over cellular networks (e.g. via small cells).

8.3.3 Usages of bus or tram stop, taxi stands and phone box

Most of these urban assets can play a role in the enhancement of the sustainability of the city and the operations of their partners. These assets can be promoted to a role which provides additional services beyond the native one.

These urban assets have in common the particularity to be places which concentrates significate number of individuals who standing there for a while and often expecting precise details related to the service delivery (e.g. real-time time-schedule, availability, traffic condition, etc.).

One-dimensional approach for connecting such urban asset to the digital multiservice city network can be to connect dynamic display boards, CCTV camera or Wi-Fi hotspot. By adopting a multi-dimensional approach, innovative and sustainable new type of operation can be offered. Local facts such as number of persons, presence of disabled persons, can be valuable information that can be taken into account by the IT system to take decisions and improve the dynamic operation of the transportation system.

Furthermore, as a place which concentrates significant number of individuals in a defined area, these urban assets may be considered as an appropriate location to deliver cellular network communication (e.g. via small cells). This would represent on one side the opportunity to improve the overall performances of the mobile network while opening a complementary channel for (geo)localized digital service information delivery directly into the user mobile terminal.

8.3.4 Usages of post box and waste trash

Most of these urban assets can play a role in the enhancement of the sustainability of the city and the operations of their partners. These assets can be promoted to a role which provides additional services beyond the native one.

These urban assets have in common a physical characteristic associated to a "level of spatial volume used".

By associating appropriated sensors, the cross domain pillar associated with the data culture and appropriated Big Data processing can add value to:

- The optimization of the paths executed by the waste collecting trucks.
- The conservation of the state of cleanness of the city by avoiding overfilled bin.
- The optimization of the paths executed for the sent mail collection.
- The opening of the post boxes to other type of content to be shipped (e.g. e-commerce good delivery/return).
- Etc.

Associating appropriated sensors to waste trashes can also monitor air quality and pollution/ unpleasantness caused by odours in order to keep a good the quality of life for the surrounding peoples.

The position of the waste trashes on the street level is a strategic advantage, particularly in dense skyscrapers cities, when considering delivering Wi-Fi hotspot to the pedestrian, the surrounding vehicle or other city urban assets. Since the bins are located on street level, service coverage and signal quality can be outstanding as they the wireless network is not perturbed from any interference from the buildings.

8.3.5 Usages of traffic sign and traffic light

Most of these urban assets can play a role in the enhancement of the sustainability of the city. On one hand, these assets can have their operations improved and on the other promoted to a role which provides additional services beyond the native one.

These urban assets have in common the functions to signal and communicate to the proximity users (e.g. pedestrians, motorist, cyclist, drivers, workers) important information but also to secure and regulate the associated traffics (e.g. road, street, highway, rail road, tram line, crossroads, railroad crossing).

These urban assets are traditional places were sensors (e.g. motion sensor, radar, CCTVs) are located and information presented (e.g. traffic light, info screen, sound alert).

However, recent digital technologies can still increase the benefits of such urban assets. Furthermore, the connection to the digital multiservice city network of the city can empower the cross domain pillar by enabling new type of innovative services.

These urban assets are often in proximity of a substantial number of individuals. Hence, they may be considered as an appropriate location to deliver cellular network communication (e.g. via small cells). This would represent on one side the opportunity to improve the overall performances of the mobile network while opening a complementary channel for (geo)localized digital service information delivery directly into the user mobile terminal or onto next generation connected devices such as automotive which would embed a screen right into the windshield to support the driver by displaying by example a focus of the nearest traffic sign(s).

Electronic paper coupled with a dynamic access to the digital multiservice city network of the city can transform any fixed infographic traffic sign into an adaptive infographic which communicates different contextualized information to the proximity users. Such dynamic road signalling can also be of a benefit in the regulation and optimization of the traffic within the city (e.g. guidance to the nearest available parking place, guidance to the lowest a crowded street).

Enabling alternative sustainable transportation mechanisms is within the concern of many city councils. Today, cycling is considered as significant instrument that cities stimulate to answer their sustainability concerns. Prioritizing cyclist when it rains can be achieved by associating heavy rain sensors to the traffic lights operation. Nevertheless, such dynamicity of the operations has to be handled with care. Connectivity to the digital multiservice city network should be available to ensure that the monitoring and global operation of the cross-over is performing well.

8.3.6 Usages of fountains, public lavatory, watering trough, street gutter, storm drain and fire hydrant

Most of these urban assets can play a role in the enhancement of the sustainability of the city. These assets can be promoted to a role which provides additional services beyond the native one.

All of these urban assets are related to water. This water origin can be:

- water from a cave source;
- water from the distribution network;
- water from the sewing collecting network;
- water from a river;
- water from a wastewater treatment plant;
- etc.

For instance, these urban assets can be the operation points for:

- water source pumping (production) monitoring and control;
- water recycling (production) monitoring;
- water volume consumption monitoring and control;
- water quality monitoring;

- operational (pressure, temperature, hydraulic, etc.) parameters monitoring and control;
- servicing control (tap/valve: open, close, flow regulation) management and control;
- securing critical services (fire hydrant operation, water tower operation);
- water pollution (e.g. pollutant, decease microbe) containment;
- water flows (clean and dirty) monitoring;
- water leakage monitoring and control;
- water flooding (e.g. river level, drain sewer, street gutter) prevention.

Production, distribution, consumption, collection and treatment of waste water represent the full cycle in the water department. Good operations of such city responsibility is a key element of an urban system. Although numerous water services management standards have been developed there is a need for defining, through use cases, what IoT can bring into the scene to address sustainable development goals.

8.3.7 Usages of memorial, statue, and public sculpture or art

Most of these urban assets can play a role in the enhancement of the sustainability of the city. These assets can be promoted to a role which provides additional services beyond the native one and in full accordance with preservation of cultural heritage.

All of these urban assets are related to city history, local art, tourist attraction, etc. These urban assets can be collecting point for various environmental information:

- Air quality monitoring.
- Noise pollution monitoring.
- Sound level monitoring.
- Movement activity monitoring.
- Etc.

But they can also be delivery point for the information related to the urban asset itself (artist, history, art description, etc.) thru:

- A mobile terminal of the proximity users with:
  - Near Field Communication.
  - Bluetooth.
  - Wi-Fi.
  - Li-Fi.
- An associated Digital Human Interface:
  - Interactive display thru touch screen.
  - Interactive display thru camera motion tracking interface.

Digital technologies can also be a way to increase the attractiveness of the sites: interactive experiences such as adaptive lightning, voice interactions, virtual complementary educational content projections, etc.

Beside data harvesting functions, these urban assets can be considered as information delivery points, to the proximity users, either thru local display mechanism (e.g. info kiosk, interactive or not) either thru digital service delivery pushing the contextualized information directly into the user mobile terminal (e.g. smartphone, tablet) via locally generated wireless access point (e.g. Wi-Fi, Bluetooth, Near Field Communication/NFC) or thru voice and data communication over cellular networks (e.g. via small cells).

8.4 Technologies which leverage the digital sustainability of a city

Specialist Task Force 505 (STF 505) is a group of experts, funded by the European Commission and supported by ETSI, commissioned to provide on the one hand an in-depth analysis of the IoT Standardization landscape and on the other hand, an identification of the IoT standardization gaps.

STF 505 technical recommendation ETSI TR 103 375 [i.13] provides an overview of the IoT standards (requirements, architecture, protocols, tests and related open source projects) for the various landscape introduced by "IoT LSP Standard Framework Concept" [i.14] from the Alliance for the Internet of Things Innovation (AIOTI).

"The Internet of Things requires and triggers the development of standards and protocols in order to allow heterogeneous devices to communicate and to leverage common software applications. Several standardization initiatives currently co-exist, in individual standardization organization or p*artnerships (e.g. ETSI SmartM2M, ETSI SmartBAN*, ITU-T, ISO, IEC, ISO/IEC JTC 1, oneM2M, W3C, IEEE, OASIS, IETF, etc.) and also in conjunction with a number of industrial initiatives (e.g. All Seen Alliance, Industrial Internet Consortium (IIC), Open Connectivity Foundation (OCF), Thread protocol, Platform Industrie 4.0, etc.).

It is therefore necessary to understand the global dynamics of IoT standardization in order to leverage on existing standardization activities, if relevant, vis-à-vis existing initiatives and to ensure a thorough understanding of market needs and requirements.

ITU-R is working on the future International Mobile Telecommunications (IMT) for 2020 and beyond, that covers all aspects for enhanced mobile broadband telecommunication including Internet of Things (IoT). Enhanced mobile broadband networks enable high-speed and ultra-reliable mobile (Internet) connectivity to applications such as video streaming/UHD screens, work and play in the cloud, voice, augmented/virtual reality, industrial automation (M2M), smart grids, self-driving cars, smart homes/buildings and smart cities.

Sustainable digital city content is made up of many services, e.g. smart transportation, smart home, smart waste management to mention just a few. Clause 6 of ETSI TR 103 375 [i.13] focuses on the standards that are available to enable the ICT systems of a city to function as a clever and performing single integrated system.

8.5 Engineering of the urban assets (**street furnitures**)

8.5.1 Common engineering

Serious evolutions in the field of fixed and mobile connectivity and wireless contactless technologies are turning urban, passive physical asset into smart, connected street furniture which can interact in the city with the people offering contextualized contents. These interaction points should be able to communicate with inhabitants, visitors, travellers with the help of digital devices which could be mobile terminal in their hands (smartphone, tablet, etc.) or embedded in the vehicle (car, bike, bus, train, etc.) as well as Human Machine Interfaces (HMI) attached to the urban assets itself.

To provide services beyond the function for which they are engineered, street furniture and city urban assets in general should be connected to the digital multiservice city infrastructure. Interconnecting these elements should enable the municipality and related partners, to leverage the cross domain and data culture pillars.

To leverage network connectivity and digital service functions, the urban asset should be powered by electricity. The electrical power may be delivered by a permanent link to the electrical distribution network or may be consumed from a local battery source feed by solar panel or alternative power generating devices.

Energy which is consumed by the urban asset in performing its digital services should be monitored and appropriate levels of energy saving should be applied when possible. The monitoring of the consumed energy should be performed in centralized operations. However, energy saving capabilities (e.g. standby mode, sleep mode) may operate in a decentralized manner which can be on the level of the urban asset itself.

Connected urban assets are part of the whole Internet of Things sphere. As such, smart urban assets contain hardware platforms with embedded computing platform running firmware and Operating System (OS). These hardware platforms can leverage UEFI Forum Advance Configuration and Power Interface (ACPI [i.42]) specifications for power management.

When the urban asset is not connected to a permanent source of electrical energy, appropriate engineering should be applied to the battery capacity to enable the digital services functions to operate without any interruptions also during the recharging cycles.

Urban asset should require regular voltage (220 V) or low power voltage (48 V) to operate.

Urban asset should be considered as leaf node of a network for data collection and processing. When interconnecting with the digital multiservice city network, the urban asset should attach to the access network layer. However, in certain cases the urban asset may attach to the distribution network layer. Such situations are, in a non-exhaustive way, when:

- the node is enabling other network nodes to attach to the network;
- the node is acting as part of a meshed network;
- the node is performing specific network services (e.g. data packet routing/filtering, QoS);
- etc.

When the digital features set includes such function the urban asset should be considered as a layer 3 access node.

Physical network connectivity of the urban asset to the digital multiservice city infrastructure should be correctly engineered according to network characteristics required for the provided digital features set:

- low latency services should be associated with fibre connectivity;
- bandwidth intensive services should be associated with fibre connectivity;
- high upstream data rate services should be associated with fibre connectivity;
- low data rate service should be associated with wireless connectivity.

When the digital features set includes mission critical functions, the urban asset should be connected to at least two network nodes of the access layer or the distribution layer.

Network addressing of the urban asset should use IP technology and should support IPv4 and IPv6. Technologies such as Network Address Translation should be banned.

When an urban asset is considered as an access layer node which aggregates several concurrent digital services, the urban asset should be capable to identify and provide services differentiation in order to ensure the delivery of the appropriate Quality of Service to each of the leaf nodes which require it. Networking technologies such as:

- IETF Type of Services Diffserv protocol (IETF RFC 2474 [i.43], IETF RFC 2475 [i.44]) to differentiate services on the IP network layer.
- IEEE Class of Services (IEEE 802.1p [i.47]) for Ethernet Virtual LAN (IEEE 802.1q [i.37]) to differentiate services on the Media Access Control (MAC) of the Ethernet network layer.
- Wi-Fi Multimedia (WMM IEEE 802.11e [i.48]) to differentiate services on the Media Access Control (MAC) of the Wi-Fi network layer.

When an urban asset is considered as an access layer node for non IP digital leaf nodes (e.g. sensor, actuator), the urban asset IP identity should be used on behalf of this network leaf node. Furthermore, if these complementary digital technologies offer any service quality feature, they should be used to deliver end to end QoS when necessary.

In order to facilitate the IP addressing of the urban asset, a dedicated network hostname associated with an appropriate network domain name should be defined in a Domain Name Service (DNS; IETF RFC 1034 [i.40], IETF RFC 1035 [i.41]) directory. Beside the digital addressing scheme, the digital asset should be associated with a geolocation parameter indicating the geographical position within the city area. For fixed urban assets, the position can be identified by an operator; however, for mobile urban assets the position should be defined by mechanisms such as GPS, radio triangulation, etc.

The above technical engineering should be taken into consideration for each **street furniture** (urban asset) on a per use case situation. As introduced in clause 8.2, urban assets can be categorized into digital contextual purposes:

- Engineering of billboard, streetlamp, bollard and various poles, bench and picnic table.
- Engineering of bus or tram stop, taxi stands and phone box.
- Engineering of post box and waste trash.
- Engineering of traffic sign and traffic light.
- Engineering of fountains, public lavatory, watering trough, gutter, storm drain and fire hydrant.
- Engineering of memorial, statue, and public sculpture or art.

The engineering of these digital contextual purposes will be described into separated technical specification. These documents will be complementary individual specifications for these network entity (leaf nodes) and network sub-systems (IoT nodes gateways/bridges) of the presently introduced digital multi service city Next Generation Network. Clause 8.5.2 introduces the suggested technical engineering architecture for the first urban asset category.

8.5.2 Engineering of billboard, streetlamp, bollard and various poles, bench and picnic table

The urban assets can play a role in the enhancement of the sustainability of the city by providing additional services beyond the native one.

This street furniture can, with appropriated structural layouts (build-in, adjusted or revised), be promoted to a network node for various communication technologies to either harvest data of or to provide communication facilities to other network nodes.

Figure 3 shows the content and external connectivity of a particular category of the city urban assets in a little more details though this diagram is intended to illustrate the types of equipment employed, not its internal connectivity. For the purposes of the present study, the boxes marked "TxRx" will be regarded as part of the access or distribution network, as appropriate and their power requirements included in the assessments for those networks.

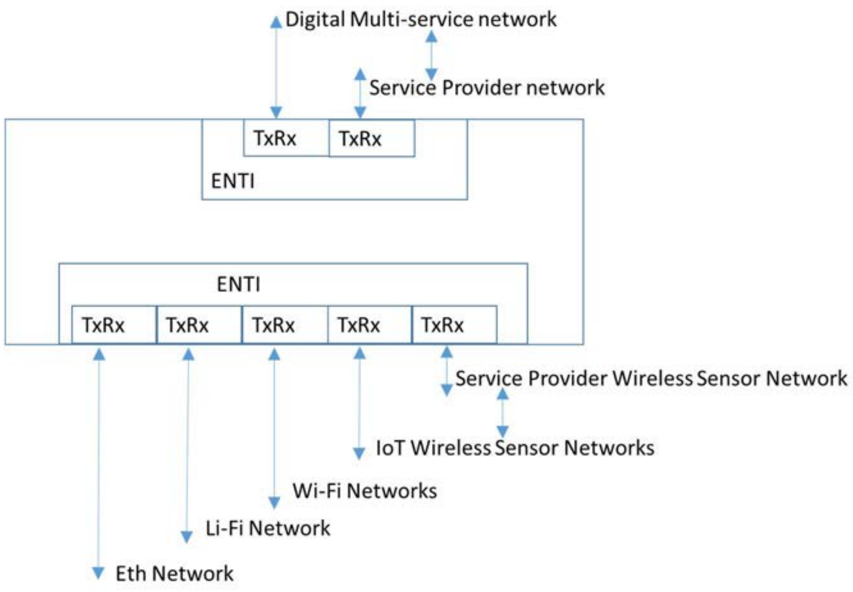

Figure 3: Engineering of urban asset

Connection link to the digital multiservice city network

Access to the digital multiservice city infrastructure from various part within the city area implies to cope with multiple distances ranges. Urban assets node links can deal with distances which ranges from hundreds of metres to a few km.

The transmission capability to achieve such distances depends of the physical communication medium: optical fibre is nowadays the preferred media to succeed in the delivery of (multi) gigabits for such distances links thru optical transmissions. Physical connectivity of the **street furniture** to the digital multiservice city network should be point-to-point fibre link to the nearest access or distribution node. However, in various cases electrical transmissions over copper (twisted pair or coax) can still be delivering acceptable high speed data rate for the connection to the digital multiservice city infrastructure.

ETSI TR 105 174-4 [i.2] and ETSI TS 105 174-4-1 [i.3] detail measures which may be taken to improve the energy management of access networks for broadband deployment.

To the extent possible the city shall do everything in order to have total control over the urban asset link to the digital multiservice city infrastructure. In other words, it is valuable and advantageous for the city to deploy its own physical networking fibre connectivity links when technically feasible. When considered in a mid (3 years) to long term (10 years) strategic vision, having the ownership of the networking links is a smarter than having contractual access to a service provider (SP) network infrastructure.

Beside such economical consideration, there are various technical reasons which drive the city to deploy its own physical fibre network infrastructure or to contract, from a carrier, for dark (unlit) fibre links:

- Freedom of the optical transmission standard: network bandwidth depends of the fibre transceivers which are bound at the extremities of the fibre link and the length of this one. According to the link needs, the municipality can lit the fibre with the most appropriate transceiver (from a single wavelength to wavelength-division multiplexing, from gigabit to multigigabits). Should a link speed need to increase, the municipality has the freedom to upgrade the transceivers.

- Freedom of the digital transmission standard: digital data transmissions can be operated by various technologies such as Metro Ethernet, MPLS, etc. According to the engineering of the digital services and the requirement for network resilience one can be more suitable than the other. Network size, number of digital services, security concerns, multi-homing requirement, etc. are concerns which drives the choice of the optimal transmission standard.

- Ease of introduction of new digital services: to leverage a single physical network infrastructure sharing while delivering to each digital service within its own controlled environment, the municipality can either chose to introduce a new IP service by the mean of a complementary VLAN in Ethernet, a complementary LSP in MPLS, or even by the assignment of a specific light wavelength which virtualizes the link at the optical level.

- Freedom of the choice of ISP: Different Internet access might be required to be served by different service providers. While public administration agents require access to specific Internet service provider with specified technical SLA (redundancy, low latency, security, etc.), schools, libraries, police, citizen free public Internet, IoT sensors, etc. may use other service providers.

ETSI TS 105 174-1 [i.1] focuses on the best practice for cabling and installations and transmission implementation independently from the ownership of these infrastructures. ETSI TS 102 973 [i.8] describes a proposal of requirements for a Network Termination (NT) device in Next Generation Access Networks.

Data communication service

To deliver data connectivity to neighbourhood network nodes towards the digital multiservice city network, the urban asset may support the following set (or subset) of standardized technologies:

- Wireless networking: IEEE 802.11 [i.22] Wi-Fi:
  - Hotspot should support speed requirements: IEEE 802.11ac [i.50] and IEEE 802.11ah [i.26] and may support IEEE 802.11ad [i.49].
  - Hotspot should support services differentiations: multiple Service Set Identifiers (SSID) for services separation and IEEE 802.11e [i.48] for QoS.
  - Hotspot may support wireless meshing IEEE 802.11s [i.23].

- Fixed networking IEEE 802.3 [i.30] Ethernet:
    - Ethernet access ports should support Fast Ethernet and Gigabit Ethernet standard:
        - IEEE 802.3u [i.33] (100BASE-TX/UTP; 100BASE-FX/Glass Optical Fibre (GOF), Plastic Optical Fibre (POF));
        - IEEE 802.3ab [i.32] (1000BASE-TX/UTP);
        - IEEE 802.3z [i.34] (1000BASE-X/Glass Optical Fibre (GOF)); and
        - future IEEE 802.3bv [i.51] (1000BASE-X/Plastic Optical Fibre (POF)).
    - Energy efficiency should be considered according to IEEE 802.3az [i.31].
    - Ethernet switching should support multiservice separation (VLAN IEEE 802.1q [i.37]) and traffic priority (VLAN IEEE 802.1p [i.47]).
    - Local power source should be available by IEEE 802.3af [i.35] "Power over Ethernet" or IEEE 802.3at [i.36] "Power over Ethernet plus".
- Wireless networking: Li-Fi [i.21].
- Wireless networking: cellular networking (2G/3G/4G, etc.) [i.52].
- IETF Type of Services Diffserv protocol (IETF RFC 2474 [i.43], IETF RFC 2475 [i.44]) to differentiate services on the IP network layer when routing IP.

Environment sensing and operation service

The distribution of such urban asset within the city area enables to establish a significate sensing network for various type of services such as environmental sensing (e.g. air quality, noise level) thru either locally connected sensors or thru the connection to Wireless Sensor Network (WSN). Furthermore, as the urban asset has an identity on the digital multiservice city network, individual control of the native service (e.g. lightning) can be operated remotely.

When the urban asset is considered as an access layer node for non IP digital leaf nodes (e.g. sensor, actuator), the urban asset IP identity should be used on behalf of this network leaf node. Furthermore, if these complementary digital technologies offer any service quality feature, they should be used to deliver end to end QoS when necessary.

The urban asset may support non IP based Wireless Sensor Network such as those based on IEEE 802.15.4 [i.25] (e.g. 6LoWPAN, Zigbee, Bluetooth low energy) and Recommendation ITU-T G.9959 [i.46] Z-Wave.

IP video surveillance service

To deliver data connectivity to IP camera (e.g. CCTV service, motion capture service, depth vision measurement, etc.), the urban asset should support Fast Ethernet and Gigabit Ethernet standard to enable high quality video streaming. Furthermore, to deliver power to the IP camera, the urban asset should support IEEE 802.3af [i.35] "Power over Ethernet" and IEEE 802.3at [i.36] (for motorized camera).

Fixed Ethernet connectivity, IEEE 802.3u [i.33] (100BASE-TX/UTP; 100BASE-FX/Glass Optical Fibre (GOF), Plastic Optical Fibre (POF)), IEEE 802.3ab [i.32] (1000BASE-TX/UTP), IEEE 802.3z [i.34] (1000BASE-X/Glass Optical Fibre (GOF)) and future IEEE 802.3bv [i.51] (1000BASE-X/Plastic Optical Fibre (POF)) should be preferred over wireless Wi-Fi connectivity to ensure service availability.

Standardization of IP video surveillance (IP CCTV) is driven by industry groups Open Network Video Interface Forum (ONVIF) and Physical Security Interoperability Alliance (PSIA).

Annex A (informative): General needs from the cities

A.1 European Innovation Partnership on Smart Cities and Communities (EIP-SCC)

The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) brings together cities, industry and citizens to improve urban life through more sustainable integrated solutions.

This includes applied innovation, better planning, a more participatory approach, higher energy efficiency, better transport solutions, intelligent use of Information and Communication Technologies (ICT), etc.

EIP-SCC invitation for commitments was closed on June 2015 with 370 eligible commitments by over 3 000 partners.

All these are published on the online European Innovation Partnership marketplace [i.38] and the first public draft of the Operational Implementation Plan [i.16], the operational annex to the Strategic Implementation Plan [i.17] gives a wealth of detailed examples for integrated smart city solutions.

The operational plan suggests several Priority Areas amongst which the third is focused on "Integrated Infrastructures":

> *"Significant and as yet insufficiently tapped value is offered by integrating the various existing and new infrastructure networks within and across cities - be they energy, transport, communications or others - rather than duplicating these needlessly. This point applies, both, to active and passive infrastructure. Many such infrastructures are ageing; budgets to replace them are stretched; they are procured and managed 'in silos'; yet the potential afforded to cities and their customers through new joined-up approaches, exploiting modern technologies is substantial. This is achievable. However it will take sustained commitment from multiple parties to access value."*

The "Integrated Infrastructures" Priority Area suggest 11 potential actions. Amongst these actions, some are strengthening and supporting the notion of digital multiservice city network infrastructure and related smart urban assets:

- Potential Action #1: The Humble Lamppost:
  - "*Reduce energy consumption and maintenance costs through implementing e.g. efficient long-lasting lighting; motion-sensing; PV-power. Use lamppost for e.g. Wi-Fi; CCTV (parking, safety, etc.). Test innovative business models.*"
- Potential Action #3: Shared infrastructure planning:
  - "*Systematically exploit synergies between smart grid and broadband infrastructure, including shared engineering works, reuse of passive infrastructures, communications networks, data centres and services.*"
- Potential Action #5: Road Systems:
  - "*Mobile ITS (location-based route/travel information + traffic light systems = optimized traffic flow to reduce emissions and energy consumption). Work with traffic management systems and automotive industry to re-use urban sensors deployed in street scenes. Exploit sensors and devices to predict traffic conditions/improve road and traffic management.*"
- Potential Action #7: Parking systems:
  - "*Connect infrastructure, people and devices, and sensors to address the up to 25 % of congestion caused by people looking for parking. Mode shift through yield management pricing.*"

- Potential Action #10: Adverse Events:
  - "*Connect key information sources with city monitoring systems (sensors, people); with city 'life-lines' infrastructures (transport, power, water, and communication) to build city resilience in the face of incidents and crisis.*"
- Potential Action #11: Intelligent Bins:
  - *"Putting sensors on bins enables cities to communicate within the waste collection system, optimizing truck routing, minimizing energy consumption and congestion, and satisfying customers."*

A.2 Humble Lamppost

Amongst the commitments for integrated smart city solutions, the Humble Lamppost [i.18] is an illustration of urban asset (**street furniture**) valorization for sustainable city development thru a digital multiservice city infrastructure.

Lighting in a city is everywhere. It is typically treated in a very tactical manner, evidenced by the ageing assets that exist, and volume of citizen complaints (in some cities it represents 20 % of the contact centre calls). Light does not come cheap - savings on energy bills is of growing attractiveness. Quality low-energy lighting is required for 'place-making', for public safety and security. It is also too often on when not needed - wasting power and money; and can result in light pollution. The lamppost is also typically a single purpose asset - for light; however that is not necessarily the only role it can play. New ICT-technologies can help transform the role of the "humble lamppost".

The goal is to demonstrate how lighting can deliver early rewards for cities providing investment funds through saving for further integrated solutions in the areas of environmental and building monitoring and traffic analysis for overall emissions reduction.

Firstly, in terms of using the existing physical infrastructure, enhanced with digital infrastructure, for multiple purposes: synergy across city services and goals.

Secondly, in significant financial terms: lighting can represent some 20 % of a cities electricity budget; and savings in energy costs and maintenance costs of 20 % and 70 % are not uncommon, through installation of more efficient lamps. This is therefore a "quick win" for smart cities. It addresses all three content domains of the EIP (to greater or lesser extents), and also services the 20/20/20 energy and climate goals.

A.3 Shared infrastructure planning

The deployment of high-speed broadband networks can be made cheaper and faster by cooperating at infrastructure and services level between sectors. Various inefficiencies and bottlenecks in the rollout process exist, which lead to high costs and heavily administrative burdens for organizations wishing to deploy networks. It is estimated that up to 80 % of the costs of deploying new networks are civil engineering costs. It is also believed that savings up to 30 % could be achieved by adopting a set of simple measures, such as maximizing use of existing passive infrastructure or co-deploying infrastructure.

The goal is to demonstrate synergies between the energy and telecommunication sectors at infrastructure and services levels whilst deploying Smart Grids in cities. In particular, the underlying vision is to work towards:

- creating a favourable business, and technological environment for a low carbon electricity grid;
- clarifying which data could be transmitted in support of Smart Grids via existing (and future) telecom network infrastructures and which data might need to have a dedicated connection/network for the purpose.

A.4 s[m2]art

Amongst the commitments for integrated smart city solutions, s[m2]art [i.45] is an illustration of street furniture valorization for sustainable city development thru a digital multiservice city infrastructure.

The project aims at creating a scalable system of smart street furniture connected together as nodes of a network for data collection and processing.

s[m2]art addresses the creation of innovative prototypes of smart street furniture which can offer smart services. In a user-friendly perspective, this furniture integrates physical objects, electronic components and digital services to meet the actual needs of users, public administrations and local utilities.

These smart street furniture address the challenges to assist reducing energy usage, environmental impact and carbon footprint while modernizing the infrastructure and creating high quality living environments.

History

Document history		
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