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**Access, Terminals, Transmission and Multiplexing (ATTM);
Sustainable Digital Multiservice Cities;
Broadband Deployment and Energy Management;
Part 2: Multiservice Networking Infrastructure
and Associated Street Furniture;
Sub-part 2: The use of lamp-posts for hosting sensing devices
and 5G networking**

Reference

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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 2, sub-part 2 of a multi-part deliverable covering Sustainable Digital Multiservice Cities (SDMC). Full details of the entire series can be found in part 1 [i.1].

Modal verbs terminology

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Introduction

The "smart city" concept radically changes the management of the community IT services.

The present document discusses the use of lamp-posts, pervasive in urban areas, as a physical infrastructure to host devices to provide data to support that evolving management model.

This re-purposing of the existing infrastructure can take advantage of the general replacement of existing light sources with high efficiency Light Emitting Diode (LED) lighting systems together with management technologies to control their operation.

A basic approach is to install circuitry to allow the subsequent installation of sensing devices which provide data directly to the community addressing parameters such as air and noise pollution. These devices do not demand substantial bandwidth within an access network and do not major demands on availability of connectivity (including power supplies).

In comparison, many of the services delivered to and for the community, will be founded on data analysis (Big or Fast Data) coming from a large number of connected devices.

The major challenges will not be the data itself, but how collect, distribute and transport it and the provision of the appropriate access networks in order to manage the connected devices, requiring connectivity with a high level of availability, in the most energy and cost-efficient manner.

The next generation of wireless networks designed as "5G" will radically change the services offered by mobile networks - not least recognizing the arrival of billions of connected devices constituting the Internet of Things (IoT), autonomous cars and drones (see Figure 1).

The 5G networks will need improved geographic coverage and enhanced bandwidth to carry higher volumes of data, with some services requiring very low latency (< 1 ms) and the need to guarantee a much higher degree of service continuity (availability) than current networks.

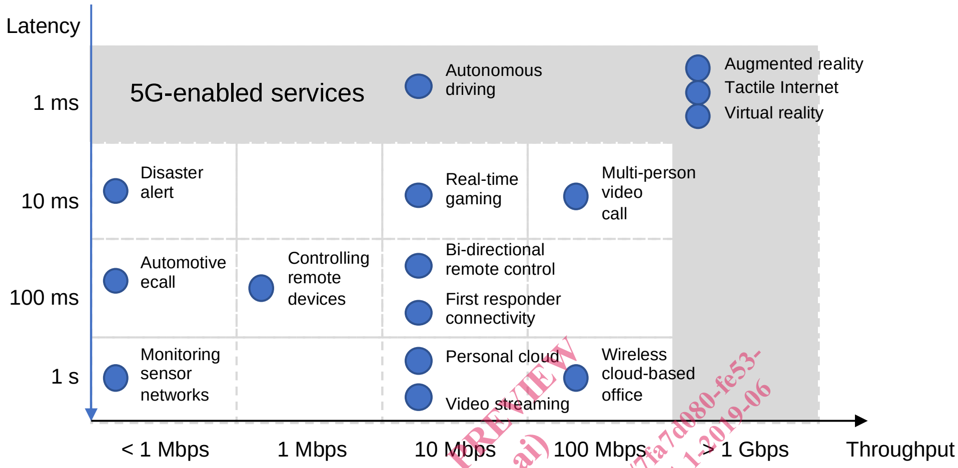

Figure 1: Examples of 5G service demands

The deployment of a 5G compliant infrastructure will have huge consequences in terms of number and variety of access points and will require substantial number of small cells to be installed at street level so to support new services such as autonomous driving. The existing lamp-post infrastructure presents an opportunity to host small cell 5G Remote Radio Units (RRUs) which can avoid deploying a specific and costly infrastructure.

NOTE: 5G, together the need to deploy other connectivity technologies (LiFi, LoRa™, WiFi, etc.), will increase the number of access points.

There are major concerns regarding the capital expenditure required to build and deploy an infrastructure with optimal coverage, reliability and quality of service and about the complexity of managing a huge number of contracts and permission with building owners for each small cell they intend to install. As a result, the use of lamp-posts as an existing physical infrastructure to host the RRUs of 5G networks represents an opportunity for the community to obtain revenue from third-party operators of the networks and also to obtain additional data to manage the increasingly "smart city". The opportunity for 5G network operators to manage a contract and permission with a single entity (the city or the public lighting operator) will drastically reduce the complexity and the bureaucracy of a city-wide deployment.

1 Scope

The present document addresses the opportunities and challenges offered by the use of lamp-posts to provide facilities supporting services required by sustainable digital multiservice cities and communities.

The replacement of existing luminaires by LED light sources offers an opportunity to increase the functionality provided by the lamp-posts - beginning with improved operational control of the lighting provided.

However, additional functionality can be supported by simultaneous installation of an electronics package to enable the lamp-post to host sensing devices. The present document describes the functions to be supported by this package together with consideration of power supply to any hosted sensing devices.

A more comprehensive replacement approach includes the incorporation of 5G services by the separate installation of small (micro- or femto-cell) network components acting as a Remote Radio Unit (RRU). The present document describes the technical challenges associated with the physical installation, provision of power, cabling and other infrastructures necessary to meet the required level of availability for these services.

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/.

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

[1] CEN EN 40-1:1991: "Lighting columns; Part 1: Definitions and Terms".

[2] ETSI EN 303 472 (V1.1.1): "Environmental Engineering (EE); Energy Efficiency measurement methodology and metrics for RAN equipment".

[3] IEC 60050-601: "International Electrotechnical Vocabulary (IEV) - Part 601: Generation, transmission and distribution of electricity - General".

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.

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

[i.1] ETSI TS 110 174-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Sustainable Digital Multiservice Cities (SDMC); Broadband Deployment and Energy Management; Part 1: Overview, common and generic aspects of societal and technical pillars for sustainability".

[i.2] CENELEC EN 50173-1: "Information technology - Generic cabling systems - General requirements".

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

[i.4] HD 60364 series: "Electrical Installations for Buildings".

[i.5] IEC 62368-3: "Audio/video, information and communication technology equipment - Safety - Part 3: DC power transfer through information technology communication cabling".

[i.6] IEEE 802.3bt™: "IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs".

[i.7] IEEE 802.3cg™: "10Mb/s Single Pair Ethernet".

[i.8] Recommendation ITU-T G.652: "Characteristics of a single-mode optical fibre and cable".

[i.9] Recommendation ITU-T G.657: "Characteristics of a bending-loss insensitive single-mode optical fibre and cable".

[i.10] Recommendation ITU-T K.50: "Safe limits for operating voltages and currents in telecommunication systems powered over the network".

[i.11] IEC 60479-2: "Effects of current on human beings and livestock - Part 2: Special aspects".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

backhaul (network): fixed network interconnecting the BaseBand Units (BBUs), collecting/distributing data traffic from/to those BBUs, to/from core network access points

Base Station (BS): network telecommunications equipment (NTE) which serves one or more cells within a coverage area of a mobile access network

big data: structured, semi-structured and unstructured data that has the potential to be mined for information and used in machine learning projects and other advanced analytics applications

core network: functional elements (that is equipment and infrastructure) that enable communication between operator sites (OSs) or equivalent ICT sites

enhanced mobile broadband: one of three primary 5G New Radio (NR) use cases defined by the 3GPP as part of its SMARTER (Study on New Services and Markets Technology Enablers) project

fast data: application of big data analytics to smaller data sets in near-real or real-time in order to solve a problem or create business value

NOTE: The goal of fast data is to quickly gather and mine structured and unstructured data so that action can be taken. As the flood of data from sensors, actuators and machine-to-machine (M2M) communication in the IoT continues to grow, it has become more important than ever for organizations to identify what data is time-sensitive and should be acted upon right away and what data can sit in a database or data lake until there is a reason to mine it.

front-haul (network): network interconnecting the BaseBand Units (BBUs) or antennas connected to them, collecting/distributing data traffic from/to those BBUs, to/from Remote Radio Units (RRUs)

lamp-post: lighting column and lantern(s) it supports

lantern: protective case for a light fitting

lighting column: support intended to hold one or more lanterns, consisting of one or more parts: a post, possibly and extension piece and, if necessary, a bracket

NOTE 1: It does not include columns for catenary lighting.

NOTE 2: Source CEN EN 40-1:1991 [1], clause 2.1.

low voltage: set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V for alternating current

NOTE 1: 1 500 V for direct current.

NOTE 2: Source IEC 60050-601 [3], 601-01-26, modified: note 1 added.

massive IoT: applications that are less latency sensitive and have relatively low throughput requirements, but require a huge volume of low-cost, low-energy consumption devices on a network with excellent coverage

mid-haul (network): network interconnecting the BaseBand Units (BBUs) to/from antennas which provide wireless connections to Remote Radio Units (RRUs)

Network Telecommunications Equipment (NTE): equipment between the boundaries of, and dedicated to providing direct connection to, core and/or access networks

Radio Access Network (RAN): telecommunications network in which the access to the network (connection between user equipment and network) is implemented over the air interface

NOTE: Source ETSI EN 303 472 [2].

urban data platform: facility to integrate the large amount of data in cities, including energy, transport, crowdsourced data, etc. and provide holistic view of the information with the aim of improvement and development of innovative smart city services

3.2 Symbols

Void.

3.3 Abbreviations

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

3GPP	3rd Generation Partnership Project
5G	Fifth Generation
AC	Alternating Current
AWG	American Wire Gauge
BBU	BaseBand Unit
BS	Base Station
CPRI	Common Public Radio Interface
C-RAN	Centralized Radio Access Network
DC	Direct Current
eCPRI	evolved Common Public Radio Interface
eMBB	enhanced Mobile BroadBand
EU	End Users
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
LED	Light Emitting Diode
LiFi	Light Fidelity (wireless technology)
LoRa™	Long Range (wireless technology)
LTE-M	Long Term Evolution for Machines
LV	Low Voltage
LVDC	Low voltage Direct Current
M2M	Machine-to-Machine
MANO	Management and Network Organization

MIMO	Multiple Input-Multiple Output
mmWave	millimetre Wave
MNO	Mobile Network Operator
NB-IoT	Narrow Band Internet of Things
NFV	Network Function Virtualisation
NSP	Network Service Platform
NTE	Network Telecommunications Equipment
PA	Power Amplifier
PoE	Power over Ethernet
PtP	Point to Point
PtMP	Point to MultiPoint
QoS	Quality of Service
RAN	Radio Access Network
RF	Radio Frequency
RFT-C	Remote Feeding Telecommunication - Current limited
RFT-V	Remote Feeding Telecommunication - Voltage limited
RRU	Remote Radio Unit
URLLC	Ultra-Reliable and Low Latency Communications
USB	Universal Serial Bus
UPS	Uninterruptable Power System
VAC	Volt Alternating Current
VCO	Voltage-Controlled Oscillator
VDC	Volt Direct Current
V-RAN	Virtual Radio Access Network
WiFi	Wireless Fidelity (wireless technology)

4 The path towards Smart street lighting

4.1 General

It is estimated that there are more than 60 million lamp-posts, or equivalent structures, supporting lanterns providing lighting for roads and other spaces across Europe.

NOTE: The figures in the present document show conventional lamp-posts but should be considered to represent any form of supporting structures for lanterns.

The current trend to replace the lights within the lanterns with LED technology offers considerable benefits to the community which are outside the scope of the present document. However, the replacement process offers the opportunity to make other changes to the components within the lamp-post to enable the provision of additional services of both direct and indirect benefit to the community.

Typical examples of such services are shown in Figure 2.

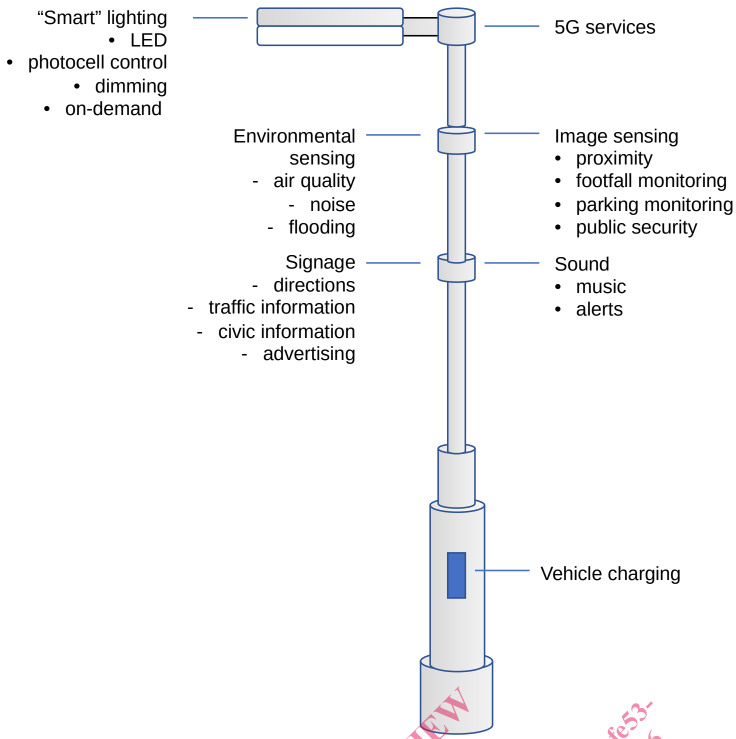

Figure 2: Examples of lamp-post service provisioning

Services of direct benefit to the community would be "smart" lighting, environmental sensing, image sensing, signage and sound. The power and data enabling these services to operated could be provided over the infrastructure already used to deliver power to the lamp-posts. Alternatively, the data could be provided over connections to existing wireless networks of third-party operators. Independent of its delivery mechanism, the data provided to and from the lamp-post is used directly by the community and the cost of producing, transporting and interpreting that data is borne by the community.

Indirect benefit to the community results from the revenue-earning opportunity of sharing of the lamp-post, as a part of a widely distributed infrastructure, with third-party providers such as those offering wireless telecommunications and vehicle charging. The demands for availability of data and power differs between such third-party services and also differs from those of the primary function of the lamp-post and the other services described above.

The present document specifically addresses the use of lamp-posts to host "direct benefit" services relating to sensing devices and "indirect benefit" services relating to the provision of 5G connectivity between End Users (EUs) and the Radio Access Network (RAN) via the RRU mounted on the poles and the onward connectivity BaseBand Unit (BBU).

The main advantages offered by lamp-posts for 5G connectivity are:

- a well-defined and ubiquitous distribution within urban environments which matches the demands for small cell coverage from the RRU - providing reduced deployment costs and timescales;
- a height which facilitates propagation of the radio signal - both extending the coverage radius of each cell and minimizing the impairment produced by large vehicles such as public transport and goods vehicles.

However, the dramatic differences in the requirements for the supply of data and power to the lamp-posts for sensing devices as compared to 5G connectivity cannot be underestimated.

Table 1 provides a non-exhaustive list of the service groups and the detailed applications that could be supported by the 5G RRUs hosted by the lamp-posts and those applications are differentiated as "Massive IoT". "Enhanced Mobile Broadband (eMBB)" and "Ultra-Reliable and Low Latency Communications (URLLC)".