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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. Full details of the entire series can be found in part 1 [i.13].

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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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.

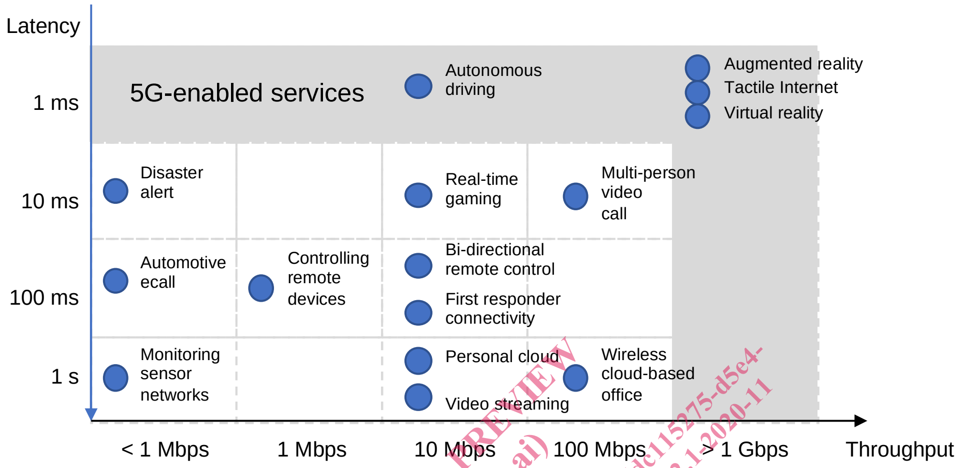

Figure 1: Examples of 5G service demands

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 radio units 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 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™, 4G, etc.), will increase the number of access points.

The 5G radio unit encompasses a series of equipment flavors which are identified as Macro base station, Mini-Macro cells, Microcells, Picocells, and Femtocells for whose characteristics are listed in Table 1:

- Macro equipment Base Station (BS) - for wide coverage - installed outdoors at higher heights (normally more than 20 m): In most cases, they will be located in the same sites as the macro-BS of the previous mobile generations but, to cover special traffic needs, it may occur they are installed at reduced height. The increased energy demand and the much higher availability need of the 5G equipment will pose tough challenges to the powering infrastructure and will likely require major upgrades, both in the power capabilities and the backup duration.

- Mini-Macro cells installed outdoors at low height (normally less than 12 m). These are designed to be quickly deployed when adding new sites, when there are increasingly requirements for capacity expansion and coverage issues in densely populated urban areas. Compared with traditional macro base stations, Mini-Macro cells feature smaller size, light weight, and environment integration that enables a time- and cost-effective network deployment.

- Microcells installed outdoors at low height (normally less than 12 m. These are designed to support a large number of users in high data traffic areas, to solve coverage issues and to support very high frequency deployment capable of covering medium/large cells and suitable for application such as for smart cities, smart metro, etc.

- Picocells normally installed indoors, at ceilings. These are suitable for enterprises, shopping centres, stadium applications, etc., for extended network coverage and data throughput.

- Femtocells - normally installed indoors, at ceilings or table-top. these are small mobile base stations designed to provide extended coverage for residential and Small Offices Home Offices (SOHO) applications. Poor signal strength from a mobile operator's macro base stations is tackled using femtocell implementation. Femtocells are primarily introduced to offload network congestion, extend coverage and increase data capacity to indoor users.

The typical characteristics of radio cells are listed in Table 1 such as power consumption, coverage radius, number of users, indoor/outdoor installation, etc. It can be noted that the Mini-Macro cells, Microcells and FWA nodes are normally installed outdoors and appropriate to be mounted on the lamp-posts.

Table 1: Radio Units Characteristics

EQUIPMENT	INSTALLATION			POWER CONSUMPTION		POWERING TYPE					BACKHAULING CONNECTION		Aggregated RF power		COVERAGE RADIUS		NUMBER OF CONCURRENT USERS	
	INDOORS	INDOORS	OUTDOORS	TYP	MAX	BATTERY	Local mains	Remote	PoE	mimimum BACKUP	Wireline / Wireless	Connection flavour	MIN	MAX	TYPICAL	MAX	TYPICAL	MAX
	Private premises	Public sites and enterprises		(W)	(W)	Duration (years)				BACKUP TIME			(W)	(W)	m	m	m	m
WIRELESS																		
COMPLEX MACRO BASE STATION (e.g. 2/3/4/5G - multiple freq, massive MIMO and multiple operators)			X	8000	24000		X			YES many hours	Wireline / wireless	Optical / mmWave		many hundreds	500	5000	1000	5000
SIMPLE MACRO BASE STATION (e.g. 2/3/4G - single freq and single operator)			X	3000	6000		X			YES few hours	Wireline / wireless	Optical / mmWave / high speed broadband		few hundreds	500	5000	300	1000
MINI-MACRO CELLS (e.g.4/5G- multiple freq, and single operator)			X	400	750		X			advised minutes	Wireline / wireless	Optical / mmWave	100	200	100	500	100	200
MICROCELLS			X	100	350		X	X		advised minutes	Wireline / wireless	Optical / mmWave	10	100	50	200	20	50
PICOCELLS		X	X	10	50		X		X	advised minutes	Wireline	ETH/Optical mmWave (FWA)	0.1	1	25	100	5	20
FEMTOCELLS	X			5	20		X			NO	Wireline	Any Broadband	0.01	0.1	10	50	3	10
FWA nodes			X	10	50		X		X	NO	Wireline	ETH/Optical mmWave (FWA)	0.1	1	25	100	5	20
WiFi Access Points	X	X	X	10	20		X	X	X	NO	Wireline	ETH / Any Broadband	0.1	0.2	20	50	5	50

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 equipment 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 wireless 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/.

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] EN 40-1:1991: "Lighting columns; Part 1: Defintions and Terms" (produced by CEN).

[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.

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] EN 50173-1: "Information technology - Generic cabling systems - General requirements" (produced by CENELEC).

[i.2] EN 50174-3: "Information technology - Cabling installation - Installation planning and practices outside buildings - General requirements" (produced by CENELEC).

[i.3] HD 60364 series: "Electrical Installations for Buildings" (produced by CENELEC).

[i.4] IEC 62368-3: "Audio/video, information and communication technology equipment - Safety - Part 3: DC power transfer through information technology communication cabling".

[i.5] IEEE 802.3bt™: "IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs".

[i.6] IEEE 802.3cg™: "10Mb/s Single Pair Ethernet".

[i.7] Recommendation ITU-T G.652: "Characteristics of a single-mode optical fibre and cable".

[i.8] Recommendation ITU-T G.657: "Characteristics of a bending-loss insensitive single-mode optical fibre and cable".

[i.9] Recommendation ITU-T K.50: "Safe limits for operating voltages and currents in telecommunication systems powered over the network".

[i.10] IEC 61140: "Protection Against Electric Shock Common Aspects for Installation and Equipment".

[i.11] IoTUK group: "The Future of Street Lighting".

NOTE: Available at https://iotuk.org.uk/wp-content/uploads/2017/04/The-Future-of-Street-Lighting.pdf.

[i.12] IEC 60479-2: "Effects of current on human beings and livestock - Part 2: Special aspects".

[i.13] 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".

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: 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].

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].

safety class: class rating in electrical appliances

NOTE 1: See IEC 61140 [i.10].

NOTE 2: Class I is based on the presence of an earthing terminal while Class II, also known as double insulated, does not need earthing terminal.

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
FWA	Fixed Wireless Access
IEEE	Institute of Electrical and Electronics Engineers

IoT	Internet of Things
IT	Information Technology
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
MIMO	Multiple Input-Multiple Output
mmWave	millimetre Wave
MNO	Mobile Network Operator
NB-IoT	Narrow Band Internet of Things
NFV	Network Functions Virtualisation
NR	New Radio
NSP	Network Service Platform
PA	Power Amplifier
PoE	Power over Ethernet
PtMP	Point to MultiPoint
PtP	Point to Point
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
UPS	Uninterruptable Power System
USB	Universal Serial Bus
V-RAN	Virtual Radio Access Network
VAC	Voltage Alternating Current
VCO	Voltage-Controlled Oscillator
VDC	Voltage Direct Current
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.