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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
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 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

- shall** indicates a mandatory requirement to do something
- shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

- should** indicates a recommendation to do something
- should not** indicates a recommendation not to do something
- may** indicates permission to do something
- need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

- can** indicates that something is possible
- cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

- will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document
- will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document
- might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document describes service and performance requirements for ambient power-enabled Internet of Things (i.e. Ambient IoT). In the context of the present document, Ambient IoT device is an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability (e.g. using a capacitor) and the energy is provided through the harvesting of radio waves, light, motion, heat, or any other power source that could be seen suitable. An Ambient IoT device has low complexity, small size and lower capabilities and lower power consumption than previously defined 3GPP IoT devices (e.g. NB-IoT/eMTC devices). Ambient IoT devices can be maintenance free and can have long life span (e.g. more than 10 years).

The aspects addressed in this document include:

- Overview of Ambient IoT service and operation,
- Functional service requirements for Ambient IoT, including communication, positioning, management, exposure, charging, security and privacy.
- Performance service requirements for Ambient IoT, including inventory, sensors, tracking, and actuator.

NOTE: How Ambient IoT device performs energy harvesting is out of scope of this technical specification.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.368: "Service requirements for Machine-Type Communications (MTC)".

[3] 3GPP TS 22.278: "Service requirements for the Evolved Packet System (EPS)".

[4] 3GPP TS 22.261: "Service requirements for the 5G system".

[5] 3GPP TS 22.011: "Service accessibility".

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Ambient IoT device: As defined in TS 22.261 [4].

3.2 (void)

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

eMTC	enhanced Machine-Type Communication
NB-IoT	NarrowBand Internet of Things
RedCap	Reduced Capability

4 Overview

4.1 Introduction

In the 5G era, various IoT technologies [2][3][4][5] such as eMTC, NB-IoT, and RedCap have been developed to fulfil the increasing demand from verticals. These IoT technologies have achieved low cost, low power and massive connections and can meet requirements of many applications. However, there are still some use cases and applications that can benefit from an IoT technology that requires less power and has lower cost than previous IoT technologies. Improvements can be made where maintenance-free devices are required (e.g. where the devices are inaccessible and it is not possible to replace the device battery) or for devices in extreme environmental conditions. Finally, ultra-low complexity, very small device size/form factor (e.g. thickness of mm), longer life cycle, etc. are required for some use cases. Ambient IoT is a technology to fulfil these market requirements.

This Technical Specification describes the Ambient IoT technology service requirements as part of the 5G system to enable new services and use cases. Ambient IoT has the potential to benefit a large number of vertical industries, e.g. smart manufacturing, logistics and warehousing, smart grid, agriculture, and smart home by providing functionalities that fulfil the needs of industrial use cases. Therefore, a new kind of IoT service for the vertical industries will be enabled by combining Ambient IoT with cellular networks, vastly benefitting the 3GPP ecosystem.

4.2 Characteristics of Ambient IoT

Not all Ambient IoT devices are the same. Nevertheless, Ambient IoT devices have the following characteristics.

- Energy harvesting. An Ambient IoT device is an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability (e.g. using a capacitor). Energy is provided through harvesting of radio waves, light, motion, heat, or any other suitable power source. Energy harvesting can be continuous or incidental (e.g. based on the vibration that a vibration sensor has to report). It cannot be assumed that Ambient IoT devices always have enough power to initiate or receive communication.
- Low complexity. Ambient IoT devices are expected to have lower complexity, smaller size, reduced capabilities and lower power consumption than previously defined 3GPP IoT devices (e.g. NB-IoT/eMTC devices). Low complexity of Ambient IoT devices is also expected to be reflected in efficient use of network resources. In general, Ambient IoT applications will deploy very large numbers of Ambient IoT devices.
- Low data rates. Generally, Ambient IoT data transmissions contain only a low amount of data.
- Life span. Ambient IoT devices can be maintenance free and can have long life span (e.g. more than 10 years). However, the life span of an Ambient IoT device can also be relatively short, e.g. when tracking a package through a logistics chain.
- Communication characteristics. Ambient IoT devices can have a variety of communication characteristics, different from other IoT devices, based on how the Ambient IoT devices are powered by energy harvesting and whether / how the harvested energy can be stored. Ambient IoT devices will only be able to communicate when they have enough power. This can be an issue, especially when communication is initiated towards the Ambient IoT device, while it is not known whether the Ambient IoT device has enough power to receive this communication. For communications initiated by the Ambient IoT device, the Ambient IoT device cannot transmit data until it has harvested / stored enough energy. Some Ambient IoT devices can be powered on demand when they need to communicate. Additionally, some Ambient IoT devices will be able to communicate on a regular basis and have communication characteristics similar to regular IoT devices.

4.3 Typical Ambient IoT use cases

Ambient IoT can support many different use cases. Nevertheless, in general the Ambient IoT use cases can be characterised in four different use case categories:

- Inventory taking. With inventory taking, the main purpose is to discover what goods (e.g. boxes, containers, packages, tools) are present in a specific area. Upon request sent by the network within the specific area, Ambient IoT devices attached to these goods report an identifier associated with the good, possibly supplemented with other information such as status, measurement results and/or location.
- Sensor data collection. With sensor data collection, the Ambient IoT device is associated with a sensor. Transfer of sensor data can be initiated by the Ambient IoT device, e.g. periodically or when the Ambient IoT device has power, or can be triggered by the network.
- Asset tracking. With asset tracking, the main purpose is to determine the location of goods. Ambient IoT devices attached to these goods report an identifier associated with the good. This can then be combined with location information. Asset tracking can also be initiated by an Ambient IoT capable UE (i.e. a UE that can communicate with an Ambient IoT device), thus finding the location of Ambient IoT devices within a particular range of the UE.
- Actuator control. With actuator control, the Ambient IoT device is associated with an actuator. Transfer of actuator commands is generally initiated by the network.

4.4 Communication modes

Ambient IoT devices are expected to be able to communicate with the 5G network and/or Ambient IoT capable UE using the one or more of the following communication modes:

Ambient IoT Direct Network Communication: represents communication between the Ambient IoT device and 5G network with no UE conveying information between the Ambient IoT device and the 5G network.

Ambient IoT Indirect Network Communication: represents communication between the Ambient IoT device and the 5G network where there is an Ambient IoT capable UE helping in conveying information between the Ambient IoT device and the 5G network.

Ambient IoT device to UE direct Communication: represents communication between an Ambient IoT device and an Ambient IoT capable UE with no network entity in the middle.

Figures depicting these communication modes are presented below:

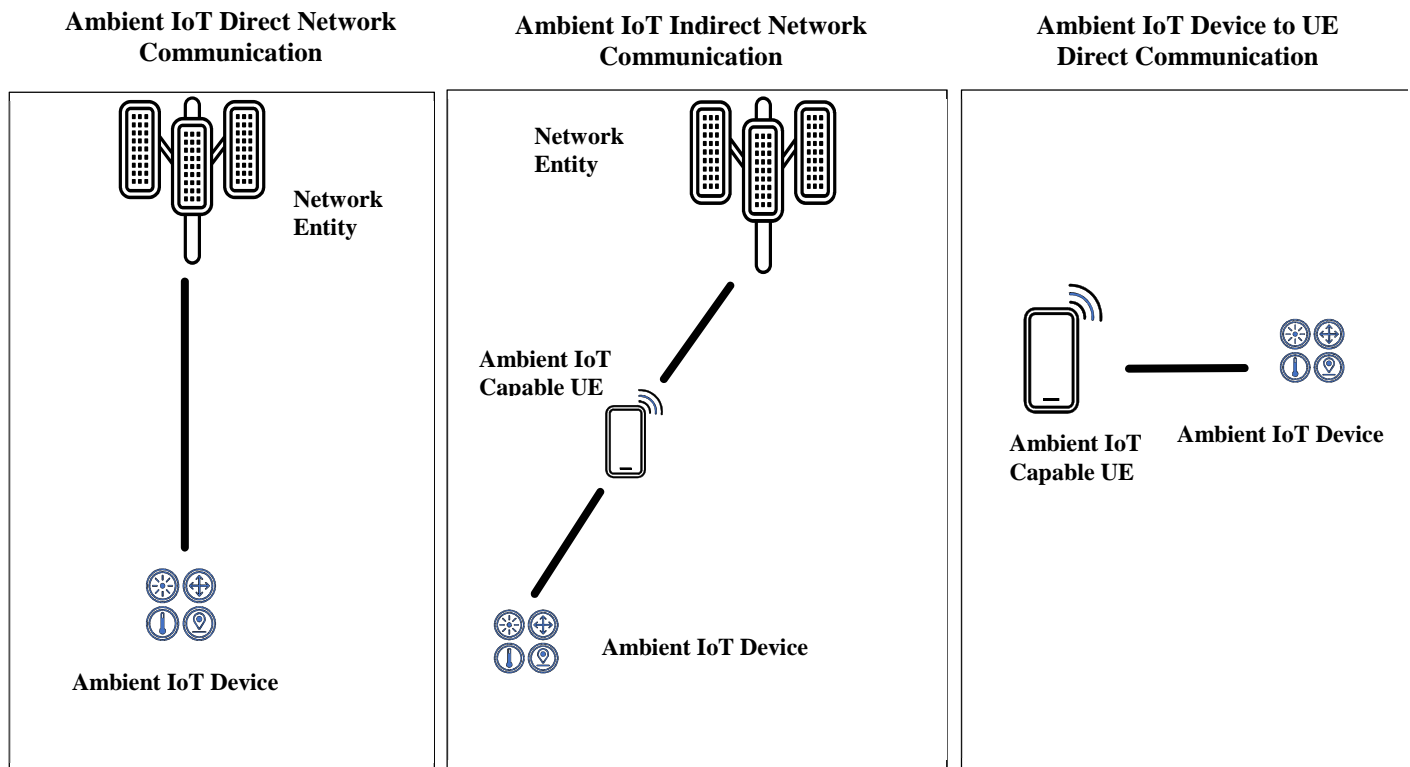


Figure 4.4-1: Ambient IoT Communication Modes

5 Functional service requirements of Ambient IoT

5.1 General

The functional requirement for Ambient IoT service includes 6 aspects, i.e.

- Communication;
- Positioning/location;
- Management;
- Collected information and network capability exposure;
- Charging;
- Security and privacy

The Ambient IoT devices have some special characteristics such as Energy harvesting, Low complexity, Low data rates, Life span, and Reachability, etc.

Ambient IoT capable UEs are 3GPP UEs with the capability to communicate with an Ambient IoT device.

5.2 Functional service requirements of Ambient IoT

5.2.1 Communication aspects

The 5G system shall be able to support 5G network or an Ambient IoT capable UE to communicate with a group of Ambient IoT devices simultaneously.

The 5G network shall support a mechanism to authorize an Ambient IoT capable UE to communicate with an Ambient IoT device.

The 5G system shall be able to support mechanisms to communicate:

- between an Ambient IoT device and the 5G network using Ambient IoT direct network communication or Ambient IoT indirect network communication, or
- between an Ambient IoT device and Ambient IoT capable UE using Ambient IoT device to UE communication.

NOTE: Examples of the communication between 5G network/Ambient IoT capable UE and Ambient IoT devices can include periodic sensor reporting or network-initiated inventory.

The 5G system shall provide suitable mechanisms to support communication between a trusted and authorized 3rd party and an Ambient IoT device or group of Ambient devices.

5.2.2 Positioning

The 5G system shall support location services for Ambient IoT devices (e.g., to locate Ambient IoT devices using absolute or relative positioning methods)

NOTE 1: The intention is not to use Ambient IoT devices to locate other Ambient IoT devices.

5.2.3 Management

The 5G network shall support suitable management mechanisms for an Ambient IoT device or a group of Ambient IoT devices.

The 5G system shall support a mechanism to:

- disable the capability to transmit RF signals for one or more Ambient IoT device that is / are currently able to transmit RF signals
- enable the capability to transmit RF signals for one or more Ambient IoT device that is / are currently disabled to transmit RF signals

Based on operator policy, the 5G system shall provide a suitable mechanism to permanently disable the capability of an Ambient IoT device or a group of Ambient IoT devices to transmit RF signals.

Subject to operator policy and regulatory requirements, the 5G system shall support suitable mechanisms for the Ambient IoT device to move between one or more networks and countries.

5.2.4 Exposure

Subject to user consent, operator policy and 3rd party request, the 5G system shall be able to obtain data from Ambient IoT devices (e.g. sensor data) and provide it to a trusted 3rd party via the 5G network.

Subject to user consent, operator's policy and 3rd party request, the 5G system shall provide information about an Ambient IoT device or a group of Ambient IoT devices (e.g. position) to the trusted 3rd party via the 5G network.

The 5G system shall enable an authorized 3rd party to instruct the 5G network to trigger a group of Ambient IoT devices in an specific area and which action the Ambient IoT devices need to perform when triggered (e.g. send ID, receive further information, send measurement value).

5.2.5 Charging

The 5G system shall be able to collect charging information in a suitable way for using Ambient IoT services on per Ambient IoT device basis or a group of Ambient IoT devices (e.g., total number of communications per charging period).

5.2.6 Security and privacy

The 5G system shall enable security protection suitable for Ambient IoT, without compromising overall 5G security protection.

The 5G system shall be able to provide a mechanism to protect the privacy of information (e.g., location and identity) exchanged during communication between an Ambient IoT device and the 5G network or an Ambient IoT capable UE.

Based on subscription and operator policies, the 5G system shall authorize an Ambient IoT capable UE to communicate with a specific Ambient IoT device or with a group of Ambient IoT devices.

6 Performance service requirements of Ambient IoT

6.1 General

Ambient IoT service can be categorized into 4 categories, namely inventory, sensor data collection, tracking and actuator control. The corresponding performance services requirements are listed in the following subclauses.

6.2 Performance service requirements for Inventory

Table 6.2-1 KPIs for inventory

Scenarios	Max. allowed end-to-end latency	Communication service availability	Reliability	User-experienced data rate	Message size	Device density	Communication range (Note 1)	Service area dimension	Device speed	Transfer interval	Positioning service latency	Positioning service availability	Positioning accuracy	Remark
Inventory or asset management	Typically, seconds level	99%	NA	<2 kbit/s	96/256 bits	<1.5 million devices/km ² indoor only (Note 2)	30 m – 50 m indoor, 200 m - 400 m outdoor	1 km ² – 10 km ²	3 km/h – 10 km/h	NA	NA	NA	3 m indoor, cell-level outdoor	
NOTE 1: The communication range is the communication distance between the ambient IoT device and the 5G network or between the ambient IoT device and an ambient IoT capable UE.														
NOTE 2: The device density is much lower in outdoors as only a subset of assets (e.g., stored indoors) will be in transit, and a much larger area for transit applies.														

6.3 Performance service requirements for sensor data collection

Table 6.3-1 KPIs for sensor data collection

Deployment	Scenarios	Max. allowed end-to-end latency	Communication service availability	Reliability	User-experienced data rate	Message size	Device density	Communication range (Note 1)	Service area dimension	Device speed	Transfer interval	Positioning service latency	Positioning service availability	Positioning accuracy	Remark
Indoor	Room environment monitoring (e.g. domicile, machinery)	20 s - 30 s	99 %	NA	<1 kbit/s	<100 bits	1.5 devices/m ²	10 m - 30 m	NA	Stationary	NA	NA	NA	NA	
	Indoor agriculture and husbandry	>10 s	99.9%	NA	<1 kbit/s	Typically, <1,000 bits	1 device/m ²	30 m - 200 m	6,000 m ² - 30,000 m ²	Quasi-stationary	15 mins - 30 mins	NA	NA	NA	
Outdoor	Smart grid	1 s	99%	NA	<1 kbit/s	Typically, <800 bits	< 10,000 devices/km ²	Typically, 50 m - 200 m	[several km ² up to 100,000 km ²]	Stationary	5 mins - 15 mins	NA	NA	several 10 m	
	Outdoor husbandry and logistics	Typically, > tens of seconds	99%	NA	<0.5 kbit/s	Typically, [<800 bits]	<5,200 devices/km ²	[300 m - 500 m]	430,000 m ²	≤ 3 km/h	15 mins	NA	NA	NA	
	Smart city	10 s - 30 s	99%	NA	<1 kbit/s	Typically, <800 bits	<1,000 devices/km ²	300 m - 500 m	City wide including rural areas	Stationary	15 mins	NA	NA	NA	

NOTE: The communication range is the communication distance between the ambient IoT device and the 5G network or between the ambient IoT device and an ambient IoT capable UE.

6.4 Performance service requirements for tracking

Table 6.4-1 KPIs for tracking

Deployment	Scenarios	Max. allowed end-to-end latency	Communication service availability	Reliability	User-experienced data rate	Message size	Device density	Communication range (Note 1)	Service area dimension	Device speed	Transfer interval	Positioning service latency	Positioning service availability	Positioning accuracy	Remark
Indoor	Indoor tracking	1 s	99.9%	NA	<1 kbit/s	<1 kbits	25 devices /100 m ² - 250 devices /100 m ²	10 m	200 m ²	up to 3km/h	60 mins	1 s	90%	1 m - 3 m, 90% availability	
Outdoor	Outdoor tracking	1 s	99.9%	NA	<1 kbit/s	<1 kbits	≤10 devices/100 m ²	500 m	Up to the whole PLMN	up to 10 km/h	60 mins	1 s	95%	several 10 m	

NOTE: The communication range is the communication distance between the ambient IoT device and the 5G network or between the ambient IoT device and an ambient IoT capable UE.

6.5 Performance service requirements for actuator control

Table 6.5-1 KPIs for actuator control

Deployment	Scenarios	Max. allowed end-to-end latency	Communication service availability	Reliability	User-experienced data rate	Message size	Device density	Communication range (Note 1)	Service area dimension	Device speed	Transfer interval	Positioning service latency	Positioning service availability	Positioning accuracy	Remark
Indoor	Indoor actuator control	Several seconds	99%	NA	2 kbit/s	<100 Bytes	<1.5 million/km ²	50 m	<250 m ² for home, and 15,800 square meters for supermarket	stationary	20 mins - 120 mins	NA	NA	3 m to 5 m indoor	
Outdoor	Outdoor actuator control for large coverage	Several seconds	99%	N/A	NA	128 bit (DL)	NA	[500] m outdoors	40,000 m ² - 4,000,000 m ²	Static	NA	NA	NA	NA	
	Outdoor actuator control for medium coverage	Several seconds	99%	NA	<2 kbit/s	<200 bits	<20 devices/100 m ²	200 m	City wide including rural areas	Static	NA	NA	NA	NA	

NOTE: The communication range is the communication distance between the ambient IoT device and the 5G network or between the ambient IoT device and an ambient IoT capable UE.

Annex A (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2023-11	SA1#104	S1-233257	-			Draft provided by editor. Note: corresponding WID not yet approved, so no official TS number	0.1.0
2023-12	SA#102	SP-231405	-			MCC clean-up for presentation for one-step approval to SA. Corresponding WID to be submitted at the same time as this TS, then a TS number will be allocated.	1.0.0
2023-12	SA#102	SP-231750	-			TR number known and added: TR 22.369	1.0.1
2023-12	SA#102	-				Approved at SA#102	19.0.0
2024-03	SA#103	SP-240202	0001	3	F	TS.22.369 adding the abbreviation	19.1.0
2024-06	SA#104	SP-240785	0006	1	D	add the definition pointer of Ambient IoT device	19.2.0
2024-09	SA#105	SP-241145	0007		D	Clarify that two Ambient IOT requirements are independent of each other	19.3.0

History

Document history		
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