Premeeting on Ambient power-enabled IoT

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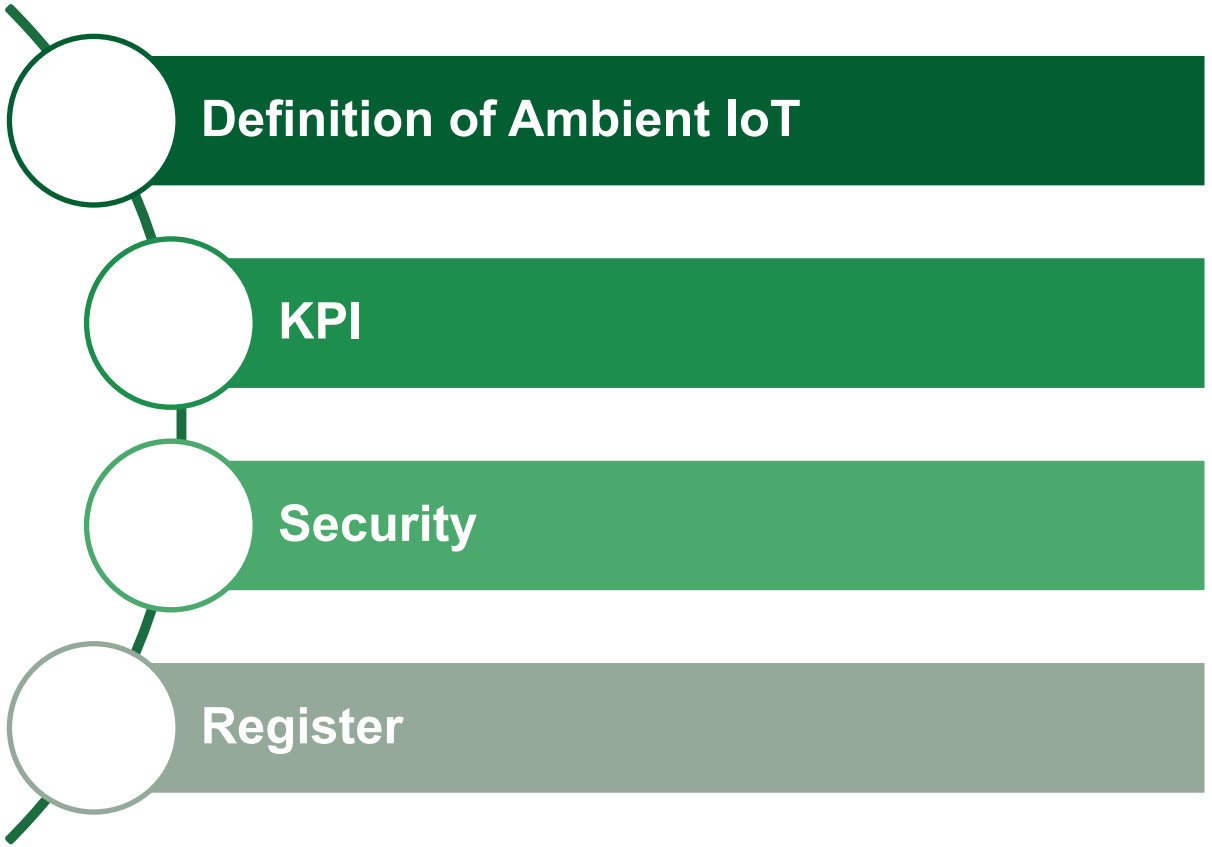
Outline



❑Definition of ambient IoT (before and during discussion)

During the discussion on the scope in SA1#98, there has been proposal but not agreed:

Ambient power-enabled Internet of Things (Ambient power-enabled IoT) device is an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability (i.e., using a capacitor). Ambient IoT device is with low complexity, small size, maintenance free and can have long life span. The device has lower capability than existing 3GPP IoT devices, e.g., NB-IoT.

3 types /2 types?

Editor's note Option A: The maximum instantaneous power consumption of Ambient power-enabled IoT device is FFS.

(FFS: the power consumption is only for communication, i.e., excluding power for sensors)

Editor's note Option B: The range of harvested power is FFS.

❑ The following can be taken into account for the definition

- Energy harvesting, battery-less or not using conventional battery
- Low complexity, small size
- Maintenance free
- (ultra-) low power consumption or constraint in power consumption
- Be able to adapt to unstable and small amount of harvested power
- Meet the unmet service requirement with existing 3GPP IoT devices (e.g.,)
- Energy storage capability?
- ~~USIM-free~~

❑Definition of ambient IoT(after discussion)

Based on the discussion during the CC on 3rd August, the following updated definition is suggested.

Ambient power-enabled Internet of Things (Ambient power-enabled IoT) device is an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability (i.e., using a capacitor) thus it can be maintenance free and can have long life span. Ambient IoT device has low complexity, small size and it shall have lower capability than existing 3GPP IoT devices, e.g., NB-IoT.

The harvested ambient power has the characteristics of FFS (e.g., A,B,C) and it is expected the maximum instantaneous power consumption for communication should be lower than FFS.

Suggestions from rapporteur:

1) battery-less, maintenance free are distinguished features of ambient IoT. If it doesn't conflict with other features, I suggest to keep it.
2) I slightly adjust the sentence: the yellow part is focus on battery-less, maintenance free… and the yellow one focus on complexity and lower capability.
3) I suggest to have both characteristics of the power and the limitation of the power consumption. We can further resolve the FFS points. Companies are encouraged to give your considerations for these FFS points when drafting the use cases.
4) OPPO may prepare one paper to discuss the definition for SA1#99.

Examples of definitions

IoT device: a type of UE which is dedicated for a set of specific use cases or services and which is allowed to make use of certain features restricted to this type of UEs.

NOTE 5: An IoT device may be optimized for the specific needs of services and application being executed (e.g. smart home/city, smart utilities, e-Health and smart wearables). Some IoT devices are not intended for human type communications.

Constraints from energy harvesting

The typical power from ambient power source is summarized as in following table1:

Table 1. Energy harvesting sources [9] [10].

Energy source	Type	Typical power
Outdoor solar light	Natural	100 mW/cm^2 (outdoor),
Indoor office light	Artificial/natural	100 μW/cm^2 (artificial light)– 10 mW/cm^2 (filtered solar light)
Radio frequency	Artificial	1uw~100uw
Thermoelectric	Artificial	60 μW/cm^2
Vibration	Artificial	4 μW/cm^3 (human motion) 800 μW/cm^3 (machines)
Ambient airflow	Natural/artificial	1 mW/cm^2
Acoustic noise	Natural/artificial	960 nW/cm^3

- From table1, it can be observed the output power harvested from various power sources is very limited, e.g. from 1uW to 100mW(per cm^2/cm^3).
- The potential pattern/profile of the power?

❑ Which KPIs are needed?

The following KPIs can be considered: (please see the notes the rapporteur highlighted)

- Communication Service Availability/Ambient IoT service availability (encourage companies to further check the 1st 3 bullets)
- End-to-end latency/Ambient IoT service latency
- Ambient IoT positioning service availability
- Max. instantaneous device power consumption (need further check whether it can be a KPI)
- User-experienced data rate (need to check the definition, whether it is the average data rate or the instant data rate)
- Message Size
- Communication range
- Device density
- ~~Devices per base station~~
- Service area dimension
- Positioning Accuracy (1)need to discuss per Use case, e.g., gNB based or relay node based(e.g., a UE), 2) it shall be positioning, not ranging? 3) suggest to have a separate KPI table for positioning 4) both horizontal and vertical dimension can be considered based on the use cases)
- Inventory rate? (need a clear definition, needs to be differentiated with User-experienced data rate)
- Moving speed/Velocity
- Periodicity of the traffic

❑ Some reference definition

communication service availability: percentage value of the amount of time the end-to-end communication service is delivered according to a specified QoS, divided by the amount of time the system is expected to deliver the end-to-end service.

NOTE 3: The end point in "end-to-end" is the communication service interface.

NOTE 4: The communication service is considered unavailable if it does not meet the pertinent QoS requirements. For example, the communication service is unavailable if a message is not correctly received within a specified time, which is the sum of maximum allowed end-to-end latency and survival time.

end-to-end latency: the time that it takes to transfer a given piece of information from a source to a destination, measured at the communication interface, from the moment it is transmitted by the source to the moment it is successfully received at the destination.

positioning service availability: percentage value of the amount of time the positioning service is delivering the required position-related data within the performance requirements, divided by the amount of time the system is expected to deliver the positioning service according to the specification in the targeted service area.

positioning service latency: time elapsed between the event that triggers the determination of the position-related data and the availability of the position-related data at the system interface.

❑ Example KPI table

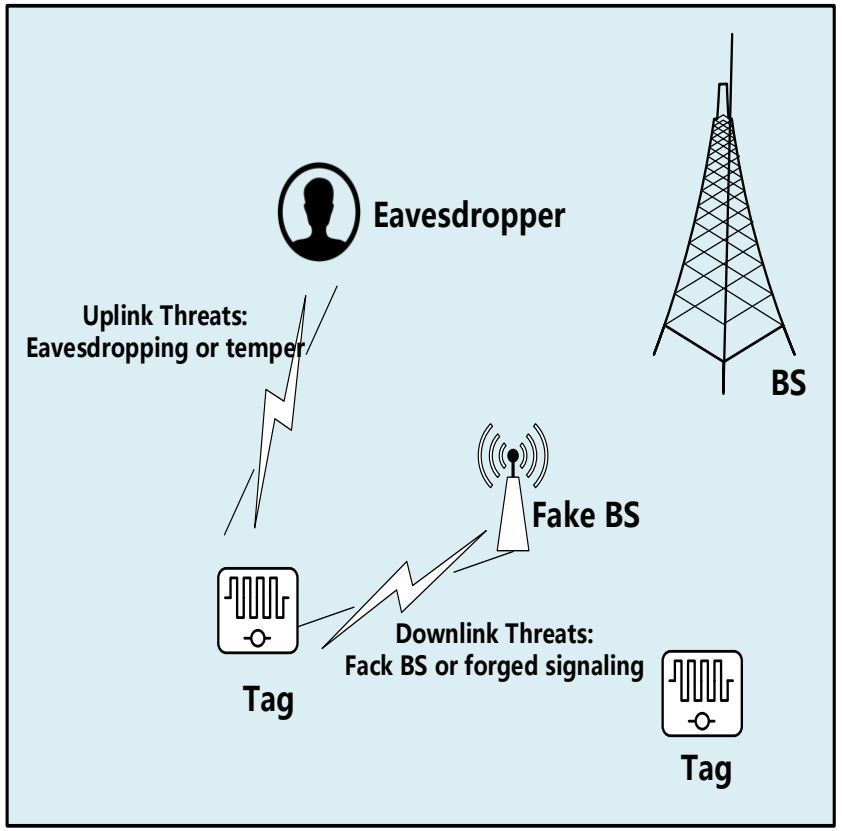
Scenario	Max. allowed end-to-end latency	Max. instantaneous device power consumption	Service bit rate: user-experienced data rate	Message Size	Device density	Communication Range (meters)	Service area dimension
Remote monitoring of transmission and distribution networks in smart grids	[1 s]	[500] μW (note 4)	[< 1kbit/s]	Typically [< 100 bytes] (note 1)	[< 10,000 /km^2] (note 3)	Outdoor: [> 50]	[several km^2 up to 100 000 km^2] (note 2)

NOTE 1: Electronic Product Code standard [5], this size is the payload size.
NOTE 2: The service are refers to the overall size of transmission and distribution networks. Typically, the size of the individual substations varies from 100m x 200m to 500m x 600m.
NOTE 3: The device density is calculated based on an individual substation, where typically several hundreds of Ambient IoT devices are required to monitor the environmental parameters.
NOTE 4: The power consumption takes into account of the power needed for communication and sensor functions.

Security

- How to specify the security aspects, e.g., authentication, authorization, integrity protection? The impacts from different stakeholder models?
- In order to resolve the potential uplink and downlink threat, the following may be needed.
  - **Authentication**: e.g., The 5G system shall support the security mechanism to enable the Ambient IoT device to authenticate the information collection request sent by network/UE and enable the network to authenticate Ambient IoT devices
  - **Authorization** : e.g., The 5G system shall support requesting an information collection from a specific Ambient IoT device while avoiding other irrelevant Ambient IoT devices to be exposed.
  - Trust mode: 3rd party credential?

- Will the device have legacy USIM?
  - Light weight security: where to store the credential and how to perform key deviation?



Register

- Whether and How the device do register to the network?

The harvested power is unstable, the reachability can’t be guaranteed. It is hardly to perform location updating.

  - Purpose of the register---aware of the existence/activation/deactivation of the device