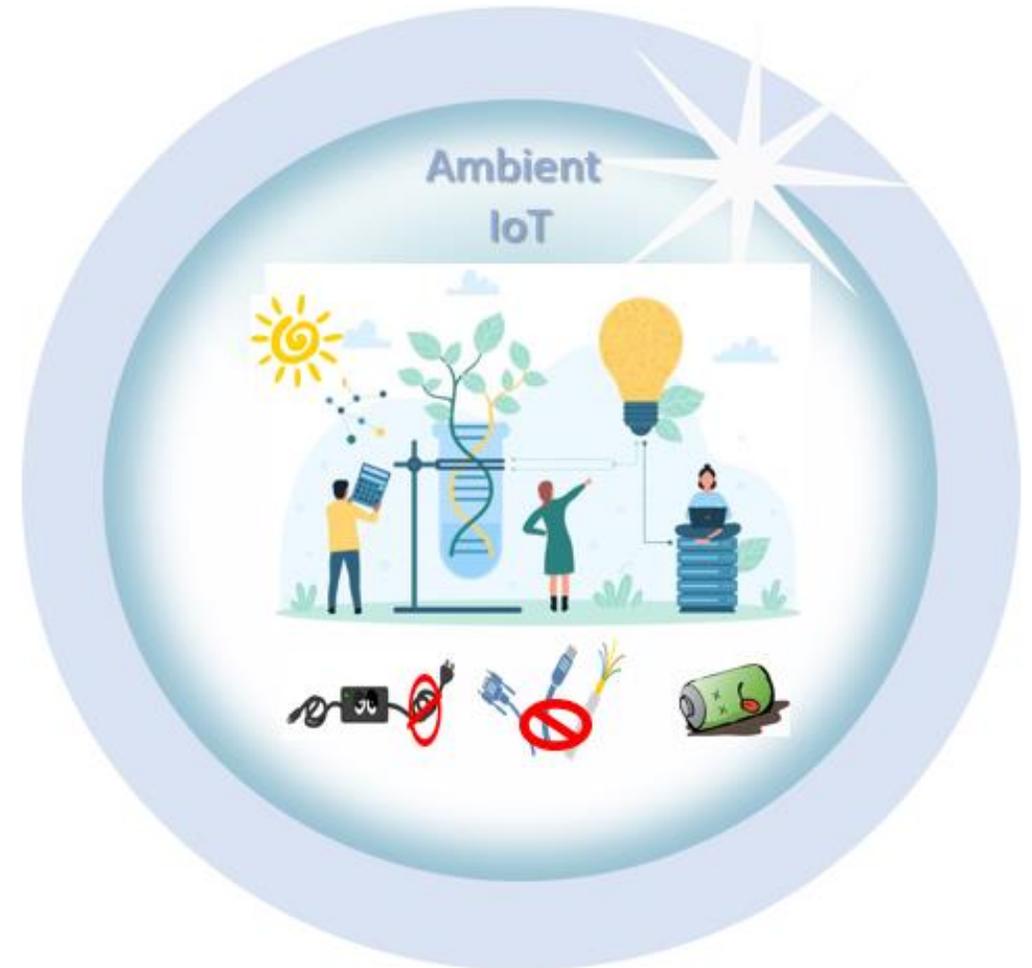
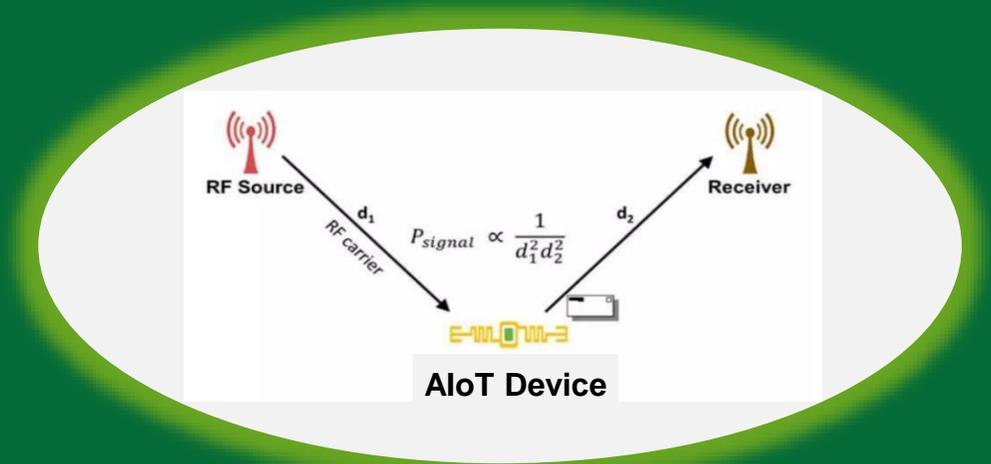


Rel-19 - Study 5G system impacts on supporting Ambient Power-enabled IoT devices



Outline



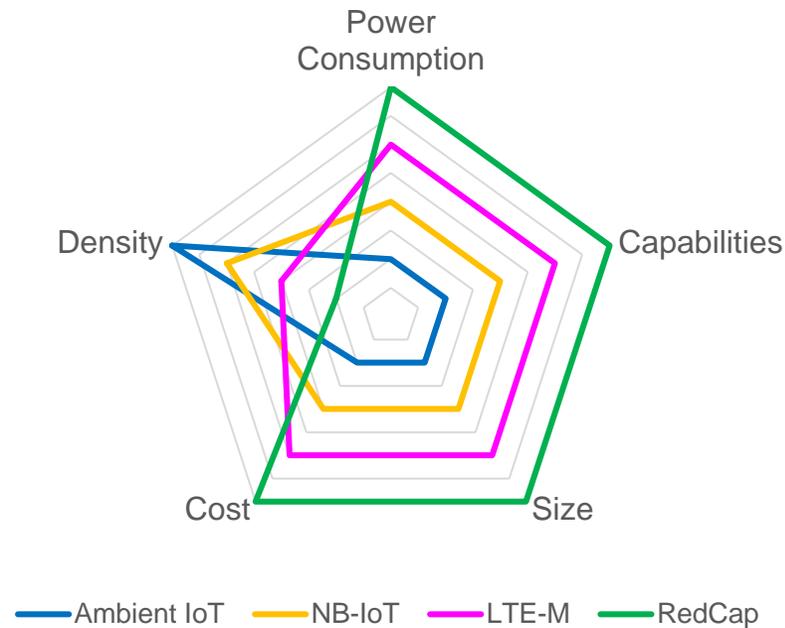
- Why Ambient IoT?
- 5G Advanced Ambient IoT service differentiation from RFID
- Use cases and Requirements from SA1
- Considerations of Ambient IoT in 5G Advanced System
- Scope Considerations of SA2 work for Ambient IoT
- Conclusions

Why Ambient IoT? (1/2)

- ◉ Ambient power-enabled IoT is an IoT service with an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability (e.g., using a capacitor)
- ◉ Massive MTC is one important use cases for 5G. NB-IoT/LTE-M/RedCap have been specified in 3GPP to support low power devices that still require battery. Ambient power-enabled IoT service, however, is to focus on **battery-less or with limited energy storage capability IoT devices** which have following key attributes:
 - Operator under **extreme environmental conditions** e.g., high pressure, extremely high/low temperature, humid environment,
 - **ultra-low complexity, very small device size**/form factor (e.g., thickness of mm), maintenance-free (e.g., no need to replace a conventional battery for the device) and longer life cycle (e.g., 20 years) etc .,
 - where a device driven by a **conventional battery is not applicable**.
 - **USIM-free** consideration for battery-less or with limited energy storage capability.

Why Ambient IoT? (2/2)

- Ambient power-enabled IoT service is **complementary** to existing Cellular IoT service to support new classes of battery-less or with limited energy storage capability IoT devices scenarios.



- SA1 is working on SI on Ambient power-enabled IoT approved in SP-220085 for requirements.
- RAN is working on SI on Ambient power-enabled IoT approved in RP-223396.

Ambient IoT Service Deployment Applications

Smart Home Network

- Ambient power-enabled IoT is also attractive for smart home applications due to its characteristics of ultra-low cost, very small form factor, washable, flexible/foldable form factor and very long-life time



Inventory

Smart Logistics and smart Warehousing

- Huge amount of goods needs to be frequently transferred, stored, loaded/unloaded, and inventoried in the logistic station or warehouse (tens of thousands of m²)
- Ambient power-enabled IoT is expected to bring in revolution and enable smart logistics and smart warehousing with its features of extremely-low cost, small form factor, maintenance-free, durability, long life span etc.



Inventory

Smart Agriculture

- Ambient power-enabled IoT benefits smart agriculture
- Ambient power-enabled IoT devices driven by solar can be used to monitor the soil moisture, soil fertility, the temperature, wind speed, plant growth



Sensors

Industrial Wireless Sensor Network (IWSN)

- In some IWSN application, the environments are harsh with high/low temperature, moving or rotation parts, high vibration conditions, humidity and other hazardous conditions.
- In these IWSN use cases, it requires devices to be maintenance-free, battery-less, ultra-low power and with long service life.



Sensors

5G Advanced Ambient IoT service differentiation from RFID(1/2)

- RFID tags are now being widely used in industries such as transportation, logistics and supply chain, retail, defense, etc., to track assets.
- The RFID Market is expected to reach **USD 35.6 billion** by 2030, it is expected to grow at a CAGR (Compound Annual Growth Rate) of 11.9% during 2022-2030^[1].
- RFID shortfall
 - ✗ Lack of integrated connectivity technology to deliver ubiquitous passive IoT services, where some IoT devices may need to communicate across long distances or through a difficult environment (such as underground), often in areas where there may be little or no telecommunications infrastructure.
- Ambient IoT service differentiations
 - ✓ Leveraging 5G Advanced System to support massive IoT service deployment (e.g. long range) to enable mobile operators to deliver ubiquitous passive IoT services to their IoT customers and to provide also value-added connectivity to the IoT backend service infrastructure.

[1] RFID Market Forest to 2030. <https://www.marketsandmarkets.com/Market-Reports/rfid-market-446.html>

5G Advanced Ambient IoT service differentiation from RFID(2/2)

◎ Ambient IoT Technology vs. RFID Technology

	RFID	Ambient IoT
Cost	Low	Low
Battery	Battery-less or limited energy storage	Battery-less or limited energy storage
Communications	Typically unidirectional	Bidirectional
Distance of Reading (Coverage)	Close	Long
Management of Tags (see NOTE-1)	No	Yes
Required Dedicated Tag Reader	Yes	No
Valued Added Cellular Connectivity support to IoT Backend Applications (i.e. IoT Backend As A Service) (see NOTE-2)	No	Yes
Leverage existing extensive infrastructure coverage (i.e. flexible location IoT coverage)	No	Yes

NOTE-1: 5GS assistance for Backend remote tag management (e.g. tag assignment and removal from an asset, etc.), tag configuration (e.g. event reporting location upon motion, real time tracking etc.), tag activation etc.

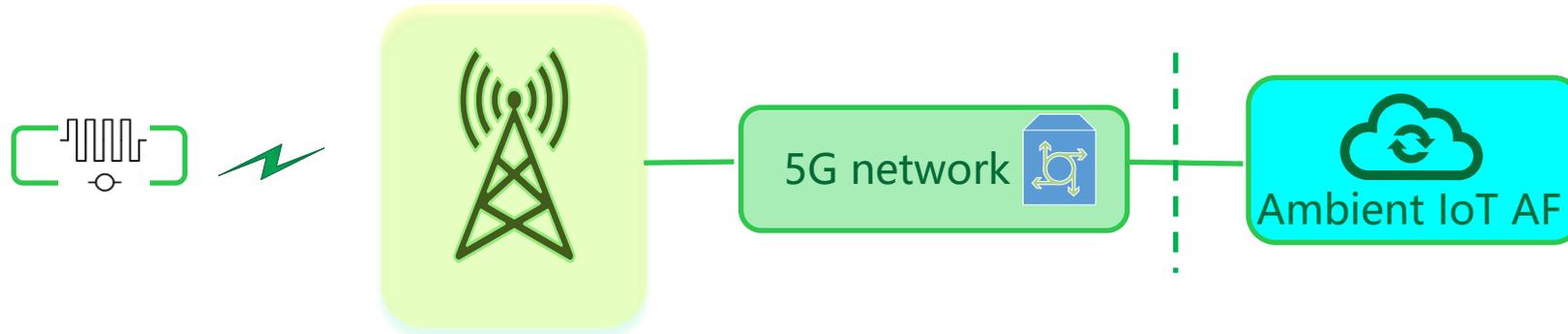
NOTE-2: Leveraging cellular infrastructure to enable the communication between the backend application and IoT device to support variety data collection and management.

Use cases and Requirements from SA1

- ⦿ Consolidated Potential requirements in SA1 to be captured in TR 22.840
 - ❖ Communications aspects of Ambient IoT devices
 - ❖ Positioning/location of Ambient IoT devices
 - ❖ Management of Ambient IoT devices
 - ❖ “Collection information” and network capability exposure
 - ❖ Charging
 - ❖ Security and privacy

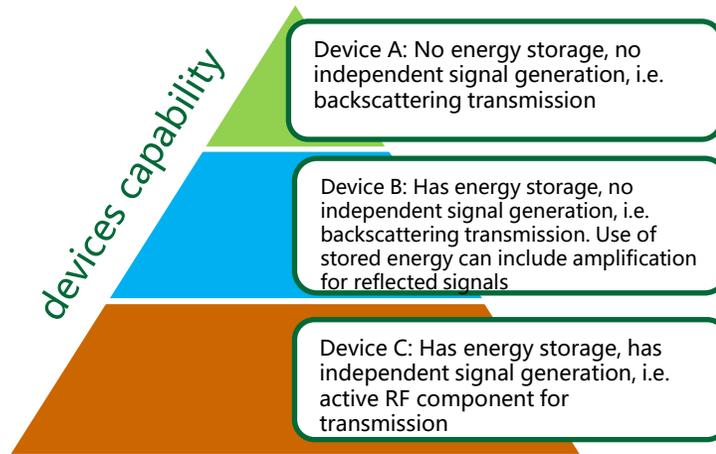
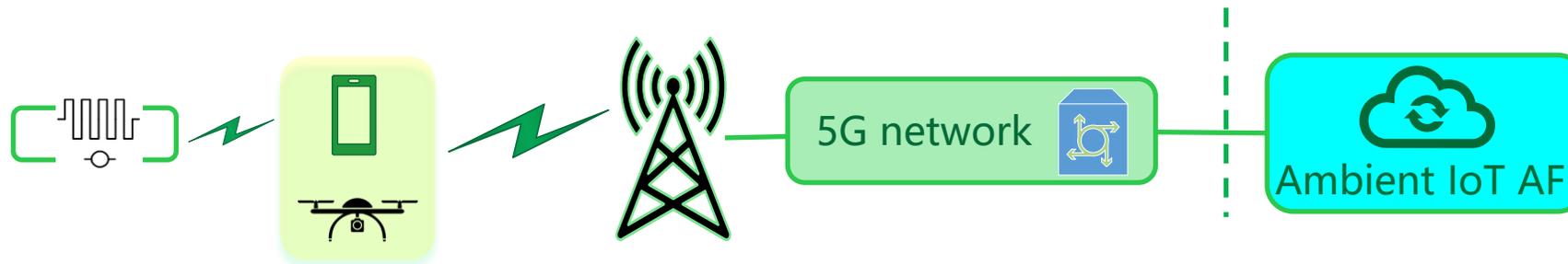
Considerations of Ambient IoT in 5G Advanced System (1/6)

Direct Mode



- ❖ DL Initiated e.g in Inventory (Smart home, logistics and warehouse)
- ❖ UL Initiated e.g Sensor data reporting (Smart Agriculture.)

Indirect Mode



- ◎ Ambient IoT devices capability: Indirect mode can be lower than direct mode
 - ❖ Device A: Ideal for indirect
 - ❖ Device B: Indirect and Direct mode
 - ❖ Device C: Indirect and Direct mode

Considerations of Ambient IoT in 5G Advanced System (2/6)

Direct Mode vs. Indirect Mode		
	Direct Mode	Indirect Mode
Device Categories and Capabilities Supported	<ul style="list-style-type: none"> Device B; Device C; 	<ul style="list-style-type: none"> Device A (ideal for indirect mode) Device B; Device C; <p>UE is involved, device capabilities, cost and power consumption can be reduced further.</p>
5G network impacts & Operator role	<ul style="list-style-type: none"> More impacts than indirect mode New Uu interface (pending RAN discussion) Operator is aware of and can control devices. 	<ul style="list-style-type: none"> Less impact to 5G network: UE is present between devices and gNB, then the existing 5G network can be reused as much as possible. Existing Uu interface with minimal impact is expected. PC5* is expected to be PC5 light. Operator is aware of and can control devices.
Coverage	<ul style="list-style-type: none"> Few 10 meters indoor; up to 200 meters outdoor 	<ul style="list-style-type: none"> Few 100 meters or kilo meters by reusing existing infrastructure
ID management of device	<ul style="list-style-type: none"> managed by operators with or without 3rd party assistance. 	<ul style="list-style-type: none"> managed by operators with or without 3rd party assistance.
Authentication and Verification of Device	<ul style="list-style-type: none"> 5G network perform the authentication and verification of device 	<ul style="list-style-type: none"> Authorized UE can perform the device verification

Considerations of Ambient IoT in 5G Advanced System (3/6)

Existing IoT

NAS based Registration

- Registration Management
- Connection Management

ID management & Authentication

- SIM based Authentication
- SUCI/SUPI used

Power saving

- eDRX
- MICO with Active Time
- MICO with Connected Time
- MICO with periodic Registration time control
- WUS
- Design up to 10 years

PDU session based data transmission

- CP/UP Clot optimization
- Non-IP Data Delivery
- Early Data Transmission
- High Latency Communication
- Serving PLMN rate control
- Small Data rate control
- Service Gap Control

- Ambient IoT devices are battery-less or with limited energy storage capability, power source depending on energy harvesting is **unstable** e.g at night or cloudy day.
- The number of Ambient IoT devices are huge. However data volume transmission for Ambient IoT is much smaller (e.g. only report device info).
- The cost of ambient IoT devices will be **ultra low**.
- Ambient IoT device can be **UICC-free**, this will challenge the existing SIM based authentication.

Ambient IoT-Direct Mode

- Registration optimization for Ambient IoT devices?
- Whether and how to apply the existing RM and CM to ambient IoT devices?

- How to perform authentication or verification for UICC-free Devices?
- How to manage IDs (e.g. IDs provided by 3rd party or operators) for ambient IoT devices?

- **unstable power source**
 - ✓ Whether and how to apply the existing power saving mechanism to ambient IoT devices?

- **More efficient small data transmission without PDU session concept.**

Considerations of Ambient IoT in 5G Advanced System (4/6)

Existing U2N relay

Communication

- PC5 link per relay service code
- IP data and non-IP data transmission

Power saving

- SL DRX

Auth & Regulatory

- SIM based authentication
 - ✓ CP/UP based authentication
- Remote UE report

- Ambient IoT devices are battery-less or with limited energy storage capability, power source depending on energy harvesting is **unstable** e.g at night or cloudy day.
- The number of Ambient IoT devices are huge. However data volume transmission for Ambient IoT is much smaller (e.g. only report device info).
- Ambient IoT device might be **UICC-free**, this will challenge the existing SIM based authentication.
- The cost of ambient IoT devices can be **ultra low**.
- U2N relay architecture (or similar) has **NOT** well considered low power IoT devices.

Ambient IoT-Indirect Mode

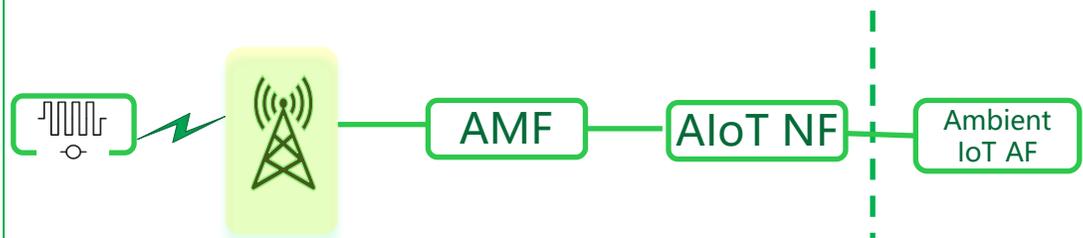
- Whether PC5* link is required for Ambient IoT devices?
- More efficient small data transmission over PC5*

- **unstable power source**
 - ✓ Whether and how to apply the exiting power saving mechanism to ambient IoT devices?
 - ✓ Existing PC5 has only supported SL DRX. What would be appropriate power saving mechanism for ambient IoT devices.

- How to perform authentication for UICC-free Devices?
- How to manage IDs (e.g. IDs provided by 3rd party or operators) for ambient IoT devices?
- How to register for Ambient IoT devices?

Considerations of Ambient IoT in 5G Advanced System (5/6)

◉ Ambient IoT with AMF (Direct Mode)



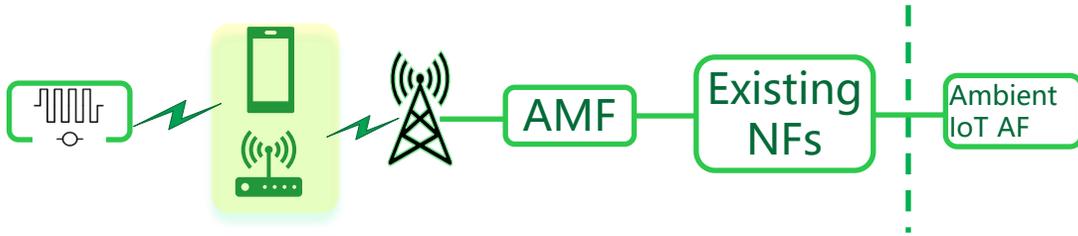
◉ Ambient IoT without AMF(Direct Mode)



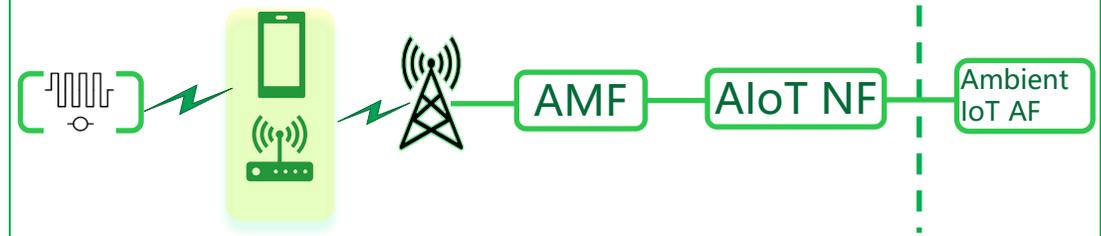
	Ambient IoT with AMF	Ambient IoT without AMF
AIoT NF introduced	<ul style="list-style-type: none"> minimize the impact on existing NFs to support more efficient data reporting Minimize impact to N2 	<ul style="list-style-type: none"> minimize the impact on existing NFs
AIoT NF service management	<ul style="list-style-type: none"> per Ambient IoT service provider (not per a tag granularity) (from AMF) 	/
RAN and CN Interface	<ul style="list-style-type: none"> Signaling per tag granularity N2 Impact minimized 	<ul style="list-style-type: none"> Signaling per Ambient IoT service provider (not per a tag granularity).
NAS supported	<ul style="list-style-type: none"> Yes Simplified procedures, No session concept 	<ul style="list-style-type: none"> No NAS Tags with much lower capabilities supported

Considerations of Ambient IoT in 5G Advanced System (6/6)

◉ Ambient IoT with existing NFs (Indirect Mode)



◉ Ambient IoT with AIoT NF (Indirect Mode)



	Ambient IoT with existing NFs	Ambient IoT with AIoT NF
AIoT NF introduced	<ul style="list-style-type: none"> ◉ No new NFs 	<ul style="list-style-type: none"> ◉ To minimize the impact on existing NFs
AIoT NF service management	/	<ul style="list-style-type: none"> ◉ per Ambient IoT service provider (not per a proxy granularity) (from AMF)
RAN and CN Interface	<ul style="list-style-type: none"> ◉ N2 Impact minimal 	<ul style="list-style-type: none"> ◉ N2 Impact minimal
NAS supported (UE)	<ul style="list-style-type: none"> ◉ Yes ◉ PDU session for data transmission 	<ul style="list-style-type: none"> ◉ Yes ◉ No session concept for data transmission
PC5* between AIoT devices and UE	<ul style="list-style-type: none"> ◉ No PC5* session ◉ Simplified procedures. 	<ul style="list-style-type: none"> ◉ No PC5* session ◉ Simplified procedures.

Scope Considerations of SA2 work for Ambient IoT

Study potential architecture enhancements to support Ambient IoT devices either connecting to gNB directly, or connecting to gNB via UE

- Identification management performed by operators with/without the 3rd party assistance
- Study how ambient IoT devices register to 3GPP network, and whether and how to support Mobility Management and Connection Management for Ambient IoT devices;
- Study architecture requirements to support authentication and authorization of Ambient IoT device
- Study the network exposure to support ambient IoT devices:
 - To support the ID management performed by operators with the 3rd party assistance;;
 - To support MM and CM with provisioning information from the 3rd party assistance;
- Study link management between Ambient IoT devices and UE
- Support of device life cycle management;
- Support of group management of ambient IoT devices

Whether and how to Session Management for data transmission

- Connectivity establishment for data transmission;
- data received or collected by the network exposed to 3rd party

Study QoS and Policy Enhancement to support Ambient IoT devices

Study how to perform positioning for Ambient IoT device;

Study access and congestion control mechanism(s) to support ultra-high density deployment scenarios of Ambient IoT devices

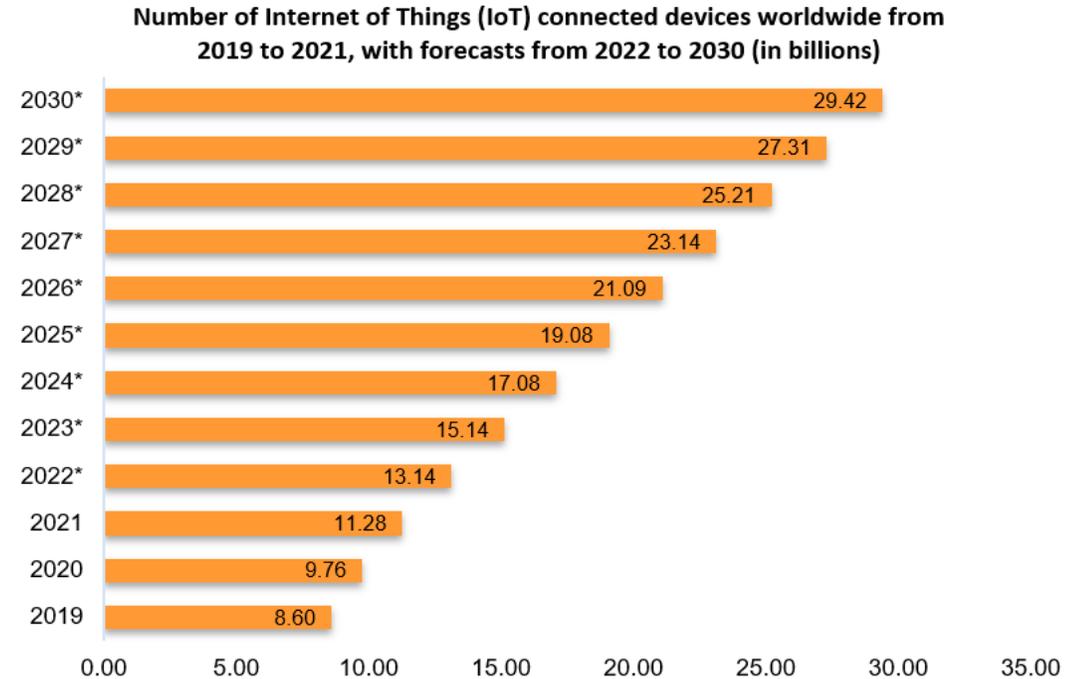
Coordination with other WGs

- Network selection with CT1; Security aspects with SA3; Charging with SA5; Service Requirement with SA1;

Conclusions

The market of IoT has been expected to reach beyond 29 billion devices till 2030 and the demand of ubiquitous coverage with the support of flexible and reliable connectivity to IoT backend promise could provide generous return to connectivity infrastructure providers, e.g. mobile operator. The scope of IoT application development services is increasing day by day as people and companies are adopting IoT trends with evolving technological trends.

Ambient IoT services over the 3GPP could proliferate the deployment justification of the 5G Advanced system by offering not only flexible IoT tag reading support for ambient IoT services, and also offering the valued added “IoT Backend As A Service” connectivity support to IoT backend applications.



This presentation articulated the technological and business motivations for the 5G Advanced system to support the Ambient IoT services. It further identified the technical challenges and architecture considerations when adding the support for the Ambient IoT to the existing cellular IoT service portfolio.

Given the materials presented, there is a solid justification for the 5G Advanced system to include the support of the Ambient IoT services in the upcoming Release 19.

