

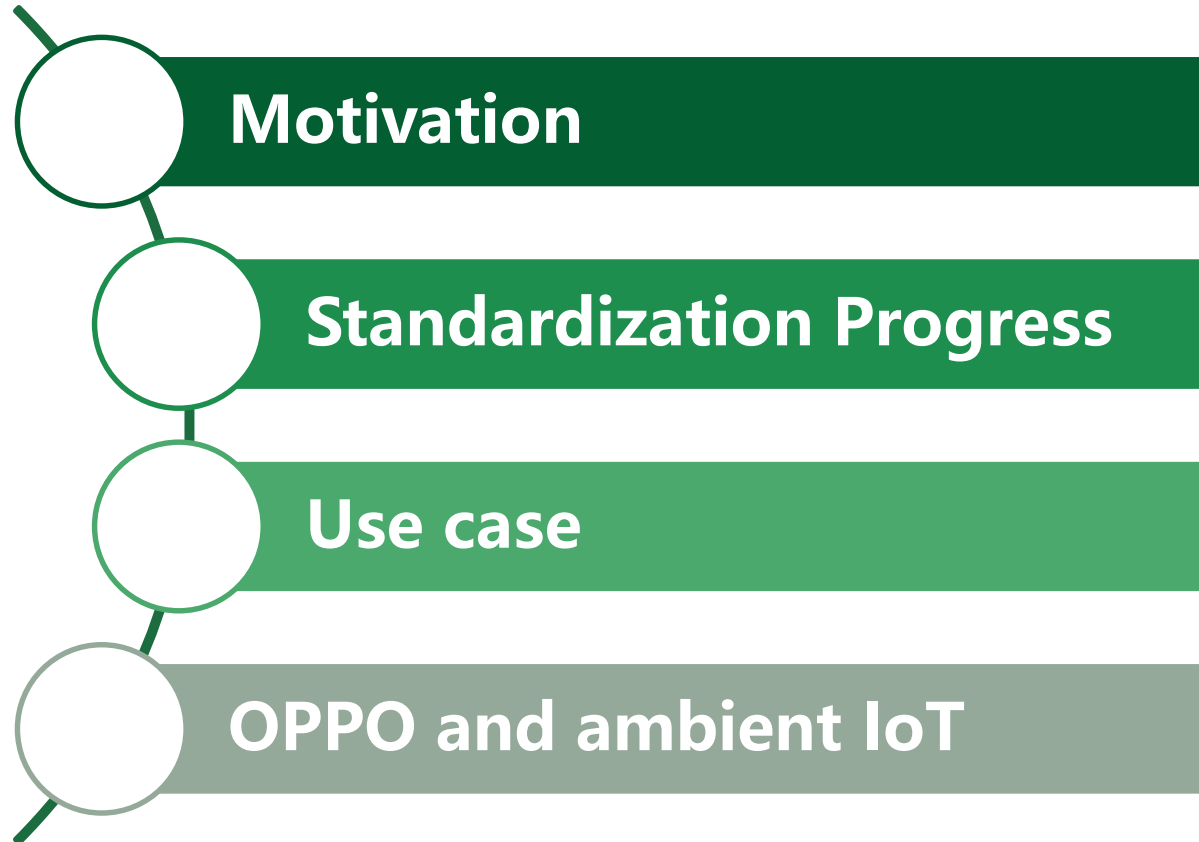
Ambient IoT

A new way to the physical world

OPPO Research Institute



Outline



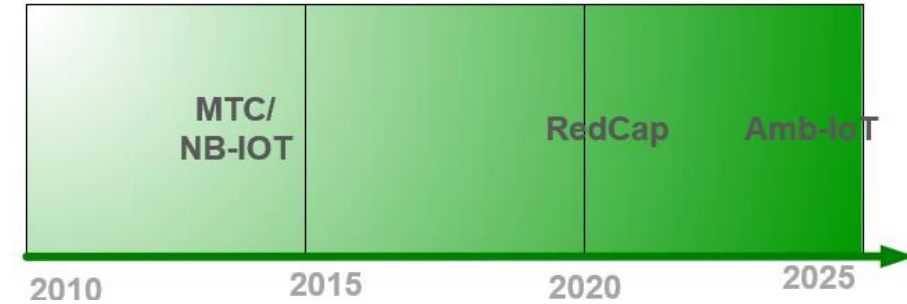
Motivation on supporting Ambient IoT

❑ Massive MTC is one important use cases for 5G. NB-IoT/MTC/RedCap have been specified in 3GPP. However, many use cases are still not covered :

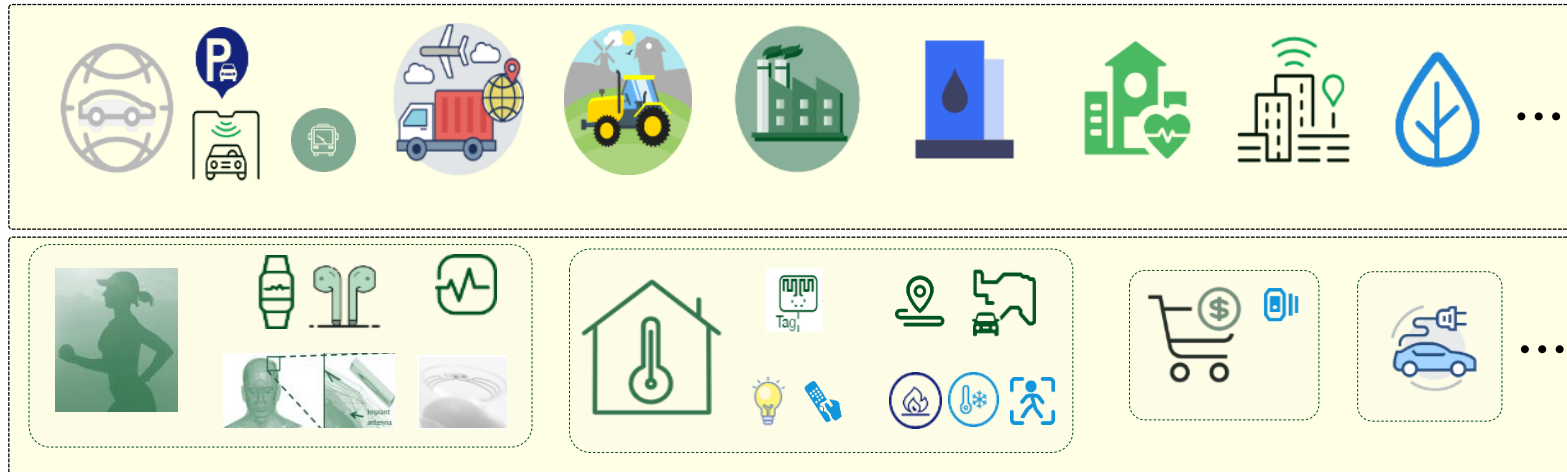
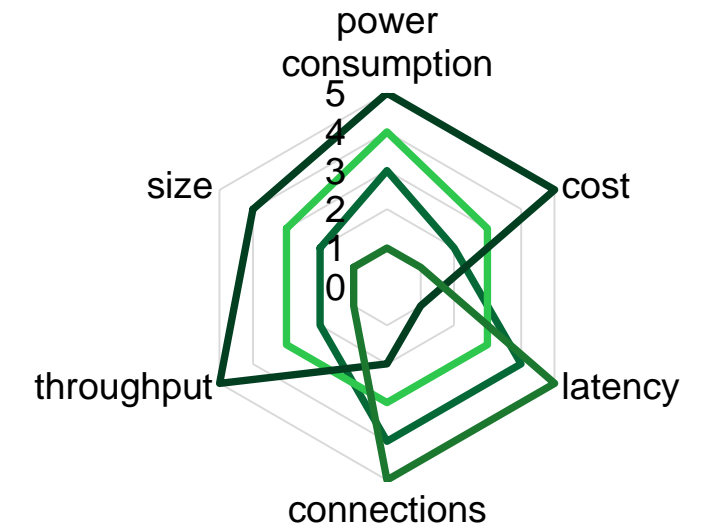
- Under extreme conditions, e.g., high pressure, extremely high/low temperature, humid etc..
- Where Ultra-low cost, very smaller form factor, maintenance-free and longer life cycle are required.

❑ Ambient IoT provides a promising scheme to fulfil the unmet requirements. Ambient IoT tag is battery-less and uses energy harvested from radio waves, light (solar), motion, heat etc.

❑ Ambient IoT would be complementary to existing 3GPP IoT technologies.



— NB — MTC — RedCAP — Amb IoT



Solution: Ambient IoT

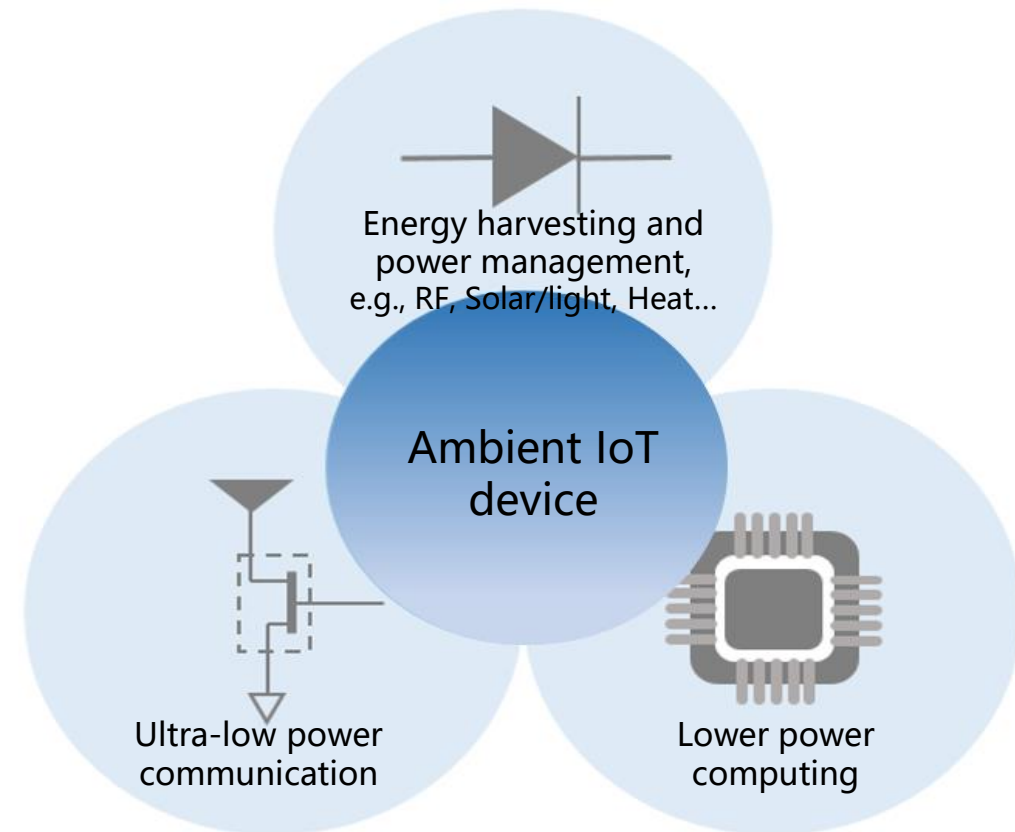
❑ A new type of IoT devices, powered by ambient power such as radio waves, solar, heat, vibration etc. is a promising way to fulfill the unmet requirement and enable many to-B and to-C applications.

❑ Ambient IoT device has the following distinguished characteristics:

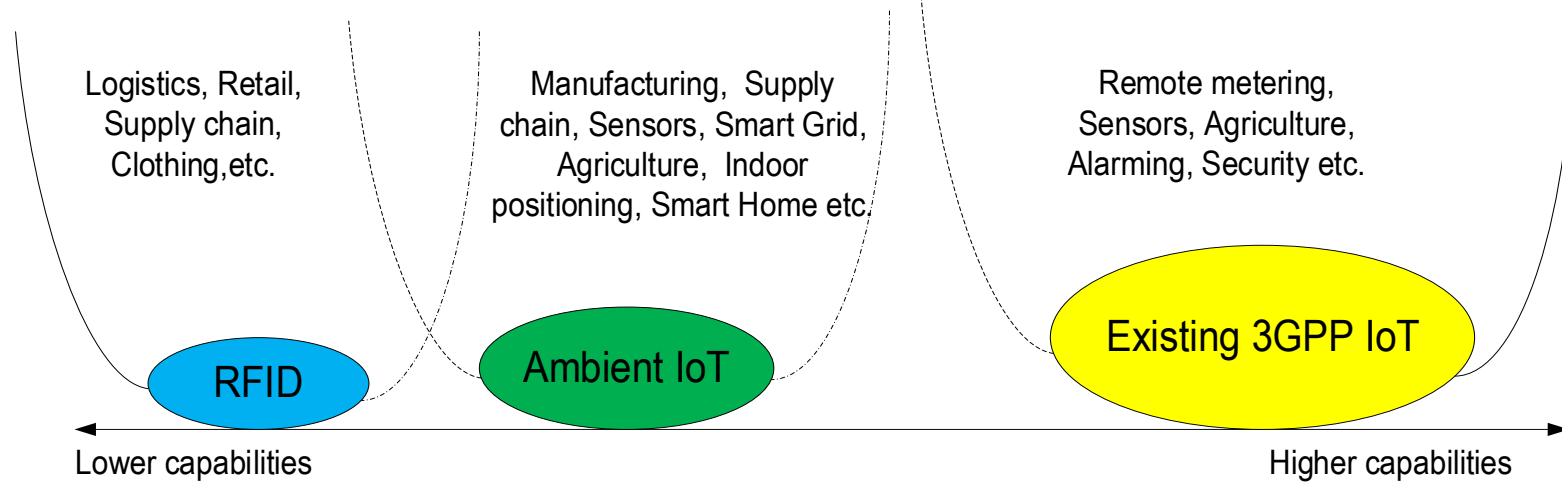
- Maintenance-free due to battery-less
- Ultra-low cost/complexity
- Small size
- Long life span(more than 10 years)...

❑ Ambient IoT can support:

- Identification
- Sensor data collection
- Positioning
- Actuation



Design target: Ambient IoT capability



	RFID	Ambient IoT	Existing IoT
Coverage	<10 m	10m~30m (RF power); Up to 200m(other ambient power)	>=1000m
Power Source	RF power only	Various ambient power (RF sensitivity ~35dBm)	Conventional Battery
Techniques	Backscattering	Backscattering(x~10x uW)/Active transmitter (200~500 uW) Ultralow-power receiver (10x~100x uW) Enhanced power saving	OFDM Narrow bandwidth Relaxed processing eDRX PSM, etc.
Power Consumption	1uw~10uw	<1mw	100x mw
Device Cost (Relatively)	Low	Medium	High
Maintenance/operation cost	Need labor cost for operation	Maintenance-free and Automated operation	Automated operation but need to replace/recharge the battery/

Standardization Progress in 3GPP

□ Study item on ambient IoT was approved in in 3GPP SA1#97(Feb. 2022)

- S1-220192 New SID: Study on Ambient power-enabled Internet of Things OPPO
- 30+ use case and the corresponding service/KPI requirement have been agreed
- 80% Completion up to Feb. 2023

□ RAN-level study item was approved in 3GPP RAN#97(Sept. 2022)

- RP-222685, “New SID: Study on Ambient IoT” , Huawei, HiSilicon, RAN#97e, September 2022.
- Focusing on : RAN deployment scenario, Device categorization, design target and feasibility

□ SA working group level study item was approved in 3GPP RAN#102(Nov. 2023)

- SP-231803, “New SID: Study on Architecture support of Ambient power-enabled Internet of Things” Huawei, OPPO

□ RAN working group level study item was approved in 3GPP RAN#102(Nov. 2023)

- RP-234058, “New SID: Study on solutions for Ambient IoT (Internet of Things) in NR” CMCC, Huawei, T-Mobile
- The study and standardization campaign will start since Feb. 2024

Expected Ambient IoT capabilities in 3GPP Rel-19

□ In Rel-19, it focus on rUC1(Inventory), rUC4 (actuator control) and indoor.

- Both direct connection(between gNB and device) and indirect connection(with intermediate UE) will be studied/supported.

□ Expected capabilities:

Device Type	Coverage	Data Rate	Band/ bandwidth	Power storage	Transmission power	Security	Function
I: backscatter	10~20m	10x kbps	800-900MHz/ 180~360kHz	Tiny capacitor	-40dBm~- 35dBm	e.g. AES 128 or Physical layer security	Inventory Positioning(Cell- level)
II (a): backscatter	20m~50m			Capacitor /Solid state battery	-25dBm~- 20dBm	e.g. AES 256 or Physical layer security	Inventory/Comm and Positioning(Cell- level)
II (b): Active transmission	20m~200m				-20dBm~0dBm		

□ Applicable use cases:

- Logistics/Warehouse, Intralogistics in manufacturing, Agriculture...
- Business mode

Use case #1: Smart home

□ Ambient IoT can be used in the following applications:

- **Asset management:** finding home belongings
- **Home environment monitoring:** e.g., temperature, humidity, gas leakage etc.

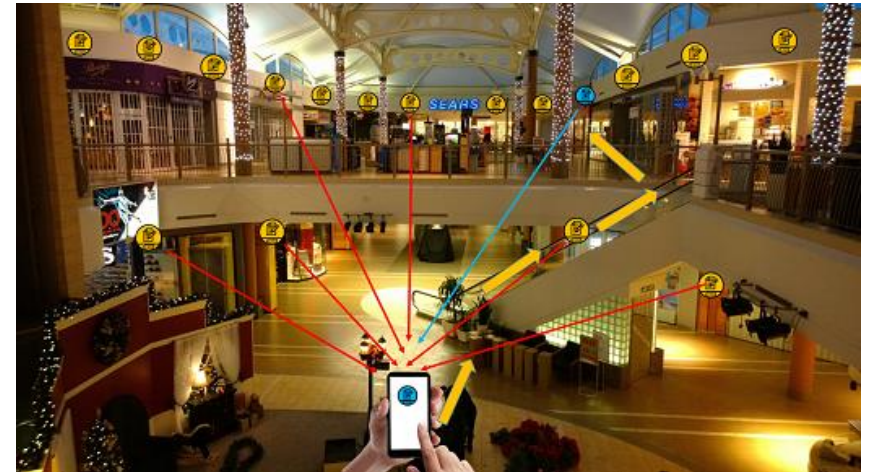
□ Requirements

- Low complexity and small size, e.g., **thickness of 1mm and area of several cm²**
- Long service life., e.g., more than 10 years.
- No need to replace/recharge a conventional battery, e.g. Maintenance-free for battery
- Coverage **up to 10m**
- Positioning **accuracy of 1~3m**



Use case #2: Indoor positioning

- ❑ Currently, there is no effective techniques for indoor positioning.
- ❑ Ambient IoT devices can be used to build an indoor positioning and navigation system.
 - For Car parking
 - Navigation in shopping centre
 - For manufacturing and logistics
- ❑ Requirements of the Ambient IoT devices:
 - Communication range: 10~30m
 - Positioning accuracy: 1~3 m horizontal accuracy and 2m vertical accuracy (i.e., can locate the specific storey)



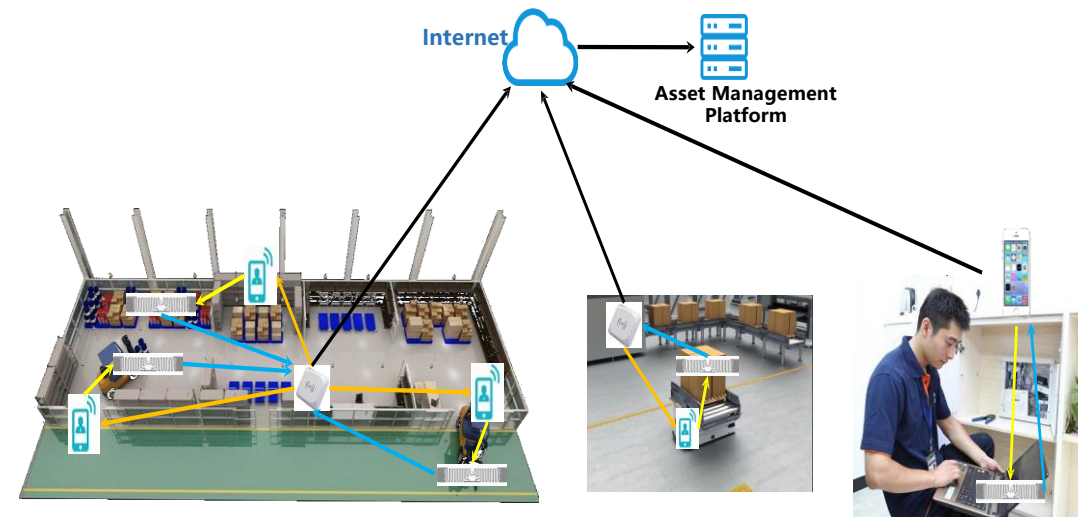
Use case #3: Intralogistics

□ Ambient IoT can enable automated intralogistics.

- Automatic Inventory management
 - An ambient device is attached on each container
 - Help to manage the supply chain
- Accurate positioning
 - Assist AGV/forklifts to pick up materials

□ Requirements

- Low complexity and small size, e.g., **thickness of 1mm and area of several cm²**
- Long service life., e.g., more than 10 years.
- Maintenance-free
- Service area: 600000m²
- Density: <1.5 Million/km²
- Coverage **up to 30m, indoor**
- Positioning **accuracy of 1~3m**



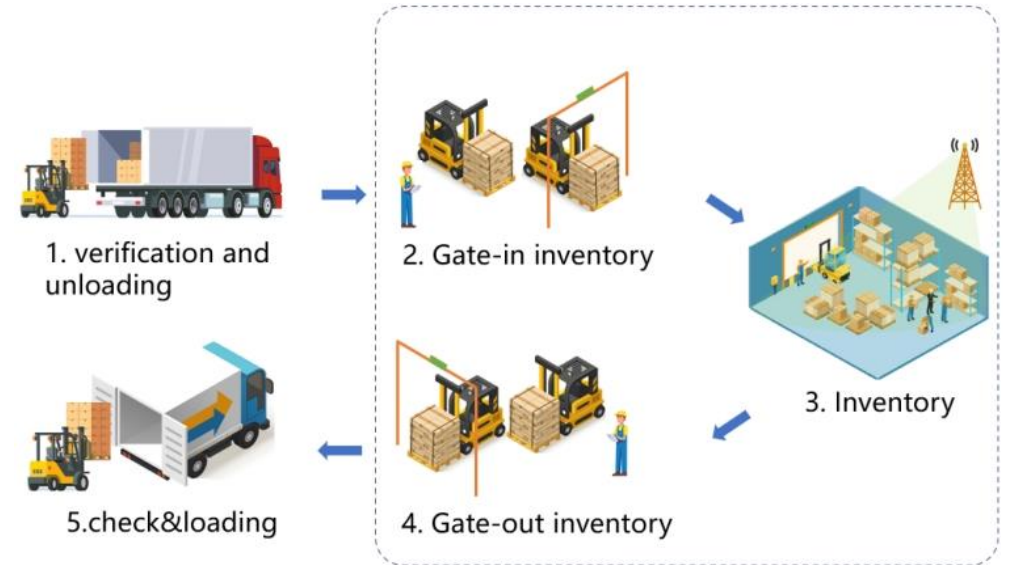
Use case #4: Warehousing

□ Ambient IoT can enable fast and automatic warehousing.

- High-efficiency loading/unloading/inventory
 - An ambient device is attached on each container
- Periodic Inventory management

□ Requirements

- Low complexity and small size, e.g., **thickness of 1mm and area of several cm²**
- **>99.5% identification accuracy** even in case of high density deployment
- Payload: 96/128bits (ID)
- Maintenance-free ambient device
- Service area: 2000~20000m²
- Coverage **10m-30m, indoor**



Use case #5: Cold-chain Transportation

□ Ambient IoT can enable safe and high-efficiency cold-chain

- The whole cold-chain can be well managed and monitored.
 - Farm->the distribution centre (DC)-> backstore->shelves
 - Each container is attached with one device
- Temperature sensing

□ Requirements

- Low complexity and small size, e.g., **thickness of 1mm and area of several cm²**
- Payload: 96/128bits (ID)
- Maintenance-free ambient device
- Service area of DC : 30000m²
- DC throughput ~50K Containers per day
- Coverage **30m, indoor**
- **Sensing interval: 15min**



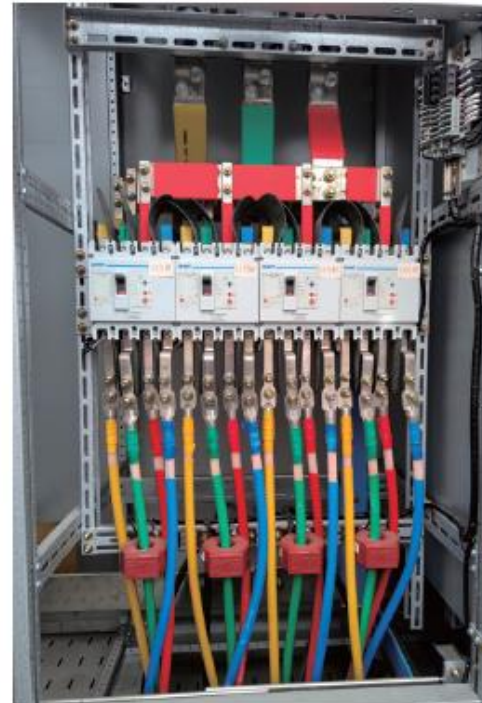
Use case #6: Industrial Wireless Sensor Network

□ Ambient IoT can be used for

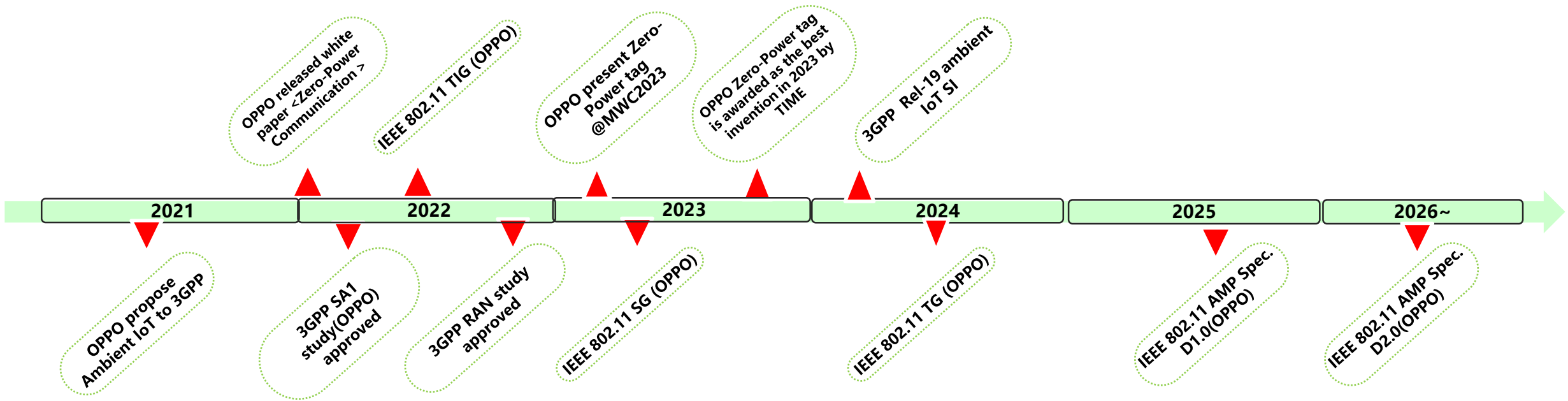
- Industrial environment/production line monitoring
- Asset tracking/positioning

□ Requirements

- **Maintenance-free** IoT network, long service life. **Battery-less** IoT device (i.e., not using a conventional battery).
- Coverage: **up to 30m** for indoor case, **up to 100m** for outdoor case
- Data rate: **100kbps**



OPPO' s contribution



phonearena.com/news/Oppo-Zero-Power-Tag-tracker-would-save-landfills-from-millions-of-AirTag

Oppe Zero-Power Tag tracker would save landfills from millions of AirTag-style batteries

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Thank you!