3GPP TSG RAN Meeting #101 **RP-232439**
Bangalore, India, September 10-15, 2023

Agenda Item: **9.2.2**

Source: **Lenovo**

Title: **Views on Ambient IoT in RAN - Deployment scenarios and Design targets**

Document for: **Discussion**

1 Introduction

This contribution presents our input to the ongoing RAN study item on Ambient IoT [1].

2 Deployment scenarios for Ambient IoT

2.1 Deployment scenarios

The following 5 deployment scenarios described in TR 38.848 are as follows:

Deployment scenario 1: Device indoors, base station indoors	Topology 1, 2, 3
Deployment scenario 2: Device indoors, base station outdoors	Topology 1, 2, 3
Deployment scenario 3: Device indoors, UE-based reader	Topology 4
Deployment scenario 4: Device outdoors, base station outdoors	Topology 1, 2, 3
Deployment scenario 5: Device outdoors, UE-based reader	Topology 4

Table 1: Shows mapping between deployment scenarios and Topology

The deployment scenarios providing mapping between connectivity topology to the indoor/outdoor deployments scenarios needed for the UC is described in Table 1. Some of the deployment scenarios such as deployment scenario 2 may not be needed for the indoor scenario inside a factory hall, hence such deployment scenarios can be down prioritized for evaluation purpose.

Proposal 1: Down prioritize deployment scenario 2 for smart factory premises

There is no mapping discussed between UCs, connectivity topology and the deployment scenarios. For e.g., for indoor inventory UC may consider prioritizing indoor deployment scenario 1, 3 and topology 1, 4. Such mapping helps in identifying the key deployment scenarios and topology needed for a UC.

Deployment scenario 1: Device indoors, base station indoors	Topology 1, 2, 3	Indoor inventory
Deployment scenario 2: Device indoors, base station outdoors	Topology 1, 2, 3	Indoor sensor, indoor command
Deployment scenario 3: Device indoors, UE-based reader	Topology 4	Indoor positioning
Deployment scenario 4: Device outdoors, base station outdoors	Topology 1, 2, 3	outdoor inventory, outdoor sensor,

		outdoor command, outdoor positioning
Deployment scenario 5: Device outdoors, UE-based reader	Topology 4	outdoor positioning

Table 2: Shows mapping of UCs to deployment scenarios and connectivity topology

Proposal 2: Discuss the mapping of UCs to the deployment scenario and connectivity topology.

3 RAN design targets

In this section, we formulate a set of RAN design targets for the Ambient IoT use cases.

- Formulate a set of RAN design targets based on the identified deployment scenarios and their characteristics for the relevant use cases, at least including
  - Power consumption
  - Complexity
  - Coverage
  - Data rate
  - Positioning accuracy

3.1 Device power consumption

The following agreement on the device power consumption target is provided below:

Agreement

Device design target for power consumption during transmitting/receiving is:

- **[Device A ≤ 10 µW] or [Device A ≤ 1 µW]**
- **Device A ≪ Device B < Device C, or Device A ≤ Device B < Device C**
- **Device C ≤ 1 mW to ≤ 10 mW**

Proposal 3: Select the target for power consumption during transmitting/receiving is:

- **Device A ≤ 10 µW**
- **Device A ≪ Device B < Device C**
- **Device C ≤ 10 mW**

Proposal 4: Select the device B power consumption as ≤ 250 µW.

The UHF RFID power consumption is nearly 1µW, since the Ambient IoT based passive tags may have better coverage range compared to the UHF RFID tags the power consumption at the Ambient IoT passive tags may be selected around 10 µW. The device B may have an reflection amplifier together with a limited energy storage device to improve the reflected signal path, hence the power consumption at the device B should be around 250 µW considering the power consumption due to the reflection amplifier and the energy storage. The agreement from RAN#98 says that the power consumption of device C should be order of magnitude lower than the NB-IoT power consumption which is around 200 mW, hence the power consumption of the device C maybe selected as 10 mW considering the heterodyne receiver architecture. However, the device A, B may use the RF or zero-IF envelope detector.

Proposal 5: Study the receiver architecture for each of the device type during RAN WG level phase.

- **Device A may use RF envelope detector or Zero-IF envelope detector as starting point**
- **Device C may use heterodyne receiver as starting point**

3.2 Coverage calculations

The coverage of the Ambient IoT device depends on the type of the device A, B & C. The device A depends on the reflected signal however the device B may have an reflection amplifier to extend the coverage of the reflected signal. The device type C may have coverage better than device A and B, but less than NB-IoT of 164dB, hence the MCL of device type C may need to be evaluated in the RAN WG1 evaluation phase.

Proposal 6: Discuss the coverage metric for each of the device type A, B and C for indoor and outdoor scenarios and connectivity topology.

Furthermore, the coverage depends on the connectivity topology. For example, the connectivity topology-1 which connects BS <--> tag for indoor factory halls with an inter-site distance of 50m using a simple pathloss model of 128.1 + 37.6*log10(distance in meters/1000) is 75dB for device A. While using an inter-site distance of 90m using a simple pathloss model of 128.1 + 37.6*log10(distance in meters/1000) is 84dB for device B.

Parameters	Device A (Passive) ISD 50m	Device B (Semi-passive) ISD 90m
Carrier frequency (GHz)	2	2
gNB power(dBm)	43	43
gNB antenna gain(dB)	8	8
gNB Rx sensitivity(dBm)	-110	-110
Pathloss (dB)	75	84
A-IoT Rx sensitivity(dBm)	-30	-40
Reflection amplifier (dB)	0	20
Tag power gain(dB)	0	0
RSRP (dBm)	-24	-33
Reflection coeff/Return loss (dB)	9	9
Pathloss (dB)	75	84
gNB Rx RSRP (dBm)	-108	-106

Table 3: Coverage evaluation assumptions

Proposal 7: The reflected path distance from the tag to the base station may be around 30~35m for device type A for 2 GHz frequency.

Proposal 8: The reflected path distance from the tag to the base station may be around 65~70m for device type B for 2 GHz frequency while assuming a reflection amplifier gain of 20dB.

Proposal 9: The return loss due to the backscattered signal's reflection coefficient could be around 8-10 dB

4 Conclusions

The following observations and proposals were made in the previous sections:

Proposal 1: Down prioritize deployment scenario 2 for smart factory premises

Proposal 2: Discuss the mapping of UCs to the deployment scenario and connectivity topology.

Proposal 3: Select the target for power consumption during transmitting/receiving is:

- **Device A ≤ 10 μW**
- **Device A ≪ Device B < Device C**
- **Device C ≤ 10 mW**

Proposal 4: Select the device B power consumption as ≤ 250 μW.

Proposal 5: Study the receiver architecture for each of the device type during RAN WG level phase.

- **Device A may use RF envelope detector or Zero-IF envelope detector as starting point**
- **Device C may use heterodyne receiver as starting point**

Proposal 6: Discuss the coverage metric for each of the device type A, B and C for indoor and outdoor scenarios and connectivity topology.

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Proposal 9: The return loss due to the backscattered signal's reflection coefficient could be around 8-10 dB

References

[1] RP-223396, "SID revised: Study on Ambient IoT", Huawei, HiSilicon, December 2022