

**3GPP TSG RAN Meeting #102**

**RP-233051**

**Edinburgh, Scotland, December 11 - 15, 2023**

**Agenda Item: 9.1.1.4**

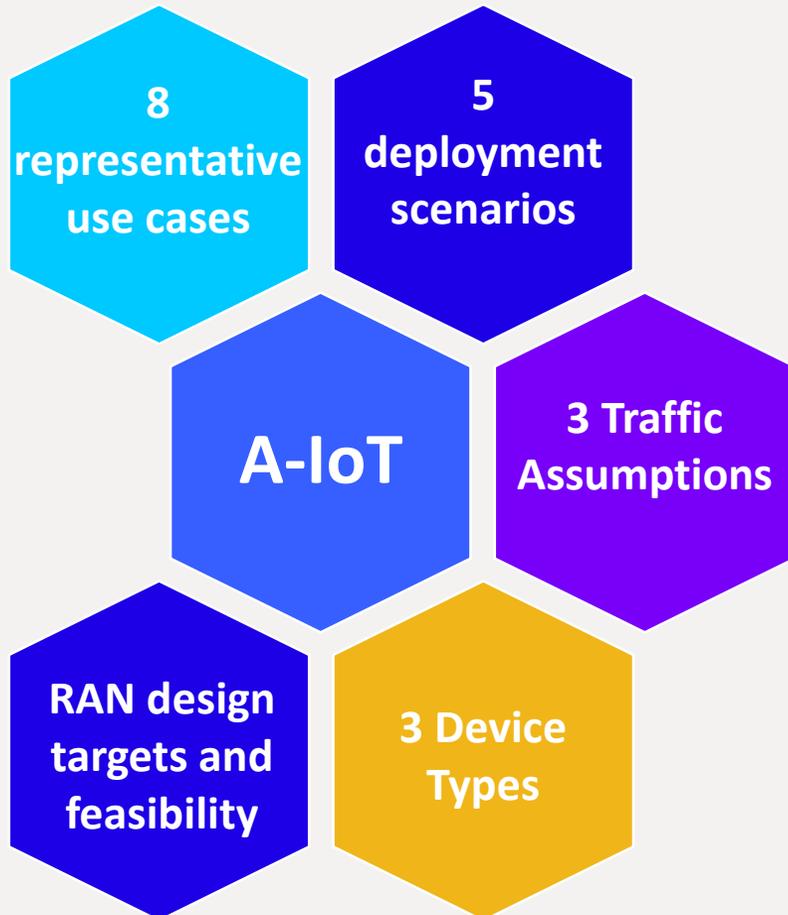
**Source: vivo**

**Title: Views on Rel-19 Ambient IoT**

**Document for: Discussion & Decision**

# RAN SI outcome (1)

## Background



### 8 representative use cases:

- (Indoor/outdoor) X (Inventory/sensor/positioning/command)

### 5 deployment scenarios and their characteristics

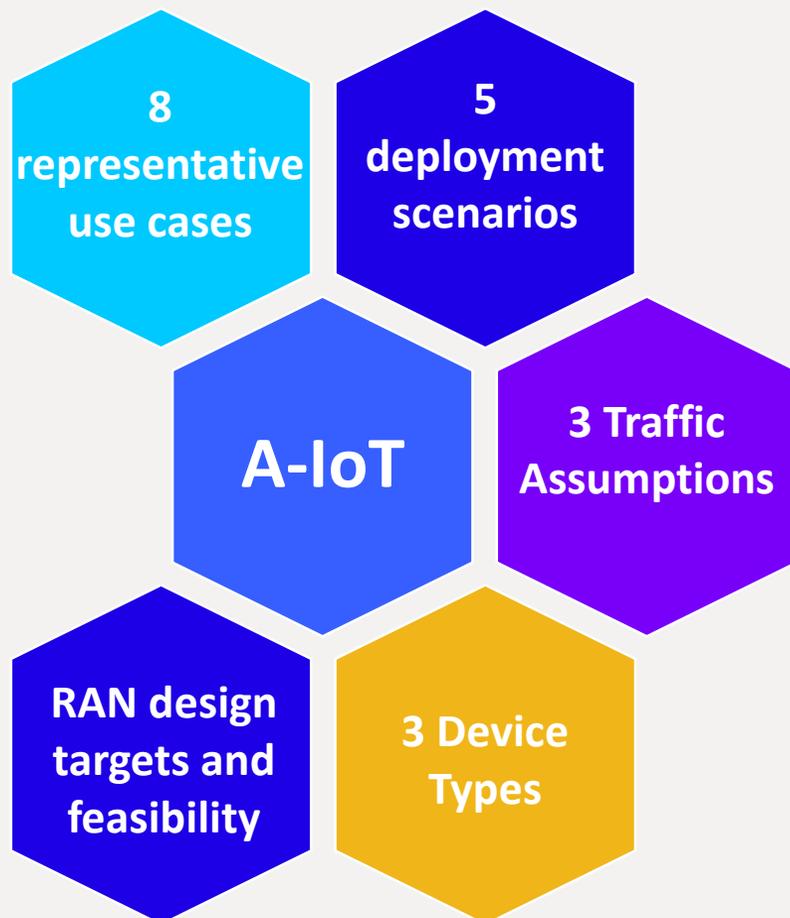
- ① Device indoor, Base station indoor;
- ② Device indoor, Base station outdoor;
- ③ Device indoor, UE as reader;
- ④ Device outdoor, Base station outdoor;
- ⑤ Device outdoor, UE as reader

### 3 Traffic Assumptions

- Device Terminated
- Device Originated (DO):
  - Device Originated Autonomous (DO-DOA)
  - Device Terminated Trigger (DO-DTT)

# RAN SI outcome (2)

## Background



3 Device Types			
	Definition	Power	Complexity
Device A	Backscatter No energy storage	$\leq [1 \mu\text{W}]$ or $[10 \mu\text{W}]$	Comparable to UHF RFID EPC C1G2
Device B	Backscatter [w/ Amplify] Energy storage	Between device A and device C	Between device A and device C
Device C	Active Transmission Energy storage	Up to 1 or 10 mW	Orders of magnitude lower than NB-IoT

### RAN design targets and feasibility

- Power consumption; Complexity; Coverage; Positioning accuracy; Data rate; Latency; Connection density etc.

# Background

## R18 RAN SI recommendations from TR38.848

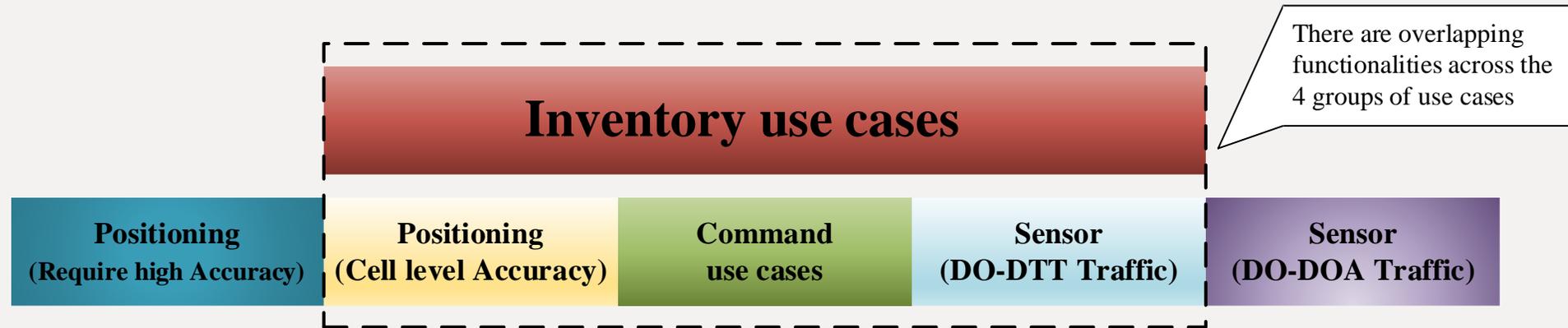
It is concluded in preliminary feasibility analysis at TSG-RAN level that Ambient IoT is feasible and beneficial, and further WG-level study is recommended prior to normative work.

For the initial WG-level study of Ambient IoT

- RAN is recommended to down-select further starting from:
  - Deployment scenario 1 with Topology 1
  - Deployment scenario 2 with Topology 1
  - Deployment scenario 2 with Topology 2
  - Deployment scenario 4 with Topology 1
  - Deployment scenario 4 with Topology 3
- FR1 licensed spectrum is recommended
  - Note: selection or prioritization between FDD and FDD/TDD is to be decided
- RAN is recommended to down-select to one or more of:
  - Spectrum in-band to NR, in guard-band to LTE/NR, and in standalone band(s)

It is recommended to direct the RAN WGs to use the design targets reported in Clause 5. The RAN WGs are expected to refine the design targets according to their technical expertise, as needed.

# Ambient IoT use cases



## Observation: There are overlapping functionalities among A-IoT use cases

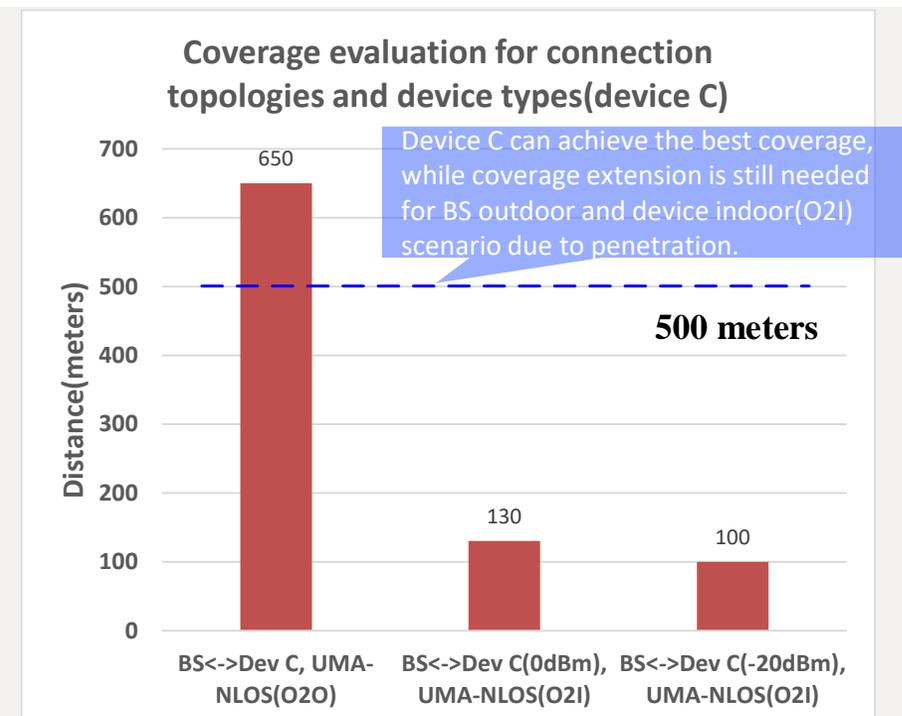
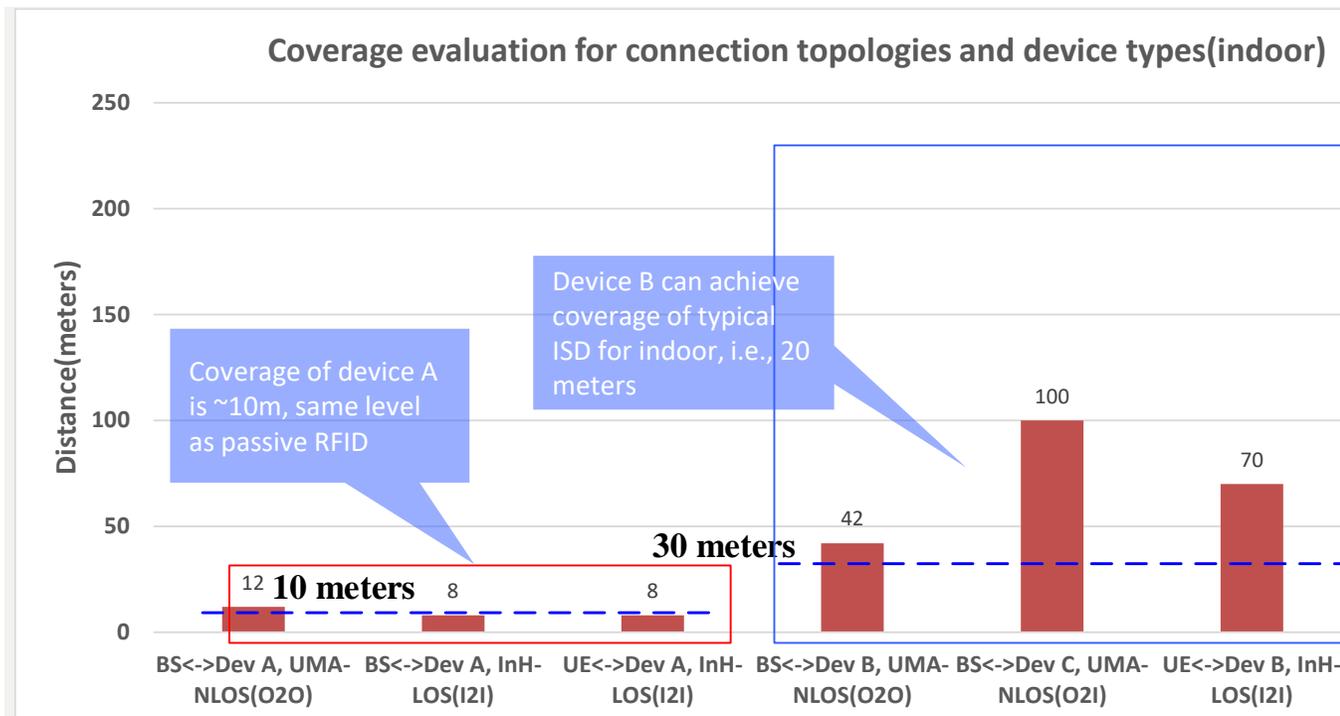
- Functionality for Sensor with DO-DTT traffic can be covered by that for inventory use cases, which also support data collection.
- Functionality for Sensor with DO-DOA traffic should be separately designed, similar to SDT/configured grant procedure in NR.
- For Positioning use case which only requires cell level positioning (appearance in coverage), can be covered by inventory use cases.
- For Positioning use case with high accuracy requirements, additional design in physical layer/higher layer is needed.
- Command use cases can be covered by inventory use cases, since it is generally based on the request.

\* Positioning related use cases with high accuracy requirements can be studied after basic signal/channel design for Ambient IoT is clear.

**Proposal:** Prioritize inventory and sensor use cases in Rel-19.

# Connection topologies

## - Coverage Analysis



### Observation:

- Coverage of device C > device B > device A
- Device A/B is typically used for indoor scenario according to coverage evaluation. Device C can be considered for outdoor scenario.
- Coverage for BS outdoor and device indoor (UMA-NLOS O2I) is less than typical ISD of urban (e.g.500meters).

**Proposal:** Intermediate node can be considered for coverage extension for deployment scenario: BS outdoor and device indoor.

- For to C use cases, UE can be used as intermediate node.
- For to B use cases, UE intermediate node can be used as complementary solution.

*\*Detailed assumptions please refer to RP-231810*

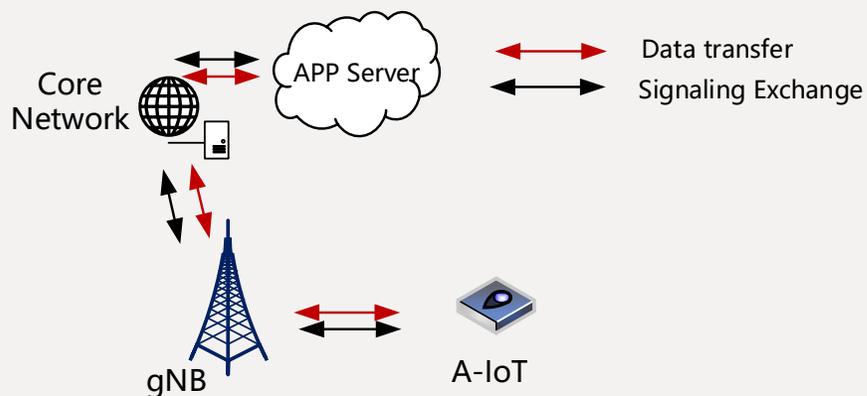
# Connection topologies

## Prioritization of the topologies

Topology (1)	Topology (2)	Topology (3)	Topology (4)
<ul style="list-style-type: none"> <li>- Full duplex self-interference suppression is required for BS&lt;-&gt;Device A/B</li> <li>- Higher requirements on BS/A-IoT Rx sensitivity</li> <li>- Lower latency</li> </ul>	<ul style="list-style-type: none"> <li>- Full duplex self interference suppression is required for intermediate node (BS/UE)&lt;-&gt;Device A/B</li> <li>- Coverage Extension compared with Topology 1</li> <li>- Suitable for 'to Personal' use cases if UE is used as intermediate node</li> </ul>	<ul style="list-style-type: none"> <li>- Full duplex BS is NOT required for Device A/B</li> <li>- Coverage Extension</li> <li>- Higher latency</li> <li>- only for Device A/B</li> </ul>	<ul style="list-style-type: none"> <li>- Full duplex is required for UE&lt;-&gt;Device A/B</li> <li>- Suitable for small coverage requirement</li> <li>- Suitable for Customer, to Personal use cases.</li> <li>- Can be considered as special case of topology 2</li> </ul>
<p><b>Proposal:</b></p> <ul style="list-style-type: none"> <li>- <i>Prioritize connection topology (1) and (2) in the study</i></li> <li>- <i>From AIoT device perspective, Unified L1 signal/channel design and higher layer protocol towards different reader types (UE or BS reader) is important</i></li> <li>- <i>Impacts to reader (BS or UE) Hardware shall be considered</i></li> </ul>			

# Protocol stack arch and functionalities

## Topology 1



- **Control Plane: ( see CP Arch)**

- A-IoT device Sublayers: A-IoT NAS, RRC, MAC, PHY. FFS A-IoT RLC.

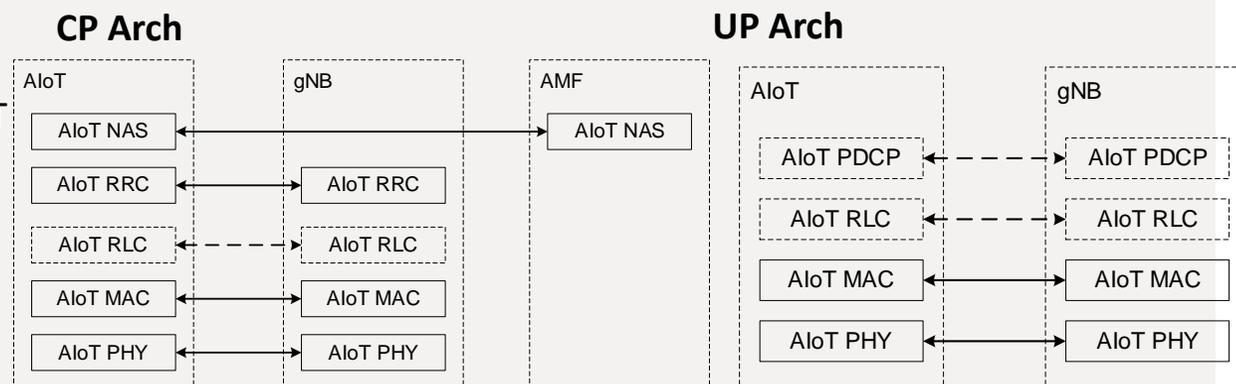
- **User Plane: (see UP Arch).**

- A-IoT device Sublayers: A-IoT MAC, PHY. FFS A-IoT PDCP, RLC.

- CP & UP Arch for example:

### General A-IoT procedures

- gNB configures resource for the A-IoT link gNB <-> A-IoT device
- gNB controls the A-IoT procedures, e.g. sends CMD, collects data.
- A-IoT data transfer to/from APP server via gNB and CN



**Proposal:** CP or UP protocol stack arch and functionalities should be considered for Topology 1.

# Protocol stack arch and functionalities

## Topology 2: UE as intermediate node

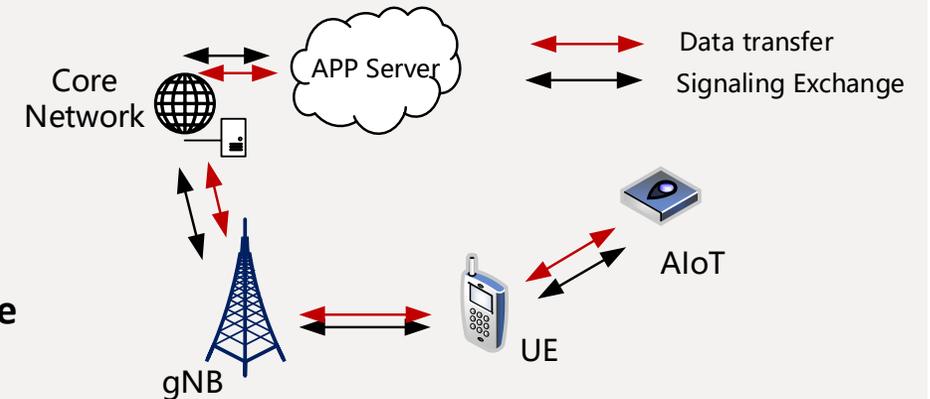
### General AIoT procedures (e.g. inventory)

#### – Option#1: AIoT procedure initiated by gNB

- gNB initiates the AIoT procedure and schedules resource for gNB <-> UE & UE <-> AIoT device links
- gNB send the inventory command to the UE reader which then forward to AIoT device
- UE collects data from AIoT device and forward to gNB

#### – Option2: AIoT procedure initiated by UE under gNB controlled resource

- gNB configures resource for the link UE <-> AIoT device
- UE initiates the inventory procedure between UE and AIoT device.
- UE collects the data from AIoT devices and send it to NW by reusing existing uu interface



# Consideration of Protocol stack arch

**Aim for a common AIoT protocol stack design for ambient IoT device towards different Reader type(BS, UE).**

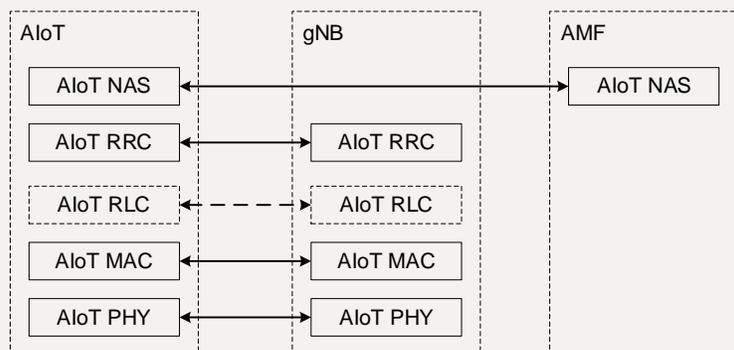
–Option 2 for Topology 2 with UE intermediate node is preferred

- Option#2 is more resource efficient and less complex:

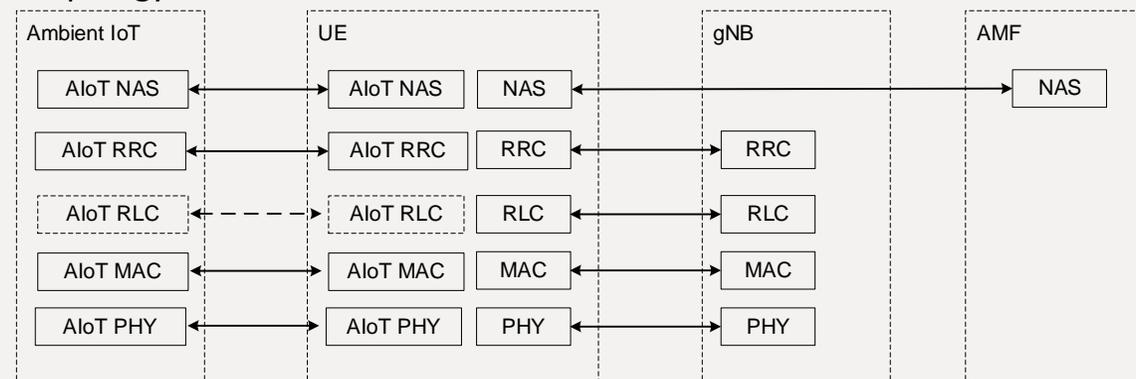
- AIoT (inventory) procedure happens between UE reader and AIoT devices
- gNB has the full control of resource used for inventory procedure between UE reader and AIoT devices
- Reuse existing uu interface to transfer the collected data from UE reader to gNB

– Following protocol architecture is given as an example, assuming CP based solution for data transfer

Topology 1 CP



Topology 2 CP



**Proposal:** Aim for a common AIoT protocol stack design for ambient IoT device towards different Reader type(BS, UE).

**Proposal:** For topology 2,

- Consider the solution with “UE reader initiating AIoT procedure under gNB controlled resource”
- Reuse UE<->gNB Uu interface to transfer collected data from UE reader to gNB

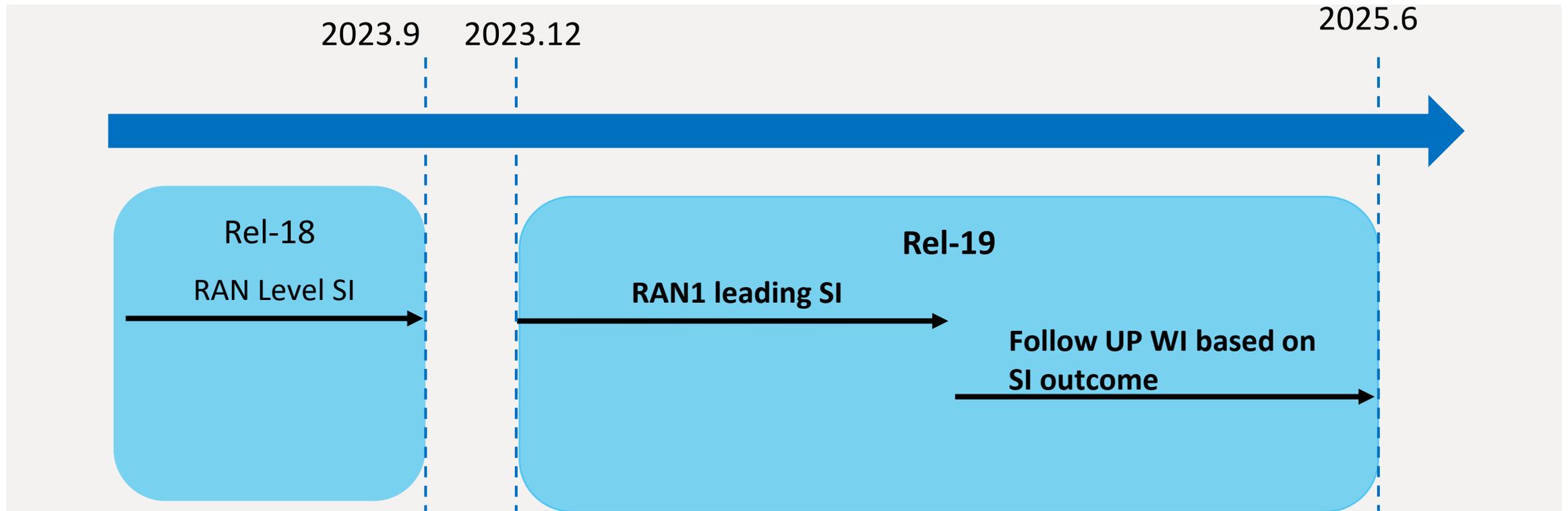
# Work load analysis



	Device C)	Device A/B	Observations
Signal Channel design for DL	YES	YES	Exploit outcome of LP-WUS SI/WI
<b>Signal Channel design for UL</b>			
Waveform/Modulation/Channel structure	OOK/BPSK	OOK based	FFS same or different for passive and active.
Line code	TBD	YES	Manchester/FM0/Miller typically used for OOK; may not need if BSPK/QPSK used for device C
FEC	TBD	TBD	Low complexity encoding scheme at AIoT devices, if introduced.
<b>Resource allocation</b>			
TBS Adapatation	YES	YES	Adaptative data rates, flexible resource allocation, HARQ retransmission, control signaling monitoring is commonly required. May be different for passive device and active device
Resource allocation	YES	YES	
HARQ/Retransmission	YES	YES	
DL control	YES	YES	
power control	YES	NA	Only for active
<b>initial access</b>			
LP-Reference signal for sync/measurements	YES	NA	Exploit outcome of LP-SS LP-WUS SI/WI
System info acquisition (MIB,SIB...)	YES	NA	Only for active
Paging	YES	Part of inventory function	Reuse legacy paging concept as baseline for active device. And may be revised as part of inventory function for passive devices.
RRM/Mobility	YES	NA	RRM only for active, passive devices may not be capable of measurements
PRACH & RACH procedure	YES	Part of inventory function	Reuse legacy RACH concept for active device. And may be revised as part of inventory function for passive devices.

***Proposal: Device A/B can be prioritized to reduce workload in Rel-19.***

# Potential Work item for Ambient IoT in Rel-19



**Proposal:** Consider SI+WI approach for Rel-19 Ambient IoT

- SI should include at least device A and device B, and at least topology 1 and topology 2(including UE as intermediate node);
- The device type(s) & topology(ies) which are mature by the end of SI can be specified in Rel-19.

THANK YOU.

谢谢。