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3GPP TSG RAN Meeting #101 RP-231792

Bangalore, India, September 11 - 15, 2023

Agenda Item: 8A.2.4

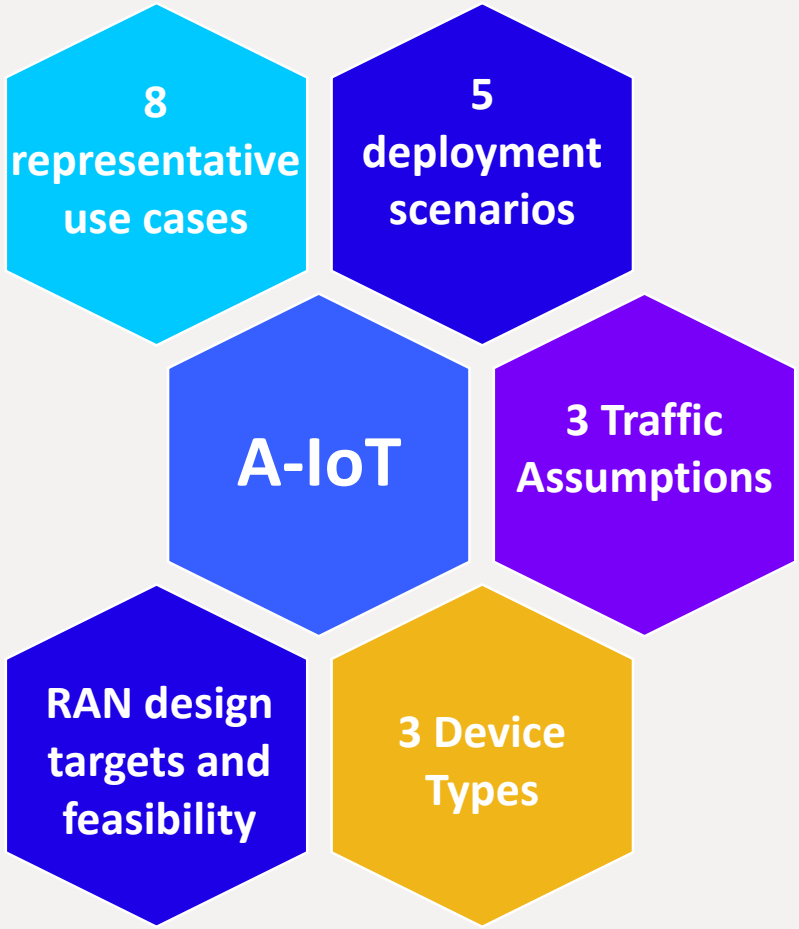
Source: vivo

Title: Rel-19 Ambient IoT (RAN1-led)

Document for: Discussion

RAN SI outcome (1)

Background



8 representative use cases:

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

5 deployment scenarios and their characteristics

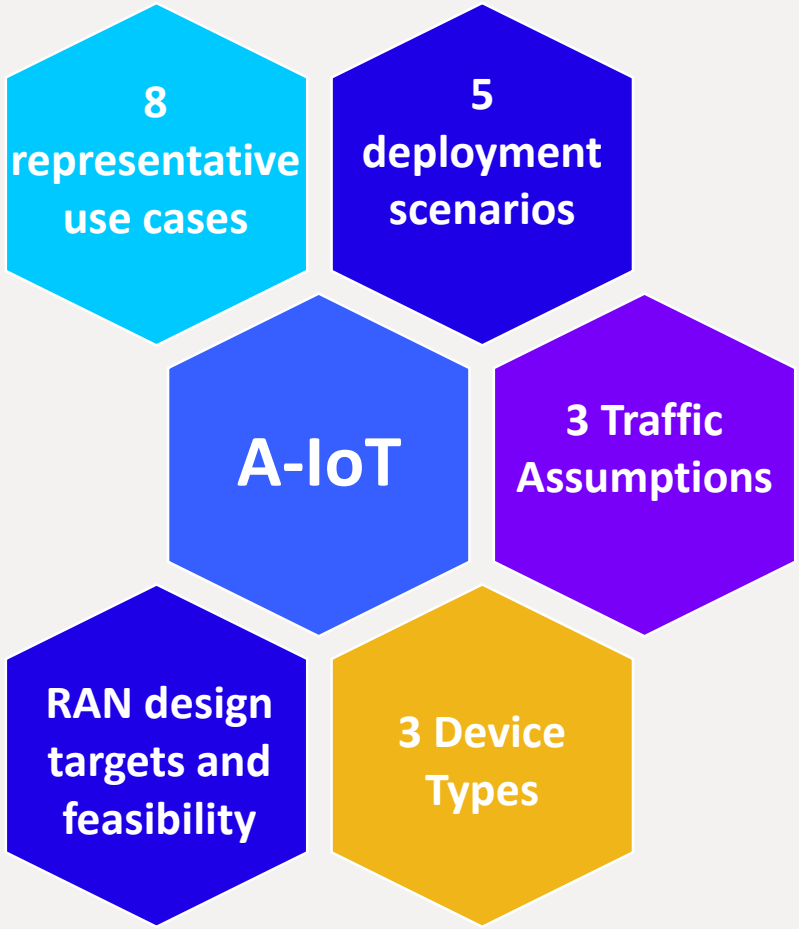
① Device indoor, Base station indoor;
② Device indoor, Base station outdoor;
③ Device indoor, UE as reader;
④ Device outdoor, Base station outdoor;
⑤ Device outdoor, UE as reader

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

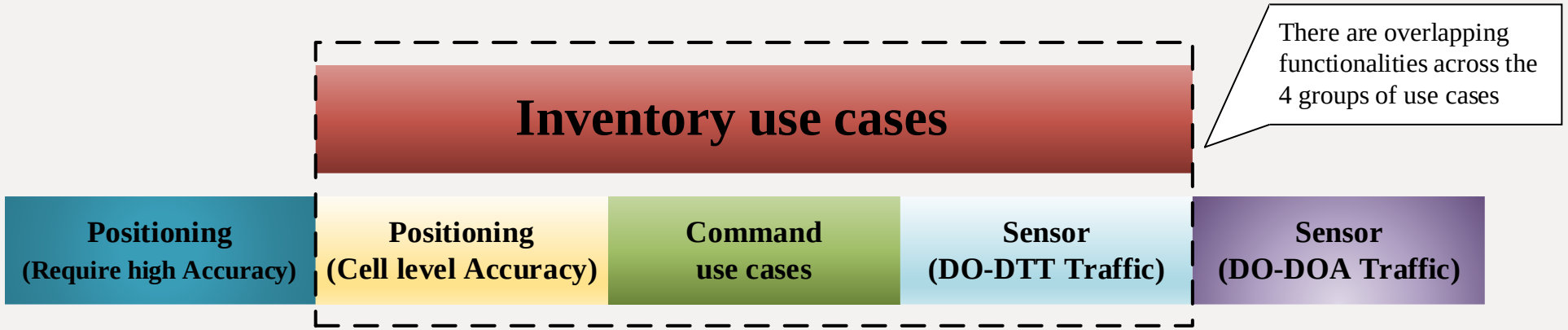
	Definition	Power	Complexity
Device A	Backscatter No energy storage	≤ [1 μW] or [10 μW]	Comparable to UHF RFID EPC C1G2
Device B	Backscatter [w/ Amplify] Energy storage	Between device A and device C	Between device A and device C
Device C	Active Transmission Energy storage	Up to 1 or 10 mW	Orders of magnitude lower than NB-IoT

RAN design targets and feasibility

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

- Required functionalities: To be concluded in RAN#101

Ambient IoT use cases



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

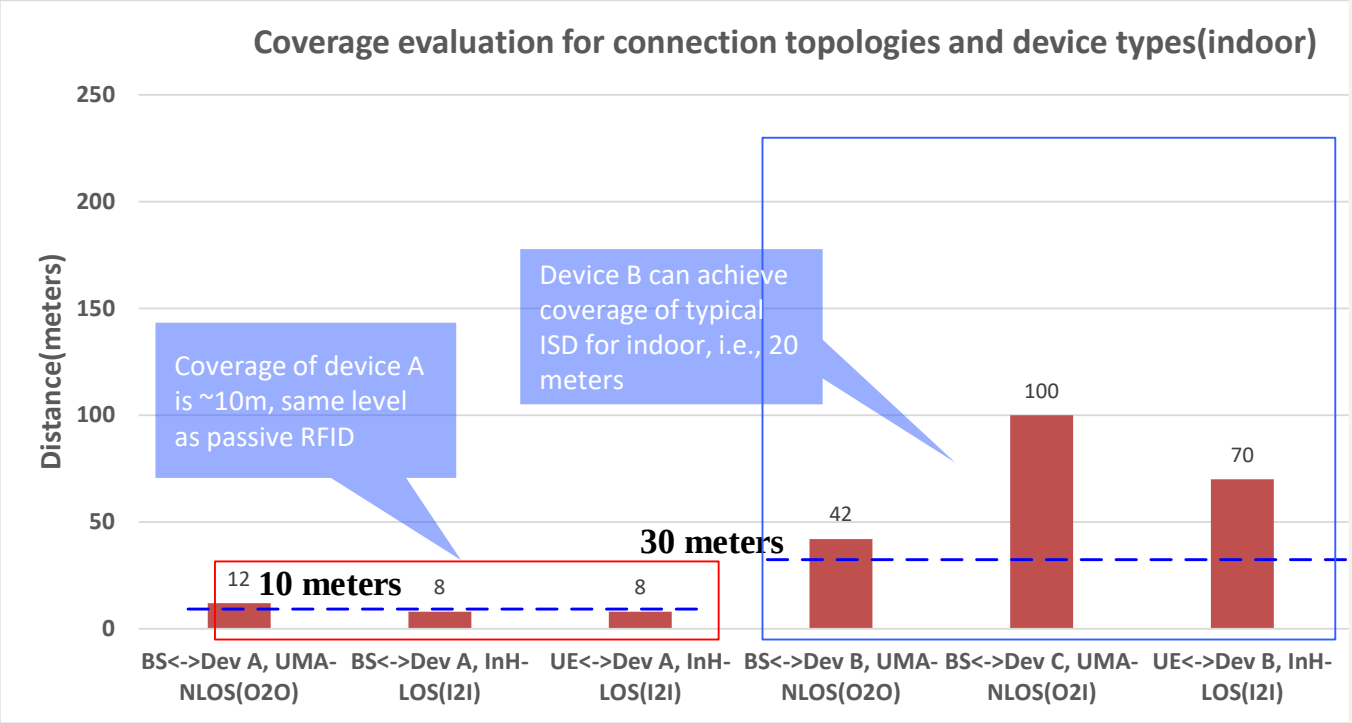
- Functionality for Sensor with DO-DTT traffic can be covered by that for inventory use cases, which also support data collection.
- Functionality for Sensor with DO-DOA traffic should be separately designed, similar to SDT/configured grant procedure in NR.
- For Positioning use case which only requires 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.

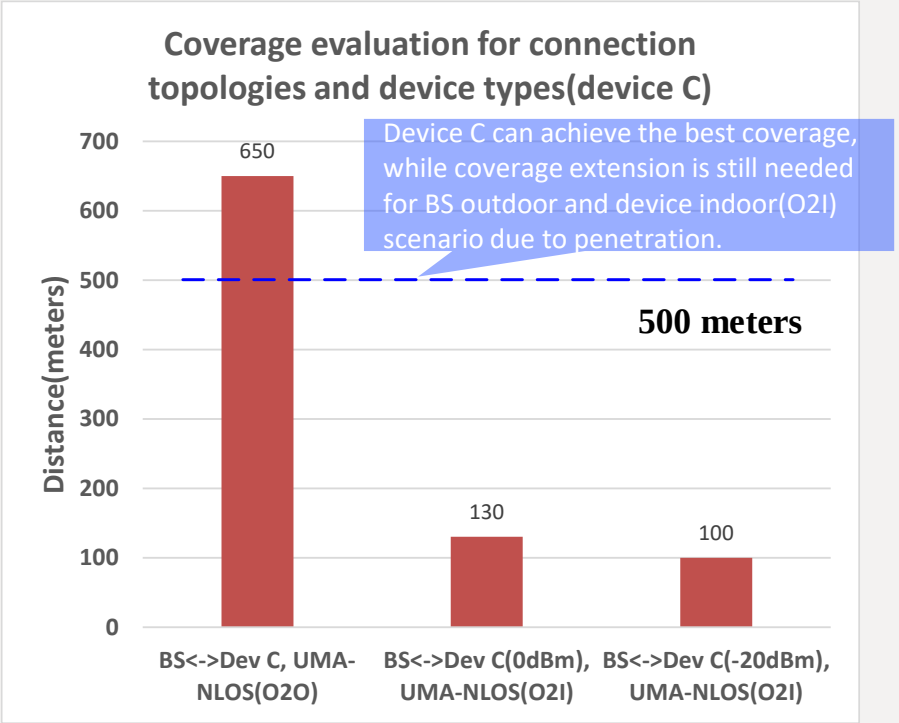
** Positioning related use cases with high accuracy requirements can be studied after basic signal/channel design for Ambient IoT is clear.*

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

Connection topologies(1)

- Coverage Analysis





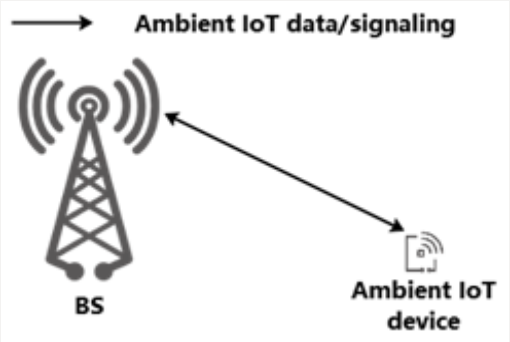
**Detailed assumptions please refer to RP-231810*

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.
- For Device C, coverage for BS outdoor and device indoor (UMA-NLOS O2I) is less than typical target ISD of urban (e.g.500meters) .
    - UE as intermediate node can be considered for coverage extension for deployment scenario: BS outdoor and device indoor.

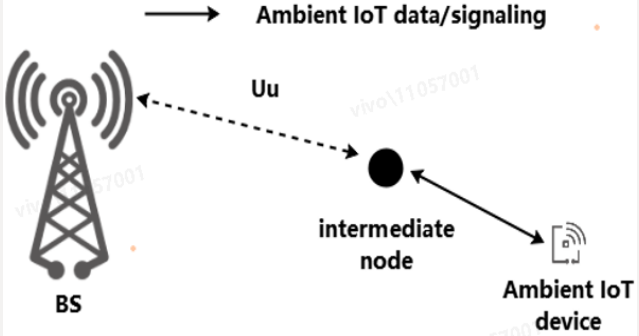
Connection topologies(2)

Topology (1)



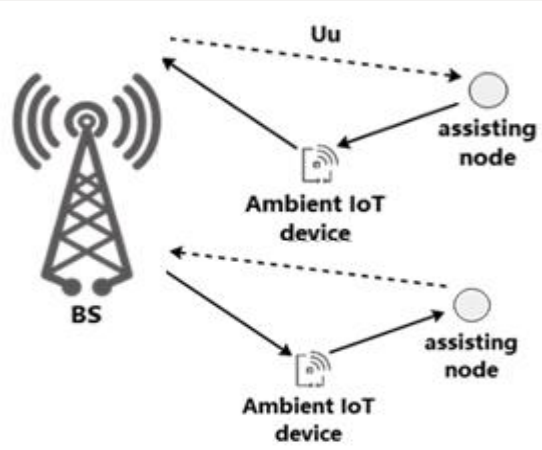
- Full duplex self-interference suppression is required for BS<->Device A/B
- Higher requirements on BS/A-IoT Rx sensitivity
- Lower latency

Topology (2)



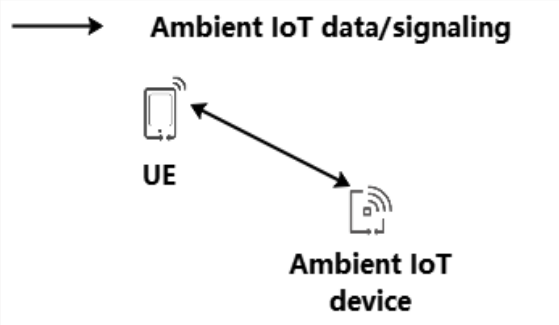
- Full duplex self interference suppression is required for inter-mediate node (BS/UE)<->Device A/B
- Coverage Extension compared with Topology 1
- Suitable for 'to Personal' use cases if UE is used as intermediate node

Topology (3)



- Full duplex BS is NOT required for Device A/B
- Coverage Extension
- Higher latency
- only for Device A/B

Topology (4)



- Full duplex is required for UE<->Device A/B
- Suitable for small coverage requirement
- Suitable for Customer, to Personal use cases.
- Can be considered as special case of topology 2

Proposal: *Further study on the four connection topologies in Rel-19 SI.*

- *Prioritize connection topology (1) and (2) in the study*
- *Unified L1 signal/channel design for BS and UE as reader cases is important to reduce implementation complexity of AIoT device*
- *Impacts to reader (BS or UE) Hardware shall be considered*

Key RAN Design Targets

- **Coverage/Data rate**
  - WG level evaluation on coverage is needed.
  - Coverage is evaluated for the prioritized topologies and 3 device types

- **Power consumption/Device complexity**
  - Further study the device Tx/Rx architecture and characteristics for each device type.

- **Identify candidate signal/channel design and procedures to achieve above design targets.**

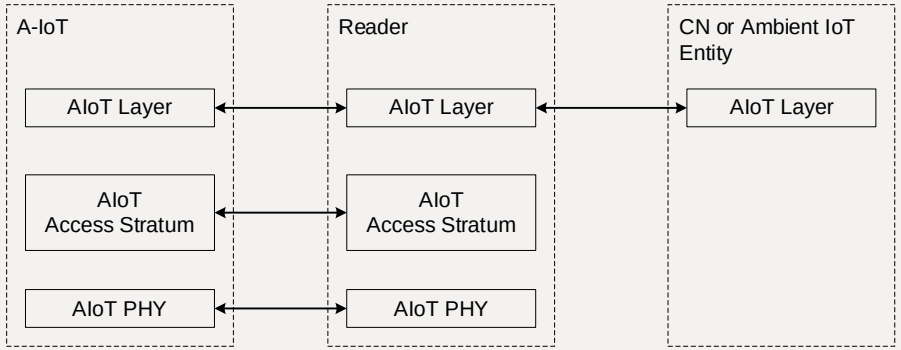
Proposal: *WG level evaluation on how to reach RAN design targets is needed in Rel-19 SI, including*

- *Candidate signal & channel design options*
- *Tx/RX architectures for AIoT devices*
- *Signaling and procedures*

Higher Layer impacts

Considerations for high layer design:

- Protocol stack architecture design for low power consumption, low complexity and low cost.
  - Access Stratum for Ambient IoT control plane and user data transmission.
  - AIoT Layer for NAS or A-IoT Service.
  - Cases with and without CN connection are considered



- Study high layer signaling procedure for the communication between A-IoT and Reader:
  - Different topology options
  - Different Ambient IoT device types and traffic types.
  - Efficient communication mechanism, e.g. minimize the interactions with the ambient IoT device.
  - Handling of device unavailability issue, intermittent operation due to energy harvesting

Proposal: *High layer study on simplified protocol stack and procedures is needed in Rel-19 SI.*

Work load analysis

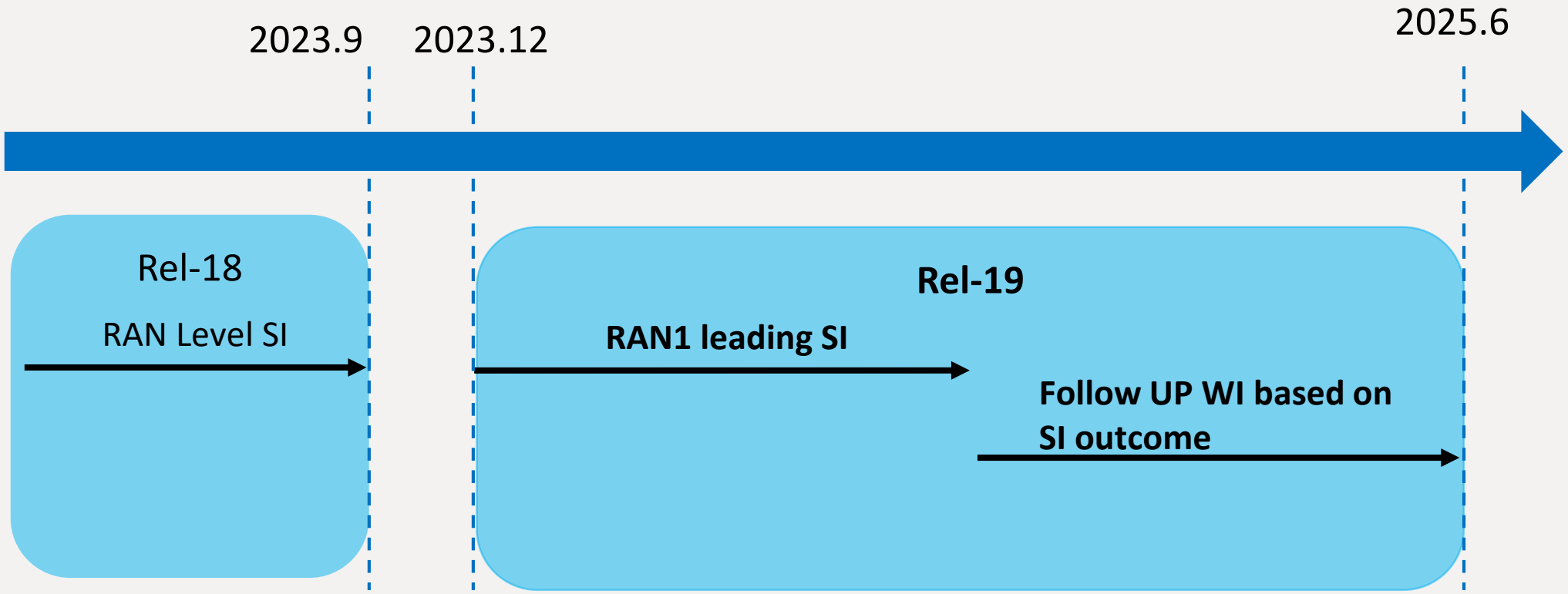
	Active (device C)	Passive (device A/B)	Observations
Signal Channel design for DL	YES	YES	Exploit outcome of LP-WUS SI/WI
Signal Channel design for UL			
Waveform/Modulation/Channel structure	OOK or BPSK	OOK based	FFS same or different for passive and active.
Line code	TBD	YES	Manchester/FM0/Miller is typically used for OOK; may not be needed if BSPK/QPSK is used for active device
FEC	TBD	TBD	Low complexity encoding scheme at AIoT devices, if introduced.
Resource allocation			
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
initial access			
LP-Reference signal for sync/meas	YES	NA	Exploit outcome of LP-SS LP-WUS SI/WI
System info acquisition (MIB,SIB...)	YES	NA	Only for active
Paging	YES	As 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	As part of inventory function	Reuse legacy RACH concept for active device. And may be revised as part of inventory function for passive devices.

Rel-19 SI scope

Objectives

- Prioritize inventory and sensor use cases
- Consider all three device types
  - Tx/Rx architectures and characteristics (frequency error, timing error, spurious emissions, etc) should be studied for AIoT devices
- Deployment scenarios
  - Prioritize TDD/FDD in licensed spectrum
  - Prioritize connection topology 1 and topology 2 (including UE as intermediate node)
  - Co-existence with existing system and UE
- WG level study of achieving RAN design KPIs， e.g., Power consumption, coverage, and etc.
  - Develop evaluation methodologies for the representative use cases and KPIs
  - Identify candidate physical signal/channel design options, physical layer procedures.
- Study High layer designs for different connection topologies, different use cases, different device types
  - Protocol stack architecture design for low power consumption, low complexity and low cost
  - High layer signaling procedure for the ambient IoT communication.

Potential Work item for Ambient IoT in Rel-19



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

- SI should include all 3 types, and at least topology 1 and topology 2(including UE as intermediate node);
- The device type(s) & topolog(ies) which are mature by the end of SI can be specified in the follow-up WI.

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THANK YOU.
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