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Agenda item: 9.1.1.4

RP-232960

Rel-19 Ambient IoT Work Scope

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Background

- TR 38.848 (v18.0.0) was agreed at RAN#101
- Summary of recommendations captured in TR 38.848 (v18.0.0):
  - RAN is recommended to down-select:
    - 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)
- This contribution provides our views regarding scoping down the above recommendations for in a RAN WG-level study/work item, targeting simple and commercially promising Ambient IoT use cases in Rel 19

Device Categorization: Overview from TR 38.848

Ambient IoT Device	Energy Storage	Signal Generation Capability Power Consumption
Device A	No	No capability – relying on backscattering, no independent signal generation/amplification
Device B	Yes	No capability – relying on backscattering, no independent signal generation, stored energy may be used to amplify reflected signals
Device C	Yes	Capable of generating RF signals

- Due to varying capabilities, Device A (and B) and Device C have quite different design targets, considerations and approaches:
  - It is easier for Device C to increase cost/power consumption for better coverage/range, data rate, latency, or other performance targets
  - Network access procedures and upper layer protocols: new/different (Device A/B) versus simplified/tailored (Device C)
- Other considerations:
  - Tap into a new market, which cannot be covered by existing 3GPP technologies (NB-IoT, etc.)
  - Reuse/upgrade of existing network cell sites/infrastructure if possible

Deployment Scenarios: Overview from TR 38.848

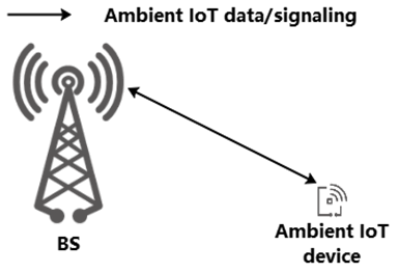
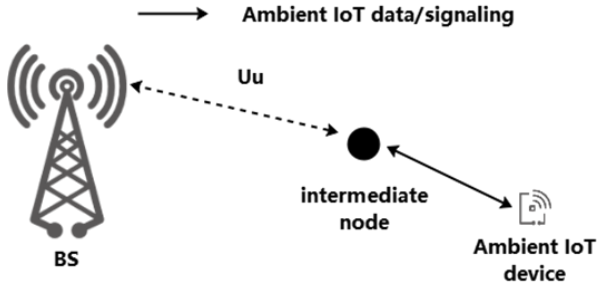
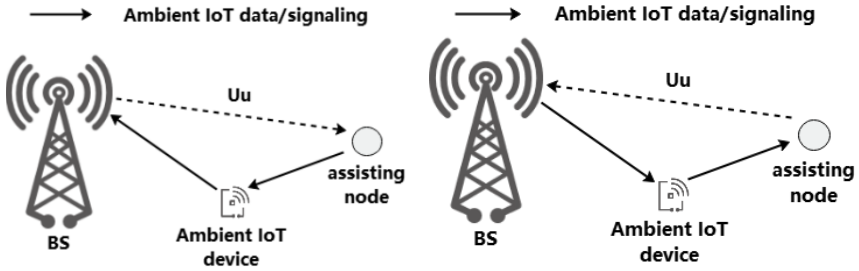
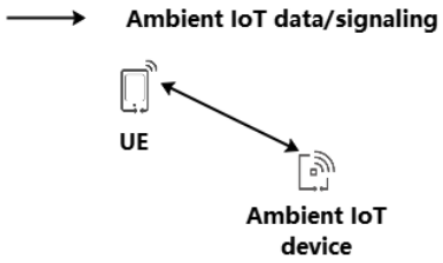
Deployment Scenario	Description
1	**Device indoors, base station indoors**
2	**Device indoors, base station outdoors**
3	Device indoors, UE-based reader
4	**Device outdoors, base station outdoors**
5	Device outdoors, UE-based reader

Deployment scenarios 1, 2 and 4 were recommended at RAN#101

Applicable representative use cases	Characteristics
Indoor/Outdoor inventory Indoor/Outdoor sensor Indoor/Outdoor positioning Indoor/Outdoor command	Environment
	Base station
	Connectivity topology
	Spectrum
	Coexistence with existing 3GPP technologies
	Traffic assumptions
	Device characteristic

- Observations:
  - Each deployment scenario is characterized by 7 parameters: environment, base station, etc.
  - Devices A, B and C are common to all deployment scenarios
  - Device-Terminated and Device-Originated traffic is common to all deployment scenarios
  - Licensed TDD and FDD, and unlicensed are common to all deployment scenarios
  - The basic connectivity topology (see next slide) is common to Deployment Scenarios 1, 2 and 4

Connectivity Topology: Observations

Connectivity Topology	Observation
Topology 1: **BS <-> Ambient IoT Device** 	• The most fundamental topology • This topology can be reused as a component for Topologies 2 and 4 • **Proposal**: Topology 1 is the **basic topology**
Topology 2: **BS <-> Intermediate node <-> Ambient IoT Device** 	• Intermediate node can be a relay, IAB, UE, repeater • A-IoT to intermediate node link can (largely) reuse Topology 1 • A-IoT device may see no difference with Topology 1 • **Proposal**: Consider to deprioritize Topology 2
Topology 3: **BS <-> Assisting node <-> Ambient IoT Device** 	• The A-IoT to BS communication is covered by Topology 1 • The A-IoT to assisting node may be similar to the A-IoT to BS link • Can be viewed as an extension of Topology 1 • **Proposal**: Deprioritize Topology 3
Topology 4: **UE <-> Ambient IoT Device** 	• BS is absent. Is it a special case of Topologies 2 and 3 when BS is absent and the intermediate node or assisting node corresponds to UE? W/o BS, how to establish link between A-IoT and UE? • A-IoT to UE link can (largely) reuse Topology 1 • At RAN#101, Topology 4 was not recommended

FR1 Licensed Spectrum (as recommended in RAN#101)

NR in-band spectrum	NR/LTE guard band	Stand alone
FR1 FDD and TDD bands are available; Operating frequencies ≤ 1 GHz are available for FDD bands	Limited spectrum available for a given FR1 FDD or TDD band: $G = \frac{BW_{channel} - N_{RB} \cdot 12 \cdot SCS - SCS}{2}$	Depending on standalone spectrum availability (e.g., refarmed GSM/LTE spectrum)
Transmit power is specified according to base-station classes (ranging from high to low transmit power levels) depending on macro-cell, micro-cell and pico-cell coverage	Guard-band filters may significantly attenuate RF signals; limited transmit power leading to small cell coverage Bandwidth in the guard band for low operating bands may not be sufficient	Transmit power is specified according to base-station classes (ranging from high to low transmit power levels) depending on macro-cell, micro-cell and pico-cell coverage
Suitable for indoor and outdoor deployment scenarios	Suitable for indoor deployment scenarios	Suitable for indoor and outdoor deployment scenarios
Interference is low	Susceptible to interference from adjacent bands	Interference is low

- A mixture of NR in-band spectrum, NR/LTE guard bands and standalone is possible
  - Strive for NR in-band and standalone spectrum due to Ambient IoT Device's limitation in coverage
  - Due to time constraints of Rel-19 schedule, may prioritize NR FR1 in-band spectrum and/or NR/LTE standalone to reduce RAN WG effort and workload, and guard-band spectrum can be incorporated, if needed, in later releases
- Proposal: Prioritize NR FR1 in-band spectrum and/or standalone

Upper Layers (RRC, RLC and MAC)

- RRC: legacy UE operates in 3 states, which are not suitable for Ambient IoT Devices due to their extremely low-power and low-complexity.
- PDCP: L2 functionalities such as encryption, security, etc. are too heavy for Ambient IoT Devices.
- RLC: small data does not need to be segmented; RLC retransmission cannot be supported due to lack of energy.
- MAC: many legacy MAC functions (e.g., LCH mapping, mux/demux, LCP, and BSR) are not needed if the Ambient IoT Device has just one radio bearer; HARQ retransmission may not be supported due to lack of energy.

Proposals for Rel-19 Ambient IoT Scope

- Ambient IoT RAN WG Study Item followed by Work Item in Rel-19
- Deployment scenarios and connectivity topologies:
  - Focus on Deployment scenario 1 with Topology 1
- Ambient IoT spectrum
  - Prioritize NR FR1 in-band spectrum and/or standalone
- Device A, B and C can be supported but should be operationally agnostic to NR RAN connectivity topologies
  - Focus on device types A and B in Rel-19
- Upper layers:
  - Little or no mobility, simplifying NAS and RRC messages and procedures, no PDCP, and simplifying MAC

Thank You.

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