Study on Ambient IoT

RP-233523
Agenda item: 9.1.1.4
3GPP TSG-RAN#102
Edinburgh, Scotland, December 11-15, 2023
Source: Kyocera Corporation

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Background (1/2)

- RAN-level study on Ambient IoT was completed in RAN#101.
- TR 38.848 captured extensive considerations and recommendations below.

7.2 Recommendations

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.

WG-level study on Ambient IoT is recommended in TR 38.848

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Background (2/2)

- Moderator's summary of Ambient IoT proposals for Rel-19 was provided in RAN#101 and it proposed the following discussion points [RP-232614].

1. *Discussion on SI vs. SI+WI for Rel-19 is expected at RAN#102*
2. *Potential prioritization for Rel-19 among the device types can be discussed at RAN#102*
3. *Based on the recommendation agreed in TR 38.848, RAN#102 is expected for further down-select among the following:*
   - *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*
4. *Based on the recommendation agreed in TR 38.848, FR1 licensed spectrum is recommended, and RAN#102 is expected to decide on selection or prioritization between FDD and FDD/TDD*
5. *RAN is also 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)*

Further discussions to form the SI objectives are needed in RAN#102

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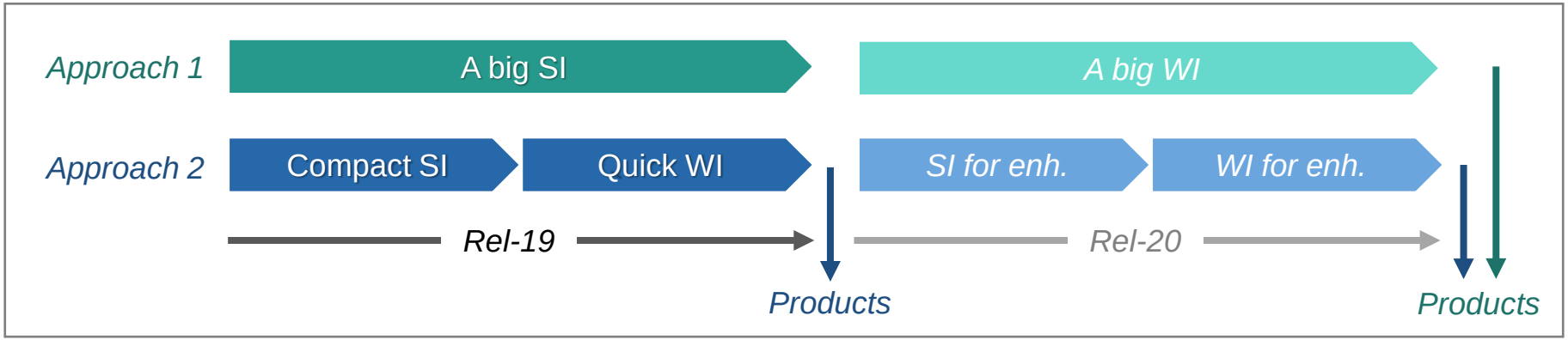
Discussion point 1: SI vs. SI+WI

- It's considered there are two approaches below:
  1. A big SI is only conducted in Rel-19, to cover all aspects that were captured in TR 38.848.
  2. A compact SI and a corresponding WI are both conducted in Rel-19, to minimize "time-to-market".



Observation

- Given TR 38.848, section 7.2, already recommended the down-scoping for the initial WG-level study, it's natural to take the "SI+WI" approach for Rel-19 Ambient IoT project.

Rel-19 Ambient IoT project should consist of "compact SI" and "corresponding WI", i.e., SI+WI

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Discussion point 2: Device types

- TR 38.848 captured the 3 device types:

> - *Device A: No energy storage, no independent signal generation/amplification, i.e. backscattering transmission.*
> - *Device B: Has energy storage, no independent signal generation, i.e. backscattering transmission. Use of stored energy can include amplification for reflected signals.*
> - *Device C: Has energy storage, has independent signal generation, i.e., active RF components for transmission.*

Observation

- As stated in TR 38.848, section 1, Ambient IoT is "*a new 3GPP IoT technology, on the basis of suitable deployment scenarios in a 3GPP system, which relies on ultra-low complexity devices with ultra-low power consumption for very-low end IoT applications.*" In addition, it's intended for the use cases that cannot be fulfilled by the existing 3GPP LPWA technologies, i.e., eMTC and NB-IoT.
- Therefore, Devices A & B, and the backscattering transmission are expected to be discussed in Rel-19.

Devices A and B are prioritized, and the backscattering transmission should be studied in Rel-19

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Discussion point 3: Deployment scenarios and Topologies (1/2)

- TR 38.848 captured the 5 deployment scenarios and the 4 topologies:

  - *Deployment scenario 1: Device indoors, basestation indoors*
  - *Deployment scenario 2: Device indoors, basestation outdoors*
  - *Deployment scenario 3: Device indoors, UE-based reader*
  - *Deployment scenario 4: Device outdoors, basestation outdoors*
  - *Deployment scenario 5: Device outdoors, UE-based reader*

  - *Topology 1: BS ↔ Ambient IoT device*
  - *Topology 2: BS ↔ intermediate node ↔ Ambient IoT device*
  - *Topology 3: BS ↔ assisting node ↔ Ambient IoT device ↔ BS*
  - *Topology 4: UE ↔ Ambient IoT device*

- TR 38.848 finally recommended to down-select starting from the 5 combinations:

  - *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*

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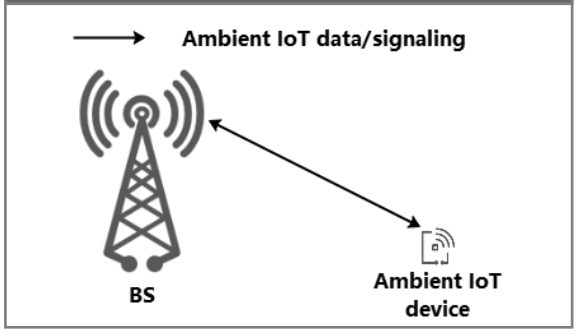
Discussion point 3: Deployment scenarios and Topologies (2/2)

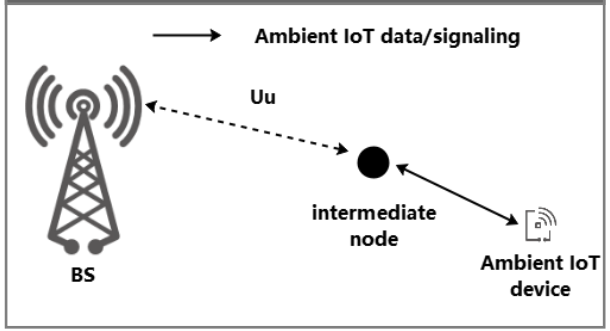
Observation

- Considering Devices A & B are more suitable to be located in indoor, and Deployment scenario 3 was already excluded from the recommendation, Deployment scenarios 1 & 2 are the targets of Rel-19 study.
- Furthermore, the common framework is preferable regardless of Deployment scenarios and Topologies:
  - Common waveform design is desirable [RAN1]
  - Common signalling design over Uu is desirable [RAN2]
  - Protocol stack for CW Tx and backscattering Rx is needed [RAN1/RAN2]

Topology 1
BS ↔ Ambient IoT device



Topology 2
BS ↔ intermediate node ↔ Ambient IoT device



Deployment scenarios 1 & 2 with Topology 1 and Deployment scenario 2 with Topology 2 should be studied

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Discussion point 4: FDD vs. FDD/TDD

- TR 38.848 recommended FR1 licensed spectrum while it's noted that possible selection/prioritization between FDD and FDD/TDD.

> - *FR1 licensed spectrum is recommended*
> - *Note: selection or prioritization between FDD and FDD/TDD is to be decided*

Observation

- If the indoor deployment scenarios are prioritized, and given FR1 is assumed as the recommendation, it's natural to consider both FDD and TDD spectrums.
  - Especially for indoor scenarios, it's beneficial to cover the upper bands in FR1, such as 3.5GHz, 4.5GHz, etc., for Ambient IoT deployments.

FR1 licensed spectrum is assumed, and both FDD and TDD spectrums should be supported in Rel-19.

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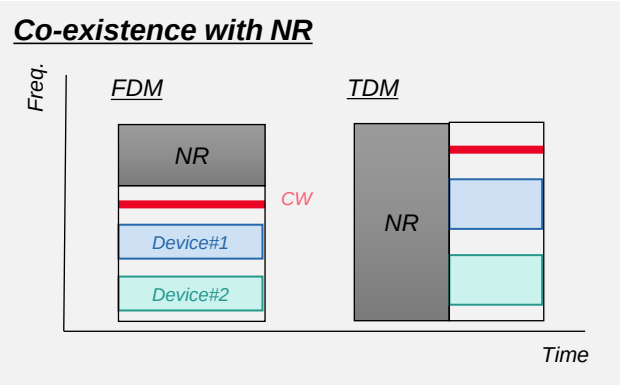
Discussion point 5: in-band, in guard-band and/or standalone

- TR 38.848 recommended down-selection among coexistence options.

> - *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)*

Observation

- Considering the current licensed spectrums in FR1 are fully used for NR operation, the co-existence with NR should be the baseline, i.e., “in-band to NR”.
  - “Standalone band” operations has no problem.



In-band Ambient-IoT operation within NR spectrums should be studied

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Potential objectives

- Study the waveform design [RAN1]
  - Topology 1 are prioritized.
  - Backscattering transmission from Devices A and B is focused.
  - Common waveform for all topologies and all devices is baseline.
  - Resource efficiency and multiple access are considered.
  - Co-existence with NR is considered.

- Study protocol stack and signalling design [RAN2]
  - Topology 2 are prioritized.
  - For Uu, NR protocol stack is reused: CP-based, UP-based and/or hybrid architectures can be studied.
  - Common protocol stack for all traffic assumptions, for all device types and for Topologies 2 is baseline.
  - Signalling for Device-terminated (DT) and Device-originated (DO) is supported.
  - Impacts to mobility of intermediate node (including Ambient IoT device) is studied.

- If needed, study network interface updates [RAN3]
  - If needed, interaction with core network (AMF) is considered.

WG-level study on Ambient IoT should be approved as Rel-19 package

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