3GPP TSG RAN Meeting#101
Bengaluru, India, September 11 - 15, 2023

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# Apple Views on Ambient IoT for Rel-19

Apple


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# Overall Justification | Ambient IoT

- New category of use-cases: There is a wide variety of use-cases including inventory/logistic management, indoor/outdoor sensors with positioning/ranging, etc. for which the current NR devices such as NB-IoT may not  fulfill all the requirements
- Ultra-low power/complexity devices: In addition to supporting the required functionalities for the different use-cases, key requirements for ultra-low power devices without the need of a power source may not be possible with existing LPWA devices
- RF energy harvesting: RF-based ambient energy harvesting can potentially be a promising technology to make big stride towards green communication

# Overview of Rel-18 RAN Study | Ambient IoT

- In RAN study item for ambient IoT in Rel-18, following key aspects are being considered:

## Ambient IoT

### Use-Cases

- rUC1: Indoor Inventory
- rUC2: Indoor Sensor
- rUC3: Indoor Positioning
- rUC4: Indoor Command
- rUC5: Outdoor Inventory
- rUC6: Outdoor Sensor
- rUC7: Outdoor Positioning
- rUC8: Outdoor Command

### Deployment Scenarios

- D1: Device Indoor, BS Indoor
- D2: Device Indoor, BS Outdoor
- D3: Device Indoor, UE Reader Indoor
- D4: Device Outdoor, BS Outdoor
- D5: Device Outdoor, UE Reader Outdoor

### Connectivity Topologies

- T1: BS <-> Ambient IoT Device
- T2: BS <-> Intermediate Node <-> Ambient IoT Device
- T3-1: BS -> Assisting Node -> Ambient IoT Device -> BS
- T3-2: BS -> Ambient IoT Device -> Assisting Node -> BS
- T4: UE <-> Ambient IoT Device

### Device Categorization

- Device Type A (No energy storage & no DO traffic)
- Device Type B (Energy storage, but no DO traffic)
- Device Type C (Energy storage & DO traffic)

### Design Targets

- User-Experienced Data Rate
- Coverage/Range
- Connection/Device Density
- Power Consumption
- Device Complexity
- Positioning Accuracy

# Overview of Rel-19 WS (RAN#100) | Ambient IoT

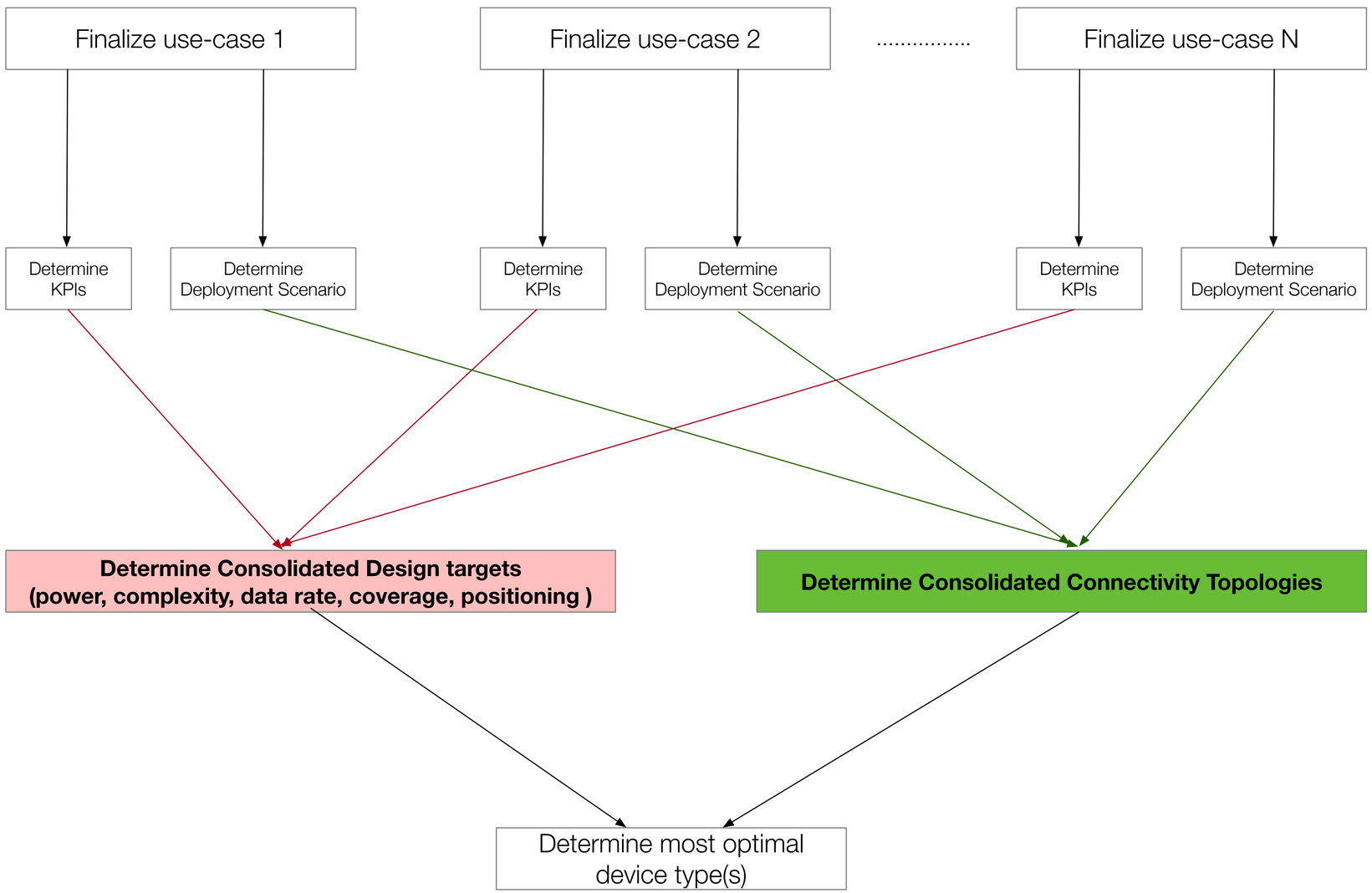
- Around 35 companies submitted contributions to Rel-19 workshop that discussed ambient IoT for a potential new study/work item in Rel-19
- Overall, companies provided their views based on the structure of discussion being currently adopted in Rel-18 RAN level study and following observations can be made based on their inputs:
  - **Observation 1**: For use-cases, majority of companies are interested to focus on three use-cases including inventory/logistics, sensors and positioning/ranging
  - **Observation 2**: For deployment scenarios, majority of companies are interested to focus on two main scenarios including D1 with device indoor, BS indoor and D4 with device outdoor, BS outdoor
  - **Observation 3**: For connectivity topologies, majority of companies are interested to focus on T1 with BS <-> ambient IoT device connectivity
  - **Observation 4**: For device categorization, there is almost an equal split among companies between the two options
    - Option 1: Focus on both device type A and device type B
    - Option 2: Focus on device type C
  - **Observation 5**: For design targets, majority of the companies want to focus on coverage/range. In addition, there is also reasonable consideration towards power consumption, positioning/ranging accuracy

# Study Considerations (1/4) | Ambient IoT

- Prioritization considerations: Based on the initial contributions/discussions during the Rel-19 WS, it is clear that prioritization in terms of all aspects is necessary to define the scope of a potential study/work item on ambient IoT in Rel-19
  - Use-cases prioritization: Prioritization from the wide set of use-cases from SA and RAN should be considered
  - Deployment Scenarios: Depending on prioritization of user-cases, only a sub-set of deployment scenarios may need to be considered
  - Topology prioritization: For more focused study and based on use-cases prioritization, 3GPP shall consider only the most essential topologies in Rel-19
  - Device type prioritization: If possible, based on use-case prioritization and required KPIs, study may focus on only a subset of device types
- Timeline considerations
  - 3GPP needs to consider one of the two alternatives for Rel-19 item on ambient IoT
    - Alt. 1: Only study item in Rel-19
    - Alt. 2: Study phase followed by normative work in Rel-19

# Study Considerations (2/4) | Ambient IoT

- From our perspective, in order to do any prioritization, there needs to be a coherency across different aspects that are being considered:
  - Down-selection/prioritization under each aspect should have a linkage to other aspect and should not be independent based simply on companies' preferences
  - Following linkage/ dependency could be used to determine focused scope for Rel-19 WG-level study



# Study Considerations (3/4) | Ambient IoT

- As a starting point for defining the scope, prioritization of use-cases is necessary
  - Among these three use-cases, positioning could be considered as a more advanced category of use-case and could be considered in future as it would require specific study/enhancements related to positioning framework
  - Therefore, it is reasonable to consider only logistics/inventory and sensor use-cases in Rel-19
- Considering logistics/inventory and sensor as two potential use-cases, following related assessment could be reasonable:
  - Coverage: For both the use-cases, indoor and outdoor coverage has been discussed. Based on the KPIs considered in SA study, following coverage requirement can be considered:
    - 30m (indoor) and 200m (outdoor)
  - Deployment scenarios: From deployment scenario perspective, it is quite evident that at least deployment scenario D1 and D4 should be considered for both outdoor and indoor coverage. In addition, for the case when device is indoor and there is no BS indoor, then it is reasonable to also consider D3, i.e. UE reader is indoor:
    - Device indoor, BS indoor; device outdoor, BS outdoor and device indoor, UE reader indoor

# Study Considerations (4/4) | Ambient IoT

- ….(Contd.)
  - Connectivity topologies: Considering above three deployment scenarios, we can consider only following topologies:
    - BS <-> Ambient IoT device and UE <-> Ambient IoT device
  - Device categories: Prioritization for device categorization is essential to have a focused study in Rel-19. Since each category of device would require quite a significant impact to all the protocol layers and framework, therefore, we should consider limiting to one of the following two options
    - Option 1: Device type A and B
      - Main benefit of these device types is low complexity and very low power consumption
      - With type A, only limited coverage can be envisioned due to no amplification and with type B, coverage can be relatively larger because of possible amplification due to energy storage
      - However, device originated traffic cannot be supported
        - In our view, although for inventory/logistics management, it is reasonable to assume that DO traffic is not needed, but if sensor use-case is to be supported, DO traffic might be needed
      - Therefore, considering the use-cases of inventory/logistics and sensors, device type A and B may not be sufficient
    - Option 2: Device type C only
      - Main benefit of these device types is possibility to support DO traffic and much higher coverage
      - Considering the use-cases of inventory/logistics and sensors, device type C should be reasonable for Rel-19 study

# Views on Potential Objectives | Ambient IoT

- Based on our assessment, we can consider following for a Rel-19 study item on ambient IoT:
  - Focus/prioritize following aspects:
    - Use-cases: inventory/logistics and sensors
    - Deployment scenarios: Indoor ambient IoT device with indoor BS, indoor ambient IoT device with indoor UE reader, outdoor ambient IoT device with outdoor BS
    - Connectivity topologies: BS <-> Ambient IoT device and UE <-> Ambient IoT device
    - Device categorization: Device type C (energy storage) with both device originated & device terminated traffic
  - Based on above focus/prioritization, study following enhancements:
    - **Objective 1**: RF-based energy harvesting signal/channel design including
      - Identify Waveform enhancements (if any)
      - Feasibility of existing channels/signals for energy harvesting
      - Multiplexing of energy harvesting signals/channels within legacy framework
      - Impact on frame/slot structure (if any)
    - **Objective 2**: Study and identify (if any) the PHY enhancements including initial access and synchronization, channel coding, signaling framework, physical channels design
    - **Objective 3**: Study and identify (if any) the impact on higher layer protocol design and signaling framework

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