3GPP TSG RAN Meeting #101
Bangalore, India, September 11 – 15, 2023
Agenda item: 8A.2.4

RP-231602

Discussion of R19 Work on Ambient IoT

Futurewei Technologies, Inc.

FUTUREWEI Technologies

Introduction

- RAN Plenary study item includes:
  - Grouping of representative use cases
  - Device categorization
  - Deployment scenarios and connectivity topologies
  - Formulation of sets of RAN design targets
- TR 38.848 (v0.2.0) was agreed at RAN#100
- The scope covered in the RAN Plenary study is very broad
- This contribution aims at scoping down to a subset of key topics to be addressed 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 generation 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 (see Slide 7 for more details)
  - Network access procedures and upper layer protocols: new/different (A/B) versus simplified/tailored (C)
- Other considerations:
  - Tap in a new market, which cannot be covered by existing specs (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

Applicable representative use cases	Characteristics
Indoor inventory Indoor sensor Indoor positioning Indoor 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, connectivity topology, spectrum, coexistence with existing 3GPP technologies, traffic assumptions, and device category
  - 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**: 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 • **Proposal**: Deprioritize Topology 4

Spectrum

- From TR 38.848, the possible spectrum options for Ambient IoT deployment scenarios include:
  - Licensed FDD
  - Licensed TDD
  - Unlicensed frequency bands

Licensed spectrum	**Unlicensed spectrum**
FR1, and FR2-1/FR2-2 frequency bands are available; For each band, FDD and/or TDD modes are defined	Limited spectrum available; typically, UHF frequency bands ranging from 858 MHz – 930 MHz
Transmit power depends on base-station classes (ranging from high to low transmit power levels) leading to macro-cell, micro-cell and pico-cell coverage	Limited transmit power leading to small cell coverage
Interference is controlled and managed by cellular networks	Interference caused by other wireless technologies can be a major problem

RAN Design Targets

Parameter	Target	Comment
Device power consumption	Device A: ≤ 1 μW Device A ≤ Device B < Device C Device C: ≤ 1 mW	Based on device categories in TR 38.848.
Device complexity	Device A < Device B < Device C	From TR 38.848
Coverage	TBD	It is an open issue in the RAN Plenary study. Coverage should be expressed in terms of communication range depending on device categories (A, B or C) and the connectivity topology. Observations: Communication range is viewed as a main design parameter, which will affect the air interface of A-IoT; WG will determine the communication range.
User experienced data rates	> 5 kb/s (maximum) > 0.1 kb/s (minimum)	From TR 38.848
Maximum message size	TBD	It is an open issue in the RAN Plenary study. Message size is upper bounded by the data rate and latency parameters.
Latency	TBD	End-to-end latency, depending on data rates, device categories and communication range.
Positioning accuracy	TBD	Depending on BS density, device categories, positioning technologies, this parameter is not viewed as a main design parameter.
Connection/device density	1.5 devices/m^2	Based on majority of use cases studied in SA1
Moving speed of device	≤ 10 km/h	Based on majority of use cases studied in SA1 and mobility support is provided by upper layers.

Upper Layers (RRC, RLC and MAC)

- RRC: legacy UE operates in 3 states, which are not suitable for A-IoT devices due to their extremely low-power and low-complexity.
- PDCP: 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 A-IoT UE has just one radio bearer; HARQ retransmission may not be supported due to lack of energy.

Proposals for Rel-19 Ambient IoT Study-Item Scope (1/2)

A minimum baseline for Rel-19

- Ambient IoT device categories
  - Decide between Device type A (and B) versus Device C
  - Focusing on either backscattering or active RF signal generation, but not on both
- Connectivity topologies for Ambient IoT
  - Focusing on Topology 1 (BS ↔ Ambient IoT device) with licensed (or dedicated) spectrum
- Ambient IoT deployment scenarios
  - Focusing on Deployment Scenarios 1, 2 and 4
  - For Deployment Scenarios 3 and 5, largely reuse the basic topology (Topology 1) design for Topology 4
- Ambient IoT spectrum
  - Focusing on licensed FR1 FDD bands (e.g., low frequency bands can be given high priority)
- RAN design targets for Ambient IoT
  - Focusing on coverage (of system) and range (of link), user experience data rates, connection/device density: RAN design targets with good tradeoff between performance, device complexity/power-consumption, and standardization efforts

Proposals for Rel-19 Ambient IoT Study-Item Scope (2/2)

A minimum baseline for Rel-19

- Ambient IoT upper layers focusing on
  - Mobility support may be limited to nomadic cases for Rel-19.
  - No DRBs (and hence no SDAP)
  - Simplifying NAS and RRC messages and procedures
    - Reducing RRC functionalities
  - No PDCP (hence no Layer-2 security) and null RLC (e.g., TM)
  - Simplifying MAC functions
    - Reusing MO-SDT and MT-SDT procedures is one potential option, but other options are not precluded

Thank You.

Copyright © 2019 Futurewei Technologies, Inc.
All Rights Reserved.

The information in this document may contain predictive statements including, without limitation, statements regarding the future financial and operating results, future product portfolio, new technology, etc. There are a number of factors that could cause actual results and developments to differ materially from those expressed or implied in the predictive statements. Therefore, such information is provided for reference purpose only and constitutes neither an offer nor an acceptance. Futurewei may change the information at any time without notice.

FUTUREWEI
Technologies