**3GPP TSG-RAN WG2 Meeting #128 \_R2-2411221**

**Orlando, USA, 18th – 22nd November, 2024 *Revision of* R2-2409812**

**Agenda Item: 8.2.1**

**Source: Huawei, CMCC, T-Mobile USA**

**Title: TP for TR 38.769 update**

**Document for: Endorsement**

# 1 Introduction

This contribution provides the text proposal on the update of TR 38.769. The new changes done by [POST128][015][AIoT] are marked by “Rapp\_Post”.

# 2 Text Proposal for TR 38.769 V1.1.0 (2024-10)

Start of Change

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 38.848: "Study on Ambient IoT (Internet of Things) in RAN".

[R1-1] RP-240826: "Revised SID: Study on solutions for Ambient IoT (Internet of Things) in NR".

[R1-2] 3GPP TR 38.869: "Study on low-power Wake-up Signal and Receiver for NR".

[R1-3] 3GPP TS 38.212: "NR; Multiplexing and channel coding".

[R1-4] EPC Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz.

9.4.1.1 References

[R1-9411-1] R1-2407608, "Discussion on evaluation assumptions and results for Ambient IoT devices", FUTUREWEI, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-2] R1-2407636, "Evaluation assumptions and results for Ambient IoT", Ericsson, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-3] R1-2407643, "Evaluation assumptions and results for Ambient IoT", Nokia, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-4] R1-2407667, "Evaluation methodology and assumptions for Ambient IoT", Huawei, HiSilicon, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-5] R1-2407705, "Discussion on evaluation assumptions and results for Ambient IoT", Spreadtrum Communications, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-6] R1-2407760, "Discussion on Link Level simulation of A-IoT", Tejas Network Limited, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-7] R1-2407860, "Evaluation methodologies assumptions and results for Ambient IoT", vivo, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-8] R1-2407968, "Evaluation assumptions and results for Ambient IoT", Xiaomi, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-9] R1-2408046, "The evaluation methodology and preliminary results of Ambient IoT", CATT, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-10] R1-2408065, "Discussion on Ambient IoT evaluations", ZTE Corporation, Sanechips, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-11] R1-2408145, "Discussion on evaluation assumptions and results for A-IoT", OPPO, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-12] R1-2408233, "Discussion on evaluation assumptions and results for Ambient IoT", HONOR, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-13] R1-2408355, "Analysis for Inventory Completion Time for Multiple A-IoT Devices", Wiliot Ltd., RAN1#118bis, Hefei, China, October 2024.

[R1-9411-14] R1-2408374, "Discussion on ambient IoT evaluation framework", NEC, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-15] R1-2408464, "On remaining evaluation assumptions and results for AIoT", Apple, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-16] R1-2408598, "Link level simulation for Ambient IoT R2D", Panasonic, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-17] R1-2408670, "Discussion on Ambient IoT evaluation", LG Electronics, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-18] R1-2408699, "Evaluation assumptions and results for A-IoT", MediaTek Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9411-19] R1-2408731, "Evaluation results for Ambient IoT", InterDigital, Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9411-20] R1-2408785, "Study on evaluation assumptions and results for Ambient IoT", NTT DOCOMO, INC., RAN1#118bis, Hefei, China, October 2024.

[R1-9411-21] R1-2408849, "Evaluation Assumptions and Results", Qualcomm Incorporated, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-22] R1-2408930, "Discussion on Evaluation assumptions and results", CEWiT, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-23] R1-2408938, "Evaluation assumption and results for AIoT", IIT Kanpur, Indian Institute of Tech (M), RAN1#118bis, Hefei, China, October 2024.

[R1-9411-24] R1-2408966, "Discussion on the evaluation assumptions for Ambient IoT devices", Lenovo, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-25] R1-2408987, "Ambient IoT evaluations", Sony, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-26] R1-2409006, "Discussion on evaluation assumptions and results for Ambient IoT", CMCC, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-27] R1-2409022, "Discussion on evaluation assumptions and results for Ambient IoT", China Telecom, RAN1#118bis, Hefei, China, October 2024.

[R1-9411-28] R1-2409027, "Considerations for evaluation assumptions and results", Samsung, RAN1#118bis, Hefei, China, October 2024.

9.4.1.2 References

9.4.2.1 References

[R1-9421-1] R1-2407610, "Discussion on physical layer design for Rel-19 Ambient IoT devices", FUTUREWEI, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-2] R1-2407628, "Discussion on general aspects of physical layer design for Ambient IoT", TCL, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-3] R1-2407638, "General aspects of physical layer design for Ambient IoT", Ericsson, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-4] R1-2407645, "General aspects of physical layer design for Ambient IoT", Nokia, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-5] R1-2407669, "On general aspects of physical layer design for Ambient IoT", Huawei, HiSilicon, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-6] R1-2407707, "Discussion on general aspects of physical layer design for Ambient IoT", Spreadtrum Communications, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-7] R1-2407734, "Discussion on general aspects of physical layer design for Ambient IoT", China Telecom, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-8] R1-2407862, "Discussion on General Aspects of Physical Layer Design", vivo, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-9] R1-2407906, "Discussion on general aspects of A-IoT physical layer design", CMCC, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-10] R1-2407970, "Discussion on physical layer design of Ambient IoT", Xiaomi, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-11] R1-2408048, "Discussion on general aspects of physical layer design", CATT, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-12] R1-2408147, "Discussion on general aspects of physical layer design of A-IoT communication", OPPO, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-13] R1-2408206, "Discussion on general aspects of ambient IoT physical layer design", NEC, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-14] R1-2408250, "Discussion on general aspects of physical layer design", Sharp, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-15] R1-2408272, "Discussion on Physical Layer Design for Ambient-IoT", EURECOM, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-16] R1-2408308, "On General Physical Layer Design Considerations for Ambient IoT Applications", Lekha Wireless Solutions, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-17] R1-2408410, "General aspects of Ambient IoT physical layer design", Sony, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-18] R1-2408466, "On remaining general physical layer design aspects for AIoT", Apple, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-19] R1-2408568, "Discussion on general aspects of physical layer design", ETRI, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-20] R1-2408599, "General aspects of physical layer design for Ambient IoT", Panasonic, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-21] R1-2408647, "Considerations for general aspects of Ambient IoT", Samsung, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-22] R1-2408672, "General aspects of Ambient IoT physical layer design", LG Electronics, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-23] R1-2408685, "Discussion on physical layer design for Ambient IoT", Comba, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-24] R1-2408701, "General aspects of physical layer design", MediaTek Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9421-25] R1-2408730, "On the general aspects of physical layer design for Ambient IoT", InterDigital, Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9421-26] R1-2408765, "Discussion on A-IoT physical layer design", ASUSTeK, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-27] R1-2408787, "Study on general aspects of physical layer design for Ambient IoT", NTT DOCOMO, INC., RAN1#118bis, Hefei, China, October 2024.

[R1-9421-28] R1-2408851, "General aspects of physical layer design", Qualcomm Incorporated, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-29] R1-2408875, "Discussion on multiple access for D2R", LG Uplus, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-30] R1-2408941, "Discussion on General aspects of physical layer design of AIoT", IIT Kanpur, Indian Institute of Tech (M), RAN1#118bis, Hefei, China, October 2024.

[R1-9421-31] R1-2408967, "Discussion on the physical layer design aspects for Ambient IoT devices", Lenovo, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-32] R1-2409005, "Discussion on general aspects of physical layer design for Ambient IoT", ZTE Corporation, Sanechips, RAN1#118bis, Hefei, China, October 2024.

[R1-9421-33] R1-2406315, "Consideration on general aspects of physical layer", Fujitsu, RAN1#118, Maastricht, Netherlands, August 2024.

[R1-9421-34] R1-2407119, "General aspects of physical layer design for Ambient IoT", ITL, RAN1#118, Maastricht, Netherlands, August 2024.

[R1-9421-35] R1-2407088, "Discussion on General aspects of physical layer design", CEWiT, RAN1#118, Maastricht, Netherlands, August 2024.

[R1-9421-yy] J. K. Wolf and R. D. Blakeney, “An exact evaluation of the probability of undetected error for certain shortened binary CRC codes,” Proc. Milcom ’88, vol. 1, pp. 287-292, 1988.

9.4.2.2 References

[R1-9422-1] R1-2407611, "Discussion on Frame Structure and Timing Aspects for Ambient IoT", FUTUREWEI, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-2] R1-2407639, "Frame structure and timing aspects for Ambient IoT", Ericsson, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-3] R1-2407646, "Frame structure and timing aspects for Ambient IoT", Nokia, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-4] R1-2407670, "On frame structure and timing aspects of Ambient IoT", Huawei, HiSilicon, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-5] R1-2407708, "Discussion on frame structure and timing aspects for Ambient IoT", Spreadtrum Communications, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-6] R1-2407907, "Discussion on frame structure and timing aspects for A-IoT", CMCC, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-7] R1-2407971, "Discussion on frame structure and timing aspects for Ambient IoT", Xiaomi, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-8] R1-2408049, "Study of Frame structure and timing aspects for Ambient IoT", CATT, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-9] R1-2408068, "Discussion on frame structure and physical layer procedure for Ambient IoT", ZTE Corporation, Sanechips, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-10] R1-2408148, "Discussion on frame structure and timing aspects of A-IoT communication", OPPO, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-11] R1-2408234, "Discussion on frame structure and timing aspects for Ambient IoT", HONOR, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-12] R1-2408251, "Discussion on frame structure and timing aspects", Sharp, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-13] R1-2408411, "Frame structure and timing aspects for Ambient IoT", Sony, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-14] R1-2408434, "Frame structure and timing aspects of Ambient IoT", InterDigital, Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9422-15] R1-2408467, "On remaining frame structure and timing aspects for AIoT", Apple, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-16] R1-2408536, "Discussion on A-IoT Frame Structure and Timing Aspects", Panasonic, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-17] R1-2408648, "Considerations for frame structure and timing aspects", Samsung, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-18] R1-2408673, "Frame structure and timing aspects for Ambient IoT", LG Electronics, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-19] R1-2408702, "Frame structure and timing aspects", MediaTek Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9422-20] R1-2408742, "Considerations for frame structure and timing aspects", Semtech Neuchatel SA, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-21] R1-2408920, "Discussion on frame structure and timing aspects for Ambient IoT", TCL, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-22] R1-2408990, "Study on frame structure and timing aspects for Ambient IoT", NTT DOCOMO, INC., RAN1#118bis, Hefei, China, October 2024.

[R1-9422-23] R1-2409008, "Discussion on Frame structure, random access, scheduling and timing aspects for Ambient IoT", vivo, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-24] R1-2409026, "Discussion on frame structure and physical layer procedures for Ambient IoT", Lenovo, RAN1#118bis, Hefei, China, October 2024.

[R1-9422-25] R1-2409057, "Frame structure and timing aspects", Qualcomm Incorporated, RAN1#118bis, Hefei, China, October 2024.

9.4.2.3 References

[R1-9423-1] R1-2407612, "Discussion on D2R and R2D Channel/Signal Aspects for Ambient IoT", FUTUREWEI, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-2] R1-2407671, "Physical channels and signals for Ambient IoT", Huawei, HiSilicon, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-3] R1-2407864, "Discussion on Downlink and uplink channel/signal aspects", vivo, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-4] R1-2408050, "DL and UL Physical Channels/signals design in support of Ambient IoT devices", CATT, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-5] R1-2408069, "Discussion on channel and signal for Ambient IoT", ZTE Corporation, Sanechips, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-6] R1-2408149, "Discussion on downlink and uplink channel/signal aspects for A-IoT", OPPO, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-7] R1-2408532, "Considerations on Intermediate UE in A-IoT", Continental Automotive, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-8] R1-2408703, "Downlink and uplink channel/signal aspects", MediaTek Inc., RAN1#118bis, Hefei, China, October 2024.

[R1-9423-9] R1-2408853, "Downlink and uplink channel/signal aspects", Qualcomm Incorporated, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-10] R1-2408932, "Discussion on Downlink and Uplink channel/signal aspects", CEWiT, RAN1#118bis, Hefei, China, October 2024.

[R1-9423-11] R1-2408943, "Discussion on Downlink and Uplink channel signal aspects for AIoT", IIT Kanpur, Indian Institute of Tech (M), RAN1#118bis, Hefei, China, October 2024.

[R1-9423-12] R1-2409023, "Downlink and uplink channel/signal aspects for Ambient IoT", Ericsson, RAN1#118bis, Hefei, China, October 2024.

RAN2 References

[R2-1] 3GPP TR 23.700-13: "Study on Architecture support of Ambient power-enabled Internet of Things".

[R2-2] 3GPP TR 33.713: "Study on security aspects of Ambient Internet of Things (AIoT) services in 5G".

[R2-3] 3GPP TS 38.300: "NR and NG-RAN Overall description; Stage-2".

[R2-4] 3GPP TS 22.369: "Service requirements for Ambient power-enabled IoT".

9.4.2.4 References

[R1-9424-1] R1-2405855, "On external carrier wave for backscattering based Ambient IoT device", Huawei, HiSilicon, RAN1#118. Maastricht, Netherlands, August 2024.

[R1-9424-2] R1-2408854, "Waveform characteristics of carrier-wave provided externally to the Ambient IoT device", Qualcomm Incorporated, RAN1#118bis, Hefei, China, October 2024.

# 3 Definitions of terms, symbols and abbreviations

This clause and its three (sub) clauses are mandatory. The contents shall be shown as "void" if the TS/TR does not define any terms, symbols, or abbreviations.

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

For the purposes of the study, RAN1 uses the following terms:

**Device 1:** ~1 µW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10*X* ppm, neither DL nor UL amplification in the device. The device's UL transmission is backscattered on a carrier wave provided externally.

**Device 2a:** ≤ a few hundred µW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10*X* ppm, both DL and/or UL amplification in the device. The device’s UL transmission is backscattered on a carrier wave provided externally.

**Device 2b:** ≤ a few hundred µW peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10*X* ppm, both DL and/or UL amplification in the device. The device’s UL transmission is generated internally by the device.

**D1T1:** Deployment scenario 1 with connectivity topology 1, according to TR 38.848.

**D2T2:** Deployment scenario 2 with connectivity topology 2, according to TR 38.848.

**Inventory**: The service provided by the network to discover and acquire the identifier of A-IoT device(s).

**Command**: The service provided by the network to send the operation instruction to the A-IoT device (e.g., read, write, etc.).

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

1SB Single sideband

2SB Double sideband

A-IoT Ambient IoT

A-IoT RAN Ambient IoT Radio Access Network

BFSK Binary frequency-shift keying

BPSK Binary phase-shift keying

CFO Carrier-frequency offset

CP Cyclic prefix

CW Carrier-wave

CW2D Carrier-wave, or carrier-wave node, to device

D2R Device to reader

DFT-s-OFDM DFT-spread OFDM

DO-A Device-originated autonomous

DO-DTT Device-originated by device-terminated trigger

DT Device-terminated

ED Envelope detector

FAR False alarm rate

FEC Forward error-correction code

FR Frequency Range

IF Intermediate frequency

IoT Internet of Things

LPWA Low-power, wide-area

LTE-MTC Long Term Evolution – Machine Type Communication

MCS Modulation and coding scheme

MDR Missed detection rate

MSK Minimum-shift keying

NB-IoT Narrowband IoT

OOK On-off keying

PDRCH Physical device-to-reader channel

PIE Pulse interval encoding

PRDCH Physical reader-to-device channel

R2D Reader to device

RF Radio frequency

RFID Radio frequency identification

SFO Sampling-frequency offset

ZIF Zero IF

Next Change

## 6.3 Protocol stack and signalling procedures

### 6.3.1 General aspects and overall procedure

The study aims that the design on the A-IoT radio interface between reader and A-IoT device is common for Topology 1 and Topology 2. The difference of topologies is transparent to the A-IoT devices and has no impact on A-IoT devices. Unless explicitly stated, the descriptions in clause 6.3 apply to all A-IoT device types and both Topology 1 and Topology 2.



Figure 6.3.1-1 Overall AS procedures between A-IoT device and reader

The overall AS procedures can be formulated as:

- Step A: A-IoT paging. Based on the service request, the reader sends the A-IoT paging message indicating device(s) that need to respond. See sub-clause 6.3.3.

NOTE 1: In the clause 6.3, the term of “A-IoT paging message” is equal to the “(initial) trigger message”. For simplification, only the former is used.

- Step B: D2R data (device ID) transmission. Triggered A-IoT device(s) perform the device ID transmission via the A-IoT random access procedure or without using the A-IoT random access procedure. See sub-clause 6.3.4 (and 6.3.5)..

- Step C1: Possible R2D data transmission (e.g., for sending the command). See sub-clause 6.3.5.

- Step C2: Possible D2R data transmission (e.g., the corresponding response to command). See sub-clause 6.3.5.

Then, above AS procedure can support indoor inventory and indoor command use cases by the following manners:

- For the detailed use case of “inventory-only”, it is supported by the procedure with Step A and Step B as baseline.

- For the detailed use case of “inventory and command”, it is supported by the procedure with Step A, Step B, Step C1 and Step C2, as baseline.

NOTE 2: For the use case of “inventory and command”, it does not imply that the A-IoT paging message includes both the inventory and command and it does not imply the inventory and command are received by the reader at the same time from upper layer.

- For the detailed use case of “command-only”:

- It can be also supported by the baseline procedure with Step A, Step B, Step C1 and Step C2.

- In addition, another candidate to support this use case is following, whose feasibility still depends on the conclusion from [R2-1] and [R2-2]:

- Step A’: A-IoT paging. Based on the service request, the reader sends the A-IoT paging message including the command, indicating device(s) to process/respond the command.

- Step C2: Possible D2R data transmission (e.g., the device ID or the corresponding response to command), via the A-IoT random access procedure or without using the A-IoT random access procedure.

The following information are considered useful to be visible to the reader from CN:

NOTE 3: It can be further discussed on whether following information is mandatory or optional.

- The A-IoT service type (e.g., inventory, command)

NOTE 4: It can be further discussed if more information on command type (e.g. read/write/disable) is useful. It is understood that the reader needs to know whether a D2R response is expected and the expected D2R message size, if there is the response for a service. It can be further discussed on the details on how the reader gets those information (related to the “expected D2R message size” discussion in sub-clause 6.3.5). It can be further discussed on whether the command type, if needed, is explicit or inferred from the “expected D2R message size” if available.

- Whether the service is targeted for one or more than one A-IoT devices

- The approximate number of target A-IoT devices of this service

### 6.3.2 Protocol stack and functionality aspects

For A-IoT, it is assumed the commands (e.g., read/write/disable) and/or inventory information are carried over A-IoT radio interface as the upper layer data. As to the protocol stack for A-IoT radio interface between A-IoT device and reader, it is assumed:

- RRC layer is not supported

- SDAP layer is not supported

- PDCP layer is not supported

- RLC layer is not supported

- A-IoT MAC layer is supported

- A-IoT physical layer is supported

- There is no control plane and user plane differentiation



Figure 6.3.2-1 Protocol stack for A-IoT radio interface between A-IoT device and reader

As to the A-IoT required functionalities, the following functionalities are supported:

- A-IoT paging (see sub-clause 6.3.3)

- A-IoT random access procedure (see sub-clause 6.3.4)

- A-IoT data transmission (see sub-clause 6.3.5)

As to the A-IoT required functionalities, at least the following functionalities are NOT supported (see TS 38.300 [R2-3] for references for any legacy NR functionality):

- AS security (The AS layer design assumes no support of AS security, unless the study in [R2-2] further concludes differently.)

- RRC states

- RRC connection management

- RRM L3 measurement reporting

- Mobility

- ASN.1 encoding/decoding

- Periodical system information and MIB

- Tracking/RAN area update procedure

- Per-packet QoS and per-QoS flow at AS level

- HARQ

- RLC ARQ/AM

- AS-layer (above physical layer) RLC-like/ARQ-like retransmission

- AS-layer (above physical layer) repetition

NOTE 2: It is not precluded that the reader and A-IoT device send the “payload” again as new transmission from A-IoT MAC perspective.

- Multiple A-IoT logical channels for upper layer data

- NR SR, as in TS 38.300 [R2-3]

- NR BSR, as in TS 38.300 [R2-3]

### 6.3.3 A-IoT paging

In A-IoT AS layer, the A-IoT paging functionality is to use A-IoT paging message to indicate device(s) that need to respond.

As to the A-IoT paging message, the identifier may be required to identify the device/group of devices in this trigger message (e.g., for the case of reaching a single or a group of devices). Following cases are studied:

- The A-IoT paging message containing an identifier of a single A-IoT device

- The A-IoT paging message containing a group ID that maps to multiple A-IoT devices

- The A-IoT paging message that does not contain any identifier, i.e., indicating all A-IoT devices that can receive the A-IoT paging message need to respond

- The A-IoT paging message containing multiple identifiers of A-IoT devices. The need for this use case is still to be confirmed/dependent according to the conclusion in [R2-1]. From RAN2 perspective, it is feasible to support paging multiple identifiers of A-IoT devices, pending on TB size and multiplexing design of A-IoT paging message.

NOTE 1: The details of the above identifier and group ID and also the use case/scenario are studied in [R2-1].

As to the A-IoT paging message, it can additionally indicate the information from which the device(s) can determine the resource(s) to be used for D2R response message(s). It can be further considered on more details for the discussion in clause 6.1.

For A-IoT device paging functionality, it is understood that the legacy paging message, legacy paging occasion and legacy DRX from NR are not supported (See TS 38.300 [R2-3] for references for any legacy NR functionality). From RAN2 perspective, it is assumed that the A-IoT device can receive as long as there is enough energy (it can be further considered on the discussion in clause 6.1 and 6.2).

It is supported that the reader can send multiple (subsequent) A-IoT paging messages that are associated with the same service request from the CN. The duplicated response from devices for the same service request should be avoided. The A-IoT paging message can include information to avoid this duplicated response from the device to a reader. It can be further discussed on how to design this information in A-IoT paging message (e.g., as stage-3 details and also considering the aspects from other WGs for this). Then, based on this information, the device determines whether to skip sending the response to A-IoT paging message or not (if the device had successfully responded the same service before). This information should be short and simple. This information can be one ID, while it can be further discussed whether the ID is generated by the reader or by the core network. It can be further discussed on the size of this information.

It can be further discussed for the scenario that different readers may send A-IoT paging messages, which are associated with the same service request from the CN, to the same device for response. If this scenario is to be in the scope, it can be further discussed, by considering the discussions from all the WGs.

It can be further discussed on whether other further information related to the possible subsequent message(s) is included in the A-IoT paging message, e.g., the service type, command type.

### 6.3.4 A-IoT random access procedure

A-IoT random access procedure is used for the Ambient IoT device(s) to access the network for data transmission.

The A-IoT random access procedure is triggered by the reader, including triggering the access for a single A-IoT device, group of A-IoT devices, or all A-IoT devices under the coverage of the reader.

The slotted-ALOHA is the baseline for A-IoT random access procedure.



Figure 6.3.4-1 General framework of slotted-ALOHA for A-IoT random access procedure

**Access occasion**: An opportunity of time-frequency resource for A-IoT device(s) to perform access (e.g., transmitting the A-IoT Msg1 by the device). A set of access occasion(s) for different A-IoT device(s) is scheduled via the R2D message (referring to the “R2D transmission triggering random access” in sub-clause 6.1.4) by the reader.

When the A-IoT device is selected to respond in accordance to the sub-clause 6.3.3, the A-IoT device performs the following procedure:

- **Step 1**: Random access type (i.e., contention-free or contention-based) and access occasion/resource determination:

- The A-IoT device determines the random access type from the A-IoT paging message, in accordance to sub-clause 6.3.3. The reader can configure either contention-free access or contention-based random access (and the corresponding configurations). It can be further discussed on whether it is explicitly or implicitly.

- If the random access is contention-free access:

- Selects the indicated D2R occasion/resource;

- Skips the contention resolution in Step 2 and performs the data transmission in accordance to sub-clause 6.3.5.

- If the random access is contention-based random access:

- Performs access occasion/resource selection: as the baseline for CBRA, at least for TDMA case, the device can randomly select one access occasion for A-IoT Msg1 within the access occasions provided/assigned by the reader. It can be further discussed if this is applicable to FDMA case. Further enhancement option(s) can be also considered after more physical layer detailed design on TDMA and FDMA;

- Performs the Step 2 for contention resolution.

- **Step 2**: Contention resolution of contention-based random access:

- There are two candidate solutions being studied for the contention resolution, as below (it can be further discussed on the down selection and/or the unified design):

- ***Solution 1: A-IoT Msg1 without data***

- A-IoT Msg1: When the A-IoT device identifies the start of its own access occasion, it sends one 16-bit random ID generated by the A-IoT device to the reader.

- A-IoT Msg2: The reader responds with the successfully received random ID.

 If the A-IoT device receives the A-IoT Msg2 including a random ID, which is the same as the previously transmitted one in A-IoT Msg1, it considers the contention resolution as successful.

- ***Solution 2: A-IoT Msg1 with data***

- A-IoT Msg1: When the A-IoT device identifies the start of its own access occasion, it sends the A-IoT Msg1 including the upper layer data, which can be the device ID and/or any other upper layer data, in addition to one 16-bit random ID generated by the A-IoT device to the reader.

- A-IoT Msg2: The reader may respond with the successfully received random ID.

 If the A-IoT device receives the A-IoT Msg2 including a random ID, which is the same as the previously transmitted one in A-IoT Msg1, it considers the contention resolution as successful. If the A-IoT Msg2 is not received by the device, the re-access is not autonomously performed while the re-access is always controlled by the reader.

- ***Solution 3: A-IoT Msg1 optionally includes data (unified solution supporting both Solution 1 and 2)***

- A-IoT Msg1: When the A-IoT device identifies the start of its own access occasion, it sends one 16-bit random ID generated by the A-IoT device to the reader. In addition, it is controlled by the reader on whether to also include the upper layer data, which can be the device ID and/or any other upper layer data.- A-IoT Msg2: The reader responds with the successfully received random ID.

 If the A-IoT device receives the A-IoT Msg2 including a random ID, which is the same as the previously transmitted one in A-IoT Msg1, it considers the contention resolution as successful.

NOTE 1: The random ID is randomly generated by the A-IoT device.

NOTE 2: The A-IoT Msg2 is used for contention resolution, since it is assumed that the size of random ID in A-IoT Msg1 should be sufficient for contention resolution purpose. It is assumed that, with the sufficient range for random ID, the probability of multiple A-IoT devices selecting the same access occasion and the same random ID for A-IoT Msg1 transmission will be sufficiently low.

NOTE 3: It is up to the reader implementation whether A-IoT Msg2 is sent in random access *Solution 2*.

NOTE 4: Further information may be included in A-IoT Msg2 by considering the discussion in clause 6.1.

NOTE 5: For the advantage and disadvantage of the above solutions, it is understood that: *Solution 1* can support relatively large coverage than *Solution 2*. *Solution 2* has the message number efficiency in case of low probability of A-IoT Msg1 collision (e.g. it can reduce one step for data transmission interaction in case of success).

After the A-IoT device considers the contention resolution as successful if the contention-based random access is used, or if the contention-free access is used, it may perform the upper layer data transmission with the reader, which can be the device ID and/or any other upper layer data, if any, in accordance to sub-clause 6.3.5.

It is also studied for the possible unification between the above contention-free access and contention-based random access, from the device perspective. In this solution, when the A-IoT device identifies the start of its own access occasion, it sends at least one 16-bit random ID generated by the A-IoT device to the reader (regardless of the contention-free or contention-based access occasion). The motivation and disadvantage to include the random ID in contention-free access are still to be further discussed. ~~At least one disadvantage is the reader doesn’t know whether the intended device is responding on the given resources.~~

It is supported for the A-IoT device to re-access in another opportunity controlled/provided by the reader (i.e., to retry the random access above), in case of D2R data transmission failure and contention resolution failure of contention-based random access.

The A-IoT device is not expected to autonomously re-access. The re-access is always controlled by reader. It is supported for reader to use the optional explicit R2D failure/success feedback indication to determine the re-access of device:

- This indication can be used at least to determine the re-access for addressing the transmisison failure of the first D2R message, which contains the device ID and/or any other upper layer data (i.e. “Msg3”);

- This indication can be also used for the following D2R data (as described in sub-clause 6.3.5), to determine the re-access for addressing the transmisison failure.

The R2D message is used by the reader to provide access occasion(s), which can be used for re-access purpose. It can be further discussed if additional information is needed in this R2D message to differentiate the re-access purpose.- “ message”

- Another option can be some R2D messages between A-IoT paging (e.g., see the other “R2D message” in Figure 6.3.4-1).

### 6.3.5 A-IoT data transmission

According to the protocol stack and functionalities in sub-clause 6.3.2, more detailed data transmission functionalities are studied in this sub-clause.

The handling of data transmission failure has been studied. It is understood that the subsequent R2D data transmission after the D2R data transmission does not need to be always sent. In case of D2R data transmission failure, the A-IoT device follows the reader subsequent R2D instruction, if any.

- For instance, the reader can repeat the R2D upper layer “command” to trigger the A-IoT device to re-send the same D2R upper layer “response” (i.e., the A-IoT device just follows the received R2D to transmit following D2R).

- For instance, the reader can re-send A-IoT Msg2 to specific device(s) to echo the random ID(s), in case of failure reception of corresponding D2R data transmission after the initial A-IoT Msg2 (i.e. “Msg3”), together with the corresponding D2R resource scheduling. This can trigger the A-IoT device to re-send the same D2R data transmision (i.e. “Msg3”). If it is supported to include the echoed random IDs for multiple devices, the re-sent A-IoT Msg2 only includes the random IDs of the devices, whose “Msg3” is not successfully received.

It is studied on the functionality of segmentation. It is understood that segmentation and reassembly would add complexity. Therefore, the simplified segmentation in the A-IoT MAC layer is studied, considering following studies in physical layer:

- In both R2D and D2R directions, there is no lower bound on the minimum TB size, and a maximum TB size of around 1000 bits can be supported.

- How large TB that can be transported at a given time depends on target coverage/data rate, energy consumption/device availability, etc.

The segmentation study focuses on D2R direction (it can be further considered on R2D direction). For the candidate solution for segmentation:

- The sequence number, the segment number and the number of segments are not supported;

- An indication is used to indicate to the reader on whether the data is segmented and whether the MAC PDU is the last segment. It can be further discussed on the size of this indication (one or two bits) and the corresponding stage3 details;

- It is beneficial for the reader to be able to trigger a re-transmission of a segment;

- It is assumed that the A-IoT device will not support AS layer buffering for A-IoT segmentation functionalities, i.e., all segment(s) are stored in upper layer(s).

The use of the following assistance information is studied (the need of each is still to be decided):

- The energy status report from the A-IoT device to the reader, which indicates that the A-IoT device, if the A-IoT device can determine this, does not have sufficient energy to perform the remaining/follow-up procedure.

- The A-IoT device may report a 1-bit energy status indication to the reader in a D2R message. It can be further discussed if and how the reader control this indication of such report.

- The reader may take this indication into account for the remaining/follow-up procedure (up to the reader implementation), e.g., the reader may choose not to transmit the subsequent messages for some time, or the reader may choose to not do anything in particular, etc.

- It is beneficial for the reader to know an estimate of expected D2R message size. This D2R message size information would be beneficial but it is not essential. Two options are studied:

- Option 1: The estimate of expected following D2R message size from the CN to the reader;

- Advantages/disadvantages of option 1: If this information is available from CN, it saves the overhead/latency caused by Option 2 in AS layer. It can be also used by the reader as early as for the first D2R message, if needed.

- Option 2: The simple message size indication from the device to the reader.

- Advantages/disadvantages of option 2: It is useful in case the CN is not able to provide or does not provide the expected D2R message size. Limited granularity is supported considering the AS layer overhead. It requires D2R message to carry this information in advance, before the reader can actually use this size information for scheduling.

From higher layer perspective, it is assumed that “AS ID” (if defined according to the design in clause 6.1) is used at least for purpose of D2R scheduling and R2D reception. From higher layer perspective, it is assumed that this “AS ID” should be a short AS layer ID, rather than the full upper layer device ID. It can be further discussed if this “AS ID” can be based on partial upper layer device ID. It can be further discussed on the length of this “AS ID”. From higher layer perspective, following options are possible for this “AS ID” (it is aimed to define one common design for all access procedures in sub-clause 6.3.4, if technically possible):

- Option 1: a random ID (if used in first D2R message) can be reused;

- Option 2: the reader assigns this “AS ID” to the device. It can be further discussed via which R2D message.- Option 3: It is up to the reader whether to reuse the random ID (if used in first D2R message) as the “AS ID” or to assign a new “AS ID”. It can be further discussed via which R2D message.

NOTE 1: The further down-selection for “AS ID” needs to consider the involved message and whether the reader needs to handle the collision.

### 6.3.6 Topology 2 aspects on the interface between UE reader and RAN

For Topology 2, the architecture/protocol stack options in [R2-1] are studied (also corresponding to the studies in sub-clause 6.4.2.1), while no new AS layer architecture/protocol stack options will be studied:

- RRC based solution: A-IoT upper layer information is explicitly forwarded via UE reader’s NR Uu RRC message.

- NAS based solution: A-IoT upper layer information is transmitted over UE reader's NAS message.

- UP based solution: A-IoT upper layer information is transmitted as UE reader's user plane data.

It is assumed that the intermediate UE authorization is performed by upper layers, according to [R2-1] and [R2-2]. It is not studied, from signalling perspective, the scenario D2T2-A1 to support bistatic mode of operation.

The radio resources used by A-IoT radio interface between the A-IoT device(s) and UE reader are controlled by the network. The radio resources, which are dedicated for a UE reader, are only configured to the UE reader via dedicated signalling. The mechanisms for shared resource pool amongst UE readers are not considered in this release. The UE reader in coverage of BS scenario is supported. The UE reader may perform the A-IoT procedure on A-IoT radio interface between the reader and the device(s), only if the radio resource configuration is valid in the cell, which is under network control. The radio resource validity across multiple cells is not supported in this release. Hence, for all options below, the resources remain valid only in the same cell in which the resources were configured.

For the case when the radio resources are allocated semi-statically by the network, the radio resource validities are studied in the following scenarios with candidate options (down-selection can be decided in the WI phase):

- Scenario 1: In RRC\_CONNECTED, the UE reader can perform A-IoT operations using the allocated A-IoT radio resource for A-IoT radio interface:

- Option 1: UE reader receives the resources configuration in NR Uu dedicated RRC signalling. The radio resources remain valid until the network releases them explicitly. This would be supported by the NR Uu RRC reconfiguration; and/or

- Option 2: UE reader receives the resources configuration in NR Uu dedicated RRC signalling, which configures a time period in which the corresponding resource can be used. The UE reader considers that the resources remain valid for that time period, unless the resource configuration is explicitly released by the network by the NR Uu RRC reconfiguration.

- Scenario 2: In RRC\_CONNECTED, the UE reader can perform A-IoT operations using the allocated A-IoT radio resource for A-IoT radio interface, upon its temporary out of connection scenarios (e.g., RLF and handover cases):

- Option 1: The UE reader considers the resources as temporarily invalid during the temporary out of connection condition. The resource may become valid again after the UE recovers from the condition.

- Option 2: The UE reader considers that the resources remain valid for that time period. It can be further discussed on whether this time period belongs to the one in Option 2 for Scenario 1 or is a different time period. It can be further discussed on whether the duration of this time period is related to the ongoing A-IoT operations.

NOTE 1: The A-IoT radio resource can be (re)configured by UE reader’s RRC reconfiguration (including during handover procedure, after re-establishment of the UE reader, etc.)

- Scenario 3: In RRC\_ INACTIVE, the UE reader can perform A-IoT operations using the allocated A-IoT radio resource for A-IoT radio interface:

- Option 1: UE receives the resources configuration in NR Uu dedicated RRC signaling, before moving to RRC\_INACTIVE. The radio resources remain valid until the network releases them explicitly. This would be supported by the NR Uu RRC reconfiguration (the UE may need to resume or be paged by the network back to RRC\_CONNECTED before that).

- Option 2: UE reader receives the resources configuration in NR Uu dedicated RRC signalling, before moving to RRC\_INACTIVE, which configures a time period in which the corresponding resource can be used. The UE reader can consider that the resources remain valid for that time period.

- Scenario 4: In RRC\_ IDLE, the UE reader can perform A-IoT operations using the allocated A-IoT radio resource for A-IoT radio interface.

- If this scenario 4 is supported, the options of scenario 3 can be the candidates.

- The support of scenario 4 (UE reader performing A-IoT operations in RRC\_IDLE) is down-prioritized. It can be considered in WI phase, if feasible with minimum specification impact.

For the radio resources allocation request, following alternatives are studied:

- Alternative 1: BS configures/allocates a set A-IoT radio resource to the UE reader, in response to a request from the UE reader; and/or

- Alternative 2: BS configures/allocates a set A-IoT radio resource to the UE reader, based on the service request from CN.

NOTE 3: The above two alternatives can co-exist. The configuration for radio resource allocation may also include the validity criteria (if applicable, see the time period in previous option 2 of those scenarios)

For the UE reader selection, it is up to RAN3 and SA2 on whether BS or CN selects the UE reader(s) and what information is shared between BS and CN. From RAN2 perspective, it is assumed, at least for RRC based solution, there may be the radio related reasons for the BS to be involved in the UE reader selection.

Next Change

## 6.4 RAN architecture aspects

This clause attempts to identify and describe architectural elements necessary to define a RAN architecture for support of Ambient IoT embedded in the overall 5G system architecture in support of topology 1 and topology 2 (as defined in TR 38.848 [2]).

This chapter also attempts to identify a functional split between RAN and CN.

The logical system architecture for A-IoT consists of the following architectural elements:

**A-IoT device**: Equipment with characteristics outlined e.g., in TS 22.369 [10] and TR 38.848 [2].

**A-IoT RAN**: Hosts certain functions for A-IoT as part of the functional in RAN.

**A-IoT radio**: Radio interface between A-IoT device and A-IoT RAN node in topology 1 and between A-IoT device and A-IoT-enabled UE in topology 2.

**A-IoT CN**: Hosts certain functions for A-IoT as of the functional in CN.

NOTE 1: the details of A-IoT CN are subject to SA2.

NOTE 2: Further details regarding A-IoT functions hosted in the A-IoT CN and in the A-IoT RAN and the respective functional split to be decided by RAN2, RAN3 and SA2.

**XX interface**: Interface between the A-IoT RAN/A-IoT-enabled gNB and the A-IoT CN on which certain A-IoT specific functions are performed.

XX interface is NG interface, NGAP is used between A-IoT RAN and AIoT CN.

NOTE 3: How the functions represented by the XX interfaces are defined in various solutions and A-IoT CN topologies (direct/indirect connection between AIoT RAN and AIOTF).

**Common reader function**: A function that communicates with the A-IoT device by means of A-IoT radio.

**A-IoT RAN node function**: A function that contains e.g., the control of the A-IoT radio resources used towards the A-IoT device.

NOTE 4: Aspects concerning coordination of the Upper Layer functions (e.g., Inventory, Command) e.g., in case these functions have to be performed over a multitude of instances of the Common Reader Function, need further discussion.

### 6.4.1 Support of Topology 1

Figure 6.4.1-1 depicts a logical system architecture for topology 1, where the Common reader function and A-IoT RAN node function are deployed within an A-IoT RAN.



Figure 6.4.1-1 Logical system architecture for topology 1

For Toplogy 1, architecture and protocol aspects of split RAN architecture are not studied.

In Topology 1, the XX interface is the NG-C interface.

Figure 6.4.1-2 shows the Protocol stack for Topology 1:



Figure 6.4.1-2. Protocol Stack for Topology 1

NOTE 1: The protocol stack in Figure 6.4.1-2 does not illustrate how A-IoT upper layer information, if any, is transported over XXAP.

For topology 1, the XXAP is terminated at an A-IoT RAN node.

The signalling transport for XXAP at the A-IoT RAN node is SCTP/IP. Other options of signalling transport for XXAP at the A-IoT RAN node (e.g., HTTP/2/TLS/TCP) were discussed, but will not be pursued.

NOTE 2: Whether “XXAP” is realised by including AIoTF information in NGAP or by carrying a new protocol layer over NGAP, needs further discussion and decision.

NOTE 3: The A-IoT CN may include AMF and A-IoTF which is up to SA2 decision.

In Topology 1, an A-IoT RAN node may serve one or more readers.

The A-IoT RAN node should enable the coordination of the usage of the A-IoT radio resources among readers.

NOTE 3: How to perform coordination of the usage of the A-IoT radio resources among readers needs further discussion.

Reader selection may need coordination between A-IoT RAN node and A-IoT CN.

NOTE 4: How to perform reader selection needs further discussions.

NOTE 5: In Topology 1, whether the AIoTF needs to be aware of the readers served by the A-IoT RAN node and their location and how this information is provided to the AIoTF needs further discussion.

### 6.4.2 Support of Topology 2

Figure 6.4.2-1 depicts a logical system architecture for topology 2, where the Common reader function is located at an A-IoT-enabled UE, and the A-IoT RAN node function is located at an A-IoT-enabled gNB.

The following definitions apply:

**A-IoT-enabled gNB**: A gNB supporting A-IoT RAN node function in topology 2, which is able to communicate with the A-IoT-enabled UE via NR Uu interface.

**A-IoT-enabled UE**: A UE supporting Common reader function, which is able to communicate with the A-IoTdevice via the A-IoT radio interface.



Figure 6.4.2-1 Logical system architecture for topology 2

NOTE 1: Figure 6.4.2-1 doesn’t illustrate the protocol between A-IoT enabled UE and A-IoT CN, if needed.

NOTE 2: The A-IoT CN could include AMF, UPF and A-IoTF, which is up to SA2 decision.

NOTE 3: Details of the radio resource management performed by the A-IoT enabled gNB are subject to RAN1 and RAN2 mechanisms.

For Toplogy 2, architecture and protocol aspects of split RAN architecture are not studied.

In Topology 2, XX interface is NG interface.

In Topology 2, the RAN architecture should enable the coordination of the usage of the A-IoT radio resources among readers.

NOTE 4: How to perform coordination of the usage of the A-IoT radio resources among readers needs further discussion.

An A-IoT-enabled gNB could support both topology 1 and topology 2, this is an implementation matter.

#### 6.4.2.1 Solutions for Topology 2

##### 6.4.2.1.0 General

To support Topology 2, the following solutions are to be studied for conveying A-IoT upper layer information:

**- RRC based solution.** With this solution, A-IoT CN applies A-IoT upper layer information explicitly over XXAP signaling. A-IoT upper layer information is then relayed explicitly to/from the A-IoT-enabled UE via NR Uu RRC.

- **NAS based solution**. With this solution, there is no explicit termination of A-IoT upper layer information at A-IoT-enabled gNB. A-IoT upper layer information is transmitted over A-IoT enabled UE's NAS.

- **UP based solution**. With this solution, there is no explicit termination of A-IoT upper layer information at A-IoT-enabled gNB. A-IoT upper layer information is transmitted as A-IoT-enabled UE's user plane data.

NOTE 1: The protocol stack for each solution option does not illustrate A-IoT CN internal architecture and how A-IoT upper layer information is transported, if any.

No evaluation and no down selection for T2 solutions has been performed in RAN3.

Only if the UE is authorized to perform the A-IoT service, the UE can communicate with the A-IoT device and be configured with AIoT radio resources controlled by the A-IoT enabled gNB.

NOTE 2: The NGAP protocol functions for the A-IoT-enabled UE authorization needs further discussions.

In RRC based solution, Reader selection may need coordination between A-IoT-enabled gNB and A-IoT CN.

NOTE 3: How to perform reader selection needs further discussions.

NOTE 4: In NAS/UP based solution, whether A-IoT CN selects the A-IoT-enabled UE for the selection needs further discussion.

##### 6.4.2.1.1 Solution1: RRC based solution

Upon receiving XXAP: A-IoT related message from A-IoT CN, the A-IoT-enabled gNB transmits the related information towards the A-IoT-enabled UE via NR Uu RRC, and vice versa.



Figure 6.4.2.1.1-1: RRC based solution of Topology 2

In this solution, XX interface is NG-C interface.

NOTE: Whether “XXAP” is realised by including AIoTF information in NGAP or by carrying a new protocol layer over NGAP, needs further discussion and decision.

##### 6.4.2.1.2 Solution 2: NAS based solution

The A-IoT related messages between the AIoTF and the A-IoT-enabled UE are carried via A-IoT-enabled UE’s DL/UL NAS packets, the A-IoT-enabled gNB handles the A-IoT-enabled UE’s NAS packets as legacy, i.e., using DL NAS Transport and UL NAS Transport procedures over NGAP.



Figure 6.4.2.1.2-1: NAS based solution of Topology 2

NOTE 1: The communication between AIoTF and the A-IoT-enabled UE via A-IoT related messages and the presence of AIoT-AP protocol are being discussed in SA2. If agreed by SA2, the AIoT-AP may carry same/similar information as defined for other solutions over XXAP, this requires coordination between RAN3 and SA2.

NOTE 2: The definition and description of AIoTF and AIoT-AP refers to TR 23.700-13 [7].

There are different ways discussed to achieve A-IoT radio resource coordination and allocation as described in 6.5.1.3. Figure 6.4.2.1.2-2 illustrates one candidate solution to support AIoT session resource control for the NAS based solution by utilising XXAP between A-IoT CN and A-IoT enabled gNB.



Figure 6.4.2.1.2-2: one candidate solution of Resource control for NAS based solution of Topology 2

For the NAS-based solution there are other candidate solutions discussed (e.g., A-IoT enabled UE request-based resource allocation) described in section 6.5.1.3 which might not need this additional protocol layer (XXAP) for resource allocation, refer to section 6.5.3.1.2.

6.4.2.1.3 Solution 3: UP based solution

The A-IoT related messages between the AIoTF and the A-IoT-enabled UE are carried via A-IoT-enabled UE’s PDU Session, the A-IoT-enabled gNB handles the A-IoT-enabled UE’s user plane data as legacy, i.e., over NG-U GTP-U tunnels.



**Figure 6.4.2.1.3-1: UP based solution of Topology 2**

NOTE 1: The communication between A-IoTF and the A-IoT-enabled UE via A-IoT related messages and the presence of AIoT-AP protocol is being discussed in SA2. As the AIoT-AP may carry same/similar information as defined for other solutions over XXAP, this requires coordination between RAN3 and SA2.

NOTE 2: The definition and description of AIoTF and AIoT-AP/Transport/IP refers to TR 23.700-13 [7].

There are different ways discussed to achieve A-IoT radio resource coordination and allocation as described in 6.5.1.3. Figure 6.4.2.1.3-2 illustrates one candidate solution to support AIoT session resource control for the UP based solution by utilising XXAP between A-IoT CN and A-IoT enabled gNB for resource control.



Figure 6.4.2.1.3-2: one candidate solution of Resource control for UP based solution of Topology 2

For the UP based solution there are other candidate solutions discussed (e.g., A-IoT enabled UE request-based resource allocation) described in section 6.5.1.3 which might not need this additional protocol layer protocol layer (XXAP) for resource allocation, refer to section 6.5.3.1.2.

## 6.5 Impacts on CN-RAN interface

### 6.5.1 Information exchanged between A-IoT CN and A-IoT RAN

#### 6.5.1.1 Inventory

Inventory can be sent by the A-IoT CN for a single device, or a group of devices, or all devices.

The Inventory Request from the A-IoT CN to the A-IoT RAN, may include the following:

(1) A-IoT Device Identification (to find a single device, a group of devices, or all devices)

NOTE 1: The definition of this identification is out of RAN3 scope.

For topology 1, A-IoT RAN needs to store the A-IoT Device Identification received from the inventory request.

NOTE 2: Whether to interpret and process AIoT Device Identification received from the inventory request needs further discussion.

(2) Scope of inventory request (e.g., a certain area in which the inventory is to be triggered)

Multiple individual A-IoT Device IDs (one ID per device) can be provided to the A-IoT CN via a single Inventory Report.

NOTE 3: For topology 1, whether device ID received from the device is sent transparently to the A-IoT CN by the A-IoT RAN depends on RAN2 and SA2.

NOTE 4: Whether the description in this clause apply to A-IoT enabled gNB in topology 2 needs further discussion and is dependent on SA2 and RAN2.

#### 6.5.1.2 Command

Command can be sent by the A-IoT CN for a single device.

For topology 1, A-IoT RAN node should be able to differentiate between command and inventory.

NOTE 1: Whether command can be performed for a group of devices depends on RAN2, SA2 and SA3.

NOTE 2: Whether the A-IoT-enabled-gNB should be able to differentiate between command and inventory needs further discussion, which depends on SA2 and RAN2.

NOTE 3: Whether the description in this clause apply to A-IoT enabled gNB in topology 2 needs further discussion and is dependent on SA2 and RAN2.

#### 6.5.1.3 A-IoT radio resource allocation in case of NAS/UP based solutions

In NAS/UP based solutions, there are different ways to trigger A-IoT session resource allocation, upon CN request or upon UE request.

A-IoT session resources can be requested by the AIoT CN in advance or in parallel to the NAS/UP based communication with the A-IoT device.

NOTE 1: In case of UE request, whether and how the A-IoT enabled gNB is informed about the A-IoT session when A-IoT enabled UE requests for A-IoT radio resources and the interaction with resource allocation needs further discussion.

NOTE 2: There were also discussions about requesting AIoT session resources along with the NAS/UP based communication. Details would need further discussions.

### 6.5.2 Signaling and Procedures for Topology 1

NOTE: XX communication depicted in the following chapters uses protocol elements (messages and information elements) detailed in section 6.5.1 and are not repeated unless additional description is necessary.

#### 6.5.2.1 Candidate procedures for A-IoT Inventory for Topology 1



Figure 6.5.2.1-1: Message flow for A-IoT Inventory in Topology 1

1a. The A-IoT CN sends an Inventory request message to the A-IoT RAN node, taking into account, among others, the A-IoT transaction scope.

1b. The A-IoT RAN node allocates and coordinates the usage of A-IoT radio resources.

2. The A-IoT RAN node sends an Inventory response message to the A-IoT CN.

NOTE 1: In step 2, the A-IoT RAN node may instead send an Inventory failure message to the A-IoT CN indicating that the inventory procedure could not be initiated towards the A-IoT device(s).

3. The A-IoT RAN node performs the inventory procedure towards the A-IoT device(s) over the A-IoT radio interface.

4a/4b. After receiving the inventory result from the A-IoT device(s), the A-IoT RAN node may send one or multiple Inventory reports towards the A-IoT CN including the received inventory result.

NOTE 2: Steps 4a/4b may happen in parallel with Step 3 for different A-IoT devices.

#### 6.5.2.2 Candidate procedures for A-IoT Command in Topology 1

 

Figure 6.5.2.2-1: Message flow for A-IoT Command in Topology 1

1. The Inventory procedures are performed in step 1, which are the same as in Figure 6.5.2.1-1 in step 1-4.

NOTE 1: Step 1 is performed for the “A-IoT Inventory and Command” case. Whether and under which conditions step 1 may be skipped in case of “Command-only” and which consequences this would have for the overall message flow depends on discussions led by SA2, SA3 and RAN2.

NOTE 2: Whether and which way steps 2a and 2b may be part of step 1 is dependent on discussions led by SA2, SA3 and RAN2.

2a. The A-IoT CN node sends a Command Request message to the A-IoT RAN.

2b. The A-IoT RAN node coordinates the usage of A-IoT radio resources and allocates A-IoT radio resources for the A-IoT command session.

3. The A-IoT RAN node performs A-IoT command procedures towards the A-IoT device over the A-IoT radio interface.

4. The A-IoT RAN node sends a Command Response message to the A-IoT CN, if any command result is received from A-IoT device, the A-IoT RAN node may include the command result in the Command response message.

NOTE 3: In step 4, the A-IoT RAN node may instead send a Command Failure message to the A-IoT CN indicating that the command procedure has failed.

### 6.5.3 Signaling and Procedures for Topology 2

#### 6.5.3.1 Candidate procedures for A-IoT Inventory for Topology 2

##### 6.5.3.1.1 RRC based solution



Figure 6.5.3.1.1-1: Message flow for A-IoT Inventory in Topology 2 - RRC-based solution

1a. The A-IoT CN sends an Inventory request message to the A-IoT enabled gNB

1b. The A-IoT enabled gNB allocates and coordinates usage of A-IoT radio resources.

1c/2a RRC communication with the A-IoT enabled UE takes place.

NOTE 1: RRC based communication is only depicted schematically, details subject to RAN2.

2. The A-IoT-enabled gNB sends an Inventory response message to the A-IoT CN.

NOTE 2: In step 2, the A-IoT-enabled gNB may instead send an Inventory failure message to the A-IoT CN indicating that the inventory procedure could not be initiated towards the A-IoT device(s).

3. The A-IoT-enabled gNB requests the A-IoT-enabled UE(s) to trigger inventory procedure towards the A-IoT device(s).

4a/4b. After receiving inventory result reported from the A-IoT enabled UEs, the A-IoT-enabled gNB may send one or multiple Inventory reports towards the A-IoT CN including the received inventory result.

NOTE 3: Steps 4a/4b may happen in parallel with Step 3 for different A-IoT devices.

NOTE 4: Step 4a/4b between A-IoT-enable UE and A-IoT-enabled gNB subject to RAN2.

##### 6.5.3.1.2 NAS/UP based solution

Editor’s Note: Whether and which of the following options on CN triggered A-IoT session resource allocation and UE triggered A-IoT session resource allocation will be finally considered needs further discussion involving other WGs as needed.

###### NAS/UP based solution – A-IoT CN triggered A-IoT session resource allocation



Figure 6.5.3.1.2-1: Message flow A-IoT Inventory in Topology 2 - NAS/UP based solution – A-IoT CN triggered A-IoT session resource allocation

This option is characterised by the A-IoT enabled gNB receiving the request to establish A-IoT session resources by the A-IoT CN.

0a. The A-IoT CN requests A-IoT session resources.

0b. The A-IoT enabled gNB coordinates A-IoT radio resources and allocates A-IoT radio resources to the A-IoT enabled UE accordingly.

0c. The A-IoT enabled gNB confirms the request for A-IoT session resources.

NOTE 1: In step 0c, the A-IoT-enable gNB can reject the request for A-IoT session resource.

1. The A-IoT CN sends an Inventory request message to the A-IoT-enabled UE.

2. The A-IoT-enabled UE(s) sends an Inventory response message to the A-IoT CN.

NOTE 2: In step 2, the A-IoT-enabled UE may instead fail the Inventory request.

3. The A-IoT-enabled UE performs the inventory procedure towards the A-IoT device(s).

4/4b. The A-IoT-enabled UE may send one or multiple Inventory reports towards the A-IoT CN including the received inventory result.

NOTE 3: Steps 4/4b may happen in parallel with Step 3 for different A-IoT devices.

###### NAS/UP based solution – A-IoT enabled UE triggered A-IoT session resource allocation



Figure 6.5.3.1.2-2: Message flow for A-IoT Inventory in Topology 2 (if - NAS/UP based solution is used) – A-IoT enabled UE triggered A-IoT session resource allocation

This option is characterised by the A-IoT enabled gNB receiving the request to establish A-IoT session resources by the A-IoT enabled UE.

Additional means to enable the AIoT CN to provide AIoT session related information directly to the AIoT enabled gNB, not shown in Figure 6.5.3.1.2-2, may be needed.

1. The A-IoT CN sends an Inventory request message to the A-IoT-enabled UE.

1a. The A-IoT enabled UE request A-IoT radio resources from the A-IoT enabled gNB.

1b. The A-IoT enabled gNB coordinates A-IoT radio resources and allocates A-IoT radio resources to the A-IoT enabled UE accordingly.

1c. The A-IoT enabled gNB responds the A-IoT radio resources to the A-IoT-enabled UE.

NOTE 5: In step 1c, the A-IoT-enable gNB can reject the A-IoT radio resource request. Details w.r.t. steps 1a and 1c are subject to RAN2 discussions.

2. The A-IoT-enabled UE sends an Inventory response message to the A-IoT CN.

NOTE 6: In step 2, the A-IoT enabled UE may instead send an Inventory failure message to the A-IoT CN indicating that the inventory procedure could not be initiated towards the A-IoT device(s), and the procedure ends.

3. The A-IoT-enabled UE(s) performs the inventory procedure towards the A-IoT device(s) over the A-IoT radio interface.

4/4b. After receiving inventory result reported from the A-IoT device(s), the A-IoT-enabled UE may send one or multiple Inventory reports towards the A-IoT CN including the received inventory result.

NOTE 7: Steps 4/4b may happen in parallel with Step 3 for different A-IoT devices.

#### 6.5.3.2 Candidate procedures for A-IoT Command for Topology 2

##### 6.5.3.2.1 RRC based solution



Figure 6.5.3.2-1: Message flow for A-IoT Command in Topology 2 (RRC-based solution)

1. The Inventory procedures are performed in step 1, which are the same as in Figure 6.5.3.1.1-1 in step 1-4.

NOTE 1: Step 1 is performed for the “A-IoT Inventory and Command” case, Whether and under which conditions step 1 may be skipped in case of “Command-only” and which consequences this would have for the overall message flow depends on discussions led by SA2, SA3 and RAN2.

NOTE 2: Whether and which way steps 2a, 2b and 2c may be part of step 1 is dependent on discussions led by SA2, SA3 and RAN2.

2a. The A-IoT CN sends a Command Request message to the A-IoT enabled gNB.

2b. The A-IoT enabled gNB coordinates A-IoT radio resources and allocates A-IoT radio resources to the A-IoT enabled UE accordingly.

2c. The A-IoT enabled gNB sends a RRC Command Request message to the A-IoT enabled UE.

NOTE 3: RRC based communication, i.e., performing the A-IoT Command procedure and allocation of A-IoT radio resources, is only depicted schematically, details subject to RAN2.

3. The A-IoT-enabled UE performs A-IoT command procedures at A-IoT interface towards the A-IoT device over the A-IoT radio interface.

4a. A-IoT enabled UE sends a Command Response message to A-IoT enabled gNB, if the command result is received from A-IoT device, the A-IoT enabled UE may include the command result in the Command Response message.

4b. The A-IoT enabled gNB sends a Command Response message to the A-IoT CN, it may include the command result in the Command Response message, if any.

NOTE 4: In step 4b, the A-IoT enabled gNB may instead send a Command Failure message to the A-IoT CN indicating that the command procedure is failed towards the A-IoT device.

##### 6.5.3.2.2 NAS/UP based solution

The A-IoT Command procedure also applies to the NAS/UP based solutions, and the AIoT Command procedure signallings are exchanged between the A-IoT enabled UE and the AIoTF over UE’s NAS/PDU session. The A-IoT session resource allocation steps described in 6.5.3.1.2 also applies to this procedure.

Next Change

## 6.10 DO-A assessment

*Editor’s note: This clause will capture the statements from any WG.*

The study included an assessment of whether the harmonized air interface design can address the DO-A use case, only to identify which part(s) of the harmonized air interface design is/are not sufficient for the DO-A use case.

From the RAN1 perspective, at least the following aspect of the air interface for DO-DTT and DT traffic types is not sufficient for the DO-A traffic type: For DO-DTT and DT traffic types, the D2R resource(s) for D2R transmission is/are indicated in a R2D transmission, but this is not applicable at least for the first D2R transmission for DO-A traffic.

The study focusses on the traffic types of DO-DTT and DT. From RAN2 perspective, the DO-A traffic type/use case cannot be supported with the current design in the study item. It is assessed that, from RAN2 perspective, at least the A-IoT paging is an aspect/part of the current design which is not sufficient for the DO-A use case.

Next Change

# 8 Conclusions and recommendations

From RAN2 perspective, RAN2 has studied Topology 1 and Topology 2, and has concluded they are feasible. In details:

- General AS procedures, A-IoT paging, A-IoT random access, A-IoT data transmission and Topology 2 aspects have been studied:

- See sub-clause 6.3.1 for the overall AS procedure and the information useful to be visible to the reader from CN, etc.

- See sub-clause 6.3.3 for the A-IoT paging function, including paging message content, paging monitoring behavior, multiple (subsequent) A-IoT paging messages for the same service, etc.

- See sub-clause 6.3.4) for the A-IoT random access, including the contention-free access and contention-based random access procedure, the message contents, the re-access solutions, etc.

- See sub-clause 6.3.2 and 6.3.5 for protocol stack for A-IoT radio interface between A-IoT device and reader, required functionalities, and A-IoT data transmission functionalities, etc.

- See sub-clause 6.3.6 for the Topology 2 specific aspects, including the architecture options and management of radio resources in A-IoT radio interface, etc.

- From RAN2 perspective, the descriptions under clause 6.3 and 6.10 are considered as the baseline conclusions.

- Following is further recommend/concluded:

- At least following features are recommended for the normative phase in the A-IoT MAC layer:

- A-IoT paging

- A-IoT random access:

- For contention-based random access, further down-selection between *Solution 1* (3step-only) and *Solution 3* (unified solution) in sub-clause 6.3.4.

- Essential functions for A-IoT data transmission

- If Topology 2 is to be considered in the normative phase, at least the following aspects are recommended:

- Forwarding of A-IoT upper layer data and A-IoT radio resource management.

- No further down-selection for Topology 2 architecture options (which are feasible) from RAN2 perspective (the final decision depends on TSGs outcome).

End of Change