3GPP TSG-RAN WG1 Meeting #118bis  R1-2409244

**Hefei, China, 14th – 18th October, 2024**

**Agenda Item: 9.4.2.2**

**Title: Final FL summary on frame structure and timing aspects for Rel-19 Ambient IoT**

**Source: Moderator (vivo)**

**Document for: Discussion, Decision**

# Introduction

This is the Final feature lead (FL) summary for agenda item (AI) 9.4.2.2 of frame structure and timing aspects for Rel-19 study item (SI) on solutions for Ambient IoT (Internet of Things) in NR.

**Next meeting will be the final session for the Rel-19 A-IoT SI. According to FL’s understanding, the remaining issues for agenda 9.4.2.2 are following:**

1. **Capture in the TR the observations regarding the trade-offs analysis among the four D2R amble options based on input from companies.**
2. **Study whether additional signal is necessary or not for frequency calibration** **for device 2b.**
3. **Update the TP in R1-2409187 endorsed in principle for section 6.2 and Annex X of TR38.769 for energy harvest, if any.**

**Note that during the meeting, it was mentioned that the unit for resource allocation in time domain will be discussed in AI 9.4.2.1 General aspects.**

# Synchronization

## R2D time synchronization

### Preamble

RAN1#118 made the following agreement related to R2D synchronization:

|  |
| --- |
| Agreement (from agenda item 9.4.2.3)  For the start-indicator part of the R2D time acquisition signal, ON/OFF pattern i.e. high/low voltage transmission is applied   * FFS: length/pattern of ON/OFF. * FFS: when TD2R\_min is applicable, whether/how the start-indicator part is included in TD2R\_min or not. To be discussed in 9.4.2.2 |

TD2R\_min is defined as the “Minimum time between a D2R transmission and the corresponding R2D transmission following it” at RAN1#116 meeting.

* [2], [4], [9], [10], [13], [18] proposed that start indicator part is not included in T\_D2R\_min.
  + [4], [10] since it does not have a significant impact on the R2D transmission latency.
  + [13] complicate the design if whether/how to exclude the start-indicator part is considered.

**FL1/FL2 High priority Proposal 3.1.1: The start indicator part of the R2D time acquisition signal is not included in TD2R\_min.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | As the agreement indicates, T\_D2R\_min does not include the R2D transmission following a D2R transmission.   * TD2R\_min: Minimum Time between a D2R transmission and the corresponding R2D transmission following it. |
| Vivo1 | Y | TD2R\_min is mainly related to the processing time restriction and transmission delay control of the device for R2D reception. In our understanding, the start indicator part is not directly related to the processing time and transmission delay of R2D. |
| ZTE Corporation, Sanechips | Y | The TD2R\_min is used for the device to prepare for receiving the R2D signal, and the SIP is part of the R2D transmission. As it is cited by QC, the TD2R\_min is defined between the minimum time gap between DR2 and R2D transmission, hence, it should not be included in TD2R\_min. |
| xiaomi | Y |  |
| CMCC | Y | Based on our observation and analysis on the start-indicator part design, seems no strong motivation to include the start indicator part especially the high voltage part in the T\_D2R,min |
| OPPO | Y | Since the start indicator part is already a part of R2D transmission of time acquisition signal, it should not be considered as part of TD2R\_min. |
| FUTUREWEI | Y |  |
| Samsung | Y |  |
| TCL | Y |  |
| DCM | ~~[N]~~ | ~~Motivation of T~~~~D2R\_min~~ ~~includes time to prepare R2D RX (e.g., TX/RX switching time), is this correct understanding? If YES, T~~~~D2R\_min~~ ~~should be defined such that device can start to monitor the start indicator part, i.e., this proposal seems to be invalid. If NO, this proposal may be OK.~~ |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| Lenovo | Y |  |
| LG | Y |  |
| Tejas Networks | Y | The start indicator for R2D time acquisition signal should be included in TR2D\_min |
| Huawei, HiSilicon | Y | Since the high-voltage part can be of a very short duration as it is required only for the device to detect a falling edge to determine the start of the low-voltage part, it does not have a significant impact on the overall inventory latency.  Another issue is that if a detection threshold determination part prior to the high-voltage part is included, it has to be within the start indicator part for the device to determine the detection threshold. |
| NEC | Y |  |
| ETRI | Y |  |
| Ericsson | Y |  |
| IITK, IITM | Y |  |
| DCM2 | Y | If this intends:  **The start indicator part of the R2D time acquisition signal is not included in [0, TD2R\_min],**  we are fine with this (though we feel that clearer text is better). |

### Time tracking using line coding

Most companies share the view that for R2D transmissions, in addition to the R2D timing acquisition signal, the device uses line codes to achieve chip-level time tracking by using the transition(s) in each codeword of the line code. Therefore, the following observation can be made:

**FL1 High Priority Proposal 3.1.2: it is observed that for R2D transmissions the device can use line codes to achieve chip-level time tracking by using the transition(s) in each codeword of the line code.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | We suggest following update:  **it is observed that for R2D transmissions the device can use line codes to achieve at least chip-level time tracking by using the transition(s) in each codeword of the line code.**  The purpose of the above suggestion is not to exclude more precise synchronization (e.g., sample-level synchronization = SFO correction, RF frequency-level synchronization = CFO correction) by using the transition(s) in each codeword of the line code. |
| Vivo1 | Y | We think this is the nature of line coding |
| ZTE, Sanechips | Y | Agree with the update by QC. |
| xiaomi | Y with comments | It should be clarified that this is decoupled with the clock calibration issue, which means even the device can track timing by using some R2D transmission, the accuracy of clock timing can still be 10^5 ppm. |
| CMCC |  | We would like to clarify the intention of this proposal:  Understanding 1: This observation is to capture the feature of R2D line code that as it is self-clocking, by using the transition(s) of each codeword, the device R2D reception is SFO robust. Then, further conclusion may be made based on this observation that midamble is not needed in R2D link.  Understanding 2: This observation is to guide the discussion regarding SFO and/or CFO correction, and it indicates that device is able to correct SFO to a certain accurate level using line code transition edges.  We are fine with Understanding 1, and if it is the intention of this observation, then we suggest refining it more precisely to avoid confusion. For example, **it is observed that for R2D transmissions the device can use ~~line codes to achieve chip-level time tracking by using~~ the transition(s) in each codeword of the line code for R2D reception, which is robust to SFO.**  For Understanding 2, we think it is too early to have such misleading observation, and we can directly discuss under Section 3.2.1. |
| OPPO | Y | Agree with QC’s understanding and suggested medication by adding “at least”. |
| FUTUREWEI | Y |  |
| Samsung | Y |  |
| TCL | Y |  |
| DCM | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y | We also agree QC’s update. |
| Lenovo | Y | Agree to add ‘at least’ |
| Tejas Networks | Y |  |
| Huawei, HiSilicon | Y | The embedded clock information in line codes e.g., in Manchester codes, helps the device to track chip-level timing. As there is always at least one transition within each codeword of line code, the device can utilize the transition(s) to continuously refresh its timing reference point for time tracking. |
| NEC | Y with comments | We suggest the following modification:  **it is observed that for R2D transmissions the device can use line codes to achieve chip-level time tracking by using the transition(s) in each codeword or between codewords of the line code.**  For example, for PIE code, the end of each codeword (i.e. bit “1” or “0”) will be low, and the beginning of next codeword will be high, and such transition can also be applied. |
| ETRI | Y | Agree with QC’s update. |
| **Based on the comments, the following updated proposal can be considered.**  **FL2 High Priority Proposal 3.1.2a: it is observed that for R2D transmissions the device can use line codes to achieve at least chip-level time tracking by using the transition(s) in each codeword or between codewords of the line code.** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| Vivo2 | Y |  |
| Ericsson | Y |  |
| IITK, IITM | Y |  |
| DCM | Y |  |
| TCL | Y |  |

### Others

#### Additional ‘ambles’

**R2D Midamble**

* [4], [5], [6], [7], [9], [10], [12], [16], [17], [28], [36], [38] proposed R2D transmission without midamble is studied as baseline
  + [10]: PIE is self-clocking encoding schemes, which is the same as Manchester, it is not necessary to additionally insert midamble between R2D transmissions for timing acquisition for PIE.
* [8] and [27] proposed to further study the midamble for A-IoT R2D transmissions with PIE encoding.
  + [27] For PIE encoding, a chip can be easily confused between 0 and 1 when the received signal strength is weak, given a larger coverage target of A-IoT compared to RFID, and in the presence of interference. The error will propagate in decoding the rest of the received signal. So, the study should include whether/how interference impacts the synchronization maintenance performance of R2D transmission.

Considering companies’ interests, following low priority proposal can be considered.

**FL1 Low Priority Proposal 3.1.3-1: R2D transmission without midamble is studied as baseline.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| ZTE, Sanechips | Y |  |
| CMCC | Y |  |
| Samsung | Y for Manchester.  N for PIE. | For R2D transmissions, midamble may be not needed if Manchester encoding is used, but for PIE, the necessity of midamble needs further discussion. At first, the impact of synchronization drift for Manchester encoding and PIE can be different. Manchester encoding uses code chips with fixed length and encodes information by transitioning between different voltage levels, wherein the voltage-level transition timings can be utilized to distinguish codeword boundary and, therefore, it is advantageous to maintain synchronization. On the contrary, PIE indicates information by varying pulse lengths and, therefore, the received signal itself cannot be directly utilized for timing acquisition. |
| Spreadtrum | Y |  |
| LG | Y |  |
| Tejas Networks | Y | The midambles can be added for higher message size. But the baseline approach should be without midambles. |
| Huawei, HiSilicon | Y |  |
| ETRI | Y |  |

**R2D Postamble**

* [27] observed that given the possible clock drift at a device, it may be still beneficial to also attach postamble at least for the determination of the end of PRDCH at a device.
* While [9], [12], [15], [28], [30], [38], [36] think the need of R2D postamble is not identified at least for the purpose of timing tracking.
* if Manchester Coding is supported, it allows for precise timing tracking with each ON-OFF transition, which can correct timing errors, hence R2D postamble used for timing tracking is not needed.

The discussion on R2D postamble used for time tracking can be postponed till the decision on necessity on R2D midamble for time tracking is made. Noe that whether to support the R2D postamble used for device to identify the end of PRDCH transmission is discussed in section 6.2.2 of this document.

#### Periodic synchronization signal

In addition to the already agreed “A R2D timing acquisition signal (e.g. R2D preamble) is included at least for timing acquisition and for indicating the start of the R2D transmission in time domain.”, whether to support periodic signal during the A-IoT communication (inventory or command) from device perspective, companies’ views are following:

* **A dedicated periodic signal has not been justified compared to other designs for Rel-19, and is not necessary or deprioritize the periodic signal for the study** [4], [7], [10], [11], [22], [27]
  + A-IoT device may not be able to maintain synchronization and timing with the network since it is in a power-off state for charging in most of the time.
  + Large resource overhead by dense periodic sync. signal transmission to compensate the large SFO
  + Additional power consumption at both device and reader side
  + More specification efforts for periodic sync. signal design and device behaviors/procedures

* **May need to study the periodic signal** [2], [8], [15], [30], [33], [34], [37]
  + Extend device availability time and reduce the outage probability
  + Minimize access collisions among the devices, improve the inventory efficiency
  + At least applied to active device
  + To support DO-A traffic

**FL1 Low Priority Proposal 3.1.3-2: An asynchronous system design for Ambient IoT is studied as baseline.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| ZTE, Sanechips | Y |  |
| CMCC | Y |  |
| Samsung | Y | We do not support any periodic signal for A-IoT, which is against the design principle that RAN1 has been studying.  On the other hand, we support to study a TDM(A) in an asynchronous system, wherein PRDCH transmissions provide a timing reference for transmission and reception in an aperiodic manner. |
| Lenovo |  | In addition on-demand synchronization like signal should not be precluded  Periodic signals may not be needed. |
| LG | Y |  |
| Huawei, HiSilicon | Y | However, it is not necessary to discuss this proposal. It is a consequence of other agreements already. |

## D2R time synchronization

### 3.2.1 SFO correction accuracy for device

For D2R time synchronization, following issues are discussed based on contributions.

* Issue#1: Whether/how device can calibrate the clock?
* Issue#2: What is the SFO accuracy after clock calibration at device side?
* Issue#3: What and how to achieve the SFO accuracy at the reader side?

**Note that the CFO for device 2b is discussed in section 3.2.2.**

#### Issue#1: Whether/how device can calibrate the clock

* [2], [3], [9], [11], [13], [14] basically agreed with the proposal presented in FLS R1-2407532 at RAN1#118 meeting.

|  |
| --- |
| **FL3 High Priority Proposal 3.1-1c: Study following two options of time/frequency synchronization for D2R transmission and reception.**   * **Option 1: device transmits D2R with an initial SFO/CFO. Reader estimates the time/frequency error of the received D2R transmission for detection/demodulation/decoding.**    + **FFS: how D2R transmission should be designed to facilitate reader’s estimation of the time/frequency error of the received D2R transmission** * **Option 2: device calibrates the device clock for D2R transmission by using R2D signal/channel and transmits D2R with a potential residual SFO/CFO. Reader estimates the time/frequency error of the received D2R transmission for detection/demodulation/decoding.**    + **FFS how device calibrates the clock based on a R2D signal/channel and what is theachievable accuracy.**     - **e.g., a device updates the number of clock samples for a D2R chip/bit without changing the clock frequency**   + **FFS how R2D signal should be designed to facilitate the clock calibration at the device**   + **FFS how D2R transmission should be designed to facilitate reader’s estimation of the time/frequency error of the received D2R transmission**   **Note: the complexity of calibrating the device clock should be minimized** |

* + [2], [3], [14] support to study and capture both the options in the TR.
  + [11] prefers option 1 as baseline.
  + [13] prefers option 2.
* [4] observed following
  + Device 1 and 2a can perform clock compensation by counting the samples within a pre-defined duration, but cannot perform the conventional clock calibration procedure based on the frequency offset estimation and correction by using e.g. a voltage-controlled oscillator (VCO).
  + Device 2b can perform clock calibration by adjusting its clock frequency using a local oscillator.
* [9] observed that device 1 calibrates the clock by for example updating the number of clock samples for a D2R chip/bit without changing the clock frequency
* [14] proposed RAN1 should clarify the definition of the “clock calibration” operation on a device and the definition of the clock calibration on a device could be,
  + Definition 1: the device updates the number of clock samples within a chip/bit according to the received R2D signal and cannot change the clock frequency.
  + Definition 2: the device changes the clock frequency according to the received R2D signal and locks the changed clock frequency.
* [24] discussed the meaning of "calibration" is different depending on the devices and proposed that the D2R transmission is calibrated signal by using R2D signal/channel.
  + For device 1 and 2a without large frequency shift: calibration based on VCO as analogue domain oscillator calibration increases the device power consumption and complexity. Counter and digital logic can be used to calibrate transmission waveform. e.g., rectangular wave to be multiplied as reflection wave periodicity is adjusted based on R2D signal/channel counting/calibration.
  + For device 2a with large frequency shift and 2b: in addition to the calibration by the digital logic, VCO based calibration is necessary as large frequency shift and LO for carrier frequency requires VCO based calibration.
* [27] views that a device calibrates the device clock for D2R transmission by using R2D signal/channel and transmits D2R with a potential residual SFO/CFO
* [33] Device performs D2R resource determination and D2R TX based on post-sync SFO, which is updated by monitoring/reception of the latest R2D sync signal.
* [34] discussed the framework of device SFO correction (clock calibration) and proposed following:
  + Device SFO correction (clock calibration) via R2D is possible by following way:
    - R2D transmission has a specific time duration *T* that a device knows the corresponding number of clock counts, *N*, with the ideal clock frequency. A device measures the time duration *T* by the actual local clock with an SFO, which is *N* +*N*. Then the device clock frequency can be estimated as where is the ideal clock sampling frequency.
    - For D2R, the device knows the number of clock counts per D2R chip, *X*, with the ideal clock frequency. Based on the measurement of the time duration T in R2D, the device adjusts the number of clock counts per D2R chip as .
      * Instead, it is possible to adjust the sampling clock frequency by the factor of using DCO as reported in [39].
  + R2D signal/channel should be designed to enable device SFO correction (clock calibration) over the time duration *T*, where the SFO correction (clock calibration) could be done:
    - Opt.1: based on Clock-acquisition part (CAP) of R2D preamble
    - Opt.2: based on Clock-acquisition part (CAP) of R2D preamble and PRDCH



(a) Opt.1: CAP is designed to enable SFO correction



(b) Opt.2: In addition to CAP, PRDCH is designed to enable SFO correctio

Fig. 3.3.1-2 Framework options of SFO correction (clock calibration) via R2D in [34]

* + To enable SFO correction (clock calibration), careful design discussions are necessary on:
    - CAP length/design and its length
    - R2D waveform such as line coding, CP handling
    - R2D transmission bandwidth for a given value of M

#### Issue#2: What is the SFO accuracy after clock calibration at device side?

**There is a Note in following working assumption on [0q] (sampling frequency) in link level simulation agreed in RAN1#117 meeting.**

* Note: Accuracy can be improved after clock calibration for at least device 2.  FFS applicable for device 1

|  |
| --- |
| **Working assumption on [0q] (sampling frequency) in link level simulation table**  Companies to report the Sampling frequency (e.g., 1.92Msps or other feasible values if any)  Initial SFO (Sampling Frequency Offset) (Fe):   * (M) Randomly select a value from the range of [0.1 ~ 1] \*10^4 ppm for device 2, * (M) Randomly select a value from the range of [0.1 ~ 1] \* 10^5 ppm for device 1, * (O) Randomly select a value from the range of [0.1 ~ 1] \*10^5 ppm for device 2, * FFS: Optionally evaluate a fixed value SFO for device 1 and 2 * Note: For random selection, the value is randomly selected per simulation drop, according to a uniform distribution * Note: Above values are only for sampling purpose. * FFS other values * Note: Above assumptions are only for LLS evaluation purpose only for R2D and [D2R].   The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T.   * Note: Accuracy can be improved after clock calibration for at least device 2.  FFS applicable for device 1 * Note: SFO after clock calibration can be applied to Fe. * FFS other models   CFO for device 2b.   * [100ppm/200ppm/1000ppm, 0.1ppm/s]”   Note: Above assumptions are for LLS evaluation purpose only  Agreement (RAN1#117)  Study whether/how an A-IoT device can count the time with sufficient accuracy (with a certain timing error due to SFO) at least for the purposes related to TDM(A) (if needed), and if so for how long after receiving an R2D transmission. |

**The understanding on the FFS whether/how the accuracy can be improved after clock calibration for device 1 has at least following impacts and hence RAN1 should discuss residual timing error values after synchronization signal detection [8].**

* **The R2D preamble/PRDCH design**
* **The D2R preamble design**
* **The amount of D2R midambles**
* **The feasibility and efficiency of FDMA and TDMA of multiple D2R transmissions**

From contributions,

* [4] proposed that, for D2R timing acquisition, device 1/2a is expected to perform clock compensation to achieve a residual SFO of up to 10^5ppm, while device 2b performs clock calibration to achieve a residual SFO of 10 ~ 100 ppm.
* [9] observed two views/options and summarize the pros and cons in Table 2-1
  + Option 1 is the device transmits the D2R with the SFO from the range of [0.1 ~ 1] \* 10^5 ppm for device 1 as agreed for LLS that the value for initial SFO
  + Option 2 is the device transmits the D2R with improved SFO accuracy which is smaller than the option 1

Table 2-1 Summary of pros and cons of each option on SFO accuracy for D2R transmission after device calibrates clock in [9]

|  |  |  |
| --- | --- | --- |
| **Options** | **Pros** | **Cons** |
| Option 1 | * Relaxed timing accuracy requirement for device * R2D preamble can be designed simpler and less overhead * Less complexity and/or power consumption for device to detect R2D preamble | * Strict timing accuracy requirement for reader * May complex D2R Preamble design with more overhead * D2R Midamble/Postamble may need to be introduced for SFO estimation * Increase reader side processing/buffering complexity if postamble is used * May reduce the efficiency for FDMA of D2R transmissions |
| Option 2 | * Loose timing accuracy requirement for reader side * D2R Preamble can be designed simpler and less overhead * D2R Midamble/Postamble may not be necessary for SFO estimation * Decrease reader side processing/buffering complexity without postamble * May enhance the efficiency for FDMA of D2R transmissions | * Strict timing accuracy requirement for device * May complex R2D Preamble design with more overhead * Higher complexity and/or power consumption for device to detect R2D preamble |

* [12] proposed the clock-acquisition part (CAP) of R2D preamble should at least include 16 chips to obtain the 5% sample error rate performance based on the evaluation in figure 2 below

图表

描述已自动生成

Figure 2: The performance of sample error rate (SER) of [12]

* [30] provided the evaluation in figure 3-1 below and proposed that from data reception performance perspective, **residual SFO requirement after device receiving R2D preamble can be set to 10000 PPM**, given device can track the PRDCH timing along the processing of Manchester on-off chips.



Figure 3‑1: R2D data reception robustness by timing tracking based on Manchester coding of [30]

* [34] present detailed analysis and evaluations on device SFO impacts on reader’s complexity to handle very large SFO for D2R demodulation, impact of large SFO on efficiency of D2R TDMA, impact of large SFO on efficiency of D2R FDMA etc and propose to enable SFO correction (clock calibration) by device before D2R transmission. Following are the observations and proposals from [34].
  + Observations
  + On reader’s complexity to handle very large SFO for D2R demodulation based on evaluations in Figs 3.2.1-3 and 3.2.1-4 of [34]
    - With SFO of [0.1 – 1] \* 10^5 ppm, it would be difficult for a reader to estimate the device clock frequency with the accuracy of 10^3 ppm or lower based on the D2R preamble
      * The target accuracy would not be achievable with testing less than 50 SFO hypotheses
    - With SFO of [0.1 – 1] \* 10^4 ppm, a reader is able to estimate the device clock frequency with the accuracy of 10^3 ppm or lower, based on the D2R preamble, by testing less than 8 SFO hypotheses
    - Therefore, for estimating device SFO at reader based on D2R preamble, SFO smaller than [0.1 – 1] \* 10^5 ppm is essential
    - Using D2R postamble requires the reader to store (I, Q) samples of the overall D2R transmission and wait channel estimation, demodulation, and decoding, until the clock frequency estimation using D2R postamble is completed and disallow a reader to process the D2R in pipeline manner
  + Impact of large SFO on efficiency of D2R TDMA
    - SFO of up to 10^5ppm leads to significant resource inefficiency for TDMA for D2R transmissions
  + Impact of large SFO on efficiency of D2R FDMA based on evaluations in Fig 3.2.3-2
    - Large SFO generates non-negligible inter-device interference for FDMAed D2R transmissions and degrades the performance of D2R even if reader can ideally estimate the SFOs of FDMed devices.
    - With SFO of [0.1 – 1] \* 10^5 ppm, inter-device interference caused by SFO causes BLER floor for some frequency shifts and therefore, the devices with the frequency shifts cannot achieve BLER = 1%
    - With SFO of 0.5 \* [0.1 – 1] \* 10^4 ppm, the performance loss due to inter-device interference caused by SFO is up to more than 10 dB for BLER = 1%
    - With SFO of [0.1 – 1] \* 10^4 ppm, the performance loss due to inter-device interference caused by SFO is limited to 1 – 2 dB for BLER = 1%
    - For D2R FDMA, SFO smaller than [0.1 – 1] \* 10^5 ppm is essential
  + Propose to capture the following in the TR.
    - Device SFO of [0.1 – 1] \* 10^5 ppm causes various issues and limitations of A-IoT D2R:
      * High reader complexity is unavoidable for SFO estimation/compensation at reader for D2R reception
      * Significant performance/efficiency loss for any of multiple access schemes (TDMA, FDMA, and CDMA)
    - It is reported that device SFO correction (clock calibration), targeting SFO of up to [0.1 – 1] \* 10^4 ppm, allows a reader to process D2R with a reasonable implementation complexity and improves performances for any of the multiple access schemes
* [34] provide evaluation on device SFO correction (clock calibration) accuracy and observed following:
  + It is possible for a device to achieve SFO <= 1% (10^4 ppm) by clock calibration via R2D using OOK envelope detector as long as time duration for clock calibration and R2D transmission bandwidth are sufficient
    - It is observed that the accuracy of SFO correction depends on the value of M for OOK, the time duration for clock calibration, and R2D transmission bandwidth
    - Longer time duration and wider bandwidth in general offers better accuracy
  + For larger values of R2D OOK M (e.g., 8, 12, 16), wider R2D transmission bandwidths than the ones agreed as starting point at RAN1#118 need to be considered for clock calibration via R2D
  + The evaluation result is summarized in Table 3.3.2-1 ~ 3.3.2-5, for reference only OOK4 M=4,8,16 is copied from [34].

Table 3.3.2-1 OOK-4 M=4, SNR 10dB, TDL-A 30ns

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Percentile that a device can achieve SFO <= 1% by clock calibration via R2D** | | | | | |
| **No. of OOK chips used for clock calibration** | **No. of OFDM symbols used for clock calibration** | **R2D transmission bandwidth** | | | |
| **1 RB** | **2 RBs** | **4 RBs** | **24 RBs** |
| 16 chips | 4 symbols | 99 % | 100 % | 100 % | 100 % |
| 40 chips | 10 symbols | 99 % | 100 % | 100 % | 100 % |
| 96 chips | 24 symbols | 97 % | 99 % | 99 % | 99 % |

Table 3.3.2-3 OOK-4 M=8, SNR 10dB, TDL-A 30ns

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Percentile that a device can achieve SFO <= 1% by clock calibration via R2D** | | | | | |
| **No. of OOK chips used for clock calibration** | **No. of OFDM symbols used for clock calibration** | **R2D transmission bandwidth** | | | |
| **1 RB** | **2 RBs** | **4 RBs** | **24 RBs** |
| 16 chips | 2 symbols | - | 97 % | 99 % | 100 % |
| 40 chips | 5 symbols | - | 98 % | 99 % | 100 % |
| 96 chips | 12 symbols | - | 98 % | 99 % | 100 % |

Table 3.3.2-5 OOK-4 M=16, SNR 10dB, TDL-A 30ns

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Percentile that a device can achieve SFO <= 1% by clock calibration via R2D** | | | | | |
| **No. of OOK chips used for clock calibration** | **No. of OFDM symbols used for clock calibration** | **R2D transmission bandwidth** | | | |
| **1 RB** | **2 RBs** | **4 RBs** | **24 RBs** |
| 16 chips | 1 symbols | - | 81 % | 89 % | 91 % |
| 40 chips | 2.5 symbols | - | 90 % | 92 % | 94 % |
| 96 chips | 6 symbols | - | 96 % | 96 % | 98 % |

#### Issue#3: How to achieve the SFO accuracy and what is the required SFO accuracy at the reader side?

Related to Issue#1 and Issue#2 that “FFS the applicability of “Accuracy can be improved after clock calibration” for device 1” discussed above, about how to achieve the SFO accuracy at the reader side for PDRCH reception, generally two options proposed by companies.

* **Option 1: Device 1/2a is expected to achieve a residual SFO from the range of [0.1 ~ 1] \* 10^5 ppm.**
* **Option 2: Device 1/2a is expected to achieve a residual SFO from the range of [0.1 ~ 1] \* 10^4 ppm.**

**For above both options, the reader estimates the time error of the received D2R transmission for detection/demodulation/decoding. Option 2 allows for a relaxed SFO estimation accuracy compared to Option 1 on reader side but requires higher SFO estimation accuracy at the device side.**

**The two options have different impacts on for example R2D preamble and/or D2R preamble, midamble, postamble design, additional complexity/power consumption is more at device side or reader side, the performance improvement and transmission efficiency for R2D and/or D2R etc.**

In detail,

* [10] observed following:
* Reader can search and detect the SFO by preamble and midamble/postamble, from 10% SFO to 0.05% residue SFO @ -3dB SNR TDL-A channel based on preamble and postamble, which is good enough for detection.
* Lower the required SFO estimation accuracy (e.g., 1%) at reader can provide 1-2 dB performance gain to higher SFO (e.g., 10%). However, it's also worth noting this comes with some trade-offs like increased device complexity and power consumption due to necessary implementation to calibrate.
* [11] provides the simulation result in figure 10 to compare the performance for SFO mitigation of case (i) where only preamble is used and case (ii) jointly using preamble + postamble. [11] observed that the “preamble + postamble” scheme has better performance on residual SFO elimination (from 10^4 level to 10^3 level at SNR=10dB) and about 3dB gain in SNR when the BLER is 10% compared with “preamble only” scheme.

图表, 折线图

描述已自动生成

Fig. 10 Comparison on residual SFO elimination performance b/w preamble only and preamble+postamble case of [11]

* [27] observed that for FDMA or CDMA cases, it is very challenging at the reader to adjust the clock based on multiple concurrent midambles received from different devices experiencing different clock drift and propose to study the impact of synchronization misalignment between devices and possible solutions for synchronization drift from multiplexed devices.
* [30] observed in the simulation figure 3-2 that to confine D2R data reception performance loss, smaller residual SFO is required for longer TBS transmission, as can be checked in the below figure (500 PPM for 96 bits, 100 PPM for 400 bits, and 50 PPM for 1000 bits)
* [30] To avoid excess time offset between R2D preamble and D2R preamble, RAN1 targets D2R preamble design with 90%-tiled estimated time error no larger than X us, X = [1].
* For A-IOT reader, comparing the estimated time offset between D2R preamble and R2D preamble with the known time offset can be used to derive and compensate SFO.
* Given X-us time error of D2R preamble detection by the reader and Y-us time offset between R2D and D2R preambles, D2R residue SFO can be derived as X/Y \* 10^6 PPM.
* At least support indicating time offset between R2D preamble and D2R preamble as Y\*X us, where Y = [2000], [10000], [20000] (and X = [1] as in the previous proposal). FFS explicitly or implicitly.

图表

描述已自动生成

Figure 3‑2: D2R performance w.r.t. different TBS and residue SFO values of [30]

* [34] presented in Figure 3.2.1-2 the evaluation result for D2R BLER performance with the presence of clock frequency error and observed that for D2R with coherent demodulation at reader, the reader needs to estimate the device clock frequency as accurate as 0.1% (10^3ppm) or lower.
  + the estimation error of less than 0.1% is necessary for a D2R transmission with 96 information bits with R = 1/2 convolutional code, and less than 0.5% is necessary for a D2R transmission with 20 information bits with R = 1/2 convolutional code.

图表, 折线图

描述已自动生成

Fig. 3.2.1-2 D2R BLER performance with the presence of clock frequency error in [34]

Considering all the discussions for Issue#1, #2 and #3, following one question on whether to capture one observation and one proposal are made:

**FL1 High Priority Question 3.2.1.1:**

* **Is it necessary to capture the following observation in the TR, or can we directly discuss Proposal 3.2.1.2 without capturing the observations?**
* **Note the observations does not imply that RAN1 will specify how a device should perform SFO correction, nor does it exclude other methods for a device to achieve SFO correction.**

**Observations 3.2.1.1:**

* **Observation #1: It is reported by [4], [9], [14], [24], [34] that device 1 can perform SFO correction (clock calibration) by updating the number of clock samples within a chip/bit according to the received R2D signal without changing the clock frequency.**
* **Observation #2: It is reported by [4] that device 1 and 2a cannot perform the conventional clock calibration procedure based on the frequency offset estimation and correction by using e.g. a voltage-controlled oscillator (VCO)**
* **Observation #3: It is reported by [24] that for device 1 and 2a without large frequency shift, calibration based on VCO as analogue domain oscillator calibration increases the device power consumption and complexity.**
* **Observation #4: It is reported by [34] that it is possible to adjust the sampling clock frequency using DCO as reported in [39].**
* **Observation #5: It is reported by [4], [24], [34] that device 2b can perform clock calibration by adjusting its clock frequency using a local oscillator.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Necessity on capture the observation 3.2.1.1 (Y or N)** | **Comments on above observations** |
| Qualcomm | Y | It is good to capture the observations as outcome of the study. |
| Vivo1 | Y | We think it is fair to capture companies’ observations. But if it is controversial to agree these observations, we can directly discuss Proposal 3.2.1.2 as FL suggested |
| ZTE, Sanechips | Y | It is better to capture the outcome of the study. Furthermore, we also provide the analysis about device’s behavior of clock calibration in our Tdoc. Therefore, the following update is suggested.   * **Observation #1: It is reported by [4], [9], [13],[14], [24], [34] that device 1 can perform SFO correction (clock calibration) by updating the number of clock samples within a chip/bit according to the received R2D signal without changing the clock frequency.** |
| xiaomi | Y |  |
| CMCC |  | We are fine to capture the observations, but some of them may need further discussion or refinement.  For example, regarding Observation #4, more details regarding the clock frequency adjustment using DCO, at least the additional power consumption introduced, can be further added in the observation to provide us a more objective views regarding different methods. |
| OPPO | Y |  |
| Samsung | N | In our understanding, SFO correction may not be critical for OOK ED, i.e., without SFO correction, a device can perform ED by adjusting a number of samples assumed in a given chip duration.  Therefore, it is more preferable to directly discuss Proposal 3.2.1.2 rather than spending time to discuss whether a device can perform calibration or not. |
| TCL | Y | Support capturing the observation into TR |
| DCM | Y |  |
| Spreadtrum |  | More prefer to discuss Proposal 3.2.1.2 directly. |
| Panasonic | Y |  |
| Lenovo | Y | We are fine to capture the observation, |
| Tejas Networks | Y |  |
| Huawei, HiSilicon | Not necessary to capture | We would like to clarify that in #1, device 1 CANNOT perform clock calibration but clock compensation, and hence would like to remove “clock calibration” in Observation #1.  **Observation #1: It is reported by [4], [9], [14], [24], [34] that device 1 can perform SFO correction ~~(clock calibration)~~ by updating the number of clock samples within a chip/bit according to the received R2D signal without changing the clock frequency.** |
| IITK, IITM | Y |  |
| **FL4: Based on the discussions in both 9.1.4.2 and 9.4.2.2 during this meeting, hope companies understand better on how device does the clock calibration/compensation. Based on the comments, no need to capture the above observations.** | | |

**FL1 High Priority Proposal 3.2.1.2: For device 1, RAN1 studies following two options of time synchronization for D2R transmission and reception.**

* **Option 1: device is expected to achieve a residual SFO target in the range of [0.1 ~ 1] \* 10^5 ppm.**
* **Option 2: device is expected to achieve a residual SFO target in the range of [0.1 ~ 1] \* 10^4 ppm.**
* **For both options, study aspects include at least following:** 
  + **FFS R2D signal/channel design to enable device to achieve the target residual SFO**
  + **FFS D2R signal/channel design based on the target residual SFO to facilitate reader’s estimation of the time error of the received D2R transmission, including the achievable accuracy at the reader side.**
  + **Implementation complexity, power consumption at device side and/or reader side**
  + **Performance and transmission efficiency**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | We believe it is important to design air-interface and procedure of A-IoT such that all device types are able to correct SFO via R2D reception such that residual SFO after the correction via R2D reception is at least 1% or lower. We support to discuss/study (1) how R2D should be designed to achieve device residual SFO <= 1% after the SFO correction via R2D reception, (2) achievable benefits from the device SFO correction via R2D reception, and (3) implementation complexity and feasibility. So, the proposal captures these aspects and hence we support the proposal.  We see there are views that the residual SFO should target <= 10%. The current FL proposal should be a good starting point capturing both viewpoints.  A couple of suggestions below. We also suggest to add Option 3 (for device 2).  **For device 1, RAN1 studies following two options of ~~time~~ synchronization via R2D reception ~~for D2R transmission and reception~~.**   * **Option 1: ~~device is expected to achieve a~~ residual SFO ~~target~~ is no more than ~~in the range of [0.1 ~ 1] \*~~ 10^5 ppm.** * **Option 2: ~~device is expected to achieve a~~ residual SFO ~~target~~ is no more than ~~in the range of [0.1 ~ 1] \*~~ 10^4 ppm.** * **Option 3: residual SFO is no more than 10^3 ppm.**   + **Note: Option 3 considers device 2 only** * **For all ~~both~~ options, study aspects include at least following:**    + **~~FFS~~ R2D signal/channel design to enable device to achieve the target residual SFO**   + **~~FFS~~ D2R signal/channel design that ~~based on the target residual SFO to~~ facilitates reader’s reception/process ~~estimation of the time error~~ of the ~~received~~ D2R transmission with the presence of the device residual SFO~~, including the achievable accuracy at the reader side~~.**   + **Implementation complexity, power consumption at device side and/or reader side**   + **Performance and ~~transmission~~ resource efficiency** |
| Vivo1 | Y | For QC’s updates, three options are for study  **For device 1, RAN1 studies following ~~two~~ three options of ~~time~~ synchronization via R2D reception ~~for D2R transmission and reception~~.** |
| ZTE, Sanechips |  | Okay with the update by QC. |
| xiaomi | Y with comments | We think option 1 is more feasible because the device 1 only have the capability to update the number of clock samples, which may have the SFO range of [0.1 ~ 1] \* 10^5 ppm. And we do not think it is suitable to design additional R2D signal/channel for clock calibration, which may bring more complexity and power consumption on the device. |
| CMCC | Y | We are fine to discuss this issue. As we clarified during the last meeting, and in our contribution, all device types are able to calibrate SFO at least based on counting sampling points. But the key issue here is that whether we need some additional R2D designs to allow the device to further improve SFO to a more precise accuracy, e.g., less than 1% for device 1. We should carefully study the necessity to do so, due to the additional complexity and power consumption introduced for devices. |
| OPPO | Y | Okay with the update by QC and Vivo1. |
| FUTUREWEI | Y |  |
| Samsung | Y |  |
| TCL | Y | For QC’s updates, option 1 and 2 is for device 1, option 3 is for device 2. So “**For device 1**” in the main bullet should be moved to sub-bullet. |
| DCM |  | Prefer the version by QC/vivo1. |
| Spreadtrum | Y |  |
| Panasonic | Y | Ok with QC’s update. |
| Lenovo | Y | Residual SFO <= 1% should take into consideration the payload size, for larger payload size like 400 bits we might need to even lower residual SFO < 0.5% |
| Huawei, HiSilicon | N | We do not agree that device 1 and 2a can achieve a residual SFO of 10^4 ppm, while device 2b can achieve a residual SFO of 10-100 ppm.  Keeping this in mind, we would prefer to rephrase the options based on the residual SFO achievable by the device types. |
| NEC | Y | We suggest to discussion applicability of each option. For example, option 1 for device 1 and device 2, and option 2 only for device 2. |
| Based on comments, the proposal is updated below  **FL2 High Priority Proposal 3.2.1.2a: RAN1 studies following options of synchronization via R2D reception**   * **Option 1: residual SFO is no more than 10^5 ppm.** * **Option 2: residual SFO is no more than 10^4 ppm.** * **Option 3: residual SFO is no more than 10^3 ppm.**   + **Note: Option 3 considers device 2 only** * **For above options, study aspects include at least following:**    + **R2D signal/channel design to enable device to achieve the target residual SFO**   + **D2R signal/channel design that facilitates reader’s reception/process of the D2R transmission** **with the presence of the device residual SFO**   + **Implementation complexity, power consumption at device side and/or reader side**   + **Performance and resource efficiency** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| Vivo2 | Y |  |
| Ericsson | Y |  |
| IITK, IITM | Y |  |
| DCM | Y |  |
| TCL | Y |  |
| Samsung | - | We think this needs to be discussed per device type. |
| As also discussed in AI 9.4.1.2, there was working assumption made in RAN1#117 meeting that  Initial SFO (Sampling Frequency Offset) (Fe):   * (M) Randomly select a value from the range of [0.1 ~ 1] \*10^4 ppm for device 2, * (M) Randomly select a value from the range of [0.1 ~ 1] \* 10^5 ppm for device 1, * Note: Accuracy can be improved after clock calibration for at least device 2.  FFS applicable for device 1   Based on the above working assumption and the received comments, the following can be considered.  **FL3 High Priority Proposal 3.2.1.2c: RAN1 studies following aspects for synchronization via R2D reception**   * + **R2D signal/channel design to enable device to achieve the target residual SFO**   + **D2R signal/channel design that facilitates reader’s reception/process of the D2R transmission** **with the presence of the device residual SFO**   + **Implementation complexity, power consumption at device side and/or reader side**   + **Performance and resource efficiency**   + **Note the target residual SFO is the accuracy after clock sync at device side that is discussed in AI 9.4.1.2** | | |
| **Company** | **Y/N** | **Comments** |
| DCM | Y |  |
|  | | |

**FL1 Low Priority Question 3.2.1.3:**

* **What is the residual SFO target for Device 2a?**
* **What is the residual SFO target for Device 2b?**
* **The question can first be addressed in AI 9.4.1.2, so it is marked as low priority.**

|  |  |  |
| --- | --- | --- |
| **Company** | * **For device 2a,** * **For device 2b,** | **Comments** |
| Samsung | - | This issue may be better discussed in 9.4.1.1 or 9.4.1.2. |
|  |  |  |
|  |  |  |

### 3.2.2 Carrier and frequency synchronization for device 2b

Fewer companies share the views on how device 2b handles carrier frequency synchronization and the accuracy it achieves.

* [15] observed that a reference carrier frequency would be needed for device 2b and propose to study whether a periodic R2D timing acquisition signal/preamble is sufficient, or a new / dedicated signal is needed to achieve the frequency synchronization accuracy for device 2b D2R transmissions.
* [34] proposed to capture the following in the TR:
  + For device 2a/2b, synchronization for carrier/large frequency is essential and identifying the solution is necessary.
  + Following two options are identified:
    - Opt.1: Introduce dedicated synchronization signal for synchronization for carrier/large frequency
    - Opt.2: Enable synchronization for carrier/large frequency using R2D OOK

**FL1 Low Priority Proposal 3.2.2: For device 2b, RAN1 studies following two options for carrier frequency synchronization:**

* **Opt.1: Introduce dedicated synchronization signal for carrier frequency synchronization**
* **Opt.2: Enable synchronization for carrier frequency using R2D signal/channel**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| ZTE, Sanechips |  | Duplicated with proposal 2.1.2-2 in 9.4.2.3 |
| CMCC |  | For this issue, we think that we should first clarify the intention to do CFO calibration, whether it is for reader to do coherent detection, or just to simply reduce the occupied BW. If it is the latter, then device can by implementation to calibrate its CFO to a level of tens of ppm, and no optional R2D design is required. |
| Samsung | Y | In our view, if the to-be-designed preamble signal (start-indicator part + clock-acquisition part) can support carrier frequency synchronization functionality for device 2b, option 2 will be a natural choice. Otherwise, we think an additional signal will be necessary for the preamble, e.g., preamble signal (start-indicator part + clock-acquisition part + training field). |
| Lenovo | Y |  |
| Tejas Networks | Y | Dedicated synchronization signal should be introduced |
| Huawei, HiSilicon |  | We prefer to define a separate CFO calibration signal. |
| Based on the CMCC’s comments, let’s first clarify by the following question  **FL3 High Priority Question 3.2.2-1: For device 2b, what is the purpose to calibration for CFO?**  **e.g., for the reader to do coherent detection, or just to simply reduce the occupied BW** | | |
| **Company** | **Comments** | |
|  |  | |
|  |  | |

**FL3 High Priority Proposal 3.2.2-2: For device 2b, RAN1 studies the following two options for carrier frequency synchronization:**

* **Opt.1: Introduce dedicated synchronization signal for carrier frequency synchronization**
* **Opt.2: Enable synchronization for carrier frequency using R2D signal/channel**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |

**FL4: following agreement was made in AI 9.4.1.2**

**Agreement**

For clock purpose #5, adopt following update.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| # | **Purpose** | **Clock**  **speed** | **Applicable**  **Device**  **types** | **Power  consumption** | **Initial clock**  **Accuracy**  **(ppm)** | **Accuracy after clock sync / calibration at device side (ppm)** |
| #5 | LO for carrier frequency (for up/down conversion) | According to carrier frequency e.g., 900 MHz | 2b | 10s ~ 100s uW | [10^~~2~~3 ~ 10^4] | Option 1: 10s (Note2)  Option 2: 100s (Note2) |
| Note 2: ~~Either internal clock counter for calibration clock counting based on at least R2D signals or clock counting based on transmission from reader~~ ~~Calibration is based on existing or new signal from reader. FFS how to calibrate (9.4.2.2).~~ No drastic temperature change is assumed during calibration. | | | | | | |

* Further study above options and strive to down select considering its implication on performance, system design, necessity, etc.
* Note: study of whether additional signal is necessary or not for calibration is discussed under agenda 9.4.2.2.

### 3.2.3 Midamble

Many companies proposed midamble is needed at least for the purpose of SFO tracking for the PDRCH with long transmission duration and it may not be necessary for PDRCH with small payload size and/or short transmission duration.

[4] provides the decoding performance of PDRCH reception for coherent detection with/without midamble with 10% SFO assumption as shown in Figure 10, and observes following:

* The midamble is essential when the packet size is large, e.g., >96bits with low overhead and obvious performance gain, while the midamble is not needed when the packet size is small, e.g., <96bits with a non-negligible overhead and non-obvious performance gain
* When a PDRCH that is 400-bit payload with a 16-bit CRC, with Manchester encoding and an 1/3 rate FEC encoder is evenly divided to 4 parts with 3 midambles and each part is no longer than 100ms, the simulation results shows no error floor at 10% and 1% BLER. Similarly, when the PDRCH is equally divided in to 3 parts with 2 midambles and each part is ~111 ms, the simulation results shows that there is an error floor at 1% BLER

图表, 折线图

描述已自动生成

Figure 1. The decoding performance of PDRCH reception with/without midamble from [4]

[5] observed from following evaluation result that with 10% SFO, for PDRCH with 400-bit payload and 16-bit CRC, midamble is needed to achieve 10% BLER target for reader using coherent detection.

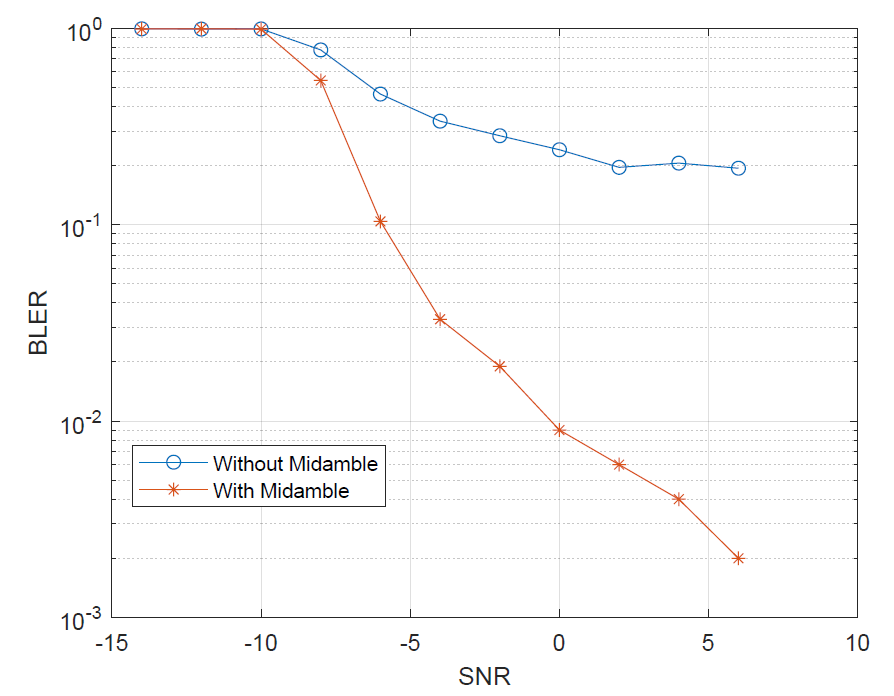


Figure 2.2.2.1-1. Simulation results of Midamble for 400bits message size from [5]

[9] provides evaluation on midamble used for timing correction and/or channel estimation purpose.

* **For timing correction**, it is observed that to achieve comparable SFO estimation accuracy and BLER performance as SFO estimation solely on preamble with 20 SFO hypotheses, 16 hypotheses on preamble is still needed even with further SFO update based on midamble/postamble. The benefit of using midamble/postamble for improving SFO and timing accuracy is limited, while additional complexity and overhead is high on midamble and postamble processing for SFO and timing refinement.

|  |  |
| --- | --- |
|  |  |
| 10dB SNR & TDL-A 30ns | (b) Mid/post-amble for sync/SFO Est (not for ChanEst) |

Figure 2.3-3 CDF of SFO estimation error in [9]

* **For coherent detection vs non-coherent detection,** it is observed that
  + For D2R transmission with sufficient midamble/postamble, 2~3 dB gain can be obtained from coherent detection at 10% BLER, at the expense of higher overhead and receiver complexity.
  + For D2R transmission with long duration,
    - Error floor can be observed even with the insertion of multiple midambles/postamble.
    - Performance of non-coherent detection may outperform coherent detection in high SNR region

|  |  |
| --- | --- |
| (a)96bits, ~6kbps, W/O SFO, ideal timing | (b)96bits, ~6kbps, W/ SFO, real timing/SFO estimation |
| (c) 400bits, ~6kbps, W/O SFO, ideal timing | (d) 400bits, ~6kbps, W/ SFO, real timing/SFO estimation |

Figure 4 Comparison between D2R w/o midamble/postamble vs D2R w/ midamble & postamble in [9]

[11] observes based on the following evaluation result that when a PDRCH that is 400-bit payload with a 16-bit CRC, with 1/2 Manchester encoding and 3 times Block level repetition, without the inserted midamble, the BLER cannot reach 0.1 even when the SNR is 15dB.



Figure 17 The simulation results comparison b/w w and w/o midamble cases for D2R transmission from [11]

[36] proposed D2R midamble for the other purpose, e.g., channel estimation or interference estimation is not considered.

[38] proposed the maximum TB size should be decided before designing the midamble.

**D2R midamble has been already discussed for several meetings. Let’s try following.**

**FL1 High Priority Proposal 3.2.3-1: For the D2R midamble, the following observations are captured in TR 38.769**

Observation #1: With up to 10% SFO, for a PRDCH with a 400-bit payload size and a 16-bit CRC, using 1/2 Manchester encoding and convolutional code of 1/3 coding rate or 3 times block level repetition:

* + It is observed by Source [4] that for coherent detection, using 3 midambles and 1 postamble is about 1 dB better at 10% BLER than using 2 midambles and 1 postamble, and it avoids an error floor at 1% BLER. The overhead for 3 midambles is 7.7%, which is acceptable for such large packet size.
  + It is observed by Source [5] and [11] that it is difficult to achieve a BLER of 10% when only preamble is used. When using a preamble and a midamble for channel estimation, BLER will significantly decrease and 10% BLER can be achieved.
  + It is observed by Source [9] that compared with non-coherent detection without any midamble/postamble, 2~3 dB gain can be obtained for coherent detection at 10% BLER with 4 midambles and 1 postamble, at the expense of 10% overhead and receiver complexity. The performance of non-coherent detection may outperform coherent detection in high SNR region for 1% or lower BLER.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | D2R postamble for reader’s SFO estimation has not been agreed. The evaluation results in the proposed observation include the cases where D2R postamble, as well as midamble is used. We suggest to split the cases to establish the observation.  More specifically, we suggest to formulate the observations as follows.  Observation #1: D2R preamble only   * It is observed by source [xx] that … * ..   Observation #2: D2R preamble + midamble   * It is observed by source [xx] that … * ..   Observation #3: D2R preamble + postamble   * It is observed by source [xx] that … * ..   Observation #4: D2R preamble + midamble + postamble   * It is observed by source [xx] that … * ..   We provided our evaluation results with D2R preamble only with SFO of up to 10% and up to 1% in [34]. We think our results should be captured under the observation for “D2R preamble only” as follows:  Observation #1: D2R preamble only   * Following is observed by Source [34]:   + With up to 10% device SFO for D2R transmission, for a D2R preamble with a sequence length of 7 chips or 15 chips, reader’s device SFO estimation error cannot be lower than 0.1% for any SNR unless reader is able to test more than 50 SFO hypotheses using correlation for the D2R preamble.   + With up to 1% device SFO for D2R transmission, for a D2R preamble with a sequence length of 7 chips or 15 chips, reader’s device SFO estimation error can be lower than 0.1% even for SNR lower than 0dB as long as reader tests 6 SFO hypotheses using correlation for the D2R preamble.   + For coherent reception of BPSK modulated PDRCH with 20 information bits with convolutional code of 1/2 coding rate, reader’s device SFO estimation error of 0.1% does not cause BLER performance degradation compared to the case where reader’s device SFO estimation error is 0%.   + For coherent reception of BPSK modulated PDRCH with 96 information bits with convolutional code of 1/2 coding rate, reader’s device SFO estimation error of 0.05% does not cause BLER performance degradation compared to the case where reader’s device SFO estimation error is 0%. |
| Vivo1 | Y | We think it is fair to capture companies’ observation at study phase |
| ZTE, Sanechips | Y | (1)it is observed that in addition to code rate, repetition times, the data rate is also an important metric that determines that need of midamble, which should be captured in the observation as well.  (2) our evaluation results of midamble/postamble/preamble can be found in R1-2408069 submitted in AI9.4.2.3. If we intend to capture these evaluations in AI9.4.2.2, our Tdoc R1-2408069 can be also cited, which can be added as reference 40.   |  | | --- | | [40] provides the decoding performance of PDRCH reception with 400 bits for coherent detection with/without midamble with 105 SFO assumption as shown in Figure 6, it is observed that:  -- Compared to using preamble and postamble, adding a midamble can bring additional performance gain of approximately 1dB in the case of 1Kbps data rate.  C:\Users\002458~1.WIN\AppData\Local\Temp\ksohtml15848\wps3.png  Figure 6 Simulation results for packet size of 400 bits,1Kbps, with and without midamble |   For Observation 1, the following modification is proposed:  Observation #1: With up to 10% SFO, for a PRDCH with a 400-bit payload size and a 16-bit CRC, using 1/2 Manchester encoding and convolutional code of 1/3 coding rate or 3 times block level repetition:   * + It is observed by Source [40] that for coherent detection, compared to using preamble and postamble, adding one midamble can bring additional performance gain of approximately 1dB at 10% BLER in the case of 1Kbps data rate.   [40] R1-2408069, Discussion on channel and signal for Ambient IoT, ZTE Corporation, Sanechips |
| xiaomi | Y |  |
| CMCC |  | We are OK to discuss and capture some observations regarding midabmle.  Note that as agreed in RAN1#116bis under this agenda item, midamble may provide multiple functionalities, e.g., timing acquisition, channel estimation, interference estimation. We prefer to reflect the differences in the observation, if possible.  At least from our analysis, for larger packet size, e.g., >= 400 bits, midamble can be inserted to assist channel estimation. Although midamble can also play the same role as preamble and/or postamble for timing acquisition, using midamble for timing acquisition will increase the overhead for midamble. In our evaluation, more than 100 chips are required to obtain decent synchronization performance, but only several chips are needed when midamble is only used for channel estimation. |
| OPPO | Y | While we think it is reasonable and fair to capture in the TR on observations made and proposed in company contributions, but we think it is more accurate that the observations should be structured in a formulation proposed by QC in the above. |
| Samsung | Y | We support the observation. |
| TCL | Y |  |
| DCM |  | We prefer QC’s version. Besides, the main bullet of the observation should be PDRCH rather than PRDCH, perhaps. |
| Spreadtrum | Y |  |
| Panasonic | Y | We support to capture the observations. |
| Huawei, HiSilicon | Y |  |
| **FL2: Based on the comments, proposal is merged with FL2 high priority proposal 3.2.4a.** | | |

**Determination of D2R midamble**

* [2], [3], [6], [28]: RAN1 to support indication/configuration of mid-amble for D2R transmissions by a reader.
* [4]: The interval of PDRCH for inserting the midamble is recommended to be configurable, e.g., ~100ms intervals.
* [5]: For large data packet and lower data rate, D2R midamble with fixed pattern is needed. For small data packet and higher data rate, D2R transmission without midamble is more preferred.
* [10]: The midamble length, overhead and other information can be indicated based on a pre-configured threshold or Indicated by the R2D control information.
* [11] proposed following three options
* Option 1: Midamble can be inserted once in-between every two L chips/bits of D2R transmission segments.
  + For a D2R transmission whose size is smaller than L (FFS: The exact value of L), the midamble transmission can be omitted;
* Option 2: Midamble location/length/pattern can be pre-defined for each type of D2R transmission;
* Option 3: Midamble location/length/pattern can be indicated dynamically by the control information carried by the corresponding R2D transmission.
* [26]: one-bit indicator in the preamble for the existence of the midamble depending upon the TBS
* [27]: For D2R midamble, the presence, location and the number of midambles can be determined based on 1) explicit indication in the preceding PRDCH, or 2) predefined rule such as the message type or payload size.

**FL1 Medium Priority Proposal 3.2.3-2: If D2R midamble is supported, study the placement and the number of midambles in relation to D2R transmission length.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | We support to study midamble in 9422, but Proposal 3.2.3-3 below seems to be part of 9423 |
| Samsung | Y | We support the proposal in high-level. In addition, it is necessary to discuss whether the ‘placement and the number’ is based on a predetermined rule or an R2D indication.  **Proposal 3.2.3-2: If D2R midamble is supported, study the placement and the number of midambles in relation to D2R transmission length.**   * **Option 1: based on a predetermined rule** * **Option 2: based on R2D indication** |
| Spreadtrum |  | It seems more suitable to discuss it in 9.4.2.3 |
| Lenovo | Y | **study the placement and the number of midambles in relation to D2R transmission length and chip duration** |
| LG | Y |  |
| NEC | Y | We support the proposal, and by considering the scenario without midamble when the payload is too small, we suggest to use “presence and pattern” instead of “placement and number” . |
| ETRI | Y |  |

**FL1 Low Priority Proposal 3.2.3-3: If D2R midamble is supported, study following options for the placement and the number of midambles.**

* **Option 1: based on reader’s indication**
* **Option 2: based on predefined rules e.g., the transmission length or payload size or message type**
* **Note above option 1 and option 2 may not be mutually exclusive.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | Not sure whether this proposal should be handled in 9422 or 9423, we are ok with either way, we suggest that both Proposal 3.2.3-2 and Proposal 3.2.3-3 should be discussed in the same agenda |
| ZTE, Sanehips |  | In our understanding, “**based on reader’s indication** ” in option 1 and “**based on predefined rules**” in option 2 are exclusive.  Moreover, we think the necessity of midamble is closely dependent on the channel coherence, therefore, simply predetermined by the factors such as transmission length is not sufficient. On the contrary, indication from reader is preferred,where the indication can be related to the factors listed in option 2.  Therefore, the following update is suggested:  **~~If D2R midamble is supported, sS~~tudy following options for the placement and the number of midambles.**   * **Option 1: based on reader’s indication** * **Option 2: ~~based on predefined rules~~ e.g., the transmission length or payload size or message type or code rate, or data rate** * **Note above option 1 and option 2 can be combined ~~may not be mutually exclusive.~~** |
| Samsung | - | Given the Proposal 3.2.3-2, we think this proposal is redundant. It is suggested to combine the two proposals as we suggested above. |
| Lenovo | Y | Yes |
| LG | Y |  |

### 3.2.4 Postamble

It is observed and mentioned by many companies that midamble can be used as the same purpose of postamble at least for SFO estimation and channel estimation.

* [4] proposed to capture following observations in TR
* D2R postamble is used to determine the final accumulated time offset for the reader to counter the large SFO and achieve fine timing recovery.
* The reader uses the D2R postamble along with the preamble to estimate the accumulated timing offset during the PDRCH by estimating the correlation peak detection of both the D2R preamble and postamble and deriving the deviation between the expected and actual number of samples between the two correlation peaks.
* The reader is assumed to be aware of the TBS and the amount of time domain resources required for the PDRCH transmission since it scheduled the PDRCH transmission and provided this information in the control information to the device.
* With the reader being aware of the PDRCH transmission length and TBS, but without a D2R postamble, the reader can only estimate the coarse ending time of the PDRCH and cannot determine the exact or finer ending time of the transmission.
* D2R postamble is used to improve the channel estimation of PDRCH, when combined with the channel estimation results of the D2R preamble.
* [9] provide evaluation to compare performance differences between D2R transmission using "preamble+4 midamble" versus "preamble+3 midamble+1 postamble" and observed following:
  + With a D2R payload of 400 bits, 16-bit CRC, 1/2 Manchester coding, and TBCC at a 1/3 code rate, the performance between preamble+3 midamble+1 postamble and preamble+4 midamble is similar at 1% and 10% BLER. However, the former requires more processing time on the reader side.



Figure 2.4-1 Comparison between D2R w/o postamble vs D2R w/ postamble in [9]

* [2], [9] observed that for timing correction and channel estimation, if the D2R preamble is insufficient under certain condition(s), one or more D2R midambles within the PDRCH could be used.
* [12] proposed no additional timing synchronization is needed since the initial timing of PDRCH could be derived from the preamble of the PDRCH. Since the reader has stringent frequency stability requirements at 0.05 ppm for gNB reader and 0.1 ppm for UE reader, the preamble could also derive the timing and frequency offset of the PDRCH from the preamble.
* [34] observed that if D2R postamble is introduced, measuring the time gap between D2R preamble and D2R postamble and comparing it with the time gap based on the ideal clock, the reader would be able to estimate the device clock frequency.
  + However, this way requires the reader to store (I, Q) samples of the overall D2R transmission and wait channel estimation, demodulation, and decoding, until the clock frequency estimation using D2R postamble is completed
  + This does not allow a reader to process the D2R in pipeline manner

About whether to support the D2R postamble used for device to identify the end of PDRCH transmission (TBS indication) is for different purpose and should be discussed separately. Please see section 6.2.1 of this document.

Given above, following can be considered:

**FL1 High Priority Proposal 3.2.4: For the D2R postamble, the following observations are captured in TR 38.769**

* **Observation #1: D2R postamble is used to** 
  + **determine the final accumulated time offset for the reader to counter the large SFO and achieve fine timing recovery.**
  + **improve the channel estimation of PDRCH, when combined with the channel estimation results of the D2R preamble.**
* **Observation #2: it is observed by source [34] that if D2R postamble is introduced, measuring the time gap between D2R preamble and D2R postamble and comparing it with the time gap based on the ideal clock, the reader would be able to estimate the device clock frequency.** 
  + **However, this way requires the reader to store (I, Q) samples of the overall D2R transmission and wait channel estimation, demodulation, and decoding, until the clock frequency estimation using D2R postamble is completed**
  + **This does not allow a reader to process the D2R in pipeline manner**
* **Observation #3: it is observed by source [9] that with a D2R payload of 400 bits, 16-bit CRC, 1/2 Manchester coding, and TBCC at a 1/3 code rate, the performance between the case of D2R transmission with preamble with 3 midamble and with 1 postamble and the case of D2R transmission with preamble with 4 midamble and without postamble is similar at 1% and 10% BLER. However, the former requires more processing time on the reader side.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | Observation #1 suggest to agree D2R postamble. However, as reported in [34], we observed D2R preamble only can achieve good performance for coherent demodulation of BPSK modulated PDRCH with 96 information bits with 1/2 rate convolutional code as long as device can correct its SFO to 1% or lower via R2D signal.  For a very long D2R transmission such as 400 information bits with FEC, D2R preamble only may not work. However, for such a very long D2R transmission, we prefer to use midamble, rather than postamble.  More specifically, we can consider following 3 options. Among them, we prefer Opt.3. Opt.3 allows reader to use different SFO estimation methods; (1) SFO estimation by using preamble for demodulating the first 200 bits of the PDRCH and SFO estimation by using midamble for the remaining 200 bits of the PDRCH; or (2) by measuring the gap between preamble + midamble to estimate SFO for demodulating the whole PDRCH. Again, as reported in [34], as long as device residual SFO is up to 1%, both (1) and (2) can achieve good demodulation performance.   * + Opt.1: N chips preamble + 400 bits PDRCH + M chips postamble   + Opt.2: N chips preamble + 100 bits PDRCH + M chips midamble + 300 bits PDRCH   + Opt.3: N chips preamble + 200 bits PDRCH + M chips midamble + 200 bits PDRCH   Total overhead is same among the above options.  It would be good to suggest companies to study further overall, what amble(s) is/are necessary in which condition(s), and to what amount. Impact of the amble(s), including reader’s complexity and spectral efficiency should also be considered. With that, we suggest something like following:  Proposal:   * + Companies are encouraged to evaluate/analyze following D2R amble(s) design options:     - Opt.1: D2R preamble only     - Opt.2: D2R preamble + midamble     - Opt.3: D2R preamble + postamble     - Opt.4: D2R preamble + midamble + postamble   + The evaluation/analysis should consider at least following aspects:     - PDRCH data/chip rate     - Device residual SFO     - Reader’s SFO estimation complexity     - Demodulation scheme (e.g., coherent or non-coherent)     - Total overhead of x-amble(s) |
| ZTE, Sanechips |  | Our evaluation results of midamble/postamble/preamble can be found in R1-2408069 submitted in AI9.4.2.3. If we intend to capture these evaluations in AI9.4.2.2, our Tdoc R1-2408069 can be also cited, which can be added as reference 40.   |  | | --- | | [40] provides the decoding performance of PDRCH reception with 96bits and 128 bits for coherent detection with/without postamble with 105 SFO assumption as shown in Figure 5, it is observed that:  -- For a packet size of 128 bits, the absence of a postamble results in an error floor at BLER of 0.01.  -- Compared to using only the preamble, adding a postamble can bring about 1dB performance gain at BLER of 0.1.  C:\Users\002458~1.WIN\AppData\Local\Temp\ksohtml15848\wps1.pngC:\Users\002458~1.WIN\AppData\Local\Temp\ksohtml15848\wps2.png  Figure 5 Simulation results for packet size of 96 and 128 bits, with and without postamble |   We also propose to add the following in the observation  **Observation #4: it is observed by source [40] that with a D2R payload of 96 bits or 128 bits, 16-bit CRC, 1/2 Manchester coding, and TBCC at a 1/3 code rate, compared to using only the preamble, adding a postamble can bring about 1dB performance gain at BLER of 0.1, and avoid error floor at BLER of 0.01 for D2R payload of 128bits.**    The following update is suggested:   * **Observation #1: D2R postamble is used to**    + **determine the final accumulated time offset for the reader to counter the large SFO and achieve fine timing ~~recovery~~ acquisition.**   + **improve the channel estimation of PDRCH, when combined with the channel estimation results of the D2R preamble.**   In our understanding, for the D2R transmission, if we compare the following two options, we think option2 may provide better performance under the constrains of the same resource overhead since the channel estimation provided by option 2 is extrapolation, while for option 3, it is interpolation.   * + - Opt.2: D2R preamble + midamble     - Opt.3: D2R preamble + postamble   [40] R1-2408069, Discussion on channel and signal for Ambient IoT, ZTE Corporation, Sanechips |
| xiaomi | Y with comments | The following modification was proposed:  ‑ improve the channel estimation of PDRCH, when combined with the channel estimation results of the D2R preamble and midamble (if any). |
| CMCC |  | We are generally fine with the layout. Our observation is aligned with Observation #1.  As commented for Observations regarding midamble, we think that a similar layout here for postamble can be considered different functionalities.  Similar comments as ZTE, we also provide some results under AI 9.4.2.3, and corresponding observation can be captured. |
| Samsung | - | Prior to agree on capturing observations, we first need to agree on the supported functionality of D2R postamble.  For instance, if postamble is only for end-of-signal indication with a very short ON-OFF pattern, the functionalities described in the observations, e.g., channel estimation, frequency synchronization, may not be even supported. |
| DCM |  | We tend to agree QC’s comment; this proposal may be premature. |
| Spreadtrum |  | As we have not make a down selection for the following agreement and Option 1 has not been excluded, D2R postamble can also be used to acquire and determine the end of the PDRCH transmission.   |  | | --- | | Agreement  For the reader to acquire the end of PDRCH transmission, study at least following options:   * Option 1: D2R postamble immediately follows the PDRCH * Option 2: Based on control information |   So we suggest to add an sub-bullet in observation#1 as follows:   * **Observation #1: D2R postamble is used to**    + **determine the final accumulated time offset for the reader to counter the large SFO and achieve fine timing recovery.**   + **improve the channel estimation of PDRCH, when combined with the channel estimation results of the D2R preamble.**   + **acquire the end of the PDRCH transmission.** |
| Huawei, HiSilicon |  | For observation#2, to avoid the device to store samples before the postamble, the midamble can be introduced. |
| **After coordination with FL of AI 9.4.2.3, companies are encouraged to provide evaluation results for ‘ambles’ to AI 9.4.2.2.**  **Based on the comments for Proposal 3.2.3-1 for D2R midamble and comments for Proposal 3.2.4 D2R postamble, for example, suggestions on amble design options, the purpose of the amble, e.g., midamble is used for SFO correction only, or it is also used for channel estimation? The purpose of postamble, only for final SFO correction, or it is also used for channel estimation. In addition, for each design option, it is also suggested that it is more constructive to report the evaluation assumptions/conditions, e.g., device SFO assumption, D2R data rate, D2R payload size, transmission length, the amount of needed midamble and related overhead. Therefore, following proposal can be considered**  **FL2 High Priority Proposal 3.2.4a:**   * **Companies are encouraged to evaluate/analyze the following D2R amble(s) design options:**   + **Option 1: D2R preamble only**   + **Option 2: D2R preamble + X midamble(s), where X ≥1**   + **Option 3: D2R preamble + postamble**   + **Option 4: D2R preamble + Y midamble(s) + postamble, where Y≥1** * **For the above options, report at least the following:** * **Purpose(s) of the preamble, midamble and postamble used for the evaluation** * **Device residual SFO** * **PDRCH data rate and payload** * **Total overhead of x-amble(s)** * **Demodulation scheme (e.g., coherent or non-coherent)** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y | Suggest to add following under the 2nd bullet:   * **Design(s) of the preamble, midamble and postamble used for the evaluation** |
| LG | Y | Also support QC’s additional bullet. |
| Vivo2 | Y | Suggest to add one bullet:   * **Design(s) on how the preamble, midamble and postambles are designed and used to achieve the purposes** |
| Ericsson | Y |  |
| DCM | Y |  |
| TCL | Y | Agree Vivo’s update. |
| NEC | Y | Suggest to add analysis assumption under overhead bullet:   * **Total overhead of x-amble(s) with the following assumption**   + **Overhead of one preamble is the same among all options;**   + **Overhead of one midamble is the same between option 2 and 4;**   + **Overhead of postamble is the same between option 3 and 4;**   Otherwise, difference in preamble would cause extra comparison. |
|  | | |

**Following is agreed on Wednesday online this meeting**

**Agreement@118bis**

* The TR will capture the following options, and companies are encouraged to analyze the tradeoffs among the following D2R amble(s) options:
  + Option 1: D2R preamble only
  + Option 2: D2R preamble + X midamble(s), where X ≥1
  + Option 3: D2R preamble + postamble
  + Option 4: D2R preamble + Y midamble(s) + postamble, where Y≥1
* For the above options, companies are encouraged to report at least the following:
* Purpose(s) of the preamble, midamble and postamble
* Whether companies assume multiple options can be supported

**In addition, the following were agreed in previous meetings**

**Agreement@116bis**

For D2R transmission, study the necessity of midamble at least for the purpose of performing timing/frequency tracking or channel estimation or interference estimation, considering at least the following:

* Modulation and Coding schemes, e.g., data modulation, line/channel coding
* Receiving methods, e.g., coherent or non-coherent
* D2R transmission length/packet size
* Midamble overhead
* Timing/frequency accuracy
* Phase accuracy

**Agreement@118**

For D2R transmission, preamble preceding the PDRCH is studied also for the potential additional functionalities:

* SFO estimation
* CFO estimation
* Channel estimation
* Interference estimation

Note: this does not preclude studying the above functionalities by using a midamble and/or postamble, if supported

FFS: Other functionalities, if any

**FL3 High Priority Proposal 3.2.4-2a: for analysing the trade-offs among the D2R amble(s) options, companies can refer to the Table 3.2.4 in section 3.2.4 of R1-2408993 for information.**

**Table 3.2.4: trade-offs analysis for D2R amble option(s)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Option(s)** | **Purpose(s) for amble(s)** | **Assumptions** | **Aspects to be considered for trade-offs analysis** |
| * Opt.1: D2R preamble only * Opt.2: D2R preamble + X midamble(s) * Opt.3: D2R preamble + postamble * Opt.4: D2R preamble + Y midamble(s) + postamble, | * Timing/frequency tracking * Channel estimation * Interference estimation * … | * Device residual SFO * PDRCH data rate, payload, coding scheme * Demodulation scheme (e.g., coherent or non-coherent) * … | * Timing/frequency accuracy for D2R reception * Amble(s) overhead * D2R Reception Performance * Impacts on Device implementation, power consumption, processing if any * Impacts on Reader implementation, power consumption, processing if any * … |

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

# Energy harvest on device availability for Tx/Rx procedures

In RAN1#118, following agreements for Direction 1 and Direction 2 were agreed together with the two Tables that will be captured in the TR based on companies’ report.

Agreement

For the study of the potential impact of device unavailability due to charging by energy harvesting, the following directions are captured in TR 38.769:

* Direction 1: Reader does not provide information to a device regarding when the device may become available/unavailable.
* Direction 2: Reader can provide information to a device based on which the device may become available/unavailable.
* Note: The applicability of Direction 1 and/or 2 to different device types 1/2a/2b may be further discussed.

Note: Direction 1 and Direction 2 are not for down-selection.

## 3.1 Direction 1 and Direction 2 solution details

For Direction 1 and Direction 2, a TP that captures solution details proposed by companies will be provided in a separate document in the draft folder “TP on Energy harvest” (can be found in the following link). Companies are encouraged to check the details. If there are any mistake/comments, please using revision mode or commend mode to correct it for easily tracking the changes/corrections. Thanks!

[TP on Section 6.2 Device (un)availability](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_118b/Inbox/drafts/9.4(FS_Ambient_IoT_solutions)/9.4.2.2%20Frame%20Structure%20and%20Timing/TP%20on%20Energy%20Harvest)

**FL1/FL2 High Priority Proposal 4.1: TP in R1-xxxxx can be approved in principle, subject to possible revisions.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | We are generally fine to capture the companies’ inputs in the TR as agreed. We agree the TP approval is subject to possible revisions.  Our inputs are captured as source [34]. We have updated the contribution to R1-2409057. Appreciate if the update is applied to the TP as well. |
| Vivo1 | Y |  |
| ZTE, Sanechips |  | Our inputs to direction 2 are suggested to be added in the TP. Thanks. |
| xiaomi | Y |  |
| CMCC | Y | Thanks FL for the effort for collecting the submitted results. |
| OPPO | Y | We have made some minor revisions to the TPs related to our contribution (e.g., typos and clarifications) in the separate document in the draft folder. |
| Samsung | Y | We support the proposal. |
| TCL | Y | Please find the our revision in “TP on Energy harvest”. |
| DCM | [N] | We thank FL for the effort, but at the same time we are not sure whether capturing all without sufficient discussion in RAN1 is really meaningful… Some would be valid, while some may not be valid. Is this OK for companies? Or do you intend to fix them all only within this week? |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| LG | Y | Our inputs are captured in the TP as source [28]. |
| Huawei, HiSilicon |  | For the solutions that describe the use of the device charge status in Direction 1 [3][8][30], we are not clear on how the device would be able to determine this information without additional hardware support, or an accurate clock to be able to count the number of slots for a long duration of time, which is not possible in device 1.  For the solutions that describe the possibility of the device performing EH during the inventory round in Direction 2 [10][15], we would prefer to first focus on the solutions that discuss the device being able to perform EH before the inventory procedure such that devices can be ensured to be charged adequately such that it can receive a Paging message and complete the inventory round. If it is found that the device still requires further EH, we can explore the EH solutions during inventory. |
| NEC | Y |  |
| Ericsson |  | We have some sympathy with DCM’s comment. Perhaps it would be possible to merge some solutions to avoid duplication? |

## 3.2 Others

**General on impacts on scheduling/processing timeline**

* [7] proposed the CW transmission window for charging/recharging the device should be included in the timing aspects.
* [13] proposed that the energy harvest time is not considered for the following time intervals.
  + - The time interval between a R2D transmission and the corresponding D2R transmission following it.
    - The time interval between a D2R transmission and the corresponding R2D transmission following it.
* [18] proposed that regarding the potential impact of device unavailability due to charging by energy harvesting, study a solution for Direction 2 on quantifying the unavailable time windows of a device.
* [21] proposed the A-IoT signalling protocol allows for device charging time during an ongoing signalling exchange.
* [26] proposed to Study on A-IoT charging duration awareness to the reader.
* [28] proposed to study energy storage status based on CW provision and their impact on the scheduling and timing, Timing between multiple R2D/D2R transmissions.
* [33] suggested to specify the energy harvest procedures with certain timeline restrictions to avoid the energy harvest proceeding in undesired time slot. A stripped-down mode without the dynamic adjustments for energy harvest can be prior to carry and try in R19.
* [37] proposed to consider the energy harvesting time due to unavailability of device for the time intervals (between R2D and D2R; between D2R and R2D; between two consecutive R2Ds; between two consecutive D2Rs) within inventory round.

**Assistant information from device**

* [27] proposed RAN1 to study when/how a device can transmit energy status report.
* [28] proposed the device can report its energy storage status to the reader.

**Packet segmentation**

* [8] proposed to consider following
  + - energy aware transmission of payload segmentation from Ambient IoT device in D2R communication
    - energy harvesting time in the scheduling/processing timings (TD2R\_D2R\_min and TD2R\_min) to transmit the remaining payload segments due to insufficient energy and the device can do energy harvesting between the segments.
* [16] proposed PDRCH could be divided into multiple sub-transmission with guard period between them, when the transmission duration is larger than a threshold that A-IoT device needs to do energy harvesting during guard period.
* [26] proposed that Dynamic segmentation of the payloads at A-IoT, depending upon the residual energy, will help exit PDRCH next to the NR frame and Each segment of the A-IoT will have CRC.
* [28] proposed reply types may be defined according to the device’s energy storage capacity. E.g., if the device’s energy storage capacity is sufficient, a reply type that transmits D2R data at once can be used, and if the device’s energy storage capacity is not sufficient, a reply type that transmits D2R data divided into several can be used.

The issue on whether to count device energy harvest time into the scheduling/processing timeline was briefly discussed in RAN1#117 meeting. Due to following,

* A reader cannot know the charging completion time of a device since the charging time depends on many factors including at least capacitor size, distance between devices and RF EH source, charging efficiency, etc.
* The energy harvest time is assumed to be up to several tens of seconds

It seems difficult and complex to include the charging time to the scheduling/processing timeline for TR2D and TD2R such kind of immediately reply. Therefore, following proposal can be the starting point for discussion.

**FL1 Low Priority Proposal 4.2: At least following time intervals do not consider the energy harvest time as baseline.**

* **The time interval between a R2D transmission and the corresponding D2R transmission following it.**
* **The time interval between a D2R transmission and the corresponding R2D transmission following it.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | Agree with FL that the reader cannot determine the energy harvesting time, as it heavily depends on the device implementation. Therefore, scheduling and processing timings based on harvesting times, which could extend to tens of seconds, is impractical. |
| ZTE, Sanechips | Y | Agreed. The interruption time caused by energy harvesting depends on many factors, which are implementation issues and unknown by the reader or NW. |
| Samsung | Y |  |
| Spreadtrum | Y |  |
| LG | N | We don’t need to make explicit agreement regarding this issue. We think it is up to device implementation. |

# Random access

**RAN2 agreements for access procedure are listed in Appendix B for reference.**

**The following clarification has been made on the RAN1 reflector:**

|  |
| --- |
| **It is not in the scope of RAN1 to define the number of steps and the function of the message for each step in random-access procedure. RAN1 can study contention resolution aspects at physical layer (in case of contention-based access) and how to use physical resources (in case of contention-free access), i.e. to study physical resources and physical channel(s)/signal(s) for contention-based and contention-free random-access procedures that are agreed to be studied by RAN2 (please refer to RAN2 agreements).** |

**[33] proposed to study the following alternatives for A-IoT communication procedure design.**

* Alt 1: One paging associated with multiple D2R slots
  + A single A-IoT paging followed by A-IoT Msg1s from multiple devices based on slotted-ALOHA followed by subsequent messages.
  + Slotted-ALOHA: A single trigger determines multiple TDMed slots and each devices selects a slot without further trigger per slot.
* Alt 2: Each paging providing a single D2R slot
  + A-IoT paging/re-paging followed by A-IoT Msg1 and subsequent messages from/to a single device, per slot.
  + Slotted-ALOHA: A single trigger determines a single slot, and the next trigger is transmitted to determine the next slot.

FL think the two Alternatives may belong to RAN2’s work and **RAN1 will focus on the resources within a ‘slot’,** based on the chair’s guidance that it is NOT in the scope of RAN1 to define the the number of steps and the function of the message for each step in random-access procedure. But FL may be wrong. If different understandings, please share your views.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE, Sanechips | The device availability, which is being discussed in RAN1, may also impact the slot determination/decrement at the device side. And also the resource associated with one slot has impact on the resource determination for scheduling. If there is no clear understanding about the slot, it may has impact on the discussion about the solutions/directions.  Therefore, we think some initial discussion should be triggered by RAN1. |
| Samsung | We share a similar understanding as FL. RAN1 can focus on designing TDMA/FDMA resources for multi-access while leaving procedure related aspects to RAN2. Alt 1, Alt 2 in the above also seem falling into RAN2 scope. |
| Spreadtrum | Agree with FL that RAN1 should focus on the time domain resources within a ‘slot’. In addition, if any discussion is trigged, RAN1 should clearly point that the time domain resources are located within a "slot" to prevent any misunderstanding by RAN2. |
| LG | Agree with FL’s comment. |
| Tejas Networks | Alt 1: One paging associated with multiple D2R slots |

## 4.1 Resource determination for Msg1

### 4.1.1 TDMA

First, most companies proposed to study TDMA for Msg.1 transmissions from multiple devices corresponding to a PRDCH providing a triggering message.

* [9] provide the evaluation in Table 4-1 and observed that for TDMA Case with 3ms, 4ms and 6.5ms A-IoT paging period for 1, 2 and 4 TDMed resources that scheduled by a single R2D transmission, compared to a single time-domain resource, multiple TDMed resources can effectively reduce totally inventory time for all schemes and reduce the R2D transmission overhead.

Table 4-1: inventory time for 100% successfully inventoried devices with the shortest paging period of [9]

|  |  |  |  |
| --- | --- | --- | --- |
| Schemes | Totally inventory time [s] | | |
| TDMA=1, Paging period: 3ms | TDMA=2, Paging period: 4ms | TDMA=4, Paging period: 6.5ms |
| OFF when fully discharged | 21.256 | 13.546 | 10.688 |
| OFF when energy <90% | 16.034 | 9.676 | 7.864 |
| SLEEP w R2D control | 11.186 | 5.634 | 2.710 |

* [12] observed that too large or too small number of TDMA resource units allocated in random access procedure will lead to increased inventory completion time and proposed to study how to determine a proper number of TDMA resource units for random access.

Table 6: Evaluation results of inventory completion time of [12]

|  |  |  |  |
| --- | --- | --- | --- |
| Initial number of FDMA units | Initial number of TDMA units | | |
| 32 | 64 | 128 |
| 1 | - | 4.29s | 3.24s |
| 2 | 2.31s | 1.46s | 2.04s |
| 4 | 1.19s | 1.22s | 1.71s |
| 8 | 1.10s | 1.16s | 1.55s |

**Then, about the maximum number of (e.g., X≥1) time domain resource(s) for D2R transmission(s) for Msg1 that is in response to a R2D transmission triggering random access**

* [1] observed following based on Figure 2 plotted mathematically:
* For TDMA of A-IoT Msg-1, the duration of transmission occasions is sensitive to the SFO. When the SFO is about 10^5, the maximum number of transmission occasions should not exceed 3 for a resource utilization of ~50%.
* For TDMA of A-IoT Msg-1, a small SFO may be needed to support reasonable number of transmission occasions (e.g., X=10) at a reasonable resource utilization (e.g., 83%)

图表, 折线图

描述已自动生成

Figure 2 in [1]: Duration of the transmission occasion Ts for several values of X and fe. assuming Tm1=1.

* [4] analyzed the maximum number of X has impacts on the required register size for clock counters in following Table 1, which further impacts to device power consumption and complexity for one 16-bit Msg1 transmission with 1kbps data rate below:

Table 1 The number of required register bit size with different X values of [4]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| The value of X | Sampling clock rate | Duration for clock counters:  (X-1)🞨Msg1 duration | Num of Samples for clock | Required register bit size | Occupied ratio of total register size |
| X = 2 | 1.92MHz | 16ms | 30720 | 16bits | 32% |
| X = 4 | 1.92MHz | 48ms | 92160 | 17bits | 34% |
| X = 8 | 1.92MHz | 112ms | 215040 | 18bits | 36% |
| X = 16 | 1.92MHz | 240ms | 460800 | 19bits | 38% |
| X = 32 | 1.92MHz | 496ms | 952320 | 20bits | 40% |
| X = 2 | 2.4MHz | 16ms | 38400 | 16bits | 32% |
| X = 4 | 2.4MHz | 48ms | 115200 | 17bits | 34% |
| X = 8 | 2.4MHz | 112ms | 268800 | 19bits | 38% |
| X = 16 | 2.4MHz | 240ms | 576000 | 20bits | 40% |

* [4] proposed for TDMA and X >= 1, the X time domain resource(s) of each Msg1 is determined by an individual corresponding R2D triggering message and capture following observations in TR.
  + The maximum value of X shall be limited, e.g. X < 6.
  + The required register size for clock counters to keep timing between R2D triggering message and Msg1 increases with the maximum number of X, which has impact to device power consumption and complexity.
  + The gap between adjacent Msg1 messages due SFO impact increases with the maximum number of X, which has impact to transmission efficiency.

In addition, many companies proposed to reserve some margin/gap conquer the potential timing error due to the inaccurate clock embedded in the device.

* [1] observed that the guard time which is the time gap between the end of a message transmission for a device with a slower clock and the beginning of the next transmission for a device with a faster clock gets shorter in subsequent instances, as shown in Figure 1 below:

图片包含 日程表

描述已自动生成

Figure 1 At the reader, each transmission occasion for devices with fast and slow clocks assuming fe=0.05, X=4 is shown [1]

* [2] proposed to study TDMA of Msg1 transmissions from multiple devices corresponding to the same trigger message for contention-based access, including following:
* What is the unit for resource allocation in time domain (e.g., Msg1 sequence length in chips or bits)?
* How are the time domain resources allocated for TDMA of Msg1 transmissions (e.g., pre-defined or by the reader)?
* How does a device determine the time domain resource for the Msg1 transmission (e.g., based on device capability/type or indicated by the reader)?
* Whether/how to address the timing error for time-adjacent Msg1 transmissions caused by the initial/residual SFO of the device?

Based on above, following proposal can be considered for Msg1 first.

**FL1 High priority Proposal 5.1.1: RAN1 studies following:**

* **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission occurs in one time domain resource.**
* **The study includes** 
  + **X=1 and X>1, the maximum value of X should be limited, considering the device implementation complexity, device power consumption and the transmission efficiency affected by SFO.**
  + **Unit for resource allocation in the time domain**
  + **Indication/updating of the X time domain resources**
  + **Device determination of a single time domain resource**
  + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | The proposal is generally good for us. We suggest a bit of editorial changes as follows:  **RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission for Msg1 occurs in one time domain resource of the X time domain resource(s).** * **The study includes**    + **Maximum value of ~~X=1 and~~ X>1~~, the maximum value of X should be limited,~~ considering the device implementation complexity, device power consumption and the transmission efficiency affected by SFO.**   + **Unit for resource allocation in the time domain**   + **Indication/updating of the X time domain resources**   + **Device determination of a single time domain resource**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| Vivo1 | Y |  |
| ZTE, Sanechips |  | On the one hand, compared to X=1 case, the case that X>1 saves X−1 R2D trigger transmissions. However, due to the large SFO of the device, (X−1) intervals need to be reserved among X Msg1 transmissions, and the interval periods increase as the increases of X, it potentially degrades the resource efficiency.  On the other hand, for X>1, devices randomly select resources from the X time-domain resources. Neither the reader nor the devices can determine which resources are selected and which are idle. Therefore, these X time-domain resources have to be predefined or be indicated based on the maximum resource duration. However, in the case of X=1, the reader can initiate another round of R2D triggering if no Msg1 is detected. Thus, in this aspect, X>1 may also lead to resource waste, consequently, increase the inventory latency.  Therefore, it is necessary to evaluate the gain of TDMed Msg1 transmissions, and the max X value. So we have the following suggestion:  **FL1 High priority Proposal 5.1.1: RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission occurs in one time domain resource.** * **The study includes**    + **X=1 and X>1, the maximum value of X should be limited, considering the device implementation complexity, device power consumption，resource efficiency and the transmission efficiency affected by SFO.**   + **Evaluation of the benefits of X>1 compared to X=1**   + **Unit for resource allocation in the time domain**   + **Indication/updating of the X time domain resources**   + **Device determination of a single time domain resource**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| xiaomi | Y |  |
| CMCC | Y | We are fine with this proposal. Our view is that X=1 and X>1 should be both supported for study. In contrast to X>1, X=1 should be the baseline. |
| OPPO | Y | We also think the time separation between the time domain resources when X>2 is also important for the study due to device SFO / timing drift. So, we suggest the following:  **FL1 High priority Proposal 5.1.1: RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission occurs in one time domain resource.** * **The study includes**    + **X=1 and X>1, the maximum value of X should be limited, considering the device implementation complexity, device power consumption and the transmission efficiency affected by SFO.**   + **Unit for resource allocation in the time domain**   + **Time separation required between time domain resources, when X>1**   + **Indication/updating of the X time domain resources**   + **Device determination of a single time domain resource**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| FUTUREWEI | Y |  |
| Samsung |  | We support the proposal in high-level. ‘R2D transmission triggering random access’ needs to be clarified a bit whether it refers to a paging message from RAN2 or another triggering message initiating each random access round. |
| TCL | Y | Agree with the proposal |
| DCM | [Y] | We do not prefer to have “**the maximum value of X should be limited**”. We suggest removing this part. |
| InterDigital | Y |  |
| Spreadtrum | Y with comments | RAN1 should clearly point that the time domain resource(s) are located within one "slot" to prevent any misunderstanding by RAN2.  **FL1 High priority Proposal 5.1.1: RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) within a slot for D2R transmission(s) for Msg1, where each D2R transmission for Msg1 occurs in one time domain resource.** * **The study includes**    + **X=1 and X>1, the maximum value of X should be limited, considering the device implementation complexity, device power consumption and the transmission efficiency affected by SFO.**   + **Unit for resource allocation in the time domain**   + **Indication/updating of the X time domain resources**   + **Device determination of a single time domain resource**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| Panasonic | Y |  |
| Lenovo | Y | We are fine with the QC addition |
| LG | Y |  |
| NEC | Y |  |
| @ZTE, two companies show the evaluation results [9] and [12] to show the benefits for X>1. So, let’s study both X=1 and X>1 and of course the maximum value of X should be limited.  @OPPO, I think “Time separation required between time domain resources, when X>1” is covered by the last bullet “Addressing timing errors for adjacent time domain resources due to residual SFO of the device”.  @ Spreadtrum, based on discussions happened in previous meetings, RAN1 will not define what is ‘slot’ means.  Based on the comments, the following proposal can be considered  **FL2 High priority Proposal 5.1.1a: RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission for Msg1 occurs in one time domain resource of the X time domain resource(s).** * **The study includes**    + **X=1 and X>1, the maximum value of X>1 should be limited, considering the device implementation complexity, device power consumption and the resource efficiency affected by SFO.**   + **Unit for resource allocation in the time domain**   + **Indication/updating of the X time domain resources**   + **Device determination of a single time domain resource**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| Vivo2 | Y |  |
| InterDigital | Y |  |
| Huawei, HiSilicon | Y with comment | Thanks FL’s proposal,  Regarding the last but one sub-bullet, we are wondering what exact meaning of this sentence “**Device determination of a single time domain resource**”, if it is timing relationship we would like to clarify it explicitly with an update. If it is mean how device select one resource from X resources we regard this is up to RAN2 procedure discussion. With above comment, we suggest the followings  **FL2 High priority Proposal 5.1.1a: RAN1 studies following:**   * **A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission for Msg1 occurs in one time domain resource of the X time domain resource(s).** * **The study includes**    + **X=1 and X>1, the maximum value of X>1 should be limited, considering the device implementation complexity, device power consumption and the resource efficiency affected by SFO.**   + **Unit for resource allocation in the time domain**   + **Indication/updating of the X time domain resource(s)**   + **Device determination of the X ~~a single~~ time domain resource(s) in terms of timing relationship**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| Ericsson | Y |  |
| IITK, IITM | Y |  |
| DCM | [Y] | OK if “**should be limited**” is removed. If only “limited” is the determination criterion, it could mean X=1 is sufficient. But actually limitation may be necessary from some perspectives and enlarging may be necessary from other perspectives. Then we will find the best max value. |
| TCL | Y | Agree with the following modification:  **X=1 and X>1, the maximum value of X (when X>1) should be limited,** |
| Samsung | Y | Fine with the proposal. ‘should be limited’ needs to be revised as X shall be always limited in any case. |

**On the details of time domain resource indication and determination for TDMA of D2R transmissions in response to a single R2D transmission**

* [2], [10]: The reader provides the total number of resources, and the devices can randomly select their own resources from the total.
  + when X>1 the number of assigned slots can in some cases be more than the available devices, FFS whether value of X can be changed after initial assignment in case of X>1
* [5] proposed the number of X and the TDRA including {the starting time, the length} of each time domain resource can be Alt.1 carried in the control information of R2D transmission triggering message or Alt.2 based on a pre-defined value.
* [8] proposed to consider grouping of one or more Tx and Rx resources for R2D and D2R communications within an occasion and use slotted aloha method to select the occasion as shown in figure 10.



Figure 10: Illustration of grouping of resources and selection of occasion using slotted aloha method from [8]

* [9] proposed following two options based on the two options agreed for D2R response timing. Figure 4-1 and 4-2 give examples for the two options.
* Option 1: Extension of the time window based solution to TDMed Msg1 transmission: introducing/defining a main time window [TD2Rstart, TD2Rend] that covers all the TDMed Msg1 resources/transmission
* Option 2: Indication based where multiple Msg1 transmission timing is indicated by Paging

|  |  |
| --- | --- |
| 图片包含 文本  描述已自动生成  4-1a: Same size/length for 1st and 2nd sub-windows | 4-1b: Different size/length for 1st and 2nd sub-windows |

Fig 4-1: Illustration for Option 1 that a main time window covers all the TDMed Msg1 resources/transmission of [9]

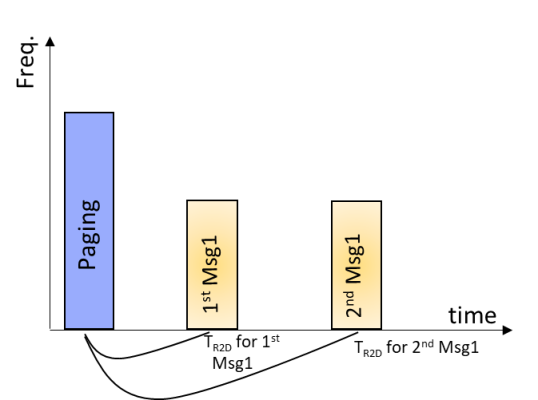


Fig 4-2: Illustration for Option 2 that multiple Msg1 response timing is indicated by Paging of [9]

* [11] proposed one sub-occasion for Msg.1 transmission can be defined as one {starting offset, length} pair within one access occasion for time domain resource allocation in D2R.
* {Starting offset, length} or only {starting offset} is used for the D2R time domain indication;
* The number of sub-occasions in one access occasion should be limited due to timing drift caused by SFO.
* [14] The position of a time domain resource can be indicated by an offset and a duration in reference to the position of the paging message
* [22] proposed reader transmits an indication of the slot start for every M slot(s) of the slotted-Aloha based contention-based access procedure and devices with high SFO prioritize the selection of D2R resources in the N slots following a R2D transmission. FFS the value of N.
* [28] for D2R response timing option 1, a separate time offset may be indicated to each device so that the transmission timing window determined by each device does not overlap; for D2R response timing option 2, the reader may indicate TR2D differently for each device to perform TDMA.
* [34] observed that for TDMA case, if back-to-back based transmission for one device is enabled, time-domain resource allocation for the rest of messages can be simple e.g., just follow the previous msg as shown in Figure 4.2-1 below.



Fig. 4.2-1 Random-access procedure with D2R timing determination of [34]

### 4.1.2 FDMA

In RAN1 #118 meeting, following agreement was achieved:

|  |
| --- |
| Agreement  Study FDMA of D2R transmissions for Msg.1 from multiple devices in response to a R2D transmission triggering random access, including following   * How the frequency domain resources are allocated for the FDMA of D2R transmissions for Msg.1 * How a device determines the frequency domain resource for the D2R transmissions for Msg.1 * Note: this does not preclude discussion on TDMA for D2R transmissions for Msg.1 |

[13] proposed to clarify the applicability of FDMA based Msg1, i.e., whether it can be applied to both 2-step and 4-step random access procedures or one of them.

**In FL’s view, agreement was made without any restriction for random access procedure from RAN1 perspective. In other word, the FDMA study applies to both 2-step and 4-step random access procedures, contention based and contention free random access.**

**Note that for contention free random access, RAN2 made following agreement, also referring to the Appendix B.**

RAN2#126

* From reader perspective, contention-free access procedure we will study single and multi-device case (depending on RAN1 discussion).

RAN2#127

* In contention-free access, the A-IoT device directly sends the upper layer data (e.g. device ID) in its very first D2R message after being triggered (i.e. skip contention resolution Msg1/2). FFS if a short AS ID is also included in the message and what type of ID for scheduling purposes.

**If different understanding that there is use case restriction for study FDMA based Msg1 (agreement made in RAN1#118 meeting), please share in the following table.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
|  |  |  |
|  |  |  |
|  |  |  |

**Regarding frequency resource allocation/determination for Msg.1**

* + [3] proposed A single R2D transmission triggering D2R transmission for Msg.1 from multiple devices indicates Manchester line coding-based small frequency shifting by randomly allocating different chip rate/length.
* [4] For D2R transmission carrying Msg1 during access procedures in FDMA manner, the following observations are captured in TR 38.769:
  + - The frequency resource set for Msg1 can be determined by line code repetition number set.
    - The maximum frequency resource number for FDMed Msg1 messages is limited due to SFO and sampling clock frequency restraint, e.g. no more than 8.
  + [7] proposed the frequency domain resource: Subcarrier allocation and the reader allocates one subcarrier to each device based on the energy status of that device.
  + [9], [10] proposed for FDMA of Msg1, the candidate frequency resources should be provided before the inventory round starts, including at least the SFS (small frequency shift) frequencies for each candidate resource.
  + [11] proposed one frequency domain resource can be defined as one {BLF, M} pair for frequency domain resource allocation in D2R, where BLF represent the backscatter link frequency and M represent the coding rate or the baseband waveform multiplied by a square-wave at M times the symbol rate.
    - For contention-based access, the reader can indicate a set of frequency domain resources (i.e., {BLF, M} pairs) target for multiple devices, and each device selected this occasion for access may need to further randomly select one to obtain its own D2R frequency resource for Msg1 transmission.
    - For contention-free access, if the R2D command is target for more than one device, the reader can indicate separate frequency domain resource associated with the ID of each device for the D2R frequency resource indication and determination, for Msg1 transmission.
* [12]: For the resource selection of random access by A-IoT devices could be based on the predefined rules (e.g., A-IoT ID mod No. of occasion with specified probability) similar to that of NR paging.
* [13]: For FMDA, the device randomly selects one frequency domain resource for Msg1 from the available frequency domain resources. And the available frequency domain resources can be default or indicated resources.
  + [16]: the resource’s location for Msg.1 transmission of each device can be determined according to the random ID or device ID.
  + [17]
  + For contention-based random access FDMed resource allocation, reader uses the Q value to indicate all the 2Q RO candidates, and the RO candidates are numbered in the frequency domain first and then in the slot/occasion in an access round. Each device randomly selects one RO candidate to send msg1.
  + For contention-free random access FDMed resource allocation, the paging devices can be associated with the RO candidates. The devices in the paging list correspond to the RO candidates in turn, and the RO candidates are first numbered in the frequency domain, and then in the time slots/occasions in the access round. Each device uses a dedicated RO candidate to send msg1.
  + [22] proposed
  + for contention-based access, reader indicate multiple sets of parameters for the D2R frequency resource/channel determination, and each device randomly select one set of parameters to obtain its own D2R frequency resource/channel.
  + for contention-free access, if the R2D command is target for more than one device, the reader can explicitly indicate the parameter for the D2R frequency resource/channel determination to each device.
* [28]: The reader explicitly provides the FDMed resource index (e.g., frequency shift value) for each device, or devices implicitly select one of the FDMed resources based on the specific parameter (e.g., device ID).
* [33] For FDMA of Msg1, when a device determines use of a slot in slotted-ALOHA, the device selects randomly a frequency-domain resource of the slot.

About the detailed parameter(s) used for indication/allocation of different frequency domain resources for the FDMA of Msg1 transmission can be left to the potential normative phase which also depends on how small frequency shifts for D2R is achieved. Given above, the following proposal is made:

**FL1 Medium priority Proposal 5.1.2-1: For contention-based random access, different frequency domain resources for Msg1 transmission is indicated in a R2D transmission triggering the random access, study following options for the devices to determine the frequency domain resource:**

* + **Option 1: the device randomly selects one of the FDMed resources**
  + **Option 2: the device selects one of the FDMed resources based on the predefined rule(s)**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| Samsung | - | Support the proposal in high-level but a couple of comments as below:   * As mentioned earlier, the ‘R2D transmission triggering the random access’ needs to be clarified.   For option 2, the predefined rules need further description. Without a clear idea on the resource selection based on a predefined rule, it is difficult to agree on listing the option. |
| Lenovo | Y | Option 2 should say study whether predefined rule can be used to select FDMed resource, FFS: details of predefined rule |
| LG | Y |  |
| Tejas Networks | Y | **Option 1: the device randomly selects one of the FDMed resources** |
| Ericsson | Y |  |
| **FL4: based on the discussions online and offline, it was clarified that how device select the resource for Msg1 transmission belong to random access procedure and belong to RAN2 work.** | | |

**FL1 Low priority Proposal 5.1.2-2: For contention-free random access, an R2D transmission that initiates the random access indicates a unique frequency domain resource for D2R transmission to each target device.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 |  | We are not quite sure what contention-free random access means. Is it just like NR CFRA where a dedicated PRACH resource is assigned? We suggest to clarify the concept of CFRA first. |
| Samsung | - | We agree the proposal in high-level. However, we can revisit this proposal after concluding the support of TDMA based access as well. |
| Lenovo | Y |  |
| LG | Y | We think a similar proposal could be considered in the TDMA case. |
| Ericsson | Y |  |

## 4.2 Msg2 related aspects

For Msg2 in response to multiple TDMed/FDMed Msg1 that is triggered by one A-IoT paging, following should be discussed.

### 4.2.1 Aspect#1: Msg2 contains only one or more than one response

* [1], [2], [4], [5], [10], [11], [13], [14], [15], [27], [5], [7], [9], [30], [34], [35] proposed to study following options on how Msg3 is scheduled by Msg2
  + - Opt.1: A single Msg2 contains a single R2D response to echo one ID received in A-IoT Msg1
    - Opt.2: A single Msg2 contains multiple R2D responses to echo all IDs received in A-IoT Msg1
    - Opt.3: A single Msg2 can contain one or more than one R2D responses to echo one or more than one ID(s) received in A-IoT Msg1, which is determined by the Reader
* [13] prefers option 3 given option 1 and 2 are special case of option 3.
* [27] pointed out that above Option 2 and Option 3 can be combined into one as “A Msg2 contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1”. This is because Option 3 is an implementation issue as it cannot be tested whether the reader echoes all the IDs or subset of the received IDs.
* [2], [35] observed that a common (single) Msg2 transmission for multiple devices can increase the power consumption of the devices but has lower control information, while separate (multiple) Msg2 transmissions will have reduced power consumption but increased control information overhead.
* [4] proposed to capture following observations for Msg2 in TR:
  + - for TDMA and X >= 1 for Msg1,
      * If separate Msg2 used,
      * The required register size for clock counters to keep timing between Msg1 and Msg2 increases with the maximum number of X, which has impact to device power consumption and complexity.
      * The gap between adjacent Msg2 messages increases with the maximum number of X, which has impact to transmission efficiency.
      * A common Msg2 can be considered to contain multiple R2D responses to echo all IDs received from Msg1 messages transmitted in the X time resources.
    - For FDMA for Msg1,
      * If separate Msg2 is used
      * The maximum number of FDMed Msg1 should be limited, e.g. no more than 6.
      * The required register size for clock counters to keep timing between Msg1 and Msg2 increases with the maximum number of FDMed Msg1, which has impact to device power consumption and complexity.
      * The gap between adjacent Msg2s increases with the maximum number of FDMed Msg1, which has impact to transmission efficiency.
      * A common Msg2 can be considered to contain multiple R2D responses to echo all IDs received in FDMed Msg1s.
* [10] proposed for option 1, assistance information such as the transmission order of multiple Msg.2 can be provided to devices to reduce monitoring complexity.

Given above, following proposal can be considered and note that there is no intention for down-selection at this point and both options should be studied further considering other WG’s progress.

**FL1 High Priority Proposal 5.2.1: RAN1 studies following options for Msg2 transmission in response to FDMA and/or TDMA of multiple Msg1 transmissions, which is initiated by a R2D transmission triggering random access.**

* **Option 1: A single Msg2 contains a single R2D response to echo one ID received in A-IoT Msg1**
* **Option 2: A single Msg2 contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | The two options need to be studied. The proposal clarifies the study should be done in RAN1. We are OK with the proposal. |
| Vivo1 | Y | We support this proposal. We think these options should be discussed in RAN1 as they are the fundamental assumption for further design in resource allocation and timeline during the multi access procedure in RAN1, as listed in Aspect#2 in 5.2.2 |
| ZTE, Sanechips |  | In our understanding, option2 considers only one single Msg2, we think another option is to consider multiple Msg2 transmissions, each of them contains multiple R2D responses, which provides more flexible scheduling/indication by reader.  We recommend to add the following option 3  Option 3: A Msg2 contain one or more R2D responses to echo one or more ID(s) received in A-IoT Msg1, where the number of devices echoed in one Msg2 is determined by the Reader |
| xiaomi |  | Maybe this discussion is coupled with RAN2 discussion, so it needs to be clarified whether this should be determined by RAN1 or RAN2 first. |
| CMCC | Y |  |
| OPPO | Y | We agree with ZTE’s proposed Option 3, for the same reason. |
| Samsung | Y |  |
| TCL | Y |  |
| DCM | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| Lenovo | Y | Please add some clarification for the timing between Msg1 and Msg2 specifically addressing multiple R2D response embedded in the single Msg2.  FFS timing relationship between Msg1 and Msg2 in case of multiple R2D responses embedded in single Msg2 |
| LG |  | In this proposal, we need to clarify about Msg2. In other words, we need to clarify whether a single Msg2 means a single Msg2 payload to be included within PRDCH or a single Msg2 means a single PRDCH for Msg2 transmission. If a single Msg2 means a single PRDCH for Msg2 transmission, we can support it.  **FL2: the intention is a single PRDCH for Msg2 transmission.** |
| Tejas Networks | Y | **Option 2: A single Msg2 contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1.**  This will reduce the latency/inventory completion time |
| NEC | Y |  |
| **Based on the comments, following proposal can be considered:**  **FL2 High Priority Proposal 5.2.1a: RAN1 studies following options for Msg2 transmission in response to FDMA and/or TDMA of multiple Msg1 transmissions, which is initiated by a R2D transmission triggering random access.**   * **Option 1: A single PRDCH for Msg2 transmission contains a single R2D response to echo one ID received in A-IoT Msg1** * **Option 2: A single PRDCH for Msg2 transmission contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1** * **Option 3: A single PRDCH for Msg2 transmission contains one or more R2D responses to echo one or more ID(s) received in A-IoT Msg1, where the number of devices echoed in one Msg2 is determined by the reader** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| Vivo2 | Y |  |
| InterDigital |  | Suggest reverting to earlier version. There is no difference between Option 2 and Option 3 as formulated.  Option 2 does not exclude possibility that there are multiple PRDCH for msg2 transmission. How the number of devices is determined is next level of detail within Option 2. |
| Huawei, HiSilicon |  | It seems the original proposal with first 2 bullets is enough. Our understanding Option 3 is on top of Option 1 and Option 2 which is a detail solution should be discussed in late stage. |
| Ericsson | Y |  |
| IITK, IITM | Y |  |
| DCM | Y | Or option 2 and option 3 can be merged |
| TCL |  | Option 2 and option 3 can be merged |
| Samsung |  | Similar comments. Option 2 and Option 3 are the same from a device perspective and it is not distinguishable. |
| **Based on the comments, following proposal can be considered:**  **FL3 High Priority Proposal 5.2.1b: RAN1 studies following options for Msg2 transmission in response to FDMA and/or TDMA of multiple Msg1 transmissions, which is initiated by a R2D transmission triggering random access.**   * **Option 1: A single PRDCH for Msg2 transmission contains a single R2D response to echo one ID received in A-IoT Msg1** * **Option 2: A single PRDCH for Msg2 transmission contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1** * **[Note if both options are supported, option 1 and/or option 2 to use is up to reader.]** | | |
| **Company** | **Y/N** | **Comments** |
| ZTE,Sanechips |  | We think the following three options should be studied for msg2 scheduling msg3. And the following Figure 1 and Figure 2 corresponds to option 1 and option 3 respectively in FL3, since **“single”** PRDCH is considered, and the “Msg2 transmission” can “all the msg2” in the main bullet.  Meanwhile, we think option 3 provides the reader the flexibility in resource allocation and scheduling, which can be also studied.  Therefore, we suggest the following option 3 to include the case that there can be **multiple msg2**, and each of them triggers **one or more msg3.** [Note: “a given set of ” has also been used in the previous agreement]   * **Option 3: A ~~single~~ PRDCH for a given set of Msg2 transmission contains multiple R2D responses to echo multiple IDs received in A-IoT Msg1**     Figure 1: Option 1    Figure 2: Option 2    Figure 3: Option 3 |
| FUTUREWEI | Y | a suggested rewording of the note  **[Note if both options are supported, whether to use option 1 and/or option 2 ~~to use~~ is up to reader.]** |
| DCM | Y | Option 2 can be updated as follows. Even if “multiple” is agreed, anyhow “single” is possible depending on situation and/or reader’s implementation. For instance, if only a single Msg1 is received, Msg2 can contain only a single echo ID.   * **Option 2: A single PRDCH for Msg2 transmission contains one or more ~~multiple~~ R2D responses to echo one or more ~~multiple~~ IDs received in A-IoT Msg1**   With this, the last note can be removed. In addition, our understanding is Option 2 includes the Option 3 commented by ZTE. |
| LG | Y with comment | We are generally fine with the proposal. But, regarding the last bullet, we think it can be discussed in the normative phase. So, we prefer to remove the last bullet. |

### 4.2.2 Aspect#2: Msg2 monitoring and Msg2 scheduling Msg3

RAN1#118 meeting agreed following:

|  |
| --- |
| Agreement  When a R2D transmission in response to a D2R transmission is expected for A-IoT Msg2 response to A-IoT Msg1 for the A-IoT device, study to define a maximum time TD2R\_max between the D2R transmission and the corresponding R2D transmission following it, so that the R2D transmission timing is expected to be within [TD2R\_min, TD2R\_max].   * FFS: whether there is a necessity to define different maximum times for different A-IoT devices |

[1], [5], [6], [9], [13], [14], [33], [34] discussed Msg2 monitoring window and timing for Msg3 transmission, especially for the case that multiple TDMed/FDMed Msg1 transmissions are scheduled by the same A-IoT paging message. In detail,

* [1] observed following for the maximum time between the D2R transmission and the corresponding R2D transmission for Msg1,
  + - For FDMA,
* If one Msg-2 support multiple R2D responses, the same value of TD2R\_max can be used
* if one Msg2 contains a single R2D response, then multiple TD2R\_max may be needed.
  + - For TDMA, multiple TD2R\_max may be needed regardless of whether Msg2 contains a single or multiple R2D responses.
* [5] proposed the minimum time TD2R\_min should be between the end of the last time domain resource and start of the corresponding Msg2 transmission following it if TDMA for Msg1 is introduced.
* [10] proposed to further study the following R2D transmission timing considering if multiple Msg2 response are transmitted in separate PRDCH,
  + The corresponding R2D transmission timing TD2R following a D2R transmission is determined based on indication from previous R2D transmission, where TR2D ≥ TR2D\_min.
* [13] proposed that the device can determine the start time of the nth Msg2 transmission to monitors the nth Msg2 after it transmits Msg1:
* For n=1, the time interval between first Msg2 and the Msg1 follows the timing relationship between a R2D transmission and the corresponding D2R transmission.
* For n≥2,
  + - Alt 1: Indicate the start time of the nth Msg2 transmission in the n-1th Msg2.
    - Alt 2: Determine the start time of the nth Msg2 transmission according to the duration of Msg3 in response to the n-1th Msg2. The Msg3 duration can be obtained based on e.g.,
      * the scheduling information in the n-1th Msg2.
      * the same duration for all Msg3 transmissions in one access round, which is known to the device.
* [9] proposed to study following two options for for a device to determine the Msg.2 reception timing in case one A-IoT paging schedules multiple TDMed/FDMed Msg1, as shown in figure 5-1
  + Opt.1 Common time window based: the starting time for the Msg2 response time window is TD2R\_min after the “last” Msg1 time domain resource that is scheduled by the A-IoT paging.
  + Opt.2 Independent Time window: the starting time for the Msg2 response time window is determined based on the control information in the A-IoT paging.
  + For both options, the length/duration for Msg2 response time window can be pre-defined and/or indicated.

|  |  |
| --- | --- |
| 5-1a: Same size/length for 1st and 2nd sub-windows | 文本  中度可信度描述已自动生成  5-1b: Different size/length for 1st and 2nd sub-windows |

Figure 5-1: illustration on options for the Msg2 response time window of [9]

* [14] proposed to study following aspects for Msg2 and Msg3 transmissions for random access.
  + How does a device monitor Msg2 transmission after it transmits Msg1, including starting time and time duration for Msg2 monitoring
  + How Msg3 is scheduled by Msg2, at least including the resource allocation
* [14] also proposed following
  + In case that one ALOHA slot can contain more than one Msg.1 resource, and one Msg.2 responds to more than one Msg.1, the monitoring of Msg.2 can be in reference to the time domain resource of last Msg. 1.
  + In case that one ALOHA slot can contain more than one Msg.1 resource, and one Msg.2 responds to only one Msg.1, a mechanism to facilitate a device to position its Msg.2 may need to be considered to save the power of the device, such as some assistant signaling or predefined rules.
* [33], [34] proposed to discuss the timing relations for the following transmissions after multiple TDMed/FDMed Msg1 scheduled by the same A-IoT paging message as shown in Fig. 4.2-2
  + Option 1: device transmits the Msg3 after the “last” Msg2 transmission (Fig. 4.2-2 (a) and (b)). In other word, the device cannot transmit Msg3 until it receives the “last” Msg2
  + Option 2: device transmits the Msg3 immediately after the corresponding Msg2 transmission (Fig. 4.2-2 (c))



Fig. 4.2-2 msg-2(s) follow msg-1s and msg-3s follow msg-2(s) of [34]



Fig. 4.2-2 (c) msg-2 and msg-3 for a msg-1 are back-to-back (immediate) of [34]

* [34] proposed to list up resource allocation options for messages in random-access procedure in RAN1, considering following relevant open issues:
  + whether/how msg-1 multiplexing is enabled
  + how a device determines D2R transmission timing
  + how msg-3 resource allocation is indicated by msg-2
  + feasible window length for msg-2 monitoring after msg-1
* [35] observed that if considering consecutive transmissions of multiple Msg2s from a reader, TD2R\_max should consider the number of PRDCH Msg2s transmitted. Also, it is necessary to define TR2D\_R2D\_min for the transmission from a reader to different devices.

Based on above, following proposal can be considered.

**FL1 High Priority Proposal 5.2.2: Study following aspects for Msg2 and Msg3 transmissions for random access, considering the impact of Msg1 multiplexing.**

* + **How does device monitor Msg2 transmission after it transmits Msg1, including starting time and time duration for Msg2 monitoring**
  + **How Msg3 is scheduled by Msg2, at least including the resource allocation**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | We suggest to clarify the study will be done in RAN1.  **RAN1 studies ~~Study~~ following aspects for Msg2 and Msg3 transmissions for random access, considering the impact of Msg1 multiplexing.** |
| Vivo1 | Y | We support to study the above aspects in RAN1, this also has impacts on the timing during the access procedure |
| ZTE,Sanechips | Y |  |
| xiaomi | Y |  |
| CMCC | Y |  |
| OPPO | Y |  |
| FUTUREWEI | Y |  |
| Samsung | Y |  |
| TCL | Y |  |
| DCM | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| Lenovo | Y |  |
| LG | Y |  |
| Tejas Networks | Y | ***Proposal 7: Msg1 contains the device generated unique random ID, message size which is the size of the next PDRCH signal, Device energy status, etc. The energy status of the device may consist of one or more bits to indicate the energy available at the device for receiving Msg1, followed by executing further communication with the reader.***  ***Proposal 9: In Msg2, the reader allocates one subcarrier to each device based on the energy status of that device. If the energy available at the device is below certain threshold, reader may choose not to allocate resource to that device. The device can get more energy form the CW signal received in the next slot and try again to communicate with reader at that slot.***  ***Frequency domain resource: Subcarrier allocation***  ***Time domain resource: OFDM slot allocation*** |
| NEC | Y |  |
| **following proposal can be considered**  **FL2 High Priority Proposal 5.2.2a: RAN1 studies the following aspects for Msg2 and Msg3 transmissions for random access, considering the impact of Msg1 multiplexing.**   * + **How does device monitor Msg2 transmission after it transmits Msg1, including starting time and time duration for Msg2 monitoring**   + **How Msg3 is scheduled by Msg2, at least including the resource allocation** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| Vivo2 | Y |  |
| InterDigital | Y |  |
| Huawei, HiSilicon | Y with comments | What the meaning of at least including the resource allocation?  According to Chair’s guidance, RAN1 only need to discuss physical layer resource aspects. |
| Ericsson | Y |  |
| DCM | Y |  |
| TCL | Y |  |
| Samsung | Y |  |
| **Based on the comments, the following proposal can be considered.**  **FL3 High Priority Proposal 5.2.2b: RAN1 studies the following aspects for Msg2 and Msg3 transmissions for random access, considering the impact of Msg1 multiplexing.**   * + **How does device monitor Msg2 transmission after it transmits Msg1, including starting time and time duration for Msg2 monitoring**   + **How Msg3 is scheduled by Msg2, including the resource allocation** | | |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI |  | The second bullet is unclear: resource allocation may be handled by RAN2 |
| DCM | Y | Time duration aspects / resource allocation aspects are RAN1 task. We do not agree with FW’s comment. |
| LG | Y |  |

## TDMA/FDMA of Msg3

Many contributions also propose to study TDMA/FDMA for Msg3 transmissions, while [13] proposed to discuss the feasibility and performance of FDMA based Msg3.

Given the companies’ interests, following proposal is made:

**FL1 High Priority Proposal 5.3-1: Study FDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**

* **How the frequency domain resources are allocated for the FDMA of D2R transmissions for Msg3**
* **How a device determines the frequency domain resource for the D2R transmissions for Msg3**
* **Note: this does not preclude discussion on TDMA for D2R transmissions for Msg.3**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y | What is the reason of having the last Note? With the Proposal 5.3-2, the note seems not necessary. |
| Vivo1 | Y | We think FDMA for Msg3 is also important for study as it facilities the access efficiency |
| ZTE, Sanechips |  | We also agree that the note is duplicated with Proposal 5.3-2. |
| xiaomi | Y |  |
| CMCC | Y | This proposal is basically the same as what we have agreed in the last RAN1 meeting regarding FDMA of D2R transmissions for Msg1, and we agree that FDMA for Msg3 should also be studied and supported. FDMA of Msg3 provides the most advantage in improving the inventory efficiency. |
| OPPO | Y | Perhaps Proposal 5.3-1 and Proposal 5.3-2 can be merged together as:  **FL1 High Priority Proposal 5.3: Study FDMA and TDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**   * **How the frequency and time domain resources are allocated for the FDMA and TDMA of D2R transmissions for Msg3** * **How a device determines ~~the frequency domain~~ a resource in frequency and time domains for the D2R transmission~~s~~ for Msg3** |
| Samsung | Y | We support the proposal in high-level. One question for the clarification: Isn’t the 1st and the 2nd bullet points the same? Otherwise, is there an additional step involved for a device to determine FD resource after the device is allocated an FD resource? |
| TCL | Y | Besides the aspects in the proposal, another question is whether the same multiplexing type (i.e., TDMA, FDMA) is used for both MSG1 and MSG 3 or not. We propose to consider the issue when discussing the resource allocation of MSG3. |
| DCM | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| LG | Y |  |
| Tejas Networks Ltd. | Y |  |
| NEC | Y |  |
| **FL2: FL1 High Priority Proposal 5.3-1 is merged with FL2 High Priority Proposal 5.3-2.** | | |

**FL1 High Priority Proposal 5.3-2: Study TDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**

* **How the time domain resources are allocated for the TDMA of D2R transmissions for Msg3**
* **How a device determines the time domain resource for the D2R transmissions for Msg3**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Vivo1 | Y |  |
| ZTE, Sanechips |  | Due to the longer duration of Msg3, the time interval between two adjacent TDMed Msg3 transmissions will be larger than adjacent TDMed Msg1 transmissions considering the impact of SFO, which may leads to resource wastage and additional inventory latency. Therefore, it is necessary to first study whether TDMA of D2R transmissions for Msg3 from multiple devices can provide significant gains.  **Study TDMA of D2R transmissions for Msg3 from Y devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**   * + **the maximum value of Y, considering the device implementation complexity, device power consumption，resource efficiency and the transmission efficiency affected by SFO.**      - **Evaluation of the benefits of Y>1 compared to Y=1**     - **Y can be 1.**   + **Addressing timing errors for adjacent time domain resources due to residual SFO of the device** |
| xiaomi | Y |  |
| CMCC | Y | OK to study. |
| OPPO |  | See our response to **Proposal 5.3-1** for merging the proposals. |
| Samsung | Y | We support the proposal in high-level. Similar question as before. |
| TCL |  | The same comment in **FL1 High Priority Proposal 5.3-1** |
| DCM | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| LG | Y |  |
| Tejas Networks | Y |  |
| NEC | Y |  |
| @ZTE, for TDMA of Msg3, it is related to the aspect#1 and #2 for section 5.2. Study TDMA of Msg3 should consider the aspects listed similar as the ones for FL2 High priority Proposal 5.1.1a. So, at this stage, may be better to consider the proposal with high-level description.  **FL2 High Priority Proposal 5.3-1a: Study FDMA and TDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**   * **How the frequency and time domain resources are allocated for the FDMA and TDMA of D2R transmissions for Msg3** * **How a device determines a resource in frequency and time domains for the D2R transmission for Msg3** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| LG | Y |  |
| Vivo2 | Y |  |
| InterDigital | Y |  |
| Huawei, HiSilicon | Y with comment | Thanks FL’s proposal,  Regarding the last sub-bullet, we are wondering what exact meaning of this sentence “**How a device determines the time domain resource for the D2R transmissions for Msg3**”, if it is timing relationship we would like to clarify it explicitly with an update. If it is mean how device select one resource from X resources we regard this is up to RAN2 procedure discussion. With above comment, we suggest the followings  **FL2 High Priority Proposal 5.3-1a: Study FDMA and TDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**   * **How the frequency and time domain resources are allocated for the FDMA and TDMA of D2R transmissions for Msg3** * **How a device determines a resource in frequency and time domains for the D2R transmission for Msg3 in terms of timing relationship or small frequency shift** |
| Ericsson | Y |  |
| DCM | Y |  |
| TCL | Y |  |
| ZTE, Sanechips |  | It may be interpreted that both FDMA and TDMA are considered for msg 3 at the same time.  Moreover, we understand the benefits of FDMA based msg 3 in terms of latency reduction.  However, for msg 3, which may be about 100bits, considering the SFO impact, the time intervals reserved for the TDMA msg3 is significant. Therefore, the latency may be increased. Meanwhile, device may need to wait for a long time to tx msg. Therefore, we think the “necessity of TDMA Msg 3” should also be part of the study.  **FL2 High Priority Proposal 5.3-1a: Study FDMA and/or TDMA of D2R transmissions for Msg3 from multiple devices in response to one or multiple Msg2 transmission(s) during access procedures, including following**   * **How the frequency and time domain resources are allocated for the FDMA and/or TDMA of D2R transmissions for Msg3** * **How a device determines a resource in frequency and time domains for the D2R transmission for Msg3** * **The necessity of TDMA Msg 3** |
| Samsung | Y |  |

Following are sone details provided by companies:

* [4] proposed for FDMA, the scheduling information of Msg3 is carried in each corresponding common Msg2.
  + - For D2R transmission carrying Msg1 during access procedures in FDMA/TDMA manner, the following observations for Msg3 are captured in TR 38.769:
      * Msg3 can be TDMed or FDMed.
      * If Msg3 TDMed,
      * The required register size for clock counters to keep timing between Msg2 and Msg3 increases with the maximum number of X, which has impact to device power consumption and complexity.
      * The gap between adjacent Msg3 messages increases with the maximum number of X, which has impact to transmission efficiency.
      * The maximum value of X for Msg3 might be even less than that for Msg1.
* [2] and [9] observed that transmission of Msg1 will require less time/frequency resources compared to Msg3 transmission for individual devices because of the difference in TBS.
* [9] and [10] observed that Msg3 transmission uses the same candidate resources as Msg1 is not an efficient way and propose the transmission resource for Msg3 can be adjusted based on the Msg2 response.
* [11], [33], [35] proposed following options on how to allocate the frequency domain resources for the multiple Msg.3
  + - Option 1: The resources for the multiple Msg.3 is identical to Msg.1, i.e., the frequency resource index is identical to Msg.1 and/or the sub-occasion index in one access occasion is identical to Msg.1;
    - Option 2: The resources for the multiple Msg.3 can be re-allocated by the control information conveyed by Msg.2.
* [13] proposed if multiple Msg3 transmissions are scheduled based on FDMA, the frequency domain resources used for Msg3 transmissions can be determined by the order of the corresponding ID echoes in a Msg2.
* [28] proposed in the case where both FDMA of Msg.1 transmission and FDMA of Msg.3 transmission are considered, study that the frequency resource index (e.g., frequency shift value) of Msg.3 transmission is defined to be the same as the frequency resource index of Msg.1 transmission for the same device.

## Others

**CDMA:**

* [7], [8], [15], [16], [13], [34] discussed CDM is feasible and proposed to study further
  + [7] discussed that code sequences can be provided in PRDCH providing triggering for random access procedure(e.g., msg0)
  + [8] provides simulation showing that binary modulated orthogonal sequence, e.g., Golay sequence, can tolerate timing error by selecting a suitable cyclic shift spacing
  + [15] provides simulation showing that CDM of RACH preambles using either m-sequences or Gold sequences of length 63 is feasible and preambles from multiple devices can be clearly detected by the reader, even in challenging conditions (SFO = 5%, SNR = 0dB)
  + [13] provides the simulation results to show that the access efficiency of Q-selection based on CDM data exceeds 2 times that of Q-selection
  + [34] gives a bunch of simulations with different power variations and SFO hypotheses
* **Meanwhile,** [4] discussed that CDMA cannot work because the large SFO at device side will break the sequences orthogonality and propose OFDMA and CDMA are not supported.

**Other enhancements**

* [13] proposed to study the enhanced slot based anti-collision algorithm, e.g. Q-selection + BTree.
* [30] proposed to study a collision handling mechanism to improve the success rate of the tags with collision by allocating some additional e.g., FDM’ed or CDM’ed resources (as Type II RA in Figure 6) resources to those collided tags.



Figure 6 A collision handling process via random access of [30]

Comments if any.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |

# Scheduling and timing relationships

* 1. Timing relations related aspects

About clarification on time between R2D and D2R or vice versa is the between the “end” of one transmission and the “start” of the next transmission, it should be clarified. But at this time being, it is difficult to make such clarification. FL proposed to study and clarify “the end” and “the start” of the transmission after the R2D and D2R waveform, basic resource allocation unit e.g., chip or bit symbol, time-domain frame structure design e.g., whether the start and/or end of the R2D transmission needs to be aligned with OFDM symbol boundary etc., become clearer.

### Timing for D2R response to R2D

|  |
| --- |
| Agreement (RAN1#117)  Study the following options for the time interval between a R2D transmission and the corresponding D2R transmission following it:   * Option 1: Define a maximum time TR2D\_max between a R2D transmission and the corresponding D2R transmission following it, so that the device transmits D2R transmission within [TR2D\_min, TR2D\_max].   + FFS: maximum time is common or different for different A-IoT devices   + FFS: maximum time for different traffic types/command types (e.g. DT or DO-DTT) and/or different use case (e.g., Inventory or Command) * Option 2: The corresponding D2R transmission timing TR2D following a R2D transmission is determined based on the control information in the R2D transmission, where TR2D ≥ TR2D\_min   + FFS the maximum value(s) for TR2D |

**For above two options, whether/how to do down-selection can be left to the potential normative phase.** In addition, some companies consider both options can be supported, for example,

* Option 1 is always required for the minimum requirement. Option 2 can be used if the D2R transmission timing is indicated by the reader; otherwise, the device transmits as soon as it is able in [TR2D\_min, TR2D\_max].
* Both Option 1 and Option 2 can be supported for A-IoT, which may also depend on A-IoT device type or capability.
* Option 2 can be used for contention free access or scheduling based D2R transmission and option 1 can be used for contention-based access.
* Option 2 is more feasible for TDMA of multiple D2R transmissions scheduled by one R2D transmission.

**About whether/how to address timing error for a D2R transmission caused by the residual SFO of the scheduled device, it is also related to proposal 5.1.1.**

* [13] proposed for the residual SFO impacts on the time interval between a R2D transmission and the corresponding D2R transmission,
  + - For Option 1, the device is required to transmit the D2R signal within its own clock-based time range [TR2D\_min, TR2D\_max] and the Reader starts detecting the D2R signal no later than the time TR2D\_min\*(1-clock error).
    - For Option 2, the device is required to transmit the D2R signal based on its own clock-based time TR2D and TR2D\*(1-clock error) should be larger than or equal to TR2D\_min.
* [14] proposed for the duration of a time domain resource for Msg.1 indicated by the paging message, some margin should be reserved to conquer the potential timing error due to the inaccurate clock embedded in the device.
* [9] and [21] noted that timing uncertainty grows as the distance between a D2R response and its associated R2D command signal increases, and the timing for the D2R response should consider the clock uncertainty or time drift due to SFO.
* [27] observed that handling timing error for a D2R transmission caused by the initial/residual SFO of the device is a reader implementation issue.
* [35] observed that for TDMed Msg1 corresponding to a paging message, TR2D\_max should consider the number of time slots for Msg1. Also, it is necessary to define TD2R\_D2R\_min for the transmission from different devices.

**No specific proposal is made for the Timing for D2R response to R2D. Instead, it is noted that many companies discuss about the time unit,**

**Time unit for the time interval**

* Variable R2D/D2R chip length [9] [10][13][27]
  + [10] proposed that the time unit for defining or indicating the time interval between a R2D transmission and the corresponding D2R transmission following it is R2D or D2R chip length
  + [13] proposed to use D2R chip duration as the unit because one information bit length can be even longer that the required interval between an R2D transmission and the corresponding D2R transmission in some coverage enhancement scenarios,
* Fixed as shortest chip length in the system [27]
* The minimum R2D chip duration allowed by the system [18]
* OFDM slot or mini-slot [12] [38]
  + the time unit for calculating the time interval between the R2D and the D2R transmission followed by it should follow NR convention like mini-slot or slot
* Codeword length of R2D/D2R [27]

**Time unit for the time domain resource allocation**

* OOK chip length for the corresponding R2D or D2R [2], [4], [5], [6], [10]
* The basic time unit for resource allocation in time domain is **integer multiple chip length or information bit length** for the corresponding R2D transmission or Msg1/Msg3 transmission or combination of them. [9]
* OFDM symbol/slot, ms:
  + [7] Time domain resource: OFDM slot allocation
  + [12] proposed that a common TTI (transmission time interval) of the A-IoT signals as the unit of the transmission resource in time domain should be defined in the A-IoT system design in order to have common design for R2D/D2R. The limited set of TBSs with their corresponding TTIs should be defined.
    - Option 1: The granularity of the TTI of the R2D signal is the NR OFDM symbol.
    - Option 2: The granularity of the TTI of the R2D signal is the mini-slot with 2 or 7 symbols or slot with 1ms at 15kHz SCS.
  + [14] proposed that coarse granularity time units (e.g., ms, OFDM slot) can be considered for msg in consideration of the potential timing error occurring at device side.
* [6] Both the first and last symbol occupied by D2R transmission should be regarded as the allocated reception time unit of gNB



Figure 1 Illustration of time resource allocation on the gNB side of [6]

**At this stage, the time unit for resource allocation and for timing relations is discussed separately, although the proposed options are the same.**

**FL1 Medium Priority Proposal 6.1.1-1: For the time unit for** **defining or indicating the time interval between a R2D transmission and the corresponding D2R transmission, study following options**

* **Option 1: Based on the chip length used for PDRCH and/or PRDCH that schedules the PDRCH**
* **Option 2: Based on the information bit length used for PDRCH and/or PRDCH that schedules the PDRCH**
* **Option 3: Based on the shortest chip length that the A-IoT system supports, corresponding to the maximum OOK-4 M values**
* **Option 4: Based on the NR OFDM symbol length**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | We think it is good to study all the options at study phase. In our view, option1/3 are more preferred as it can achieve balance between the overhead and finer granularity. |
| CMCC |  | I can understand FL’s intention that both options of the time interval between a R2D transmission and the corresponding D2R transmission are on the table at the current stage, and if down-selection is needed, it can be further handled during normative work.  But only look at this proposal, we have concerns that it may have implication that we will go for Option 2. To ease the concern, some wording suggestion on the main bullet is proposed:  **FL1 Medium Priority Proposal 6.1.1-1: For the time unit for** **defining or indicating the time interval between a R2D transmission and the corresponding D2R transmission, if Option 2 is supported, study following options**  **FL4 reply: This proposal can also be applied to Option 1, similar as RFID that the length of the time window is based on the time unit like RTcal and/or Tpri.** |
| Samsung | Y | We support to study the listed options. However, option 4 is meaningful only when D2R transmission is always NR OFDM symbol boundary aligned, which we have not agreed yet.  **FL1 Medium Priority Proposal 6.1.1-1: For the time unit for** **defining or indicating the time interval between a R2D transmission and the corresponding D2R transmission, study following options**   * **Option 1: Based on the chip length used for PDRCH and/or PRDCH that schedules the PDRCH** * **Option 2: Based on the information bit length used for PDRCH and/or PRDCH that schedules the PDRCH** * **Option 3: Based on the shortest chip length that the A-IoT system supports, corresponding to the maximum OOK-4 M values**   **~~Option 4: Based on the NR OFDM symbol length~~** |
| LG | Y |  |
| Ericsson | Y |  |

**FL1 Medium Priority Proposal 6.1.1-2: For the time unit for the time domain resource allocation, study following options**

* **Option 1: Based on the chip length used for PDRCH and/or PRDCH that schedules the PDRCH**
* **Option 2: Based on the information bit length used for PDRCH and/or PRDCH that schedules the PDRCH**
* **Option 3: Based on the shortest chip length that the A-IoT system supports, corresponding to the maximum OOK-4 M values**
* **Option 4: Based on the NR OFDM symbol length**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | We support to study these options. In our view, option 2 is more favourable as the message size can be large (e.g., as 400 bits in evaluation), and the resource allocation must ensure all the information bits in L1 can be transmitted completely. |
| Samsung | Y | We support the proposal in high-level. However, for TD resource allocation purpose, Option 3 and Option 4 does not seem to make sense.  **FL1 Medium Priority Proposal 6.1.1-2: For the time unit for the time domain resource allocation, study following options**   * **Option 1: Based on the chip length used for PDRCH and/or PRDCH that schedules the PDRCH** * **Option 2: Based on the information bit length used for PDRCH and/or PRDCH that schedules the PDRCH** * **~~Option 3: Based on the shortest chip length that the A-IoT system supports, corresponding to the maximum OOK-4 M values~~**   **~~Option 4: Based on the NR OFDM symbol length~~** |
| LG | Y |  |
| Ericsson | Y |  |
| **FL4: Note that the unit for resource allocation in time domain will be discussed in AI 9.4.2.1 General aspects.** | | |

### Timing for R2D response to D2R

RAN1#118 meeting agreed following:

|  |
| --- |
| Agreement  When a R2D transmission in response to a D2R transmission is expected for A-IoT Msg2 response to A-IoT Msg1 for the A-IoT device, study to define a maximum time TD2R\_max between the D2R transmission and the corresponding R2D transmission following it, so that the R2D transmission timing is expected to be within [TD2R\_min, TD2R\_max].   * FFS: whether there is a necessity to define different maximum times for different A-IoT devices |

* [3], [9] proposed that no need to limit above agreement only for A-IoT Msg2 response to a Msg1 and proposed to capture in TR38.769 that it is necessary to define a maximum time TD2R\_max between the D2R transmission and the corresponding R2D transmission following it, so that the R2D transmission timing is expected to be within [TD2R\_min, TD2R\_max].
* While [13] think the necessity to define the time intervals between D2R transmission and the corresponding R2D transmission in other cases has not been justified.

**The Msg2 response time is discussed in section 5.2. Therefore, no specific proposal is made here.**

### Timing gap between D2R and D2R (**TD2R\_D2R\_min**)

[4], [36] proposed to clarify the case for the time interval between D2R and D2R transmission before studying the value(s) of it.

[9], [22], [28] proposed the device acknowledges the reception of R2D transmission by indicating whether it needs more time to prepare the D2R transmission, similar as in-process reply in RFID.

Based on the discussions in RAN1#116bis meeting, the TD2R\_D2R\_min usage proposed by companies include following:

* Use case 1. Similar as in-process reply in RFID that for some R2D commands, a device replies firstly to Reader that it needs more time for processing/ preparation followed by the corresponding D2R response to the R2D command.
* Use case 2. Different segments of a single PDRCH
* Use case 3. Energy harvesting

**FL1 Low Priority Question 6.1.3: Do you support to study TD2R\_D2R\_min and TD2R\_D2R\_max that are the minimum and maximum time between two different consecutive PDRCH transmissions from the same A-IoT device at least for use case 1 (e.g., similar as in-process reply in RFID)?**

* **Any other use case you prefer to study?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| Samsung | - | We are more interested in use case 2, wherein a device has a limited capability to process a large TB and, therefore, a preceding PRDCH indicates to split the D2R TB in two consecutive PDRCH transmissions. |
|  |  |  |

### Other aspects

**About the values for the minimum/maximum processing time**

It may be premature to discuss the detailed values without knowing the applicable data/chip rates, sampling rate, message contents or command types to be transmitted/received for A-IoT devices and Reader. Therefore, the discussion related to the exact values can be deprioritized for this meeting.Following views are summarized for information:

* [4] propose the values from ISO 18000-6C UHF RFID are a reference for further study TR2D\_min, and TR2D\_R2D\_min, and the value of TR2D\_min is assumed to be higher than the value used in RFIDs to account for the complicated processing in Ambient IoT devices.
* [4], [10] propose for TD2R\_min and TD2R\_maxthat is related to the reader’s processing latency, the impact on the existing BS implementation e.g. ms-level time is included in the study. [3] proposed A-IoT features of RAN1 study should not require any implementation restriction especially for the existing gNB/UE.
* [22] observed that device processing time can include the time needed to collect information from surrounding environment e.g., using sensors.
* Same or different processing time for different A-IoT devices:
  + [3], [5], [7], [10], [15], [11] proposed that RAN1 to prioritize a common processing time for different A-IoT devices.
  + [4], [10], [13], [21], [22], [28], [30], [34], [36], [37] considers different processing time for different A-IoT devices
    - [4], [28]: Different TR2D\_max values can be defined for different devices in order to account for their differing transmitter processing times, especially since device 2b would require longer processing times.
* Same or different processing time for different traffic types/command types (e.g., DT or DO-DTT) and/or different use case (e.g., Inventory or Command):
  + [3], [10], [7], [13], [21], [22], [28], [30], [34], [36], [37] proposed to consider different processing time
  + [5], [15] propose RAN1 to prioritize a common processing time for different traffic types/command types.
  + [11] proposed to postpone the discussion after RAN2 has decided all of the candidate R2D Commands and the potential reply types.

**About timing aspects related to Topology 2**

* [15], [36] mentioned that TD2R\_min and TR2D\_R2D\_min may be different for different topologies
* [28] proposed to consider following for Topology 2
* How to determine the timing of the R2D synchronization signal from intermediate node (e.g., applicability of the UL TA) to Ambient IoT devices.
* For the case where an intermediate node (UE) requires UL sync re-adjustment to gNB, consider to study whether to provide longer timing (compared to normal UEs) during RACH procedure to ensure UL sync re-adjustment time for the intermediate node.

**About timing aspects related to deployment scenarios**

* [28] proposed to consider following
* time delay for forwarding of the received D2R signal/channel from the reader/ intermediate node (i.e., R2) for D2R reception to the reader/ intermediate node (i.e., R1) for R2D/CW transmission, in the case where the R1 and R2 are different.
* time delay for frequency retuning in device between R2D reception and D2R transmission, in the case where the FDD spectrums (i.e., DL band or UL band) for the R2D transmission and the D2R transmission are different.

Comments, if any.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |

* 1. Scheduling related aspects

### 5.2.1 Reader’s identification of the end of PDRCH transmission

For the reader to acquire the end of PDRCH transmission, some companies think it is necessary to identify whether there is a case where the reader does not know the end/length/TBS of the PDRCH for option 1 and option 2 selection. Note that whether D2R postamble is needed for other purposes like D2R timing correction is a separate discussion in previous section 3.2.4.

Companies’ views for the two options are summarized below.

**Option 1:** D2R postamble immediately follows the PDRCH is considered by [5], [8], [6], [11], [13], [17], [20], [22], [18],

* [8], [11], [13], [22]: for the case that the reader lacks knowledge of the packet size

**Option 2:** Based on control information is considered as baseline by [2], [3], [4], [6], [8], [9], [10], [15], [11], [12], [17], [16], [27], [25], [18], [34]

* [2], [3]: For D2R transmissions, the data packet size and PDRCH transmission length should be indicated by the reader
* [10]: TBS of PDRCH is indicated or derived by R2D control information provided by the reader in the previous PRDCH as baseline. But FFS on when devices with different EPC sizes are inventoried together, indication of TBS needs further study
* [4], [11]: The reader knows the TBS and the amount of time domain resources required for the PDRCH transmission and can use this information to figure out when the transmission is supposed to end since it scheduled the transmission
* [15]: postamble needs more resources for transmission, and add latency delay to the decoding; possibly using the D2R control information in D2R preamble
* [6]: can be indicated by R2D control information, but the end occasion indicated by D2R control information should be deprioritized in the current stage.
* [34]: R2D can indicate the code or format of the D2R to indicate the end of D2R

In addition, [6], [8], [11], [17], [28], [18] consider supporting both options and different options can be used for different cases or based on reader’s indication.

* [8]: option 2 can be used for scheduling-based D2R transmission
* [11]: option1/option2 depends on whether reader know the transmission length of D2R response, whether there is/in which case the reader can know the length of D2R response is up to other WG’s discussion.
* [6]: support option1, option 2 can be used for some scenarios. E.g., RN16 scheduled by Msg.0
* [17]: both option 1 and option 2 could be used for R2D and D2R transmission
* [28]: reader can indicate whether to include postamble in the D2R transmission via R2D control information. If the reader indicates not to include a postamble, the end of D2R transmission can be included in the R2D control information (or D2R control information).
* [18]: proposed to consider a combination of two options, e.g. to minimize impact of mis-detection of the postamble and correctly determine timing for a subsequent R2D reception even in case of not successfully receiving/decoding the R2D control information

**For the case where reader doesn’t know the exact TBS from devices, even if it exists, the question would be whether we want to design the system to let the reader control and determine/allocate the resource. Note that RAN2 agreed in RAN2 #127 that “RAN2 will study the need and use of a simple message “size” reporting to the reader”. Considering all above, following proposal is made:**

**FL1 Medium Priority Proposal 5.2.1-1:**

* **For PDRCH with variable payload size, RAN1 studies the TBS of PDRCH indicated or derived by R2D control information as baseline at least for the case that reader knows the TBS.**
* **For PDRCH with a fixed TBS in response to an R2D transmission, reader acquires the end of PDRCH transmission by the fixed TBS.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | For the 2nd bullet, there is no explicit TBS indication in R2D. |
| Samsung | Y | We support the proposal in high-level. However, the case when the actual TBS is smaller than the indicated TBS needs to be addressed.  **FL1 Medium Priority Proposal 5.2.1-1:**   * **For PDRCH with variable payload size, RAN1 studies the TBS of PDRCH indicated or derived by R2D control information as baseline at least for the case that reader knows the TBS.**   + **When the available data size is smaller than the TBS indicated by R2D control information, the actual TBS is indicated in the PDRCH.** * **For PDRCH with a fixed TBS in response to an R2D transmission, reader acquires the end of PDRCH transmission by the fixed TBS.** |
| InterDigital |  | There may never be a case where the reader knows for sure the TBS that the device provides, because possibility of insufficient energy, processing time, etc. If the goal is to ensure that the reader maintains control over the resource, we can replace TBS with “Maximum TBS”. |
| LG | Y |  |
| ETRI | Y |  |
| Ericsson | Y |  |

**FL1 Low Priority Question 5.2.1-2:**

* **Is there a case where the reader does not know the TBS of the PDRCH?**
* **If there is such a case, which option is preferred?**
  + **Option 1: the TBS of PDRCH is determined and indicated from the device to reader**
  + **Option 2: the TBS of PDRCH is determined and indicated by the reader**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | N | We think even if exist, the system should be designed to allow the reader to control the D2R resource allocation and therefore TBS for each scheduled D2R resource allocation are always known to reader. |
| Samsung | Y | We think that the first question is answered by RAN2 implicitly as they study the need for message size reporting.  For both options, they seems not mutually exclusive, as there can be a situation where a reader may not always and instantaneously know the available data size at the device. |
| InterDigital | Y | Cases may include: insufficient energy available at the device, uncertainty on the amount of data available in device, insufficient processing time. |
| Tejas **Networks** | Y | **Option 1: the TBS of PDRCH is determined and indicated from the device to reader** |

### 5.2.2 Device’s identification of the end of PRDCH transmission

**For Option 1 that R2D postamble immediately follows the PRDCH to indicate or derive the end of the PRDCH,**

* **The claimed necessities/benefits for Option 1 are following:**
* **P1: It implicitly indicates the TBS with higher efficiency**
  + [4], [5], [6], [8], [13]: Considering the message size can be up to about 1000 bits, i.e., 125 bytes, then about 7 bits are needed to indicate the TBS in granularity of bytes.
* **P2: No need to predefine the set of possible TB sizes in standards, it can support any TBS.** 
  + [4], [5], [8], [13]
* **P3: Postamble is necessary in the case of short data packet, since the device may not have enough time to finish processing the R2D control information.** 
  + [3], [5]
* **P4: further assist timing synchronization as well as indicate the end** 
  + [11]
* **P5: better forward-compatibility for more dynamic PRDCH payload size in future use cases other than inventory and command**
  + [25]
* **P6: no separate PRDCH formats is needed (e.g., PRDCH format with TBS indication)**
  + [4]
* **The claimed unnecessities/concerns for Option 1 are following**
* **C1: For R2D data transmission (e.g., R2D command has a specific structure) with a fixed length, no need for an explicit indication through a postamble** 
  + [6], [9], [27], [34], [37]
* **C2: More device power consumption and detection failure if device miss/false-detects the postamble** 
  + [9], [12], [16], [17]
* **C3: Additional signal needs to be defined and to be detected by the device**
  + [15]
* **C4: If the payload size of the subsequent D2R/R2D data transmission is configured/indicated by readers to devices** 
  + [9], [34], [37],[20]
* **C5: For indoor inventory and command use cases, the introduction of R2D postamble only for certain (limited type of) PRDCH transmissions that have variable payload is questionable** 
  + [9], [34]
* **C6: More resources are needed for the postamble transmission, and adding latency delay to the decoding** 
  + [15]

**For Option 2 that based on R2D control information to indicate or derive the end of the PRDCH**

* **The claimed necessity/benefits for Option 2 are following:**
* **P1: For smaller or fixed TBS, Option 2 can be used to mitigate the postamble overhead** 
  + [9]
* **P2: More robust, Lower miss/false-detection probability compared to option 1** 
  + [9], [12], [16], [17]
* **P3: Since the R2D transmission will include a control information, it is preferred to indicate the transmission duration using the R2D control information** 
  + [9], [15]
* **P4: No additional power consumption caused by the miss detection compared to option 1** 
  + [9], [17]
* **P5: Option 2 for its simplicity and effectiveness** 
  + [12], [15],[30]
* **P6: sufficient and offers greater flexibility for scheduling and operations**
  + [38]
* **The claimed unnecessity/concerns for Option 2 are following**
* **C1: bit- or byte-level TBS indication can lead to a large padding overhead** 
  + [4], [8], [13]
* **C2: Processing time for control information may not be enough for short data packet** 
  + [3], [5]
* **C3: Need to predefine the set of possible TB sizes in standards** 
  + [5], [8]
* **C4: Less flexible to accommodate the dynamic variation of PRDCH payload size for future extension and have impact on variation of PRDCH length (e.g., due to presence of D2R control information)**
  + [25]
* **C5: Need to predefine a separate PRDCH format for end indication and device would have to perform blind detection of the different formats**
  + [4]

In addition, [3], [10], [17], [18], [27] proposed to consider both options,

* [3]: Option 1 is for short data packet, option 2 is for long data packet, the reader guarantees a minimum processing time of control information, and the control information field is ahead of the data packet
* [10]: Option 1 is the baseline and Option 2 can be used for small TBS to further mitigate the postamble overhead.
* [17]: both option 1 and option 2 could be used for R2D and D2R transmission
* [18]: consider combination of the above Option 1 and Option 2 to minimize impact of postamble miss-detection and correctly determine timing for a subsequent R2D reception even if control information is incorrectly decoded
* [27]: option1 can be additionally used given the possible clock drift at a device at least for PRDCH

In UHF RFID, most of the Interrogator to Tag commands has one field of “command code”, by the “command code”, the Tag knows the R2D transmission length. For A-IoT, at least for traffic types DO-DTT and DT with focus on rUC1 (indoor inventory) and rUC4 (indoor command), it is not clear about companies’ views on whether similar i.e., for many of PRDCH transmissions, ‘command code’ like control field should be specified and the numbers of bits for the R2D commands are to be specified.

**FL1 Low Priority Proposal 5.2.2-2: An A-IoT device can identify the end of a PRDCH transmission that carries an R2D command with a size exclusive to that specific command.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| ZTE, Sanechips |  | Whether device can identify PRDCH transmission via the R2D command depends on the detailed design of R2D command. We think a more feasible way is via R2D postamble. |
| Samsung | Y |  |
| LG | Y |  |

### 5.2.3 R2D chip length indication

For R2D chip length indication, it was agreed in the RAN#117 meeting

|  |
| --- |
| Agreement  For R2D, the clock-acquisition part of the R2D time acquisition signal is used to determine the OOK chip duration   * + FFS: Pattern design to support determination of chip duration |

* [2], [4], [5], [10], [12], [18], [23], [27], [34], [38]: The clock-acquisition part of R2D timing acquisition signal (e.g., R2D preamble) preceding the PRDCH indicates the information of chip length used for the following PRDCH transmission.
  + [5], [12], [27] proposed that the chip length for the clock-acquisition part of R2D timing acquisition signal and the chip length for the following PRDCH transmission is same for simplicity
  + [10], [18], [27] further proposed that same chip duration of clock-acquisition part of the preamble is applied for both control information and data packet of the PRDCH
  + **Meanwhile**, [13], [15] proposed that separately encoding for control information and data payload in PRDCH to pursue different reliability
* [28]: By R2D preamble(s) similar as RFID that preamble/frame sync includes DL symbol length or by PRDCH payload (e.g., in case when PIE is not used)
* [36]: by control information. Support several chip durations for R2D transmission, and indicate a chip duration by control information for the R2D transmission

Therefore, following proposal is made:

**FL1 Low Priority Proposal 6.2.3: As a baseline, the same chip length is studied for both the clock-acquisition part of the R2D timing acquisition signal and the subsequent RDCH transmission.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | We see no clear motivation to have separate chip lengths for control and data as control and data are transmitted together. |
| ZTE, Sanechips | Y |  |
| Samsung | Y |  |
| ETRI | Y |  |

### 5.2.4 D2R chip length indication

|  |
| --- |
| **Agreement**@RAN1#118  For D2R scheduling, the following information potentially can be explicitly/implicitly indicated to the device via corresponding PRDCH:   * Time domain resources * Frequency domain resources * MCS-like information * **Chip duration** * ID associated with device(s) * Repetitions   FFS: other information  FFS: For each information, whether higher-layer signaling and/or L1 R2D control signaling is used |

For D2R chip length indication,

* [5], [8], [26], [28], [30], [34], [36]: by R2D control information.
  + [8]: prioritize the chip duration indication of D2R transmission using explicit indication in the L1 control information in PRDCH
  + [34]: D2R chip duration can be indicated as an integer multiple or fraction of R2D chip duration
* [7], [28]: Combination of R2D preamble and R2D control information
  + [7]: the smallest time unit of resource allocation for D2R is the period of square wave for SFS modulation, therefore this information should be provided in control information of PRDCH. The baseline chip duration before applying SFS can either be derived from R2D preamble or R2D control information

In addition, [5] considers it may NOT be necessary/desirable to (re-)indicate the D2R chip length for each and every PDRCH transmission and proposed two directions:

* Direction 1, each R2D control information before D2R transmission carries the D2R chip length. In other word, each R2D control information carried the D2R chip length for the following one D2R transmission.
* Direction 2, partial R2D control information before D2R transmission carries the D2R chip length. In other word, partial R2D control information carried the D2R chip length for the following multiple D2R transmission.

Based on above, following is proposed.

**FL1 High Priority Proposal 5.2.4-1: RAN1 studies following options for the D2R chip length identification**

* **Option 1: by R2D preamble**
* **Option 2: by R2D control information**
* **Note above two options are not mutually exclusive**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| Vivo1 | Y |  |
| ZTE, Sanechips | Y |  |
| xiaomi | Y |  |
| OPPO | Y |  |
| FUTUREWEI | Y |  |
| Samsung | Y | We support the proposal in high-level. We suggest to add a note for clarity.  **FL1 High Priority Proposal 5.2.4-1: RAN1 studies following options for the D2R chip length identification**   * **Option 1: by R2D preamble** * **Option 2: by R2D control information** * **Note above two options are not mutually exclusive**   **Note: Different options may correspond to different line encoding schemes** |
| TCL | Y |  |
| DCM | Y |  |
| InterDigital | Y |  |
| Spreadtrum | Y |  |
| Panasonic | Y |  |
| LG | Y |  |
| Tejas Networks Ltd. | Y |  |
| Huawei, HiSilicon |  | For the D2R chip length, it has to be indicated by the reader in the D2R grant in the preceding PRDCH transmission. The R2D chip length determined by the device using the clock acquisition part of the R2D timing acquisition signal can be used as a reference for the D2R chip length. |
| NEC | Y |  |
| ETRI | Y |  |
| Ericsson | Y |  |
| IITK, IITM | Y |  |

### 5.2.5 Other scheduling information

**For R2D transmission,**

The following agreements related to R2D scheduling aspects were agreed in RAN1#118 meeting:

|  |
| --- |
| Agreement  For R2D reception, the following information potentially can be explicitly/implicitly indicated to the device via PRDCH:   * ID associated with device(s) intended for the reception of R2D, potentially including all devices (if supported) * FFS: other information   FFS: For each information, whether higher-layer signaling and/or L1 R2D control signaling is used |

Based on the above agreement, companies provide further details about the agreed scheduling information as well as further additional scheduling information to be included in PRDCH for R2D scheduling.

**ID associated with device(s) is discussed in [1], [3], [4] with the following details**

* ID associated with device(s) intended for the reception of R2D is in L1 R2D control information, which allows a device to avoid decoding an unintended PRDCH transmission to increase device availability [1]
* The agreed information related to the ID is not a separate L1 control information, and should be included in the PRDCH transmission itself [4]
* Instead of sending device ID in the control signals, a specific sequence can be used to indicate the intended device [3]

[4] proposed that there is no need to indicate MCS, since for PRDCH, only OOK is applied, while FEC code is not supported; While other companies discussed following potential scheduling information may or may not be needed for R2D transmission:

* **MCS related information/parameters** for different use cases and channel condition are proposed by [20], [15], [13], [36]
  + Coding scheme and/or coding rate [15], [13]
  + Chip rate/chip length [36]
* **TBS related information/parameters** [5], [6], [10], [12], [15], [14], [20], [27], [34]
  + By a ‘command code’ like or ‘command type’ like control field, for certain message types with a fixed size, e.g., a command with a fixed message size [6], [10], [14], [27], [34], where [10] mentioned this information should be in L1 signal
  + By an explicit indication for certain message types with a variable size [27]
  + the starting position and ending position of time resources can be derived by preamble and coding rate+TBS respectively [15]
  + **From FL: TBS is related to the discussion in section 6.2.2 Device’s identification of the end of PRDCH transmission**
* [4], [5] mentioned that R2D scheduling timing between the R2D control information and the R2D data transmission is NOT needed as long as
  + the starting time of the PRDCH is indicated by the R2D timing acquisition signal, while the chip length is indicated by the clock acquisition part of this signal [4].
  + TDRA can be derived from preamble and TBS/postamble [5]
* [10] proposed that the timing of a subsequent R2D response to a D2R is determined based on the indication from the previous R2D. (e.g., Reader may have to response to multiple devices, i.e. multiple Msg2)
* [4], [5] mentioned that frequency domain location for PRDCH is NOT needed as the envelope detection used by Ambient IoT devices convert the RF signal at any frequency within the effective band to baseband; Meanwhile [15] proposed frequency resource should be considered, without differentiating R2D or D2R.
* Repetition if supported [5], [13]
* Message type indication [13]
  + The information indicates whether the R2D carries the signaling that is transmitted before Msg1 (e.g., paging message), or after Msg1 (specific signaling for one or a group of device, e.g., Msg 2 or Msg 4), to prevent devices that have not sent Msg1 from detecting unnecessary R2Ds

Given above, only one low priority proposal is made:

**FL1 Low Priority Proposal 5.2.5-1: Indication of Frequency domain location for PRDCH demodulation is NOT needed for A-IoT device using envelope detection.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y |  |
| Samsung | Y |  |

**For D2R transmission**

The following agreements related to D2R scheduling aspects were agreed in RAN1#118 meeting:

|  |
| --- |
| Agreement  For D2R scheduling, the following information potentially can be explicitly/implicitly indicated to the device via corresponding PRDCH:   * Time domain resources * Frequency domain resources * MCS-like information * Chip duration * ID associated with device(s) * Repetitions   FFS: other information  FFS: For each information, whether higher-layer signaling and/or L1 R2D control signaling is used |

Based on the above agreement, companies provide further details about the agreed scheduling information as well as further additional scheduling information to be included in PRDCH for D2R scheduling

* [4] proposed that each PRDCH contains the scheduling information for its following PDRCH in a higher-layer message to avoid any separate PHY layer procedures or specification effort, while offering flexibility in terms of the size of the D2R grant.
* **In contrast**, several companies [2][20] suggested that the scheduling information for PDRCH could be included in the L1 layer. Specifically, [2] proposed that TBS can be in L1 control information.
* **From FL: whether the control information should be L1 or L2 is up for discussion in agenda 9.4.2.3.**

**For potential scheduling information required for D2R transmission,**

* MCS-like information [3], [5], [15], [13], [25], [36] with the following details:
  + Modulation (if multiple) [3], [15], [5], [36], where [15] mentioned that modulation can be predefined
  + Coding scheme and/or coding rate [5], [15], [13], [36]
  + Chip length [4], [5], [25], [36]
    - **From FL: chip length is related to the discussion in section 6.2.4, D2R chip length indication**
* TBS related information/parameters [2], [4], [5], [10], [12], [26], [15], [34], [36]
  + R2D can indicate the code or format of the D2R [34]
  + the starting position and ending position of time resource can be derived by preamble and coding rate+TBS respectively[15]
  + TBS of PDRCH is indicated or derived by R2D control information is baseline, but there are also cases that the Reader doesn’t know the exact TBS from device (e.g. EPC size may be different for different devices in the same inventory round) and need further consideration [10]
    - **From FL: TBS is related to the discussion in section 5.2.1 Reader’s identification of the end of PDRCH transmission**
* Time domain resources [3], [4], [5], [6], [10], [11], [12], [15], [20], [21], [22], [23], [27], [33], [36] with the following details:
  + [3] mentioned that the scheduling information for multiple A-IoT devices could be sent by the reader and can be in the data of PRDCH
  + Amount/duration of time resources [4], [22]
    - The number of slots for each round of the slotted-Aloha procedure [22]
  + Timing of transmission or time interval [5], [6], [10], [12], [8], [9], [10], [11], [20], [21], [22], [23], [27], [33], [30]
    - timing of PDRCH should be indicated to another reader receiving PDRCH if CW node is a different than the reader [3]
    - when the response does not use contention-based resources[21]
    - the slot start for every M slot(s) of the slotted-Aloha based contention-based access procedure[22]
    - time offset between R2D preamble and D2R preamble to adapt the residue SFO w.r.t. targeted transmission time (related to selected TBS and data rate/MCS) [30]
    - indicate a time unit in time domain for D2R transmission to avoid the transmission collision among multiple devices for CFRA [8]
    - a set of {Starting offset, length} or only {starting offset} defined for sub-occasion(s) is used for the D2R time domain indication for CBRA, the specific sub-occasion associated with the device ID for CFRA[11]
    - timing delay parameters for a specific device or group of devices[27]
    - for CFRA, start timing is provided by reader indication. Otherwise, define a timing interval to limit the transmission occasion range [6]
    - time positions for each candidate resource for TDMA[10]
* Frequency domain resources[3], [5], [8], [22], [10], [11], [15], [27], [36]
  + the scheduling information for multiple A-IoT devices could be sent by the reader and can be in the data of PRDCH [3]
  + subchannel indication[8]
  + the number of frequency resources for Msg1 transmission[22]
  + Small Frequency Shift (SFS) modulation or Uplink frequency offset[10]
  + {BLF, M} pairs for CBRA, separate frequency domain resource associated with the device ID for CFRA[11]
* Repetition related aspects(e.g., number) [5], [36]
* ID associated with device(s) [3], [12], [36]
  + [3] mentioned that the A-IoT ID information is in control signal if D2R from multiple devices are scheduled and the corresponding scheduling information of D2R transmission is in PRDCH data. If A-IoT ID is not indicated, device does not decode the overall data.
  + [12] proposed that device ID can be provided by clock acquisition part of D2R preamble
* Midamble information [2], [6], [11], [26], [28]
  + location, and number of D2R midambles [2], [11], [6]
  + presence of midamle in D2R [2], [11], [28]
  + midamble information is based on reader indication or predefined condition(e.g., pre-configured chip length or bit length)[2], [6], [11]
  + presence of midamble is based on TBS and 1-bit indicator in preamble signalling that the transmission of the target device is not completed yet[26]
  + **From FL: depends on discussion of midamble for D2R in section 3.2.3 Proposal 3.2.3-2**
* Postamble presence in D2R [28]
* Additional parameters (e.g., Divide Ratio and the value of “Q”) [11]
* Access control parameters: Such as access probability, prohibit timers [27]
* Indicator for 2-step or 4-step random access[27]
* Indicator for whether Msg 4 is expected for 4-step random access [27]

**No specific proposal is made for the time being.**

|  |  |
| --- | --- |
| **Company** | **Comments, if any** |
|  |  |

**Others**

In addition to above scheduling information for R2D/D2R, some discussions on the PRDCH/PDRCH cast type and scheduling type, D2R control information, scheduling restrictions and scheduling aspects related to Topology 2 are summarized as below:

* Regarding the scheduling type/cast type [8], [36], [15]
  + [15] proposed to support dynamic scheduling (DG), while de-prioritize SPS and Configured Grant (CG) based scheduling
  + [8] proposed to study unicast and groupcast D2R
  + [36] proposed to support both unicast PRDCH and broadcast PRDCH to trigger single device, group of devices and all devices
  + [27] proposed to support PRDCH (i.e., Msg 2) providing a ACK or a group ACK for Random access
  + [27] proposed to support PRDCH providing a command in a device-specific or device-group-specific manner involving D2R data transmission, and PRDCH providing a group ACK for more than one successfully received PDRCH data transmission for command mode
  + **From FL: For cast type, it is noted that RAN2#125bis agreed following**

|  |
| --- |
| **Agreement**  **We will study the support for access triggering for a single device, group of devices, or all devices. RAN2 to discuss the contention-based and contention-free access procedures and detailed solutions.** |

* **Regarding D2R control information,** [13] discussed that L1 D2R control information is not well justified, while some companies [20], [15], [16], [22], [25] discussed the potential D2R control information, with the following rationales/use cases:
  + [16], [25] proposed to study information reporting from device
  + [25] ACK/NACK corresponds to PRDCH transmission
  + [22] Required time to prepare the D2R transmission
  + Message size/status related information if reader may not be aware of the exact status/payload of the D2R [15], [22], [16]
    - [22]D2R transmission payload information
    - [22] expected D2R transmission duration
    - [15] [22] end of D2R transmission, where [15] proposed that the end of PDRCH transmission at the reader is based on D2R control information (possibly using the D2R preamble)
    - [16] ratio based indication, which is defined as device remaining data size over the previous indicated/scheduled data size for more efficient D2R scheduling

**Scheduling restriction for gNB**

[10] proposed to consider parallel querying in each scheduling decision window to improve inventory efficiency if scheduling decision window (e.g., can only make scheduling decision every 5ms) exists due to scheduling restriction of gNB or intermediate UE

**Scheduling aspects related to Topology 2**

* [8] proposed that
  + same downlink synchronization signals/channels are designed for gNB in Topology 1 and UE in Topology 2, device does not need to differentiate whether a detected synchronization signal/channel is from a gNB or a UE
  + Study how to configure UE in Topology 2 for providing synchronization services to ambient IoT
  + Study radio resource allocation mechanism for intermediate node in Topology 2
* [28] proposed to consider following for Topology 2
* discuss how to determine the timing of the R2D synchronization signal from intermediate node to Ambient IoT devices, e.g., IN transmits a R2D synchronization signal by applying both its UL TA and additional TA offset provided by NW
* time delay for forwarding of the received D2R signal/channel from the reader/ intermediate node (i.e., R2) for D2R reception to the reader/ intermediate node (i.e., R1) for R2D/CW transmission, in the case where the R1 and R2 are different.
* time delay for frequency retuning in device between R2D reception and D2R transmission, in the case where the FDD spectrums (i.e., DL band or UL band) for the R2D transmission and the D2R transmission are different.
* studying whether to provide longer timing (compared to normal UEs) during RACH procedure to ensure UL sync re-adjustment time for the intermediate node
* only UEs in the connected state can be operated as intermediate node (IN) and it can transmit the R2D transmission by applying its valid UL TA
* [33] discussed some issues related to intermediate UE’s behaviors for Topology 2.
  + How to schedule intermediate UE’s transmission/reception in communication with A-IoT UE, e.g., scheduling DCI.
  + Reporting behavior after communication b/w intermediate UE and A-IoT UE, e.g., how to schedule reporting timing/resource from intermediate UE, which contents to be reported, etc.
  + SCS/BWP switching rule if required, e.g., whether the existing BWP switching mechanism is used when SCS of signal for A-IoT UE is different.
  + Processing time requirement b/w scheduling and transmission at intermediate UE, including SCS switching and/or waveform switching aspects.
  + Overlap handling at intermediate UE, e.g., UL transmission vs PRDCH reception

**Comments, if any**

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |

# DO-A Gap

According to the following objective in the SID, the part(s) of the harmonized air interface design insufficient for the DO-A use case need to be identified.

|  |
| --- |
| *From RP-240826 [13]*  …   1. Traffic types DO-DTT, DT, with focus on rUC1 (indoor inventory) and rUC4 (indoor command).  * From RAN#104, the study will assess whether the harmonized air interface design (per bullet ‘A’ above) can address the DO-A (Device-originated autonomous) use case, only to identify which part(s) of the harmonized air interface design (per bullet ‘A’ above) is/are not sufficient for the DO-A use case.   … |

[2] suggested capturing in the TR that the following aspects of the harmonized air interface may not be sufficient for the DO-A traffic type:

* Synchronization:
  + Some R2D transmission is needed for timing correction before the device carries out DO-A transmission.
    - This R2D transmission could for example be a periodic synchronization signal or a periodic paging-like message.
* Random access:
  + One or more D2R resources for potential Msg1 transmission need to be provided in advance to a device in order for it to be able to do DO-A transmission.
    - This D2R resource could for example be provided through a (periodic) paging-like message.
* Scheduling and timing:
  + The D2R resource(s) for potential Msg1 transmission can be provided through (periodic) paging-like messages, which the device can use for DO-A access.
    - A time window after each paging-like message could potentially be defined, so that the device could be allowed to autonomously decide where in window to carry out the DO-A transmission.

[4] proposed to capture the missing mechanisms/schemes to support DO-A traffic from the starting point of the Ambient IoT air interface for inventory and command by comparing the Rel-19 A-IoT design to the legacy NR/LTE mobile-originated access procedures and configurations.

* Device-initiated access procedure.
  + Either an inventory or a command starts from a paging message from reader to one or multiple devices
* Preconfigured resources for access occasion.
  + The resource(s) for the access occasion(s) are indicated in the paging message. It is in the way of “on-demand” resource allocation, rather than the semi-static configuration in NR/LTE.
  + Devices does not achieve, and cannot maintain, synchronized timing with the reader. The timing acquisition will be done through the preamble at the head of each R2D/D2R transmission. Based on the asynchronous system, the resource of each access occasion may need to be indicated by an R2D message ahead of it.
* Optionally, buffer-size report for D2R data (if not supported in R19)
  + Not sure that there will be buffer size report to support the use cases of inventory and command in R19, as the message size of the D2R data could be indicated by e.g. core network

[27] proposed RAN1 to first establish common understanding on DO-A operation (for example by following questions), and perform gap analysis in coordination with RAN2 on RAN2 related issues, e.g., buffer-size report.

* Question 1) What’s the expected use case for DO-A, i.e., in what circumstance a device is expected to transmit autonomously?
* Question 2) Is a device expected to be completely out of sync, or the device can utilize other PRDCHs such as semi-persistently transmitted beacon-like PRDCH or PRDCH addressed to other devices?
* Question 3) How is DO-A triggered, assuming that a device does not randomly transmit arbitrary data?
* Question 4) Are we sure at this point that BSR-like mechanism is not supported or that it is indeed needed for DO-A since it was agreed in RAN2 #127 that “RAN2 will study the need and use of a simple message “size” reporting to the reader”?

**FL1 High Priority Proposal 7-1: From RAN1 perspective, capture at least following aspects of the harmonized air interface may not be sufficient for the DO-A traffic type in the TR.**

**Aspect #1: Synchronization**

* **Some R2D transmission is required for timing correction before the device executing DO-A transmission.**

**Aspect #2: Device initiated access procedure**

* **An inventory or a command starts with a R2D transmission e.g., A-IoT paging message from reader to one or multiple devices. Devices require pre-allocated D2R resources for potential D2R transmission to perform DO-A transmission.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm |  | From our perspective, the obvious missing piece for DO-A is the Aspect #2. It is not clear yet whether Aspect #1 is really missing for DO-A. Therefore, we suggest to delete Aspect #1 and keep Aspect #2. |
| Vivo1 | Y | We are ok with listing aspects that may need different designs from DT/DO-DTT. |
| ZTE, Sanechips |  | We think the DO-A traffic can be also achieved by two directions:  Direction 1: DO-A transmission is triggered by periodic/frequency R2R transmission  Direction 2:DO-A transmission is initiated by device  For the two aspects listed in Proposal 7-1 only focuses on direction 2. |
| OPPO |  | Beside the synchronization (Aspect #1) and device initiated access procedure (Aspect #2), we think how the energy of a device is (pre-)charged for the very first transmission from the device and subsequent operations (or the assumption behind it) should be captured as well (e.g., Aspect #3).  We are OK with listing aspects (at a top-level) that may be different to the inventory or command process that starts with a R2D transmission. But currently, we are not sure   * + For Aspect #1, if a R2D transmission is required for timing correction before the device executing DO-A transmission   + For Aspect #2, if a device requires pre-allocated D2R resources at least for the first D2R transmission from the device.   The above sub-bullets under Aspect #1 and #2 seem to be very specific solution design. It is better to leave them out for now, and just lists aspects that would be different for DO-A traffic for the study. |
| FUTUREWEI |  | Comment from oppo is ok |
| Samsung | Y |  |
| DCM |  | We are OK to have discussion, but whether something is insufficient or not is unclear in this stage. We suggest postponing to agree this, and keeping study further. |
| Spreadtrum | Y |  |
| Panasonic | Y | We are ok for listing the aspects. |
| Lenovo | Y | We are fine to capture the observation, in aspect#1 we can write as study whether existing R2D or a separate R2D is needed …. |
| Huawei, HiSilicon | Y with comments | Ok to list high-level aspects, but prefer to take care over setting hard “requirements” already in Rel-19. The SID does not ask us to set “requirements”, only to identify which parts of Rel-19 are not sufficient for DO-A traffic. We also think it can give RAN plenary a misleading view that there is no insufficiency relating to BSR-like operation.  Under Aspect#1: Suggest to add “**If synchronization is assumed for DO-A**” to be more accurate, and also address some company’s concerns.  “**Some R2D transmission**” should be general enough, e.g., it could be existing R2D or a separate R2D. We are ok to have such general description.  Under Aspect#2: “**An inventory or a command starts with a R2D transmission e.g., A-IoT paging message from reader to one or multiple devices.**”: this sentence seems irrelevant, suggest to remove it.  In summary, we suggest red changes below.  ==  **FL1 High Priority Proposal 7-1: From RAN1 perspective, capture at least following aspects of the harmonized air interface may not be sufficient for the DO-A traffic type in the TR.**  **Aspect #1: Synchronization**   * **If synchronization is assumed for DO-A, some R2D transmission ~~is required~~ for timing correction before the device executing DO-A transmission.**   **Aspect #2: Device initiated access procedure**   * **~~An inventory or a command starts with a R2D transmission e.g., A-IoT paging message from reader to one or multiple devices. Devices require~~ pre-allocated D2R resources for potential D2R transmission to perform DO-A transmission.**   **Aspect #3: Buffer-size reporting like mechanism, if not supported or if not sufficient in Rel-19.** |
| Based on the comments, following can be considered  **FL2 High Priority Proposal 7-1a: From RAN1 perspective, capture at least following aspect of the harmonized air interface may not be sufficient for the DO-A traffic type in the TR.**   * **For DO-DTT and DT traffic types, the D2R resource(s) for D2R transmission is/are indicated in a R2D transmission. For DO-A traffic, devices require pre-allocated D2R resource(s) for potential D2R transmission(s).** | | |
| **Company** | **Y/N** | **Comments** |
| OPPO |  | In our understanding, for DO-A traffic, a device only needs to have one pre-allocated D2R resource for the very first initial D2R transmission. Subsequent D2R resource(s) can be allocated/indicated by the reader after the initial D2R transmission is received at the reader. So, we propose the following modification:  **FL2 High Priority Proposal 7-1a: From RAN1 perspective, capture at least following aspect of the harmonized air interface may not be sufficient for the DO-A traffic type in the TR.**   * **For DO-DTT and DT traffic types, the D2R resource(s) for D2R transmission is/are indicated in a R2D transmission. For DO-A traffic, a device~~s~~ requires a pre-allocated D2R resource~~(s)~~ for ~~potential~~ the initial D2R transmission~~(s)~~.** |
| Qualcomm | Y | OPPO’s comment may probably be valid. However, since we have not yet understood the DO-A procedure, it is perhaps sufficient to keep the generic statement as FL proposes. |
| Vivo2 | Y |  |
| Ericsson | Y |  |
| DCM | Y | Prefer OPPO’s version. |
| TCL | Y |  |
| Huawei, HiSilicon |  | Similar comment with QC that it’s better to keep the description generic since the detailed DO-A procedure is unclear now. There is no need to highlight initial transmission, we can keep things generic.  Suggest following red changes.  ==  **FL2 High Priority Proposal 7-1a: From RAN1 perspective, capture at least following aspect of the harmonized air interface may not be sufficient for the DO-A traffic type in the TR.**   * **For DO-DTT and DT traffic types, the D2R resource(s) for D2R transmission is/are indicated in a R2D transmission. For DO-A traffic, a device~~s~~ requires at least one pre-allocated D2R resource~~(s)~~ for potential D2R transmission(s).** |
| Samsung | Y |  |

# Time domain frame structure for A-IoT

* 1. Alignment between R2D and NR frame structure

**On whether to align the end of R2D transmission with OFDM symbol boundary**

**From reader perspective for waveform generation perspective**

* [4], [5], [6], [9], [10], [12], [15],[13], [27] **support the alignment** to ease the generation of an OFDM waveform
* [15] beneficial for reducing the TBS indication granularity to OFDM symbol level
* [4] proposed to include padding before the R2D waveform generation for PRDCH, when the generated number of chips for the PRDCH do not fully occupy the last OFDM symbol for DFT-s-OFDM-based transmitter where the time sequence/signal is processed by the DFT and IFFT module in order, as shown in following figure.

图形用户界面, 应用程序

描述已自动生成

Figure 13. Example of alignment with an OFDM symbol of [4]

* [5] based on Reader’ s implementation to make this alignment. For example, padding “0” or padding with repeated partial of R2D signal



Figure 2.1.1-1. Example of alignment with NR symbol or slot boundary of [5]

* [13] proposed to use the flexible postamble to pad the last OFDM symbol and make it into an integer symbol to perform the alignment of the last OFDM symbol
* [6], [13] properly design the TBS and code rate to ensure that R2D transmission terminated at the end of OFDM symbol, e.g., the data rate value that is not divisible by the number of OFDM symbols per millisecond is better to be avoided
* [9], [10]: From reader point of view, it can pad zeros or other bits based on its implementation, but from device point of view, it does not care what is following after the end of R2D transmission as it stops monitoring
* [12] proposed to support TTI (transmission time interval) of the A-IoT signals associated with the TBS size, and the length of the R2D transmission would at least align with the multiple of the NR OFDM symbol, such as 2OSs mini-slot, 7OSs mini-slot or a slot
* Meanwhile, [11], [19] proposed that the end of R2D transmission is unnecessary to be aligned with the boundary of an NR symbol
* [11] most of the transmission packets size in A-IoT R2D direction is small, no need for alignment.
* [19] keeping the end of R2D transmission aligned with an OFDM symbol is not efficient due to the varied and numerous data packages.
* In addition, [4], [11], [20] **slot level alignment** may not be needed as it may reduce efficiency of R2D transmission/scheduling. [36] mentioned whether the end of R2D transmission is aligned with the boundary of an NR symbol, the impact of CP handling should be considered

**For A-IoT timing relations**

On whether the “end” of a R2D transmission is aligned with OFDM symbol boundary or not, the views from companies are diverged. **It has impact on timeline discussions.**

* [13]: the end of ‘R2D transmission’ includes the R2D postamble, and a flexible postamble or a proper TBS/code rate is to ensure the alignment
* [4]: The end of the R2D transmission is not needed to be aligned with the OFDM symbol boundary to improve the transmission efficiency, i.e., the postamble is used to indicate the end of the transmission, after which padding is performed, if needed. See Figure 14 (b)



Figure 14 from [4]

**FL1 Medium Priority Proposal 8.1:**

* **For R2D waveform generation using DFT-s-OFDM-based transmitter, from reader perspective, padding is needed when the generated number of chips for the R2D transmission does not fully occupy the last OFDM symbol.**
* **For A-IoT timing relations, from both device and reader perspective, the end of R2D transmission is not needed to be aligned with the OFDM symbol boundary.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 | Y | We think padding is necessary for easy OFDM waveform generation. But the padding may not impact the timeline. |
| ZTE, Sanechips |  | The two bullets seems contradicted to each other. If the end of R2D transmission is not needed to be aligned with the OFDM symbol boundary, why padding is needed. |
| Samsung | - | Question for clarification. Isn’t the 1st and the 2nd bullet points contradicting each other at least from the reader perspective? |
| LG | Y |  |
| Tejas Networks | - | The two bullets are contradicting.  We think the padding is necessary (when the chip size does not occupy the entire OFDM slot) to align the PDRCH frame to NR boundary |
| **@ZTE,** Samsung and Tejas Networks, the 1st bullet is from waveform generation perspective, which uses **DFT-s-OFDM-based transmitter. But 2nd bullet is from the A-IoT timing relations perspective, reader and device should have the aligned understanding on the timing relations, as shown in the figure 14 of [4].**  C:\Users\w00468695\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\55E63EEE.tmp  Figure 14 from [4]    **FL2 High Priority Proposal 8.1a:**   * **For R2D waveform generation using DFT-s-OFDM-based transmitter, padding is needed when the generated number of chips for the R2D transmission does not fully occupy the last OFDM symbol.** * **For A-IoT timing relations, from both device and reader perspective, the end of R2D transmission is not needed to be aligned with the OFDM symbol boundary.** | | |
| **Company** | **Y/N** | **Comments** |
| LG | Partially Y | We can support the first bullet.  For the second bullet, based on the previous agreement, the minimum and maximum of TR2D is defined as the timing gap between ending of R2D transmission and starting of D2R transmission. So, we need to clarify first whether the padding is part of the R2D transmission. |
| Vivo2 | Y |  |
| Samsung | - | Having difficulty how to relate the second bullet point with the first bullet point. |
| NEC | Y to bullet 1 | “Postamble” means the end of PRDCH transmission, and continuing transmission of padding bits is confusing. |
| **FL3 High Priority Proposal 8.1b: For R2D waveform generation using DFT-s-OFDM-based transmitter, padding is needed when the generated number of chips for the R2D transmission does not fully occupy the last OFDM symbol.** | | |
| **Company** | **Y/N** | **Comments** |
| FUTUREWEI | Y with comment | While the intent is understood, using “needed” implies a requirement. Perhaps a rephrase  **For R2D waveform generation using DFT-s-OFDM-based transmitter, ~~padding is needed~~ when the generated number of chips for the R2D transmission does not fully occupy the last OFDM symbol, padding can be used.** |
| LG | Y |  |

* 1. Alignment between D2R and NR frame structure

**On whether to align the D2R reception/transmission with NR symbol and/or symbol boundary**

[4], [5], [6], [9], [10], [11], [28], [23], [19], [20], [32], [36] proposed Rel-19 A-IoT study **does not** assume that the start and the end of a D2R reception is aligned with an NR time boundary.

* + [9] proposed from the transmitter i.e., device and the receiver i.e., Reader perspective, the start of D2R transmission or reception cannot be assumed to be aligned with NR OFDM symbol boundary within the CP range. In addition, for D2R transmission, A-IoT device does not apply and maintain the timing advance (TA).
  + [10] observed following:
    - For D2R transmission only consider [TR2D\_min, TR2D\_max], it is impossible to align the D2R transmission within the NR symbols and/or slots.
    - For D2R transmission with an indicated time gap from R2D transmission, it is up to gNB or intermediate UE whether to align the D2R transmission within the NR symbols and/or slots. Furthermore, the impact of large SFO should be considered to verify the feasibility of such alignment among different devices.
  + [11] asynchronized transmission is starting point
  + [19] mentioned that aligning with NR symbol or NR slot boundary in D2R transmission is thankless considering timing drift
  + [19] proposed that dynamic guardian symbols can address the issues arising from the lack of alignment
  + [32] symbol level alignment is not possible considering the time drift at device

[32] proposed that although there is no need for alignment of symbol boundary, but should study how to achieve alignment of the start of D2R transmission with **NR slot**

Meanwhile,

[12] proposed that from the reader perspective, resource for the D2R could be considered to align with the boundary of the OFDM symbol to reserve enough time to cover D2R length and timing error. And the resource unit is TTI, which is same as that of R2D

[33] Proposed to study alignment between the D2R reception and a NR time boundary (NR symbol/slot boundary).

* Device performs D2R resource determination and D2R TX based on post-sync SFO, which is updated by monitoring/reception of the latest R2D sync signal.
  + Assume post-sync SFO is much smaller than the initial SFO
  + Alt 1 (One paging associated with multiple D2R slots), R2D sync signal can be transmitted periodically during potential D2R TX occasions
  + Alt 2 (Each paging providing a single D2R slot), R2D sync signal should be transmitted periodically between two R2D messages within each slot



Fig.7: Temporarily periodic R2D sync signal for highly-time aligned system of [33]

Given above, following proposal can be considered.

**FL1 Medium priority Proposal 8.2: The D2R transmission can be controlled by the reader to be confined within one or multiple expected slot(s) or mini-slot(s) or OFDM symbol(s), instead of alignment of OFDM symbol boundary.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Vivo1 |  | We think this should be an observation instead of a proposal as how to achieve this slot(s) or mini-slot(s) or OFDM symbol(s) level control seems to be reader implementation. |
| Samsung | N | We think this proposal is unnecessary as it is anyway agnostic to devices. |
| LG | N |  |
| Tejas Networks Ltd. | Y |  |

# Agreements achieved in RAN1#118bis

**Agreement**

TP in R1-2409187 is endorsed in principle for section 6.2 and Annex X of TR38.769, subject to possible revisions.

* The contents in the Tables are further checked by companies and targeted for completion in RAN1#119.

**Agreement**

The start indicator part of the R2D time acquisition signal is not included in TD2R\_min.

**Agreement**

For R2D reception, the device can use line codes to achieve at least chip-level time tracking by using the transition(s) of the line code.

**Agreement**

* The TR will capture the following options, and companies are encouraged to analyze the tradeoffs among the following D2R amble(s) options:
  + Option 1: D2R preamble only
  + Option 2: D2R preamble + X midamble(s), where X ≥1
  + Option 3: D2R preamble + postamble
  + Option 4: D2R preamble + Y midamble(s) + postamble, where Y≥1
* For the above options, companies are encouraged to report at least the following:
* Purpose(s) of the preamble, midamble and postamble
* Whether companies assume multiple options can be supported

**Agreement**

RAN1 studies following:

* A R2D transmission triggering random access determines X time domain resource(s) for D2R transmission(s) for Msg1, where each D2R transmission for Msg1 occurs in one time domain resource of the X time domain resource(s).
* The study includes
  + Study X=1 and X>1 and X>=1, the maximum value of X>1 should be set considering the device implementation complexity, device power consumption, the resource usage efficiency affected at least by SFO, and inventory latency.
  + Size(s) for resource allocation in the time domain
  + Determination of the X time domain resource(s) by the device
  + Addressing timing errors for adjacent time domain resources due to residual SFO of the device

**Agreement**

Study FDMA and/or TDMA of D2R transmissions for Msg3 from multiple devices in response to a given set of one or multiple Msg2 transmission(s) during access procedure, including following

* How the frequency and time domain resources are allocated for the FDMA and/or TDMA of D2R transmissions for Msg3

**Agreement**

From RAN1 perspective, capture in the TR that 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.

**Conclusion**

For the purpose of the Rel-19 study, the study on DO-A in RAN1 is considered completed based on the above agreement.

**Agreement**

RAN1 studies the following options for Msg2 transmission in response to multiple Msg1 transmissions, which is initiated by a R2D transmission triggering random access.

* Option 1: A PRDCH for Msg2 transmission corresponds to a A-IoT Msg1 received from one device
* Option 2: A PRDCH for Msg2 transmission corresponds to multiple A-IoT Msg1 received from different devices

**Agreement**

RAN1 studies the starting time and time duration for Msg2 monitoring for Msg2 reception.

**Agreement**

For analysing the trade-offs among the D2R amble(s) options, companies can refer to the Table 3.2.4 in section 3.2.4 of R1-2408993 for information.

**Agreement**

For R2D waveform generation using DFT-s-OFDM-based transmitter, from transmitter perspective, when the generated number of chips for the R2D transmission does not fully occupy the last OFDM symbol, at least padding can be used.

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [**R1-2407611**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407611.zip) | Discussion on Frame Structure and Timing Aspects for Ambient IoT | FUTUREWEI |
| [2] | [**R1-2407639**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407639.zip) | Frame structure and timing aspects for Ambient IoT | Ericsson |
| [3] | [**R1-2407646**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407646.zip) | Frame structure and timing aspects for Ambient IoT | Nokia |
| [4] | [**R1-2407670**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407670.zip) | On frame structure and timing aspects of Ambient IoT | Huawei, HiSilicon |
| [5] | [**R1-2407708**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407708.zip) | Discussion on frame structure and timing aspects for Ambient IoT | Spreadtrum Communications |
| [6] | [**R1-2407735**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407735.zip) | Discussion on frame structure and timing aspects for Ambient IoT | China Telecom |
| [7] | [**R1-2407762**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407762.zip) | Resource allocation and framestructure of A-IoT | Tejas Network Limited |
| [8] | [**R1-2409026**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_118b/Inbox/R1-2409026.zip) | Discussion on frame structure and physical layer procedures for Ambient IoT | Lenovo |
| [9] | [**R1-2409008**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_118b/Inbox/R1-2409008.zip) | Discussion on Frame structure, random access, scheduling and timing aspects for Ambient IoT | vivo |
| [10] | [**R1-2407907**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407907.zip) | Discussion on frame structure and timing aspects for A-IoT | CMCC |
| [11] | [**R1-2407971**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407971.zip) | Discussion on frame structure and timing aspects for Ambient IoT | Xiaomi |
| [12] | [**R1-2408049**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408049.zip) | Study of Frame structure and timing aspects for Ambient IoT | CATT |
| [13] | [**R1-2408068**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408068.zip) | Discussion on frame structure and physical layer procedure for Ambient IoT | ZTE Corporation, Sanechips |
| [14] | [**R1-2408113**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408113.zip) | Discussion on frame structure and timing aspects | Fujitsu |
| [15] | [**R1-2408148**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408148.zip) | Discussion on frame structure and timing aspects of A-IoT communication | OPPO |
| [16] | [**R1-2408207**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408207.zip) | Discussion on frame structure and timing for ambient IoT | NEC |
| [17] | [**R1-2408234**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408234.zip) | Discussion on frame structure and timing aspects for Ambient IoT | HONOR |
| [18] | [**R1-2408251**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408251.zip) | Discussion on frame structure and timing aspects | Sharp |
| [19] | [**R1-2408264**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408264.zip) | Discussion on Frame structure and timing aspects for A-IoT | China Unicom |
| [20] | [**R1-2408370**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408370.zip) | Discussion on frame structure and timing aspects | Google |
| [21] | [**R1-2408411**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408411.zip) | Frame structure and timing aspects for Ambient IoT | Sony |
| [22] | [**R1-2408434**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408434.zip) | Frame structure and timing aspects of Ambient IoT | InterDigital, Inc. |
| [23] | [**R1-2408467**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408467.zip) | On remaining frame structure and timing aspects for AIoT | Apple |
| [24] | [**R1-2408536**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408536.zip) | Discussion on A-IoT Frame Structure and Timing Aspects | Panasonic |
| [25] | [**R1-2408569**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408569.zip) | Discussion on frame structure and timing aspects | ETRI |
| [26] | [**R1-2408596**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408596.zip) | Frame Structure and Timing Aspects for Ambient IoT | IIT, Kharagpur |
| [27] | [**R1-2408648**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408648.zip) | Considerations for frame structure and timing aspects | Samsung |
| [28] | [**R1-2408673**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408673.zip) | Frame structure and timing aspects for Ambient IoT | LG Electronics |
| [29] | [**R1-2408687**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408687.zip) | Discussion on frame structre and timing aspects for Ambient IoT | BUPT |
| [30] | [**R1-2408702**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408702.zip) | Frame structure and timing aspects | MediaTek Inc. |
| [31] | [**R1-2408742**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408742.zip) | Considerations for frame structure and timing aspects | Semtech Neuchatel SA |
| [32] | [**R1-2408763**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408763.zip) | Discussion on frame structure and timing aspect | ASUSTeK |
| [33] | **R1-2408990** | Study on frame structure and timing aspects for Ambient IoT | NTT DOCOMO, INC. |
| [34] | [**R1-2408852**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408852.zip) | Frame structure and timing aspects | Qualcomm Incorporated |
| [35] | [**R1-2408901**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408901.zip) | Discussion on frame structure and timing aspects for Ambient IoT | WILUS Inc. |
| [36] | [**R1-2408920**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408920.zip) | Discussion on frame structure and timing aspects for Ambient IoT | TCL |
| [37] | [**R1-2408931**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408931.zip) | Discussion on Frame structure and timing aspects | CEWiT |
| [38] | [**R1-2408942**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408942.zip) | Frame structure and timing aspects of AIoT | IIT Kanpur, Indian Institute of Tech (M) |
| [39] | A Low-Power Continuously-Calibrated Clock Recovery Circuit for UHF RFID EPC Class-1 Generation-2 Transponders, Chi-Fat Chan, et. al., IEEE Journal of Solid-State Circuits, Vol. 45, Issue. 3, March 2010 | | |

# Appendix A: Previous Agreements for 9.4.2.2

RAN1#116:

|  |
| --- |
| Agreement  From RAN1 perspective, at least when a response is expected from multiple devices that are intended to be identified, an A-IoT contention-based access procedure initiated by the reader is used.  Agreement  For A-IoT contention-based access procedure, at least slotted-ALOHA based access is studied.  Agreement  At least the following time domain frame structure is studied for A-IoT R2D and D2R transmission.   * For R2D transmission,   + A R2D timing acquisition signal (e.g. R2D preamble) is included at least for timing acquisition and for indicating the start of the R2D transmission in time domain. * For D2R transmission,   + A D2R timing acquisition signal (e.g. D2R preamble) is included at least for timing acquisition and for indicating the start of the D2R transmission in time domain. * FFS other necessary component(s), e.g. midamble, postamble, periodic sync signal, control fields, guard period   Agreement  For further discussion, the following terminologies are used for A-IoT for studying processing time aspects:   * TR2D\_min: Minimum Time between a R2D transmission and the corresponding D2R transmission following it. * TD2R\_min: Minimum Time between a D2R transmission and the corresponding R2D transmission following it. * TR2D\_R2D\_min: Minimum Time between two different consecutive R2D transmissions to the same A-IoT device. * TD2R\_D2R\_min: Minimum Time between two different consecutive D2R transmissions from the same A-IoT device. * The study should consider at least following aspects   + Implementation restrictions for the existing BS/UE   + [Processing time is common or different for different A-IoT devices]   + [Processing time for different traffic types/command types (e.g. DT or DO-DTT) and/or different use case (e.g., Inventory or Command)] * FFS other timing aspects |

RAN1#116bis:

|  |
| --- |
| Agreement  For R2D transmission, if OFDM-based waveform is used, the start of R2D transmission from reader perspective is assumed to be aligned with the boundary of an NR OFDM symbol (including the CP) for in-band/guard-band operation.  Agreement  To determine or derive the end of PRDCH transmission, study at least following options:   * Option 1: R2D postamble immediately follows the PRDCH to indicate the end of the PRDCH. * Option 2: Based on R2D control information.   Agreement  For the reader to acquire the end of PDRCH transmission, study at least following options:   * Option 1: D2R postamble immediately follows the PDRCH * Option 2: Based on control information   Agreement  For D2R transmission, study the necessity of midamble at least for the purpose of performing timing/frequency tracking or channel estimation or interference estimation, considering at least the following:   * Modulation and Coding schemes, e.g., data modulation, line/channel coding * Receiving methods, e.g., coherent or non-coherent * D2R transmission length/packet size * Midamble overhead * Timing/frequency accuracy * Phase accuracy   Agreement  RAN1 study the R2D transmission without midamble as the baseline if Manchester encoding is used.   * FFS the necessity for the R2D transmission with midamble if PIE is used. |

RAN1#117:

|  |
| --- |
| Agreement  Study whether/how an A-IoT device can count the time with sufficient accuracy (with a certain timing error due to SFO) at least for the purposes related to TDM(A) (if needed), and if so for how long after receiving an R2D transmission.  Agreement  Scheduling information of PDRCH transmission is provided by a corresponding PRDCH.  **Conclusion**  RAN1 discussion related to the potential impact of device unavailability due to charging by energy harvesting will occur in agenda item 9.4.2.2.  Agreement  Study the following options for the time interval between a R2D transmission and the corresponding D2R transmission following it:   * Option 1: Define a maximum time TR2D\_max between a R2D transmission and the corresponding D2R transmission following it, so that the device transmits D2R transmission within [TR2D\_min, TR2D\_max].   + FFS: maximum time is common or different for different A-IoT devices   + FFS: maximum time for different traffic types/command types (e.g. DT or DO-DTT) and/or different use case (e.g., Inventory or Command) * Option 2: The corresponding D2R transmission timing TR2D following a R2D transmission is determined based on the control information in the R2D transmission, where TR2D ≥ TR2D\_min   + FFS the maximum value(s) for TR2D |

RAN1#118:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agreement  When a R2D transmission in response to a D2R transmission is expected for A-IoT Msg2 response to A-IoT Msg1 for the A-IoT device, study to define a maximum time TD2R\_max between the D2R transmission and the corresponding R2D transmission following it, so that the R2D transmission timing is expected to be within [TD2R\_min, TD2R\_max].   * FFS: whether there is a necessity to define different maximum times for different A-IoT devices   Agreement  Study FDMA of D2R transmissions for Msg.1 from multiple devices in response to a R2D transmission triggering random access, including following   * How the frequency domain resources are allocated for the FDMA of D2R transmissions for Msg.1 * How a device determines the frequency domain resource for the D2R transmissions for Msg.1   Note: this does not preclude discussion on TDMA for D2R transmissions for Msg.1  Agreement  For the study of the potential impact of device unavailability due to charging by energy harvesting, the following directions are captured in TR 38.769:   * Direction 1: Reader does not provide information to a device regarding when the device may become available/unavailable. * Direction 2: Reader can provide information to a device based on which the device may become available/unavailable. * Note: The applicability of Direction 1 and/or 2 to different device types 1/2a/2b may be further discussed. * Note: Direction 1 and Direction 2 are not for down-selection.   For Direction 1, following can be the template to capture the solution details proposed by companies, if any.   |  |  | | --- | --- | | Source | Details | | Source [x] | Solution description  Observations or Analysis or Evaluations  Specification impacts, if any | | Source [y] | Solution description  Observations or Analysis or Evaluations  Specification impacts, if any |   For Direction 2, following can be the template to capture the solution details proposed by companies, if any.   |  |  | | --- | --- | | Source | Details | | Source [x] | Solution description  Observations or Analysis or Evaluations  Specification impacts, if any | | Source [y] | Solution description  Observations or Analysis or Evaluations  Specification impacts, if any | |

# Appendix B: RAN2 Agreements for Random Access

RAN2#126 (excerpt)

**Agreements**

1 As baseline, the “inventory only” case is supported by the procedure:

- Step A: A-IoT paging;

- Step B: Device ID transmission (via Random Access or without using RA). Details are FFS

2 As baseline, the “inventory and command” case is supported by the procedure:

- Step A: A-IoT paging;

- Step B: Device ID transmission (via Random Access or without using RA). Details are FFS

- Step C: reader to device data transmission (e.g. the R2D command), and

- Step D: corresponding device to reader data transmission (e.g. the feedback). FFS whether this is optional, pending other WG discussions.

Clarify in TR that inventory and command doesn’t mean that AIoT paging includes both Inventory and Command in the same message. This doesn’t mean that inventory and command are received by the reader at the same time from upper layer.

3 From RAN2 point of view we will study “Command only” use case.

FFS the options on how to support it :

Initial trigger message from the reader contains the command. Final feasibility depends on SA2 and SA3 work/conclusions.

Use baseline procedure for “inventory and command”(i.e. first triggers inventory procedure and then sends command)

**Agreements on 2 step CB RA**

1. A-IoT Msg1: The device sends Device ID and/or any other upper layer data (depending on upper layer request). FFS what device ID is and whether an additional random ID is needed. This doesn’t preclude any other RAN1 agreed information
2. A-IoT Msg2: the reader may echo some information from Msg1. FFS what some information is. “Msg2” usage/presence can be further discussed

**Agreement**

**From reader perspective, contention-free access procedure we will study single and multi-device case (depending on RAN1 discussion)**.

**Agreements**

1 RAN2 will study the following cases for AIoT paging message:

* a message containing an ID of a single A-IoT device.
* a message containing a group ID that maps to multiple A-IoT devices.
* a message that does not contain an ID, i.e., addressed for all devices that can receive the AIoT message.
* a message containing multiple IDs of A-IoT devices. Need to confirm the need for this use case based on SA2 discussion.

What device ID and group ID and scenarios is depending on SA2 discussion.

2 AIoT paging message indicate information from which the device can determine resources to be used for response (D2R message). FFS how (e.g. implicit/explicit/configured/preconfigured) and what resources (dedicated and/or shared) are provided to the device taking into account RAN1 discussion.

3 From RAN2 perspective, we assume the device can receive as long as there is enough energy. We will wait for RAN1 further progress on device monitoring details.

***Agreements on “4 step” RA***

1 A-IoT Msg1: the device sends an ID to the reader. ID is a random ID generated by device (FFS how it is generated, e.g. randomly generated or generated based on Device ID). FFS on ID size. This doesn’t preclude any other RAN1 agreed information

2 A-IoT Msg2: the reader echos the ID received in Msg1. Further information may be included in mgs2 based on RAN1 agreements

3 A-IoT Msg3: device sends Device ID and/or any other upper layer data (depending on upper layer request)

* The device considers the contention resolution as successful, if the Msg2 including the same random ID in Msg1 is received. RAN2 assumes the size of random ID in Msg1 should be sufficient for contention resolution purpose.
* “Msg4” (i.e. the subsequent R2D transmission after D2R transmission) does not need to be always sent in random access. “Msg4” can be considered to handle the Msg3 transmission failure (due to various reasons). “Msg4” usage/presence can be further discussed.

RAN2 will not use “Msg4” term for further discussion of the random access.

RAN2#127 (excerpt)

**Agreements**

- RAN2 will study the need and use of energy status report to be delivered from the device to the reader in case the device does not have energy for the follow up messages. FFS details on signaling

- RAN2 will study the need and use of a simple message “size” reporting to the reader

**Agreements:**

1 Support mechanism for reader to be able to trigger multiple/subsequent AIoT paging messages that are associated with the same request from the CN. Study how to avoid duplicated response from devices

**Agreements**

- For 3-step CBRA Support fixed random ID size is 16 bit. The ID is randomly generated.

- Failure/success indication of D2R will be studied. FFS if it would be implicit or explicit and for which use case it is needed. FFS whether it is applied only to some cases.

**Agreements**

- for 2step CBRA, RAN2 design will support msg2. Whether it is needed it is up to the reader. FFS when it is needed. For 2-step CBRA (when mgs2 is needed), the random ID (fixed 16bits) is also included in A-IoT Msg1, and is echoed in A-IoT Msg2. FFS if there will be devices support only 2-step RA and any other optimizations will be needed for such devices.

- **In contention-free access, the A-IoT device directly sends the upper layer data (e.g. device ID) in its very first D2R message after being triggered (i.e. skip contention resolution Msg1/2).**  FFS if a short AS ID is also included in the message and what type of ID for scheduling purposes.

- FFS if reader assigns the AS ID for scheduling purposes

**Agreements**

1 RAN2 is responsible for the interface between intermediate node (i.e. Reader) and RAN for topology 2.

2 A-IoT air interface in topology 1 between A-IoT device and reader is fully reused in topology 2, i.e. topology is transparent to the A-IoT device and there is no impact on A-IoT device.

3 RAN2 assumes that intermediate UE authorization is performed by upper layers. RAN2 impact can be studied after further SA/RAN3 progress.

4 RAN2 will study the impacts to RAN2 based on the SA2 identified architecture options (i.e. no new AS layer architecture options will be studied)

5 NW is in control of resources to be used by AIoT air interface.

6 Will support in-coverage and study cases for reader “temporarily” out of connection (e.g. RLF, HO). May consider extendibility to future “temporarily” out of coverage case with full NW control of resources (if possible).