**3GPP TSG-RAN WG2 Meeting #127-bis R2-24xxxxx**

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

**Agenda Item: 8.2.x.x**

**Source: Huawei, HiSilicon**

**Title: Report of [POST127][033][AIoT] Random Access**

**Document for: Discussion and Decision**

# 1 Introduction

This contribution gives the discussion summary of following post email discussion.

* **[POST127][033][AIoT] Random Access (Huawei)**

 Intended outcome: Discuss Failure/success indication aspects and FFS for CBRA and on FFS on AS ID for scheduling purposes

 Deadline: long

## Scope and structure

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| Some FFSs about the random access in RAN2 agreements:* *Handling of contention resolution failure and access failure at the device will be studied in RAN2, including failure detection and re-access. FFS details*
* *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.*
* *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.*
* *wait for further RAN1 progress on indication of the start of access occasion.*

Some FFS points about random access in the current TR:“*- If the random access is contention-based random access:**- Performs access occasion/resource determination/selection: [FFS];*” |

Rapporteur clarifications on the scope and discussion structure of this email discussion:

* To have a clear/comprehensive discussion on “Failure/success indication aspects”, it is better that companies share their understanding on:
	+ First, who/how to detect the D2R failure (See [2.1.1](#_2.1.1_Failure_detection));
	+ Second, the consequence/device behavior after the D2R failure (See [2.1.2](#_2.1.2_Consequence_of));
	+ Third, the need/when/how to provide the failure/success indication (See [2.1.3](#_2.1.3_Need/when/how_to)),
	+ Then, the follow-up discussion to handle the failure by re-access will continue in [2.2.4](#_2.2.4_Re-access);
* As to some FFSs for CBRA, several aspects are discussed:
	+ When the Msg2 is needed in 2step RA (See [2.2.1](#_2.2.1_When_Msg2));
		- The related optimization is also good to collect companies’ views (See [2.2.2](#_2.2.2_2-step_RA));
	+ One critical step is missing between the “reader triggers RA procedure” to “device sends Msg1”, i.e. how the device selects/determines the access occasion.
		- It is time to have some very high-level discussion and common views on the essence of the slotted ALOHA procedure (See [2.2.3](#_2.2.3_Access_occasion)) and have some basic terminologies/concepts for the re-access discussion;
	+ Re-access is also one critical FFS point while RAN2 does not have chance to touch it yet. It is also the follow-up discussion after 2.1.2 (See [2.2.4](#_2.2.4_Re-access));
* FFS on AS ID for scheduling purposes (See [2.3](#_2.3_AS_ID_1)). The intention is to consider all cases, e.g. contention-free access and CBRA.

## Contact information

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# 2 Discussion

## 2.1 Failure/success indication related

This discussion initially focuses on the D2R transmission for Msg3 and any following D2R transmission for data as examples. It will be nice if the discussion can somehow extend to Msg1 transmission and Msg2 reception failure cases (if possible).

### 2.1.1 Failure detection for D2R data transmission

RAN1 studied the timing relationship options:

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| A-IoT processing time aspects are studied in terms of the following timing relationships:*T*R2D\_min: Minimum time between a R2D transmission and the corresponding D2R transmission following it.*T*D2R\_min: Minimum time between a D2R transmission and the corresponding R2D transmission following it.*T*D2R\_max: Maximum time between the D2R transmission and the corresponding R2D transmission following it, so that the R2D transmission timing is expected to be within [*T*D2R\_min, *T*D2R\_max], 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.*T*R2D\_R2D\_min: Minimum time between two different consecutive R2D transmissions to the same A-IoT device.*T*D2R\_D2R\_min: Minimum time between two different consecutive D2R transmissions from the same A-IoT device.For the time interval between a R2D transmission and the corresponding D2R transmission following it, there are two options studied:Option 1: Define a maximum time *T*R2D\_max between a R2D transmission and the corresponding D2R transmission following it, so that the device transmits D2R transmission within [*T*R2D\_min, *T*R2D\_max].Option 2: The corresponding D2R transmission timing *T*R2D following a R2D transmission is determined based on the control information in the R2D transmission, where *T*R2D ≥ *T*R2D\_min. |

Based on the service type (inventory and/or command), the reader understands whether the device is supposed to feedback to one R2D transmission. **Reader** can detect the D2R transmission (Msg3) failure, based on the above timing relationship, i.e. no corresponding D2R (Msg3) received after reader sends R2D transmission (Msg2). But, the reader may have no idea whether it is caused by Msg2 failure or Msg3 failure.

The above understanding also applies to the following data transmission, e.g. “Msg4” and “Msg5” and indeed for any subsequent message (i.e. the failure to receive a message at the reader may be due to the loss of the D2R transmission or due to loss of the preceding R2D transmission which schedules the D2R transmission).

**Device** can determine/consider the D2R (e.g. Msg3) success, if there are subsequent R2D data received (e.g. in inventory plus command use case). In case there is no subsequent R2D data to transmit, reader may schedule the next/another device.

Note one example of the reader implementation: After reader sends “Msg4 carrying the command” to the device, if there is no “Msg5 carrying the feedback” received, reader may re-send the same “Msg4 carrying the command” to re-trigger the same “Msg5 carrying the feedback”. This example may happen in some reader implementation once or multiple times.

However, the **device** cannot determine whether its last D2R data transmission (Msg3 or following D2R transmission pending on the use case) is successfully received by the reader or not, since there may be no more subsequent R2D transmission to this device after that (e.g. if the D2R transmission was the last transmission of this service).

Question 1: Do you agree the following understandings on failure detection by reader and device?

* Part 1: The reader is able to detect the failure when D2R data transmission fails (but no differentiation is possible at the reader side between the failure due to the preceding R2D part that schedules the D2R transmission or failure of the following D2R transmission itself);
* Part 2: The device may not be able to detect/determine its D2R data transmission failure (of its last D2R data) without indication from reader.

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| **Companies** | **Yes or No** | **Comments** |
| CATT | Yes |  |
| Apple | See comments | For Part 1, we think it would be more accurate to say the reader can detect a failure, but it may be not sure whether is result of a R2D failure or D2R failure.For Part 2, we think RAN1 has agreed that for Msg1/2, “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].” So, the device may be able to detect a failure for Msg1/Msg2 exchange if it receives Msg2 in time. The answer would be yes if we assume the part 2 above is only about Msg3 failure case. |
| LG | Yes | Part 1 – RAN2 already assume that there will be feedback to reader for an R2D msg. Therefore, a reader is able to detect a transmission failure (e.g. no feedback)Part 2 – We agree to part 2 of the understanding. Either of following assumptions is required. One is that the reader sends ACK if it receives successfully. The other is that the reader sends NACK if it does not receive successfully. We prefer the latter one. |
| CMCC | Yes | For Part 1, energy detection or CRC may help reader detect D2R data transmission fail, but it can hardly know it’s caused by device or reader itself. For Part 2, even UE doesn’t have the ability to detect uplink transmission failure without implicit or explicit indication from gNB. |
| vivo | Yes |  |
| Nokia | Yes with comments | Part 1: Timer-based as well as CRC-based failures are detectable at the RX, however the differentiation of interference from low-SINR reception may be difficult.Part 2: The RX cannot know what happened at TX unless there is TX-to-RX feedback. |
| Vodafone |  | Part 1: I think the easiest implementation of the reader in case of 3 step RACH is just timer based (e.g. if the reader sent msg 2, but no message 3 was received, there is failure). Part 2: The device is listening all the time in my understanding, so if it sent e.g. msg 1, it would expect to get msg 2 in case of 3 step RACH within a particular time and so it can understand that something went wrong. I think it is also given in case of contention resolution as msg 2 should have 16Bit Random ID as we agreed during last meeting. |
| Ericsson | Part 1 yes, but Yes and No for Part 2 | We have two general comments regarding how **this email discussion is organized**.1. Generally, for each of issues/questions, it would be preferred that all possible options are to be discussed/evaluated rather to exclude certain option artificially, so that we can capture the study outcome for all options in the TR, and may recommend specific options over other options based on pros and cons. Even some options can be considered as the baseline when the study item is concluded.
2. Regarding the terms and the model, i.e., clause 2.2.3

the terms and definitions on the procedure seems to directly mimic RF-Id including defining terms and steps while we in RAN2 have not discussed and agreed on the details of those, and where there are other variants to be considered (not only in discussions but also in the TR for later down selection). The follow up questions are therefore also limited into that assumption.For part 1, we agree with the understanding. For part 2, In AS, it is true that the device may not be able to determine a D2R transmission failure if there is no AS feedback from the reader and no subsequent (upper layer) R2D transmissions. In addition, it is also feasible for a device to determine its D2R transmission was successful or failed based on upper layer message (explicitly or implicitly). |
| Nordic | Yes |  |

### 2.1.2 Consequence of D2R data transmission failure

In order to have some common understanding on the need of failure detection, we may need to first discuss the usage of this failure detection (or, the motivation for the device to be aware of the failure), i.e. the **device** **behavior** after/as the consequence of failure detection:

* **Option 1**: Re-transmit the D2R data
	+ In case the R2D provides the D2R scheduling for this device (within the timing relationship);
	+ Note the RLC/HARQ like re-transmission is not supported. If the device just feedbacks according to the received upper layer data resent by reader, it seems not relying on any AS layer failure indication;
* **Option 2**: Re-access in another opportunity (i.e. retry the random access)
	+ In case there is no R2D providing the D2R scheduling for this device (within the timing relationship);
	+ Use the re-access procedure to send the D2R data, while the contention resolution may be needed again in the re-access;
	+ The details of re-access will be further discussed in [2.2.4](#_2.3_AS_ID).
* **Option 3**: No particular action
	+ It means no solution for AS layer reliability for D2R data, and it relies on CN to re-initiate the new service;

Option 4: Follow Reader’s paging/triggering message

Question 2: Which option(s) do you support as to the device behavior in case of D2R data transmission failure?

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| **Companies** | **Option(s)** | **Comments** (companies can also indicate their understandings on the **reader** behaviors in case of D2R data transmission failure) |
| CATT | Option 3 | For the data transmission, even multiple devices are successfully decoded in A-IoT Msg1, the subsequent PDRCH data transmission should be allocated with orthogonal resource to avoid interference. That is to say, the failure of Msg3 may occur only when the channel quality of PDRCH is bad enough, instead of conflicted resource. Note that this issue can also be mitigated by the PDRCH repetition discussed by RAN1.If we go with option 1 or option 2, the channel quality may be still under bad situation, so re-transmitting data or re-access may also suffer failure at this moment.Suggest CN implementation to re-initiate the new service. By this way, the device does not need to be aware of the data transmission failure. |
| Apple  | Option 4 | We assume this question is still only focus on Msg3 failure case. In general, we think this is up to reader, and the device cannot decide itself. Whether another triggering/paging message is triggered by CN or AS layer of reader itself can be further discussed. |
| LG | Option 2 | At least, for MSG2 of 3-step CBRA, re-access in another access opportunity is reasonable because the contention resolution is not confirmed.For other subsequent messages, we prefer handling them in the same manner |
| CMCC | Prefer Option 2, see comment | Option 2 can be the baseline. Option 3 is not in RAN2’s scope.From our perspective, the importance of Msg3 containing device ID is higher than other R2D data (e.g., upper layer data), as a result, the device's behavior in response to D2R data transmission failure can vary before and after contention resolution, Therefore, if a D2R transmission failure occurs during the RA process, Option 1 and/or 2 could be considered. However, if the failure happens after RA, it could be handled by the CN, or the CN could indicate whether retransmission-like procedure is needed. |
| Huawei, HiSilicon | Option 2 | Considering the re-access due to contention resolution failure is anyway needed, Option 2 can be reused to improve the reliability in AS layer.For Option 3, in case of group devices inventory using the group ID/mask, CN may not able to detect the missing of one specific device ID, since CN has no knowledge of correct full list of device ID. Therefore, Option 3 is not sufficient (but option 3 is allowed by implementation). |
| vivo | Option 2  | As the part 1 in Q1, the reader is able to detect the D2R transmission failure and indicate to the device this failure. Upon the failure indication, the baseline behavior of device is to re-access in another access round. In this way, the success probability of inventory can be improved and the channel quality of PDRCH may be recovered in that time. Hence, option 2 can be baseline.In option 1, if the reader can indicate the device to re-transmit the D2R data immediately, it seems that already successful Msg1 and Msg2 can avoid repeated attempts and start recovery directly from Msg3. However, this re-transmission of Msg3 data may be redundant with RAN1 repetition mechanism.In option 3, it will have a long latency and extra signaling overhead to re-initiate the new service by CN. Furthermore, option 3 does harm for QoS satisfaction of inventory, e.g. success rate and latency. |
| Nokia | Option 2 with commens | The reader shall trigger re-transmission opportunities, eg by using “delta” paging (ie Option 2 but with explicit reader control) as devices cannot detect reader-side failures and unilateral device-triggered re-transmission may still fail again if the underlying problem such as interference persists. Otherwise, any notion of e2e reliability is assumed to be managed by upper layers (eg AF). |
| Vodafone | Option 3 | On data retransmissions, I think that the delay on the air is much higher compared to the delay between the readers and CN and therefore, I do not see how the retransmission mechanisms between Device and Reader would be helpful and speed up the communication. |
| Ericsson | comment | We are fine to study/evaluate all options. It is sufficient to capture pros and cons, and dependency on AS feedback for all options. At this point, it is too early to perform down-selection. Down-selection can be performed later after RAN2 has done sufficient evaluation.In our view, option 1 and 2 would rely on AS feedback, while option 3 and 4 may not rely on AS feedback.  |
| Nordic | See comments | In a failed transmission Msg1 (or not received Msg2) case Option 2 could be a baseline. However, the control should be on the reader so that the device never initiates a re-access on its own i.e. more like Apple’s Option 4. |

### 2.1.3 Need/when/how to feedback the failure/success indication

Some online discussion minutes are cited here:

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| Subesequent R2D message Discussions on subsequent transmission after msg3. - Docomo asks if the reader can determine whether there was a failure. Intel thinks that there is a case where the reader knows that it hasn’t received but doesn’t know it happens. - Intel thinks that even the device sends a failure indication the device doesn’t know what to do.- Xiaomi thinks that there is a case where it can be useful to configure the random value again. - LG thinks that this would be useful to resolve the collision between device. - Huawei thinks that the reader can indicate the failure to the device and the device can re-attempt access. - Ericsson thinks that in some cases it is needed and in some cases it is not needed, so we should study cases it may be needed. - MEdiatek thinks that if there was data in msg3 we should acknowledge it, but not necessarily a failure indication for msg3. - Lenovo thinks it is necessary. - Vodafone is not sure that msg3 contains data, just device ID. - Interdigital thinks that the device has already completion contention so it would be beneficial for the reader to indicate so it doesn’t have to trigger another message. ZTE agrees. - Qualcomm thinks that there are different use cases and in some cases it is needed. R2D should indicate whether subsequent acknowledgement should be expected by device.  |

As to the discussion points *“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”*, based on the online comments and companies contributions in section [4.1](#_4.1_Failure/success_indication), rapporteur provides following understandings:

When the indication can be absent (i.e. implicit indication on the success):

* **Case 1**: The reader has the subsequent R2D data to transmit for this device (e.g. command after inventory), i.e.
* After D2R data transmission, if device receives its R2D data transmission, it considers the success of previous D2R data transmission by default.

When the indication is needed:

* **Case 2**: The reader has no more subsequent R2D data to transmit for this device (e.g. after the device sends feedback to the command), where we have several options:
* Option 1: 1-bit indication with two code-points as “success” and “failure”;
* Option 2: 1-bit indication for success indication (while its absence means failure);
* Option 3: 1-bit indication for failure indication (while its absence means success);
* Option 4: no AS feedback (success or failure) indication
* Option x: ?

NOTE: in this discussion, we only discuss the “failure/success indication” rather than the “message”, while which R2D message to use/piggyback can be discussed later.

Question 3a: (with the above discussion on the failure detection and device behavior as the consequence of failure detection) Do you agree the R2D explicit failure/success indication for the D2R data transmission is not needed in case 1?

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| **Companies** | **Yes or No** | **Comments**  |
| CATT | Yes |  |
| Apple | See comment | Yes for “command after inventory” caseNo for “command after command” case. In this case, the reception of a new command does not mean the device’s prior response has been received correctly. |
| LG | Yes  |  |
| CMCC | Yes | Agree with rapporteur, the existence of subsequent R2D data can be regarded as an implicit indication. But if absence, timing accuracy for device should be considered. |
| vivo | Yes | The subsequent R2D data is implicit success indication in case 1 |
| Nokia | Yes | There is no such need. |
| Vodafone | Yes(see comments) | Confused by question: “if device receives its R2D data transmission”. If the reader receives R2D data transmission within time X, it can assume that previous D2R transmission was successful |
| Ericsson | Yes |  |

Question 3b: (with the above discussion on the failure detection and device behavior as the consequence of failure detection) Do you support the explicit R2D failure/success indication for the D2R data transmission in case 2? (Please clarify your preferred option, if yes for case 2)

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| **Companies** | **Yes or No** | **Comments**  |
| CATT | No | Similar view as our comments in Q2, i.e., the device does not need to be aware of the data transmission failure. It can be left to CN implementation to re-initiate new service. |
| Apple | No | To simplify the device implementation. AIoT device would rather be agnostic to the consequence of its UL transmission. We are OK to not introduce any indication |
| LG | No | For success case, from the underlying principle of 3-step CBRA, success of msg3 transmission is implicitly indicated. In other words, no msg4 transmission indicate success of msg3.For failure case, there is no agreement on the failure indication for D2R data transmission. We think that there is a case where explicit failure indication is needed. For example, the reader does not successfully receive the D2R transmission, the reader transmits the failure indication to the device in order to perform the re-access procedure. |
| CMCC | Yes | Support Option 3 in case 2. Device should be aware of whether its RA is success or not to decide whether to re-access. Msg3 failure is not very common hence NACK is preferred. For other D2R data, i.e., upper layer data, it is up to CN. |
| Huawei, HiSilicon | Yes | Slightly prefer option 1 or 2. In any option, we may need to clarify the missing of this indication should be interpreted as “failure” by device, considering the possibility of missing of the R2D message carrying this indication. |
| vivo | Yes | As our above answers, it cannot be left to CN to recover failure which does harm for QoS satisfaction and efficiency. We prefer a simple indication mechanism, i.e. failure only indication. Since the probability of success is usually much greater than that of failure, the absence of explicit failure indication means success. This failure only indication mechanism can also cover the subsequent R2D data in case 1 and new access occasion for another device, which can be implicit success.Hence, we prefer Option 3 with removal “1-bit indication” since it can be left to stage 3 design. We propose to re-word Option 3 to failure only indication |
| Nokia | No | E2e reliability is assumed to be provisioned by upper layers (Option X – no indication). |
| Vodafone | No | Agree with CATT |
| Ericsson | comment | Case 2 is not complete; we would like to add one more option **Option 4: no AS feedback (success or failure) indication.** It is too early/premature for RAN2 to discuss detailed signaling options for AS feedback. RAN2 should focus on discussion of the need of AS feedback, which is also dependent on RAN1 discussions. Since there are other L1/L2 tools feasible to improve transmission reliability, e.g., repetition, segmentation etc. The issue may be also dependent on whether Msg1 transmission and Msg3 transmission are coherent, if there is coherence between Msg1 and Msg3, it may be less likely that the device succeeds to transmit Msg1, while fails to transmit Msg3. |
| Nordic | Yes | And agree with Apple as well. |

## 2.2 Some FFS for CBRA

### 2.2.1 When Msg2 is needed in 2step RA

Some online discussion minutes and contribution proposals are cited here:

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| R2-2406682 Discussion on Random Access for Ambient IoT AppleProposal 3 Regardless of Solution 1/Solution 2, A-IoT Msg2 (or equivalent) is always transmitted for the sake of contention resolution and to acknowledge the success of device’s RA attempt. R2-2406752 Discussion on random access of Ambient IoT SpreadtrumProposal 5: Msg2 is not needed if reader has subsequent transmission with device. |
| - Qualcomm thinks that msg2 is similar to msg4 (i.e. subsequent transmission). We should have a unified solution with the 3 step RA. Vodafone thinks that we should resolve contention based on random number. - Huawei thinks that for 2-step RA msg2 is needed. Mediatek thinks that it is important for the AS to have an AS device to address the device. ZTE thinks it is important to simplify the devices and including random number will be good. - Intel explains that there are cases where msg2 is not needed. Inventory only cases – device ID sent to reader and if you don’t receive it you can trigger the device to send the ID again. For command – it may be needed- Apple doesn’t see the complexity of supporting different design as the UE would only support either 2-step or 4-step. Vodafone thinks that logistically this is difficult to differentiate between devices. Williot agrees that there can devices that only support 2 step RA. - ZTE thinks that the difference between 2 and 3 step is just the reader indicating to the UE simply send random ID or send data as well.  |

*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.*

As to the above RAN2 agreement FFS parts, rapporteur has following understandings on the need of Msg2 in 2step CBRA:

* Purpose-1: Msg2 is always needed to carry the received random ID, due to the contention resolution purpose;
	+ Some online comments claim that, for inventory-only case, there is no need to address the contention in Msg1. It means the device ID reporting will be probably missed when there is the contention (without AS layer reliability mechanism).
* Purpose-2: Whether Msg2 is needed to carry the “failure/success indication” follows the same principle as Question 3 in [2.1.3](#_2.1.3_Need/when/how_to).
* Purpose-3: Msg2 is needs to provide the scheduling information for the following D2R data transmission if any.
* Purpose-x: ?

Question 4: Do you agree the Msg2 is always needed for 2step CBRA, considering the above purposes?

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| **Companies** | **Yes or No** | **Comments** (please clarify the exact case when Msg2 can be absent, if answer is no) |
| CATT | Yes | Prefer unified solution for 2-step CBRA |
| Apple | Yes with comments | We agree with Purpose-1 and Purspoe-3, but not purpose-2. |
| LG | Yes | We think that the Msg2 of 2step CBRA corresponds the Msg2 and Msg4 of 3step CBRA because CBRA needs the contention resolution. In 3step CBRA, the Msg2 is used for the completion of the contention resolution. After the completion of the contention resolution, the device considers that the random access procedure is successfully completed.Since 2step CBRA is also contention based random access, it should apply the same principle as 3step CBRA.  |
| CMCC | Yes | Msg2 is necessary as an indication for D2R data transmission success or failure. |
| vivo | Yes | Msg2 is always needed for contention resolution, success indication and following scheduling in different cases. |
| Nokia | Yes with comments | No strong views except that Msg2 should always have the same format to promote unified design. Strictly speaking, unified design would also require Msg2 to be always sent (tradeoff between resource efficiency and implementation complexity). In case Msg2 is the last message used in an ACKing-only function (Inventory), it may be omitted, ideally based on (CN) config. |
| Vodafone | Yes(comments) | For 2-step CBRA, where msg 1 contains the device ID and only if this procedure is adapted by 3GPP (we are not sure, this should be the case as sending device full ID in msg 1 will make this message much bigger and also require sending it more often in case of failure), msg 2 should be sent for propose 1. |
| Ericsson | Yes | First, we want to highlight that rapporteur has artificially ruled out the option that Msg2 is not needed from the discussion. It is good to also include that option to allow companies express their views. We think Msg2 is always needed for 2-step CBRA for contention resolution purpose i.e., purpose 1. Whether purpose-2 and purpose-3 are also valid can be further discussed. Especially for Purpose-2, our comments for Question-3 are also applicable here. |
| Nordic | Yes with comments | As discussed during the meeting there might be use cases where Msg2 is not really needed. Especially, if the device does not know whether its D2R transmission failed and re-access would always be reader initiated (see Q2), it is simple to support Msg2-less use case. |

### 2.2.2 2step RA optimization

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| - Huawei thinks that for 2-step RA msg2 is needed. Mediatek thinks that it is important for the AS to have an AS device to address the device. ZTE thinks it is important to simplify the devices and including random number will be good. - Intel explains that there are cases where msg2 is not needed. Inventory only cases – device ID sent to reader and if you don’t receive it you can trigger the device to send the ID again. For command – it may be needed- Apple doesn’t see the complexity of supporting different design as the UE would only support either 2-step or 4-step. Vodafone thinks that logistically this is difficult to differentiate between devices. Williot agrees that there can devices that only support 2 step RA. - ZTE thinks that the difference between 2 and 3 step is just the reader indicating to the UE simply send random ID or send data as well.  |
| **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.  |

Question 5: For the proponents of optimization for 2step RA, please clarify the optimizations

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| **Companies** | **Comments** (you can also suggest WF before we actually make agreement on the support of “only 2-step RA” right now) |
| Apple | The optimization could be: not including 16-bit random ID in Msg 1, assume the A-IoT reader will echo a partial device ID back in Msg 2 for contention resolution purpose. How to generate partial device ID can be further discussed in normative phase.  |
| CMCC | We think that the random ID is not necessary in 2-step RA. If there is further data transmission between reader and device, reader can use partial device ID to address the device or as reader can request an AS address for data transmission after RA.Always sending random ID in 2-step RA can waste device energy. |
| Vodafone | In our view, we should be careful creating environment, where different devices support different kinds of RACH procedure. In our view, 3 step RACH is sufficient to be supported. We are not sure about the need for 2Step CBRA, but if the design should be common to 3step RACH, meaning msg 2 includes random ID |
| Ericsson | This question is mainly concerning Stage 3 discussion and can be discussed later (e.g., after RAN2 has made recommendation based on outcome of the study phase). For each device (type), we think both 3/4 step RA and 2 step RA can be studied and supported at least in the study phase. They are applicable to different load situations. E.g., 3/4 step RA may be applicable if there is high load/congestion, while 2 step RA may be applicable if there is low load and low congestion. |
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### 2.2.3 Access occasion in slotted ALOHA

#### 2.2.3.1 Terminology and modelling

In order to have some reference for discussion, following terminologies and demonstration figures are given:



Figure 2.2.3-1 The overall framework example of slotted ALOHA random access

**Access occasion**: An opportunity of time/frequency resource for A-IoT device to perform access (e.g. transmitting the A-IoT Msg1).

**Access round**: One access round consists a certain amount of access occasions for difference devices, which are assigned via one R2D message (e.g. [R2D Round Trigger message]) by the reader.

**Paging round**: One paging round consists one or multiple access rounds, which is initiated by the A-IoT paging message. One service request may associate with multiple paging rounds.

NOTE 1: The need of (multiple) access round(s) and the difference/combination with paging round will be discussed later in section [2.2.4](#_2.3_AS_ID), not here.

#### 2.2.3.2 What is slotted ALOHA? Definition of access occasion

It is understood as RAN1 discussion/issue/responsibility on the detail of following **block** in the above figure, i.e. the definition or determination of the exact time/frequency domain resources of Msg1.



Figure 2.2.3-2 The RAN1 responsibility in the random access (the resource for Msg1)

Please see below RAN1 progress on the above Msg1 resource related issues:

|  |
| --- |
| **FL proposal in R1-2407532 for TDMA**FL4 High priority Proposal 6.1.1-1b: A **R2D transmission triggering** random access determines X time domain resource(s) available for D2R transmission(s) **for Msg1**, where each D2R transmission occurs in one time domain resource.* FFS X=1 or X>=1 considering the necessity, pros and cons.

**RAN1 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 |

Observation 1: In the RAN1 design, there is one “R2D transmission triggering” which determines/initiates [X-time domain and] Y-frequency domain resources for Msg1 transmission.

Rapporteur would like to clarify the RAN1 and RAN2 work split:

|  |
| --- |
| **RAN1 Chair clarification in RAN1 reflector**:*“I have been coordinating with the RAN2 Chair and would like to provide the following guidance for companies’ submissions on random access for agenda 9.4.2.2: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).David”***RAN2 agreements**: * *RAN2 confirms slotted-ALOHA is the baseline for Ambient IoT random access*
* *RAN2 to discuss the contention-based and contention-free access procedures and detailed solutions.*
* *Handling of contention resolution failure and access failure at the device will be studied in RAN2, including failure detection and re-access. FFS details*
 |

Observation 2: To decouple the RAN1 resource design and RAN2 message/procedure design for random access, it can be up to RAN2 discussion on using which R2D message to support this “R2D transmission triggering”.

#### 2.2.3.3 What is slotted ALOHA? To distribute devices into slots

Some related proposals from contributions are cited in section [4.2](#_4.2_Access_occasion).

RAN2 confirms slotted-ALOHA is the baseline for Ambient IoT random access.

Based on the TR 38.848 target device density, there could be up to thousands of devices to respond the paging trying to perform the random access.

From RAN2 perspective, as to the slotted-ALOHA procedure, reader first selects many devices and then distribute those devices into many “slots”.

Observation 3: From RAN2 perspective, slotted-ALOHA needs to support the distribution of many devices (value *N*), selected by the one A-IoT paging, into similar/close number of access occasions (or “slots”) (value *Q*).

Observation 4: One A-IoT paging message may select up to several hundred of devices (or possibly even more).

Question 6a: Do you agree that: As the basic assumption, from RAN2 perspective, slotted-ALOHA needs to support the distribution of many devices (could be up to several hundred of devices), selected by the one A-IoT paging, into similar/closed number of access occasions.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments**  |
| CATT | Yes with comments | Generally, we agree with the rapporteur’s view. But it can be left to reader implementation to determine the number of access occasions within an access round, due to the fact that the number of devices which do not successfully access to the reader will be decreased at the subsequent access round. So no need to have “into similar/closed number of access occasions”. |
| Apple | NO | We think we do not need make any assumption on how reader allocates CBRA resource because this is up to reader implementation. The reader may not even have an idea of the number “N”, so it is hard to say it can dimension the access occasion accordingly. Even if CN provides an N, this is just an upper bound and the actual devices which can be discovered could be much less. So, we do not agree with “similar/close” part of the proposal. |
| LG | Yes |  |
| CMCC | Yes | To our understanding, between two paging messages, there can be multiple access occasion with explicit boundary indication (similar to *QueryRep* command in RFID) to partition tag.Slotted-ALOHA is most efficient when only one device transmits in one access occasion. |
| vivo | See comment | Left to reader implementation. |
| Nokia | See comments | Agree with the concept of multiple access occasions. Their usage is to be flexible to which end for example “delta” paging shall be used to correct suboptimal resource allocation (eg Q adaptation). |
| Vodafone | yes | According to 38848:According to the consolidated potential KPIs in TR 22.840, the maximum connection density target is:- 150 devices per 100 m2 for indoor scenarios.- 20 devices per 100 m2 for outdoor scenarios.Also a reader may cover more than 100m2 as per simulation assumptions of 38.769. |
| Ericsson | No | As other companies commented, how a reader allocates a number of occasions/resources, is fully up to reader implementation. It is unnecessary for RAN2 to make the above assumption. The characteristics of A-LOHA are mainly up to RAN1 discussion.  |
| Nordic | No | Left for reader implementation |

As to the RAN1 discussion on the access occasions in response to/assigned by one “R2D transmission triggering”, it can be X\*Y access occasions, which is a limited number (e.g. 2\*4 in some cases). This is because that the large SFO of A-IoT device limits the value of X, and the frequency-shit capability of A-IoT device limits the value of Y.

Observation 5: When reader intends to allocate many access occasions (e.g. *Q*=several hundred), it needs to allocate multiple (value *R*) blocks of X\*Y access occasions, due to the limited number of X\*Y (e.g. less than or about 10).

$N≈Q=R\*\left(X\*Y\right),$ for example $Q=600, \left(X\*Y\right)=10$ requires $R=60$

Therefore, it is necessary to support multiple “R2D transmission triggering” after one A-IoT paging.

Question 6b: Do you agree that: After one A-IoT paging message (which selects/indicates the devices to perform RA procedure), there can be multiple “R2D transmission triggering” to schedule the Msg1 resources?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments**  |
| CATT | Yes | Agree with rapporteur it should have multiple rounds where each round is triggered by reader for the intention of re-timing by the device, due to the large SFO of A-IoT device. |
| Apple | No. (Wait for RAN1) | This needs to discussed in RAN1 first. Whether there are any further triggers/sync signals to indicates the start of AO is up to RAN1 to decide. The Msg 1 resource scheduling part is also need RAN1 input.  |
| LG | Yes |  |
| CMCC | Yes | Ambient IoT device has very limited capability, this design is better in reliability and efficiency. |
| vivo | See comments | What is the meaning of “R2D transmission triggering”? Refers to R2D Round Trigger or R2D Trigger in Figure 2.2.3-1? |
| Nokia | No | RAN1 is discussing AIoT synchronization mechanisms and so RAN2 shall wait for their progress before discussing own paging / trigger / synchronization messages |
| Vodafone | See comments | Not sure it is really needed, but we also not sure we understand the question fully.Is this for TDMA or FDMA? In RAN1 this was not discussed, it was only based on a single R2D transmission triggering.The latest proposal by RAN1 considers only one R2D transmission triggering for multiple X time domain resources for TDMA: **FL4 High priority Proposal 6.1.1-1b: A R2D transmission triggering random access determines X time domain resource(s) available for D2R transmission(s) for Msg1, where each D2R transmission occurs in one time domain resource.*** **FFS X=1 or X>=1 considering the necessity, pros and cons.**

Also for FDMA it is only considered 1 R2D transmission triggeringAgreementStudy 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 |
| Ericsson | No (wait for RAN1) | Agree with Apple, Nokia that this should be left for RAN1 decision. |
| Nordic | No |  |

Then, RAN2 can discuss the **message design** options to support the above “R2D transmission triggering”:

* Option 1: Separate R2D message (e.g. Occasions Trigger message); *(somehow like the QueryRep message in RFID)*
* Option 2: Reuse the naming of “A-IoT paging message”, but with different content (i.e. not including the paging identifier/device ID/group ID for selecting devices);
* Option x: ?

Question 6c: Do you agree to use a new separate R2D message (e.g. Occasions Trigger message) to support the RAN1 agreed “R2D transmission triggering” for Msg.1 resource(s)?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** (you can also indicate other preferred terms or your thinking on the message design) |
| CATT | Yes | A separate R2D msg to trigger new round is more flexible, as there may be the situation where the initial trigger msg indicates the devices that need to response, but the access occasion is delayed until some time duration after the initial trigger msg. In this situation, separate round trigger msg helps the acquisition of timing info. |
| Apple | NO (Wait for RAN1) | First, in RAN1 agreement, “R2D transmission” and “triggering” are two different part of the sentence, it does not imply there is a separate “Occasion triggering message” other than the existing “paging message” which is “triggering” the whole CBRA procedure. |
| LG | Yes | We prefer a term that means clearly “start of access occasion”. |
| CMCC | Yes | We would like a dedicated message as the trigger message of access occasion for CBRA. It can be much shorter than paging message (e.g., just a header, no other content as the *QueryRep* command) and thus more efficient.Paging message can also act as a trigger message, but only in CFRA. |
| vivo | See comments | It is important to first discuss and agree the function and role clearly. Msg design can be left to stage 3. |
| Nokia | No | RAN1 is discussing AIoT synchronization mechanisms and so RAN2 shall wait for their progress before discussing own paging / trigger / synchronization messages |
| Ericsson | No | The discussion should be up to RAN1 decision. Agree with Apple and Nokia, that RAN1 is discussing this issue. |
| Nordic | See comments | Wait for RAN1 |

#### 2.2.3.4 What is slotted ALOHA? Selection among access occasions

The next RAN2 issue is **how the device selects a certain access occasion** after the reader assigns/distributes the access occasions.

Following proposals are referred from RAN2#127 contributions:

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| --- |
| R2-2406341 Random Access for Ambient IoT device NEC* Proposal-4: in addition to the RA slot selection, the device may need to randomly selects one frequency location among the available frequency locations for that “RA slot” to send MSG-1 to the reader.

R2-2406460 Unified random-access procedure for A-IoT ZTE* Proposal 9: If the DL trigger message indicates more than one UL resource for transmission of the MSG1 for a given device (CBRA), the device shall randomly select one of the resources for UL message transmission

R2-2406716 A-IoT random access procedure Huawei* Proposal 2c: A-IoT device randomly selects one access occasion among the multiple time-domain access occasions in the access round.

R2-2406899 Random access procedure for Ambient IoT China Telecom* Proposal 2: The device can randomly select one occasion in one access round.

R2-2407317 Views on Random Access Aspects of Ambient IoT Qualcomm* Proposal 1: The AIoT devices selects the AIoT access occasion among the resources provided by Reader. The resource selection in the time domain of the AIoT access occasion is supported. Other schemes of the resource selection of the AIoT occasions can be further studied by RAN1/RAN2.

R2-2407458 Further discussion on Ambient IoT random access Samsung* Proposal 1: For contention-based access procedure, the reader provides the total number of access occasions to the devices, from which each device randomly selects one access occasion for A-IoT Msg1 transmission. FFS on detailed configuration.
 |

Based on the common spirit from above proposals, rapporteur propose to first agree the high-level device selection behaviours.

Question 7: Do you agree: From RAN2 perspective for random access procedure, the device randomly selects one access occasion for A-IoT Msg1 (corresponding to a time and/or frequency resource) from *Q* access occasions provided/assigned by the reader, as the baseline for CBRA?

**“Access occasion**: An opportunity of time/frequency resource for A-IoT device to perform access (e.g. transmitting the A-IoT Msg1).”

NOTE: This question does not intend to discuss the exact message to assign the *Q* access occasions.

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| CATT | Yes |  |
| Apple  | Wait for RAN1 | The “randomly selects one” part in this question is to be determined by RAN1. We tend to think the device can support it, but some other options may also be considered such as based on device ID, device energy status...etc. So, whether this is the only viable solution for A-IoT device is to be decided by RAN1.  |
| LG | Yes | We think that the remaining energy should be considered as well. For example, a device with low energy level may randomly select the first part of access occasions to save its energy (not to wait long time for access attempt). In other way, a device with low energy level may randomly select the last part of access occasions to have more time for energy harvesting. |
| CMCC | Yes | IoT-NTN discusses CRDSA, where device selects two occasions in an access round and sends Msg1 with pointer twice. It can be more time efficient but it is also consuming twice device energy. So just one occasions is fine for Ambient IoT. |
| vivo | See comments | One-step random selection: randomly selects one access occasion from total number of access occasions in one access round; Two-step random selection: randomly selects one “R2D trigger/QueryRep” and then randomly selects one access occasion in the range of the selected “R2D trigger/QueryRep”;It can be FFS to choose one-step random selection or two-step random selection. We slightly prefer two-step random selection since small random numbers are easier operation for device. Besides, scheduling freedom of each “R2D trigger/QueryRep” can be retained and left for RAN1 design. |
| Nokia | See comments | Similar view to Apple. FFS whether Q could / should be updatable during subsequent occasions. |
| Vodafone | yes |  |
| Ericsson | No | Eventually, how to select access occasions should be up to RAN1 decision.Do access occasions cover only occasions in time or cover both occasions in time and frequency? For the latter, the answer may be different since devices may have different frequency shifting capabilities. In other words, in frequency domain, devices may be not able to do random selection.For pure TDM based multiple access, the above assumption is fine |
| Nordic | Yes with comments | We should wait for RAN1. |

### 2.2.4 Re-access

Some related proposals from companies contributions are cited in section [4.3](#_4.3_Re-access).

One potential failure case to trigger the re-access is already discussed in the [2.1.2](#_2.1.2_Consequence_of). Another failure case is the contention resolution failure (i.e. not received the correct random ID in Msg2 timing relationship).

In general, we may need to first confirm the support the re-access in case of failure.

Question 8: Do you support the A-IoT device to perform re-access in another opportunity (i.e. retry the random access), at least in case of contention resolution failure?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** (you can also indicate other failure cases to trigger re-access, if any) |
| CATT | Yes |  |
| Apple | Wait for RAN1 | We think for Msg1/Msg 2 failure, although RAN1 defines a timing restriction/bound for the reader to send subsequent Msg 2, whether the device need re-access is to be further discussed in RAN1. From RAN2 perspective, we think we have agreed to have a subsequent paging round to provide random access opportunities for failed devices. So, it is not clear why we need to have another mechanism for “re-access” especially for Msg 1 failure.  |
| LG | Yes |  |
| CMCC | Yes | From our perspective, reader can always trigger a re-access round for access failure handle. Whether to preform CN-initiated re-access is up to CN, but RAN has to at least support re-access or access failure handling when it is indicated. |
| vivo | Yes |  |
| Nokia | See comments | A re-transmission should possible only after an explicit permission by the reader (eg, via “delta” paging).In general, a device should be restricted to a single transmission attempt for each paging instance. |
| Vodafone | See comments | Is this question related to autonomous device retry?  |
| Ericsson | Yes | We think this is a valid issue. All options should be evaluated. RAN2 can focus on reader initiated re-access, which may be beneficial to reduce latency compared to CN initiated (re)access. |
| Nordic | Yes with comments | Re-access should only be triggered by a reader.  |



**Access round**: One access round consists a certain amount of access occasions for difference devices, which are assigned via one R2D message (e.g. [R2D Round Trigger message]) by the reader.

**Paging round**: One paging round consists one or multiple access rounds, which is initiated by the A-IoT paging message. One service request may associate with multiple paging rounds.

In the definitions, both [Round Trigger message] and A-IoT paging message may assign the total number of access occasion in the following round. And, A-IoT paging message additionally includes the paging identifier for selecting the devices. Following discussion for below options can decide the need of each later.

As to **where/when to perform the re-access**, there are several options:

* **Option 1**: In the same access occasion
	+ Proponent companies may need to clarify whether the reader will extend additional sub-access occasions in this access occasion *(something like “adding more sub-access occasions specific for re-access purpose”)*.
* **Option 2**: In the following access occasion of the same access round
	+ Proponent companies may need to clarify:
		- Option 2a: whether the reader will extend additional access occasions in this access round. (something like “*adding more access occasions specific for re-access purpose*”, i.e. adaptive length/number of access occasions of this access round), or
		- Option 2b: whether the device just re-accesses in the later already allocated access occasions, which were originally intended for the initial access of other devices.
* **Option 3**: In the next access round
	+ This implies the need of multiple access rounds (one for initial access and others for re-access) and the need of R2D Round Trigger message to assign the *Q* value of access occasions in the beginning of the access round.
* **Option 4**: In the next paging round
* Option 5: the round length is adaptive. The round can be adjusted by increasing its length or terminating earlier upon detection of too high collision. More time occasions are added in current round or in the new round (if current one terminated)
* Option x:?

Question 9: Which option(s) do you prefer about when to perform the re-access? It will be better if you can first clarify your understanding on the need/definition of access round/paging round (in the comment box)

|  |  |  |
| --- | --- | --- |
| **Companies** | **Option(s)** | **Comments** |
| CATT | Option 2a/2b | Generally speaking, we prefer Option 2a/2b.For Option 1, the access occasion needs to be variable in time-domain to allow multiple access attempts, which may further check with RAN1.For Option 3/4, no motivation was found to delay the random access for a device to next round or next paging round, as the current round has multiple access occasions for the device to use.We understand that Option 2b may aggravate the burden for contention resolution in the subsequent access occasions. So Option 2a is also acceptable to us, for example, define specific access occasions for re-access. |
| Apple | Option 4 or Wait for RAN1  | First, we do not agree with the assumption of “access round within paging round” modeling. This is neither agreed in RAN1 nor RAN2, and we cannot make selections based on a model which has not been discussed.So far, RAN2 has only agreed that subsequent paging message will be supported to handle paging failures .That leaves only Option 4 as the only legitimate choice from RAN2 perspective as new Msg 1 will be transmitted by the decice after receiving subsequent paging message. But we are fine to wait for RAN1 to decide the exact device-side behavior of Msg 1 failure first, if needed. |
| LG | See comments | RAN2 did not discuss the concept of the access round and paging round and the need of the access round and paging round. Thus, before discussing above options, RAN2 need to discuss that the concept of the access round and paging round is needed.In our view, the paging can be used for two purposes. One is that the initial paging is associated with a service request to perform the first access procedure. The other is that the subsequent paging is associated with the same service request to perform the re-access procedure. Thus, we think that the access round is not needed, and only paging round is needed. |
| CMCC | No Option 2b | Option 1/2a/3/4 is acceptable for us.Option 2b is not preferred given that the re-access device may collide with initial access device that also select the same occasion. Which is harmful for efficiency.Option 3 and 4 are similar, but Option 4 is more like a CN-based solution. |
| Huawei, HiSilicon | Option 3 and 4 | The problem of option 1 is: it is not fair for the devices which select the access occasion in the back of this round, if the devices selecting the access occasion in the beginning cause much delay due to re-access.The problem of option 2b: It causes more collision for the later access occasions.One point on option 2a: If the signaling to “add more access occasions” can indicate the number of occasion assigned for re-access, there is no significant difference with option 4, which also uses the R2D message to assign the number of access occasion in the beginning of the next access round for re-access.Option 4 is always there, i.e. device is allowed to perform re-access upon received the subsequent paging message for the same service. |
| vivo | Option 3 | No matter whether this re-access is caused by a collision or a failure, the next access round is baseline option. In the next access round, all rest devices randomly select access occasion again and with the change of time, the bad link may be recovered for failure device(s). Option 3 is simpler.Both Option 1 and Option 2 are optimization. In these two options, it seems that the specific device can reduce the access latency. However, there is no benefit for the overall performance from the perspective of all paged devices.Option 4 is for missing paging case or new device(s) arrival. |
| Nokia | Option 3/X – see comments:  | A device may use the next access round but only upon explicit command from the reader. In other words, no unilateral device-originated re-access/re-transmissions should be possible. |
| Ericsson | Not option 1 | First, we agree with Apple and LG that, RAN1/2 need to first discuss and agree on the concept of access round and paging round, before discussing detailed options.Second, for the options, we suggest adding one more optionOption 5: the round length is adaptive. The round can be adjusted by increasing its length or terminating earlier upon detection of too high collision. More time occasions are added in current round or in the new round (if current one terminated).Note: this option 5 may be considered to be merged with option 2a, if feasible.For option 1, some retransmission resources/sub-occasions may be required to be allocated/reserved in advance, which may cause resource waste if those resources turn out to be not used at the end.With option 2, devices which have failed to transmit don’t need to wait for the next round. Devices which have failed and other devices which have not transmitted would access the rest time occasions at the same time. The queue would pile up during the rest time occasions in this round. Option 3/4 may be simpler from gNB/intermediate UE design perspective as devices are assumed to retry in a next round upon unsuccessful access attempt. gNB/intermediate UE is not required to reserve occasions and resources for re-accesses ahead. However, in a different round, devices performing re-accesses may suffer from longer access delay. With option x, the length for each round (i.e., number of time occasions) is set by gNB/intermediate UE depending on collision rate. So, after RAN1 and RAN2 has agreed on the concept/model of the access round and the paging round, RAN2 can further discuss pros and cons focusing on option 2, 3, 4 and 5. |
| Nordic | See comments | Options that include explicit trigger from the reader i.e., Options 2a, 4 and maybe 3. The device shall not initiate re-access on its own. |

## 2.3 AS ID for scheduling purposes

RAN1 concludes the general usage of AS ID for scheduling purpose:

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| --- |
| AgreementFor 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 informationFFS: For each information, whether higher-layer signaling and/or L1 R2D control signaling is usedAgreementFor 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 |

RAN2 initiates the discussion with following status:

|  |
| --- |
| - 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 |

Terminology: In this discussion, we call it “**AS scheduling ID**”, corresponding to the “AS ID for scheduling purposes” in RAN2 agreements and “ID associated with device(s)” for “D2R scheduling” and “R2D reception” in RAN1 agreements. **But, please note the “AS ID” in RAN2 agreement/discussion may not be exactly same as the “ID associated with device(s)” in RAN1 agreement/discussion.**

Based on the RAN1 discussion, there two potential purposes of this “AS scheduling ID”:

* 1) D2R scheduling: the ID associated with specific device for this D2R scheduling;
* 2) R2D reception: the ID which indicates the targeted device supposed to receive/decode its unicast R2D.

NOTE: It should be the RAN1 final decision on whether this AS scheduling ID is really needed in D2R scheduling and R2D reception, while RAN2 only attempts to studies some assumptions.

The Msg1 scheduling part may be different with the other D2R/R2D message:

* For CBRA Msg1 “scheduling”, there may be no need of such AS scheduling ID, since the reader actually provides the “schedule” information for contention based resources, rather than a specific device scheduling/resource.
* For CFRA Msg1 “scheduling”, it seems the reader can directly use the paging identifier/device ID to do the resource mapping from dedicate resource to specific device.

Then, the discussion of this AS scheduling ID is actually for the scheduling/reception after Msg1 transmission.

In the beginning, it could be straight forward to discuss the following assumption:

Question 10: Do you assume this AS scheduling ID is a short AS layer ID, rather than the upper layer device ID (FFS for resource allocation of the first D2R transmission in contention-free access)?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| CATT | Yes | Since the device ID is contained in the inventory/command signaling, which is transparent to the reader according to the key issue in SA3, it is straightforward that this is a short AS scheduling ID. |
| Apple | No | First, we think “FFS if a short AS ID is also included in the message” means there is no agreement to support to have this short AS ID in CFRA messages yet.In our view, for A-IOT air interface scheduling, think there is no need of a AS ID like C-RNTI. Given that the reader may only have one or two transactions towards a A-IOT device per hour or even longer, the device may not want to maintain any additional “short AS ID”, especially because it may even forget those ID when it goes through energy on-off cycles . |
| LG | Yes |  |
| CMCC | Yes | An upper layer device ID can be very long, and a shorter AS layer ID (e.g., no more than 16 bit) can be more time and energy efficient. |
| vivo | Yes | Like C-RNTI in Uu. |
| Nokia | Yes | We can assume this but need to be aware of update frequency as RAN1 thinks frequent or recurring writing to non-volatile memory should be avoided. |
| Vodafone | No | Not sure, it is needed, butThis discussion does not seem productive if RAN2 would just make assumptions on what RAN1 has agreed regarding the ID. We should discuss if we assume this ID is needed and what for and if this clash at the end with RAN1 assumptions we can clarify it with RAN1 via LS |
| Ericsson | No (comment) | Agree with Vodafone, whether AS scheduling ID is needed, should be decided first. Therefore, we prefer to have a deeper discussion for the need and format of AS ID, e.g., as described in clause 2.8 of our paper [R2-2406818](file:///C%3A%5CUsers%5Cpanidx%5COneDrive%20-%20InterDigital%20Communications%2C%20Inc%5CDocuments%5C3GPP%20RAN%5CTSGR2_127%5CDocs%5CR2-2406818.zip) submitted in RAN2#127. In addition, we may also need to consider the potential impact to the device’s complexity, if AS scheduling ID needs to be stored in the device’s non-volatile memory. If AS scheduling ID is needed, there may be several options to generate it: random ID, part of the CN ID. |
| Nordic | Yes | Whether AS ID/Short ID is needed for CFRA case is to be seen. |

As to the assignment/allocation of this AS scheduling ID, companies may also discuss their understanding on whether this AS scheduling ID should be the device-unique ID among the devices in the current service under a reader.

For **CBRA case**, since there is the random ID in Msg1 for contention resolution, this ID can be somehow unique after the reader address the contention via Msg2. If it can be reused later as the AS scheduling ID, some signalling can be saved.

Question 11a: Do you agree: From RAN2 perspective, the random ID in Msg1 can be reused as the AS scheduling ID, after the reader addresses the contention by Msg2 in CBRA?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Yes or No** | **Comments** |
| CATT | Yes but with comments | The random ID in Msg1 can be reused as the AS scheduling ID, after the reader addresses the contention by Msg2 in CBRA. But there is an observed corner case: when both device 1 and device 2 sent the same 16-bit number to reader in msg1 but unfortunately, the reader only decoded the ID from device1, and failed to decode the ID from device2. So when the reader sent back the received 16-bit ID which may be decoded by both device 1 and 2, device 2 will be miss lead and will fail in the subsequent procedure. So we need further check with RAN1 whether it is allowed for this corner case. |
| Apple | No | The size of 16-bit Random ID is designed for “contention-resolution” purpose and is only good for contention resolution period. Any longer-term usage of this ID will result further collisions with “random ID”s generated by new devices triggered by additional paging messages. |
| LG | Yes |  |
| CMCC | Yes | It is feasible at least within a paging/access round. Beyond that, the random ID in Msg1 may collide. |
| vivo | Yes |  |
| Nokia | Yes |  |
| Vodafone | No | I think the question is how long would the device store such an ID. The example from CATT, we would see as a corner case, but in general, if the scheduling ID is needed, it would be better to define an independent ID |
| Ericsson | No (comment) | See comments for Q10, we think RAN2 should first discuss the need of the AS ID then discuss how to generate unique AS ID. |
| Nordic | No | As a general principle the Short ID should be very short lived i.e., using it after Msg2 is questionable. Also the overall need for AS scheduling ID or Short ID after Msg is not clear.  |

For **contention-free access,** this AS scheduling ID can be initially assigned/allocated by several options:

* Option 1: reader assigns a device specific AS scheduling ID before Msg1 (e.g. via A-IoT paging);
* Option 2: a random ID in Msg1 can be reused
* Option 3: an ID calculated based on the dedicated Msg1 time/frequency resource (e.g. RA-RNTI-like);
* Option 4: an ID assigned by the reader after Msg 3, if AS ID to be supported by an A-IOT device

Question 11b: Which option do you prefer for the AS scheduling ID allocation in contention-free access case?

|  |  |  |
| --- | --- | --- |
| **Companies** | **Option**  | **Comments** (you may also need to consider how the Msg2 reception and Msg3 transmission work) |
| CATT | With comments | An AS scheduling ID is required to associate with device(s) intended for the reception of R2D. Option 1/2/3 are feasible according to the analysis as below:-For Option 1, the reader needs to know the device ID info contained in the initial trigger msg so that it can assigns a device specific AS scheduling ID.-For Option 2, similar view as our comment in Q11a.-For Option 3, the dedicated resource should be associated with the device ID contained in the initial trigger msg. So similar with Option 1, the reader also needs to know the device ID info so that it can make such association.Generally we have no strong view on this, but if we go with Option 2, suggest further check with RAN1. |
| Apple | Option 4 | Option 1 is infeasible. Option 2/3 is not good as they will cause collisions issues, as we explained in Q11a.If we want to support short AS ID, the only viable option is to have reader assign this in Msg 4 or later…But we think this may be only supported by certain device which can afford to write this ID in its non-volatile memory. |
| LG | Option 2 |  |
| CMCC | Option 1 and 3 | Option 1 is simpler and more effective compared to Option 2, where device doesn’t generate the random ID and send it. Reader can assign a unique ID to device within its coverage area.Option 3 bring benefits under certain circumstances where device doesn’t need to send its scheduling ID to reader, nor reader need to assign an ID and sent it to device |
| vivo | Option 4 or Option 2 | Option 1 may waste ID resources and paging overhead since specific device paging may be also broadcast in several readers. Only one reader is useful and others are wasted.Option 2 may achieve a unified content for Msg1 in 2-step CBRA and CFRA. Option 3 is not preferable since timing reference in A-IoT is not similar with Uu.In our option4, Msg2 for CFRA may be via dedicated resource to one device. Even the content of Msg2 can be reused. Multiplexing of Msg2 with multiple devices can be FFS now. |
| Nokia | See comments | We don’t think there is any need for a new ID to be stored and maintained by the reader(s) and devices. At least RAN2 should first understand what would happen in case the device gets within range of another reader.We think the A-IoT paging should be harmonized and keep this as upper layer ID. |
| Vodafone |  | no strong view, but slightly we prefer not to go to option 2 |
| Ericsson | No for single device contention free access; FFS for multiple devices contention free case. | At least for single device contention free case, we don’t see the need of AS scheduling ID. In this case, there is only one target device for the assigned resources, there is no ambiguity between the reader and the device regarding resource allocation. Whether contention free is supported for multiple devices, can be further discussed. |
| Nordic | See commands | Option 1 would work for CFRA case. Option 2 would be preferred for CBRA case with an assumption the ID is short lived. Don’t want to add/invent yet another ID so option 4 should not be considered. |

3 Conclusion

This contribution makes the following proposals:

TBD

# 4 References: Companies proposals in RAN2#127

## 4.1 Failure/success indication

**R2-2406341 Random Access for Ambient IoT device NEC**

Proposal-13: Support subsequent R2D transmission of “ACK/NACK” indication after D2R transmission of Msg.3 when the second trigger message is supported.

**R2-2406392 Random Access Procedure for A-IoT Device vivo**

Proposal 5. A device can determine contention resolution failure immediately if next Msg2/MsgB with other random ID than itself or next Msg0 is received (without further TDM or FDM solution).

Proposal 6. For 4-step RACH, after the device sends the Msg3, it can consider the access success and no re-access is needed any more.

**R2-2406542 Discussions on AIoT Random Access Fujitsu**

Proposal 1: In 3-step random access, a NACK may be used to handle the Msg3 transmission failure.

Proposal 6: The acknowledgement to one AIoT device in one R2D transmission is supported as baseline.

**R2-2406711 Random Access Procedure for Ambient IOT InterDigital**

Proposal 6: In contention-based random access, the reader may optionally transmit a subsequent R2D (after access procedure) to the device. RAN2 studies at least the following cases for subsequent R2D message transmission and the corresponding message contents: 1) Indication of a failure to receive MSG3, 2) Providing command to the device; 3) Providing resources required by the device for further/subsequent device unicast (re)transmission, 4) Providing a temporary device ID.

Proposal 7: Absence of the subsequent R2D message (after access procedure) can be interpreted by the device to mean at least successful data transmission and no additional command reception.

**R2-2406716 A-IoT random access procedure Huawei**

Proposal 14: After the device transmits the A-IoT Msg1, it considers A-IoT random access as failed, if the A-IoT Msg2 is not successfully received and it has received the R2D message indicating start of the next access occasion for another device.

Proposal 15a: Reader can send an R2D message to the device, which indicates whether its A-IoT procedure (data transmission for inventory and/or command) is successfully done or not.

Proposal 15b: After the device transmits the A-IoT Msg3 or the following upper layer data, the failure/success of D2R transmission is determined based on the following R2D message (e.g. according to above Proposal 15a).

**R2-2406752 Discussion on random access of Ambient IoT Spreadtrum**

Proposal 3: Msg4 is needed only if the reader has not received Msg3 successfully.

**R2-2406786 Discussion on UL multiple access Ericsson**

Proposal 11 For 4-step contention-based random access, study if Msg4 is needed to acknowledge Msg3 transmission considering the reliability requirements of the use case and energy usage cost at the devices.

**R2-2406880 Discussion on random access for Ambient IoT Lenovo**

Proposal 7: Device detects access failure if NACK for Msg3 is received from the reader.

Proposal 11:“Msg4” presence/absence has following three cases:

Case 1: “Msg4” is presence to provide NACK to device when Msg3 failure.

Case 2: “Msg4” is presence to provide ACK for confirming the correctly reception of Msg3 for the case that there is no subsequent access trigger message.

Case 3: “Msg4” is not presence if Msg3 is correctly received and there is the subsequent trigger message.

**R2-2406899 Random access procedure for Ambient IoT China Telecom**

Proposal 6: The reader should send a failure indication message to the device if it can't receive the A-IoT Msg3 after sending A-IoT Msg2.

**R2-2406987 Further consideration on Ambient IoT random access CMCC**

Proposal 14: Introduce a R2D A-IoT message (NAK) to indicate reader’s failure reception of A-IoT Msg3, whose absence indicates otherwise.

**R2-2407344 Discussion on A-IoT random access HONOR**

Proposal 1: For 3-step CBRA, the subsequent R2D transmission after Msg3 could be used for the following one or both potential cases:

 Confirm the failure/success reception of Msg3.

Scheduling/transmission for the following higher layer data.

Proposal 2: RAN2 confirms that the subsequent R2D transmission after Msg3 is not always present in 3 Step CBRA (e.g., present to confirm the failure reception of the Msg3 while the absent of it indicates the success reception of Msg3).

**R2-2407458 Further discussion on Ambient IoT random access Samsung**

Proposal 6: The device considers A-IoT Msg3 transmission as successful if the subsequent R2D transmission to this device is received. Subsequent R2D transmission is either for sending the command or for indicating the successful transmission of A-IoT Msg3.

**R2-2407542 Discussion on Failure Handling Rakuten Mobile**

Proposal 4: Detection of failure and triggering retries. The reader should have mechanisms to detect when MSG3 is not received or decoded correctly and trigger retries. This can be determined by the absence of an expected response within a predefined timeframe.

Proposal 5: Use of MSG4: If MSG3 is not received, the reader can send an MSG4 to request a retransmission or provide new instructions to the device.

## 4.2 Access occasion determination

R2-2406341 Random Access for Ambient IoT device NEC

Proposal-3: RAN2/RAN1 needs to study if we adopt the similar approach (as “QUERYREP” command for RFID) for AIoT device for the purpose of RA slot count down, and synchronization or clock tracking.

Proposal-4: in addition to the RA slot selection, the device may need to randomly selects one frequency location among the available frequency locations for that “RA slot” to send MSG-1 to the reader.

R2-2406392 Random Access Procedure for A-IoT Device vivo

Proposal 10. There should be a Secondary Msg0 to indicate next RACH occasion starting point in the same RACH round, which may omit the initial paging message and RACH configuration.

Proposal 11. There should be a Master Msg0 to indicate next RACH round starting point, which may carry the initial paging message and/or new RACH configuration.

R2-2406484 Discussion on the Random Access for Ambient IoT CATT

Proposal 8a: Introduce frame start-like command to initiate the access procedure based on slot-ALOHA.

Proposal 8b: Introduce occasion start-like command to indicate the start of a new access occasion within the current frame.

R2-2406716 A-IoT random access procedure Huawei

Proposal 1: RAN2 agrees that the reader transmits one explicit R2D message to define/indicate the start/boundary of the access occasion (instead of defining the NR RACH occasion by absolute timing).

Proposal 2b: The total number of time-domain access occasions within one access round is indicated by the reader.

R2-2406899 Random access procedure for Ambient IoT China Telecom

Proposal 1: Introduce a D2R A-IoT Msg0 to indicate the start of access occasion and provide synchronization for A-IoT device. Can discuss what other indication should be captured, e.g., RA type.

R2-2407265 Discussion on random access aspects for Ambient IoT LG Electronics

Proposal 7. In order to indicate the start of the access occasion, the reader should send a start indication for the access occasion to the A-IOT device(s). Then, the A-IOT device(s) performs the contention-based or contention-free access procedure.

R2-2407458 Further discussion on Ambient IoT random access Samsung

Proposal 2: For contention-based access procedure, the reader explicitly indicates the starting point of each access occasion to the devices by R2D signalling for A-IoT Msg1 transmission.

R2-2407536 Discussion on Random Access procedure for Ambient IoT Philips

Proposal 2: Reader may transmit access occasion announcement message.

R2-2406361 Discussion on access procedure for ambient IOT Xiaomi

Proposal 1: R2D command-based slot definition in Slotted-ALOHA access is supported, i.e., the tag considers the beginning of a new slot based on R2D command reception.

## 4.3 Re-access

R2-2406341 Random Access for Ambient IoT device NEC

Proposal-11: RAN2 should study the possibility for the device to try to access via another access occasion within the current access round or after the current access round after initial access contention failure.

Proposal-12: Introduce second trigger message following the initial trigger message within the same access round.

R2-2406379 Consideration on A-IoT Random access Intel

Proposal 5: AIoT device shall wait for the reader to trigger the next round of operation when it does not have enough energy to complete the requested operation.

Proposal 7: AIoT device shall wait for the reader to trigger the next round of operation upon detection of an AIoT RACH failure.

R2-2406392 Random Access Procedure for A-IoT Device vivo

Proposal 7. A device which detects contention-failure or access failure, re-accesses in the next RACH round.

Proposal 8. The RACH round length is adaptive. One round can be terminated earlier by the reader, e.g. upon detection of too high collision/blank. A new round, e.g. with more/less RACH occasions, is initiated.

R2-2406484 Discussion on the Random Access for Ambient IoT CATT

Proposal 12: RAN2 to discuss the following options as the baseline of re-access,

Option 1 – Perform re-access in the subsequent access occasions, including the ones within the current frame or in the subsequent frames;

Option 2 – Complete the access procedure within one access occasion, i.e. perform re-access in the same access occasion as the one used for initial access.

R2-2406542 Discussions on AIoT Random Access Fujitsu

Proposal 3: The device considers access failure when no valid ACK is received after sending the first access message, or a NACK is received from the reader after the uplink data transmission.

Proposal 4: RAN2 to study the following options for handling device access failure:

Option 1: support re-access in the same access round.

Option 2: support delta access in next access round.

Proposal 5: Support re-access in the same access round (Option 1). Dedicate transmission occasions for re-access in the end of the same access round may be used for re-access by the devices which experienced access failure in the previous transmission occasions.

R2-2406711 Random Access Procedure for Ambient IOT InterDigital

Proposal 2: When access failure is detected, MSG1 retransmissions with additional access occasions in the same round can be performed by either: 1) selecting multiple access occasions for MSG1 transmission, 2) use of additional occasions configured by reader for failed MSG1

R2-2406716 A-IoT random access procedure Huawei

Proposal 16: After the D2R transmission, the device should perform re-access in case of the “A-IoT procedure failure”, including the contention resolution failure and D2R data transmission failure.

Proposal 17: The device performs the re-access in the next access round, rather than in the same access round after detecting a failure, so that the reader is able to adjust the number of access occasions in the next round.

R2-2406752 Discussion on random access of Ambient IoT Spreadtrum

Proposal 6: If contention resolution fails due to collision, A-IoT device will perform the access again in the next access round upon receiving the new trigger message from reader.

R2-2406764 Further discussions on A-IoT random access ETRI

Proposal 11: The device needs the following configuration information for re-access

waiting time (or waiting access occasions) for Msg2 reception after Msg1 transmission;

window size for re-selecting access occasions;

maximum number of retransmission attempts;

transmission power ramping configuration, if needed

R2-2406786 Discussion on UL multiple access Ericsson

Proposal 12 For handling contention resolution failure and access failure, RAN2 to study the three options:

a. Option 1: a device which experiences contention-failure or access failure, re-accesses in the same round.

b. Option 2: a device which experiences contention-failure or access failure, re-accesses in the next round.

c. Option 3: the round length is adaptive. The round can be adjusted by increasing its length or terminating earlier upon detection of too high collision. More time occasions are added in current round or in the new round (if current one terminated).

Proposal 13 For devices with unsuccessful random access, RAN2 to study the response message (Msg2) indicating additional information related to back-off and re-access.

R2-2406880 Discussion on random access for Ambient IoT Lenovo

Proposal 8: Device can perform re-access in the same occasion, or re-access in the same round, or re-access in the next round, or re-access when a pre-defined back-off timer expires.

R2-2406899 Random access procedure for Ambient IoT China Telecom

Proposal 7: RAN2 to support that A-IoT devices can re-access in the next access round if access failure occurs.

R2-2406987 Further consideration on Ambient IoT random access CMCC

Proposal 13: RAN2 to study at least the following options for both 2-step and 3-step CBRA Msg1 failure handling,

Device attempts to re-access in the next access round.

Device attempts to re-access in the next access occasion.

R2-2407022 Discussion on Random Access for A-IoT Transsion Holdings

Proposal 3: The retry access configuration can be provided in the trigger message for the failed access device to retry access without the reader re-initiated trigger.

R2-2407265 Discussion on random access aspects for Ambient IoT LG Electronics

Proposal 7. In order to indicate the start of the access occasion, the reader should send a start indication for the access occasion to the A-IOT device(s). Then, the A-IOT device(s) performs the contention-based or contention-free access procedure.

Proposal 12. If contention resolution or access procedure is failed, the A-IOT device perform the re-access procedure within the next round.

R2-2407317 Views on Random Access Aspects of Ambient IoT Qualcomm

Proposal 7: If the AIoT devices contention resolution is unsuccessful or the AIoT data transmission is failed, the AIoT devices should be able to perform AIoT re-access. FFS details of AIoT re-access.

Proposal 8: RAN2 to study the following options for AIoT devices to perform AIoT re-access.

Option 1: AIoT devices perform re-access only upon reception of next trigger message from Reader.

Option 2: AIoT devices autonomously perform re-access without waiting for next trigger message from Reader.

Proposal 9: During AIoT re-access, AIoT devices can transmit the AIoT Msg1 again in a newly selected access occasion or in an indicated access occasion.

R2-2406770 Discussion on random access for A-IoT OPPO

Proposal 7 If the device detects RA failure, the device may re-access in the next RA round.

R2-2406361 Discussion on access procedure for ambient IOT Xiaomi

Proposal 18: The network can trigger devices in one slot to perform re-access more than one times.