**3GPP TSG RAN WG1 #117 R1-2405436**

**Fukuoka, Japan, May 20th – 24th, 2024**

**Source: Moderator (CMCC)**

**Title:** **FL summary#2 for Ambient IoT evaluation**

**Agenda: 9.4.1.1**

**Document for:** **Discussion & Decision**

# Background

A new SI for ambient IoT is started[26]. This document summarizes the contributions [1 - 25] for AI 9.4.1.1 in RAN1#117. The issues/proposals in this document are marked with [open]/[closed], or [H]/[M]/[L] priority (for the current meeting)

# Online/offline proposals

## Monday online (R1-2405435)

**[H][****P3.5.9-v1]**

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| **Proposal**  In the link level simulation, coherent receiver is considered for D2R receiver. |

#### [H][Proposal-3.4.3-pathloss-v1]

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| **Proposal:**   * **For CW2D pathloss model applied to the D1T1-A1/A2/B and D2T2-A1/A2/B scenarios, using the same pathloss model defined in TR38.901 as used for R2D/D2R.** |

#### [H][Proposal-3.4.7-v1]

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| **Proposals:**  Add Row [0D] in the link budget table as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [0D] | Topology/Pathloss model | InF-DH NLOS | [0D]-D2R-Alt1: InF-DL NLOS  [0D]-D2R-Alt2: InH-Office LOS | |

#### [H][Proposal-3.4.4-BudgetAlt-v1]

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| **Proposals:**   * For R2D link in the coverage evaluation for device 2,   + *Budget-Alt1* is used if receiver architecture is RF ED is used   + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED is used * Note: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed. |

#### [H][Proposal-3.4.6-v1]

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| **Proposals:**  Update the link budget table Row [0C] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [0C] | Center frequency (MHz) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) | |

#### [H][Proposal-3.4.11-v1]

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| **Proposals:**  Update the link budget table Row [1G] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | For A-IoT device, 0dBi ~~(M), -3dBi (O)~~ | |

#### [H][Proposal-3.4.14-v1]

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| **Proposals:**  Update the link budget table Row [1N] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1N] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | For BS, 0 dB  For intermediate UE, 3 dB | N/A | |

#### [H][Proposal-3.4.18-v1]

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| **Proposals:**  Update the link budget table Row [1N] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1N] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | N/A | For BS, 0 dB  For intermediate UE, 3 dB | |

#### [H][Proposal-3.4.27-v1]

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| **Proposals:**  Update the link budget table Row [3A] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | 4dB | 3dB for InH-LOS  7.2dB for InF-DL-NLOS | |

**[H][****P3.5.1-v1]**

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| **Proposal**  For the link level simulation,   * An RMS delay spread of 150 ns is considered for TDL-A channel model. * An RMS delay spread of 30 ns is considered for TDL-D channel model. |

**[H][****P3.5.3-v1]**

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| **Proposal**  For the link level simulation in coverage evaluation, {16 bits, 96 bits, 400 bits} are considered for message size. |
| **Proposal**  Update the ED bandwidth parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ ED bandwidth | ~~[X] MHz~~  The ED bandwidth is needed for calculating the noise power, which is referred as item [2B1] in link budget template for R2D link:   * For RF ED receiver, the ‘ED bandwidth’ is regarded as the device RF filter bandwidth. * For IF ED receiver, the ‘ED bandwidth’ is regarded as the device IF filter bandwidth. * For ZIF receiver, the ‘ED bandwidth’ is regards as the device BB filter (i.e., BB LPF) bandwidth.   FFS: The value(s) of ED bandwidth [X] MHz or it is reported by companies. | |

**[H][****P3.5.6-v1]**

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| **Proposal**  Update the BB LPF parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at ~~[Y] kHz~~ half of R2D transmission bandwidth, i.e., 90 kHz as baseline.  Companies to report [X = 3, 5]. | |

**[H][****P3.5.8-v1]**

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| **Proposal**   * For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the transmission bandwidth. |

**[M][****P3.5.10-v1]**

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| **Proposal**  Companies are encouraged to consider the approach for detecting ascending or descending edges for OOK based line coding for R2D in the link level simulation. |

**[H][****P3.5.7-1-v1]**

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| **Proposal**  In the link level simulation, consider report the following assumptions,   * D2R transmission bandwidth * D2R [OOK/BPSK/BFSK chip rate] * D2R reception bandwidth   For D2R transmission bandwidth, the following alternatives for considered and target to down-select to one alternative,   * **[1a]-Alt1-1:**    + DSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is 2X kHz (M) and 2Y kHz (O). * **[1a]-Alt1-2:**    + DSB   + Alt. 1-1 with SFS   + The total transmission bandwidth is 4X kHz (M) and 4Y kHz (O). * **[1a]-Alt2-1:**    + DSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O). * **[1a]-Alt2-2:**    + DSB   + Alt. 2-1 with SFS.   + The total transmission bandwidth is 2X kHz (M) and 2Y kHz (O). * **[1a]-Alt3:**    + SSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O). * The value of X and Y is as follows,   + Alternative 1:     - X = 15     - Y =180   + Alternative 2:     - X and Y reported by companies,       * the value may be related to, e.g.,         + Reference data rate         + Coding scheme         + Repetition         + With or without SFS         + SSB or DSB * Note: The transmission bandwidth is the frequency domain resources used for a device for D2R transmissions (exclude guard band). * Note:   + SFS stands for small frequency shift   + SSB stands for single sideband and DSB stands for double sideband   For D2R [OOK/BPSK/BFSK chip rate], it is reported by companies.  For D2R reception bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power.   * Assume the receiver matches the transmitter's modulation: SSB for SSB, DSB for DSB. * Companies to report the value. |

#### [H][Proposal-3.2.1-latency-v1]

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| **Proposal**:  Definition of the latency is refined as follows,   * For inventory use case (for DO-DTT traffic type):   + The time interval between the time that the inventory request is sent from BS/intermediate UE to a A-IoT device and the time that the inventory report is successfully received at BS/intermediate UE from the A-IoT device. * For command use case (for DT traffic type):   + The time interval between the time that the DL command is sent from BS/intermediate UE and the time that the command is successfully received at A-IoT device. * Note: the successfully received is considered as follows and one alternative is selected from Alt 1 or Alt 2 below,   + Alt 1: The first attempt is taken into account.   + Alt 2: One or more round(s) of attempts are considered. * Note: the latency is evaluated for a single A-IoT device. * Note: Time for energy harvesting is not included in the definition of latency. |

#### [H][Proposal-3.2.4-multi-device-metric-v1]

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| The following performance metric is considered for evaluation purpose only,   * Inventory completion time for multiple A-IoT device   + For inventory use case, the  ‘*Inventory completion time for multiple A-IoT devices*’ is defined as the time a reader successfully completed the inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverageby the reader   + Z = {99%(Mandatory), 90%(Optional)} |

#### [H][Proposal-3.3.1-low-scenario-v1]

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| **Proposal:**  Deprioritize D2T2-A1 for evaluation.   * FFS other scenarios which are high or low priority. |

#### [M][Proposal-3.3.1-spectrum-v1]

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| **Proposal:**   * The followings scenarios are considered for evaluation,   + D1T1: FDD DL spectrum for R2D transmission   + D2T2: FDD UL spectrum for R2D transmission   + D2T2-C: FDD UL spectrum for D2R transmission |

#### [M][Proposal-3.3.2-topology-v1]

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| **Proposal:**  For the layout used for evaluation purpose, the following is assumed,   * Uniform Distribution of CW nodes for scenario D1T1-B and D2T2-B,   + Details are reported by companies, such as CW node location * Uniform distribution of intermediate UE for scenario D1T1-B and D2T2-B,   + Details are reported by companies, such as number of intermediate UEs, inter-distance among intermediate UEs and/or intermediate UE movement. * [The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.] |

#### [H][Proposal-3.4.1-RFEH-v1]

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| **Proposal:**  For coverage evaluation for device 1, coverage of RF-EH link is considered to be evaluated by using *Buldget-Alt1*.   * FFS: value(s) of the predefined threshold * FFS whether RF-EH link is also considered to be evaluated for device 2 by using *Buldget-Alt1* |

#### [H][Proposal-3.4.12-v1]

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| **Proposals:**  Update the link budget table Row [1H] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | * N/A | * OOK: 6 dB * PSK: 0 dB   ~~Note: Only for device 1~~  ~~FFS: for device 2a~~  It is applicable for device 1 and 2a | |

#### [H][Proposal-3.4.19-v1]

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| **Proposals:**  Update the link budget table Row [2D] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2D] | Receiver Noise Figure (dB) | For RF-ED receiver   * 24dB?, 30dB?, Device 1 * 20dB, Device 2   For IF/ZIF receiver   * 15dB, Device 2 | For BS as reader   * 5dB   For UE as reader  7dB | |

#### [H][Proposal-3.4.13-v1]

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| **Proposals:**  Remove Row [1H] in the link budget table.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | ~~[1J]~~ | ~~FFS: Ambient IoT on-object antenna penalty~~ | * ~~0.9dB or 10.4~~ | ~~0.9dB or 10.4~~ | |

#### [H][Proposal-3.4.22-v1]

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| **Proposals:**  Remove Row [2H] in the link budget table.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | ~~[2H]~~ | ~~FFS: Ambient IoT on-object antenna penalty~~ | * ~~0.9dB or 10.4~~ | ~~0.9dB or 10.4~~ | |

#### [H][Proposal-3.4.26-v1]

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| **Proposals:**  Update the link budget table Row [2L] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + {-30dBm, -36dBm, -40dBm} * For device 2 if RF-ED is used   + {-40dBm, -45dBm} * For device 2 if RF-ED is not used   + *<Editor’s note: need to decide which budget-alt is used first.>* * For RF-EH,   + -30dBm   + *<Editor’s note: Depending on the discussion in 3.4.1.>*   For Budget-Alt2,   * Calculated (see note1) | Calculated (see note1)  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |   Note 1:  …  [2L]:   * For R2D and *Budget-Alt2*,   + [2L] = [2G] + [2F] * For D2R,   + [2L] = [2G] + [2F] + [2K2] , device 1/2a   + [2L] = [2G] + [2F], device 2b |

**[H][****P3.5.2-v1]**

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| **Proposal**  For link-level simulation in coverage evaluation, [1] kbps (M) and [7] kbps (O) is considered for the reference data rate. |

**[H][****P3.5.4-1-v1]**

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| **Proposal**  In the link level simulation, consider the following assumptions on sampling frequency offset and timing drift model for device baseband processing,   * Sampling frequency is 1.92 Msps. * Initial sampling frequency offset (Fe) is between [104 ~ 105] ppm. FFS Fe. * The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T. |

**[H][P3.5.4-2-v1]**

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| **Proposal:**  In the link level simulation, consider one of the following carrier frequency offset and drifting model for device 2b:   * Option 1: Reuse CFO model defined in TR 38.869 (option 1 or 2 in Table 6.2-3) * Option 2: Reuse CFO model defined in TR 38.869 with new value for maximum CFO [> 200 and <1000] ppm, and frequency drifting rates [> 0.1] ppm/s. |

**[H][****P3.5.5-v1]**

## Tuesday offline (R1-24XXXX)

**[H][P3.5.3-v2]**

**Proposal**

For the link level simulation in coverage evaluation, {[16 or 24] bits, 96 bits, [400] bits} are considered for message size.

After offline discussion

**[H][P3.5.3-v3]**

**Proposal**

For the link level simulation in coverage evaluation, {[16 or 24] bits, 96 bits, [400] bits} are considered for message size.

#### [H][Proposal-3.2.4-multi-device-metric-v1]

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| --- |
| The following performance metric is considered for evaluation purpose only,   * Inventory completion time for multiple A-IoT device   + For inventory use case, the  ‘*Inventory completion time for multiple A-IoT devices*’ is defined as the time a reader successfully completed the inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverageby the reader   + Z = {99%(Mandatory), 90%(Optional)} |

After offline discussion

#### [H][Proposal-3.2.4-multi-device-metric-v2]

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| --- |
| The following performance metric is considered for evaluation purpose only,   * Inventory completion time for multiple A-IoT device   + For inventory use case, the  ‘*Inventory completion time for multiple A-IoT devices*’ is defined as the time a reader successfully completed the reception of inventory information / inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverageby the reader   + Z = {99%(Mandatory), 90%(Optional)}   + Note: this does not indicate to have a design target for the metric ‘*Inventory completion time for multiple A-IoT device*’ and companies can report the value(s).   + [Note: numeric analysis is considered to avoid SLS as much as possible.] |

#### [H][Proposal-3.3.1-low-scenario-v1]

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| --- |
| **Proposal:**  Deprioritize D2T2-A1 for evaluation.   * FFS other scenarios which are high or low priority. |

**[H][P3.5.5-v1]**

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| --- | --- | --- | --- | --- |
| **Proposal**  Update the ED bandwidth parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ ED bandwidth | ~~[X] MHz~~  The ED bandwidth is needed for calculating the noise power, which is referred as item [2B1] in link budget template for R2D link:   * For RF ED receiver, the ‘ED bandwidth’ is regarded as the device RF filter/matching network bandwidth. * For IF ED receiver, the ‘ED bandwidth’ is regarded as the device IF filter bandwidth. * For ZIF receiver, the ‘ED bandwidth’ is regards as the device BB filter (i.e., BB LPF) bandwidth.   FFS: The value(s) of ED bandwidth [X] MHz or it is reported by companies. | |

**[H][P3.5.5-v2]**

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| --- | --- | --- | --- | --- |
| **Proposal**  Update the ED bandwidth parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ ED bandwidth | ~~[X] MHz~~  The ED bandwidth is the bandwidth for calculating the noise/interference (if any) power, which is referred as item [2B1] in link budget template for R2D link:  FFS: The value(s) of ED bandwidth [X] MHz (e.g., 1.92MHz / 10MHz for RF-ED, 180KHz for IF/ZIF receiver) or it is reported by companies. | |

**[H][P3.5.6-v1]**

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| --- | --- | --- | --- | --- |
| **Proposal**  Update the BB LPF parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at ~~[Y] kHz~~ half of R2D transmission bandwidth, i.e., 90 kHz as baseline.  Companies to report [X = 3, 5]. | |

#### [H][Proposal-3.4.9-v2]

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1E3] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E3] | CW2D distance (m) | N/A | For [1E]-D2R-Alt1:   * + D1T1-B:     - 10m,     - 20m,     - Assumed that [1E]-D2R-Alt2 applies, with the CW node located at the reader   + D2T2-B:     - 5m,     - 10m,   + FFS other values   For [1E]-D2R-Alt2:   * + Calculated (see note 1)   Note: only applicable for device 1/2a  Note: for [1E]-D2R-Alt2,   * The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. | |

#### [H][Proposal-3.4.26-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2L] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + {-30dBm, -36dBm, -40dBm} * For device 2 if RF-ED is used   + {-40dBm, -45dBm} * For device 2 if RF-ED is not used   + *<Editor’s note: need to decide which budget-alt is used first.>* * For RF-EH,   + -30dBm   + *<Editor’s note: Depending on the discussion in 3.4.1.>*   For Budget-Alt2,   * Calculated (see note1) | Calculated (see note1)  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |   Note 1:  …  [2L]:   * For R2D and *Budget-Alt2*,   + [2L] = [2G] + [2F] * For D2R,   + [2L] = [2G] + [2F] + [2K2] , device 1/2a   + [2L] = [2G] + [2F], device 2b |

#### [H][Proposal-3.4.4-BudgetAlt-v2]

*<Editors’ Note: copy the text from TR38.869 section 7.1.1a.1.1 RF envelope detection>*

##### 7.1.1a.1.1 RF envelope detection

For OOK-1/2/4 with RF envelope detection, some sources ([7A-1] [7A-2] [7A-3] [7A-4] [7A-5] [7A-6]) provided analysis, with relative power consumption and noise figure summarized in Table 7.1.1a-1.

* The relative power consumption for ON state is in the range of 0.01~0.2.
* The noise figure is in the range of 12~22 dB.

**Table 7.1.1a-1 Relative power consumption and noise figure for OOK-1/2/4 with RF envelope detection**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source reference | [7A-1] | [7A-2] | [7A-3] | [7A-4] | [7A-5] | [7A-6] |
| Power consumption  (ON state) | 0.05 for single-branch, 0.01 for each additional branch | 0.01 | 0.01~0.1 | 0.01 | 0.01~0.1 | 0.05~0.2 |
| Noise figure (dB) | 20 | 17~22 | [12-18] | 20 | 15 | 20 |

**Proposal**

* For R2D link in the coverage evaluation for device 2,
  + *Budget-Alt1* is used if receiver architecture is RF ED is used
  + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED is used
* Note1: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed.
* Note2: this does not imply any M value is achievable with the sensitivity given by *Budget-Alt1* for RF ED
* Note3: For device 2 with an RF ED-based receiver on the R2D link, if the receiver sensitivity derived from *Budget-Alt2*, assuming a noise figure of [22dB], exceeds the activation threshold based on *Budget-Alt1*, then *Budget-Alt2* is applied.

#### [H][Proposal-3.4.14-v2]

**Proposal**

Update the link budget table Row [1N] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [1N] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | For BS, 0 dB  For intermediate UE, 1 dB | N/A |

**Proposal**

Update the link budget table Row [2X] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [2X] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | N/A | For BS, 0 dB  For intermediate UE, 1 dB |

#### [H][Proposal-3.4.27-v1]

**Proposal**

Update the link budget table Row [3A] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [3A] | Shadow fading margin (dB) | For D1T1: 4 dB  For D2T2: 3dB for InH-LOS  7.2dB for InF-DL-NLOS | For D1T1: 4 dB  For D2T2: 3dB for InH-LOS  7.2dB for InF-DL-NLOS |

#### [H][Proposal-3.4.2.1-CWModel-v1]

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| Proposal:  For coverage evaluation,   * In the case of CW outside topology with ‘B’ scenarios or CW inside topology with ’A1’ scenarios   + The digital baseband processing of CW self-interference handling is not modelled in link level simulation (LLS). It is included in the link budget analysis by reporting the CW cancellation capability value.   + Note: ’A2’ scenarios have already been agreed. * The remaining CW interference [2K1], receiver sensitivity [2L] and receiver sensitivity loss [2K2] are computed as follows, * FFS: CW cancellation capability [2K] values, by considering the following potential issues:   + Different values for different scenarios, e.g., D1T1/D2T2, A1/A2/B   + Different values for different CW waveforms (single-tone or multi-tone)   + The feasibility study is considered to be discussed in 9.4.2.4 and/or RAN4. |

## Tuesday online (R1-2405436)

# Discussions

## Terminologies

Note: the following is used in this document,

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

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

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

**Ambient IoT device:** *simply as ‘D’*

**Ambient IoT reader:** *simply as ‘R’,*

* *‘R’ is base station for topology 1.*
* *‘R’ is intermediate node for topology 2.*

**R2D (Forward link)**:

* *It is for R-to-D communication. For topology 1, it denotes the downlink communication, i.e., BS-to-AIoT device. For topology 2, it denotes the intermediate node to AIoT device communication.*

**D2R (Reverse link)**:

* *It is for D-to-R communication. For topology 1, it denotes the uplink communication, i.e., AIoT device -to-BS. For topology 2, it denotes the AIoT device to intermediate node communication.*

**CW:** *carrier wave*

**CW2D:** *CW node to Ambient IoT device link.*

**ED:** *Envelope detector*

**RF-EH:** *RF energy harvesting*

**PRDCH:** *Physical Reader-to-Device Channel*

**PDRCH:** *Physical Device-to-Reader Channel*

**D1T1:** *Deployment scenario 1, Topology 1*

**D2T2:** *Deployment scenario 2, Topology 2*

## Remaining design targets / performance metrics

RAN SID task RAN1 to discuss the followings

1. Conclude at least the following aspects of design targets left to WGs in Clause 5 (RAN design targets) of TR 38.848 [RAN1].
   * Clause 5.3: Applicable maximum distance target values(s)
   * Clause 5.6: Refine the definition of latency suitable for use in RAN WGs
   * Clause 5.8: 2D distribution of devices

And in RAN#103, the following is agreed,

**Proposal 5v2**

* RAN design targets for user experienced data rate, maximum message size, and moving speed of device: those can be used as assumptions in coverage evaluations, i.e. the coverage evaluations are done under the conditions that meet those targets.
* Evaluations of RAN design targets for latency and connection/device density are allowed by the Rel-19 SID and observations on those evaluations can be captured in the TR38.769
* Note: this is as per the SID: “*NOTE: Assessment performance of the design targets is within the study of feasibility and necessity of proposals in the following objectives, e.g. by inspection of reference implementations in the field, simulations, analytically*.”

### [H]Refine the definition of latency suitable for single-device case

#### Related Tdoc Proposals

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| Apple | ***Proposal 1: Definition of latency for a single device is refined as follows:***   * ***For inventory use case (for DO-DTT traffic type):***   + ***The time interval between the time that the inventory request is sent from BS/intermediate UE to a A-IoT device and the time that the inventory report is successfully received at BS/intermediate UE from the A-IoT device.*** * ***For command use case (for DT traffic type):***   + ***The time interval between the time that the DL command is sent from BS/intermediate UE and the time that the command is successfully received at A-IoT device.*** * ***Note: Time for energy harvesting is not included in the definition of latency.*** |
| CATT | **Proposal 14: The latency for A-IoT should include the following components:**   * + **Signal propagation delay of the R2D link, D2R link and the link between gNB and intermediate UE should all be included.**   + **Processing delay at A-IoT device, gNB and intermediate UE.**   + **Buffer delay: Scheduling delay used to wait for the scheduled transmission time.**   + **Access delay: Retransmission delay due to the failed initial transmission caused by the collision with other A-IoT devices.** |
| China Telecom | ***Proposal 6: Definition of the latency is defined as follows,***  ***For inventory use case (for DO-DTT traffic type): The time interval between the time that the inventory request is sent from BS/intermediate UE to an A-IoT device and the time that the inventory report is successfully decoded at BS/intermediate UE from the A-IoT device.***  ***For command use case (for DT traffic type): The time interval between the time that the DL command is sent from BS/intermediate UE and the time that the command is successfully decoded at the A-IoT device.***  ***Note: the latency is evaluated for single A-IoT device.***  ***Note: Time for energy harvesting is not included in the definition of latency.*** |
| CMCC | **Proposal 3: Refine the definition of latency suitable for use in RAN WGs**   * **For inventory use case:**    + **The time interval between the time that the inventory request is sent from BS/intermediate UE and the time that the inventory report is successfully received at BS/intermediate UE.** * **For command use case:**    + **The time interval between the time that the DL command is sent from BS/intermediate UE and the time that the commands successfully received at A-IoT device.** * **FFS the components (e.g., processing time at BS and/or A-IoT device) to be included in the calculation of latency.** * **Note: the latency definition is for a A-IoT device.** |
| Ericsson | **Proposal 6** **For the definition of the latency for a single device, we support the proposal P3.2.1-(1) in [7]. The definition can be further refined assuming an ideal condition where packets are received without any collisions or errors on the first attempt. Therefore, the square brackets around “successfully” in the definition can be removed.** |
| Huawei | ***Proposal 2: Refine the definition of latency as***   * ***For inventory use case (for DO-DTT traffic type): Time from the beginning of the query/triggering message transmission from basestation or intermediate node to a device, to the end of the successfully received reported message transmission from the device to basestation or intermediate node.*** * ***For command use case (for DT traffic type): Time from the beginning of the triggering message transmission from basestation or intermediate node to a device, if presented, to the end of the successfully received command message transmission from the basestation or intermediate node to the device.***   ***Note: The successful reception probability is set to 90% for each transmission during the procedure.*** |
| Interdigital | **Proposal 4: Define Latency for IoT device 1 or 2a as the time from the querying of IoT device by BS or intermediate node (e.g., UE) via CW signal to the time of backscattered message reception by BS or intermediate node (e.g., UE) from IoT device.** |
| LGE | ***Proposal 1: Definition of latency can be defined as,***   * ***Inventory: The time interval between the time that the inventory request is sent from BS/intermediate UE to a AmIoT device and the time that the inventory report is received at BS/intermediate UE from the AmIoT device*** * ***Command: The time interval between the time that the DL (or R2D) command is sent from BS/intermediate UE and the time that the command is received at AmIoT device*** |
| Nokia | **Proposal 1:** Definition of the latency is refined as follows,  - For inventory use case (for DO-DTT traffic type):  o The time interval between the time that the inventory request is sent from BS/intermediate UE to a A-IoT device and the time that the inventory report is successfully received at BS/intermediate UE from the A-IoT device.  - Note: the latency is evaluated for a single A-IoT device.  Note: Time for energy harvesting is not included in the definition of latency. |
| OPPO | Proposal 6: The latency of DO-DTT traffic is defined as the time from the triggering message arriving at the [MAC] layer of the reader to the moment when the response from the A-IoT device is received and successfully decoded by the reader. The latency of DT traffic is defined as the time from the data arriving at the [MAC] layer of the reader to the moment when the data is received and successfully decoded by the A-IoT device. |
| Qualcomm | **Proposal 2: Definition of the latency for a single device inventory is defined as follows.**   * **The time interval between the time that the first inventory request for the device is sent from a reader (BS/intermediate UE) to the A-IoT device and the time that inventory report is successfully received by the same of different reader from the A-IoT device considering one or more round(s) of inventory requests, if any.** |
| Qualcomm | **Proposal 3: Definition of the latency for a single device command is defined as follows.**   * **The time interval between the time that the first command for the device is sent from a reader (BS/intermediate UE) to the A-IoT device and the time that acknowledgement from the device is successfully received by the sa me of different reader considering one or more (s) of commands, if any.** |
| Samsung | Proposal 13. Definition of the latency is refined as follows:   * For the inventory use case: the time interval between the time that the inventory request is sent from a reader and the time that the inventory message from a tag is successfully received at the reader.   + The successful reception means that the reader has a successful CRC check in the inventory message. * For the command use case: the time interval between the time that the command is sent from a reader and the time that the command is successfully received at a tag.   + The successful reception means that the tag has a successful CRC check in the command. * The processing time is not included in latency. |
| Spreadtrum | ***Proposal 2:*** ***The definition of latency is different for indoor inventory and indoor command***   * ***For indoor inventory, the latency is the duration from the time of the inventory request transmission from the reader to the device, to the time that the response from the device is successfully decoded by the reader.*** * ***For indoor command, the latency is the duration from the time of the R2D command transmission from the reader to the device, to the time that the R2D command is successfully decoded by the device.*** |
| Vivo | **Proposal 25:**  - **For inventory use case (for DO-DTT traffic type), the latency is defined as the time interval between the time that inventory request, i.e., Msg.0 is sent from the reader and the time that a device unique identifier, i.e., Msg.3 is received at the reader side from the A-IoT device.**  - **For command use case (for DT traffic type), the latency is defined as the time interval between the time that the R2D command is sent from reader and the time that an D2R acknowledgement is received at the reader side from the A-IoT device.** |
| ZTE | ***Proposal 15: The latency of command for single device and inventory for single and multiple devices needs to be defined and evaluated.*** |
| ZTE | ***Proposal 16: For the inventory latency evaluation, 2-step like random access procedure and 4-step like random access procedure can be taken as a starting point in latency evaluation. The details, such as the message size and transmission gap, can be reported by companies.*** |
| ZTE | ***Proposal 17: The evaluation assumptions in Table 6 can be considered for command completion time for single device.***  Table 6 Example of latency evaluation assumptions for command   |  |  | | --- | --- | | **Parameters** | **Values** | | R2D preamble time length | 8×25 us | | Message size (bits) | 1000 | | CRC length (bits) | 16 | | Transmission time per bit | 200 us | | Total transmission time of R2D command signal | 203 ms | |
| ZTE | ***Proposal 18: The evaluation assumptions in Table 7 and 8 can be considered for inventory completion time for single device.***  Table 7 Example of latency evaluation assumptions for 2-step based inventory of single device   |  |  |  | | --- | --- | --- | | **Parameters** | | **Values** | | Message size  (Number of bits) | Step 1 signal: Query command | 8 | | Step 2 signal: Device ID | 96 | | CRC length (Number of bits) | | 16 for Step 2 signal | | Transmission time per bit | | 200 us | | Preamble length | | 8×25 us for R2D and D2R | | Interval between R2D and D2R signals | | 10×25 us |   Table 8 Example of latency evaluation assumptions for 4-step based inventory of single device   |  |  |  | | --- | --- | --- | | **Parameters** | | **Values** | | Message size  (Number of bits) | Step 1 signal: Query command | 8 | | Step 2 signal: RN16 | 16 | | Step 3 signal: Acknowledge | 16 | | Step 4 signal: Device ID | 96 | | CRC length (Number of bits) | | 16 for Step 4 signal | | Transmission time per bit | | 200 us | | Preamble length | | 8×25 us for R2D and D2R | | Interval between R2D and D2R signals | | 10×25 us | | Interval between D2R and R2D signals | | 5×25 us | |

#### Discussion (round 1)

The current TR38.848 has the following description of the latency definition. And it is agreed in SID that RAN WGs can refine a definition of latency suitable for their work within the above.

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| **5.6 Latency**  The one-way end-to-end maximum latency targets, as defined in TR 22.840, are:  - Longer latency target: 10 seconds  - Shorter latency target: 1 second  A use case is assigned to a latency target according to TR 22.840. RAN WGs can refine a definition of latency suitable for their work within the above.  NOTE: The time for charging the Ambient IoT device storage (if present) is not included in the latency defined above. Time for energy harvesting, charging, etc. is regarded as an implementation issue only.  NOTE: the one-way end-to-end maximum latency is assumed to also include query/triggering time. |

For evaluation of the latency, during the RAN#103, the following is agreed,

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| **Proposal 5v2**   * RAN design targets for user experienced data rate, maximum message size, and moving speed of device: those can be used as assumptions in coverage evaluations, i.e. the coverage evaluations are done under the conditions that meet those targets. * Evaluations of RAN design targets for latency and connection/device density are allowed by the Rel-19 SID and observations on those evaluations can be captured in the TR38.769 * Note: this is as per the SID: “*NOTE: Assessment performance of the design targets is within the study of feasibility and necessity of proposals in the following objectives, e.g. by inspection of reference implementations in the field, simulations, analytically*.” |

Form the contributions, the following can be observed,

1. **Support for Single A-IoT Device Latency Definition**:
   * All companies listed in the document support the refine the definition of latency for a single A-IoT device.
   * ZTE: Highlights the need to define and evaluate latency for both single-device and multiple-device scenarios.
2. **Consideration of Different Traffic Types**:
   * All companies consider different traffic types, typically distinguishing between DO-DTT for inventory use cases and DT for command use cases.
3. **Exclusion of Energy Harvesting Time from Latency Definition**:
   * There is a consensus among all companies that the time for energy harvesting should not be included in the latency calculation.
4. **Inclusion of Successful Decoding**:
   * Most companies such as Apple, China Telecom, CMCC, Huawei, Nokia, OPPO, Qualcomm, Spreadtrum and Samsung include successful decoding in their latency definition
   * Companies like Ericsson emphasize defining latency under ideal conditions where packets are received without collisions or errors on the first attempt. Huawei has similar consideration that the successful reception probability is set to 90% for each transmission during the procedure, which means the first attempt is considered.
   * Qualcomm emphasize defining latency considering one or more inventory requests / commands. CATT also thinks access delay due to retransmissions is taken into account.
5. **Components Considered in Calculating Latency**:
   * CATT: Includes signal propagation delay, processing delay at the AIoT device and network nodes, buffer delay, and access delay due to retransmissions.
   * However, Samsung explicitly states the processing time is not included in latency.
6. **ZTE** provides the evaluation assumptions for inventory / command completion time for single device which can be a start point for information.

#### [H][Proposal-3.2.1-latency-v1]

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| **Proposal**:  Definition of the latency is refined as follows,   * For inventory use case (for DO-DTT traffic type):   + The time interval between the time that the inventory request is sent from BS/intermediate UE to a A-IoT device and the time that the inventory report is successfully received at BS/intermediate UE from the A-IoT device. * For command use case (for DT traffic type):   + The time interval between the time that the DL command is sent from BS/intermediate UE and the time that the command is successfully received at A-IoT device. * Note: the successfully received is considered as follows and one alternative is selected from Alt 1 or Alt 2 below,   + Alt 1: The first attempt is taken into account.   + Alt 2: One or more round(s) of attempts are considered. * Note: the latency is evaluated for a single A-IoT device. * Note: Time for energy harvesting is not included in the definition of latency. |

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| **Company** | **Comments** |
| Futurewei | Support the refined latency definition of both inventory and command use cases. Prefer Alt 1. |
| Xiaomi | To simplify to definition, for the consideration of “successfully”, we think Alt 1 is more suitable and also feasible for evaluation. And still we have two questions,  Q1: From single device perspective, if TDM-based access is applied, the waiting time for a device to wait for its corresponding transmission occasion is also taken into account?  Q2: currently the details of inventory process is not determined, 2-step and 4-step access are both discussed. so the latency includes all the time for inventory process either being 2-step or 4-step? |
| Huawei, HiSilicon | Regarding Alt1 and Alt2, we support Alt 1.  As defined in the SA TR, the latency is a one-way end-to-end latency, and this does not account for the device performing multiple rounds of sending a NACK and requesting for a Query repetition.  For the inclusion of the term “successfully received” in the definition, we need to define what “successfully” means. To this end, we want to define it as at least a 90% successful transmission rate, which corresponds to the initial BLER of 10% for each transmission. |
| QC | In general we are fine. Regarding Alt1 and Alt2, in our understanding Alt2 takes into account all un-successful rounds (i.e., including retransmissions). While Alt1 consider only the “last” query (which may or may not be the first one) query. Please clarify Alt1.  We prefer Alt2 taking into account retransmission of queries. |
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### Applicable maximum distance target values(s) (TR38.848 Clause 5.3)

#### Related Tdoc proposals

|  |  |
| --- | --- |
| Apple | ***Proposal 4: For the scenarios whether the transmit reader and receive reader are different, further discuss how the maximum target distance is determined*** |
| Apple | ***Proposal 5: For different scenarios, whether same or separate maximum target distance is determined can be based on the outcome of link budget analysis*** |
| CATT | **Proposal 12: The detailed values of maximum distance target can be set based on further evaluation results.** |
| China Telecom | ***Proposal 7: It is suggested to not set different values of maximum distance targets for different scenarios.*** |
| Huawei | ***Proposal 1: For an Ambient IoT device, the maximum distance target is the maximum evaluated distance among different scenarios.*** |
| Interdigital | **Proposal 3: Support multiple distance target value(s) based on scenario and IoT device type.** |
| MediaTek | **Proposal 15: The maximum distance target is set separately for device 1 and device 2a&2b**   **For device 1, the maximum distance target is 10 - 20m**   **For device 2a&2b, the maximum distance target is 20 - 50m** |
| OPPO | Proposal 5: Distance target for Device 1 is [10m, 20m], for Device 2a with backscattering is [20 m, 50m), for type 2b with active transmission is 50m. |
| Qualcomm | **Proposal 4: Update agreement as follows.**  **Agreement**  **The maximum distance targets are set separately for device 1, device 2a, device 2b, respectively**   * **RAN1 can decide the detailed target values within in the range of 10m to 50m after link budget study.** * **Determine different target values depending on scenario, topology, spectrum, etc.** |
| Spreadtrum | ***Proposal 1: Maximum distance target should be set separately for Device 1, Device 2a, and Device2b respectively, jointly considering different deployment scenarios as well.*** |

#### Discussion (round 1)

It is agreed as follow during the meeting,

Agreement

The maximum distance targets are set separately for device 1, device 2a, device 2b, respectively

* FFS detailed values and RAN1 can further decide the target within in the range of 10m to 50m after link budget study.
* FFS whether to set different values for different scenarios

1. **Setting Different Values for Different Scenarios**
   * **Yes: Interdigital**, **Qualcomm**, **Spreadtrum** support setting maximum distance targets separately for different devices and considering different deployment scenarios
   * **No: China Telecom**, **Huawei**.
     + **China Telecom** Suggests not setting different values of maximum distance targets for different scenarios, advocating for a consistent value across scenarios.
     + Huawei thinks the maximum distance target is the maximum evaluated distance among different scenarios.
   * Further discussed based on the outcome of link budget analysis: **Apple**, **CATT**
2. **Detailed Target Value within the Range of 10m to 50m and After Link Budget Study**:
   * **Consensus**: This viewpoint is generally agreed upon, indicating that companies support a flexible approach to setting target values based on the outcomes of a link budget analysis.
   * Device 1 [10m, 20m]: **OPPO**, **MediaTek**
   * Device 2a [20m, 50m): **OPPO** **MediaTek**
   * Device 2b
     + 50m: **OPPO**
     + [20m, 50m): **MediaTek**

Moderator recommends companies to provide views on the following questions.

**Question 1**: FFS detailed values for each device type

**Question 2**: FFS whether to set different values for different scenarios

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| **Company** | **Comments** |
| Tejas Networks Ltd. | Yes. Set different values for different scenarios |
| Huawei, HiSilicon | For Question 1: Based on our link budget analysis, the value of the maximum distance for Device 1 is 27m for both D2R and R2D, and >50m for Device 2a and 2b.  For Question 2: Since we are tasked to determine the maximum distance, we should consider the maximum evaluated distance across different scenarios, and not consider different values for each scenario. |
| QC | We think having different targets for different scenarios would make more sense than having single number. We also support “Further discussed based on the outcome of link budget analysis”. |
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### Connect density/Device distribution (TR38.848 Clause 5.8)

See section 3.3.2

### Inventory completion time for multiple devices

#### Related Tdoc Proposals

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| Apple | ***Proposal 2: For inventory use case, the ‘Inventory completion time for multiple A-IoT devices’ is defined as the time a reader successfully read completed the inventory process for Z% of A-IoT devices for a given number of reachable A-IoT devices within corresponding coverage by the reader***   * ***FFS: value(s) of Z*** * ***Note: system level simulation is not required to evaluate this metric*** |
| CATT | **Proposal 20: Numerical analysis can be used in delay evaluation for A-IoT.** |
| CMCC | **Proposal 5: The following performance metric is considered for evaluation purpose only,**   * **Inventory completion time for multiple A-IoT devices**   + **For inventory use case, the ‘Inventory completion time for multiple A-IoT devices’ is defined as the time a reader successfully completed the inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverage by the reader**     - **FFS: Z = {99%(Mandatory), 90%(Optional)}**   + **A numerical analysis is conducted rather than a full system-level simulation.** |
| CMCC | **Proposal 6: The following assumptions are considered for evaluating inventory completion time for multiple A-IoT devices,**   |  |  | | --- | --- | | **Assumptions** | **Reported values / schemes** | | * Random access schemes   + slot-aloha is considered as baseline, # of slots is reported by companies.   + Companies to provide the details of the schemes. |  | | * R2D data rate   + refer to the LLS assumptions, |  | | * D2R data rate   + refer to the LLS assumptions, |  | | * Message size   + refer to the LLS assumptions, |  | | * Device distribution, [near, middle, far] = [TBD%, TBD%, TBD%]   + FFS [near, middle, far] with     - different data rate, or     - different BLER   + Considering the topologies provided above, [near, middle, far] = [30%, 30%, 40%] as a start point |  | | * [Impact of RF energy harvesting and power consumption]   + Maximum 10 seconds charging time,   + 1uF capacitor for device 1, 10uF capacitor for device 2   + 1/3 of the energy of capacitor can be discharged   + Active power consumption is 1uW for device 1 and 100, 500 uW for device 2   + Sleep power consumption is 0.1uW (RTC clock is running, monitoring is suspended)   + charging energy efficiency 5% - 10%, FFS details |  | | * Device number   + 600 devices / reader |  | |
| Ericsson | [Proposal 7 Study inventory completion time for multiple A-IoT devices, i.e., the time required for a reader to successfully complete the inventory process for 99% of the A-IoT devices for a given number of reachable A-IoT devices within the coverage of the reader.](#_Toc166256572) |
| Huawei | ***Proposal 3: The study does not include the overall latency of the inventory of multiple devices.*** |
| Lenovo | ***Proposal 5: Consider long latency target of 10 seconds considering latency of inventory and actuator command use case requirement is provided as several seconds.***   * ***Evaluate the sustainable operation time, energy harvesting, different scheduling mechanism within the inventory process and its impact on latency*** |
| Lenovo | ***Proposal 6: The following performance metric is considered for evaluation purpose only,***   * ***Inventory completion time for multiple A-IoT devices [s]*** * ***For inventory use case, the ‘Inventory completion time for multiple A-IoT devices’ is defined as the time a reader successfully read completed the inventory process for [Z]% of A-IoT devices for a given number of reachable A-IoT devices within corresponding coverage by the reader*** * ***FFS: Z = {99%(Mandatory), 90%(Optional)}*** |
| Lenovo | ***Proposal 7: The assumption to be considered for the invention completion time evaluation includes:***   * ***Duration of the random access round (ms)*** * ***Device distribution*** * ***Number of Devices*** * ***Message size*** * ***Capacitor sizes*** * ***Impact of sustainable operation time of the device including RF energy harvesting and the related component such as rectifier resistances, capacitance sizes, initial stored energy etc.,*** * ***Power consumption for Tx, sleep, Rx etc., for each device type*** * ***Scheduling methodology e.g., slotted Aloha etc.,*** |
| Lenovo | ***Proposal 8: RAN1 should evaluate the number of devices to be inventorized in a given area in an inventory round, considering***   * ***Collision due to the number of devices participating in an inventory round.*** * ***Target latency considering the energy harvesting within the inventory round.*** |
| Lenovo | ***Proposal 21: Evaluate the power consumption of the Ambient IoT device within a inventory round considering duty cycle-based operation,***   * ***Periodic Rx and synchronization*** * ***Minimum sleep state to maintain the RAM memory*** * ***Tx operation for transmitting random access and EPC ID*** |
| Lenovo | ***Observation 4: The minimum capacitance size to sustainably operate the device within an inventory round varies with the received power i.e., E2H link budget.*** |
| Lenovo | **Proposal 22: Consider the outage probability as non-availability of energy from the capacitor to sustainably operates the Ambient IoT device within an inventory round to transmit EPC ID.** |
| Lenovo | **Proposal 23: Consider the rectifier efficiency as a function of received power for storing the harvested energy in device capacitor.** |
| Lenovo | ***Observation 5: The required minimum capacitance size to sustainably operate the Ambient IoT device in a slotted Aloha scheme is 15µF.*** |
| Lenovo | ***Proposal 24: For RF energy harvesting evaluation, study defining the minimum capacitance size to achieve sustainable operation time without an outage probability considering power dissipation due to scheduling.*** |
| Lenovo | ***Observation 6: The minimum required capacitance size to achieve certain outage probability can be relaxed using energy aware scheduling.*** |
| Lenovo | ***Proposal 25: Consider studying scheduling of Ambient IoT device by taking into consideration the available energy at the capacitor and the received power.*** |
| Lenovo | ***Observation 7: Sustainable operation time of the device is defined as the time duration of the Ambient IoT devices to operate successfully within an inventory round without going into outage and the sustainable operation time of a device varies with the distance from the emitter.*** |
| Lenovo | ***Observation 8: Energy harvesting having positive impact on the sustainable operation time of the Ambient IoT device.*** |
| Lenovo | ***Proposal 26: Evaluate the sustainable operational duration of Ambient IoT devices with and without Energy harvesting within an inventory round.*** |
| LGE | ***Proposal 2: Multiple device needs to be considered for evaluation performance in inventory use case*** |
| OPPO | [Proposal 21: “Inventory completion time for multiple devices” in R1-2403815 should be agreed and used as the performance metric for the evaluation of inventory latency.](#_Toc166247520) |
| Qualcomm | **Proposal 5: Inventory completion time for multiple A-IoT devices is defined.**   * **For inventory use case, the ‘Inventory completion time for multiple A-IoT devices’ is defined as the time a reader successfully complete the inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverage by the reader**   + **FFS: Z = {99%(Mandatory), 90%(Optional)}**   + **FFS assumptions for the followings: Company to report** * **Random access schemes** * **R2D and D2R data rate** * **Message size** * **Device distribution, [near, middle, far] = [TBD%, TBD%, TBD%]** * **Impact of RF energy harvesting and power consumption** * **device number** |
| Qualcomm | **Proposal 11: RAN1 introduces inventory traffic model as follows.**   * **Periodic inventory request from A-IoT server with periodicity of [15] min.** * **Reader generation multiple inventory queries over multiple rounds to read A-IoT devices.**   + **The query generation timing depends on the random-access procedure.** * **Reader generates multiple queries until inventory timer expires, or reader decides to stop inventory process early (due to no more reading).** |
| Qualcomm | **Proposal 12: RAN1 consider RF energy harvesting in its inventory evaluation.** |
| Qualcomm | **Proposal 13: RAN1 to use PCE curve (or table) to study the impact of charging during inventory process.** |
| Qualcomm | **Proposal 14: RAN1 to capture sensitivity in the PCE curve or table for evaluation purpose.** |
| Qualcomm | **Observation 4: If energy harvesting is not properly evaluated, then, system design could end up with a solution which neither meet design requirements nor address target use case.** |
| Qualcomm | **Proposal 15: RAN1 to perform evaluation of inventory process considering following aspects in evaluation.**   * **Single Reader / [multiple Readers]** * **Pathloss only channel model / [fading channel]** * **Multiple A-IoT devices** * **Energy harvesting model** * **Power consumption model** * **Inventory procedure (including random access scheme)** |
| Samsung | Proposal 14. Study the evaluation methodology for a performance metric for multiple tags which can be the total time the reader takes to perform inventory or command process for the entire tags.  FFS: a performance criteria for each use case. |
| Spreadtrum | ***Proposal 3: Support the metric of inventory completion time for multiple A-IoT devices. The ‘Inventory completion time for multiple A-IoT devices’ is defined as the time a reader successfully read completed the inventory process for [Z]% of A-IoT devices for a given number of reachable A-IoT devices within corresponding coverage by the reader***   * ***Z = {99%(Mandatory), 90%(Optional)}*** * ***Assumptions for the followings: Company to report***   + ***Random access schemes***   + ***R2D and D2R data rate***   + ***Message size***   + ***Device distribution***   + ***Device number*** |
| Vivo | **Proposal 24:  The following performance metric is considered for evaluation purpose only,**  **Inventory completion time for multiple A-IoT devices [s]**  - **For inventory use case, the  ‘Inventory completion time for multiple A-IoT devices’ is defined as the time readers  successfully completed the inventory process for [Z]% of A-IoT devices for a given number/distribution of A-IoT devices by the reader**  - **FFS: Z = {99%(Mandatory), 90%(Optional)}** |
| ZTE | ***Proposal 19: The evaluation assumptions in Table 9 can be considered for inventory completion time for multiple devices.***  Table 9 Evaluation assumptions of inventory latency for multiple devices   |  |  |  | | --- | --- | --- | | **Parameters** | | **Values** | | Random access procedure | | 4-step access | | Anti-collision algorithm | | Slot-ALOHA | | Number of Ambient IoT devices | | 600 | | Initial number of slots for ALOHA | | 32, 512 | | Message size  (Number of bits) | Query command | 8 | | Decrement command | 4 | | RN16 | 16 | | Acknowledge of RN16 | 16 | | Device ID | 96 | | CRC length (Number of bits) | | 16 for device ID | | Transmission time per bit | | 200 us | | Preamble length | | 8×25 us for R2D and D2R | | Interval between R2D and D2R signals | | 10×25 us | | Interval between D2R and R2D signals | | 5×25 us | |

#### Discussion (round 1)

1. **Metric for "Inventory completion time for multiple A-IoT devices"**:
   * Yes, several proposals (e.g., Apple Proposal 2, CMCC Proposal 5, Qualcomm Proposal 15, OPPO Proposal 21) suggest defining this metric as it is crucial for understanding the efficiency of inventory processes in A-IoT systems.
   * No, Huawei mentions the study does not include the overall latency of the inventory of multiple devices.
2. **Type of Evaluation (SLS or Numeric Analysis)**:
   * Proposals (e.g., Apple Proposal 2, CMCC Proposal 6, CATT Proposal 20) suggest using numerical analysis instead of full system-level simulations (SLS) to manage the complexity and reduce the workload. However, the final approach may depend on the availability of accurate models and the need for detailed insights.
3. **Consideration of RF Energy Harvesting and Power Consumption**:
   * Yes, proposals (e.g., Lenovo Proposal 24, Qualcomm Proposal 12) emphasize the importance of considering RF energy harvesting and power consumption. These factors significantly impact the sustainable operation time and the overall performance of A-IoT devices.
4. **Evaluation assumptions**
   * **Z**
     + Ericsson and Spreadtrum suggests Z = {99%(Mandatory), 90%(Optional)}
   * **Consideration of Device Distribution**:
     + Device distribution should be considered (e.g., CMCC Proposal 6, Qualcomm Proposal 15), with proposals suggesting different distributions (near, middle, far) and their respective percentages. This is important to accurately reflect real-world scenarios and to evaluate the performance of A-IoT systems comprehensively.
   * **Random Access Schemes**:
     + Slot-aloha is considered as the baseline random access scheme, with the number of slots reported by companies (CMCC Proposal 6, ZTE Proposal 19).
   * **RF Energy Harvesting**:
     + Maximum charging time of 10 seconds is considered, with specific capacitor sizes for device 1 (1uF) and device 2 (10uF) (Lenovo Proposal 7).
     + Energy efficiency of charging is between 5% - 10%, and only a portion of the capacitor's energy can be discharged (Lenovo Proposal 7).
     + Qualcomm asks RAN1 to use PCE curve (or table) to study the impact of charging during inventory process. RAN1 to capture sensitivity in the PCE curve or table for evaluation purpose. (Qualcomm Proposal 13-14).
   * **Power Consumption**:
     + Active power consumption is specified for device 1 (1uW) and device 2 (100, 500 uW), with sleep power consumption at 0.1uW (Lenovo Proposal 7).
   * **Device Number**:
     + A specific number of devices per reader is considered, with 600 devices/reader mentioned (CMCC Proposal 6, ZTE Proposal 19).
   * **Message Size**:
     + Message sizes are reported by companies, with reference to the LLS assumptions (CMCC Proposal 6).
     + ZTE Suggest the followings

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| Message size  (Number of bits) | Query command | 8 |
| Decrement command | 4 |
| RN16 | 16 |
| Acknowledge of RN16 | 16 |
| Device ID | 96 |

1. **Data Rates**:
   * R2D and D2R data rates are referenced according to the LLS assumptions (CMCC Proposal 6).
   * ZTE Proposes the followings

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| Transmission time per bit | 200 us |
| Preamble length | 8×25 us for R2D and D2R |
| Interval between R2D and D2R signals | 10×25 us |
| Interval between D2R and R2D signals | 5×25 us |

#### [H][Proposal-3.2.4-multi-device-metric-v1]

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| The following performance metric is considered for evaluation purpose only,   * Inventory completion time for multiple A-IoT device   + For inventory use case, the  ‘*Inventory completion time for multiple A-IoT devices*’ is defined as the time a reader successfully completed the inventory process for [Z]% of A-IoT devices for a given number of A-IoT devices within corresponding coverageby the reader   + Z = {99%(Mandatory), 90%(Optional)} |

#### [H][Proposal-3.2.4-multi-device-assumptions-v1]

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| For evaluation of the Inventory completion time for multiple A-IoT device, the following is assumed or reported by companies,   |  | | --- | | **Assumptions** | | * Random access schemes   + slot-aloha is considered as baseline, # of slots is reported by companies.   + Companies to provide the details of the schemes. | | * R2D data rate   + refer to the LLS assumptions, | | * D2R data rate   + refer to the LLS assumptions, | | * Message size  |  |  |  | | --- | --- | --- | | Message size  (Number of bits) | Query command | 8 | | Decrement command | 4 | | RN16 | 16 | | Acknowledge of RN16 | 16 | | Device ID | 96 | | | * Device distribution, [near, middle, far] = [TBD%, TBD%, TBD%] | | * [Impact of RF energy harvesting and power consumption]   + FFS details on, maximum charging time, capacitor size, active/sleep power consumption, PCE, percentage of the capacitor's energy for discharging and etc. | | * Device number   + 600 devices / reader | |

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| **Company** | **Comments** |
| Xiaomi | Generally OK, But the minimum time between PRDCH and PDRCH, and the minimum time between PDRCH and PRDCH(if exists) should also be considered. |
| Huawei, HiSilicon | We raised the following concerns in the email discussion after Changsha, which have not been addressed in this proposal:   * + - There is no latency design target defined for multi-device inventory latency on a careful interpretation of the related TRs/TSs, and we are to strive to minimize evaluation cases, whereas this proposal increases them.     - Based on previous discussions, if the evaluation requires SLS, it would drastically increase the workload.     - Would the definition consider only the initial transmission or retransmissions as well?   We can decide on the necessity of this definition once the aforementioned issues are sorted. |
| QC | We support defining new metric of inventory completion time.  For evaluation assumption, we propose simplified version of evaluation; considering   * Single reader * Multiple devices * Pathloss only model * Impact of RF energy harvesting and power consumption * Power consumption model * Etc.   This approach will significantly decrease required efforts and time for evaluation.  We are open for companies to numerical analysis, but this approach may requires good modelling of inventory access procedure and collision / retransmission / etc, which we think more complicated and difficult than above simplified version of evaluation. |
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### Others

#### Related Tdoc Proposals

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| CATT | **Proposal 15: KPIs to be considered for evaluation should include the link level performance, coverage, latency and coexistence.** |
| Lenovo | ***Proposal 1: Consider the candidate target peak power consumption for the passive Ambient IoT device type 2B containing amplification and storage between 300 to 500 µW.*** |
| Lenovo | ***Proposal 2: Consider the candidate target peak power consumption for the active Ambient IoT device type 2A containing amplification and storage between 500 to 1000 µW.*** |
| Qualcomm | **Proposal 6: Adopt following KPIs for evaluation purpose.**   * **Latency for single device (sec)** * **Inventory completion time (sec)** * **Device power/energy consumption (uW/uJ)** * **Energy storage size (uF)** |

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| **Company** | **Comments** |
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## Deployment scenarios for coverage and coexistence evaluation

### Scenarios definition

#### Related Tdoc Proposals

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| Apple | ***Proposal 3: Following scenarios are further down-selected and updated for evaluation purpose:***   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | ***Scenario*** | ***CW Inside/outside topology*** | ***Diagram of the scenario*** | ***Description of the scenario*** | ***Device 1/2a/2b*** | ***CW spectrum*** | ***D2R spectrum*** | ***R2D spectrum*** | | ***D1T1-A1*** | *CW inside topology* | *A black background with a black square  Description automatically generated with medium confidence* | * *CW node inside topology 1* * *‘CW’ in CW2D and ‘R2’ in D2R are different* * *‘CW’ in CW2D and ‘R1’ in R2D are same* * *‘R1’ in R2D and ‘R2’ in D2R are different* | *Device 1, 2a* | *Case 1-1 (inside topology, DL)*  *Case 1-2 (inside topology, UL)* | *Same as CW* | *DL* | | **D1T1-B** | CW outside topology | A black background with a black square  Description automatically generated with medium confidence | * CW node outside topology 1 * ‘CW’ in CW2D and ‘R’ in D2R are different * ‘CW’ in CW2D and ‘R’ in R2D are different * ‘R’ in R2D and ‘R’ in D2R are same |  | Case 1-4 (outside topology, UL) | Same as CW | *DL* | | ***D1T1-C*** | *No CW* | *A black background with a black square  Description automatically generated with medium confidence* | * *No CW Node.* | *Device 2b* | *N/A* | *UL* | *DL* | | ***D2T2-A1*** | *CW inside topology* | *A black background with a black square  Description automatically generated with medium confidence* | * *CW node inside topology 2* * *‘CW’ in CW2D and ‘R2’ in D2R are different* * *‘CW’ in CW2D and ‘R1’ in R2D are same* * *‘R1’ in R2D and ‘R2’ in D2R are different* * *BS communicates with R1 and R2* | *Device 1, 2a* | *Case 2-2 (inside topology, UL)* | *Same as CW* | *UL* | | **D2T2-B** | CW outside topology | A black background with a black square  Description automatically generated with medium confidence | * CW node outside topology 2 * ‘CW’ in CW2D and ‘R’ in D2R are different * ‘CW’ in CW2D and ‘R’ in R2D are different * ‘R’ in R2D and ‘R’ in D2R are same * BS communicates with R |  | Case 2-3 (outside topology, DL)  Case 2-4 (outside topology, UL) | Same as CW | *UL* | | ***D2T2-C*** | *No CW* | *A black background with a black square  Description automatically generated with medium confidence* | * *No CW Node.* * *BS communicates with R* | *Device 2b* | *N/A* | *UL* | *UL* | | *Note: this table is for the case where D2R is in the same spectrum as CW2D.* | | | | | | | | |
| CMCC | **Proposal 1: Prioritize D1T1-A1/A2/B and D2T2-B for further coverage evaluation.** |
| Ericsson | [Proposal 8 Regarding interference in D1T1-A1 and D2T2-A1 scenarios, RAN1 to clarify whether R2 is dedicated only to receiving D2R or if it can also transmit CW signal at the same time.](#_Toc166256573) |
| Ericsson | [Proposal 9 For the D2T2-C scenario, like D1T1-C, UL spectrum can be considered for D2R link.](#_Toc166256574) |
| Huawei | ***Proposal 4: The study assumes FDD downlink spectrum for R2D transmissions in D1T1.*** |
| Huawei | ***Proposal 5: In D1T1, the study assumes the following spectrum for both CW2D and D2R transmission.***   * ***D1T1-A: DL spectrum (Case 1-1)*** * ***D1T1-B: UL spectrum (Case 1-4)*** |
| Huawei | ***Proposal 6: In D1T1-B, the CW distribution is reported by companies.*** |
| Huawei | ***Proposal 7: The study assumes uplink spectrum for the R2D transmission in D2T2.*** |
| Huawei | ***Proposal 8: The study assumes UL spectrum for both CW2D and D2R transmission in both D2T2-A and D2T2-B.*** |
| Huawei | ***Proposal 9: The study assumes UL spectrum for the D2R transmission in D2T2-C.*** |
| Huawei | ***Proposal 10: The intermediate UEs are assumed to be deployed following uniform distribution with e.g. 10 m /20 m distance between every two adjacent intermediate UEs.*** |
| Huawei | ***Proposal 11: The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.*** |
| Huawei | ***Proposal 12: In D2T2-B, the CW distribution is reported by companies.*** |
| Interdigital | **Proposal 1: Perform coverage evaluation in InF-DH environment for D1T1 scenario and InF-DL environment for D2T2 scenario.** |
| Lenovo | ***Proposal 9: Evaluate the feasibility of in-band Ambient IoT communication within the FDD-UL spectrum to avoid switching between FDD-UL and FDD-DL bands.*** |
| Lenovo | ***Proposal 11: For topology 2, the intermediate node i.e., UE communicates with the Ambient IoT device using the FDD-UL spectrum.*** |
| Lenovo | ***Proposal 12: For topology 2, consider studying FDD like operation for Ambient IoT device.***  ***Observation 2: Higher transmit power for the fixed ceiling node in the UL spectrum may not violate the SAR regulation.*** |
| Lenovo | ***Proposal 13: For both topology 1 and topology 2 evaluate internal and external carrier wave transmission. On the spectrum of carrier wave transmission and backscattered signal evaluate following cases considering different interference scenarios, frequency shifting capability and harmonized spectrum for topology 1 and topology 2,***   * ***Case 1: Carrier wave transmission on DL spectrum and corresponding backscattering transmission on UL spectrum*** * ***Case 2: Carrier wave transmission on DL spectrum and corresponding backscattering transmission on DL spectrum*** * ***Case 3: Carrier wave transmission on UL spectrum and corresponding backscattering transmission on UL spectrum*** * ***Case 4: Carrier wave transmission on UL spectrum and corresponding backscattering transmission on DL spectrum*** |
| LGE | ***Observation 1: For D1T1-A (indoor BS + indoor AIoT device, CW inside topology), based on the agreements in AI 9.4.2.4, the case where all transmissions (R2D/CW/D2R) are in either DL or UL spectrum can be studied.*** |
| LGE | ***Observation 2: For D1T1-B (indoor BS + indoor AIoT device, CW outside topology), based on the agreements in AI 9.4.2.4, the following two cases can be studied:***   * ***Case 1) R2D in DL spectrum and CW/D2R in UL spectrum*** * ***Case 2) All (R2D/CW/D2R) in UL spectrum (Case 2 is common to D1T1-A and D1T1-B)*** |
| LGE | ***Proposal 7: For Deployment scenario 1 with topology 1, for D1T1-A1/A2/B/C, at least the spectrum deployment scenario in which all the transmissions (R2D/CW/D2R) are in UL spectrum should be evaluated for coverage and coexistence.***   * ***The scenario in which R2D is in DL spectrum and D2R(/CW) is in UL spectrum can also be evaluated for the case where device 2b coexists with devices 1/2a with the CW outside topology.*** |
| LGE | ***Observation 3: For D2T2-A (outdoor BS + Indoor Intermediate UE + Indoor AIoT device, CW inside topology), based on the agreements in AI 9.4.2.4, the case where all transmissions (R2D/CW/D2R) are in UL spectrum can be studied.*** |
| LGE | ***Observation 4: For D2T2-B (outdoor BS + Indoor Intermediate UE + Indoor AIoT device, CW outside topology), based on the agreements in AI 9.4.2.4, the case where all transmissions (R2D/CW/D2R) are in UL spectrum can be studied.*** |
| LGE | ***Proposal 8: For Deployment scenario 2 with topology 2, for D2T2-A1/A2/B/C, only the spectrum deployment scenario in which all the transmissions (R2D/CW/D2R) are in UL spectrum is evaluated for coverage and coexistence.*** |
| MediaTek | **Observation 10: Scenario of D2T2-B with Case 2-3 (CW outside topology on DL spectrum) could introduce severe interference for legacy NR UE.** |
| MediaTek | **Proposal 10: Scenario of D2T2-B with Case 2-3 (CW outside topology on DL spectrum) should be excluded for further coverage evaluation.** |
| MediaTek | **Proposal 11: For D2T2-C, support D2R on UL spectrum.** |
| NEC | **Proposal 1: Consider the evaluation requirements of use cases relevant to Indoor inventory for Ambient IoT study.** |
| NEC | **Proposal 6: RAN1 to not consider D1T1-B and D2T2-A2 for evaluation study.** |
| Nokia | **Proposal 2: Prioritize in-band deployments with scenarios A1 and B where the CW transmitting node is not the D2R receiving reader. Scenarios A1 should have the highest priority since their D2R coverage is not limited by R2D.** |
| DOCOMO | **Proposal 2: For scenario definition for evaluation,**   * **at least UL spectrum should be assumed for D2T2-C D2R spectrum.** * **FFS: DL spectrum.** |
| OPPO | [Proposal 13: Link budget evaluation for D2T2-A2 should be down prioritized as the intermediate UE cannot support CW cancellation.](#_Toc166247512) |
| Qualcomm | **Proposal 7: For evaluation, have lower priority for D2T2-A1 and D2T2-B.** |
| Qualcomm | **Proposal 8: For evaluation purpose, update following table with the choices of R2D spectrum and D2R spectrum.**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Scenario** | **CW Inside/outside topology** | **Diagram of the scenario** | **CW spectrum** | **D2R spectrum** | **R2D spectrum** | | **D1T1-A1** | CW inside topology | A black background with a black square  Description automatically generated with medium confidence | Case 1-1 (inside topology, DL)  Case 1-2 (inside topology, UL) | Same as CW | DL | | **D1T1-A2** | A black background with a black square  Description automatically generated with medium confidence | Same as D1T1-A1 | Same as CW | DL | | **D1T1-B** | CW outside topology | A black background with a black square  Description automatically generated with medium confidence | Case 1-4 (outside topology, UL) | Same as CW | DL | | **D1T1-C** | No CW | A black background with a black square  Description automatically generated with medium confidence | N/A | UL | DL | | **D2T2-A1** | CW inside topology | A black background with a black square  Description automatically generated with medium confidence | Case 2-2 (inside topology, UL) | Same as CW | UL | | **D2T2-A2** | A black background with a black square  Description automatically generated with medium confidence | Same as D2T2-A1 | Same as CW | UL | | **D2T2-B** | CW outside topology | A black background with a black square  Description automatically generated with medium confidence | Case 2-3 (outside topology, DL)  Case 2-4 (outside topology, UL) | Same as CW | UL  (DL has potentiel regulation issue.) | | **D2T2-C** | No CW | A black background with a black square  Description automatically generated with medium confidence | N/A | UL / DL | UL | | Note: this table is for the case where D2R is in the same spectrum as CW2D. | | | | | | |
| Qualcomm | **Proposal 9: Reduce the hall size of D2T2 InF-DL case to 120x50m.** |
| Spreadtrum | ***Proposal 4: All D1T1-A/B/C should be considered in both coexistence and coverage evaluations.***  ***Observation 1: D2T2-A1 will complicate A-IoT system design, as different nodes for CW2D/R2D and D2R need promptly coordination to support inventory use case, especially huge spec. impact is expected for D2T2-A1.*** |
| Spreadtrum | ***Proposal 5: Down-prioritize D2T2-A1 scenario for coverage and coexistence evaluation.*** |
| Spreadtrum | ***Proposal 6: UE in DL spectrum for and BS in UL spectrum are not supported.*** |
| Vivo | **Proposal 1:**  **Prioritize DL spectrum for R2D for D1T1. And R2D for D2T2 is on UL spectrum to align with RAN4 agreements.** |
| Vivo | **Proposal 2: UE is uniformly distributed over the horizon area, and only the AIoT devices with nearby UE reader is counted in the evaluation.**  - **To access a given number of A-IoT devices, the UE can be re-dropped multiple times to reach the nearby AIoT devices.**  - **The definition of ‘nearby’ can be determined based on predefined RSRP threshold or distance between UE reader and AIoT device, which can be up to companies’ setup in evaluations.** |
| Xiaomi | ***Proposal 2: Not support the scenarios that the R2D reader is different from the D2R reader.*** |
| Xiaomi | ***Proposal 3: Operating spectrum of the device should be large enough to cover both DL and UL spectrum, so that device can support to transmit and receive on either DL or UL spectrum.*** |
| Xiaomi | ***Observation 2: Topology 1 has obviously better coverage performance than Topology 2 due to better transmit power/antenna gain/self-interference cancellation capacity/noise figure.*** |
| Xiaomi | ***Observation 3: For Topology 1, D2R link has obviously better coverage performance than R2D link due to receiver sensitivity of gNB is much better than Device. For Topology 2, D2R link has slightly better coverage performance than R2D link due to detection performance of OOK signals by UE is only slightly better than device.*** |
| ZTE | ***Proposal 1: The following deployment scenarios should be evaluated for Ambient IoT coverage.***   * ***D1T1-A1/A2/B/C and D2T2-A2/B/C*** |
| ZTE | ***Proposal 2: The following spectrum usage is suggested for Ambient IoT coverage evaluation:***   * ***D1T1: Use FDD UL/DL spectrum for R2D, CW and D2R transmission;*** * ***D2T2: Use FDD UL spectrum for R2D, CW and D2R transmission*** |

#### Discussion (round 1)

Scenarios companies wants to deprioritized are summarized as follows,

**D1T1-A1**

* -

**D1T1-A2**

* Apple

**D1T1-B**

* NEC

**D2T2-A1**

* Apple, CMCC, Qualcomm, Spreadtrum, ZTE

**D2T2-A2**

* Apple, CMCC, NEC, OPPO

**D2T2-B**

* MediaTek (CW case 2-3), Qualcomm

Regarding the spectrum usage, the followings prioritized cases proposed by companies are observed,

|  |  |  |  |
| --- | --- | --- | --- |
| ***Scenario*** | ***CW spectrum*** | ***D2R spectrum*** | ***R2D spectrum*** |
| **D1T1-A1** | Case 1-1 (inside topology, DL)   * *Huawei*   Case 1-2 (inside topology, UL) | Same as CW | *DL*   * *Apple, Huawei, LGE, DOCOMO, Qualcomm, vivo*   *UL*   * *LGE* |
| **D1T1-A2** | Same as D1T1-A1 | Same as CW | *DL*   * *Huawei, LGE, DOCOMO, Qualcomm, vivo*   *UL*   * *LGE* |
| **D1T1-B** | Case 1-4 (outside topology, UL)   * *Huawei* | Same as CW | *DL*   * *Apple, Huawei, LGE, DOCOMO, Qualcomm, vivo* |
| **D1T1-C** | N/A | *UL* | *DL*   * *Apple, Ericsson, Huawei, LGE, DOCOMO, Qualcomm, vivo* |
| **D2T2-A1** | Case 2-2 (inside topology, UL) | Same as CW | *UL*   * *Apple, Huawei, Lenovo, LGE, Qualcomm, vivo, ZTE* |
| **D2T2-A2** | Same as D2T2-A1 | Same as CW | *UL*   * *Huawei, Lenovo, LGE, Qualcomm, vivo, ZTE* |
| **D2T2-B** | Case 2-3 (outside topology, DL)  Case 2-4 (outside topology, UL)   * *ZTE,* MediaTek (exclude 2-3) | Same as CW | *UL*   * *Apple, Huawei, Lenovo, LGE, Qualcomm, vivo, ZTE* |
| **D2T2-C** | N/A | *UL*   * *Apple, Huawei, Lenovo, MediaTek, DOCOMO, Qualcomm, ZTE*   *DL*   * *Qualcomm* | *UL*   * *Apple, Ericsson, Huawei, Lenovo, LGE, Qualcomm, vivo, ZTE* |

#### [H][Proposal-3.3.1-low-scenario-v1]

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| **Proposal:**  Deprioritize D2T2-A1 for evaluation.   * FFS other scenarios which are high or low priority. |

#### [M][Proposal-3.3.1-spectrum-v1]

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| **Proposal:**   * The followings scenarios are considered for evaluation,   + D1T1: FDD DL spectrum for R2D transmission   + D2T2: FDD UL spectrum for R2D transmission   + D2T2-C: FDD UL spectrum for D2R transmission |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Generally OK with [Proposal-3.3.1-low-scenario-v1].  And for D2T2-A2, we also support to deprioritize it, sincet it would be difficult for UE to do self interference cancelation.  For [Proposal-3.3.1-spectrum-v1], we would like to understand it by further step. our view is that a device should be able operate in both D1T1 and D2T2, and if the current [Proposal-3.3.1-spectrum-v1] is supported, that means the matching network of device should be able to coverage both DL and UL spectrum? Or do we assume that a device can only operate in D1T1 or can only operate in D2T2, and there would be 2 different device types in the network? |
| Tejas Networks Ltd. | Support [Proposal-3.3.1-spectrum-v1] |
| Huawei, HiSilicon | We are fine with the proposal related to the spectrum, but are not sure about deprioritizing the particular scenario for evaluation, specifically D2T2-A1, because it is the only deployment scenario that handles the case where the CW node is inside the topology. |
| Qualcomm | * The followings scenarios are considered for evaluation,   + D1T1: FDD DL spectrum for R2D transmission   + D2T2: FDD UL spectrum for R2D transmission   + D2T2-C: FDD DL/UL spectrum for D2R transmission   For D2T2-C, the FDD DL spectrum needs to be considered as well since this is the case where UE does not require full duplex capability at UE side. |
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### Topology and distributions assumptions

#### Related Tdoc Proposals

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| Apple | ***Proposal 6: For D2T2 scenarios, no additional consideration is needed for evaluation assumption related to the devices involved in the evaluation***   * ***This can be considered as outcome of the analysis*** |
| CATT | **Proposal 10: The distribution of outside CW emitter and intermediate UE should guarantee the transmission and reception power for each link can support normal communication. The impact of different spectrums on the transmission power should also be considered in the calculation.** |
| CMCC | **Proposal 2: Further discussion for the follows,**   * **The 'CW2D distance (m) value(s)' for coverage evaluation in RAN1** * **Intermediate UE dropping and which devices are involved in the evaluations for D2T2 for coexistence evaluation in RAN4** |
| CMCC | **Proposal 4: For 2D distribution of devices**   * **The devices are uniformly distributed in the system as starting.** * **For simplicity, system level simulation is not required.** |
| FutureWei | ***Proposal 1: CW nodes are distributed uniformly in D1T1 and D2T2.*** |
| FutureWei | ***Proposal 2: adopt the CW node placement Option 1 as the baseline for D1T1 and D2T2.*** |
| Interdigital | **Proposal 5: RAN1 to select between two options for distribution of devices:**   * **Option 1: All devices are uniformly dropped.** * **Option 2: All devices are divided in groups (per BS). Each group is uniformly dropped within a circle of radius R around the BS, where R is determined according to coverage analysis.** |
| Huawei | ***Proposal 6: In D1T1-B, the CW distribution is reported by companies.*** |
| Huawei | ***Proposal 10: The intermediate UEs are assumed to be deployed following uniform distribution with e.g. 10 m /20 m distance between every two adjacent intermediate UEs.*** |
| Huawei | ***Proposal 11: The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.*** |
| Huawei | ***Proposal 12: In D2T2-B, the CW distribution is reported by companies.*** |
| MediaTek | **Proposal 12: For coverage evaluation of D2T2, intermediate UE drop uniformly distributed over the horizontal area for both scenarios of InH-office and InF-DL.**   **FFS intermediate UE dropping number for different scenarios and different device types.** |
| OPPO | Proposal 8: The 150 devices per 100 m2 are uniformly distributed for the indoor scenario. |
| OPPO | Proposal 9: For D2T2, intermediate UE dropping is same as the BS in the same scenario. |
| OPPO | Proposal 10: For ‘B’ scenarios, CW is located in the middle of 4 adjacent BS or intermediate UEs. |
| Qualcomm | **Observation 1: The goal of T2 is not to provide continuous coverage (as T1). The goal of T2 is to address consumer use case, e.g., using smartphone to read tags nearby.** |
| Qualcomm | **Observation 2: For D2T2, UE dropping density does not need to be high considering consumer use case.** |
| Qualcomm | **Observation 3: For D2T2, there is inherent spatial correlation occurring in device location and reader UE’s location due to the intention of users to read nearby tags using his/her smartphone.** |
| Qualcomm | **Proposal 10: Update table with following modification**  **The following layout is used for evaluation purpose,**   * ~~FFS: CW distribution for D1T1-B and D2T2-B~~  |  |  |  |  | | --- | --- | --- | --- | | **Parameter** | **Assumptions for D1T1** | **Assumptions for D2T2** | | | **Scenario** | **InF-DH** | **InH-office** | **InF-DL** | | **Hall size** | **120x60 m** | **120 x50 m** | **~~300x150 m~~**  **120 x50 m** | | **Room height** | **10 m** | **3m** | **10 m** | | **Sectorization** | **None** | | | | **BS deployment / Intermediate UE dropping** | **18 BSs on a square lattice with spacing D, located D/2 from the walls.**   * **L=120m x W=60m; D=20m** * **BS height = 8 m**   **A black dots on a white background  Description automatically generated** | * **~~L=120m x W=50m;~~** * **Intermediate UE height = 1.5 m**   **Intermediate UE dropping**   * **Uniform** * **Density: [2] UEs in the entire hall** | * **~~L=300m x W=150m;~~** * **Intermediate UE height = 1.5 m**   **Intermediate UE dropping**   * **Uniform** * **Density: [2] UEs in the entire hall** | | **Device distribution** | **Device Height= 1.5 m**  **AIoT devices drop uniformly distributed over the horizontal area** | **Device Height= 1.5 m**  **AIoT devices drop uniformly distributed over the horizontal area**  **Device involved in evaluation: only devices who’s long term rx power is above its sensitivity are involved in the evaluations.**  **~~FFS: which devices are involved in the evaluations~~** | **Device Height= 1.5m**  **AIoT devices drop uniformly distributed over the horizontal area**  **Device involved in evaluation: only devices who’s long term rx power is above its sensitivity are involved in the evaluations.**  **~~FFS: which devices are involved in the evaluations~~** | | **Device mobility (horizontal plane only)** | **3 kph** | **3 kph** | **3 kph** | | **CW distribution** | **Company to report including locations, density, height, etc, if any** | **Company to report including locations, density, height, etc, if any** | **Company to report including locations, density, height, etc, if any** | |
| Vivo | **Observation 1: Unlike BS reader in D1T1, the movement of UE intermediate node in the indoor area is more in line with the actual deployment.** |
| Vivo | **Observation 2:**  **If an intermediate UE is randomly dropped without considering UE movement, very low percentage of AIoT device can be inventoried by UE reader, if all AIoT devices are counted in evaluation due to limited coverage range.** |
| ZTE | ***Proposal 4: Following alternatives can be considered for intermediate UE layout in D2T2:***   * ***Alt1: intermediate UEs are stationary and dropped in a similar layout as BS in D1T1;*** * ***Alt2: intermediate UEs are mobile and a single UE is assumed for D2T2 layout.*** |
| ZTE | ***Proposal 5: For D1T1-B, the layout of CW nodes in Figure 1 can be considered.***    Figure 1 Layout of CW source for D1T1-B |
| ZTE | ***Proposal 6: For D2T2-B, the layout of CW nodes can be arranged in a (W/10)×(L/10) dimensional matrix with the row spacing and column spacing of 10m.*** |

#### Discussion (round 1)

1. **Distribution of CW nodes for scenario D1T1-B and D2T2-B:**

* **Uniform Distribution:** 
  + **FutureWei Proposal 1, OPPO Proposal 10, ZTE Proposal 6,**
* **Specific Layout Proposals:**
  + **ZTE:** Offers detailed layout proposals for CW nodes. For D1T1-B, it references a specific layout depicted in Figure 1, and for D2T2-B, it proposes a matrix arrangement with 10m spacing between nodes.



Figure 1 Layout of CW source for D1T1-B

* + **OPPO** Proposal 10: For ‘B’ scenarios, CW is located in the middle of 4 adjacent BS or intermediate UEs.
* **Company to report**
  + Qualcomm Proposal 10: Company to report including locations, density, height, etc, if any
  + Huawei Proposal 6 and 12: In D1T1/D2T2-B, the CW distribution is reported by companies.

1. **Method of dropping intermediate UE for scenario D2T2**
   * **Uniform distribution**
     + **Huawei Proposal 10:** The intermediate UEs are assumed to be deployed following uniform distribution with e.g. 10 m /20 m distance between every two adjacent intermediate UEs.
     + **OPPO Proposal 9: For D2T2, intermediate UE dropping is same as the BS in the same scenario**
     + **ZTE (Proposal 4, Alt 1)**
     + **MediaTek Proposal 12**
     + **Interdigital Proposal 5 (option 1)**
   * **Others factors**
     + **Qualcomm** (**Proposal 10**) suggested intermediate UE dropping is Density: [2] UEs in the entire hall
     + **ZTE (Proposal 4, Alt 2),** intermediate UEs are mobile and a single UE is assumed for D2T2 layout.
     + **Vivo (Observation 1),** Unlike BS reader in D1T1, the movement of UE intermediate node in the indoor area is more in line with the actual deployment.
     + **Interdigital (Proposal 5 option 2):** All devices are divided in groups (per BS). Each group is uniformly dropped within a circle of radius R around the BS, where R is determined according to coverage analysis.
2. **Devices involved in the evaluations for D2T2:**
   * **CMCC:** Requests Intermediate UE dropping and which devices are involved in the evaluations for D2T2 for coexistence evaluation in RAN4
   * **Qualcomm:** States that only devices with a long-term received power above their sensitivity are considered in the evaluations, setting a criterion for device inclusion in D2T2 evaluations.
   * **Huawei:** The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.

#### [M][Proposal-3.3.2-topology-v1]

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| **Proposal:**  For the layout used for evaluation purpose, the following is assumed,   * Uniform Distribution of CW nodes for scenario D1T1-B and D2T2-B,   + Details are reported by companies, such as CW node location * Uniform distribution of intermediate UE for scenario D1T1-B and D2T2-B,   + Details are reported by companies, such as number of intermediate UEs, inter-distance among intermediate UEs and/or intermediate UE movement. * [The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.] |

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| **Company** | **Comments** |
| Futurewei | Support with the following minor changes:   * Uniform distribution of intermediate UE for scenario D2T2~~D1T1-B and D2T2-B~~, |
| QC | The density of UE does **not** need to be high as that of BS since the scenario RAN1 evaluate for T2 is not about providing continuous coverage using UEs. For T2, the UE density does not need to be high given (1 or 2 should be good enough.) that T2 use case is more like smart home/office use case. Only one of two UEs in the entire hall should be good enough for evaluation.  The device can be uniformly distributed within a radius R from dropped UE. For T2, the smartphone user’s intention to read device makes them to be spatially correlated in smartphone user’s inventory process.  Please remove bracket.  ~~[~~The devices within the calculated maximum distance, which is obtained by the corresponding link budget calculation, from each intermediate UE will be involved in the evaluations.~~]~~ |
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### Others

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| **Company** | **Comments** |
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## Link budget

### RF-EH included in link budget evaluation

#### Related Tdoc proposals

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| China Telecom | ***Proposal 1: For coverage evaluation for device 1 and device 2, the RF-EH link is considered to be evaluated by using Buldget-Alt1.*** |
| CMCC | **Proposal 7: For device 1 coverage evaluation, RF energy harvesting with -30dBm activation threshold is considered. FFS for device 2a/2b.** |
| LGE | ***Proposal 3: Support WayFoward-RF-EH-2 or WayFoward-RF-EH-3 for coverage evaluation*** |
| Ericsson | Proposal 4 Regarding the coverage assessment of the RF EH link, our preference is WayForward-RF-EH-2: For coverage evaluation for device 1, RF-EH link is evaluated using Budget-Alt1.  • FFS: value(s) of the predefined threshold. |
| LGE | ***Proposal 6: RF-EH should be considered for link level simulation assumption*** |
| MediaTek | **Observation 9: For device 1 with EH only from RF, the link budget of reader-to-device is limited by the activation threshold of the EH circuity, i.e., a EH-limit case. While for device 2a/2b with EH from more than RF, the link budget of reader-to-device is limited by the sensitivity power of the device, i.e., a communication-limit case.** |
| MediaTek | **Proposal 9: For link budget calculation, RF-EH link should be evaluated for device 1 with Budget-Alt1 (i.e., a predefined threshold).** |
| OPPO | Proposal 1: The coverage for RF-EH link should be evaluated. |
| ZTE | ***Proposal 8: For D1T1-A1/A2 and D2T2-A2, the RF-EH link should be evaluated based on Budget-Alt1 for device 1.*** |

#### Discussion (round 1)

If RF-EH is used by AIoT devices, the coverage of RF-EH link may be bottleneck for the case when the activation/energy harvesting threshold is higher than the data reception threshold. Hence many companies express their views that RF-EH should be included in the link budget evaluation.

* **Support and Evaluate RF-EH Link**
  + China Telecom (device 1 and 2),
  + CMCC (device 1),
  + Ericsson (device 1),
  + LGE,
  + MTK (device 1),
  + OPPO,
  + ZTE (device 1)

#### [H][Proposal-3.4.1-RFEH-v1]

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| **Proposal:**  For coverage evaluation for device 1, coverage of RF-EH link is considered to be evaluated by using *Buldget-Alt1*.   * FFS: value(s) of the predefined threshold * FFS whether RF-EH link is also considered to be evaluated for device 2 by using *Buldget-Alt1* |

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| **Company** | **Comments** |
| Xiaomi | Generally OK.  But still one question about the predefined threshold for energy harvest, we think the energy harvest efficiency be considered when setting the threshold to make sure the energy harvest efficiency is not too low to support the communication operation. |
| Tejas Networks Ltd. | The predefined device activation threshold should be used as receiver sensitivity (for Device 1) to evaluate the maximum R2D coverage as the device should receive this minimum power to be activated and communicate with the reader. |
| Huawei, HiSilicon | We don’t support the proposal.  Device has energy storage. After the device stored enough energy, the device can work with communication receiver sensitivity even in case lower than energy harvesting threshold. It does not make sense to simply say energy harvesting threshold is the bottleneck. And further the energy source can be anything transmitting RF energy which not necessarily have same EIRP and location of R2D transmitter, which can also be up to implementation solutions. Thus no need to do such evaluation which is not belonging to any potential specification work.  In summary, we think the coverage should be focused on R2D and D2R. RF-EH is not included in coverage evaluation from our suggestion. |
| QC | Fine with to include RF-EH link in link budget analysis. |
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### Interference modelling

#### CW interference modelling

##### Related Tdoc proposals

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| CMCC | **Proposal 12: For CW interference modelling in coverage evaluation,**   * **For CW inside topology with ‘A2’ scenarios, CW interference can be considered in link budget calculation**   + **Obtain the remaining CW interference after CW interference cancellation from CW node by Tx power and CW cancellation capability, and calculate the minimum receiver sensitivity by taking remaining CW interference into consideration** * **For CW outside topology or CW inside topology with bistatic D2R backscatter, assuming CW has no impact to the receiver sensitivity loss.** |
| Ericsson | Observation 8 The reader's ability for CW cancellation can vary depending on whether the CW is a single-tone or multi-tone waveform.  Proposal 10 Different values for CW cancellation capability [2K] can be considered for scenarios A2 (monostatic) and A1/B (bistatic).  Proposal 11 Different values for CW cancellation capability [2K] can be considered for D1T1 and D2T2.  Proposal 12 RAN1 to discuss and determine a model for CW cancellation capability [2K] for the different scenarios (D1T1/D2T2-A1/A2/B) and CW waveforms (single-tone or multi-tone). The specific values to be used for the different parameters in the model can be up to companies to report. |
| FutureWei | ***Proposal 3: For scenarios “A1” and “B” the residual CW interference is modeled as additional noise, just as for scenarios “A2”. The only difference is to add an additional 20 dB on top of the CW cancellation capability reported for scenarios “A2”.*** |
| Huawei | ***Proposal 19: For coverage evaluation, the CW interference modeling for the ‘A1’ and ‘B’ scenarios reuses that for the ‘A2’ scenarios.*** |
| Huawei | ***Proposal 20: The candidate values for “CW cancellation” can be reported from the set of {130, 140, 150}, which can be used for all the scenarios.*** |
| Huawei | ***Proposal 21: For D2R link budget calculation, the Remaining CW interference (2K1) can be calculated by the following formula.*** |
| Huawei | ***Proposal 22: For D2R link budget calculation, the Receiver sensitivity loss (2K2) can be calculated by the following formula.*** |
| NEC | **Proposal 3: Discuss the evaluation methodology for modelling the self-interference due to the DL carrier wave transmission in receiving UL from the IoT devices for backscatter communication.** |
| Nokia | **Proposal 4: Study the impact of CW interference in scenarios A1 and B in LLS. Consider link performance with different values of signal-to-interference ratio.** |
| DOCOMO | **Proposal 10: For link budget calculation, for the CW cancellation for D2R, i.e., in row [2K] of link budget calculation table,**   * **Study how CW interference would be different for monostatic (‘A2’ scenarios) and bistatic (‘A1’ scenarios and ‘B’ scenarios)** * **Study how CW interference would be different depending on CW node isolation** * **Study how CW cancellation capability would be different for BS and UE** * **Study how CW cancellation capability would be different for CW waveform of single tome and multi-tone** * **FFS: Whether/how to consider cross-link interference of CW** |
| OPPO | [Proposal 12: CW Interference is included in link budget calculation in ‘B’ scenarios or ’A1’ scenarios, the interference is derived by CW transmit power (single tone as baseline), CW to reader distance, and CW cancellation at BB (reported by company).](#_Toc166247511) |
| OPPO | [Proposal 14: If CW node is inside topology, receiver sensitivity is calculated according to the required SINR, noise power, and CW interference. CW wave interference is NOT simulated in the LLS.](#_Toc166247513) |
| OPPO | [Proposal 18: CW interference to UL reception at BS and DL reception at UE should be studied in RAN1.](#_Toc166247517) |
| Qualcomm | **[2K] CW cancellation (dB)**   * D2R   + Monostatic (D1T1-A2, D2T2-A2)     - Companies to report   + Bistatic (D1T1-A1, D1T1-B, D2T2-A1, D2T2-B)     - Companies to report   + It depends on IC capability assumed, which could be different across companies. * CW interference cancellation   + There could be two contributors to CW interference w/ different nature; tx leakage and Rx IMD     - Tx leakage: This is the interference generated from Tx chain due to nonlinearity in Tx chain (spectral regrowth), and/or poor isolation between tx and rx. Increasing isolation reduces tx leakage to rx path. If, there is CW only in tx signal, then, it would be less affected due narrow footprint of CW. If there are CW multiplexed with other NR signal (in-band), then, tx leakage impact could be large due to non-linearity of tx chain.     - Rx IM3: This interference is generated due to non-linearity of rx path (e.g., mixer, LNA, etc). The CW and backscattered signal could generate intermodulation (IM3), interfering backscattered signal itself.   + The total CW-interference can count both tx leakage and Rx IM3.   + How to compute CW interference and CW cancellation is FFS companies to report. |
| Vivo | **Proposal 13: when calculating Receiver Sensitivity [2L], consider the receiver sensitivity loss parameter 2K2 for D2R link.**  - **2L(receiver sensitivity) = 2F(Noise power) + 2G(Required SNR) + 2K2(Receiver sensitivity loss)** |
| Vivo | **Proposal 23: Model the CW self-interference in link level simulation for the case of CW outside topology with ‘B’ scenario or CW inside topology with ’A1’ scenario.** |
| ZTE | ***Proposal 9: The following approach is used to derive receiver sensitivity in D2R link for D1T1-A1/A2/B and D2T2-A2/B.***   * ***Remaining CW interference [2K1]=CW Tx power[1E1]+ Antenna gain[1E2]－CW cancellation capability[2K]*** * ***Receiver sensitivity loss [2K2] = 10\*log10(1+10^((Remaining CW interference[2K1]－Noise Power [2F])/10))*** * ***Receiver sensitivity [2L] = Required SNR [2G] + Noise Power [2F] + Receiver sensitivity loss [2K2]*** |

##### Discussion (round 1)

In RAN1#116bis, the following is agreed,

Agreement

For coverage evaluation, subject to further discussion on which scenarios to evaluate,

* In the case of CW inside topology with ’A2’ scenarios
  + The digital baseband processing of CW self-interference handling is not modelled in link level simulation (LLS). It is included in the link budget analysis by reporting the CW cancellation capability value.
* FFS: In the case of CW outside topology with ‘B’ scenarios or CW inside topology with ’A1’ scenarios

For the contributions for this meeting, FL will address the following issues,

**1. link budget analysis or LLS**

For contributions for this meeting,

* Alt 1: Many companies ([FUTUREWEI], [Huawei], [CATT], [CMCC], [ZTE], [OPPO], [NTT DOCOMO]) think that for scenarios “A1” and “B” the residual CW interference is modelled in the link budget analysis and hence the CW interference handling is not modelled in link level simulation (LLS).
* Alt 2: [Nokia], [vivo] propose to study CW interference in scenarios A1 and B in LLS

Considering this, FL suggest to go with Alt 1.

**2. How to consider the impact of CW interference**

A value of CW cancellation capability[2K] can be reported in link budget analysis by companies (ZTE, Qualcomm, Huawei, CMCC, FutureWei). And some companies suggested that the remaining CW interference and receiver sensitivity loss can be calculated by the following formula (Huawei, ZTE, vivo),

***Receiver sensitivity [2L] = Required SNR [2G] + Noise Power [2F] + Receiver sensitivity loss [2K2]***

However, Qualcomm suggest how to compute CW interference and CW cancellation is FFS companies to report.

Considering the situation, FL suggest to agree with the above formula for computing [2K1], [2K2], [2L]

**3. How to compute CW cancellation**

* [Ericsson] consider the following approach to obtain CW cancellation capability [2K] for monostatic backscattering(scenario ‘A2’) and bistatic backscattering(scenario ‘A1’ and ‘B’)
  + A2 (monostatic): CW cancellation [2K] = Spatial isolation + RF-IC suppression + BB/IF self-interference cancellation
  + A1/B (bistatic): CW cancellation [2K] = CW2R pathloss + beam nulling + RF-IC suppression + BB/IF self-interference cancellation
* [FUTUREWEI] thinks for scenarios “A1” and “B” the residual CW interference is modelled as additional noise, just as for scenarios “A2”. [CMCC] has similar proposal.
* [Huawei] observed that the CW cancellation capability can reach around 150 dB, and recommend to report the capability from a pre-defined set of e.g. {130, 140, 150} dB.
* [OPPO] further mentioned that for D2T2, due to the limited form factor of intermediate UE, it is not feasible to support special isolation and consequently disable BB cancelation.
* [Qualcomm] CW interference cancellation
  + There could be two contributors to CW interference w/ different nature; tx leakage and Rx IMD
    - Tx leakage: This is the interference generated from Tx chain due to nonlinearity in Tx chain (spectral regrowth), and/or poor isolation between tx and rx. Increasing isolation reduces tx leakage to rx path. If, there is CW only in tx signal, then, it would be less affected due narrow footprint of CW. If there are CW multiplexed with other NR signal (in-band), then, tx leakage impact could be large due to non-linearity of tx chain.
    - Rx IM3: This interference is generated due to non-linearity of rx path (e.g., mixer, LNA, etc). The CW and backscattered signal could generate intermodulation (IM3), interfering backscattered signal itself.
  + The total CW-interference can count both tx leakage and Rx IM3.
  + How to compute CW interference and CW cancellation is FFS companies to report.

#### [H][Proposal-3.4.2.1-CWModel-v1]

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| Proposal:  For coverage evaluation,   * In the case of CW outside topology with ‘B’ scenarios or CW inside topology with ’A1’ scenarios   + The digital baseband processing of CW self-interference handling is not modelled in link level simulation (LLS). It is included in the link budget analysis by reporting the CW cancellation capability value.   + Note: ’A2’ scenarios have already been agreed. * The remaining CW interference [2K1], receiver sensitivity [2L] and receiver sensitivity loss [2K2] are computed as follows, * FFS: CW cancellation capability [2K] values, by considering the following potential issues:   + Different values for different scenarios, e.g., D1T1/D2T2, A1/A2/B   + Different values for different CW waveforms (single-tone or multi-tone)   + The feasibility study is considered to be discussed in 9.4.2.4 and/or RAN4. |

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| **Company** | **Comments** |
| Xiaomi | For the case of CW outside topology with ‘B’ scenarios or CW inside topology with ’A1’ scenarios, we think its OK not to consider CW interference.  And if we do want to model it , for remaining CW interference, the pathloss of CW between CW node and the PDRCH reader should also be considered, |
| Huawei, HiSilicon | We are supportive of FLS proposal.  In addition, we would point out since the 2K2 is defined as a negative dB in above equation, the equation in calculation of 2L should be corrected as  Or, reverse the calculation of 2K2 by exchange the numerator and denominator |
| QC | In general, for scenario A1 and B and even for other use case, how to model CW interference cancellation capability may need further discussion/understanding. |
| OPPO | Generally OK. For the calculation of receiver sensitivity loss [2K2], the above formula should be aligned with that used in FL Proposal-3.4.25-v1.   * The remaining CW interference [2K1], receiver sensitivity [2L] and receiver sensitivity loss [2K2] are computed as follows, |
| vivo | For modelling receiver sensitivity loss, our original proposal is to modelling receiver sensitivity loss due to non-linear distortion, i.e., IM3 at Rx path caused by remaining CW interference, which have investigated in receiver in RFID reader, and our detailed modelling is provided as follows,   * + - Modeling method of receiver sensitivity loss caused by IM3 can refer to R4-2304433:     - , and   While comparing with FL proposal, the difference is that we use Rx\_IM3(derived from remaining CW interference) to replace Remaining CW interference [2K1] in Receiver sensitivity loss [2K2] calculation. Given this situation, we are flexible to consider the Rx\_IM3 as the Remaining CW interference [2K1], and report an equivalent CW cancellation value which makes Rx\_IM3 equal to remaining CW interference[2K1] in [2K2] calculation.  Hence, we suggest the following revision of the FL proposal that  And Equivalent CW cancellation capability [2K] value can be reported considering different modelling methods of receiver sensitivity loss. |

#### Other interference

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| **Company** | **Proposals** |
| Nokia | Proposal 5: For R2D link budget, add an interference-to-noise (I/N) parameter to model interference. A receiver sensitivity degradation, dB, should be added to the receiver sensitivity for MPL calculation. |
| CATT | Proposal 6: Self-interference due to CW transmission and cross interference due to simultaneous transmission of multiple A-IoT devices should be considered in the modelling of D2R reception at gNB/UE. |
| NEC | Observation 3: Different stages of the logistics or inventory management operations (like unloading, gate-in inventory, gate-out inventory, check and loading) require a reader to poll a response from any IoT device within its communication range. This may lead to a reader receiving interfering UL transmissions from multiple IoT devices within its range.  Observation 4: When a reader receives interfering UL transmissions from multiple IoT devices, a successful UL reception can be considered when the reader is able to decode UL transmission from the IoT device which is closest to the reader and within the coverage of the reader’s Rx beam (i.e. IoT device which experiences lowest path loss).  Proposal 4: Study the performance of the case where a reader using backscatter communication receives interfering UL transmission from multiple IoT devices within its range.  Observation 5: For the scenarios which require deployment of large number of IoT devices (e.g. automobile manufacturing), a reader may experience high CLI in receiving UL transmission from an IoT device due to interfering DL transmission(s) from nearby reader(s)  Proposal 5: Investigate the CLI for receiving backscatter UL transmission for the scenario where a large number of IoT devices and readers are deployed within a manufacturing site. |

Some companies consider to model the multi-cell interference and NR/LTE interference in the evaluation.

* [Nokia] thinks for R2D link, co-channel interference and adjacent channel interference can be modelled as additional noise
* [CATT] thinks multi-device cross-interference should also be considered in the modelling of D2R reception at gNB/UE.
* [NEC] proposed to investigate the CLI for receiving backscatter UL transmission for the scenario where a large number of IoT devices and readers are deployed

### Pathloss model

#### Related Tdoc proposals

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| CMCC | **Proposal 9: The following pathloss model can be used in the coverage evaluation for RF-EH, R2D and D2R links**   * **For D1T1, InF-DH NLOS is used.** * **For D2T2, InF-DL NLOS is used.** * **For D2T2, InH-Office LOS is used.** * **Note: the definition of the above channel model refers to TR38.901** |
| CMCC | **Proposal 10: CW2D pathloss model is considered as follows,**   * **For D1T1-A1/A2/B and D2T2-A1/A2/B, same channel model is used for CW2D and R2D/D2R.** * **Note: the definition of the above channel model refers to TR38.901** |
| Comba | **Proposal 4:**  **For D1T1, InF-DH NLOS model defined in TR38.901 is considered as pathloss model in coverage evaluation.**  **For D2T2, InF-DL (NLOS) and InH-Office(LOS) model defined in TR38.901is used as pathloss model in coverage/coexistence evaluation.** |
| Interdigital | **Proposal 2: Coverage evaluations and link budget calculations assume both LOS/NLOS pathloss or NLOS pathloss only to account for worst-case propagation conditions.** |
| ZTE | ***Proposal 3: The pathloss model of CW2D link should be assumed for Ambient IoT evaluations.***   * ***The same pathloss model as R2D and D2R can be used for CW2D.*** |
| Huawei | Proposal 17: For D1T1-B, InF-DH NLOS channel model is used for the calculation of the path loss corresponding to the CW2D distance, with a shadow fading margin of 4 dB.  Proposal 18: For D2T2-B, InF-DL LOS or InH-Office LOS channel model can be used for the calculation of the path loss corresponding to the CW2D distance, if InF-DL or InH-Office channel model is used for R2D and D2R link, respectively. The corresponding shadow fading margin is 4 dB and 3 dB, respectively. |

#### Discussion (round 1)

**[Questions]:**

* What is the pathloss model for CW2D?
* LOS or NLOS should be assumed for CW2D?

For CW2D channel mode,

* same channel model as R2D and D2R link is considered by [Ericsson], [Tejas Networks Ltd], [Huawei], [vivo], [CMCC], [ZTE]
* For D1T1
  + InF-DH NLOS is used by: [Ericsson], [Tejas Networks Ltd], [Huawei], [vivo], [CMCC], [ZTE]
* For D2T2,
  + InF-DL NLOS is used by: [Ericsson] [Tejas Networks Ltd], [CMCC], [ZTE]
* InH-Office LOS is used by: [vivo], [ZTE]

#### [H][Proposal-3.4.3-pathloss-v1]

|  |
| --- |
| **Proposal:**   * **For CW2D pathloss model applied to the D1T1-A1/A2/B and D2T2-A1/A2/B scenarios, using the same pathloss model defined in TR38.901 as used for R2D/D2R.** |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | support |
| Tejas Networks Ltd. | support |
| QC | We are ok with proposal. |
|  |  |

### [2J] Budget-Alt 1 or 2 for device 2 @ Rx

#### Related Tdoc proposals

|  |  |
| --- | --- |
| **Source** | **Proposal** |
| Ericsson | Observation 1 The receiver sensitivity varies significantly between different Rx architectures (which is possible for Devices 2a and 2b) for the same device.  Observation 2 When Budget-Alt1 is used, it is difficult to determine the trade-offs between  Observation 3 When Budget-Alt1 is used, it is difficult to determine the trade-offs between coverage and data rate for different values of M when the OOK-M waveform is employed in the R2D link.  Proposal 3 RAN1 to clarify how to study the coverage impacts for R2D link for different values of M when employing OOK-M waveform if Budget-Alt1 is used.  Proposal 4 Regarding the coverage assessment of the RF EH link, our preference is WayForward-RF-EH-2: For coverage evaluation for device 1, RF-EH link is evaluated using Budget-Alt1.  • FFS: value(s) of the predefined threshold. |
| FUTUREWEI | Proposal 5: For Device 2a, in R2D link, the receiver sensitivity is the poorer of the receiver sensitivity of Budget-Alt1 and Budget-Alt2.  Proposal 6: For Device 2b, Both R2D and D2R links use the receiver sensitivity from Budget-Alt2.  Proposal 17: 2J: propose to use the lower sensitivity calculated from Budget-Alt1 and Budget-Alt2 for device 2a.  Proposal 19: 2L: propose to use -30 dBm Device 1 and -40 dBm for Device 2a where RF-ED is used in Budget-Alt1. |
| Huawei | Proposal 34: For Device 1, Budget-Alt1 is recommended for the evaluation of the receiver sensitivity, which is assumed to be e.g. -36 dBm.  Proposal 35: For Device 2 with RF-ED receiver, Budget-Alt1 is recommended for the evaluation of the receiver sensitivity, which is assumed to be e.g. -46 dBm.  Proposal 36: For Device 2 with IF-ED or ZIF receiver, Budget-Alt2 is recommended for the evaluation of the receiver sensitivity, which can be calculated based on a noise figure of 24 dB or [30] dB. |
| Samsung | Observation 8. In the case of Device 2, depending on the transmission scheme and SFO assumptions used in R2D transmission, either Budget-Alt1 or Budget-Alt2 can determine the coverage.s or adverse effects on the human body.  Proposal 12. For Device 2, the receiver sensitivity should be calculated and compared based on both Budget-Alt1 and Budget-Alt2. |
| CATT | Proposal 18: Budget-Alt 1 should be used in the coverage evaluation for R2D link for Device 2. The definition of activation/energy harvesting threshold should be clarified. |
| CMCC | Proposal 8: For coverage evaluation,   * For R2D link, Budget-Alt1 is used to obtain receiver sensitivity at least for device 1 and device 2a, and further discuss device 2b. * For RF-EH, Budget-Alt1 is used for devices with energy harvesting from RF. |
| ZTE | Proposal 7: For device 2a and 2b, Budget-Alt1 is used for R2D link in the coverage evaluation. |
| OPPO | Proposal 2: Budget-Alt1 should be used for the coverage evaluation for RF-EH, -25~-30dBm can be considered in this evaluation.  Proposal 3: Budget-Alt1 should be used for device 2a and 2b with RF envelope, -45dBm/-30dBm should be considered as the threshold for device with/without LNA.  Proposal 4: Budget-Alt2 should be used for device 2b with IF or zero-IF detector. |
| MediaTe | Proposal 8: For the coverage evaluation of device 2a/2b, prefer Budget-Alt2 to reflect the relation between the data rate and coverage. |
| Qualcomm | [2J] Budget-Alt1/Budget-Alt2   * R2D   + For device 1 and 2, RF-ED receiver, use Budget-Alt1.   + For device 2b, IF or ZIF receiver, use Budget-Alt2. * D2R   + Budget-Alt2 |
| Sony | Proposal 1: Consider Alt-1 as the approach in R2D link budget analysis for type-2a devices. |

#### Discussion (round 1)

During the RAN1#116bis, budget-Alt 1 RF-ED is agreed for device 1.

Agreement

For R2D link in the coverage evaluation, for device 1

* *Budget-Alt1* is used (note: receiver architecture is RF ED)

For D2R link in the coverage evaluation,

* *Budget-Alt2* is used.

Form the contributions, the following can be observed,

* **For device 2a with RF-ED**
  + ***Budget-Alt1*:** [Ericsson], [Nokia], [Huawei](RF ED), [Spreadtrum](RF ED), [vivo](RF ED), [CATT], [CMCC](RF ED), [Sony], [ZTE], [xiaomi], [OPPO](RF ED), [InterDigital, Inc.], [Qualcomm](RF ED), [IIT Kanpur, IITM]
  + ***Budget-Alt2*:** [Ericsson], [MediaTek], [Comba]
    - [Ericsson], [MediaTek] observed if use *Budget-Alt1*, it is difficult to determine the trade-offs between coverage and data rate for different values of M when the OOK-M waveform is employed in the R2D link. And RAN1 needs to clarify how to study the coverage impacts if *Budget-Alt1*is used.
  + Poorer receiver sensitivity of *Budget-Alt1* and *Budget-Alt1*: [FUTUREWEI]
* **For device 2a with IF/ZIF-ED**
  + - ***Budget-Alt1***: [Huawei](IF-ED/ZIF)
* **For device 2b**
  + - *Budget-Alt1* can be used: [Ericsson], [Nokia], [Huawei](RF ED), [CATT], [ZTE], [xiaomi], [OPPO](RF ED), [InterDigital, Inc.]
    - *Budget-Alt2* can be used: [Ericsson], [FUTUREWEI], [Huawei](IF-ED/ZIF), [Spreadtrum](if RF ED not used), [OPPO](IF/ZIF), [MediaTek], [Qualcomm](IF/ZIF), [Comba]

#### [H][Proposal-3.4.4-BudgetAlt-v1]

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| **Proposals:**   * For R2D link in the coverage evaluation for device 2,   + *Budget-Alt1* is used if receiver architecture is RF ED is used   + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED is used * Note: this does not preclude to have LLS for device 1 and 2 R2D link with RF-ED if needed. |

|  |  |
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| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | support |
| Tejas Networks Ltd. | Support |
| QC | Ok  Need to better understand intention behind this Note. |
|  |  |

### [1E] Total Tx Power @ Tx

#### Related Tdoc Proposals

|  |  |
| --- | --- |
| **Source** | **Observations/proposals** |
| Ericsson | Observation 7 For scenarios ‘B’, it is important to clarify if the CWT is moving or fixed in the known location (similar to BSs). For the moving CWT the distance of the few meters can be considered as CW2D distance  Proposal 5 To ensure comparability of D2R coverage results across different companies, RAN1 to agree on a common assumption for the distance between the CWT and the A-IoT device. |
| FUTUREWEI | Proposal 4: For scenario “B” where the CW node is outside of the topology and provides power coverage for the devices, the device’s transmit power is the activation level of the device. The CW2D distance is the maximal coverage distance of the CW node.  Proposal 8: 1E: for device 1/2a, use D2R-CWRxPower-Alt. For device 2b, use -20 dBm. |
| Tejas Networks Ltd. | Proposal 1: The maximum achievable distance between CW transmitter and Device should be decided based on the Device activation threshold, which is considered as the read sensitivity or receiver sensitivity for PRDCH and CW2D reception. Considering a fixed CW2D distance for CW inside topology limits the coverage between Reader and Device as the Reader and CWT are collocated. |
| Nokia | Observation 2: For Devices 1 & 2a in D2R link, item 1E of the link budget table should be “received CW power” at the device.  Proposal 6: Add “Received CW power for devices 1/2a” to the description of item 1E in the link budget table, as well as the calculation of 1E.  Proposal 7: Evaluate D2R coverage for backscattering Devices 1 and 2a in two cases. A pessimistic case when the received CW power at the device barely reaches the device’s activation threshold. A optimistic case where the CW source is in close proximity to the device. |
| Huawei | Proposal 26: In the D2R link budget calculation, different assumptions of the Total Tx power [1E] is used for different devices.   * For Device 1: CW received power [1E5] - Ambient IoT backscatter loss [1H]. * For Device 2a: CW received power [1E5] + Ambient IoT backscatter amplifier gain [1K]. * For Device 2b: -20 dBm [M], -10 dBm [O]   Proposal 27: The CW received power [1E5] is calculated as  CW received power [1E5] = CW Tx power [1E1] + CW Tx antenna gain [1E2] - CW2D pathloss [1E4]  Proposal 28: Candidates of CW Tx power [1E1] reuses the assumptions of Total Tx power [1E] in R2D. |
| Qualcomm | * Balanced MPL calculation * Since D2R link computation assumes device tx power at sensitivity level. Thus, this could potentially make D2R link be bottleneck link (i.e., R2D distance > D2R distance). * In balanced MPL/distance calculation, half of sum MPL (L = (R2D MPL + D2R MPL)/2) is calculated first. Then, mid point rx power L between Reader EIRP and Reader D2R sensitivity is computed; R = Reader EIRP – L. * K = max(R, dev sensitivity - device ant gain + dev mod loss + cable loss) * This allows shorter link to increase and longer link to decrease making them be balanced. * In monostatic case, balanced MPL maximizes min(R2D MPL, D2R MPL). * For bistatic case, it depends on CW transmitter location. |
| Spreadtrum | Proposal 7: For CW outside topology, the Tx power of device can be calculated by Tx power of CW and the distance between emitter and device. For CW inside topology, how to determine the Tx power of the device for CW inside topology should be further studied. |
| CMCC | |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + 33dBm(M), ~~FFS:~~ 38dBm(O), ~~one smaller value [FFS: 23 or~~ 26~~]~~ dBm(M)   + ~~FFS: additional constraints on PSD~~ * ~~FFS: For UE in DL spectrum for indoor~~ * For UL spectrum for indoor,   + 23dBm (M)   + FFS: 26dBm(O)   ~~Other values are NOT precluded subject to future discussion.~~ | * For device 1/2a:   + For scenarios ‘A1’ and ‘A2’,     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.   + For scenarios ‘B’,     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors. * For device 2b:   + D2R-dev2bTxPower-Alt1: -20 dBm(M)   + D2R-dev2bTxPower-Alt2: -10 dBm(O)   + ~~Other values are NOT precluded subject to future discussion.~~ |   For R2D,   * Firstly, transmission by the UE within the downlink spectrum should be avoided, given the current limitations imposed by the legacy design from coexistence aspects. * Secondly, companies are debating whether to impose specific PSD limitations, as the PSD of A-IoT devices is not anticipated to exceed that of NR significantly.   + However, at least for reader that are not co-located deployed with NR gNB, no PSD limitation should be imposed. When reader and NR gNB are transmitted and shared by one PA, 26 dBm can be considered such that it will not exceed that of NR significantly. |

#### Discussion (round 1)

The proposals are summarized as follows,

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + 33dBm(M), FFS: 38dBm(O), one smaller value [FFS: 23 or 26] dBm(M)   + FFS: additional constraints on PSD * FFS: For UE in DL spectrum for indoor * For UL spectrum for indoor,   + 23dBm (M)   + FFS: 26dBm(O)   Other valuesare NOT precluded subject to future discussion. | * For device 1/2a:   + D2R-CWRxPower-Alt1:     - Company to report CW Tx/Rx power together with CW2D distance (see [1E1]~[1E5])   + D2R-CWRxPower-Alt2:     - Balanced MPL/distance (see [1E1]~[1E5], ~~and subject to [1E3] = = [4B])~~ * For device 2b:   + D2R-dev2bTxPower-Alt1: -10 dBm(O)   + D2R-dev2bTxPower-Alt2: -20 dBm(M)   + Other values are NOT precluded subject to future discussion. | For R2D   * For BS   + 23dBm: [Lenovo](UL), [InterDigital, Inc.](UL), [NTT DOCOMO]   + 24dBm: [Qualcomm]   + 26dBm: [Huawei], [ZTE](UL)   + 33dBm: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [Sony], [ZTE], [OPPO], [Lenovo], [NTT DOCOMO], [MediaTek], [Comba], [IIT Kanpur, IITM]   + 38dBm: [Huawei]   + Additional constraints on PSD     - [NTT DOCOMO] think constraints on PSD should be applied at least for smaller total Tx power of BS, such as[20 or 24] dBm/MHz * For UE,   + 23dBm: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [Sony], [OPPO], [Lenovo], [InterDigital, Inc.], [NTT DOCOMO], [MediaTek], [Comba], [IIT Kanpur, IITM]   + 26dBm(O): [Huawei], [ZTE], [MediaTek]   For D2R   * For device 2b:   + -10 dBm: [Tejas Networks Ltd], [CMCC], [ZTE], [OPPO], [Lenovo], [InterDigital, Inc.], [MediaTek]   + -20 dBm: [Ericsson], [FUTUREWEI], [Huawei], [Spreadtrum], [vivo], [CMCC], [ZTE], [OPPO], [Comba] * For device 1/2a:   + Companies view refer to Section 3.4.3   + [Huawei] consider the Total Tx power is decided based on CW received power [1E5] and Ambient IoT backscatter loss[1H] / Ambient IoT backscatter amplifier gain [1K]     - For Device 1: [1E5] - [1H].     - For Device 2a: [1E5] + [1K]. |

**Total Tx Power (dBm) for R2D**

For R2D

* For BS
  + 23dBm: [Lenovo](UL), [InterDigital, Inc.](UL), [NTT DOCOMO]
  + 24dBm: [Qualcomm]
  + 26dBm: [Huawei], [ZTE](UL)
  + 33dBm: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [Sony], [ZTE], [OPPO], [Lenovo], [NTT DOCOMO], [MediaTek], [Comba], [IIT Kanpur, IITM]
  + 38dBm: [Huawei]
  + Additional constraints on PSD
    - [NTT DOCOMO] think constraints on PSD should be applied at least for smaller total Tx power of BS, such as[20 or 24] dBm/MHz
* For UE,
  + 23dBm: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [Sony], [OPPO], [Lenovo], [InterDigital, Inc.], [NTT DOCOMO], [MediaTek], [Comba], [IIT Kanpur, IITM]
  + 26dBm(O): [Huawei], [ZTE], [MediaTek]

For the PSD restriction,

* [NTT DOCOMO] think constraints on PSD should be applied at least for smaller total Tx power of BS, such as[20 or 24] dBm/MHz.
* [CMCC] thinks at least for reader that are not co-located deployed with NR gNB, no PSD limitation should be imposed. When reader and NR gNB are transmitted and shared by one PA, 26 dBm can be considered such that it will not exceed that of NR significantly.

**Total Tx Power (dBm) for D2R**

In RAN1#116bis, the following is agreed,

Agreement

For coverage evaluation purpose,

* For scenarios ‘A1’ and ‘A2’,
  + The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.
* For scenarios ‘B’,
  + The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value.
    - FFS: CW2D distance (m) value(s)

From the contributions, the followings are observed,

For scenarios ‘A1’ and ‘A2’,

* [1E]-D2R-Alt1: The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.
  + For scenarios ‘A1’ and ‘A2’, [Tejas Networks Ltd.], [ZTE] consider Alt-1 for device 2a;
  + For scenarios ‘A1’ and ‘A2’, [FUTUREWEI], [CMCC]consider Alt-1 for device 1/2a
  + [OPPO] uses Alt-1 for device 1/2a in scenarios ‘A1’, ‘A2’, ‘B’.
  + Some revisions are proposed as follows,

For scenarios ‘B’,

* [1E]-D2R-Alt2: The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value.
  + [Ericsson], [CATT], [Huawei] consider to use Alt-2 for scenarios ‘A1’, ‘A2’, ‘B’, and [Ericsson] propose to agree on a common assumption for the distance of CW2D.
  + [Spreadtrum], [InterDigital, Inc.], [CMCC], [Qualcomm] consider to use Alt-2 for device 1/2a for scenarios ‘B’
  + [Tejas Networks Ltd.], [ZTE] consider Alt-2 for device 2a in scenarios ‘B’
  + [Nokia] consider an optimistic case where CW node is close to device (e.g., 1m or 2m)

Other suggestions,

* The activation threshold of the device could be used as the device Tx power and the maximal CW2D distance is decided based on the activation threshold
  + [FUTUREWEI] For scenarios ‘B’
  + [Tejas Networks Ltd.], [ZTE] For device 1
  + [Nokia] consider this as a pessimistic case for evaluation
  + [InterDigital, Inc.] use this for scenarios ‘A1’, ‘A2’
* Balanced MPL calculation is used to determine device Tx power
  + [Qualcomm] consider this for monostatic case

#### [H][Proposal-3.4.5-TxPower-v1]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1E] as follows,  *<Editor’s Note: With change mark>*   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + [1E]-R2D-Alt1: 33dBm(M),   + [1E]-R2D-Alt2: ~~FFS:~~ 38dBm(O), ~~one smaller value [FFS: 23 or~~ 26~~]~~ dBm(M)   + ~~FFS: additional constraints on PSD~~ * ~~FFS: For UE in DL spectrum for indoor~~   + [1E]-R2D-Alt3:     - FFS: [20 or 24] dBm/MHz is used if PSD constraints are imposed (company to report the condition for applying PSD constraints in Row [xxx]: Other notes) * For UL spectrum for indoor,   + [1E]-R2D-Alt4:23dBm (M)   + [1E]-R2D-Alt5:~~FFS:~~ 26dBm(O)   ~~Other values are NOT precluded subject to future discussion.~~ | * ~~For device 1/2a:~~   + ~~D2R-CWRxPower-Alt1:~~     - ~~Company to report CW Tx/Rx power together with CW2D distance (see [1E1]~[1E5])~~   + ~~D2R-CWRxPower-Alt2:~~     - ~~Balanced MPL/distance (see [1E1]~[1E5], and subject to [1E3] = = [4B])~~ * ~~For device 2b:~~   + ~~D2R-dev2bTxPower-Alt1: -10 dBm(O)~~   + ~~D2R-dev2bTxPower-Alt2: -20 dBm(M)~~ * For device 1/2a:   + [1E]-D2R-Alt1: (For scenarios ‘B’)     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.   + [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For device 2b: (For scenarios ‘C’)   + [1E]-D2R-Alt3: -20 dBm(M)   + [1E]-D2R-Alt4: -10 dBm(O)   + ~~Other values are NOT precluded subject to future discussion.~~ |   *<Editor’s Note: Clean version without change mark>*   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + [1E]-R2D-Alt1: 33dBm(M),   + [1E]-R2D-Alt2: 38dBm(O),   + [1E]-R2D-Alt3:     - FFS: [20 or 24] dBm/MHz is used if PSD constraints are imposed (company to report the condition for applying PSD constraints in Row [xxx]: Other notes) * For UL spectrum for indoor,   + [1E]-R2D-Alt4: 23dBm (M)   + [1E]-R2D-Alt5: 26dBm(O) | * For device 1/2a:   + [1E]-D2R-Alt1: (For scenarios ‘B’)     - The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value and other related factors.   + [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’)     - The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For device 2b: (For scenarios ‘C’)   + [1E]-D2R-Alt3: -20 dBm(M)   + [1E]-D2R-Alt4: -10 dBm(O) | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | support |
| Tejas Networks Ltd. | For Device 1, the Device Tx power should be the device activation threshold. The CW2D distance should be computed accordingly. |
| OPPO | [1E]-D2R-Alt1: (For scenarios ‘B’): The distribution of CW nodes for scenarios ‘B’ is still open to discuss, if CW nodes have fixed location in scenarios ‘B’ as BS/Intermediate UE, the Device Tx Power can be also calculated by assuming CW2D pathloss = D2R pathloss.  [1E]-D2R-Alt2: (For scenarios ‘A1’ and ‘A2’): Based on assuming CW2D pathloss = D2R pathloss, the following formulas for calculating this item can be captured in note 1:  For device 1:  [1E] = ([1E1] + [1E2] + [1H] + FFS: [1J] – [2C] + [2L]) \* 0.5  For device 2a:  [1E] = ([1E1] + [1E2] + [1H] + FFS: [1J] – [1K] – [2C] + [2L]) \* 0.5 |
|  |  |
|  |  |

### [0C] Center frequency

#### Discussion (round 1)

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| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) | * 900MHz: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [Apple], [CMCC], [ZTE], [xiaomi], [OPPO], [Lenovo], [InterDigital, Inc.], [MediaTek], [IIT Kanpur, IITM] * 700-900MHz: [Comba] * 2GHz (O): [xiaomi] |

#### [H][Proposal-3.4.6-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [0C] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [0C] | Center frequency (MHz) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | support |
| Wiliot | We support adding 2GHz for the evaluations. |
| Tejas Networks Ltd. | We support the FL and evaluation of 900MHz is mandatory and 2GHz is optional for company. |
| QC | ok |

### [0D] Topology

#### Discussion (round 1)

Add an item to report which pathloss model is used for link budget calculation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [0D] | Topology/Pathloss model | InF-DH NLOS | InF-DL NLOS / InH-Office LOS | [CMCC] propose to add one item of ‘Topology[0D]’ for companies to report the cannel model used for link budget calculation.  [MediaTek] also adds a content of ‘Pathloss model’ to indicate the pathloss model used for link budget.  For R2D   * InF-DH NLOS: [Ericsson], [Tejas Networks Ltd], [Nokia], [Huawei], [Apple], [CMCC], [Sony], [ZTE], [xiaomi], [InterDigital, Inc.], [MediaTek]   For D2R   * InF-DL NLOS: [Ericsson], [Tejas Networks Ltd], [Apple], [CMCC], [Sony], [ZTE], [xiaomi], [InterDigital, Inc.] * InH-Office LOS: [Nokia], [Apple], [Sony], [ZTE] |

#### [H][Proposal-3.4.7-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Add Row [0D] in the link budget table as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [0D] | Topology/Pathloss model | InF-DH NLOS | [0D]-D2R-Alt1: InF-DL NLOS  [0D]-D2R-Alt2: InH-Office LOS | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | We think the proposal is a little conflicted with previous agreement  Agreement  For D1T1,   * InF-DH NLOS model defined in TR38.901 is used for D2R and R2D links as pathloss model in coverage evaluation.   For D2T2,   * InF-DL and InH-Office model defined in TR38.901is used as pathloss model in coverage evaluation,   + NLOS for D2R and R2D links if InF-DL is used   + LOS for D2R and R2D links if InH-Office is used |
| QC | In general, fine. Remove topology in “~~Topology/~~Pathloss model” |
|  |  |
|  |  |
|  |  |

### [1E1] CW Tx Power @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1E1] | CW Tx power (dBm) | N/A | * 23dBm for UL spectrum, FFS 26dBm * 33dBm(M), 38dBm (O) for DL spectrum   Note: only applicable for device 1/2a | * 23dBm for UL spectrum: [Ericsson], [FUTUREWEI], [Huawei], [Spreadtrum], [vivo](D2T2), [CMCC], [ZTE], [OPPO], [InterDigital, Inc.], [NTT DOCOMO], [Qualcomm], [Comba] * 26dBm for UL spectrum: [FUTUREWEI](scenario’B’), [Qualcomm] * 33dBm(M) for DL spectrum: [Ericsson], [Spreadtrum], [vivo](D1T1), [CMCC], [ZTE], [OPPO], [NTT DOCOMO], [MediaTek], [Qualcomm], [Comba] * 38dBm (O) for DL spectrum: [vivo], [Qualcomm] * Note: only applicable for device 1/2a |

#### [H][Proposal-3.4.8-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1E1] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E1] | CW Tx power (dBm) | N/A | For scenario ‘A1’ and ‘A2’,   * Report same or different assumption as [1E]. If it is different, report the value   For scenario ‘B’,   * Report same or different assumption as [1E]. If it is different, report the value   Note: only applicable for device 1/2a | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Generally OK. |
| Huawei, HiSilicon | We would like to clarify our understanding the intention of the proposal is candidates of CW Tx power [1E1] reuses the candidates assumption of Total Tx power [1E] in R2D.  With this assumption, the value used for CW in one link budget calculation can be different to the value used in R2D according to scenario cases. E.g. R2D transmitting in DL with 33dBm, while CW is transmitting in UL with 23dBm, but all the values are come from same candidates set defined in 1E for R2D.  Whether FLS proposal allows to report other value beyond candidates defined in 1E for R2D should be clarified. |
| QC | ok |
|  |  |
|  |  |

### [1E3] CW2D distance @ Tx

#### Discussion (round 1)

In RAN1#116bis,

Agreement

For coverage evaluation purpose,

* For scenarios ‘A1’ and ‘A2’,
  + The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.
* For scenarios ‘B’,
  + The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value.
    - FFS: CW2D distance (m) value(s)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1E3] | CW2D distance (m) | N/A | * For D2R-CWRxPower-Alt1:   + [Company to report] * For D2R-CWRxPower-Alt2:   + Calculated   Note: only applicable for device 1/2a | For D2R   * For D1T1-A1/A2   + 14m: [Ericsson] * For D1T1-B   + 5m: [Ericsson], [Tejas Networks Ltd]   + 10m: [Spreadtrum], [CMCC], [xiaomi](UL spectrum), [InterDigital, Inc.]   + 15m: [vivo]   + 20m: [xiaomi](DL spectrum)   + 27m: [Huawei](device 1)   + 50m: [Huawei](device 2a) * For D2T2-A1/A2   + 5m: [Ericsson] * For D2T2-B   + 5m: [Ericsson], [vivo]   + 10m: [Spreadtrum], [CMCC], [xiaomi](UL spectrum), [InterDigital, Inc.]   + 20m: [xiaomi](DL spectrum) |

Besides, several companies [Ericsson][vivo] pointed out if the CW node is moving, then the CW can be close to the device. Ericsson proposed several meters for instance.

#### [H][Proposal-3.4.9-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1E3] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1E3] | CW2D distance (m) | N/A | For [1E]-D2R-Alt1:   * + D1T1-B:     - 10m,     - 20m,   + D2T2-B:     - 5m,     - 10m,   + FFS other values   For [1E]-D2R-Alt2:   * + Calculated (see note 1)   Note: only applicable for device 1/2a | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Generally OK. One question, all the distance candidates are mandatory? |
| Tejas Networks Ltd. | The maximum achievable distance between CW transmitter and Device should be decided based on the Device activation threshold (for device 1), which is considered as the read sensitivity or receiver sensitivity for PRDCH and CW2D reception. Considering a fixed CW2D distance for CW inside topology limits the coverage between Reader and Device as the Reader and CWT are collocated.  For Device 2a, we propose to choose an optimal distance for CW2D for a fixed transmit power from the base station (R) such that the similar distance can be achieved for PDRCH. This method gives a balanced MPL/distance between R/R1/R2 and D which is optimal. |
| Huawei, HiSilicon | This is not OK for us.  For D1T1-B, we would like to add the followings to reflect the case outside CW node is deployed at same location of Reader as a candidate, thus the assumption of Alt 2 can be reused for this case to report.  For [1E]-D2R-Alt1:   * + D1T1-B:     - 10m,     - 20m,     - CW2D pathloss = D2R pathloss |
| QC | In general, it looks ok. We hope to keep numbers in bracket [x]. Since if CW transmitter and device are too far, there is no point of using outside CW transmitter, and if they are too close, then, it is less likely to have such situation happens. |
|  |  |

### [1F] Transmission Bandwidth used for the evaluated channel @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180k(M),  360k(O),  1.08MHz(O) | UL data rate: xx bps  FFS: data rate for each case | For R2D   * 180kHz: [Ericsson], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [OPPO], [InterDigital, Inc.], [MediaTek], [IIT Kanpur, IITM]   For D2R   * 180kHz: [Tejas Networks Ltd], [Huawei](O), [LG Electronics], [InterDigital, Inc.], [Qualcomm](for SSB) * 15kHz: [Huawei](M), [xiaomi], [OPPO], [MediaTek], [Qualcomm](for SSB) * 180\*2kHz: [Qualcomm](for DSB) * 15\*2kHz: [Qualcomm](for DSB) * Omit the part: [CMCC]   [vivo] propose to report {data rate, line code scheme, number of CW tones} for the D2R transmission, instead of reporting a BW value for [1F].  [CMCC] thinks whether and how Tx side transmission bandwidth for D2R in the link budget calculation is not clear. |

It is related to the link-level simulation assumptions for D2R transmission bandwidth. Please see section 3.5.7

#### [H][Proposal-3.4.10-v1]

*<Editor’s Note: will be updated after discussion in section 3.5.7 finished.>*

### [1G] Tx antenna gain @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | * For A-IoT device, 0dBi (M), -3dBi (O) | * For A-IoT device   + 0dBi: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Huawei], [Spreadtrum], [vivo], [CMCC], [Sony], [ZTE], [OPPO], [Lenovo], [InterDigital, Inc.], [Qualcomm], [Comba]   + -3 dBi: [Qualcomm](O) |

Considering majority supports of 0dB, FL suggest to only consider 0dB for D2R

#### [H][Proposal-3.4.11-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1G] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | For A-IoT device, 0dBi ~~(M), -3dBi (O)~~ | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | Is “2dBi” also mandatory besides 6dBi for BS indoor? Or it is a typo and should be “optional”?  Generally OK with the proposal. |
| QC | -3dBi is realistic value. |
|  |  |
|  |  |

### [1H] Ambient IoT backscatter loss @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | * N/A | * OOK: Y dB * PSK: X dB   Note: Only for device 1   * FFS: for device 2a | For OOK   * 2dB: [Samsung] (if Option 1 for CINR/CNR definition) * 6dB for OOK: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Huawei], [Spreadtrum], [CMCC], [ZTE], [xiaomi], [OPPO], [InterDigital, Inc.], [Qualcomm], [Comba], [IIT Kanpur, IITM] * 8dB for OOK: [Samsung], [vivo] * 3~10dB: [MediaTek]   For PSK   * 0 dB for BPSK: [Huawei], [Spreadtrum], [CMCC], [Qualcomm], [Comba] * 2dB: [Samsung] * 3dB: [OPPO] * 0~3dB: [MediaTek] * [Tejas Networks Ltd] also consider additional 6dB backscatter loss besides modulation factor   The backscatter loss is used   * for device 1: [Huawei], [Nokia], [Spreadtrum], [Tejas Networks Ltd.](backscatter loss), [xiaomi] * for device 1 and 2a: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd.](modulation factor), [vivo], [CATT], [CMCC], [ZTE], [InterDigital, Inc.] |

#### [H][Proposal-3.4.12-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1H] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | * N/A | * OOK: 6 dB * PSK: 0 dB   ~~Note: Only for device 1~~  ~~FFS: for device 2a~~  It is applicable for device 1 and 2a | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | For “PSK: 0 dB” we doubt very much, the energy efficiency for backscattering a signal can achieve 100%? |
| QC | Ok. |
|  |  |
|  |  |

### [1J] Ambient IoT on-object antenna penalty @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1J] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | For R2D   * 0.9dB-cardbord sheet: [Spreadtrum], [Sony], [Lenovo], [MediaTek], [IIT Kanpur, IITM] * 4.7dB: [Lenovo] * 10.4dB-Aluminium slab: [Sony], [Lenovo]   For D2R   * 0.9dB: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Spreadtrum], [ZTE], [Lenovo], [InterDigital, Inc.], [Comba], [IIT Kanpur, IITM] * 4.7dB: [Lenovo] * 10.4dB: [Lenovo] * Removed by: [Huawei], [CMCC], [MediaTek]   + Proper antenna design of devices can ensure the appropriate antenna gain |

* Most companies think 0.9dB for evaluation is a reasonable choice.
* Two companies [Lenovo][Sony] wants to study 4.7-10.4dB when device is close to Aluminium slab.
* Two companies [Huawei][CMCC] think this row can be removed. And [MediaTek] thinks proper antenna design of devices can ensure the appropriate antenna gain.

#### [H][Proposal-3.4.13-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Remove Row [1H] in the link budget table.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | ~~[1J]~~ | ~~FFS: Ambient IoT on-object antenna penalty~~ | * ~~0.9dB or 10.4~~ | ~~0.9dB or 10.4~~ | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| QC | In reality, device could be placed on various material. So, it would be good to have a model to capture different materials like cardboard (0.9dB) or aluminium-slab (10.4dB).  We prefer to keep this row.  R2D is N/A.  D2R is 0.9dB or 10.4dB |
|  |  |
|  |  |

### [1N] Cable, connector, combiner, body losses, etc @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1N] | FFS: Cable, connector, combiner, body losses, etc. (dB) | FFS | N/A | For BS,   * 0 dB: [Huawei], [Samsung], [MediaTek] * 1dB: [IIT Kanpur, IITM] * 3dB: [OPPO], [Lenovo], [InterDigital, Inc.]   For intermediate UE   * 0dB: [Samsung] * 1dB: [Huawei], [IIT Kanpur, IITM] * 3dB: [OPPO], [Lenovo], [InterDigital, Inc.]   For AIoT deivce   * 0 dB: [Huawei](M) * 1dB: [Huawei](O), [InterDigital, Inc.]   Removed by: [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [CMCC], [Xiaomi] |

#### [H][Proposal-3.4.14-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1N] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1N] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | For BS, 0 dB  For intermediate UE, 3 dB | N/A | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| QC | For both BS and UE, we suggest using 1dB.  It is not clear why how 0dB is justified for BS.  In other SI/WIs, we see that 1dB is used at UE side.  At BS side 3dB is used. But, given that this BS is smaller micro-BS, we can consider using 1dB. |
|  |  |
|  |  |
|  |  |

### [1M] EIRP @ Tx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [1M] | EIRP (dBm) | Calculated  FFS: any limitation of the EIRP subject to future discussion | Calculated | * For RF-EH/R2D,   + [1M]=[1E]+[1G]: [Ericsson], [Tejas Networks Ltd.], [Nokia], [Spreadtrum], [Samsung], [CMCC], [Sony], [ZTE], [xiaomi]   + [1M]=[1E]+[1G]-[1J]- [1N]: [Lenovo] * For D2R of Device 1,   + [1M]= [1E5]+[1G]-[1H]-[1J]: [Ericsson]   + [1M]= [1E]+[1G]-[1H]-[1J]: [Nokia], [ZTE], [xiaomi], [Lenovo]   + [1M]= [1E]+[1G]-[1H]: [vivo], [CMCC] * For D2R of Device 2a,   + [1M]= [1E5]+[1G]-[1H]-[1J]+[1K]: [Ericsson]   + [1M]= [1E]+[1G]-[1H]-[1J]+[1K]: [FUTUREWEI], [Spreadtrum], [ZTE], [Lenovo]   + [1M]= [1E]+[1G] -[1J]+[1K]: [Nokia], [xiaomi]   + [1M]= [1E]+[1G]-[1H]+[1K]: [vivo], [CMCC] * For D2R of Device 2b,   + [1M]=[1E]+[1G]-[1J]: [Ericsson], [xiaomi], [Lenovo]   + [1M]=[1E]+[1G]: [CMCC], [ZTE] * EIRP constraints   + [Samsung] mentioned that high EIRP may cause signal leakage issue or adverse effects on the human body, and restrictions such as (1) setting a maximum limit for EIRP, (2) PSD limitation, need to be applied   + [NTT DOCOMO] suggests limiting the max EIRP as [35]dBm for R2D |

#### [H][Proposal-3.4.15-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1M] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1M] | EIRP (dBm) | Calculated (see Note 1)  FFS: any limitation of the EIRP subject to future discussion | Calculated (see Note 1) |   Note 1:  …  [1M]:   * For R2D,   + [1M] = [1E] + [1G] - FFS:[1N] - FFS: [1J] * For D2R   + Device 1:     - [1M] = [1E] + [1G] - FFS:[1H] - FFS:[1J]   + Device 2a:     - [1M] = [1E] + [1G] + [1K] - FFS:[1H] - FFS:[1J]   + Device 2b:     - [1M] = [1E] + [1G] - FFS:[1J]   … |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | OK |
| Tejas Networks Ltd. | Support |
| QC | For R2D, Connection/cable loss [1N] needs to be considered.  For D2R, Reflection loss (1H) needs to be included for device 1/2a. |
|  |  |
|  |  |

### [2B] Bandwidth used for the evaluated channel @ Rx

#### Discussion (round 1)

Noise and interference power is calculated based on [2B] or [2B1],

* For R2D
  + Singal bandwidth is determined by transmission bandwidth
  + Noise and interference power for RFED/IF receiver is ED bandwidth.
  + Noise and interference power for ZIF receiver is the same as transmission bandwidth.
* For D2R
* Singal bandwidth is determined by transmission bandwidth or occupied bandwidth (i.e., transmission bandwidth plus potential guard band)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2B] | Bandwidth used for the evaluated channel (Hz) | FFS: relation with the transmission bandwidth used for the evaluated channel | * FFS: whether the values are single side-band or double side-band * Note: The value is used for calculating the noise power   FFS: relation with the transmission bandwidth used for the evaluated channel | For R2D   * 180kHz: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [Huawei], [Spreadtrum], [CMCC], [Lenovo], [InterDigital, Inc.], [MediaTek], [Comba], [IIT Kanpur, IITM] * 5MHz: [Nokia] * 10MHz: [OPPO]   For D2R   * 180kHz: [FUTUREWEI], [Tejas Networks Ltd], [Lenovo], [InterDigital, Inc.] * 15kHz+2\*1.5kHz: [Huawei] * 15kHz: [Spreadtrum], [CMCC], [MediaTek], [Comba] * 10MHz: [ZTE] * 4RB: [xiaomi] * 18kHz: [OPPO] * Need to clarify the assumption on SSB/DSB   + [CMCC](DSB is considered), [NTT DOCOMO] |

Since the related parameters are already included in the LLS table, it is preferred to refer to that.

#### [H][Proposal-3.4.16-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2B] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2B] | Bandwidth used for the evaluated channel (Hz) | Refer to LLS assumptions, BB LPF BW is reported. | Refer to LLS assumptions, [receiver bandwidth?] is reported.  - Note: The value is used for calculating the noise power | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | How is R2D 2B is used in link budget analysis? |
|  |  |
|  |  |
|  |  |
|  |  |

### [2B1] RF CBW @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2B1] | FFS: RF CBW (Hz) | FFS:   * 10MHz * 20MHz * Other values   Note: The value is used for calculating the noise power | N/A | For R2D   * 10MHz: [Ericsson], [OPPO](w RF filter), [MediaTek], [IIT Kanpur, IITM] * 20MHz: [FUTUREWEI], [Samsung], [vivo], [OPPO](wo RF filter) * [Ericsson] consider the [2B1] to calculate noise power for R2D and D2R * [FUTUREWEI] consider the [2B1] to calculate noise power for R2D * [CMCC] think the item should be ‘ED channel BW’ for R2D to calculate noise power and refers to LLS assumption. * Removed by: [Huawei], [DOCOMO]   + Values captured in [2B] are used for calculating noise power |

Since the related parameters are already included in the LLS table, it is preferred to refer to that.

#### [H][Proposal-3.4.17-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2B1] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2B1] | ED bandwidth~~FFS: RF CBW~~ (Hz) | * Refer to LLS assumptions [1b] ED bandwidth for R2D and company reports this value.   Note: The value is used for calculating the noise power | N/A | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei, HiSilicon | We prefer to remove [2B1], since ED BW will not be used for coverage Budget Alt-1. We are fine to discuss ED-BW in LLS. |
|  |  |
|  |  |
|  |  |
|  |  |

### [2X] Cable, connector, combiner, body losses, etc.@Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2X] | FFS: Cable, connector, combiner, body losses, etc. (dB) | * N/A | * FFS | * For BS   + 0 dB: [Huawei], [Samsung], [MediaTek]   + 1dB: [IIT Kanpur, IITM]   + 3dB: [OPPO], [InterDigital, Inc.], [Lenovo] * For intermediate UE   + 1dB: [Huawei]   + 3 dB: [OPPO], [Lenovo] * For AIoT devices   + 0 dB: [Huawei](M)   + 1dB: [Huawei](O), [InterDigital, Inc.], [IIT Kanpur, IITM]   Removed by: [FUTUREWEI], [Tejas Networks Ltd], [Nokia], [CMCC] |

#### [H][Proposal-3.4.18-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [1N] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [1N] | ~~FFS:~~ Cable, connector, combiner, body losses, etc. (dB) | N/A | For BS, 0 dB  For intermediate UE, 3 dB | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| QC | We recommend to use 1dB for both BS and UE.  It is not clear how 0dB for BS could be justified and 3dB is used for UE. |
|  |  |
|  |  |
|  |  |

### [2D] Receiver Noise Figure @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2D] | Receiver Noise Figure (dB) | FFS: 20dB or 24dB or 30dB for *Budget-Alt2*   * FFS: different values for device architecture | For BS as reader   * 5dB   For UE as reader   * 7dB | For R2D   * As report in Table 7.1.1a-1, Table 7.1.1a-2, and Table 7.1.1a-3 in TR 38.869: [Ericsson] * 20dB: [FUTUREWEI], [vivo], [Lenovo](device 1), [InterDigital, Inc.], [MediaTek] * 24dB: [Huawei], [Comba] * 30dB: [Spreadtrum], [Lenovo](device 2) * 77.2dB: [Samsung] |

As suggested by Ericsson, the following is copy and pasted,

* As report in Table 7.1.1a-1, Table 7.1.1a-2, and Table 7.1.1a-3 in TR 38.869: [Ericsson]

**Table 7.1.1a-1 Relative power consumption and noise figure for OOK-1/2/4 with RF envelope detection**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source reference | [7A-1] | [7A-2] | [7A-3] | [7A-4] | [7A-5] | [7A-6] |
| Power consumption  (ON state) | 0.05 for single-branch, 0.01 for each additional branch | 0.01 | 0.01~0.1 | 0.01 | 0.01~0.1 | 0.05~0.2 |
| Noise figure (dB) | 20 | 17~22 | [12-18] | 20 | 15 | 20 |

**Table 7.1.1a-2 Relative power consumption and noise figure for OOK-1/2/4 with heterodyne architecture with IF envelope detection**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source reference | [7A-1] | [7A-2] | [7A-3] | [7A-4] | [7A-5] | [7A-6] |
| Power consumption  (ON state) | 0.1 for single-branch, 0.01 for each additional branch | 0.5 | 0.1~1 | 0.1 | 0.1~1 | 1~4 |
| Noise figure (dB) | 15 | 10~15 | [9-15] | 15 | 12 | 12~15 |

**Table 7.1.1a-3 Relative power consumption and noise figure for OOK-1/2/4 with homodyne/zero-IF architecture with baseband envelope detection**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Source reference | [7A-1] | [7A-2] | [7A-3] | [7A-4] | [7A-5] | [7A-6] | [7A-7] | [7A-8] | [7A-9] | [7A-10] |
| Power consumption  (ON state) | 0.09 for single-branch, 0.01 or 0.02 for each additional branch | 0.5 | 0.1~1 | 0.1 | 0.05~  0.5 | 0.5~1 | 0.1~0.5 | 4 | ~1 | 0.1~0.5 |
| Noise figure (dB) | 15 | 10~15 | [10-16] | 15 | 12 | 15 | 12~15 | 15 | ~15 | 12 |

#### [H][Proposal-3.4.19-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2D] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2D] | Receiver Noise Figure (dB) | For RF-ED receiver   * 24dB?, 30dB?, Device 1 * 20dB, Device 2   For IF/ZIF receiver   * 15dB, Device 2 | For BS as reader   * 5dB   For UE as reader  7dB | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok, but the Noise Figure may not be needed for Device 1 because it uses a predefined activation level. |
| QC | This needs more discussion for RF-ED NF values. |
| OPPO | Receiver Noise Figure [2D] is used to calculate the noise power for Budget-Alt 2 in coverage evaluation. For RF-ED receiver, Budget-Alt 1 is agreed for device 1 in coverage evaluation during RAN1 #116bis, and Budget-Alt 1 is also proposed to be used for device 2 if receiver architecture is RF ED in FL Proposal-3.4.4-BudgetAlt-v1. In our understanding, it is not necessary to determine a value for RF-ED receiver as the value will not be used for coverage evaluation.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2D] | Receiver Noise Figure (dB) | ~~For RF-ED receiver~~   * ~~24dB?, 30dB?, Device 1~~ * ~~20dB, Device 2~~   For IF/ZIF receiver   * 15dB, Device 2 | For BS as reader   * 5dB   For UE as reader  7dB | |
|  |  |
|  |  |

### [2F] Noise Power @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2F] | Noise Power (dBm) | * Calculated | * Calculated | For R2D   * [2F]=[2D]+[2E]+*lin2dB*([2B]): [Spreadtrum], [Samsung] * [2F]=[2D]+[2E]+*lin2dB*([2B1]): [FUTUREWEI]   For D2R   * [2F]=[2D]+[2E]+*lin2dB*([2B]): [Tejas Networks Ltd.], [Spreadtrum], [CMCC], [ZTE], [xiaomi], [Lenovo] * [2F]=[2D]+[2E]+*lin2dB*([2B1]): [Ericsson] |

#### [H][Proposal-3.4.20-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2F] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2F] | Noise Power (dBm) | Calculated (see Note 1) | Calculated (see Note 1) |   Note 1:  …  [2F]:   * For R2D,   + [2F] = [2D] + [2E] +*lin2dB*([2B1]) or [2F] = [2D] + [2E] +*lin2dB*([2B]) * For D2R   + [2F] = [2D] + [2E] +*lin2dB*([2B]) |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | OK |
|  |  |
|  |  |
|  |  |
|  |  |

### [2G] Required SNR/CNR @ Rx

#### Discussion (round 1)

Agreement

For the R2D LLS for ED, report followings (as start point).

* CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and~~/or~~ interference (if any) power spectral density in the device ED channel bandwidth
* signal transmission bandwidth
* ED channel bandwidth

FFS: exact definition of ED channel bandwidth for RF-ED, IF receiver

FFS: which and how to report for R2D ZIF receiver and D2R

*Please see section 3.5.8 for detailed information this meeting.*

#### [H][Proposal-3.4.21-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Remove Row [2G] in the link budget table.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2G] | Required SNR/CNR | Reported by company | Reported by company | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | How is SNR different from CNR? |
|  |  |
|  |  |
|  |  |
|  |  |

### [2H] Ambient IoT on-object antenna penalty @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2H] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | For R2D   * 0.9dB: [Ericsson], [Spreadtrum], [ZTE], [InterDigital, Inc.], [Qualcomm], [IIT Kanpur, IITM] * 10.4: [Qualcomm]   For D2R   * 0.9dB: [Ericsson], [Spreadtrum], [Qualcomm], [ZTE], [Lenovo] * 10.4: [Qualcomm]   Removed by: [Huawei], [vivo], [CMCC] |

* Most companies think 0.9dB for evaluation is a reasonable choice.
* One companies [Qualcomm] wants to study10.4dB when device is close to Aluminium slab.
* Two companies [Huawei][CMCC][vivo] think this row can be removed.

#### [H][Proposal-3.4.22-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Remove Row [2H] in the link budget table.   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | ~~[2H]~~ | ~~FFS: Ambient IoT on-object antenna penalty~~ | * ~~0.9dB or 10.4~~ | ~~0.9dB or 10.4~~ | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| QC | We prefer to include this item. |
|  |  |
|  |  |

### [2K] CW cancellation @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2K] | CW cancellation (dB) | N/A | For [monostatic backscatter], FFS   * [140dB for BS] * [120dB for UE]   For [bistatic backscatter]  Assuming CW has no impact to the receiver sensitivity loss. | For D1T1-A2   * 140dB: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [CMCC], [ZTE], [OPPO], [InterDigital, Inc.], [MediaTek] * 120dB: [IIT Kanpur, IITM] * 83dB: [vivo], exclude BB   For D2T2-A2   * 120dB: [Ericsson], [FUTUREWEI], [Tejas Networks Ltd], [CMCC], [ZTE], [InterDigital, Inc.] * 66dB: [vivo], exclude BB   For D1T1-A1/B   * No impact of CW interference: [Ericsson], [Tejas Networks Ltd], [CMCC] * 160dB: [FUTUREWEI] * 150dB: [OPPO](D1T1-A1) * 145dB: [OPPO](D1T1-B) * 140dB: [Huawei], [InterDigital, Inc.], [IIT Kanpur, IITM] * 88dB: [vivo], exclude BB   For D2T2-A1/B   * No impact of CW interference: [Ericsson], [CMCC] * 140dB: [FUTUREWEI] * 120dB: [InterDigital, Inc.] * 100dB: [OPPO](for D2T2-A1) * 95dB: [OPPO](for D2T2-B) * 72dB: [vivo], exclude BB   [vivo] thinks the [2K] should not include digital BB suppression |

Please section 3.4.2.1 for CW interference modelling considerations. In this section, the CW cancellation values are observed.

#### [H][Proposal-3.4.23-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2K] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2K] | CW cancellation (dB) | N/A | For scenario A2,   * 140dB for BS * 120dB for intermediate UE   For scenario A1/B,   * {140dB , 150dB, 160dB, Ideal } for BS * {95dB?, 100dB?, 120dB, 140dB, Ideal } for intermediate UE   It is up to companies to report which value are used in the evaluation.  Note:   * ‘Ideal’ implies that the evaluation does not account for the impact of CW interference on receiver sensitivity * Only applicable for device 1/2a | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | For scenario A1/B, we prefer not to consider CW Interference. That is “ideal” for BS and intermediate UE. |
| QC | This requires further study. |
| OPPO | In FL Proposal-3.4.2.1-CWModel-v1, the CW cancellation modelling is also considered for ‘A1’ scenarios and ‘B’ scenarios, so ‘Ideal’ should be removed from the candidate values. |
|  |  |
|  |  |

### [2K1] Remaining CW interference @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2K1] | Remaining CW interference (dB) | * N/A | Calculated | For scenarios ‘A2’ D2R  [2K1]=[1E1]+[1E2]-[2K]: [Ericsson], [Huawei], [CMCC], [ZTE] |

#### [H][Proposal-3.4.24-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2K1] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2K1] | Remaining CW interference (dB) | N/A | Calculated (see Note 1)  Note: only applicable for device 1/2a |   Note 1:  …  [2K1]:   * [2K1] = [1E1] + [1E2] - [2K] |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | Generally OK |
|  |  |
|  |  |
|  |  |
|  |  |

### [2K2] Receiver sensitivity loss @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2K2] | Receiver sensitivity loss(dB) | * N/A | Calculated | * [Huawei] calculate the receiver sensitivity loss by[2K2]= *lin2dB*(*dB2lin* ([2F])/(*dB2lin*([2F])+*dB2lin*([2K1]) )) * [vivo] proposed the receiver sensitivity loss is determined by carrier wave power leakage into LNA and parameter of LNA, and the same calculation as R18 SBFD can be used.   + D1T1-A2: 10.82 dB   + D1T1-B: 1.31 dB   + D2T2-A2: 17.52 dB   + D2T2-B: 2.74 dB   [ZTE], [OPPO] calculate the receiver sensitivity loss by[2K2]= 10\*log10(1+10^(( [2K1]－ [2F])/10)) |

The proposed formula from Huawei and ZTE/OPPO seems to be the same

#### [H][Proposal-3.4.25-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2K2] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated (see Note 1)  Note: only applicable for device 1/2a |   Note 1:  …  [2K2]: |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | The formular should be [2K2]= *lin2dB*(*dB2lin* ([2F])/(*dB2lin*([2F])+*dB2lin*([2K1]) )) |
| Tejas Networks Ltd. | Support |
|  |  |
|  |  |
|  |  |

### [2L] Receiver Sensitivity @ Rx

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + FFS:{-30dBm ~ -36dBm} * For device 2 if RF-ED is used   + FFS * For device 2 if RF-ED is not used   + N/A   For Budget-Alt2,   * Calculated | Calculated  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used | For Budget-Alt1, receiver sensitivity can be determined respectively for different device types and architecture   * For device 1 ,   + -40~-45: [Ericsson]   + -40: [Ericsson]   + -36: [Huawei], [CMCC], [InterDigital, Inc.]   + -35: [Spreadtrum], [ZTE], [MediaTek],   + -30: [FUTUREWEI], [Samsung], [vivo], [Apple], [Sony], [xiaomi], [OPPO], [Lenovo], [IIT Kanpur, IITM]   + -25dBm: [Nokia]   + -20: [Tejas Networks Ltd] * For device 2a if RF-ED is used   + -36dBm: [Sony]   + -40~-35: [Qualcomm]   + -40~-45: [Ericsson] (wo LNA)   + -40: [Ericsson] (wo LNA), [FUTUREWEI], [Samsung], [Lenovo]   + -45: [Nokia], [Spreadtrum], [vivo], [CMCC], [xiaomi], [OPPO], [InterDigital, Inc.]   + -46: [Huawei]   + -47: [ZTE]   + -50~-55: [Ericsson](w LNA)   + -50: [Ericsson](w LNA), [IIT Kanpur, IITM]   + -55: [Tejas Networks Ltd] * For device 2 if RF-ED is not used   + -80~-85: [Ericsson](ZIF)   + -80: [Ericsson](ZIF)   + -90~-95: [Ericsson](Low-IF)   + -90: [Ericsson](Low-IF) * For device 2b   + -85: [Tejas Networks Ltd]   + -55: [ZTE], [Lenovo]   + -45dBm: [Nokia], [CMCC](RF ED), [xiaomi], [OPPO](RF ED), [InterDigital, Inc.]   + -40dBm: [Samsung] * For RF-EH   + -30: [CMCC](device 1), [InterDigital, Inc.](device 1), [Comba](device 1)   + -25~-30: [OPPO]   For Budget-Alt2,   * For R2D   + [2L]=[2F]+[2G]: [Samsung], [xiaomi] * For D2R of scenarios ‘A1’ and ‘B’   + [2L]=[2F]+[2G]: [Spreadtrum], [CMCC] * For D2R of scenarios ‘A2’   + Add dB to the receiver sensitivity: [Ericsson], [Nokia]   + [2L]=*lin2dB*(*dB2lin*([2K1])+*dB2lin*([2F]))+[2G]: [CMCC] * For D2R of device 1 /2a   + [2L]=[2F]+[2G]-[2K2]: [Huawei]   + [2L]=[2F]+[2G]+[2K2]: [vivo], [ZTE]   + [2L] = [2G] + dB2lin(lin2dB([2F]) + [2K1])): [Lenovo] * For D2R of device 2b   + [2L]=[2F]+[2G]: [ZTE], [Lenovo] |

#### [H][Proposal-3.4.26-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [2L] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + {-30dBm, -36dBm, -40dBm} * For device 2 if RF-ED is used   + {-40dBm, -45dBm} * For device 2 if RF-ED is not used   + *<Editor’s note: need to decide which budget-alt is used first.>* * For RF-EH,   + -30dBm   + *<Editor’s note: Depending on the discussion in 3.4.1.>*   For Budget-Alt2,   * Calculated (see note1) | Calculated (see note1)  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |   Note 1:  …  [2L]:   * For R2D and *Budget-Alt2*,   + [2L] = [2G] + [2F] * For D2R,   + [2L] = [2G] + [2F] + [2K2] , device 1/2a   + [2L] = [2G] + [2F], device 2b |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | Generally OK. But all the listed candidate values are mandatory? |
| QC | Please put all the numbers in the bracket. |
| OPPO | Since [2K2] is defined as a positive dB in above proposal, the formula for calculating [2L] should be corrected as:   * For D2R,   + [2L] = [2G] + [2F] ~~-~~ [2K2] , device 1/2a   + [2L] = [2G] + [2F], device 2b |
|  |  |

### [3A] Shadow fading margin

#### Discussion (round 1)

The shadow fading std for each pathloss model defined in TR38.901 can be assumed

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | * + TBD | * + TBD | * For D1T1   + 4dB: [FUTURWEI], [Tejas Networks Ltd], [Nokia], [Huawei], [Spreadtrum], [Samsung], [vivo], [CMCC], [ZTE], [xiaomi], [OPPO], [InterDigital, Inc.], [MediaTek], [Qualcomm], [IIT Kanpur, IITM]   + 4.8dB: [Ericsson] * For D2T2   + 3dB(InH-LOS): [Nokia], [Samsung], [ZTE], [OPPO]   + 7.2dB(InF-DL-NLOS): [FUTUREWEI], [Spreadtrum], [Samsung], [vivo], [CMCC], [xiaomi], [IIT Kanpur, IITM]   + 8 dB: [Ericsson] |

#### [H][Proposal-3.4.27-v1]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposals:**  Update the link budget table Row [3A] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | 4dB | 3dB for InH-LOS  7.2dB for InF-DL-NLOS | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| QC | ok |
|  |  |
|  |  |

### [3C] BS selection/macro-diversity gain

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [3C] | BS selection/macro-diversity gain (dB) | 0 dB  FFS: other values are not precluded | 0 dB  FFS: other values are not precluded | For R2D   * 6dB: [CMCC](RH-EH in D1T1) |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Xiaomi | OK |
| QC | 0dB |
|  |  |
|  |  |
|  |  |

### [4A] MPL

#### Discussion (round 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Company views** |
| [4A] | MPL (dB) | Calculated | Calculated | * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]: [vivo](scenarios ‘A1’, ‘B’), [Nokia], [Spreadtrum], [CMCC], [ZTE], [xiaomi],[Lenovo] * For scenarios ‘A2’   + For device 1,     - [4A]=([1E1]+[1E2]-[1H]+ [2C]-[2L]-[3A]-[3B]+[3C]+[3D])/2: [vivo]     - [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H]):[xiaomi]   + For device2a:     - [4A]=([1E1]+[1E2]-[1H]+[1K]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D])/2: [vivo]     - [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K]): [xiaomi] |

#### [H][Proposal-3.4.29-v1]

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| **Proposals:**  Update the link budget table Row [3A] as follows,   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [4A] | MPL (dB) | Calculated (see note 1) | Calculated (see note 1) |   Note 1:  …  [4A]:   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] |

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| **Company** | **Comments** |
| Xiaomi | To align with last meeting agreement, we propose the following,   * + For scenario B/C, [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]   + For scenario A1/A2,     - For device 1, [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H])     - For device 2a, [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K])   Last meeting agreement:  Agreement  For coverage evaluation purpose,   * For scenarios ‘A1’ and ‘A2’,   + The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For scenarios ‘B’,   + The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value.     - FFS: CW2D distance (m) value(s) |
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### Overall Link budget template

#### Related Tdoc Proposals

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| CATT | **Proposal 4: The impact of different modulation schemes on the coverage performance should be reflected in the link budget template.** |
| CATT | **Proposal 5: The power loss related to backscattering should be taken into account in the modelling of A-IoT D2R signal transmission for Device 2a.** |
| CATT | **Proposal 6: Self-interference due to CW transmission and cross interference due to simultaneous transmission of multiple A-IoT devices should be considered in the modelling of D2R reception at gNB/UE.** |
| CATT | **Proposal 9: The direct-link interference should be reflected in link budget analysis by similar approach as self-interference, without specific LLS modelling.** |
| CATT | **Proposal 13: The transmission power of carrier wave should be determined based on the assumption that the carrier wave is transmitted in UL spectrum.** |
| CATT | **Proposal 17: For the “Total Tx Power” in the link budget template, D2R-CWRxPower-Alt1 should be used.** |
| CATT | **Proposal 18: Budget-Alt 1 should be used in the coverage evaluation for R2D link for Device 2. The definition of activation/energy harvesting threshold should be clarified.** |
| CATT | **Proposal 19: The item “Ambient IoT backscatter loss” in the link budget template should be considered for both Device 1 and Device 2a.** |
| China Telecom | ***Proposal 2: Support to add 2GHz as an optional carrier frequency configuration in the simulation assumptions.*** |
| China Telecom | Proposal XX:   |  |  |  |  | | --- | --- | --- | --- | | **Parameters** | | **Assumptions** | **Our assumptions** | | **Common parameters** | | |  | | Carrier frequency | | 900 MHz (M); 2 GHz (O) | 900 MHz, 2 GHz | | SCS | | 15 kHz as baseline | 15kHz | | Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies | Preamble+data+CRC | | Channel model | | TDL-A or TDL-D | TDL-A | | Delay spread | | [30, 150] ns | 30ns | | Device velocity | | 3 km/h | 3km/h | | Number of Tx/Rx chains for Ambient IoT device | | 1 | 1 | | BS | Number of antenna elements | 2 or 4 | 2 | | Number of TXRUs | 2 or 4 | 2 | | Intermediate UE | Number of antenna elements | 1 or 2 | - | | Number of TXRUs | 1 or 2 | - | | Reference data rate | | [0.1, 1, 5] kbps | 7kbps | | BLER target | | 1%, 10% | 1% | | Sampling frequency | | Note: this will be updated according to the agreements made for sampling frequency | 1.92MHz | | Other assumptions | | To be reported by company | - | | **R2D specific parameters** | | |  | | Device 1/2a/2b | | Options are as follows,  - Device 1, RF-ED  - Device 2a, RF-ED  - Device 2b, RF-ED/IF-ED/ZIF  Note: will be updated according to agreements from 9.4.1.2 | Device 1 | | Transmission bandwidth (w.r.t. D2R data rate) | | 180 kHz as baseline | 180KHz | | FFS: ED bandwidth | | [X MHz] | 10MHz | | FFS: BB LPF | | [X]-order Butterworth filter with cutoff frequency at [Y] kHz | 5-order Butterworth filter with cutoff frequency at 180 kHz | | Message size | | [FFS: 16, 32,64, 400 bits] | 16 bits | | Waveform | | OOK waveform generated by OFDM modulator | OOK waveform | | Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol | OOK-4, 1 chip per OFDM symbol | | Line code | | Companies to report, e.g., Manchester encoding, PIE | Manchester | | FEC | | No FEC as baseline | NO | | ADC bit width | | 1-bit for device 1, 4-bit for device 2 | 1 bit | | Detection/decoding method for Line code | | Companies to report | Count the sampling point | | Other assumptions | | To be reported by company | Ideal assumption | | **Require SINR/SNR or Required CINR/CNR** | | |  | | Required SINR/SNR or Required CINR/CNR | | Note: Required SINR/SNR or required CINR/CNR according to BLER target | Required CNR | |
| CMCC | **Proposal 7: For device 1 coverage evaluation, RF energy harvesting with -30dBm activation threshold is considered. FFS for device 2a/2b.** |
| CMCC | **Proposal 11: Add one item of “Topology [0D]” into the link budget template, and the topology for D2T2 can be reported by companies. Corresponding channel model used for link budget calculation is referred to each topology as agreed in RAN1#116bis.** |
| CMCC | **Proposal 13: the following tables are considered for link budget calculation,**  **Table 2.5-1 Link budget template**  **<skip>** |
| CMCC | **Proposal 14: The items listed in link budget template can be calculated respectively as below，**  **EIRP([1M])**   * For RF-EH and R2D, [1M]=[1E]+[1G] * For D2R of Device 1, [1M]= [1E]+[1G]-[1H] * For D2R of Device 2a, [1M]= [1E]+[1G]-[1H]+[1K] * For D2R of Device 2b, [1M]=[1E]+[1G]   **Noise Power ([2F])**   * [2F]=[2D]+[2E]+*lin2dB*([2B])   **Remaining CW interference ([2K1])**   * For D2R of scenario ‘A2’, [2K1]=[1E1]+[1E2]-[2K]   **Receiver Sensitivity ([2L])**   * For D2R of scenarios ‘A1’ and ‘B’, [2L]=[2F]+[2G] * For D2R of scenarios ‘A2’, [2L]=*lin2dB*(*dB2lin*([2K1])+*dB2lin*([2F]))+[2G]   **MPL ([4A])**   * [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D] |
| Ericsson | [Proposal 1 RAN1 to clarify the device Rx architecture to be assumed for R2D coverage evaluation for Devices 2a and 2b.](#_Toc166256565) |
| Ericsson | [Proposal 5 To ensure comparability of D2R coverage results across different companies, RAN1 to agree on a common assumption for the distance between the CWT and the A-IoT device.](#_Toc166256570) |
| FutureWei | ***Proposal 4: For scenario “B” where the CW node is outside of the topology and provides power coverage for the devices, the device’s transmit power is the activation level of the device. The CW2D distance is the maximal coverage distance of the CW node.*** |
| FutureWei | ***Proposal 9: 1E1: CW Tx Power can go up to 26 dBm in UL in “B” scenarios, i.e. scenarios with CW node outside of topology.*** |
| FutureWei | ***Proposal 10: 1F: companies report UL data rates.*** |
| FutureWei | ***Proposal 11: 1G: propose to use only 0 dB.*** |
| FutureWei | ***Proposal 12: 1H: applies for both Device 1 and Device 2a.*** |
| FutureWei | ***Proposal 13: include Item 1H in Item 1M calculation of Device 2a, i.e.***  Device type 2(backscatter): |
| FutureWei | ***Proposal 14: remove Item 1L in Item 1M calculation of Device 1 / 2a and Device 2b*** |
| FutureWei | ***Proposal 15: For RF envelope-based devices, due to the lack of narrow band RF filter at the frontend, the bandwidth to calculate noise power should be at least the system bandwidth, denoted by Item 2B1, for R2D links.*** |
| FutureWei | ***Proposal 16: propose to use 20MHz for RFCBW.*** |
| FutureWei | ***Proposal 17: 2J: propose to use the lower sensitivity calculated from Budget-Alt1 and Budget-Alt2 for device 2a.*** |
| FutureWei | ***Proposal 18: 2K: propose to use 140dB for BS and 120dB for intermediate UE in Scenarios “A2”. For Scenarios “A1” or “B” add 20 dB on top of values used in monostatic backscattering.*** |
| FutureWei | ***Proposal 19: 2L: propose to use -30 dBm Device 1 and -40 dBm for Device 2a where RF-ED is used in Budget-Alt1.*** |
| FutureWei | ***Proposal 20: For coverage of Deployment D1T1-A, adopt the evaluation assumptions listed in Table 4 for Device 1 and Device2a Ambient IoT devices.*** |
| FutureWei | ***Proposal 21: For coverage of Deployment D1T1-B, adopt the evaluation assumptions listed in Table 5 for Device 1 and Device2a Ambient IoT devices.*** |
| FutureWei | ***Proposal 22: For coverage of Deployment D1T1-C, adopt the evaluation assumptions listed in Table 6 for Device 1 and Device 2a Ambient IoT devices.*** |
| FutureWei | ***Proposal 23: For coverage of Deployment D2T2-A, D2T2-B and D2T2-C, adopt the evaluation assumptions listed in Tables 7-9 for Device 1, Device 2a and Device2b Ambient IoT devices.*** |
| Huawei | ***Proposal 13: Remove the “Ambient IoT on-object antenna penalty” in the row of [1J] and [2H] in the link budget template.*** |
| Huawei | ***Proposal 14: Include the “Cable, connector, combiner, body losses, etc.” in the row of [1N] and [2X] in the link budget template, with the follow assumptions.***   * ***For indoor basestation, it is set to 0 dB.*** * ***For intermediate UE, it is set to 1 dB.*** * ***For Ambient IoT device, it is set to 0 dB (M) with 1 dB (O).*** |
| Huawei | ***Proposal 15: Remove the “RF CBW” in the row of [2B1] in the link budget template.*** |
| Huawei | ***Proposal 16: The shadow fading margin in row [3A] corresponding to the InF-DH NLOS, InF-DL NLOS, and InH-Office LOS channel model can be set to 4 dB, 7.2 dB, and 3 dB, respectively.*** |
| Huawei | ***Proposal 17: For D1T1-B, InF-DH NLOS channel model is used for the calculation of the path loss corresponding to the CW2D distance, with a shadow fading margin of 4 dB.*** |
| Huawei | ***Proposal 18: For D2T2-B, InF-DL LOS or InH-Office LOS channel model can be used for the calculation of the path loss corresponding to the CW2D distance, if InF-DL or InH-Office channel model is used for R2D and D2R link, respectively. The corresponding shadow fading margin is 4 dB and 3 dB, respectively.*** |
| Huawei | ***Proposal 20: The candidate values for “CW cancellation” can be reported from the set of {130, 140, 150}, which can be used for all the scenarios.*** |
| Huawei | ***Proposal 23: For D2R link budget calculation, the Receiver Sensitivity (2L) can be calculated by the following formula.*** |
| Huawei | ***Proposal 24: The transmit power of an indoor Ambient IoT BS is assumed to be 33 dBm (M), 26 dBm (M), and 38 dBm (O).*** |
| Huawei | ***Proposal 25: The transmit power of an intermediate UE in D2T2 is assumed to be 23 dBm (M) and 26 dBm (O).*** |
| Huawei | ***Proposal 26: In the D2R link budget calculation, different assumptions of the Total Tx power [1E] is used for different devices.***   * ***For Device 1: CW received power [1E5] - Ambient IoT backscatter loss [1H].*** * ***For Device 2a: CW received power [1E5] + Ambient IoT backscatter amplifier gain [1K].*** * ***For Device 2b: -20 dBm [M], -10 dBm [O]*** |
| Huawei | ***Proposal 27: The CW received power [1E5] is calculated as***  ***CW received power [1E5] = CW Tx power [1E1] +*** ***CW Tx antenna gain [1E2] - CW2D pathloss [1E4]*** |
| Huawei | ***Proposal 28: Candidates of CW Tx power [1E1] reuses the assumptions of Total Tx power [1E] in R2D.*** |
| Huawei | ***Proposal 29: The reflection loss of Device 1 is assumed to be -6 dB or 0 dB for OOK or BPSK, respectively.*** |
| Huawei | ***Proposal 30: Data rate can be reported together with the transmission bandwidth used for the evaluated D2R channel.*** |
| Huawei | ***Proposal 31: The D2R transmission bandwidth used for the evaluated channel is assumed to be 15 kHz (M) or 180 kHz (O).*** |
| Huawei | ***Proposal 32: The reception bandwidth used for the evaluated channel is assumed to be set as follows.***   * ***For R2D link, the reception bandwidth equals the transmission bandwidth used for the evaluated channel*** * ***For D2R link, the reception bandwidth equals the occupied bandwidth used for the evaluated channel*** |
| Huawei | ***Proposal 33: The antenna gain of Ambient IoT device is assumed to be 0 dBi.*** |
| IITK, IITM | **Proposal 1: Ambient IoT on-object antenna penalty should be considered at least for device type 1/2a, whether the object is cardboard or aluminum sheet.** |
| IITK, IITM | **Proposal 2: For the D2R link (device-1/2a/2b), cable, connector, combiner, body losses, etc., should be considered at least 1dB.** |
| IITK, IITM | **Proposal 3: For the evaluation performance metric for device type 2, the link budget of the R2D link should be calculated using budget Alt1.** |
| IITK, IITM | **Proposal 4: For the D2R communication link, 140dB CW interference mitigation capability should be considered when BS is a reader.** |
| IITK, IITM | **Proposal 5: For the D2R communication link, 120dB CW interference mitigation capability should be considered when UE is a reader.** |
| Lenovo | ***Proposal 14: Consider higher transmit power in the UL spectrum for the fixed ceiling mounted node*** |
| Lenovo | ***Proposal 15: For the evaluation of Ambient IoT, consider the following parameters.***   * ***Modulation factor for D2R link: 1, 0.5, 0.25*** * ***On-object penalty for R2D and D2R links: 0.9dB, 4.7 dB, 10.4dB*** * ***Fading margin: 3dB for Emitter to device, 7dB for R2D and D2R*** * ***Cable loss: 3dB*** |
| Lenovo | ***Proposal 16: For the evaluation of Ambient IoT, consider BS station sensitivity according to the BLER target and the corresponding SINR of D2R communication link.*** |
| Lenovo | ***Proposal 17: For R2D consider on-object penalty and cable loss for calculating the link budget.***  -[1J]- [1N] |
| Lenovo | ***Proposal 18: For D2R consider backscattering loss and remaining interference at BS for device 1 and device 2a.***   * Device 1: * Device 2a: * Device 2b: * 2F: * For device 1, device 2a [2L] = [2G] + *dB2lin*(([2F]) + [2K1])) * For device 2b [2*L*] = [2*G*] + [2*F*] |
| Lenovo | ***Proposal 19: Consider an emitter to device distance of >5m for coverage evaluation of Ambient IoT device type 1, >10m for device type 2a*** |
| MediaTek | **Table 3. View on the FFS and highlighted part in the link budget template agreed in RAN1 #116b [4]**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **MTK View** | | **(0) System configuration** | | | |  | | [0A] | Scenarios | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C |  | | [0A1] | CW case | N/A | 1-1/1-2/1-4/2-2/2-3/2-4 |  | | [0B] | Device 1/2a/2b | Device 1/2a/2b | Device 1/2a/2b |  | | [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) |  | | **(1) Transmitter** | | | |  | | [1D] | Number of Tx antenna elements / TxRU/ Tx chains modelled in LLS | For BS:  - 2(M) or 4(O) antenna elements for 0.9 GHz  For Intermediate UE:  - 1(M) or 2(O) | 1 |  | | [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + 33dBm(M), FFS: 38dBm(O), one smaller value [FFS: 23 or 26] dBm(M)   + FFS: additional constraints on PSD * FFS: For UE in DL spectrum for indoor * For UL spectrum for indoor,   + 23dBm (M)   + FFS: 26dBm(O)   Other valuesare NOT precluded subject to future discussion. | * For device 1/2a:   + D2R-CWRxPower-Alt1:     - Company to report CW Tx/Rx power together with CW2D distance (see [1E1]~[1E5])   + D2R-CWRxPower-Alt2:     - Balanced MPL/distance (see [1E1]~[1E5], ~~and subject to [1E3] = = [4B])~~ * For device 2b:   + D2R-dev2bTxPower-Alt1: -10 dBm(O)   + D2R-dev2bTxPower-Alt2: -20 dBm(M)   Other values are NOT precluded subject to future discussion. | R2D  1)FFS: For UE in DL spectrum for indoor (if supported): 23dBm and 26dBm based on TS 38.101  D2R  1)Highlighted part  1.1) For device 1/2a: OK  1.2) For device 2b: Both -10dBm and -20dBm are mandatory | | [1E1] | CW Tx power (dBm) | N/A | * 23dBm for UL spectrum, FFS 26dBm * 33dBm(M), 38dBm (O) for DL spectrum   Note: only applicable for device 1/2a | OK | | [1E2] | CW Tx antenna gain (dBi) | N/A | * Company to report, the value equals to   + UE Tx ant gain, or   + BS Tx ant gain   Note: only applicable for device 1/2a |  | | [1E3] | CW2D distance (m) | N/A | * For D2R-CWRxPower-Alt1:   + [Company to report] * For D2R-CWRxPower-Alt2:   + Calculated   Note: only applicable for device 1/2a | OK | | [1E4] | CW2D pathloss (dB) | N/A | Calculated  Note: only applicable for device 1/2a | OK | | [1E5] | CW received power (dBm) | N/A | Calculated  Note: only applicable for device 1/2a | OK | | [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180k(M),  360k(O),  1.08MHz(O) | UL data rate: xx bps  FFS: data rate for each case | At least 15kHz.  FFS larger BW | | [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | * For A-IoT device, 0dBi (M), -3dBi (O) | OK | | [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | N/A | * OOK: Y dB * PSK: X dB   Note: Only for device 1  FFS: for device 2a | OOK: 3-10dB  PSK: 0-3dB | | [1J] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | Do not need or 0.9dB considering carboard sheet | | [1K] | Ambient IoT backscatter amplifier gain (dB) | N/A | * 10 dB (M) * 15 dB (O)   Note: Only for device 2a |  | | [1N] | FFS: Cable, connector, combiner, body losses, etc. (dB) | FFS | N/A |  | | [1M] | EIRP (dBm) | Calculated  FFS: any limitation of the EIRP subject to future discussion | Calculated |  | | **(2) Receiver** | | | |  | | [2A] | Number of receive antenna elements / TxRU / chains modelled in LLS | Same as [1D]-D2R | Same as [1D]-R2D |  | | [2B] | Bandwidth used for the evaluated channel (Hz) | FFS: relation with the transmission bandwidth used for the evaluated channel | * FFS: whether the values are single side-band or double side-band * Note: The value is used for calculating the noise power   FFS: relation with the transmission bandwidth used for the evaluated channel |  | | [2B1] | FFS: RF CBW (Hz) | FFS:   * 10MHz * 20MHz * Other values   Note: The value is used for calculating the noise power | N/A | 10MHz or 20MHz RF CBW supported for calculating noise power of RF-ED, or transferring CNR to SNR | | [2C] | Receiver antenna gain (dBi) | same as [1G]-D2R | Same as [1G]-R2D |  | | [2X] | FFS: Cable, connector, combiner, body losses, etc. (dB) | N/A | FFS |  | | [2D] | Receiver Noise Figure (dB) | FFS: 20dB or 24dB or 30dB for *Budget-Alt2*  FFS: different values for device architecture | For BS as reader   * 5dB   For UE as reader   * 7dB |  | | [2E] | Thermal Noise power spectrum density (dBm/Hz) | -174 | -174 |  | | [2F] | Noise Power (dBm) | Calculated | Calculated |  | | [2G] | Required SNR | Reported by company | Reported by company |  | | [2H] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | Do not need or 0.9dB considering carboard sheet | | [2J] | Budget-Alt1/ Budget-Alt2 | For R2D link in the coverage evaluation, for device 1   * *Budget-Alt1* is used (note: receiver architecture is RF ED)   FFS: device 2 | Budget-Alt2 |  | | [2K] | CW cancellation (dB) | N/A | For [monostatic backscatter], FFS   * [140dB for BS] * [120dB for UE]   For [bistatic backscatter]   * Assuming CW has no impact to the receiver sensitivity loss. | OK | | [2K1] | Remaining CW interference (dB) | N/A | Calculated |  | | [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated |  | | [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + FFS:{-30dBm ~ -36dBm} * For device 2 if RF-ED is used   + FFS * For device 2 if RF-ED is not used   + N/A   For Budget-Alt2,   * Calculated | Calculated  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used | For device 2, Budget-Alt2 | | **(3) System margins** | | | |  | | [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | TBD | TBD |  | | [3B] | polarization mismatching loss (dB) | 3 dB | 3 dB |  | | [3C] | BS selection/macro-diversity gain (dB) | 0 dB  FFS: other values are not precluded | 0 dB  FFS: other values are not precluded |  | | [3D] | Other gains (dB) (if any please specify) | Reported by companies with justification | Reported by companies with justification |  | | **(4) MPL / distance** | | | |  | | 4A | MPL (dB) | Calculated | Calculated |  | | 4B | Distance (m) | Calculated | Calculated |  | |
| NEC | **Proposal 2: Uplink coverage performance needs to be evaluated for each scenario associated with backscatter communication.** |
| Nokia | **Proposal 3: Use the standard deviation of the path loss model as the shadow fading margin in link budget.** |
| Nokia | **Proposal 5: For R2D link budget, add an interference-to-noise (I/N) parameter to model interference. A receiver sensitivity degradation, dB, should be added to the receiver sensitivity for MPL calculation.** |
| Nokia | **Observation 2: For Devices 1 & 2a in D2R link, item 1E of the link budget table should be “received CW power” at the device.** |
| Nokia | **Proposal 6: Add “Received CW power for devices 1/2a” to the description of item 1E in the link budget table, as well as the calculation of 1E.** |
| DOCOMO | **Proposal 4: For link budget calculation, for the total transmission power on BS in DL spectrum for indoor, i.e., in row [1E] for R2D of link budget calculation table,**   * **38 dBm can be removed** * **the smaller value should be 23 dBm** * **constraints on PSD should be applied at least for the case with smaller total transmission power value such as [20 or 24] dBm/MHz** |
| DOCOMO | **Proposal 5: For link budget calculation, for the total transmission power on UE in DL spectrum for indoor, i.e., in row [1E] for R2D of link budget calculation table, 23 dBm should be assumed as mandatory value.** |
| DOCOMO | **Proposal 6: For link budget calculation, for the CW transmission power, i.e., in row [1E1] for D2R of link budget calculation table,**   * **33 dBm and 23 dBm should be assumed as mandatory value assuming BS as CW node in DL spectrum** * **23 dBm should be assumed as mandatory value assuming UE as CW node** |
| DOCOMO | **Proposal 7: For link budget calculation, for the EIRP for R2D, i.e., in row [1M] for R2D of link budget calculation table, constraints on EIRP should be applied as [35] dBm.** |
| DOCOMO | **Proposal 8: For link budget calculation, for the bandwidth for receiver for R2D, i.e., in row [2B] and [2B1] of link budget calculation table,**   * **Row [2B1] is removed** * **For RF-ED device as receiver, the Rx bandwidth is RF BPF bandwidth which corresponds to, e.g, CBW** * **For IF device as receiver, the Rx bandwidth is IF filter bandwidth which corresponds to, e.g, occupied bandwidth** * **For ZIF device as receiver, the Rx bandwidth is BB LPF bandwidth which corresponds to, e.g, occupied bandwidth** * **Note: The value is used for calculating the noise power** |
| DOCOMO | **Proposal 9: For link budget calculation, for the bandwidth for receiver for D2R, i.e., in row [2B] of link budget calculation table, the Rx bandwidth is occupied bandwidth which includes transmission bandwidth and guard band.**   * **Note: The value is used for calculating the noise power** * **The assumption of SSB/DSB should be discussed considering the assumption on SSB/DSB for Tx bandwidth for D2R.** |
| OPPO | [Proposal 11: Considering the values given in Table 1 of R1-2404868 for link budget calculation.](#_Toc166247510) |
| Qualcomm | **Proposal 1: RAN1 to update excel sheet with above modifications from [1E] to [3A].**  **[1E] Total Tx power**   * For device 1/2a   + **For R2D**, As one of small value, 24dBm could be chosen. From **错误!未找到引用源。**, we see that companies have reported 23/24dBm for local area BS tx power.   + **For D2R**, the CW rx power depends on the assumption on CW transmitter location. If CW is inside topology, then, CW transmitter could be co-located with BS or UE. If CW is outside topology, then, it depends on assumed CW transmitter location.     - CW inside network       * Use **D2R-CWRxPower-Alt2** (Balanced MPL/distance)     - CW outside network       * Use **D2R-CWRxPower-Alt1** (Companies to report) * For device 2b   + D2R-dev2bTxPower-Alt2: -20 dBm (M)   + D2R-dev2bTxPower-Alt2: -10 dBm (O) * Balanced MPL calculation * Since D2R link computation assumes device tx power at sensitivity level. Thus, this could potentially make D2R link be bottleneck link (i.e., R2D distance > D2R distance). * In balanced MPL/distance calculation, half of sum MPL (L = (R2D MPL + D2R MPL)/2) is calculated first. Then, mid point rx power L between Reader EIRP and Reader D2R sensitivity is computed; R = Reader EIRP – L. * K = max(R, dev sensitivity - device ant gain + dev mod loss + cable loss) * This allows shorter link to increase and longer link to decrease making them be balanced. * In monostatic case, balanced MPL maximizes min(R2D MPL, D2R MPL). * For bistatic case, it depends on CW transmitter location.   **[1E1] CW Tx power**   * D2R   + UL spectrum: 23 dBm (M) ~~FFS:~~ 26dBm (O)   + DL spectrum: 33 dBm (M), 38dBm (O)   **[1F] Transmission Bandwidth used for the evaluated channel (Hz)**   * D2R   + 15\*2kHz, 180\*2kHz (for DSB)   + 15kHz, 180kHz (for SSB)   + Note: Other values can be optionally evaluated. This is only for evaluation purpose.   **[1G] Tx Antenna gain**   * D2R   + 0dBi (M), -3dBi (O)   **[1H] Ambient IoT backscatter Loss**   * D2R   + OOK: -6dB   + PSK: 0dB   **[2B] Bandwidth used for the evaluated channel**   * R2D   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference power for RFED/IF receiver is ED bandwidth.     - Companies to report assumed ED bandwidth   + Noise and interference power for ZIF receiver is the same as transmission bandwidth [1F]. * D2R   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference bandwidth is determined same as transmission bandwidth [1F].     - In this case, reader receiver is OFDM receiver which can perform FFT and remove noise in non-transmission bandwidth. * Recommend to replace 2B with noise and interference bandwidth.   **[2B1] FFS: RF CBW**   * R2D   + This may not be needed as long as 2B is properly defined. * D2R   + This may not be needed as long as 2B is properly defined.   **[2H] FFS: Ambient IoT on-object antenna penalty**   * For both R2D and D2R   + 0.9dB for cardboard   + 10.4dB for aluminum slab   **[2J] Budget-Alt1/Budget-Alt2**   * R2D   + For device 1 and 2, RF-ED receiver, use Budget-Alt1.   + For device 2b, IF or ZIF receiver, use Budget-Alt2. * D2R   + Budget-Alt2   **[2J1] CW interference power (dBm)**   * A new row is necessary where CW interference power is captured.   + Monostatic (D1T1-A2, D2T2-A2)     - Could be the same as CW tx power   + Bistatic (D1T1-A1, D1T1-B, D2T2-A1, D2T2-B)     - CW power is attenuated by pathloss between CW transmitter and reader receiver.   **[2K] CW cancellation (dB)**   * D2R   + Monostatic (D1T1-A2, D2T2-A2)     - Companies to report   + Bistatic (D1T1-A1, D1T1-B, D2T2-A1, D2T2-B)     - Companies to report   + It depends on IC capability assumed, which could be different across companies. * CW interference cancellation   + There could be two contributors to CW interference w/ different nature; tx leakage and Rx IMD     - Tx leakage: This is the interference generated from Tx chain due to nonlinearity in Tx chain (spectral regrowth), and/or poor isolation between tx and rx. Increasing isolation reduces tx leakage to rx path. If, there is CW only in tx signal, then, it would be less affected due narrow footprint of CW. If there are CW multiplexed with other NR signal (in-band), then, tx leakage impact could be large due to non-linearity of tx chain.     - Rx IM3: This interference is generated due to non-linearity of rx path (e.g., mixer, LNA, etc). The CW and backscattered signal could generate intermodulation (IM3), interfering backscattered signal itself.   + The total CW-interference can count both tx leakage and Rx IM3.   + How to compute CW interference and CW cancellation is FFS companies to report.   **[2L] Receiver sensitivity (dBm)**   * R2D   + Device 2 RFED receiver: [-40, -35]dBm   + Device 2b with IF/ZIF receiver: [-60, -50]dBm * D2R   + Calculated   **[3A] Shadow fading margin**   * For both R2D and D2R   + 4dB |
| Samsung | Observation 5. The modulation factor may or may not be independent of the modulation scheme, depending on the definition of CINR/CNR. |
| Samsung | Observation 6. Excessively high EIRP such as 44 dBm can cause issues such as signal leakage into adjacent channels or adverse effects on the human body. |
| Samsung | Proposal 8. To prevent problems caused by excessively high EIRP, one of the following restrictions can be applied: (1) setting a maximum limit for EIRP, (2) PSD limitation. |
| Samsung | Proposal 9. Ambient IoT backscatter loss is defined as follows in the link-budget template.   * Budget-Alt1: 8 dB for OOK and 2 dB for BPSK * Budget-Alt2: 2 dB for OOK and BPSK based on Option 1 for CINR/CNR definition. |
| Samsung | Proposal 10. 77.2 dB is used for the receiver noise figure of device 2. |
| Samsung | Proposal 11. – 30 dB for device 1 and – 40 dB for device 2 are used for the receiver sensitivity in Budget-Alt2.  Proposal 12. For Device 2, the receiver sensitivity should be calculated and compared based on both Budget-Alt1 and Budget-Alt2. |
| Spreadtrum | ***Proposal 8: Table 1 is adopted for Link budget parameters and values of coverage evaluation.***  ***Observation 2: For R2D, the coverage of device 1 can achieve nearly 40m, the coverage of device 2a can achieve over 100m, and the coverage of device 2b can far exceed the maximum coverage requirement. For D2R, the coverage is lower in CW inside topology than that in CW outside topology considering CW interference.*** |
| Tejas | **Proposal 1: The maximum achievable distance between CW transmitter and Device should be decided based on the Device activation threshold, which is considered as the read sensitivity or receiver sensitivity for PRDCH and CW2D reception. Considering a fixed CW2D distance for CW inside topology limits the coverage between Reader and Device as the Reader itself transmitting the CW signal to the Device.** |
| Tejas | **Proposal 2: A suitable transmit power from the Reader (base station) should be chosen to achieve the maximum coverage that satisfies all the distances for the physical channels PRDCH, PDRCH, and CW2D.** |
| Tejas | **Proposal 3: In the case of CW inside topology for Device 1, the Device activation threshold plays a critical role to decide the maximum coverage. Thus, a suitable Device activation threshold should be decided that maximizes the final coverage.** |
| Tejas | **Proposal 4: In case of CW inside topology, the PDRCH distance is inversely proportional to CW2D distance. Therefore, an optimal distance should be chosen for a fixed transmit power from the base station (R) that gives a balanced MPL/distance between R/R1/R2 and D. In case of CW outside topology, a fixed CWT to tag/Device distance can be considered to evaluate the maximum coverage for Device 2a.** |
| Vivo | **Observation 3: Both 33dBm and 38dBm Tx power correspond to output power of micro-cell, up to 24dBm transmission power can be assumed for pico-cell according to RAN4 requirements.** |
| Vivo | **Observation 4: Transmission Bandwidth depends on the data rate and line code scheme assumed for PDRCH.** |
| Vivo | **Observation 5: [2B] Bandwidth used for the evaluated channel for D2R at receiver side is used for noise power calculation rather than [1F] Transmission Bandwidth.** |
| Vivo | **Observation 6: The transmission BW is further expanded if multiple single tone CW is used.** |
| Vivo | **Observation 7: The antenna gain of RFID tag should not be compared with UE antenna gain due to different form factor and design considerations**  - **UE antenna has different design priorities compared with RFID, such as compact size, multi-band operation, and user comfort.**  - **For a RFID tag, the antenna can be optimized with less restrictions compared with antenna in UE, e.g., using larger area for antenna and working in a single frequency band.** |
| Vivo | **Observation 8: If option-2 SINR degradation is used as metric for co-existence evaluation in RAN4, RAN1 may not need to provide LLS results to RAN4.** |
| Vivo | **Observation 9: Given budget-Alt1 is used for coverage evaluation, which does not require LLS, it is not clear whether the SINR-BLER mapping results from LLS in RAN1 would be convergent and useful to RAN4 co-existence evaluation, especially for R2D with RF-ED.** |
| Vivo | **Proposal 3:**  **For device 2b with active AIoT UL transmission, -20dBm Tx power can be assumed.** |
| Vivo | **Proposal 4:**  **38 dBm can be considered as optional for CW Tx power for micro-cell. And support Tx power of 23dBm for pico-cell.** |
| Vivo | **Proposal 5: Report {data rate, line code scheme, number of CW tones} for the D2R transmission, instead of reporting a BW value for [1F].** |
| Vivo | **Proposal 6: Leave the [2B] up to company report a value, which can contain the BW of the PDRCH subject to data rate and line code scheme, and guard gap considering SFO/CFO.** |
| Vivo | **Proposal 7: Adopt 0 dBi antenna gain for AIoT device.** |
| Vivo | **Proposal 8: For AIoT transmission based on backscatter, 8dB can be assumed for backscatter loss.** |
| Vivo | **Proposal 9: For device 1: EIRP[1M] = Total tx power[1E] + Tx antenna gain[1G] – Ambient backscatter loss[1H]**  坼 **For device 2a: EIRP[1M] = Total tx power[1E] + Tx antenna gain[1G] – Ambient backscatter loss[1H] +Ambient IoT backscatter amplifier gain[1K]** |
| Vivo | **Proposal 10: The item of 2H (Ambient IoT on-object antenna penalty) is removed.** |
| Vivo | **Proposal 11: For the parameter 2K (CW cancellation), consider only the RF/analog domain cancellation, digital baseband suppression is not reported in link budget template.** |
| Vivo | **Proposal 12: The item of 2K2 is up to company report, and can be further updated depending on RAN4 output.** |
| Vivo | **Proposal 13: when calculating Receiver Sensitivity [2L], consider the receiver sensitivity loss parameter 2K2 for D2R link.**  - **2L(receiver sensitivity) = 2F(Noise power) + 2G(Required SNR) + 2K2(Receiver sensitivity loss)** |
| Vivo | **Proposal 14: For item 2A(Shadow fading margin), consider the value of 4 dB for InF-DH-NLOS, and consider the value of 3 dB in InH-LOS, consider the value of 7.2 dB for InF-DL-NLOS.** |
| Vivo | **Proposal 15: For D2R, The MPL(4A) can be calculated according to the formula**   **For D1T1-B and D2T2-B scenario**  - Image   **For D1T1-A1 (A2) and D2T2-A2 scenario**  -Image  -Image |
| Vivo | **Proposal 16: Adopt link budget template parameter and value in the Table 2 for AIoT coverage evaluation.** |
| Xiaomi | ***Proposal 4: The recommended parameters for link budget template in Table 2 can be considered.***  Table 2. Link template budget   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | **Xiaomi comments** | | **(0) System configuration** | | | |  | | [0A] | Scenarios | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C |  | | [0A1] | CW case | N/A | 1-1/1-2/1-4/2-2/2-3/2-4 |  | | [0B] | Device 1/2a/2b | Device 1/2a/2b | Device 1/2a/2b |  | | [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) | Currently, FDD spectrum located on 700~900Mhz, and also 2Ghz. We are fine with any of these frequencies. | | **(1) Transmitter** | | | |  | | [1D] | Number of Tx antenna elements / TxRU/ Tx chains modelled in LLS | For BS:  - 2(M) or 4(O) antenna elements for 0.9 GHz  For Intermediate UE:  - 1(M) or 2(O) | 1 |  | | [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + 33dBm(M), FFS: 38dBm(O),   + FFS: additional constraints on PSD * For UE in DL spectrum for indoor, 23dBm * For UL spectrum for indoor,   + 23dBm (M)   + FFS: 26dBm(O) | * For device 1/2a: * For scenarios ‘A1’ and ‘A2’,The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss. * For scenarios ‘B’,The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value. * For device 2b: * D2R-dev2bTxPower-Alt2: -20 dBm(M) | For device 1/2a, the D2R Tx power is already agreed in R1#116b meeting | | [1E1] | CW Tx power (dBm) | N/A | * 23dBm for UL spectrum, FFS 26dBm * 33dBm(M), 38dBm (O) for DL spectrum   Note: only applicable for device 1/2a |  | | [1E2] | CW Tx antenna gain (dBi) | N/A | * UE Tx antenna gain 0 dBi, if UE is CW Node, * BS Tx ant gain 6 dBi, if BS is CW Node   Note: only applicable for device 1/2a |  | | [1E3] | CW2D distance (m) | N/A | * For scenario ‘B’,DL spectrum, CW2D distance =20m; For scenario ‘B’,UL spectrum, CW2D distance =10m.   Note: only applicable for device 1/2a |  | | [1E4] | CW2D pathloss (dB) | N/A | Calculated  Note: only applicable for device 1/2a |  | | [1E5] | CW received power (dBm) | N/A | Calculated  Note: only applicable for device 1/2a |  | | [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180k(M),  360k(O),  1.08MHz(O) | 15kHz |  | | [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(O) * For intermediate UE, 0 dBi | * For A-IoT device, 0dBi (M), |  | | [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | N/A | * 6dB   Note: Only for device 1  FFS: for device 2a |  | | [1J] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | We think it is also OK to neglect it and count it directly to antenna gain of ambient IoT Device | | [1K] | Ambient IoT backscatter amplifier gain (dB) | N/A | * 10 dB (M) * 15 dB (O)   Note: Only for device 2a | Ambient IoT backscatter loss is already merged into amplifier gain | | [1N] | FFS: Cable, connector, combiner, body losses, etc. (dB) | FFS | N/A | Not considered currently | | [1M] | EIRP (dBm) | Calculated  FFS: any limitation of the EIRP subject to future discussion | Calculated |  | | **(2) Receiver** | | | |  | | [2A] | Number of receive antenna elements / TxRU / chains modelled in LLS | Same as [1D]-D2R | Same as [1D]-R2D |  | | [2B] | Bandwidth used for the evaluated channel (Hz) | FFS: relation with the transmission bandwidth used for the evaluated channel | * 4RB * Note: The value is used for calculating the noise power   FFS: relation with the transmission bandwidth used for the evaluated channel | Considering small frequency shifting, the Rx should be able to receive D2R on any possible shifted frequency, so the Bandwidth used for the evaluated channel should be larger than D2R bandwidth and cover all possible shifted frequencies. | | [2B1] | FFS: RF CBW (Hz) | FFS:   * 10MHz * 20MHz * Other values   Note: The value is used for calculating the noise power | N/A | If Budget-Alt 1 is applied, no need to calculate the noise power | | [2C] | Receiver antenna gain (dBi) | same as [1G]-D2R | Same as [1G]-R2D |  | | [2X] | FFS: Cable, connector, combiner, body losses, etc. (dB) | N/A | FFS |  | | [2D] | Receiver Noise Figure (dB) | FFS: 20dB or 24dB or 30dB for *Budget-Alt2*  FFS: different values for device architecture | For BS as reader   * 5dB   For UE as reader   * 7dB |  | | [2E] | Thermal Noise power spectrum density (dBm/Hz) | -174 | -174 |  | | [2F] | Noise Power (dBm) | Calculated | Calculated |  | | [2G] | Required SNR | Reported by company  N/A if Budget-Alt1 is applied | D1T1:-5.4dB  D2T2: 7.2dB |  | | [2H] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 | We think it is also OK to neglect it and count it directly to antenna gain of ambient IoT Device | | [2J] | Budget-Alt1/ Budget-Alt2 | Budget-Alt1 | Budget-Alt2 |  | | [2K] | CW cancellation (dB) | N/A | For [monostatic backscatter], FFS   * [140dB for BS] * [120dB for UE]   For [bistatic backscatter]   * Assuming CW has no impact to the receiver sensitivity loss. |  | | [2K1] | Remaining CW interference (dB) | N/A | Calculated |  | | [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated |  | | [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + -30dBm * For device 2 if RF-ED is used   + -45dBm * For device 2 if RF-ED is not used   + -45dBm   For Budget-Alt2,   * Calculated | Calculated  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |  | | **(3) System margins** | | | |  | | [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | According to the propagation model in TS 38.901 and scenario | According to the propagation model in TS 38.901and scenario | 4dB for InF LOS and InF-DH NLOS  7.2dB for InF-DL NLOS | | [3B] | polarization mismatching loss (dB) | 3 dB | 3 dB |  | | [3C] | BS selection/macro-diversity gain (dB) | 0 dB  FFS: other values are not precluded | 0 dB  FFS: other values are not precluded | Consider it is an indoor scenario, BS selection/macro-diversity gain is not expected. | | [3D] | Other gains (dB) (if any please specify) | Reported by companies with justification | Reported by companies with justification | Not considered currently. | | **(4) MPL / distance** | | | |  | | 4A | MPL (dB) | Calculated | Calculated |  | | 4B | Distance (m) | Calculated | Calculated | InF-DH pathloss model for D1T1 and InF-DL pathloss model for D2T2 in TR 38.901. |   The values are calculated according to the followings   * 1M   + For R2D, [1M] = [IE]+[1G]   + For D2R,     - Device type 1:[1M] = [1E]+[1G]-[1H] -[1J]     - Device type 2(backscatter): [1M] = [1E]+[1G]-[1J]+[1K]     - Device type 2(active): [1M]=[1E]+[1G] -[1J]+[1L] * 2F: [2F]=[2E]+[2D]+lin2dB([2B]) * 2L   + For R2D and Budget-Alt1, [2L] = [2G]   + For R2D and Budget-Alt2, [2L] =[2G]+[2F]   + For D2R and Budget-Alt2,     - If CW interference is not considered, [2L] = [2G]+[2F]     - If CW interference is considered, Obtain [2L] according to the following formula,       * , where dB2lin(\*) is function that converts dB to linear value. * 4A   + For scenario B/C, [4A]=[1M]+[2C]-[2L]-[3A]-[3B]+[3C]+[3D]   + For scenario A1/A2,     - For device 1, [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]-[1H])     - For device 2a, [4A]=0.5\*([1E1]+[1E2]-2\*[3A]-2\*[3B]-[1J]-[2L]+[2C]+[1K])   4B is derived from pathloss model in Appendix B. |
| ZTE | ***Proposal 10: The above updated link budget template can be adopted for Ambient IoT coverage evaluation.***  According to the agreements, the link budget template is initially presented in reference [1]. For the initial template, we have following considerations and updates.   * 1E * For D2R, ~~and device 1/2(backscatter), whether this value is need (not regarded as an input variable but regarded as indirect variable), or based on backscatter activation power threshold~~ * For device 1, the device Tx power = activation power threshold   The Tx power of backscatter signal is equal to the CW power received by device. Device 1 requires RF energy to activate and power. If the received CW power is less than activation threshold, the device will not work. Therefore, it is assumed that the Tx power of device 1 is equal to its activation threshold.   * For device 2a   + D1T1-A1/A2 and D2T2-A2: the device Tx power is calculated by assuming CW2D pathloss = D2R pathloss.   + D1T1-B and D2T2-B: the device Tx power is calculated by CW received power which can be derived by at least CW Tx power (dBm), CW antenna gain (dBi), CW2D distance (m) and pathloss model. * 1M * For R2D, * For D2R, * Device 1:   (i.e., TxEIRP = Total Tx Power + Tx antenna gain－backscatter loss (e.g., due to impedance mismatch, Modulation factor)－Object antenna penalty)   * Device 2a:   (i.e., TxEIRP = Total Tx Power + Tx antenna gain－backscatter loss (e.g., due to impedance mismatch, Modulation factor)－Object antenna penalty+Amplifier gain)   * Device 2b:   (i.e., TxEIRP = TxPowerBW + TxAntGain)   * 2F: * 2L * For R2D, ~~and~~ Budget-Alt1~~, [2L] = [2H]~~ * ~~For R2D and Budget-Alt2, [2L] = [2G]+[2F]~~ * For D2R and Budget-Alt2, ~~Refer to section [xxx] (Proposal [P4-3])~~ * Device 1 and 2a: [2L] = [2G]+[2F] +[2K2]   (i.e., Receiver Sensitivity = Required SNR +Noise Power +Receiver sensitivity loss)   * Device 2b: [2L] = [2G]+[2F]   (i.e., Receiver Sensitivity = Required SNR +Noise Power)   * 4A * 4B is derived from pathloss model in Table 5 * ~~Refer to section [XXX] (Proposal [P4-3-2])~~ * InF-DH NLOS for D1T1 * InF-R2D NLOS/InH-Office LOS for D2T2. |

#### Discussion (round 1)

This link budget table will further be updated depending on the discussion of section 3.4.1 to section 3.4.29.

#### [H][Proposal-3.4.30-v1]

*<Editor’s note: will update the overall link budget table after the discussion of section 3.4.1 to section 3.4.29>*

## Link level simulation assumptions

In RAN1#116bis post-meeting email discussion, the following table is agreed for coverage evaluation assumptions in link level simulation and as start point. Other values/options are not precluded and subject to future discussion.

**Table 3.5: Link lelvel simulation assumptions for coverage evaluation**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Parameters** | | **Assumptions** |
|  | **R2D/D2R common parameters** | | |
| **[0a]** | Carrier frequency | | Refer to link budget template |
| **[0b]** | SCS | | 15 kHz as baseline |
| **[0c]** | Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |
| **[0d]** | Channel model | | <Editor’s Note: will be updated according to the agreements made for channel model> |
| **[0e]** | Delay spread | | [30, 150] ns |
| **[0f]** | Device velocity | | 3 km/h |
| **[0g]** | Number of Tx/Rx chains for Ambient IoT device | | 1 |
| **[0h1]** | BS | Number of antenna elements | 2 or 4 |
| **[0h2]** | Number of TXRUs | 2 or 4 |
| **[0j1]** | Intermediate UE | Number of antenna elements | 1 or 2 |
| **[0j2]** | Number of TXRUs | 1 or 2 |
| **[0m]** | Reference data rate | | [0.1, 1, 5] kbps |
| **[0n]** | Message size | | * D2R:   + [FFS: 16, 96, 400 bits] * R2D:   + [FFS: 16, 32, 64, 400bits] |
| **[0p]** | BLER target | | 1%, 10% |
| **[0q]** | Sampling frequency | | <Editor’s Note: will be updated according to the agreements made forSampling frequency> |
| **[0r]** | Device 1/2a/2b | | Options are as follows,   * Device 1, RF-ED * Device 2a, RF-ED * Device 2b, RF-ED/IF-ED/ZIF   <Editor’s Note: will be updated according to agreements from 9.4.1.2> |
|  | **R2D specific parameters** | | |
| **[1a]** | Transmission bandwidth | | 180 kHz as baseline |
| **[1b]** | FFS: ED bandwidth | | [X MHz] |
| **[1c]** | FFS: BB LPF | | [X]-order Butterworth filter with cutoff frequency at [Y] kHz |
| **[1d]** | Waveform | | OOK waveform generated by OFDM modulator |
| **[1e]** | Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |
| **[1f]** | Line code | | Companies to report, e.g., Manchester, PIE |
| **[1g]** | FEC | | No FEC as baseline |
| **[1h]** | ADC bit width | | 1-bit for device 1  4-bit for device 2 |
| **[1j]** | Detection/decoding method for Line code | | Companies to report |
|  | **D2R specific parameters** | | |
| **[2a]** | Transmission bandwidth (w.r.t. D2R data rate) | | [FFS: 15kHz, 180kHz] |
| **[2b]** | Waveform (CW) | | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |
| **[2d]** | Modulation | | Companies to report modulation, e.g., OOK, BPSK, BFSK |
| **[2e]** | Line code | | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |
| **[2g]** | FEC | | Companies to report, e.g., CC, No FEC |
| **[2h]** | ADC bit width | | Companies to report, e.g., 11-bit |
| **[2j]** | D2R receiver | | FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver |
|  | **Other assumptions** | | |
| **[3a]** | Other assumptions | | To be reported by company |
| **[3b]** | Note: Companies to report required SINR according to BLER target. | | |

### [0e] Delay spread

#### Related Tdoc Proposals

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| FUTUREWEI | ***Proposal 7: For link level simulations when either TDL-A or TDL-D channel model is used, select a delay spread value of 39 ns.*** |
| Huawei, Hisilicon | ***Proposal 37: An RMS delay spread of 150 ns is recommended for the TDL-A channel model.***  ***Proposal 38: An RMS delay spread of 20 ns is recommended for the TDL-D channel model.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | Delay spread | 30ns | |
| CATT | **Proposal 11: Delay spread of 30ns for InH-Office LOS model and 150ns for InF-DH and InF-DL model can be used in LLS.** |
| China Telecom | ***Proposal 3: An RMS delay spread of 150ns is recommended for TDL-A channel model in D1T1 and D2T2.***  ***Proposal 4: An RMS delay spread of 30ns is recommended for TDL-D channel model in D2T2.*** |
| CMCC | **Proposal 16: For link level performance evaluation, 30ns delay spread is considered mandatory.**   |  |  | | --- | --- | | **Parameters** | **Assumptions** | | Channel model | * For D1T1, TDL-A channel model is used for R2D link and for D2R link for InF-DH scenario. * For D2T2,   + TDL-A channel model is used for R2D link and for D2R link if InF scenario is considered   + TDL-D channel model is used for R2D link and for D2R link if InH-Office scenario is considered | | Delay spread | 30ns (M), 150 ns (O) | |
| Comba | **Proposal 5: TDL-A 30ns and TDL-C 300ns can be considered as starting point for link level simulations.** |
| Qualcomm | **Proposal 16: Use 30ns for Mandatory and 150ns for optional.** |

#### Discussion (round 1)

From reviewing the submitted contributions in this meeting, 8 companies provide their views on the value of delay spread for the agreed TDL-A and TDL-D channel model, where proponents using a common value for both channel models and proponents using different values for different channel models break even.

* Common values for both channel models (4): FUTUREWEI, Spreadtrum, CMCC, Qualcomm
* Different values for different channel models (4): Huawei/Hisilicon, CATT, China Telecom, Comba

The proposed values are summarized as follows:

* 30 ns (6): Spreadtrum, CATT (TDL-D), China Telecom (TDL-D), CMCC (Mandatory), Comba (TDL-A), Qualcomm (Mandatory)
* 150 ns (5): Huawei/Hisilicon (TDL-A), CATT (TDL-A), China Telecom (TDL-A), CMCC (Optional), Qualcomm (Optional)
* 39 ns (1): FUTUREWEI
* 20 ns (1): Huawei/Hisilicon (TDL-D)

Based on the inputs, perhaps a way forward is to consider 30 ns for LOS condition and 150 ns for NLOS condition. The following proposal is then formulated.

**[H][P3.5.1-v1]**

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| **Proposal**  For the link level simulation,   * An RMS delay spread of 150 ns is considered for TDL-A channel model. * An RMS delay spread of 30 ns is considered for TDL-D channel model. |

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| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| QC | For indoor where tx to rx distance is short, delay spread is short.  According to 38.901,  Short-delay profile is for median RMS DS for LOS.  Normal-delay profile is for median RMS DS for NLOS.  Long-delay profile is for 90% RMS DS for NLOS.  We propose 59ns for TDL-A.  We propose 30ns for TDL-D. |

### [0m] Reference data rate

#### Related Tdoc Proposals

The proposals are summarized as follows:

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| **Source** | **Proposals** |
| Huawei, Hisilicon | ***Proposal 39: Link-level simulations assumes 0.1 kbps data rate [M] and 1 kbps [O] for the coverage evaluations of both R2D and D2R link.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | Reference data rate | * D2R:   + 5 kbps * R2D:   + 7 kbps | |
| Samsung | Observation 1. For R2D, when using a 15 kHz SCS OFDM-based OOK-1 with Manchester line coding, the achievable data rate is 7 kbps if CP is included as data.  Observation 2. For R2D, to achieve a lower data rate than 7 kbps with OFDM-based OOK waveform, (1) using a lower subcarrier spacing than 15 kHZ or (2) mapping multiple OFDM symbols to a single data symbol while using 15 kHz SCS can be considered.  Proposal 1. For the sake of simplicity, for R2D, mapping multiple consecutive OFDM symbols to a single ship can be considered for the evaluation.  Observation 3. For R2D transmission, the data rate can be differently calculated depending on CP handling approaches.  Proposal 2. For R2D transmission, set the reference data rates separately depending on CP handling approaches for the evaluation purpose. |
| vivo | Proposal 17: Adopt 5kbps as the reference data rate. |
| China Telecom | *Proposal 5: Reference data rates 0.1* kbps, 1 kbps *and* 5 kbps *for LLS coverage evaluation can be considered.* |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | Reference data rate | [0.1, 1, 5] kbps | R2D   * 7kbps for M=1 * 14kbps for M=2 * 28kbps for M=4   D2R: 14kbps | |

#### Discussion (round 1)

From reviewing the submitted contributions in this meeting, a few companies provide their views on the reference data rate. Most companies suggest having a reference data rate to be sufficient low to obtain better coverage results.

**Summary of Data Rate Proposals:**

* **0.1 kbps:** Huawei, Hisilicon; China Telecom
* **1 kbps:** Huawei, Hisilicon; China Telecom;
* **5 kbps:** Spreadtrum (D2R); vivo; China Telecom;
* **7 kbps:** Spreadtrum (R2D); Samsung; MediaTek (for M=1)
* **14 kbps:** MediaTek (R2D for M=2); MediaTek (D2R)
* **28 kbps:** MediaTek (R2D for M=4)

Based on the inputs, the following proposal is formulated.

**[H][P3.5.2-v1]**

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| **Proposal**  For link-level simulation in coverage evaluation, [1] kbps (M) and [7] kbps (O) is considered for the reference data rate. |

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| **Company** | **Comments** |
| Xiaomi | [1] kbps (M) and [7] kbps (O) are for both D2R and R2D? |
| Wiliot | We propose simulation should use higher rates for inventory, such as 200kbps for R2D and 3Mbps for D2R. Otherwise we need to consider: 1. R2D: AIoT device can not filter out interference, so long R2D transmissions will likely be blocked by OOB interference.  2. D2R transmissions are all unicast, so every device must transmit. Low rates mean very long inventory processing (which uses the same rates as LLS), high latencies and also lengthy/complex NR traffic slow downs. Note: such bit rates are within power budget for all devices (1,2a and 2b). |
| QC | We think 0.1kbps, 1kbps, 5kbps are too low – Not acceptable.  RFID UL data rate reaches hundreds of kbps.  We should use realistic numbers.  A-IoT device might not be able to sustain such a low data rate. |

### [0n] Message size

#### Related Tdoc Proposals

The proposals are summarized as follows:

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| **Source** | **Proposals** |
| Ericsson | Observation 9：The outcome of the coverage evaluation (with a message size of 400 bits) can be used as input to the discussion on whether segmentation of a message into several TBs is needed or not.  Proposal 15：For coverage evaluation, the message size of 400 bits is mandatory for R2D and D2R. |
| Huawei, Hisilicon | ***Proposal 40: The message size used in the link-level simulation is assumed to be [16, 96, 400] bits for both R2D and D2R link.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | Message size | * D2R:   + 16bits * R2D:   + 16bits | |
| ZTE | ***Proposal 14: Consider the following assumptions in the LLS:***   * ***R2D/D2R message size: 16, 96 bits*** * ***D2R receiver: coherent receiver*** |
| Lenovo | ***Proposal 4: For evaluating Ambient IoT, consider candidate maximum TBS for UL transmission:***   * ***100-150 bits for Passive device Types 1, 2B*** * ***200-250 bits for Active device Type 2A*** |
| NTT DOCOMO | **Proposal 15: For link level simulation, at least [96] bits should be included for evaluation assumption of message size.**   * **The message size can be refined based on the discussion on maximum TBS.** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | Message size | * D2R:  [FFS: 16, 96, 400 bits] * R2D: [FFS: 16, 32, 64, 400bits] | R2D: 64 bits  D2R: 96 bits | |
| Qualcomm | **Proposal 17: update table as follows.**   |  |  | | --- | --- | | **Message size** | * **D2R:**    + **~~[FFS:~~ 16, 96, 400 bits~~]~~** * **R2D:**    + **~~[FFS:~~ 16, 32, 64, 400bits~~]~~** | |

#### Discussion (round 1)

From reviewing the submitted contributions in this meeting, several companies provide their views on the message size:

* Most companies (e.g., Ericsson, Huawei/Hisilicon, ZTE, NTT DOCOMO) prefer to have a common message size for R2D and D2R.
* 1 company (Ericsson) suggest considering up to hundreds of bits so that RAN1 can provide inputs for RAN2 discussion on segmentation.
* 1 company (Lenovo) propose to consider different message size for different device types.

**Summary of Proposals:**

* **16 bits:** Spreadtrum (D2R, R2D), ZTE, MediaTek (D2R, R2D), Qualcomm (D2R, R2D)
* **32 bits:** MediaTek (R2D), Qualcomm (R2D)
* **64 bits:** MediaTek (R2D), Qualcomm (R2D)
* **96 bits:** Huawei, Hisilicon; ZTE; NTT DOCOMO; MediaTek (D2R), Qualcomm (D2R)
* **100-150 bits:** Lenovo (Passive device Types 1, 2B)
* **200-250 bits:** Lenovo (Active device Type 2A)
* **400 bits:** Ericsson; Huawei, Hisilicon; MediaTek (D2R, R2D); Qualcomm (D2R, R2D)

Based on the inputs, FL suggests starting from common message size for both R2D and D2R

**[H][P3.5.3-v1]**

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| **Proposal**  For the link level simulation in coverage evaluation, {16 bits, 96 bits, 400 bits} are considered for message size. |

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| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| Wiliot | Support suggested FL proposal |
| QC | We suggest to consider 400bits with higher data rate only. |

### [0q] Sampling frequency

#### Related Tdoc proposals

The proposals are summarized as follows:

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| **Source** | **Proposals** |
| Ericsson | Proposal 13: Reuse the initial clock error and clock drift assumptions as for LP-WUR in TR 38.869. Specifically, for all A-IoT device types, down-select between the following options for the initial clock error [ppm] and clock drift [ppm/s]:   * Option 1: (200, 0.1) * Option 2: (50, 0.1) * The clock error post synchronization/calibration is FFS. |
| Huawei, Hisilicon | ***Proposal 43: The sampling frequency is assumed to be 1.92 MHz for the R2D receiver.***  ***Proposal 44: The SFO can be modelled as continuously accumulated timing drift of ∆T = Fe × T in the link-level simulations, with the number of Fe set to a random selection from {-105 ppm, 105 ppm} per transmission.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | Sampling frequency | * D2R:   + 300kHz * R2D:   + 1.92MHz | |
| CMCC | **Proposal 15: The following sampling frequency offset are considered in the evaluations,**   |  |  | | --- | --- | | **Parameter** | **Values** | | **Device Sampling Frequency** | * **Initial Sampling Frequency Offset (SFO) [104 ~ 105] ppm** * **Sampling frequency = 1.92 MHz** |   **Note:**   * **The relationship between the SFO (Fe) and corresponding timing drift (ΔT) over a time(T) isΔT = ±Fe \* T** * **When the power is off for the device, the oscillator for sampling is no longer running and the device does not maintain any time reference.** |
| Samsung | **Proposal 5.** For D2R transmission, study how much initial SFO correction can be achieved based on device type and utilized algorithms.  Proposal 6. The following sampling frequency offset are considered in the link level simulation.   * Initial sampling frequency offset (SFO) = [105] ppm   **Proposal 7.** 1.92Msps is considered in the link level simulation as the sampling rate for tag. |
| vivo | Proposal 18: 1.92MHz sampling rate can be assumed for device with 1μW peak power consumption, and 3.84MHz sampling rate can be assumed for device with a few hundred μW power consumption. |
| ZTE | ***Proposal 12: The*** ***following is suggested in the modeling of timing error of Ambient IoT device.***   * ***For device type 1: SFO is between [104 ~ 105] ppm;*** * ***For device type 2a: SFO is between [103 ~ 104] ppm;*** * ***For device type 2b: using CFO model defined in TR38.869 and assume maximum frequency offset [50 or 100] ppm, frequency drifting [0.1] ppm/s.***   ***Proposal 13: The*** ***following two options are provided to model the SFO impact on the D2R transmission***   * ***Option 1: D2R chip duration varies on a per-chip basis*** * ***Option 2: variation of D2R chip duration is the same across one D2R transmission*** |
| OPPO | **Proposal 15: For Device 1 or 2a the SFO is in the range of 104 ~ 105 ppm, for Device 2b the CFO defined in TR 38.869 (option 1 or 2 in Table 6.2-3) should be used.** |
| LGE | ***Proposal 4: Sampling frequency offset and timing drift model need to be modeled separately according to the device types*** |
| Lenovo | ***Proposal 3: For evaluating Ambient IoT, for example for synchronization evaluation, consider different initial sampling frequency offset based on the device type and the supported receiver architecture.***   * ***Device type 1 and Device type 2a :* 10^4 - 10^5 ppm** * ***Device type 2b:* 10^3 - 10^4 ppm** |
| NTT DOCOMO | **Proposal 11: For link level simulation, study initial sampling offset for each device type which corresponds to the SFO without receiving corresponding timing acquisition/synchronization signal.**   * **initial sampling offset can be [104 ppm to 105] as a starting point** * **FFS: Whether/how initial SFO can be different depend on the device type**   **Proposal 12: For link level simulation, study post-synchronization sampling frequency offset for each device type which corresponds to the compensated SFO after receiving timing acquisition/synchronization signal.**   * **FFS: detailed value for each device**   **Proposal 13: For link level simulation,**   * **Initial SFO is applied to the evaluation of preamble or other synchronization signal if any** * **Post-sync SFO should be applied to the evaluation of PRDCH/PDRCH**   **Proposal 14: For link level simulation, the relationship between the SFO (Fe) and corresponding timing drift (ΔT) over a time(T) is modelled as ΔT = ±Fe \* T.**   * **FFS: The starting point of ‘T’** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | Sampling frequency | * *<Editor’s Note:~~Refer to Proposals in section 3.5.3~~will be updated according to the agreements made for ~~channel model~~* *Sampling frequency >* | 1.92MHz for both D2R and R2D | |
| Qualcomm | **Proposal 24: For evaluation purpose, it is assumed that device 1/2a/2b can support at least following three clocks in Table 5 for sampling/sleep, frequency shifting, carrier frequency generation within their power consumption budget.**  Table 5 List of clocks to be considered for evaluation of A-IoT devices   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Clock # | Description | Applicable  device types | Clock  speed | Power  consumption | Initial clock  Accuracy (i.e., before calibration) | Accuracy after  clock calibration | | Clock 1 | Sampling for sync signal or preamble detection.  Light sleep w/ memory retention | Device 1, 2a, 2b | [10s] kHz to [1]MHz | << 1uW | [1, 10]% error | After clock calibration based on sync signal/preamble or symbol clocking information from line coding, accuracy of <1% is achieved. | | Clock 2 | Frequency shift for backscattering | Device 1, 2a | A few [1] MHz | <1uW  <10s uW | [1~5]% error before calibration. | Accuracy of <1% is achieved. | | Clock 3 | Reference clock for generating carrier frequency for active device. | Device 2b | A few [1] MHz | 10s ~ 100 uW | [1~5]% before calibration | After clock calibration based on sync signal, clock can achieve accuracy of [50]ppm. | |

#### Discussion (round 1)

Based on the submitted contributions in this meeting, companies provide their views on sampling frequency for the device.

* **On sampling frequency**: Majority views (e.g., Huawei/Hisilicon, CMCC, Samsung) propose 1.92 MHz, 1 company (vivo) considers 1.92 MHz for device 1 and 3.84 MHz for device 2, 1 company (Spreadtrum) considers 1.92 MHz for R2D and 300 kHz for D2R, and 1 company (Ericsson) considers a 32 kHz crystal oscillator with lower frequency error.
* **On SFO and drifting model**:
  + Some companies (e.g., Ericsson, Huawei/Hisilicon, CMCC, Qualcomm) considers that a single SFO assumption should be adopted for all device types in the link level simulation. On the other hand, other companies (e.g., ZTE, LGE, Lenovo) suggest different SFO assumptions for different device types.
  + Regarding the SFO value, Huawei/Hisilicon and Samsung propose to use 105 ppm, other companies propose to consider a value within a range, e.g., from 104~105 ppm. Meanwhile, Ericsson proposes a much lower initial clock error reusing that in TR 38.869.
  + Many companies (e.g., Huawei/Hisilicon, CMCC, ZTE, NTT DOCOMO) discuss the drifting model.
  + Some companies (e.g., Ericsson, Samsung, NTT DOCOMO) propose to study post synchronization sampling frequency offset.
* **On CFO and drifting model:** A few companies (e.g., Ericsson, ZTE, Qualcomm) also considers carrier frequency offset and drifting model for device 2b.

Based on the inputs, the following proposals are formulated.

**[H][****P3.5.4-1-v1]**

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| **Proposal**  In the link level simulation, consider the following assumptions on sampling frequency offset and timing drift model for device baseband processing,   * Sampling frequency is 1.92 Msps. * Initial sampling frequency offset (Fe) is between [104 ~ 105] ppm. FFS Fe. * The timing drift ΔT over a time T is modelled as ΔT = ±Fe \* T. |

**[H][P3.5.4-2-v1]**

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| **Proposal:**  In the link level simulation, consider one of the following carrier frequency offset and drifting model for device 2b:   * Option 1: Reuse CFO model defined in TR 38.869 (option 1 or 2 in Table 6.2-3) * Option 2: Reuse CFO model defined in TR 38.869 with new value for maximum CFO [> 200 and <1000] ppm, and frequency drifting rates [> 0.1] ppm/s. |

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| **Company** | **Comments** |
| Futurewei | Support **P3.5.4-1-v1** |
| Wiliot | We support Option 2, with a drift rate of 1000 ppm/s. |
| QC | Device needs slower clock which could be used for lower power operation, e.g., sleep, backoff, etc. For sampling, even lower clock could be used. The internal clock of running 1.92MHz does not necessarily mean that sampling rate should be equal to that. |
| OPPO | Regarding SFO value, we prefer different assumptions for different device types. For Device 1 or 2a the SFO is between 104 ~ 105 ppm, for Device 2b the SFO is between 103 ~ 104 ppm.  Regarding CFO value, we prefer Option 1. |

### [1b] ED bandwidth for R2D

#### Related Tdoc proposals

The proposals are summarized as follows:

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| **Source** | **Proposals** |
| Ericsson | Proposal 14 For R2D LLS, for RF-ED architecture, assume a 10-MHz bandwidth for the ED channel. For ZIF and IF-ED architectures, the channel bandwidth is assumed to be equivalent to the occupied bandwidth (i.e., transmission bandwidth plus potential guard band). |
| FUTUREWEI | ***Proposal 16: propose to use 20MHz for RF CBW.*** |
| Huawei, Hisilicon | ***Proposal 15: Remove the “RF CBW” in the row of [2B1] in the link budget template.***  ***Proposal 32: The reception bandwidth used for the evaluated channel is assumed to be set as follows.***   * ***For R2D link, the reception bandwidth equals the transmission bandwidth used for the evaluated channel*** * ***For D2R link, the reception bandwidth equals the occupied bandwidth used for the evaluated channel***   ***Proposal 42: The ED bandwidth is set to 1.92 MHz for the link-level simulation of the R2D link.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | FFS: ED bandwidth | 10 MHz | |
| vivo | Proposal 19: 20MHz ED bandwidth can be assumed for R2D receiver with RF-ED as starting point.  Proposal 20: The ED bandwidth for receiver with IF-ED should be slightly larger than the transmission bandwidth of R2D considering guard gap for frequency error. |
| CMCC | **Proposal 13-12:**   |  |  |  |  | | --- | --- | --- | --- | | **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** | | [2B1] | ~~FFS: RF CBW (Hz)~~  ED channel BW (MHz) | ~~FFS:~~   * ~~10MHz~~ * ~~20MHz~~ * ~~Other values~~   Refer to LLS assumptions  Note: The value is used for calculating the noise power | N/A |   **Proposal 17：**  **The corresponding changes for the LLS table are as follows,**   |  |  | | --- | --- | | **R2D specific parameters** | | | Transmission bandwidth | 180 kHz as baseline | | ~~FFS:~~ED bandwidth | * the ED channel bandwidth is needed for calculating the noise power,   + For RF-ED receiver, the ‘ED CBW’ is regarded as the device RF filter BW (e.g., 10-20MHz) which are used for calculating the noise power   + For IF receiver, the ‘ED CBW’ is regarded as the device IF filter BW which are used for calculating the noise power   + For ZIF receiver, the ‘ED CBW’ is regards as the device BB LBP BW which are used for calculating the noise power   + Note: the above is being referred as [2B1] for R2D link in link budget template.   The value is reported by companies. | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at [Y] kHz, reported by companies | |
| OPPO | **Proposal 11: Considering the values given in Table 1 of R1-2404868 for link budget calculation.**   |  |  | | --- | --- | | [2B1] RF CBW (Hz) | 20MHz if no RF filter (M); 10MHz if with RF filter (O) | |
| NTT DOCOMO | **Proposal 8: For link budget calculation, for the bandwidth for receiver for R2D, i.e., in row [2B] and [2B1] of link budget calculation table,**   * **Row [2B1] is removed** * **For RF-ED device as receiver, the Rx bandwidth is RF BPF bandwidth which corresponds to, e.g, CBW** * **For IF device as receiver, the Rx bandwidth is IF filter bandwidth which corresponds to, e.g, occupied bandwidth** * **For ZIF device as receiver, the Rx bandwidth is BB LPF bandwidth which corresponds to, e.g, occupied bandwidth** * **Note: The value is used for calculating the noise power** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | FFS: ~~RF-~~ED bandwidth | * [X MHz] | 10MHz | |
| Qualcomm | **Proposal 1: RAN1 to update excel sheet with above modifications from [1E] to [3A].**  **[2B] Bandwidth used for the evaluated channel**   * R2D   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference power for RFED/IF receiver is ED bandwidth.     - Companies to report assumed ED bandwidth   + Noise and interference power for ZIF receiver is the same as transmission bandwidth [1F]. * D2R   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference bandwidth is determined same as transmission bandwidth [1F].     - In this case, reader receiver is OFDM receiver which can perform FFT and remove noise in non-transmission bandwidth. * Recommend to replace 2B with noise and interference bandwidth.   **[2B1] FFS: RF CBW**   * R2D   + This may not be needed as long as 2B is properly defined. * D2R   + This may not be needed as long as 2B is properly defined.   **Proposal 18: Update table as follows.**   |  |  | | --- | --- | | **R2D specific parameters** | | | Transmission bandwidth | 180 kHz as baseline | | ED bandwidth | Companies to report | | RF/IF/BB filter | Companies to report – 3dB bandwidth , filter order | |

#### Discussion (round 1)

In the last meeting, the following items/parameters and assumptions for link budget calculation and link level simulation were discussed and still open for further study:

* In link budget template for R2D receiver: 1) [2B] Bandwidth used for the evaluated channel (Hz); 2) [2B1] FFS: RF CBW (Hz).
* In link level simulation assumption template for R2D: 1) FFS: ED bandwidth; 2) FFS: BB LPF.

From reviewing the submitted contributions in this meeting, as the above parameters are somehow related, companies provide their views either under link budget template or link level simulation assumption template. The views regarding RF CBW and ED bandwidth are summarized below.

* **On RF CBW**: Several companies (e.g., Huawei/Hisilicon, NTT DOCOMO, Qualcomm) propose to remove [2B1] RF CBW in the link budget template, as for devices with RF ED architecture, Budget-Alt 1 is used to determine the receiver sensitivity; while for devices with IF or ZIF ED architecture, such parameter can be equivalent to the bandwidth used for calculating the noise and/or interference power. Specifically, some companies (e.g., CMCC, Qualcomm) suggest that such assumptions can refer to the ED bandwidth in the link level simulation.
* **On ED bandwidth**:
  + Many companies understand the ED bandwidth is related to the receiver architecture (e.g., Ericsson, vivo, CMCC, Qualcomm). To be specific, for RF ED, the ED bandwidth is regard as the bandwidth of RF filter, for ZIF ED, the ED bandwidth is regard as the bandwidth of the BB filter, and for IF ED, some companies consider it the same as ZIF ED while some companies think that ED bandwidth of IF ED is regard as the bandwidth of IF filter. For RF ED architecture, assumptions such as 10 MHz and 20 MHz are proposed. For ZIF and/or IF ED architecture, assumptions using occupied bandwidth (i.e., transmission bandwidth plus guard RBs) or using IF/BB LPF bandwidth are proposed.
  + On the other hand, 1 company (Huawei/Hisilicon) considers the purpose of R2D LLS is to provide the link performance and therefore propose to use 1.92 MHz as the ED bandwidth in the link level simulation.

From FL’s understanding, the ED bandwidth is an important parameter to calculate the noise and/or interference power in the link level simulation, which are also FFS bullets in the agreement of SNR/CNR calculation. For devices with RF ED architecture, FL agrees that Budget Alt 1 is enough for coverage evaluation, but it should be noted that the link level simulation for R2D is also useful for RAN4 to evaluate coexistence of NR interferes AIOT reception. In this sense, it would be more appropriate to assume ED bandwidth with respect to different receivers. Therefore, the following proposal is formulated.

**[H][P3.5.5-v1]**

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| --- | --- | --- | --- | --- |
| **Proposal**  Update the ED bandwidth parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ ED bandwidth | ~~[X] MHz~~  The ED bandwidth is needed for calculating the noise power, which is referred as item [2B1] in link budget template for R2D link:   * For RF ED receiver, the ‘ED bandwidth’ is regarded as the device RF filter bandwidth. * For IF ED receiver, the ‘ED bandwidth’ is regarded as the device IF filter bandwidth. * For ZIF receiver, the ‘ED bandwidth’ is regards as the device BB filter (i.e., BB LPF) bandwidth.   FFS: The value(s) of ED bandwidth [X] MHz or it is reported by companies. | |

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| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| Huawei, HiSilicon | We can accept discuss ED bandwidth in LLS. But it is not preferred to clarified it is needed for calculating the noise power in a general way since coverage for RF-ED should not be used by calculation noise power. And the device may not have RF filter as an implementation choice. Thus we made the following suggestion:  The ED bandwidth is needed for LLS and can be used for calculating the noise power for Budget-Alt2~~, which is referred as item [2B1] in link budget template for R2D link~~:   * For RF ED receiver, the ‘ED bandwidth’ is regarded as the device RF ~~filter~~ bandwidth. * For IF ED receiver, the ‘ED bandwidth’ is regarded as the device IF filter bandwidth. * For ZIF receiver, the ‘ED bandwidth’ is regards as the device BB filter (i.e., BB LPF) bandwidth.   FFS: The value(s) of ED bandwidth [X] MHz or it is reported by companies. |
| QC | LLS is also used for RAN1 link performance evaluation. |

### [1c] BB LPF for R2D

#### Related Tdoc proposals

The proposals are summarized as follows:

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, Hisilicon | ***Proposal 41: The LPF bandwidth for the R2D receiver at device is set*** ***according to the transmission bandwidth of the R2D transmission.*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | FFS: BB LPF | [5]-order Butterworth filter with cutoff frequency at 90 kHz | |
| CMCC | **Proposal 17：**  **The corresponding changes for the LLS table are as follows,**   |  |  | | --- | --- | | **R2D specific parameters** | | | Transmission bandwidth | 180 kHz as baseline | | ~~FFS:~~ED bandwidth | * the ED channel bandwidth is needed for calculating the noise power,   + For RF-ED receiver, the ‘ED CBW’ is regarded as the device RF filter BW (e.g., 10-20MHz) which are used for calculating the noise power   + For IF receiver, the ‘ED CBW’ is regarded as the device IF filter BW which are used for calculating the noise power   + For ZIF receiver, the ‘ED CBW’ is regards as the device BB LBP BW which are used for calculating the noise power   + Note: the above is being referred as [2B1] for R2D link in link budget template.   The value is reported by companies. | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at [Y] kHz, reported by companies | |
| vivo | **Proposal 21: BB LPF with cutoff frequency >= 2\*R2D data rate can be assumed for LLS evaluation.** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | FFS: BB LPF | * [X]-order Butterworth filter with cutoff frequency at [Y] kHz | X=1  Y=90kHz | |
| Qualcomm | **Proposal 1: RAN1 to update excel sheet with above modifications from [1E] to [3A].**  **[2B] Bandwidth used for the evaluated channel**   * R2D   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference power for RFED/IF receiver is ED bandwidth.     - Companies to report assumed ED bandwidth   + Noise and interference power for ZIF receiver is the same as transmission bandwidth [1F]. * D2R   + Singal bandwidth is determined by transmission bandwidth [1F]   + Noise and interference bandwidth is determined same as transmission bandwidth [1F].     - In this case, reader receiver is OFDM receiver which can perform FFT and remove noise in non-transmission bandwidth. * Recommend to replace 2B with noise and interference bandwidth.   **Proposal 18: Update table as follows.**   |  |  | | --- | --- | | **R2D specific parameters** | | | Transmission bandwidth | 180 kHz as baseline | | ED bandwidth | Companies to report | | RF/IF/BB filter | Companies to report – 3dB bandwidth , filter order | |

#### Discussion (round 1)

Based on the submitted contributions in this meeting, companies’ views on BB LPF are provided. Many companies consider that the BB LPF cutoff frequency should be dependent on the R2D transmission bandwidth. In addition, some companies (e.g., CMCC, Qualcomm) point out that BB LPF bandwidth can refer to item [2B] in the link budget template.

Based on the inputs, the following proposal is formulated.

**[H][P3.5.6-v1]**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Proposal**  Update the BB LPF parameter in link level simulation table as follows:   |  |  | | --- | --- | | R2D specific parameters | | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at ~~[Y] kHz~~ half of R2D transmission bandwidth, i.e., 90 kHz as baseline.  Companies to report [X = 3, 5]. | |

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

### [1a] Transmission bandwidth for D2R

#### Related Tdoc proposals

The proposals are summarized as follows:

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, Hisilicon | ***Proposal 31: The D2R transmission bandwidth used for the evaluated channel is assumed to be 15 kHz (M) or 180 kHz (O).***  ***Proposal 32: The reception bandwi dth used for the evaluated channel is assumed to be set as follows.***   * ***For R2D link, the reception bandwidth equals the transmission bandwidth used for the evaluated channel*** * ***For D2R link, the reception bandwidth equals the occupied bandwidth used for the evaluated channel*** |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | Transmission bandwidth  (w.r.t. D2R data rate) | 15kHz | |
| vivo | **Observation 4: Transmission Bandwidth depends on the data rate and line code scheme assumed for PDRCH.**  **Observation 5: [2B] Bandwidth used for the evaluated channel for D2R at receiver side is used for noise power calculation rather than [1F] Transmission Bandwidth.**  **Observation 6: The transmission BW is further expanded if multiple single tone CW is used.**  **Proposal 5: Report {data rate, line code scheme, number of CW tones} for the D2R transmission, instead of reporting a BW value for [1F].** |
| LGE | ***Proposal 5: Consider transmission bandwidth of 180kHz as a baseline for D2R transmission*** |
| NTT DOCOMO | **Proposal 9: For link budget calculation, for the bandwidth for receiver for D2R, i.e., in row [2B] of link budget calculation table, the Rx bandwidth is occupied bandwidth which includes transmission bandwidth and guard band.**   * **Note: The value is used for calculating the noise power** * **The assumption of SSB/DSB should be discussed considering the assumption on SSB/DSB for Tx bandwidth for D2R.** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | Transmission bandwidth  (w.r.t. D2R data rate) | ~~15 kHz as baseline~~  ~~For Device 1 and 2a, 15 kHz as baseline~~  ~~For Device 2b, [180] kHz as baseline~~   * [FFS: 15kHz, 180kHz] | 15kHz (a single tone of OFDM) | |
| Qualcomm | **Proposal 1: RAN1 to update excel sheet with above modifications from [1E] to [3A].**  **[1F] Transmission Bandwidth used for the evaluated channel (Hz)**   * D2R   + 15\*2kHz, 180\*2kHz (for DSB)   + 15kHz, 180kHz (for SSB)   + Note: Other values can be optionally evaluated. This is only for evaluation purpose.   **Proposal 19: Include both 15kHz and 180kHz.**   |  |  | | --- | --- | | Transmission bandwidth  (w.r.t. D2R data rate) | 15kHz, 180kHz | |

#### Discussion (round 1)

For D2R link level simulation, the concept regarding transmission bandwidth should be further clarified and aligned. The transmission bandwidth is initially defined from the transmission side, i.e., the device side, which means how much frequency domain resources are used for the device to backscatter or transmit D2R transmissions. Generally, the transmission bandwidth should be used to calculate the noise and interference (if any) power at the receiver side, because both transmitter side and receiver side see the same thing. But in Ambient IoT D2R, the bandwidth from transmitter side and receiver side may not the same. Another issue is that for the transmission bandwidth from device side, we need to further clarify whether single sideband or double sideband is assumed, and with or without small frequency shifting.

To clarify these issues, a figure is shown below for the sake of explanation:

* From device perspective, companies understanding on the frequency domain resources used for D2R transmission should be aligned.
  + First, for device 1 and device 2a which backscattering D2R transmissions, it is noticed that it may not be feasible to generate SSB spectrum, and DSB should be assumed.
  + Consider the case without small frequency shifting, suppose that the line coded chip rate is 7.5 kHz (this is related to at least the data rate, whether repetition is used, and the coding scheme), which indicates that in baseband, the SSB spectrum is 7.5 kHz, and the DSB spectrum is 15 kHz.
  + Consider the case with small frequency shifting (square wave modulation in RFID is considered), suppose that the backscatter link frequency is 480 kHz, i.e., the line coded chip rate is multiplied by 64 times, then the transmission signals appear at frequency locations at +/- 480 kHz, therefore the total transmission bandwidth is 15 kHz \*2 = 30 kHz.
* From reader perspective, the reader will use baseband filter to filter out the D2R transmissions. The reception bandwidth here is at least related to the following factors:
  + The baseband filter capability.
  + With or without small frequency shifting.
  + The reader implementation on which part of the received signal is filtered out (single side or double side).
  + The guard RBs considering the frequency domain offset due to e.g., device’s SFO.

For example, considering the case without small frequency shifting, the reader filters out 15 kHz DSB spectrum, suppose that SFO is 105 ppm, the distortion would be at most +/- 1.5 kHz, the reception bandwidth is 18 kHz. Considering another case with small frequency sifting with BLF = 480 kHz, the reader filters out both sides of the received signals, i.e., 30 kHz, again, with 10% SFO, the distortion would be at most +/- 49.5 kHz for each side, the reception bandwidth in total is 228 kHz.



Based on the above analysis, the following proposals are formulated.

**[H][P3.5.7-1-v1]**

|  |
| --- |
| **Proposal**  In the link level simulation, consider report the following assumptions,   * D2R transmission bandwidth * D2R [OOK/BPSK/BFSK chip rate] * D2R reception bandwidth   For D2R transmission bandwidth, the following alternatives for considered and target to down-select to one alternative,   * **[1a]-Alt1-1:**    + DSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is 2X kHz (M) and 2Y kHz (O). * **[1a]-Alt1-2:**    + DSB   + Alt. 1-1 with SFS   + The total transmission bandwidth is 4X kHz (M) and 4Y kHz (O). * **[1a]-Alt2-1:**    + DSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for two sidebands, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O). * **[1a]-Alt2-2:**    + DSB   + Alt. 2-1 with SFS.   + The total transmission bandwidth is 2X kHz (M) and 2Y kHz (O). * **[1a]-Alt3:**    + SSB   + X kHz (M) and Y kHz (O) is considered for D2R transmission bandwidth without SFS.   + The value is for one sideband, i.e., the total transmission bandwidth for DSB is X kHz (M) and Y kHz (O). * The value of X and Y is as follows,   + Alternative 1:     - X = 15     - Y =180   + Alternative 2:     - X and Y reported by companies,       * the value may be related to, e.g.,         + Reference data rate         + Coding scheme         + Repetition         + With or without SFS         + SSB or DSB * Note: The transmission bandwidth is the frequency domain resources used for a device for D2R transmissions (exclude guard band). * Note:   + SFS stands for small frequency shift   + SSB stands for single sideband and DSB stands for double sideband   For D2R [OOK/BPSK/BFSK chip rate], it is reported by companies.  For D2R reception bandwidth is the bandwidth used at the reader side to filter out the D2R signals for calculating noise and interference (if any) power.   * Assume the receiver matches the transmitter's modulation: SSB for SSB, DSB for DSB. * Companies to report the value. |

**[H][P3.5.7-2-v1]**

|  |
| --- |
| **Proposal**  Update the link level simulation table as follows:  *<Editor’s Note: will be updated after the previous proposal is agreed>* |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei, HiSilicon | We are supportive of Alt2-1, and for Alt 2-2 we think it still remains same X and Y as Alt2-1 |
|  |  |
|  |  |

### [3b] SNR/CNR calculation

#### Related Tdoc Proposals

The proposals are summarized as follows:

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Nokia | **Observation 3: When the receiver bandwidth (e.g. ED channel BW) is not matched to the transmission bandwidth, the received signal power is not SNR ⨉ (receiver bandwidth).**  **Proposal 8: Receiver sensitivity calculation must take into account the difference between the transmission bandwidth and the receiver channel bandwidth if LLS result is used as input.** |
| Samsung | Observation 4. The current definition of CINR/CNR for R2D still contains ambiguities regarding the definition of signal power.  Proposal 3. CINR/CNR for R2D should be defined using Option 1 to ensure that all evaluations are based on uniform criteria:   * Option 1: Both signal power and noise are calculated over only the ON duration of OOK signal.   Observation 5. The modulation factor may or may not be independent of the modulation scheme, depending on the definition of CINR/CNR.  **Proposal 4.** For D2R transmission, CINR/CNR should be defined such that both signal power and noise are calculated only over the duration when the signal is actually transmitted; specifically, the ON duration for OOK and the entire duration for BPSK. |
| CATT | **Proposal 16: In link level simulation for A-IoT, both R2D and D2R SNR should be considered for dual link, the** **SNR calculation is the direct calculation of the Tx power from the A-IoT device over the noise.** |
| CMCC | **Proposal 17:**  **For the R2D LLS, report followings (as start point).**   * **CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth.** * **Signal transmission bandwidth** * **ED channel bandwidth** * **BB LPF** * **the ED channel bandwidth is needed for calculating the noise power,**   + **For RF-ED receiver, the ‘ED CBW’ is regarded as the device RF filter BW (e.g., 10-20MHz) which are used for calculating the noise power**   + **For IF receiver, the ‘ED CBW’ is regarded as the device IF filter BW which are used for calculating the noise power**   + **For ZIF receiver, the ‘ED CBW’ is regards as the device BB LBP BW which are used for calculating the noise power**   + **Note: the above is being referred as [2B1] for R2D link in link budget template.** * **The BB LPF is reported by companies and is being referred as [2B] for R2D link in link budget template.**   **For the R2D LLS, the SNR/SINR calculation in the transmission bandwidth can be used and reported by companies.**  **The corresponding changes for the LLS table are as follows,**   |  |  | | --- | --- | | **R2D specific parameters** | | | Transmission bandwidth | 180 kHz as baseline | | ~~FFS:~~ED bandwidth | * the ED channel bandwidth is needed for calculating the noise power,   + For RF-ED receiver, the ‘ED CBW’ is regarded as the device RF filter BW (e.g., 10-20MHz) which are used for calculating the noise power   + For IF receiver, the ‘ED CBW’ is regarded as the device IF filter BW which are used for calculating the noise power   + For ZIF receiver, the ‘ED CBW’ is regards as the device BB LBP BW which are used for calculating the noise power   + Note: the above is being referred as [2B1] for R2D link in link budget template.   The value is reported by companies. | | ~~FFS:~~ BB LPF | [X]-order Butterworth filter with cutoff frequency at [Y] kHz, reported by companies |   **…**   |  | | --- | | Note:   -       ~~Companies to report required SINR according to BLER target.~~  R2D LLS, report followings (as start point).   * CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth.   For the R2D LLS, the SNR/SINR calculation in the transmission bandwidth can be used and reported by companies. | |
| ZTE | ***Proposal 11: For the R2D LLS of ZIF receiver and D2R LLS, report followings:***   * ***CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and/or interference (if any) power spectral density in the receiver RF channel bandwidth.***   + ***Signal transmission bandwidth***   + ***ED channel bandwidth*** |
| MediaTek | **Proposal 6: For RF-ED and IF-ED, the bandwidth of the RF-BPF and IF filter could be regarded as the ED channel bandwidth, respectively.**  **Proposal 7: For R2D ZIF receiver and D2R, support SNR/SINR as the output of the LLS.** |
| Qualcomm | **Proposal 20: Envelope detector (ED) bandwidth is determined as follows.**   * **For RF ED/IF receiver: bandwidth within which interference and noise is considered to the input of ED** * **For ZIF receiver: same as signal transmission bandwidth** |
| Comba | **Proposal 3: SINR is defined as the ratio of signal power received in the transmission bandwidth to the noise and interference power received in the device RF channel bandwidth.** |

#### Discussion (round 1)

In RAN1#116bis, the following is agreed,

|  |
| --- |
| Proposal#5 (V05r1)  For the R2D LLS for ED, ~~the following is considered as start point,~~ report followings (as start point).   * CINR/CNR~~in LLS~~, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and~~/or~~ interference (if any) power spectral density in the device ED channel bandwidth. * signal transmission bandwidth * ED channel bandwidth   FFS: exact definition of ED channel bandwidth for RF-ED, IF, ~~ZIF~~ receiver  FFS: which and how to report for R2D ZIF receiver and D2R |

From reviewing the contributions submitted in this meeting, companies provide views on remaining issues of CNR or SNR calculation.

* On the exact definition of ED channel bandwidth for RF-ED and IF-ED receiver, it is highly related to the discussion on ED bandwidth and views are summarized in Section 3.5.5.
* On which and how to report for R2D ZIF-ED receiver, companies views are also shared in Section 3.5.5, where the CNR/CINR considers the BB LPF bandwidth, i.e., related to the R2D transmission bandwidth.
* On which and how to report for D2R, several companies (e.g., CMCC, MediaTek) propose to use SINR/SNR in the transmission bandwidth.
* In addition, 1 company (Samsung) points out that the current definition of CNR or SNR is ambiguous for different modulation schemes. Samsung suggests clarifying that in case of OOK modulation is used, whether the signal power and noise power are calculated only over the duration of OOK ON chips or are calculated over the durations of both OOK ON and OFF chips. Samsung prefers the former.

Regarding the exact definition of ED bandwidth for RF-ED, IF-ED receiver, and definition regarding R2D ZIF receiver, the discussion is handled in Section 3.5.5 and Section 3.5.6.

Regarding the issue raised by Samsing, in FL’s views, considering OOK modulation, the noise and interference (if any) always exist at the reader side no matter it is ON chip or OFF chip, by calculating noise power only over the durations of ON chips, it artificially improves the performance of modulation and coding schemes with shorter ON durations and the comparison seems unfair.

Based on the inputs, the following proposal is formulated to update SNR/CNR calculation for D2R LLS part.

**[H][P3.5.8-v1]**

|  |
| --- |
| **Proposal**   * For the D2R LLS, the SINR/SNR is reported and it is defined as the ratio of signal power to noise and interference (if any) power in the transmission bandwidth. |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| Xiaomi | OK |
| QC | ok |

### [2j] D2R receiver

#### Related Tdoc proposals

From reviewing the submitted contributions in this meeting, a few companies provide their views on the D2R receiver, in which most companies suggest using coherent receiver for better link performance. The proposals are summarized as follows:

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| Huawei, Hisilicon | ***Proposal 46: The study uses the assumptions in Table 1 for link-level simulations.***   |  |  | | --- | --- | | D2R receiver | Coherent receiver | |
| Spreadtrum | ***Proposal 9: Table 4 is adopted for LLS parameters and values of coverage evaluation.***   |  |  | | --- | --- | | D2R receiver | coherent receiver | |
| ZTE | ***Proposal 14: Consider the following assumptions in the LLS:***   * ***R2D/D2R message size: 16, 96 bits*** * ***D2R receiver: coherent receiver*** |
| MediaTek | |  |  |  | | --- | --- | --- | | **Parameters** | **Assumptions** | **MTK assumptions** | | D2R receiver | * FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver | Non-coherent receiver | |

#### Discussion (round 1)

Coherent detection are proposed by many companies (Huawei/Hisilicon, Spreadtrum, ZTE), while one company (MTK) proposes to use non-coherent receiver. Considering the reader generally can perform more complex processing than device. Based on the inputs, the coherent receiver is formulated.

**[H][P3.5.9-v1]**

|  |
| --- |
| **Proposal**  In the link level simulation, coherent receiver is considered for D2R receiver. |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Support |
| QC | ok |
|  |  |

### [1j] Detection/decoding method for line code

#### Related Tdoc Proposals

Based on the submitted contributions in this meeting, a few companies discuss examples on decoding algorithm for R2D data reception, so that further alignment can be pursued on the link level evaluation. The proposals are summarized as follows:

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| CATT | **Proposal 3: The performance of RF envelope detection should be considered in the modelling of signal detection algorithm of receiver.** |
| CMCC | **Proposal 18: Timing based Manchester decoding approach by capturing ascending/descending edges is adopted for link level performance evaluation.** |
| OPPO | **Proposal 16: Detecting ascending/descending edges is considered as the baseline approach for timing based OOK Manchester/PIE decoding.** |
| MediaTek | **Proposal 4: Consider the Manchester coding for estimating sampling frequency offset and timing offset.**   |  |  |  |  | | --- | --- | --- | --- | | **Parameters** | | **Assumptions** | **MTK assumptions** | | Detection/decoding method for Line code | Companies to report | | * Average samples and then compare the ON/OFF in OOK duration if SFO is not present * Detecting ascending/descending edge of OOK if SFO is considered | |

#### Discussion (round 1)

In the last meeting, it has been agreed up to companies to report the detection/decoding method for line code.

Note that Ambient IoT devices may not be feasible to perform average operation among multiple samplings, the simplest and most power efficient approach should be the rising/falling edge detection, which is robust to the impact of SFO on R2D reception. In this sense, FL thinks that it would be good to encourage companies to consider such detection/decoding method.

Therefore, the following proposals are formulated:

**[M][P3.5.10-v1]**

|  |
| --- |
| **Proposal**  Companies are encouraged to consider the approach for detecting ascending or descending edges for OOK based line coding for R2D in the link level simulation. |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Futurewei | Ok |
| QC | This is implementation issue. Companies can report. |
|  |  |

### Other assumptions

#### Related Tdoc Proposals

|  |  |
| --- | --- |
| **Source** | **Proposals** |
| CATT | **Proposal 3: The performance of RF envelope detection should be considered in the modelling of signal detection algorithm of receiver.**  **Proposal 1: Interrogation signals from transmitter node in A-IoT should be modeled in the evaluation, including signal generation, waveform & modulation, channel coding, signal spreading and beamforming.**  **Proposal 2: The modelling of TTI for A-IoT with alignment to NR legacy slot, mini-slot or OFDM symbol boundary should be considered.**  **Proposal 7: Demodulation algorithm corresponding to ASK, PSK, FSK and decoding algorithm for channel coding should be considered in reader reception node modelling.**  **Proposal 8: In the reader reception node modelling, information correction and decision algorithm (e.g., decision matrix**) **should be considered.** |
| CMCC | **Proposal 19: Add one line in D2R specific parameter to clarify the reader's sampling frequency.**   |  |  | | --- | --- | | **D2R specific parameters** | | | **Reader Sampling frequency** | 30.72Msps | |
| Qualcomm | **Proposal 22: For link level evaluation, RAN1 adopt following envelop detection ED model with squaring operation of input signal followed by low pass filtering as below.**  A black background with a black rectangle and two squares  Description automatically generated  **Proposal 23: RAN1 to adopt the practical comparator model captured in Table 4 for link evaluation.**  Table 4 Practical comparator’s input output relation [22]   |  |  | | --- | --- | | Model | Output | | Practical | # | |  | | : probability of high level output | |   **Observation 6: Devices in practice could have rx power lower than sensitivity yet has higher SNR than required SNR.**  **Observation 7: SNR vs BER/BLER curves could be valid with some SNR shifts only for devices with rx power higher than sensitivity.** |
| NEC | **Observation 3: Different stages of the logistics or inventory management operations (like unloading, gate-in inventory, gate-out inventory, check and loading) require a reader to poll a response from any IoT device within its communication range. This may lead to a reader receiving interfering UL transmissions from multiple IoT devices within its range.**  **Observation 4: When a reader receives interfering UL transmissions from multiple IoT devices, a successful UL reception can be considered when the reader is able to decode UL transmission from the IoT device which is closest to the reader and within the coverage of the reader’s Rx beam (i.e. IoT device which experiences lowest path loss).**  **Proposal 4: Study the performance of the case where a reader using backscatter communication receives interfering UL transmission from multiple IoT devices within its range.**  **Observation 5: For the scenarios which require deployment of large number of IoT devices (e.g. automobile manufacturing), a reader may experience high CLI in receiving UL transmission from an IoT device due to interfering DL transmission(s) from nearby reader(s)**  **Proposal 5: Investigate the CLI for receiving backscatter UL transmission for the scenario where a large number of IoT devices and readers are deployed within a manufacturing site.** |
| LGE | ***Proposal 6: RF-EH should be considered for link level simulation assumption*** |
| MediaTek | **Proposal 1: Evaluate synchronization performance related to preamble design.**  **Proposal 2: Evaluate CDF of timing error or residual SFO after synchronization for a given preamble design**  **Proposal 3: Evaluate detection performance regarding residue timing error, e.g., after synchronization by preamble** |

#### Discussion (round 1)

Based on reviewing contributions submitted in this meeting,

* CMCC proposes to clarify the sampling frequency at reader side.
* Qualcomm discusses that since envelop detection receiver would be a good candidate for all device types, therefore, the envelop detector model is proposed to be considered in the link level simulation. CATT also proposes to consider the modelling of RF envelope detection method.
* MediaTek Proposed the followings
* Evaluate synchronization performance related to preamble design
* Evaluate CDF of timing error or residual SFO after synchronization for a given preamble design
* Evaluate CDF of timing error or residual SFO after synchronization for a given preamble design

Qualcomm discusses a realistic comparator model considering comparator bias and ambiguity is proposed to reflect the phenomenon that the operating SNR of Ambient IoT devices restricted by the activation threshold or sensitivity is much higher compared to typical SNR values.

Based on the inputs, the following proposal is formulated, and companies are encouraged to provide views on the added assumptions.

**[M][P3.5.11-v1]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Proposal**  Update the link level simulation table by adding the following rows:   |  |  | | --- | --- | | **R2D specific parameters** | | | Envelop detection model | Envelop detection model is with squaring operation of input signal followed by low pass filtering as below.  A black background with a black rectangle and two squares  Description automatically generated | | Practical comparator model | Use the practical comparator model in the following table in link level simulation.  Table: Practical comparator’s input output relation [22]   |  |  | | --- | --- | | Model | Output | | Practical | # | |  | | : probability of high level output | | | | **D2R specific parameters** | | | Reader sampling frequency | 30.72Msps | |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Support ED model. |
|  |  |
|  |  |

### Overall Link level simulation assumption

**Table 3.5.12 Summary of views of LLS assumptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Parameters** | | **Assumptions** | **Proposals/Views** |
|  | **R2D/D2R common parameters** | | |  |
| **[0a]** | Carrier frequency | | Refer to link budget template |  |
| **[0b]** | SCS | | 15 kHz as baseline |  |
| **[0c]** | Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |  |
| **[0d]** | Channel model | | Agreement  In the link level simulation, considering the following channel model,   * For D1T1, TDL-A channel model is used for R2D link and for D2R link for InF-DH scenario. * For D2T2,   + TDL-A channel model is used for R2D link and for D2R link if InF scenario is considered   + TDL-D channel model is used for R2D link and for D2R link if InH-Office scenario is considered   FFS delay spread for each case. |  |
| **[0e]** | Delay spread | | [30, 150] ns | * 39 ns [Futurewei] * 20 ns [HW, TDL-D] * 150 ns [HW, TDL-A], [CATT, TDL-A], [CTC, TDL-A], [CMCC, O], [Qualcomm, O] * 30 ns [Spreadtrum, TDL-A], [Samsung, TDL-A], [CATT, TDL-D], [CTC, TDL-D], [CMCC, M], [Qualcomm, M], [Comba, TDL-A] |
| **[0f]** | Device velocity | | 3 km/h |  |
| **[0g]** | Number of Tx/Rx chains for Ambient IoT device | | 1 |  |
| **[0h1]** | BS | Number of antenna elements | 1 [Futurewei], [Spreadtrum], [MediaTek] |  |
| **[0h2]** | Number of TXRUs | 1 [Futurewei], [Spreadtrum], [Samsung], [MediaTek] |  |
| **[0j1]** | Intermediate UE | Number of antenna elements | 1 [Futurewei], [Spreadtrum], [Samsung], [MediaTek] |  |
| **[0j2]** | Number of TXRUs | 1 [Futurewei], [Spreadtrum], [Samsung], [MediaTek] |  |
| **[0m]** | Reference data rate | | [0.1, 1, 5] kbps | * 14 kbps [Futurewei], [MediaTek, D2R and R2D M=2] * 0.1 kbps [HW, M], [Samsung], [CTC] * 1 kbps [HW, O], [CTC], [Comba] * 5 kbps [Spreadtrum, D2R], [Samsung], [CTC] * 7 kbps [Spreadtrum, R2D], [MediaTek, R2D M=1] * 28 kbps [MediaTek, R2D M=4] |
| **[0n]** | Message size | | * D2R:   + [FFS: 16, 96, 400 bits] * R2D:   + [FFS: 16, 32, 64, 400bits] | * D2R:   + 16 bit [Futurewei], [HW], [Spreadtrum], [Samsung], [ZTE], [Qualcomm], [Comba]   + 32 bit [Comba]   + 96 bit [Futurewei], [HW], [ZTE], [MediaTek], [DCM], [Qualcomm], [Comba]   + 400 bit [Ericsson], [HW], [Samsung], [Qualcomm] * R2D:   + 16 bit [Futurewei], [HW], [Spreadtrum], [ZTE], [Qualcomm]   + 32 bit [Qualcomm], [Comba]   + 64 bit [MediaTek], [Qualcomm]   + 96 bit [Futurewei], [HW], [ZTE], [DCM], [Comba]   + 400 bit [Ericsson], [HW], [Qualcomm] |
| **[0p]** | BLER target | | 1%, 10% | * 1% [Comba] * 10% [vivo] |
| **[0q]** | Sampling frequency | | <Editor’s Note: will be updated according to the agreements made forSampling frequency> | * 1.92 MHz [HW], [Spreadtrum, R2D], [CMCC], [MediaTek] * 300 kHz [Spreadtrum, D2R] |
| **[0r]** | Device 1/2a/2b | | Options are as follows,   * Device 1, RF-ED * Device 2a, RF-ED * Device 2b, RF-ED/IF-ED/ZIF   <Editor’s Note: will be updated according to agreements from 9.4.1.2> |  |
|  | **R2D specific parameters** | | |  |
| **[1a]** | Transmission bandwidth | | 180 kHz as baseline | * 10 MHz [Ericsson, for RF ED architecture], [Spreadtrum], [MediaTek] * 20 MHz [Futurewei] * 1.92 MHz [HW], [Nokia] * Occupied BW [Ericsson, for IF/ZIF ED architecture] |
| **[1b]** | FFS: ED bandwidth | | [X MHz] | * [3, 5]-order RC filter with cutoff frequency at half of the transmission bandwidth [HW] * [5]-order Butterworth filter with cutoff frequency at 90 kHz [Spreadtrum] * 1-order Butterworth filter with cutoff frequency at 90 kHz [MediaTek] |
| **[1c]** | FFS: BB LPF | | [X]-order Butterworth filter with cutoff frequency at [Y] kHz |  |
| **[1d]** | Waveform | | OOK waveform generated by OFDM modulator |  |
| **[1e]** | Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |  |
| **[1f]** | Line code | | Companies to report, e.g., Manchester, PIE |  |
| **[1g]** | FEC | | No FEC as baseline |  |
| **[1h]** | ADC bit width | | 1-bit for device 1  4-bit for device 2 |  |
| **[1j]** | Detection/decoding method for Line code | | Companies to report |  |
|  | **D2R specific parameters** | | |  |
| **[2a]** | Transmission bandwidth (w.r.t. D2R data rate) | | [FFS: 15kHz, 180kHz] | * 180 kHz [Futurewei], [HW, O], [LGE, baseline], [Qualcomm] * 360 kHz [Futurewei] * 15 kHz [HW, M] [Spreadtrum], [Qualcomm], [MediaTek], [Comba] |
| **[2b]** | Waveform (CW) | | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |  |
| **[2d]** | Modulation | | Companies to report modulation, e.g., OOK, BPSK, BFSK |  |
| **[2e]** | Line code | | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |  |
| **[2g]** | FEC | | Companies to report, e.g., CC, No FEC |  |
| **[2h]** | ADC bit width | | Companies to report, e.g., 11-bit |  |
| **[2j]** | D2R receiver | | FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver | * Coherent receiver [HW], [Spreadtrum], [ZTE], * Non-coherent receiver [Samsung], [MediaTek] |
|  | **Other assumptions** | | |  |
| **[3a]** | Other assumptions | | * Receiver sampling frequency = 30.72 MHz [CMCC] * Envelop detector model [CMCC], [Qualcomm]   Practical comparator model [Qualcomm] |  |
| **[3b]** | Note: Companies to report required SINR according to BLER target. | | | Note:  R2D LLS, report followings (as start point).   * CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and interference (if any) power spectral density in the device ED channel bandwidth. * For the R2D LLS, the SNR/SINR calculation in the transmission bandwidth can be used and reported by companies.   [CMCC] |

#### Discussion (round 1)

From reviewing the submitted contributions in this meeting, many companies propose or provide views on the overall link level simulation assumptions, which is summarized in Table 3.5.12 in section 3.5.12.

The link-level simulation table will further be updated depending on the discussion of section 3.5.1 to section 3.5.11.

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| **Company** | **Comments** |
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## Others

### Coexistence

#### Related Tdocs

|  |  |
| --- | --- |
| CATT | **Proposal 21: RAN1 should qualitatively analyse the effect of different frequency deployment modes for A-IoT coexistence evaluation.** |
| CATT | **Proposal 22: Spectrum utilization, inter-channel interference with NR signals should be considered in both in-band and guard band deployment scenarios.** |
| Lenovo | ***Proposal 10: Study the Ambient IoT communication in the NR standalones and NR/LTE guard bands with duplexing spacing of < 2MHz between FDD-DL and FDD-UL frequency for Ambient IoT DL and UL communication.*** |
| MediaTek | **Proposal 13: Regarding co-existence and interference evaluation, the corresponding study in RAN1 is not precluded.** |
| OPPO | [Proposal 17: Co-existence evaluation is conducted by RAN4 based on the input on evaluation assumptions from RAN1.](#_Toc166247516) |
| OPPO | [Proposal 19: Evaluation assumptions in Table 2 of R1-2404868 should be provided to RAN4 for the evaluation of co-existence.](#_Toc166247518) |
| OPPO | [Proposal 20: The A-IoT transmission bandwidth, transmission power, assumed guard-band size, and filtering capability of A-IoT devices should be provided to RAN4 for co-existence evaluation.](#_Toc166247519) |
| Spreadtrum | ***Proposal 10: Support coexistence evaluation for spectrum deployment in-band to NR, in guard-band to LTE/NR, in standalone band(s).*** |
| Spreadtrum | ***Proposal 11: The interference between A-IoT link and NR legacy Uu link needs to be analyzed for coexistence evaluation.*** |
| Spreadtrum | ***Proposal 12: The impact of CW on A-IoT D2R reception and NR UL reception needs to be considered in coexistence evaluation.*** |
| Xiaomi | ***Proposal 5: The evaluation cases illustrated in Table 3/4/5 can be considered for the co-existence evaluation.*** |
| Xiaomi | ***Proposal 6: The ACLR, ACS, ACIR or SINR degradation can be used as the metrics for the co-existence evaluation*** |
| vivo | **Observation 8: If option-2 SINR degradation is used as metric for co-existence evaluation in RAN4, RAN1 may not need to provide LLS results to RAN4.**  **Observation 9: Given budget-Alt1 is used for coverage evaluation, which does not require LLS, it is not clear whether the SINR-BLER mapping results from LLS in RAN1 would be convergent and useful to RAN4 co-existence evaluation, especially for R2D with RF-ED.** |

#### Discussion (round 1)

* **Co-existence evaluation** 
  + RAN1
    - CATT, MediaTek recommends the corresponding study in RAN1 is not precluded regarding co-existence and interference evaluation.
    - CATT Proposal 22: Spectrum utilization, inter-channel interference with NR signals should be considered in both in-band and guard band deployment scenarios.
    - However, OPPO thinks co-existence evaluation is conducted by RAN4
* **Coexistence assumptions**
  + - OPPO recommends that RAN1 provide evaluation assumptions and specific A-IoT technical parameters to RAN4 for conducting the coexistence evaluation.
* **Coexistence Cases**
  + - Xiaomi Proposal 5: The evaluation cases illustrated in Table 3/4/5 can be considered for the co-existence evaluation.
    - Spreadtrum: The interference between A-IoT link and NR legacy Uu link and impact of CW on A-IoT D2R reception and NR UL reception should be considered in coexistence evaluation

During the April RAN1 post-meeting email discussion, the followings are discussed but not agreed,

**Proposal#1  (V05r1)**

**Conclusion:**

RAN1 can inform RAN4 ~~can refer to~~scenarios, system parameters, link~~[/system]~~level simulation assumptions and companies’ evaluation results (for RAN1 design evaluation if any), if needed, including e.g., BLER target and its corresponding required SNR, sensitivity for ~~both~~[FFS: EH,] R2D and D2R link.

RAN4 is conducting coexistence evaluation, which will involve conducting a system level simulation (SLS) to assess the SINR, received power and etc. In light of RAN1’s upcoming link level simulation (LLS) for A-IoT, the feature lead recommends that RAN4 focuses on the SLS for coexistence evaluation while RAN1 proceeds with the ongoing evaluation and provide information and ask for feedback if any.

#### [H][Proposal-3.7.1 -coex-v1]

|  |
| --- |
| **Conclusion:**  RAN1 can inform RAN4 scenarios, system parameters, link level simulation assumptions and companies’ evaluation results (for RAN1 design evaluation if any), if needed, including e.g., BLER target and its corresponding required SNR/CNR, sensitivity for [FFS: EH,] R2D and D2R link. |

|  |  |
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| **Company** | **Comments** |
| Xiaomi | OK |
|  |  |
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### Evaluation results

Input general comments here

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| **Company** | **Comments** |
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#### Coverage results

##### Related Tdoc Proposals

[Ericsson, Tejas Networks,Nokia,Huawei,Spreadtrum,Samsung,Apple,CATT,CMCC, Sony, ZTE, xiaomi, Lenovo, InterDigital, MTK, Comba, IIT Kanpur, IITM] provide their link budget calculation results for different links, scenarios, device types and different CW cases and some initial observations are made.

|  |  |
| --- | --- |
| Source | proposal |
| Ericsson | Observation 10: Based on our coverage evaluation results, the coverage distance is less than 10 m for the following cases:   * Device1: (R2D in D2T2), (D2R in all cases except D1T1-A1 case 1-1, D1T1-B and D2T2-B case 2-3), * Device 2a: (D2R in D2T2-A2, case 2-2)   Observation 11: Based on our coverage evaluation results, the D2R and R2D coverage distances of the Device 2b are better than those of the Device 1 and Device 2a in all cases. Also, the coverage distances of the Device 2a are larger than the corresponding coverage distances of the Device 1. |
| Tejas Networks Limited | **Observation 1: For D1T1-A1 (CW inside topology, bistatic), considering 33 dBm transmit power and -20 dBm receiver sensitivity for both PRDCH and CW2D, and -100 dBm receiver sensitivity for PDRCH (using *budget Alt-1*), the maximum distance d1 from Reader R1 to Device D is 7.6 m for downlink transmission and the maximum distance d2 from Device to Reader R2 is 33.5 m for uplink transmission.**  **Observation 2: For D1T1-A2 (CW inside topology, monostatic), considering 33 dBm transmit power and -20 dBm receiver sensitivity for both PRDCH and CW2D, and -100 dBm receiver sensitivity for PDRCH (using *budget Alt-1*), the maximum distance d from Reader R to Device D (same as Device to Reader) is 7.6 m for both downlink transmission and uplink transmission.**  **Observation 3: For D1T1-B (CW outside topology, monostatic), considering 33 dBm and 23 dBm transmit power for PRDCH and CW2D, respectively, -35 dBm and -20 dBm receiver sensitivity for PRDCH and CW2D, respectively, and -100 dBm receiver sensitivity for PDRCH (using *budget Alt-1*), the maximum distance D from Reader R to Device D (same as Device to Reader) is 33.5 m for both downlink transmission and uplink transmission. The CWT should be kept at 1.4 m distance from the Device to receive minimum signal power of -20 dBm.**  **Proposal 1: The maximum achievable distance between CW transmitter and Device should be decided based on the Device activation threshold, which is considered as the read sensitivity or receiver sensitivity for PRDCH and CW2D reception. Considering a fixed CW2D distance for CW inside topology limits the coverage between Reader and Device as the Reader itself transmitting the CW signal to the Device.**  **Observation 4: For D1T1-A1, the maximum distance d1 from Reader R1 to Device D increases with transmit power, whereas, the maximum distance d2 from Device to Reader R2 is fixed.**  **Observation 5: For D1T1-A2, the maximum distance from Reader to Device D (same as D to R, same as CWT to D) increases with transmit power and then decreases due to the increase in remaining interference (2I in Table 1) due to CW transmission.**  **Observation 6: For D1T1-B, the maximum distance is the minimum of PRDCH and PDRCH (monostatic scenario), which increases with transmit power and then saturates. The CWT is kept at a fixed distance of 1.4 m to receive the minimum power of -20 dBm at the Device side.**  **Proposal 2: A suitable transmit power from the Reader (base station) should be chosen to achieve the maximum coverage that satisfies all the distances for the physical channels PRDCH, PDRCH, and CW2D.**  **Observation 7: In case of D1T1-A1, with decreasing Device activation threshold, the maximum distance d1 increases, as the Device read sensitivity increases and d2 decreases, as the Device transmit power decreases.**  **Observation 8: In case of D1T1-A2, with decreasing Device activation threshold, the maximum distance for PRDCH and CW2D increases and PDRCH decreases. As it is a monostatic, the final distance is the minimum among all. Thus, the final maximum distance between the Reader/CWT and Device increases up to certain value and then decreases.**  **Observation 9: In case of D1T1-B, the maximum distance for PRDCH is fixed as the receiver sensitivity is kept fixed (-35 dBm). However, the distance for PDRCH decreases due to the transmit power form Device. The maximum CW2D distance increases as the threshold decreases. Thus, a CW transmitter can be kept at a suitable distance to achieve received signal power above the threshold to trigger the Device and that decides the maximum distance for PDRCH, which decides the final maximum distance.**  **Proposal 3: In the case of CW inside topology for Device 1, the Device activation threshold plays a critical role to decide the maximum coverage. Thus, a suitable Device activation threshold should be decided that maximizes the final coverage.**  **Observation 10: For D1T1-A1 (CW inside topology, bistatic), a high value of PRDCH distance is achieved due to the low sensitivity of the RF-ED (due to LNA). However, the PDRCH distance is inversely proportional to CW2D distance. Hence an optimal distance is achieved that balances both the PRDCH and CW2D distance, and hence maximizes the final distance. Thus, d1 = d2 ~ 37 m is the final maximum distance achieved in our link budget analysis.**  **Observation 11: For D1T1-A2 (CW inside topology, monostatic), although the PRDCH distance is very high, the interference due to CW transmission at receiver of the Reader degrades the receiver sensitivity. Thus, in this scenario the maximum distance is reduced to ~22 m.**  **Observation 12: For D1T1-B (CW outside topology, monostatic), since the received signal power at the Device side is not dependent on the Device activation threshold for Device 2a, the CW transmitter to Device/tag distance is kept 5 m (fixed) and based on the received signal power at the Device the PDRCH distance is calculated. In our analysis maximum 50 m distance is achieved between the Reader and Device in this topology.**  **Proposal 4: In case of CW inside topology, the PDRCH distance is inversely proportional to CW2D distance. Therefore, an optimal distance should be chosen for a fixed transmit power from the base station (R) that gives a balanced MPL/distance between R/R1/R2 and D. In case of CW outside topology, a fixed CWT to tag/Device distance can be considered to evaluate the maximum coverage for Device 2a.**  **Observation 13: In case of D1T1-A1, the maximum distance d1 and d2 increases with increasing with transmit power of Reader. However, an optimal distance d1 = d2 can be achieved that maximizes the final coverage. Fixing CW2D distance at a certain value independently, limits the final maximum distance between R1/R2 and D in CW inside topology.**  **Observation 14: In case of D1T1-A2, the maximum distance between R and D increases with increasing with transmit power of Reader. However, the increment is rather small due to the CW interference at the receiver of the Reader. An optimal distance can be achieved that maximizes the final coverage. Fixing CW2D distance at a certain value independently, limits the final maximum distance between R and D in CW inside topology.**  **Observation 15: In case of D1T1-B, the maximum distance for PDRCH depends on the distance between CWT and Device. In our observation a maximum distance of 50.8 m can be achieved with CW2D distance of 5 m for CW outside topology. Increasing CW2D distance will decrease the PDRCH distance.**  **Proposal 5: A fixed transmit power of 33 dBm is proposed to set for Device 2a. The CW2D distance should be chosen optimally based on the system parameters that maximizes the final distance in case of CW inside topology. The CW2D distance can be fixed to 5 m in case of CW inside topology.**  **Observation 16: For D1T1 C, the maximum achievable distance using Device 2b is 180 m for the system parameters given in Table 12.**  **Observation 17: For D1T1 C, the PDRCH distance is independent of the base station transmit power as the Device transmit power is fixed to -10 dB. Thus, the maximum achievable distance is 180 m for the system parameters given in Table 12.**  **Observation 18: It can be observed that the distance achieved in this case is smaller than the D1T1 topology due to the low transmit power of UE. However, a higher distance can be achieved in the case of CW outside topology.**  **Observation 19: Similar to the Observation 7, d1 increases and d2 decreases with decreasing Device activation threshold.**  **Observation 20: It has been observed that the coverage is maximum at -24 dBm in monostatic scenario as the PDRCH distance decreases with decreasing Device activation threshold for Device 1.**  **Observation 21: In case of CW outside topology, a higher coverage can be achieved with lower receiver sensitivity of -35 dBm (sensitivity of RF-ED) for PRDCH for Device 1. CWT ensures a minimum signal power to be received to power up the Device. Therefore, unlike D2T1-A1 and D2T2-A2, receiver sensitivity of Device is independent of the Device activation threshold.**  **Observation 22: In case of CW outside topology, a higher coverage can be achieved with lower receiver sensitivity of -35 dBm (sensitivity of RF-ED) for PRDCH for Device 1. CWT ensures a minimum signal power to be received to power up the Device. Therefore, unlike D2T1-A1 and D2T2-A2, receiver sensitivity of Device is independent of the Device activation threshold.**  **Observation 23: Similar to the D1T1, CW inside topology for Device 2a, the PDRCH distance is inversely proportion to CW2D distance. Therefore, an optimum distance is achieved for both the channels that maximizes the final distance. For CW outside topology a fixed 5 m distance for CW2D is considered.**  **Observation 24: In case of Device 2b, the maximum distance of 63.7 m can be achieved with the system parameters provided in Table 20.** |
| Nokia | **Observation 1: R2D link has a short coverage (about 4 m) distance for Ambient IoT Device 1 in D2T2 scenarios. Therefore, the intermediate UE acting as a reader for Device 1 must be in its close proximity.** |
| Spreadtrum Communications | ***Observation 2: For R2D, the coverage of device 1 can achieve nearly 40m, the coverage of device 2a can achieve over 100m, and the coverage of device 2b can far exceed the maximum coverage requirement. For D2R, the coverage is lower in CW inside topology than that in CW outside topology considering CW interference.*** |
| Samsung | Observation 7. For device 1, R2D coverage can range from 4 to 14 m in D1T1 and from 5 to 8 m in D2T2.  Observation 8. In the case of Device 2, depending on the transmission scheme and SFO assumptions used in R2D transmission, either Budget-Alt1 or Budget-Alt2 can determine the coverage.  Proposal 12. For Device 2, the receiver sensitivity should be calculated and compared based on both Budget-Alt1 and Budget-Alt2.  **Observation 9.** Miller encoding scheme, 0.1% BLER can be achieved when CNR is about -3dB. With an example of FDMA-based transmissions between three devices using Miller-4, Miller-8, and Miller-16, respectively, the link level BLER performance of FDMA-based case have ~0.3dB loss compared with single use case, which is acceptable performance loss for each user**.** |
| Apple | ***Observation 1: For R2D link for device type A, following coverage range is observed for scenarios D1T1-A, D1T1-B, D2T2-A1 and D2T2-B with following assumptions***   |  |  |  |  | | --- | --- | --- | --- | | **Scenario** | **Pathloss Model**  ***(For both R2D)*** | **MPL**  **(dB)** | **R2D Coverage Range**  **(meters)** | | **D1T1-A1** | InF-DH NLoS (900MHz FDD) | 68 | **~ 40m** | | **D1T1-B** | InF-DH NLoS (900MHz FDD) | 68 | **~ 40m** | | **D2T2-A1** | InF-DL NLoS (900MHz FDD) | 53 | **~ 10m** | | **D2T2-B** | InF-DL NLoS (900MHz FDD) | 53 | **~10m** | | **D2T2-A1** | InH-Office LoS (900MHz FDD) | 53 | **~18m** | | **D2T2-B** | InH-Office LoS (900MHz FDD) | 53 | **~18m** | |
| CATT | **Observation 2: The coverage of Device 1 under D2T2 scenario is poor and further enhancement is needed.** |
| CMCC | **Observation 1: For device 1 in D1T1-A1/B, the coverage distance would be limited by R2D link. It is observed that about 26m coverage distance can be achieved with 2dBi BS antenna gain, and larger coverage distance of 40.33m with 6dBi BS antenna gain.**  **Observation 2: For device 2a in D1T1-A1, the coverage distance can be approximately 68.8m/105.03m limited by R2D link if 33dBm CW Tx power is assumed. While the coverage distance is limited by D2R link if 23dBm CW power is assumed, the coverage is about 62.66/95.71m.**  **Observation 3: For device 1/2a in D1T1-A2, D2R link may be the bottleneck due to the CW interference. It is observed the coverage distance is around 18/23m for device 1, and around 32/40m for device 2a.**  **Observation 4: For D2R link in D1T1, larger coverage distance can be achieved in case of CW outside topology.**  **Observation 5: For D2T2-A1/B/C, the coverage of R2D is the bottleneck due to limited transmit power (23 dBm) from intermediate UE and device activation threshold, and coverage distance is about 7.4m for device 1 and 13.3m for device 2a.**  **Observation 6: For D2R link in D2T2, when CW outside topology is used, with larger CW power received at device side, better coverage performance can be achieved.** |
| Sony | **Observation 2**: for D1T1 InF-DH scenario with NLoS transmission, the following observation is obtained   * 9 m effective range for type-1 device attached to aluminium slab; 30 m effective range for type-1 device attached to the cardboard sheet. * 20 m effective range for type-2a device attached to aluminium slab; m effective range for type-2a device attached to the cardboard sheet.   **Observation 3**: In D2T2 InF-DL scenario with NLoS link, both types of passive device could be energized by the UE-reader, but with limited coverage if they are attached on the materials that do not affect severely the device antenna impedance matching, e.g., cardboard sheet. However, R2D link communication is not possible when the passive device is attached to an Aluminium slab.  **Observation 4**: In D2T2 InH-office scenario with LoS link, for the type-1 device, 10 m range is observed when it is attached to the cardboard sheet while less than 4 m range is observed when it is attached to the aluminium slab. As for the type-2a device, 24 m range is observed when it is attached to the cardboard sheet while less than 6.5 m range is observed when it is attached to the aluminium slab. |
| ZTE, Sanechips | ***Observation 1: For device 1,***   * ***For RF-EH link in D1T1-A1/A2, RF energy harvesting cannot be supported for CW in UL spectrum and the maximum coverage distance of EH is 9.7m for CW in DL spectrum*** * ***For RF-EH link in D2T2-A2, the maximum coverage distance is 4.7m for CW in UL spectrum.*** * ***For R2D and D2R links in D1T1, assuming that device Tx power equals to activation threshold, the maximum coverage distance is approximately 32 m for CW in DL spectrum.*** * ***For R2D and D2R links in D2T2-A2, assuming that device Tx power equals to activation threshold, the coverage of D2R is the bottleneck and the maximum of D2R is 14.2 m.***   ***Observation 2: For device 2a,***   * ***For D1T1-A1 and A2, the maximum coverage distances are respectively 32 m and 43 m based on R2D MPL=D2R MPL when R2D is transmitted in DL spectrum.*** * ***For D1T1-B, assuming that Tx power of device 2 is same as that of device 1, the maximum coverage distance is 118 m for R2D link and 163 m for D2R link.*** * ***For D2T2-A2, the maximum coverage distances are approximately 16 m based on R2D MPL=D2R MPL.*** * ***For D2T2-B, assuming that Tx power of device 2 is same as that of device 1, the maximum coverage distance is 100 m for R2D link and 89 m for D2R link.***   ***Observation 3: For device 2b,***   * ***For D1T1-C, the maximum coverage distance of R2D link is 301 m for R2D in DL spectrum and the maximum coverage distance of D2R link is 220 m for device Tx power of -20 dBm and 629 m for -10 dBm.*** * ***For D2T2-C, the maximum coverage distance of R2D link is 328 m for R2D in DL spectrum and the maximum coverage distance of D2R link is 147 m for device Tx power of -20 dBm and 558 m for -10 dBm.*** |
| Xiaomi | ***Observation 2: Topology 1 has obviously better coverage performance than Topology 2 due to better transmit power/antenna gain/self-interference cancellation capacity/noise figure.***  ***Observation 3: For Topology 1, D2R link has obviously better coverage performance than R2D link due to receiver sensitivity of gNB is much better than Device. For Topology 2, D2R link has slightly better coverage performance than R2D link due to detection performance of OOK signals by UE is only slightly better than device.***  ***Observation 4: Coverage performance of different scenarios and different links are quite diverse.***  ***Proposal 4: The recommended parameters for link budget template in Table 2 can be considered.*** |
| Lenovo | ***Proposal 19: Consider an emitter to device distance of >5m for coverage evaluation of Ambient IoT device type 1, >10m for device type 2a*** |
| InterDigital, Inc. | **Observation 1: For deployment scenario 1/topology 1, coverage is limited by the Reader-to-Device channel due to the low sensitivity of the A-IoT device.**  **Observation 2: For deployment scenario 2/topology 2, coverage is limited by the Device-to-Reader channel for device types 1 and 2a.**  **Observation 3: The coverage of deployment scenario 2/topology 2 is worse than deployment scenario 1/topology 1.**  **Observation 4: IoT device Rx sensitivity is the bottleneck for achievable coverage range.**  **Observation 5: NLoS propagation loss assumption provides a worst-case estimate of coverage range.** |
| MediaTek Inc. | **Observation 11: A balanced MPL for R2D and D2R coverage evaluation can improve the D2R coverage.**  **Proposal 15: The maximum distance target is set separately for device 1 and device 2a&2b**   * **For device 1, the maximum distance target is 10 - 20m** * **For device 2a&2b, the maximum distance target is 20 - 50m** |
| Comba | **Proposal 6:** **MPL and distance can be considered from the link budget template in table3** |
| IIT Kanpur, Indian Institute of Tech (M) | **Observation 1: Based on coverage evaluation results, the coverage is less than 20m for the following cases:**   * **Device 1: (D1T1-A1, case 1-1/2, R2D), (D1T1-A2, case1-1/2, R2D, D2R), (D2T2 for all cases, R2D).**   **Observation 2: D1T1 has better coverage performance than D2T2 due to higher transmit power of BS in D1T1 compared to intermediate UE in D2T2.**  **Observation 3: For D2T2, D2R link has better coverage than R2D link due to better receiver sensitivity or detection performance of reader being BS or UE*.***  **Observation 4: For the Device 1 R2D link, D1T1 can meet the coverage requirements of over 10 meters, whereas in D2T2, due to the limited transmit power of intermediate UE and device activation threshold, it is difficult to achieve coverage requirements.**  **Observation 5: In D1T1, Device 2a can achieve the D2R and R2D coverage requirements of 50 meters.**  **Proposal 1: Ambient IoT on-object antenna penalty should be considered at least for device type 1/2a, whether the object is cardboard or aluminum sheet.**  **Proposal 2: For the D2R link (device-1/2a/2b), cable, connector, combiner, body losses, etc., should be considered at least 1dB.**  **Proposal 3: For the evaluation performance metric for device type 2, the link budget of the R2D link should be calculated using budget Alt1.** |

##### Discussion (no need to feedback)

According to the workplan, it is encouraged companies to provide initial results in the RAN1#117.

FL will try to collect the initial results and provide a document to collect the results. But we will not discuss the observations of the results in this meeting.

#### LLS performance

##### Related Tdoc Proposals

[Nokia] provides LLS evaluation results to see the impacts of sampling frequency offset on A-IoT decoding performance considering two payload sizes.

[Samsung] provides BLER performance of FDMA-based multiple D2R transmissions comparing with non-multiplexing case, and negligible performance degradation is observed for Miller based FDMA for the specific simulation parameters.

[CATT] provides some initial decoding performance results of R2D link and D2R link with OOK/ASK modulation under TDL-A and TDL-D channel.

[China Telecom] gives some initial R2D decoding performance for 900MHz and 2GHz carrier frequency.

[CMCC] provides some initial R2D decoding performance with different RF-ED decoding schemes and different payload sizes.

[xiaomi] provides some initial D2R performance comparison considering different sampling rates.

[Lenovo] provides D2R link detection performance considering different pulse widths and different timing errors.

[MTK] gives some initial R2D link ED performance for device 2a and 2b w/o SFO.

[Qualcomm]provides initial evaluation results showing the impacts of ASCI, Guard RB size, ACI, ideal/practical comparator modeling and transmission BW on the performance.

[Comba] provides some initial performance of the D2R link with BPSK and different line codes.

|  |  |
| --- | --- |
| Source | proposal |
| Nokia | **Observation 4: As the payload length increases, the impact of sampling offset degrades the detection performance.**  **Proposal 10: Consider the need for midamble if the payload size is bits to ensure reliable detection of AIoT payload.** |
| Samsung | **Observation 9.** Miller encoding scheme, 0.1% BLER can be achieved when CNR is about -3dB. With an example of FDMA-based transmissions between three devices using Miller-4, Miller-8, and Miller-16, respectively, the link level BLER performance of FDMA-based case have ~0.3dB loss compared with single use case, which is acceptable performance loss for each user**.** |
| CATT | **Observation 1: The performance of OOK under TDL-D is much better than TDL-A due to power variation under TDL-D channel is much smaller than TDL-A channel.** |
| China Telecom | ***Observation 1: The performance of R2D transmission is around 22.5dB for 900MHz carrier frequency, and 24.5dB for 2GHz carrier frequency in the 1% operation point.***  ***Observation 2: The performance gap in different carrier frequencies is around 2dB, which seems not too large in the order of magnitude of 20 dB.*** |
| Xiaomi | ***Observation 1: For D2R sinuous waveform, with sampling rate increased from 240kHz to 3.84MHz, required SINR at BS is decreased*** ***from -2dB to -8dB, and the required SINR is decreased from 7dB to 1dB.*** |
| Lenovo | ***Observation 3: Pulse width (bit width) affects the performance of D2R link due to both the effect of channel delay spread and timing error. The performance @1%BLER of D2R OOK signal using short pulses of 16us is ~2dB less than that of 66us pulses.***  ***Proposal 20: For evaluating D2R link, different pulse widths such as 8us, 16us, 32us should be considered.*** |
| MediaTek Inc. | **Observation 1: The BB LPF after ED may not effectively filter out noise beyond 180kHz.**  **Observation 2: A BB LPF before ED with a 180kHz bandwidth for Device 2b can remove noise beyond 180kHz and offers significantly better performance compared to a 10MHz RF BPF.**  **Observation 3: The accumulation of sample error caused by sampling frequency offset will also introduce a timing offset.**  **Observation 4: The impact of SFO degrades performance by 3dB.**  **Proposal 4: Consider the Manchester coding for estimating sampling frequency offset and timing offset.**  **Proposal 5: For LLS assumption, company should report whether/how clock calibration is assumed.**  **Proposal 6: For RF-ED and IF-ED, the bandwidth of the RF-BPF and IF filter could be regarded as the ED channel bandwidth, respectively.**  **Proposal 7: For R2D ZIF receiver and D2R, support SNR/SINR as the output of the LLS.** |
| Qualcomm Incorporated | **Observation 11: ASCI has significant influence on OOK reception.**  **Observation 12: Larger numbers of guard RBs give better performance.**  **Observation 13: Error floor is caused by ASCI.**  **Observation 14: Even small power boost ACI has huge impact on link performance.**  **Observation 15: Increasing Q factor can improve link performance. But, link performance is still severely impacted by strong ACI.**  **Observation 16: Ideal comparator model with extra noise (modeled by noise figure) couldn’t capture influence of Q value change.**  **Observation 17: Practical model can capture change of signal voltage absolute value.** |
| Comba | **Proposal 5:** **In D2R links, Miller encoding combined with CC encoding can improve the link coverage performance, but the complexity of the device needs to be considered.** |

##### Discussion (no need to feedback)

According to the workplan, it is encouraged companies to provide initial results in the RAN1#117.

FL will try to collect the initial results and provide a document to collect the results. But we will not discuss the observations of the results in this meeting.

#### Coexistence results

##### Related Tdoc Proposals

It seems no results inputs although some companies propose to study coexistence with NR.

##### Discussion (no need to feedback)

### Others

|  |  |
| --- | --- |
| MediaTek | **Proposal 1: Evaluate synchronization performance related to preamble design.** |
| MediaTek | **Proposal 2: Evaluate CDF of timing error or residual SFO after synchronization for a given preamble design** |
| MediaTek | **Proposal 2: Evaluate CDF of timing error or residual SFO after synchronization for a given preamble design** |
| MediaTek | **Proposal 3: Evaluate detection performance regarding residue timing error, e.g., after synchronization by preamble** |
| NEC | **Proposal 4: Study the performance of the case where a reader using backscatter communication receives interfering UL transmission from multiple IoT devices within its range.** |
| Nokia | **Proposal 9: Include analysis of Ambient IoT device form-factor/industrial design constraints and associated impact on antenna performance, link budget, and polarization mismatch over frequency in the RAN1 study.** |
| OPPO | Proposal 7: Up to SA3 to lead/drive the discussion on security requirement. |
| Qualcomm | **Observation 5: The choice of Q factor in matching network determines the selectivity and bandwidth of A-IoT device.** |
| Qualcomm | **Proposal 21: RAN1 and RAN4 to study the impact of Q factor in A-IoT link performance and energy harvesting; reasonable value of Q, pro/con of using high/low Q factor considering frequency in band(s) across operators.** |
| Qualcomm | Proposal 25: Adopt power model captured in 错误!未找到引用源。. Table 2 Power model for A-IoT device   |  |  |  |  | | --- | --- | --- | --- | | Device State | Description | Power consumption | Note | | WUR power detection | Incident rx power level is detected | [0.01] |  | | WUR sequence detection | T-Sync detection | [1, 2] | Additional power needed to run sequence correlator | | Rx (demod) | Device 1 | [1] | FL control/data reception and processing | | Device 2 | [10, 50, 100, 150, 200, 400] | | Tx | Device 1 | [1] | BL reflection for device 1/2a or active signal transmission for device 2b. Device 2a could also use reflection amplification. | | Device 2 | [100, 200, 300, 400, 500] | | Light Sleep | Working clock is running.  Memory in retention mode. | [0.1, 0.2, 0.5] | Sleep between e.g., query and query in inventory process | | Off (for cold start) | Device is completely off.  No memory retention.  No clock running.  No Rx/Tx.  Energy is being harvested. | 0 |  | | Deep Sleep (for warm start) | No memory retention.  No Rx/Tx. | [0.003, 0.005, 0.01] | Half of energy storage is full. Harvesting for warm start. | | Charging | Energy can be harvested. | [Y1, Y2, Y3, … ] | Whether to support simultaneous EH and other function (WUS/Rx/Tx/etc) depends on device architecture, RFFE assumptions.  Y values are negative numbers and depend on energy harvesting efficiency and incident power level | | Note: Power consumptions numbers are just for evaluation purpose. | | | | |
| Xiaomi | ***Proposal 1: The link between the gNB and the intermediate UE for the topology 2 is not included in the evaluation.*** |

# SID

This study targets a further assessment at RAN WG-level of Ambient IoT, a new 3GPP IoT technology, suitable for deployment in a 3GPP system, which relies on ultra-low complexity devices with ultra-low power consumption for the very-low end IoT applications. The study shall provide clear differentiation, i.e. addressing use cases and scenarios that *cannot* otherwise be fulfilled based on existing 3GPP LPWA IoT technology e.g. NB-IoT including with reduced peak Tx power.

General Scope

The definitions provided in TR 38.848 are taken into this SI, and the following are the exclusive general scope:

1. The overall objective shall be to study a harmonized air interface design with minimized differences (where necessary) for Ambient IoT to enable the following devices:
2. ~1 *µ*W peak power consumption, has energy storage, initial sampling frequency offset (SFO) up to 10*X* ppm, neither DL nor UL amplification in the device. The device’s UL transmission is backscattered on a carrier wave provided externally.
3. ≤ a few hundred *µ*W peak power consumption1, has energy storage, initial sampling frequency offset (SFO) up to 10*X* ppm, both DL and/or UL amplification in the device. The device’s UL transmission may be generated internally by the device, or be backscattered on a carrier wave provided externally.

* *X* is to be decided in WGs.
* Coverage design target: Maximum distance of 10-50 m with device indoors as per TR 38.848: “*…a range that WGs can sub-select within*”.
* For Topologies 1 & 2 (UE as intermediate node under NW control) per TR 38.848, with no RRC states, no mobility (i.e. at least no cell selection/re-selection -like function), no HARQ, no ARQ.

NOTE 1: It is to be understood that “≤ a few hundred *µ*W” means WGs are not tasked with setting a particular value, and that it will be for WG discussions to determine if a presented design with corresponding power consumption satisfies the “≤ a few hundred *µ*W” requirement.

1. Deployment Scenarios with the following characteristics, referenced to the tables in Clause 4.2.2 of TR 38.848:

* Deployment scenario 1 with Topology 1
  + Basestation and coexistence characteristics: Micro-cell, co-site
* Deployment scenario 2 with Topology 2 and UE as intermediate node, under network control
  + Basestation and coexistence characteristics: Macro-cell, co-site
  + The location of intermediate node is indoor

1. FR1 licensed spectrum in FDD.
2. Spectrum deployment in-band to NR, in guard-band to LTE/NR, in standalone band(s).
3. 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.

Transmission from Ambient IoT device (including backscattering when used) can occur at least in UL spectrum.

The following objectives are set, within the General Scope:

1. Evaluation assumptions
2. Conclude at least the following aspects of design targets left to WGs in Clause 5 (RAN design targets) of TR 38.848 [RAN1].
   * Clause 5.3: Applicable maximum distance target values(s)
   * Clause 5.6: Refine the definition of latency suitable for use in RAN WGs
   * Clause 5.8: 2D distribution of devices
3. Define necessary further evaluation assumptions of deployment scenarios for coverage and coexistence evaluations [RAN1, RAN4]
4. Identify basic blocks/components of possible Ambient IoT device architectures, taking into account state of the art implementations of low-power low-complexity devices which meet the RAN design target for power consumption and complexity. [RAN1]
5. Define link budget calculation for coverage, including whether/how to model carrier wave from node(s) inside or outside the connectivity topology.

NOTE: Assessment performance of the design targets is within the study of feasibility and necessity of proposals in the following objectives, e.g. by inspection of reference implementations in the field, simulations, analytically.

NOTE: strive to minimize evaluation cases in RAN1.

1. Study necessary and feasible solutions for Ambient IoT as prescribed in the General Scope, including decisions on which functions, procedures, etc. are needed and not needed, and ensuring at least the required functionalities in Section 6.2 of TR 38.848.

Study of positioning in Rel-19 is RAN3-led, limited to functionalities which would have no, or minimal, specification impact (note: this does not imply any decision relating to WI creation).

Study the feasibility and required functionalities for proximity determination (coordination with SA3 is required for privacy aspects).

* RAN1-led:

For the Ambient IoT DL and UL:

* + Frame structure, synchronization and timing, random access
  + Numerologies, bandwidths, and multiple access
  + Waveforms and modulations
  + Channel coding
  + Downlink channel/signal aspects
  + Uplink channel/signal aspects
  + Scheduling and timing relationships
  + Study necessary characteristics of carrier-wave waveform for a carrier wave provided externally to the Ambient IoT device, including for interference handling at Ambient IoT UL receiver, and at NR basestation.

For Topology 2, no difference in physical layer design from Topology 1.

* RAN2-led:
  + Study and decide which functions are needed for an Ambient IoT compact protocol stack and lightweight signalling procedure to enable DO-DTT and DT data transmission, and study those functions.

For example:

* + - Paging
    - Random access
    - Data transmission, including necessary radio resource control aspects, respecting the limitation in the General Scope
    - Interactions with upper layers

For functionalities not listed above, they are studied only if found essential.

* RAN3-led:
  + Identify necessary impacts on signaling and procedures for CN-RAN interface, to enable:
    - Paging
    - Device context management
    - Data transport
  + Identify RAN architecture aspects, including whether support for split architecture is necessary.
  + Identify potential solutions for locating an Ambient IoT device with no specification impact, e.g. reusing existing user location report, or minimal specification impact to convey location information to core network.
* RAN4-led:
  + Coexistence study of Ambient IoT and NR/LTE.
  + RF requirements study for Ambient IoT:
    - Ambient IoT BS transmission and reception
    - Ambient IoT Device, as per the General Scope, transmission and reception
    - Intermediate node (UE), as per the General Scope, transmission and reception

RAN2 and RAN3 are expected to identify RAN-CN functional split in coordination with SA2.

Note: This study shall target for an IoT segment well below the existing 3GPP IoT technologies, e.g. NB-IoT, eMTC, RedCap, etc. The study shall not aim to replace existing 3GPP LPWA technologies.

# Agreements

## RAN1#116

Agreement

For this study item, the coverage evaluation methodology is based on the following steps.

For an evaluation scenario

* For each of the link *i*,
  + Step 1: Obtain the required SINR for the physical channels under target scenarios and service/reliability requirements if **Budget-Alt2** is used for this link *i*.
  + Step 2: Obtain the receiver sensitivity using the method **Budget-Alt1** (if a predefined threshold is assumed to derive the receiver sensitivity)or **Budget-Alt2** (if no predefined threshold is assumed to derive the receiver sensitivity).
  + Step 3: Obtain the coverage performance for link *i* based on the receiver sensitivity from step 2 and link budget template.
* The coverage results for each link are provided.
* FFS: what links are evaluated besides R2D and D2R (e.g., RF-EH)
* FFS whether/how to model the interferenceFFS: for which device(s) a predefined threshold is assumed

Note the following alternatives for obtaining receiver sensitivity are defined,

* **Budget-Alt1:** receiver sensitivity is derived by a predefined threshold and no LLS is needed for link budget calculation
  + The results rely on the received sensitivity and maximum transmit power, and directly calculate the maximum distance / pathloss based on these values and other related parameters. The link-level simulation (LLS) performances, such as required SINR can be satisfied for such case and no LLS is needed for link budget calculation.
* **Budget-Alt2:** receiver sensitivity is derived by required SINR which is given by LLS results
  + The results rely on link-level simulation results, e.g., required SINR which corresponds to detail LLS assumptions (e.g., BW, coding, data rate). And based on the required SINR, the received sensitivity can be calculated and then the maximum distance / pathloss can be derived.
  + Note: For noise power, a noise figure value needs to be provided.

Agreement

MPL and distance is used as performance evaluation metric for link budget calculation.

* Note: the distance is derived from MPL and corresponding pathloss model.
* FFS: Pathloss model

Agreement

The following pathloss model is used in the coverage evaluation.

* For D1T1,
  + InF-DH defined in TR38.901 is used.
  + Decide which of the following is used for each link,
    - NLOS
    - LOS
  + FFS: InF-SH
* For D2T2, down-select from the following path loss models
  + InF-DL defined in TR38.901 where the BS path loss model is reused for intermediate-UE with antenna height of 1.5m
  + InH-Office model defined in TR38.901, (a.k.a, InH\_B in Report ITU-R M.2412-0) where the BS path loss model is reused for intermediate-UE with antenna height of 1.5m
  + Decide which of the following is used for each link,
    - NLOS
    - LOS

**Conclusion**

Companies are encouraged to consider Table 3.4.2 in R1-2401735 for their contributions to RAN1#116bis regarding link budget template.

## RAN#103

**Agreement**

* Regarding the objective in the SID: *Study necessary characteristics of carrier-wave waveform for a carrier wave provided externally to the Ambient IoT device, including for interference handling at Ambient IoT UL receiver, and at NR basestation.*
  + This objective allows studying CW waveform characteristics which would need control of the CW node(s), e.g. waveform characteristics that impact interference such as when CW is transmitted or not transmitted, power, bandwidth, spectrum, etc.
* No SID revision is necessary

**Agreement**

* Confirm that study of design of energy harvesting signal/waveform is out of SI scope in Rel-19
* The potential impact of energy harvesting on device availability for transmission and reception procedures can be considered for the study
  + One device’s charging by energy harvesting can be assumed up to several tens of seconds
    - Note: this value can be revisited in future RAN plenary meetings, if necessary
  + TR 38.848 clause 5.6 statement on latency remains the case with respect to a single device, i.e.: “*NOTE: The time for charging the Ambient IoT device storage (if present) is not included in the latency defined above. Time for energy harvesting, charging, etc. is regarded as an implementation issue only.*”
* No SID revision is necessary

**Agreement**

* RAN design targets for user experienced data rate, maximum message size, and moving speed of device: those can be used as assumptions in coverage evaluations, i.e. the coverage evaluations are done under the conditions that meet those targets.
* Evaluations of RAN design targets for latency and connection/device density are allowed by the Rel-19 SID and observations on those evaluations can be captured in the TR38.769 in relation to the candidate techniques being studied for meeting those targets.
* Note: this is as per the SID: “*NOTE: Assessment performance of the design targets is within the study of feasibility and necessity of proposals in the following objectives, e.g. by inspection of reference implementations in the field, simulations, analytically*.”

## RAN1#116bis

Agreement

For R2D link in the coverage evaluation, for device 1

* *Budget-Alt1* is used (note: receiver architecture is RF ED)

For D2R link in the coverage evaluation,

* *Budget-Alt2* is used.

Agreement

The following scenarios are defined,

* FFS: which of these scenarios will be evaluated.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Scenario** | **CW Inside/outside topology** | **Diagram of the scenario** | **Description of the scenario** | **Device 1/2a/2b** | **CW spectrum** | **D2R spectrum** | **R2D spectrum** |
| **D1T1-A1** | CW inside topology |  | * CW node inside topology 1 * ‘CW’ in CW2D and ‘R2’ in D2R are different * ‘CW’ in CW2D and ‘R1’ in R2D are same * ‘R1’ in R2D and ‘R2’ in D2R are different | Device 1, 2a | Case 1-1 (inside topology, DL)  Case 1-2 (inside topology, UL) | Same as CW |  |
| **D1T1-A2** |  | * CW node inside topology 1 * same ‘CW’ and ‘R’ node for CW2D, D2R and R2D | Same as D1T1-A1 | Same as CW |  |
| **D1T1-B** | CW outside topology |  | * CW node outside topology 1 * ‘CW’ in CW2D and ‘R’ in D2R are different * ‘CW’ in CW2D and ‘R’ in R2D are different * ‘R’ in R2D and ‘R’ in D2R are same | Case 1-4 (outside topology, UL) | Same as CW |  |
| **D1T1-C** | No CW |  | * No CW Node. | Device 2b | N/A | UL |  |
| **D2T2-A1** | CW inside topology |  | * CW node inside topology 2 * ‘CW’ in CW2D and ‘R2’ in D2R are different * ‘CW’ in CW2D and ‘R1’ in R2D are same * ‘R1’ in R2D and ‘R2’ in D2R are different * BS communicates with R1 and R2 | Device 1, 2a | Case 2-2 (inside topology, UL) | Same as CW |  |
| **D2T2-A2** |  | * CW node inside topology 2 * same ‘CW’ and ‘R’ node for CW2D, D2R and R2D * BS communicates with R | Same as D2T2-A1 | Same as CW |  |
| **D2T2-B** | CW outside topology |  | * CW node outside topology 2 * ‘CW’ in CW2D and ‘R’ in D2R are different * ‘CW’ in CW2D and ‘R’ in R2D are different * ‘R’ in R2D and ‘R’ in D2R are same * BS communicates with R | Case 2-3 (outside topology, DL)  Case 2-4 (outside topology, UL) | Same as CW |  |
| **D2T2-C** | No CW |  | * No CW Node. * BS communicates with R | Device 2b | N/A | FFS |  |
| Note: this table is for the case where D2R is in the same spectrum as CW2D. | | | | | | | |

Agreement

For D1T1,

* InF-DH NLOS model defined in TR38.901 is used for D2R and R2D links as pathloss model in coverage evaluation.

For D2T2,

* InF-DL and InH-Office model defined in TR38.901is used as pathloss model in coverage evaluation,
  + NLOS for D2R and R2D links if InF-DL is used
  + LOS for D2R and R2D links if InH-Office is used

Agreement

The following layout is used for evaluation purpose,

* FFS: CW distribution for D1T1-B and D2T2-B

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Assumptions for D1T1** | **Assumptions for D2T2** | |
| Scenario | InF-DH | InH-office | InF-DL |
| Hall size | 120x60 m | 120 x50 m | 300x150 m |
| Room height | 10 m | 3m | 10 m |
| Sectorization | None | | |
| BS deployment / Intermediate UE dropping | 18 BSs on a square lattice with spacing D, located D/2 from the walls.   * L=120m x W=60m; D=20m * BS height = 8 m | * L=120m x W=50m; * Intermediate UE height = 1.5 m   FFS: Intermediate UE dropping | * L=300m x W=150m; * Intermediate UE height = 1.5 m   FFS: Intermediate UE dropping |
| Device distribution | Device Height= 1.5 m  AIoT devices drop uniformly distributed over the horizontal area | Device Height= 1.5 m  AIoT devices drop uniformly distributed over the horizontal area  FFS: which devices are involved in the evaluations | Device Height= 1.5m  AIoT devices drop uniformly distributed over the horizontal area  FFS: which devices are involved in the evaluations |
| Device mobility (horizontal plane only) | 3 kph | 3 kph | 3 kph |

Agreement

In the link level simulation, considering the following channel model,

* For D1T1, TDL-A channel model is used for R2D link and for D2R link for InF-DH scenario.
* For D2T2,
  + TDL-A channel model is used for R2D link and for D2R link if InF scenario is considered
  + TDL-D channel model is used for R2D link and for D2R link if InH-Office scenario is considered
* FFS delay spread for each case.

Agreement

For coverage evaluation, subject to further discussion on which scenarios to evaluate,

* In the case of CW inside topology with ’A2’ scenarios
  + The digital baseband processing of CW self-interference handling is not modelled in link level simulation (LLS). It is included in the link budget analysis by reporting the CW cancellation capability value.
* FFS: In the case of CW outside topology with ‘B’ scenarios or CW inside topology with ’A1’ scenarios

Agreement

The maximum distance targets are set separately for device 1, device 2a, device 2b, respectively

* FFS detailed values and RAN1 can further decide the target within in the range of 10m to 50m after link budget study.
* FFS whether to set different values for different scenarios

Agreement

The table below is agreed (except for the yellow part)

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| **(0) System configuration** | | | |
| [0A] | Scenarios | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C | D1T1-A1/A2/B/C  D2T2-A1/A2/B/C |
| [0A1] | CW case | N/A | 1-1/1-2/1-4/2-2/2-3/2-4 |
| [0B] | Device 1/2a/2b | Device 1/2a/2b | Device 1/2a/2b |
| [0C] | Center frequency (MHz) | 900MHz (M), 2GHz (O) | 900MHz (M), 2GHz (O) |
| **(1) Transmitter** | | | |
| [1D] | Number of Tx antenna elements / TxRU/ Tx chains modelled in LLS | For BS:  - 2(M) or 4(O) antenna elements for 0.9 GHz  For Intermediate UE:  - 1(M) or 2(O) | 1 |
| [1E] | Total Tx Power (dBm) | * For BS in DL spectrum for indoor   + 33dBm(M), FFS: 38dBm(O), one smaller value [FFS: 23 or 26] dBm(M)   + FFS: additional constraints on PSD * FFS: For UE in DL spectrum for indoor * For UL spectrum for indoor,   + 23dBm (M)   + FFS: 26dBm(O)   Other valuesare NOT precluded subject to future discussion. | * For device 1/2a:   + D2R-CWRxPower-Alt1:     - Company to report CW Tx/Rx power together with CW2D distance (see [1E1]~[1E5])   + D2R-CWRxPower-Alt2:     - Balanced MPL/distance (see [1E1]~[1E5], ~~and subject to [1E3] = = [4B])~~ * For device 2b:   + D2R-dev2bTxPower-Alt1: -10 dBm(O)   + D2R-dev2bTxPower-Alt2: -20 dBm(M)   Other values are NOT precluded subject to future discussion. |
| [1E1] | CW Tx power (dBm) | N/A | * 23dBm for UL spectrum, FFS 26dBm * 33dBm(M), 38dBm (O) for DL spectrum   Note: only applicable for device 1/2a |
| [1E2] | CW Tx antenna gain (dBi) | N/A | * Company to report, the value equals to   + UE Tx ant gain, or   + BS Tx ant gain   Note: only applicable for device 1/2a |
| [1E3] | CW2D distance (m) | N/A | * For D2R-CWRxPower-Alt1:   + [Company to report] * For D2R-CWRxPower-Alt2:   + Calculated   Note: only applicable for device 1/2a |
| [1E4] | CW2D pathloss (dB) | N/A | Calculated  Note: only applicable for device 1/2a |
| [1E5] | CW received power (dBm) | N/A | Calculated  Note: only applicable for device 1/2a |
| [1F] | Transmission Bandwidth used for the evaluated channel (Hz) | 180k(M),  360k(O),  1.08MHz(O) | UL data rate: xx bps  FFS: data rate for each case |
| [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | * For A-IoT device, 0dBi (M), -3dBi (O) |
| [1H] | Ambient IoT backscatter loss (dB)  Note: due to, e.g.,   * impedance mismatch * Modulation factor | N/A | * OOK: Y dB * PSK: X dB   Note: Only for device 1  FFS: for device 2a |
| [1J] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 |
| [1K] | Ambient IoT backscatter amplifier gain (dB) | N/A | * 10 dB (M) * 15 dB (O)   Note: Only for device 2a |
| [1N] | FFS: Cable, connector, combiner, body losses, etc. (dB) | FFS | N/A |
| [1M] | EIRP (dBm) | Calculated  FFS: any limitation of the EIRP subject to future discussion | Calculated |
| **(2) Receiver** | | | |
| [2A] | Number of receive antenna elements / TxRU / chains modelled in LLS | Same as [1D]-D2R | Same as [1D]-R2D |
| [2B] | Bandwidth used for the evaluated channel (Hz) | FFS: relation with the transmission bandwidth used for the evaluated channel | * FFS: whether the values are single side-band or double side-band * Note: The value is used for calculating the noise power   FFS: relation with the transmission bandwidth used for the evaluated channel |
| [2B1] | FFS: RF CBW (Hz) | FFS:   * 10MHz * 20MHz * Other values   Note: The value is used for calculating the noise power | N/A |
| [2C] | Receiver antenna gain (dBi) | same as [1G]-D2R | Same as [1G]-R2D |
| [2X] | FFS: Cable, connector, combiner, body losses, etc. (dB) | N/A | FFS |
| [2D] | Receiver Noise Figure (dB) | FFS: 20dB or 24dB or 30dB for *Budget-Alt2*  FFS: different values for device architecture | For BS as reader   * 5dB   For UE as reader   * 7dB |
| [2E] | Thermal Noise power spectrum density (dBm/Hz) | -174 | -174 |
| [2F] | Noise Power (dBm) | Calculated | Calculated |
| [2G] | Required SNR | Reported by company | Reported by company |
| [2H] | FFS: Ambient IoT on-object antenna penalty | * 0.9dB or 10.4 | * 0.9dB or 10.4 |
| [2J] | Budget-Alt1/ Budget-Alt2 | For R2D link in the coverage evaluation, for device 1   * *Budget-Alt1* is used (note: receiver architecture is RF ED)   FFS: device 2 | Budget-Alt2 |
| [2K] | CW cancellation (dB) | N/A | For [monostatic backscatter], FFS   * [140dB for BS] * [120dB for UE]   For [bistatic backscatter]   * Assuming CW has no impact to the receiver sensitivity loss. |
| [2K1] | Remaining CW interference (dB) | N/A | Calculated |
| [2K2] | Receiver sensitivity loss(dB) | N/A | Calculated |
| [2L] | Receiver Sensitivity (dBm) | For Budget-Alt1,   * For device 1 (RF-ED),   + FFS:{-30dBm ~ -36dBm} * For device 2 if RF-ED is used   + FFS * For device 2 if RF-ED is not used   + N/A   For Budget-Alt2,   * Calculated | Calculated  Note: the receiver sensitivity includes the receiver sensitivity loss [2K2], i.e. after CW cancellation at least if ‘A2’ scenario is used |
| **(3) System margins** | | | |
| [3A] | Shadow fading margin (function of the cell area reliability and lognormal shadow fading std deviation) (dB) | TBD | TBD |
| [3B] | polarization mismatching loss (dB) | 3 dB | 3 dB |
| [3C] | BS selection/macro-diversity gain (dB) | 0 dB  FFS: other values are not precluded | 0 dB  FFS: other values are not precluded |
| [3D] | Other gains (dB) (if any please specify) | Reported by companies with justification | Reported by companies with justification |
| **(4) MPL / distance** | | | |
| 4A | MPL (dB) | Calculated | Calculated |
| 4B | Distance (m) | Calculated | Calculated |

*<Editor Notes: Note 1 will be updated once the table has stabilized >*

Note1: calculated values in the Table XXXX are derived according to the followings,

* 1E
  + For D2R, and device 1/2(backscatter), whether this value is need (not regarded as an input variable but regarded as indirect variable), or based on backscatter activation power threshold
* 1M
  + For R2D,
  + For D2R,
    - Device 1:
    - Device 2a:
    - Device 2b:
* 2F:
* 2L
  + For R2D and Budget-Alt1, [2L] = [2H]
  + For R2D and Budget-Alt2, [2L] = [2G]+[2F]
  + For D2R and Budget-Alt2, Refer to section [xxx] (Proposal [P4-3])
* 4A
* 4B is derived from pathloss model
  + Refer to section [XXX] (Proposal [P4-3-2])

Note2: (M) denotes the value is mandatory to be evaluated. (O) denotes the value can be optionally evaluated.

Agreement

For coverage evaluation purpose,

* For scenarios ‘A1’ and ‘A2’,
  + The Device Tx Power is calculated by assuming CW2D pathloss = D2R pathloss.
* For scenarios ‘B’,
  + The Device Tx Power is calculated by CW received power which can be derived by at least CW2D distance (m) value.
    - FFS: CW2D distance (m) value(s)

Agreement

The draft LS in R1-2403769 is endorsed with the following changes:

* For the last agreement copied in the LS, remove the green highlight in the second column and delete “note 1” with its yellow highlights.
* Revise the first sentence in the LS as follows:
  + RAN1 has discussed and agreed the following aspects. RAN1 would like to clarify that parts highlighted in yellow are not yet agreed by RAN1.
* Revise the action to RAN4 as follows:
  + RAN1 respectfully asks RAN4 to take the above information into account for coexistence studies and to provide a response if needed.

Final LS is agreed in R1-2403782.

[Post-116bis-AIoT] – Xiaodong (CMCC)

Email discussion on Ambient IoT evaluation assumptions from April 23 until April 26

* focus on proposals P3.7.1-v1, P3.5.8-v2, P3.2.1-(1)-v2, P3.2.4-v1 and P3.5.5-v1 in section 2 of [R1-2403768](file:///C:\Users\xdshe\AppData\Roaming\Microsoft\Docs\R1-2403768.zip).

Agreement

For the R2D LLS for ED, report followings (as start point).

* CINR/CNR, where CINR/CNR is defined as the ratio of signal power spectral density in the transmission bandwidth to the noise and~~/or~~ interference (if any) power spectral density in the device ED channel bandwidth
* signal transmission bandwidth
* ED channel bandwidth

FFS: exact definition of ED channel bandwidth for RF-ED, IF receiver

FFS: which and how to report for R2D ZIF receiver and D2R

Agreement

The following table of coverage evaluation assumptions in link level simulation is considered as start point.

* Other values/options are not precluded and subject to future discussion.

**Table: Coverage evaluation assumptions**

|  |  |  |
| --- | --- | --- |
| **Parameters** | | **Assumptions** |
| **R2D/D2R common parameters** | | |
| Carrier frequency | | Refer to link budget template |
| SCS | | 15 kHz as baseline |
| Block structure | | Blocks as agreed in 9.4.2.3, or other blocks reported by companies |
| Channel model | | <Editor’s Note: will be updated according to the agreements made for channel model> |
| Delay spread | | [30, 150] ns |
| Device velocity | | 3 km/h |
| Number of Tx/Rx chains for Ambient IoT device | | 1 |
| BS | Number of antenna elements | 2 or 4 |
| Number of TXRUs | 2 or 4 |
| Intermediate UE | Number of antenna elements | 1 or 2 |
| Number of TXRUs | 1 or 2 |
| Reference data rate | | [0.1, 1, 5] kbps |
| Message size | | * D2R:   + [FFS: 16, 96, 400 bits] * R2D:   + [FFS: 16, 32, 64, 400bits] |
| BLER target | | 1%, 10% |
| Sampling frequency | | <Editor’s Note: will be updated according to the agreements made forSampling frequency> |
| Device 1/2a/2b | | Options are as follows,   * Device 1, RF-ED * Device 2a, RF-ED * Device 2b, RF-ED/IF-ED/ZIF   <Editor’s Note: will be updated according to agreements from 9.4.1.2> |
| **R2D specific parameters** | | |
| Transmission bandwidth | | 180 kHz as baseline |
| FFS: ED bandwidth | | [X MHz] |
| FFS: BB LPF | | [X]-order Butterworth filter with cutoff frequency at [Y] kHz |
| Waveform | | OOK waveform generated by OFDM modulator |
| Modulation | | OOK  Companies to report, e.g., OOK-1, OOK-4 with M chips per OFDM symbol |
| Line code | | Companies to report, e.g., Manchester, PIE |
| FEC | | No FEC as baseline |
| ADC bit width | | 1-bit for device 1  4-bit for device 2 |
| Detection/decoding method for Line code | | Companies to report |
| **D2R specific parameters** | | |
| Transmission bandwidth (w.r.t. D2R data rate) | | [FFS: 15kHz, 180kHz] |
| Waveform (CW) | | Companies to report waveform, e.g., unmodulated single tone, multi-tone(multiple unmodulated single tone) |
| Modulation | | Companies to report modulation, e.g., OOK, BPSK, BFSK |
| Line code | | Companies to report, e.g., Manchester encoding, FM0 encoding, Miller encoding, no line coding |
| FEC | | Companies to report, e.g., CC, No FEC |
| ADC bit width | | Companies to report, e.g., 11-bit |
| D2R receiver | | FFS: Reader receiver, e.g., coherent receiver / non-coherent receiver |
| **Other assumptions** | | |
| Other assumptions | | To be reported by company |
| Note: Companies to report required SINR according to BLER target. | | |

## RAN1#117

Agreement

In the link level simulation, coherent and non-coherent receiver can be evaluated for D2R receiver.

Agreement

For CW2D pathloss model applied to the D1T1-A1/A2/B and D2T2-A1/A2/B scenarios, using the same pathloss model defined in TR38.901 as used for R2D/D2R.

Agreement

Add Row [0D] in the link budget table as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [0D] | Topology/Pathloss model | For D2T2:  [0D]-Alt1: InF-DL NLOS  [0D]-Alt2: InH-Office LOS  For D1T1:  [0D] InF-DH NLOS | For D2T2:  [0D]-Alt1: InF-DL NLOS  [0D]-Alt2: InH-Office LOS  For D1T1:  [0D] InF-DH NLOS |

Agreement

Update the link budget table Row [0C] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [0C] | Center frequency (MHz) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) | [0C]-Alt1: 900MHz (M),  [0C]-Alt2: 2GHz (O) |

Agreement

* For R2D link in the coverage evaluation for device 2,
  + *Budget-Alt2* is used if receiver architecture is IF/ZIF ED is used

Agreement

Update the link budget table Row [1G] as follows,

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Item** | **Reader-to-Device** | **Device-to-Reader** |
| [1G] | Tx antenna gain (dBi) | * For BS for indoor, 6 dBi(M), 2dBi(M) * For intermediate UE, 0 dBi | For A-IoT device, 0dBi ~~(M), -3dBi (O)~~ |

Agreement

For the link level simulation,

* An RMS delay spread of 30 ns and [150] ns is considered for TDL-A channel model.
* An RMS delay spread of 30 ns is considered for TDL-D channel model.

# Reference

Section 9.4.1.1

1. R1-2403840 Evaluation assumptions and results for Ambient IoT Ericsson
2. R1-2403858 Discussion on evaluation assumptions and results for Ambient IoT devices FUTUREWEI
3. R1-2403885 Evaluation assumption and preliminary results for Ambient IoT Tejas Networks Limited
4. R1-2403886 Evaluation assumptions and results for Ambient IoT Nokia
5. R1-2403952 Evaluation methodology and assumptions for Ambient IoT Huawei, HiSilicon
6. R1-2404026 Discussion on evaluation assumptions and results for Ambient IoT Spreadtrum Communications
7. R1-2404115 Considerations for evaluation assumptions and results Samsung
8. R1-2404177 Evaluation methodologies assumptions and results for Ambient IoT vivo
9. R1-2404284 On evaluation assumptions and link budget analysis for AIoT Apple
10. R1-2404401 The evaluation methodology and preliminary results of Ambient IoT CATT
11. R1-2404427 Discussion on evaluation assumptions and results for Ambient IoT China Telecom
12. R1-2404456 Discussion on evaluation methodology and assumptions CMCC
13. R1-2404500 Initial evaluation results for Ambient IoT Sony
14. R1-2404554 Discussion on Ambient IoT evaluations ZTE, Sanechips
15. R1-2404618 Evaluation methodology and assumptions for Ambient IoT Xiaomi
16. R1-2404793 Discussion on ambient IoT evaluation framework NEC
17. R1-2404868 Discussion on evaluation assumptions and results for A-IoT OPPO
18. R1-2404888 Discussion on Ambient IoT evaluation LG Electronics
19. R1-2404939 Discussion on the evaluation assumptions for Ambient IoT devices Lenovo
20. R1-2404957 Evaluation assumptions for Ambient IoT InterDigital, Inc.
21. R1-2405042 Study on evaluation assumptions for Ambient IoT NTT DOCOMO, INC.
22. R1-2405076 Evaluation assumptions and results MediaTek Inc.
23. R1-2405155 Evaluation Assumptions and Results Qualcomm Incorporated
24. R1-2405214 Evaluation assumptions for Ambient IoT Comba
25. R1-2405296 Evaluation assumption and preliminary results for AIoT IIT Kanpur, Indian Institute of Tech (M)

Others

1. RP-234058 New SID: Study on solutions for Ambient IoT (Internet of Things) in NR Huawei (moderator, RAN1 Vice-Chair)

# History

**RAN1#116bis**

R1-2403515 FL summary #1 for Ambient IoT evaluation Moderator (CMCC)

R1-2403516 FL summary #2 for Ambient IoT evaluation Moderator (CMCC)

R1-2403643 FL summary #3 for Ambient IoT evaluation Moderator (CMCC)

R1-2403643 FL summary #3 for Ambient IoT evaluation Moderator (CMCC)

**RAN1#116**

R1-2401647 FL summary #1 for Ambient IoT evaluation Moderator (CMCC)

R1-2401735 FL summary #2 for Ambient IoT evaluation Moderator (CMCC)

R1-2401874 FL summary (final) for Ambient IoT evaluation Moderator (CMCC)