3GPP TSG RAN Meeting #104 RP-241193
Shanghai, China, June 17 – 20, 2024
Agenda Item: 9.2.2

Views on Rel-19 Ambient IoT

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1. Study on Impact of Energy Harvesting on Device Availability

No Progress

- On RF energy harvesting, the following agreement was made in RAN#103.
  - *"The potential impact of energy harvesting on **device availability for transmission and reception** procedures can be considered for the study [RAN2, RAN1]*
    - *Duration of one device's unavailability due to 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"*
- The understanding was that both RAN1 and 2 can discuss this topic based on its relevance
- During RAN1#117, when there was online/offline discussion on RF energy harvesting, any meaningful agreement or conclusion was blocked by limited number of companies stating that RAN1 has to wait for RAN2 to study this topic first.
  - However, it turned out that RAN2#126 agreed that *"... We will wait for RAN1 further progress on device monitoring details."*
- **Observation 1**: For past three meetings, there has been NO progress on the study of "impact of energy harvesting on device availability for transmission and reception" although majority of companies have had strong interest and provided inputs in tdocs.

1. Study on Impact of Energy Harvesting on Device Availability

- RAN1 needs to lead the study of the following aspects:
  - RF energy harvesting efficiency, charging/discharging behavior
  - Energy storage size and corresponding device sustainable operation time
  - Device states (e.g., OFF/sleep/Rx/Tx/etc.) definitions
  - Device monitoring behavior in inventory procedure
  - Device wake up/sleep enabler block (e.g., energy/power/sequence detector in device architecture)
- **Observation 2**: RAN needs to clarify lead WG related issue and give clear guidance on RAN1 scope.

RF Energy Harvesting

- Although energy source is not limited to RF, it is important to study/assume RF signal as main energy source in 3GPP study
  - For device 1, RAN1 agreed that RF is the only energy source for energy harvesting.
  - For low cost/low complexity, device 2 needs RF energy harvester which is cheap yet reliable, i.e., the cost for device 2 using other energy sources is too high to address the inventory use case.
  - Without RF energy harvesting, A-IoT system/device will not be able to properly address inventory use case.
- **Observation 3:** RF energy harvesting is a critical part of Rel-19 A-IoT SI for all device types. In case it is not properly studied within SI timeframe, we believe that A-IoT system will not be able to support inventory. *Therefore, we would view the SI in-complete without studying the RF energy harvesting aspects, and not suitable for WI conversion.*

Proposal 1: RAN1 needs to lead the study of impact of RF energy harvesting on device availability for Tx and Rx.

- If RF energy harvesting is not properly studied or addressed in the TR, the SI will remain incomplete, and we would not be able to support any WI conversion.

1. Study on Impact of Energy Harvesting on Device Availability

Proposal 2: Update RAN#103 agreement as follows

Proposal 2

- Confirm that study of design of energy harvesting signal/waveform is out of SI scope in Rel-19
- The potential impact of RF energy harvesting on device availability for transmission and reception procedures is studied ~~can be considered for the study~~ [~~RAN2,~~ RAN1, RAN2]
  - Duration of one device's unavailability due to charging by RF 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

- Furthermore, to help RAN1 make progress, RAN should give a clear guidance on RAN1 study on RF energy harvesting.

Proposal 3: RAN1 to study RF energy harvesting related aspects under 9.4.2.2 and 9.4.1.2 including

- RF energy harvesting efficiency, charging/discharging behavior
- Energy storage size and corresponding device sustainable operation time
- Device states (e.g., OFF/sleep/Rx/Tx/etc.) definitions
- Device monitoring behavior in inventory procedure
- Device wake up/sleep enabler block (e.g., energy/power/sequence detector)
- Etc.

2. Latency Metric for Single Device

- With RAN#103 guidance, RAN1 has discussed single device latency definition so far, but *No progress* was made.
  - ***"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." …*
- The controversial part was whether the metric includes "successful" or not in its definition.
  - If included, the metric could be used as metric to measure latency including retransmission.
  - If *not* included, then, the metric can not be used for evaluation since it will be a constant (fixed number) – assuming every rx is successful.
- One company has been consistently against including "successful", which lead to *No progress* in the Latency KPI.
- As a good reference, a definition used in [1] includes *retransmissions* – requiring *successful* reception.
  - *NR DL User Plane Latency (5.7.1.1.1)*
    - *Total one-way User Plane Latency is defined as* $T_{UP} = T_1 + n \times T_{HARQ}$, *where*
    - T_1 *is DL data transfer delay,* T_{HARQ} *is HARQ retransmission delay.*
    - n *is the number of re-transmission* ($n \geq 0$)
- **Observation 3**: Latency defined in "37.910 Self evaluation toward IMT-2020 submission" includes retransmissions. The very least, the A-IoT latency definition should account for the time needed for the reader to determine whether retransmission is or is not necessary

[1] 37.910 Study on Self evaluation towards IMT-2020 Submission

2. Latency Metric for Single Device

- Based on this, we make following proposal:

Proposal 4: *The 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" means counting retransmissions, if any, needed for successful decoding, or at least the time needed for the reader to determine that no retransmission is necessary.*
- *Note: the latency is evaluated for a single A-IoT device.*
- *Note: Time for energy harvesting is not included in the definition of latency.*

3. Latency Metric for Inventory Process

Inventory Completion Time

RAN Study on A-IoT Design Target

- The Rel-19 A-IoT SID focus use case is "*inventory*" for *multiple devices* [2].
- Design target for device density is 150 devices per 100 m^2 for indoor scenarios [3].
- **Observation 4**: Inventory for multi devices is target use case of Rel-19 A-IoT study.

No progress in RAN1

- For past meetings, there has been efforts from many companies to introduce latency metric for multiple devices – "inventory completion time". However, it was consistently blocked by a limited number of companies based on the argument that studying multi device inventory latency is not in SID scope based on RAN#103 discussion, therefore it should not be discussed in RAN1.
- The following clarification in RAN#103 was not meant to preclude the definition of latency for multi devices inventory.
  - 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.*"
- **Observation 5**: The clarification in RAN#103 was **not** meant to preclude the definition of latency for multi devices inventory.

Proposal 5: For studying inventory procedure, RAN to clarify whether studying inventory completion time is within the scope of Rel-19 A-IoT SI.

[2] RP-234058 SID: Study on solutions for Ambient IoT (Internet of Things) in NR
[3] 38.848 SA1 Study on Ambient IoT (Internet of Things) in RAN

3. Latency Metric for Inventory Process

Inventory Completion Time

Evaluation of Inventory Process and KPI

- Inventory, the main focus use case, is almost always involved with multiple devices [4].
- To design proper inventory evaluation procedure in RAN1, RAN1 needs to define KPI – inventory completion time and evaluate inventory procedure for multiple devices.
- No proper study/evaluation for inventory procedure would results in poor system design and incomplete study.
- Based on discussion, we make following proposal for inventory completion time KPI.

Proposal 6: 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 coverage by the reader
  - Z = {99%(Mandatory), 90%(Optional)}
  - FFS: Evaluation method
  - ~~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.]~~

[4] 22.840 Study on Ambient power-enabled Internet of Things

4. Proximity Determination

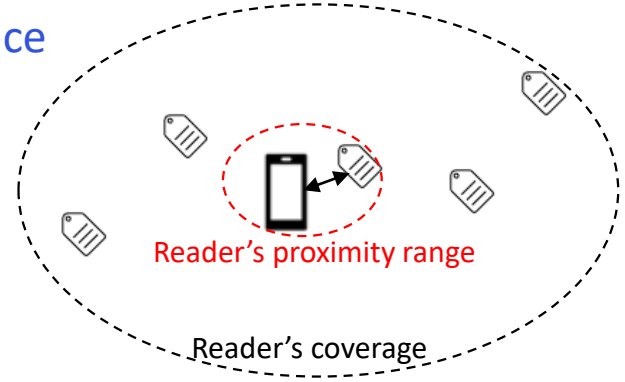
- According to SID RP-240826:
  - Study the feasibility and required functionalities for proximity determination, which is the determination of whether BS or intermediate UE and ambient IoT device are near each other or not (coordination with SA3 is required for privacy aspects).
- RAN1#117 Agreement:
  - *Study the following schemes for proximity determination:*
    - *Option 1: If reader receives D2R transmission from the device in response to R2D transmission, then device is determined as near*
      - *FFS: Details on reception criteria (e.g. either successful or not) at reader and device*
    - *Option 2: Device is determined to be near the reader based on measurements at the reader side*
      - *FFS: Details on measurement methods*
  - *FFS: Whether/how transmit power of R2D and/or D2R is considered for proximity determination.*
- However, in RAN1 discussion, the use case, scenario and the corresponding definition of 'near' was questioned, which slowed down the decision making.
  - Companies have different views on whether transmit power at ambient IoT device should be factor in proximity determination or not.
    - The "near" determined by the reader should not be different for the devices transmitting with different power.
  - There is uncertainty as to how proximity is defined/measured in bi-static cases (with different Tx/Rx reader) scenarios.

4. Proximity Determination

- Typical use case and proposed definition of proximity determination:
  - To enable NFC-like functionality, proximity determination is to identify one A-IoT device within a very close range (less than 1m).
    - For power measurement-based techniques, if the devices transmit D2R with very different Tx power, the 'near' determination by the reader based on the D2R measurement/detection would deviate the intention of proximity determination.
      - E.g., 20dB Tx power difference between device 1 and device 2 and the distance relative to the reader could be 10 times different assuming a pathloss exponent of 2 (free space).

Proposal 7: Clarify that the use case for proximity determination is to identify whether a device is in a very close range (less than 1m, exact value to be refined in RAN1) from the reader.

- The 'near' determination by the reader should NOT be very different for the devices with different transmit power.



- Typical scenario of proximity determination:
  - Mono-static scenario with same Tx/Rx reader is most useful for proximity determination.
    - E.g., a handheld UE/reader to be able to identify a particular A-IoT device it is pointed at with a very close range, rather than targeting multiple A-IoT devices all within the reader's coverage.
  - No clear motivation to consider bi-static scenario with different Tx/Rx reader.

Proposal 8: Rel-19 A-IoT study to prioritize the proximity determination only for mono-static scenario with the CW inside topology.

5. CW Node Control

- RAN#103 agreed to endorse:

Proposal 3v2 (endorsed)

- 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

- Although the *control of the CW node(s)* needed for studying CW waveform characteristics is in the SID scope, there is no offline/online discussion in RAN1 so far and it is not clear how to capture the study of the CW node control in the TR.

- **Proposal 9:** Capture in the TR the aspects related to the control of the CW node(s) which impact interferences, including time/frequency/power resource allocation, such as when CW is transmitted or not transmitted, power, bandwidth, spectrum, etc.

Conclusion

- The focus use case of Rel-19 A-IoT SI is the inventory use case. Addressing the use case requires low cost/complexity device – device 1/2a/2b. RF energy harvesting is a critical component enabling low cost / low complexity devices.
- We see the overall progress in this SI on studying the impact of RF energy harvesting on device availability on Rx/Tx is very poor, even after the last RAN guidance.
- *If RF Energy Harvesting is not properly studied in the SI, we believe the SI is not useful and is incomplete, and we would not be able to support any conversion to WI (mid-Rel-19 or later).*
- RAN should give clear guidance on RAN1 study scope as follows:
  - RAN1 is to study of impact of RF energy harvesting on device unavailability of Rx/Tx, without waiting for RAN2
  - Agree on the latency definition for a single device
  - Agree on the latency definition and evaluation of multi device case; inventory completion time
- Clarify the use case for proximity determination as a method for identifying whether a device is in a range < 1m from the reader in monostatic scenario.
- Capture in the TR the aspects related to the control of the CW node(s) which impact interference, including time/frequency/power resource allocation, such as when CW is transmitted or not transmitted, power, bandwidth, spectrum, etc.

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