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# Discussions on x-IoT

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# x-IoT: A new class of IoT solutions

- Various use cases based on ambient power-enabled IoT solutions, e.g., for automated warehousing, asset tracking and inventory management, have been identified by SA1 (TR 22.840). The family of such devices are referred to as x-IoT devices.
- A clear understanding of the various use-cases, practical feasibility, and technical requirements from the perspective of the radio access technology remains to be established.
- In general, x-IoT devices can be considered as complementary solution to the existing IoT devices of eMTC, NB-IoT, and RedCap (with or without support of LP-WUR), potentially characterized by
  - x-IoT device may target extreme low complexity and power consumption
  - x-IoT device may be assumed not to have a battery
  - x-IoT device may cater to use-cases with very low QoS (throughput and latency) requirements.
- Two types of x-IoT devices can be studied
  - Pure batteryless devices with no energy storage capability, e.g., backscatter communication
    - Extreme energy saving but with limited capability
  - Devices with energy storage capability that do not need to be replaced or recharged manually
    - Compared to devices w/o energy storage, such devices may support more functionalities including improved coverage and sensitivity but increased complexity.
    - No battery is equipped in such devices.
    - The source for energy harvesting may not be limited to radio waves.

# x-IoT: Operation modes

- x-IoT device may communicate
  - with an isolated reader;
    - The reader and/or x-IoT device is transparent to RAN
  - with gNB directly;
    - May not be preferred as a single solution due to potentially severe coverage issues
  - with gNB via a relay, IAB node, repeater, or a UE
    - The UE may be a regular UE or an operator-deployed UE.
- Different combinations of energy harvesting and communication should be investigated for x-IoT devices
  - A UE may act as the source for energy harvesting at x-IoT device
  - A UE may help to relay a DL transmission from gNB to x-IoT device
  - A UE may forward an UL signal from x-IoT device to gNB
  - Combinations of above functions for a UE
- The study should assess practical feasibility of UE-based access for x-IoT devices.

# x-IoT: Important features

- Positioning
  - Positioning support for x-IoT device is considered in the study in SA1
  - Difficulties for positioning of x-IoT devices
    - x-IoT device is of low capability hence may not be capable of positioning related measurements and calculations
    - x-IoT device is of short energy supply hence may not be able to transmit positioning signals to multiple reader/relay/BS
    - x-IoT device often has a short coverage, hence the benefit of positioning may be limited in certain use-cases
  - On the other hand, certain use-cases may only require coarse positioning estimates, e.g., whether certain items have been delivered or left a warehouse, etc.
  - It would be imperative to identify the appropriate positioning requirements for the new use-cases that may be practically achievable for x-IoT devices.

- Connection to CN
  - A key differential factor for 3GPP is the support of powerful core network compared to other standards
  - Effective security operation relies on the functionalities of CN support
  - Though RAN may not be the right forum to discuss the details on CN connectivity, it is preferred that RAN assumes CN connection in the study
  - This aspect should require coordination with SA and impacts practical feasibility of solutions for the air interface as well.

# Coexistence with existing 3GPP technologies

- NR as baseline for x-IoT
  - For physical layer
    - Changes in physical layer are inevitable since the existing OFDM waveform and QAM modulation is not efficient for power saving
    - LP WUR/WUS studied in a Rel-18 study item can be a reference for physical layer of x-IoT, e.g., OOK modulation and envelop detection
  - For high layer
    - Existing NR protocol stack may serve as a starting point
    - Unnecessary protocols/procedures can be removed or simplified.
- x-IoT may be operated in a frequency that is different from the cellular network, i.e., out-of-band
- In-band transmission of x-IoT devices in a carrier of cellular network should be considered too

# A RAN-level Rel-18 study on x-IoT

- A RAN-level study to assess feasibility and relevance to 3GPP technologies for the use-cases identified by SA1 can be considered during Rel-18.
- The study should focus on determining specifics on:
  - Use-cases and associated deployment scenarios and frequency bands
  - Typical performance requirements from the communication system
  - Target device complexity including power generation/harvesting capabilities
  - Target coverage for the considered throughput and latency performances
  - Target positioning scenarios and performance
  - Radio access methods and involved nodes (e.g. gNB, UE, repeater, IAB node, etc.)
  - Initial considerations on coexistence within NR systems

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