G3 for Battery-Powered Devices

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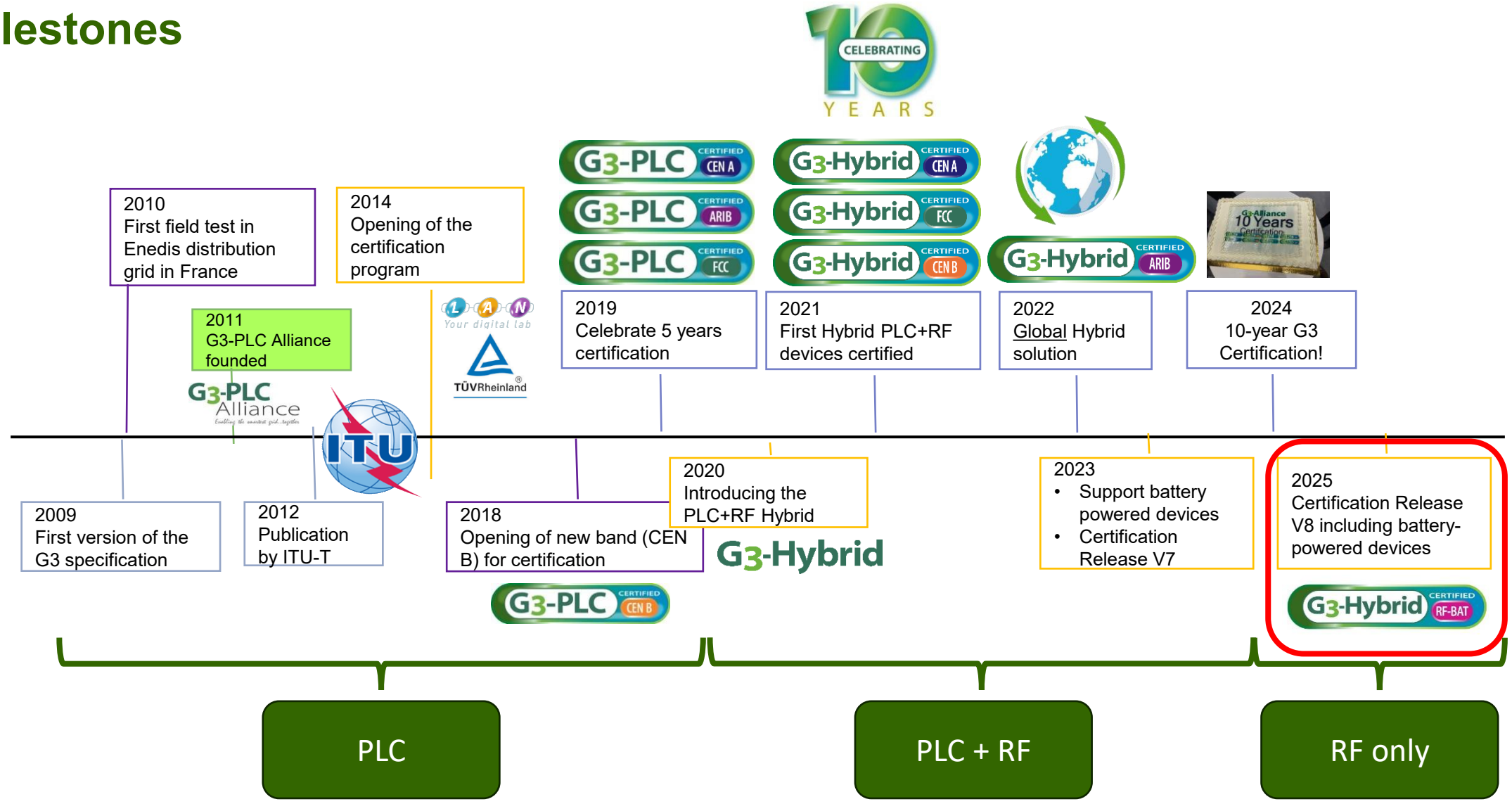
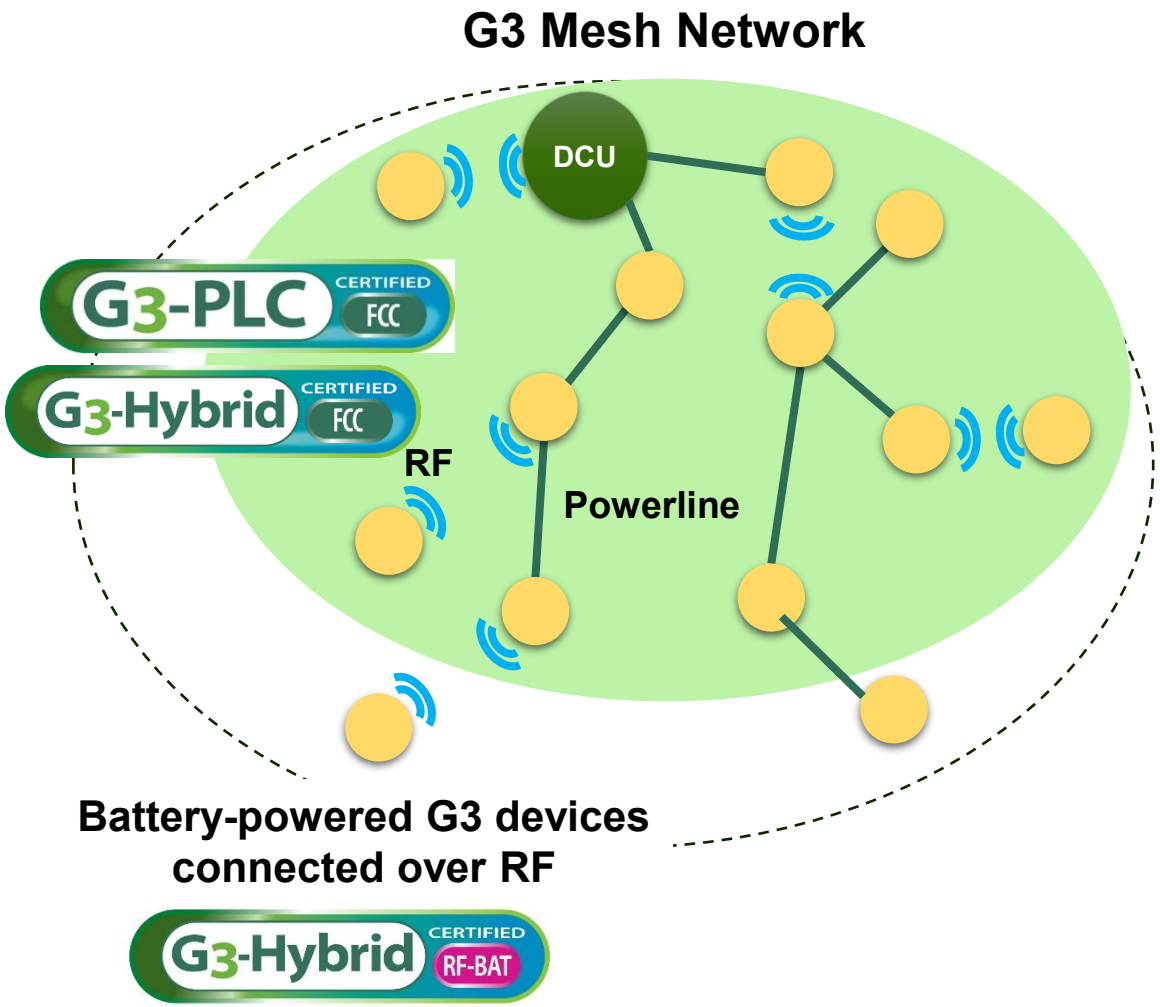
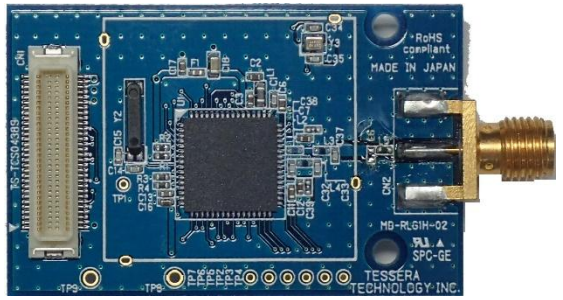
G3 Alliance: Milestones



Battery-powered G3 devices connected over RF



- Key Features:
  - Low-power operation, deep sleep mode enables up to 20 years battery life
  - Seamless integration into G3 networks (same authentication, addressing etc.)
  - Battery-powered devices attach as leaf nodes (no routing) to the network via G3-Hybrid devices (RF-only connection)



Example: Renesas RL78/G1H – Low-power MCU/Transceiver

G3 Battery-Powered Device:
Use Case Example: Multi-Utility Metering

- Electricity Metering
  - ❖ Easy deployment, low total cost of ownership
  - ❖ High success rate of daily profile readouts
  - ❖ High availability (always on)
  - ➢ Achievable with existing G3 PLC/RF Hybrid technology

- Gas-/Water Metering
  - ❖ Easy deployment, low total cost of ownership
  - ❖ High success rate of daily profile readouts
  - ❖ Long battery lifetimes (10 to 20 years)
  - ➢ Achievable with new G3 low-power battery-powered device technology

G3 Battery-Powered Device:
Use Case Example: Multi-Utility Metering

Independent

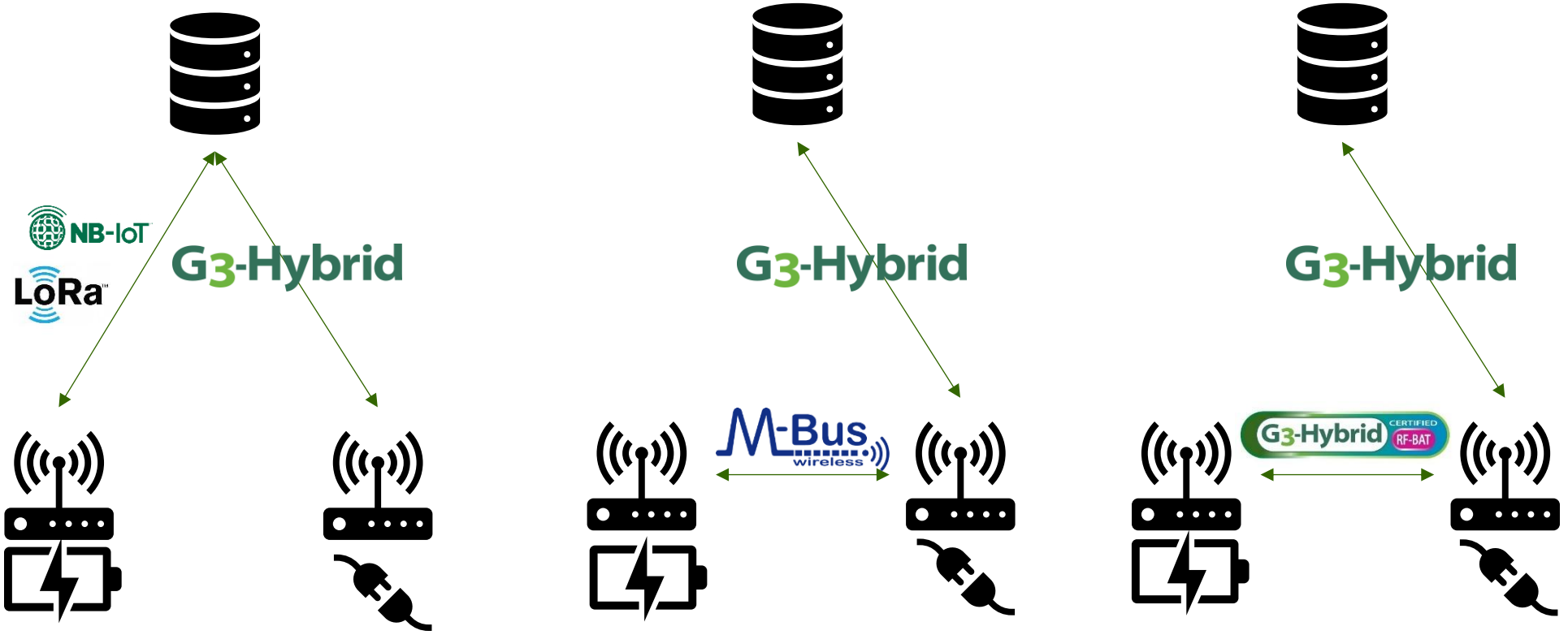
- No coordination required
- Operation of multiple networks ⇨ Higher cost

Gateway

- More complex deployment with multiple technologies
- Operation of single network ⇨ Lower cost

Integrated

- Easy deployment
- Operation of single network ⇨ Lower cost



G3-Hybrid combines Powerline and Radio communication in a single solution

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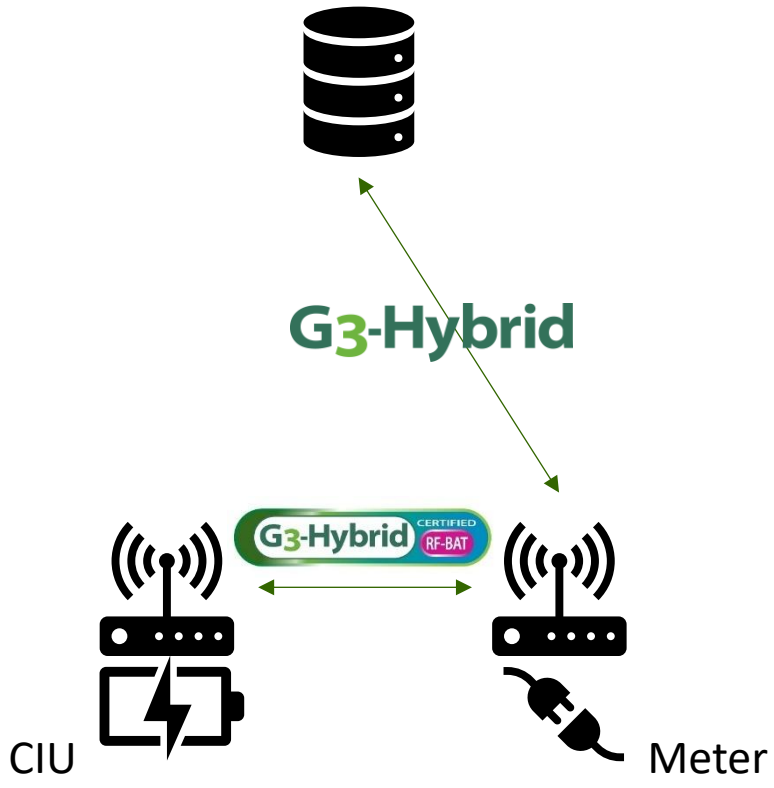
G3 Battery-Powered Device:
Use Case Example: Customer Interface Unit

CIU Communication

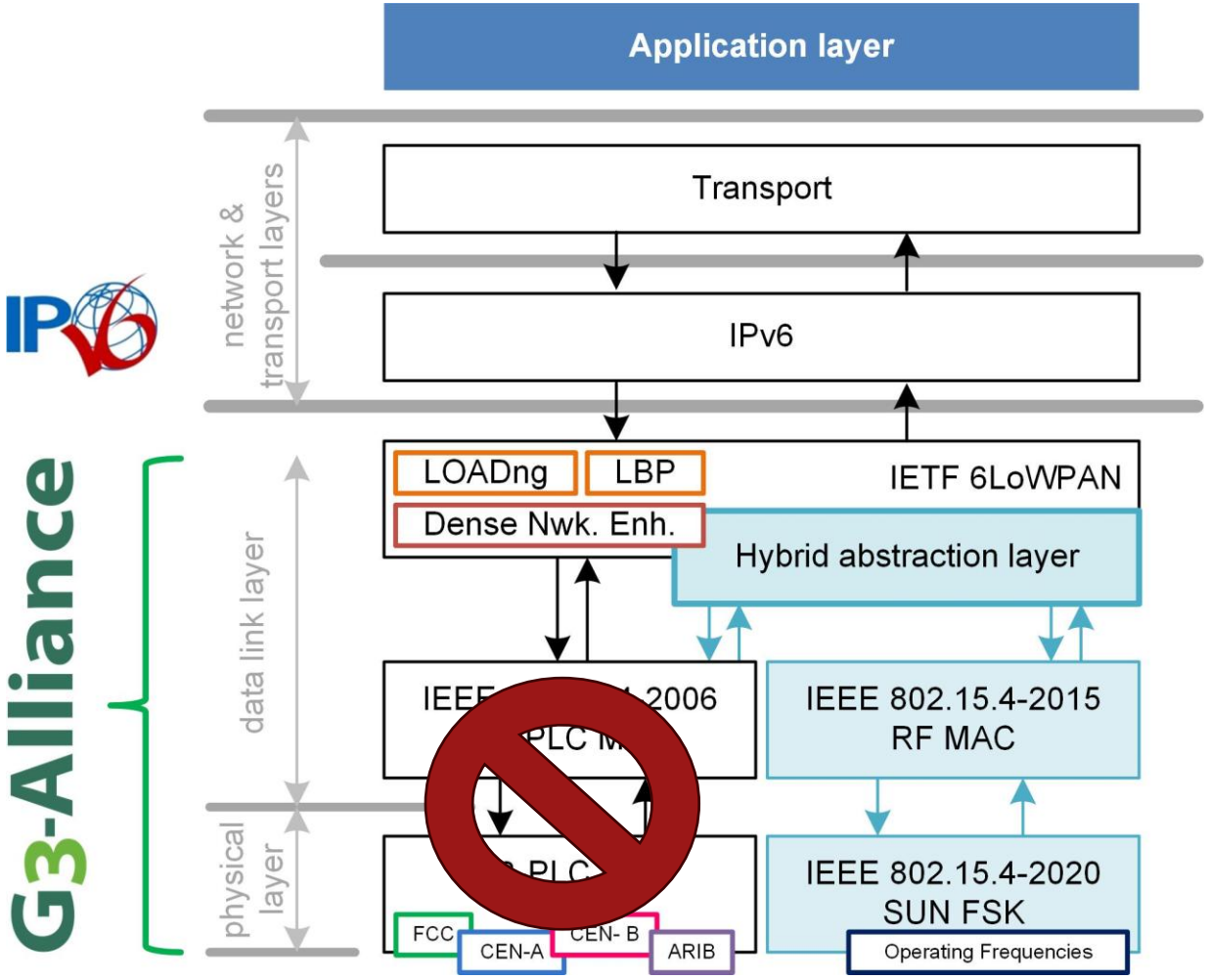
- ❖ Easy deployment
- ❖ Use existing RF radio

⇨ Lower cost



- Customer Interface Unit
  - ❖ Many deployments require a CIU for customer interaction (payment, consumption information etc.)
  - ❖ The CIU connects to a specific pre-paired meter
  - ❖ A CIU can be battery-powered, i.e. low-power operation is crucial
  - ❖ A CIU can re-use radio connectivity already available in the meter to optimize cost
  - ➢ Achievable with new G3 battery-powered device technology

G3 Battery-Powered Device: Protocol Stack



- Employs IPv6 with UDP transport
- Operates as PLC-only or PLC/RF hybrid
- Hybrid abstraction layer automatically selects best available link
- Global solution: 863 MHz, 870 MHz and 915 MHz bands, Single Frequency/Frequency Hopping
- **Battery-powered device is RF-only and supports deep-sleep operation for long battery lifetime**

G3 Battery-Powered Device: Main Features

Topic	Requirements
Energy budget	• Long deep-sleep cycles enable low-power operation • No forwarding of messages in the mesh network • Design target is battery lifetime of 20 years @ CR 3V/2000mAh
Channel Access	• Fixed channel & frequency hopping operation for global adoption • Wake-up times and sleep cycles are configurable to support different use cases and allow battery lifetime trade-off
Backwards compatibility	• Authentication and addressing are fully interoperable with G3 PLC/RF devices
Leaf node to parent communication	• G3-Hybrid devices can parent multiple battery-powered leaf nodes • Communication between parent and leaf node only uses RF medium • Parent and leaf establish a unicast route (point-to-point communication) to communicate bi-directionally
Join process	• Battery-powered leaf nodes bootstrap like regular G3 devices, i.e. obtain GMKs and short addresses during the join procedure

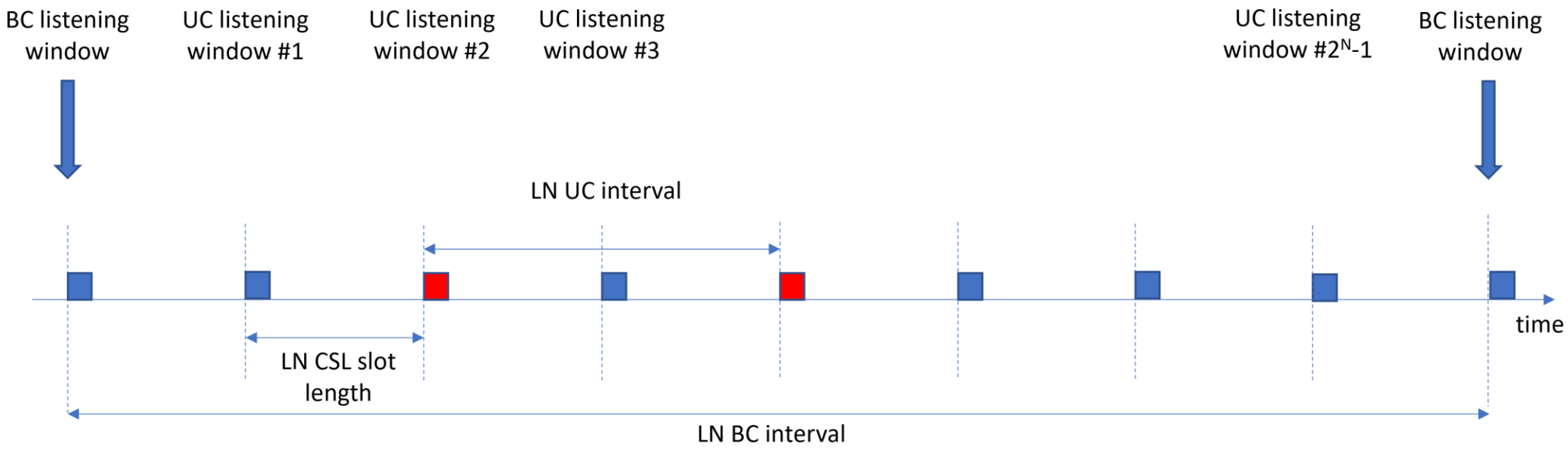
G3 Battery-Powered Device: Technical Specification

- **Network discovery (for both Single Carrier and Frequency Hopping modes)**
  - Discovery is based on the existing beacon request/beacon exchange.
  - Leaf Node (LN) sends an Enhanced Beacon Request with new “BF-IE” to enable nodes supporting LN parenting to reply positively if certain specific criteria are satisfied

- **Time synchronization**
  - Energy consumption in reception (RX) mode is much lower than in transmission (TX) mode ➔ TX time shall be reduced as much as possible to achieve long battery lifetimes
  - Yet, time synchronization is crucial, especially for FH ➔ to minimize the number of TX, a passive synchronization mechanism based on Coordinated Sampled Listening (CSL) [802.15.4 §6.12.2] is adapted for use with G3 hybrid
  - To improve efficiency, an LN shall maintain two separate CSL periods:
    - A broadcast period that allows reception of broadcast frames sent by a parent to all its child nodes
    - A unicast period that allows reception of unicast frames sent by a parent to a dedicated leaf node

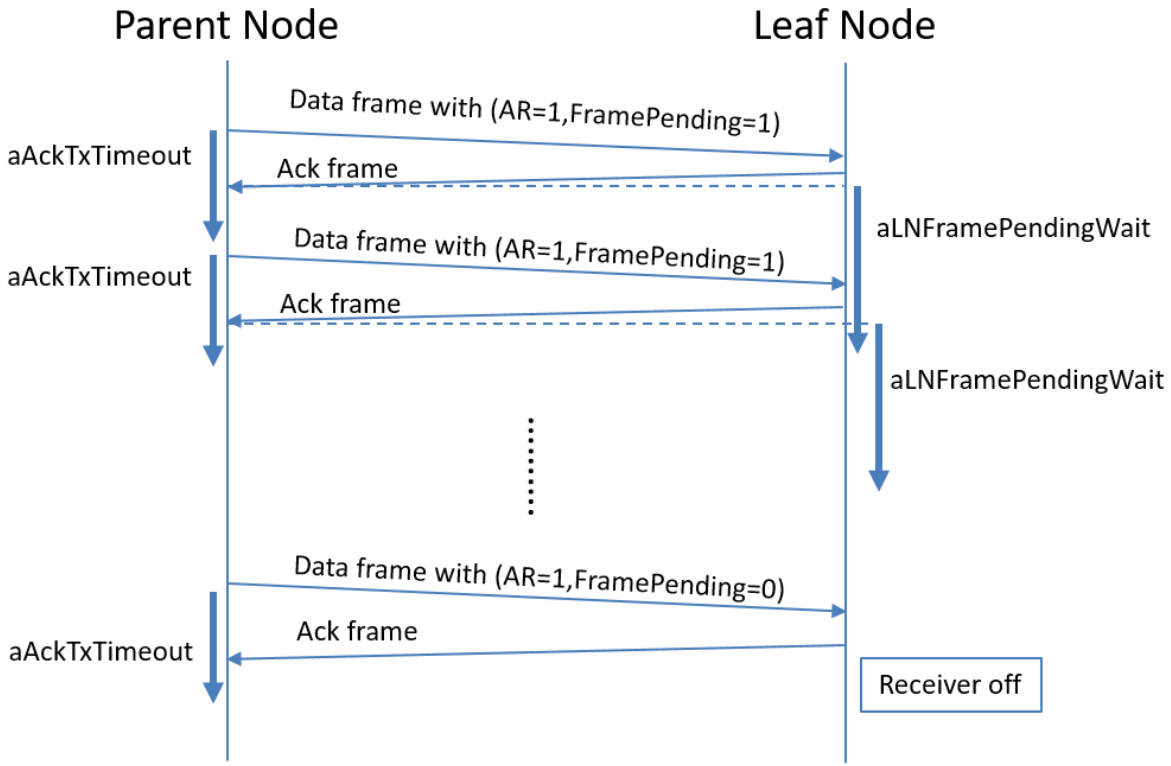
G3 Battery-Powered Device: Technical Specification

- **Time synchronization**
  - Overview of the time synchronization schedule (comprising Unicast and Broadcast LN listening windows) determined by a parent node for all of its LNs:



G3 Battery-Powered Device: Technical Specification

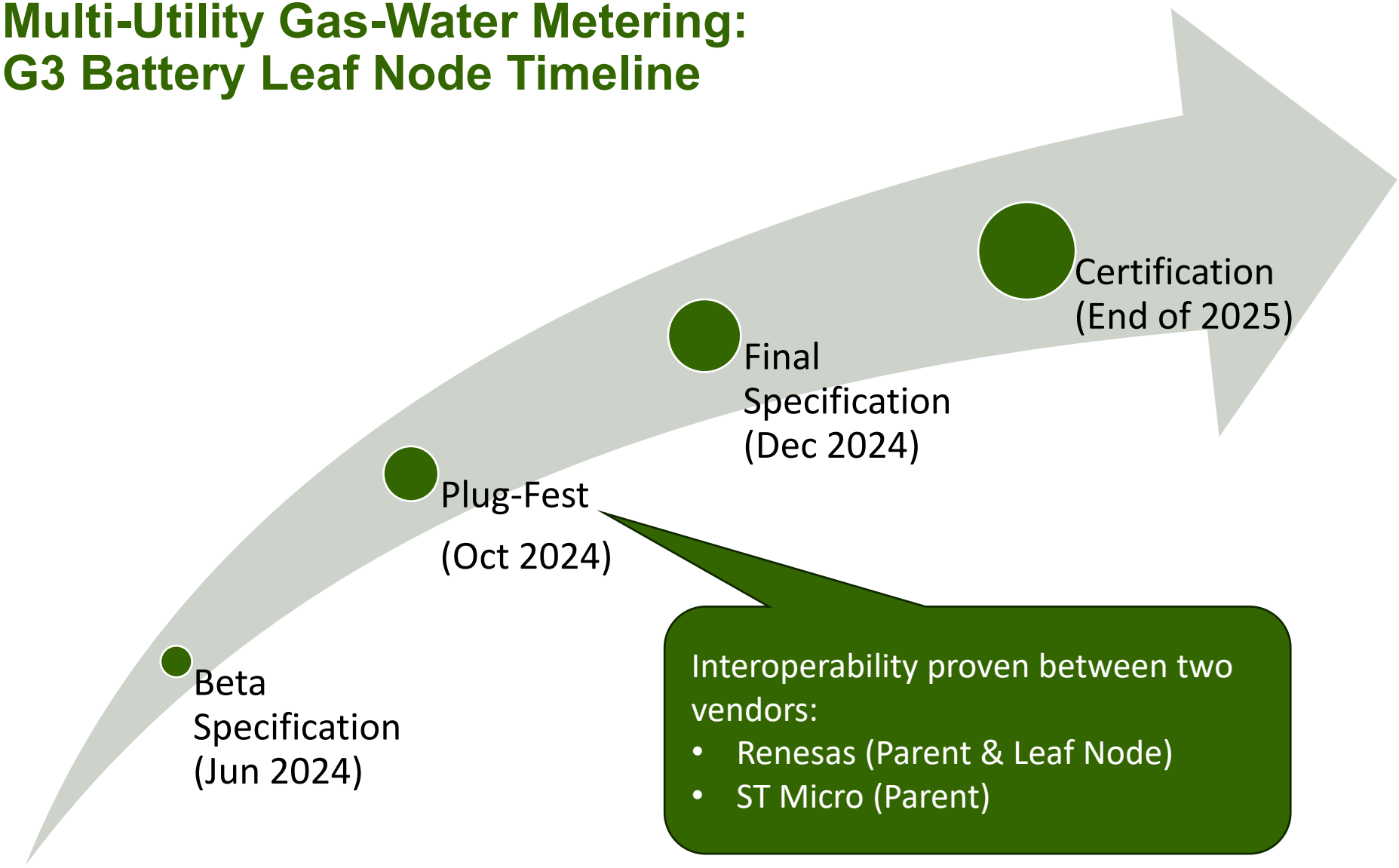
- **Data transmission**
  - LN to parent communication
    - ❖ Unicast: Data transmission can be initiated at any time.
    - ❖ Multicast: LNs shall not initiate multicast transmissions.
  - Parent to LN communication
    - ❖ Unicast: Data transmission can be initiated at UC listening windows.
    - ❖ Multicast: Data transmission can be initiated at BC listening windows.
  - In order to maximize the throughput, the parent node may send data continuously to its child nodes, using the Frame Pending bit set to 1



G3 Battery-Powered Device: Technical Specification

- **Information Element Definition**
  - Beacon Filter IE (BF-IE)
    - ❖ Can be included in an Enhanced Beacon Request to control which G3-Hybrid device may reply with a Beacon frame, based on functionality support or reception quality
  - Leaf Node Unicast Timing Request IE (LNUCTR-IE)
  - Leaf Node Unicast Timing IE (LNUCT-IE)
    - ❖ A LNUCTR-IE may be sent in a frame whenever UC time synchronization is needed (e.g. at initial join)
    - ❖ A LNUCT-IE is sent in an Enh-ACK as an answer to the LNUCTR-IE received in the frame triggering Enh-ACK transmission
  - Leaf Node Broadcast Timing IE (LNBCT-IE)
    - ❖ A LNBCT-IE carries timing info valid for all child nodes and is present in all frames sent from the parent to its child nodes.

Multi-Utility Gas-Water Metering: G3 Battery Leaf Node Timeline



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Thank you for listening, questions ?

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