Low Power Wireless Architecture

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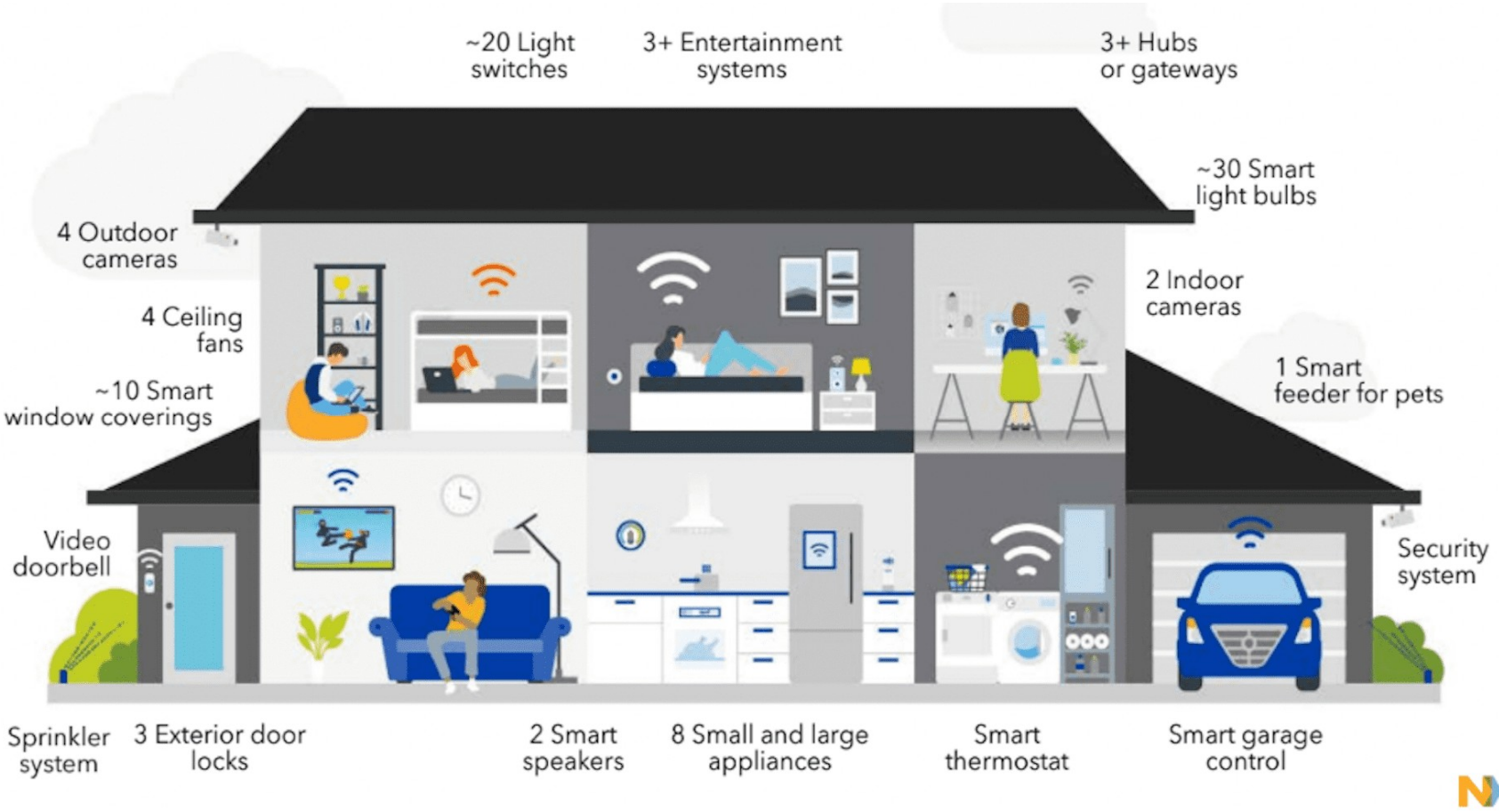
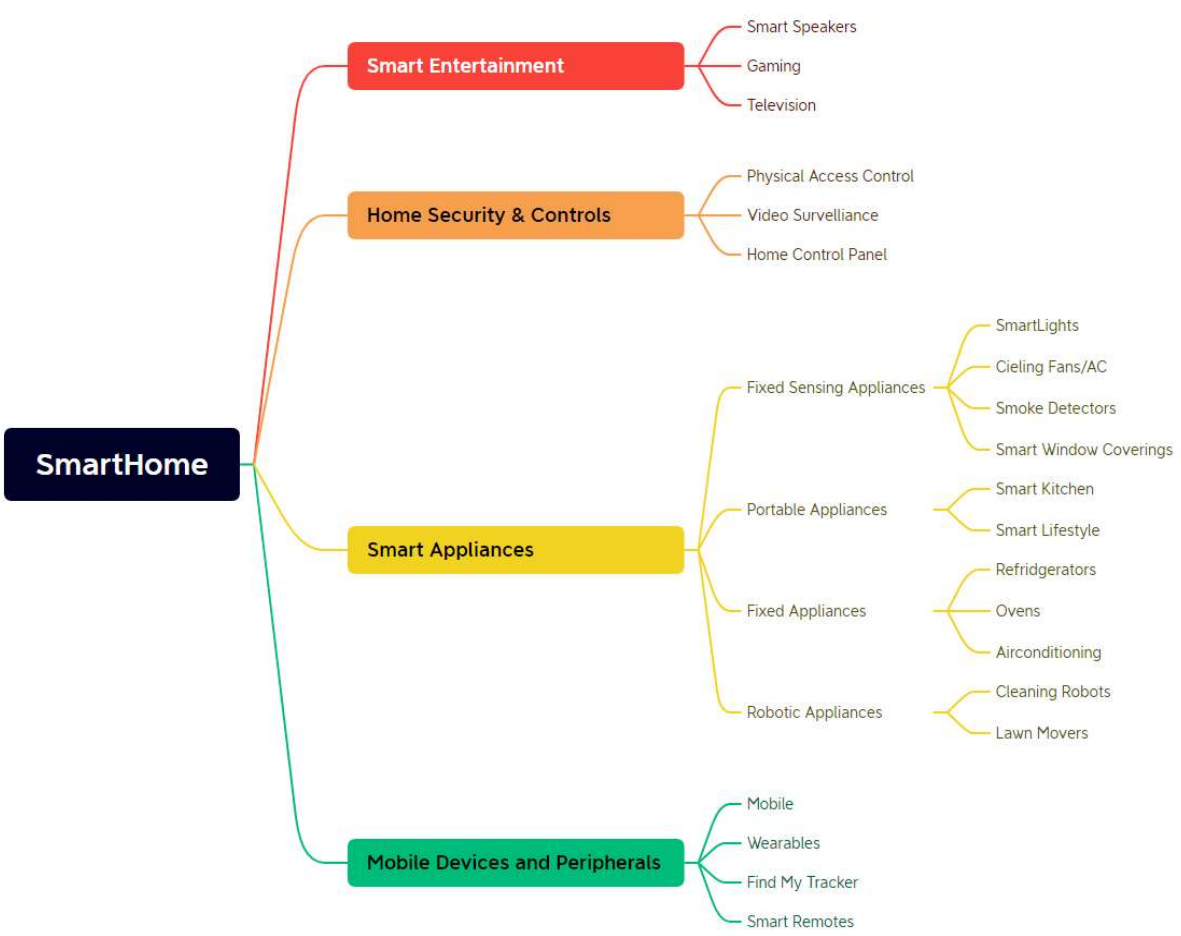
A Typical SmartHome Ecosystem



References : NXP public website

Requirements



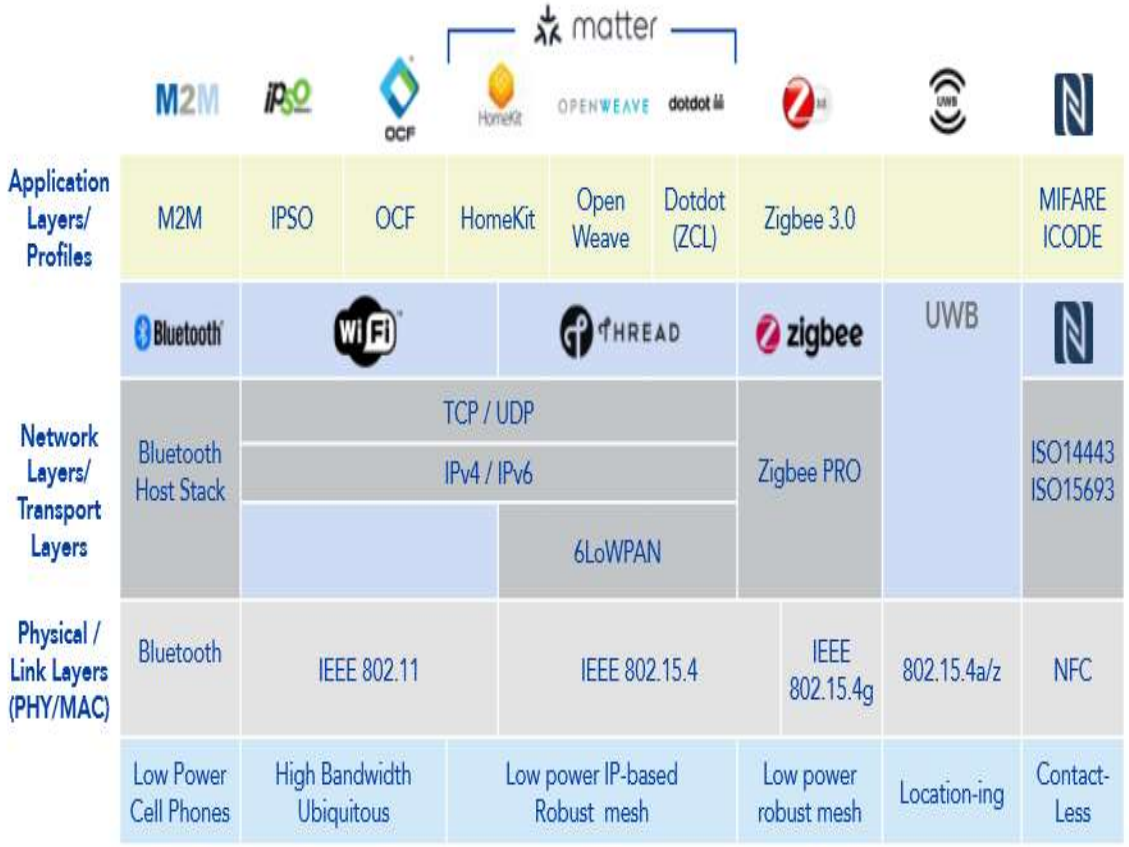
- Low Latency
- Streaming
- Idle Power
- Positioning Capability, Object Detection

- Data Rate
- Range
- Connection Density
- Position Capability

- Range
- Idle Power
- Interoperability
- Object Detection
- Mesh routing

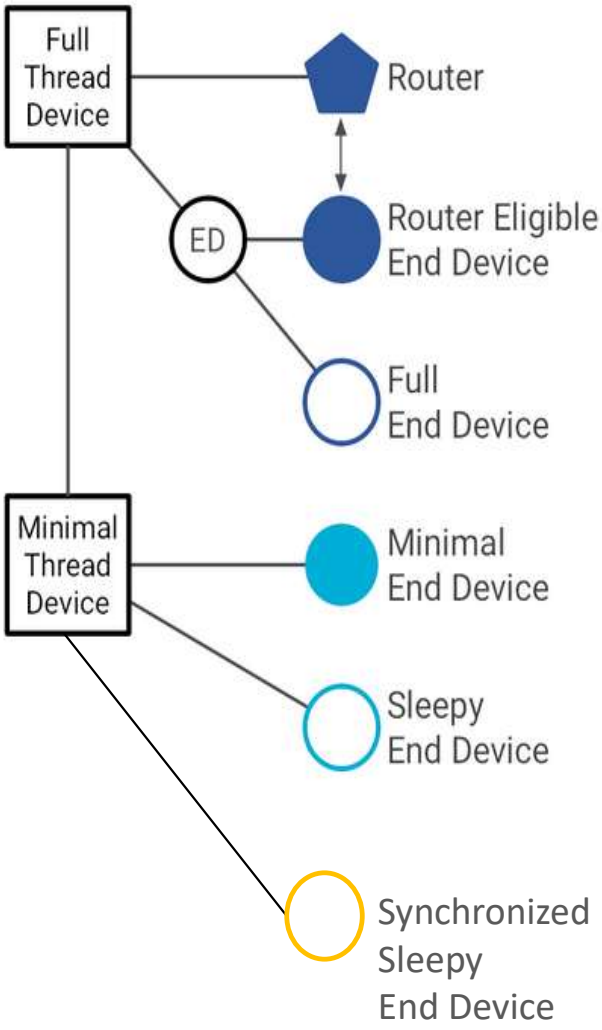
- Idle and Active Power
- Range
- Position Capability

Low Power Wireless Protocols in SmartHome



- Bluetooth traditionally for device to device synchronous communication for application like music, file transfer etc
- BLE is power optimized for asynchronous communication to enable infrequent status and control data b/w device-device
- Zigbee optimized for range, scalability and robustness and low complexity
- Thread addressed the fragmentation at network layer and host layer to simplify interoperability and optimize system level power consumption
- UWB currently is a location sensor with proprietary application stack. Advances in integrating the technology to standards like Aliro is bringing UWB into mainstream home automation.
- NFC (though not classified as low power wireless tech) is now majorly used for commissioning and pairing of wireless products simplifying device discovery and attestation.

References : , NXP Thread, Nordic Semi public websites



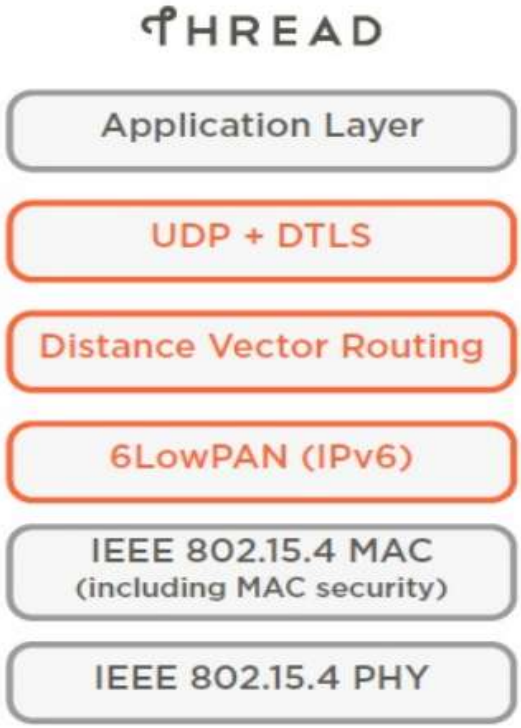
- Full End Devices which can take over router functions if need arises

- Always on for asynchronous receive any time
- Maintains routing table to perform few thread management functions

- Always on and can transmit/receive any time
- Link Metrics Probing

- Always polls the parent to receive data
- Can transmit any time asynchronously to parent
- Enhanced Frame Pending to reduce poll requests
- Enhanced Keep Alive to reduce echo pings
- Link Metrics Probing
- Latency depends on device's polling frequency

- Co-ordinated Sample Listening for Rx
- Latency depends on the agreed transmission window



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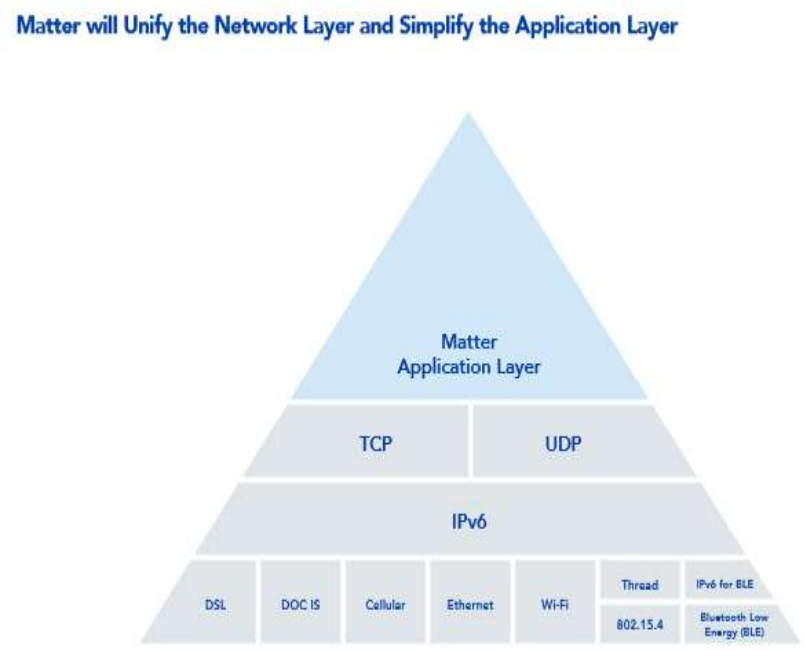
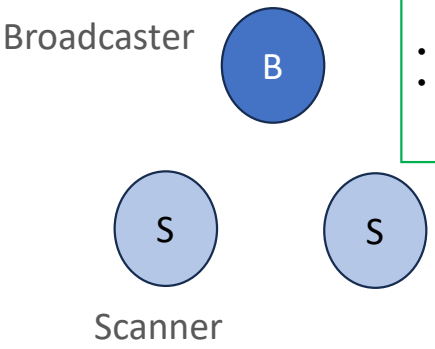
Matter



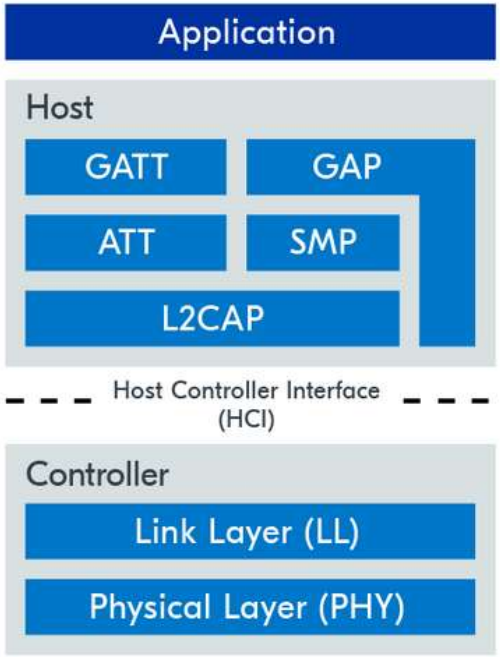
- Unified application language
- Standardizes application actions across device types
  - Lighting, SmartPlugs, Switches, Sensors..
- Data model simplifies end-2-end device usecase development
  - Device→Nodes[]→Endpoints[]→Clusters→ Attribute/State/Event
- Interfaces non Matter devices and Matter enabled devics
- Application Layer routing/security and framing

BLE

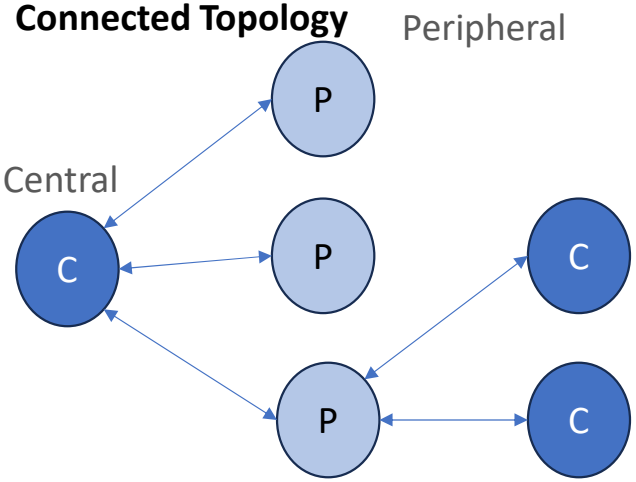
Broadcast Topology



- Broadcaster devices only send advertisement packets periodically and do not have 1:1 or 1:n connections
- Typically coin cell powered trackers
- Also home appliances providing OOB information for commissioning/pairing



Connected Topology

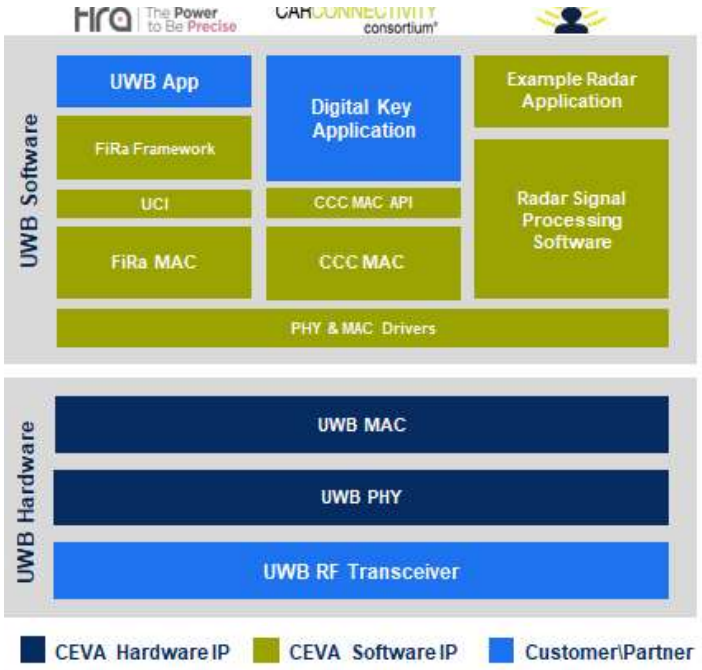


- Peripherals periodically send advertisement on 3 limited channels (reducing the time taken to advertise)
- Optimized to receive scan request and negotiate w/o full connection
- Supplementary advertisement mechanism to avoid connection before all acceptance is negotiated.
- Sleeps between advertising intervals and connection intervals
- Supervision timeout to avoid wasted power consumption on conn loss
- Peripheral Latency (skipping few connection timer events)
- Low MTU Sizes and multi PHY modes to tradeoff power vs data rate vs range

References : , NXP Thread, Nordic Semi public websites

UWB

- Inherently low power physical layer with short bursts and psd of -41.3dBm
- Can support upto 31Mbps leading to fast control data or application data transmission compared to other low power wireless
- Block based scheduling and dynamic MAC time grid management ensures higher sleep time for higher distances and lower latency for lower distances
- Uses BLE for discovery and OOB link negotiation. Fixed channel operation per session leading to lesser complex radio baseband operations and less system power.
- High multipath immunity leads to lesser channel errors and no retry mechanism
- Link features like Block Striding, Autonomous session termination, Initiation time, Time Sync etc leads to better power efficiency.
- Infrastructure less Radar mode achieves object detection at very less power as it transmits a burst of impulses for a short time and go to sleep until next event.



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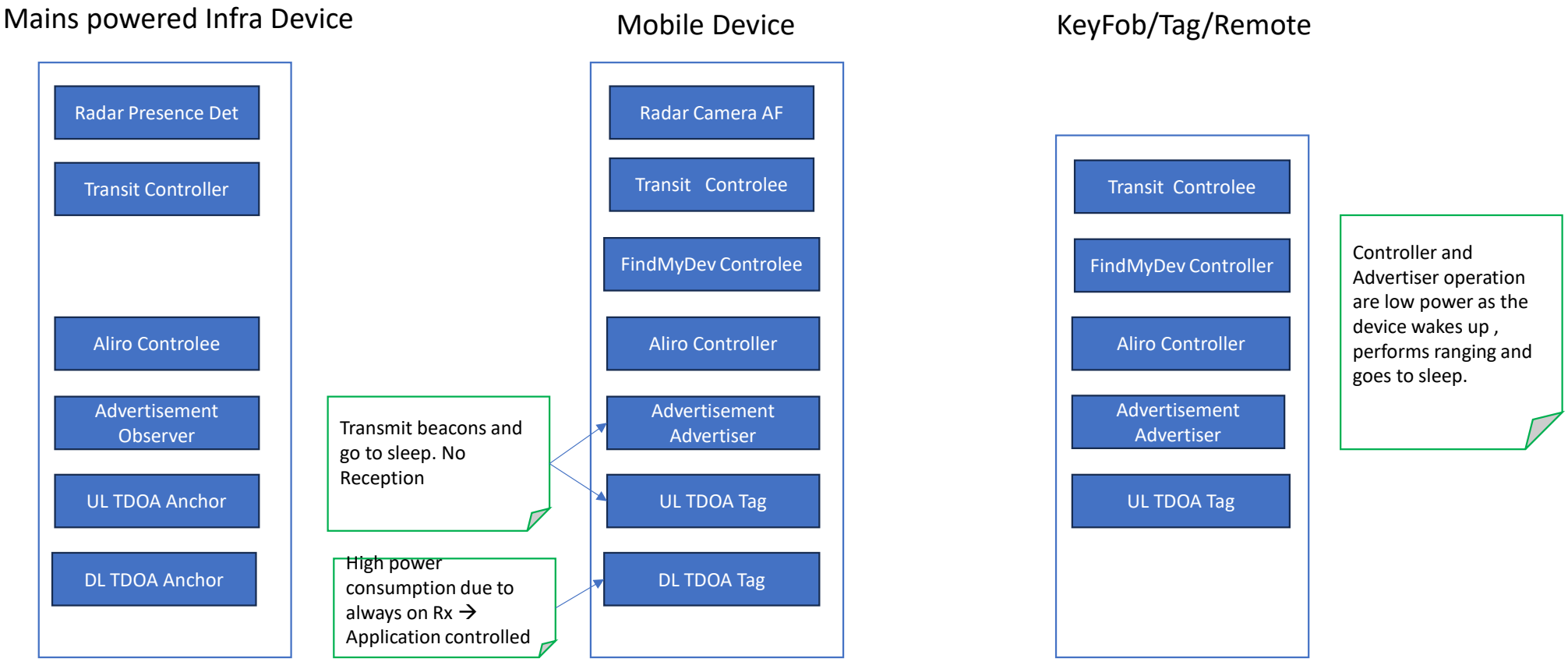
UWB Device Configurations



System/FW Architecture for low power wireless

- Standby mode entry and exit overhead needs to be optimized
- Parallelism between packet preparation, modem configuration , Tx/Rx to optimize slot time
- Optimized session/link scheduler that does not introduce holes in MAC time grid and cause collisions
- Optimized use of retention memory to reduce standby power at same time maintain link context
- Parallelism between Signal processing of CIR and Radio operations
- Multi core architecture /partitioning and clock gating management
- Host protocol definition that optimizes unnecessary wakeups

Q&A