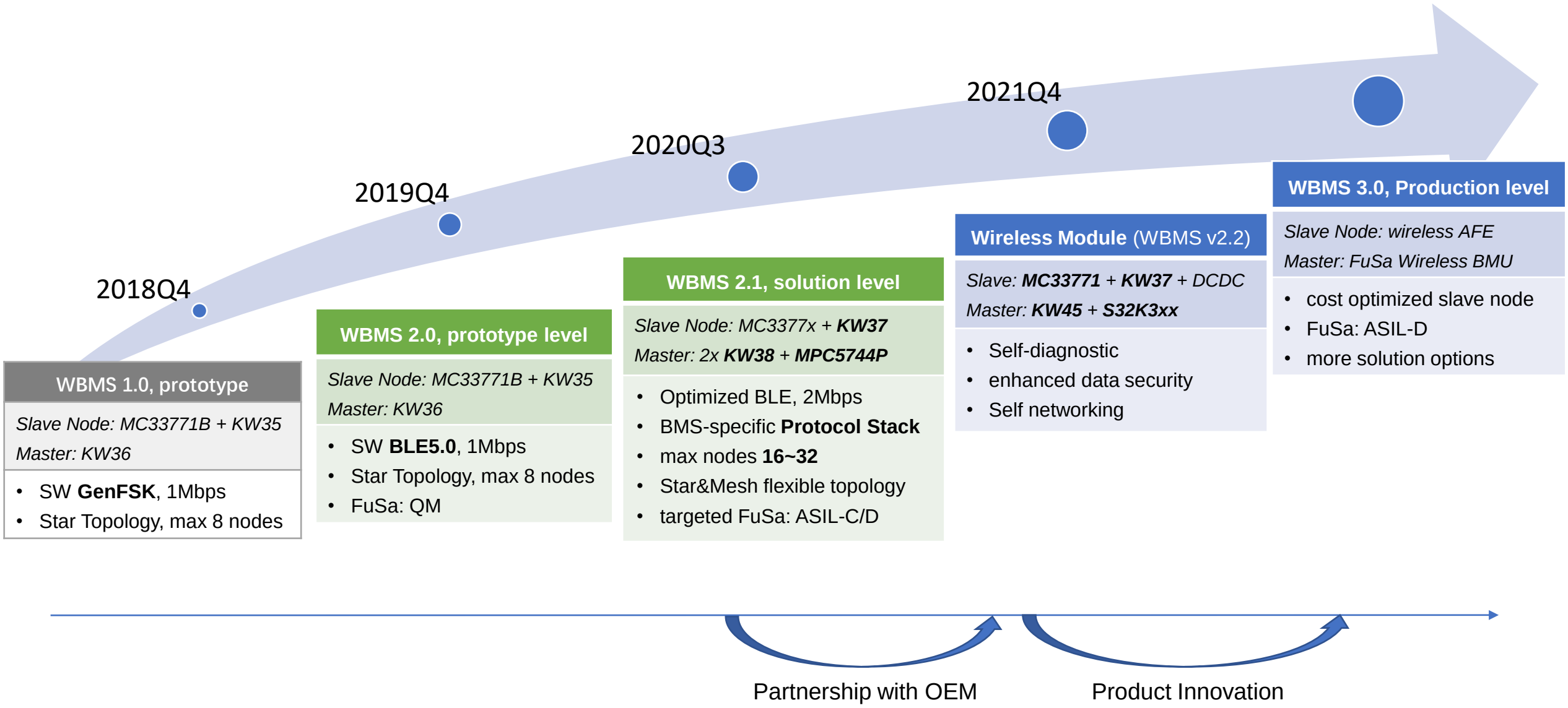
NXP WBMS

NXP APPLICATION TEAM

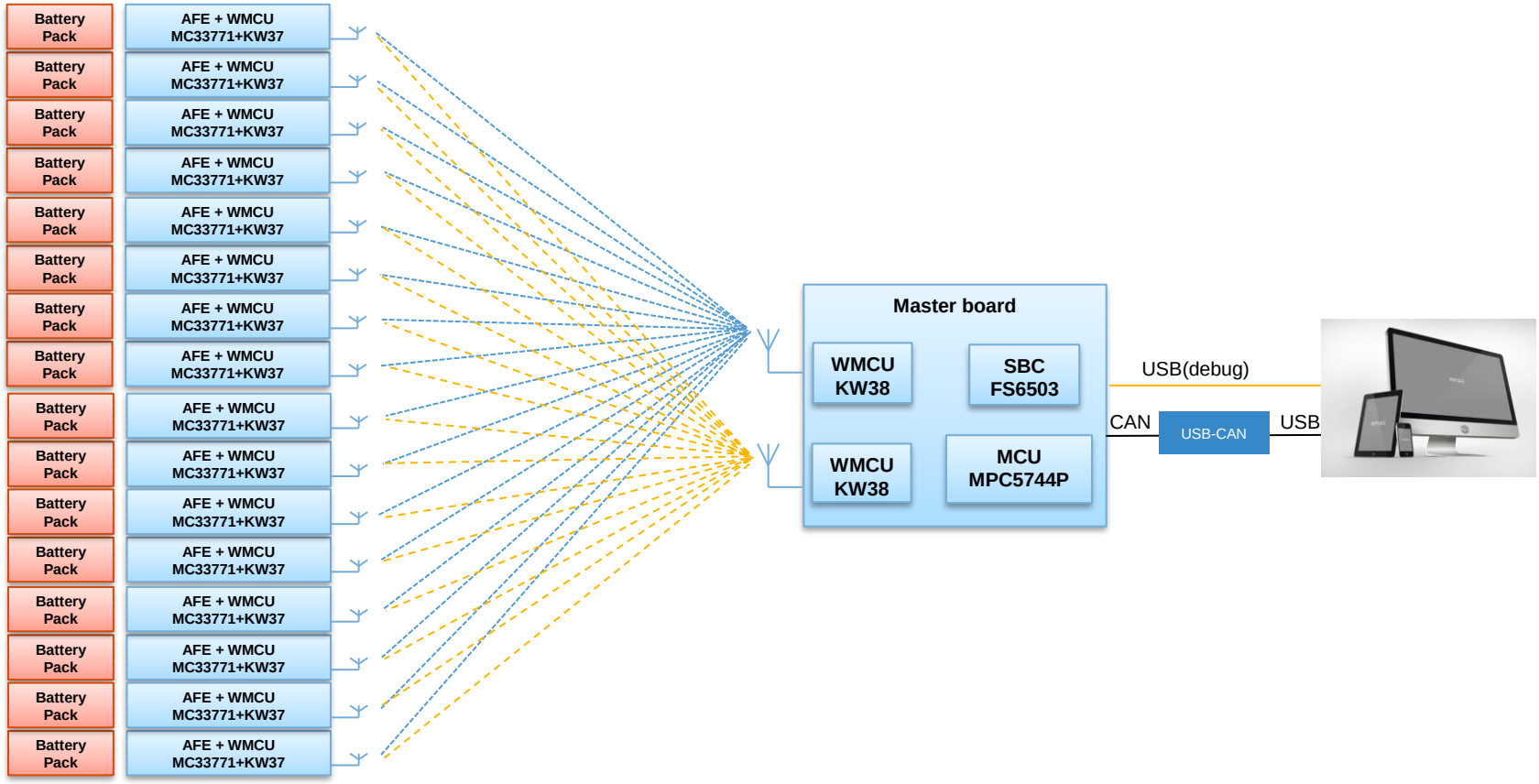
XIAOFENG JIA

NXP Wireless BMS Roadmap (BMS China)



HARDWARE

WBMS V2.1 New Feature

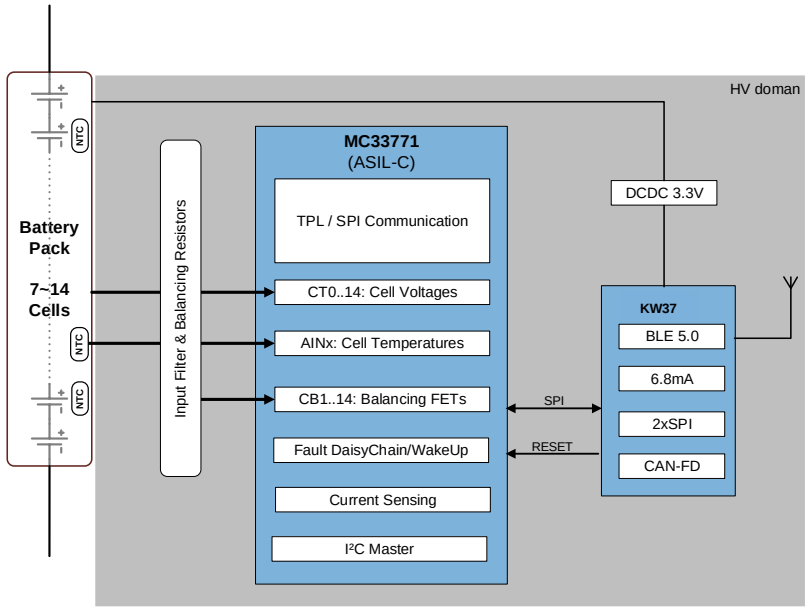


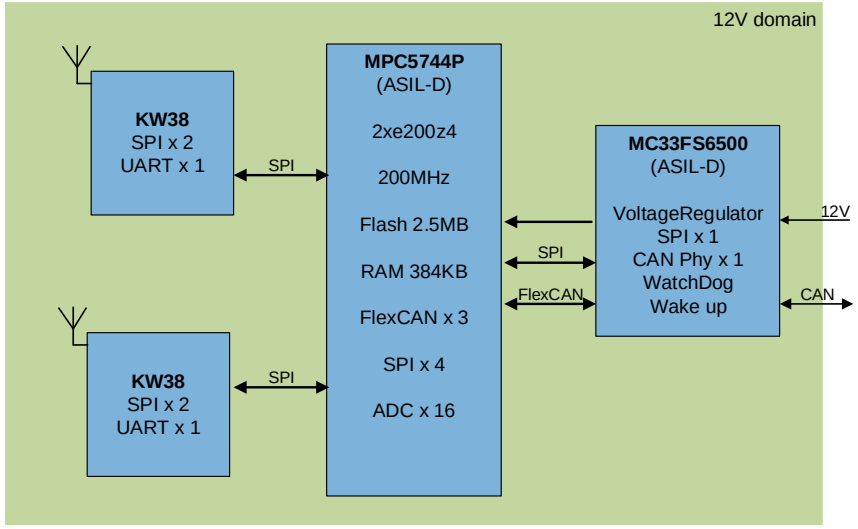
- **New Feature**
  - Full feature BLE5.0
  - KW37/38 implement
  - Master board support up to 32 continuous connection
  - Slave board support up to 2 continuous connection
  - Add external antenna connector as an option
  - Master board support 2 + 16 or 2 + 32 network.
  - Free Software IDE MCUXpress, SDK

WBMS 2.1 Hardware

- **Slave Board RevE**

- **Master Board RevA**





- **Slave Board RevE**
  - Update Wireless MCU from KW35 to KW37(QM)
  - External Antenna connector as option
- **Master Board RevA**
  - New controller board creation
  - Two KW38(QM) as a dedicate communication MCU
  - MPC5744P(ASIL-D) as a main controller
  - CAN interface to GUI as 1Mbps speed
  - Two external antenna connector as option

WBMS V2.1 Demo Kit

- **Feature**
  - 1 Master board + 10 slave board (8 on box, 2 mobile)
  - Topology :

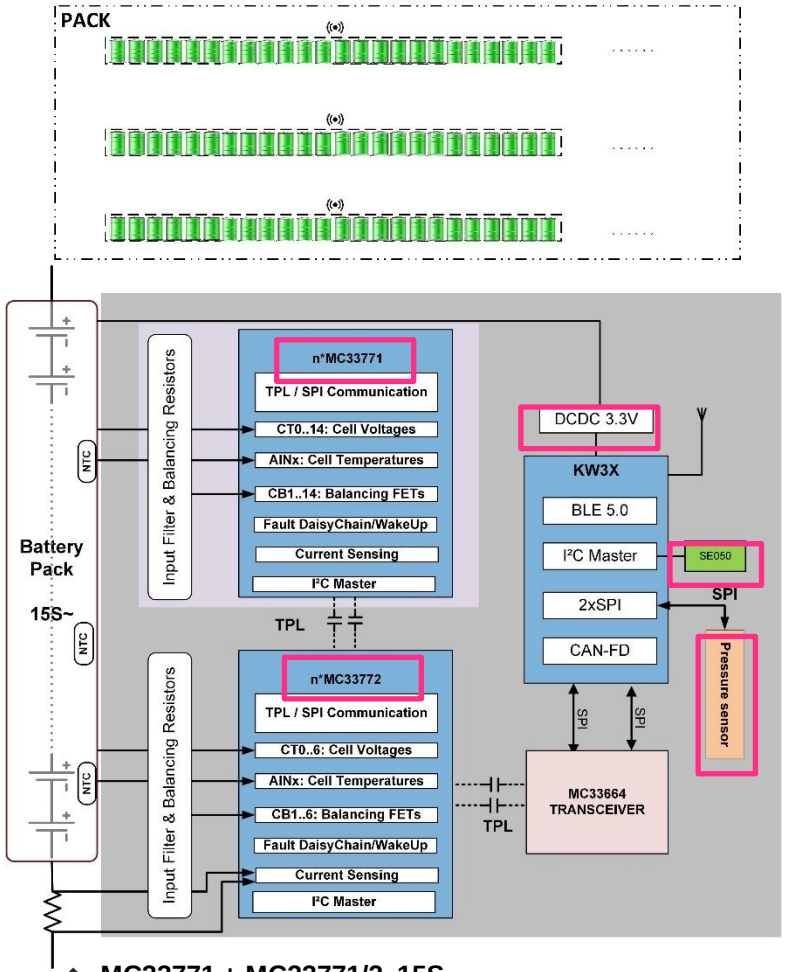
    1 master → 4 slave on box, 1 mobile

    1 master → 4 slave on box, 1 mobile

    Two network work in parallel
  - CAN interface to unionGUI (1Mbps)
  - BLE 5.0 , 2Mbps
  - WBMS protocol V1.0
  - Two slave mobile could check wireless distance → stability

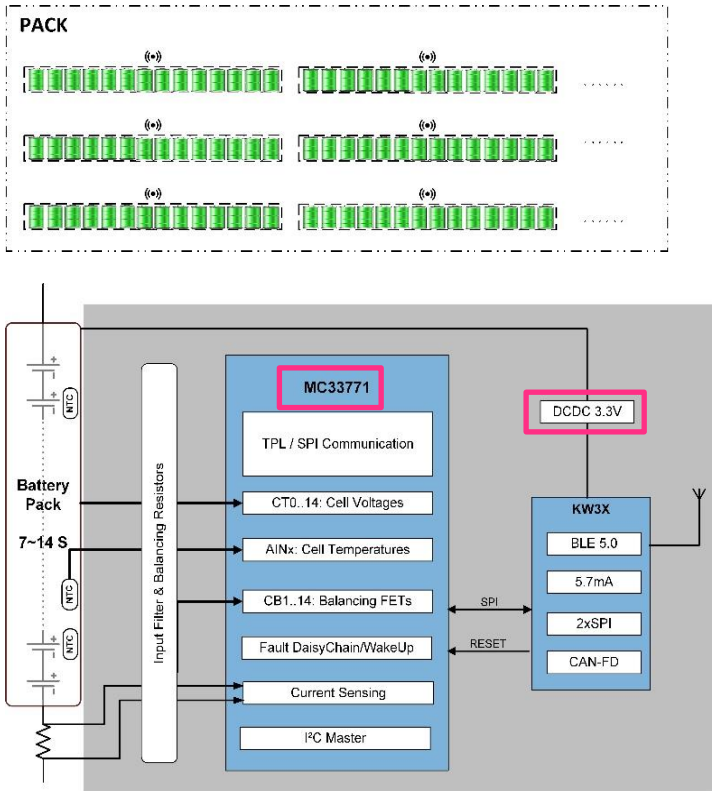
“Wireless Module” Coverage upon battery modules

large module：15S~



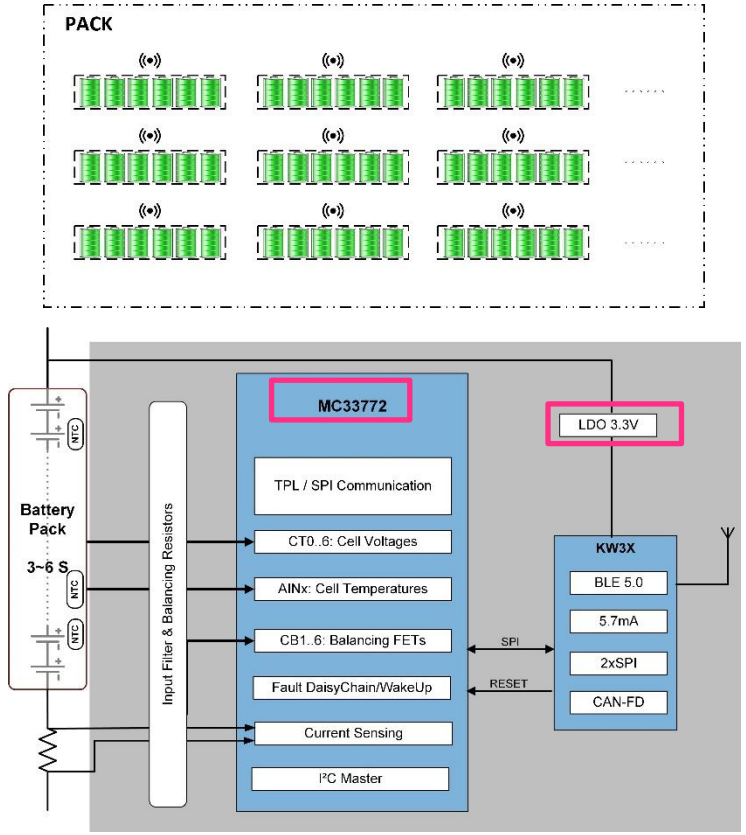
- MC33771 + MC33771/2, 15S~
- HV DCDC to supply KW3x device
- capacitor-isolation in board
- optional Pressure Sensor in the module
- optional HW authentication with NXP Security Element

Middle module：7~14S



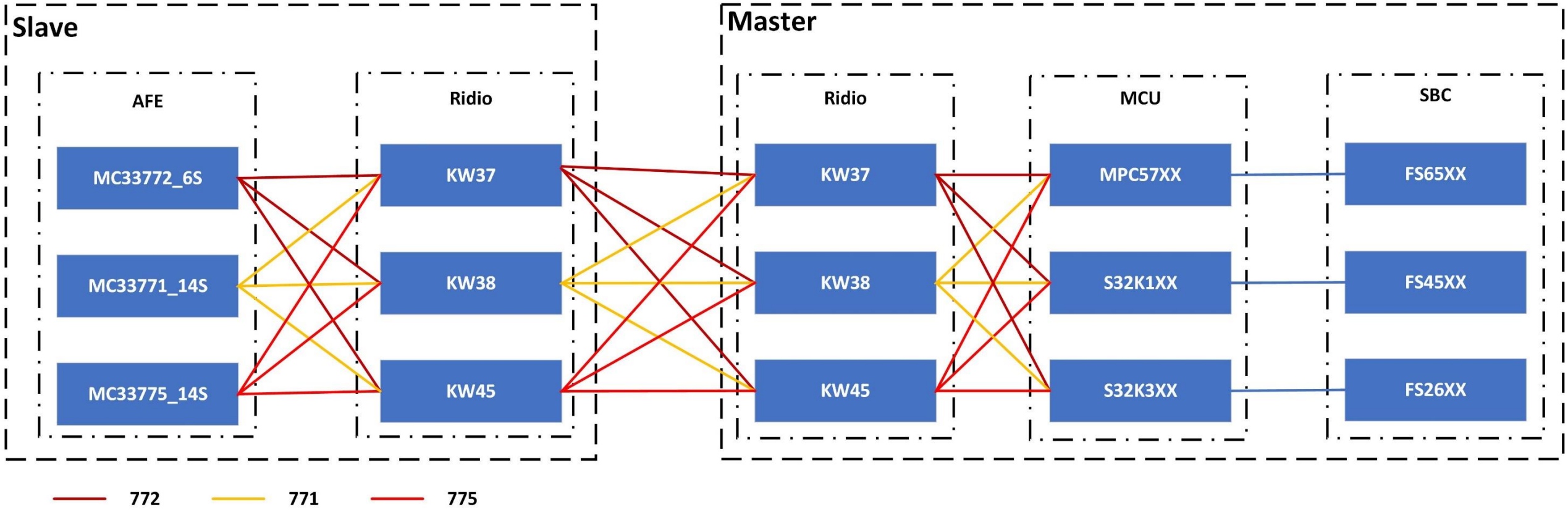
- 1 x MC33771 , 7~14 S
- external DCDC to supply KW3x device

Small module：3~6S



- 1 x MC33772 , 3~6 S
- external LDO to supply KW3x device

Wireless BMS BOM Select



SOFTWARE

NXP Stack Protocol for W-BMS

Bat module
- ✓ ID traceability
- ✓ Self-diagnostic
- ✓ Automated network grouping
- ✓ Battery monitoring with OTA access

Network Architecture
- Provide flexible network topology： **BMU + AFE x n application architecture**
- **For ESS Application, support long distance communication.**
- Based on **mature wireless protocol**

Stability
- NXP WBMS involve whole **2.4GHz frequency range** that could escape conflict with other wireless working devices.
- **Fast recovery** once communication failure happened. Strong **anti-interference of burst wireless noise.**
- Provide 3 options for **wireless signal antenna design** to build stable communication and **low cost.**

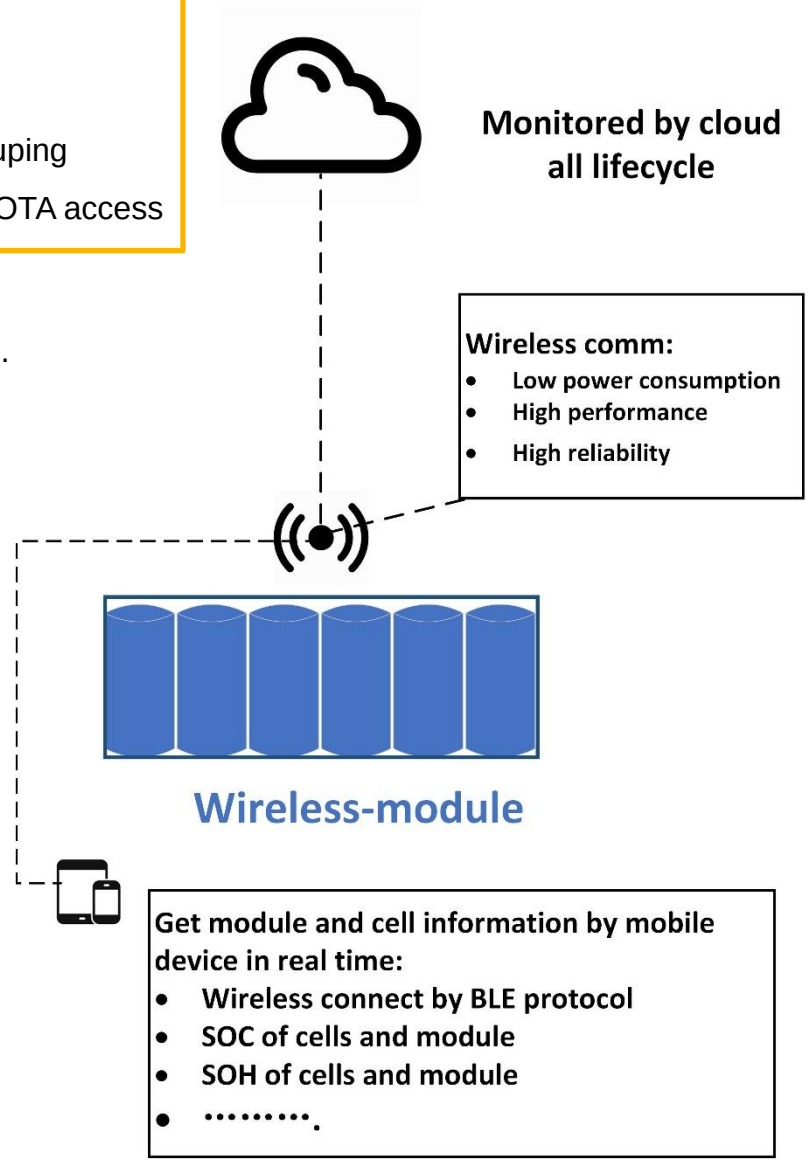
Real-Time Data
- Runtime **checking the AFE data effectiveness** within a battery cell polling time.
- **Simplify the start-up process**, **get fast network establishing speed** when every Key-On event.

Maintenance
- support **OTA** for firmware update.
- Support **Android / IOS system mobile devices connection**.
- **Easy to replace a failure module** from running network.
- **Tracking/stored AFE data** in module to **support module-level battery pack replacement**.

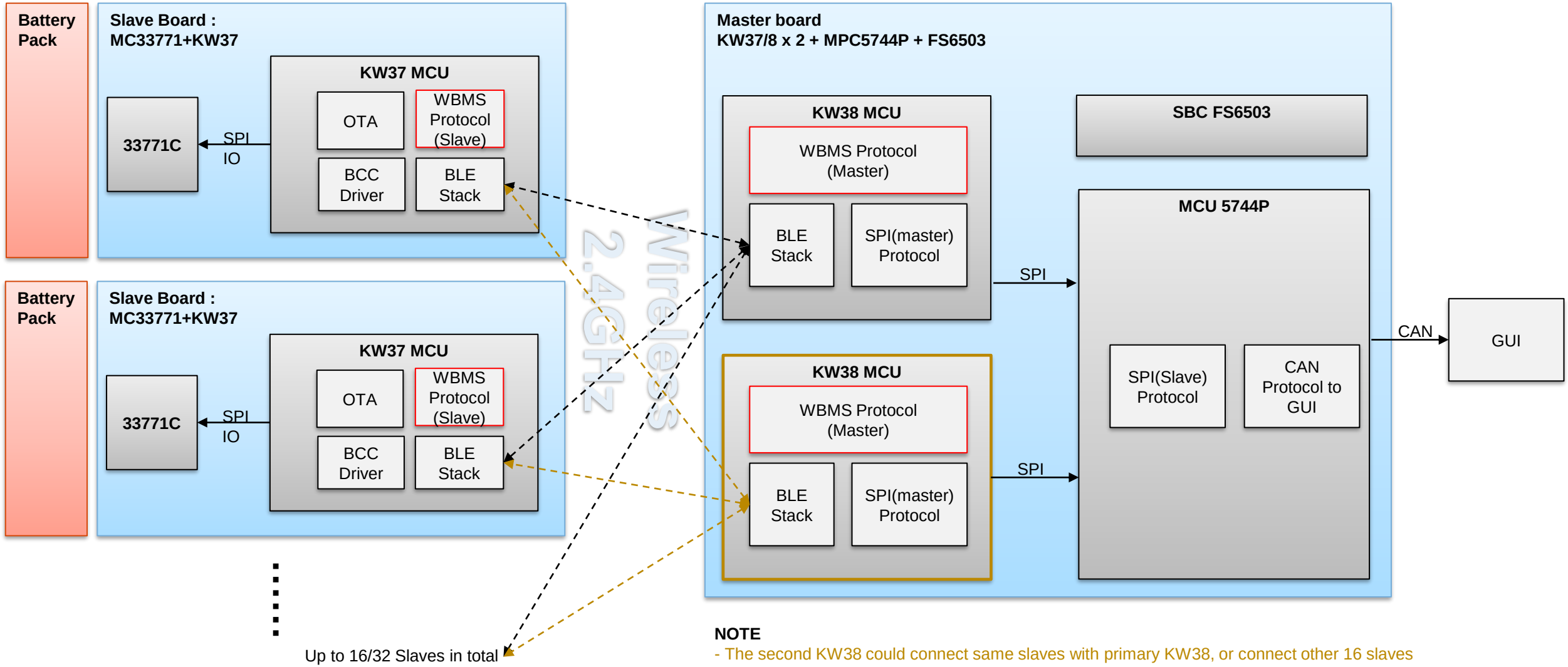
Security
- Adopt the **most secure symmetric encryption algorithm** that is **widely used in the mobile device** in the world.

Consumption
- Ultra **low power consumption**
- **Protocol** could adjusted or optimized by software configure to get extremely low power consumption.

Functional Safety
- Targeting functional safety **ASIL-D** level.



WBMS V2.1 Software Architecture



NOTE

- The second KW38 could connect same slaves with primary KW38, or connect other 16 slaves

WBMS Develop environment setup

- IDE
  - IAR system
    - commercial, have to pay for it

  - MCUXpresso
    - NXP provide for free, download from NXP official website

NXP KWXX

Kinetis KW37/38/39 MCU Family | Features

Core/Memory/System
- Cortex-M0+ running up to 48 MHz
- **KW37**: 512kB (2x256kB, swappable) Program Flash with ECC ***OR***
- **KW38/39**: 256kB Program Flash + 256kB FlexNVM both with ECC;
- 64 kB SRAM
- **KW38/39**: 8 KB of user-segment defined byte write/erase EEPROM
  - Allocation of FlexNVM (minimum 32KB) to EEPROM emulation will determine effective endurance
- Four independently programmable DMA controller channels

Radio
- Support for Bluetooth LE 5.0 and Generic FSK
  - High Speed (2 Mbps), Long Range, Advertising Extensions
- -97 dBm receiver sensitivity in BLE 1Mbps mode
- -105 dBm receive sensitivity in BLE long range 125kbps mode
- -30 to +5 dBm programmable output power

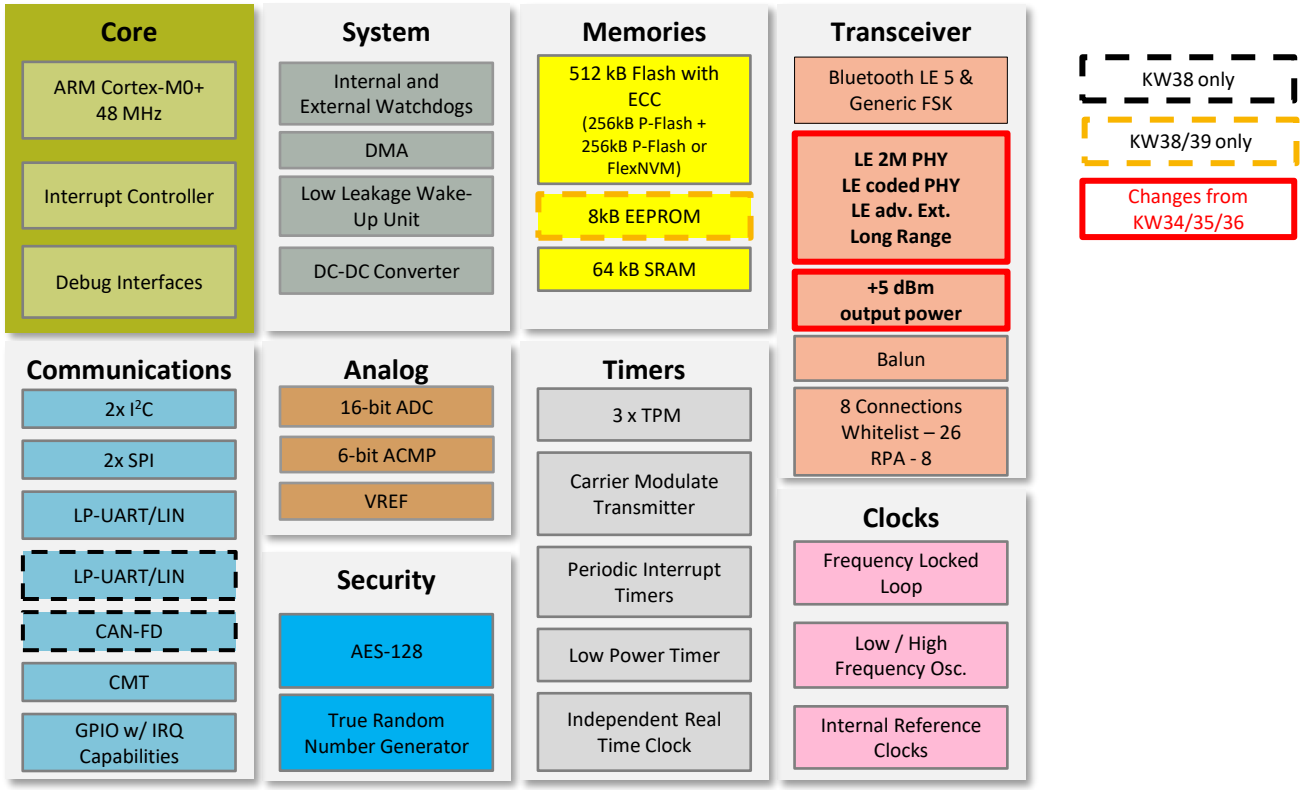
Communications/HMI/Timers
- 2xSPI, LP-UART with LIN, 2xI2C, CMT, GPIO with IRQ capability (KBI)
- **KW38**: CAN-FD and 2nd UART with LIN
- 3x FlexTimer (TPM) with PWM & quadrature decode support
- Low Power (LPTMR), Programmable Interrupt (PIT) and RTC timers

Analog
- 16-bit ADC with integrated temperature sensor and battery monitor
- 6-bit High-speed Analog Comparator
- 1.2V voltage reference (VREF)

Security
- AES Accelerator and True Random Number Generator

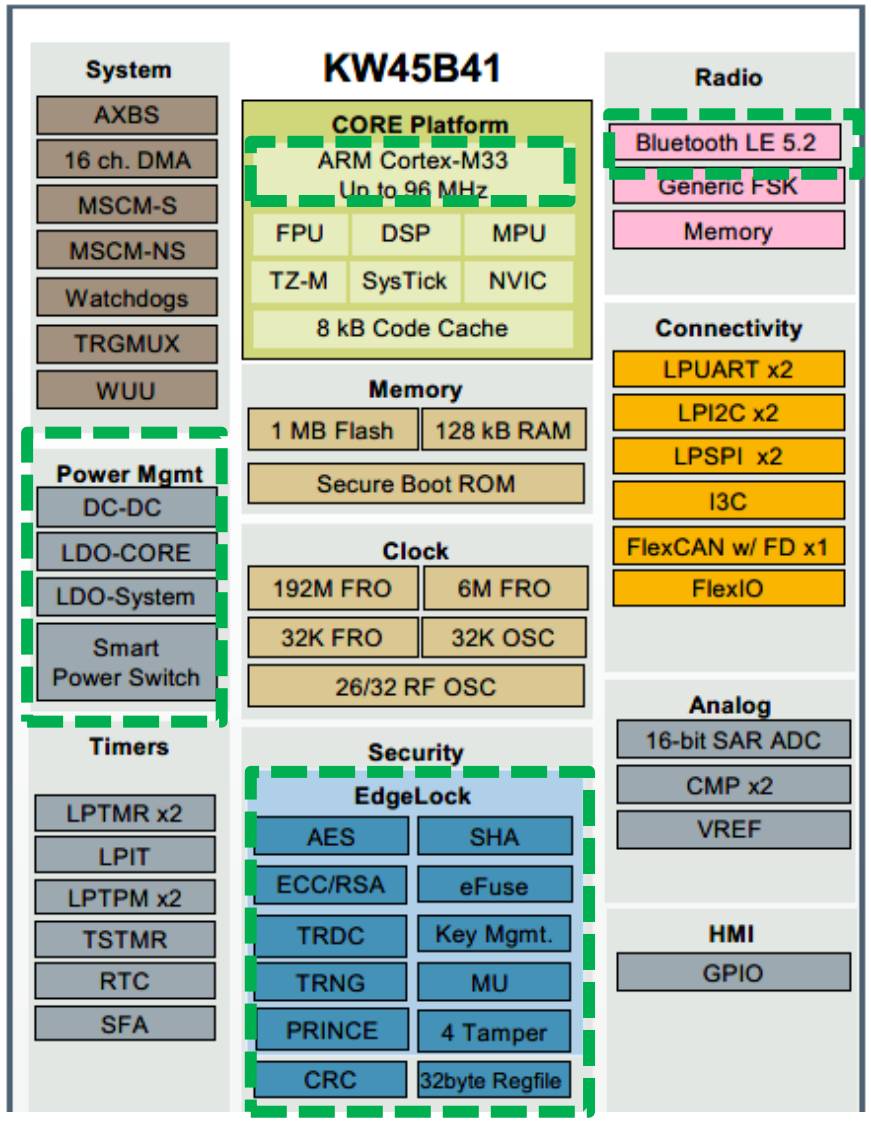
Unique Identifiers
- 80-bit device ID programmed at factory
- 40-bit unique number can be used for Bluetooth Low Energy

Operating Characteristics
- Voltage range: Buck 2.1 V to 3.6V, Bypass 1.71 V to 3.6 V
- Ambient temperature range: –40 to 105 °C
- AEC Q100 Grade 2 Automotive (A version) Qualification
- Industrial (Z version) Qualification



Device	CAN FD	2nd UART with LIN	8KB EEPROM	Qualification Tier	Package
MKW37A512VFT4	N	N	N	AEC Q100 Grade 2	7x7 48-pin HVQFN "Wettable"
MKW37Z512VFT4				Industrial	
MKW38A512VFT4	Y	Y	Y	AEC Q100 Grade 2	
MKW38Z512VFT4				Industrial	
MKW39A512VFT4	N	N	Y	AEC Q100 Grade 2	

KW45 Wireless MCU| Features



Core Platform
- Up to 96 MHz Cortex-M33 , <45uA/MHz
- TrustZone-M, MPU, IEEE 754 FPU, DSP
- 8 kB Code Cache

Memory
- 1 MB Flash
- 128kB RAM w/ ECC (32kB)
- Secure Boot ROM

EdgeLock Secure Enclave
- Trusted resource domain controller (TRDC) providing access policies for embedded memory and peripherals
- Advanced flash access protection
- Optional flash encryption and on-the-fly decryption
- Hardware encryption and decryption
  - Symmetric Key Encryption: AES-128/192/256
  - Asymmetric Key Encryption: RSA-1024/2048/3072/4096, ECC P–192/224/256/384/521
  - Digital Signature Algorithms: ECDSA
  - Hash Algorithms: SHA2-224/384/512
- Psuedo & True Random Number Generator (P/TRNG)
- Up to 4 digital tamper pins

Bluetooth LE Radio
- Bluetooth LE 5.2 radio supporting direction finding, high-speed, long range, advertising extensions
- Up to 24 simultaneous Bluetooth LE connections
- Generic FSK modulation (Up to 2 Mbps)
- Radio memory for Bluetooth LE LL (Controller)
- Receiver Sensitivity
  - -95 dBm, 2 Mbps Bluetooth LE
  - -98 dBm, 1 Mbps Bluetooth LE
  - -101.5 dBm, 500 kbps Bluetooth LE Long Range
  - -106 dBm, 125 kbps Bluetooth LE Long Range
- Programmable Transmit Output Power up to +10 dBm

Communication Interfaces
- 2x LPSPI, one up to 40MHz
- 2x LPUART, w/ IrDA
- 2x LPI2C, one up to 3.4M bps
- 1x I3C
- 1x FlexCAN w/ FD support
- 1x FlexIO

Timers
- 2x 6-ch LP Timer/PWM Module (TPM)
- 1x 4-ch LP Interval Timer (LPIT)
- 2x Low Power Timer (LPTPM)
- 1x Timestamp Timer (LSTMR)
- 2x Internal Watchdog, 1x External Watchdog
- 1x RTC w/ 32 byte Register File
- Signal Frequency Analyzer (SFA)

Analog
- 1x 16-bit SAR ADC, up to 2Msps
  - 2x Single End 16-bit ADC
- 2x Comparator
- 1.0-2.1V Programmable Voltage Reference

Power Management
- DCDC, 1.71 to 3.6 V, LDO-Sys, 1.71 to 3.6V
- LDO-Core, 1.71~3.6 V (Enable); 0.84~1.21 V (Bypass)
- <100 nA Smart Power Switch (low leakage)

Qualification
- AEC-Q100 Grade2
- Extended operating temp up to +120°C (Ta)

- **Packages**
- 48HVQFN “Wettable” 7x7, 0.5p
- 40HVQFN “Wettable” 6x6, 0.5p

WIRELESS MODULE

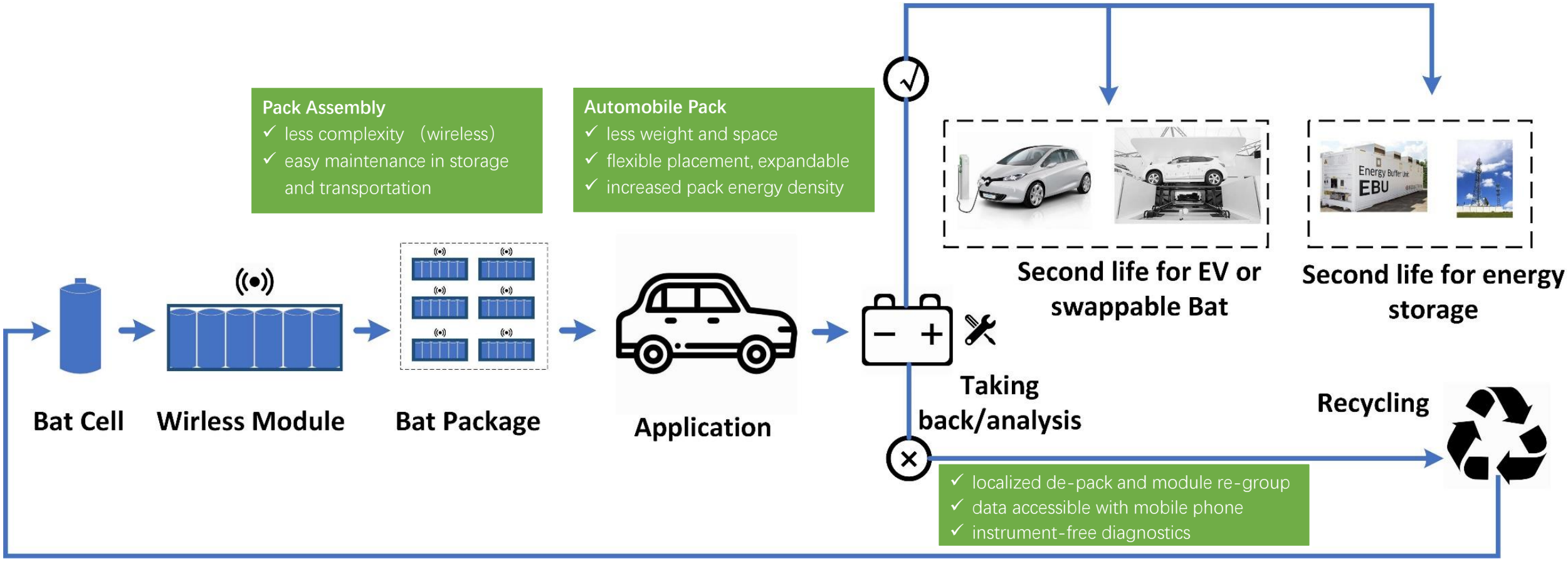
“Wireless Module” concept

Battery Swap
- ✓ swap in module-level
- ✓ localized module replacement
- ✓ easy management in bat bank

ESS
- ✓ Easy maintenance

Pack Assembly
- ✓ less complexity （wireless）
- ✓ easy maintenance in storage and transportation

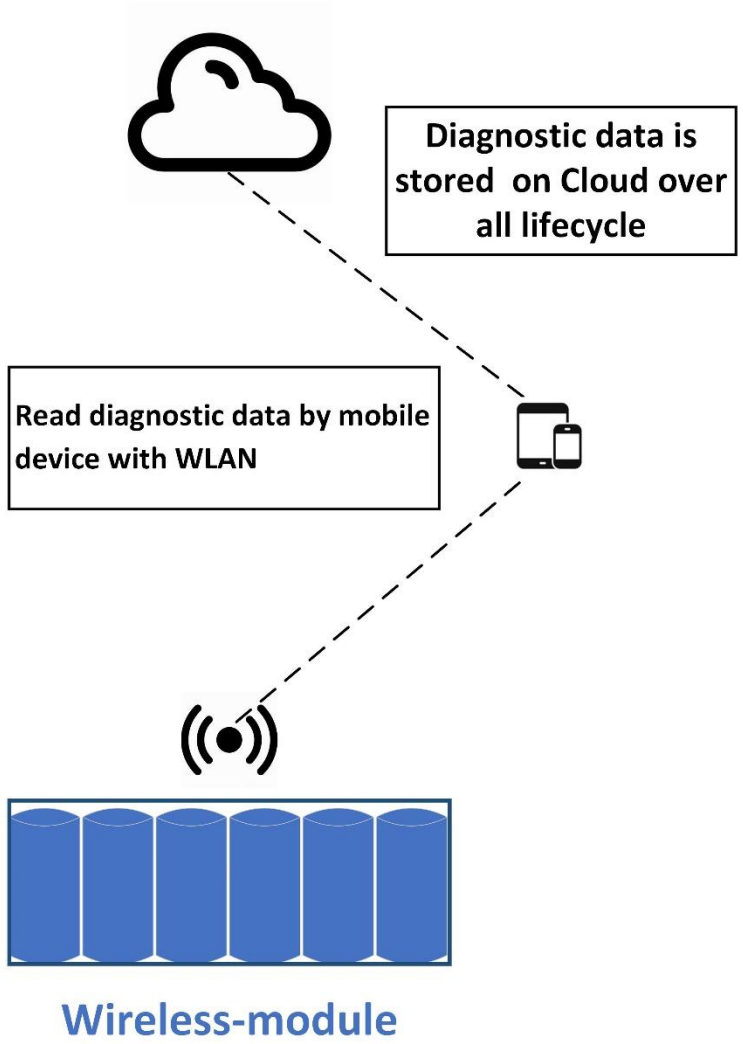
Automobile Pack
- ✓ less weight and space
- ✓ flexible placement, expandable
- ✓ increased pack energy density



NXP Wireless Module Over Battery LifeCycle

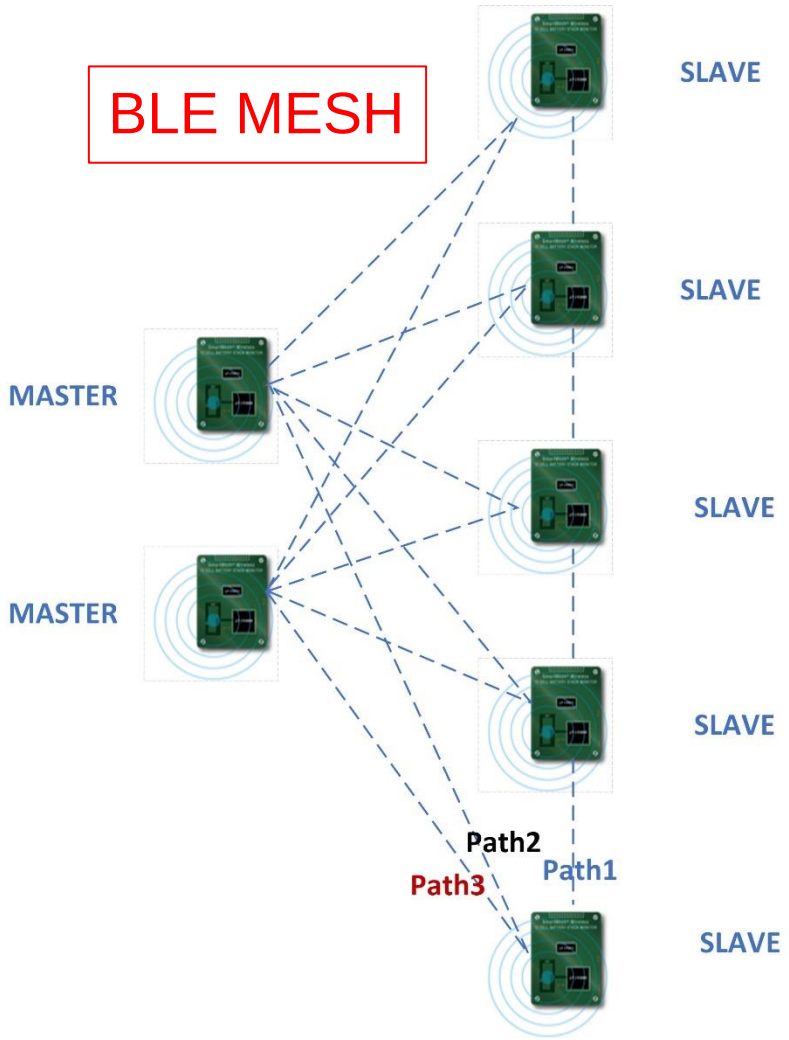
Self Diagnosis and diagnostic with cloud data

	Diagnosis Items	Module	PACK	In-service	taking back/analysis	Cascade Utilization
1	Cell OT					
2	Cell UT					
3	Cell Temperature rising too fast					
4	Cell OV					
5	Cell UV					
6	Bad Cell Consistency					
7	Module UV					
8	Module OV					
9	Module Consistency					
10	Charge Current OC					
11	Dis-charge Current OC					
12	SOH too low					
13	SOC too high					
14	SOC too low					
15	SOC Drop Suddenly					
16	Communication Fault					



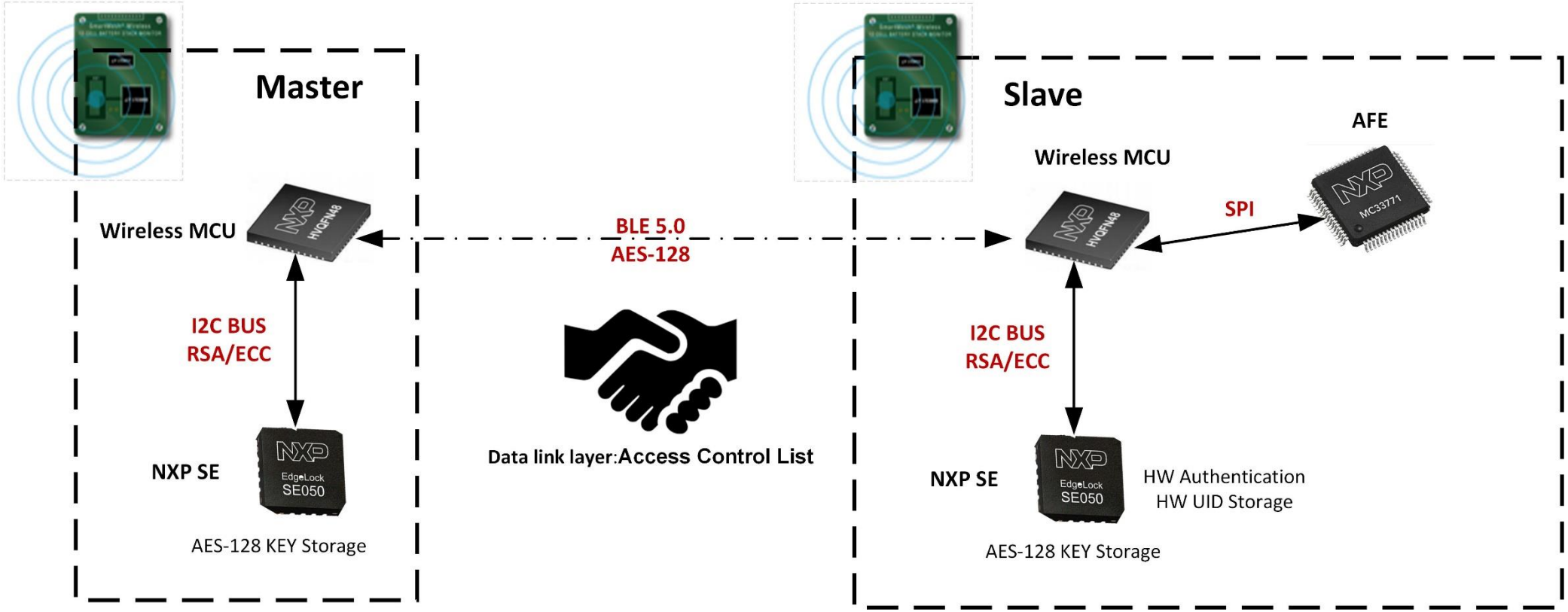
Automated network grouping

- Channel hopping design for multi-network coexistence, redundancy and reliability
- Each slave communicates with both network master and one other slave (3 paths)
- If transmission has no action, automatically resent on different channel and/or different path
- Master monitor RF performance and data latency, and provides problem notifications
- If one master fails, the other Manager handles all network traffic but warning
- If both masters fail, all slaves network is still alive and slave hop to be master which organize the communication again
- Slave in the network is replaced or added, the new slave will be involved in the network automatically



Access with data security

- Access control list based on MAC addresses of KW3x
- HW authentication for dedicated module device(welcome for battery bank)
- AES-128 communication encryption algorithm
- Secure AES-128 key access based on RSA/ECC encryption algorithm



SECURE CONNECTIONS
FOR A SMARTER WORLD