LoRa® Solutions: Long-Range Wireless Communication Technology and Its Application in Various IoT Fields

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

Presented by:
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March 28, 2023

Agenda

- LoRa® & IEEE® 802.15.4
- LoRaWAN® & MiWi™
- Microchip LoRa Solutions & Demos
- LoRa Field Test
- LoRa Applications
- Summary

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LoRa®

LoRa® & IEEE® 802.15.4

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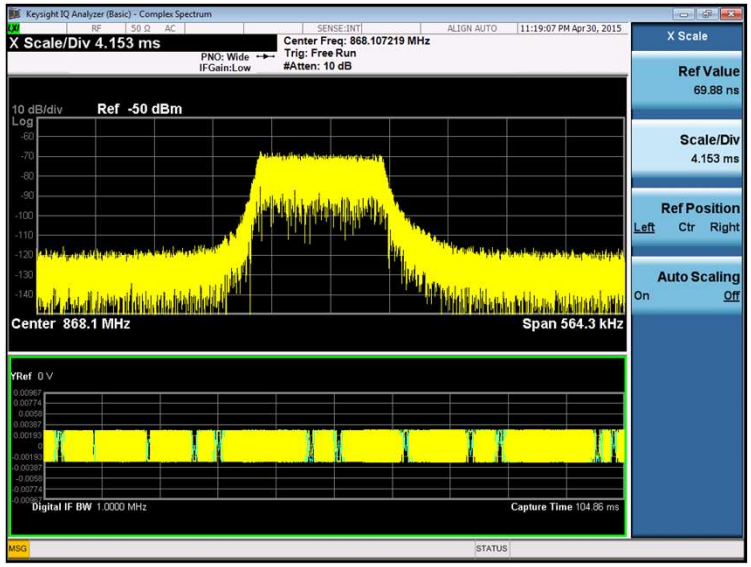
What is LoRa® Technology?

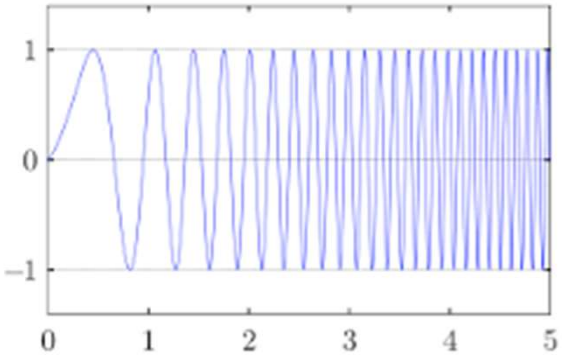
A combination of two major concepts:

- **LoRa spread spectrum modulation (The “PHY” layer)**
  - Provides the core long range capability
    - Up to 5 km range in urban environment, up to 15 km suburban
  - Developed by Semtech, built in to SX127x transceiver ICs
  - SX1301 gateway baseband chip allows multiple receive channels and spreading factors
- **LoRaWAN® network protocol**
  - Provides a cellular-like network (aka large-star topology)
  - Defined by IBM & Actility, made open by the LoRa Alliance®
    - https://lora-alliance.org/resource-hub/lorawantm-specification-v11
  - Microchip developed/owns/maintains LoRaWAN stacks for our LoRaWAN products.

LoRa® Technology Modulation

- Proprietary Spread Spectrum Technology
- Developed by Semtech Corporation (http://www.semtech.com/)
- Chirped-FM
- Processing gain = increased receive sensitivity
- Enables longer range at expense of lower data rate





LoRa® Technology Modulation

- **Spreading Factor (SF)**
  - Programmable SF:

    7, 8, 9, 10, 11, 12
  - The higher the SF the more information transmitted per bit; therefore, higher processing gain
- **Bandwidth (BW)**
  - Programmable signal BW settings:

    125 kHz, 250 kHz, 500 kHz
  - For a given SF, a narrower BW = increased receive sensitivity; however, increased time on air
- **Forward Error Correction (FEC) Code Rate (CR)**
  - Additional coding rate provides more redundancy to detect errors and correct them
- **Great information at https://youtu.be/T3dGLqZrjIQ?t=2122**

LoRaWAN® Modulation Settings

Longest Distance on LoRa® Modulation

- **Data Rate (DR) = 0**
  - LoRa modulation
  - Spreading Factor (SF) = SF12
  - Bandwidth (BW) = 125 kHz
  - Coding Rate (CR) = 4/5
- **Bit Rate = 292 bps**
- **Max Application Payload Size = 51 bytes**
  - Time On Air = 2466 ms

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LoRaWAN® Modulation Settings

Highest Bit Rate on LoRa® Modulation

- **Data Rate (DR) = 6**
  - LoRa modulation
  - Spreading Factor (SF) = SF7
  - Bandwidth (BW) = 250 kHz
  - Coding Rate (CR) = 4/5
- **Bit Rate = 10937 bps**
- **Max Application Payload Size = 222 bytes**
  - Time On Air = 185 ms

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IEEE® 802.15.4

LoRa® & IEEE® 802.15.4

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What is IEEE® 802.15.4?

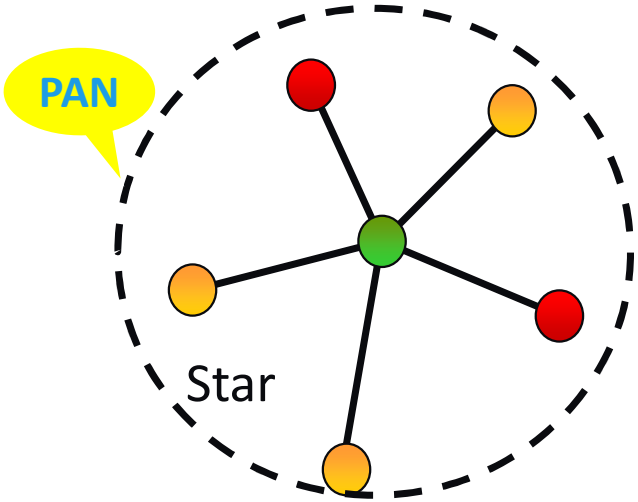
- **Features:**
  - Low power – for battery sensitive applications
  - Low data rate (250 kbps max)
- **Defines the following:**
  - Medium Access Control (MAC) and Physical Control (PHY) layers
  - Security (AES128 bit encryption)
  - Packet Types and Formats
- **Supports multiple network topologies**
  - Star, Mesh, Clustered Tree
- **Supports multiple communication protocols**
  - ZigBee®, MiWi™, MiWi P2P

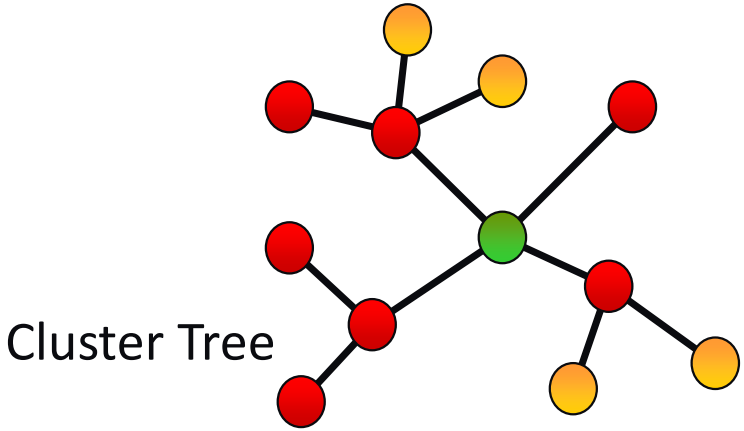
IEEE® 802.15.4 Devices

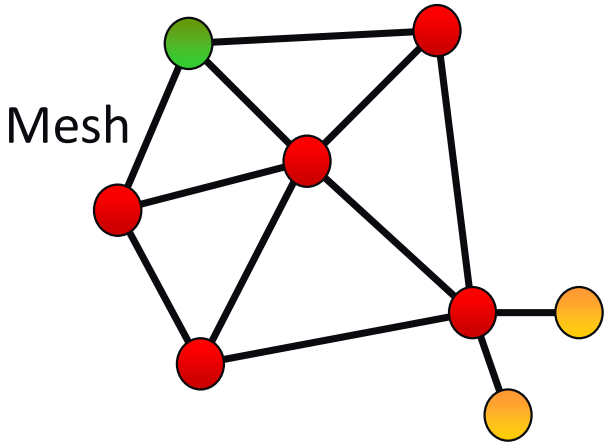
- **IEEE 802.15.4 Network Device Types**
  - Full Function Devices - FFD
  - Reduced Function Devices - RFD

- **IEEE 802.15.4 Network Device Roles**
  - IEEE Pan Coordinator - FFD
  - IEEE Coordinator - FFD
  - IEEE Device - RFD

IEEE® 802.15.4 Topology Examples







Full **F**unction **D**evice **(FFD)**

Reduced **F**unction **D**evice (**RFD**)

Coordinator (FFD)

PAN = **P**ersonal **A**rea **N**etwork

Total devices in a PAN = 65536

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Message Types and Network Reliability

- **Message Types**
  - Broadcast/Multicast
  - Unicast
- **Other approaches for making Reliable Networks**
  - Enable Clear Channel Assessment (CCA) for CSMA-CA
  - Frequency Agility
  - Aloha Mechanism

Security

- **Message Encryption**
  - Messages are meaningless without security key (CTR)

- **Message Authentication**
  - Message has not changed in any way during transmission (CBC-MAC)

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LoRaWAN®

LoRaWAN® & MiWi™

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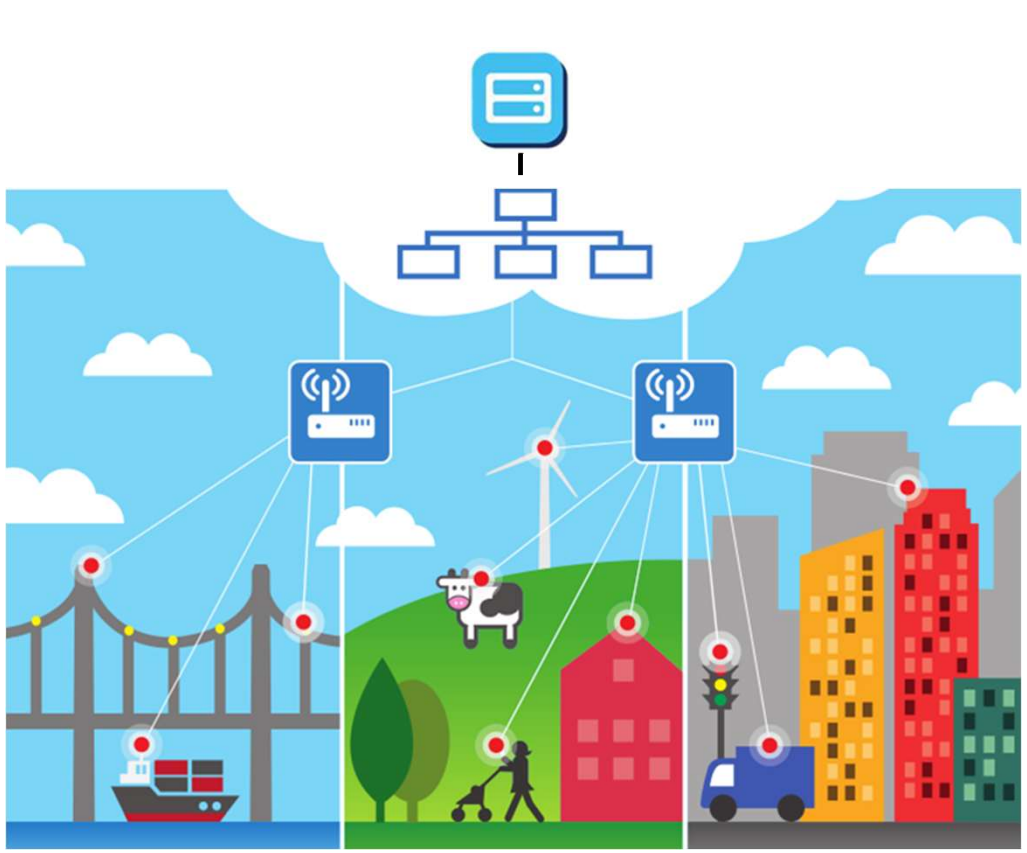
LoRaWAN® Network



Application Server

Network Server

Gateways

End-Devices

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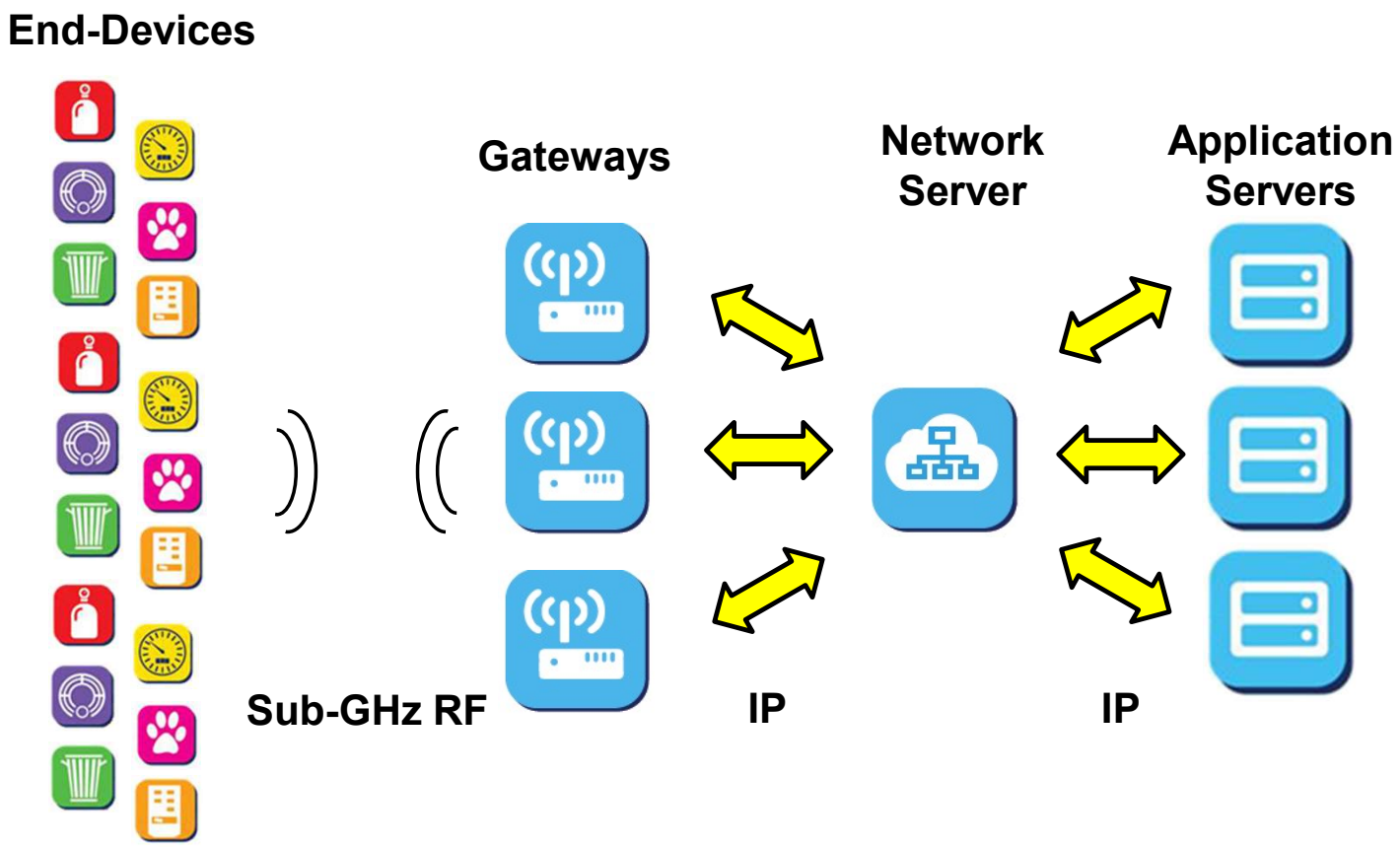
LoRaWAN® Network Physical Topology



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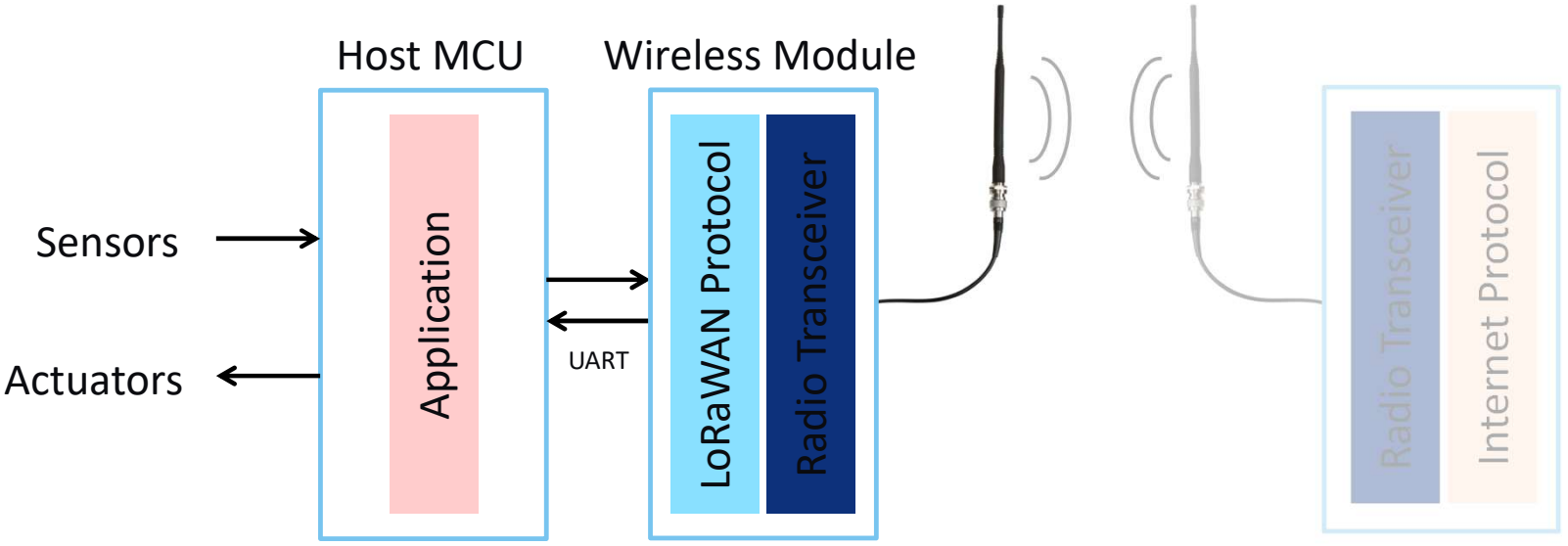
LoRaWAN® Network Protocol

- **End-Device**
  - The “Thing” in IoT
  - Single-hop wireless communication to one or many Gateway(s)



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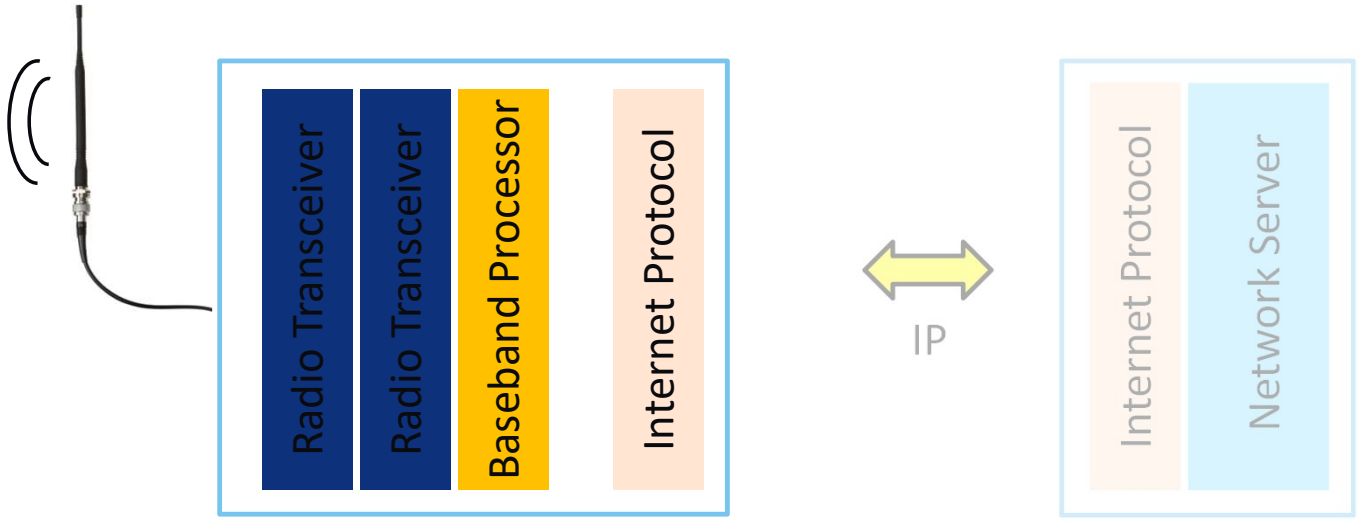
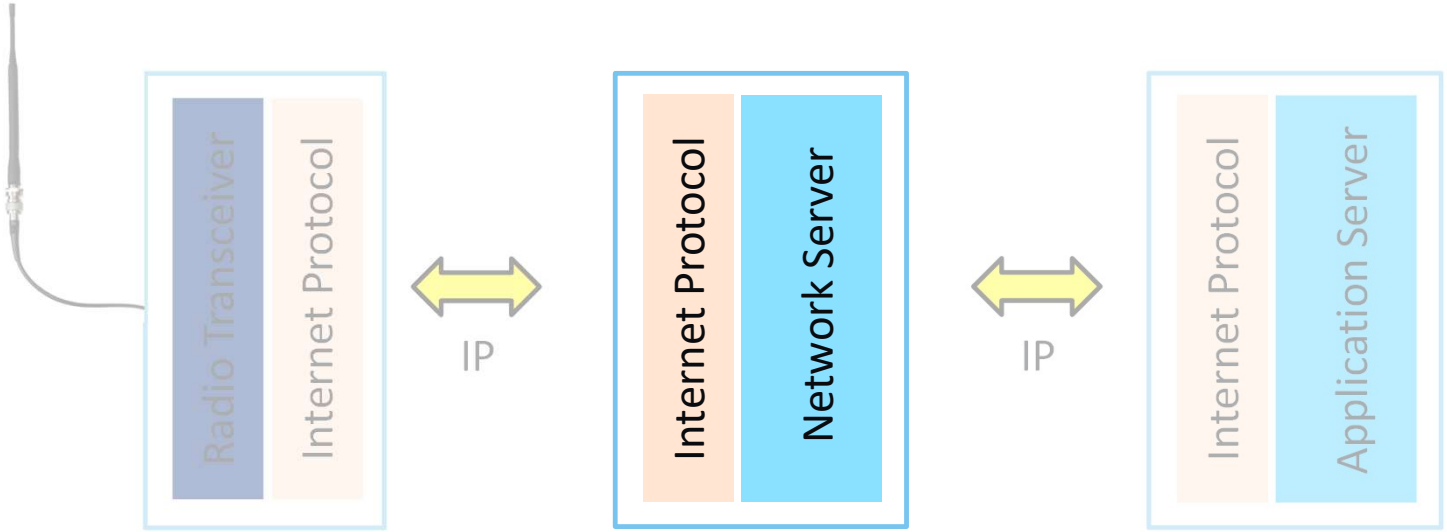
LoRaWAN® Network Protocol

- **Gateway**
  - LoRaWAN RF Network to LoRaWAN Backend Services
  - Data is “passed through” to Servers
  - Connected to Network Server via standard IP connection
  - Listens to multiple channels at the same time



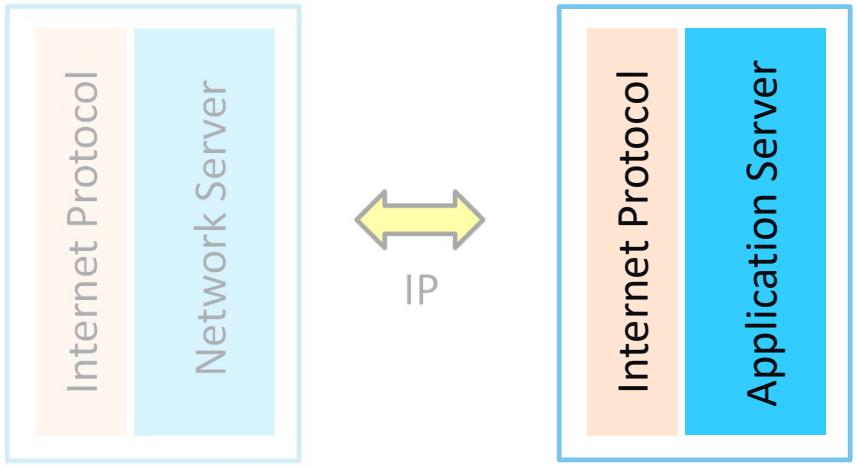
LoRaWAN® Network Protocol

- **Network Server**
  - Network Server authenticates data
  - If data is addressed to Network Server, data is processed
  - Else data will be forwarded to Application Server
  - Connected to the Application Server via standard IP connection



LoRaWAN® Network Protocol

- **Application Server**
  - Consumer of data
  - Application Server decrypts data
  - Multiple Application Servers can exist within the same LoRaWAN Network



Example: Each Application Server handles specific type of data

Electric Meter

Vending Machine

Smoke alarms

MiWi™

LoRaWAN® & MiWi™

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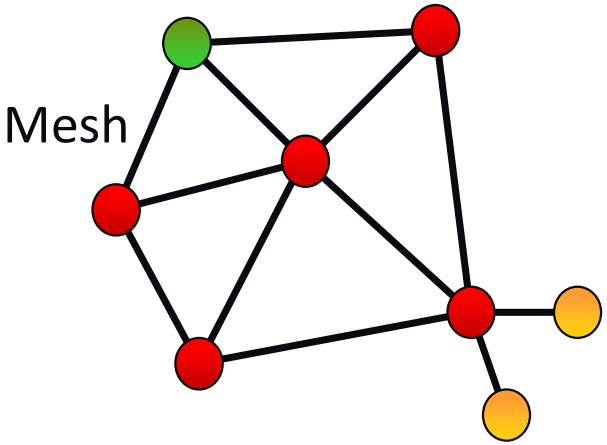
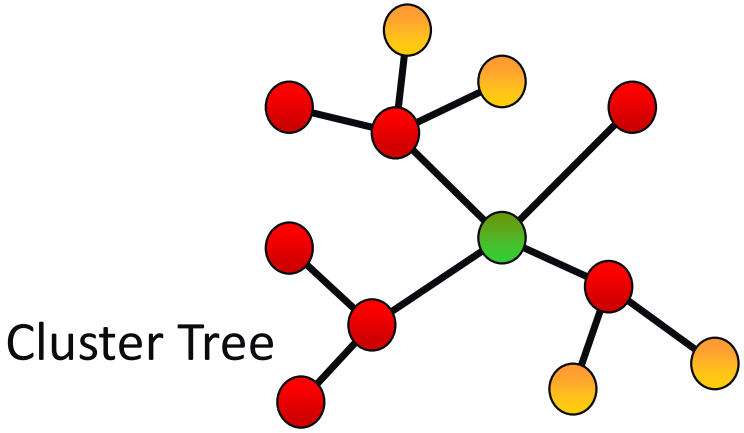
Introduction to MiWi™ Protocol

- **Proprietary Wireless Networking Protocol Stack**
- **Supports**
  - IEEE® 802.15.4 - **2.4 GHz**
  - Sub-GHz – **315/433/700/868/915 MHz**
- **Designed for**
  - Data rate up to 250 kbps
  - Distance more than 100 M without interference
  - Designed for Low Power
- **Network Topology**
  - Peer-2-Peer
  - Star
  - Mesh





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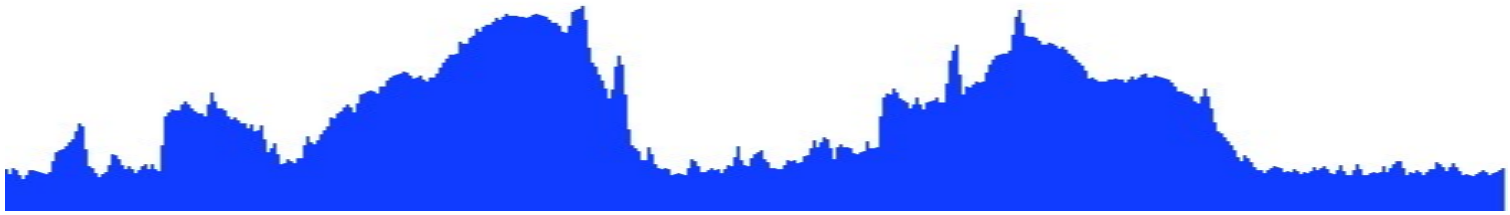
MiWi™ Features

- **Active Scan**
  - Used to get information on PAN and near by connecting nodes
  - Channel, signal strength, PAN-ID

- **Energy Scan**
  - Used to Determine the Least Noisy Channel to Operate the PAN



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MiWi™ Features

- **Frequency Agility**
  - Channel Hopping
  - Resynchronization
  - Frequency Hopping is managed by Pan Coordinator

- **Network Freezer**
  - When a Network Loses Power
  - Restore the Network Parameters after Power Failure

MiWi™ Features

- **Sleeping End Devices (RFDs)**
  - Put Device into Sleep Mode to Save Power

- **Indirect Messaging**
  - Messages Cached until RFD wake up

- **Security**
  - CCM-32/64/128 Implemented with Hardware AES.
  - Software Implementation of Security when needed.

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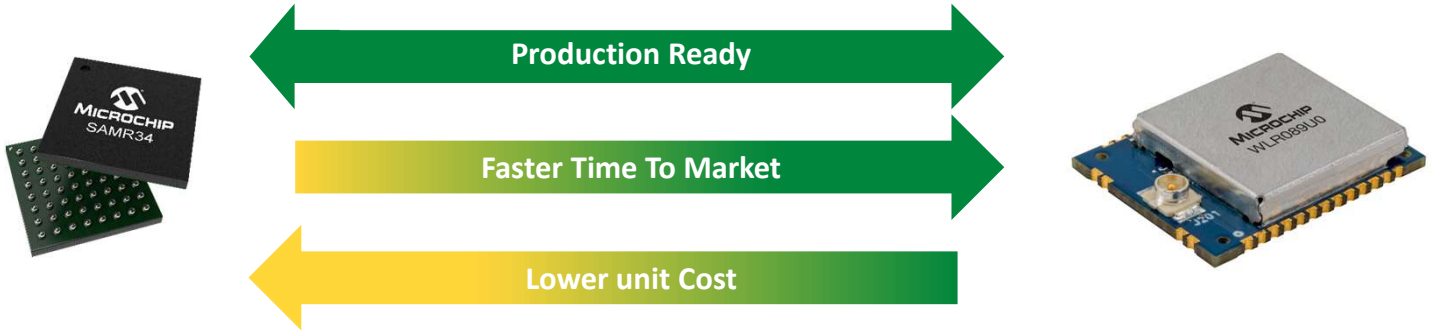
Microchip LoRa® Solutions

Chip Down or Module, the Choice is Yours!

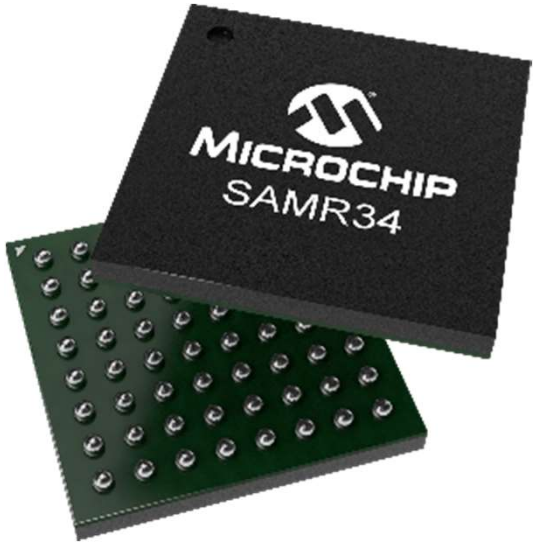


- **SAM R34 IC**
  - Production ready ICs
  - FCC/IC/RED certified reference designs
  - Increased flexibility
  - Ideal for cost-sensitive applications

- **WLR089U0 Module**
  - Production ready Modules
  - Fully certified – FCC/IC/RED/MIC/KCC/ ANATEL/UKCA
  - Reduced risk and faster development
  - Ideal for time-sensitive applications

SAM R34 Family of SiPs

- **Industry's lowest power LoRa® technology SiP**
- **Certified chip-down design package**
- **Proven LoRaWAN® software stack**
- **Flexible development environment**



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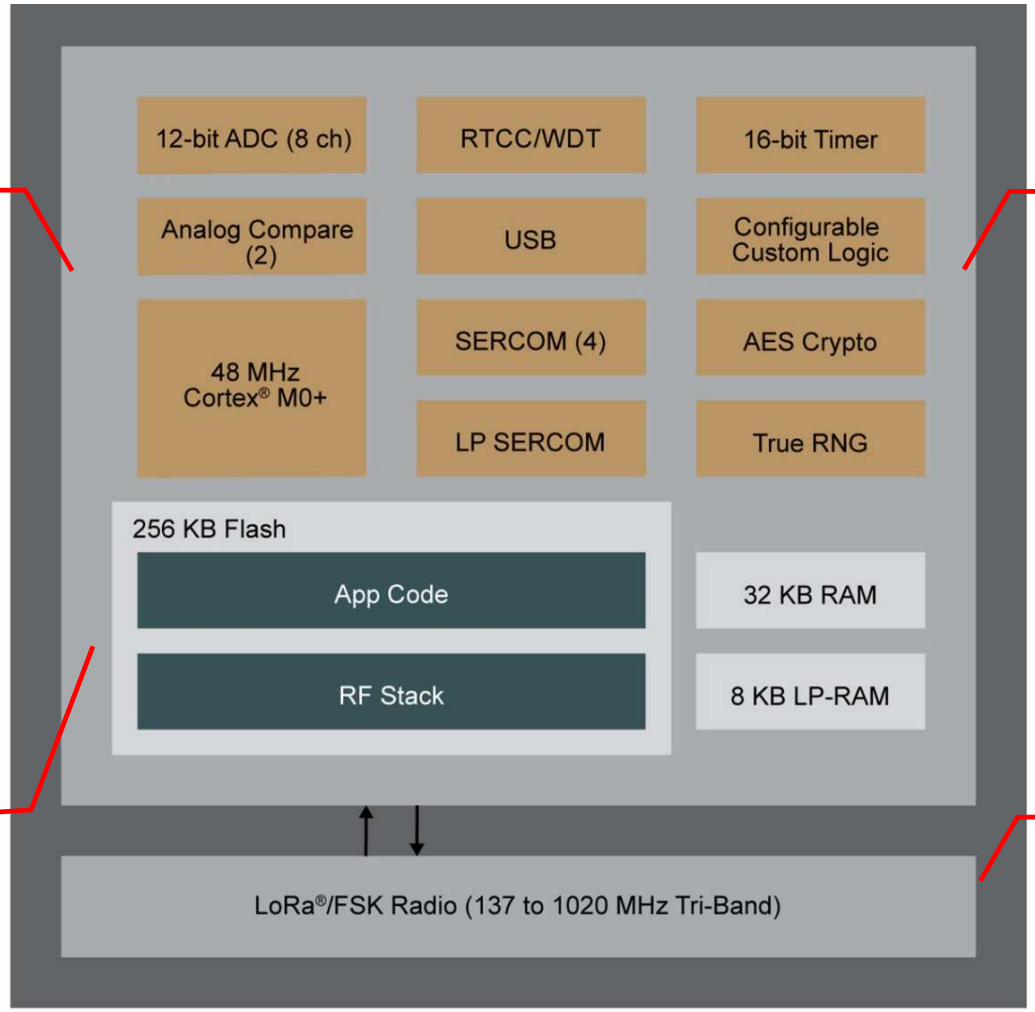
SAM R34 Hardware Features

Ultra-low Power

Down to 790 nA BACKUP
Down to 1.4 uA Standby
Low Power RAM with battery back-up retention



Peripherals

1 Msps ADC
Full speed USB
SERCOM configurable as USART, I2C, SPI or LIN

Memory and Package

256 KB Flash
40 KB RAM
Plenty of room for application
Compact 6x6mm BGA package

Radio Features

Up to 20 dBm TX power
Down to -148 dBm RX sensitivity
LoRa, (G)FSK, (G)MSK and OOK modulations

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WLR089U0 Module Overview

- Ultra-low power, regulatory-**certified** LoRa® **module**, based on SAM R34 LoRa IC
- **Ease of use** with integrated u.FL connector
- Complete development platform and LoRaWAN® software to **reduce time to market**

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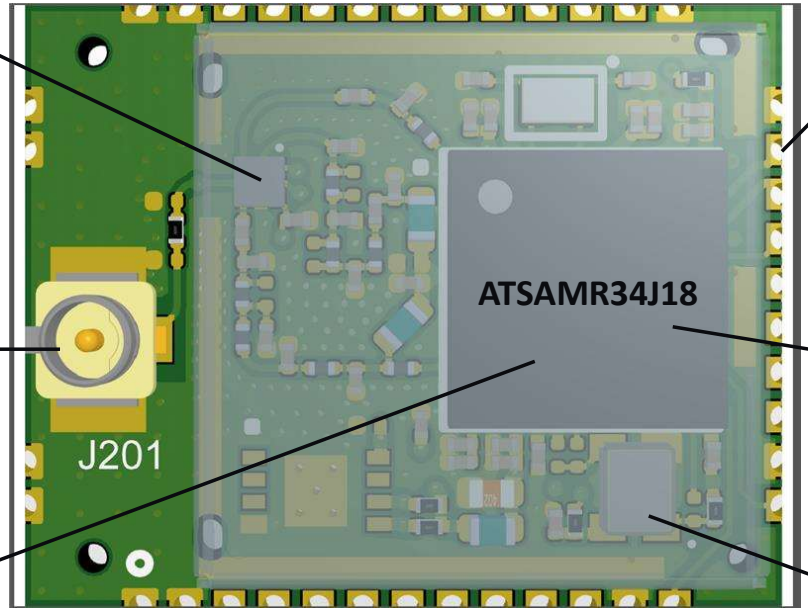
WLR089U0 Module Features

SAM R34 based Module
Designed for long battery life
Compact 17 x 13.5 mm

RF Switch to enable 868 and 915 MHz bands

u.FL antenna connector

256 KB Flash/40 KB RAM for application & LoRaWAN Stack



Serial, USB, Analog and Digital I/O

Low-power backup mode 790 nA

Integrated TCXO

FCC, IC, RED, MIC, NCC, KCC, ANATEL, UKCA Certified

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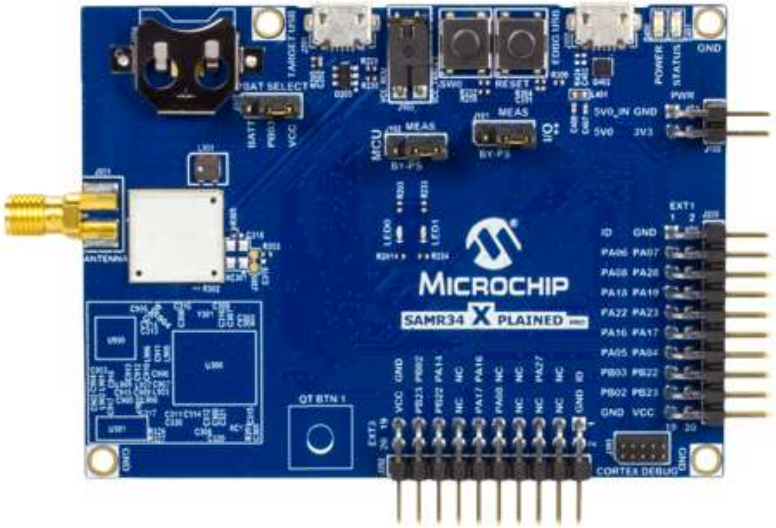
SAM R34 Development Tools

- FCC, ISED certified, and EU RED assessed
- Supported by Chip-down design package
- On-board Embedded Debugger (EDBG)
- Extension headers for connecting to boards
- Embedded current measurement circuitry
- Data Visualizer support
- Antenna included
- Over 20 Software examples



SAM R34 Xplained Pro Evaluation Kit (DM320111)

Get Started in 3 Easy Steps

Download and Launch Atmel Studio

Connect Xpro kit to computer

Select example demos from ASF

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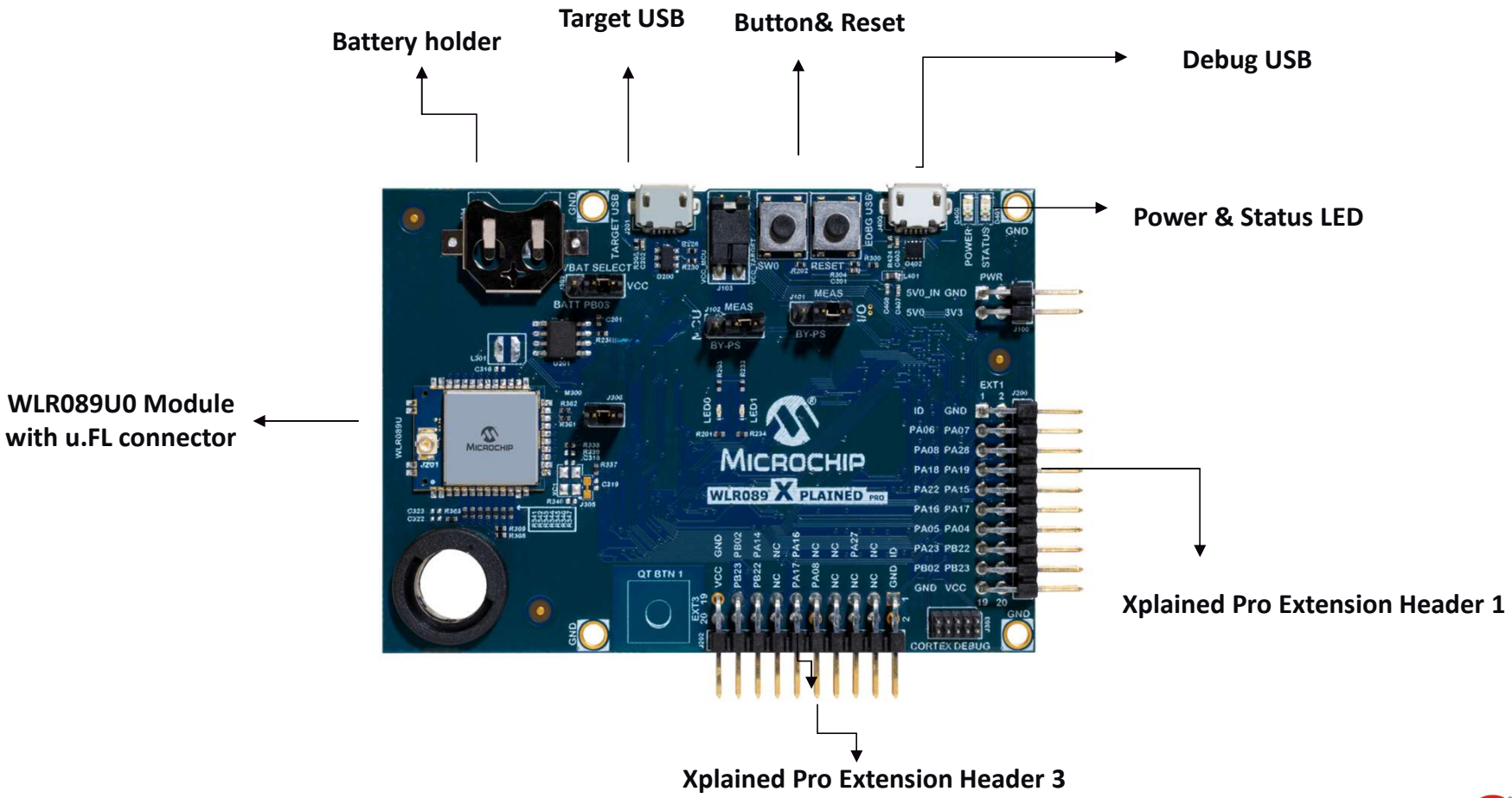
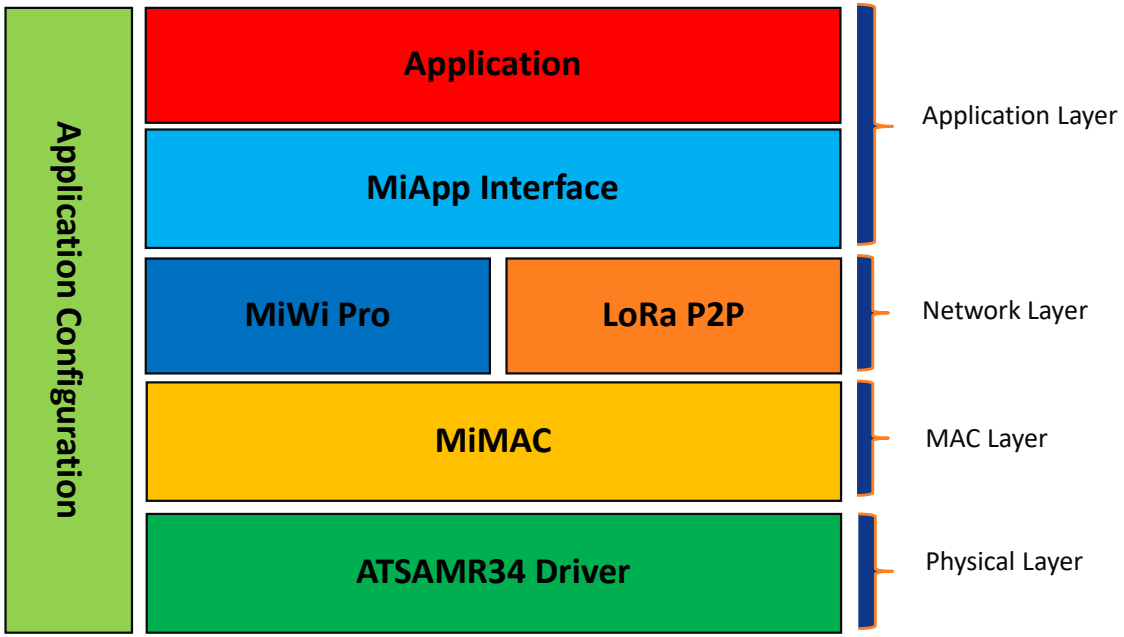
WLR089 Xplained Pro Evaluation Kit

www.microchip.com/EV23M25A

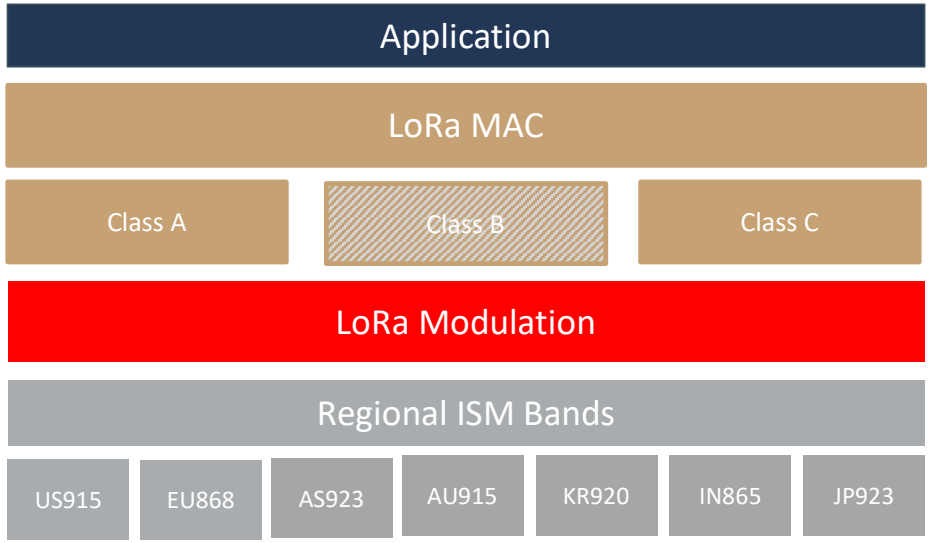


LoRa® Software Features

LoRa P2P & MiWi™



LoRaWAN®



✓ LoRaWAN 1.0.4 ✓ Class A and Class C ✓ Multi-region support

✓ Developed, Maintained and Supported by Microchip

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Getting Started – Development Tools

World-class platform for Microchip MCUs/wireless

- Microchip Studio

- **Powerful**
  - Supports MCU and wireless development and debugging

- **Easy to use**
  - Includes WLR089U0 software examples
  - Integrated WLR089U0 training modules

- **Extensible**
  - Supports data & power visualization

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Design Resources

www.microchip.com/LoRa

- **SAM R34 Xplained Pro Design Files & WLR089U0 Module Design Files**
  - Includes Schematic/BOM/Gerber (Altium design package)
- **Hardware Design Guidelines Application Note**
  - Provides RF design, PCB layout guidelines and circuit optimization techniques
- **SAM R34 & WLR089U0 Radio Utility Commands Reference Guide**
  - Various commands for RF testing on SAMR34 & WLR089U0
- **MCHPRT Tool for LoRa®**
  - Tool and firmware project for RF and certification testing along with detailed documentation

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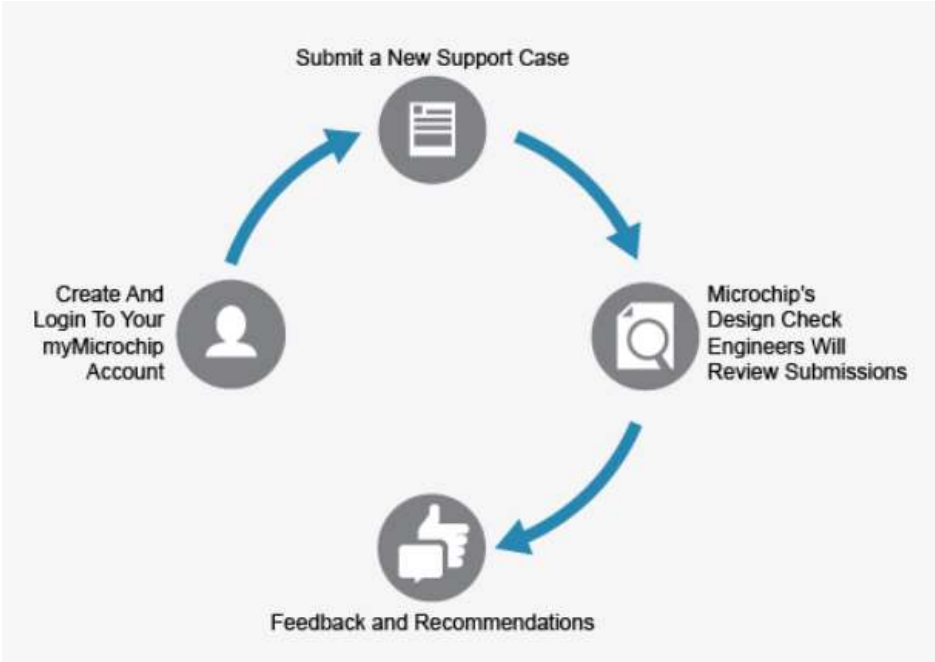
Expert RF & Layout Design Review

www.microchip.com/checkservices

- Comprehensive wireless hardware design checklist with recommendations to reduce design risk
- Personalized, value-added service to review your design
- Support from initial schematic capture to final PCB layout



LoRa® Field Test

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LoRa® Field Test Environment - Rural

Coordinator: Bibong Mt.

End Device: Wolak Mt.

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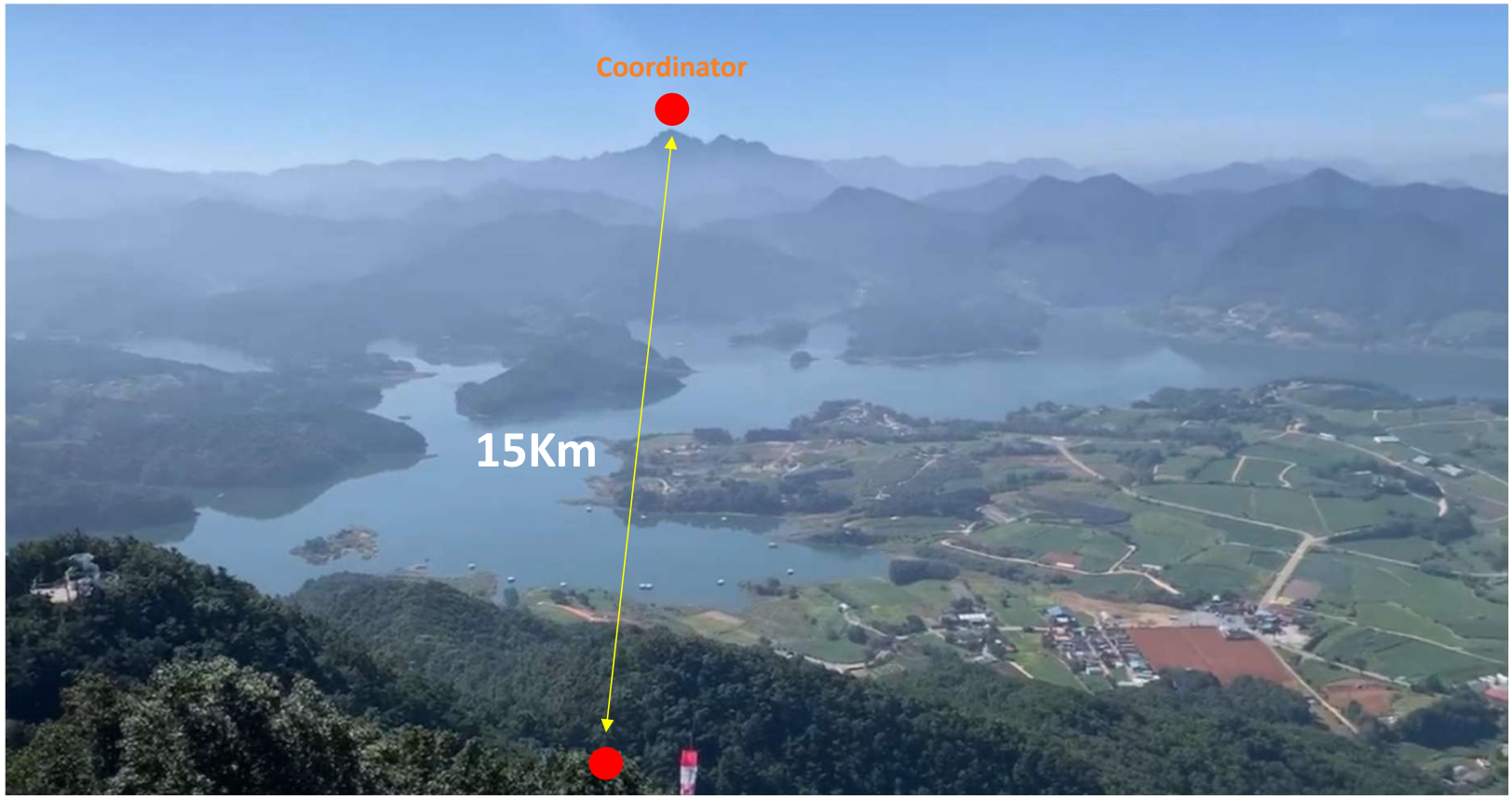
LoRa® Field Test Environment - Rural



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LoRa® Field Test Result – Rural

- **Test Condition**
  - Stack: MiWi™
  - Channel: 10, 20, 30
  - Band width: 125 KHz
  - TX Power: 10 dBm, 16 dBm
  - Antenna: 1.5 dBi
  - Data rate: 5.4 Kbps, DR0-SF7

- **Test Result**
  - Distance: 15 Km
  - RSSI: -120 dBm ~ -123 dBm

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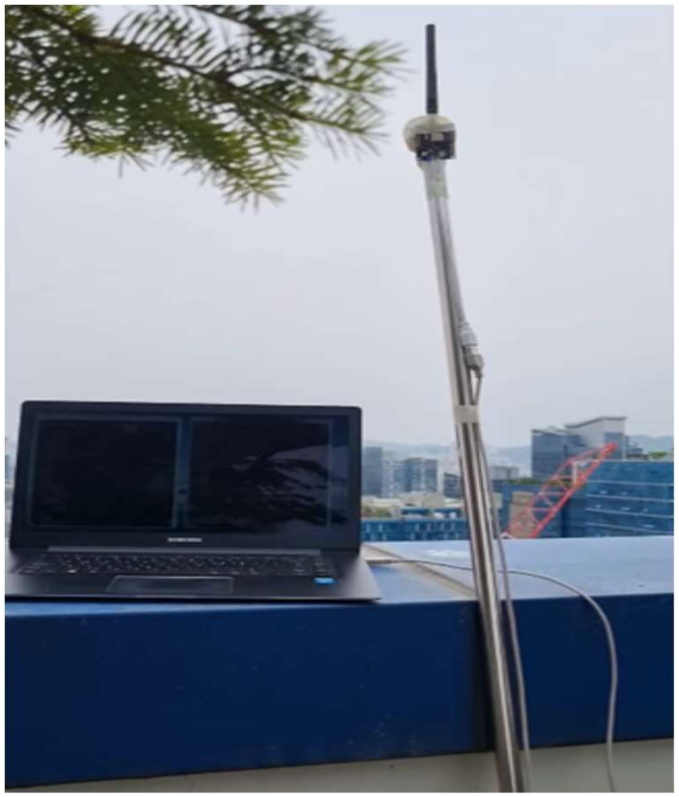
LoRa® Field Test Environment – Urban

Coordinator: Gasan-Dong



End Device: Seoksu-Dong

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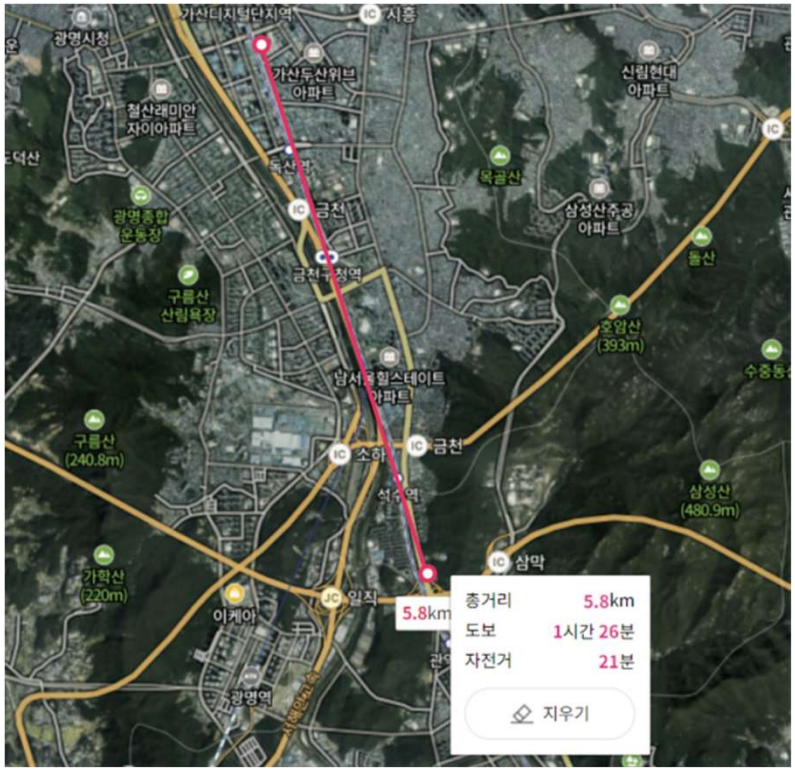
LoRa® Field Test Result – Urban

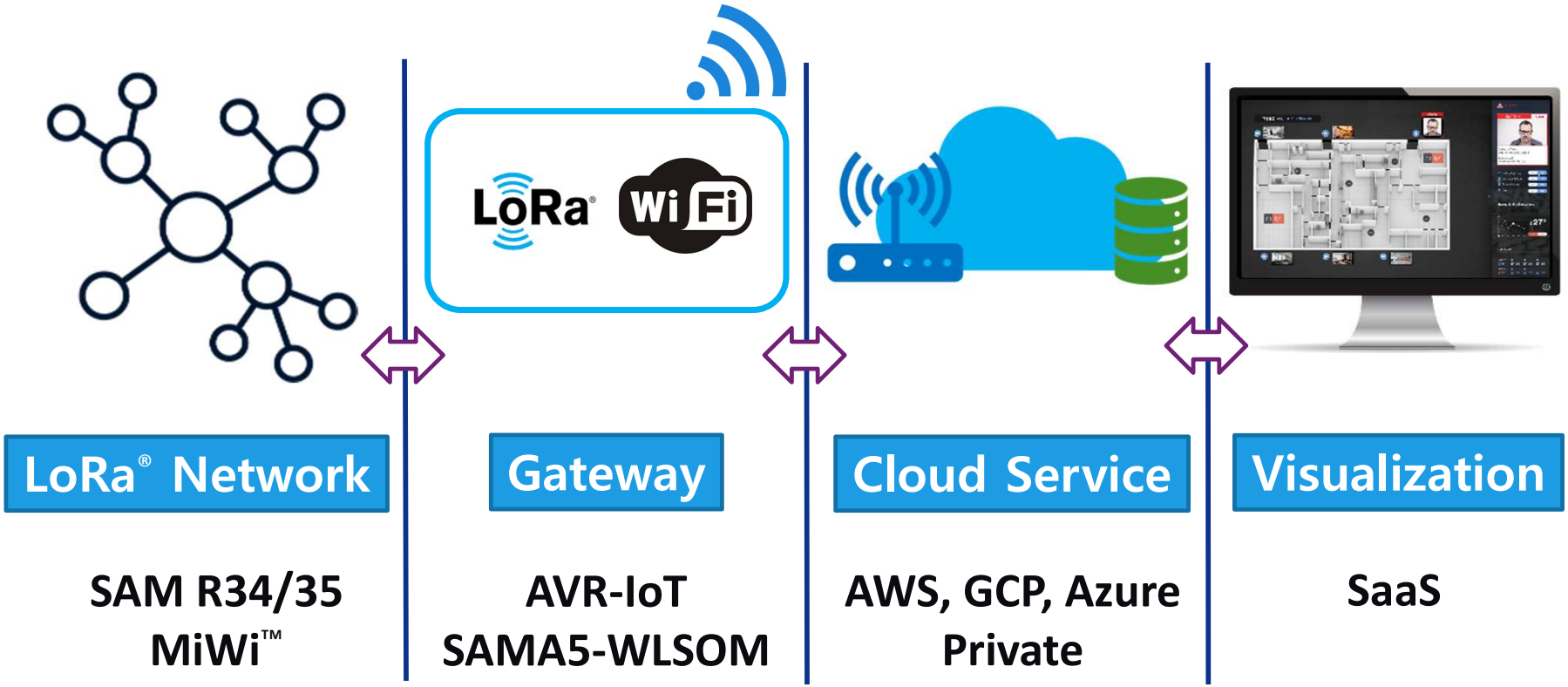
- **Test Condition**
  - Stack: MiWi™
  - Channel: 30
  - Band width: 125 KHz
  - TX Power: 16 dBm
  - Antenna: 1.5 dBi
  - Data rate: 5.4 Kbps, DR0-SF7

- **Test Result**
  - Distance: 5.8 Km
  - RSSI: -113 dBm ~ -118 dBm



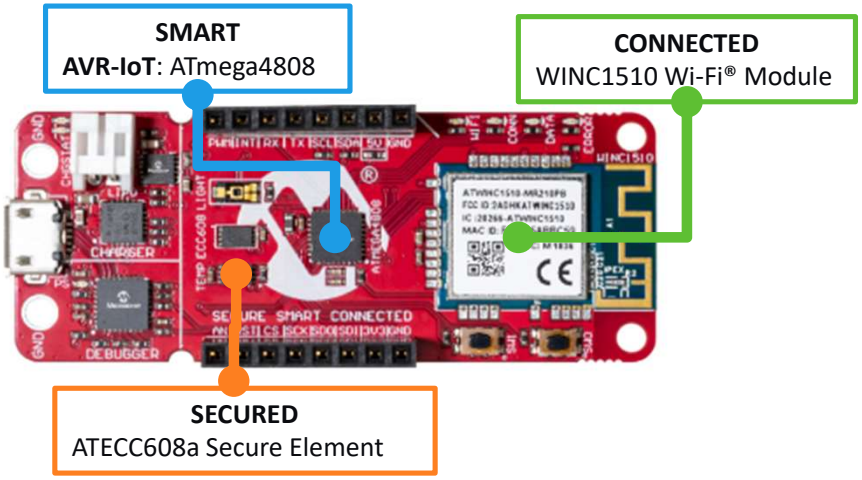
LoRa® Demos

IoT Demo

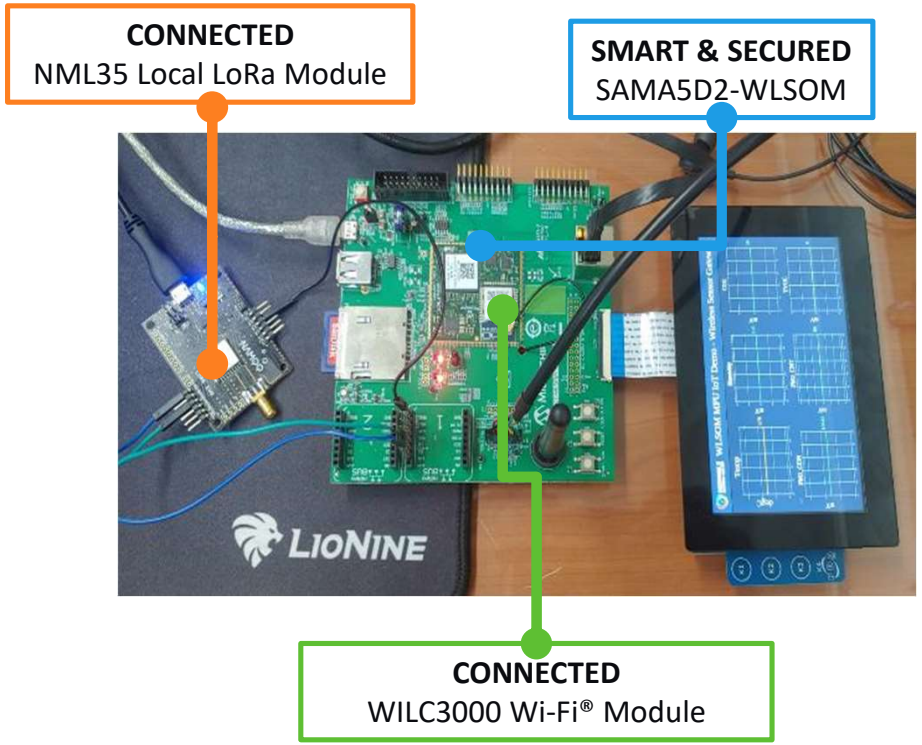


IoT Demo

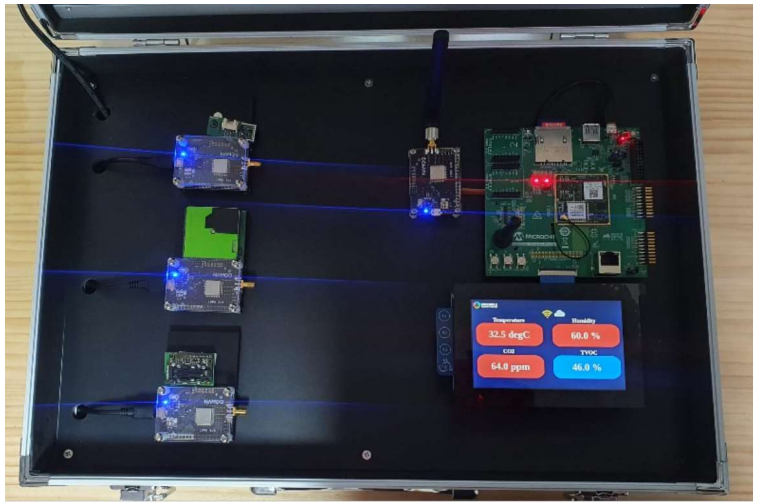
- **Low-cost Gateway**

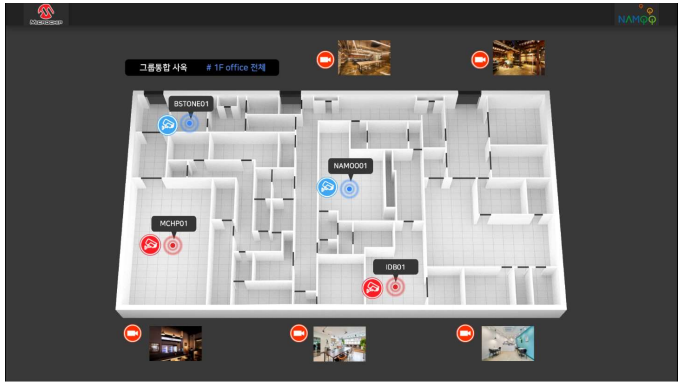


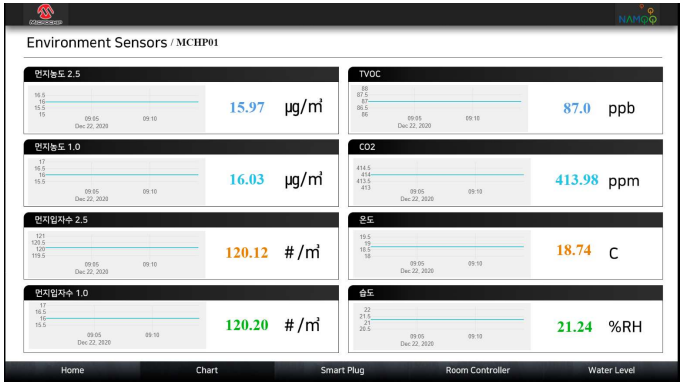
- **Featured Gateway**



IoT Demo



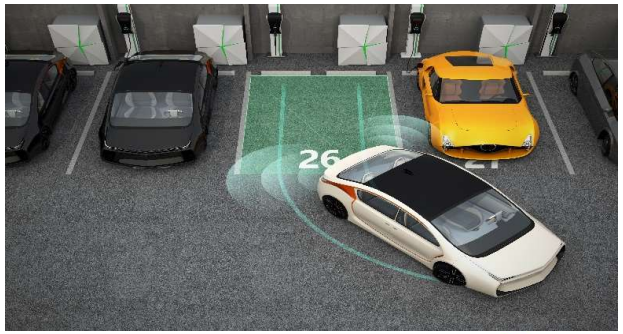




LoRa® Applications

Markets & Applications

- Security Systems
- Logistics & Supply Chain Tracking
- Parking Space Management
- Facility/Building Management
- Environmental Monitoring
- Smart Metering & Leak Detection
- Irrigation Systems
- Assisted Living/Home Care
- Agricultural Monitoring



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Use Cases

Smart Farm

- Smart Capsule for Cattle
- Moisture Monitoring
- Weigh Scale for Poultry Farm

Security & Safety

- Emergency Door Control
- Explosion-proof Detector
- Industrial Controller & Instruments

Smart Home

- Built-in Air Purifier
- Smart Water Meter
- Door Lock

Environmental Monitoring

- Smart Green Poll
- Levee Monitoring
- Streetlight Control

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Summary

- LoRa® vs IEEE® 802.15.4
- LoRaWAN® vs MiWi™
- Microchip LoRa Solutions
- LoRa IoT Demo
- LoRa Applications & Use Cases

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Thank you