19065 IoT4

Getting Up and Running with LoRaWAN™ Long-Range Networking

Objectives

- **At the end of this class, the student will be able to:**
  - List 3 advantages of the LoRaWAN™ Network Protocol
  - Configure, Activate (Join), and Communicate with the RN2903 Wireless Module
  - Create a LoRaWAN™ End-device application using the LoRa™ Technology Mote

Agenda

- Internet of Things (IoT)
- LoRaWAN™ Network Protocol
- LoRa™ Technology Wireless Modules
- Getting Started with RN2903 Module
- Hands-on Labs

Agenda

- **Internet of Things (IoT)**
- LoRaWAN™ Network Protocol
- LoRa™ Technology Wireless Modules
- Getting Started with RN2903 Module
- Hands-on Labs

Internet of Things (IoT)

- **Loosely defined paradigm**
  - Connected devices
  - Communication happens without human intervention
- **“Thing” can contribute to “big data”**
  - Cloud-handled data
  - Queries on the cloud data can offer a high-level view

Internet of Things (IoT)

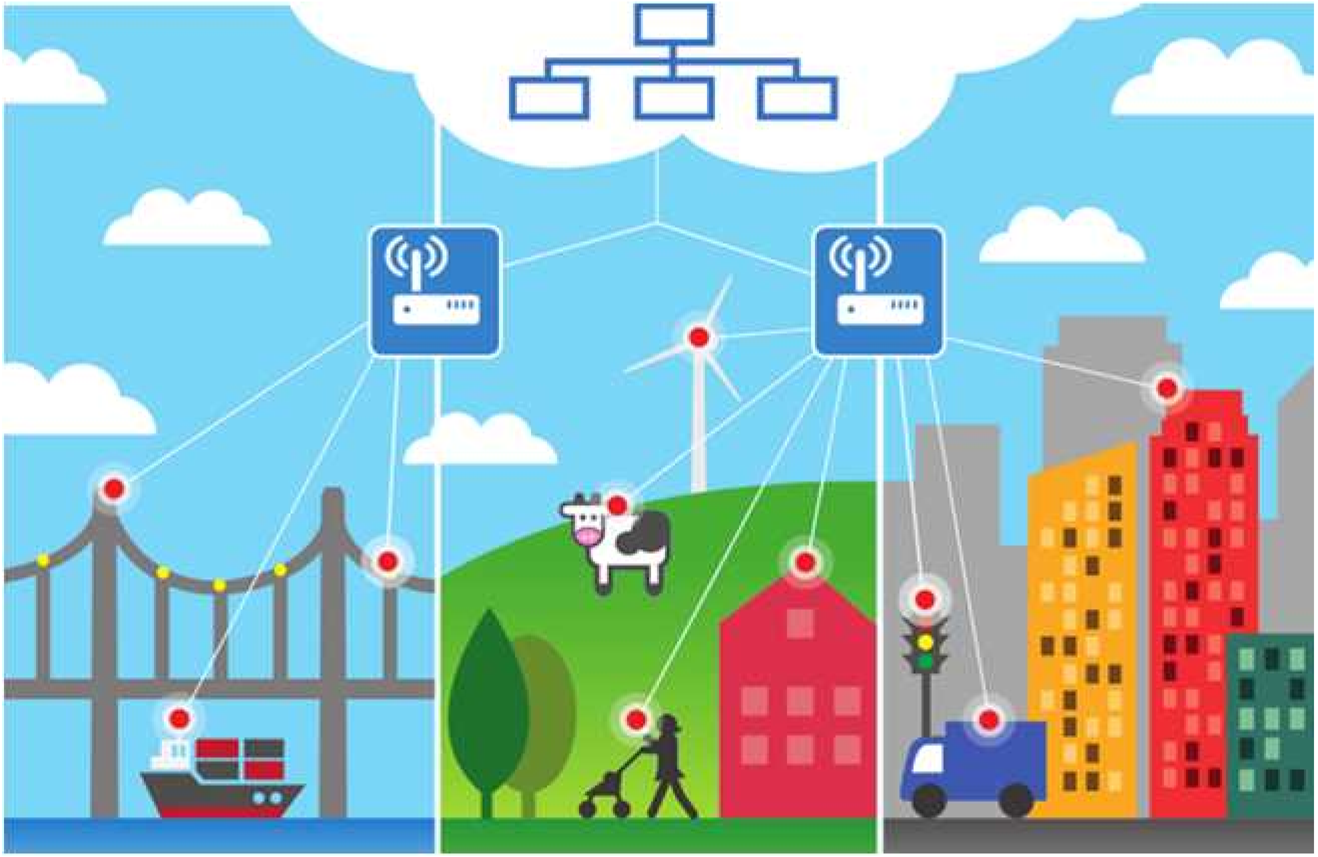
Types of Wireless Networks



Personal Area	Local Area	Wide Area
Bluetooth®	Wi-Fi®	Cellular (2G, 3G, 4G-LTE)

Internet of Things (IoT)

LoRaWAN™ Network



Monitoring / Control Light Control

Smart Agriculture Smart Energy

Smart City Smart Home and Security

Internet of Things (IoT)

Who is the LoRa™ Alliance?

- The LoRa™ Alliance (http://lora-alliance.org/) is an open, non-profit association of members.
- Mission: to standardize Low Power Wide Area Networks (LPWAN)
- Alliance members will collaborate to drive the global success of the LoRaWAN™ protocol

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Agenda

- Internet of Things (IoT)
- **LoRaWAN™ Network Protocol**
- LoRa™ Technology Wireless Modules
- Getting Started with RN2903 Module
- Hands-on Labs

Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - **LoRa™ Technology Modulation**
  - **How does LoRaWAN™ Technology Work?**
  - **End-Device Classes**
  - **End-Device Activation (Joining)**
  - **Security**
  - **End-Device Data Communication (Class A)**
  - **Adaptive Data Rate (ADR)**

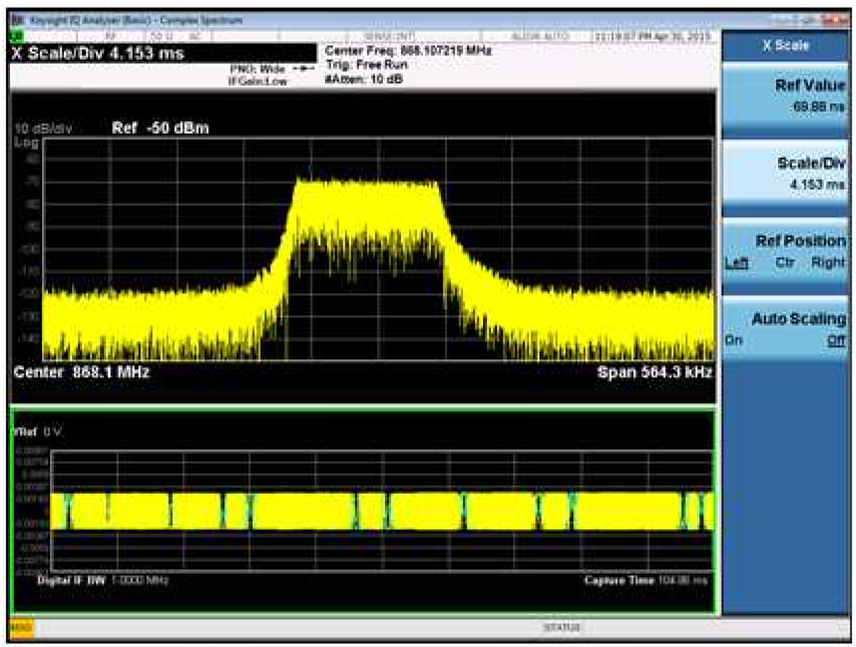
Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - **LoRa™ Technology Modulation**
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - End-Device Activation (Joining)
  - Security
  - End-Device Data Communication (Class A)
  - Adaptive Data Rate (ADR)

LoRaWAN™ Network Protocol

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



LoRaWAN™ Network Protocol

LoRa™ Technology Modulation

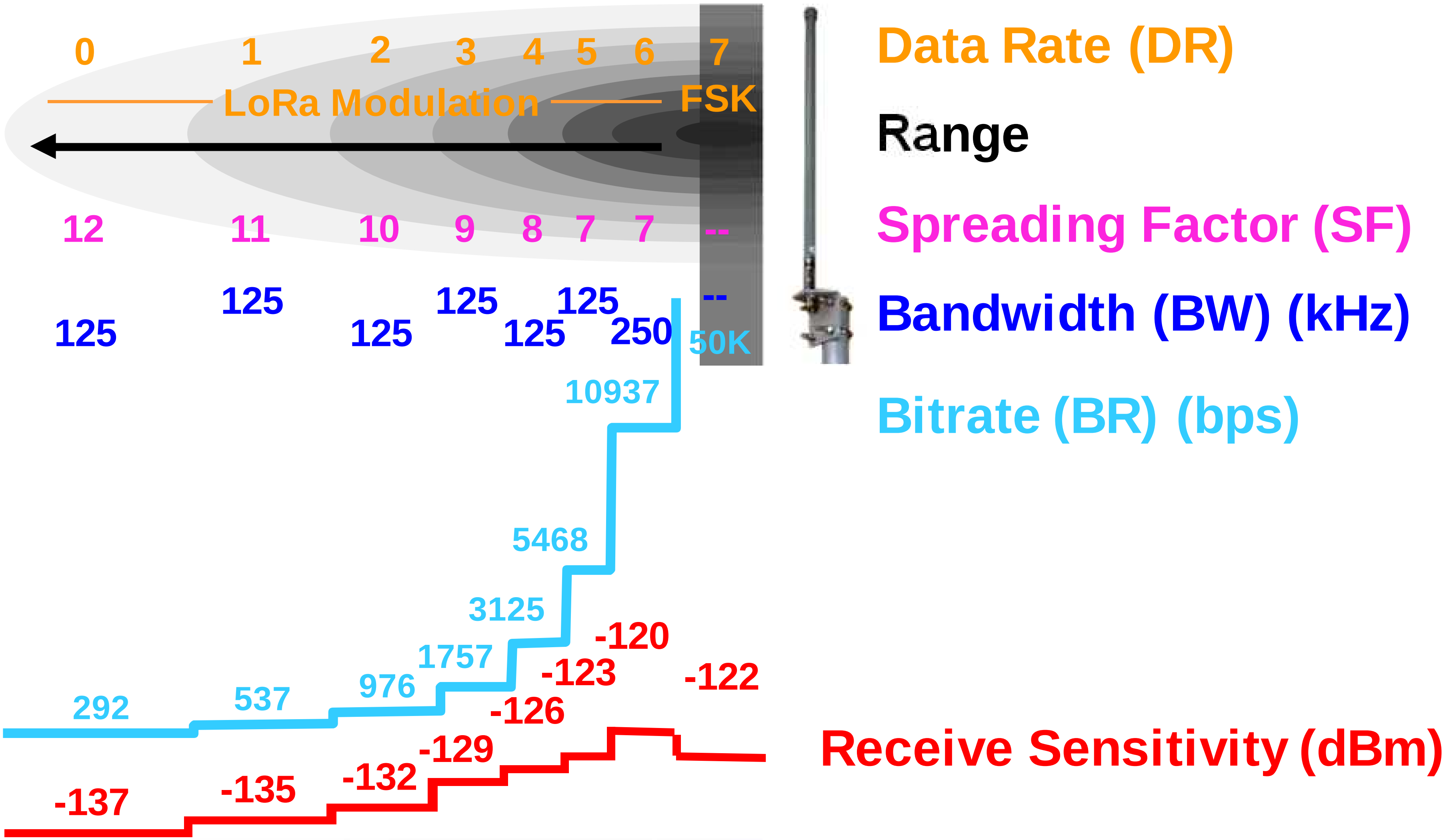
- **Spreading Factor (SF)**
  - Programmable SF:

    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

LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for Europe



LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for Europe

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

LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for Europe

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

LoRaWAN™ Network Protocol

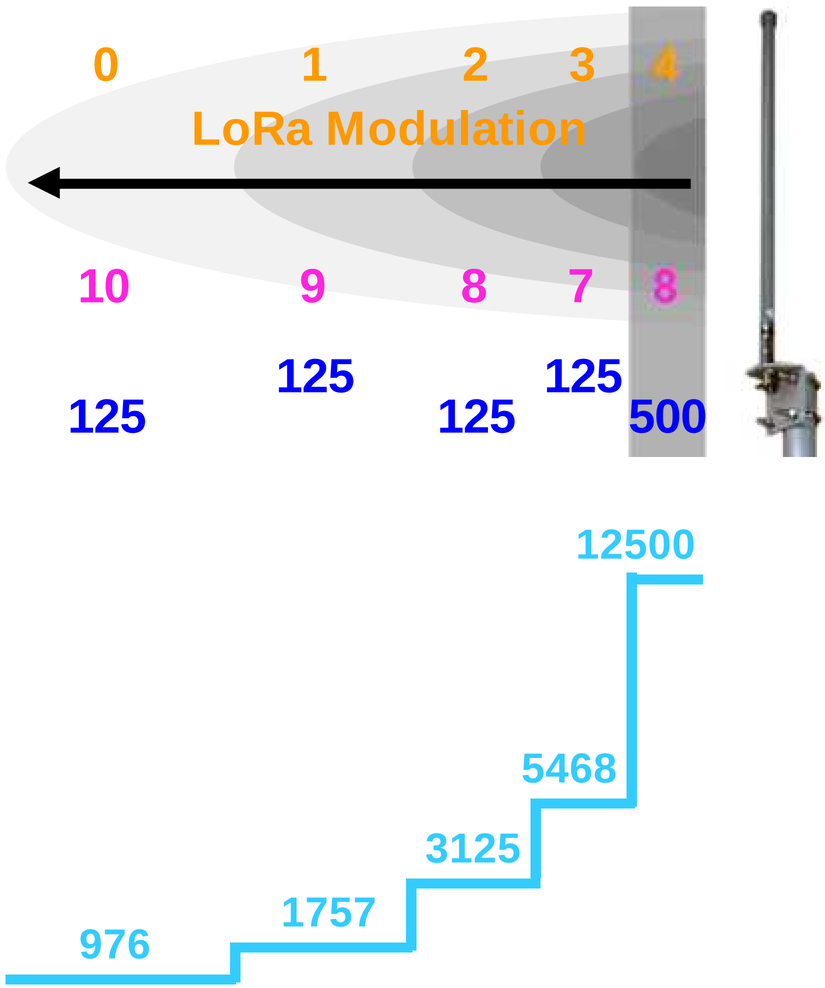
LoRaWAN™ Modulation Settings for Europe

Highest Bit Rate on GFSK Modulation

- **Data Rate (DR) = 7**
  - FSK modulation
- **Maximum Bit Rate = 50 kbps**
- **Max Application Payload Size = 222 bytes**
  - Time On Air = 39 ms

LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for North America



Data Rate (DR)

Range

Spreading Factor (SF)

Bandwidth (BW) (kHz)

Bitrate (BR) (bps)

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LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for North America

Longest Distance on LoRa Modulation

- **Data Rate (DR) = 0**
  - LoRa™ modulation
  - Spreading Factor (SF) = SF10
  - Bandwidth (BW) = 125 kHz
  - Coding Rate (CR) = 4/5
- **Bit Rate = 976 bps**
- **Max Application Payload Size = 11 bytes**
  - Time On Air = 371 ms

LoRaWAN™ Network Protocol

LoRaWAN™ Modulation Settings for North America

Highest Bit Rate on LoRa Modulation

- **Data Rate (DR) = 4**
  - LoRa™ modulation
  - Spreading Factor (SF) = SF8
  - Bandwidth (BW) = 500 kHz
  - Coding Rate (CR) = 4/5
- **Bit Rate = 12500 bps**
- **Max Application Payload Size = 242 bytes**
  - Time On Air = 175 ms

LoRaWAN™ Network Protocol

LoRaWAN™ Channels

- **License free Sub-GHz Frequencies**
  - Europe: 868 MHz Band
  - Network channels can be freely attributed by the network operator
  - Three mandatory channels that all gateways should constantly receive:

Modulation	Bandwidth [kHz]	Channel Frequency [MHz]	FSK Bitrate or LoRa DR / Bitrate	Nb Channels	Duty cycle
LoRa	125	868.10 868.30 868.50	DR0 to DR5 / 0.3-5 kbps	3	<1%

LoRaWAN™ Network Protocol

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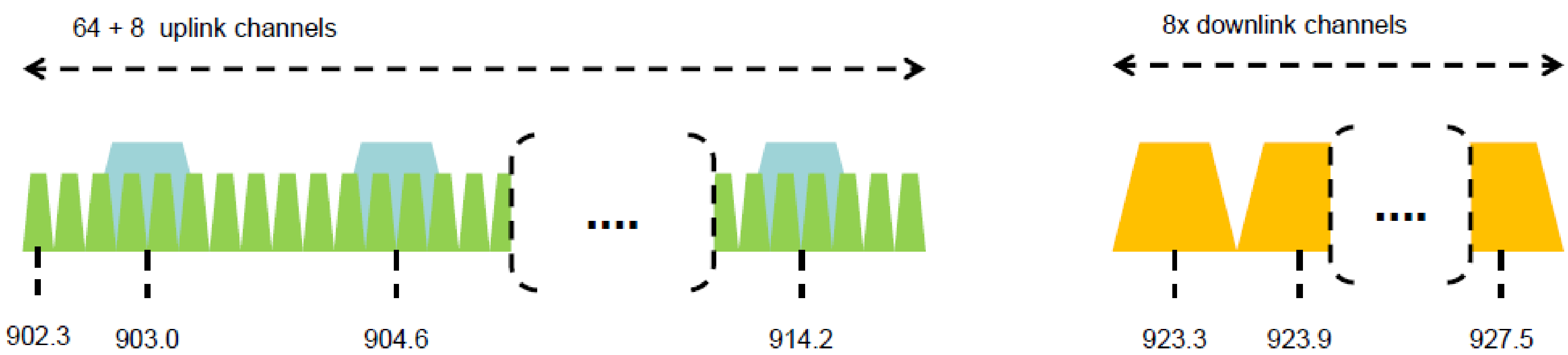
LoRaWAN™ Channels

- **License free Sub-GHz Frequencies**
  - North America: 915 MHz Band
  - Upstream: 64 channels numbered 0 to 63, DR0 to DR3
  - Upstream: 8 channels numbered 64 to 71, DR4
  - Downstream: 8 channels numbered 0 to 7, DR8 to DR13



Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - LoRa Technology Modulation
  - **How does LoRaWAN™ Technology Work?**
  - End-Device Classes
  - End-Device Activation (Joining)
  - Security
  - End-Device Data Communication (Class A)
  - Adaptive Data Rate (ADR)

LoRaWAN™ Network Protocol

What is LoRaWAN™ Network Protocol?

- **Low Power Wide Area Network (LPWAN)**
  - Bidirectional
  - Simple Star Network Topology
  - Low data rate
  - Low cost
  - Long battery life

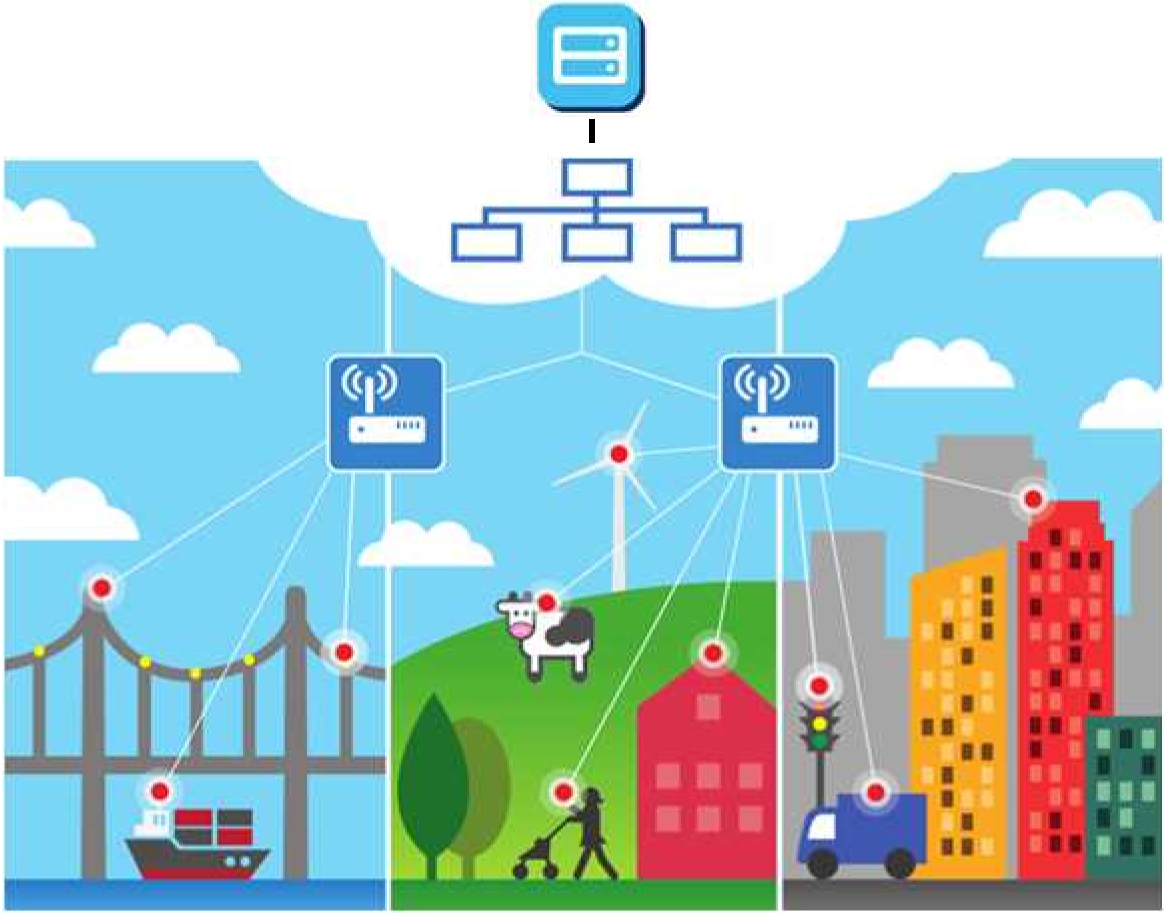
Enables simpler network architecture:
- ***No repeaters***
- ***No mesh routing complexity***

- **Ideal for:**
  - Internet of Things (IoT)
  - Machine-to-Machine (M2M)
  - Industrial Automation
  - Low Power Applications
  - Battery Operated Sensors
  - Smart City
  - Smart Meter
  - Smart Agriculture

http://lora-alliance.org/What-Is-LoRa/Technology

LoRaWAN™ Network Protocol

LoRaWAN™ Network



Application Server

Network Server

Gateways

End-Devices

LoRaWAN™ Network Protocol

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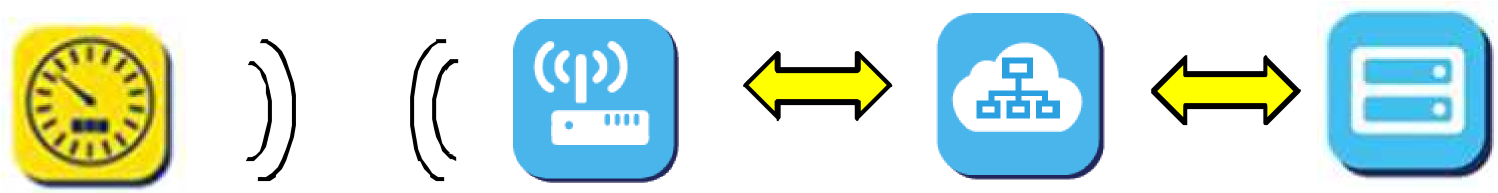
How does LoRaWAN™ Technology Work?

Physical Topology

End-Device | Gateway | Network Server | Application Server



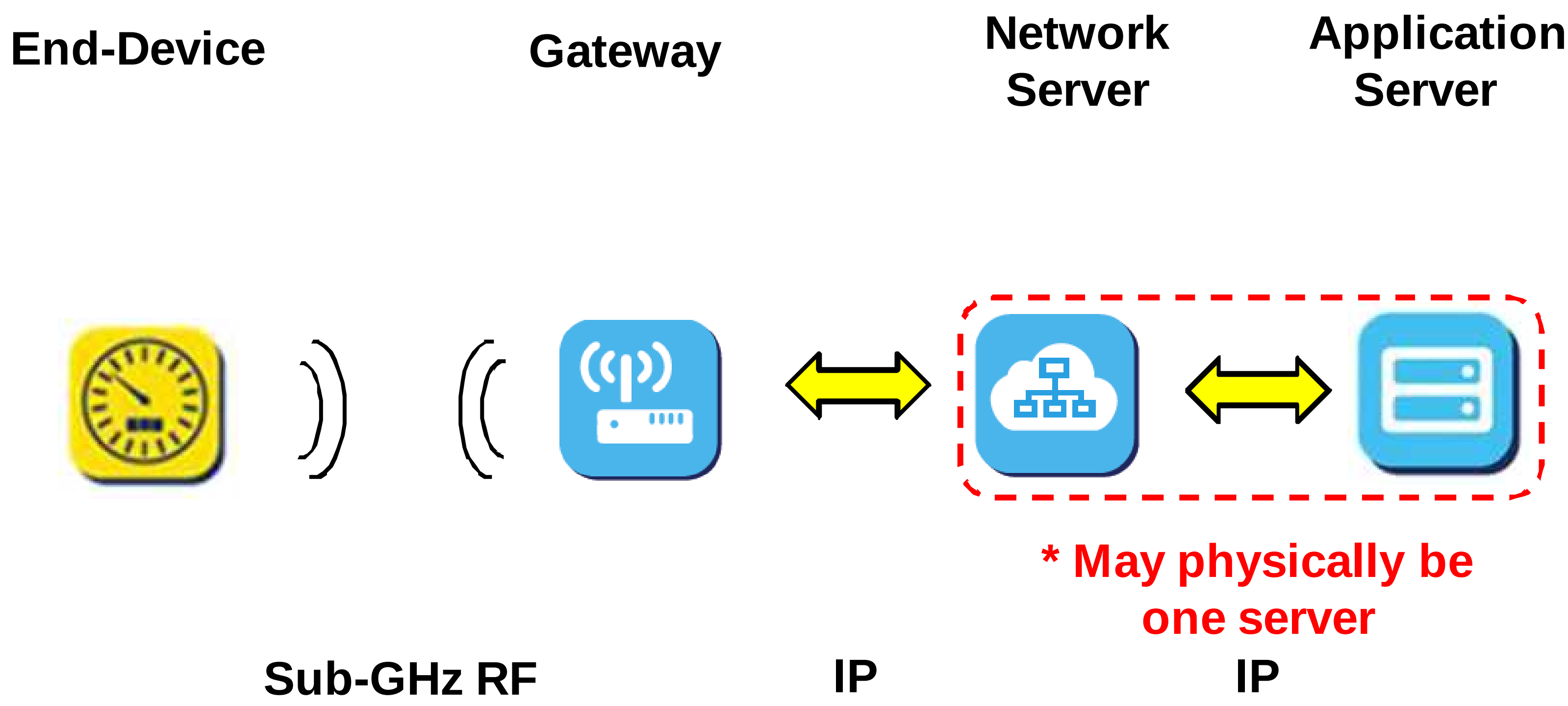
Sub-GHz RF | IP | IP

Advanced Network Topology

LoRaWAN™ Network Protocol

How does LoRaWAN™ Technology Work?

Physical Topology

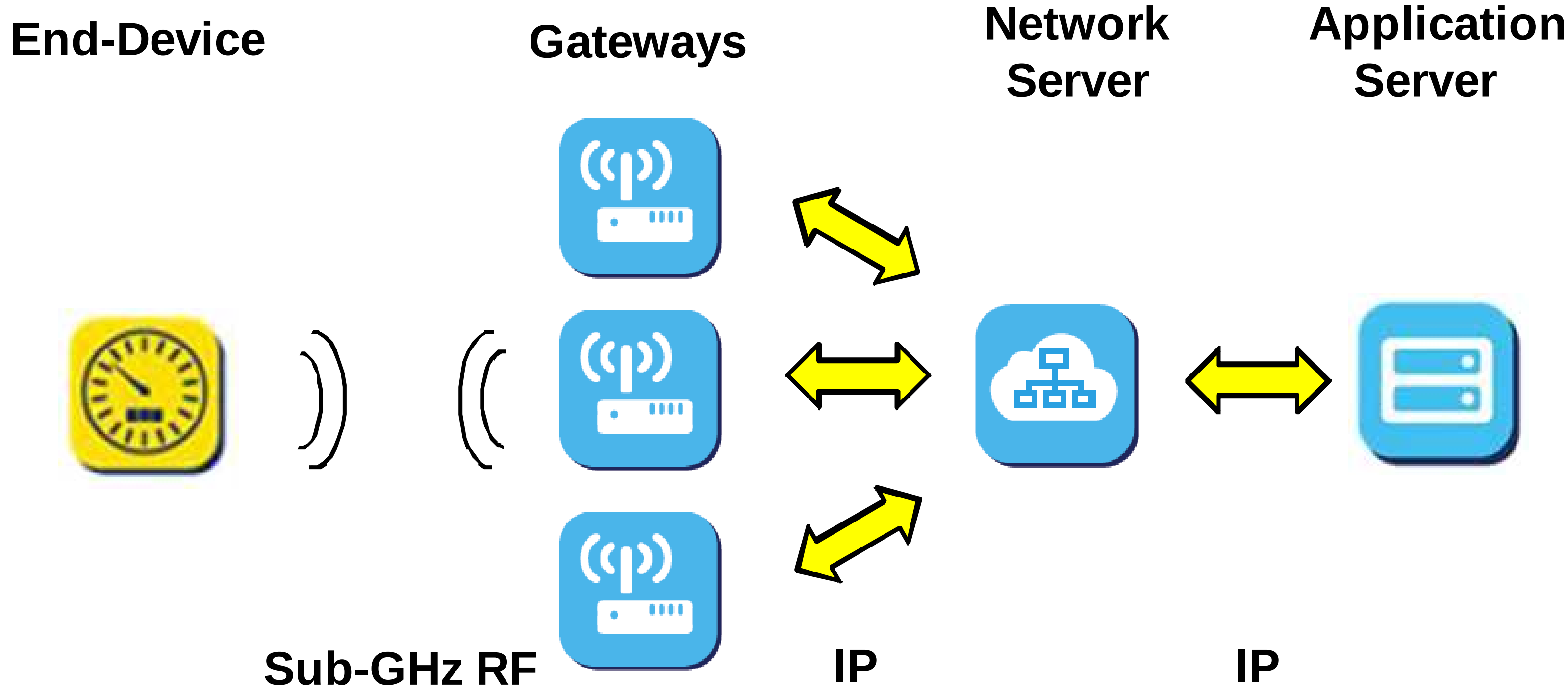


Advanced Network Topology

LoRaWAN™ Network Protocol

How does LoRaWAN™ Technology Work?

Physical Topology

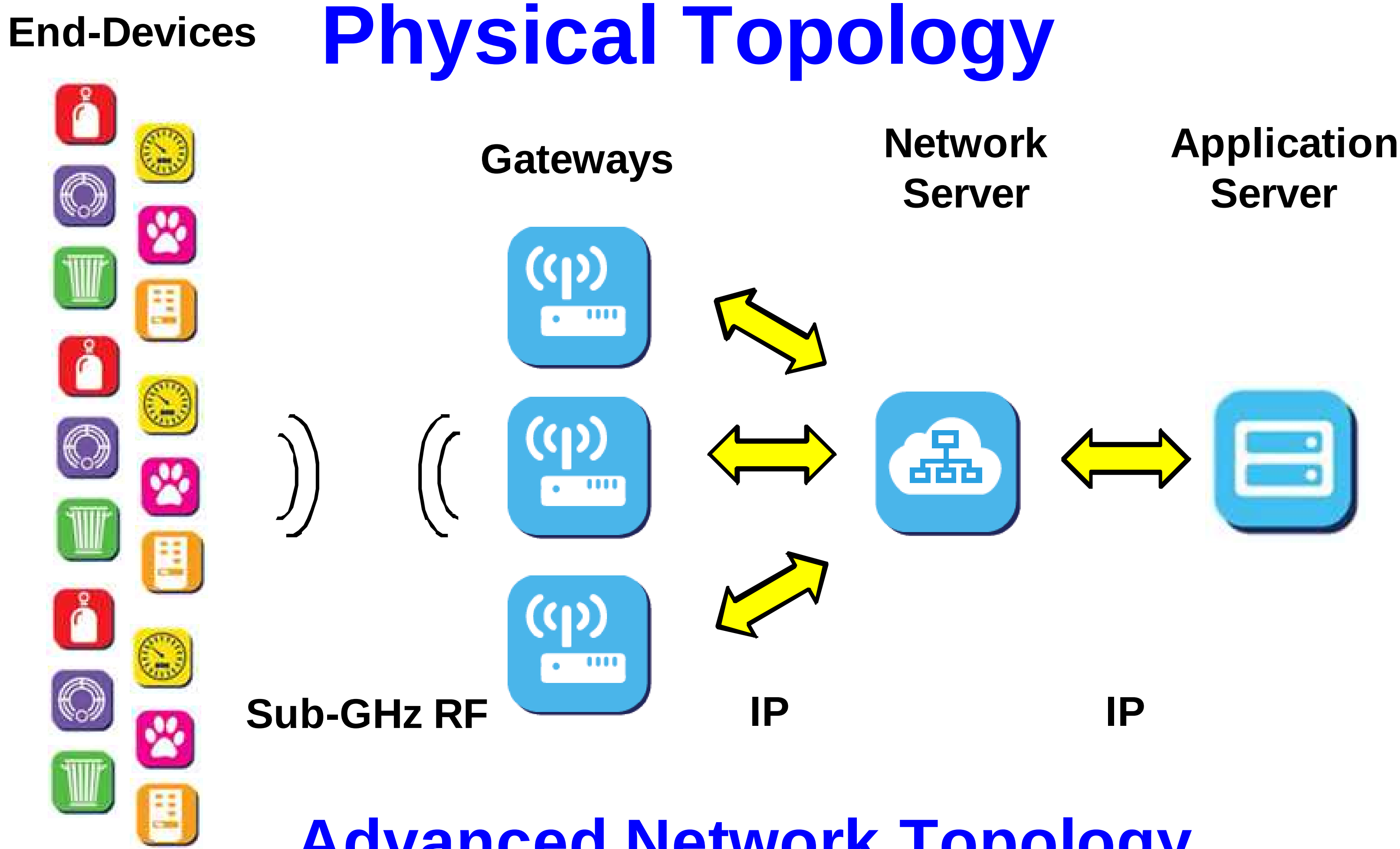


Advanced Network Topology

LoRaWAN™ Network Protocol

How does LoRaWAN™ Technology Work?

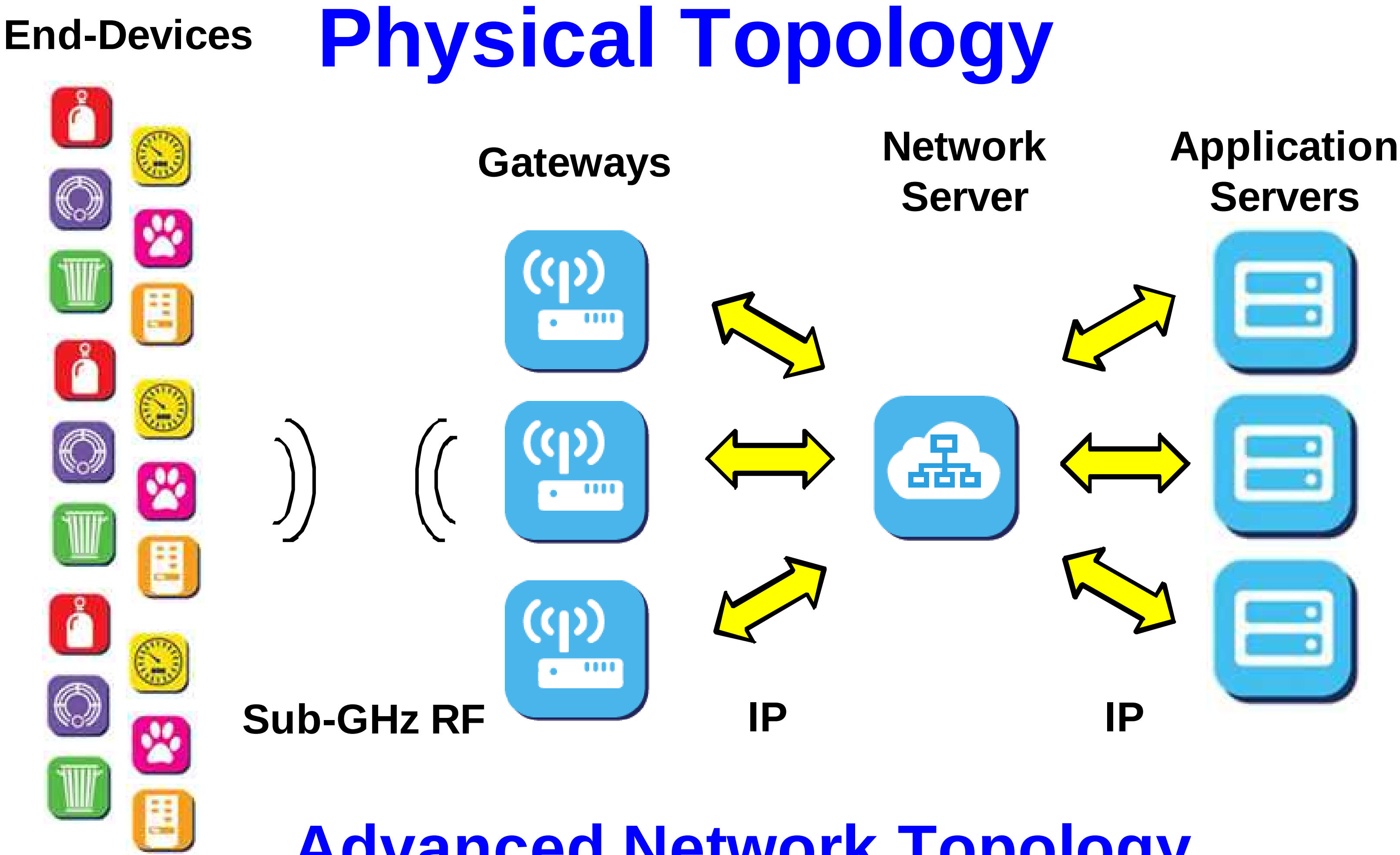
Physical Topology



Advanced Network Topology

LoRaWAN™ Network Protocol

How does LoRaWAN™ Technology Work?

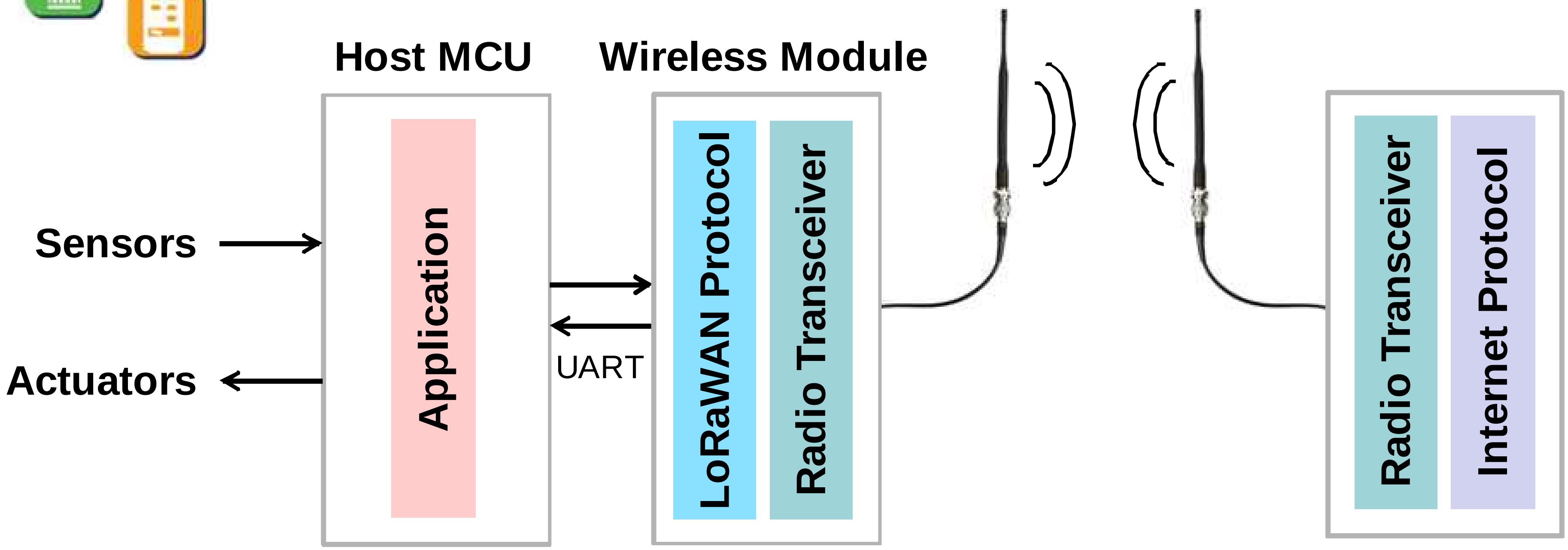


Advanced Network Topology

LoRaWAN™ Network Protocol

End-Device

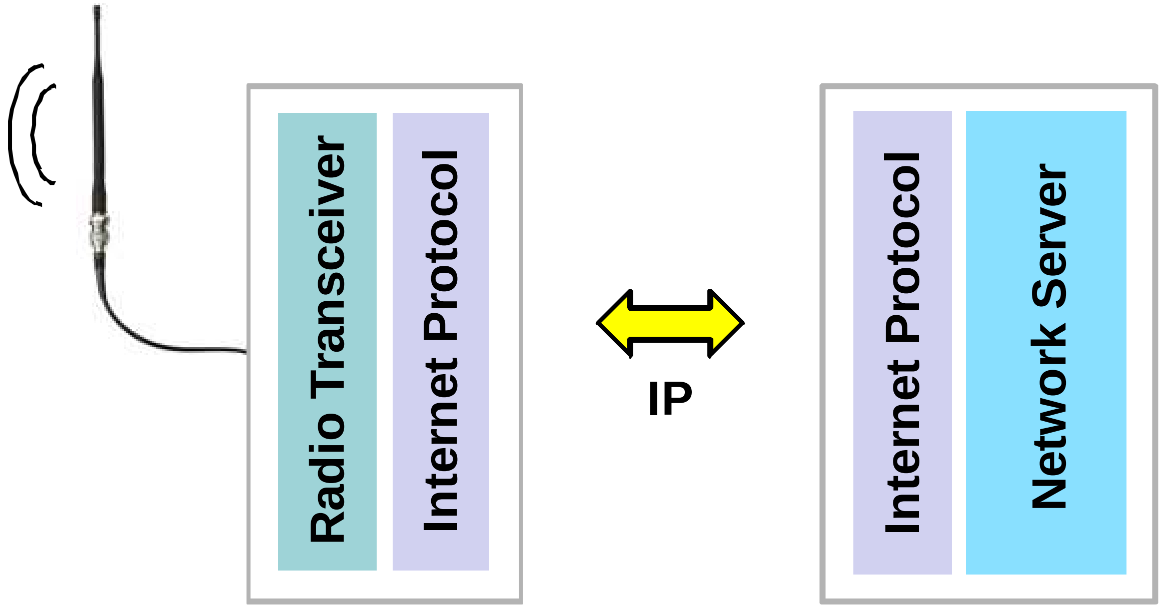
- The "Thing" in IoT
- Single-hop wireless communication to one or many **Gateway(s).**



LoRaWAN™ Network Protocol

Gateway

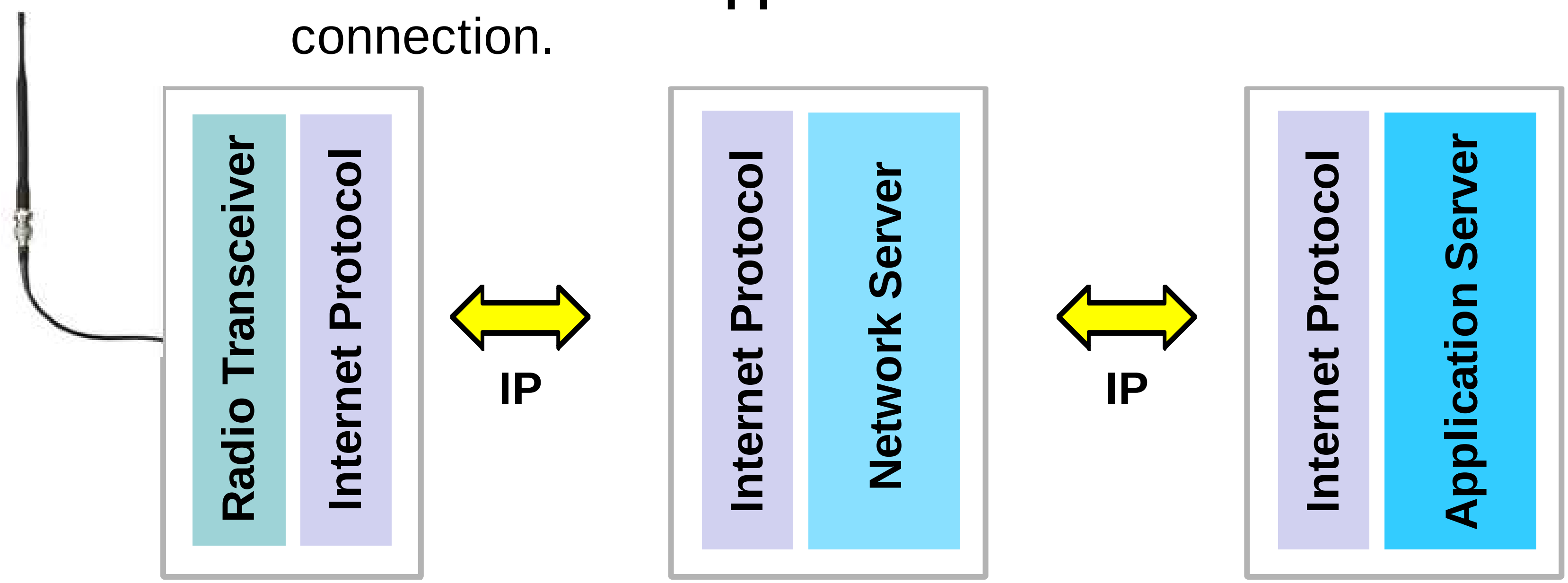
- Interface the LoRaWAN RF Network to LoRaWAN Backend Services
- Data is “passed through” to Servers
- Connected to **Network Server** via standard IP connection.



LoRaWAN™ Network Protocol

Network Server

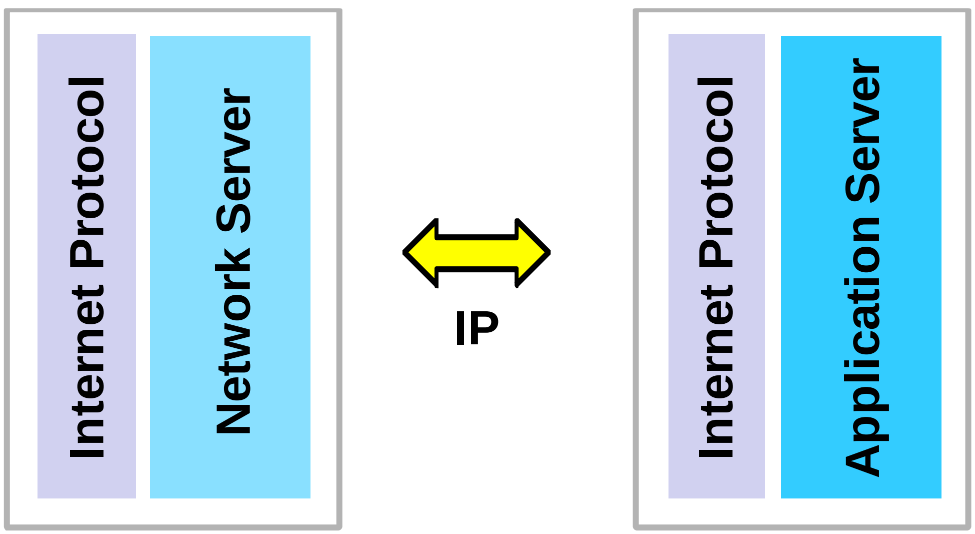
- **Network Server** authenticates data
- If data is addressed to **Network Server**, data is processed
- Else data will be forwarded to **Application Server**
- Connected to the **Application Server** via standard IP connection.



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

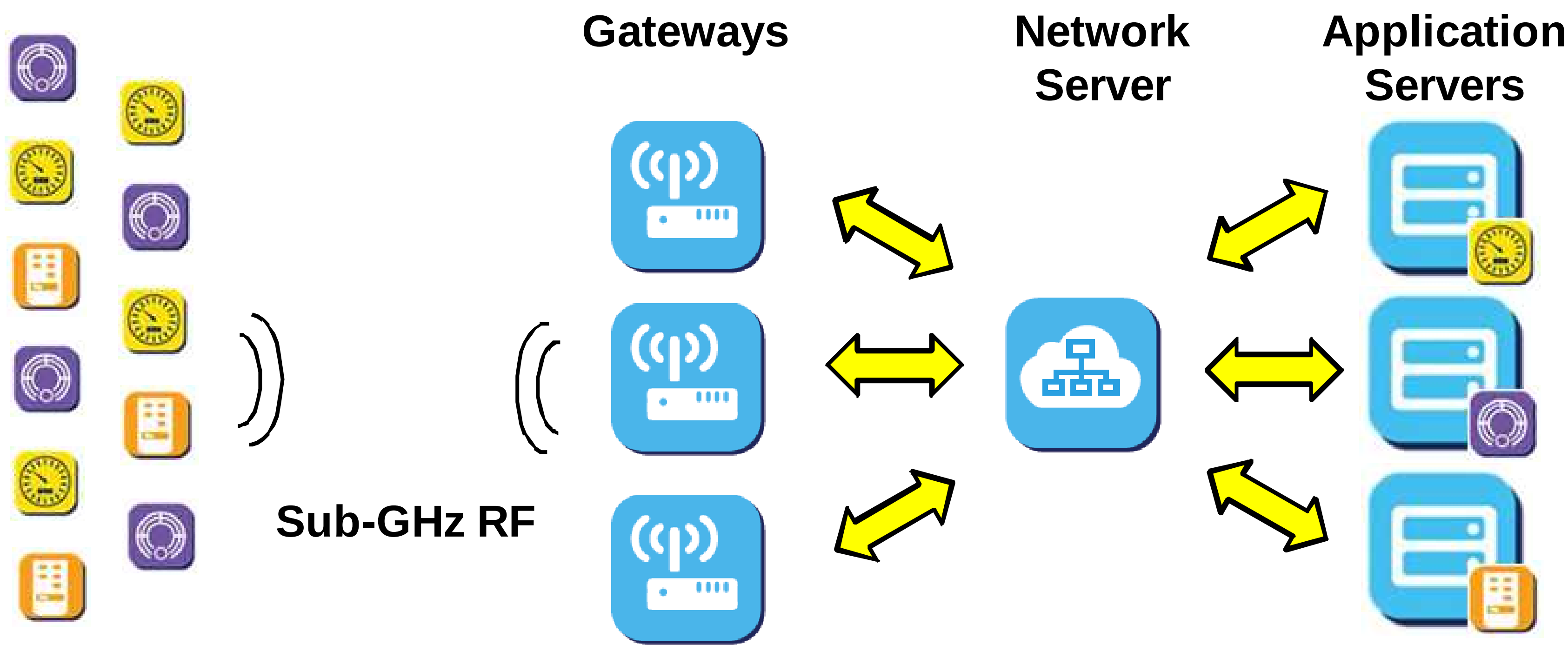
Electric Meter

Vending Machine

Smoke alarms

LoRaWAN™ Network Protocol

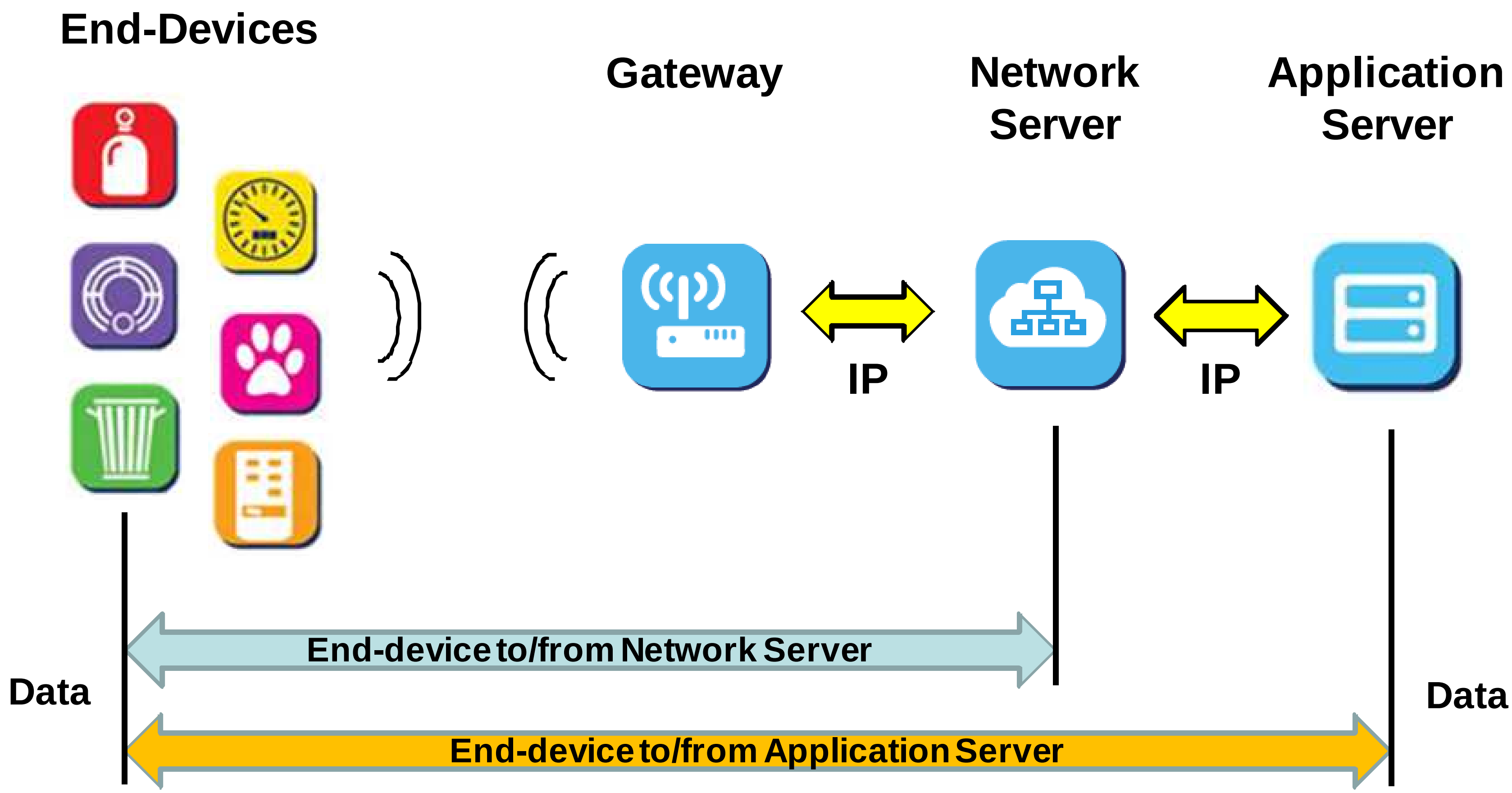
Multiple Application Servers Example



LoRaWAN™ Network Protocol

How does LoRaWAN™ Technology Work?

Logical Data Flow (Programmer's Model)



Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - Lora™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - **End-Device Classes**
  - End-Device Activation (Joining)
  - Security
  - End-Device Data Communication (Class A)
  - Adaptive Data Rate (ADR)

LoRaWAN™ Network Protocol

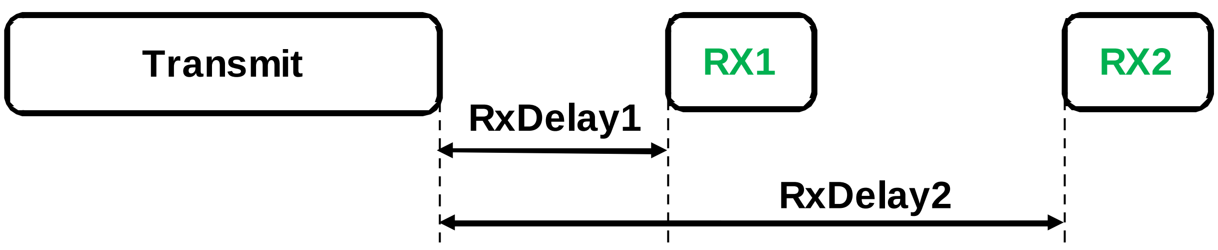
End-Device Classes

- **Each end-device class has different behavior depending on the choice of optimization:**
  - Battery Powered – Class A
  - Low Latency – Class B
  - No Latency – Class C

LoRaWAN™ Network Protocol

End-Device Classes

- **Battery Powered – Class A**
  - Bidirectional communications
  - Unicast messages
  - Small payloads
  - Long intervals
  - End-device initiates communication (uplink)
  - Server communicates with end-device (downlink) during predetermined response windows:



LoRaWAN™ Network Protocol

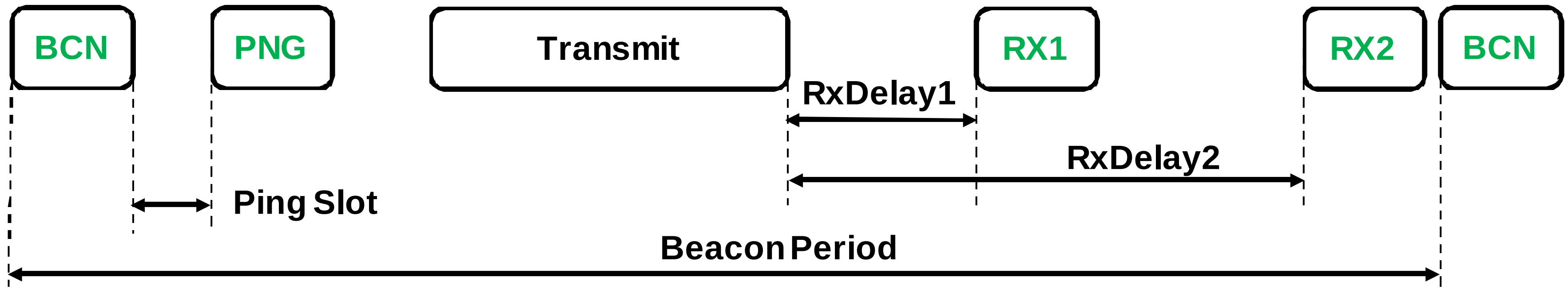
End-Device Classes

- **Battery Powered – Class A**
  - **Pros**
    - Lowest power consumption = longest battery life
  - **Cons**
    - Long latency
- **Examples**
  - Battery powered sensors

LoRaWAN™ Network Protocol

End-Device Classes

- **Low Latency – Class B**
  - Bidirectional with scheduled receive slots
  - Unicast and Multicast messages
  - Small payloads
  - Long intervals
  - Periodic beacon from gateway
  - Extra receive window (ping slot)
  - Server can initiate transmission at fixed intervals



LoRaWAN™ Network Protocol

End-Device Classes

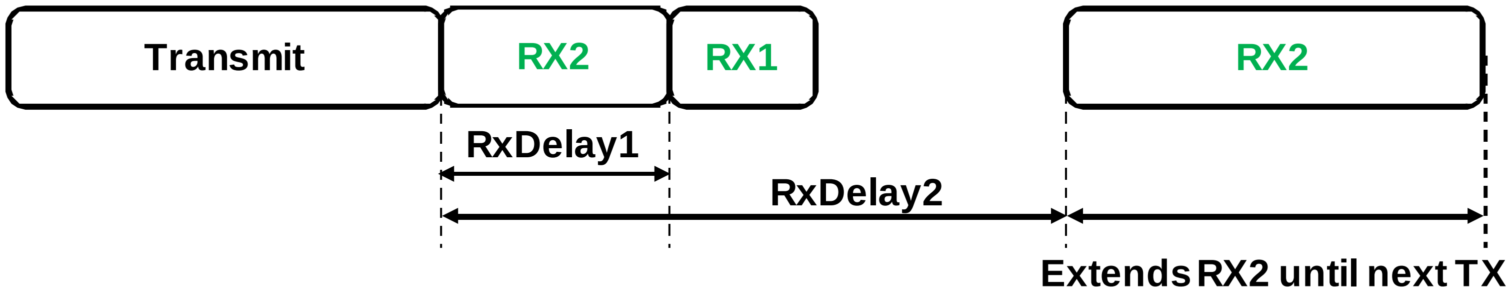
- **Low Latency – Class B**
  - **Pros**
    - Deterministic latency
  - **Cons**
    - Higher power consumption

- **Examples**
  - Battery powered actuator end-device

LoRaWAN™ Overview

End-Device Classes

- **No Latency – Class C**
  - Bidirectional communications
  - Unicast and Multicast messages
  - Small payloads
  - Server can initiate transmission at any time
  - End-device is constantly receiving



LoRaWAN™ Network Protocol

End-Device Classes

- **No Latency – Class C**
  - **Pros**
    - Lowest receive latency
    - End-device has continuous receive window
  - **Cons**
    - Highest power consumption
      (expect end-device to be mains powered)

- **Examples**
  - Mains power low-latency actuator end-device

Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - LoRa™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - **End-Device Activation (Joining)**
  - Security
  - End-Device Data Communication (Class A)
  - Adaptive Data Rate (ADR)

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

- **Before an end-device can communicate on the LoRaWAN network, it must be activated**
- **The following information is required:**
  - Device Address (DevAddr)
  - Network Session Key (NwkSKey)
  - Application Session Key (AppSKey)

Let’s look at each of these in detail…

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

- **Device Address (DevAddr)**
  - 32-bit identifier
  - Unique within the network
  - Present in each data frame
  - Shared between End-device, Network Server, and Application Server
- **Differentiates nodes within the network, allowing the network to use the correct encryption keys and properly interpret the data**

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

- **Network Session Key (NwkSKey)**
  - 128-bit AES encryption key
  - Unique per end-device
  - Shared between end-device and Network Server
- **Provides message integrity for the communication**
- **Provides security for end-device to Network Server communication**

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

- **Application Session Key (AppSKey)**
  - 128-bit AES encryption key
  - Unique per end-device
  - Shared between end-device and Application Server
  - Used to encrypt / decrypt application data messages
- **Provides security for application payload**

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

- **To exchange this information, two activation methods are available:**

Over-the-Air Activation (OTAA)	Activation By Personalization (ABP)
• Based on Globally Unique Identifier • Over the air message handshaking	• Shared keys stored at production time • Locked to a specific network
	

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LoRaWAN™ Network Protocol

End-Device Activation (Joining)

Over-the-Air-Activation (OTAA)

- End-device transmits Join Request to application server containing:
  - Globally unique end-device identifier (DevEUI)
  - Application identifier (AppEUI)
  - Authentication with Application key (AppKey)
- End-device receives Join Accept from application server

(continued…)

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LoRaWAN™ Network Protocol

End-Device Activation (Joining)

Over-the-Air-Activation (OTAA)

- End-device authenticates Join Accept
- End-device decrypts Join Accept
- End-device extracts and stores Device Address (DevAddr)
- End-device derives:
  - Network Session Key (NwkSKey)
  - Application Session Key (AppSKey)

Security Keys

LoRaWAN™ Network Protocol

End-Device Activation (Joining)

DOWNLOAD

Activation By Personalization (ABP)

- The following information is configured at production time:
  - Device Address (DevAddr)
  - Network Session Key (NwkSKey)
  - Application Session Key (AppSKey)
- No over the air handshaking
- Device is ready to communicate on the network without any additional procedure.
- Note that the end result is the same, the DevAddr and security keys are now known to the end-device

Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - LoRa™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - End-Device Activation (Joining)
  - **Security**
  - End-Device Data Communication (Class A)
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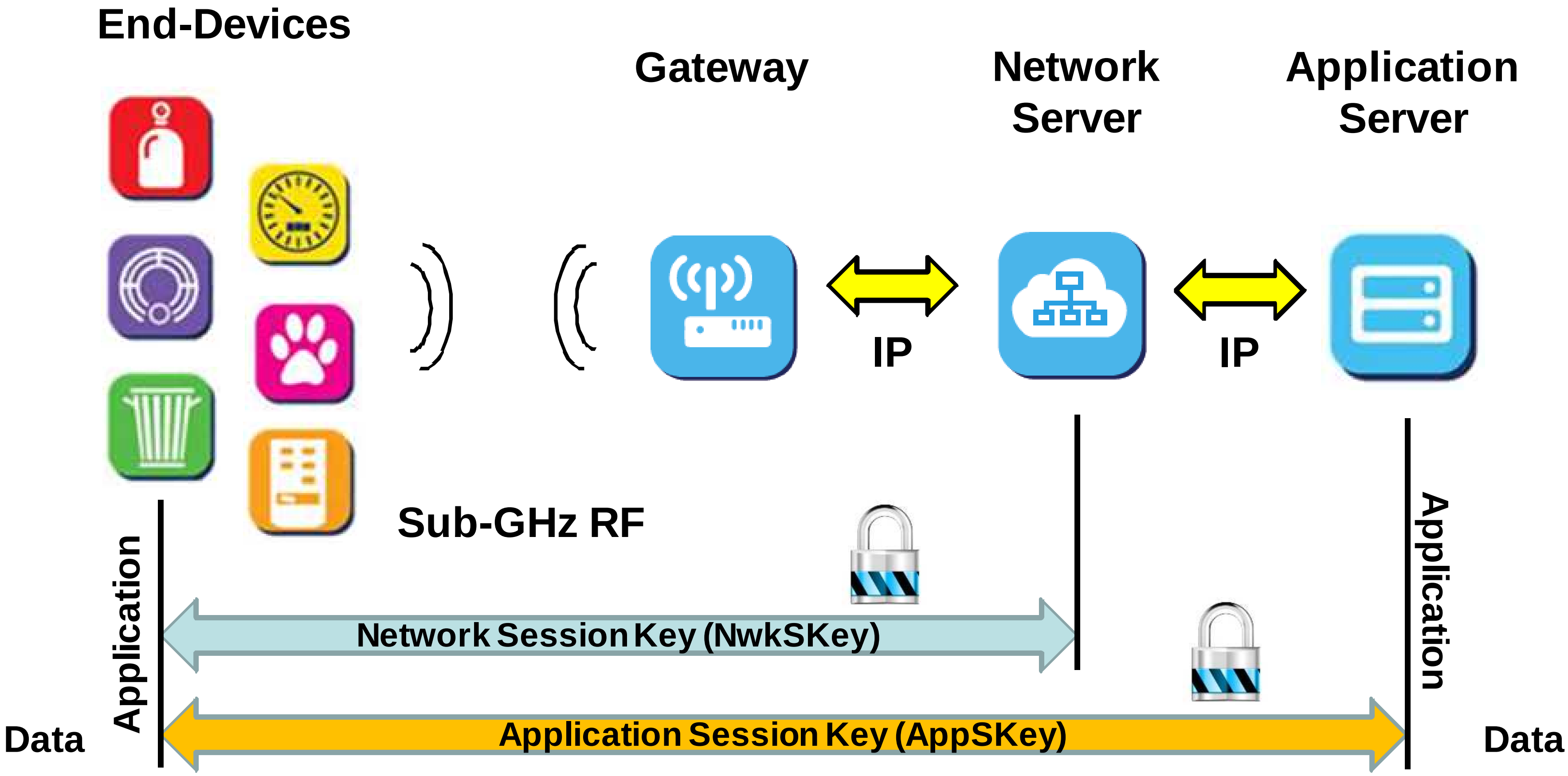
LoRaWAN™ Network Protocol

Security

Logical Data Flow (Programmer's Model)



LoRaWAN™ Network Protocol

Security

- **Based on 802.15.4 Security**
  - AES-128
- **Enhancement**
  - Network Session Key (NwkSKey)
  - Application Session Key (AppSKey)
  - Network Server authenticates Application Data
  - Network Server cannot decrypt Application Data

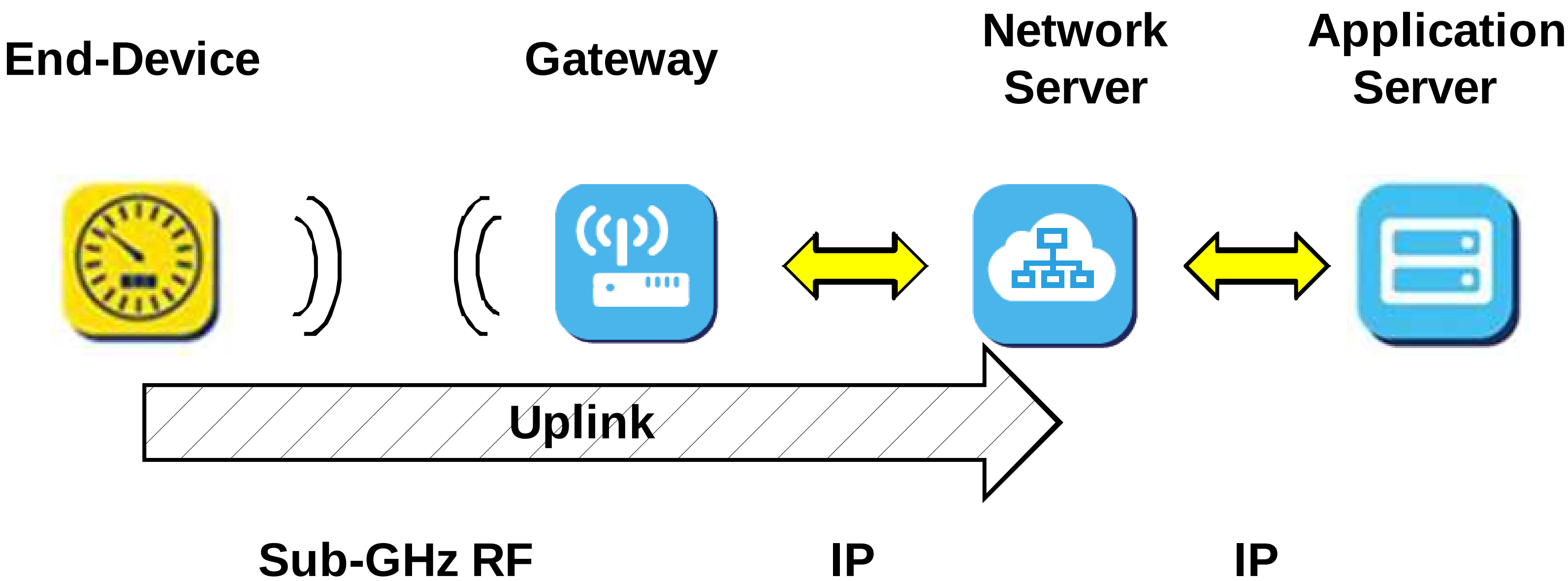
Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - LoRa™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - End-Device Activation (Joining)
  - Security
  - **End-Device Data Communication (Class A)**
  - Adaptive Data Rate (ADR)

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

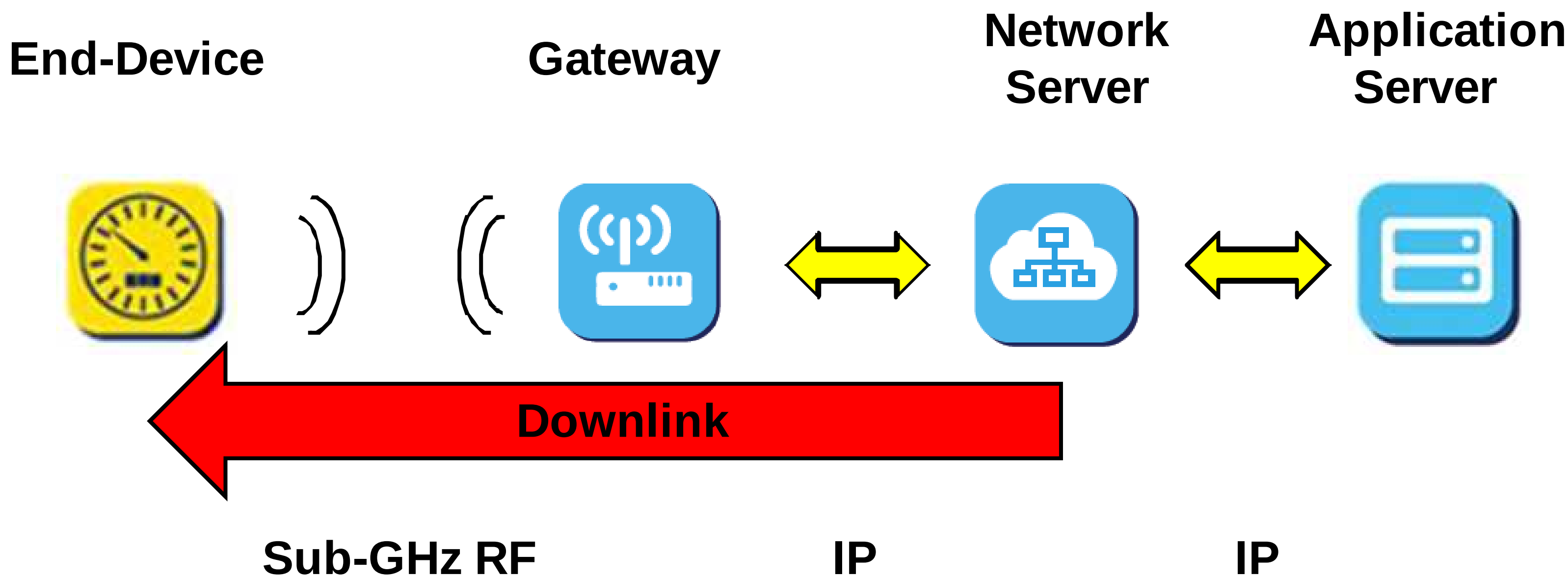
- **Uplink Message**
  - End-Device to Network Server relayed by one or many Gateways



LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

- **Downlink Message**
  - Sent by the Network Server to only one End-Device and is relayed by a single Gateway



LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Unconfirmed-Data Message

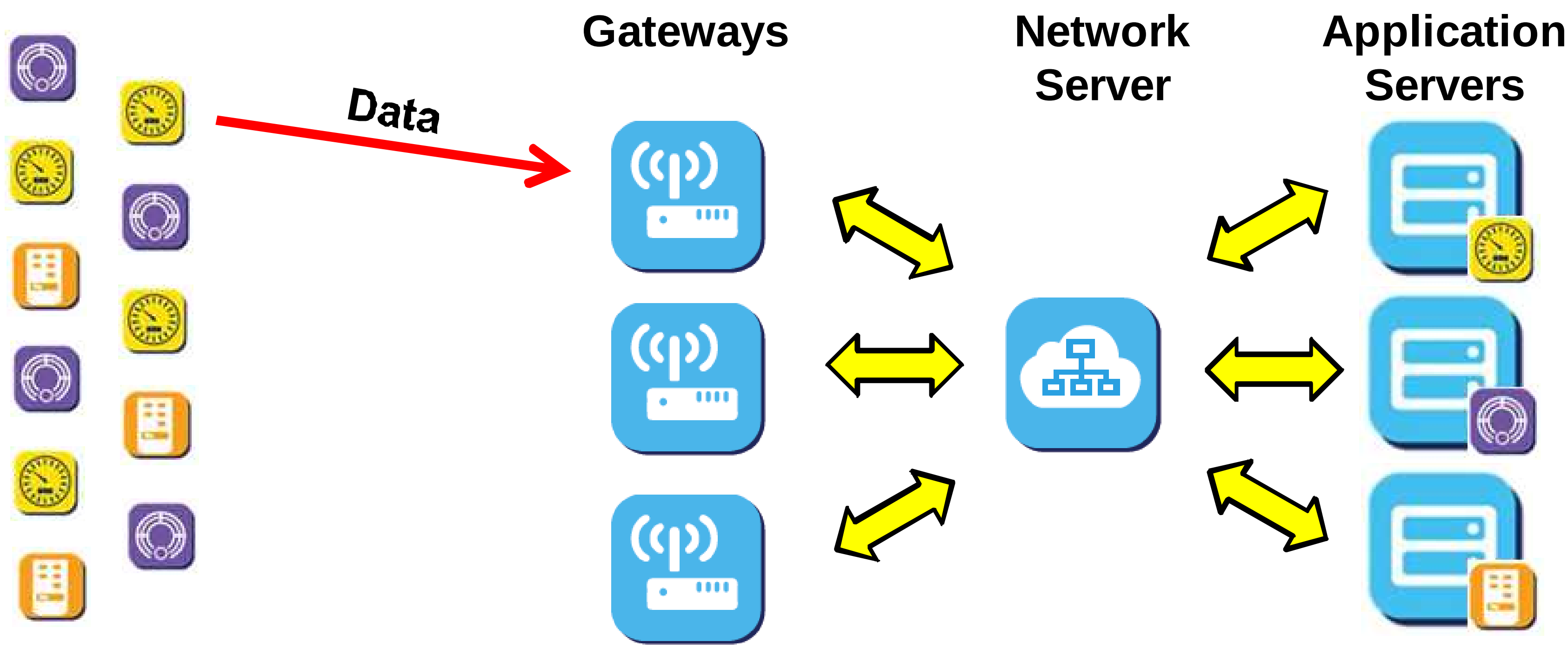
End-Device Data Message does not require an acknowledgement

Let’s look at an example…

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Unconfirmed-Data Message

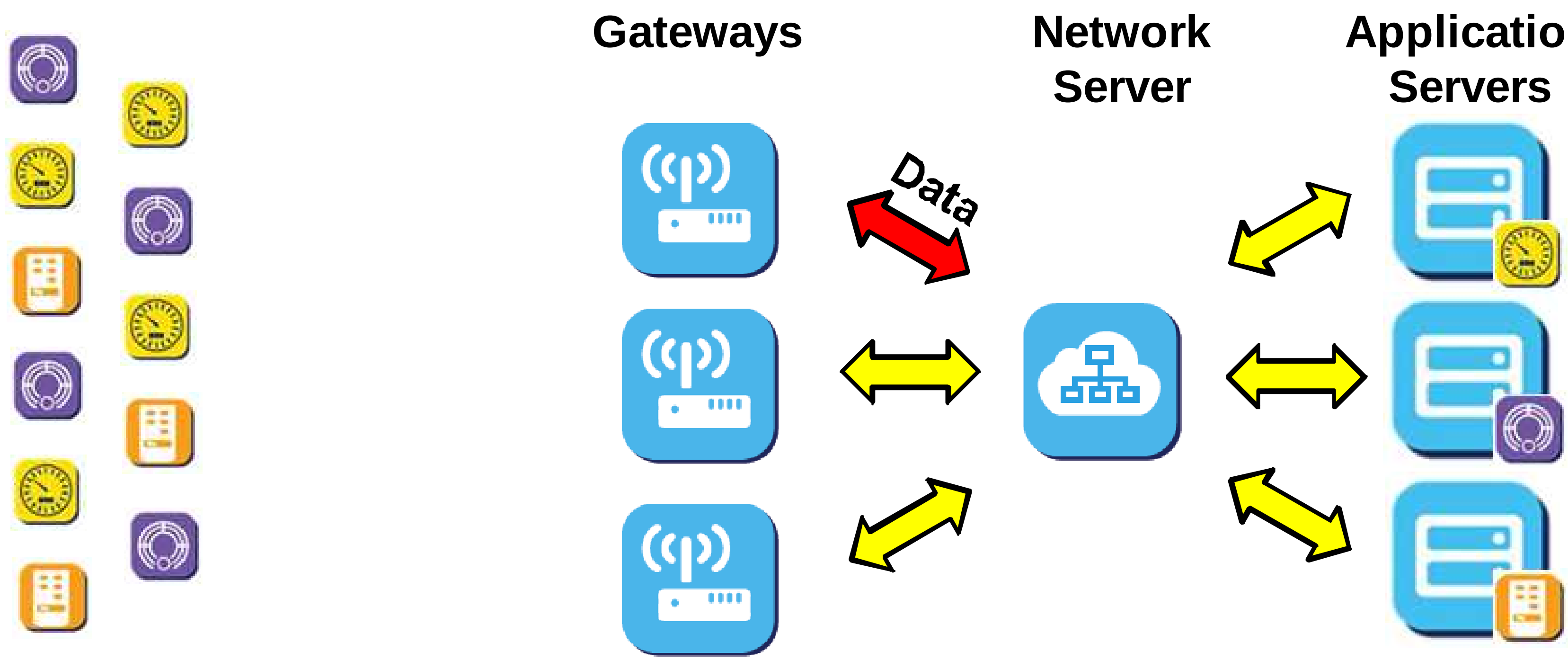


1. Electric meter transmits data

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Unconfirmed-Data Message

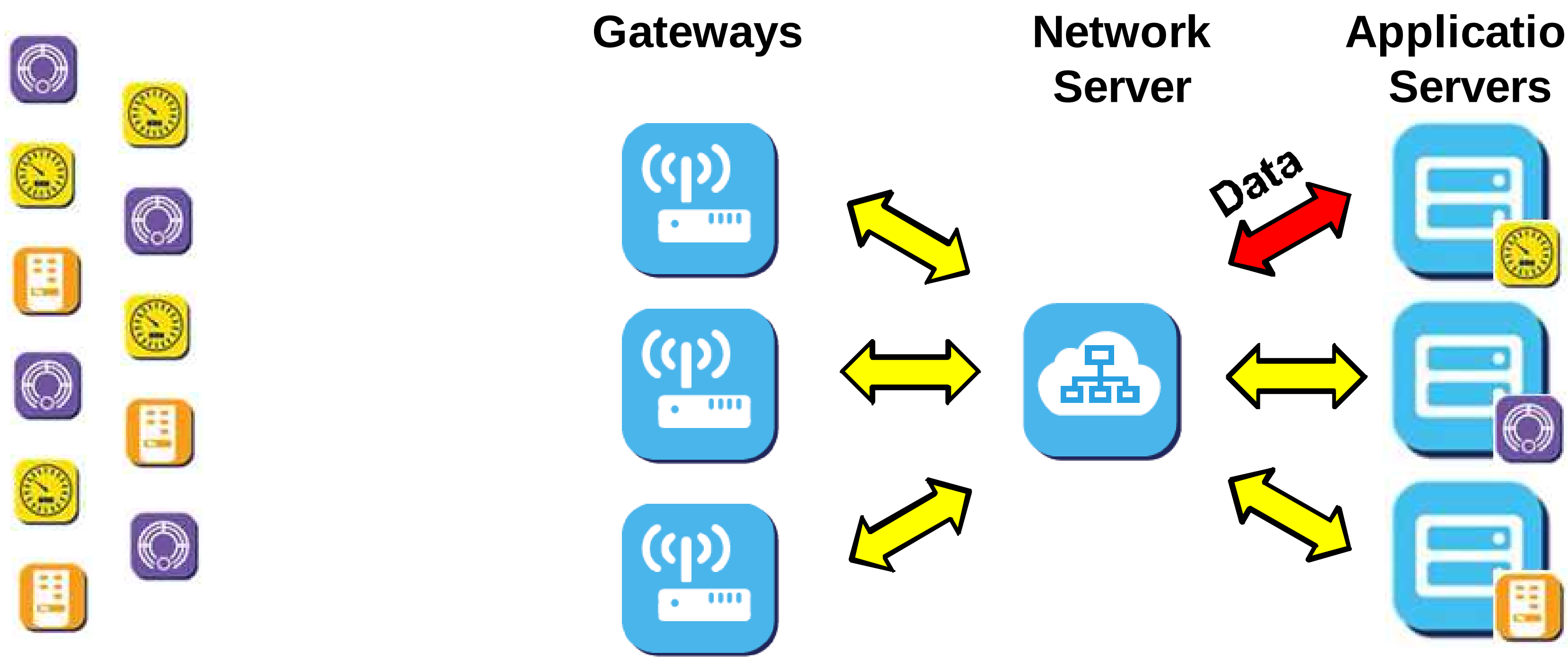


2. Gateway receives data and passes to Network Server

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Unconfirmed-Data Message

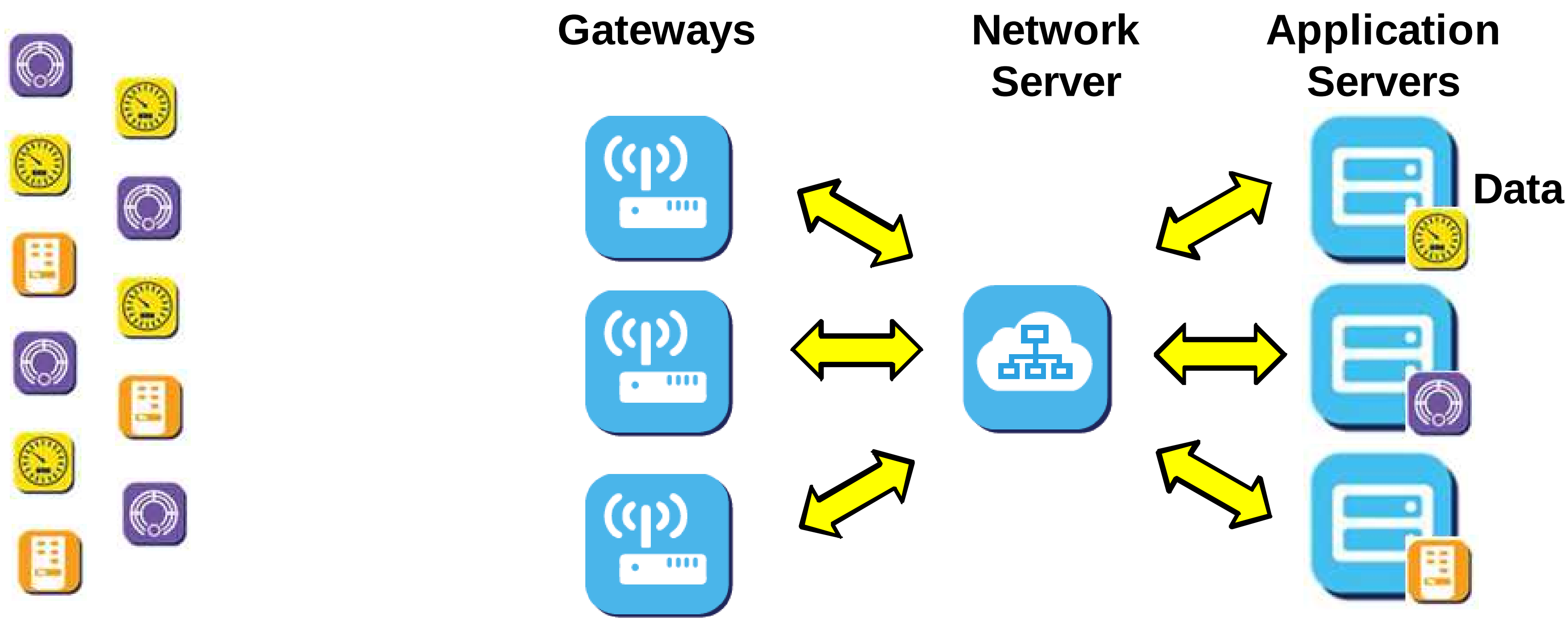


3. The Network Server authenticates data and passes it to Electric Meter Application Server

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Unconfirmed-Data Message



4. Electric Meter Application Server decrypts data

LoRaWAN™ Network Protocol

End-Device Data Communications

Confirmed-Data Message

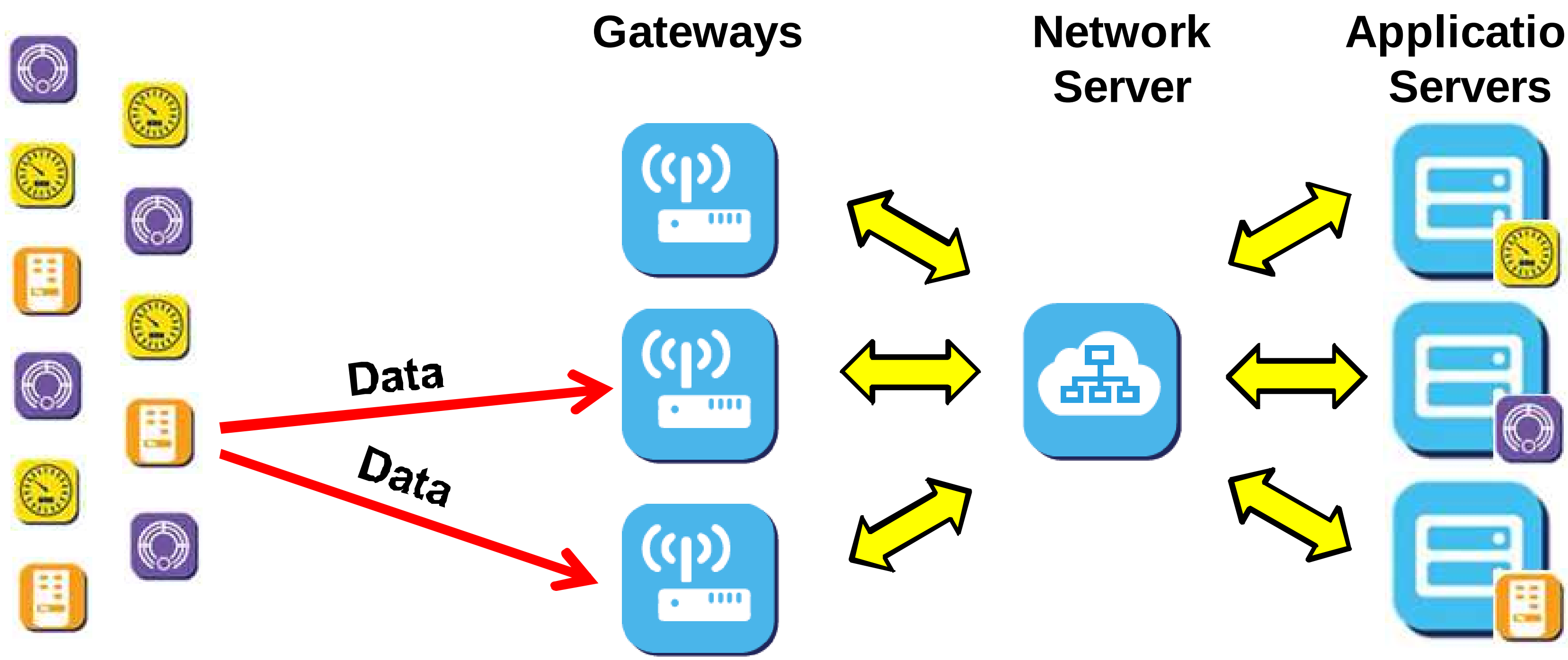
End-Device Data Message has to be acknowledged by the receiver

Let’s look at an example…

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message

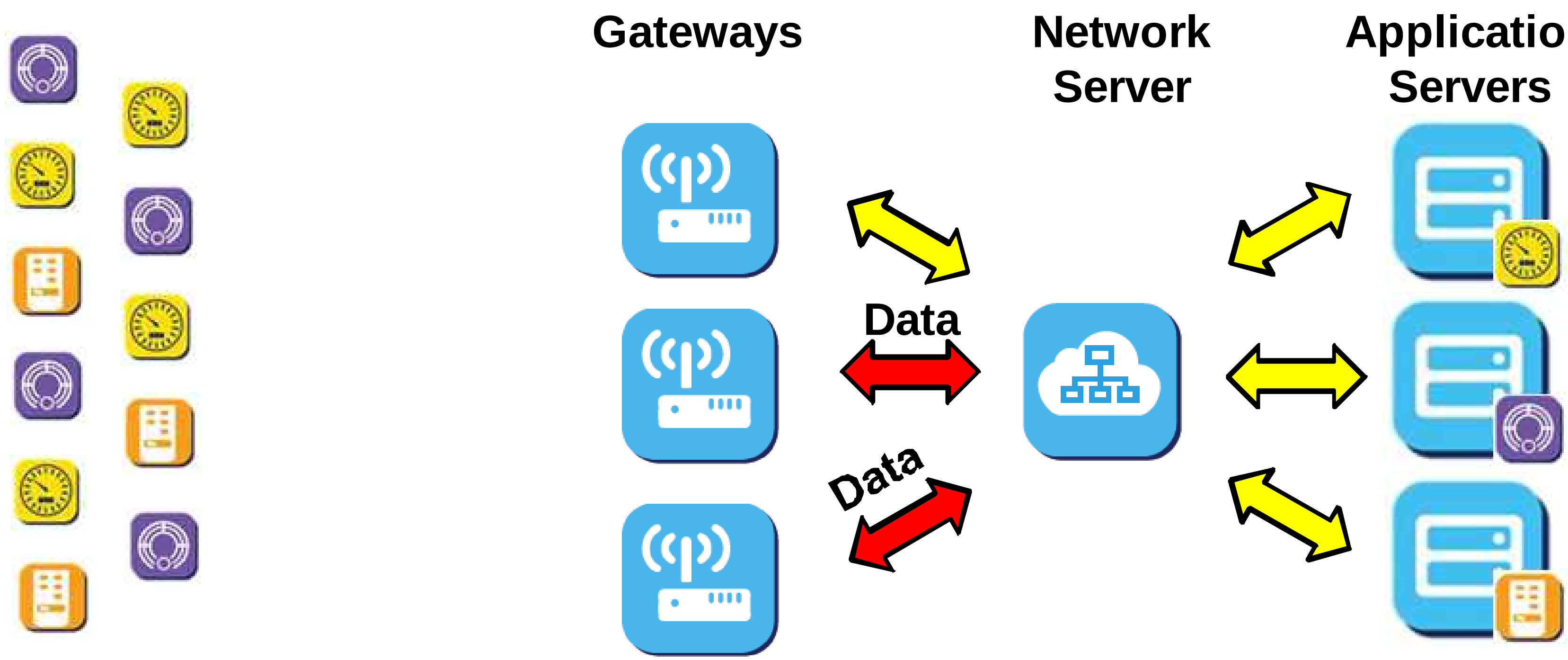


1. Vending Machine transmits data.
It is received by two Gateways.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message

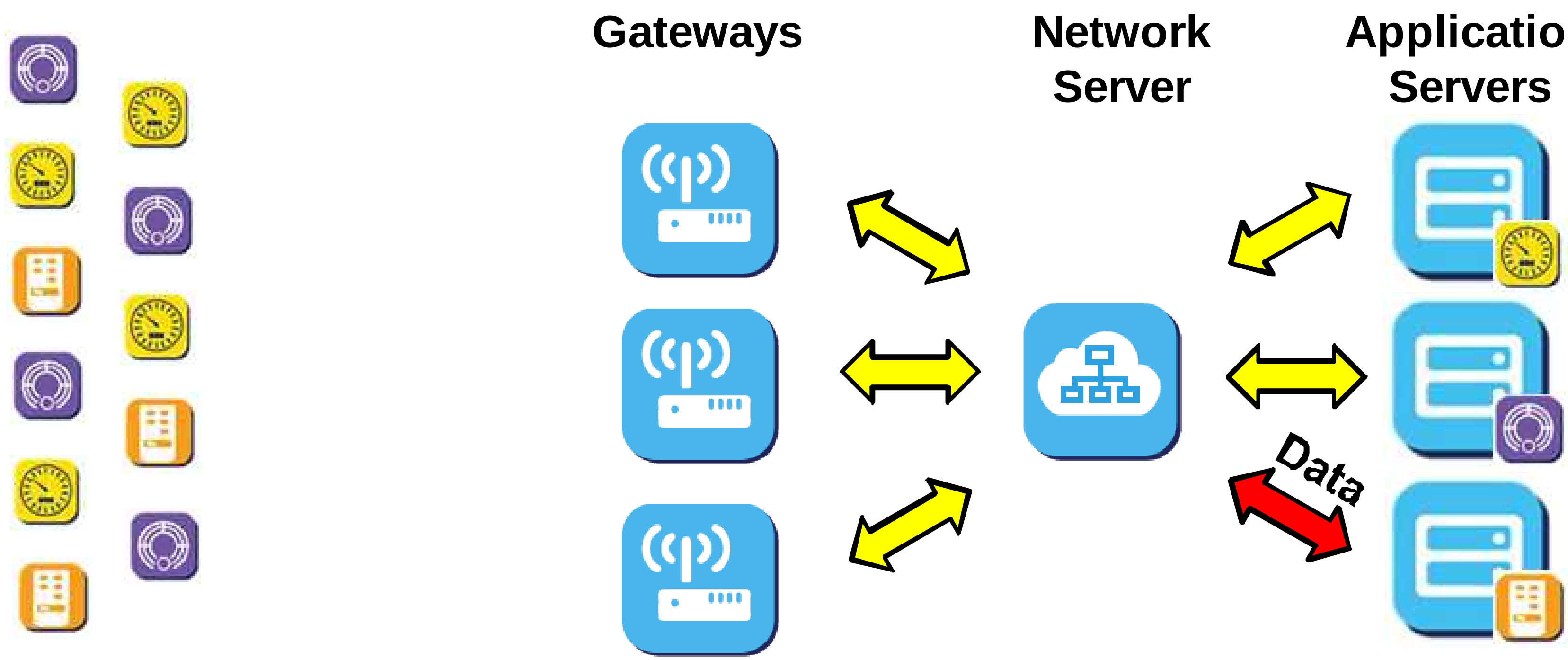


2. Both gateways "pass through" the data to the Network Server.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message

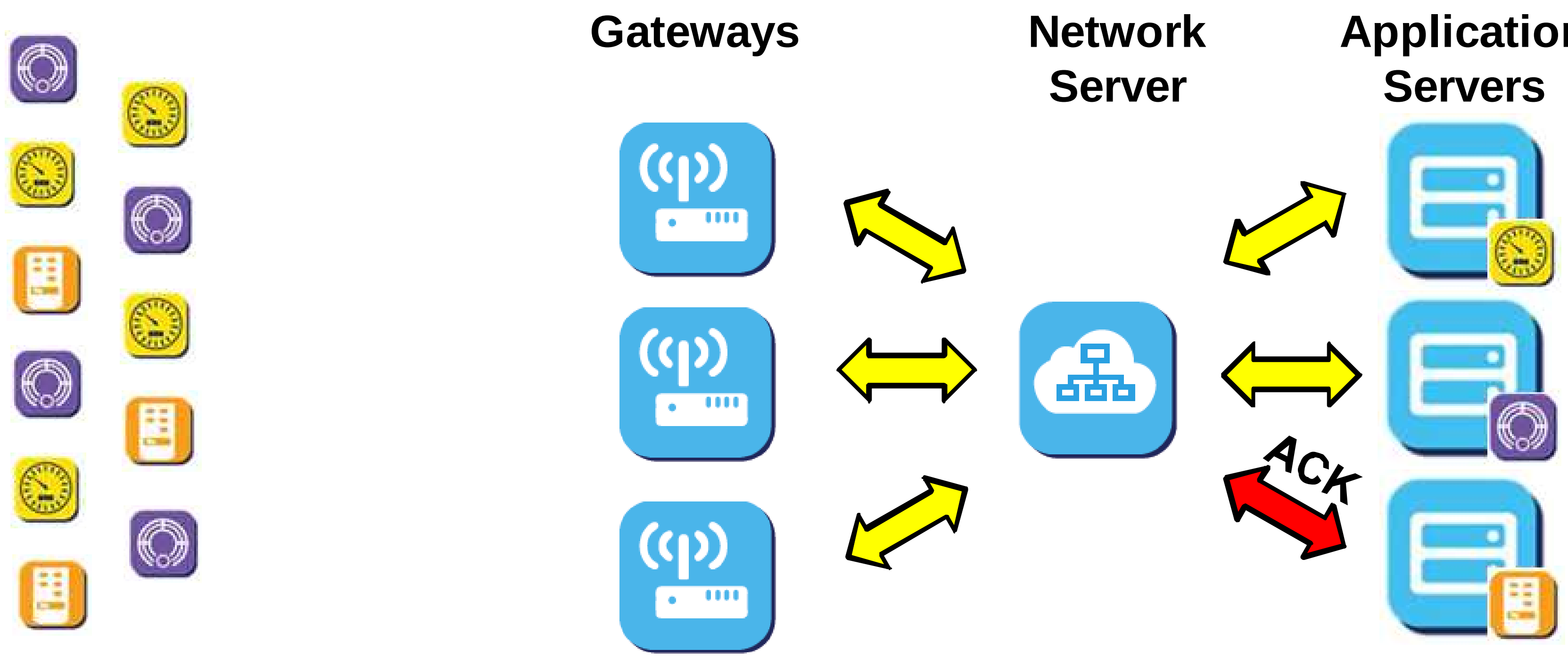


3. The Network Server forwards the data to the Vending Machine Applications Server

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message

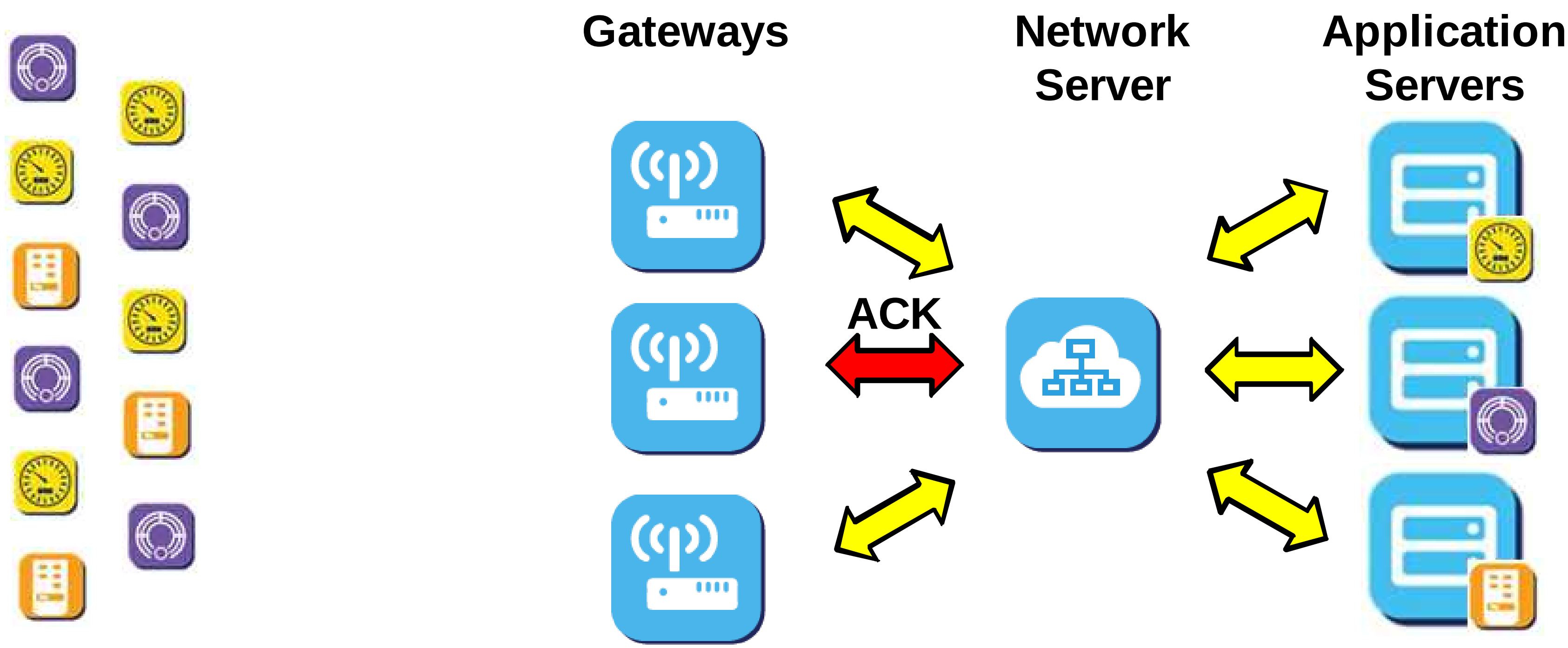


4. The Vending Machine Applications Server sends an acknowledgement

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message

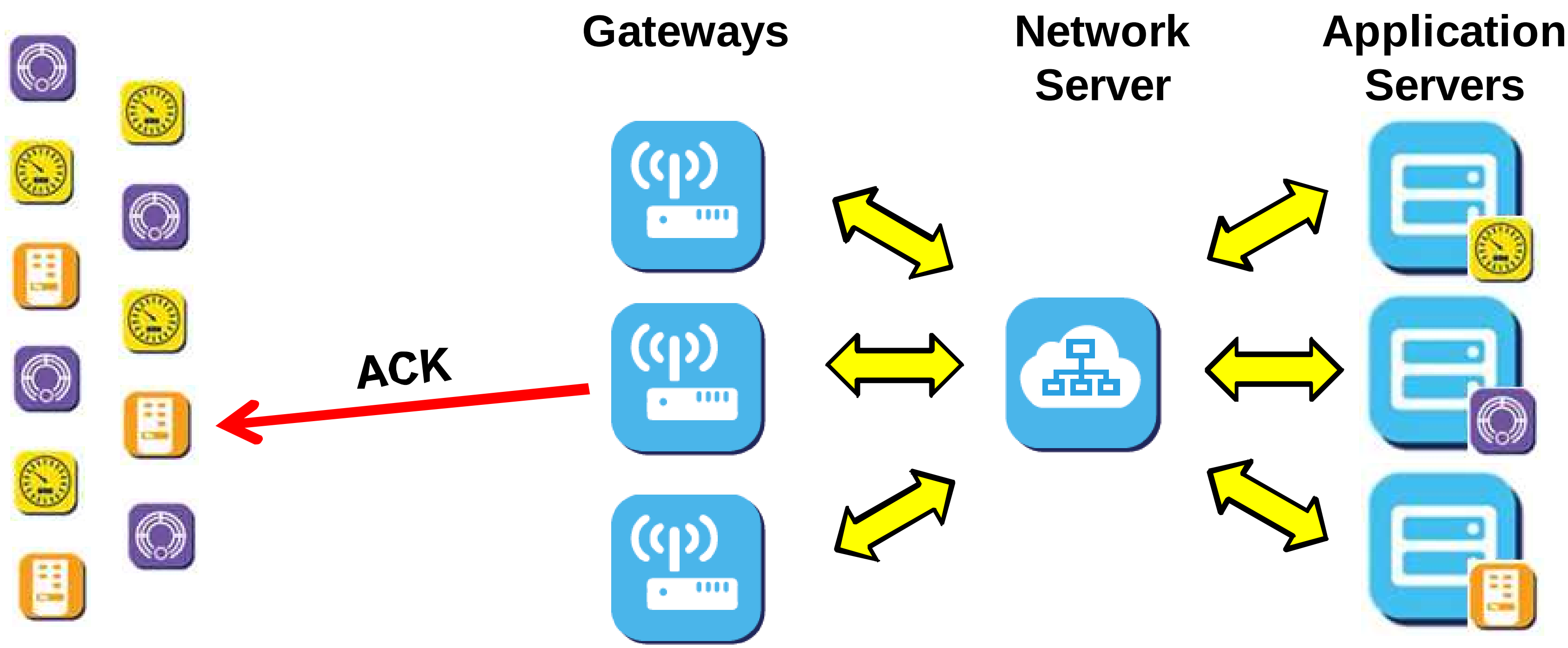


5. The Network Server selects the best path (gateway) to transmit the acknowledgement to the end-device.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Confirmed-Data Message



6. The Gateway transmits the acknowledgement to the end-device

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

If the Application Server has a Data Message for the End-Device…

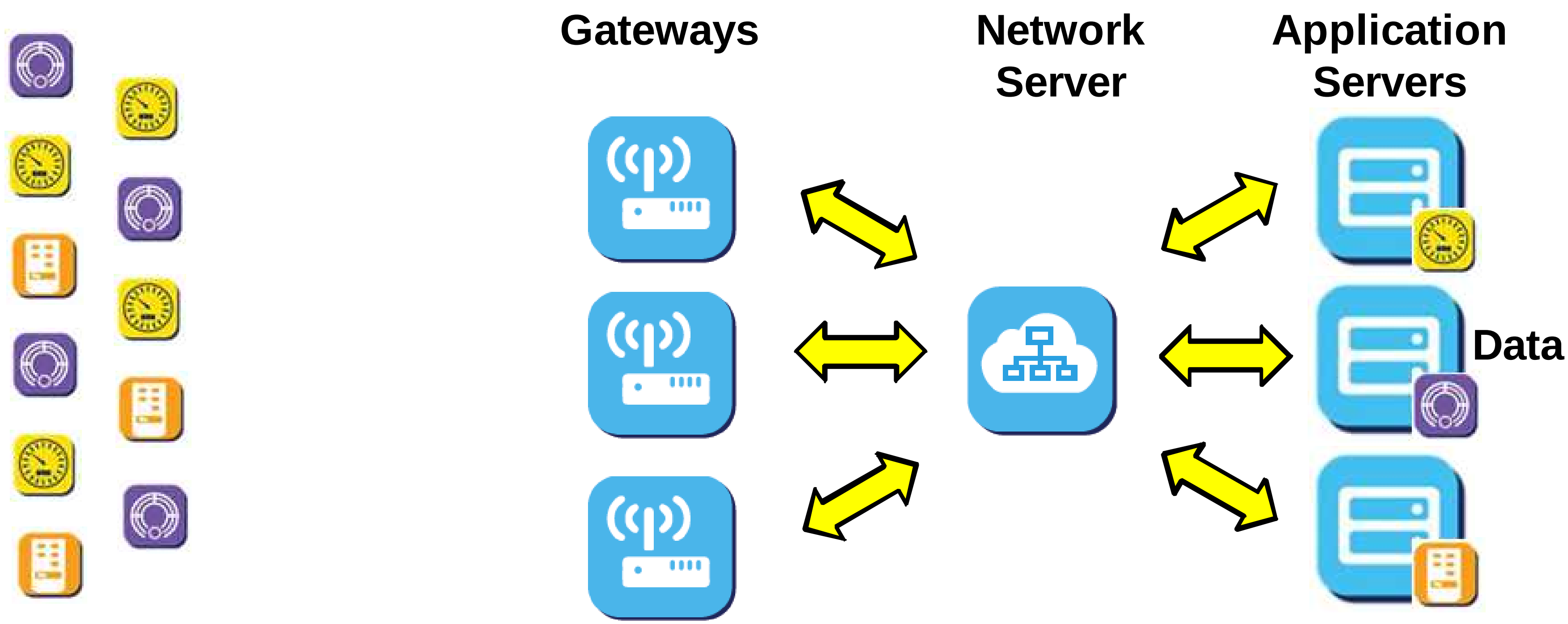
… the Application Server has to wait until the End-Device initiates a transmission.

Let's look at an example…

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

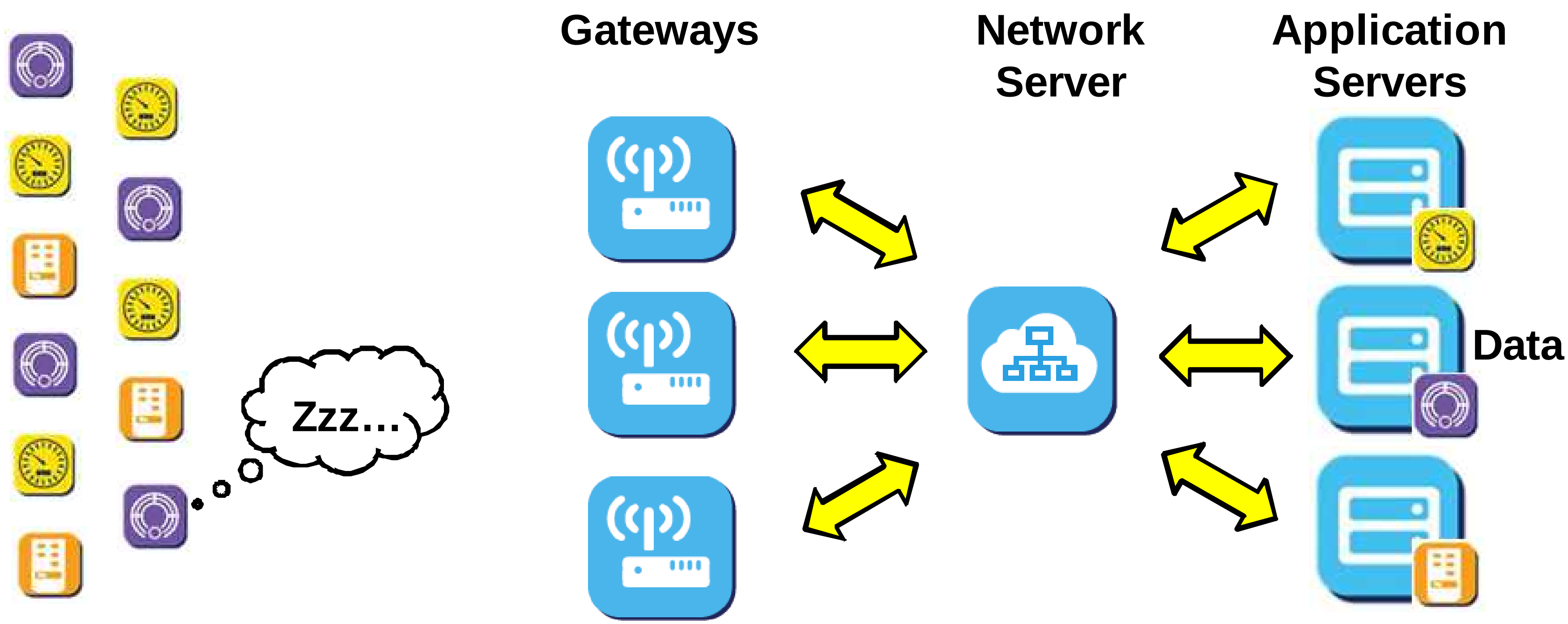


1. The Smoke Detector Application Server has Data for the highlighted Smoke Detector

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

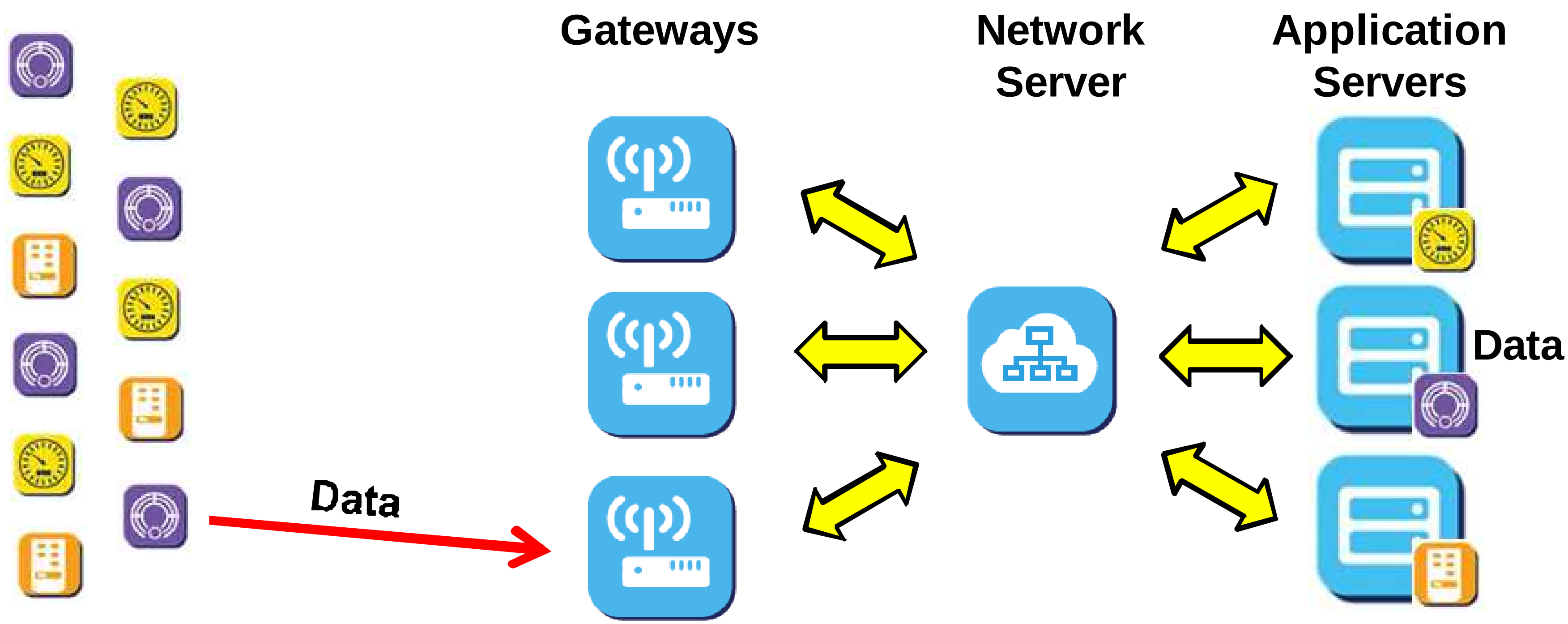


2. However, it has to wait until the Smoke Detector wakes up and transmits a Data Message

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

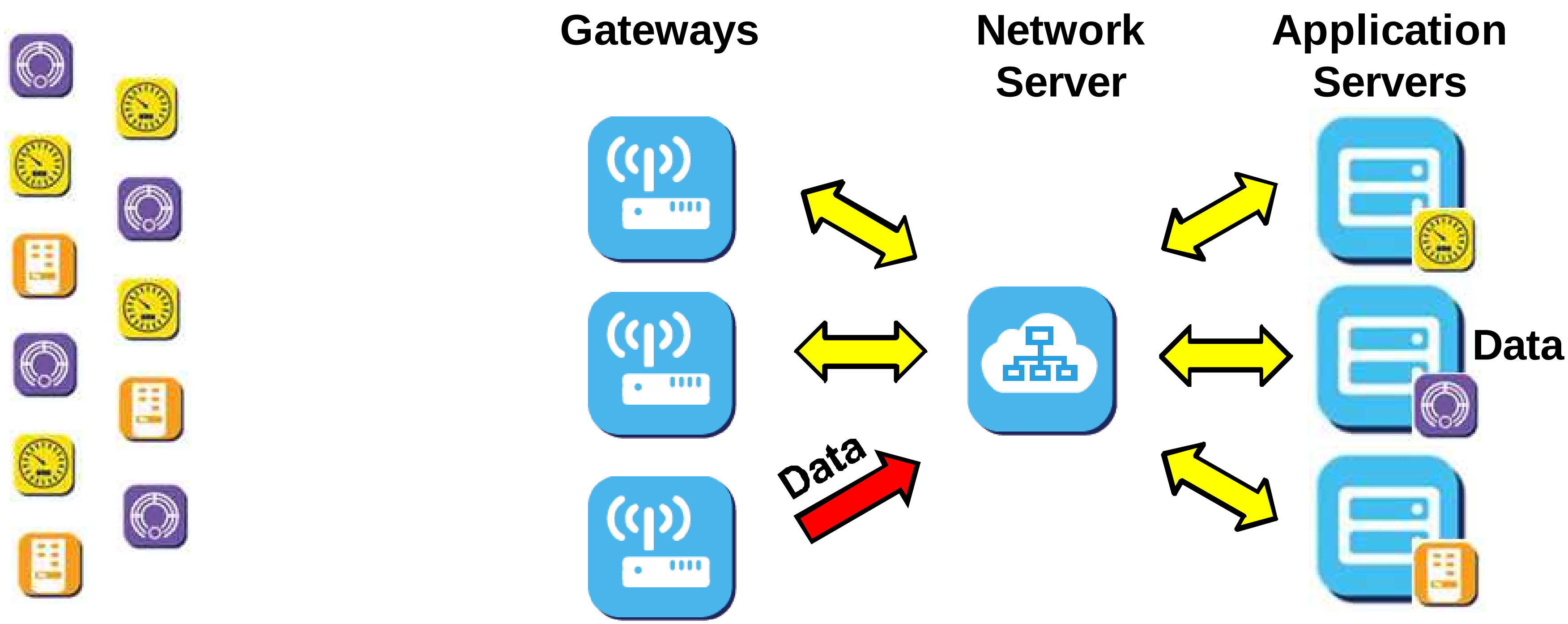


3. When the Smoke Detect transmits, the Data Message moves Upstream

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

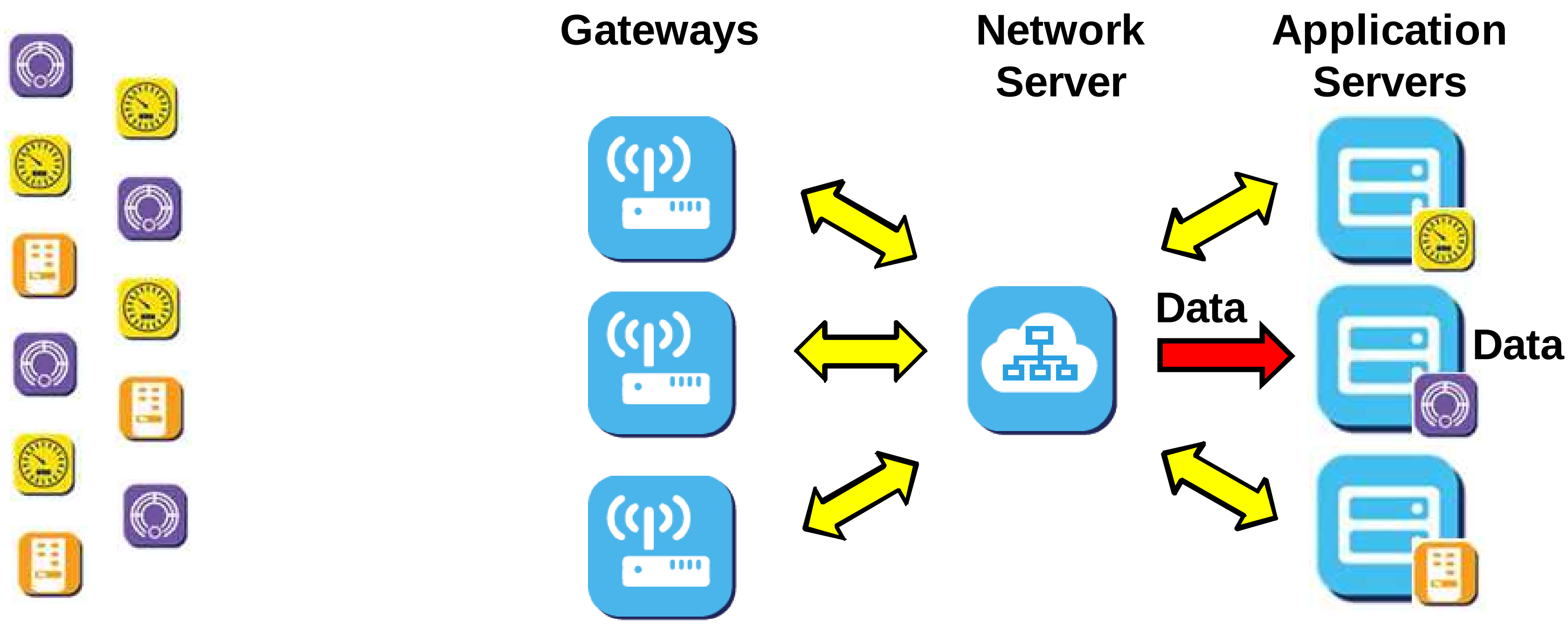


4. Passed through the Gateway…

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

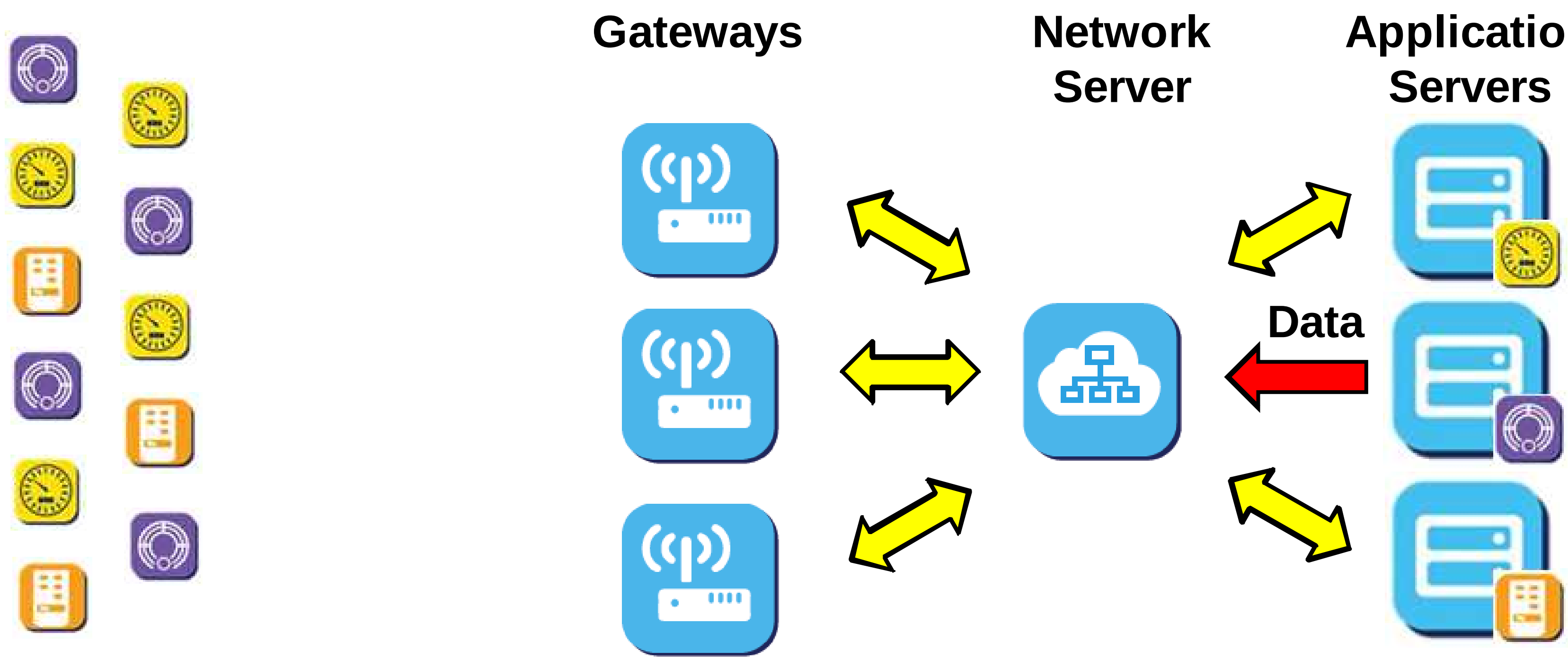


5. … and the Network Server sends to the Smoke Detector Application Server.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

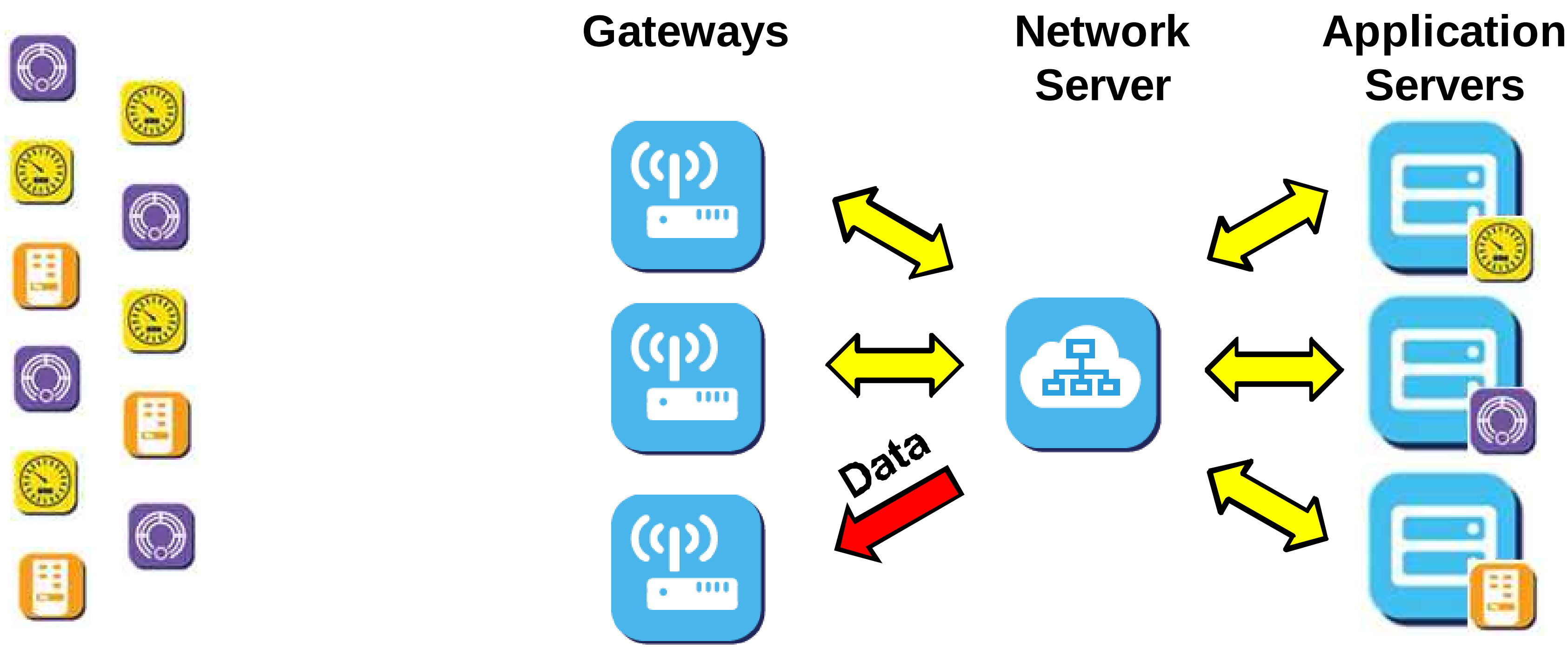


6. The Smoke Detector Application Server can now send the data message to the Smoke Detector.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message

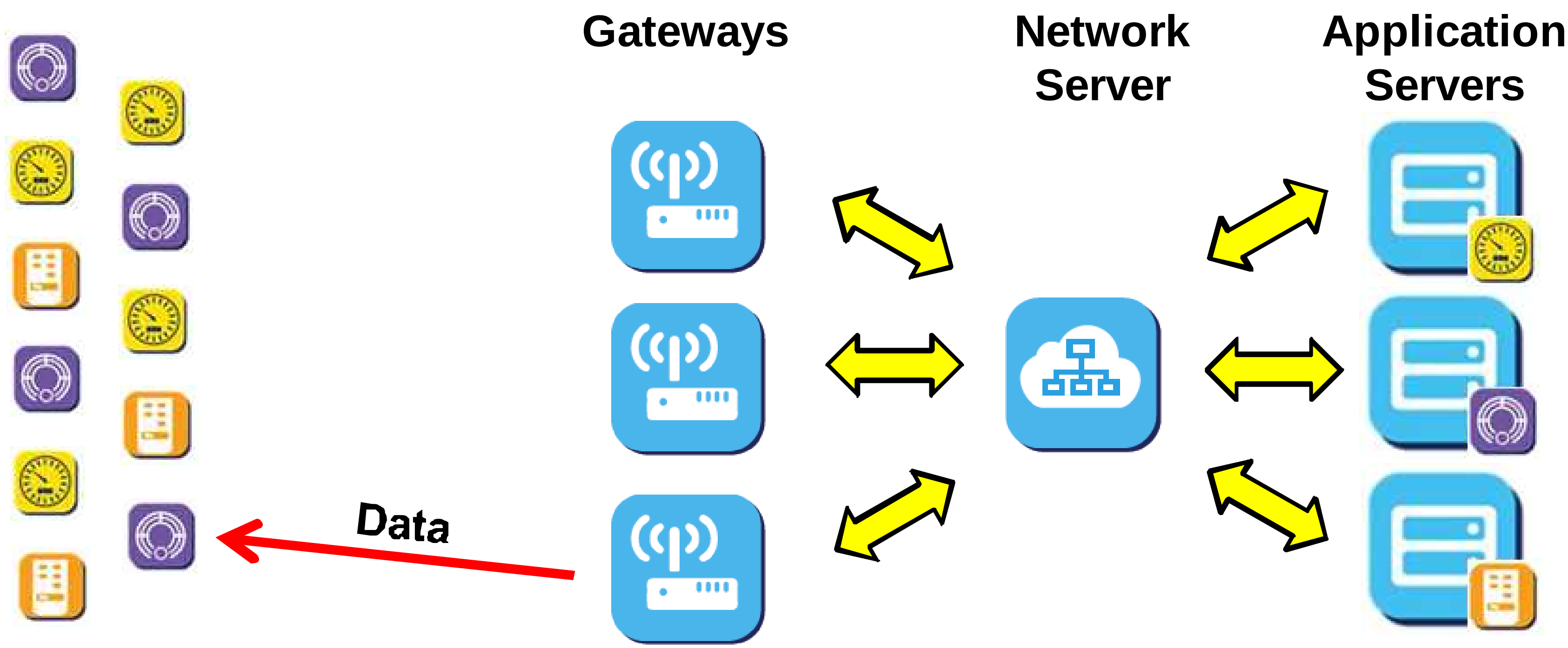


7. The Network Server sends the Data Message to the appropriate Gateway.

LoRaWAN™ Network Protocol

End-Device Data Communications (Class A)

Application Server Data Message



8. The Data Message is transmitted to the Smoke Detector during one of the two Receive Windows.

Sub-Agenda

- **LoRaWAN™ Network Protocol**
  - LoRa™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - End-Device Activation (Joining)
  - Security
  - End-Device Data Communication
  - **Adaptive Data Rate (ADR)**

LoRaWAN™ Network Protocol

Adaptive Data Rate (ADR)

- **LoRaWAN can manage**
  - data rate and
  - RF power output

for each end-device to

  - Optimize for fastest data rate,
  - Maximize battery life, and
  - Maximize network capacity

based on range from gateway

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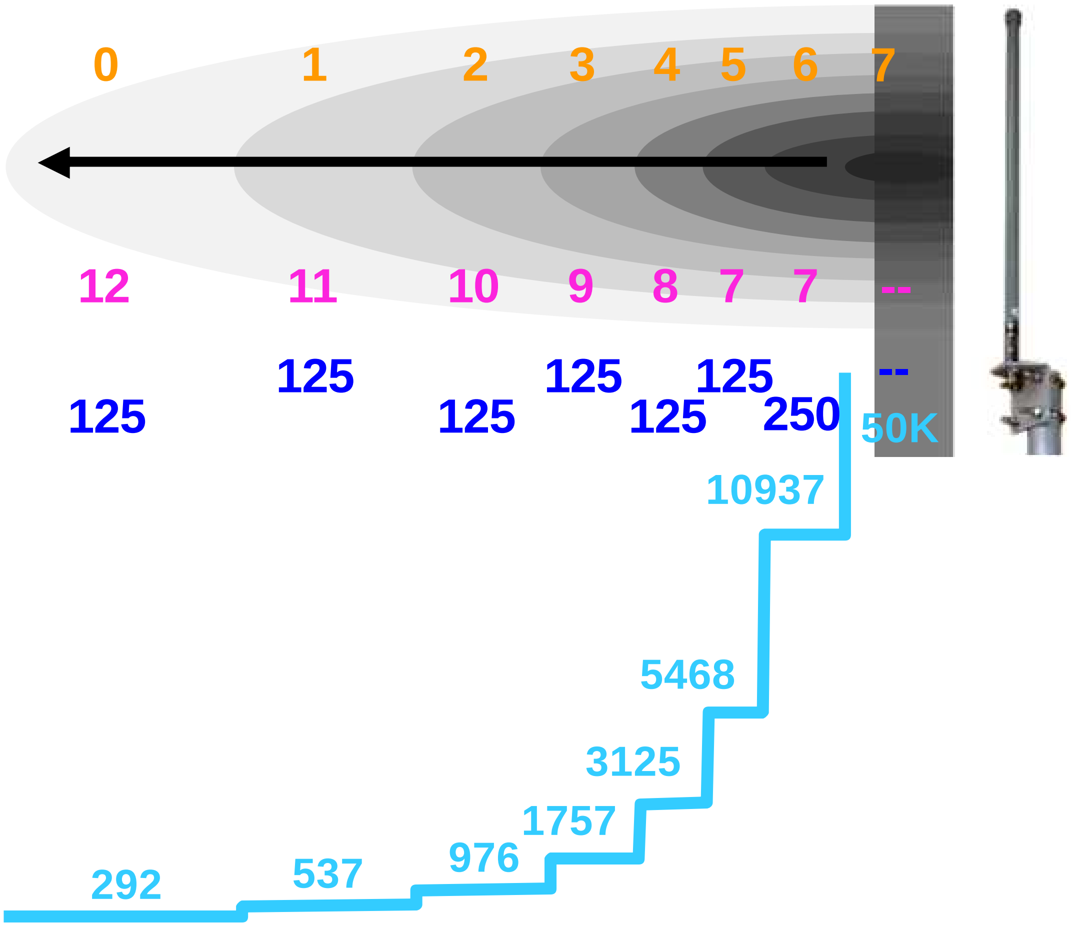
LoRaWAN™ Network Protocol

Adaptive Data Rate (ADR)



Data Rate (DR)

Range

Spreading Factor (SF)

Bandwidth (BW) (kHz)

Bitrate (BR) (bps)

Note: European data rates shown

Summary

- LoRaWAN™ Network Protocol
  - LoRa™ Technology Modulation
  - How does LoRaWAN™ Technology Work?
  - End-Device Classes
  - End-Device Activation (Joining)
  - Security
  - End-Device Data Communication
  - Adaptive Data Rate (ADR)

Agenda

- Internet of Things (IoT)
- LoRaWAN™ Network Protocol
- **LoRa™ Technology Wireless Modules**
- Getting Started with RN2903 Module
- Hands-on Labs

LoRa™ Technology Wireless Modules

- **RN2483 LoRa™ Technology Transceiver Module**
  - European (EU) 868/433 MHz
  - R&TTE Directive Assessed Radio Module
  - TX Power: up to +14 dBm
  - Power Consumption: 1.6 uA in Sleep

- **RN2903 LoRa™ Technology Transceiver Module**
  - North American (NA) 915 MHz
  - FCC and IC modular certification
  - TX Power: up to +20 dBm
  - Power Consumption: 2.2 uA in Sleep

LoRa™ Technology Wireless Modules

- **General Features**
  - Fully integrated module
  - On-board LoRaWAN™ Class A protocol stack
  - ASCII Command Interface over UART
  - UART Device Firmware Upgrade (DFU)
  - Integrated MCU and Crystal
  - EUI-64 Node Identity Serial EEPROM
  - 14 GPIOs
  - Compact form factor: 17.8 x 26.7 x 3 mm

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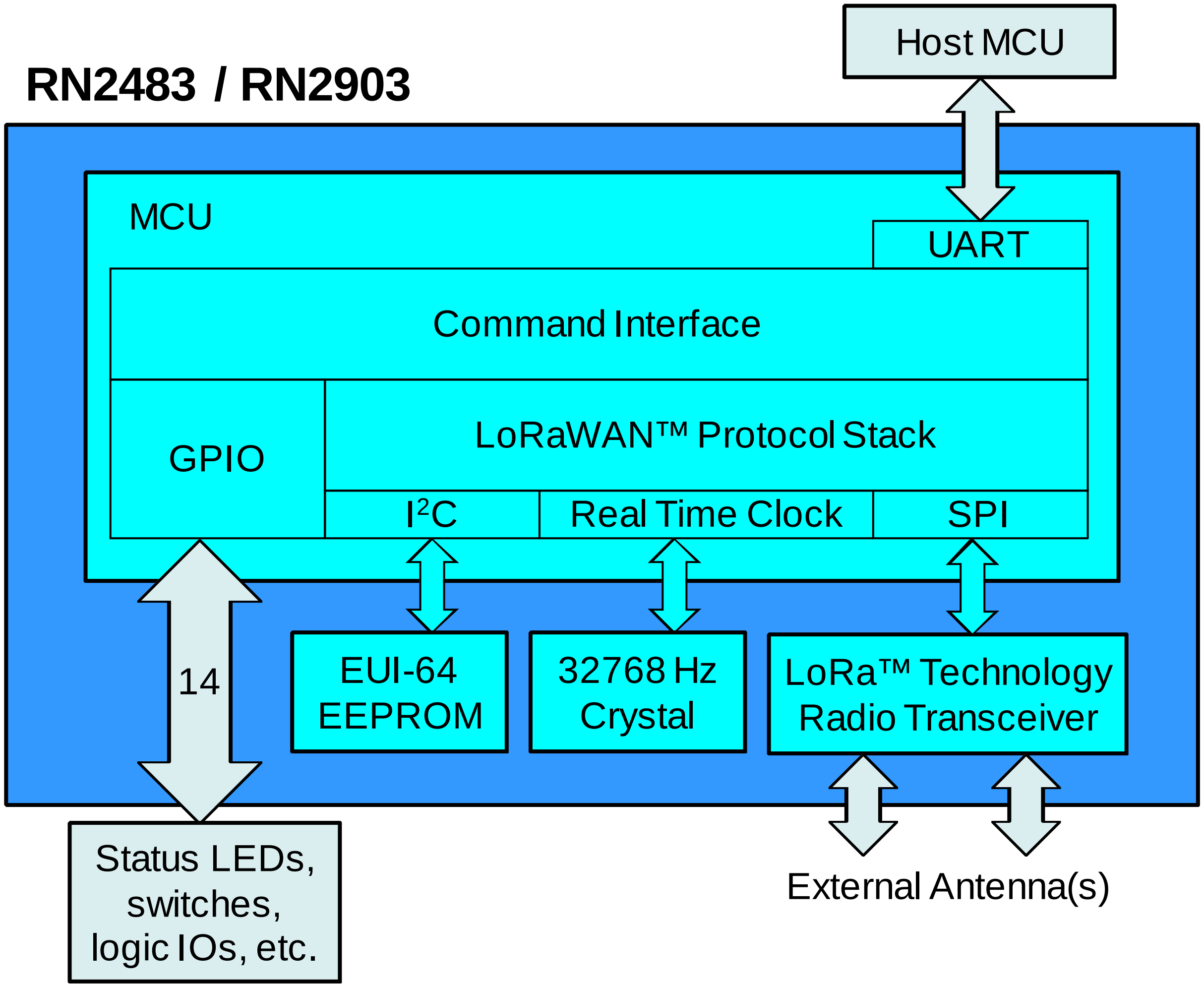
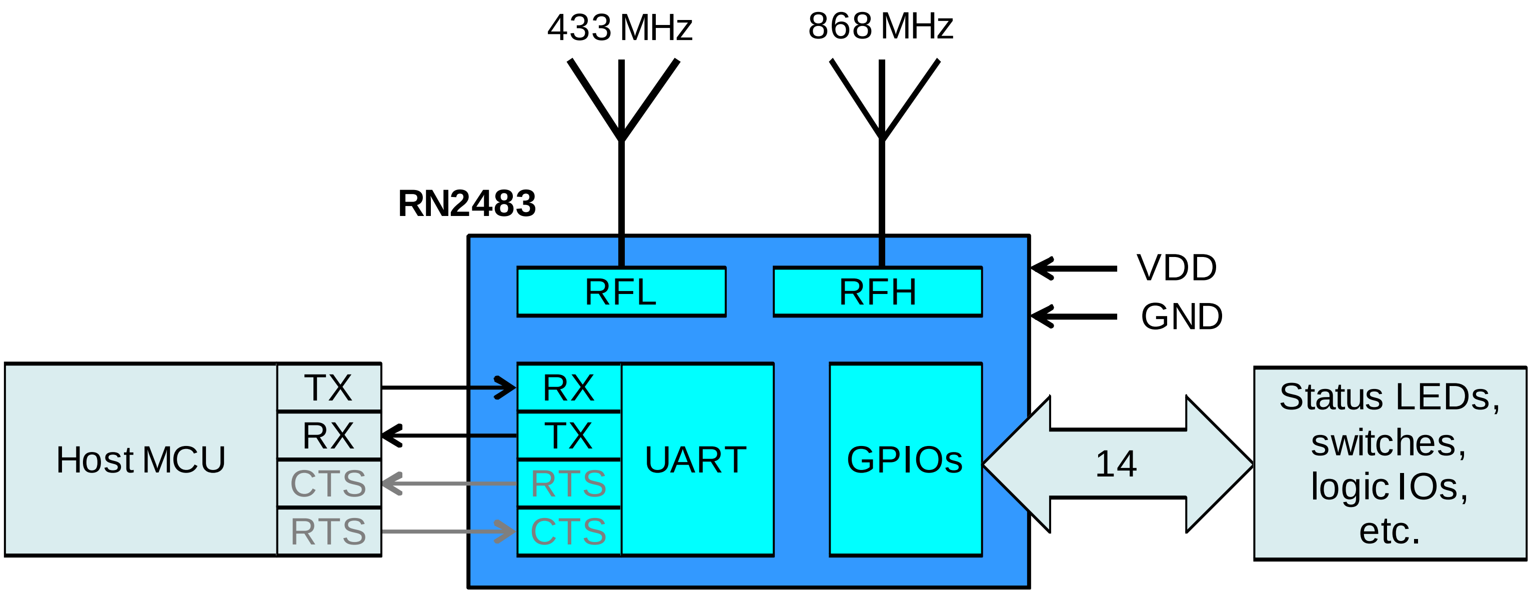
LoRa™ Technology Wireless Modules

Block Diagram



LoRa™ Technology Wireless Modules

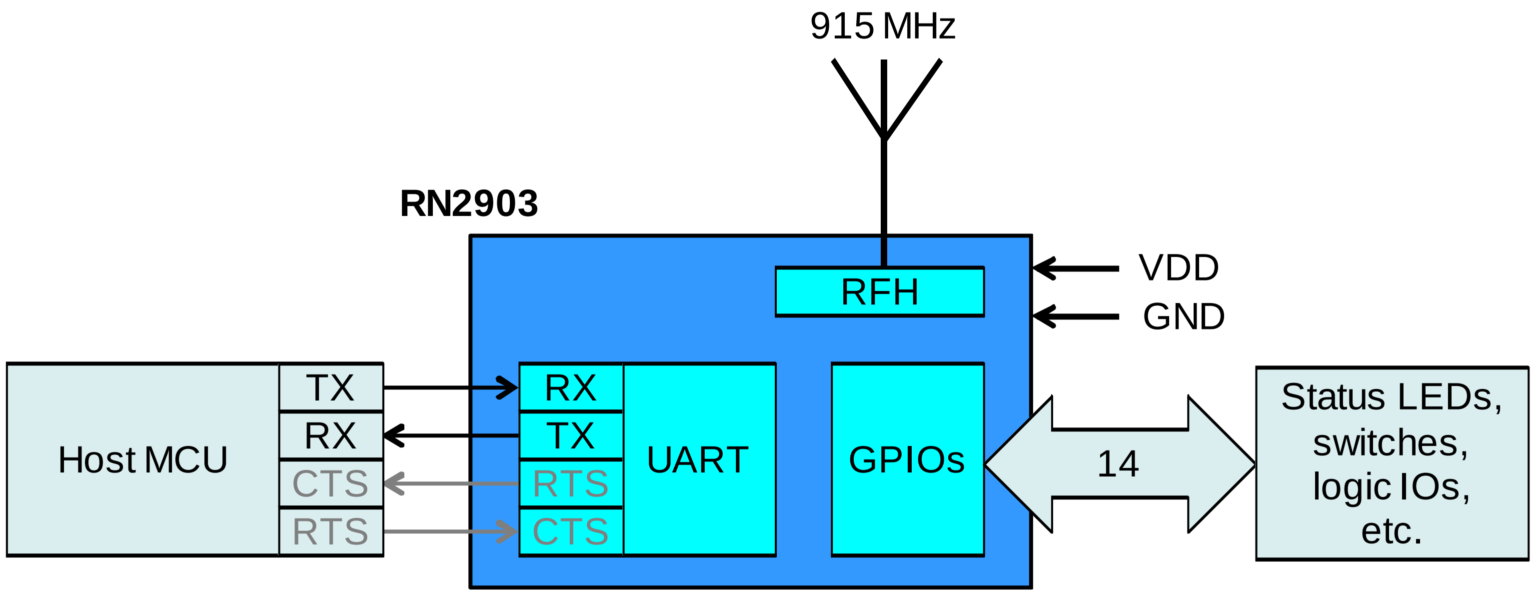
RN2483 LoRa™ Technology Transceiver Module



Note: Optional RTS and CTS control lines will be supported in future firmware releases.

LoRa™ Technology Wireless Modules

RN2903 LoRa™ Technology Transceiver Module



Note: Optional RTS and CTS control lines will be supported in future firmware releases.

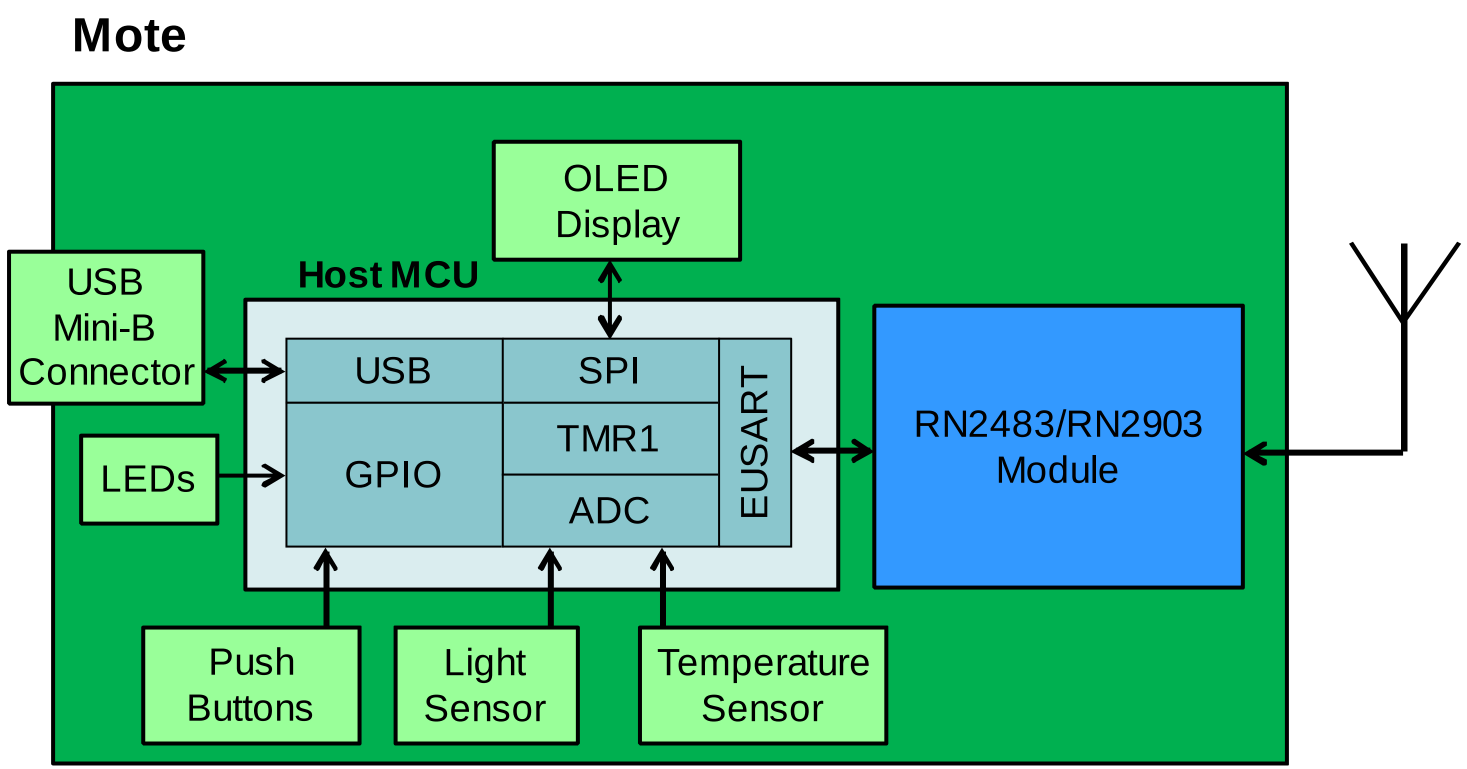
LoRa™ Technology Wireless Modules

Development Tools

RN-2483-MOTE
RN-2903-MOTE

RN-2483-PICTAIL™
RN-2903-PICTAIL

LoRa™ Technology Mote Block Diagram



LoRa™ Technology Wireless Modules

- **Control Interface**
  - UART (TX/RX) communication
  - Default Baud Rate: 57600, 8N1, no flow control
  - Supports Auto Baud Detection

- **Command Interface**
  - Human Readable Text
  - Command Request => Command Reply / Replies
  - Command Request initiated by Host MCU
  - Command Reply initiated by the LoRa Technology Wireless Module

LoRa™ Technology Wireless Modules

- **Command Syntax**
  - Key word(s) issued, followed by optional parameter(s)
  - Separated by **`space`** Character
  - Key Word(s) Case Sensitive
  - Parameter(s) Case Insensitive
  - **`CR+LF`** Command Delimiter

- **Command Request example:**

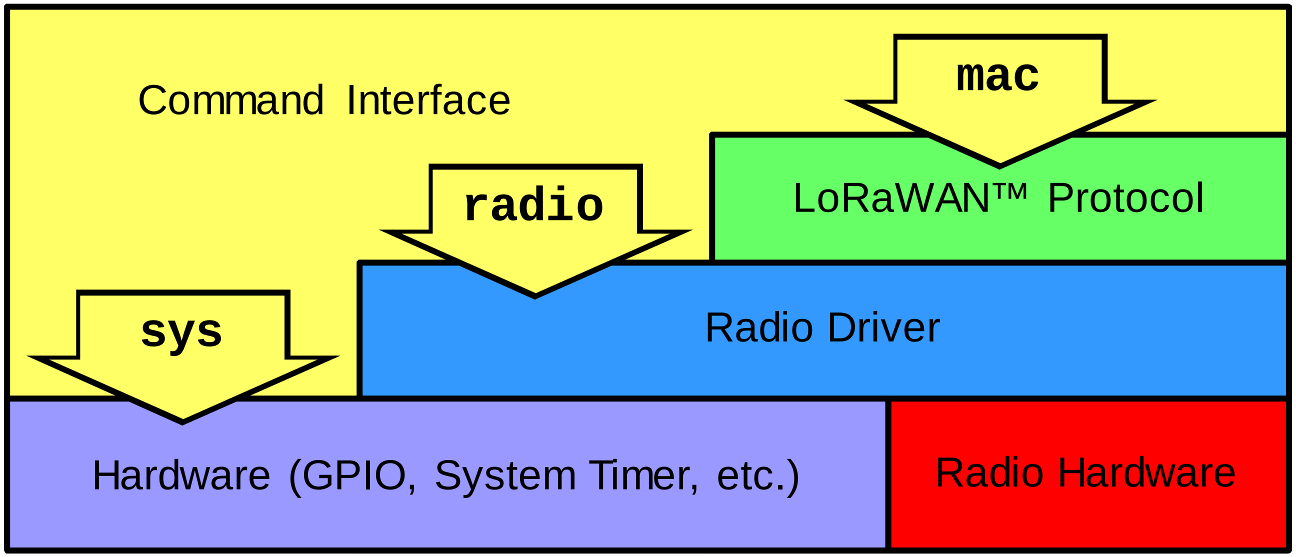
```
< mac set devaddr 048E436e\r\n
```

- **Command Reply example:**

```
> ok\r\n
```

LoRa™ Technology Wireless Modules

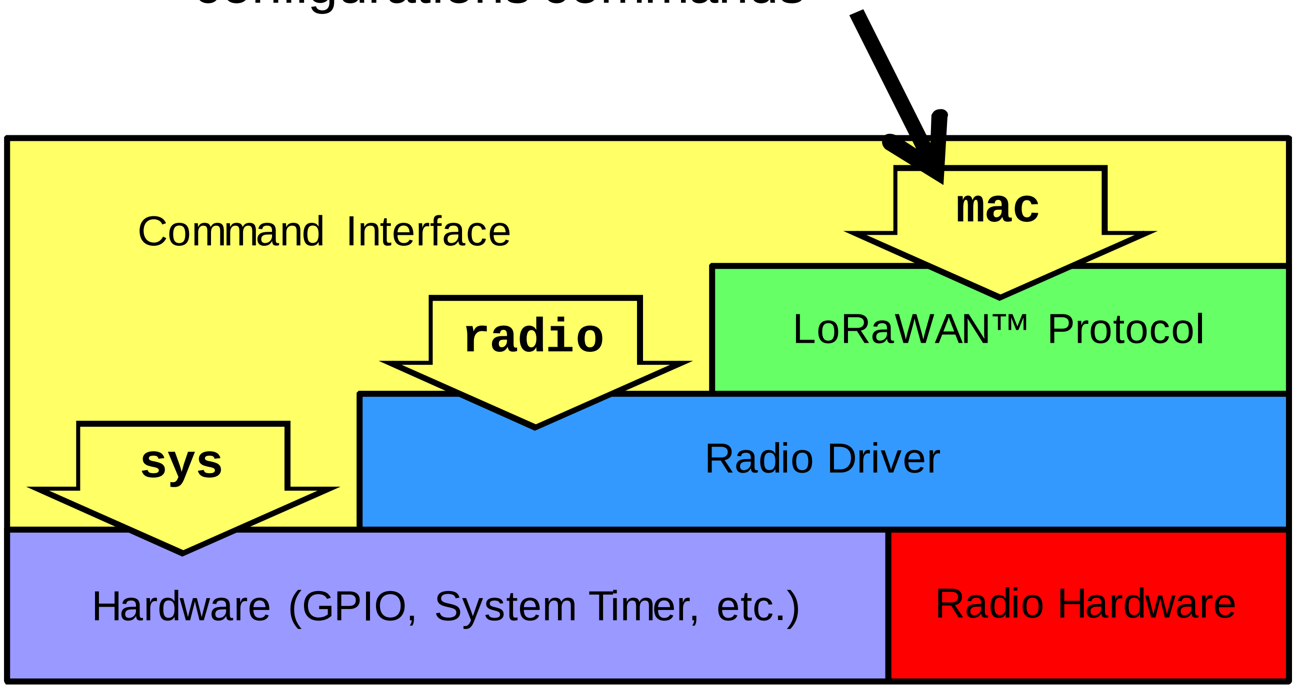
Command Interface



LoRa™ Technology Wireless Modules

Command Interface

`mac` **:** Issues LoRaWAN™ Class A protocol network communication behaviors, actions and configurations commands



LoRa™ Technology Wireless Modules

`mac` **:** Issues LoRaWAN™ Class A protocol network communication behaviors, actions and configurations commands

Parameter	Description
`reset`	Resets the RN2483 module to a specific frequency band.
`tx`	Sends the data string on a specified port number and sets default values for most of the LoRaWAN parameters.
`join`	Informs the RN2483 module to join the configured network.
`save`	Saves LoRaWAN Class A configuration parameters to the user EEPROM.
`forceENABLE`	Enables the RN2483 module after the LoRaWAN network server commanded the end device to become silent immediately.
`pause`	Pauses LoRaWAN stack functionality to allow transceiver (radio) configuration.
`resume`	Restores the LoRaWAN stack functionality.
`set`	Accesses and modifies specific MAC related parameters.
`get`	Reads back current MAC related parameters from the module.

LoRa™ Technology Modules

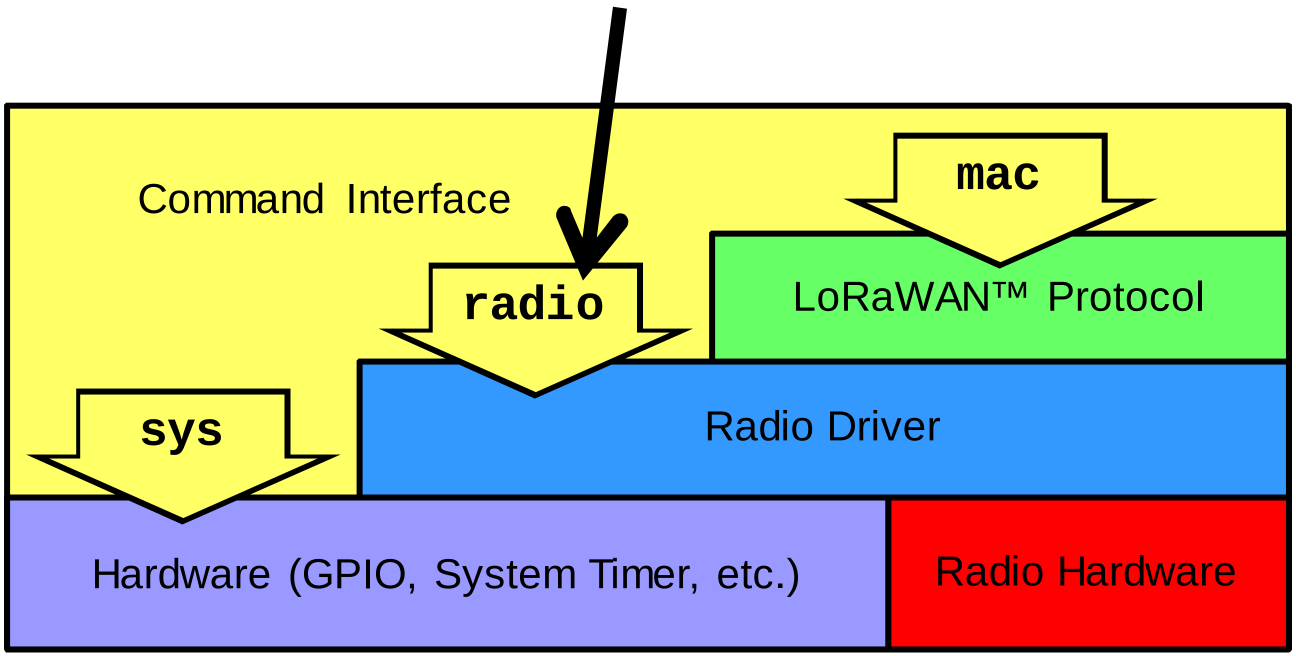
```
< mac set devaddr 048E436E
> ok

< mac join abp
> ok
> accepted
```


LoRa™ Technology Wireless Modules

Command Interface

`radio` : Issues radio specific configurations, directly accessing and updating the transceiver setup



LoRa™ Technology Wireless Modules

`radio`: Issues radio specific configurations, directly accessing and updating the transceiver setup

Parameter	Description
`rx`	This command configures the radio to receive simple radio packets according to prior configuration settings.
`tx`	This command configures a simple radio packet transmission according to prior configuration settings.
`cw`	This command will put the module into a Continuous Wave (cw) Transmission for system tuning or certification use.
`set`	This command allows modification to the radio setting directly. This command allows for the user to change the method of radio operation within module type band limits.
`get`	This command grants the ability to read out radio settings as they are currently configured.

Note 1: The `mac pause` command must be called before any radio transmission or reception, even if no MAC operations have been initiated before.

LoRa™ Technology Wireless Modules

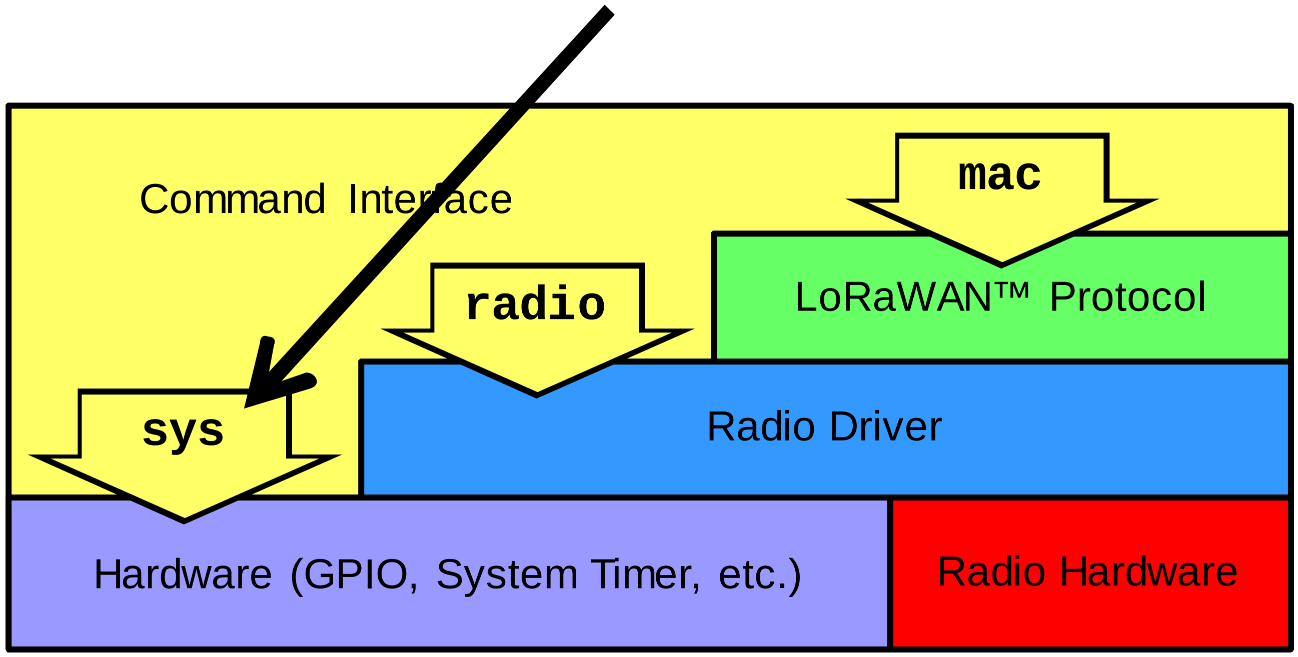
```
< radio cw on
> ok

< radio get mod
> lora
```

LoRa™ Technology Wireless Modules

Command Interface

sys : Issues system level behavior actions, gathers status information on the firmware and hardware version, or accesses the module user EEPROM memory



LoRa™ Technology Wireless Modules

sys : Issues system level behavior actions, gathers status information on the firmware and hardware version, or accesses the module user EEPROM memory

Parameter	Description
sleep	Puts the system in Sleep for a finite number of milliseconds.
reset	Resets and restarts the RN2483 module.
eraseFW	Deletes the current RN2483 module application firmware and prepares it for firmware upgrade. The RN2483 module bootloader is ready to receive new firmware.
factoryRESET	Resets the RN2483 module's configuration data and user EEPPROM to factory default values and restarts the RN2483 module.
set[1]	Sets specified system parameter values.
get[1]	Gets specified system parameter values.

LoRa™ Technology Wireless Modules

```
< sys sleep 5000
> ok

< sys reset
> RN2483 0.9.5 Mar 24 2015 14:17:03
```

Agenda

- Internet of Things (IoT)
- LoRaWAN™ Network Protocol
- LoRa™ Technology Wireless Modules
- **Getting Started with RN2903 Module**
- Hands-on Labs

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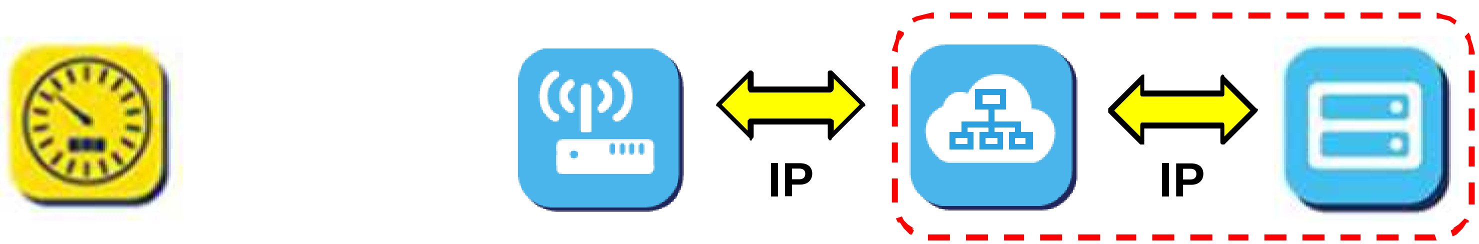
Getting Started with RN2903 Module

End-Device

Gateway | **Network Server** | **Application Server**



Getting Started with RN2903 Module

End-Device with Over-the-Air Activation (OTAA) and uplink data transmission

- **Configuration**
  - `mac set deveui C3D1000030000001`
  - `mac set appeui DEDEAAAA00000030`
  - `mac set appkey ABAAAA9AAAAA7B69545555655555558496`
- **Activation**
  - `mac join otaa`
- **Communication**
  - `mac tx uncnf 16 48454c4c4f`

Getting Started with RN2903 Module

End-Device with Activation By Personalization (ABP) and uplink data transmission

- **Configuration**
  - `mac set devaddr 0482FF05`
  - `mac set nwkskey D95AC917E01FF24B69F4D9F9A0C4EC8D`
  - `mac set appskey 70169735FDC5CD64F3C3ECE938DFCFE2`
- **Activation**
  - `mac join abp`
- **Communication**
  - `mac tx uncnf 16 48454c4c4f`

Agenda

- Internet of Things (IoT)
- LoRaWAN™ Network Protocol
- LoRa™ Technology Wireless Modules
- Getting Started with RN2903 Module
- **Hands-on Labs**

Lab Summary

- **In the following labs you will:**
  - Configure the RN2903
  - Activate the RN2903
  - Communicate with the Application Server
  - Setup RN2903 Mote for stand-alone operation and observe sensor data on Application Server
  - Modify existing host MCU source code to send light sensor data to app server

Lab 1

Lab 2

Using Serial Terminal

Lab 3

Using MPLAB® X IDE

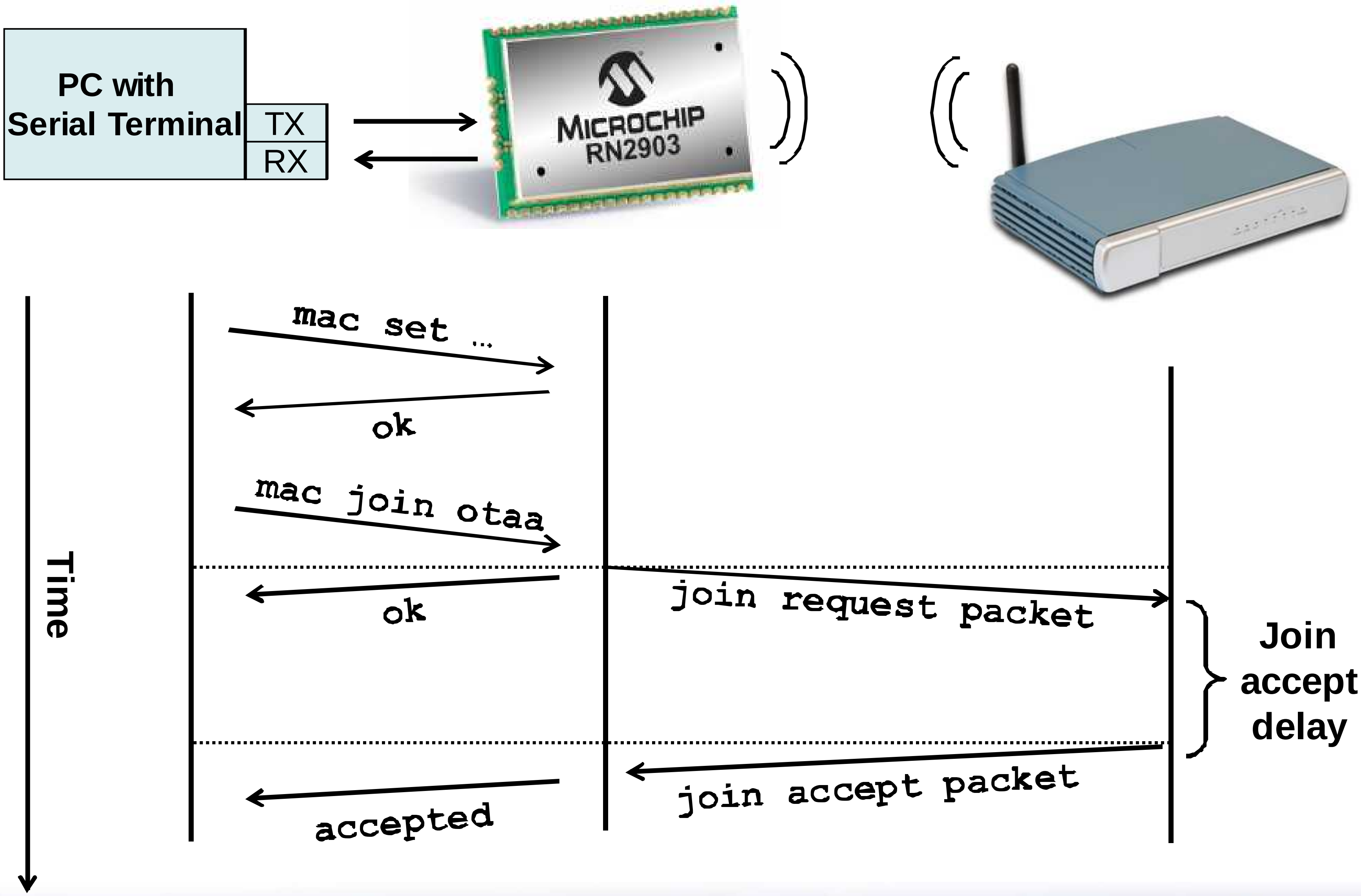
Lab 1:

RN2903 Module configuration and Over-the-Air Activation (OTAA)

Lab 1 Objectives

- **Configure the RN2903 Module**
- **Activate the RN2903 Module using Over-the-Air Activation (OTAA) with the ASCII command set**

Lab 1


PC with
Serial Terminal
TX
RX
MICROCHIP
RN2903
Time
mac set ...
ok
mac join otaa
ok
join request packet
Join
accept
delay
join accept packet
accepted

Lab 1 Summary

- **In this lab we have...**
  - Successfully configured and activated RN2903 Module using the ASCII command set

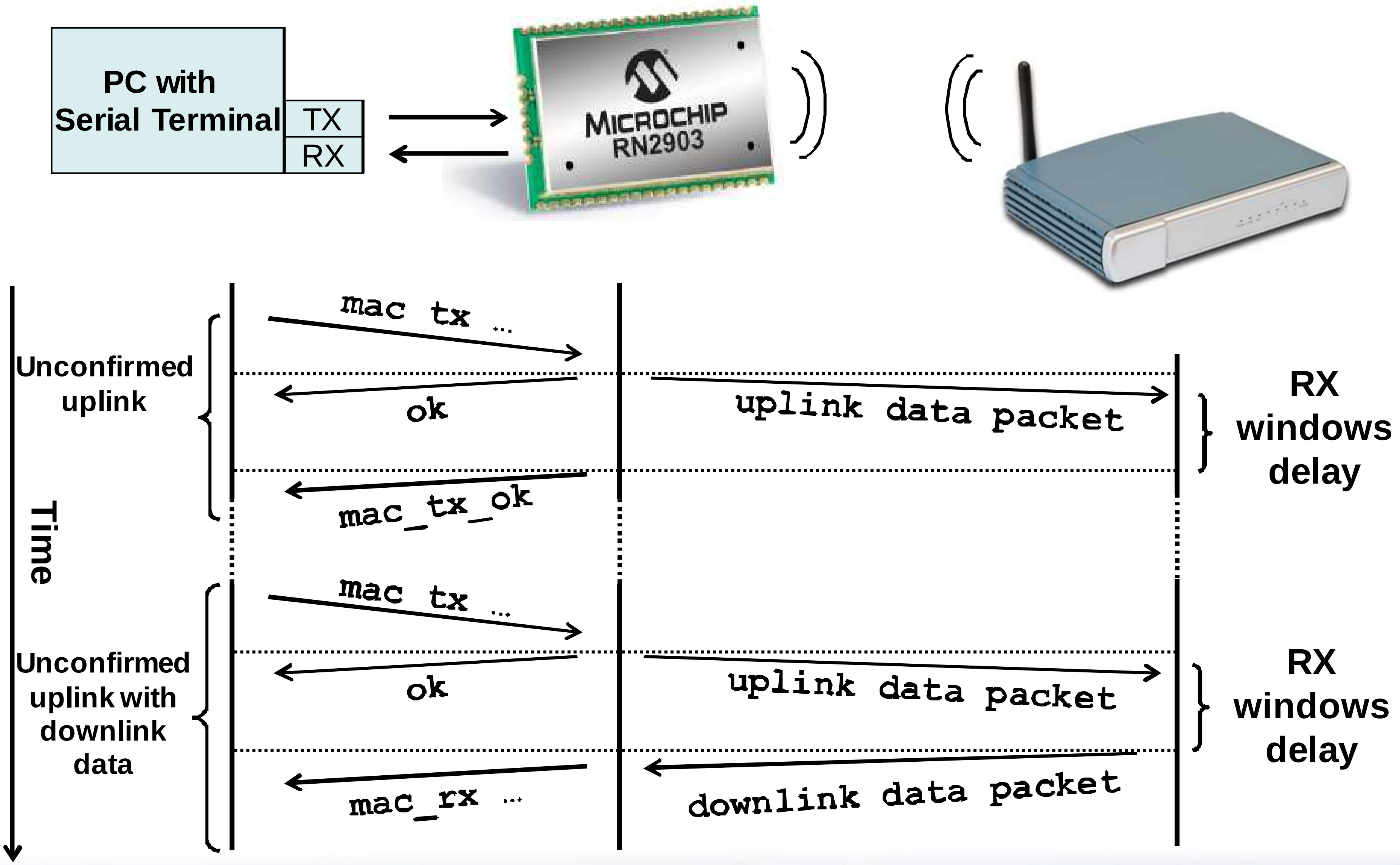
Lab 2:

RN2903 Module bidirectional communication

Lab 2 Objectives

- **Communicate with the Application Server by using RN2903 Module ASCII command set**
  - Uplink and Downlink
  - Confirmed and Unconfirmed

Lab 2


PC with
Serial Terminal
TX
RX
MICROCHIP
RN2903
Time
Unconfirmed uplink
mac tx ...
ok
uplink data packet
mac_tx_ok
RX windows delay
Unconfirmed uplink with downlink data
mac tx ...
ok
uplink data packet
mac_rx ...
downlink data packet
RX windows delay

Lab 2 Summary

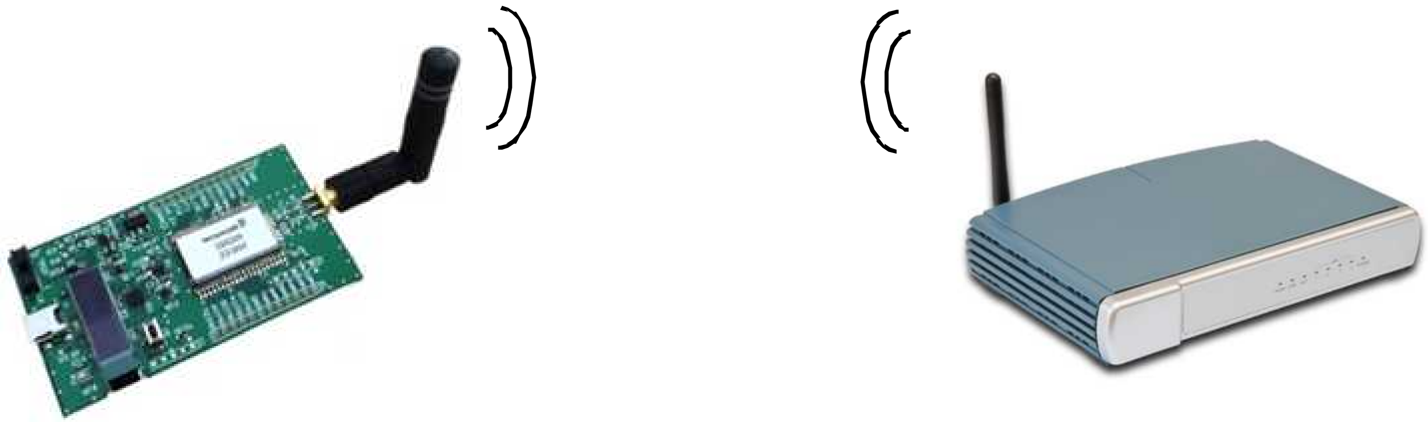
- **In this lab we have...**
  - Successfully transmitted and received data by using the RN2903 Module command set

Lab 3:
Stand-alone end-device application

Lab 3 Objectives

- **Setup RN2903 Mote for stand-alone operation and observe sensor data on Application Server**
- **Modify existing host MCU source code to send light sensor data to Application Server**

Lab 3



Lab 3 Summary

- **In this lab we have...**
  - Successfully operated an end-device application

Summary

- Internet of Things (IoT)
- LoRaWAN™ Network Protocol
- LoRa™ Technology Wireless Modules
- Getting Started with RN2903 Module
- Hands-on Labs

Additional Resources

- **http://lora-alliance.org/**
- **http://www.microchip.com/lora**
- RN2483 Low-Power Long Range LoRa™ Technology Transceiver Module
- RN2483 LoRa™ Technology Module Command Reference User's Guide
- RN2903 Low-Power Long Range LoRa™ Technology Transceiver Module
- RN2903 LoRa™ Technology Module Command Reference User's Guide

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Q & A

Thank You!

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