IoT connectivity made easier
STM32 MCUs & LoRa®

October, 2019
1. What is IoT?
2. Communication technologies – Overview
3. LPWAN
4. LoRa® and LoRa Alliance
5. LoRa® technology modulation and LoRaWAN™ network protocol
6. STM32 boosting LoRa® (Roadmap, demos, competition, and schedule)
What is IoT?

While M2M networks connect machines in closed systems, IoT enhances the exiting networks through an intelligent cloud.
IoT use cases

• Consumer
  - Services
    • Health tracking
    • Food lifestyle
    • Weight control
    • FW update …

• Industrial
  - Ethernet
  - Network Server
  - Gateway
  - 3G / 4G / Ethernet
  - LoRa®
  - Application Server
  - Admin control

Wi-Fi

BLE

Wi-Fi

4G

Wi-Fi

4G

Wi-Fi

4G

Wi-Fi

4G
Driving the Next Semiconductor Growth

45 billion connected devices are expected by 2023

Source: ABI Research
ISM worldwide regulation

Output Power vs Duty Cycle

<table>
<thead>
<tr>
<th>Countries</th>
<th>Frequency band review</th>
<th>Max. output power</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>868 MHz</td>
<td>14 dBm</td>
</tr>
<tr>
<td>USA</td>
<td>915 MHz</td>
<td>20 dBm</td>
</tr>
<tr>
<td>Korea</td>
<td>900 MHz</td>
<td>14 dBm</td>
</tr>
<tr>
<td>Japan</td>
<td>920 MHz</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>862 to 875 MHz</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>868 MHz</td>
<td></td>
</tr>
<tr>
<td>Vietnam</td>
<td>920 to 925 MHz</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>865 to 867 MHz</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>922 MHz</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>920 to 925 MHz</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>922 MHz</td>
<td></td>
</tr>
<tr>
<td>ANZ</td>
<td>915 to 928 MHz</td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td>920 to 925 MHz</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>470 to 510 MHz</td>
<td>17 dBm</td>
</tr>
</tbody>
</table>
Sub-GHz and IoT

The 2 solutions to address the IoT over LPWAN

- **Sub-GHz is a fragmented** segment with many dedicated protocols and solutions to address different needs
- An initiative of **standardization** is on-going with LTE, LoRa®, Sigfox …
- **Standardization** will be an **enabler** for **industrial** applications (meters), **Smart Cities**
What is LoRa®?

1. A Sub-GHz wireless technology enabling low data rate communication over long distances
2. Targeting M2M and Internet of Things, IoT applications
3. LoRa® technology provides a WAN capability, using a MAC protocol named LoRaWAN™

**Long range**
- Greater than cellular
- Deep indoor coverage
- Star topology

**Max lifetime**
- Low power optimized
- **10- to 20-year** lifetime
- >10x vs cellular M2M

**Multi-usage**
- High capacity
- Multi-tenant
- Public network

**Low cost**
- Minimal infrastructure
- Low-cost end-node
- Open software

**True location**
- Indoor and outdoor
- Accurate

**Bidirectional**
- Bidirectional
- Scalable capacity
- Broadcast

**Global mobility**
- True mobility
- Seamless
- Roaming

**Security**
- Unique ID
- Application
- Network

Source: Semtech
The Internet of Things era is now

The LoRa® Alliance is an open, non-profit association of members. Its mission is to ensure that LoRaWAN™ is THE open global standard for SECURE, CARRIER-GRADE IoT LPWAN connectivity.

Visit www.lora-alliance.org
The LoRa® Alliance

NEW MEMBERS IN 2018:
+71

2018 SPECIFICATION DOWNLOADS:
>60,000
Up 650% over 2017

2018 CERTIFIED PRODUCT GROWTH:
+106% increase over 2017

REGIONAL SPECIFICATIONS:
Two new regional specs added in 2018 (new regions where LoRaWAN™ can be used)

ADDED RU864-870 CHANNEL PLAN TO SUPPORT RUSSIA

ADDED RECOMMENDED CHANNEL PLANS FOR LATIN AMERICA

2018 LORAWAN™ NETWORK OPERATORS ADDED:
+38
>100 total = 61% increase over 2017

Source: LoRa Alliance
The LoRa® Network Deployment

- 100+ Countries with LoRaWAN deployments

January 2019

LoRa® Alliance is not responsible for the accuracy of information presented

- 100 Network Operators
- 9 Operators are LoRa-Alliance members
- LoRa-Alliance: > 460 members

Source: LoRa Alliance
LoRa® technology modulation

- LoRa® technology is based on the Spread Spectrum Technology
- It is a Chirped Frequency Modulation
# LoRaWAN™ device classes

3 classes to cover all use cases

<table>
<thead>
<tr>
<th>Class name</th>
<th>Intended usage</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (&quot;all&quot;)</td>
<td><strong>Battery powered sensors</strong> (or actuators with no latency constraint) &lt;br&gt;Most energy efficient communication class. &lt;br&gt;Must be supported by all devices.</td>
<td><strong>Mainly uplink with two potential downlink slots after each uplink</strong></td>
</tr>
<tr>
<td>B (&quot;beacon&quot;)</td>
<td><strong>Battery powered actuators</strong> &lt;br&gt;Energy efficient communication class for latency controlled downlink. &lt;br&gt;Based on slotted communication synchronized with a network beacon.</td>
<td><strong>Programmed downlink slots to allow control within certain latency limits</strong></td>
</tr>
<tr>
<td>C (&quot;continuous&quot;)</td>
<td><strong>Main powered actuators</strong> &lt;br&gt;Devices which can afford to listen continuously. &lt;br&gt;No latency for downlink communication.</td>
<td><strong>Lowest latency command and control for less power critical devices</strong></td>
</tr>
</tbody>
</table>

Source: Semtech
LoRaWAN™ device classes

Class A – Bidirectional Communication

Receiver Initiated Transmission strategy (RIT)

For every uplink, there are two possible downlink slots. Downlink is possible only at these times.

Network Server selects:
(1) Gateway for downlink
(2) Which downlink slot to use
LoRaWAN™ device classes

Class B – Bidirectional Communication

There are pre-programmed downlink slots. Downlink is possible at any of these times. Application dependent.

Network Server selects:
1) Gateway for downlink
2) Which downlink slot to use

Pre-programmed RX slots synchronized by gateway beacons
LoRa® network protocol

Network topology overview

- Devices
- Gateways
- Network Servers
- Application Servers

- Long-range Sub-GHz LoRa®
- 3G / 4G / Ethernet (IP)
- Ethernet (IP)
LoRa® network protocol

Solution providers

Device

SILICON
SEMTECH
STI

MODULES
mPura
RisingHF

DEVICES
Bosch
Mueller Systems

GATEWAY
CISCO

NETWORK SERVER
IBM

APPLICATION SERVER
senet

*Powered by STM32*
LoRaWAN™ - Security

A native 128-bit AES security network protocol

• Device Address (DevAddr) is a 32-bit identifier
  • Unique within the network
  • Available in each data frame and shared between end-device, N.S and A.S

• Network Session Key (NwkSKey) is a 128-bit AES encryption key
  • Unique per end-device and shared between end-device and N.S
  • It allows message integrity communication between end-device and N.S

• Application Session Key (AppSKey) is a 128-bit AES encryption key
  • Unique per end-device and shared between end-device and A.S
  • It is used to encrypt / decrypt A.S server messages to the end-device

• To increase end-device authentication and security, a secure element can be added to the device
ST and Semtech LoRa® Agreement

• Semtech Corporation and STMicroelectronics announce an agreement on Semtech's Lora® long-range wireless RF technology

• Intended to boost STM32 MCUs with LoRa® technology to target internet of things deployments by mobile network operators and large-scale private networks

→ STMicroelectronics and Semtech partnership Press Release
LoRa® powered by STM32™

www.st.com/stm32-lrwan

Flexible design architecture
More than 1000 STM8/STM32 part numbers

USI® Module
AT command

STM32

LoRa®

Murata® Module
All-in-one Open

All-in-one LPWAN

* I-CUBE-LRWAN STM32 Embedded Software (LoRaWAN™ stack) is compatible with Semtech SX127x & SX126x transceivers
Open Murata® LoRa® module

Powered by STM32L0

STM32L072CZY6TR

- 192 Kbytes of Flash memory
- 20 Kbytes of RAM
- 6 Kbytes of EEPROM

Open LPWAN Module

+14dBm
+20dBm

Sigfox ready

XTAL 32.768Hz

STSAFE Optional

RFSW8001

Matching Network

 SX1276 (137 to 1020 MHz) 

Antenna

VDD_RF, VDD_MCU, VDD_USB

ADC 1-4

MCU_RST, VREF+, BOOTO, LSE

SPI1

RESET

DIO 0-4

SPI2

LPTM1, I2C1, UART1, USB, MCO

Debug_1, Debug_2, TOXO_out, Debug_3, Debug_4, SWIO/CLK, WKUP1, DAC1

GND
USI® LoRa® module - AT command set

**Powered by STM32L0**

STM32L052T8Y6TR
- 64 Kbytes of Flash memory
- 8 Kbytes of RAM
- 2 Kbytes of EEPROM

**SX1272**
(860 to 1020 MHz)

- XTAL – 32MHz
- RFI_HF
- VR_PA
- PABOOST
- SPI1
- RESET
- DIO 0-4

- VDD_RF
- VDD_MCU
- VDDA
- ADC 1-3
- MCU_RST
- BOOT0
- WKUP1
- SWDIO
- SWCLK
- I2C1
- UART1
- LPTM1

**XTAL – 32.768 kHz**

Optional on open module version

Cost optimized
RisingHF® LoRa® module - AT command set

Powered by STM32L0

STM32L07
- 192 Kbytes of Flash memory
- 20 Kbytes of RAM
- 6 Kbytes of EEPROM

SX1278
(434 / 470 MHz)

Matching Network
- RFI_HF
- VR_PA
- PA_BOOST

XTAL – 32MHz

XTAL – 32.768 kHz

Up to 8 IOs

Configurable Output
Let’s get started

With a wide and existing ecosystem

(Click on the icon or link)

Hardware tools

- Discovery kit
  ST and Murata®
  P/N: B-L072Z-LRWAN1

- Expansion board
  ST and USI®
  P/N: I-NUCLEO-LRWAN1

- LoRa Starter Pack
  ST, USI® & RinsingHF®
  P/N: P-NUCLEO-LRWAN2
  P/N: P-NUCLEO-LRWAN3

Dev tools

- STM32CubeMX
- ST-Link Utility
- Partners IDE

LoRaWAN™ stack

- System Workbench for STM32
- I-CUBE-LRWAN
Hardware tools

B-L072Z-LRWAN1: Murata® STM32™ and LoRa® Discovery kit

- **Integrated ST-Link/V2-1**: mass storage device flash programming
- **2 push buttons, 2 color LEDs, Jumper settings**
- **Arduino™ extension connectors**: easy access to add-ons
- **Murata® module**
- **SMA Antenna connector**
- **Flexible board power supply**: through USB or external source
I-NUCLEO-LRWAN1: USI® STM32™ Nucleo expansion board for LoRa®

- Pressure, humidity, temperature, and 3D MEMS
- Arduino™ extension connector
- SMA antenna connector
- USI® module
Hardware tools

P-NUCLEO-LRWAN 2 & 3: LoRaWAN™ Starter Pack

Gateway & end-node shields on Arduino™ extension connectors

SMA antenna connector

USI® module

RisingHF® module

Pressure, humidity, temperature, 3D MEMS

Gateway

End-Node

Pack P-NUCLEO-LRWAN2
EU/US/APAC (868/915/923 MHz)

Pack P-NUCLEO-LRWAN3
CN (433/470 MHz)
LoRa® technology powered by STM32

The widest ecosystem-ever now available!

- Best-in-class in ultra-low-power and Long Range
- Widest HW and SW ecosystem
- Easy to use

LoRa® Gateway STM32F7 based

B-L072Z-LRWAN1
LPWAN Discovery kit

I-NUCLEO-LRWAN1
LoRa® + Mems Shield

STANDALONE SOLUTIONS
LoRa® Nucleo Packs
Releasing your creativity with the STM32

http://www.st.com/stm32-Irwan