IoT connectivity made easier
STM32 MCUs & LoRa®
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.

Cloud

- Real-time analytics
- Managed APIs
- Internet scale awareness

**Internet of Things**

Things

Human (us)
IoT use cases

• Consumer

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

  Wi-Fi
  BLE
  Wi-Fi
  4G

• Industrial

  Ethernet
  Application Server
  Admin control

  Network Server
  3G / 4G / Ethernet
  Gateway
  LoRa®
IoT - Driving the next semiconductor growth

45 billion connected devices are expected by 2020

Source: ABI, ST
Communication Technologies - Overview

- **Short Range**
  - Wi-Fi / BT
  - Bluetooth
  - LoRa
  - Sub-GHz
  - 2.4 GHz

- **Cellular**
  - GSM
  - 4G LTE-M
  - 4G LTE-NB-IOT
  - 5G
  - 850/1900 MHz
  - 900/1800 MHz

- **LPWAN**
  - Sigfox
  - LoWPAN

**Baud rate**
- Mbps
- Kbps
- bps

**Range**
- 10 m
- 100 m
- 1 km
- 10 km
## 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>20 dBm</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 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**

The 2 solutions to address the IoT over LPWAN
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

2017 * MEMBER GROWTH: +193
58% increase over 2016

2017 CERTIFIED PRODUCT GROWTH: +176%
increase over 2016

2017 LoRaWAN™ NETWORKS ADDED: +31
100% increase over 2016

2017 SPECIFICATION DOWNLOADS: 8,024

REGIONAL SPECIFICATIONS EXPANSION: NEW MARKETS
INDIA
Adding support for Australia’s recent regulatory change
to its ISM band, expanded Korea band

Source: LoRa Alliance

* More than 480 members in July 2018
The LoRa® Network Deployment

- **80** Network Operators
- Operating in **46** countries
- **54** Alliance Member Operators
- Near **100** Countries with LoRaWAN deployment

Legend:
- Alliance Member Public Networks
- Other LoRaWAN deployment

April 2018

LoRa Alliance is not responsible for the accuracy of information presented
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></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> (“all”)</td>
<td><strong>Battery powered sensors</strong> (or actuators with no latency constraint)</td>
<td><strong>Mainly uplink with two potential downlink slots after each uplink</strong></td>
</tr>
<tr>
<td></td>
<td>Most energy efficient communication class. Must be supported by all devices.</td>
<td></td>
</tr>
<tr>
<td><strong>B</strong> (“beacon”)</td>
<td><strong>Battery powered actuators</strong></td>
<td><strong>Programmed downlink slots to allow control within certain latency limits</strong></td>
</tr>
<tr>
<td></td>
<td>Energy efficient communication class for latency controlled downlink.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Based on slotted communication synchronized with a network beacon.</td>
<td></td>
</tr>
<tr>
<td><strong>C</strong> (“continuous”)</td>
<td><strong>Main powered actuators</strong></td>
<td><strong>Lowest latency command and control for less power critical devices</strong></td>
</tr>
<tr>
<td></td>
<td>Devices that can afford to listen continuously. No latency for downlink communication.</td>
<td></td>
</tr>
</tbody>
</table>
LoRaWAN™ device classes

Class A – Bidirectional Communication

*Receiver Initiated Transmission strategy (RIT)*

- Uplink Received by multiple gateways
- 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

**END DEVICES**

- End Devices transmit at any time (ALOHA)
- Programmed wait 1
- Rx slot 1

**NETWORK**

- Uplink packet
- Rx slot 2
- Programmed wait 2
- Downlink 1
- Downlink 2

Source: Semtech
LoRaWAN™ device classes

Class B – Bidirectional Communication

Coordinated Sampled Listening (CSL)

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

Source: Semtech
LoRa® network protocol

Network topology overview

- **Devices**
  - D1
  - D2
  - D3
  - Dx

- **Gateways**
  - Long-range Sub-GHz LoRa®
  - 3G / 4G / Ethernet (IP)

- **Network Servers**
  - Ethernet (IP)

- **Application Servers**
LoRa® network protocol

Solution providers

Device

SILICON
- SEMTECH
- STM

MODULES
- MURATA
- FOXCONN
- MULTITECH
- NEMESIS

DEVICES
- BOSCH
- MUELLER SYSTEMS
- SCHNEIDER ELECTRIC
- HOME RIDER SYSTEMS

GATEWAY
- CISCO
- SAGECOM
- KERLINK
- RISINGHF

NETWORK SERVER
- IBM
- HP
- ORBIWISE
- ACTILITY
- STREAM
- SAGEMCOM
- SENET

APPLICATION SERVER
- SENET
- LIBELIUM
- WIPRO
- DIGI MONDO
- MY DEVICES

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.

↓ ST and Semtech partnership press release
LoRa® powered by STM32™

www.st.com/stm32-lrwan

USI® Module
AT command

Cost-optimized solution

Flexible design architecture
More than 1000 STM8/STM32 part numbers

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

SX1276
(137 to 1020 MHz)

+14dBm
+20dBm

Sigfox ready
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 – 32 MHz

XTAL – 32.768 kHz

Optional on open module version
Let’s get started

With a wide and existing ecosystem

Hardware tools

- **Nucleo pack**
  - ST and Semtech
  - P/N: P-NUCLEO-LRWAN1

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

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

Dev tools

- **STM32CubeMX**
- **ST-Link Utility**
- **Partners IDE**
- **System Workbench for STM32**

LoRaWAN™ stack

- **arm KEIL arm MBED Enabled**
- **I-CUBE-LRWAN**
New hardware tool

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

- Flexible board power supply: through USB or external source
- 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

arm MBED Enabled
New hardware tool

I-NUCEO-LRWAN1: USI® STM32™ Nucleo expansion board for LoRa®

- SMA antenna connector
- Pressure, humidity, temperature, and 3D MEMS
- Arduino™ extension connector
- USI® module
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® + Mem Shield

P-NUCLEO-LRWAN1
LoRa® Nucleo Pack
Release your creativity
with the STM32

www.st.com/stm32-Lrwan