

Getting Started in LoRaWAN Hands On

Class 5: Testing Our LoRaWAN design

December 1, 2017

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This Week's Agenda

11/27 An Overview of Low-Power IoT Technologies

11/28 Introduction to LoRa and LoRaWAN

11/29 The design of a LoRaWAN node, hands-on

11/30 No Service? No Problem!

Building your own LoRaWAN server

12/1 Testing Our LoRaWAN design

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12/1 **Testing Our LoRaWAN design**

More On Device Classes

Device classes

Flexibility in power conservation versus fast network initiated transmission

Class A 🤤

Device initiated communication

Devices are typically in deep sleep and send messages on intervals and/or events

Only after uplink transmission, there is a receive window for downlink messages

Best for most sensor applications and battery conservation

Class B 🕒

Time synchronized communication

The network broadcasts beacons for devices to sync time

In so-called ping slots, devices wake up and the network may send downlink messages

Best for most downlink intensive applications

Class C ⚡

Network initiated communication

The devices are continuously listening, often temporarily or on power supply

The network can send downlink message at any given time

Best for downlink intensive applications that require low latencies

Question 1 – What is “ALOHA” networking and where did the name come from?

Back To Our Device

The screenshot shows the LORION web interface. The top navigation bar includes 'Dashboard > Applications > SampleApp' and 'Community Network c.j.lord@ieee.org'. The left sidebar contains a menu with items: 'back to applications', 'SampleApp BE-7E-03-25', 'Output', 'Join Server', 'Security', 'Log', 'Downloads', 'Devices', 'Device guides', 'Enroll device', 'Import ABP', 'Import OTAA', and 'Bulk import'. The main content area is titled 'Devices' and features four action buttons: 'Generate new device', 'Enroll new device', 'Import existing OTAA', and 'Import existing ABP'. Below these buttons, a section titled 'Devices in this application [0]' contains a table with columns: RSSI, SNR, DSNR, SF, BAT, ADR, Class, Application EUI, Device EUI, Devaddr, Last data, SeqNo, and SeqDn. The 'Device EUI' and 'Devaddr' columns have search input fields labeled 'search EUIs' and 'search DevAddr' respectively.

New Device Generated

“Random” EUI

Devices

Generate new device Enroll new device Import existing OTAA Import existing ABP

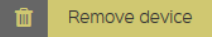
Devices in this application [0]

RSSI ↕	SNR ↕	DSNR	SF ↕	BAT	ADR	Class ↕	Application EUI ↕	Device EUI ^	Devaddr ↕	Last data ↕	SeqNo ↕	SeqDn ↕
				N/A	ADR	A	BE-7E-00-00-00-03-25	BE-7A-00-00-00-00-03-BB	00-B3-B6-AA	never	-1	0

LORIIOT Generates ADDR, Keys

Device BE-7A-00-00-00-03-BB

DevEUI BE7A0000000003BB big endian (use by default)
BB03000000007ABE little endian (for LoRaWAN non-compliant devices)

 Remove device

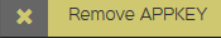
AppEUI BE7E000000000325 big endian (use by default)
2503000000007EBE little endian (for LoRaWAN non-compliant devices)

DevAddr 00B3B6AA big endian (use by default)
AAB6B300 little endian (for LoRaWAN non-compliant devices)

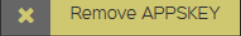
NOTE: Use big endian representation by default. Only use the little endian value when suspecting problems.

See the [device guides](#) for personalized, device specific configuration commands

LoRaWAN AES128 Keys

AppKey ...A483920C  Remove APPKEY
Application Key (Device Key) If you want to enable over-the-air join, add or derive the device's application key.

NwkSKey ...68E18E99
Network Session Key

AppSKey ...D9D56276  Remove APPSKEY
Application Session Key

NOTE: When copy-pasting an AES128 key, use it as it is. It is a cryptographic key without the notion of endianness

See the [device guides](#) for personalized, device specific configuration commands

Presented by:

Original Contents of configuration.h

```
#define OVER_THE_AIR_ACTIVATION          1
#define LORAWAN_PUBLIC_NETWORK          true
#define STATIC_DEVICE_EUI                0
#define LORAWAN_DEVICE_EUI              { 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01 }

#define LORAWAN_APPLICATION_EUI         { 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01 }
#define LORAWAN_APPLICATION_KEY         { 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7,
0x15, 0x88, 0x09, 0xCF, 0x4F, 0x3C }
#define LORAWAN_NETWORK_ID              ( uint32_t )0
#define STATIC_DEVICE_ADDRESS            0

#define LORAWAN_DEVICE_ADDRESS          ( uint32_t )0x0100000a
#define LORAWAN_NWKSKEY                  { 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7,
0x15, 0x88, 0x09, 0xCF, 0x4F, 0x3C }
#define LORAWAN_APPSKEY                  { 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7,
0x15, 0x88, 0x09, 0xCF, 0x4F, 0x3C }
```


Values from LORIIOT

Semtech LoRaMAC-node | ABP Setup

Setup for device with EUI BE-7A-00-00-00-00-03-BB

```
#define LORAWAN_PUBLIC_NETWORK true
#define LORAWAN_DEVICE_EUI { 0xBE,0x7A,0x00,0x00,0x00,0x00,0x03,0xBB }
#define LORAWAN_DEVICE_ADDRESS (uint32_t) 0x00B3B6AA
#define LORAWAN_NWKSKEY { 0x6F,0x4E,0x52,0x76,0x26,0x43,0x63,0x99,0xC7,0xC2,0x52,0x99,0x68,0xE1,0x00,0x00 }
#define LORAWAN_APPSKEY { 0x3A,0x18,0x0A,0x33,0xFC,0xDF,0x2F,0x9B,0xCB,0xCB,0x7D,0x09,0xD9,0xD5,0x00,0x00 }
```

Semtech LoRaMAC-node | OTAA Setup

Setup for device with EUI BE-7A-00-00-00-00-03-BB

```
#define LORAWAN_DEVICE_EUI { 0xBE,0x7A,0x00,0x00,0x00,0x00,0x03,0xBB }
#define LORAWAN_APPLICATION_EUI { APPEUI not enabled for this application }
#define LORAWAN_APPLICATION_KEY { 0x0C,0x06,0x57,0x08,0xBD,0xEE,0x0A,0x49,0x35,0xD3,0xB9,0xE6,0x00,0x00,0x00,0x00 }
```

Final configuration.h

```

/*!
 * Device address on the network (big endian)
 *
 * \remark see STATIC_DEVICE_ADDRESS comments
 */
#define LORAWAN_DEVICE_ADDRESS          ( uint32_t )0x0100000a

/*!
 * AES encryption/decryption cipher network session key
 */
#define LORAWAN_NWKSKEY                 { 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7, 0x15, 0x88, 0x09, 0xCF }

/*!
 * AES encryption/decryption cipher application session key
 */
#define LORAWAN_APPSKEY                 { 0x2B, 0x7E, 0x15, 0x16, 0x28, 0xAE, 0xD2, 0xA6, 0xAB, 0xF7, 0x15, 0x88, 0x09, 0xCF }

#endif /* OVER_THE_AIR_ACTIVATION == 0 */

//Setup for device with EUI BE-7A-00-00-00-00-03-BB

#define LORAWAN_PUBLIC_NETWORK true
#define LORAWAN_DEVICE_EUI { 0xBE,0x7A,0x00,0x00,0x00,0x00,0x03,0xBB }
#define LORAWAN_DEVICE_ADDRESS (uint32_t) 0x00B3B6AA
#define LORAWAN_NWKSKEY { 0x6F,0x4E,0x52,0x76,0x26,0x43,0x63,0x99,0xC7,0xC2,0x52,0x99,0x68,0xE1,0x8E,0x99 }
#define LORAWAN_APPSKEY { 0x3A,0x18,0x0A,0x33,0xFC,0xDF,0x2F,0x9B,0xCB,0xCB,0x7D,0x09,0xD9,0xD5,0x62,0x76 }

//Setup for device with EUI BE-7A-00-00-00-00-03-BB

#define LORAWAN_DEVICE_EUI { 0xBE,0x7A,0x00,0x00,0x00,0x00,0x03,0xBB }
//#define LORAWAN_APPLICATION_EUI { APPEUI not enabled for this application }
#define LORAWAN_APPLICATION_KEY { 0x0C,0x06,0x57,0x08,0xBD,0xEE,0x0A,0x49,0x35,0xD3,0xB9,0xE6,0xA4,0x83,0x92,0x0C }

#ifdef __cplusplus
}
#endif

#endif /* __LORA_COMMISSIONING_H__ */

```

Presented by:

Finish Our End Node

- Set channel plan as I showed yesterday
- Set the other switches in hw_conf.h
- Compile and run

Modify hw_conf.h

```
#ifndef USE_B_L072Z_LRWAN1
#include "stm3210xx_hal.h"
#include "b-1072z-lrwan1.h"
#include "stm3210xx_hal_conf.h"
#include "mlm3210xx_hw_conf.h"
#endif

/* -----Preprocessor compile swicth----- */
/* debug swicthes in debug h */
#define DEBUG
#define TRACE

/* uncomment below line to never enter lowpower modes in main.c*/
//#define LOW_POWER_DISABLE

/* debug swicthes in bsp.c */
//#define SENSOR_ENABLED
```

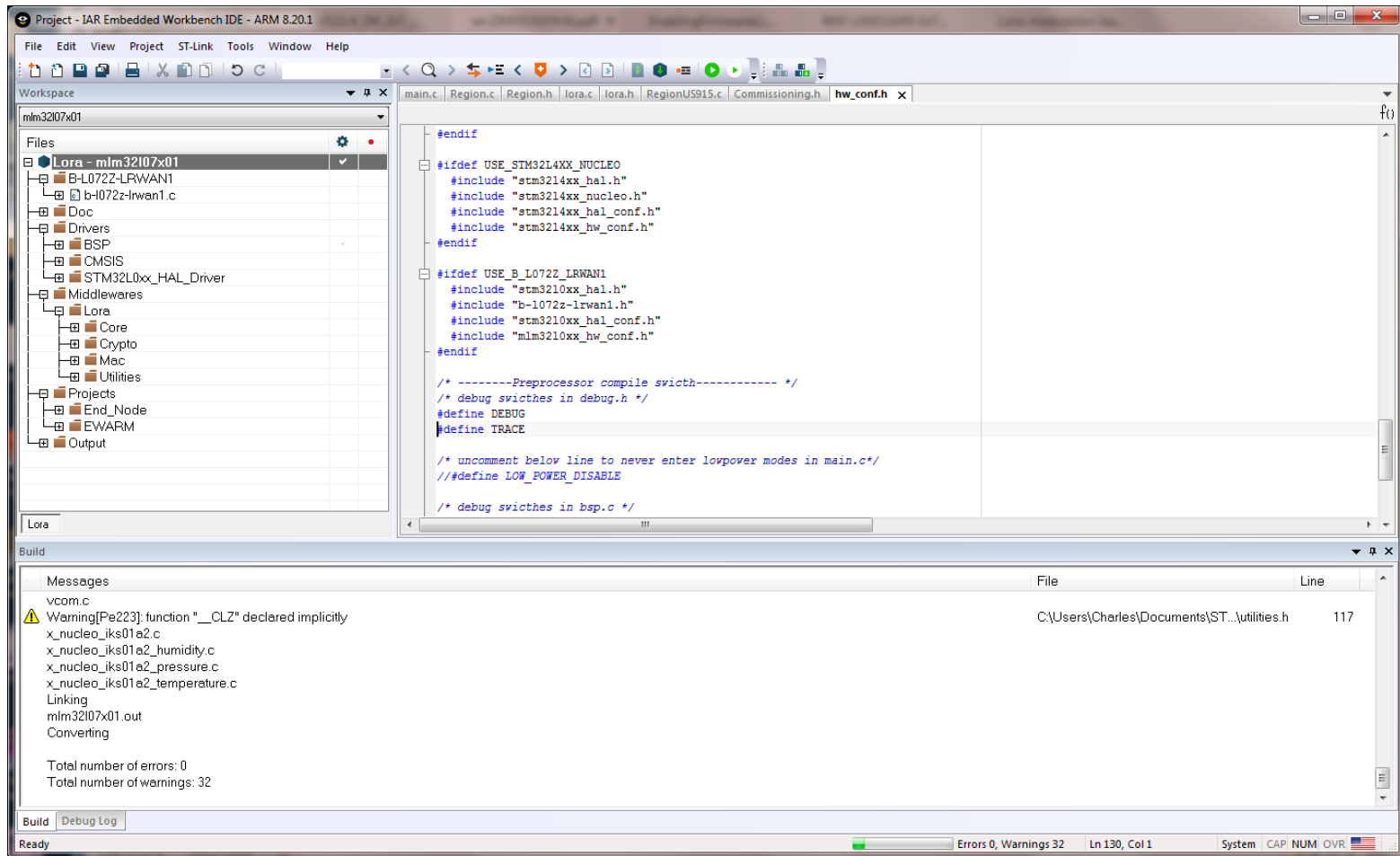
These are the HAL for our board

Uncomment these for testing

Leave these two commented out

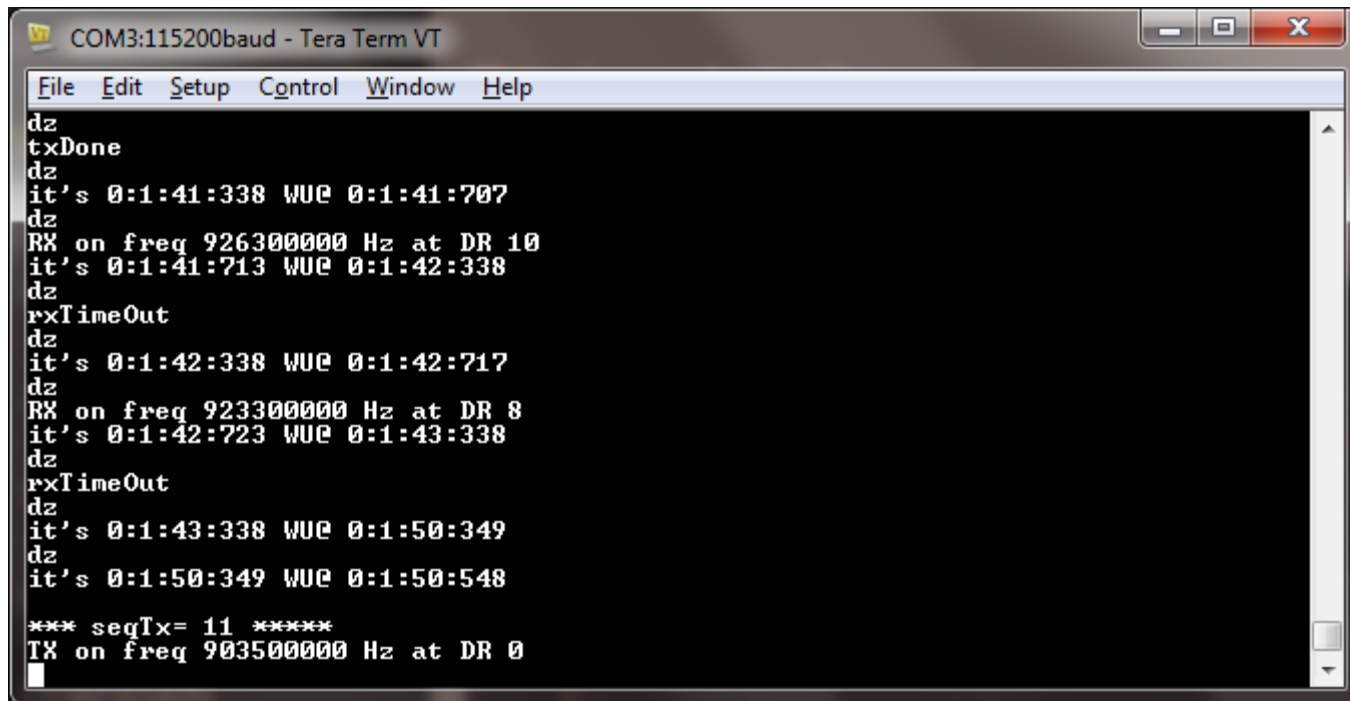
Question 2 – Should LOW_POWER_DISABLE be turned on? Why or Why Not?

0 errors, 32 warnings*



Presented by:

Check our Serial Port



```
COM3:115200baud - Tera Term VT
File Edit Setup Control Window Help
dz
txDone
dz
it's 0:1:41:338 WUC 0:1:41:707
dz
RX on freq 926300000 Hz at DR 10
it's 0:1:41:713 WUC 0:1:42:338
dz
rxTimeOut
dz
it's 0:1:42:338 WUC 0:1:42:717
dz
RX on freq 923300000 Hz at DR 8
it's 0:1:42:723 WUC 0:1:43:338
dz
rxTimeOut
dz
it's 0:1:43:338 WUC 0:1:50:349
dz
it's 0:1:50:349 WUC 0:1:50:548
*** seqTx= 11 *****
TX on freq 903500000 Hz at DR 0
```

To Program other STM nodes

1. Register in LORIOT
2. Start new project in IDE
3. Change channel plan (if applicable)
4. Update commissioning with info from LORIOT console
5. Compile, download, test

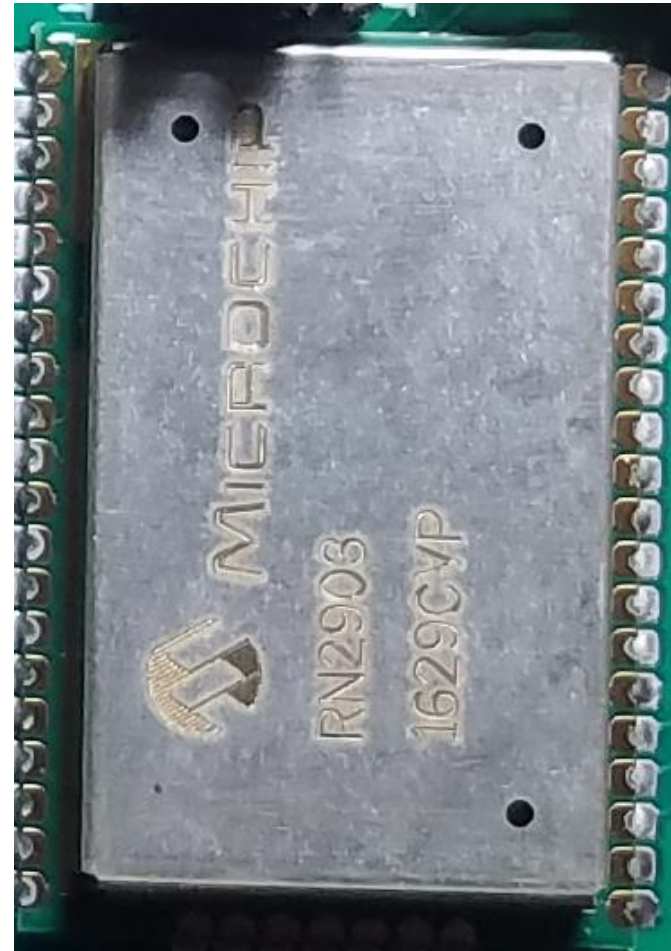
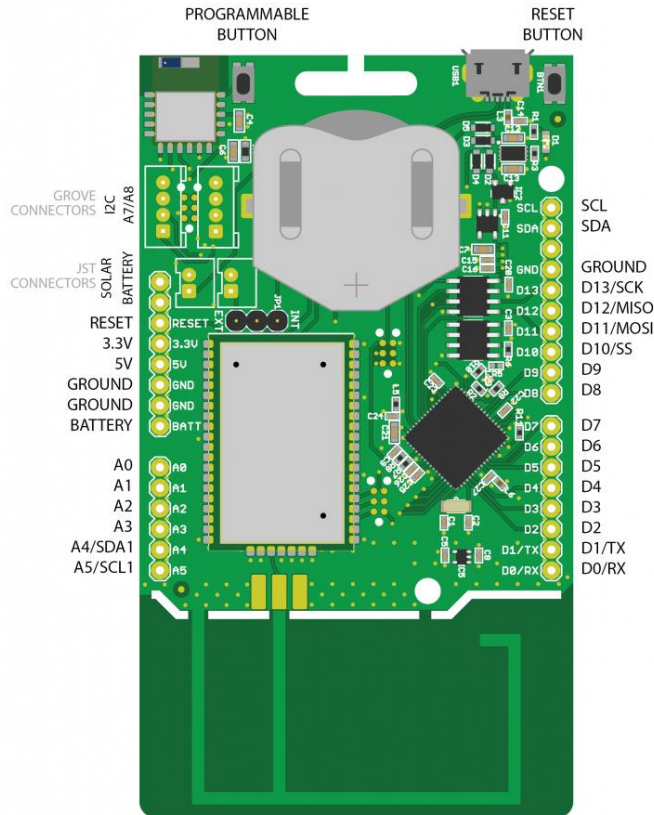
SODAQ ExpLoRer

- Project board designed as badge board
- ATSAM21J18, 32-Bit ARM Cortex M0+
- Runs Arduino OS
- Program with Arduino IDE
- Custom board file:



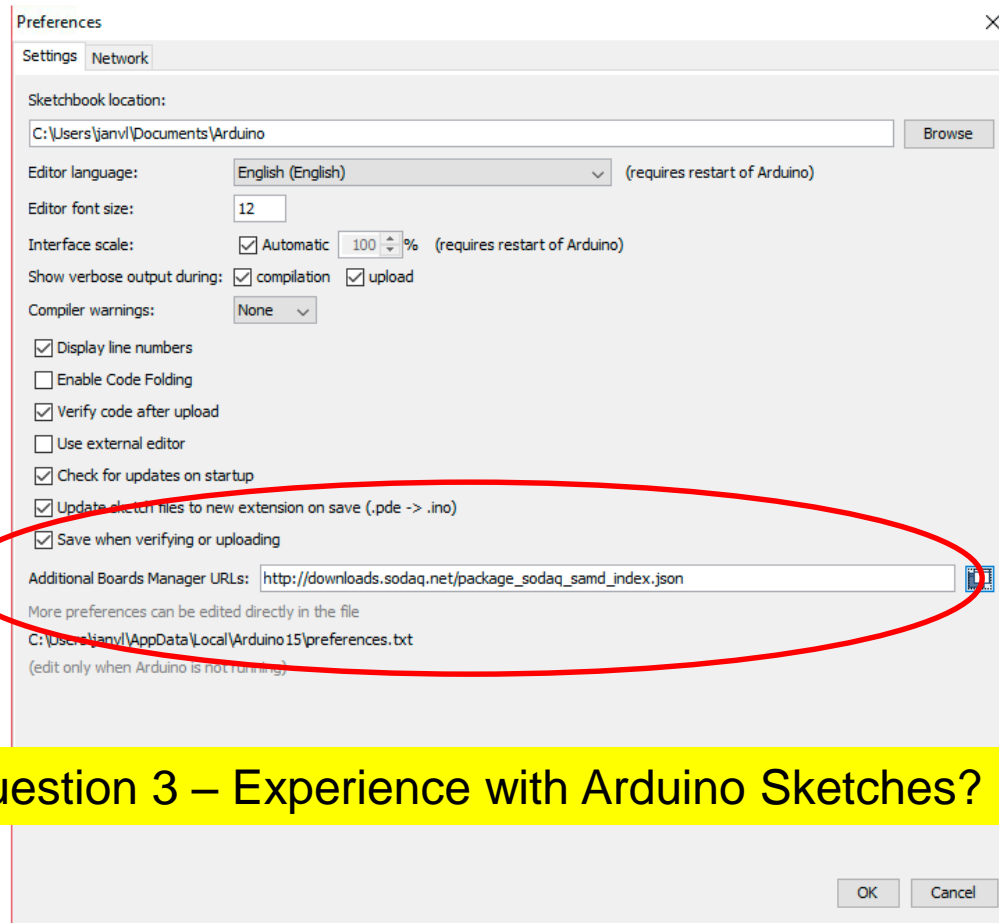
http://downloads.sodaq.net/package_sodaq_samd_index.json

Make Sure it is RN2903 if for US915



Presented by:

Arduino File / Preferences



Question 3 – Experience with Arduino Sketches?

Adding SODAQ ExpLoRer to LORIoT

Microchip RN2903 | General

The module comes with a pre-programmed EUI. You can retrieve the EUI by issuing the `mac get deveui` command. The following commands assume you have successfully enrolled the device using the enroll mechanism. For the US bands with gateways limited to 8 channels, you need to specifically disable the unavailable channels by issuing commands `mac set ch status [CHANNEL NUMBER] off`.

Microchip RN2903 | ABP Setup

Setup for device with EUI BE-7A-00-00-00-00-03-BB

```
mac set devaddr 00B3B6AA
mac set nwkskey 6F4E527626436399C7C2529968E18E99
mac set appskey 3A180A33FCDF2F9BCBCB7D09D9D56276
mac set ch status 8 off
mac set ch status 9 off
mac set ch status ... off
mac set ch status 64 off
mac save
mac join abp
```

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TTN

COMMUNITIES LABS LEARN SUPPORT FORUM SHOP

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Join our first global LoRaWAN developer conference

Get Tickets



BUILDING A GLOBAL INTERNET OF THINGS NETWORK TOGETHER.

Learn More →

BUILDING A FULLY DISTRIBUTED INTERNET OF THINGS DATA

DesignNews

Blue Ridge Advanced Design and Automation
Asheville, North Carolina

20

CEC CONTINUING
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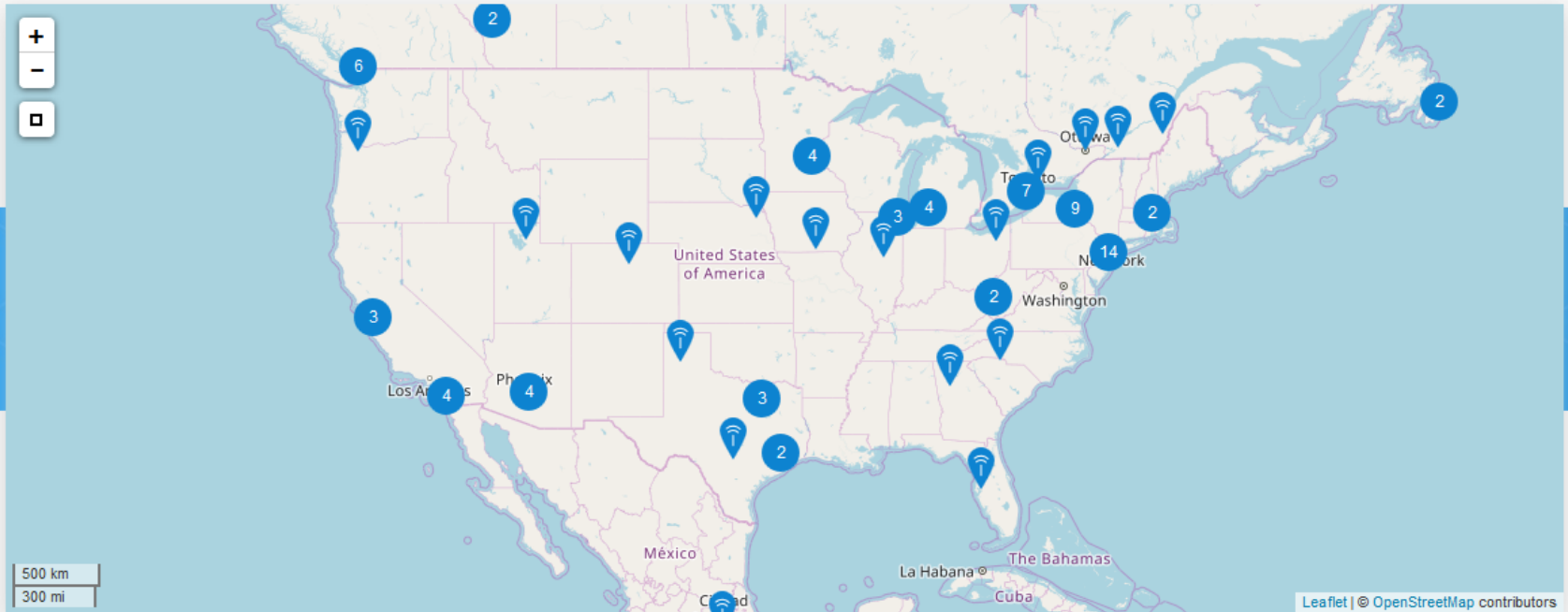
Current Nodes – Changes Often

At this moment, there are 1535 gateways up and running along with 1300 Kickstarter gateways



Zoom on US

At this moment, there are 1621 gateways up and running



Free Basic (Community) Membership

Get started.

JOIN 27875 DEVELOPERS



DEVELOPERS

Get started with building your next smart project. From smart trash bins, mouse traps, water leakage sensors to metering.

1621 ACTIVE GATEWAYS



NETWORK

The gateways make the network. The design of LoRaWAN allows to make very scalable and low cost networks. Join the global collaborative network of LoRaWAN peering organisations.

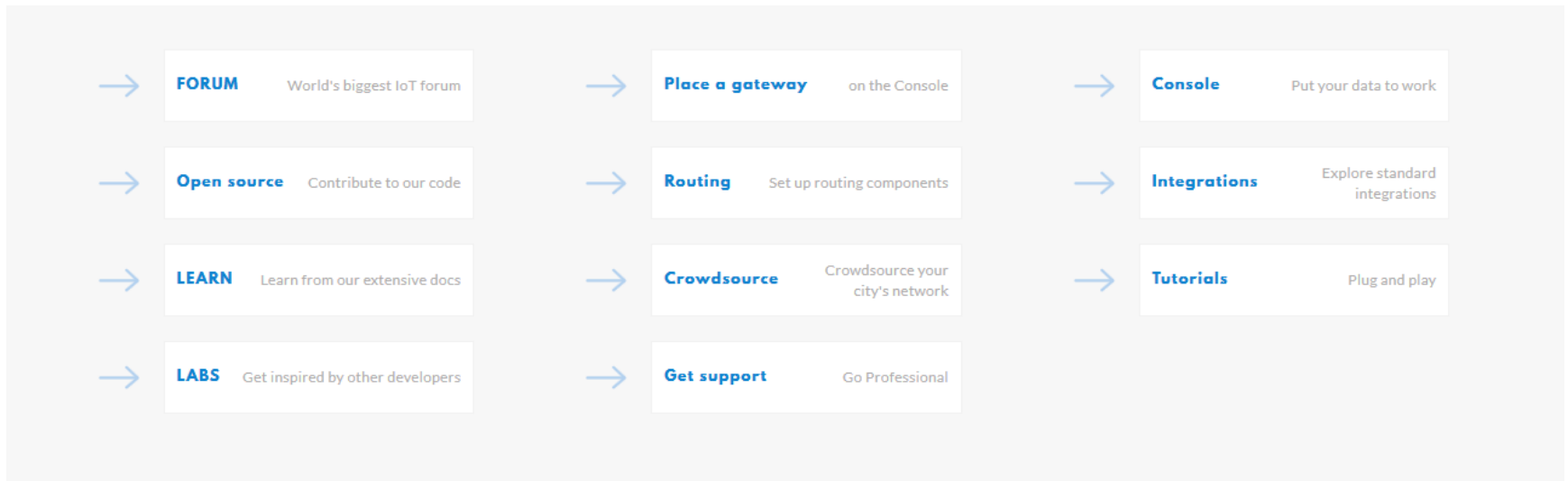
13614 APPLICATIONS DEPLOYED



APPLICATIONS

Your application will receive the end-to-end encrypted data and transform it into business value. Learn how to use any platform around or build your own application.

Menus




→ FORUM World's biggest IoT forum	→ Place a gateway on the Console	→ Console Put your data to work
→ Open source Contribute to our code	→ Routing Set up routing components	→ Integrations Explore standard integrations
→ LEARN Learn from our extensive docs	→ Crowdsourcing Crowdsource your city's network	→ Tutorials Plug and play
→ LABS Get inspired by other developers	→ Get support Go Professional	

My Gateway is Registered

GATEWAY OVERVIEW ⚙️ settings

Gateway ID brada_one

Description Blue Ridge Advanced Design SEED ONE

Owner  **BradaTech** [Transfer ownership](#)

Status ● not connected

Frequency Plan United States 915MHz

Router ttn-router-us-west

Gateway Key

Last Seen ⓘ

Received Messages ⓘ

Transmitted Messages ⓘ

<https://pages.arm.com/Webinar-Getting-started-with-LoRa.html>

The slide features a background image of a car on a road at night with light trails. In the top left, the 'arm' logo is in white, and to its right is a white cloud icon with a signal tower. Below the cloud, the text 'THE THINGS NETWORK' is written in white. On the right side, there is a large orange rectangle containing the text 'Webinar' and 'Getting started with LoRa using Arm Mbed and The Things Network'. At the bottom right, a blue rectangle contains the names 'Jan Jongboom, Arm' and 'Johan Stokking, The Things Industries'. A yellow horizontal bar is positioned above the blue one. In the bottom left corner, there is a small copyright notice: '© 2017 Arm Limited'.

arm THE THINGS NETWORK

Webinar

Getting started with LoRa using Arm Mbed and The Things Network

Jan Jongboom, Arm
Johan Stokking, The Things Industries

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Remember to Sign Up for LORIIOT

Browser address bar: <https://us1.loriot.io/register.html>

LORIIOT HOME TECHNOLOGY PRODUCTS NEWS CAREER CONTACT [LOG IN](#)

FREE ACCOUNT REGISTRATION

Upon registration, you will be able to connect your LoRa gateway to our network, personalize your LoRa end-nodes and retrieve your data frames.

FREE ACCOUNT INCLUDES

- ★ One free Gateway Connectivity slot
- ★ One Free Network Application
- ★ Capacity of 10 devices
- ★ Existing devices can be imported into our system
- ★ Existing gateways can be migrated to our system

NEED MORE?

[GET IN TOUCH](#)

ALREADY HAVE AN ACCOUNT?

REGISTRATION FORM

Server location:

First name:

Last name:

Country:

E-mail:

Password:

I agree with [Terms of Service](#)

[CREATE A FREE ACCOUNT](#)

<https://portal.senetco.io/>



senet
portal

Username



Password



[Forgot Password or Username ?](#)

Login

[Create New Account](#)

<http://machineq.com/>



Current Locations



Reminders

- Live Demo on both my RPi gateway and Senet at Embedded Systems Conference next Thursday 9AM
- I will be posting more on ongoing LoRa and LoRaWAN at my website
- NEXT on CEC – Warren Miller and “Industrial Ethernet Designs with MCUs – A Hands-On Introduction” December 11-15!!

Question 4 – What topics would YOU like to see?

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12/1 Testing Our LoRaWAN design

Please stick around as I answer your questions!

- Please give me a moment to scroll back through the chat window to find your questions
- I will stay on chat as long as it takes to answer!
- I am available to answer simple questions or to consult (or offer in-house training for your company)

c.j.lord@ieee.org

<http://www.blueridgetechnc.com>

<http://www.linkedin.com/in/charleslord>

Twitter: @charleslord

<https://www.github.com/bradatrainning>