



Workshop Introduction to LoRa Sensor Networking

**Hackaday Superconference
Pasadena, November 2, 2018**

WHAT YOU WILL LEARN

WHAT IS LORA, AND WHAT MAKES IT DIFFERENT

- Bandwidth, Range, Power
- Network provider: The Things Network

Globalsat LM-110H1 LoRa module

- Manual setup with serial communication
- Useful AT commands
- Joining a local LoRa network
- Transmit data to an application
- Receive data from an application
- Visualize data in MyDevices Cayenne

WHAT IS LORA?

Long range, low energy, wireless communication

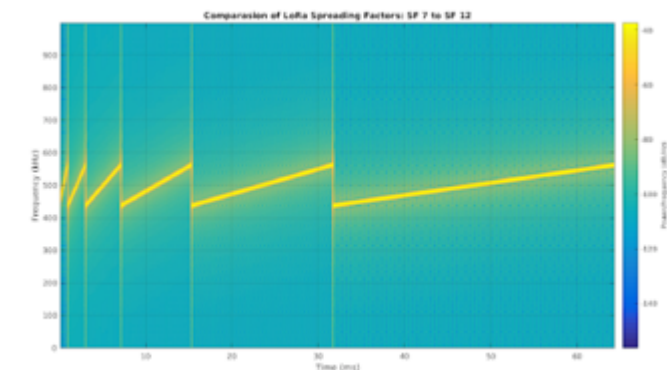
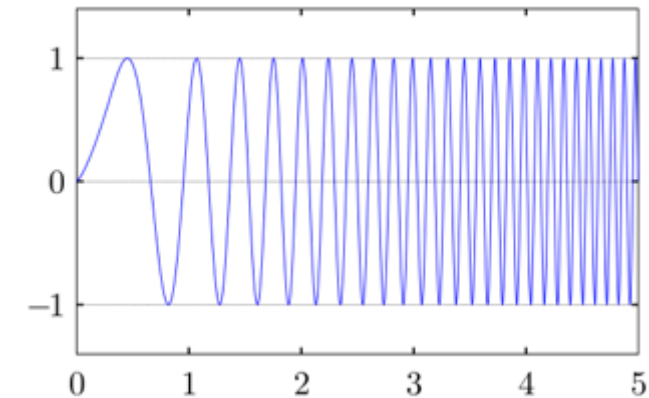
- Typical 5 mile range with line-of sight
- Suitable for battery operated sensors
- Small data packets, 30 seconds/day air time
~ every 15 - 30 minutes
- Star network topology
- One gateway can support hundreds of stations

Unlicensed Frequency bands

- USA 902 – 928 MHz, 64 channels
- Europe 863 – 870 MHz, 8 channels

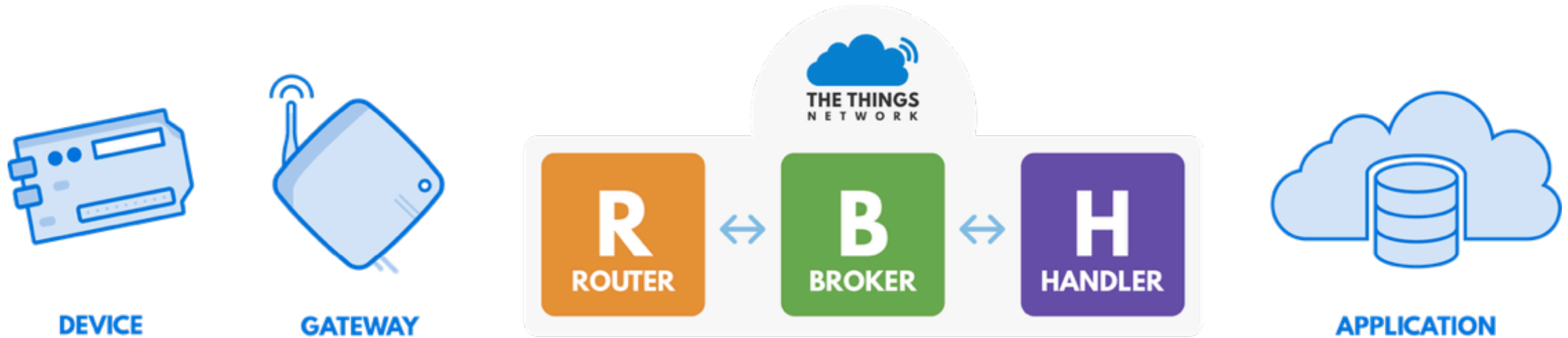
Modulation

- Chirp spread spectrum, 3 x greater distance than NB FSK
- Data rate depends on bandwidth and spreading factor

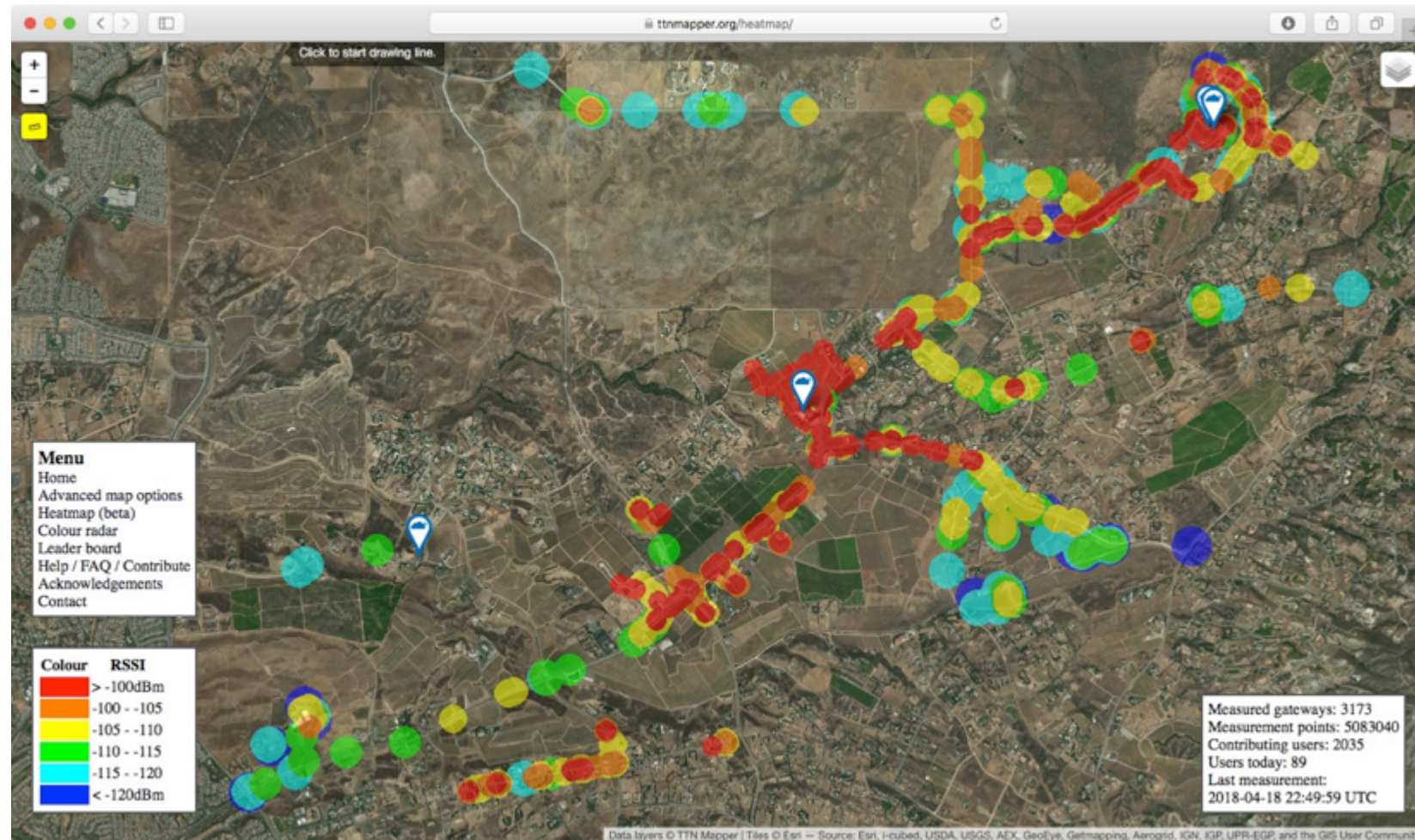


Sakshama Ghoslya

LORA NETWORK ARCHITECTURE



LORA NETWORK IN TEMECULA



ttnmapper.org

WORKSHOP PLAYGROUND

LORAWAN GATEWAY

- Multitech Conduit
- Set up for TheThingsNetwork



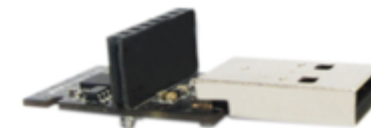
LORA NETWORK PROVIDER: TTN

- Free to use LoRaWAN networking
- Community owns and deploys the network
- 5,000 communities worldwide



YOUR WORKSHOP KIT

- Globalsat LM-110H1 LoRa radio module
- NL100 USB-2-Serial adapter
- 915 MHz Antenna



GLOBALSAT LM-110H1

Hardware Specifications

Chipset	SEMTECH LoRa SX1276
LoRaWAN Class	Class A device, Receives after Tx
Frequency	862-870MHz (Model: LM-110E) 902-928MHz (Model: LM-110H)
Transmission Power	100mW (max.)
UART	Baud Rate : 57600bps Parity: 8N1
Operation Voltage	3.0V~6V
Current Consumption	Receiving: 21 mA (typical) Transmitting: 125 mA (typical) Sleeping: 5 uA (typical)
Transmission Distance	1KM~10KM (0.81Kbps)
Receiving Sensitivity	-132dBm@0.81Kbps

LM-110H1 Pin Definition

Pin	Signal Name	I/O	Description
1	GND	-	Ground
2	VCC	-	3.0 – 6.0V
3	RXD	Input	3.3V UART input
4	TXD	Output	3.3V UART output
5 -7	-	-	-

BEFORE WE GET STARTED

WIFI

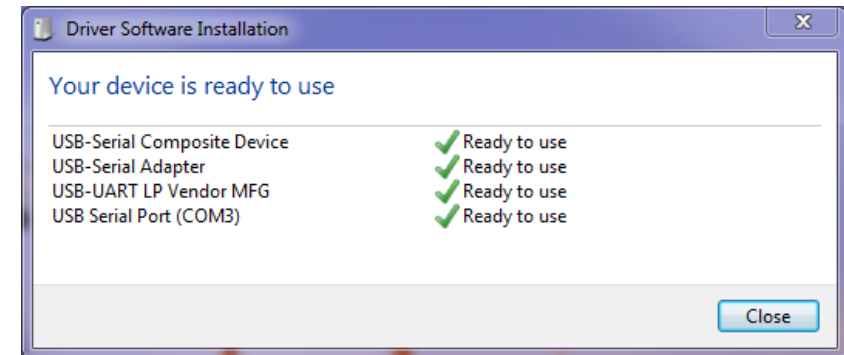
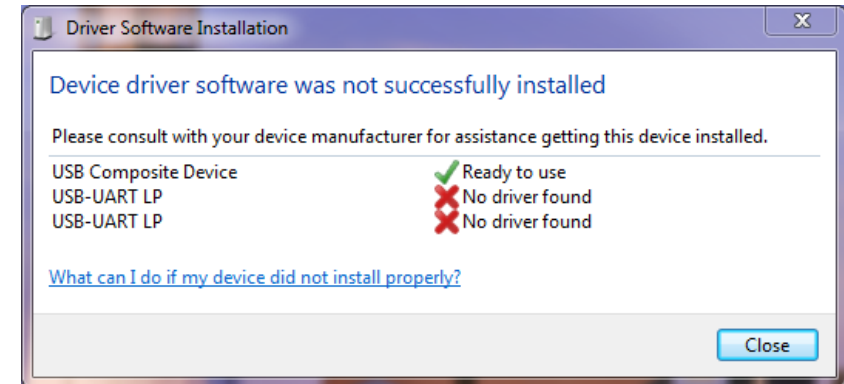
- SSID:
- Pass:

WINDOWS USERS

- Install Cypress USB serial driver

Everybody

- Install CoolTerm serial communications program
<http://freeware.the-meiers.org>
- Set up user account at thethingsnetwork.org
- Set up user account at mydevices.com



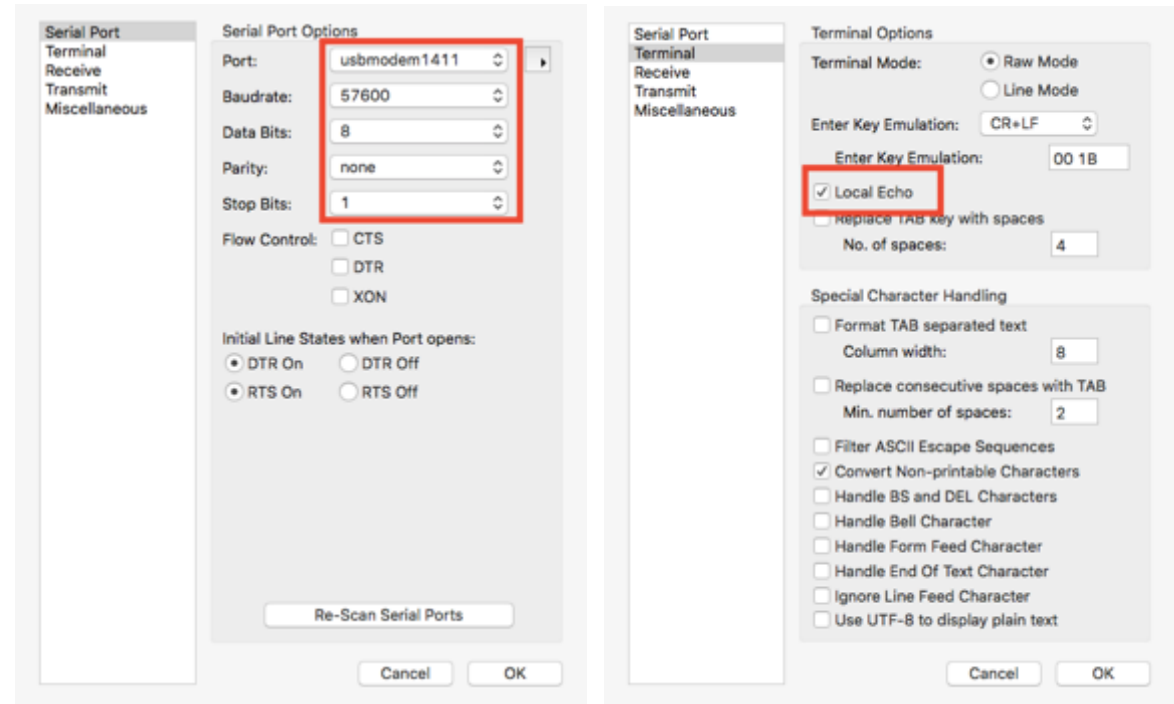
BEFORE WE GET STARTED-2

CoolTerm Settings

- Select correct serial port
- Baudrate:
57600, 8 bits, no parity, 1 stop bit
- Terminal: Local Echo

The Things Network

- Set up a user account
- <https://account.thethingsnetwork.org/register>



AT COMMANDS QUICK REFERENCE

Command	Description	Response
AAT1 Reset	Reboot the LM-110H1	OK
AAT1 Save	Save parameters to flash	OK
AAT1 SLEEP	Enter sleep mode	OK
AAT2 JoinMode=1	OTAA activation mode	OK
AAT2 DevEui=?	Device LoRa Mac address	8-byte hex number
AAT2 AppEui= (enter hex here)	Application identifier	OK
AAT2 AppKey= (enter hex here)	Encryption key	OK
AAT2 Tx=2,uncnf,AABBCC (hex payload)	Send data	OK Tx_ok Tx_noACK Tx_no_free_ch Tx_not_joined Rx ...

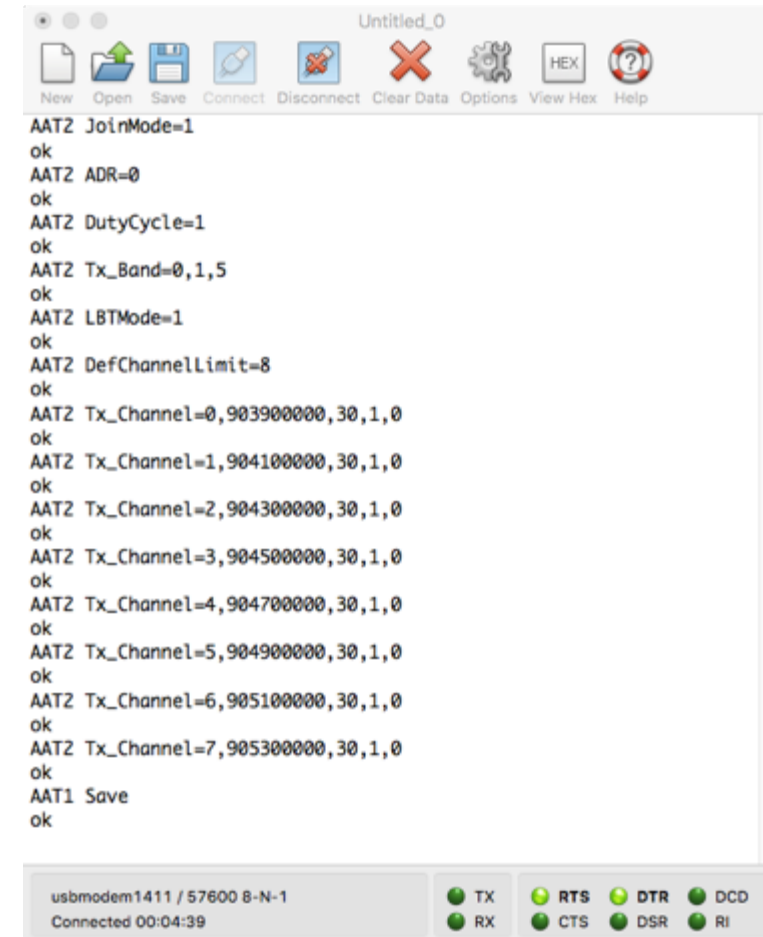
MODULE MANUAL CONFIGURATION

AAT2 JoinMode=1
AAT2 ADR=0
AAT2 DutyCycle=1
AAT2 Tx_Band=0,1,5
AAT2 LBTMode=1
AAT2 DefChannelLimit=8

Same for every
module setup

Frequencies can differ
per network provider

AAT2 Tx_Channel=0,903900000,30,1,0
AAT2 Tx_Channel=1,904100000,30,1,0
AAT2 Tx_Channel=2,904300000,30,1,0
AAT2 Tx_Channel=3,904500000,30,1,0
AAT2 Tx_Channel=4,904700000,30,1,0
AAT2 Tx_Channel=5,904900000,30,1,0
AAT2 Tx_Channel=6,905100000,30,1,0
AAT2 Tx_Channel=7,905300000,30,1,0
AAT1 Save

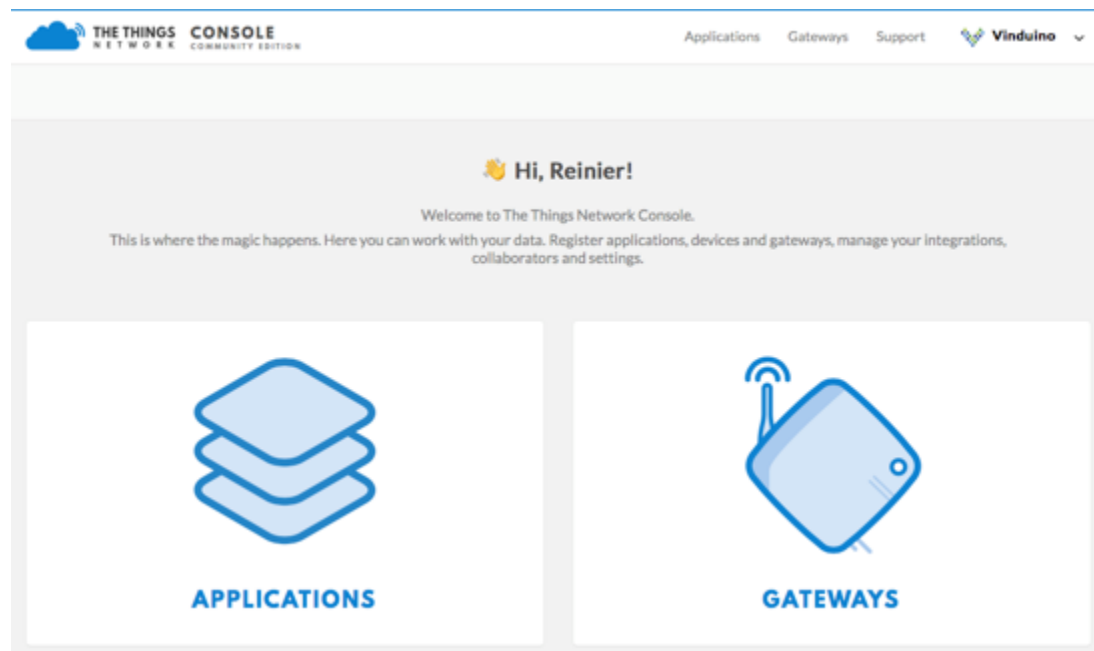


The screenshot shows a software window titled 'Untitled_0' with a menu bar containing 'New', 'Open', 'Save', 'Connect', 'Disconnect', 'Clear Data', 'Options', 'View Hex', and 'Help'. The main text area displays the following configuration commands and responses:

```
AAT2 JoinMode=1
ok
AAT2 ADR=0
ok
AAT2 DutyCycle=1
ok
AAT2 Tx_Band=0,1,5
ok
AAT2 LBTMode=1
ok
AAT2 DefChannelLimit=8
ok
AAT2 Tx_Channel=0,903900000,30,1,0
ok
AAT2 Tx_Channel=1,904100000,30,1,0
ok
AAT2 Tx_Channel=2,904300000,30,1,0
ok
AAT2 Tx_Channel=3,904500000,30,1,0
ok
AAT2 Tx_Channel=4,904700000,30,1,0
ok
AAT2 Tx_Channel=5,904900000,30,1,0
ok
AAT2 Tx_Channel=6,905100000,30,1,0
ok
AAT2 Tx_Channel=7,905300000,30,1,0
ok
AAT1 Save
ok
```

At the bottom, a status bar shows 'usbmodem1411 / 57600 8-N-1' and 'Connected 00:04:39'. To the right of the status bar are several status indicators: TX, RX, RTS, CTS, DTR, DSR, DCD, and RI, each with a corresponding green light icon.

TTN ADD APPLICATION



This screenshot displays the 'Add Application' form within the console. The breadcrumb trail at the top reads 'Applications > Add Application'. The form is titled 'ADD APPLICATION' and contains several input fields, each with a green checkmark indicating successful validation. The fields are: 'Application ID' (with the value 'workshop-exampleapp-101918'), 'Description' (with the value 'This is my personal application integration'), 'Application EUI' (with the value 'EUI issued by The Things Network'), and 'Handler registration' (with the value 'ttn-handler-us-west'). At the bottom right of the form, there are two buttons: a 'Cancel' button and a green 'Add application' button.

MODULE MANUAL CONFIGURATION-2

AAT2 DevEui=?

000DB53908643681

(should be the same as module marking)

Save DevEUI for
TTN registration

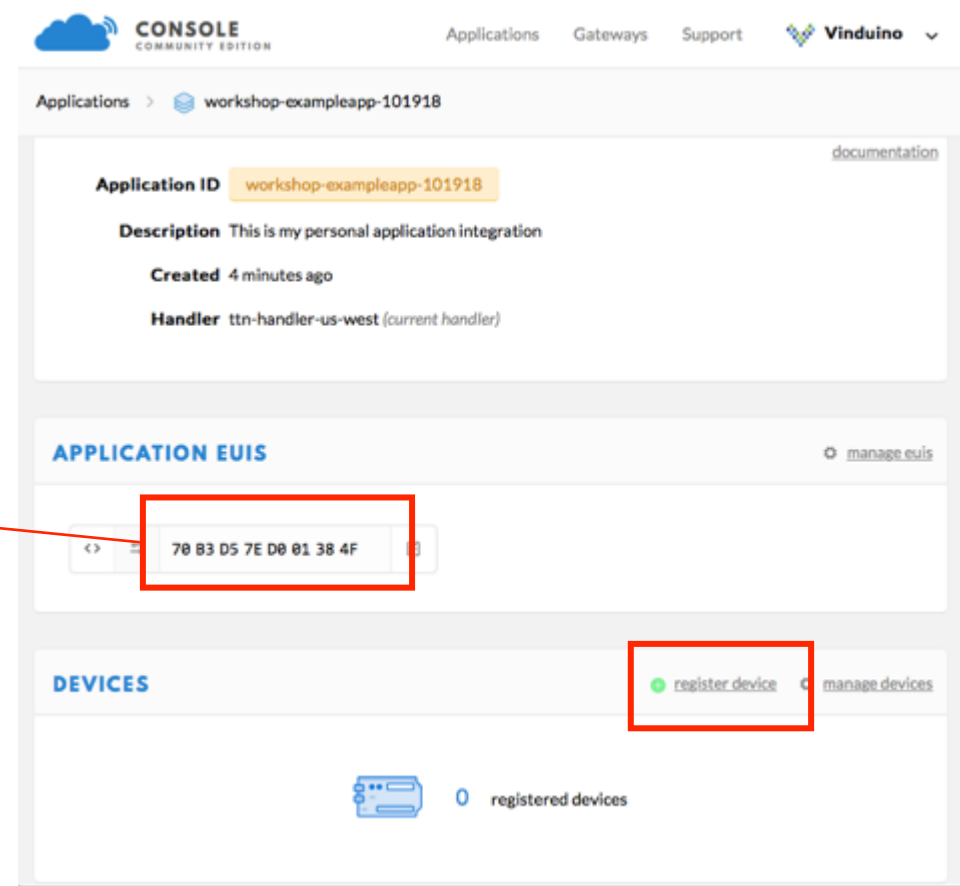
AAT2 AppEui=70B3D57ED001384F

AAT1 Save

AAT2 AppKey=

AAT1 Save

AAT1 Reset



TTN REGISTER DEVICE

AAT2 AppKey=C788778DF20CB86827D20C0A60CC140C

AAT1 Save

AAT1 Reset

The screenshot shows the 'REGISTER DEVICE' form in the TTN Console. The form includes fields for 'Device ID' (workshop-test-device-1), 'Device EUI' (00 0D B5 39 08 64 36 81), 'App Key' (a field with a note 'this field will be generated'), and 'App EUI' (70 83 D5 7E D0 01 38 4F). A red arrow points from the 'App Key' field to the text 'AAT2 AppKey=C788778DF20CB86827D20C0A60CC140C' above the form.

The screenshot shows the 'DEVICE OVERVIEW' page for the device 'workshop-test-device-1'. The page displays the 'Application ID' (workshop-exampleapp-101918), 'Device ID' (workshop-test-device-1), 'Activation Method' (OTAA), 'Device EUI' (00 0D B5 39 08 64 36 81), 'Application EUI' (70 83 D5 7E D0 01 38 4F), and 'App Key' (C788778DF20CB86827D20C0A60CC140C). The 'App Key' field is highlighted with a red box. A red arrow points from the 'App Key' field in the 'REGISTER DEVICE' form to the 'App Key' field in the 'DEVICE OVERVIEW' page.

CONNECTED TO THE LORA NETWORK!!

Untitled_0

New Open Save Connect Disconnect Clear Data Options View Hex Help

```
AAT2 DevEui=?  
000DB53908643681  
AAT2 AppEui=70B3D57ED001384F  
ok  
AAT1 Save  
ok  
AAT2 AppKey=C788778DF20CB86827D20C0A60CC140C  
ok  
AAT1 Save  
ok  
AAT1 Reset  
ok  
Program start  
Send join request  
JOIN_ACCEPT
```

usbmodem1411 / 57600 8-N-1
Connected 01:09:34

TX RX RTS CTS DTR DSR DCD RI

APPLICATION DATA

Filters: uplink downlink activation ack error

time counter port

13:03:43 devaddr: 26 02 24 6C appeui: 70 B3D57E D001 38 4F deveui: 000DB5 39 08 64 36 81

Activation

Device Address

26 02 24 6C

Device EUI

00 0D B5 39 08 64 36 81

App EUI

70 B3 D5 7E D0 01 38 4F

Metadata

```
{  
  "time": "2018-10-18T20:03:43.416600514Z",  
  "frequency": 903.9,  
  "modulation": "LORA",  
  "data_rate": "SF100W125",  
  "coding_rate": "4/5",  
  "gateways": [  
    {  
      "gtw_id": "wilson-creek-winery",  
      "timestamp": 4213932260,  
      "time": "2018-10-18T20:03:45Z",  
      "channel": 0,  
      "rssi": -43,  
      "snr": 10.5  
    }  
  ]  
}
```

NOW LET'S SEND SOME DATA!!

Untitled_0

New Open Save Connect Disconnect Clear Data Options View Hex Help

AAT2 Tx=2,uncnf **AABBCC**

ok
Tx_ok

usbmodem1411 / 57600 8-N-1
Connected 01:24:07

☒ TX ☒ RTS ☒ DTR ☒ DCD
☒ RX ☒ CTS ☒ DSR ☒ RI

APPLICATION DATA || pause clear

Filters uplink downlink activation ack error

time	counter	port	payload
13:19:33	2	2	AABBCC

Uplink

Payload

AA BB CC

Fields

no fields

Metadata

```
{
  "time": "2018-10-18T20:19:33.509907844Z",
  "frequency": 905.1,
  "modulation": "LORA",
  "data_rate": "SF100W125",
  "coding_rate": "4/5",
  "gateways": [
    {
      "gtw_id": "wilson-creek-winery",
      "gtw_trusted": true,
      "timestamp": 869025772,
      "time": "2018-10-18T20:19:34Z",
      "channel": 6,
      "rssi": -42,
      "snr": 10.5,
      "rf_chain": 1,
      "latitude": 33.567566,
      "longitude": -117.009895,
      "altitude": 600,
      "location_source": "registry"
    }
  ]
}
```

Estimated Airtime

206.848 ms

RECEIVING DATA

DEVICE OVERVIEW

Application IDworkshop-exampleapp-101918

Device IDworkshop-test-device-1

Activation MethodOTAA

Device EUI00 80 B5 39 08 64 36 81

Application EUI70 83 D5 7E 00 81 38 4F

App Key

Device Address26 02 24 6C

Network Session Key

App Session Key

Status17 minutes ago

Frames up 2reset frame counters

Frames down 0

DOWNLINK

Scheduling

replacefirstlast

FPort2

Confirmed

Payload

bytesfields

CC BB AA

3 bytes

Send

Untitled_0

NewOpenSaveConnectDisconnectClear DataOptionsView HexHelp

AAT2 Tx=2,uncnf,AABBCC
ok
Tx_ok
AAT2 Tx=2,uncnf,AACCEE
ok
Rx 2 CCBBA

Class A device receives data only after transmitting

usbmodem1411 / 57600 8-N-1
Connected 01:44:09

TX

RX

RTS

CTS

DTR

DSR

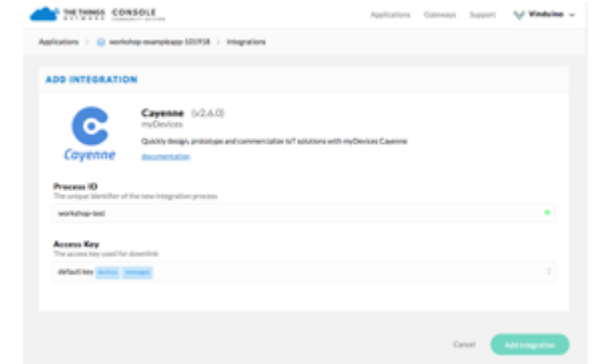
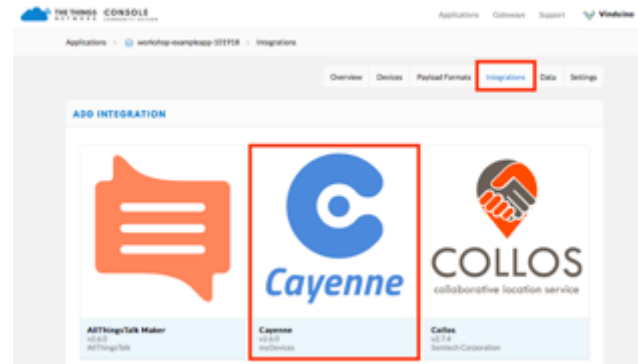
DCD

RI

VISUALIZE YOUR SENSOR DATA

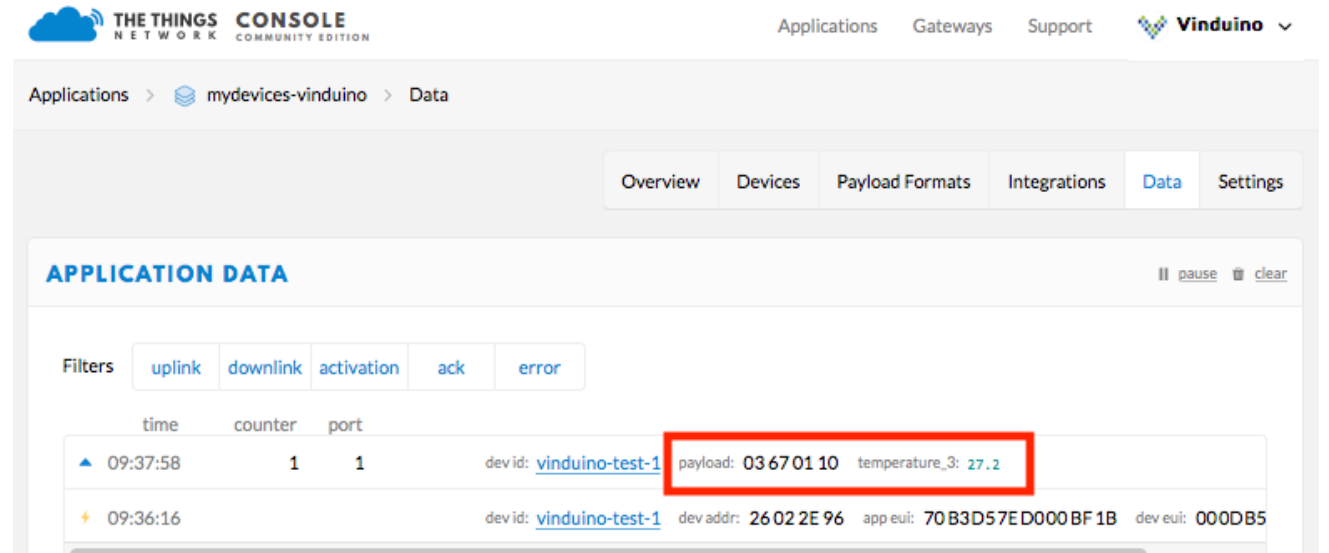
ADD CAYENNE INTEGRATION

- Process ID : any unique name
- Access Key: use default key



TEST INTEGRATION

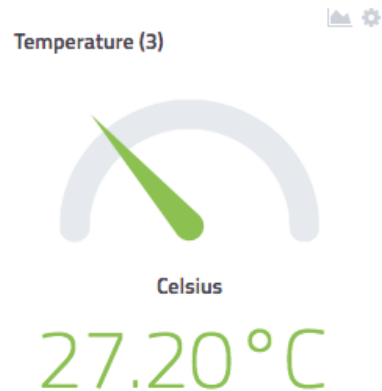
- AAT2 Tx=1,uncnf,03670110
- 03=data channel
- 67= data type, Temperature
- 0110= Value = 272 =>27.2C



USING CAYENNE

SET UP DEVICE IN CAYENNE

- Add new ... Devices & Widgets
- Select LoRa / TheThingsNetwork
- In devices list: select Cayenne LPP
- Enter DevEUI:
- AAT2 Tx=1,uncnf,03670110



Cayenne
Cayenne LPP
Cayenne Low
Power Payload

This device uses [Cayenne LPP](#)

Name
Cayenne LPP

DevEUI

Activation Mode
Already Registered ▼

Tracking

Location
This device doesn't move ▼

Address

Add device

CONGRATULATIONS



USEFUL LINKS

www.thethingsnetwork.org/community/losangeles/

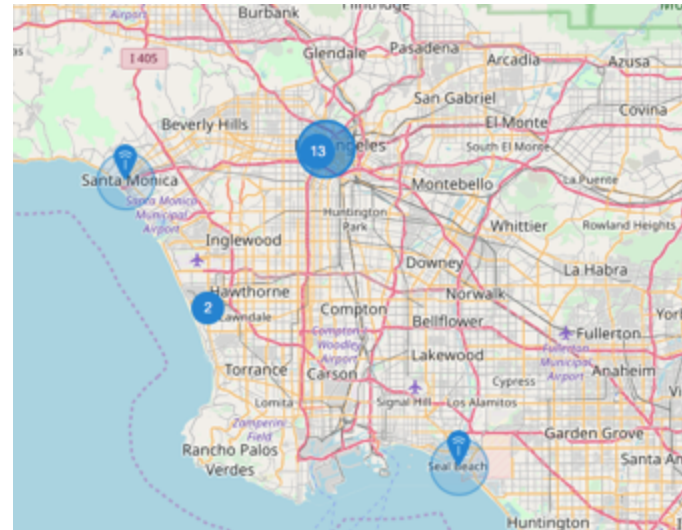
<https://www.thethingsnetwork.org>

www.usglobalsat.com

www.vinduino.com

www.tindie.com

lora-alliance.org





THANK YOU