everynet LoRaWAN Gateway v.2 User Manual

Changelog

Date	Changes	Author

Disclaimer

The gateway is not intended for disassembly and comes completely ready for operation. These instructions are intended for you use at your own risk.

Contents

General Description

The LoRaWAN™ Network Server and all network management and monitoring tools are provided by the everynet Platform in both UI and API forms. The comprehensive and powerful everynet platform includes: gateway management, device management, comprehensive statistics logging, notifications, alarms, coverage maps, data routing, and full integration to over 40 of the most popular IoT vertical applications.

The everynet network gateway is a very compact, fully featured LoRaWAN™ compliant network base station. It has been designed to offer low cost, be simple to install, and to run LoRaWAN network infrastructure. With integrated GPS and 3G antennas, a PoE main supply with an integrated back up battery; both resilience and dual backhaul capabilities have been provisioned. The gateway has a range of >15Km LoS and >2Km in dense urban environments.

Hardware Description

Processor and memory

- CPU: ARM926, 454MHz
- RAM: DDR2, 128Mb
- FLASH: NAND, 512Mb
- Battery powered Real time clock
- Advanced power management (ability to cut power off any peripherals)

Sensors

- Mainboard temperature sensor
- CPU Temperature sensor
- Humidity sensor
- Battery voltage sensor
- Hardware watchdog

Connectivity

- LoRaWAN™ compliant (eu868, us915)
- Ethernet 10/100 Base T
- 3G HSDPA/UMTS 900/2100MHz
- UART debug port

Power

- IEEE 802.3af, PoE, 48v
- Maximum power consumption: 15W
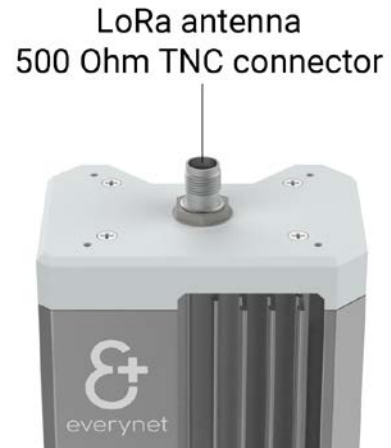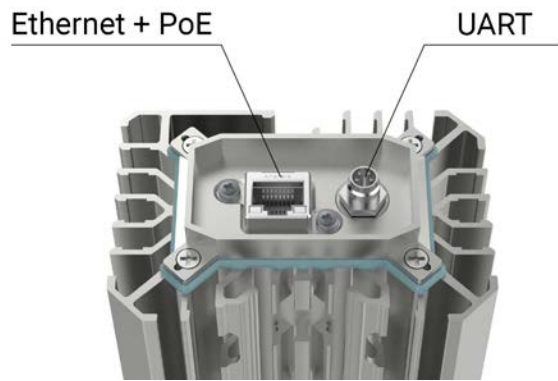- Industrial Li-Pol 2000mAh backup battery

Mechanical

- Dimensions: 145x93x64 mm
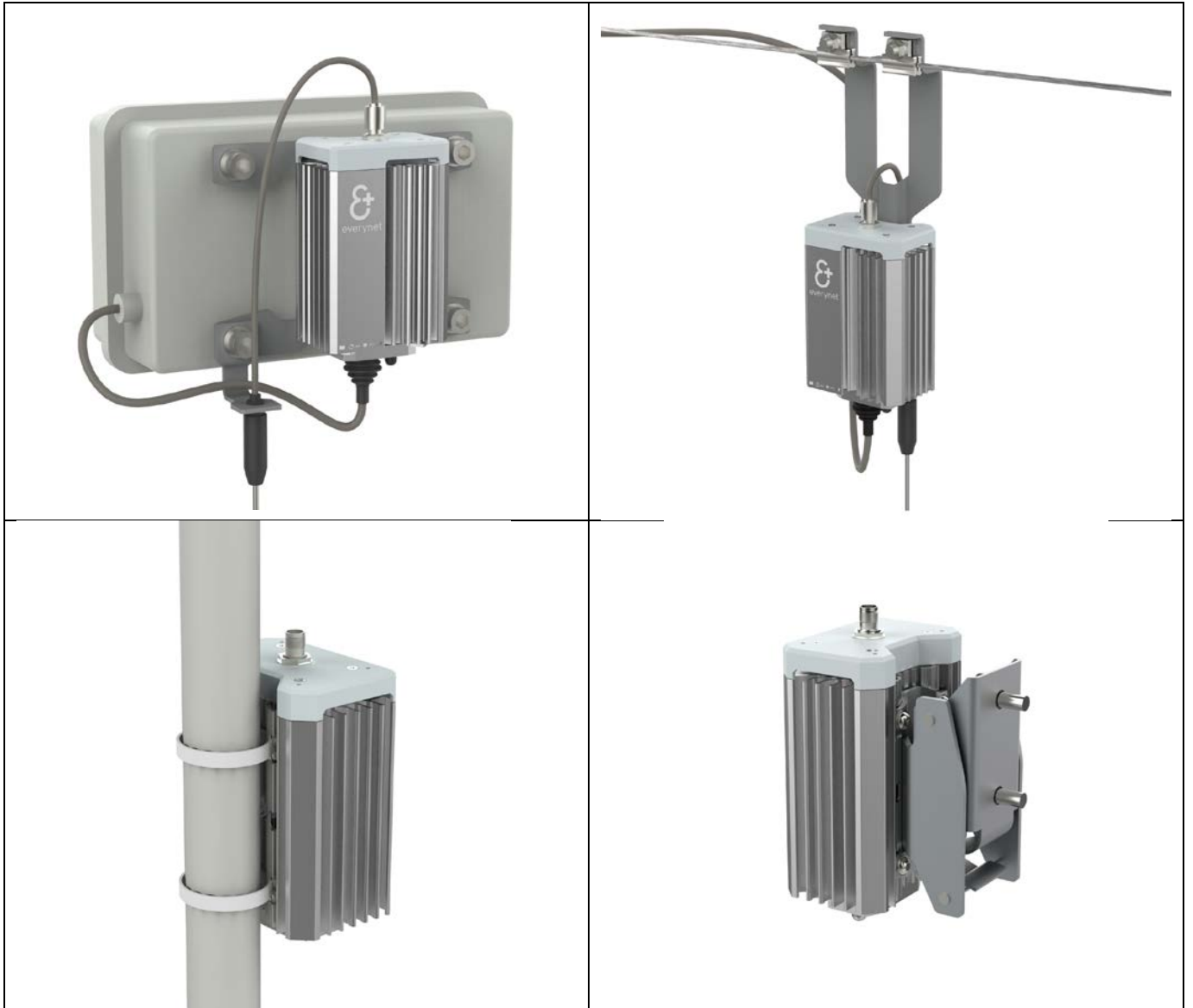- Weight: 750g
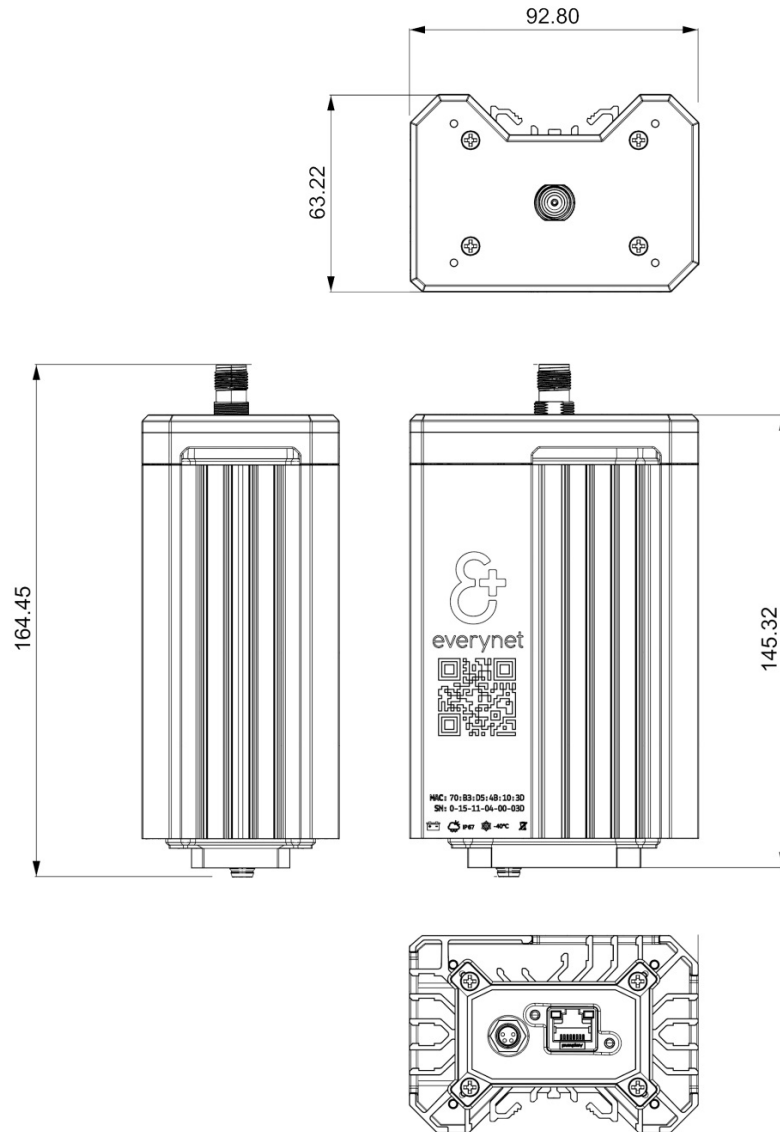
Gateway connectors

There are three connectors on a gateway: Ethernet + PoE, UART and antenna.
All connectors are shown on the images below.

Mounting options

There are four mounting options available:

- pole mount - rooftop or tower
- strand mount
- box/wall mount
- removable wall mount

Antenna options

EU868

- High gain omnidirectional antennas:
    - 10 dBi, 1.5m, Model: A10-868, supplied by Everynet
    - 5 dBi, 1m, Model: OMB.868.B05F21, http://www.digikey.com/product-search/en?keywords=OMB.868.B05F21
    - Adapter N-plug to TNC-plug, http://www.digikey.com/product-detail/en/amphenol-rf-division/242133/ACX1367-ND/1012044
- Indoor antenna:
    - -2.3 dBi, http://www.digikey.com/product-detail/en/linx-technologies-inc/ANT-868-CW-HWR-SMA/ANT-868-CW-HWR-SMA-ND/1139579
    - Adapter SMA-plug to TNC-plug, http://www.digikey.com/product-detail/en/amphenol-rf-division/242105/ACX1328-ND/1012005

US915

- High gain omnidirectional antennas:
    - 8.1 dBi, 1.6m, Model: A09-F8NF-M, http://www.digikey.com/product-detail/en/digi-international/A09-F8NF-M/A09-F8NF-M-ND/615825
    - Adapter N-plug to TNC-plug, http://www.digikey.com/product-detail/en/amphenol-rf-division/242133/ACX1367-ND/1012044
- Indoor antenna:
    - 1.9 dBi, http://www.digikey.com/product-detail/en/linx-technologies-inc/ANT-916-CW-HWR-SMA/ANT-916-CW-HWR-SMA-ND/1139580
    - Adapter SMA-plug to TNC-plug, http://www.digikey.com/product-detail/en/amphenol-rf-division/242105/ACX1328-ND/1012005
- Strand mount antenna:
    - 4.9 dBi, TI.16, http://www.digikey.com/product-search/en?keywords=TI.16
    - Adapter N socket to TNC Plug, http://www.digikey.com/product-detail/en/pomona-electronics/73046/73046-ND/2074251

Accessories

- Weatherproofing:
    - Scotch Super 33+, https://www.amazon.com/Scotch-Electrical-75-Inch-66-Foot-0-007-Inch/dp/B00004WCCL
    - 3M-2155, https://www.amazon.com/3M-2155-Rubber-Splicing-Tape/dp/B001CGVEXS
    - Tutorial: http://static.dxengineering.com/pdf/weatherproofingcoax-techtip.pdf
- Lightning protection:
    - CN-UB-70DC-6-SB, https://www.phoenixcontact.com/online/portal/us?uri=pxc-oc-itemdetail:pid=2803153&library=usen&pcck=P-24-04-02&tab=1
    - Adapter N-plug to TNC-plug, http://www.digikey.com/product-detail/en/amphenol-rf-division/242133/ACX1367-ND/1012044

Radio capability

EU868 performance

- Modulation: LoRa™, FSK
- Sensitivity: up to -140 dBm
- Output power (conducted): +14 dBm
- Frequency: 868MHz, ISM band

- Number of frequency channels: 8
- Number of LoRa™ demodulators: 49
- Range, SU: up to 15km

US915 performance

- Modulation: LoRa™, FSK
- Sensitivity: up to -135±1 dBm
- Output power (conducted): +25 dBm
- Frequency: 915MHz, ISM band

- Number of frequency channels: 8
- Number of LoRa™ demodulators: 49
- Range, SU: up to 15km

Link budget

EU868 link budget

This is an example of EU868 link budget calculation.

Uplink

Area Type	DU	U	SU	RU
GW Receive Sensitivity	-141	-141	-141	-141
GW Antenna Gain	10	10	10	10
Cable and Connector loss	0,5	0,5	0,5	0,5
Shadowing Margin	9	9	9	4
Penetration Loss	27	24	21	15
Interference Margin	3	3	3	2
Sensor Antenna Gain	0	0	0	0
Sensor Tx Power	14	14	14	14
MAPL	125,5	128,5	131,5	143,5

Downlink

Area Type	DU	U	SU	RU
Sensor Receive Sensitivity	-138	-138	-138	-138
Sensor Antenna Gain	0	0	0	0
Cable and Connector loss	0,5	0,5	0,5	0,5
Shadowing Margin	9	9	9	4
Penetration Loss	27	24	21	15
Interference Margin	3	3	3	2
GW Antenna Gain	10	10	10	10
GW Tx Power	14	14	14	14
MAPL	122,5	125,5	128,5	140,5

US915 link budget

This is an example of US915 link budget calculation for 36dB radiated power and Microchip RN2903 end devices with output power 18.5dB.

Uplink

Area Type	DU	U	SU	RU
GW Receive Sensitivity	-134	-134	-134	-134
GW Antenna Gain	11,2	11,2	11,2	11,2
Cable and Connector loss	0,5	0,5	0,5	0,5
Shadowing Margin	9	9	9	4
Penetration Loss	27	24	21	15
Interference Margin	3	3	3	2
Sensor Antenna Gain	0	0	0	0
Sensor Tx Power	18,5	18,5	18,5	18,5
MAPL	124,2	127,2	130,2	142,2

Downlink

| Area Type	DU	U	SU	RU
Sensor Receive Sensitivity	-132	-132	-132	-132
Sensor Antenna Gain	0	0	0	0
Cable and Connector loss	0,5	0,5	0,5	0,5
Shadowing Margin	9	9	9	4
Penetration Loss	27	24	21	15
Interference Margin	3	3	3	2
GW Antenna Gain	11,2	11,2	11,2	11,2
GW Tx Power	24,8	24,8	24,8	24,8
MAPL	128,5	131,5	134,5	146,5

Channel plan
EU868 Channel Plan
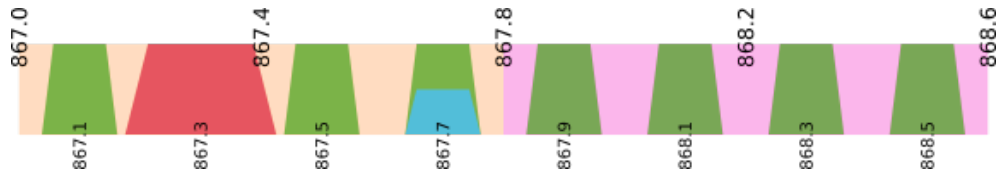
Channel list:
- 867.1MHz DR 0-5 (SF12-SF7; BW125)
- 867.5MHz DR 0-5 (SF12-SF7; BW125)
- 867.7MHz DR 0-5 (SF12-SF7; BW125)
- 867.9MHz DR 0-5 (SF12-SF7; BW125)
- 868.1MHz DR 0-5 (SF12-SF7; BW125)
- 868.3MHz DR 0-5 (SF12-SF7; BW125)
- 868.5MHz DR 0-5 (SF12-SF7; BW125)
- 867.3MHz DR 6 (SF7; BW250)
- 867.7MHz DR 7 (FSK; BW125)

US915AB Channel Plan

It is not possible to cover one US sub-band using two SX1257 ADC, because 500kHz RX channel will be split between two frontends.

It is decided to cover 800kHz with center frequencies in sub-bands A and B and use 500kHz channel from sub-band A.
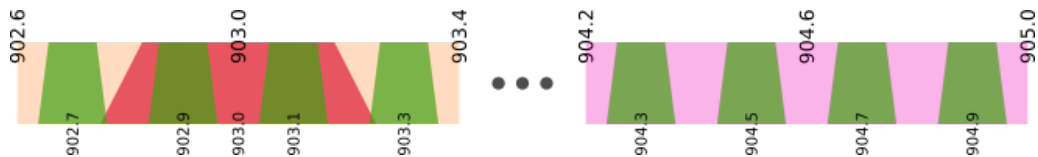
Channel list:
- 902.7MHz DR 0-3 (SF10-SF7; BW125)
- 902.9MHz DR 0-3 (SF10-SF7; BW125)
- 903.1MHz DR 0-3 (SF10-SF7; BW125)
- 903.3MHz DR 0-3 (SF10-SF7; BW125)
- 904.3MHz DR 0-3 (SF10-SF7; BW125)
- 904.5MHz DR 0-3 (SF10-SF7; BW125)
- 904.7MHz DR 0-3 (SF10-SF7; BW125)
- 904.9MHz DR 0-3 (SF10-SF7; BW125)
- 903.0MHz DR 4 (SF8; BW500)

Capacity
Model assumptions

- one base station and many devices (1:10,000+);
- each device transmits one message of length L in a certain period;
- the "phase" (starting moment) of message transmission is chosen for each device randomly according to uniform distribution in this period;
- the data rate of message transmission is computed as the sum of the data rates of all transmission channel and denoted by R;
- at each moment, the base station can receive only one message. If two messages are being sent simultaneously at the same exact moment, both of them are lost.
- we must compute the average number of messages that can be successfully received given that their fraction is bounded from below by minimal quality Q, capacity is calculated for the given model and can be used for any ALOHA system

ALOHA model

- the probability of having k new messages arrive during a time interval u is given by Poisson distribution as $P(k) = (\lambda u)^k e^{-\lambda u} / k!$, where λ is the average message arrival rate (the number of sent messages per second);
- a device can start successful transmission of a message at some moment as long as no other device began one within the previous t seconds or starts one within the next t seconds. Otherwise, the messages would overlap and lost. Thus, a space of 2t seconds is needed for each message;
- the probability P that a device's message transmission was successful (experienced no collision), i.e. zero messages were transmitted during a time interval 2t is $P = P(0)_{u=2t} = e^{-2\lambda t} = e^{-2\rho}$, where $\rho = \lambda t$ is normalized total traffic expressed as a fraction of the channel capacity.

US915 Estimation

If the message size L = 22 bytes = 176 bits (10 bytes per frame + 12byte protocol & security overhead), then capacity could be expressed as shown in a table:

Quality	DR (data rate)	R, bit/sec	Throughput, msg/second	Throughput, msg/hour
30% PRR (Q < e −1 ≈ 37%)	0	7 808	8	29377
	1	14 056	14	52884
	2	25 000	26	94060
	3	43 744	45	164582
	4	12 500	13	47030
80% PRR (Q > e −1 ≈ 37%)	0	7 808	4	14255
	1	14 056	7	25662
	2	25 000	12	45643
	3	43 744	22	79864
	4	12 500	6	22821

EU868 Estimation

If the message size L = 22 bytes = 176 bits (10 bytes per frame + 12byte protocol & security overhead), then capacity could be expressed as shown in a table:

Quality	DR (data rate)	R, bit/sec	Throughput, msg/second	Thruoghput, msg/hour
80% PRR	0	2 000	2	7 303
	1	3 520	4	12 853
	2	7 840	8	28 627
	3	14 080	14	51 412
	4	25 000	25	91 286
	5	43 760	44	159 787
	6	11 000	11	40 166
	7	50 000	51	182 572
80% PRR	0	2 000	4	15 050
	1	3 520	7	26 487
	2	7 840	16	58 994
	3	14 080	29	105 949
	4	25 000	52	188 120
	5	43 760	91	329 285
	6	11 000	23	82 773
	7	50 000	105	376 240

Installation

Powering the gateway up

The gateway will automatically turn on after inserting a PoE cable into the RJ45 connector. It will take some time (<1 minute) before indication appears on a connector. Note, indication on the connector is not a classic Ethernet indication.

Mounting on pole

Warning!

- If you prepare Ethernet cable first, do not forget the rubber protective cover
- Prepare Ethernet connection and mounting place before installation
- Select mounting point wisely

Check installation point:

- Antenna should be installed on top of the building/tower. There should not be any buildings or other obstacles which restricts the antenna's field of view. Good examples are tall, standalone buildings.
- Antennas should be mounted on top of a pole, otherwise, antenna will be shadowed by the pole.
- If mounting pole is used to hold other equipment, this equipment should be mounted under the antenna.
- These objects should be as far away as possible from the mounted antenna:
    - big, heavy construction made from metal
    - vertical constructions with a large surface area made from concrete or metal (ex. wall or roof)

Mounting pole should be made of metal and should be grounded.

Follow the following instructions:
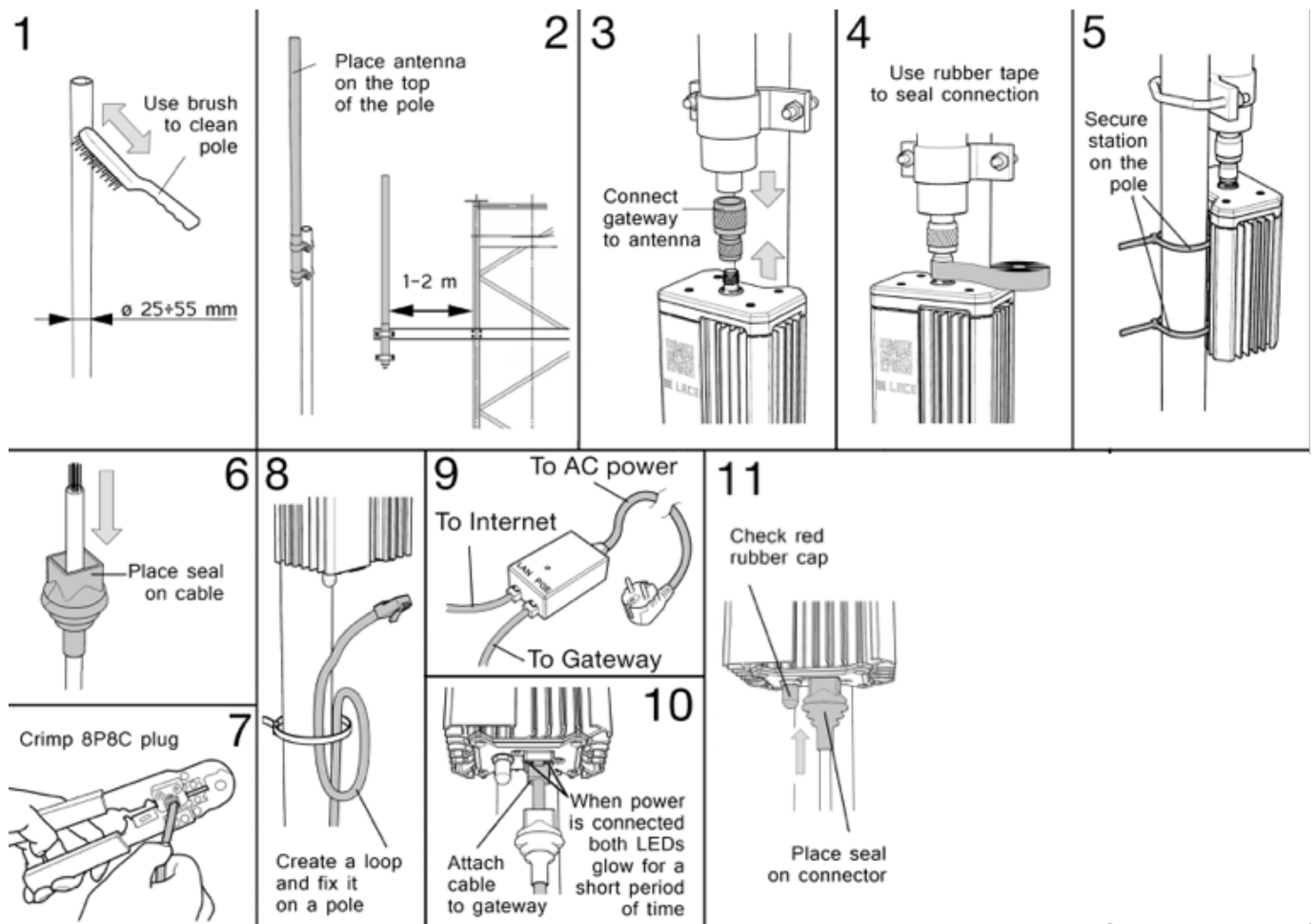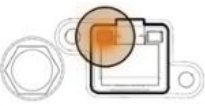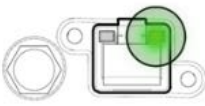
Check connection

The gateway can be in two different states: normal operation and recovery. Recovery mode is used during software updates or «kernel panic» mode. Please check state indication after gateway installation.

Normal mode - **BOTH** LEDs work

Normal mode				
Mobile	Ethernet	GPS fix		
OK	OK	OK		
OK	FAIL	OK		
FAIL	OK	OK		
OK	OK	FAIL		
OK	FAIL	FAIL		
FAIL	OK	FAIL		
FAIL	FAIL	N/A		

Recovery mode - <u>ONLY ONE</u> LED work

Recovery mode		
Base station does not work		
Contact technical support		

Insert SIM card

The everynet gateways has a GSM module and can use 2G/3G backhaul as a backup. In general SIM card already installed in your GW, but if you want to change it you could follow the next steps.

Step 1. Switch off the gateway

Please make sure that gateway is switched off: the led on the Ethernet port should not be lit. If the led is lit, you should switch the gateway off. For this, you should:
- remove red cap from service connector
- close the upper contact as shown on picture below (using a paper clip for example) and wait for 5 seconds

Step 2. Remove the screws on back cover of GW and remove the cover
To remove the screw on back cover please remove 6 screws marked by the red circles in the picture below. After that, remove the cover.

Step 4. Remove SIM card and insert a new one
The location of SIM card slot is marked in the picture bellow. Please use a little push to remove SIM card and then insert it as a described on the back side of the slot.
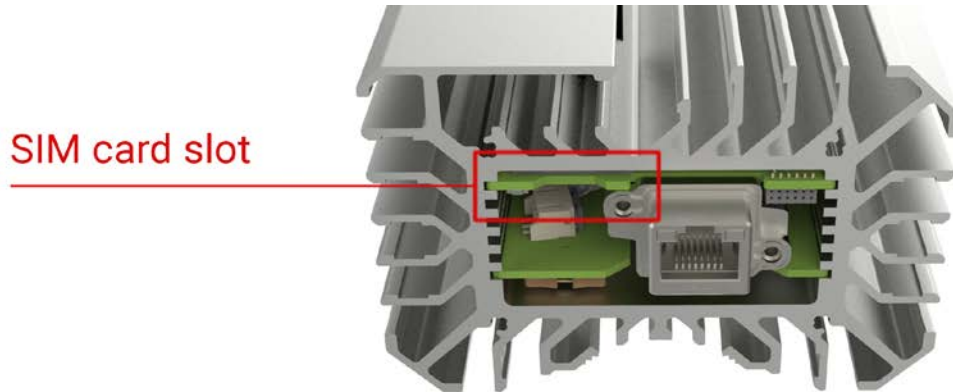

Step 5. Close the cover
Close the cover and tighten all screws back. Please make sure that the rubber gasket is not jammed and screws are tightened.

Step 6. Switch on the gateway and change APN settings
After installing a new SIM card, you will need to change the APN settings. To do this you must connect the gateway to the PoE adapter and to a wired Internet. Then you should contact to your account manager and provide APN for new SIM (this information is available from the SIM card provider). After you receive a confirmation from your account manager you can use new SIM and 2G/3G backhaul.

Turning gateway off

Because gateway is powered by internal battery, it is not possible to turn it off by removing PoE connector. To turn it off, find "switch off" contacts, like shown on image below and connect them with a paperclip or any metal object for 5 seconds. Gateway should turn off.
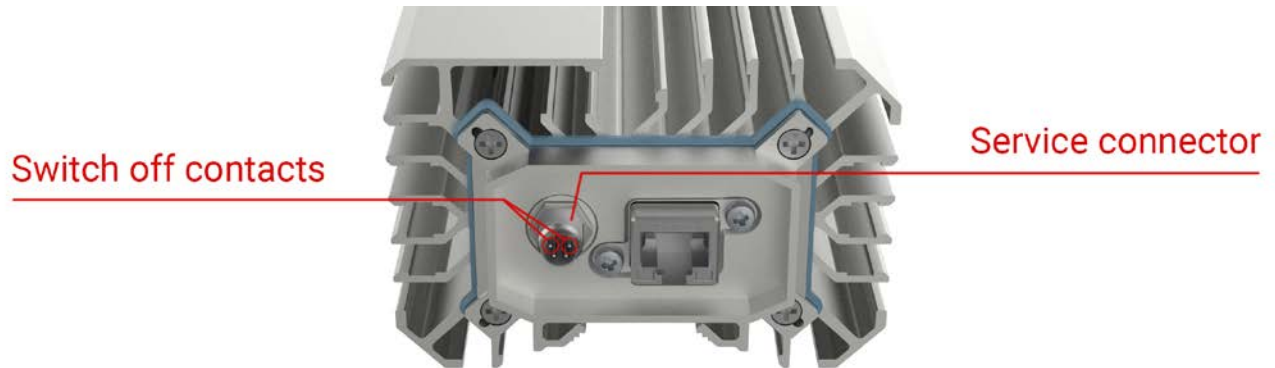
Connectivity

General information

One of the most frequent reasons of gateway outages is backhaul outage. The everynet gateway is designed to use two backhaul connections: Ethernet as a primary connection and 3G as a backup.

All everynet gateways are provisioned from the factory to connect with everynet platform, so you do not need perform any gateway configuration. All gateway traffic is encrypted and goes through a VPN connection, each gateway has own encryption keys. Major traffic types shown on image below.
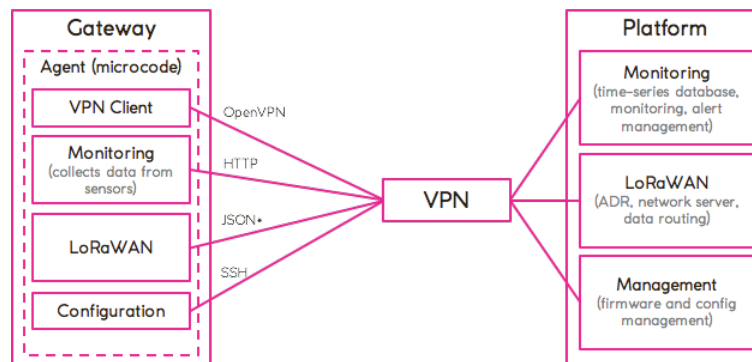
According to our statistics, gateway requirements for backhaul are quite modest:
- Minimum load, no LoRa messages it is 15Mb per 24 hours, or 1.3kbit/s.
- Maximum load, 80000 LoRa messages per hour, it is 1280 Mb per 24 hours, or 256kbit/s.

Ethernet connection requirements

Ethernet connection should be follow these requirements:
- Ethernet cable should contain all 8 wires.
- Network should provide DHCP for IP address allocation.
- Following ports should be open:
  - OpenVPN: [*.*.vpn.loran.io] 13400/UDP
  - NTP: [*.ntp.loran.io] 123/UDP
- Since we have no external IP by default, all traffic is proxying through NAT. So inbound port in this situation is random.

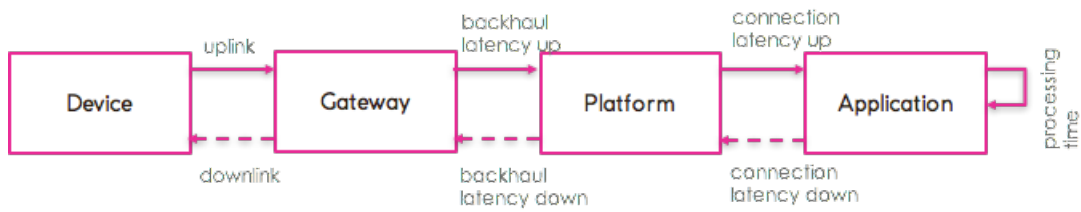## Cellular connection requirements

These are SIM-card requirements:
- Uplink: 256 kbit/s
- Downlink: 256 kbit/s
- Round-trip delay: <400ms
- Packet loss: < 5%

- SIM size is BIG

It is possible to use 3G backhaul only, but we recommend it only for PoC projects.

Time between "uplink" and "downlink" should be exactly one second according to LoRaWAN specification. This means, that maximum round-trip time should not exceed 400 ms, but the faster – the better. You should comply with requirement to use 3G as a primary backhaul.

Local console cable

It is possible to connect a UART console cable to gateway to run additional commands, which typically are not needed.

The everynet gateway is a Linux machine with advanced CLI, so it is possible to perform many operations using CLI.

Services:
- Check core availability
- Check packets statistics
- Check current connection GW using
- Check NTP synchronization status
- Check all logs: kernel, interfaces, services, etc.

Connections:
- Check VPN tunnel activity and availability
- Check Ethernet connection availability
- Check 3G connection availability
- Check if POE connected or not

Other:
- Check battery voltage and charging status
- Check sensors current values
- Check GPS parameters (FIX, satellites count, HDOP, VDOP, TIME, etc.)

Connectivity checks:
- VPN tunnel checks

- Ethernet checks (ping, link, DHCP, routes, DNS)
- 3G checks (ping, link, RSSI, SNR, IMSI, IMEI)
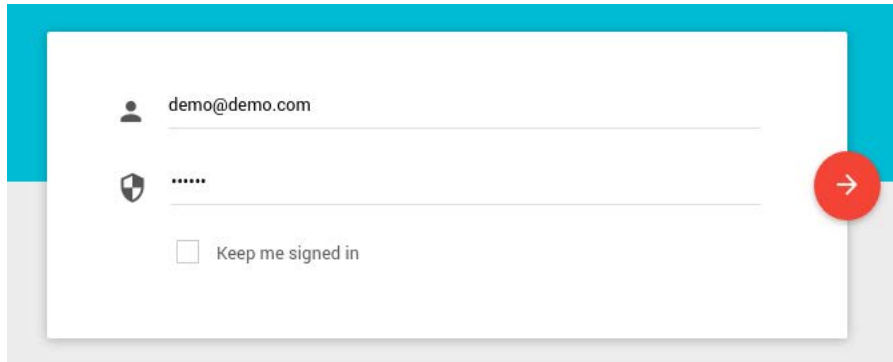

Configuration:
- Ethernet: IP, subnet, default route, DNS servers
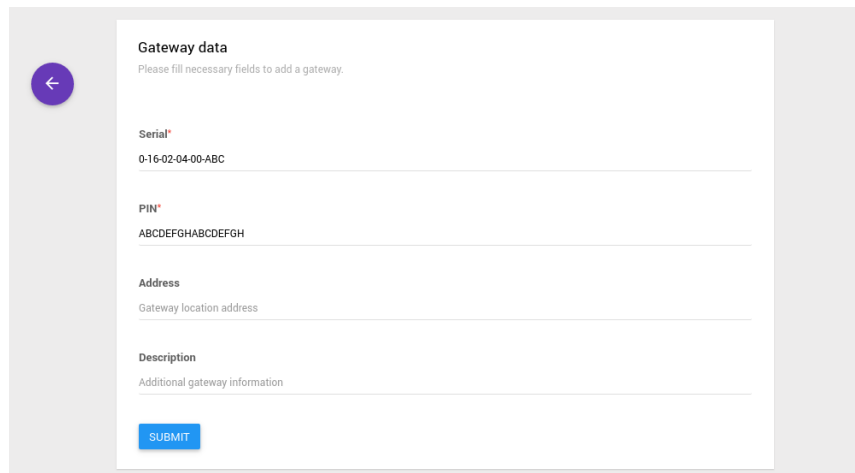- 3G: PIN, APN

Provisioning

This guide assumes that you are already registered at my.everynet.com. If you do not have an account, please contact your account manager.

1. Go to my.everynet.com
2. Log in with your username and password

3. Select "Gateway management" tab
4. Click on "Add gateway" button and select "everynet Gateway"⌷OBJ⌷
5. Enter serial number exactly as it printed on the gateway itself.   Enter pin code for this gateway, it is printed on a the outside of the gateway box. If you cannot find a gateway PIN code, please contact everynet support.

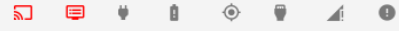6. Now the new gateway will show up in your gateway management list.

Search text

GATEWAY	ADDRESS	STATUS								
0-16-02-04-00-ABC	Manhattan, New York, NY									STATI

Health monitoring

Everynet uses a comprehensive agent capable of gathering **all possible information** the gateway can provide. The limitation is not the agent, but rather capabilities of the gateway itself.   The everynet agent can be loaded on any LoRaWAN compliant gateway. Every piece of data that is available to collect, the everynet agent collects. All gateways are in same VPN, so Everynet network server polls gateway every 30 seconds using HTTP protocol.

Gateway sensors metrics

- HW and SW versions
- GPS availability
- Humidity
- CPU temperature
- Mainboard temperature
- CPU voltage
- Main battery voltage
- PoE power status
- Charger status (charger fault)
- Presence of the battery (battery fault)

Network interface (3G (PPP), VPN, Ethernet) metrics

- Link presence (Ethernet, 3G)
- Interface availability (up/down)
- Network FIFO buffers information
- IP packets RX/TX statistics (count, bytes, errors count)
- Link speed/Packet rate
- Average and current ping time to network server

Process metrics

- Total process count
- Process count by group (running, died, …)
- Seconds CPU spent in each kernel mode (idle, iowait, …)
- Load average (5M, 10M, 15M)
- Each process uptime
- Each process total number of context switches
- Each process total number of interrupts serviced
- Total number of forks
- Number of currently runnable kernel scheduling entities
- Number of open file descriptors
- Maximum number of open file descriptors
- Number of processes blocked waiting for I/O to complete

Memory metrics

- Virtual memory size in bytes
- Resident memory size in bytes
- Total memory size
- Current memory used by kernel for different purposes (Buffers, Cached, Swapped, ...)

Storage (Filesystem) metrics

- Size in bytes
- Free space in bytes
- Space available to non-root users in bytes
- Total file nodes
- Total free file nodes

Misc

- System uptime
- System boot time
- Repeated reboot counter (to detect kernel issues)

Server-side metrics

In addition to above metrics we calculate the following gateway metrics on network server side:

- Gateway time synchronization accuracy (to detect potential downlink issues)
- Network fabric latency (to detect potential downlink issues an perform scheduling procedures)
- LoRaWAN message up/down rate per gateway/channel
- Total number of up/down messages per gateway/channel
- Gateway/Sensor time on air (do detect duty-cycle or dwell-time violation)
- Number of sensors that use this gateway for data transmission
- Cell interference level and background noise
- Min/Max/Average: data rate (spreading factor + bandwidth), PRR, RSSI, SNR