Development of Smart Energy Meter Based on LoRaWAN in Campus Area

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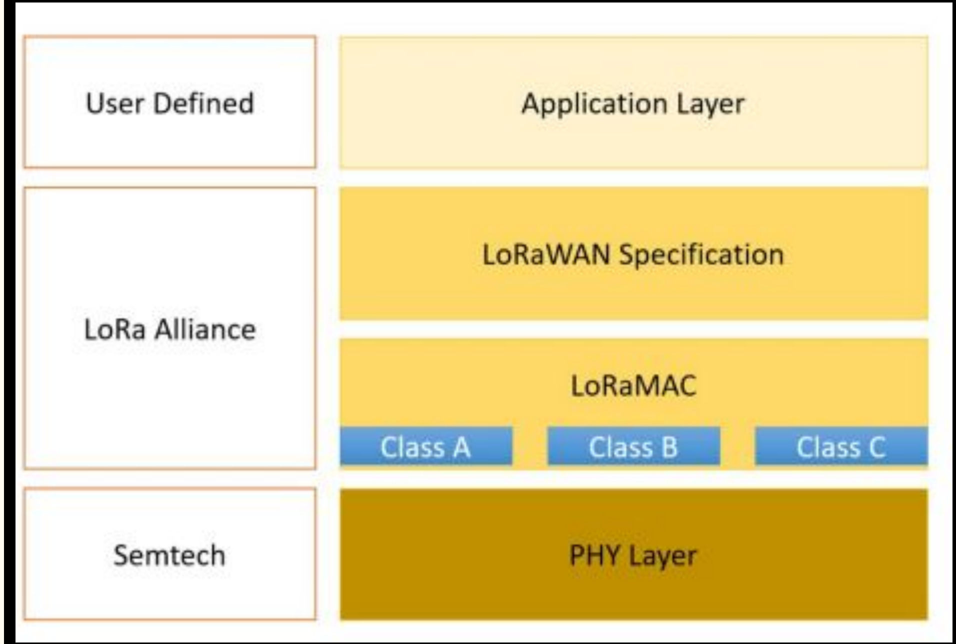
INTRODUCTION

- Smart meters will increasingly replace conventional electric meters for offering many advantages including the ability for automatic reporting and eliminating the need for staff to do the door-to-door visit to read the meter.
- LoRaWAN can be one of the key promising technologies that offer long-range connectivity compared to conventional automatic meter reading systems.
- LoRaWAN based smart energy meter was proposed to monitor the energy consumption in campus area.
- Some of the advantages include its semi open-source characteristic, allowing high flexibility in system development compared to the use of other LPWA technologies.
- Developers have a direct access to most of the technologies used inside the LoRaWAN and are free to build their own infrastructure

LoRaWAN communication protocol

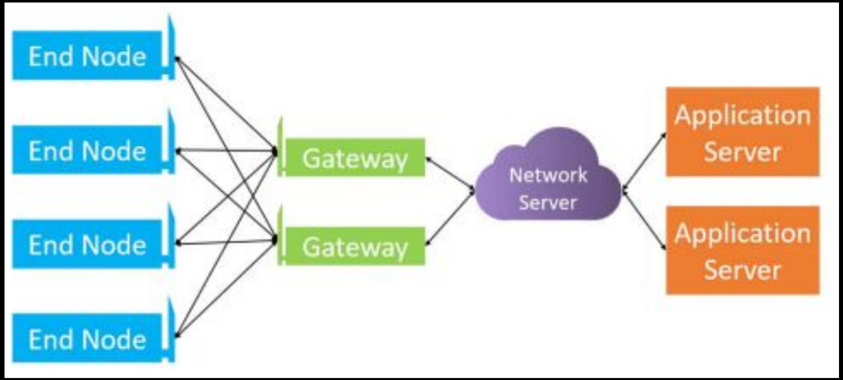
- Long Range (LoRa) is the Physical Layer (PHY) including wireless modulation technology

- Three device classes are defined by LoRa Alliance: class A, class B and class C for power consumption plans and latency trade-off. Class A has low power consumption with trade off high latency, which is suitable for battery powered IoT devices.



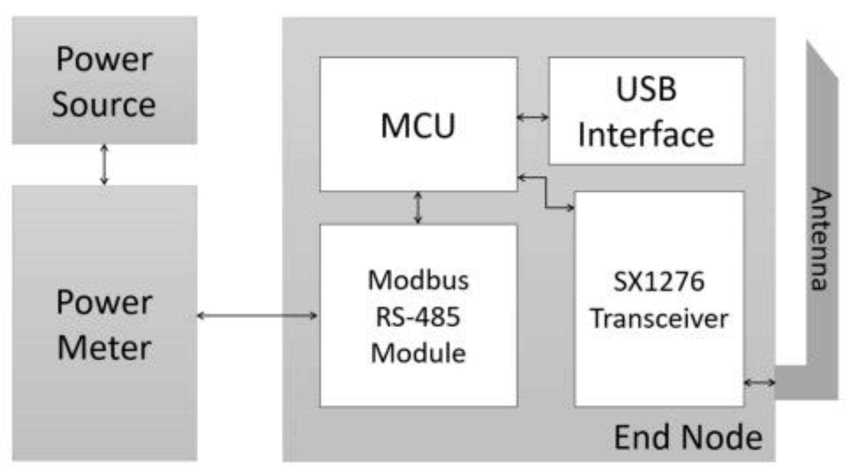
LoRaWAN basic architecture

- The end node could be in form a sensor device, actuator device, or a combination of both that transmit and receive the data to/from gateway.
- Gateway works as a data bridge between the network server and end node
- The network server has a responsibility to handle several processes, including data decrypting and payload decoding, and provides the MQTT broker as a medium for data exchange between the gateway and application server
- Application server displays data to end users



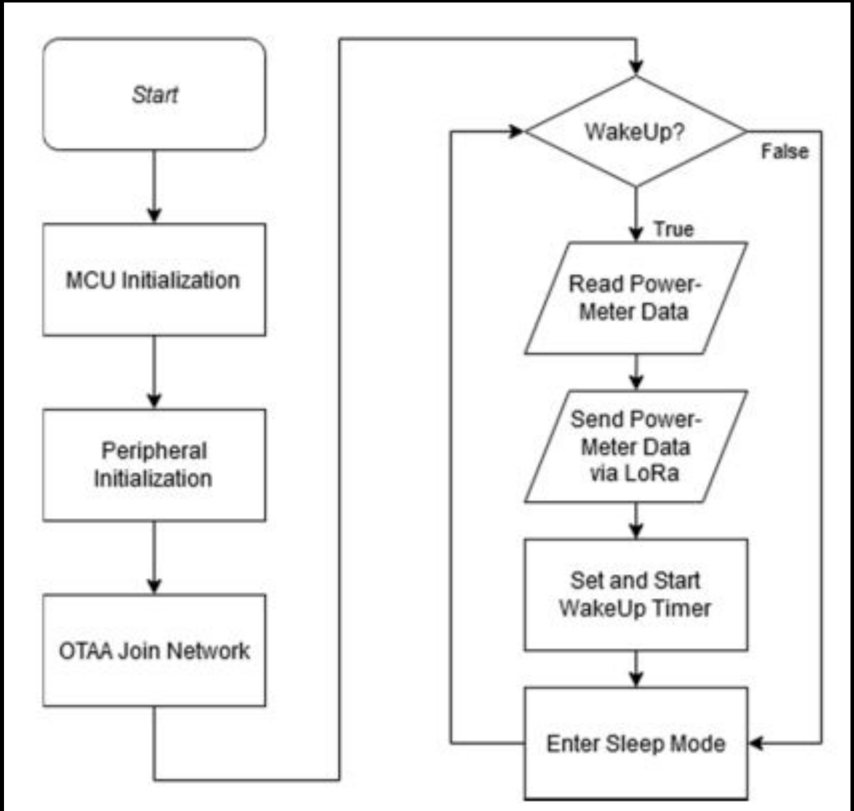
Block diagram of proposed LoRaWAN-based smart energy meter

- The MCU communicates with the Modbus RS-485 module and the USB interface using UART communication, while the communication to the SX1276 is carried out using SPI, interrupt pin, and general-purpose input/output (GPIO) pin.
- The Modbus RS-485 module is connected to the existing power meter using RS-485 serial communication.



Flowchart of proposed LoRaWAN-based smart energy meter

- The firmware is designed to use the LoRaWAN Class A where the activity flow is shown in Fig
- The end node transmits 30 bytes of payload in every 30 minutes.



EXPERIMENT SCENARIOS AND RESULTS

Field Test I

- The first scenario is to investigate the mapping of LoRa signal and observe the LoRa signal range in campus area.
- There are hundred of data collection points. For each point, three packets are sent by the device with height of 1.5m above the ground level.
- The minimum received RSSI, minimum received SNR, and the maximum range in campus area are -107 dBm, -16.5 dB, 1.242 km, respectively.

Field Test II

- The second scenario is to investigate the LoRa performance under the different antenna parameters.
- Two LoRaWAN nodes are placed at a height of about 3 meters above ground level in urban areas,
- While the gateway is placed inside a building with a height of approximately 5 meters above ground level.
- The data are observed from September 4, 2020 to September 7, 2020.

Field Test I

The gateway is installed on the top of the pole located at the rooftop of the Department of Electrical Engineering and Information Technology UGM at altitude of 40 m above ground level.The figure shows the node locations for packet transmission around campus area. The gateway location is shown by red star.

Field Test I

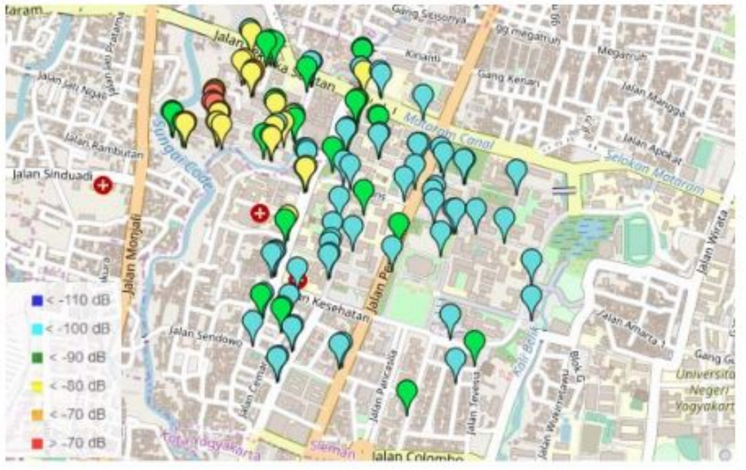
The experiment is carried out by setting the node parameters as described to observe

- The farthest distance of the node can successfully transmit a packet to the gateway
- The minimum RSSI that the gateway can decode
- The minimum SNR the gateway can decode
- SNR mapping of nodes within the gateway range
- RSSI mapping of nodes within the gateway range

Parameter	Value
Antenna Type	Omnidirectional
Antenna Gain	3 dBi
Antenna VSWR at 923 MHz	1.141
Spreading Factor	10
Transmit Power	14 dBm
Payload Size	1 Byte
Frequency Plan	AS923 (920-923 MHz)

Field Test I-Results

RSSI mapping of received packets



SNR mapping of received packets

Field Test I-Results

Parameter	Value
Packet transmitted	300 packets
Packet received	125 packets
Packet delivery ratio	0.416
Maximum received RSSI	-66 dBm
Minimum received RSSI	-107 dBm
Maximum received SNR	13.8 dB
Minimum received SNR	-16.5 dB
Maximum range	1.242 km

Field Test II

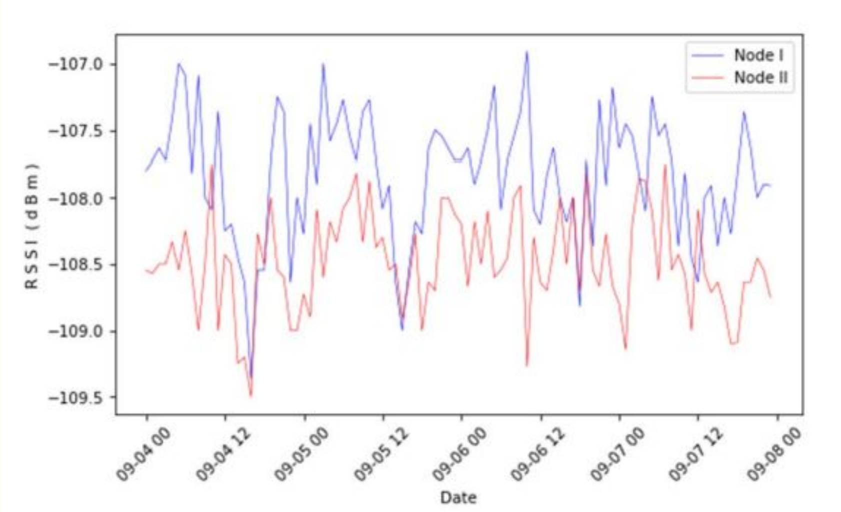
This field test aims to observe the following points:

- How different antenna parameters affect the received RSSI and SNR
- How different antenna parameters affect the packet loss ratio

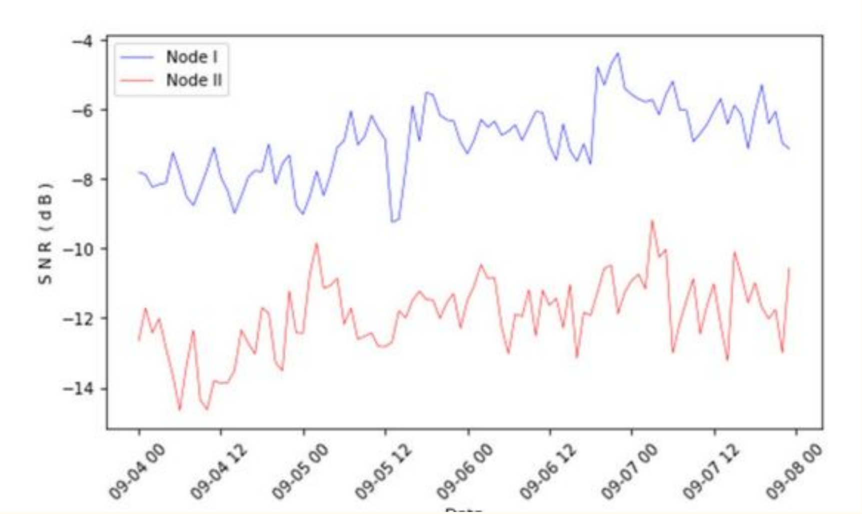
PARAMETER	NODE II	NODE I
Antenna Type	Omnidirectional	Omnidirectional
Antenna Gain	5 dBi	2.15 dBi
VSWR at 923 MHz	3.182	1.507
Spreading Factor	10	10
Transmit Power	16 dBm	16 dBm

Field Test II-Results

Hourly average RSSI of the packet transmitted by nodes I and II



Hourly average SNR of the packet transmitted by nodes I and II



Field Test II-Results

	Node I	Node II
Packet Transmitted	1067	1053
Packet Received	1058	908
Packet Loss	9	145
Packet Loss Ratio	0.84 %	13.77 %
Packet Received SNR Avg	-6.91 dB	-11.84 dB
Packet Received SNR Std	1.62	1.98
Packet Received RSSI Avg	-107.83 dBm	-108.48 dBm
Packet Received RSSI Std	1.21	1.18