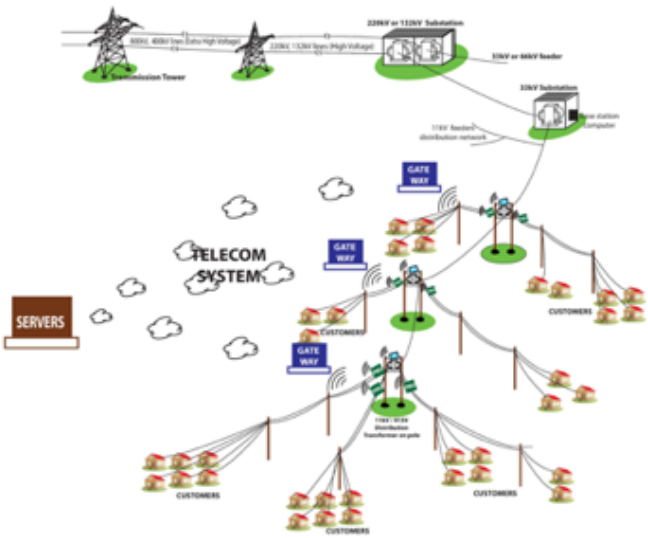
From Smart Grid to Future Marketplace

Introduction

Smart grid technologies can improve the effectiveness of the power distribution and transmission system by making it possible to use existing power infrastructure more efficiently. Implementation of smart grid solutions could for instance, represent an alternative to investment in new power generation capacity or new power lines. Smart grid technologies have also proven to reduce costs concerning generation, outages, operational costs of the transmission and distribution and as well as mitigate carbon dioxide (CO2) emissions.

Smart Grid solution integrates Load Management Units (LMUs) in the overall electricity grid management using Internet of Things technology. LuminGo has developed a fourth generation of Supervisory Control and Data Acquisition (SCADA) system to monitor and control low voltage lines of the electricity distribution infrastructure through mesh and telecommunication networks. The hardware and software architectures are designed to safely and reliably monitor and control the operations over large electrical networks in urban and rural areas.

However, Smart Grid technology has also raised various security issues which will be a growing concern. Physical attacks, cyber-attacks or natural disasters are major notable form of threats to Smart Grid deployment which could lead to infrastructural failure, blackouts, energy theft, customer privacy breach, endangered safety of operating personnel… The Block Chain has the potential to improve the security of Smart Grid.



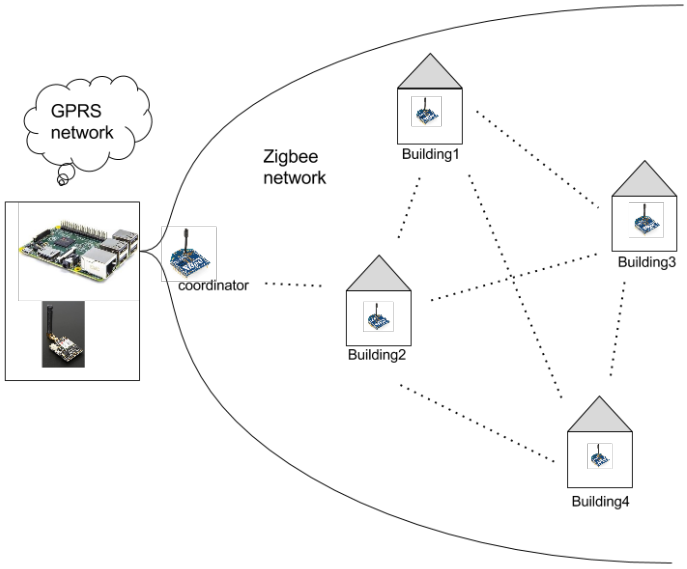
The System

The system uses embedded software algorithms and advanced P2P communication protocols to enable each LMU to communicate not only with the central cloud, but also directly with nearby LMUs. The Gateways are integrated in the telecommunication network and are sending and receiving information to a cloud service.

The LMUs, installed at junctions on the lines, analyse power quality on the low voltage lines and control contactors. Thanks to distributed intelligence, they can instantly detect faults, protect the main grid from short circuiting, report, locate and solve the faults.

The system architecture is divided as follow:

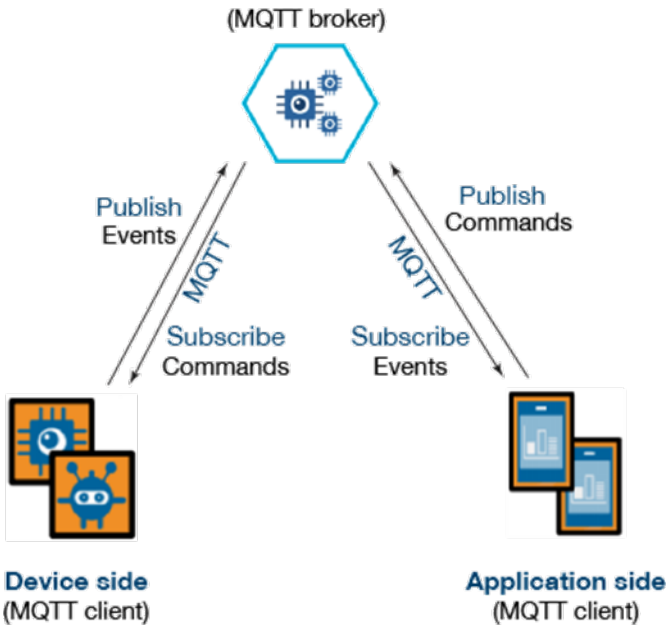
1. The LMUs located on poles at specific junctions consist of low-power digital radio devices, different sensors and contactors. The wireless mesh network collects data from multiple terminals using specific protocol and wireless mesh modules with a range of 750m line of sight. Adding new nodes to the network is simplified and the network remain reliable even when some nodes fails to work. The figure below illustrates the wireless mesh network and the communication with the gateway.



2. The LMUs send their collected data to the gateway through the mesh network. This data is received by the coordinator. The central gateway collects the data from the coordinator node of the mesh network through a UART interface. The gateway is equipped with 3G/4G connection module.

3. The gateway aggregates all the data it receives using the differing LMU IDs. It waits until all the LMUs in the system have data attached to them, then sends this information to:
    a. a Real-time Database for long-term storage.
    b. a Cloud service allows the sensors to send the data and store it with the time stamp in the database. Based on application requirements, the actuator messages can be triggered to the end terminals.

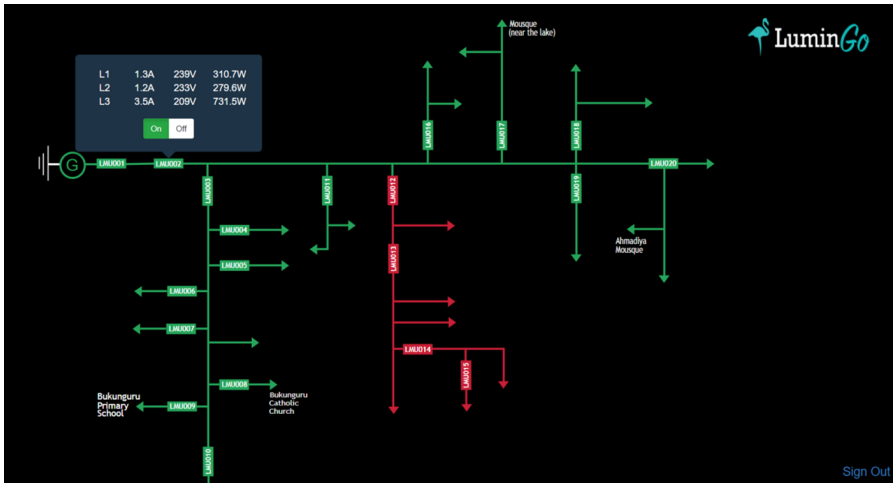
    Data is sent via MQTT (Message Queue Telemetry Transport), a simple, light weight, publish/subscribe messaging protocol. MQTT protocol is ideal for constrained networks with low bandwidth, high latency, data limits and fragile connection. The figure below illustrates the device side and application side with subscription nodes which communicate to the MQTT broker, instantiated in the cloud instance.



The gateway will subscribe and once it is authenticated, it will start publishing the data as "Events" and listening to the commands from the broker. It will send the sensor values periodically according to the user configured time.

4. The Cloud service receives data in real-time and sends it to a web application where data is available in a dynamic user interface.

5. The Data stored in the database is logged and available for performance evaluation.



Block Chain technology

The electricity market is characterized by a growing number of renewable energies. Depending on the meteorological conditions, generation plants that generate their electricity from wind, sun and water are running at high or low energy generation levels. At the same time, customers are requesting more flexibility and access to a wider range of services on offer at anytime. By integrating a private blockchain in the grid control and monitoring, we can create a new level of engagement with consumers. The system increases trust and enables consumers to become prosumers and active participants in the electricity market. The system covers the energy data from the start to the end

point in the energy supply system and create a previously unknown transparency and control option in the energy market.

By making the energy data fully transparent and publicly accessible, Block Chain technology can bring full transparency to the Energy Market. Wind power, solar and biogas plants can provide renewable electricity over neighbourhood grids and make available locally produced and supplied electricity for flexible customers. The generating plants are equipped with block chain technology. Every kilowatt hour (kWh) that is generated is recorded in our decentralised, private register with a unique registration code. Consumers increasingly want to know that the ethical claims companies make about their services are real. Distributed ledger and blockchain technology provide an easy way to certify that the stories of the things we buy are genuine. Transparency comes with blockchain-based timestamping of a date and location, for renewable energy this corresponds to an identification number for each and every kWh that is generated and transmitted over the blockchain.

An “electricity wallet” software provides the customer with transparent information of each kWh of electricity that is consumed - every unit of electricity can be traced down to where it is produced whether it is renewable energy or whether it originates from a nuclear power plant for instance. The electricity customers can choose from which generation plant they want to be supplied. Customer preferences are noted in a Smart Contract and thereafter executed on automatically to guarantee supply with electrical energy from the preferred energy generation plant. The delivery is verified by transferring the coded kilowatt hour to the customer's energy wallet. Thus, blockchain technology enables the buying and selling of the renewable energy generated in the neighborhood microgrids. For instance when your neighbours solar panels make excess energy, blockchain based Smart Contracts automatically redistribute it to a customer nearby who is willing to buy local and clean energy generated from the sun.

Moreover, Block Chain will improve data security for the following reasons:

- Block Chain is decentralized. Instead of storing data in a single location, Block Chain breaks everything into small chunks and distributes them across the entire network.
- Block Chain offers encryption and validation. Everything that occurs on the Block Chain is encrypted and it’s possible to prove that data has not been altered.
- Block Chain is virtually impossible to hack. The data is decentralized, encrypted, and cross-checked by the whole network. Once a record is on the ledger, it’s almost impossible to alter or remove without it being noticed and invalidating the signature.
- The private Block Chain can restrict access to specific users. Anyone accessing the private Block Chain will have to authenticate their identity to gain access privileges and can be restricted to specific transactions.

THE USER GROUPS

The flexible Electricity Market System is based on peer-to-peer system for data input from individual meters at generation units, monitoring and control systems in the distribution grid and End-User platform sending and receiving information over the private Block Chain for increased transparency and accountability.

Grid companies: The electricity companies own and run the grid and are responsible for transporting the electricity from production sites to the users. The Block Chain can help these companies to interact more efficiently with their consumers. For instance, the grid operator has new possibilities to manage the grid by providing incentive to individual customers that benefit the network as a whole during heavy use of the network infrastructure.

Electricity users: An end-user platform creates interaction and awareness. The software provides the customer with transparent information on the origin of each kWh of electricity and give the customer the possibility to choose from which generation plant he/she wants to be supplied. The platform will link the electricity customers to the LMUs via mobile technology and will provide them with information regarding service reliability, power quality, etc. The software provides an efficient interface between consumers and power providers - effectively the software facilitates demand response activity and builds trust and interest among customers in managing energy consumption in a more inclusive and resilient manner.

Electricity producers: Producers can choose whether the electricity they generate is to be sold to electricity traders or users, sold via the electricity market or used for their own purposes.