Ensuring Uninterrupted Utility Communications: Leveraging LoRa for Resilient Data Transmission

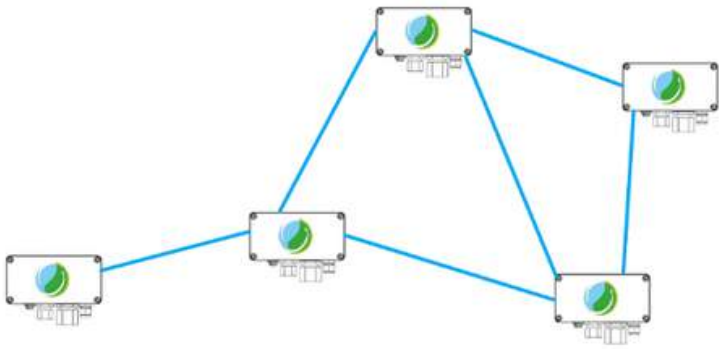
INTRODUCTION

As the demand for reliable, efficient, and long-term communication systems in the growing utility sector, Edge has integrated Long Range (LoRa) Mesh technology alongside traditional cellular communication protocols. LoRa offers a low-power, long-range communication option that is ideal for IoT applications, including energy, smart cities, agriculture and industrial systems. Notably, LoRa's ability to maintain communication over distances up to extended miles in rural areas and several miles in urban environments provides a significant advantage when 4G cellular connectivity is compromised. By incorporating LoRa Mesh into Edge's Grid Data Logger utility sensor, alongside 4G communications, the system ensures highly reliable data transmission through a robust, self-healing mesh network. This dual-mode approach enhances the robustness of utility communication systems, optimizes operational efficiency and reduces costs.

THE NETWORK

LoRa Mesh offers unique benefits to users of the Edge Zero low voltage (LV) network monitoring solution, as it builds a self-organizing and self-healing communications network.

Example of an Edge Zero LoRa Mesh Nework



The LoRa Mesh is a self-forming, or self-healing, wireless network in which each device, or "node," broadcasts its routing map once every minute to enable regular updating across the network. This means. that newly discovered nodes can be added or inactive nodes can be removed in real time.

DEFINING LORA

LoRaWAN is a centralized network architecture in which each LoRa device communicates directly with a gateway. These gateways relay the data to a central network server. This topology is highly suitable for large-scale IoT deployments, providing robust management and scalability through centralized control.

LoRa Mesh is a decentralized network in which devices communicate directly with each other, forming a self-organizing and self-healing mesh. This allows data to be relayed over longer distances by hopping through neighboring nodes, enhancing the network's range and resilience without relying on a centralized gateway.

FACTORS AFFECTING DATA TRANSMISSION THROUGH LORA

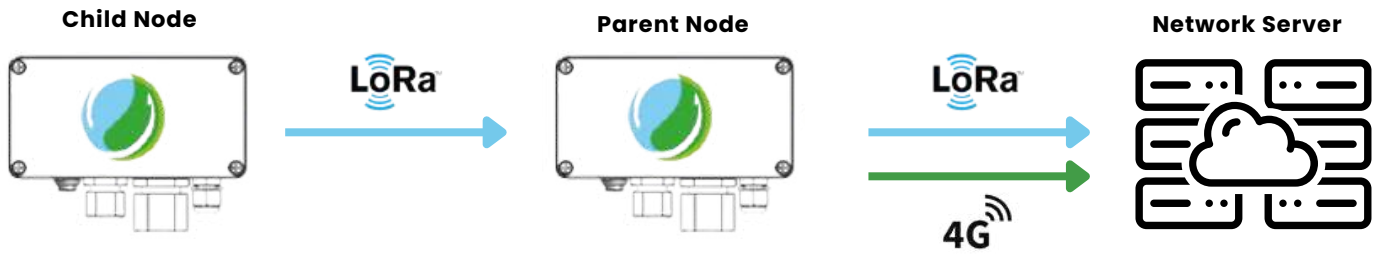
Understanding the factors that influence data transmission through LoRa is crucial for optimizing performance and reliability. By examining the factors below, utility companies can better design and implement sensor networks that leverage the strengths of LoRa technology.

- **Received Signal Strength Indicator (RSSI)** — A measure of the power level that a wireless device receives from a signal. The closer the value to 0 dBm is, the stronger the signal.
- **Distance Between Antennas** — Longer distances weaken a signal from one antenna to another.
- **Obstruction in the Signal Path** — Trees, buildings and other structures that directly block line-of-sight propagation can also block and weaken a signal's strength.
- **Number of Nodes** — The number of nodes connecting to a single node affects the RSSI of every other node in the mesh. The more child nodes, the worse the RSSI.

A 'BOTH/AND' SOLUTION

The EdgeSensor (600 Series) sensor has two modes of communication: 4G and LoRa. 4G is the primary mode for sending data to the cloud. If 4G loses communication, after 2 minutes, LoRa will take over communications. Leveraging a LoRa Mesh architecture, the unit in question will act as a child node. The child node will establish a connection with a different EdgeSensor unit that has access to 4G. This unit is denoted as the Parent node and will relay the child node's data to the cloud.

EdgeSensor (600 Series) LoRa Communications



During LoRa Mesh transmission, the cloud communications algorithm continuously tries to recover from the 4G communications loss until the Datagram Transport Layer Security (DTLS) link is re-established. At this point, the unit will return the communication path to 4G as the primary link.

LORA MESH DIAGNOSTICS

The Edge Zero platform enables out-of-the-box diagnostics so that utility personnel can understand the system's communications performance. Each device queues an "offline" event (type 35) when 4G is offline, sends "signal" status (tag 122) via LoRa mesh, and after 4G recovery, resends signal status with LTE info. Configurable status reports are enabled by default.

LORA ROUTE SELECTION

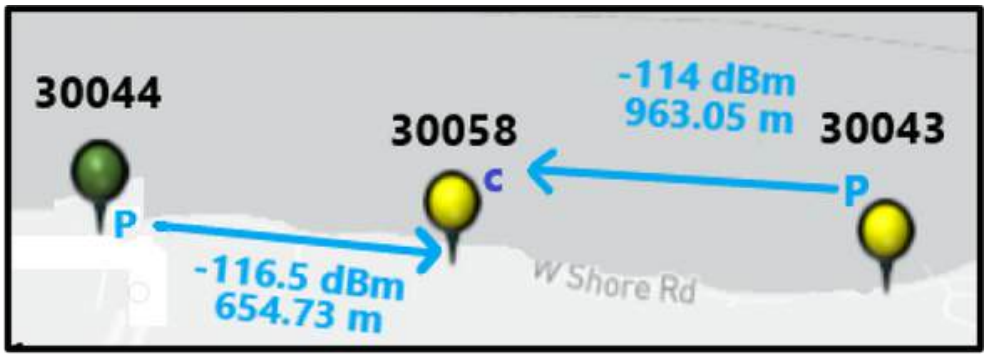
The device selects a 4G relay node based on proximity and Received Signal Strength Indicator (RSSI), choosing the nearest node with the highest signal. The system also avoids redundant database records and changes nodes only after 3 minutes of no confirmation.

CASE STUDY: VERMONT ELECTRIC COOPERATIVE'S IMPLEMENTATION OF LORA TECHNOLOGY

The practical application of LoRa technology in utility networks can be clearly illustrated through the experience of Vermont Electric Cooperative (VEC). In June 2024, data from a specific EdgeSensor revealed instances where 4G connectivity was unavailable, triggering the activation of LoRa communications. This scenario provided an opportunity to observe LoRa's effectiveness in maintaining data transmission continuity. The unit successfully utilized mesh networking, relaying its data through two Parent nodes. This real-life example underscores the robustness and reliability of LoRa technology in real-world conditions, highlighting its value as a complementary communication protocol in utility operations.

LORA MESH SETUP

- The indicators below represent the sensors deployed on distribution transformers. The colors of the indicators reflect current load statuses.
- The "P" indicates a Parent unit or an EdgeSensor unit that has cellular communications active.
- The "c" indicates a Child unit, one that no longer can communicate via cellular and has switched over to LoRa.



Distance to Parent Unit: The Child unit is 654 m and 963 m (0.4 and 0.6 miles, respectively) away from the two nearest Parent units.

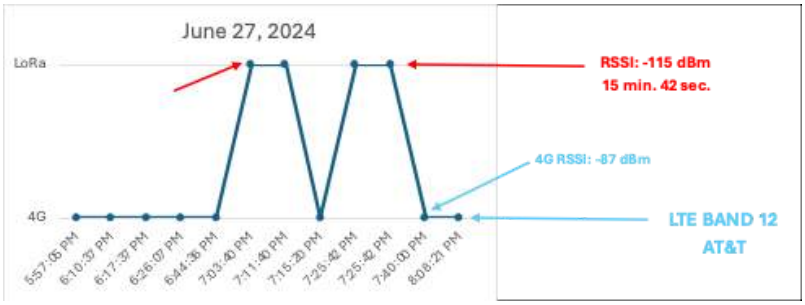
LORA IN ACTION

The Child unit within VEC's network experienced a disruption in its primary 4G cellular communication. During certain periods, the unit could not establish or maintain a 4G connection, potentially due to signal interference, network congestion, or geographical challenges. When the 4G connectivity was lost, the system seamlessly transitioned to using LoRa communications. The Child unit employed a mesh networking approach, identifying and connecting to nearby Parent nodes within its range. These Parent nodes, which still had access to 4G connectivity, acted as relays. The Child unit transmitted its data to the first Parent node, which then forwarded the data to a second Parent node.

RESULTS

The mesh network transmission ensured that all data reached the network server, maintaining the integrity and continuity of communication despite the initial cellular disruption. This process demonstrated the resilience of LoRa technology alongside cellular communications and its critical role in ensuring uninterrupted data flow within utility networks.

The strategic integration of LoRa with 4G in Edge Zero's EdgeSensor embodies a forward-thinking approach to modern utility challenges. Embracing this technology is a necessity for utilities aiming to lead in an increasingly interconnected and dynamic world.



LoRa Mesh and 4G Over Time: The graph indicates the time transition of the unit from 4G to LoRa or LoRa to 4G. This algorithm allows the unit to quickly route the best path for the data to reach Edge server.

edgezero.co
hello@edgezero.co