Installation Guide:
Oregon Hazelnut Farm

1.0 Introduction

This document provides detailed installation guidelines for E2E telemetry solution. This solution focuses on aggregation of various sensor data from remote edge nodes to a centralized gateway using low power long range wireless technology and reliable communication of data to cloud. This is achieved by creating a private star network using unlicensed radio spectrum in the Industrial, Scientific and Medical (ISM) bands on south bound interface and traditional communication technologies like cellular/satellite for north bound interface which is highly scalable and cost efficient. This document also provides detailed steps followed in the pilot installation of the solution on a hazelnut orchard at Hillsboro, Oregon. The pilot installation focused on remote soil moisture, temperature and onsite weather data monitoring.

1.1 Terminology

Table 1. Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoT</td>
<td>Internet of Things</td>
</tr>
<tr>
<td>ZTD</td>
<td>Zero-Touch Deployment</td>
</tr>
<tr>
<td>PoC</td>
<td>Proof of Concept</td>
</tr>
<tr>
<td>PoE</td>
<td>Power over Ethernet</td>
</tr>
</tbody>
</table>

2.0 General Installation Practices

This section describes the general installation practices for the Orchard Canyon solution and could be extrapolated for different installations.

The installation consists of three main components sensors, sensor hubs and gateway. For sensor hub placement, basic survey has to be performed to identify locations within the field for optimal signal strength of the wireless communication. The sensor hub placement should cause minimum destruction to installation site. It is important to choose sensor hub enclosure design based on the physical requirements on the installation site. For example, in agricultural fields, it might be required to remove and re-install the sensor hub based on the crop growing cycle. The elevation and terrain of
the land might affect the number of sensor hubs required for the installation. The gateway should be placed in a location with regulated AC power source. It is recommended to use voltage stabilizer to protect the gateway from any kind of power surges. The sensor hub and gateway components should be provided with air vents and enclosures to prevent condensation.

3.0 On-Site Orchard Canyon Solution Installation Example

The installation at Hillsboro, Oregon involved aggregation of data from different sensors installed on the farm via central gateway to cloud.

Orchard Canyon end to end installation consisted of the following

- Installation of Gateway, and Cellular Modem.
- Installation of LoRa Antenna for the gateway.
- Installation of Sensors and Sensor hubs.

Four sensor hubs were installed at four different locations. Sensor hub 2 and 3 were installed at a distance 0.1 mile from the Gateway, sensor hub 1 and 5 were installed at a distance 0.5 mile from the Gateway

*Figure 1 Hillsboro Deployment*
The solution was installed in a Hazelnut orchard. Sensor hub 2 and 3 were planted on rows consisting of new plantation and sensor hub 1 and 5 were planted in rows consisting of 3 to 4 year old trees. Refer Figure 3 for sensor hubs installed on field.

3.1 Gateway Placement

The gateway was placed at the barn. The barn was selected for gateway placement as it
was in line-of-sight with the sensor hubs for LoRa communication and also provided power supply and access to the roof for antenna placement. Figure 4 shows the gateway and antenna installed at the barn.

*Figure 4 Gateway and Antenna installed at the Barn*

The Gateway is powered using PoE adapter. For internet connectivity, the gateway is connected to Cellular Modem. Cellular antenna was connected to cellular Modem’s SMA port for better connectivity.

The Gateway has IP67 rated enclosure hence it does not need any additional outer enclosure. Refer section 3.1.1 for gateway lora antenna installation. The other components cellular modem, Ethernet switch, UPS power strip, weather station base receiver and base station display are placed inside separate enclosure for weather protection.

Refer Figure 13 from left to right, the first enclosure contains Cellular Modem, Ethernet hub and weather station display. The second enclosure consists of UPS Power strip. The third enclosure contains PoE Adapter for the Gateway and the Weather station base receiver. Refer Figure 5 for connecting the data cable and power cable to the gateway. The power cable (black cable) is connected to the gateway and the data cable is connected to the Ethernet switch.
110 AC power was fed into the enclosure to the UPS power strip in the middle enclosure. Refer Figure 6 for the power source from Barn. Each enclosure had PVC connection between them to reduce separate penetrations for each cable and to minimize the holes required in each enclosure. The PVC allows for upgrades and updates of the equipment making it far easier because none of the changes interfere with the moisture barriers. In addition, using PVC between enclosures reduces the requirements of the individual cables so that they do not need to be external, UV rated cables as they are free from environmental exposure. The Gateway is connected with two LoRa Antennas connected to n-type female port of the gateway. Refer Figure 12 for gateway installation with LoRa antennas.
3.1.1 Gateway Antenna Placement

*Figure 7 LoRa Antenna Ports*

![LoRa Antenna Ports](image)

The LoRa antenna for the gateway is placed at the roof of the barn for better signal reception. The Antenna must be installed away from metal. Refer Figure 4 for antenna installation.

3.2 Sensor Hub Placement and Sensor Installation

3.2.1 Sensor Hub Placement

*Figure 8 Sensor Hub Installation*

![Sensor Hub Installation](image)

Each sensor hub consisted of 3 soil moisture sensors and one soil temperature sensor. Figure 8 shows soil moisture sensor installed at the orchard. The orchard and the terrain were analyzed carefully before installing the actual sensors and sensor Hub. Sensor Hub 1 and 3 were installed amidst new plantation while sensor hubs 5 and 1 were installed further away in fully grown trees. The antenna on the sensor hub measures 26 inches from ground. Each sensor hub is supported with PVC pipe to provide visibility.
and protect it from farm tools during plowing and harvesting. The sensor hub is powered using 3.6V Lithium Battery. Refer Figure 9 for fixing battery on the sensor hub. The battery could last long for 2 years and does not require frequent replacements. In addition to the screws, the sensor hub was sealed with tape on all four sides and a small hole made at the bottom to prevent moisture inside sensor hub.

**Figure 9 Sensor Hub Case Open, Showing Battery**

![Sensor Hub Case Open, Showing Battery](image)

### 3.2.2 Sensor Installation

**Figure 10 Sensor Hubs and Sensors Mounted, Ready for Installation**

![Sensor Hubs and Sensors Mounted, Ready for Installation](image)
The soil temperature sensors are attached to the black cables coiled in the center of the photo. The soil moisture sensors are green and white, attached to the green and white cables coiled at the bottom of the photo. Each is shown in more detail in Figure 11.

**Figure 11 Soil Moisture Sensor (left), Soil Temperature Sensor (right)**

The battery, purple, is visible. It is shown in more detail in Figure 9.

The soil moisture sensors were soaked for 24 hours prior installing in the field. The 3 soil sensors of each hub were installed at 1, 2 and 3 feet depths respectively. The recommended installation included replacing the removed soil as slurry. The soil temperature was installed at 1 feet depth to measure soil temperature.

### 3.3 Weather Station Installation

The weather station Kit contains sensors to measure temperature, humidity, pressure, rain, UV, solar radiation and wind speed. The sensors communicate using RF with weather station base receiver. The weather station display and base receiver are in the same physical enclosure as the Ethernet hub and POE adapter as part of gateway installation as shown in Figure 13.
The location for the weather station sensors was chosen closer so that they are within the transmit range of the weather station base receiver. The temperature and humidity sensors were installed in the same physical enclosure as the PoE Adapter.

3.4 Verification and validation of installation

The section covers procedures to validate if the installation was successful
3.4.1 Validation of Gateway Installation

The led status on gateway will indicate any failure in powering up the gateway. Refer Figure 14 for the led status on successfully powering the gateway. Refer section 3.1 for powering the gateway.

*Figure 14 Led Status on Gateway on successful Power on*

3.4.2 Validating data flow from sensor hub to cloud

The data flow from sensor hub to cloud can be validated by verifying Sensor Data cloud dashboard. Refer Figure 15 for successful aggregation of sensor data on the cloud dashboard.

*Figure 15 Successful aggregation of sensor data on Data Cloud*
3.4.3 Validation of weather station data to cloud

If the weather station sensors and base receiver are placed within range, the sensor data should be observed on weather station display and Sensor Data cloud dashboard. Refer Figure 17 for successful aggregation of weather station data.

Figure 17 Successful aggregation of weather station data on Sensor Data Cloud