**IoT System Component Overview and Selection Rationale**

**Considerations and Constraints**

The selection of components for the Soil Moisture IoT Prototype and the LoRa Gateway based off the following considerations and constraints:

1. **Budget Constraints:** With a $0 budget, all components must be sourced from existing supplies at the University of Western Australia, meeting requirements of the problem while balancing functionality.
2. **Compatibility**: Components are chosen for their compatibility with each other, reducing integration complexity. TTGO T-Beam, with its integrated features (LoRa, GPS, ESP32), serves as the system's core, and other components are used to build the rest of the system.
3. **Flexibility and Scalability:** Selected components are versatile and cost effective, allowing for easy swapping or upgrading if needed. For example, while capacitive soil moisture sensors are used for this current phase prototype, in future phases more precise sensors can be integrated without significant changes to system architecture.
4. **Power Management:** Critical aspect of the design requirements is low power consumption. Components like 18650 Li-ion battery and the TTGO T-Beam are selected for their ability to support long operation times with features like sleep cycles and selective activation of modules (e.g. GPS).
5. **Documentation Availability:** Each component has extensive documentation and strong community support, crucial for troubleshooting and ensuring the project’s success. This is especially important in this project where time and team member’s expertise in IoT are limited.
6. **Client Preferences:** We considered client preferences when selecting components. Consequently, we selected boards that have long range communication modules with built in power management and Soil Moisture sensors are out of scope for this phase and will be addressed in future phases by teams whose capabilities and experience are better aligned and suited for sensor selection.

**Specific Component Selection Rationale**

**1. Microcontroller: TTGO T-Beams**

* **Integrated Features:** Combines an ESP32 microcontroller with Wi-Fi, Bluetooth, LoRa communication, and a GPS module, reducing need for multiple separate components.
* **Flexibility:** Supports multiple communication protocols, allowing for easy future modifications.
* **Low Power Consumption:** Ability to enter deep sleep mode and the selective use of the GPS module and LoRa transmission power contribute to efficient power management.

**2. Soil Moisture Sensors: Capacitive Soil Moisture Sensor v2.0**

* **Compatibility:** Works well with the Analog (ADC) inputs of TTGO T-Beam.
* **Low Power Consumption:** Designed for low power operation, suitable for battery-powered systems.
* **Adequate for Prototype:** For simulating Soil Moisture reading at 3 different depths. Sufficient to showcase for feasibility testing, with option to upgrade in future phases.

**3. Battery: 18650 Li-ion Battery**

* **Capacity and Longevity:** Reliable power with sufficient capacity to maintain system operation over extended periods.
* **Rechargeable:** Ensures long-term usability without recurring costs, aligning with budget constraints and power generation components can be added in future phases e.g. Solar Power.
* **Compatibility:** Matches power requirements of the TTGO T-Beam and Components.

**4. LoRa Communication Module (Integrated with TTGO T-Beam)**

* **Integrated Communication:** LoRa module is built into TTGO T-Beam.
* **Long-Range Capability:** Ideal for transmitting data over long distances, crucial for field-based monitoring with distances up to 15km and beyond supported at the expense of power (transmission power).

**5. GPS Module (Integrated with TTGO T-Beam)**

* **Time Synchronization:** Provides accurate time-stamped data for monitoring soil moisture trends and synchronising real time clock (RTC) across different devices for duty cycles, sleep cycles and data transmission.
* **Power Efficiency:** GPS module is activated only when needed.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **System Type** | **Component Type** | **Component Make and Model** | **No. of Components** | **Total Cost** | **Voltage** | **Current** | **Libraries** | **Relevant Links** |
| Soil Moisture IoT Prototype and LoRa Gateway | Board Microcontroller, WiFi | [TTGO T-Beam v1.1](https://www.lilygo.cc/products/t-beam-v1-1-esp32-lora-module) | 2 | Available at UWA | See AXP192 datasheet for input and output ranges | See AXP192 datasheet for input and output ranges | [LilyGo Github](https://github.com/Xinyuan-LilyGO/LilyGo-LoRa-Series/blob/master/assets/image/t-beam_v1.1_pinmap.jpg)– LoRa Sender Receiver code  [TinyGPS](https://www.arduino.cc/reference/en/libraries/tinygps/) – GPS Module | [1. Pin Diagram](https://github.com/Xinyuan-LilyGO/LilyGo-LoRa-Series/blob/master/assets/image/t-beam_v1.1_pinmap.jpg)  [2. Deep Sleep](https://www.reddit.com/r/esp32/comments/movnp3/comment/hlad7wh/)  [3. Firmware](https://meshtastic.org/docs/hardware/devices/tbeam/?t-beam=1.1)  [4. Transmission Power](https://tinymicros.com/wiki/TTGO_T-Beam#Resources) |
| Soil Moisture IoT Prototype and LoRa Gateway | Battery | [18650 Samsung INR18650-30Q Battery](https://www.alldatasheet.com/datasheet-pdf/view/1131828/SAMSUNG/INR18650-30Q.html) | 2 | Available at UWA | Nominal Voltage: 3.6V | Battery Capacity: 3000mAh | [Arduino Low Power](https://www.arduino.cc/reference/en/libraries/arduino-low-power/lowpower.deepsleep/) – For Deep Sleep | N/A |
| Soil Moisture IoT Prototype and LoRa Gateway | Power Management Unit | [AXP192](https://www.alldatasheet.com/datasheet-pdf/pdf/1134496/XPOWER/AXP192.html) (Part of TTGO T-Beam) | 2 | Available at UWA | Input Voltage: 2.9V – 6.3V  Output Voltage:  3.3V – 5V | Maximum 1.2A at 3.3V | [LilyGo PMU](https://github.com/Xinyuan-LilyGO/LilyGo-LoRa-Series/tree/master/examples/PMU) – Example PMU code | N/A |
| Soil Moisture IoT Prototype | Prototyping Wires (F/M) | [Jumper Wire 20cm Ribbon (F/F, 40pcs)](https://core-electronics.com.au/solderless-breadboard-jumper-cable-wires-female-female-40-pieces.html) | 1 pack | Available at UWA | N/A | N/A | N/A | N/A |
| Soil Moisture IoT Prototype | Prototyping Wires (M/M) | [Jumper Wire 20cm Ribbon (M/F, 40pcs)](https://core-electronics.com.au/male-female-jumper-wire-40-20cm.html) | 1 pack | Available at UWA | N/A | N/A | N/A | N/A |
| Soil Moisture IoT Prototype | Prototyping Wires (M/M) | [Jumper Wire 20cm Ribbon (M/M, 40pcs)](https://core-electronics.com.au/jumper-wire-20cm-ribbon-of-40pcs.html) | 1 pack | Available at UWA | N/A | N/A | N/A | N/A |
| Soil Moisture IoT Prototype | Breadboard | [Solderless Breadboard](Professional%20Solderless%20Breadboard%20BB400%20-%20400%20tie%20points%20(Metal%20Backing%20Plate)) | 1 | Available at UWA | N/A | N/A | N/A | N/A |
| Soil Moisture IoT Prototype | Soil Moisture Sensor | [Capacitive Soil Moisture Sensor (v2.0)](https://core-electronics.com.au/capacitive-soil-moisture-sensor-v20.html) | 3 | Equivalent available at UWA | Operating Voltage: 3.3V - 5.0V | Current Consumption: 5.68mA | [Testing and Calibration](https://tutorials.probots.co.in/using-soil-moisture-sensor-capacitive-v2-0-module-for-arduino/) – Example Arduino Code | [1. Connecting to ADC](https://youtu.be/pFQaFnqpOtQ?si=VTVHsh_XowTvk_oX&t=204)  [2. Connecting to Arduino UNO](https://arduino-tutorials.net/tutorial/capacitive-soil-moisture-sensor-arduino) |

**Components List**

This is a comprehensive list of components we require to create an MVP prototype that can be used to demonstrate the Soil Moisture Monitoring System and Communication to the LoRa gateway before the data is transmitted to AWS IoT Core over the Internet using MQTT protocol.