Remote GPIO Control Based on LoRa

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Background

The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

Research Questions

Due to the limitation of the size and power supply of most IoT components, IoT devices have to tradeoffs between data transmission rate, range and battery life. Most IoT sacrifice Long-range communication capability for faster a data transmission rate and longer battery life. However, under some circumstances user will require a Long-range network in order to make an IoT network that works in area with poor infrastructures. In order to solve such problem, we decided the best way to handle the Long-Range IoT Communications would be reconstruct a communication protocol based on LoRa standard due to its excellent Long-Range Communication capability and low power consumption. To generalize the protocol for most Microcontroller devices and enable user to access lower-level hardware control, we focus on implementing our protocol as a **Serial GPIO control protocol**.

Objectives

The goal of this project is to use LoRa protocol's advantage to build our Low-Power, Long-Ranged remote GPIO control protocol. Such system will enable user alternative for remote control and monitoring of GPIO pins on a demote device from a local console using LoRa protocol. Such protocol should enable user to:

- Construct LoRa mesh network via setup wizard
- LoRa node identification in LoRa mesh network
- Read/Write target LoRa Node's GPIO pin via command lines
- Across-the-Internet access to LoRaWan gateways and LoRa Network Meshes

Why LoRa?

LoRa (short for long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology. LoRa is a long range, low power wireless platform that enable users to construct a robust wireless platform of Internet of Things.

The main benefits of LoRa are long-range, low-power and low-cost connectivity. Compared to other protocol such as Cellular protocols or the WiFi protocol, LoRa's range and power consumption advantage has give LoRa capability to construct a larger, cheaper IoT network.

Parameters	IWSN		Low Power Wide Area Network (LPWAN)			
	WirelessHART	ISO100.11a	LoRa	Sigfox	LTE-M1 (LTE Cat M1)	NB-IoT (LTE Cat NB1)
Operating Frequency	2.4 GHz	2.4 GHz	915 MHz for the U.S., 868 MHz for Europe, and 433 MHz for Asia	868 MHz, 902 MHz ISM	-	-
Maximum Range	~200m	~200m	2-15 km	up to 3 km	2.4 million miles of square coverage in US	10-15 km
Throughput	250 kbps	250 kbps	0.3 kbps to 50 kbps	100 bps up, 600 bps down	Up to 1 Mbps	20 kbps to 144 kbps
Latency	10ms (direct to gateway), 30 ms (1 hop) to 50 ms	~ 100 ms	1-2 s (round-trip)	1–30s	10-15ms	1.6s to 10s
Bandwidth	3 MHz	5 MHz	7.8 to 500 kHz	100 Hz UL channels; 600 Hz DL channels	1MHz to 1.4 MHz	180 kHz
Security	AES Encryption	AES Encryption	AES Encryption	Devices work predominantly offline	-	-
Battery life	several years	several years	10+ years	10+ years	5+ years	5+ years
Capacity (Number of connected devices)	30,000	unlimited	100,000+	-	-	55,000 devices per cell
Network Topology	star + point-to-point + Mesh	star + Mesh	star-of-stars topology	one-hop star topology	-	most topologies are star-based
Licensed or Unlicensed spectrum	Unliscensed	Unliscensed	Unliscensed/Licensed	Unliscensed	Liscensed	Liscensed
Price	****	****	**	*	****	***

Figure 1. LoRa vs. Other Communication Protocols

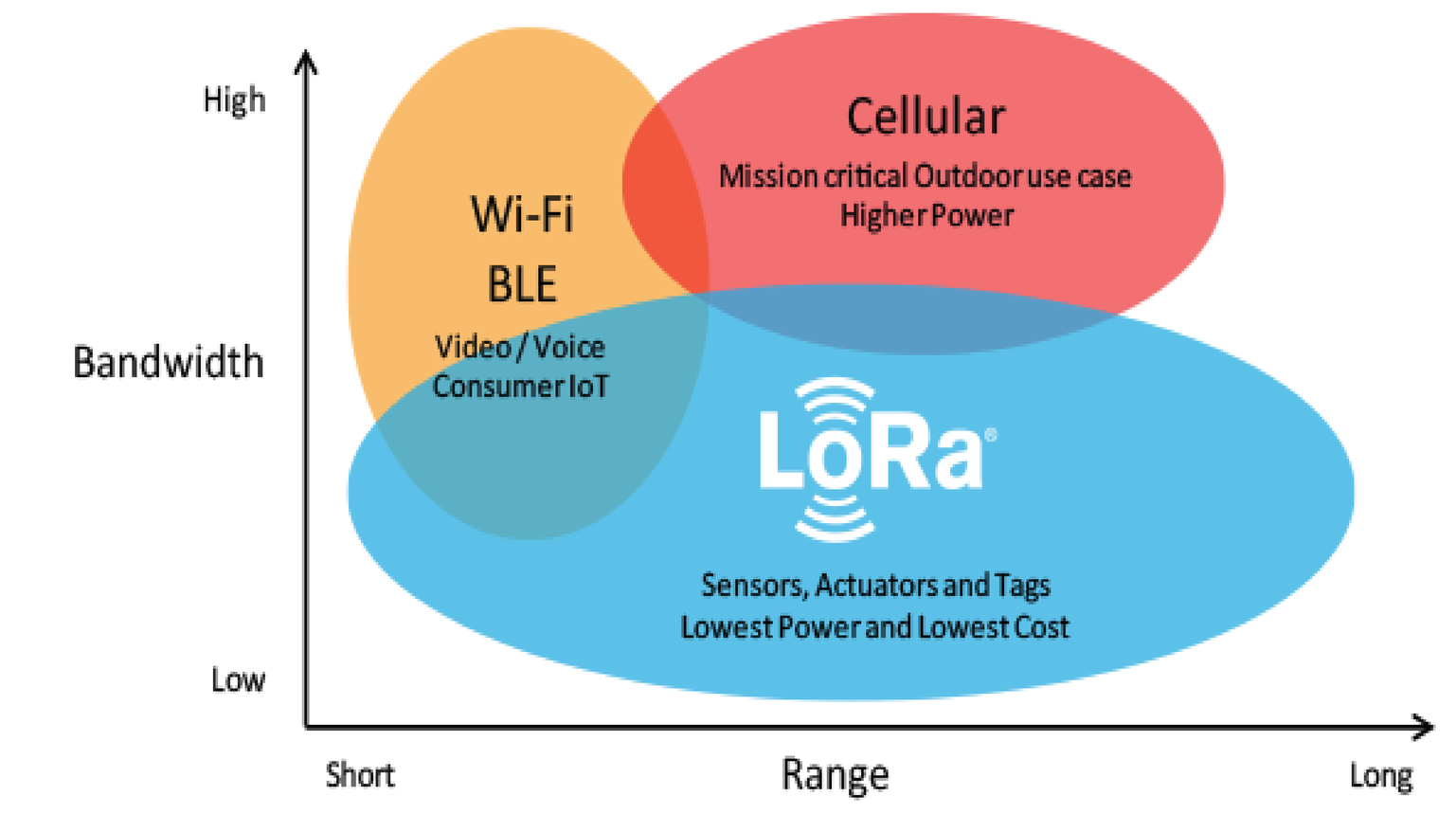

Table 1. LoRa vs. Other Communication Protocols

System Architecture

Our GPIO Remote Control System is composed of subsystems below:

- LoRa Node: Microcontroller that set up with LoRa module, capable of controlling Sensors and Actuators using GPIO ports
- LoRa Gateway: Router equipped with a LoRa concentrator, allowing it to receive LoRa packets and send it across the Internet to give user Across-the-Internet access to other LoRa Gateway.
- Command Console: Optional central control node to give user option to remotely configure LoRa Nodes or broadcast any given message.
- Cloud Server: Integrated via The Things Network, capable of communicating with multiple LoRa Gateways
- Sensors/Actuators: Devices that communicate with LoRa Node via GPIO ports, capable of sensing and interacting with surrounding environments.

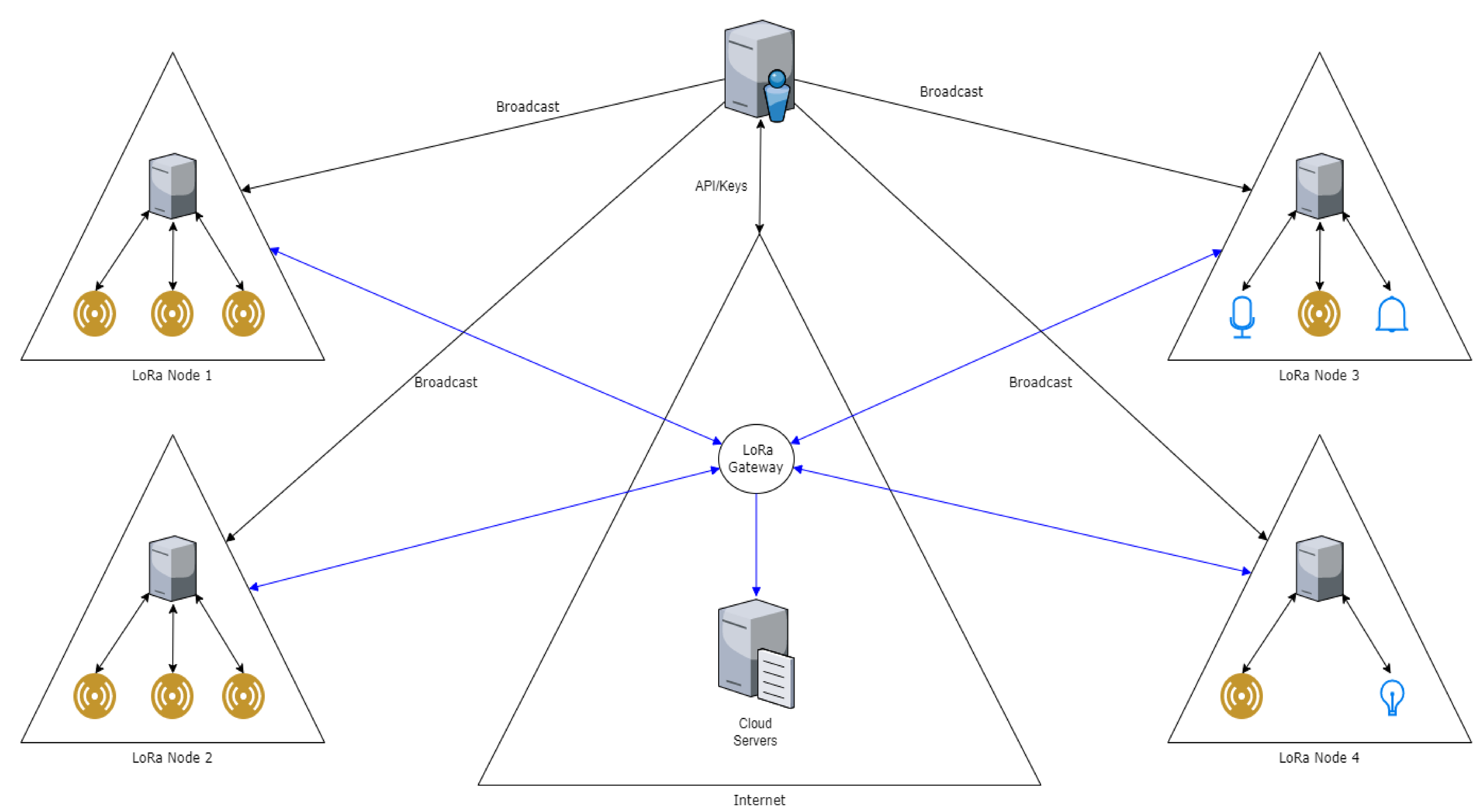

Figure 2. LoRa/LoRaWan GPIO Control System

Example Use Case

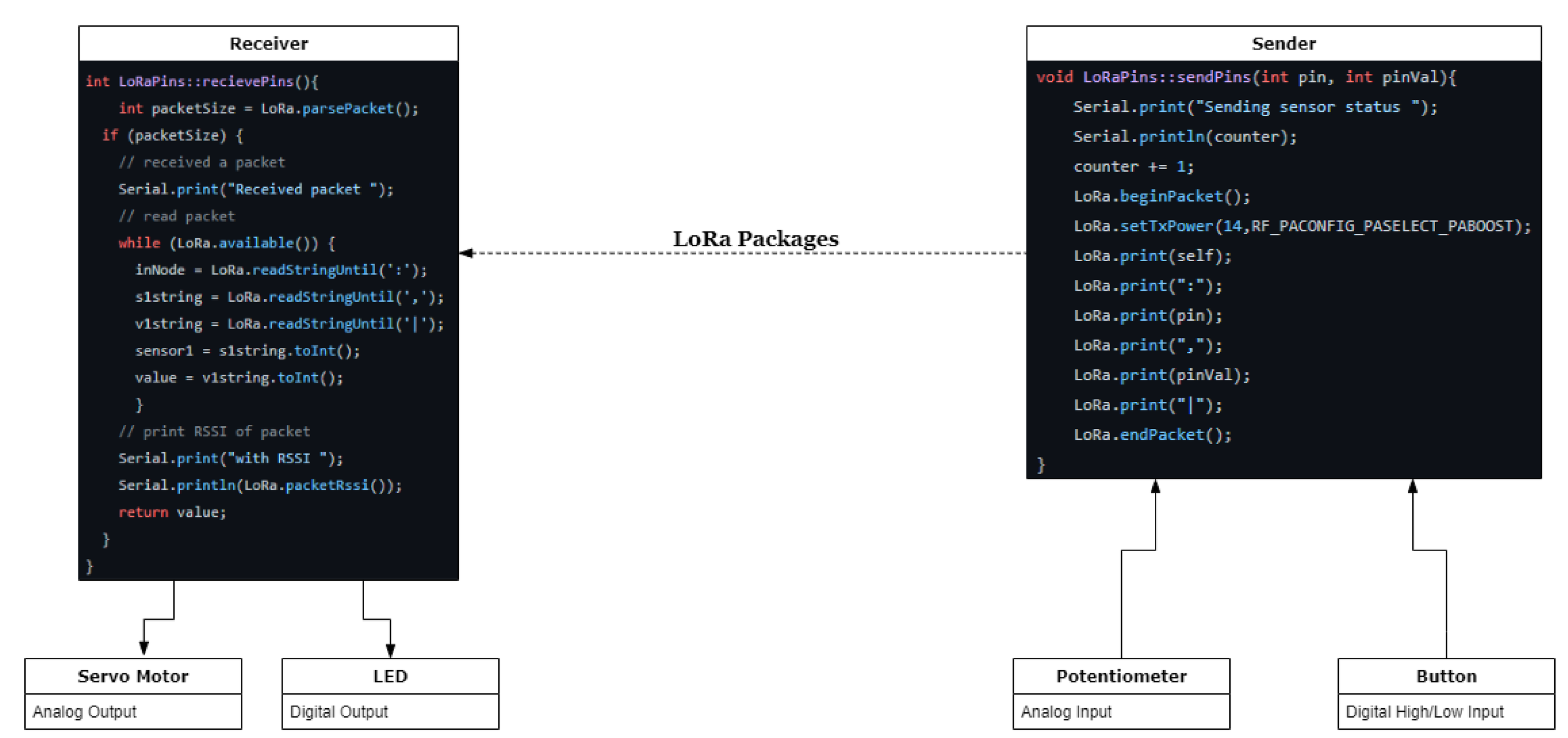

Figure 3. An example of using different types of I/O in two LoRa Node

Preliminary Results

At the end of this development, we have successfully designed and implemented a setup package for user to set up a local LoRa mesh network of microcontroller devices. User can simply use the setup package to configure each different LoRa Nodes to construct a multiple networks of local nodes.

After the user configures and constructs the local network, user may use the LoRa Message Broadcast system to Read and Write respective pre-configured GPIO pins on target LoRa Node.

We also attempted to integrate such system with the LoRaWan protocol to enable user to have Across-the-Internet access to LoRaWan gateways and other LoRa Network Meshes. We were able to establish a LoRaWan gateway in order to utilize the LoRaWAN protocol, but further work will be needed to make the protocol able to identify and communicate with other LoRaWan gateway and LoRa local mesh network.

Conclusion

During the development of this project, we have built a solid foundation for the future development of the protocol. Due to the limitation of time, we were only able to utilize local LoRa protocol for LoRa local mesh network construction. However, we are close to implementing the LoRaWan protocol to enable user to have Across-the-Internet access via LoRaWan gateway in order to expand user's IoT network. In short, we have achieved:

- Enable user to remotely Read/Write target LoRa Node's GPIO port (Digital & Analog)
- LoRa node identification in LoRa mesh network
- Package that allow user to construct LoRa mesh network with relative ease

Future Works

- More API support
- LoRaWan integration
- User keys/tokens support for better security
- Messages Queue System to ensure communication robustness
- Across-the-Internet access to LoRaWan gateways and LoRa Network Meshes