Software Design Description
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1.0 Introduction

1.1 Purpose

This document contains the complete design descriptions of the GPS Mesh design, architecture, data flow, an user interface features of the entire system.

The primary audiences of this document are the software developers.

1.2 Scope

Initial Release Features:

The release will be comprised of Raspberry Pi Zero W based nodes and a laptop to act as the observer computer. Each node will help build the mesh network and disseminate GPS data to every other device connected. The observer computer will display node locations in real-time while within range of the mesh network in a user interface. While the nodes are within range, the observer computer will collect and store GPS location and network topology data in a MongoDB database.

Future Release Features:

The observer computer will be able to reconstruct and display previous race data. It will be able to show node movements overlaid on a map in the user interface. This will show the node locations while the nodes were out of range of the observer using data stored in the MongoDB database.

1.3 Glossary

Node – Raspberry Pi Zero W with attached GPS module
Observer – Laptop that collects, stores, and displays node location and network topology data
Mesh network – Ad-hoc network created by all nodes and the observer computer. Behaves similarly to a WiFi network.
MongoDB – Database tool created by MongoDB, Inc.
UDP – User Datagram Protocol. Network protocol that does best effort, no guarantee delivery with no acknowledgement from the recipient.
GPS satellite – Satellite that GPS modules fix to in order to obtain GPS location data

Network topology – Adjacency list representation of the network. Each vertex represents a node and an edge represents a connection within range of that node.

1.4 References

Vision and Scope document

SRS document

This project is in collaboration with Computer Science Faculty members, Dr. Aran Clauson and Dr. David Bover.

1.5 Overview of Document

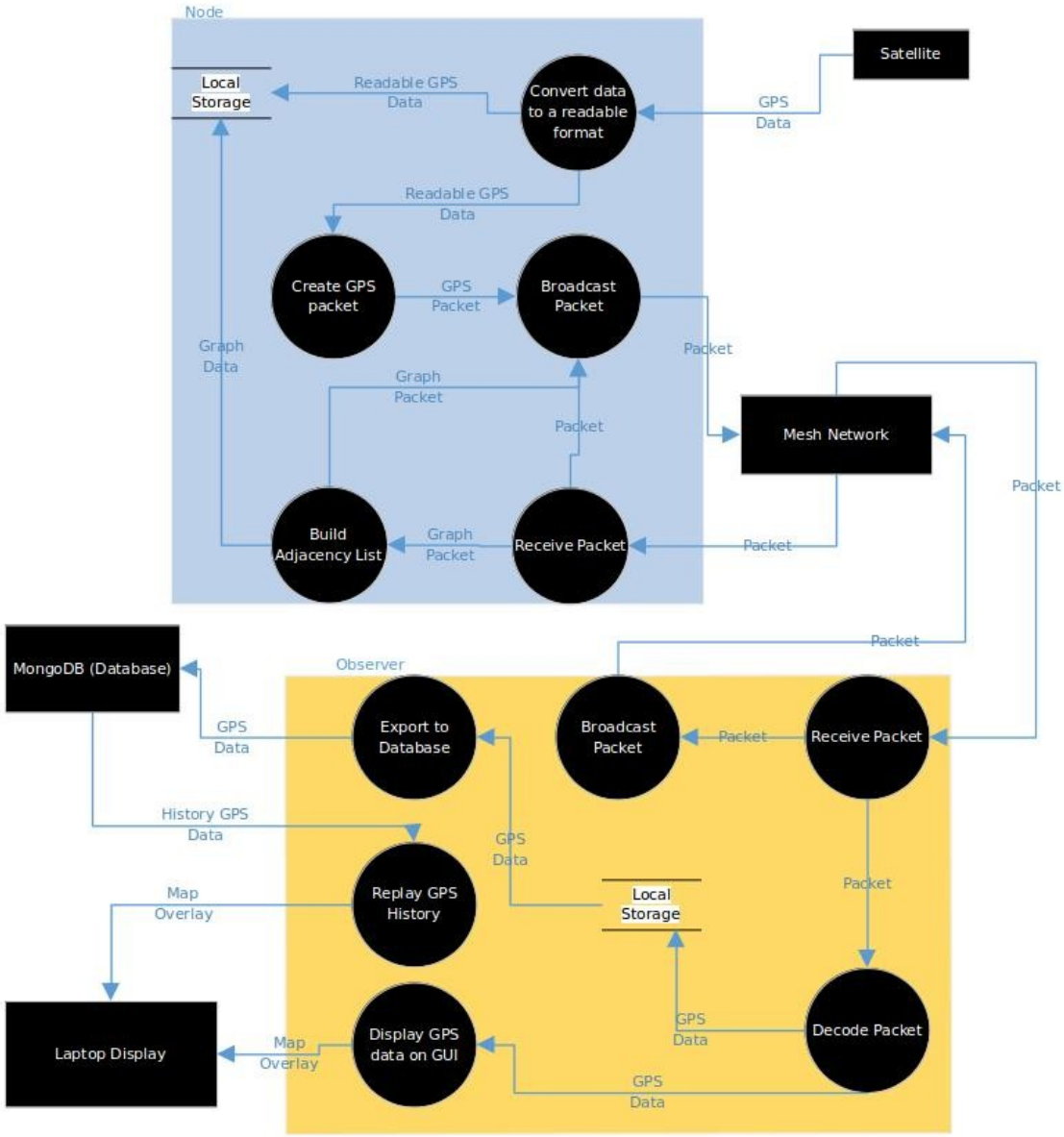
Section 2 demonstrates the flow of data and information between the satellite, nodes, mesh network, observer, and database.

Section 3 demonstrates the architecture design of the entire system in an architecture diagram.

Section 4 discusses User Interface Design

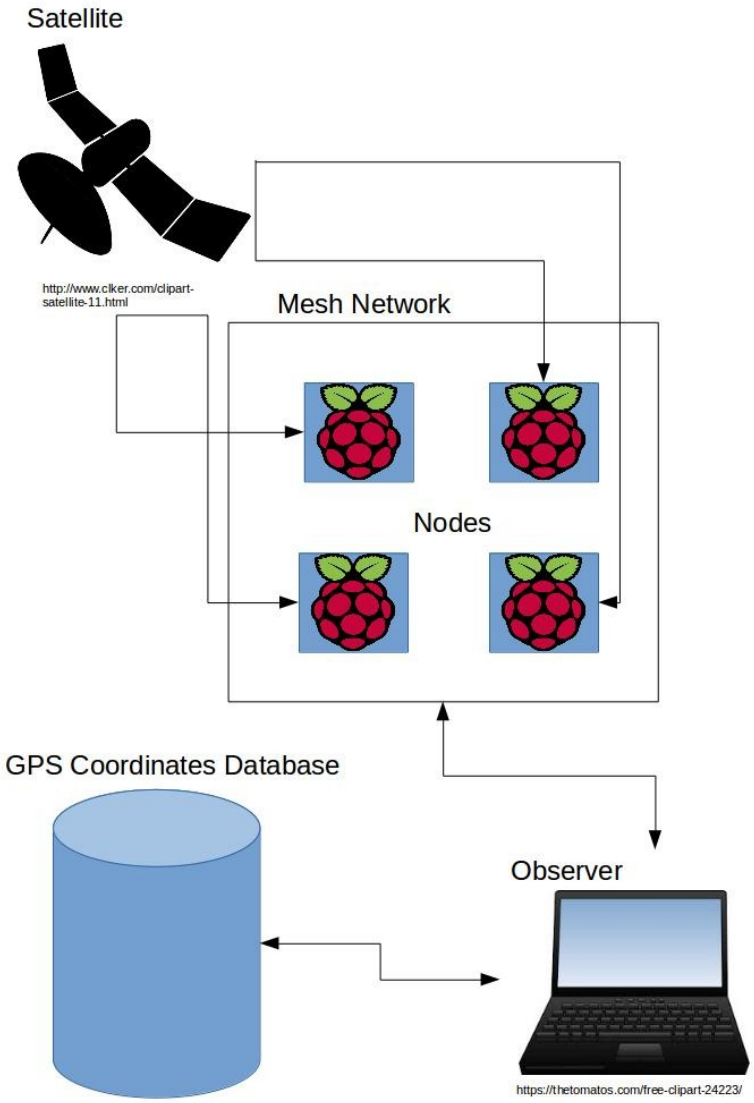
Section 5 discusses how nodes and the observer collect data in real time

2.0 Deployment Diagram



Above is the data flow diagram for our GPS-mesh network. The meshnetwork is comprised of nodes and an observer. The nodes collect GPS data from the GPS sattelites. Then nodes store the information, create a GPS packet, and broadcast that packet to the mesh net. Upon receiving a GPS packet from the mesh, the nodes will create an adjacency list which will store the immediate network topology connected to the receiving node. This adjacency list will then be broadcast to the mesh net. The observer will be receiving packets from the mesh net, rebroadcast the packet, decode the packet, store the GPS data in local storage, and display the GPS data to the GUI on the laptop running the software. Local storage will export the information to a MongoDB database. This database will be used to create a history of the race, which will then be displayed on the laptop.

3.0 Architecture Diagram



Each Raspberry Pi is connected in a mesh network. Individual Raspberry Pis collect GPS information from the satellite. Raspberry Pis broadcast their GPS coordinates to every device connected to the mesh network. The observer computer connects to the mesh network to collect information that has been broadcast. The observer computer reads and writes GPS coordinates into the GPS Coordinate Database.

4.0 User Interface Design

4.1 Map Overlay User Interface of Observer

The map overlay user interface will be a tab of a computer window that displays an interactive map near the top of the window with a table similar to a spreadsheet right below this interactive map. While the observer is in operation, the observer will be collecting GPS data from nodes and displaying this data in real-time on the user interface. Specifically, whenever the observer receives GPS data from one or more nodes, the observer will plot the GPS position of the corresponding node on the map overlay. Also, as each GPS data point is collected, the table will be populated line by line to display node name, IP address, time stamp, longitude, and latitude.

4.2 Node List User Interface

The node list user interface will be a second tab of the same computer window of the map overlay interface that will display the entire list of nodes that the observer has received GPS data from. This list will be a table where each line corresponds to a specific node and displays data such as the node name, IP address, and the last time data was collected for the node. The purpose of this interface is to provide a overall view of all the nodes that form the mesh network. From this interface, users can request GPS data history from a specific node or multiple nodes at once by highlighting the node or nodes in the table and clicking the retrieve button.

5.0 Real-Time Design

The nodes and observer computer utilize UDP to broadcast messages to all other devices in the mesh network. Each device sends a JSON message to the broadcast address, pushing the message to all other devices within range. When a device receives a message, it unpacks the JSON and decrements a Time To Live (TTL) value. If the TTL reaches zero, the message is not re-broadcast. This prevents the network from being congested by old messages. Packets containing GPS location data are broadcast every 15 seconds due to the GPS module fixing to the satellite at that interval, and packets containing network topology data are broadcast every 45 seconds to allow enough time to build a decent topology.