IntelliBus Design Review Presentation

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ECE-4872-L10
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Problem

Human congestion in public areas and transportation leads to **money spent on inefficient public transportation** and **higher rates of virus transmission and exposure.**

Local governments are looking for ways to **reduce costs** and **more efficiently utilize public transit.**

Solution

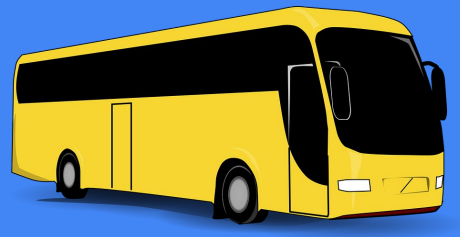
IntelliBus provides **real-time** passenger data capture and analytics, so that transportation authorities can **better utilize resources and provide a better service** to their customers.

Description

Project Goal - design and prototype an IoT device that will track bus location and the aggregate number of riders.

Passenger Counting System	Cloud-Based Web Application
• Infrared Sensors • LIDAR Sensors • Microcontroller • LTE-M module • GPS antenna	• AWS IoT gateway with public IP address • noSQL database on AWS • Website with chart JS dashboards and OpenLayers maps API

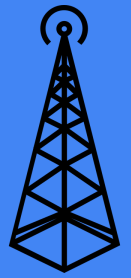
Customer Requirements



Target User - Transportation Departments without passenger data

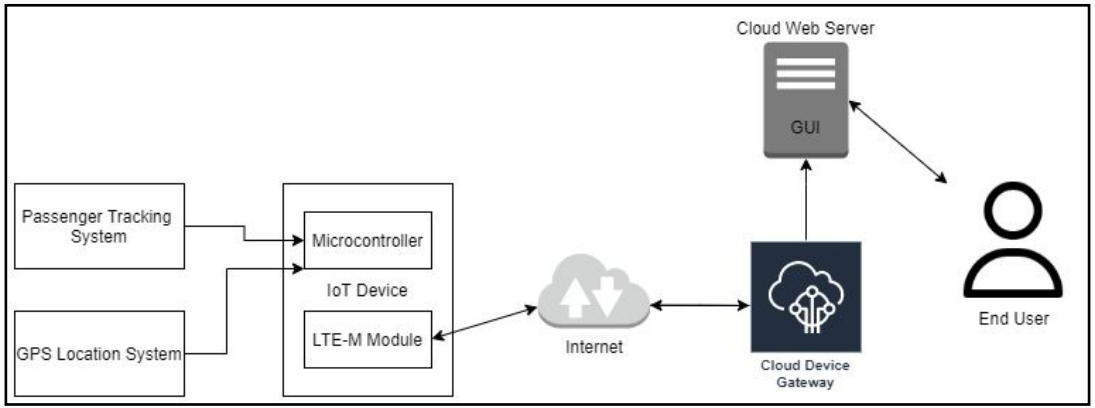
Requirement	Priority
Accurate display of passenger counts	HIGH
Easy to Install	HIGH
Cost less than $800	MEDIUM
Timely web application response	MEDIUM

Engineering Requirements



Requirement	Priority	Customer Need
Transmit to the cloud with a minimum throughput	HIGH	Accuracy & Timeliness
Respond HTTP requests within 5 s	HIGH	Accuracy & Timeliness
Area < 680 cm^2	HIGH	Ease of Installation
Charge using 5V USB	HIGH	Ease of Installation
Embedded device cost under $200	MEDIUM	Cost & Scalability

System Overview



- Low SWaP IoT Devices & Sensors
- Cloud-based IoT Endpoint and Processing
- Visualization with Open-source GIS software
- End-User access through a web-portal

System Overview - Technologies

Visualization

Map Framework

AJAX HTTP

ChartJS

Data Processing

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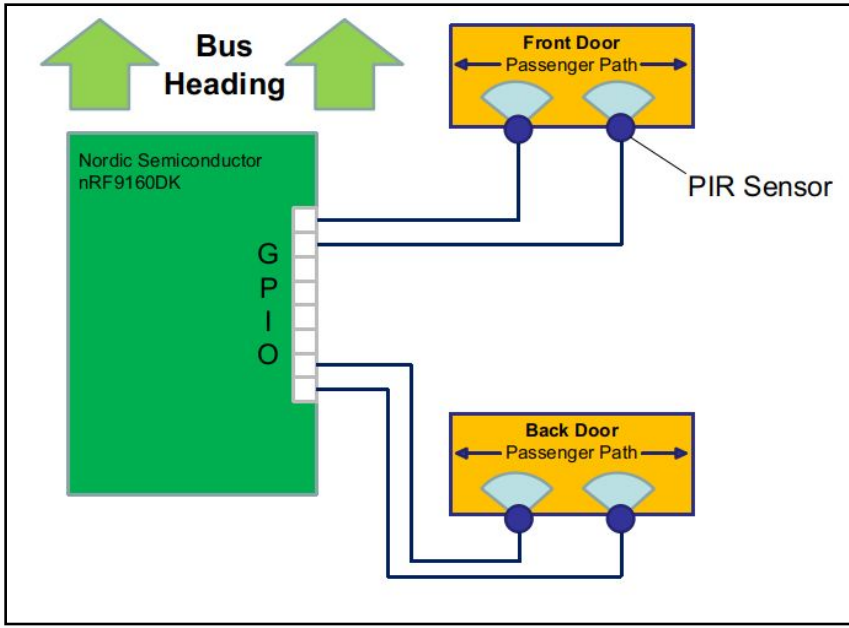
On-bus Hardware Organization

- Jumper wires connect the microcontroller to the sensors
- GPIO ports are used for communication as sensors produces a digital 1 or 0
- A pair of 2 sensors for each door
- Sensors are placed facing the passing passengers



PIR Sensor -- Sensor option #1

Passive InfraRed sensors

- Common practice for motion detectors
- Differential detection units -- robust to changing ambient temperature
- Adjustable ambient threshold
- Low cost (~$2 per unit)
- Challenge: ~2s recovery time after each motion detection to be ready for another

LIDAR Sensor -- Sensor option #2

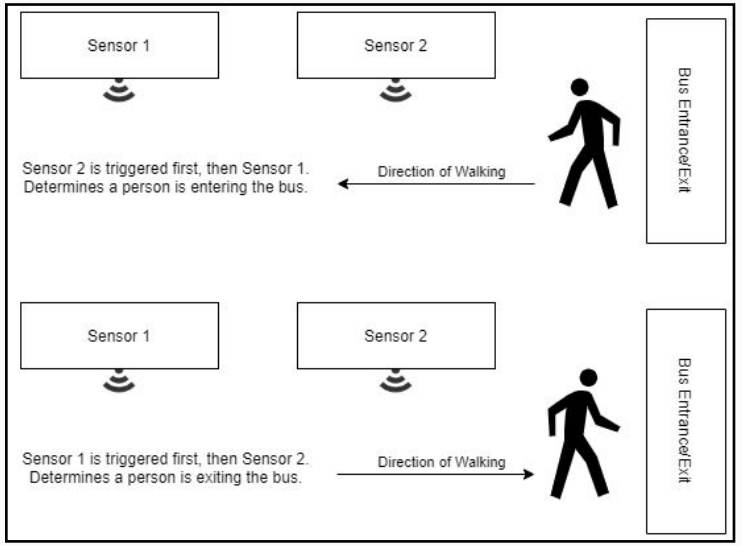
- VL53L0X LIDAR ToF sensor
- Time of flight sensors use the travel time of a laser beam to detect distance
- Range: 50mm - 1200mm
- 33ms delay
- I2C communication
- Dimensions: 21.0mm x 18.0mm
- $14.95

Passenger Counting Mechanism

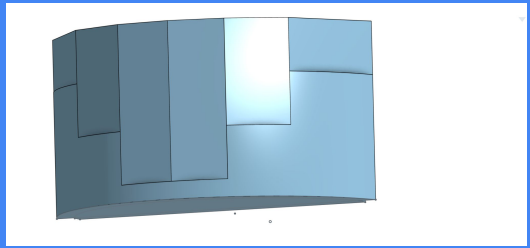
- Two sensors will face the path of passenger's entry and exit
- When passenger moves in / out of the bus, the two sensors triggers at different times

Edge Cases to Consider:

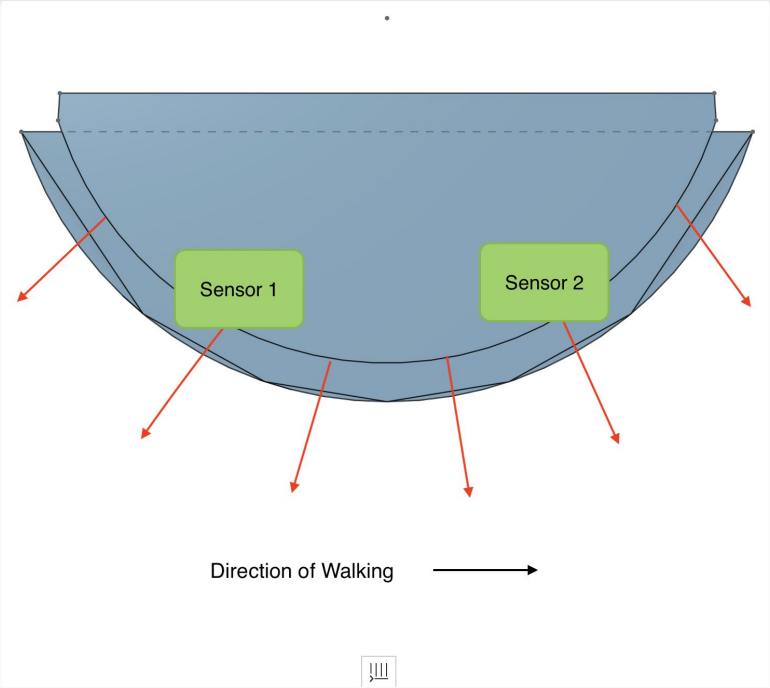
- Capturing invalid data while the bus is moving
- Person standing in front of the sensors
- Preventing double counts
- Reliability and timeliness of the sensors



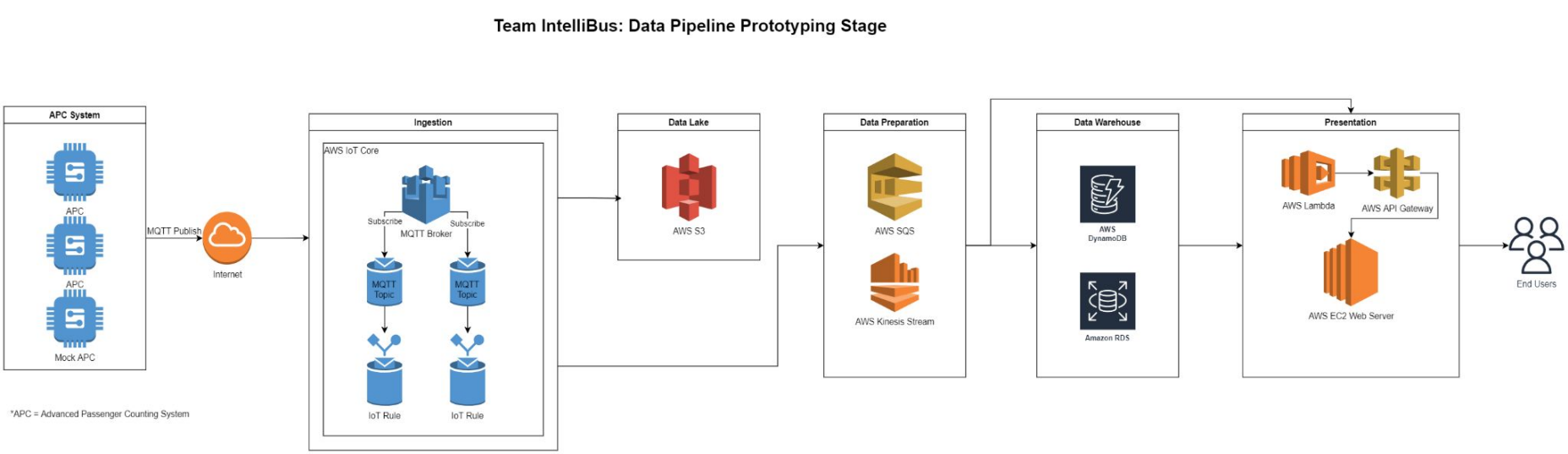
3D Sensor Housing



- Ellipse with 12 cm minor axis and 19 cm major axis
- ABS material
- Variable sensor heights and angles for optimal movement detection
- Drill holes for wiring and mount sensors to front face
- Separate housing for nordic board



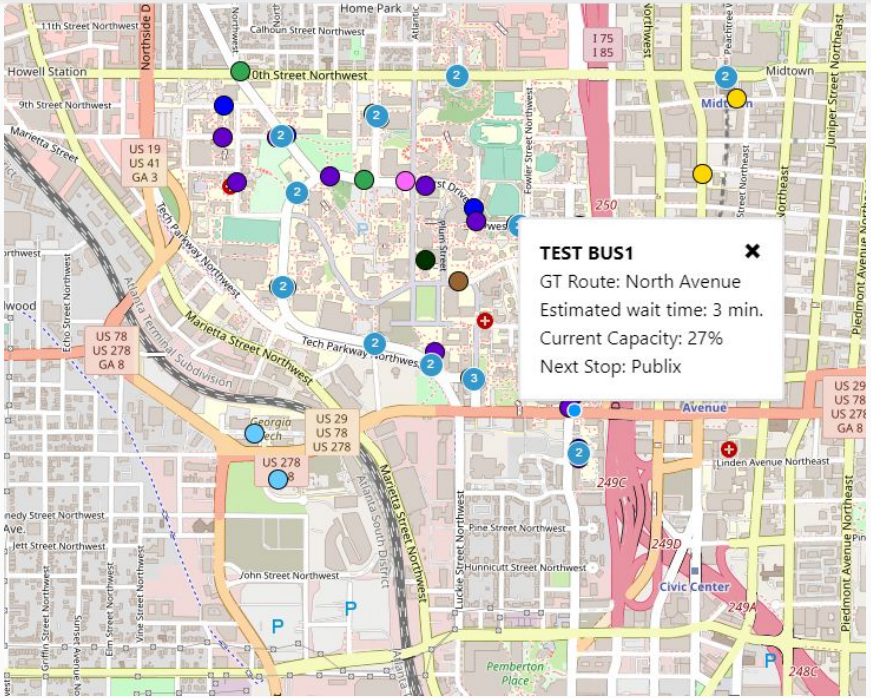
Prototyping Data Pipeline



Enterprise Data Pipeline (Scaled Deployment)

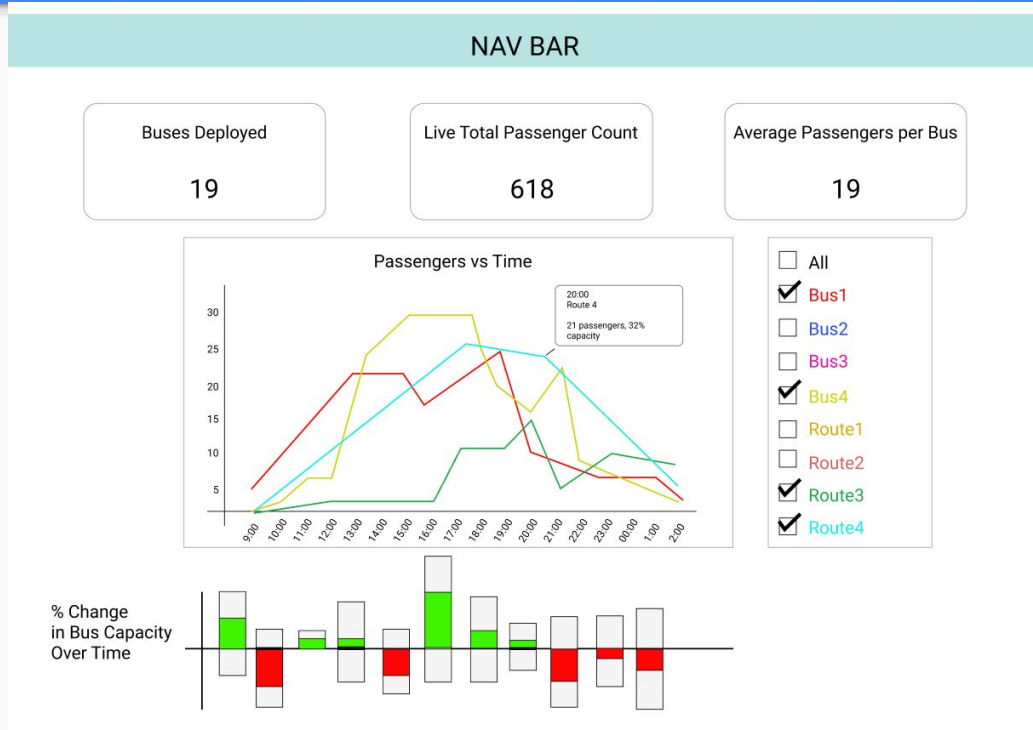
- Auto Scaling Group -- DynamoDB
- Load Balancing -- EC2 Instance
- Data Lake -- Archiving to Glacier
- Machine Learning -- AWS SageMaker or AWS EMR

Map Display

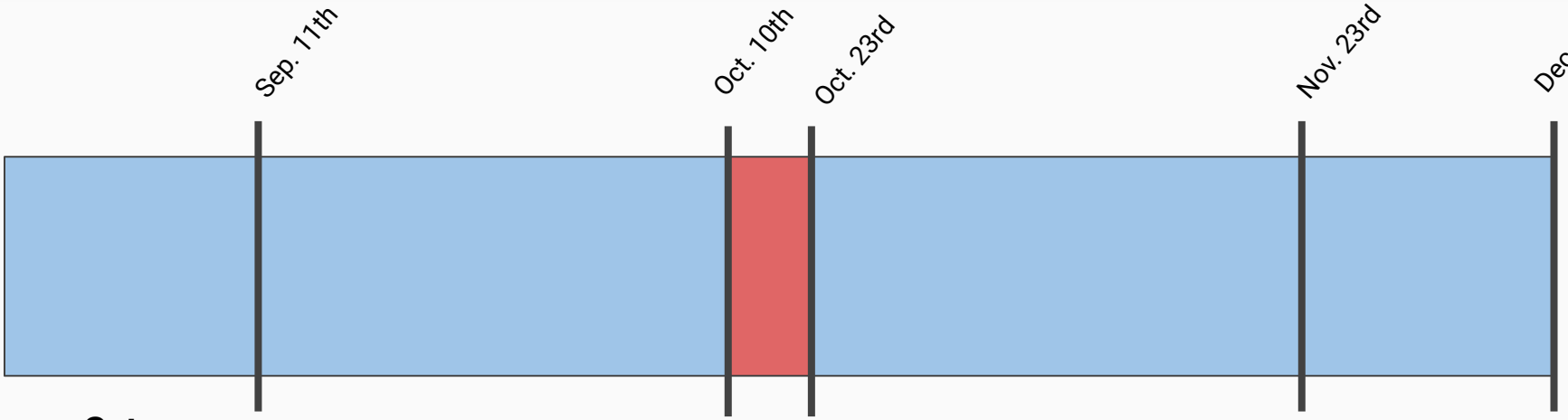


- Catalog of all bus stops
- HUD of bus/route information
  - Capacity **
  - ETA
  - Next Stop
- Colored Routes

Analytics Dashboard



Schedule



Setup

Local Environments

Hardware setup

Small-Scale Integration

Hardware and IoT communication

WebApp and Visualization integration

Total System Integration

Sensor → IoT → Backend → Visualization → WebApp

Presentation

Package repo & demo

Expo Presentation

Updated Budget

Product	Cost
Cellular IoT Development Kit x2	$276.00
Infrared Sensors	$10.00
LIDAR Sensor x4	$0.00 (from lab)
Wires and Connectors	$10.00
External GPS antenna	$11.00
Total Parts Expense	**$307.00**

Using open-source software tools and AWS free-tier helped save on cost.

Funding ($125 per student): $500
\- Parts Expense: ($307.00)
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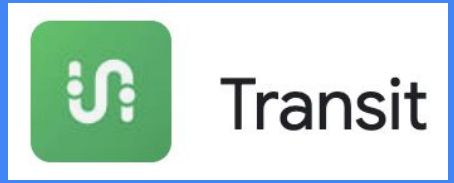
$193.00

Applications & Competitors



- Public Transportation
- Airlines
- Predictive maintenance
- Shopping centers

- The Transit Bus App
- The Smart Transit People Counting Camera from Beijing Vion Technology
- Passio Technologies APC

Leadership Roles

Noah Chong - Webmaster, Frontend Software Lead, Expo Coordinator

Shadman Ahmed - Project Leader, Backend Software Lead

David Pan - Financial Manager, Embedded Systems Co-Lead

Thomas Talbot - Embedded Systems Co-Lead, Documentation Lead

Any Questions?

References

[1] Transit, “What do bus riders want? Crowding info.,” 31-Aug-2020. [Online]. Available: https://archive.transitapp.com/what-do-bus-riders-want-crowding-info-db89b6d0b5ec. [Accessed: 18-Oct-2021].

[2] “Smart Transit People Counting Camera,” *Vionvision*. [Online]. Available: http://vion-tech.com/en/industry/27.html. [Accessed: 18-Oct-2021].

[3] “Passenger Counting,” *Passio Technologies*, 03-Apr-2020. [Online]. Available: https://passiotech.com/passenger-counting/#. [Accessed: 26-Oct-2021].