ECE4871 Project Summary

Project Title	IntelliBus
Team Members (names and majors)	Shadman Ahmed - CMPE Noah Chong - CMPE Thomas Talbot - CMPE Yue Pan - CMPE
Advisor / Section	Professor Vijay Madisetti
Project Abstract (250-300 words)	The purpose of this project is to design and prototype an IoT device that will track how many passengers are on a bus and provide real-time updates of bus locations. The IoT device will connect to the cloud, which will process the raw data from the IoT device and present the number of passengers and bus location map in a GUI application. Knowing in real-time the bus location and how many people are on it can provide valuable information to transportation departments and passengers. Our proposed automated passenger counting system (APC) will automate passenger counting and allow transportation departments to optimize fleet schedules based on peak passenger loads. Our project will also let riders check where a bus is located and how many people are on it from their smartphones. Passengers will be able to make informed decisions about which busses to wait for and which ones to avoid. Furthermore, the passenger tracker system could serve as meta-data for city planners and future infrastructure. The IntelliBus embedded system will include an ARM-based microcontroller to control and send/receive data between infrared sensors and the LTE module. A pair of infrared or LIDAR sensors by the bus doors will connect with the cellular IoT device's GPIO pins. An LTE module within the cellular IoT device will provide communication to the cloud system with location and passenger count updates. The AWS system will consist of microservices for handling IoT device data traffic and end-user requests. The AWS IoT Core Device Gateways is used for bi-directional communications and processing of incoming IoT device data to a database. Transportation department end-users can visualize relevant data from the database on the web page. The dashboard will include relevant statistics such as the number of busses deployed, live total passenger count, and average passengers per bus. The analytics web page will also include line graphs of passenger counts by time intervals, and a bar graph showing the % change in passengers over time. Passenger end-users can also view a map with bus locations and passenger counts on web applications hosted on cloud microservices. All of the cloud services can scale as the number of IoT devices and users increases.

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List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	Codes and standards that affect the project include the following: (i) eMTC (LTE Cat-M1)- The enhanced Machine Type Communication is a wide-area network technology that enables a range of cellular services to internet of things applications. The LTE-M network will enable communication between the embedded device and the head-end system. The network's bandwidth constraints will influence the size and frequency of transmissions. (ii) Power- The IoT device will initially be powered using a lithium-polymer with a minimum capacity of 1500 mAh. The battery on the device can be recharged with a 5V USB port. Eventually, the power source on-board the bus can be used as a supply. The limited availability of power on a moving bus will influence our embedded system's size and capability. (iii) Microcontroller Connections- UART, SPI, and I2C protocols can be used to allow peripheral device communication with the embedded computer. The peripheral communication protocol will influence the wiring and operation of the embedded system. (vii) ISO/IEC 20922:2016- Message Queuing Telemetry Transport (MQTT) standard leverages TCP/IP (or other network protocols) to provide light weight, open and simple publish/subscribe messaging transport for IoT devices. (viii) RFC 2616- Hypertext Transfer Protocol (HTTP) consensus standard provides generic and stateless hypermedia information for any digital data. HTTP can be used in REST APIs and provides a standard for communication between devices on the internet.
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	**Accuracy of sensors** - Robust, flexible sensors can be implemented using machine learning; however, to balance time, cost, and effort, our team has pivoted towards using primitive sensors, such as lasers and proximity sensors, rather than more complicated devices, such as cameras. **Privacy concerns** - Using cameras to uniquely identify individuals and their traveling habits leads to privacy concerns. Such data collection cannot be justified for this project; thus, pivoting towards generic, non-identifying sensors helps achieve our goals without fear of litigation. **Per-bus cost -** Since our targeted customer is transportation companies with hundreds of buses, the per-bus cost must be carefully controlled within an acceptable threshold. **Embedded Processor RAM** - The limited IoT device memory will relegate data analysis and visualization to the cloud service. The embedded processor will do little more than receive sensor inputs, package the data, and send it to the web app over the LTE-M network.

Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	**WiFi vs. LTE -** A WiFi module is significantly cheaper than an LTE module. However, it does not offer a wide range or consistent network connection. An LTE module allows reliable connections to a network for dependable location and sensor updates from virtually anywhere but at a higher cost. The LTE module was ultimately chosen over WiFi for its ability to support strong mobile connections. **Infrared vs. Video Sensors -** A video-based human recognition model requires minimal changes to existing hardware since most buses nowadays are equipped with security cameras. However, we cannot ensure a video-based solution's accuracy or robustness within the limited time window. Moreover, the related privacy concerns of video monitoring might impede the implementation. On the other hand, infrared sensors are an easy-to-implement and affordable solution for our project. Monitoring bus passengers via infrared sensors may not be as accurate as video monitoring. However, tracking passengers with infrared will allow the project to be completed on time and within budget.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** trade-offs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	Our project's primary hardware-software interface communicates passenger count and location updates from a microcontroller to a cloud system over the LTE-M network. The embedded program running on the microcontroller will need to be aware of the sensor inputs and LTE-M network connections. Additionally, the device code will need to package incoming data into a form that is usable for the back-end. Sensors and relevant data processing are other aspects of our implementation. We plan to place multiple passive infrared sensors on the bus door to detect a human body's movement and direction. Each sensor will send separate inputs to the microcontroller, and the data needs to be correctly decoded to adjust the total passenger count.

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Leadership Roles (ECE4871 & Forecasted for ECE4872) (NOTE: ECE4872 requires definition of additional leadership roles including: 1.Webmaster 2. Expo coordinator 3. Documentation	ECE 4871 & 4872 Leadership Roles: Shadman Ahmed: Overall Team Coordinator, Backend Software Lead, Webmaster Noah Chong: Frontend Software Lead, Expo Coordinator, Webmaster Thomas Talbot: Embedded Systems co-lead, Documentation Lead Yue Pan (David): Embedded Systems co-lead, Testing Lead

International Program: Global Issues (Less than one page) (Only teams with one or more International Program participants need to complete this section)	N/A