UCSC Bus Tracking System 3.0 (BTS 3.0)
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Introduction
Students & faculty at UCSC require accessible, reliable, and accurate information to create an efficient schedule for moving around, and off (to/from) campus. We aim to provide an integrated bus tracking system that will be accessible to all campus bus users. Bus Tracking System 3.0 (BTS3) will address the cost issues encountered with the previous systems, create a scalable maintenance plan for TAPS, and add an Estimated Time of Arrival (ETA) feature at major bus stops.

Our Product Compared to our Competitors:
1) Compared to off-the-shelf tracking systems such as GMY Synconometrics, our system is:
   a) Cheaper
   b) Without monthly fees for cellular service
   c) Equipped with a route sign
2) Compared to Bus Tracking System 2 (BTS2), our system is:
   a) Cheaper
   b) Compatible with all types of campus buses
   c) Easier to implement
   d) Longer lasting
   e) Properly documented (Technical and user manual for TAPS)
   f) Equipped with an ETA feature

Why is a bus tracking system necessary for UCSC?
We surveyed 208 UCSC students in order to understand the needs of the campus' residents. We were interested to know the dependency of students on the buses to commute around the campus and which features are more desirable to the students: a digital ETA board at each bus stop or a mobile-phone application. We also cared about the effect of a reliable bus systems, create a scalable maintenance plan for TAPS, and add an ETA feature at major bus stops.

On-Bus System
Responsible for acquiring GPS data, displaying bus routes, and sending bus data to the base station subsystem.

Base Stations
Responsible for receiving bus data and sending it to the server. There are five base stations on campus to ensure full data coverage of the campus.

Back-end Server
Responsible for data storage and interfaces the data-collecting subsystems with the user interface subsystems. Major components include:
   a) MySQL database server for storing bus data
   b) FreeBSD web server for interfacing with the database server

ETA Display System
Responsible for displaying bus ETAs for the main routes such as UPPER, LOOP, OUT AT BASE.

Results
On-Bus System Improvements to BTS2:
- The system now operates on a 12-V power system, allowing us to include bike shuttles and cutaway buses used for the night core route.
- The route sign cost decreased from $800 to $92.21+tax/hr unit, while still providing the main routes: LOOP, UPPER, BASE, CORE.
- The tracking part of the system now operates independently from the route sign. This feature is important for buses that do not need a route sign like the bike shuttles.

Base Station Improvements to BTS2:
- The system no longer uses any custom parts, allowing for easier installation and maintenance for the system.
- New micro SD cards have been chosen for the Raspberry Pi to increase the lifespan from 4 years to an estimated lifespan of more than 4 years.

Addition of the ETA Display System:
- The ETA display retrieves ETA data from the web server via WiFi.
- The ETA display can display 3-5 different routes, which can be changed by the client via the web server.
- ETA colors change from blue to yellow to red as the ETA counts down to indicate approaching buses. The three colors are distinguishable for people with any of the four types of color vision depicted in the left figure below. Arrows indicate the selected colors in each color wheel.
- The system with no wireless connection to the TAPS server.

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Conclusion
Each system within the BTS3 design was successfully constructed according to their respective requirements. However, due to limited access to UCSC campus, we were unable to do the full system field testing. A Standard Operating Procedure (SOP) along with the Technical and User Manual will be provided to TAPS for future testing and implementation.