Continuous Visualization of CyRide Through an Interactive Map

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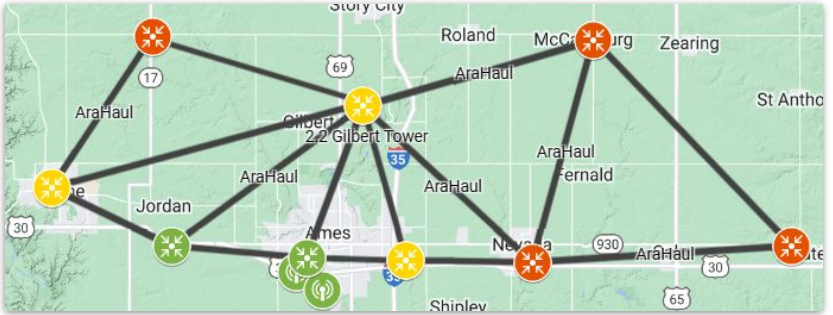
Client: Dr. Mohammed Soliman

Client: ARA Research

- Advanced wireless network research
- Integrating wireless technology in rural and agriculture areas
- Base Stations with Stationary and Mobile User Equipment (UEs)

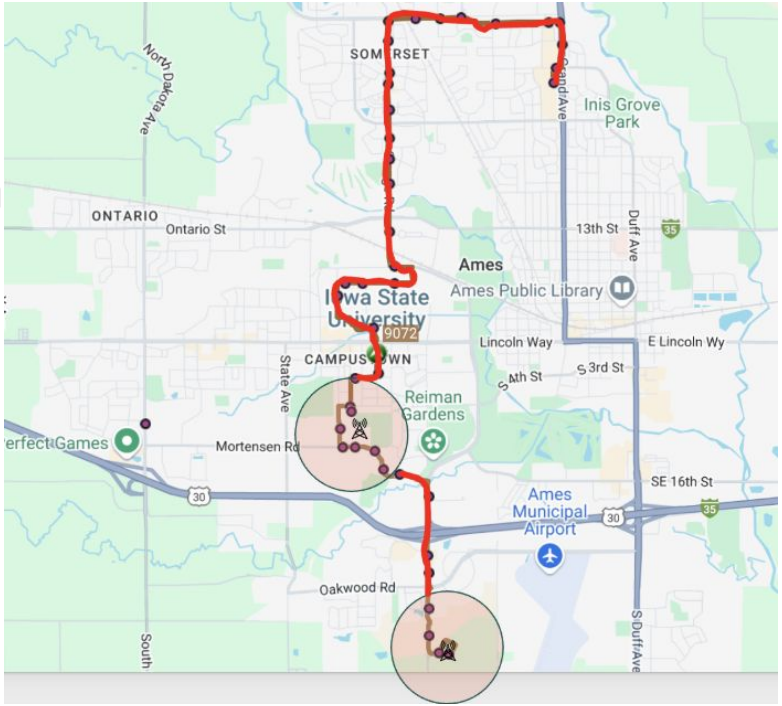
Problem statement

- ARA wants to visualize the real-time location of the CyRide UE through an interactive map
- Web application enables visualization of locations
- Machine learning can predict future bus locations



Goal:

- Predict the connection strength of ARA network throughout Ames when inside/outside of coverage areas.
- Provide a visualization of bus connectivity and real-time locations.
- Allows ARA to make more informed decisions while network planning.
- Enables ARA experimenters torun mobile experiments continuously



Requirements

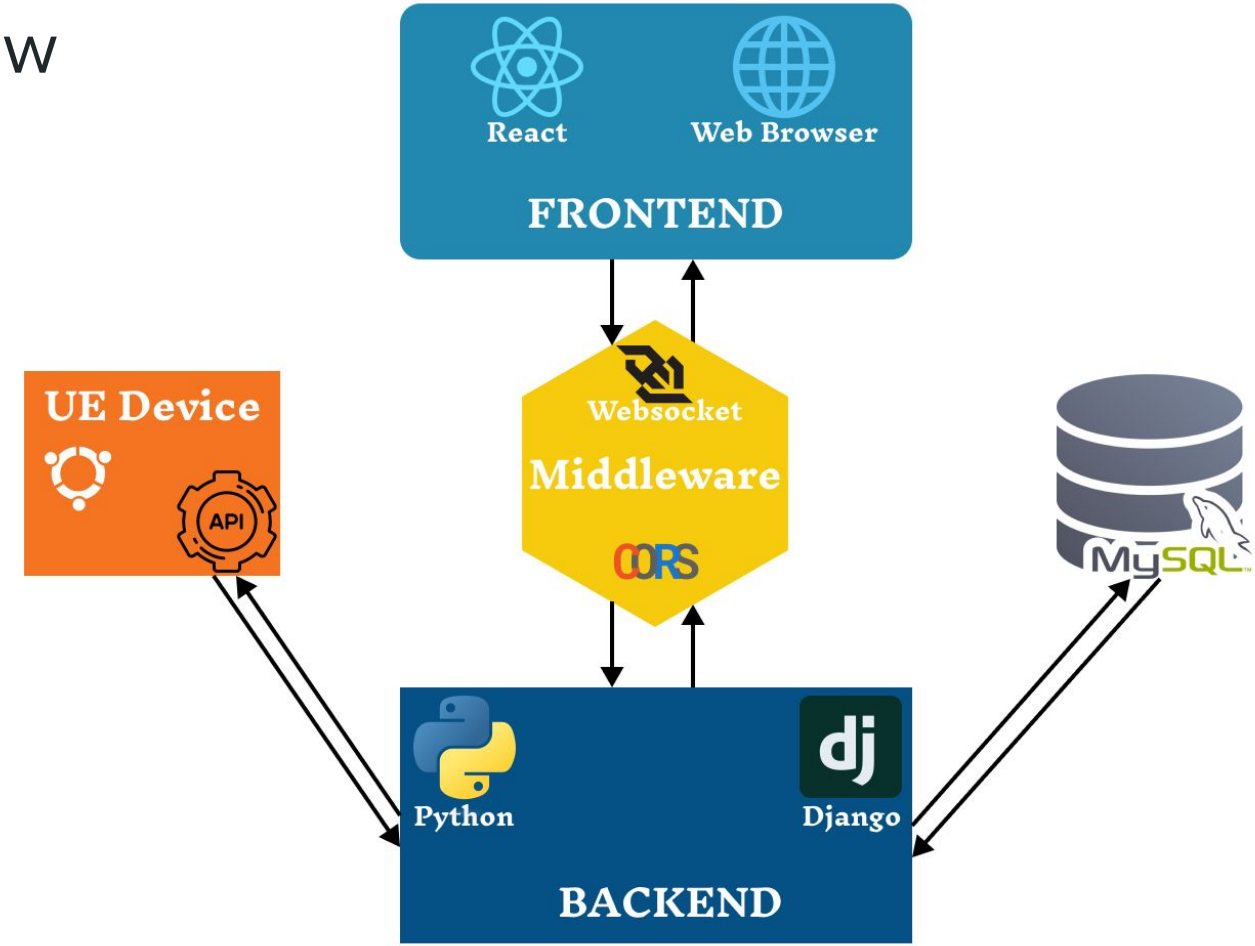
- Bus updates even with no connectivity with location prediction form machine learning
- Live data collection from UE
- Interactive map UI
- Seasonality to bus prediction
- Historical data storage

Challenges

- Integrating with the mobile UE to get real-time data
- Live data has to have low latency, but high-frequency updates are required for live bus tracking
- Need to merge live and historical data for the model to consume, but syncing different data sources is complex
- Machine Learning predictive modeling integration

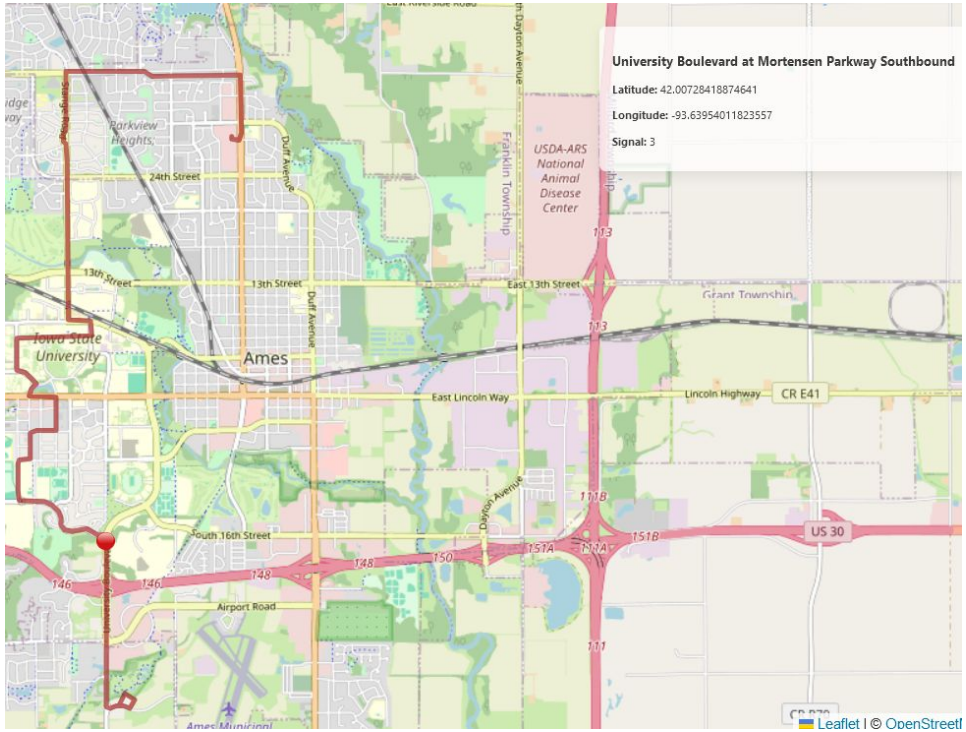
Design Overview

- Front to back communication
- Middleware
- UE Device Integration



Design breakdown – Frontend

- TypeScript & React
  - Website structure and UI components
- Interactive Map UI
  - With Leaflet using Open-Street-Map
- Real-Time Data
  - Updates via WebSocket

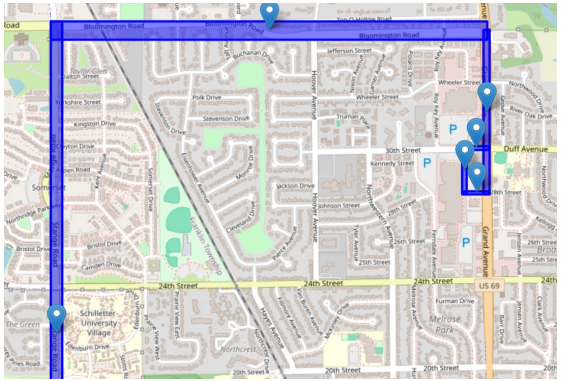


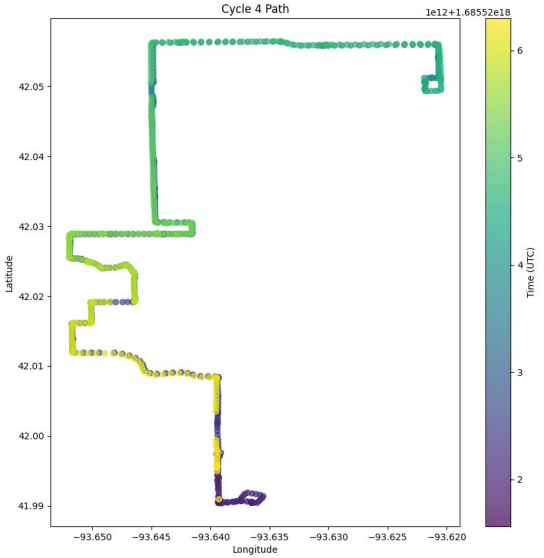
Design breakdown – Backend

- Data Collection
  - Historical data in a database
  - UE API for live data
- Data Cleaning
  - Filter data into specific route
- Machine Learning Integration
  - Predictions hosted on backend, filling gaps during connectivity loss.
- Real-Time Communication
  - WebSocket pushes live updates and predictions to the frontend.

Data Cleaning

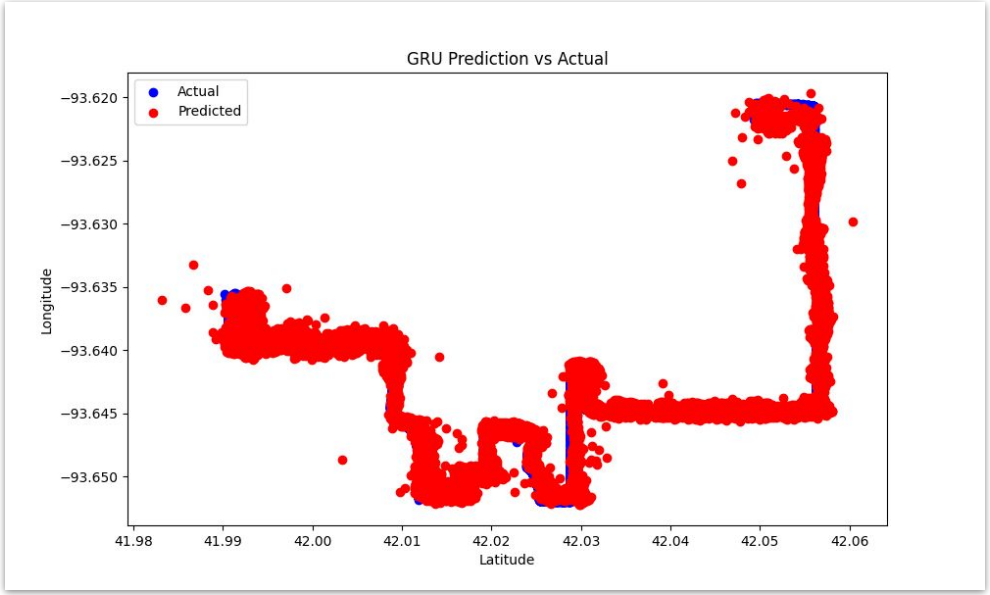
- Purpose Data Cleaning
  - Organize into cycles and remove outliers
- Route Zoning
  - Finding the zones/roads of the route
- Route Cycles
  - Organized cycles used for the ML





Machine Learning

- Purpose of the model
  - Signal Backup & Route Estimation
- Why GRU?
  - Memory Efficiency & Sequence Tracking
- Training with ADAM
  - Historical Data & Steady Adjustments
- Prediction
  - Recent Context + Model



Testing

- Jest Unit Tests
- Django Unit Tests
- Playwright E2E Testing
- Built into CI/CD pipeline

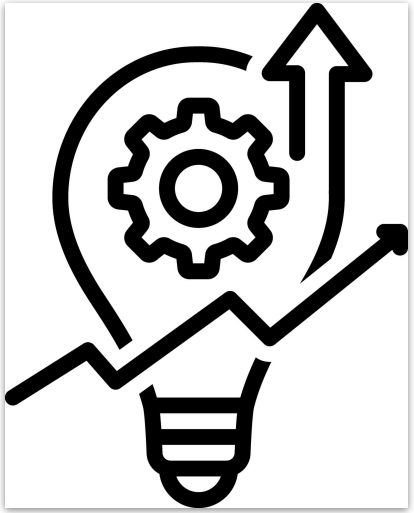
Zero Cost

- From Google to Leaflet
  - Cost adds up, now free requests
- ETG Server Provided
  - Free Host
- LibreNMS (Querying from UE)
  - Free Fetch
- ARA UE Device + Base Station
  - Free Equipment

Impact

- Helps with conducting experimental research using mobile UEs and the base stations
- Allows researchers to conduct experiments with UEs even without connectivity
- Track bus connectivity to give information on multiple routes and use cases.

Future enhancements



- Expand to other public transit systems or vehicle types across broader regions
- Modify schema to incorporate weather conditions and terrain data to better account for factors influencing connectivity
- Build a comprehensive dashboard for data analytics to include trend analyses, historical comparisons, and customized reporting features to facilitate strategic decision-making

Growth

- Technical skills
  - React-Django-CORS-SQL (RDCS)
  - Open-source & free technologies

- Soft skills
  - Code compatibility, accountability, universal design
  - Time management and Collaborative teamwork

Demo video