# Real-Time Data and Simulation for Optimizing Regional Mobility

Anne Berres, Srinath Ravulaparthy, Kuldeep Kurte, Jibonananda (Jibo) Sanyal
Computational Urban Sciences Group, Computational Sciences and Engineering Division
Oak Ridge National Laboratory

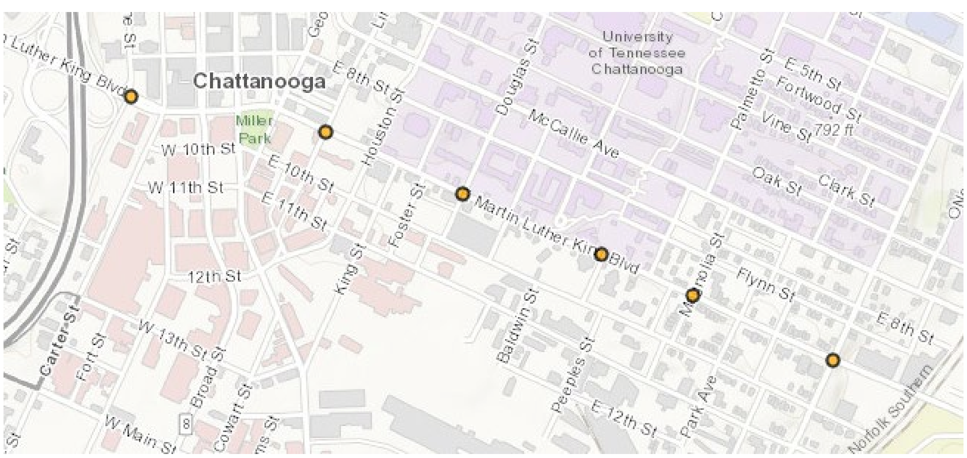
## Problem Background & Context

Traffic congestion on roadways results in increased travel times, reduced speeds, and increased queueing of vehicles. Congestion typically occurs when demand exceeds capacity on roadways and at intersections. As cities begin addressing traffic congestion, a plethora of solutions are being implemented, out of which Intelligent Traffic Cameras (ITC) are gaining popularity. ITC systems are aimed at traffic monitoring and incident detection (e.g., accidents) to ultimately ensure safe and efficient movement of vehicles through the transportation system in a given region. These tools are extremely important for traffic planners especially within the context of smart cities, emerging mobility services, and connected and autonomous vehicles (CAVs).

To this end, the city of Chattanooga has deployed multiple cameras along major corridors in the region. The vendor for these cameras is GridSmart Technologies. The cameras monitor traffic at various intersections on a minute-by-minute basis. The typical data recorded at the intersection includes but is not limited to vehicular movements (e.g., through traffic, left-turn and right turn movements) and average speed of oncoming traffic.

## Data Description and Usage

For this Data Challenge, we are providing traffic data for Martin Luther King Boulevard in Chattanooga, TN. This corridor is adjacent the University of Tennessee Chattanooga and extends into the downtown area. The Chattanooga Department of Transportation has placed GridSmart sensors at six intersections along the corridor. These sensors collect real-time information about all vehicles that cross the intersection, derived from a fisheye camera video stream (imagery is not included in this data challenge). The dataset spans January 20–27, 2019 (8 days). On Martin Luther King Jr. Day (January 21), a parade took place on this corridor.




***Six GridSmart sensors are located along Martin Luther King Jr. Boulevard.***

The dataset comprises the following:

- A small road network of Martin Luther King Jr. Boulevard and surrounding areas is provided in shapefile and GeoJSON format.
    - Roads: Roads are defined as line segments which have nodes along the way. Each line segment has information on number of lanes and other parameters. A small portion of the road network is synthetic, as it was missing in the original dataset.
    - Intersections: Intersections are available as point data.
- GridSmart sensor locations are provided as point data in shapefile and GeoJSON format.
- Road closure details.
- Measured traffic data for each sensor during the time period of January 20–27, 2019.
    - For each sensor, we provide a folder with one csv file per day.
    - For each vehicle that enters the intersection, the sensors provide:
        - A time stamp (hh:mm).
        - Approach orientation. Data point can be **N**orth, **S**outh, **E**ast, **W**est, or **U**ndefined. For instance, "W" means that the driver is *West-bound* or approaching from the east.
        - Turn direction. Data point can be **S**traight, **L**eft, **R**ight or **U**-Turn.
        - Length in feet. According to the Transportation Research Board, National Academy of Sciences, any vehicle 50 ft or longer is considered a truck.
    - Speed in miles per hour.
    - Light phase. Data point can be **G**reen, **Y**ellow, **R**ed, **P**ermanent **G**reen, or **N**one.

Participants are welcome to bring in additional (public) datasets and fuse it with the provided data to create meaningful insights.

**Challenge Questions**

1. **We need an elegant way to visualize traffic volumes (i.e., number of vehicles) and speed by vehicle type if necessary.** Some guidelines here are:
    a. Visualize the hourly variation of attributes across the corridor and intersections.
    b. Interactive capability across the corridor (e.g., mapping capability).
2. Traffic management and planning is resource intensive. To optimize planning efforts, anomaly and outlier detection is of paramount importance in the system. **We need you to come up with techniques/methods for anomaly detection in data along with the corridor and/or the intersections.** Some guidelines here are:
    c. These anomalies can vary from discontinuous traffic volumes along the corridor to large discrepancies in recorded speed profiles.
3. Traffic congestion occurs when demand exceeds supply in the transportation system. **We want you to define congestion metrics and investigate the variability and reliability of congestion.** These can be across different hours of the day or different days of the week. Some guidelines here are:
    d. Congestion can be defined according to travel time, speed, or demand.
    e. Commute times typically remain stable during weekdays when compared with weekends.
4. Traffic management is better deployed when the future state of the system and resource allocation can be anticipated. **For this purpose, we want you to build a predictive**

**model capable of forecasting traffic in the short term (e.g., what is the expected level of congestion in next 15 minutes based on previous system state).** Some guidelines here are:

   f. Traffic management is typically carried out at the corridor level (i.e., made up of multiple intersections).
   g. The system mostly follows conservation principles wherein traffic entering and exiting the system can be tracked. This is true even in predictive models.

5. Any predictive model should be grounded in real-world data. **For this purpose, we ask you to robustly validate the predictive model for better inference and traffic management applications.**
   h. Model validation can be performed using several techniques (e.g., split the data into training and test data).
   i. Predictive models are never deterministic. What level of uncertainty is involved in these forecasts?

**Team Description and Data Challenge Overview**

The Computational Urban Sciences Group led by Jibonanda (Jibo) Sanyal is working with Anne Berres, Kuldeep Kurte, and Srinath Ravulaparthy to apply cutting-edge computational modeling and simulation techniques to solve issues in the urban sciences. Their research is at the nexus of transportation planning and operations, spatial sciences, energy sciences, statistics, and high-performance computing (HPC). This current collaboration is based on the US Department of Energy-funded project on Real-Time Data & Simulation for Optimizing Regional Mobility. The goal of this project is to evaluate and improve regional traffic congestion by developing and applying a cyber–physical control system strategy for real-time and predictive control of traffic patterns. By implementing this system in a modest-sized urban/suburban region, the project team expects to achieve a 20% energy savings at the regional level by delivering smart and efficient mobility.

This dataset generated as part of this project is aimed at developing a cyber–physical system to enable energy-efficient mobility systems from early-stage HPC-based research and development through demonstrations to commercialize the optimization of mobility, energy efficiency, and productivity in a regional traffic domain. The researchers are excited to share this dataset, as this is first-of-its kind data coming directly from sensors in the city of Chattanooga, where intelligent traffic management planning is key to addressing safe and efficient movement of vehicles through the system. Ultimately, benefits from connected and smart sensors will come in the nearer term from accelerated intelligent infrastructure impacts on the operation and movement of conventional vehicles. The group hopes that participants will excel and contribute in terms of data and visualization analytics, algorithm development, and deployment to this cross-disciplinary data challenge.