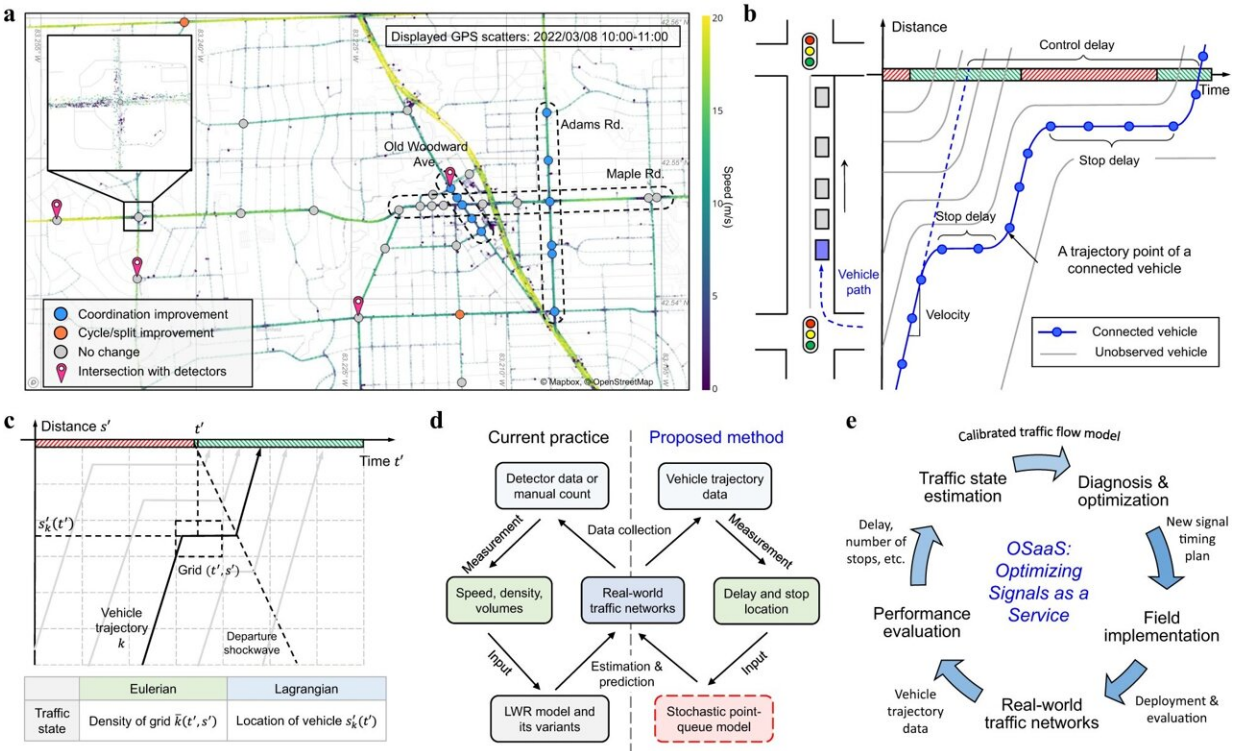


Improving traffic signal timing with a handful of connected vehicles

February 20 2024, by Jim Lynch



Traffic signal retiming with vehicle trajectories. **a** Trajectory point scatters in the City of Birmingham, Michigan, which has a total of 34 signalized intersections, including three main corridors and some isolated intersections. Each point represents a vehicle’s location at a certain timestamp, and the color of the point changes with speed. Corridors and intersections that were identified with traffic signal re-timing opportunities are labeled with different colors. **b** Time-space (TS) diagram and connected vehicle trajectory. The blue line shows the vehicle trajectory of a connected vehicle. Each blue dot represents a trajectory point. **c** Eulerian and Lagrangian traffic state representations. Eulerian

traffic state representation defines the traffic state as the density of each cell, while the Lagrangian keeps track of the movement of the vehicle. **d** Comparison of current practice based on fixed-location detector data and the proposed method with vehicle trajectories. LWR models are frequently used to model traffic flow from detector data, which directly provides speed, density, and volumes at certain locations. We utilize the stochastic point-queue model under the Newellian coordinates, where vehicle trajectory data, which directly provides delays and stop locations, is the only input. **e** OSaaS system: an integrated closed-loop system with performance evaluation, traffic state & parameter estimation, diagnosis, optimization, and field implementation. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-45427-4

With GPS data from as little as 6% of vehicles on the road, University of Michigan researchers can recalibrate traffic signals to reduce congestion and delays at intersections significantly.

In an 18-month pilot study conducted in Birmingham, Michigan, the team used connected vehicle data insights provided by General Motors to test its system, resulting in a 20% to 30% decrease in the number of stops at signalized intersections. GM vehicles make up 6-10% of cars currently on the road in the United States.

Officially, it's the world's first large-scale, cloud-based traffic signal retiming system, and it represents a major opportunity for communities to recalibrate their signal patterns at a reduced cost. U-M's research [appears](#) in *Nature Communications*.

The U-M system takes GPS data from a percentage of vehicles on the road and extrapolates traffic patterns. For example, a connected vehicle that comes to a stop roughly 100 feet from an [intersection](#) strongly indicates that it is behind at least three or four other vehicles.

"While detectors at intersections can provide traffic count and estimated speed, access to vehicle trajectory information, even at low penetration rates, provides more valuable data including vehicle delay, number of stops, and route selection," said Henry Liu, U-M professor of civil engineering and director of both Mcity and the Center for Connected and Automated Transportation.

There are roughly 320,000 traffic signals in the U.S., and the annual congestion costs—direct and indirect—associated with those intersections come out to \$22.9 billion. Those costs include time spent waiting at lights, as well as unnecessary energy consumption caused by signal times that can be improved.

Most [traffic signals](#) operate on a time-of-day signal timing plan, where preset patterns are in place for morning, afternoon, evening, and overnight. Traffic planners attempt to coordinate those cycles with surrounding intersections to allow cars to flow between intersections with as little stop-and-go travel as possible.

"The reason these signals should be changed more often is that traffic is always changing," Liu said. "A good example is the traffic patterns we saw in the year before COVID's arrival and the two years afterward. Your morning peak hour changed drastically with so many people working from home. When you see that kind of change, you need to retime these signals."

Optimizing signals to keep up with changes in traffic flows isn't a simple task. The costs and time involved in doing traffic counts and recalculation mean most municipalities won't reassess for two to five years or sometimes decades.

While adaptive signals have been around since the 1970s, detecting vehicles at intersections to reprogram signals almost in [real-time](#), the

cost has kept them from widespread use. Installation of an adaptive system at a single intersection can cost as much as \$50,000, with regular maintenance required—a price tag not all communities can afford. The U-M system for optimization would cost a fraction of that of an adaptive system.

The U-M system, called a probabilistic time-space diagram, allows for a smaller percentage of connected [vehicle](#) data to do the same workload as sensors at an adaptive traffic signal. To test its effectiveness, researchers collected data over the course of three weeks in March 2022 from each of Birmingham's 34 signalized intersections—most of which are fixed-time systems.

"What this has done is really solve our data collection issue," said Gary Piotrowicz, deputy managing director of the Road Commission for Oakland County. "And I could argue that this is going to be the way everybody in the country does it. Once they've solidified the system, there's no reason to do it any other way."

Liu's team features several graduate students including Zachary Jerome, a graduate research assistant and member of the Michigan Traffic Lab who helped develop U-M's algorithm. Jerome worked directly with RCOC and hopes to collaborate with industry partners to help other municipalities deploy this cost-saving technology.

"The opportunity to work with industry to bring this groundbreaking technology into real-world applications is incredibly inspiring," Jerome said. "My vision is that this system will provide a revolutionary signal retiming solution for communities across the world that is scalable, sustainable and efficient."

More information: Xingmin Wang et al, Traffic light optimization with low penetration rate vehicle trajectory data, *Nature Communications*

(2024). [DOI: 10.1038/s41467-024-45427-4](https://doi.org/10.1038/s41467-024-45427-4)

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