Reducing traffic congestion, remotely

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At the Intelligent Transportation Systems World Congress last week, MIT researchers received one of the best-paper awards for a new system, dubbed RoadRunner, that uses GPS-style turn-by-turn directions to route drivers around congested roadways.

In simulations using data supplied by Singapore's Land Transit Authority, the researchers compared their system to one currently in use in Singapore, which charges drivers with dashboard-mounted transponders a toll for entering congested areas.

The Singapore system gauges drivers' locations with radio transmitters mounted on dozens of gantries scattered around the city, like the gantries used in many U.S. wireless toll systems. RoadRunner, by contrast, uses only handheld devices clipped to cars' dashboards. Nonetheless, in the simulations, it yielded an 8 percent increase in average car speed during periods of peak congestion.

Moreover, for purposes of comparison, the MIT researchers restricted themselves to road-access patterns dictated by Singapore's existing toll system. Modifying those patterns—encouraging or discouraging the use of different stretches of road—could, in principle, lead to even greater efficiency gains.

"With our system, you can draw a polygon on the map and say, 'I want this entire region to be controlled,'" says Jason Gao, a graduate student in electrical engineering and computer science who developed the new system together with his advisor, Professor of Electrical Engineering and Computer Science Li-Shiuan Peh. "You could do one thing for a month and test it out and then change it without having to dig up roads or rebuild gantries."

Gao and Peh also tested their system on 10 cars in Cambridge, Mass. Of course, 10 cars is not enough to dramatically affect local traffic patterns. But it was enough to evaluate the efficiency of the communications system and of the vehicle-routing algorithm. It also provided reliable data about the system's performance for use in simulations.

Max capacity

Urban toll systems like the one in Singapore designate certain regions—with gantries at every entry point—as prone to congestion.

Drivers are charged a fee for entering any such region, so they have an incentive to avoid it. The fee fluctuates over the course of the day, according to historical traffic data.

RoadRunner, by contrast, assigns each such region a maximum number of cars. Any car entering the region must acquire a virtual authorization that Gao and Peh call a "token." If no tokens are free, RoadRunner routes the car around the region using turn-by-turn voice prompts.

The version of RoadRunner used in the Cambridge tests was largely decentralized: A car leaving a region would wirelessly announce that its token was available, and a car seeking to enter the region would request it. The system used a wireless standard called 802.11p, a variation on Wi-Fi that uses a narrower slice of the electromagnetic spectrum but is licensed for higher-power transmissions, so that it has a much larger broadcast range.

It could be that the time savings promised by RoadRunner would be enough to induce commuters to use it. But it would also be possible to modify the system so that any car entering a congestion-prone region without a token would be assessed a small fine.

Reporting a car for tokenless entry would require uploading data to a central server, but it wouldn't require specifying the car's location at a resolution finer than that of the region. So Gao believes that, even though RoadRunner relies on GPS data, it wouldn't compromise drivers' privacy any more than existing urban toll systems do. In fact, he argues, it would compromise privacy less, since cars that followed the system's routing instructions would never have their locations reported.

An app for that

In their experiments, Gao and Peh used cellphones to control commercial 802.11p radios, which are about the size of a typical electronic-toll dashboard transponder. But in the future, it may be possible to embed the radios directly into cellphones.

At the International Symposium on Low Power Electronics and Design in August, Gao, Peh, and lead author Pilsoon Choi, a postdoc in Peh's group, together with researchers at Nanyang Technological University in Singapore, presented a paper demonstrating that an 802.11p radio built from gallium nitride and controlled by silicon electronics would consume half the power that existing radios do.

Moreover, the Singapore-MIT Alliance for Research and Technology (SMART) has developed a technique for integrating gallium nitride into existing silicon-chip manufacturing processes and is currently building a chip-fabrication facility to implement it.

"In Singapore, the government already requires every single registered vehicle to have a dash-mounted transponder," Gao says. "That's already there, so you might as well take advantage of it. In other places, where you don't have that in place, it would be easier to deploy it if you said, 'You can download this app and just leave your cellphone on your dashboard.'"

"A distributed decision process is an alternative to centralized models that has to be explored and, as far as I know, has been rarely if not ever addressed," says Jean Bergounioux, secretary general of ATEC ITS France, a French industrial research consortium dedicated to novel transportation systems. "RoadRunner offers the possibility of decentralizing as many decisions as possible at the lower level, without excluding that global decisions be made at the upper level."

"It's worth getting into field trial as soon as possible to test and evaluate the feasibility of its industrial development and deployment," Bergounioux adds.

More information: The complete paper is available online: projects.csail.mit.edu/wiki/pu … runner_itswc2014.pdf

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