Cars and roads share info, alert drivers

Today’s drivers tune into traffic updates on their car radios. But tomorrow’s drivers are likely to rely on a very different kind of radio system to help them avoid congestion. Under the U.S. Department of Transportation’s IntelliDrive research initiative, researchers are developing a range of applications that transmit data between moving vehicles, and between vehicles and the transportation infrastructure.

Professor M. Imran Hayee of the University of Minnesota Duluth’s Department of Electrical and Computer Engineering, along with his team of students, is developing a system that transmits congestion data to motorists near work zones, where traffic jams and collisions with maintenance workers are a safety hazard. The research is supported by the Northland Advanced Transportation Systems Research Laboratories (NATSRL), part of the ITS Institute.

The new system is one of many applications now being developed based on the Dedicated Short-Range Communications (DSRC) standard, which was allocated specifically for ITS applications by the USDOT in 1999. Like the familiar 802.11 wireless networking standards that enable laptop computers and other electronic devices to connect to data networks, DSRC is designed for short-range use—typically less than 1,000 meters. It offers high data transmission rates with low latency and is largely unaffected by weather disturbances, both of which are critical characteristics for ITS applications with rapidly moving vehicles.

DSRC is intended to support both vehicle-to-vehicle applications, such as cooperative forward-collision warning, and vehicle-to-infrastructure applications, such as electronic toll collection. In both cases, vehicles and infrastructure components become nodes on a wireless network. Each vehicle’s onboard DSRC system constantly updates the topology of its local network as vehicles and infrastructure nodes enter and leave the system’s coverage area.

Hayee designed a system consisting of a portable roadside unit (RSU) that can be installed easily in work zones and onboard units (OBUs) to be installed in vehicles. Both types of unit are commercially available. The RSU gathers data on the location and speed of nearby vehicles by engaging their OBUs. With these data, the RSU determines average travel time in the vicinity of the work zone and locates the start of congestion (SoC)—the point where traffic changes from a free-flowing state to a congested state. This information is then broadcast back to the OBUs. Each OBU calculates the distance to the start of congestion and displays the information via a separate user interface enabling the driver to decide whether to take an alternate route and warning him or her of a sudden speed reduction.

The process of determining travel time and locating the start of congestion involves processing data from GPS receivers in the vehicles’ OBUs. Each OBU responds to queries from the roadside unit as it comes into range before encountering congestion. Although these GPS location data may entail significant errors, a preliminary error-correction operation is first carried out within the OBU to ensure that the vehicle is traveling toward the RSU and is within the area where data on vehicle movement will be useful for calculating travel time and locating the start of congestion.

A vehicle that passes the OBU’s preliminary location check is then subject to a fine location check by the RSU. This second, more precise check rules out the possibility that the approaching vehicle is traveling on a nearby parallel road within the error margin of the preliminary check. Only after passing the fine position check is a vehicle recognized as a source of speed and congestion data for the RSU. At this point, the OBU begins to transmit messages containing time, speed, and location data to the RSU at one-second intervals until it reaches the point where congestion ends. As soon as an OBU passes beyond the end of congestion (EoC) point, the RSU processes the data it has received, updates the start of congestion and travel time locations, and prepares to contact the next OBU to arrive in its coverage area.

Because data from private vehicles are transmitted automatically in an uncontrolled environment, protecting the privacy of users is a key concern. The DSRC communication protocols underlying Hayee’s prototype system include built-in security features that ensure the privacy of users. This is done through the use of encryption, which makes it impossible for eavesdroppers to understand the information transmitted by the system.

The power to increase fuel efficiency isn’t up to auto manufacturers alone. Efficient driver behavior can also help achieve large reductions in fuel consumption. In a recent study funded by the National Highway Traffic Safety Administration, ITS Institute researchers investigated fuel-economy display (FED) devices that provide feedback on driver behavior to determine their contributions to fuel savings.

At a recent research seminar, Justin Graving, a research fellow at the ITS Institute’s HumanFIRST program, presented his work evaluating how features of fuel-economy displays affected fuel consumption during simulated driving. Study results indicated that the presence of a fuel-economy display promoted fuel-efficient driving, but also showed that when instructed, drivers were able to reduce their fuel consumption without the aid of a display.

The U.S. Department of Energy suggests that driving sensibly (no hard braking, reducing aggressive driving, and reducing rapid acceleration) can improve a car’s fuel efficiency by 33 percent, and observing the speed limit can improve it by 23 percent. Other behaviors that can help improve fuel efficiency include not idling for longer than 20 seconds at a time, using cruise control and overdrive gears, avoiding changes in momentum, and keeping the windows up at speeds of 40 mph or higher.

If such drastic results can be achieved through driver behavior alone, the obvious question is: How do we get people to drive more efficiently? The answer,
measures that protect DSRC applications from eavesdropping, falsification of data, and other attacks. The researchers also designed their system with privacy in mind; the RSU lacks access to any potentially identifying information from the vehicle OBUs, and data on travel time and congestion are discarded once circulated.

According to a recently published report on the research, the system can be adapted to any road by changing the input parameters of the RSU; the OBU does not require any data about the road being monitored. The RSU requires only input parameters for key GPS waypoints on the road and settings for communication with OBUs. In operation, the RSU sends specific parameters related to the road segment to the OBU, which uses these parameters in its communications with the RSU.

The use of a consumer smartphone as the driver interface is one of the innovative aspects of the prototype system, and one that allows significant cost savings, especially for those vehicles that lack a built-in dedicated interface. Rather than a dedicated driver interface, which is expected in future vehicles, each OBU is equipped with a communication interface device that can connect to a smartphone via the Bluetooth wireless networking protocol. An application installed on the smartphone connects to the OBU automatically and presents information to the driver in the form of text messages. The researchers note that the system architecture supports the use of different user interfaces as needed to avoid driver distraction.

Hayee tested the prototype extensively in a variety of congestion scenarios in both urban and rural areas. The field tests showed that the system can accurately determine travel time and the location of the start of congestion in real time under changing traffic conditions.

One limitation of the current system is that optimal performance requires a clear line of sight between the RSU and OBUs. However, the researchers already plan to address this issue in their future development of the system by enabling vehicle-to-vehicle data networking: moving data along a network of vehicle-based units rather than between only the infrastructure base station and individual vehicles will eliminate the need for a direct line of sight.

The matrix displays four types of destinations for travelers who drive, transit or by car.

People who make transportation and land-use decisions in the Twin Cities region have a new tool: an online “accessibility matrix” that illustrates variations in accessibility—the ability of people to reach the destinations they need or want to visit—to different types of destinations for travelers who drive, bike, walk, or use transit.

The tool is hosted by the ITS Institute’s Minnesota Traffic Observatory (MTO), a transportation laboratory staffed by experts in managing large data sets and creating visual models of complex data. The matrix displays four types of maps: accessibility (the ability to reach destinations), mobility (the ability of people to move on the network), travel time (how long it will take to get between census blocks with each of the travel modes), and land use (the distribution of activities by census block). Users can select up to four filters, including year, mode, time of day, and destination type (such as retail, restaurants, or recreation). The result, for example, could

Researchers exhibit at USDOT

Two ITS Institute projects were featured in poster presentations at University Research Technology Transfer Day, an exhibition of the U.S. Department of Transportation’s Research and Innovative Technology Administration (RITA), on April 6 at the USDOT headquarters in Washington, D.C.

“Traffic Signal Performance Measurement Using High-Resolution Data: The SMART-Signal System,” led by Associate Professor Henry Liu of the Department of Civil Engineering, simultaneously collects event-based high-resolution traffic data from multiple intersections and generates real-time arterial performance measures.

“Smartphone-Based Novice Teenage Driver Support System (TDSS)” was developed to help inexperienced drivers by providing real-time, in-vehicle feedback. In addition to the poster exhibit, the project was selected for a podium presentation, given by researcher Janet Creaser. Co-investigators of this research are ITS Institute director Max Donath, research fellows Creaser and Alec Gorjestani, and HumanFIRST Program director Mike Manser.

“Janet and Henry did a great job answering questions from the many participants who stopped at their tables,” Donath said, adding that the posters generated considerable interest among attendees. The event highlighted research products that have been or are in the process of being deployed into the marketplace or affecting policy.

Institute lab hosts online accessibility tool

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Graving said, is either through training or by providing feedback to drivers through fuel-economy displays.

Graving’s project set out to accomplish two primary goals. The first, to document the design range of FEDs, aimed to determine the similarities and differences across the marketplace, where there are no existing guidelines for design. Building on this work, the second goal was to identify common display components that helped drivers improve their efficiency and present recommendations to auto manufacturers for inclusion within larger stylistic changes.

“There’s a wide range of potential designs out there and a lot of times the manufacturers just follow what they think the consumers want...but there’s no clean, clear evidence that those displays actually help,” said Michael Manser, director of the HumanFIRST program and member of the project team.

The project team selected three key components to include in the test FEDs: combined short-term (e.g., instant mpg)

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Graduate student Buddhika Maitipe puts the DSRC unit in a car for the system’s field demonstration.
In Minnesota, most intersection-related crashes occur at rural, two-way-stop intersections because drivers stopped on a minor road often cannot see traffic on the major road. Nearby vertical and horizontal curves increase the risk when entering the intersection. At these intersections, right-angle crashes account for the largest percentage of crashes, and most are related to drivers’ inability to recognize a safe gap in the traffic stream.

To improve safety at these rural, two-way-stop intersections, researchers from the University of Minnesota Duluth, working with St. Louis County, Minnesota, developed the ALERT System (Advanced LED Warning Signs for Rural IntersectionsPowered by Renewable Energy). Sponsored by the Minnesota Local Road Research Board, this low-cost, dynamic warning system provides traffic information to drivers approaching the intersection.

Vehicle detectors placed at each approach send messages to LED blinker signs. The system is wireless and powered by solar panels, which eliminates problems associated with buried wires as well as the need to connect to a local power grid.

The system was installed at the intersection of West Tischer Road and Eagle Lake Road in Duluth. This intersection has a severe vertical curve on the east approach of the major road and an intersection at nearly in the intersection. Westbound drivers on the minor road cannot see cross traffic until they are nearly in the intersection.

Westbound drivers see the message “CROSS TRAFFIC WHEN FLASHING,” North and southbound drivers on the minor road see the message “VEHICLE APPROACHING WHEN FLASHING.”

The research team included Taek Kwon, a professor in the Department of Electrical and Computer Engineering; research associate Ryan Weidermann; and St. Louis County traffic engineer Victor Lund.

According to Lund, ALERT was “tremendously successful” at changing driver behavior. When the alert signs were flashing, westbound traffic on the major road slowed 4 mph, drivers on the minor road waited longer before crossing, and roll-throughs were eliminated.

However, when the alert sign was not flashing, drivers on the minor road apparently assumed there was no cross traffic. As a result, they did not always obey the stop sign, and roll-throughs increased, Lund says. This increases the risk of crashes when the device stops working—as ALERT did on several sunless days last winter.

Driver-assistance devices for intersections, such as ALERT, are effective, Lund says. But he adds that standardization is needed before these devices can be widely used. This means that state and federal standards must be established for messaging, illumination, and placement of signs. Fail-safe issues—such as malfunctioning solar panels—must also be dealt with.

Ease of maintenance is also an issue. Lund notes that county employees currently need to climb a ladder to service ALERT, but he’s hopeful that one day all components will be enclosed in a ground-level service cabinet, which would eliminate the need for a ladder and allow for easier access.

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In an environment with little or no traffic, a fuel-economy display could be effective for increasing mpg.

The study results showed that both the FED group and the control group members (who were only asked to drive more efficiently) were able to increase their mpg significantly (11 percent and 4 percent, respectively). Graving concluded that in an environment with little or no traffic, a fuel-economy display could be an effective tool for increasing miles per gallon. “Within an urban environment when traffic is present you may have a benefit in mpg with a fuel-economy meter, but the features of the display could prove distracting, depending on the design,” Graving said.

Further research is needed to support a conclusion that having a fuel economy display in a vehicle compromises driving safety by contributing to distraction, because its presence may not be problematic. It’s important to develop and test other ways to deliver fuel economy information, such as with auditory messages, that do not lead to looking away from the road frequently, Graving said.

Signs use solar power to make rural intersections safer

Fuel display

Drivers created two FEDs—one showing how acceleration affected fuel efficiency (too low or too high), and one showing instant fuel economy. Both displays also included a trip average indicator. Graving and his team then evaluated the impact these displays had on fuel economy within the context of simulated driving. Thirty human test subjects were asked to drive fuel efficiently in the HumanFIRST driving simulator and were assigned the acceleration display, the instant fuel economy display, or no display at all. None of the subjects were given instructions on how to drive fuel-efficiently.

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Conference features Institute researchers

ITS Institute researchers discussed their work at the 22nd Annual CTS Transportation Research Conference in St. Paul, Minnesota, May 24 and 25. Presentations included:

- “Development and Evaluation of an Advanced LED Warning System for Rural Intersections,” Taeik Kwon, Department of Electrical and Computer Engineering (Duluth)
- “E-Workplace: Telecommuting Reduces Congestion in the Twin Cities Metropolitan Area,” Adeel Lari, Humphrey School of Public Affairs
- “Impact of Transit Signal Priority on Bus Service Performance,” Chen-Fu Liao, Department of Civil Engineering
- “Vision-Based Bicyclist and Pedestrian Counting Systems,” Guruprasad Somasundaram, Department of Computer Science and Engineering

Career Expo draws record attendance

The ITS Institute teamed up with the Center for Transportation Studies, the Minnesota chapter of the Women’s Transportation Seminar, the Minnesota Local Road Research Board, the Minnesota Local Technical Assistance Program, and the Council of Supply Chain Management Professionals to put on the 2011 Transportation Career Expo on March 1. The event drew more than 100 students eager to learn about transportation-related careers, receive job-hunting tips, and network with potential employers.

The expo featured a general-session panel discussion with transportation industry experts presenting career alternatives and preparation strategies. Among those serving on the panel was past ITS Institute Student of the Year award recipient Fay Cleaveland, now a transportation planner with the Minnesota Department of Transportation.

An exhibitor fair offered networking and employment-seeking opportunities with representatives from the public and private sectors and professional organizations.

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