'Smart' traffic boxes could help monitor roads, save money

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Ohio State University engineers are working to make the traffic control boxes that stand beside major freeways smarter.

They've developed new software that helps the computerized boxes locate road incidents -- such as traffic back-ups or accidents -- and notify transportation authorities at lower cost, especially in rural areas.

For a large city like Columbus, Ohio, the savings could add up to tens of thousands of dollars a month. For a state like California the savings could be over a million dollars a year.

Over the last few decades, transportation departments around the country have installed devices called "loop detectors" to monitor traffic at key points on the road network, explained Benjamin Coifman, associate professor of civil and environmental engineering and geodetic science at Ohio State. He is also an associate professor of electrical and computer engineering.

The car-sized wire loops buried in the pavement effectively act as metal detectors. When a car passes over a loop, the detector sends a signal to a computer in a control box at the side of the road.

The controller may simply count the number of cars that pass by and calculate average speed, or it may actively control traffic. Ramp meters are one example -- they limit the number of cars entering a freeway by controlling a traffic signal on the on-ramp.

But Coifman knows that the controller boxes can do much more.

"The basic technology of these devices is very reliable, and such detectors are becoming more widespread as congestion increases," he said. "But little attention has been paid to how they are used.

"It's as if you handed a teenager a cell phone and said, 'make all the calls you like.' A lot of information gets transmitted, you might only be interested in a small amount of it, and you get a large phone bill at the end of the month."

The main cost of using such devices is the cost of sending electronic signals between them and the transportation center that is doing the monitoring. Normally, controller boxes transmit their data very frequently. Some do so as often as once every twenty seconds.

"When the number of controller boxes in use around the country was small, the communication costs were small, but now that the numbers are increasing, so are the bills," Coifman said. He wants to help states leverage those detector stations and keep costs down.

He and former graduate student Ramachandran Mallika wrote software that enabled the controller boxes to detect traffic incidents and get important messages back to the traffic control center using a fraction of the bandwidth that was previously required.

In the October 2007 issue of the journal Transportation Research Part A, they report that their software achieved better than 90 percent accuracy in reporting traffic conditions at the interchange between two busy Columbus, Ohio interstates -- using up to 200 times fewer signals than before.

Instead of sending all of the data all of the time, the new software infers road conditions based on traffic patterns. It determines whether conditions are critical enough for an alert to be sent to a state transportation authority. Otherwise, it sits quietly and leaves the communication channel free.

For example, if traffic stalls at an interchange, the controller box could alert authorities that it suspects an accident. If conditions are fine, no data are sent.

"With this approach, no news is good news," Coifman said.

The approach is more efficient, because the controller boxes only send signals to the control center when absolutely necessary, which reduces communications costs. The transportation authorities would only need to electronically "ping" a quiet station once in a while, to make sure it was still working.

Between pings, the station would store non-critical data -- such as the traffic counts that authorities use to determine if a road needs resurfacing -- to be retrieved later.

Traffic detectors are being deployed in larger numbers to address the costs of traffic congestion, Coifman pointed out. He cited a report that estimated the net cost of urban congestion in the United States to be over $63 billion in 2003, almost double the cost of 10 years earlier. The average American also loses 47 hours to traffic delays every year. More than half of those costs -- both in time and money -- were found to be due to roadway incidents such as accidents.

Coifman hopes that his software can help traffic control centers identify incidents more efficiently, so that people can spend less time in traffic, and recoup some of those costs.

Columbus was a good place to develop the software. Ohio is the seventh-most-populated state in the United States, and nearly two million of its 11 million residents live in the Columbus metropolitan area. The population is growing, and so is the traffic.

Coifman and Mallika tested their software using loop detector data from one of the heaviest-traveled corridors in Columbus: the interchange between Interstates 70 and 71, which cross near the middle of downtown.

Given the signals captured by loop detectors during four known traffic incidents that occurred in 2005, the software accurately identified when -- and approximately where -- each incident occurred.

Whenever a detector noticed a dramatic decrease in the speed of cars or the number of cars that passed by, it communicated with the traffic management center, which then pinged the neighboring detector stations to perform a kind of triangulation to locate the incident that was affecting traffic.

The engineers found in all four test cases, the software didn't trigger a data signal to the control center until it had correctly determined that an incident had happened.

On average, the controller boxes in this simulation sent fewer than 10 signals a day -- 200 times less than they would normally send.

The engineers also looked at dozens of detector stations over an entire month. Even using fewer than 10 signals a day, the software was able to accurately calculate traffic speeds with greater than 90 percent accuracy, compared to situations when all the data were sent.

"We found that, even though we were sending a lot less information, we could still get the same picture of what was happening on the road," Coifman said.

In Columbus, his communication scheme would pay off the most for data gathered from rural areas.

That's because the Ohio Department of Transportation (ODOT) has already reduced its ongoing data transmission costs within Columbus by purchasing its own communication lines; ODOT-owned fiber optic cable now connects most loop detector stations inside the city limits. So the city has virtually unlimited bandwidth to capture data from the most congested areas.

But ODOT doesn't own data lines outside the city proper, where burgeoning suburbs are pushing out into once-rural areas. There, just as residents have to pay for phone and Internet service to their homes, ODOT has to pay for the use of pre-existing communications lines to get data from its loop detectors.

"Under the current practice of sending all of the data back to the traffic management center, it does not make sense to place instruments at locations that only occasionally see congestion," Coifman said. But if these distant detector stations sent data to ODOT headquarters only when necessary, communications costs would likely drop.

"When an incident occurs, the authorities could know much quicker, and ODOT would have a more complete picture," he added. "The same strategy would work in any city."

Source: Ohio State University