Study shows that vehicle-to-vehicle navigation systems really do work

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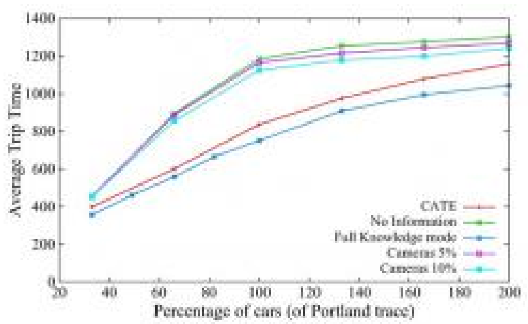

Total average trip time (in seconds) as traffic flows increase: CATE vs. camera infrastructure. Image credit: Leontiadis, et al. ©2011 IEEE

(PhysOrg.com) -- Traffic congestion is not only annoying, it’s expensive. In 2005, traffic congestion cost an estimated $78.2 billion in 437 urban areas in the US, according to the Texas Transportation Institute’s 2007 Urban Mobility Report. The cost is measured by the travel time index, which is the ratio of travel time in rush hours to travel time at quiet periods, and has increased from 1.09 in 1982 to 1.26 in 2005. In addition to the use of public transportation and bicycle commuting to address this problem, some researchers have been developing intelligent transportation systems in which vehicles use near-real-time traffic data to choose the fastest route and decrease congestion throughout the network.

However, there has been some debate on whether or not these high-tech systems actually work – that is, whether or not they minimize the overall average travel time of all vehicles in a traffic network. Some studies during the past several decades have shown that even having perfect traffic information does not guarantee lower congestion. In one model, a traffic network in which every vehicle had full information of the roads had the same overall performance as a traffic network with no information feedback.

Now a new study shows that navigation systems in which vehicles collect and share traffic information with each other can decrease the average travel time of all vehicles in a traffic network. In contrast to some of the previous studies that found the opposite result, this study dealt with a fully decentralized, crowd-sourced system rather than sensors located at specific road locations, and also tested the system using real-life experiments and simulations of more complex, realistic traffic flows compared with the simpler models in previous studies.

The researchers, Ilias Leontiadis from the University of Cambridge and coauthors from there, the University of Bologna, and the University of California, Los Angeles, will have their study published in an upcoming issue of *IEEE Transactions on Intelligent Transportation Systems*.

First, the researchers designed a smart navigation system called CATE (Computer-Assisted Traveling Environment). In CATE, every vehicle acts as a traffic sensor by sending traffic data every time it exits a road segment, which is typically at an intersection. The data, which includes the intersection, the time the vehicle entered the road segment, and the time the vehicle exited the road segment, gets sent to other vehicles via a wireless network. As demonstrated by experiments at UCLA's Campus Vehicular Testbed (C-VeT), the low data rates that the technology requires can easily be supported by the bandwidth used by personal wireless devices, such as GPS systems or smart phones.

Next the researchers compared different algorithms that these devices might use to choose the best route based on the traffic information they receive. Using computer simulations as well as traffic data collected in downtown Portland, Oregon, the researchers found that, with the best algorithms, 64% of vehicles reduced their travel time by more than 10%. Of the rest, 23% had trip times within 10% of their times without the information (and so were considered to not really be affected), and the remaining 13% required more time than without the information. The researchers attribute the increased time to the fact that some traffic was being diverted into relatively open roads that consequently became busier than before.

Still, the overall average trip time was significantly reduced when the CATE navigation system was used. The researchers also found that, when just 34% of the vehicles used CATE, the performance of the entire traffic network was comparable to the performance when up to 100% of the vehicles used the system.

“The results show that crowd-sourced information can be used to estimate traffic conditions,” Leontiadis told *PhysOrg.com*. “Since traffic measurements are subjected to a lot of noise (e.g., some vehicles might be caught in traffic lights, some not, etc.), we showed that this information is still valuable when the appropriate algorithm is used in order to correlate information from multiple vehicles.”

Part of the reason for the positive results of the evaluation is due to the way that CATE works compared with other navigation systems, such as video cameras or induction loops that monitor select street locations. With these latter systems, all vehicles can instantly access the same information using cellular networks or FM radio stations. However, not all streets are monitored, which can cause unknown congestion in these areas. In contrast, all streets with vehicles that use CATE are monitored, so vehicles do not congest streets due to lack of information. Also, all vehicles have a slightly different perspective of the traffic conditions, which may lead to more individualized routes. Leontiadis explained that one of the surprising results was how quickly and effectively information could spread among vehicles.

“Although the information spreads quite quickly, we still receive information based on past observations,” he said. “We expected a phenomenon that in computer science (networks) is called ‘route flapping.’ This happens when traffic constantly moves (flaps) from one route to another due to delay of information. For example, imagine that there are two highways to travel between cities (A and B). If I broadcast that a highway A is currently empty while highway B is busy, then every vehicle that hears this information will select A. Highway A will then become congested as more and more vehicles will start going there and due to the fact that the information that A is now getting congested needs some time to reach incoming vehicles. When eventually this information is out, most vehicles will switch to highway B, causing problems there. This constant flapping between A and B happens on computer networks (the internet). Surprisingly we didn't observe this problem: based on our results, it seems that the speed at which the information spreads is much faster than the speed that road traffic builds up.”

By showing that a decentralized intelligent transportation system can greatly improve traffic flow, the results of the study could lead to significant economic savings. The study also opens up new research directions, such as investigating the impact of different algorithms and flow intensities on the average travel time. Other areas for improvement include better algorithms, ways to lower bandwidth, and data encryption for security issues.

More information: Ilias Leontiadis, Gustavo Marfia, David Mack, Giovanni Pau, Cecilia Mascolo, and Mario Gerla. “On the Effectiveness

of an Opportunistic Traffic Management System for Vehicular Networks." *IEEE Transaction on Intelligent Transportation Systems.* To be published. DOI:10.1109/TITS.2011.2161469