SII – Sustainability Innovation Inventory

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"Mobile Century" Traffic Monitoring Study (Berkeley, CA)

Executive Summary

The Mobile Century project uses cellular technology to capture real-time traffic data on major roads. It aims to take advantage of the fact that many drivers already carry cell-phones, thus providing a convenient, comprehensive, and inexpensive network of potential traffic monitoring devices. Mobile phones have been described as having the potential to provide a service similar to publicly authored databases – that is, everyone contributes, therefore making data collection light work and useful information widely available. Using common personal mobile technology rather than dedicated devices to measure traffic reduces public costs and increases the accuracy and coverage of traffic monitoring.

On February 8, 2008, the Mobile Century project – in a collaboration between the California Department of Transportation, the California Center for Innovative Transportation, Berkeley's Department of Civil and Environmental Engineering, and the mobile phone company Nokia – conducted a full-day test on a 10-mile section of U.S. I-880 with one hundred cars driving the section

in loops. During the study, the one hundred test vehicles with GPS-enabled phones and traffic monitoring software comprised approximately 5% of traffic on the road, a rate chosen to match predictions about the market for GPS-enabled cell-phones in the near future. The results of the February test were promising, and the Mobile Century project plans to launch a larger test study with increased numbers of participants driving their normal commuting routes over a larger area for an extended period of time.

Why Implement Mobile Phone-Enabled Traffic Monitoring?

Road congestion has become a fact of life in urban areas, and traffic monitoring is known to significantly contribute to sustainable urban design. According to aggregate traffic and emissions studies conducted for urban areas in the United States, for example, traffic congestion resulted in the following estimated losses for travelers in 2005:

	Average Per Driver Loss	Average Per Driver Loss in Dense Urban Areas	Country Total Loss
Extra travel time (hours/year)	38 hrs/yr	54 hrs/yr	4.2 billion hrs/yr
Extra fuel used (gallons/year)	26 gal/yr	38 gal/yr	2.9 billion gal/yr
Extra carbon emissions (kilograms/year)	229 kg CO_2	334 kg CO_2	25.5 billion kg CO_2
Money lost (USD/year)	$710	$1,014	$78 billion

Table 1: Tangible consequences of traffic congestion for drivers in the United States in 2005. *For more EPA emissions data, go to: http://www.epa.gov/otaq/climate/420f05004.htm; for the full Texas Transportation Institute Urban Mobility Report, go to: http://mobility.tamu.edu/ums/report/.*

To alleviate the consequences of traffic congestion, traditional traffic monitoring systems currently use radar, cameras, or sensors on the road surface to measure traffic density and speed. These fixed-location sensors are expensive to install and require regular maintenance; consequently, traffic monitoring is currently limited to specific stretches of highway.
By tapping into the GPS-enable mobile phone network, municipalities can get better coverage of major roads with less public infrastructure. Additionally, drivers with mobile phones will be able to receive traffic data back and plan their trips based on data they themselves helped to collect. Drivers will also be able to receive data through their phones about weather conditions or accident reports on non-crowded roads, as well as find information about faster side-routes near congested highways.

Current Technology

Security Concerns

The major technical consideration limiting mobile phone-enabled traffic monitoring is individual privacy. Data transmitted from individual phones could theoretically allow someone to track the owner of the phone, and customers have expressed concerns about giving governments Big Brotherlike surveillance capabilities along with traffic data. While the Mobile Century study has done significant work to address these concerns (see next section), privacy considerations will probably always limit the applicability of such technology. For example, the Mobile Century project has decided that mobile phone travel information in residential neighborhoods does not provide sufficient anonymity and will not be tracked. Currently, customers have the option to switch off their GPS transmitting function on their phones; therefore, any traffic monitoring system that plans to rely on mobile phones as data collectors will have to be designed to be trustworthy enough to discourage the majority of phone users from opting out.

The Mobile Century project's "privacy-by-design" system ensures that individual privacy is privileged "even occasionally at the expense of data quality," according to the Lagrangian Sensor Systems Laboratory at Berkeley. The traffic data collection software is designed to broadcast only along specific roadways of interest (i.e. predominantly residential roads with low traffic and no obvious side-route benefits are excluded). Data transmitted from individual mobile phones is subsequently sent using a "banking-grade" encryption method. Additionally, data collection occurs through a distributed architecture, which allows phone identification information to be separated from traffic data during transmission and dispersed among different data management units to increase the anonymity of the individual signals. Finally, as mentioned above, individual mobile phone users retain the option to switch off the data collection and transmission functions on their phones.

Data Collection and Transmission

The Mobile Century project uses Nokia N95 mobile phones upgraded with traffic monitoring software to collect and transmit readings of speed and location. The GPS-enabled N95 phones are capable of taking speed and location measurements every 3 seconds and are precise to within 3 mph and 10 meters. Anonymous speed and location data collected by the N95 software is then sent wirelessly to data servers, which analyze the information to provide real-time traffic data back to the public via mobile phone or the Internet.

The February 2008 "proof of concept" test double-checked the accuracy of the mobile phone data with data collected from cameras set up on bridges along the test route.

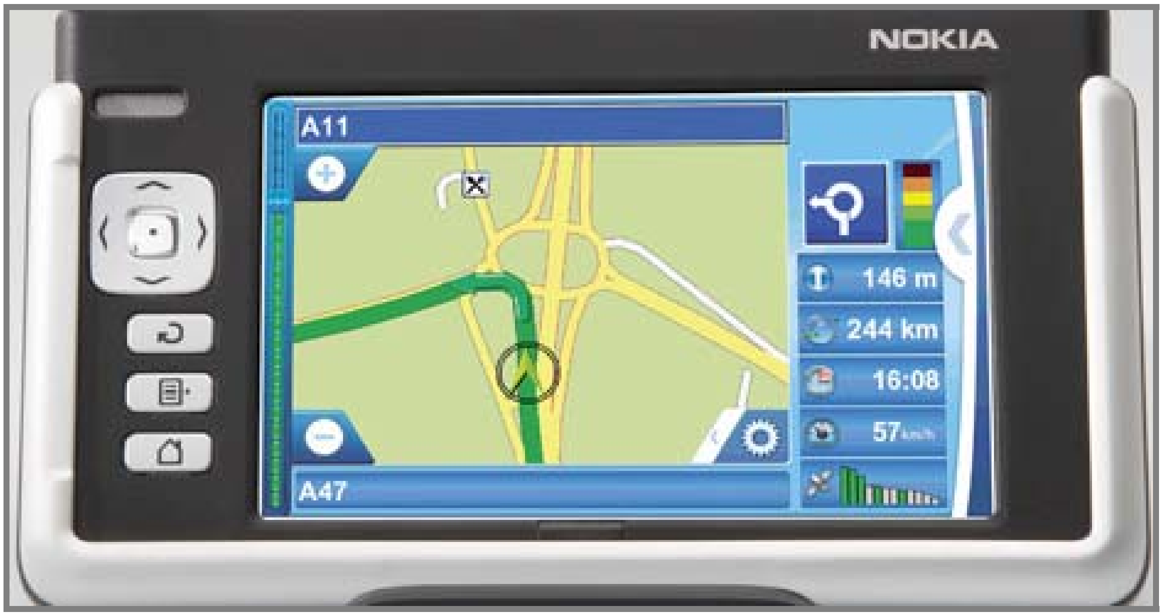

Figure 1: Nokia Traffic Monitoring Mobile Phone Software

Technology & Experience Roadmap

While mobile phone direct traffic monitoring is still in its infancy, the Mobile Century project is pushing further research “at an aggressive pace” because of the large potential societal impact of the technology. The following sections describe some potential considerations for implementing a large-scale mobile phone-based traffic management system. Potential technologies that could be linked to mobile phone navigation systems are also identified.

Maintaining Pedestrian-Friendly Roads near Congested Freeways: Lessons Learned from the TomTom-Vodafone Partnership

The Dutch in-car navigation system manufacturer TomTom currently has a partnership with Vodafone to use aggregate data from mobile phone towers to monitor traffic along major routes in the Netherlands. TomTom has used this data successfully to warn its customers about real-time traffic delays. The TomTom-Vodafone traffic monitoring partnership uses information about the number of cellular phone signals communicating with each Vodafone base station to extrapolate the number of phones on a particular section of roadway. The monitoring system then uses this information to determine the amount of traffic congestion and length of delays on certain roadways. TomTom software incorporates this data into its navigation advice by color-coding roads based on traffic conditions and providing estimated travel times (see figure 2, below).

Since implementation of the TomTom-Vodafone partnership, the Association of Netherlands Municipalities (VNG) has raised concerns about the effects of additional through-traffic on local roads not intended for heavy use, especially in the famously bicycle- and pedestrian-friendly Netherlands. Dutch city officials are consequently working with digital map companies to determine which side roads should be recommended for avoiding traffic, while maintaining a safe environment for pedestrians and bicyclists. Mobile phone-based navigation programs in other countries will also have to address this issue to keep city streets safe for non-car travelers while working towards alleviating traffic congestion.

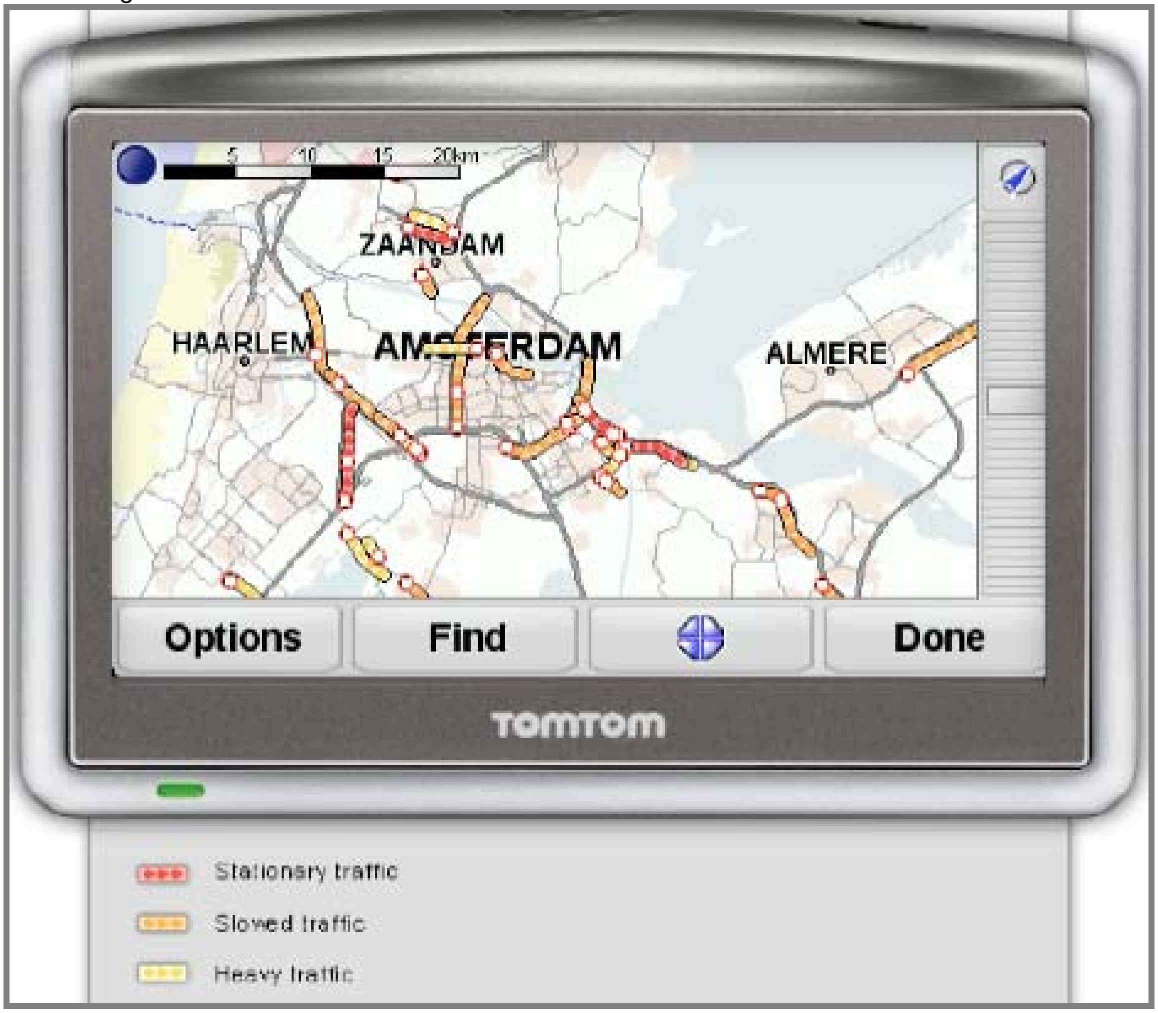

Figure 2: TomTom navigation system with Vodafone traffic information. *While the TomTom-Vodafone partnership encounters fewer privacy concerns than the Mobile Century project, aggregate data collected from phone towers is less comprehensive and less precise than data collected directly from the phones themselves.*

Electronic Road Pricing, Congestion Charging, and Public Parking

Many recent traffic management initiatives that employ market-pricing models to limit congestion – such as congestion pricing in Singapore, Stockholm, and London; adaptive parking meter pricing in San Francisco; and variable toll pricing on highways and bridges across the world – have been experimenting with communications support systems to facilitate use of the new systems. These communications systems alert drivers about pricing schedules, adjustments to pricing, and/or outstanding charges via the Internet and mobile phones, thus giving drivers greater convenience and encouraging a more efficient overall system.

These initiatives could both benefit from and be tied into a mobile phone GPS traffic monitoring system. More up-to-date traffic information from the cellular network could help regulate road or parking pricing to control demand, and knowledge about road pricing and parking availability could help drivers evaluate different route options. Such coordination could streamline an entire regional transportation network, with traffic and traffic regulation forming a continual fast feedback loop.

Trip Planning

On an individual level, many contemporary mobile phones also function as personal schedulers. Combining traffic data sent directly to one's mobile phone with personal schedule data kept on the phone could allow mobile phone users to better coordinate their travel planning before they get on the road. Personal scheduling software could incorporate traffic data automatically to give up-to-date travel planning information and notify drivers if they need to leave earlier to stay on schedule. Such coordination could act as a traffic calming measure, as fewer drivers would be caught in unexpected delays that could contribute to road rage. It may also encourage travelers to stay off the roads and opt for public transportation where available during times of severe traffic delays.

Future Directions

The Mobile Century project's initial trials opened up areas of future research for refining the data collection system. Continuing work on phone anonymity requires more research on the tradeoffs between privacy, accuracy, coverage, and data collection costs.

Additionally, while the current phones are capable of transmitting data every three seconds, this transmission rate delivered more data than was needed for traffic assessment during the Mobile Century test in February. Since more transmitted phone data requires more bandwidth at the receiving end, which ultimately translates to more money and more electricity, Mobile Century researchers are working out the "optimum subset" of data they need to accurately determine traffic conditions.

The project has plans to expand its scope to track 1000 cars in their daily activities for an extended period of time, so it will be worth keeping an eye out for new developments in mobile phone traffic monitoring in the near future.

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