CPS:Small: Transforming a City's Transportation Infrastructure through an Embedded Pervasive Communication Network

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Abstract

The objective of this inter-disciplinary research is to develop new technologies that transform the streets of a city into a hybrid transportation/communication system, called the *Intelligent Road* (iRoad), where autonomous wireless devices are co-located with traffic signals, forming a wireless network that fuses real-time transportation data from all over the city to support a wide range of new applications. The project will establish the theories and protocols for a high-speed, pervasive, wireless platform that can lead to transformative changes in the way transportation monitoring and control functions are designed, managed and operated. Its main technical approach is to build new wireless capacities of quantitative bandwidth distribution, rate/delay assurance, and location-dependent security through distributed queue management, adaptive rate control, and multi-layered trust. The potential applications include real-time traffic map, online best-route query, intelligent fuel-efficient vehicles, coordinated traffic signal control, and remote accident assessment.

In order for iRoad to support the above applications, this project needs to solve an array of difficult problems. The first challenge is to design sophisticated schemes for wireless bandwidth management, such that limited bandwidth can be quickly reallocate from one wireless link to another based on real-time communication traffic dynamics. The second challenge is to differentiate and prioritize various types of data flows carried by the iRoad system and provide rate or delay assurance for high-priority flows. The third challenge is to ensure the security for transportation applications in an open wireless environment. The fourth challenge is to establish the engineering framework that can efficiently leverage the iRoad's capabilities for the next-generation transportation management systems. To meet these challenges, the proposed research plan consists of the four components: 1) quantitative bandwidth distribution among wireless links in iRoad, 2) rate and delay assurance in iRoad, 3) security and robustness of iRoad, and 4) an iRoad-based self-learning framework for intelligent transportation systems. Successful completion of these research tasks will advance the state of the art in both wireless technologies and transportation engineering. The research outcome is likely to be broadly applicable in other wireless systems as well.

The potential impact of the iRoad system is tremendous at a time when the country is modernizing its transportation infrastructure. Information technologies have already been widely used to improve the efficiency of transportation management and control in various aspects. The practical value of this research project is to provide a pervasive communication infrastructure and a common engineering framework that are embedded in the streets of a city to integrate various control functions and amply the effectiveness of many existing technologies. If iRoad or other similar networks of its kind are successful, they may provide some of much-needed tools for enhancing the ailing transportation infrastructure in many cities of this country.