

ACCESS: Ad hoc Crowdsourcing for CongEstion Support

Tamer Nadeem, Old Dominion University (nadeem@cs.odu.edu)

Stephen Olariu, Old Dominion University

Byungkyu “Brian” Park, University of Virginia

Introduction

Most traffic signals in the US run a set of predefined timing plans that set the signal’s cycle length and green phase length based on the time of the day. In most cases, the optimization of the signal systems currently occurs off-line at either the isolated intersection or corridor level. One of the major disadvantages of this approach is that it requires data on traffic-turning movements be regularly collected to develop optimized traffic signal plans off-line. A second major disadvantage is that the time-of-day based signal timings do not adapt well to unexpected changes in traffic demand. For example, if an incident on the roadway network causes travel patters to change significantly, the signals often cannot fully accommodate the changes in flow, resulting in traffic buildup and congestion. In order to ensure that the signals function as well as possible, they have to be re-timed regularly to reflect current conditions. Unfortunately, due to budget or manpower limitations, transportation agencies often neglect to re-time signals resulting in unnecessary delays to the traveling public. As recently as 2012, the Federal Highway administration estimated that more than 75% of the country’s 330,000 traffic signals are operating with outdated or uncoordinated signal timing plans [1].

Problem Statement

While the transportation agencies have devoted substantial effort to optimizing traffic signals at the corridor level, to the best of our knowledge, the problem of rescheduling the timing of traffic lights at the scale of a wider urban area is still very much uncharted territory. The principle reason behind this state of affairs is the combinatorial explosion inherent in the process of transiting from small-scale to large-scale complex problems. This is clearly the case when the traffic flows from several corridors compete for non-shareable resources – time and road bandwidth. In an ideal world, the municipal Traffic Management Center (TMC) would have at its disposal a number of supercomputers that could be used to compute in near real-time optimal timing plans for all the traffic signals under its jurisdiction. In reality, no municipality can afford the huge expenditure involved in purchasing and maintaining a huge computational resource solely dedicated to optimizing traffic flow. One alternative would be for the TMC to outsource this huge computational task to one of the existing cloud service providers. This approach, however, would be not only be costly but, due to the overheads involved, would not guarantee traffic signal re-timing in useful time, say, to mitigate the effects of an unexpected congestion event.

Proposed Approach

The promise of vehicular networking, consisting of vehicles that can communicate to

improve safety and provide traveler information, has captivated the networking research community over the past several years. Applications and protocols have been proposed, standards are being written, and hardware is being developed to support this vision. The societal benefits and potential for commercial profits will drive the production of vehicles equipped with advanced computational, communication, storage, and sensing capabilities. With almost seven million new cars purchased in the US each year [2], we will soon have millions of these advanced vehicles on our roadways.

Under present-day practices, the vehicles on our roadways and city streets are mere spectators that witness traffic related events without being able to participate in the mitigation of their effect. We envision a cyber-physical framework for harnessing the on-board computational resources in vehicles stuck in urban congestion (cyber world) in order to assist transportation agencies with preventing and dissipating congestion through large-scale signal re-timing (physical world). Our framework is called ACCESS: Ad hoc Crowdsourcing for CongESTion Support. What makes this approach unique is that we suggest that in such situations the vehicles have the potential to cooperate with various transportation authorities to solve problems that otherwise would either take an inordinate amount of time to solve or could not be solved for lack of adequate municipal resources. Instead of re-timing signals at the corridor level only, ACCESS offers the opportunity to optimize traffic flow at the municipality level by making dynamic use of vehicular network probe data to re-time signals. ACCESS will enable traffic signals to be more responsive to actual conditions, rather than being based on historic volume counts.

ACCESS offers direct benefits to both drivers and the municipality. By developing timing plans that respond to current traffic conditions, overall traffic flow will improve, carbon emissions will be reduced and the economic impact of congestion, in terms of wasted fuel and lost productivity hours, will be lessened. We anticipate that, given the right incentives, the drivers will be more than willing to participate in vehicular crowdsourcing thus contributing to developing improved signal timing plans. In turn, this will benefit the driving public through travel timesaving and reduced fuel consumption costs. ACCESS will allow the municipality to dynamically respond to traffic conditions while simultaneously reducing investment in the computational resources that would be required for traditional adaptive traffic signal control systems.

References

[1] Texas Transportation Institute. 2012 urban mobility report.
<http://mobility.tamu.edu/ums/>, December 2013.

[2] US Department of Transportation, Research and Innovative Technology Association, "National Transportation Statistics",
http://www.bts.gov/publications/national_transportation_statistics, 2010