Traffic control systems

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Traffic flow accounts for as much as one-third of global energy consumption. However, unconventional changes in managing traffic flow could significantly reduce harmful CO2 emissions. ETH Zurich Professor for Sociology, Dirk Helbing, has developed a self-organised control system for traffic lights that could improve vehicular traffic flow by up to 95 percent.

Dr. Helbing, Professor of Sociology at the ETH Zurich Chair of Sociology, a specialist in modelling and simulation, supports his claim with a recent study called 'Efficient Self-Control of Traffic Flows in Urban Networks Using Short-Sighted Anticipation'. Professor Helbing and co-author, Stefan Lämmer of the Institute for Transport and Economics at Dresden University of Technology, propose a self-organized control system for traffic lights that could improve vehicular traffic flow by up to 95 percent. The system relies on the joining of two distinct strategies.

Traffic light system antiquated

The problem, Professor Helbing explains, is that heavy investments in traffic light systems were made in the 1960s and 70s rendering most systems today, due to use, age and technological advancement, antiquated. Forty to fifty years ago when traffic volume was lighter, the main job of traffic light systems was to manage peak traffic during the day or, for example, sporting events. The lights were centrally controlled, and not programmed to adjust in real time. Rather, they were mostly optimised for pre-established assumed situations, meaning for

situations that traffic planners had faced in the past.

The disadvantage of this strategy, especially today, is that the more traffic lights there are to coordinate, the more difficult it is to optimize control of the lights. Why" The dilemma is well-known: the larger the number of nodes, or lights, in a system the more computation is necessary until finally computational time “explodes”. “Even for normal-sized cities, super computers are just not fast enough to compute all of the different options that exist for controlling traffic lights. So the number of choices actually considered by the optimization program is significantly reduced,” says Professor Helbing.

Most traffic lights, therefore, continue to be programmed offline, regardless of the realities of the road.

Unfortunately, “the variation in the number of vehicles that queue up at a traffic light at any minute of the day is huge,” Professor Helbing says. None of this variation is considered when optimizing for typical Monday or Friday traffic volume curves. “You are optimizing for a situation that basically is true on average but that is never true for any single day or minute: essentially for a situation that never exists. Plus, even adaptive traffic lights in modern control schemes are usually restricted to a variation of cycle-based control.”

One strategy is not enough

Professor Helbing and Stefan Lämmer propose a decentralized system instead that would make travel time more predictable, though traffic light sequence less so. First, the researchers tried to optimize the flow of traffic at one light of an intersection. This localized approach worked well as long as traffic flow through the intersection was not too high. Once volume rose, however, locally programmed lights did not clear traffic off of side roads fast enough and led to back-ups at other

intersections. Professor Helbing concluded “On its own, this optimizing strategy was worse than traffic light controls already in place.”

Another component, a stabilizing strategy, was then studied. This strategy cleared traffic when it reached a critical threshold, but it was inconsistent with travel time minimization. Unlike the optimization strategy, the stabilizing strategy performed poorly at all volumes. On its own, it too could not compete with today’s traffic light control systems.

However, “it turns out that the two strategies properly combined perform better than today’s traffic light controls at all traffic volumes. So the combination of two inferior strategies can perform much better – if we do it right,” Professor Helbing says.

Simulation tests show the combined strategies work well. With non-periodic - not cyclically repeated - traffic lights releasing long traffic queues, travel time even becomes more predictable. Flow is kept stable, fuel consumption and emissions are reduced.

Success depends on motorists

However, the success of the new system will depend on how motorists react, Professor Helbing points out. Drivers are used to the present cycle of traffic lights and anticipate ‘their turn’ to enter an intersection. The combined strategy would disrupt such expectations: if the traffic load is heavy in one direction, that road will be served two times, while others will be served only once. To support driver acceptance and avoid undesirable side effects, such as increased frustration or even accidents, any new traffic control system would need government support and funding by way of a well-publicised awareness campaign directed to the general public during the system’s introductory phase.

In Asian countries, where infrastructure is still being built, is where

Professor Helbing thinks investment in the combined strategies might first take place. In Europe the “pain and pressure for change may still not be great enough”.

In the end, cost will be a determining factor. The new technologies will have to show that they are cheaper to run than the present system.

Testings ahead

The need to lower CO2 emissions could, however, accelerate the development, suggests Professor Helbing. “You have to decide whether it is necessary to force people to use their cars less, or if the same goals can be achieved through coordinating traffic flows better. If the answer is coordination, then let’s go for the better technology.”

Politicians need to be informed of the options. And the traffic light systems themselves must now be tested through practical application. Professor Helbing is nonetheless optimistic that they will out-perform the systems of today.

“What we don’t know is how big an advantage the news systems will be. But all the facts point to decentralised traffic control. This will be the paradigm of the future.”

Source: ETH Zurich/Swiss Federal Institute of Technology