Adaptive Signal Control Technology: State of Practice

Geeva George
Assistant Professor
Department of civil Engineering
RIT, Kottayam, MG University

Abstract— Adaptive Signal Control Technology (ASCT) adjusts the timing plan of traffic signals based on prevailing traffic conditions and traffic needs. Since early 1970, ASCT had developed throughout Europe and later in United States. ASCT is not implemented much in India. The ability to improve traffic operation and control performance as well as to break barrier in limiting its implementations will be depended on the better understandability of the system. In this paper a comparison between various adaptive signal control technologies is discussed with a mention of indigenous solution to the adaptive signal. The recent works and developments in this area is also reviewed.

Key words: Adaptive Signal, ASCT

I. INTRODUCTION

The main motivation for vehicular communication systems is safety and eliminating the excessive cost of traffic collisions. World Health Organisation’s global status report on road safety 2015, reflecting the information across 180 countries indicates that road accidents annually cause approximately 1.25 million deaths worldwide; which accounts about one fourth of all deaths caused by injury. 50 million persons are injured in traffic accidents. If preventive measures are not taken road death is likely to become the seventh- leading cause of death in 2030 from ninth place in 2004 according to World Health Organization. Number of person killed per one lakh population as per Ministry of Road Transport and Highways Transport Research Wing (MORTH) shows Indian situation equally worse.

According to MORTH there occur 14 accidents per hour. This number can be significantly lowered by deploying local warning systems through vehicular communications. Traffic signals are very effective in controlling vehicles especially at congested urban intersections. Among the various control strategies; namely, fixed time, coordinated, traffic responsive, and adaptive control; adaptive control has greater potential in chaotic and heterogeneous traffic. Implementing adaptive control requires real-time traffic information [1].

In this paper a comparison between various adaptive signal control technologies is discussed with a mention of indigenous solution to the adaptive signal.

II. LITERATURE REVIEW

Conventional signal system uses pre-programmed, daily signal timing schedules that do not monitor system performance, nor can they adjust automatically to accommodate traffic patterns that are different from the peak periods during which they were designed to operate. Pre-timed control frequently results in the inefficient usage of intersection capacity because of the inability to adjust to variations in traffic flow and actual traffic demand; this inefficiency is pronounced when flows are substantially below capacity.

ASCT has been around since the early 1970s with the majority of the use and development taking place throughout developed countries. Adaptive signal control technologies adjust when green lights start and end to accommodate current traffic patterns to promote smooth flow and ease traffic congestion by continuously detecting vehicular traffic volume. It computes optimal signal timings based on the detected volume. Adaptive control consists of cycle time intervals that are extended in response to vehicle detectors. The controllers are capable of not only varying the cycle length and green times in response to detector actuations, but also alter the order and sequence of phases. Coordinating traffic signals along a single route so that vehicles get progressive green signal at each junction is another important aspect of ASCT.

Reference [2] emphasize that the only alternative to increasing the road capacity is to maximize the existing available infrastructure and to get optimum returns from new investments on highway building. Intelligent transport systems provide opportunities to achieve this. In order to achieve better safety and decrease the number of accidents, injuries and fatalities, new approaches to highway safety are required. ITS technologies can be applied to reduce traffic exposure, reducing the probability of crash occurrence, and minimizing the consequences of a crash. There is great potential in India for these technologies.

The ever-increasing vehicular population has brought about a reduction in the efficiency of traffic signal systems which have gone from being traffic controllers to queue generators. Signals are now being blamed for the long queue formations and pollution at intersections.

Reference [3] gives an overview on intelligent management system for traffic control and coordination tasks. In the paper concepts of Intelligent Traffic Management Systems (ITMS) are designed to act as intelligent assistants that cooperate with the traffic engineer in the task of defining and applying traffic management decisions.

The two most widely deployed systems are SCATS (Sydney Coordinated Adaptive Traffic System) and SCOOT (Split Cycle and Offset Optimization Technique) [4] [5] [6]. Since 1990, Federal Highway Administration (FHWA) has recognized the benefits to be achieved by the implementation of adaptive control over the traditional time-of-day (TOD) selection of fixed cycle length timing patterns, and has sponsored several programs aimed at developing adaptive signal systems, such as RT-TRACS in the 1990’s and ACS-Lite during the 2000’s [7] [8].

A very detailed study of all known adaptive signal operators in North America was done by Stevanovic, (Stevanovic, 2009). His study included the survey of adaptive system operators from UK, Australia, New Zealand, Canada, Chile, Ireland and China, [9]. The pioneer study, in this area done by Selinger and Schmidt tried to address some of the issues raised by Stevanovic. Their surveys covered the
systems like SCOOT (Split Cycle Offset Optimization Technique), SCATS (Sydney Coordinated Adaptive Traffic System), LA ATCS (LA DOT Adaptive Traffic Control System), RHODES (Real Time Hierarchical Optimized Distributed Effective System), ACS-Lite, OPAC (Optimization Policies for Adaptive Control) and InSync [10].

A study on Vehicular Ad-Hoc Network or VANET technology used to collect and aggregate real-time speed and position information on individual vehicles to optimize signal control at traffic intersections was attempted by Reference [11]. They implemented adaptive traffic signal control algorithm that reduces the delays experienced by the vehicles as they pass through the intersection. This algorithm produces lower delays, compared with other method and the pre timed signal control method. The proposed approach is simulated using Vb.net and compared with the already existing fixed time traffic control system by Dorle and Patel. In their study they observed that the VANET approach posses better working than the existing approaches [12].

Reference [13] developed a real time traffic signal control strategy using genetic algorithm implemented in MATLAB. A traffic emulator is developed in JAVA to represent dynamic traffic conditions. The emulator conducts surveillance after fixed interval of time and sends the data to genetic algorithm, which then provides optimum green time extensions and optimizes signal timings in real time on traffic control.

III. ADVANTAGES AND DISADVANTAGES OF ASCT

The main benefits of adaptive signal control technology over conventional signal systems are that it can automatically adapt to unexpected changes in traffic conditions, improve travel time reliability by reducing delays and decreasing travel times; reduce congestion and shorten queues, reduce fuel consumption and reduce carbon dioxide emissions, prolong the effectiveness of traffic signal timing, reduce the complaints that agencies receive in response to outdated signal timing, make traffic signal operations proactive by monitoring and responding to gaps in performance. They are also adaptable to short-term fluctuations in traffic flow and usually increase capacity (by continually proportioning green time). Thus they provide continuous operation under low volume conditions and are especially effective at multi phase signal intersections.

If traffic demand pattern is very regular, the extra benefit of adding local actuation is minimal, perhaps non-existent. Their installation cost is two to three times the cost of a pre-timed signal installation. Actuated controllers are much more complicated than pre-timed controllers, increasing the maintenance costs. They also require careful inspection and maintenance to ensure proper operation.

IV. ADAPTIVE SYSTEMS IMPLEMENTED IN INDIA

Indian traffic scenario is entirely difficult to implement adaptive signal controls due to following characteristics. A vehicle entering the approach (upstream) on a particular lane need not maintain the same at the intersection. Uncontrolled side roads, on-street parking and high mix of traffic makes it difficult to obtain correct measure of traffic count which is highly complex. There is always a probability of data loss due to power failure and network failure. Availability of funds is also a controlling factor in Indian scenario.

Area Traffic Control System is an indigenous solution for Indian Road Traffic, which optimizes traffic signal, covering a set of roads for an area in a city. It is an intelligent traffic signal control system that use data from vehicle detectors and optimize traffic signal settings in an area to reduce vehicle delays and stops. The original technology on ATCS was developed by Centre for Development of Advanced Computing (CDAC, Thiruvananthapuram), WML is manufacturing the same and have supplied more than 200 controllers in cities such as Delhi, Pune, Jaipur, and Ahmedabad. Agencies came forward for ATCS Technology were M/s. WebeL Mediatronics Ltd., Kolkata, M/s. KELTRON, Thiruvananthapuram, M/s. Bharat Electronics Ltd., Bangalore.

The Composite Signal Control Strategy (CoSiCoSt) developed by CDAC Thiruvananthapuram optimizes a weighted combination of delay and number of stops in real-time. CoSiCoSt is designed to cater to the typical Indian driving and traffic conditions such as poor lane discipline and high heterogeneity and bears an Indian Patent (No: 239258 Title: A Method for Synchronizing Heterogeneous Road Traffic and System thereof) jointly owned by the Department of Electronics and Information Technology (DeitY) and CDAC.

WiTraC is a state-of-the-art Vehicle Actuated Wireless Traffic Control System developed by CDAC under the DeitY funded ITS Program. CoSiCoSt-W has custom interface to the WiTraC and has many improved features for real-time signal coordination in vehicle actuated mode of signal operation.

The measure of effectiveness considered for the measure of impact of CoSiCoSt network model which was implemented in Pune are average travel speed, average delay, average saving in fuel and average saving in time. The evaluation showed average travel speed increase in the range of 2% to 12% .Reduction in average delay was observed in the range of 11% to 30%. The estimated annual fuel savings in the year 2006 due to implementation was about Rs. 4.77 Crores and an annual time saving benefits estimated about Rs. 0.83 Crores. Overall total annual saving in the year 2006 was estimated as Rs. 5.60 Crores and 9.06% increase in traffic Volume [14].

V. TRAFFIC SIGNAL OPTIMIZATION USING SIMULATION

Various simulation programmes have evolved that helps us in optimization of signals. A comprehensive introduction to the world of traffic operations analysis and optimization tools was given in traffic analysis software tools (TRC Circular 2000). TRANSYT-7F [15] is designed to optimize traffic signal systems for arteries and networks based on average delay. SYNCHRO optimizes signal timings based on percentile delay. PARAMICS optimization is based on average delay. Using hourly traffic volumes, user-defined saturation flow rates and optional minimum green times, PASSER IV can optimize the progression bands for main arteries as well as coordinated crossing arteries by computing the optimum cycle length, splits, phase sequences. VISSIM is microscopic time step, behavior based simulation model which optimizes the intersection signal considering delay as stochastic variable. Both TRANSYT 7F and SYNCHRO are
macroscopic models while PARAMICS and VISSIM are micro simulation models. Since all these are commercial software packages, sufficient changes to the internal parameters satisfying customized user requirements cannot be made easily.

A recent study indicated that a signal timing plan based on direct signal optimization using stochastic and microscopic simulation model produces better performance than that of macroscopic simulation based method [16]. VISSIM was developed at University of Karlsruhe, Germany during early 1970. Due to the possibility of optimization using delay as stochastic variable and incorporating heterogeneous traffic conditions into the software VISSIM can be used to analyze and study the effectiveness of road networks in Indian conditions to an extent.

VI. CONCLUSIONS

There are serious differences of opinion among practitioners regarding the effectiveness of adaptive signal control technology and serious concerns about the difficulty in analyzing these systems. Significant funds are being spent on adaptive control systems, in many cases without a firm understanding of their benefits versus costs. The evaluation of the performance of adaptive traffic signal systems requires care to ensure that the measures actually reflect the manner in which the systems operate and measure the impact on all road users who are affected by the system. This technology popularised in developing countries has started getting acceptance in India and this leads to the development of an Indigenous solution, CoSiCoSt system for Indian scenario. The case studies reported in this paper for Pune city have illustrated that indigenous adaptive systems provide clearly observable and significant benefits over traditional TOD operation, even during congested peak periods and incidents.

The systems supplied so far are working satisfactorily at different environmental condition, and hence proven. Signal optimization tool VISSIM can be effectively implemented in Indian conditions to study the effectiveness of adaptive signals in reducing delays at intersections.

ACKNOWLEDGMENT

The author would like to thank the Department Of Civil Engineering, RIT, Kottayam and Jijo MT Assistant traffic engineer, Systra MVA Consulting India Pvt Ltd for their valuable help and support in preparing this work.

REFERENCES