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ASSESSMENT OF AREA TRAFFIC CONTROL SYSTEM IN BANGKOK BY THE MICROSCOPIC SIMULATION MODEL

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Abstract: This paper presents the assessment of the effectiveness of Split Cycle Offset Optimization Technique (SCOOT) in Bangkok using a microsimulation technique. Three types of region—isolated intersection, corridor, and grid road network area were evaluated. PARAMICS simulation emulated the real world traffic conditions that operated on two types of signal controls: SCOOT (With SCOOT) and police control (Without SCOOT). The results from comparison between the existing controls and the optimal fixed time controls indicated that SCOOT and the current police control performed better than the optimal fixed time plans at Chula Soi 12 intersection, but worse at Sripaya-Chareonkrung intersection. In the corridor area, it was evident that SCOOT brought about lower intersection delay than the coordinated fixed time plans. In the grid network area, Without SCOOT control showed more effectiveness in decreasing delay than the fixed time control while SCOOT had no benefit in this area, compared to the optimized plan.

Key Words: SCOOT, Adaptive Signal Control, Microscopic Simulation, PARAMICS, TRANSYT

1. INTRODUCTION

Traffic congestion in Bangkok has been recognized as a national problem by government officials and as one of the top social problems by the public. Bangkok people travel on streets at speeds of less than 10 kilometers per hour in the central area during peak hours and this reality certainly affects not only the travelers' mood, but also the national economy. Traffic congestion has negative effects on the environment, fuel consumption, health, and society. To relieve the problem, Bangkok Metropolitan Administration (BMA) and the national government have instituted several measures, and one of them is the implementation of an advanced traffic signal control system, which is expected to increase traffic efficiency and safety through better traffic management.

A SCOOT traffic signal control system was installed in Bangkok in 1994 by Peek Traffic (Thailand) under the development of Bangkok ATC project. In the ATC stage 1 (ATC1), SCOOT was installed at 143 intersections and 3 flyovers in the Bangkok inner core area. Sixty one out of these 143 intersections are approved and accepted by BMA while the rest are in an approval process. Starting in 1998, the project was expanded to ATC2, covering another 226 intersections in the Bangkok downtown perimeter areas.

Even though studies on the benefits of SCOOT implementation have been carried out around the world and positive results are reported in many places, the degree of benefits rely on many factors, such as traffic conditions, network configuration, the system setting, etc. Bangkok's SCOOT effectiveness has therefore been suspicious and contentious. It is not known whether SCOOT provides more efficiency and benefit than manual control and fixed time control. Thus, the current practice the SCOOT control is turned off during peak hours because the police traffic officers are afraid that SCOOT might worsen congestion. In addition, there are no studies or data to verify the effectiveness of SCOOT in Bangkok, specifically in the ATC1 network.

The other promising method, apart from the field evaluation, is the assessment of the traffic control system through traffic simulation. Traffic simulation is a computerized environment that allows the modelers to introduce various traffic control techniques and directly obtain the traffic performance. Being on a predetermined platform, simulation offers flexibility in testing different scenarios as well as control changes under the same environment. The evaluation of traffic signal control systems using simulation technique has been widely performed in the past ten years. With recent sophisticated simulation packages, the control system can be simulated in the traffic environment or even interfaced with the simulated traffic data. The simulation discloses the resulting traffic conditions and potential problems that would lead to an appropriate solution without altering the actual physical and control conditions.

Therefore, it is valuable to address the evaluation of the SCOOT traffic signal control system in Bangkok using a simulation model, which determines the measures of effectiveness (MOE) representing the efficiency of SCOOT compared to the existing control.

2. METHOD

2.1 Study Area

The selection of the study area must consider the traffic volumes and control setting conditions. The level of efficiency of SCOOT may vary by the level of traffic demand. There might be either a high or low level of demand that SCOOT cannot handle the signals properly. The selected sites should have all range of the traffic volume condition.

In Bangkok, SCOOT control is divided into several sub-regions and aims at optimizing the signals within their own boundaries. Although the interconnection between two sub-regions is important, it is crucial to investigate the effectiveness of controlling traffic within the regions, as the outputs from the SCOOT optimizing course of action. The determination of the effectiveness of the control within the region would directly demonstrate the ability of SCOOT control. The effectiveness of the control in the interconnected area is possible to be determined but the control condition is depended on other conditional settings and physical circumstances, and the pure effectiveness of the SCOOT control cannot be obtained. Therefore, it is suggested that the direct effectiveness of SCOOT control must be sought from a group of intersections in the same control area (sub-region). In addition, the setting of sub region in Bangkok area was done by the experience of installers, Peek Traffic (Thailand). They tied up intersections to be corridor or grid network with some 4-5 intersections. Therefore, the assessment in this study will select sub regions according to installer's implementation as the representative of ATC area in Bangkok.

Three types of study areas are proposed for this study: isolated signals, a corridor and a grid network. Each network type would answer different detail of research questions above and thus could lead to distinctive methodologies, data collection and analysis, and conclusion. The

selected isolated intersections in the study were Chula Soi 12 (Z1024) and Sripaya-Chareonkrung (Z1141). The Chula Soi 12 intersection is on Phayathai Road located near Maboonkrong shopping center (MBK) and Chulalongkorn University. The main objectives of the isolated intersection evaluation is to find the decrease in delay for all vehicles. The area traffic control allows signals to coordinate with each other and thus yields more efficiency.
Varying splits to accommodate traffic volume released from the upstream signal and changing the offset to increase more green time utilization is expected to be the benefit of SCOOT compared to the existing control in a corridor. The overall objective of the system is to improve travel time in the corridor without great penalty to the minor streets. For this study a section of Bumrungmuang road (region S1), approximately 1.5 kilometer long and including 5 signalized intersections (S1070, S1044, S1160, S1161 and S1002) was selected.

At the network level, an aggregate performance of the whole network can be a good indicator of the control efficiency. The network is defined as a set of road links and intersections forming a connection and the intersections are all controlled by SCOOT as a single control region. For this study a part of the road network in the Pahurad area belonging to a single SCOOT control region (Region T) was selected. The network consists of 5 signalized intersections (T1081,T1176,T1055,T1130 and T1094). The locations of the intersections in the study are illustrated in figure 1.

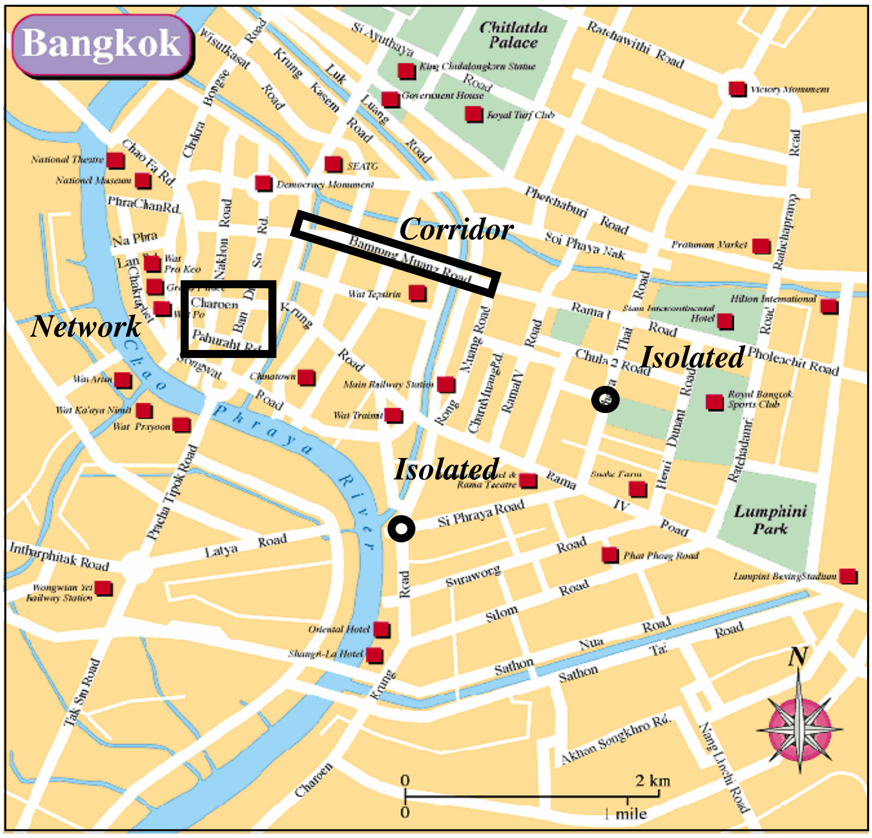

Figure 1 Locations of Study Area

2.2 Data Collection

The data were collected during various time periods and under various traffic conditions, including a.m. peak period (7.00 to 9.00 a.m.), p.m. peak period (4.00 to 6.00 p.m.) and off-peak periods (10.00 to 12.00 a.m., 1.00 to 3.00 p.m.) The signal cycle length, phase pattern, and traffic volume were recorded using video cameras which were positioned at the stop line of each intersection approach. One video camera was positioned to record the presence of vehicles exiting at the stop line and the other camera recorded the approaching traffic volumes from the upstream of the study intersection. Data were extracted thereafter in the office and stored in a video format. As a result, two types of traffic volumes from intersections, entering volume and exiting volume, were obtained. The traffic volumes were counted every 10 seconds in the office.

2.3 Model Construction

This study selected Paramics simulation software as a simulation platform, since Paramics (Version 3) claims that it can realistically model the behavior of individual vehicles on an urban and highway road network and provide users with the capability to visualize the progress of vehicles while the simulation is running. Moreover, it has a built-in capability to include flexible signal timings and interface to advanced signal control functions. The Paramics software system consists of three main modules: Paramics Modeller, Paramics Processor, and Paramics Analyser.

The modeler had to add phases and set the priority directions for all movements according to recorded (actual or tested signal) data. Offsets could also be defined for signal coordination. However, signal timings in Paramics can be specified with a specific language (similar to a script) that controls temporary changes to signal timing. In other words, the signal plan is a conditional statement that allows users to code IF-THEN-ELSE statements to change green time or other signal parameters such as cycle, offset, gap, occupancy etc.

The Paramics plan language has been designed to be extensible for any commercial signal controller like SCOOT. Because the SCOOT green time (and other signal parameters) varied from phase to phase and cycle to cycle, in this study, green time "3-level method" was written in a "plan" file to change green time in every cycle replicating the actual SCOOT signal records. Since the study did not attempt to replicate SCOOT algorithm, as they were proprietary and unknown, the resulting signal plans used in the simulation came from historical actual SCOOT phasing plans that collected from study periods. The example of plan file and phase file can be described as below.

"Plan file"

```
##cycle i
if (hour = a and minute = b )
{
 green2=K;
}
```

"*Phase file*"

```
use plan i on node j phase k
    with loops
      Loop name  lane n
      with parameters
      0
```

During our study, there was no added on module of O-D matrix estimation likes Estimator (Released on Paramics Version 4.0) so we were searching the most appropriate method to determine the dynamic O-D matrix. Moreover, SCOOT control adapts itself accoding to realtime traffic demand approaching to key measured intersection as well as O-D matrix must be estimated and inputed to Paramics more exhaustively and precisely. This is considered as the mian obstruction for Paramics users in that time. The study, therefore, adopted an approach to estimate time varying traffic demand, done by Nanne Jacob VAN DER ZIJPP (1996) at Delft University, Netherlands regarding dynamic demand (O-D matrix) estimator (DelftOD) to overcome the O-D obstruction. Eventhough DelftOD are mostly adopted for freeway O-D estimation, we found many flexiblility of this software to slice O-D matrix to input to Paramics. The past research was an estimation of O-D matrices of a network by slowly varying split probabilities which reflect the prevailing traffic conditions and travel demand of the entire network. The basic required data of OD matrix estimators are entering and exiting traffic demands (EE flow) from detectors data or automated vehicle identification (AVI) data, with a link speed profile as an optional input. In this study, videotape recorded data of entering and exiting volumes every 10 seconds, from all link detection locations in the network, yield a very good compatible input data to the DelftOD program. DelftOD also provides the confidential limit of estimated and observed data, thus the user can confident on the data's reliability. Output data obtained from DelftOD was dynamically delivered to Paramics simulation model, thereafter. Figure 3 shows the data path from DelftOD matrix estimator to Paramics.

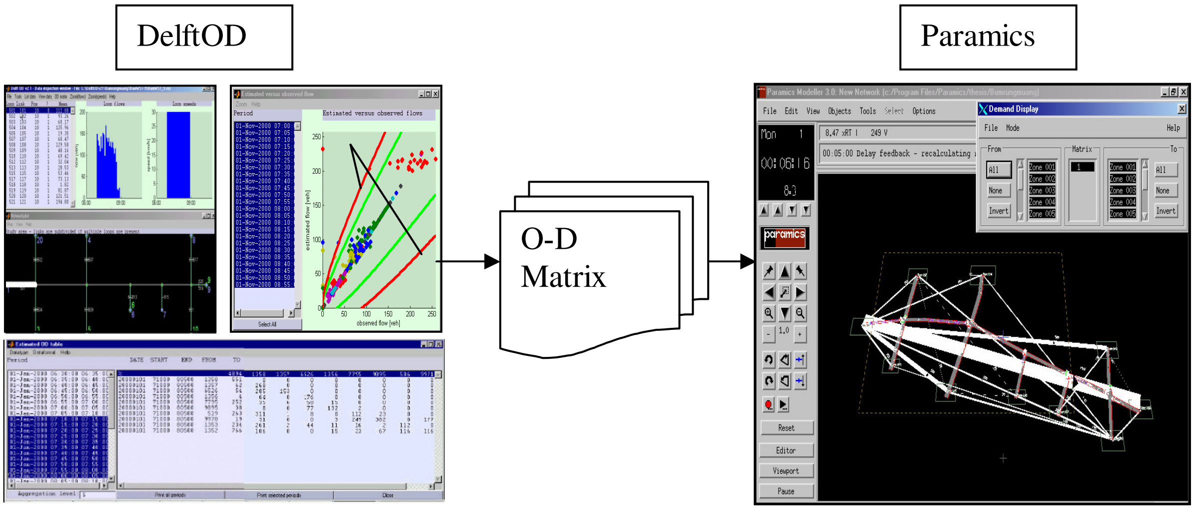

Figure 2 The Data Path from DelftOD to Paramics

2.4 Model Calibration

Paramics allows user to calibrate many parameters via Programmer modules that user can code their own car following and lane change model. Nevertheless, the fundamental element of calibrated parameter should include headway, reaction time, driver behavior and aggressive by comparing output data versus queue length, travel time, turning count and link volume. The most important variables to calibrate are mean target headway and reaction time (Abdulhai, Sheu and Recker, 1999). The calibrated parameters in this study were consequently focused on time headway and reaction time while the other parameters were kept default value.

The default value of mean headway and mean reaction time are both set of 1.0 second. Mean headway values were early recommended by many studies around 2 second (Highway Capacity Manual, 1985). For reaction time, suggested range is 0.3-2.0 seconds (Johansson et al., 1971). Headway and reaction time of previous study may be the representative of local driver behavior especially for Thai driver. Therefore, we reduced the mean headway from field data observation by measured from video tapes. Headway was collected from arrival headway of all lanes approaching to Chula Soi12 intersections. Data were collected in Without SCOOT day on the major street (Chula-Maboonkrong) to maintain ordinary condition. The finding of mean headway was further applied to others networks as mean headway default value. The result of mean headway' s distribution is illustrated in figure 4

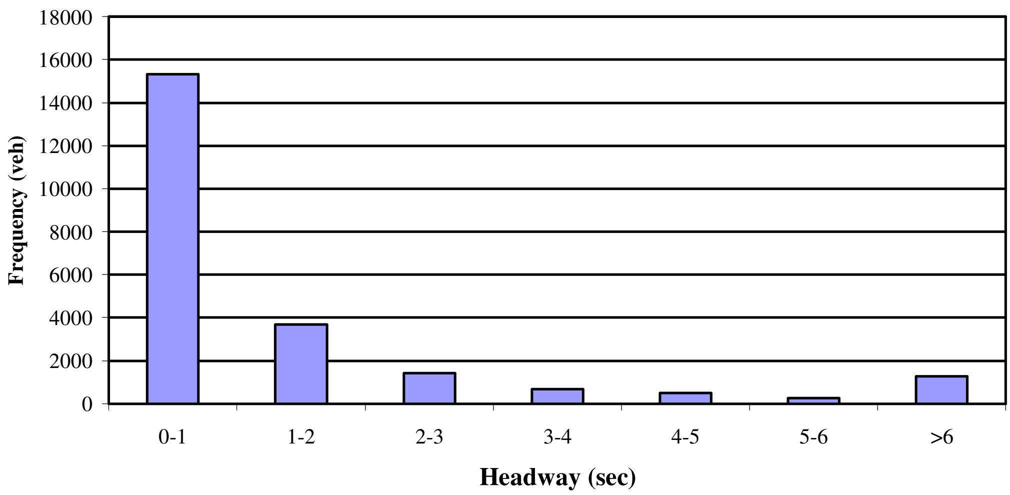

Figure 4 Headway distributions in Chula Soi 12 intersection

To find the most appropriate reaction time value, the procedure followed the guidance of California PATH Research Report (1999). There is some a little difference in our study. The procedure was to fixed time headway equal to 1.3 seconds (average headway) that already found in field and varied reaction time from range of 0.3-1.9 seconds. Selected reaction time was used in core parameter in Paramics in each run to determine the most suitable reaction time that gave minimum of total generated flow error during 7-9 am. at Chula Soi12 intersection. The total generated flows were gathered to check with real world data as sensitivity analysis. Reaction time having least of error was selected to further model. The reaction time value found in this study was kept as default value .It was found that reaction time equal 1.3 sec can give least of error (-0.03%). As a result, in this study, the headway and reaction time were assumed to 1.3 second.

2.5 Model Validation

The methodology to validate the model was to select the internal node in an isolated intersection, corridor and network area to check their turning counts compared to actual data in each time slice. The study selected Chula Soi 12 intersection (isolated intersection) during 7:00-9:00 am. was selected .The result showed that turning count of isolated intersection was accurate when checked with actual data (percent error= +12.0 % and percent absolute error = 15.4%. The results can be described that, for signalized intersections study area, the more complicate network built, the less accuracy gained.

2.6 The Design of Simulation Study

The two control methods were implemented on the simulation model to determine the MOE on each study area. Therefore, the measures of effectiveness were determined for each short time interval and the indicators of two control methods at the time slices having the same level of volumes can be directly compared. The journey time of simulation model was collected from origin-zones which to destination-zones. For network layout, the measure of effectiveness was plus vehicle traveled distance and total network delay.

In addition, an optimized fixed time plan was calculated by TRANSYT-7F or Synchro®. Synchro® was used to optimized cycle length and green split of isolated intersection since TRANSYT-7F cannot optimized one intersection but network The collection of traffic volume in With SCOOT day of corridor and network area were used to determine the fixed time signal by using TRANSYT-7F. TRANSYT-7F version 9.4, the latest version, comprises of CYCOPT, GA. and TRANSYT-7F module. CYCOPT was employed to determine the optimized cycle length while G.A. was used to find offset. Bumrungmuang and Phahurad network were again used to determine fixed time plan during SCOOT tested period. The outcome signal phases from TRANSYT-7F were input to Paramics "plan" files like SCOOT manner but change once per hour. The advantage of the optimized fixed time plan was to reduce overall intersection delay and provide the most optimal signal setting for a network area. The benefit of this step was supposed to reveal SCOOT signal control that attempts to make coordination among signals. To determine the optimized fixed time plan by TRANSYT-7F, range of cycle time was vary from 30-300 seconds. CYCOPT was employed to find the most optimized cycle length and then use GA. to determine offsets of signalized intersections. TRANSYT-7F was used in the last step to find out split proportion in cycle length. The delay saving that gathered from Paramics output were compared.

3. RESULT

According to the study plan, the three types of road network (isolated, corridor and network intersections) were conducted for different purposes, and therefore each network would demonstrate the comparisons on different MOEs.

3.1 Isolated Intersection

The main purpose of the isolated intersection assessment was to determine the difference in delay between the two types of control, SCOOT and the existing control system. Average System Delay (ASD) in Paramics was defined in term of a difference between simulated travel time and calculated free-flow time of all current vehicles in a network. See equation 1

$$ASD = \Sigma_{\forall i}(STT_i - FTT_i) / \Sigma_{\forall i} N_i \quad (1)$$

Where STT_i is simulated travel time of vehicle that traveled in the network, FTT_i is calculated free flow travel time of vehicle, N_i is the total number of vehicles.

The comparison of the delay and stoppage time of traffic employing SCOOT and Without SCOOT control on the isolated intersections were summarized in Table 1.

3.2 Corridor Result

The main purpose of the corridor evaluation was to compare the travel times of two days of different control; With SCOOT and Without SCOOT. Mean speed on Bumrungmuang road was additionally calculated in Paramics from all current vehicles at the corridor intersections. In a similar manner to average delay calculation, the mean speed was calculated from Paramics with different seed number in order to see the stability of outcomes and warm up period outputs were also excluded from the analysis.

The total effectiveness of a corridor network is presented in term of average travel time (ATT) from origin sector to destination sector. The method is to gather the group of original ones to one origin sector and destination zones to one destination sector. Then, we collected the travel time data from sector to sector.

$$ATT = \Sigma_{\forall i} TT_i / \Sigma_{\forall i} N_i \quad (2)$$

Where TT_i is simulated travel time of vehicle that traveled in the network, N_i is the total number of vehicles.

In addition, mean speed profile gathering from the Parwiz macro excel were compared. Travel time and mean speed result were summarized in table 2.

Table 1 Isolated intersection evaluation

Isolated Intersection Evaluation				
Chula Soi 12 Intersection				
Time	Average Delay (sec)		Average Stoppage Time (sec)	
	W/ SCOOT	W/O SCOOT	W/ SCOOT	W/O SCOOT
7:00-9:00 am.	125.85 n=495 Sd=10.58	205.37 n=285 Sd=27.72	843.75 n=495 Sd=124.81	1430.76 n=285 Sd=245.61
10:00-12:00 am.	61.21 n=525 Sd= 7.60	60.98 N=550 Sd=1.38	79.56 n=525 Sd=85.26	55.62 n=525 Sd=6.26
1:00-3:00 pm.	99.63 n=550 Sd= 11.89	119.71 n=550 Sd=25.96	517.1 n=550 Sd=140.92	649.95 n=550 Sd=259.24
4:00-6:00 pm.	72.68 n=550 Sd= 4.99	217.5 n=550 Sd=98.60	193.11 n=550 Sd=48.59	1392.11 n=550 Sd=694.03
Sripaya-Chareonkrung Intersection				
Time	Average Delay (sec)		Average Stoppage Time (sec)	
	W/ SCOOT	W/O SCOOT	W/ SCOOT	W/O SCOOT
7:00-9:00 am.	33.89 n=550 Sd=1.40	na	47.72 n=550 Sd=11.24	na
10:00-12:00 am.	31.27 n=550 Sd= 0.55	29.79 n= 550 Sd= 0.59	23.79 n=550 Sd= 3.28	33.77 n=550 Sd=6.67
1:00-3:00 pm.	34.21 n=550 Sd=0.48	35.22 N=550 Sd=3.57	44.81 n=550 Sd=3.79	96.31 n=550 Sd=35.42
4:00-6:00 pm.	35.67 n=550 Sd=1.03	89.74 n=550 Sd=25.20	58.72 n=550 Sd=7.25	378.09 n=550 Sd=56.45

Note n=number of data at every minute from 5 runs except warm periods Sd=Standard Deviation

Table 2 Travel time and mean speed on Bumrungmuang Road

Duration	Travel Time (Origin-Destination sector)				Mean Speed (kph)			
	W/ SCOOT		W/O SCOOT		W/ SCOOT		W/O SCOOT	
	Average	No. of Veh	Average	No. of Veh	Average	N (Sd)	Average	N (Sd)
7:00-9:00 am	0:10:15	1274	0:24:41	2370	14.60	525 (3.47)	6.91	525 (3.06)
1:00-3:00 pm	0:14:31	1089	0:23:32	756	9.68	525 (3.78)	8.75	525 (4.15)
4:00-6:00 pm	0:11:28	1707	0:14:53	1310	12.66	525 (4.42)	14.53	525 (8.19)

Note 10:00-12:00 am. on the W/ SCOOT day was disregarded due to the royal convoy,
N=Number of data from 5 runs, Sd= Standard deviation

3.3 Network

The main objective of network evaluation was to determine total traveled distance and total network delay as summarized in Table 3. Total delay in network was calculated the delay of all vehicles passed trough network; however, the number of vehicles were also reported so that it can be considered when comparing two types of control.

Table 3 Comparison of total traveled distance and total delay

Duration	Total traveled distance (m)		Total Delay (veh-sec)	
	W/ SCOOT	W/O SCOOT	W/ SCOOT	W/O SCOOT
7:00-9:00 am	1,634,466	1,923,015	8,714,252 N=6,009	7,065,520 N=6,944
1:00-3:00 pm	14,413,133	2,031,744	7,365,992 N=9,777	6,862,800 N=7,125
4:00-6:00 pm	1,949,849	2,508,504	2,013,850 N=7,492	3,623,674 N=9,496

N= Number of vehicles

3.4 Comparison of the simulated control and the optimized fixed time plan

This step of the study was to determine the differences in delay between SCOOT control and their optimized singal timing plans (for the same traffic conditions). The optimal signal timing plans were calculated by either TRANSYT-7F model (version 9.4) or Synchro® (version 4.0). The signal timing plans were developed for each hour. This method can reveal the real benefit of SCOOT or even without SCOOT control by a direct comparison to the theoretical optimal traffic performance in the same traffic conditions.

The optimized cycle length and green split were determined in TRANSYT-7F in the case where the network contained more than one intersection and Synchro® was employed in signal timing determination for a single intersection. The optimal timing plans were calculated using traffic volumes in the study day. For an isolated intersection, the signal timing was obtained directly from Synchro® (optimal cycle length and intersection split function). For corridor and network intersections, the optimal cycle time were searched within the range of 30-300 seconds in the Cycle Optimization (CYCOPT) module, a new feature in the TRANSYT-7F version 9.4. Then, the optimal green time durations and offsets were determined in the Genetic Algorithm module (G.A.). The optimal signal timings for all intersections in a network were established at the same time. The optimized signal timing plans were then written in the plan file of Paramics for every hour of simulation periods. Unfortunately, in the Phahurad network, it was found that the optimal cycle length, searched by TRANSYT, touched nearly minimum of the cycle length range (30 seconds) and this cycle time was too short and unacceptable. In addition, traffic condition seemed distorted when observed in Paramics modeller visulalization.

To solve this problem, The optimal cycle time was determined by Synchro® to verify (compare with) the cycle length from TRANSYT. It was found that Synchro® gave approximately 60 second of the optimal cycle length in the Phahurad network. Therefore, the minimum practical cycle length was reset to 60 seconds in all networks, especially in the Phahurad network. TRANSYT-7F was then used to find the optimal timing plan. It should be noted that in this study the default value of amber time and all red were 3 sec and 1 sec respectively.

The optimal fixed time plans were further input into Paramics to produce the outputs of control effectiveness. In Paramics, delay and entering volume on each link were gathered every hour throughout the entire simulation period. The results were directly collected from Paramics Analyser module that reported all statistical values. Link delay and link count (MOE from Paramics) were gathered in each run. The results presented the delay between two forms of control: With SCOOT day versus the optimized plan and Without SCOOT versus the optimized plan to judge for the relative and absolute performance among With SCOOT, Without SCOOT, and optimized plan

Table 4 Comparison of optimized plan and With SCOOT,
Without SCOOT delay during all day

Intersections	Daily Delay Average (sec/veh)					
	With SCOOT day			Without SCOOT day		
	Optimized plan	With SCOOT	Percent Decrease	Optimized plan	Without SCOOT	Percent Decrease
1.Isolated Intersection						
1.1 Chula Soi 12	50.1	40.9	18.45	59.0	42.5	27.97
1.2 Sripaya-Chareonkrung	8.4	17.3	-105.00	6.5	15.0	-131.78
2. Corridor Intersection						
2.1 Samranrat	68.1	59.5	12.56	126.5	116.6	7.80
2.2 Mansri	141.8	95.8	32.40	381.5	165.9	56.52
2.3 Yukol2	228.5	241.9	-5.87	146.2	164.2	-12.28
2.4 Anamai	285.0	139.1	51.18	246.3	115.6	53.06
2.5 Kasatseuk	7.0	13.2	-88.27	9.8	18.3	-87.35
Period average	146.1	109.9	24.74	182.0	116.1	36.22
3. Network Intersection						
3.1 Sapanmohn	40.3	136.1	-237.78	291.7	157.9	45.86
3.2 Sikuk Phayasri	20.1	52.0	-159.10	68.0	80.8	-18.89
3.3 Chareonkrung	37.0	62.4	-68.62	116.6	101.0	13.38
3.4 Unakan	33.8	72.1	-113.20	77.2	81.9	-6.11
3.5 Phahurad	86.2	141.3	-63.89	110.5	59.6	46.05
Period average	43.5	92.8	-113.38	132.8	96.3	27.52

4. Conclusion

The purpose of this study was to assess the effectiveness of adaptive control: With SCOOT and Without SCOOT control by various MOEs. The study was conducted on the isolated, corridor and network intersections in Bangkok area. Microscopic simulation model was deployed to model and evaluate the effect of adaptive traffic signal control by emulating the signal timing and traffic demand that recorded from the field observation. The study presented some of benefits and limitation of systems in each area types. The study also determined the differences of delay with optimized plan that calculated by TRANSYT-7F and Synchro traffic analysis program. The main purpose of this method was to compare the result to the theoretical optimized fixed time plan for each area type. Paramics software was used to determine the effectiveness of signal timing plan and to assess the network wide performance.
Even though the study areas were selected from small regions in Bangkok, they were the most suitable representative type of area that we mostly found in ATC phase 1. The results can only represent their own locations; isolated, corridor and network. However, the interpretation to the bigger area and overall network can be done with careful assumption.

Various of MOEs presented the differences, from Paramics simulation, between With SCOOT and Without SCOOT controls. In addition, traffic condition and performance with the optimized fixed time control under the With and Without SCOOT traffic flow conditions are simulated. The most significant improvement occurred at only corridor intersections by SCOOT control. However, the benefit of SCOOT on the main line was at some price on the minor disadvantages, as the minor streets experience increasing but not substantial delay. This is consistent with the SCOOT objective in which the intersection delay is minimized. The benefit of Without SCOOT control was found at Chula Soi 12 and the network intersections. SCOOT is therefore recommended to a corridor intersections rather than network intersections. The contribution of SCOOT was discounted during high traffic demand periods. Without SCOOT (by manual control) is considerably recommended to the congested intersection and especially for network intersections. However, the optimized fixed time plan also provides the advantages for the uncongested isolated intersection.

The microscopic simulation models are comprised of many advantages to test traffic scenarios according to policy change. In this study, the microscopic model was applied to assess the off-line SCOOT model and the existing control. In addition, the model also provided the state-of – the-art solution for the modern traffic engineering discipline. In the other hand, simulation model incorporates a mechanism to shorten the solution by its limitation that was generally found in many simulation packages. The limitation implies the confidence of the solution and application, thus the users should pay their attentions to cope with such problems/limitations.

The abilities of SCOOT were possibly not fully reflected in the tested network due to the minimal time spent in the fine-tuning the SCOOT parameters. The reason for non-ideal fine-tuning was because the fine-tune staffs were not fully exercised and the SCOOT control configurations (and the study area) were predetermined without any close examination. Since the assumption of this study were that all systems are complete and configured for the best operations, the author placed the suspicion that the SCOOT may perform better if there is more effort on the system calibration. The existing arrangement of control system may be attributed to inconsistent results of SCOOT performances. The acceptance of the SCOOT results thus must be considered with caution, nevertheless the results from the simulation show that SCOOT is able to improve the condition in some cases.

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REFERENCES

Abdulhai, B., Sheu, J.and Recker, W. (1999) Simulation of ITS on the Irvine FOT area using Paramics 1.5 Scaleable Microscopic Traffic Simulator, Phase 1: Model Calibration and Validation, **A Report Prepared by California PATH Program of the University of California**.

Johansson, G. and Rumar, H. (1971) Drivers' Brake Reaction Times. **Human Fact, Vol.3,** 23-27.

Peek Traffic (1983) **SCOOT V.2.4 Traffic Handbook.** The Crown, United Kingdom.

Quadstone.Co.ltd. (April, 2001) **Paramics Modeller Calibration Flamework [online].** Available from: URL:http://www.paramics-online.com.

Van Der Zijpp, N.J. (1996) **Dynamic Origin-Destination Matrix Estimation on motorway networks**. Doctoral dissertation, Transportation Planning and Traffic Engineering Section, Faculty of Civil Engineering, Delft University of Technology.

Van Der Zijpp, N.J. (1997) Dynamic OD-Matrix Estimation from Traffic Counts and Automated Vehicle Identification Data. **Transport Research Record, Vol. 1607**, 1-17.