Traffic State Comparison of Signalized Intersections Using SIDRA and SYNCHRO Software

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Article Info		Abstract
	The number of shopping malls and vehicles in Baghdad has quickly increased along with the city's population. This has resulted in an increase in daily trips, which affects the roadway network's traffic flow and causes congestion, particularly on Al-Mansour Street and Al-Rowad Street near the city center. To determine the best signal time, the 14th Ramadan signalized intersection was evaluated and analyzed using the SIDRA 8.0 and SYNCHRO 11.0 software. First, the findings revealed that the chosen traffic facility is presently experiencing a substantial reduction in service level that is leading to forced conditions (LOS "F"). It is suggested that the cycle time at the intersection of the 14th Ramadan be changed from 240 seconds to 160 seconds and 125 seconds in SIDRA and SYNCHRO, respectively. Signal timings have reduced the delay for the 14th Ramadan intersection (76.8%), thus improving LOS from (F) to (D) for the intersection. The best delays after optimization in SYNCHRO 11.0, however, were 31% reduction with LOS of (E and D). Cycle times have also been lowered for the intersection to 25% as part of the optimum signal timing optimization. In SYNCHRO 11.0, which is better than SIDRA 8.0, the back of the queue has improved at the 14th Ramadan intersection by 33%. However, SYNCHRO has a better representation than SIDRA for current traffic saturation.

1. Introduction

Tools for traffic analysis are created to help transportation experts assess the approaches that best meet the demands of their jurisdiction in terms of transportation [1,2]. Tools for traffic analysis in particular might be useful to practitioners [3]. There are several traffic modeling tools and pieces of software on the market right now [4-6]. The most important software package focuses on managing traffic flow. The applications of the software tools used for traffic processes are many [7]. A portion of the program offers an alternative to the traditional use of techniques for analyzing the capacity of highways. While other sections make use of the simulation to evaluate the impact of changing traffic plans, geometric arrangements, and control strategies. Similar to this, some devices include built-in optimization features that enable the development of optimal control mechanisms. These software programs include SIDRA, SYNCHRO, VISSIM, TRANSYT-7F, PASSER IV, PASSER IV, HCS2000, and more [8-12]
Al-Arkawazi [13] investigated how signalized intersection delay reduction affected fuel use, operating costs, and exhaust

pollution. By calculating the junction delay, operating cost, and emissions, SIDRA 5.1 was used to assess the current state of a few chosen crossings. According to the simulation's findings, fuel consumption, operating expenses, and emissions were high and inversely correlated with junction delay. While using the method outlined in the Highway Capacity Manual [14] and the Synchro program, two signalized crossings in Duhok city—the Salahaddin Mosque and Zari Land intersections—were evaluated for their capacity performance by Hussein [15].
Al-Ameria signalized intersection was chosen as a case study to illustrate the delay issue at Baghdad intersections by Rajab et al. [16]. The research region is close to several tourist sites, and the crossroads, which is west of Bagdad City, has heavy traffic. In this research, the HCS 2010 software was utilized to calculate the delay and assess the level of service for each approach and the intersection.
The general aim of this study is to estimate the intersection performance and level of service using Sidra Intersection software and Synchro Studio software and make a statistical

comparison to confirm which software is more compatible in such an environment.

Three congested intersections of Al-Khalani, Al-Wathba, and Amin located on Al-Jumhuriya Street in the central business district of Baghdad were selected by Namir et al. [17]. The required traffic and engineering data are collected manually and O-D scanning technology is used to estimate the distribution of traffic in different directions. SIDRA and TRAFFICQ software are used for traffic analysis process requirements. It was concluded that the proposed improvement of the aforementioned intersections is necessary to enhance the capacity and operation of Al-Jumhuriya Street in the central business district of Baghdad.

Al-Fallah signalized intersection was chosen as a case study to illustrate the delay issue at Baghdad intersections by Abdul-Razzak et al. [18]. Al-Fallah intersection which lies in the northeastern of Baghdad city is considered one of the highly congested urban centers, and suffers congestion, particularly during morning and evening peak hours. The objective of this study is to analyze the delay time, degree of saturation, and level of service in the Al-Fallah intersection in Baghdad City using Synchro.10 software in addition to evaluating and analyzing the intersection form choosing the best suggestion.

2. Methodology

2.1. Framework

The methods for gathering data and the steps for doing the essential data analysis are described in this chapter. In Baghdad city, two signalized intersections were chosen (14th Ramadan intersection). The selection procedure took several criteria into account (location, traffic volume, geometry, vehicle classification, and others). At the chosen crossings, precise geometry survey and video recording data were gathered to perform an analysis. "Fig. 1" depicts the study technique understandably.
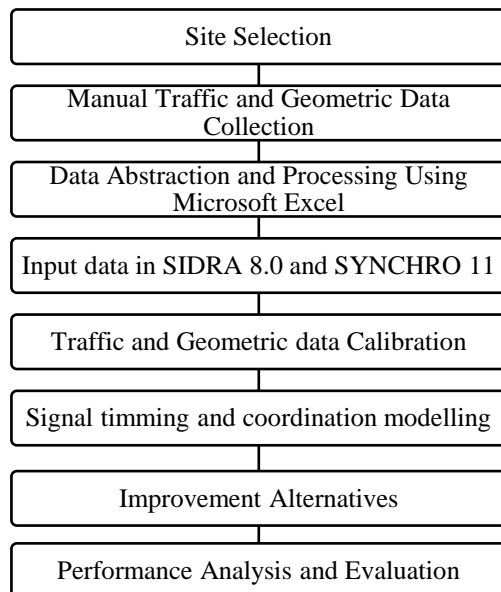
Figure 1. Study flow chart

2.2. Study Area and Data Collection

Within Baghdad's Central Business District (CBD), where the research took place, there are two multi-lane divided urban roadways. Al-Mansour Street has two intersections and one roundabout, and Al-Rowad Street has one intersection and one roundabout. These streets are perpendicular to each other and connected by the 14th Ramadan Intersection, as shown in "Fig. 2". Two multi-lane split roadways in the heart of Baghdad's Central Business District (CBD) make up the study area [18].

The right of way along Al-Mansour Roadway is 50 meters, while the length of the street itself is 2.6 kilometers. It can be classified according to its function and design to class IV urban minor arterial [19]. It has three lanes in each direction, separated by a 3 m width of the raised median. It starts at the 14th Ramadan Intersection and ends with Al-Faris Al-Arabi Square. 14th Ramadan Intersection is a three-leg signalized intersection, connecting 14th Ramadan Street with Al-Mansour Street. The geometric layout is illustrated in "Fig. 3".
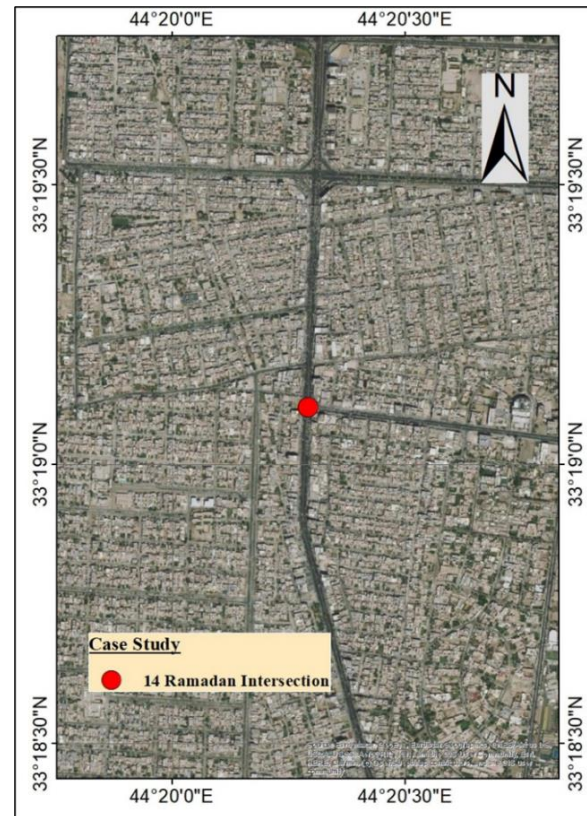
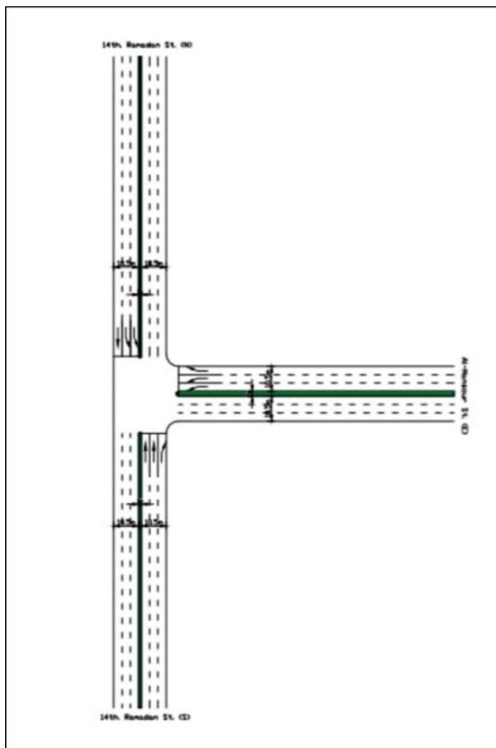**Figure 2.** Map location of 14th Ramadan signalized

Figure 3. The geometric design of the legs intersection of the 14th Ramadan Intersection

2.3. Traffic Signal Data

For the subject intersections, cycle duration and phase length have been taken from video recordings and are displayed in Table 1. For both lost time categories, Table 2 and Fig.4 illustrate how the software packages' default settings are considered. Due to challenges with lost time measurements in the automated system under traffic police supervision, default values are used [20].

Table 1. Order, phasing, and cycle length of signalized phases

Intersection	Phase Length (sec.)				Cycle Length (sec.)
	↑↱	⇌	⇅	⇆	
14th Ramadan Intersection	60	-	45	30	89

Table 2. Time lost and added to the specified intersection's green time

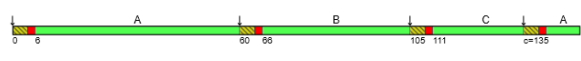| Software	Lost Time (sec.)
SYNCHRO	2.5
SIDRA	2.0

Figure 4. Movement phase timing for selected intersection for the 14th Ramadan intersection

3. Results and Discussions

This section includes an analysis of the data that was gathered, suggestions for improvements, and an assessment of the improvements using the calibrated software (SIDRA Intersection 8.0 and SYNCHRO 11.0). As a bonus, the results of the SIDRA and SYNCHRO applications show the change in performance metrics between the pre- and post-optimization of the selected intersection.

3.1. Average Delay Results

The average delay is the measure of effectiveness to evaluate the performance operation of a signalized intersection. The difference in the average delay of vehicles at the north, west, and east approaches of the 14th Ramadan intersection are presented in Fig. 5 and 6 for 4:00 – 5:00 p.m. which is extracted from the whole time (12:00 to 9:00 p.m.). North approaches have the highest delay with (a 130%) increase in delay for the 14th Ramadan intersection representing, the most delay time at selected peak hours for selected signalized intersections since the Al-Mansour district is a commercial district that attract**s** shoppers after working time.
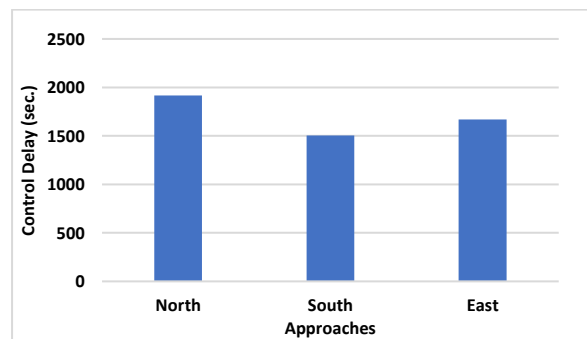

Figure 5. Average delay of 14th Ramadan Intersection at time 4:00 – 5:00 p.m. (peak hour)
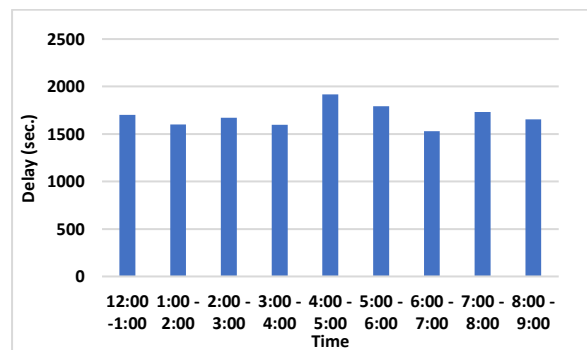

Figure 6. The total delay of the study area at different periods

For more accurate analysis, it is required to explore the traffic demand within a week and estimate the average delay for different days (Monday, Tuesday, and Wednesday) within the peak hours. "Fig. 7" shows the variation of average delay, and a maximum value was obtained on Monday. Based on that the

selected period is approved for coverage of critical demand and utilized for evaluation in this research.
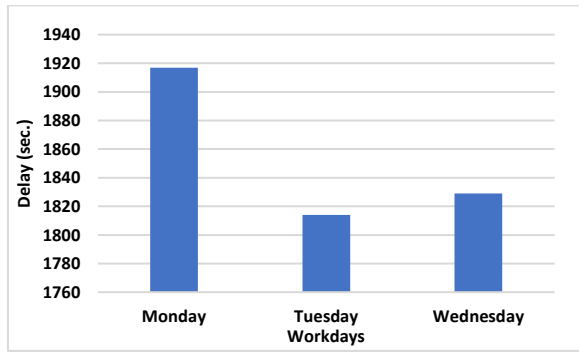

Figure 7. The total delay of the study area at different periods

3.2. Degree of Saturation

Demand outpaces capacity in oversaturated situations, hence a degree of saturation greater than 1.0 is anticipated. "Fig. 8" shows the results of the evaluation of the current data using Sidra Intersection 8.0 for the 14th Ramadan intersection.

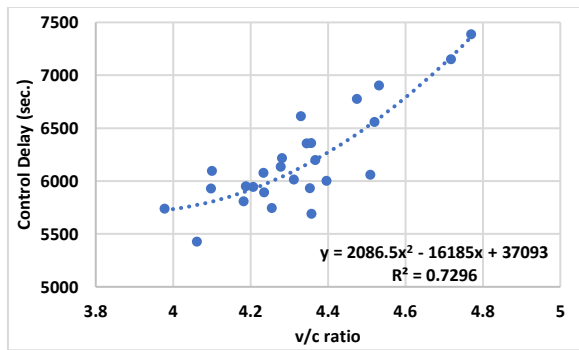$$y = 2086.5x^2 - 16185x + 37093$$
$$R^2 = 0.7296$$

Figure 8. Effect of v/c on control delay at 14th Ramadan intersection

3.3. Back of Queue for Signalized Intersection

Fig. 9 indicates the average back-of-queue distance in meters for every lane used by vehicle movement at the 14th Ramadan intersection, as simulated by the SIDRA software for modeling vehicle wait times.
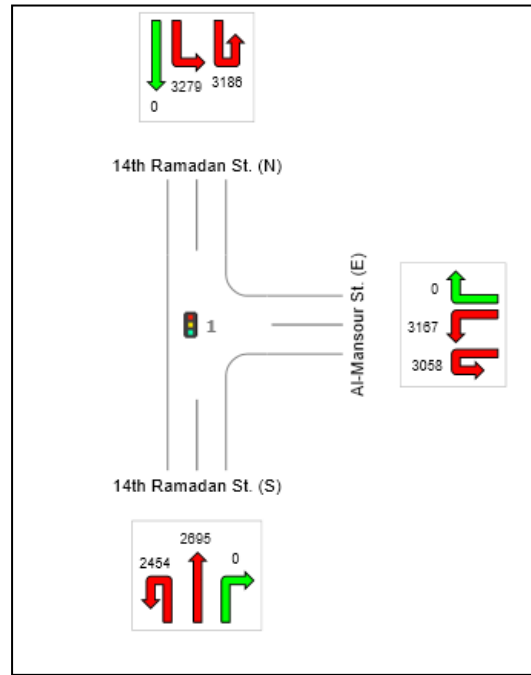

Figure 9. Average back-of-queue distance in meters for the 14th Ramadan intersection

3.4 Level of Service (LOS)

The average control delay, a measure of driver discomfort, frustration, fuel consumption, and longer travel times, was used to establish a Level of Service (LOS) at signalized intersections in HCM 2000. To depict realistic control delay ranges, levels of service are established. 14th Ramadan intersection is running at LOS "F" with an average control delay per intersection, as indicated in Table 3 displayed in "Fig. 10" at maximum delay on Monday, following the aforementioned criterion study intersections.

Table 3. Average control delay and L.O.S for 14th Ramadan intersection at 4:00-5:00 p.m. on Monday

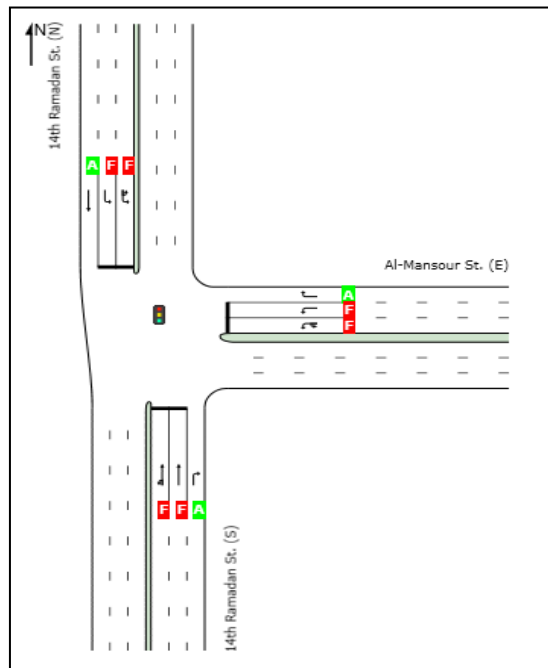| Approaches	North	South	East	Total
Delay (sec.)	2431.7	1182.7	2040.4	1916.6
L.O.S	F	F	F	F

Figure 10. L.O.S current result for the 14th Ramadan intersection on Monday from 4:00 – 5:00 p.m

Signal timing per phase is shown in Fig. 11 for the 14th Ramadan intersection. The results show the intersection performance per hourly values (4:00 – 5:00) p.m. with a cycle time of 150 seconds.
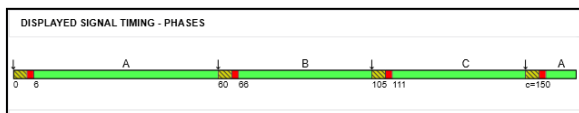

Figure 11. Signal timing per phase for the 14th Ramadan intersection via SIDRA

3.5 Improvement Strategy Via SIDRA

Traffic signal timing optimization has been done for both intersections to decrease the delay, which will improve the level of service of intersections by running the programs in different signal timing to find the most decreased delay. As presented in Table 4 and "Fig. 12" phase information is detailed for the 14th Ramadan intersection including input values of yellow time and all-red time, phase time and green time values, phase actuation, and phase split values less than 100%. Recent papers were in concur with this study's results [21]

Table 4. Phase timing summary for the 14th Ramadan intersection

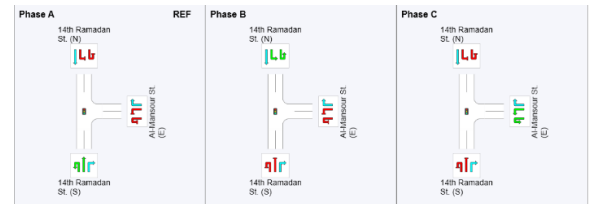| Phase Time	South	North	East
Phase Change (seconds)	0	60	105
Green (seconds)	54	39	39
Yellow (seconds)	4	4	4
All Red (seconds)	2	2	2
Phase (seconds)	60	45	45
Phase Split (%)	40%	30%	30%

Figure 12. Output phase sequence for 14th Ramadan intersection

3.6 Traffic Results Using SYNCHRO 11.0

SYNCHRO/SimTraffic 11.0 was used to assess and model the current traffic flow at the 14th Ramadan intersection. The intersection experiences a high value of delay which means an oversaturation condition, according to the data in Table 5. SYNCHRO 11.0 provides adequate results for heavy traffic. Due to the fundamental geometric design of SIDRA Junction 8.0, which simulates the accurate orientation of intersection legs by degrees, it produces irrational results for the 14th Ramadan Intersection. "Fig. 13" provides the traffic data outcome for the junction of 14th Ramadan and Al-Rowad using SYNCHRO 11.0.

Table 5. Phase timing summary for the 14th Ramadan intersection

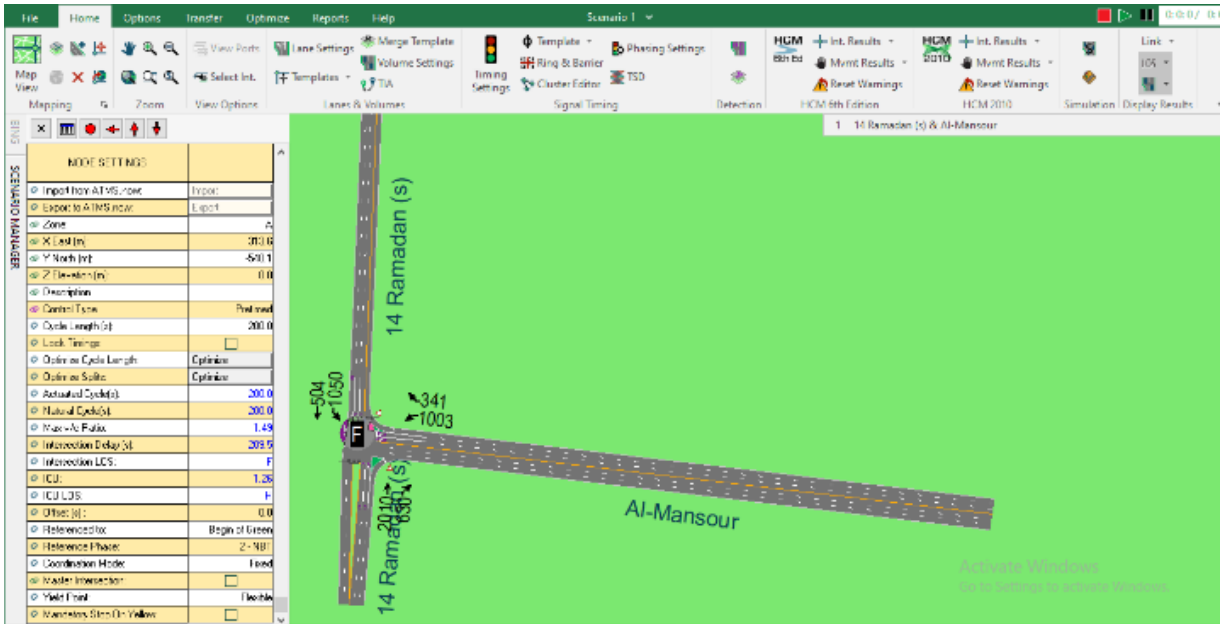| Intersection	Saturation Degree (v/c)	Average Delay (second)	LOS
14th Ramadan	7.43	1087	F

Figure 13. Traffic data result for the 14th Ramadan intersection using SYNCHRO 11.0

Several items are used for the intersection such as delay, back of the queue, stops, and degree of saturation. "Fig. 14" shows the full details of existing traffic operation for the 14th Ramadan intersection via SYNCHRO 11.0.

Signal timing per phase is shown in "Fig 15" for the 14th Ramadan intersection. The results show the intersection performance per hourly values (4:00 – 5:00) p.m.

TIMING SETTINGS	WBL	WBR	NBT	NBR	SBL	SBT
Trailing Detector (m)	0.0	0.0	0.0	0.0	0.0	0.0
Minimum Initial (s)	5.0	—	5.0	—	5.0	5.0
Minimum Split (s)	22.5	—	22.5	—	22.5	22.5
Total Split (s)	109.0	—	26.0	—	105.0	109.0
Yellow Time (s)	3.5	—	3.5	—	3.5	3.5
All-Red Time (s)	1.0	—	1.0	—	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0
Lagging Phase?	☐	—	☑	—	—	☐
Allow Lead/Lag Optimize?	☑	—	☑	—	—	☑
Recall Mode	Max	—	Max	—	Max	Max
Speed limit (km/h)	48	—	48	—	—	48
Actuated Effct. Green (s)	104.5	240.0	21.5	240.0	100.5	104.5
Actuated g/C Ratio	0.44	1.00	0.09	1.00	0.42	0.44
Volume to Capacity Ratio	0.79	0.25	7.43	0.47	0.85	0.73
Control Delay (s)	63.1	0.4	Error	1.1	70.8	62.8
Queue Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay (s)	63.1	0.4	Error	1.1	70.8	62.8
Level of Service	E	A	F	A	E	E
Approach Delay (s)	47.2	—	2216.0	—	—	68.2
Approach LOS	D	—	F	—	—	E
Queue Length 50th (m)	233.4	0.0	~1068.8	0.0	258.1	219.3
Queue Length 95th (m)	260.5	0.0	#1095.1	0.0	287.1	268.9
Stops (vph)	849	0	1368	0	940	415
Fuel Used (l/hr)	108	14	4552	8	100	44

Figure 14. Average control delay, L.O.S, Saturation, and queue for the 14th Ramadan intersection at 4:00-5:00 p.m. on Monday via SYNCHRO
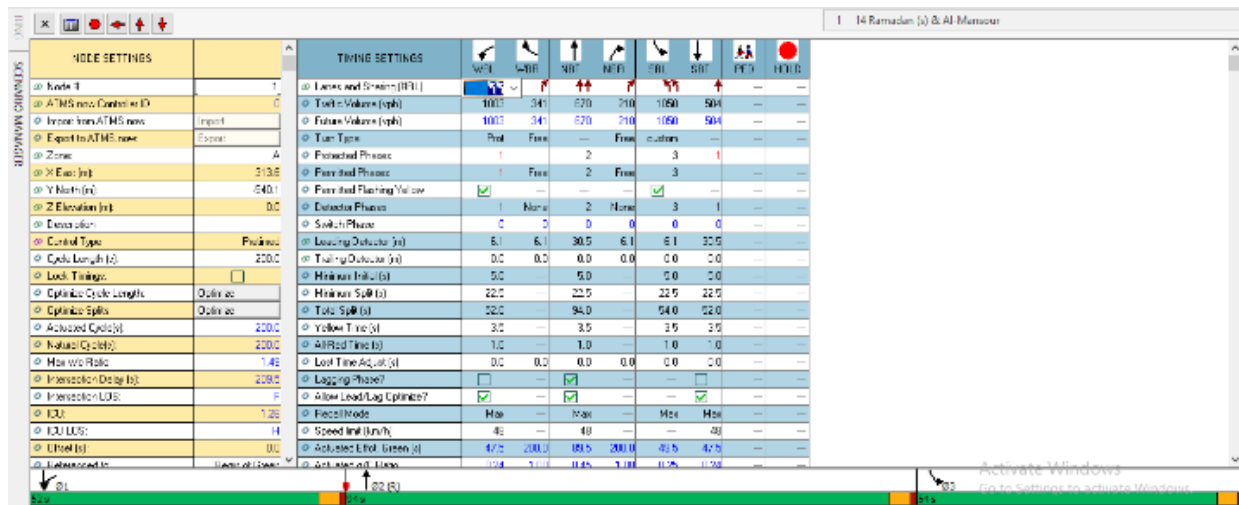

Figure 15. Signal timing per phase for the 14th Ramadan intersection via SYNCHRO

3.7 Comparison between SIDRA 8.0 and SYNCHRO 11.0 Improvement Results

Fig. 16 to Fig. 20 show the comparison between SIDRA improvement and SYNCHRO improvement for the delay, cycle time, degree of saturation, back of the queue, and L.O.S as a measure of effectiveness for the 14th Ramadan intersection.
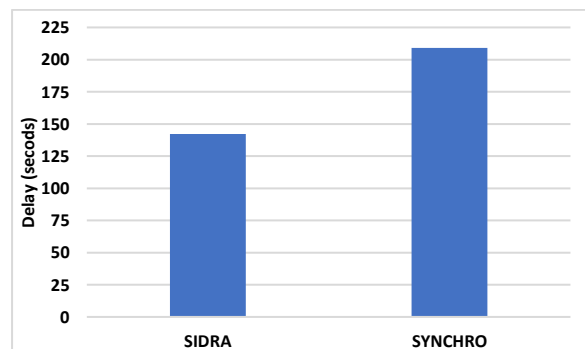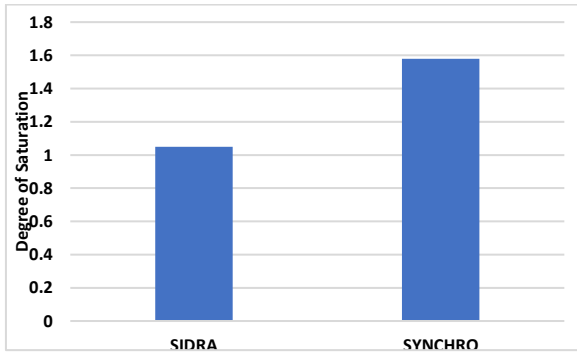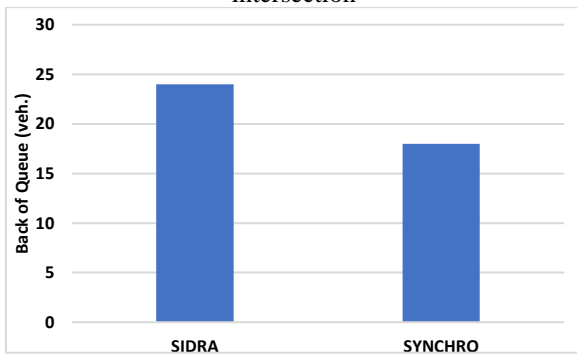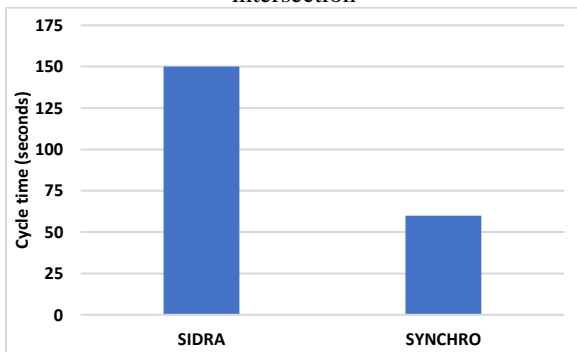

Figure 16. Comparison of delay between SIDRA and SYNCHRO improvements for the 14th Ramadan intersection
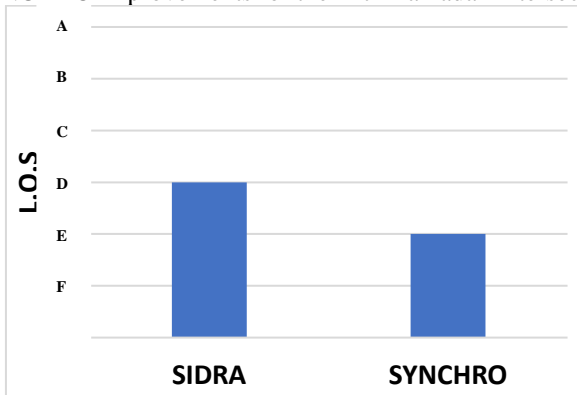
Figure 17. Comparison of the degree of saturation between SIDRA and SYNCHRO improvements for the 14th Ramadan intersection

Figure 18. Comparison of the back of queue between SIDRA and SYNCHRO improvements for the 14th Ramadan intersection

Figure 19. Comparison of cycle time between SIDRA and SYNCHRO improvements for the 14th Ramadan intersection

Figure 20. Comparison of L.O.S between SIDRA and SYNCHRO improvements for the 14th Ramadan intersection

Fig. 16 to Fig. 20 show that delays have improved for the intersection by 32% in SIDRA 8.0 better than Synchro 11.0. The degree of saturation has been improved for the 14th Ramadan intersection by 34% in SIDRA 8.0 better than Synchro 11.0. While the back of the queue has been improved for the intersection by 33%. SYNCHRO 11.0 is better than SIDRA 8.0 because SIDRA deals with the intersection node only while SYNCHRO takes into account the delay and back of the queue of all links that connected to the intersection.

4. Conclusions

The key findings that can be made from the main objectives are summarized within the restrictions of the traffic aspects of the study area. Firstly, the difference in the average delay of vehicles at the north, south, and east approaches of 1917, 1506, and 1670 seconds respectively for the 14th Ramadan intersection. While in SYNCHRO 11.0, the average delays were 63.1 and 70.8 seconds for both east and north approaches for 4:00 – 5:00 p.m. at the 14th Ramadan intersection. The degree of saturation has been improved for the 14th Ramadan intersection by 34% in SIDRA 8.0 better than Synchro 11.0. The back of the queue has been improved for both intersections by 33% for the 14th Ramadan intersection in SYNCHRO 11.0 better than SIDRA 8.0. Also, the level of service for all periods shows worse traffic operation (LOS F) using SYNCHRO 11.0. Finally, in terms of simulating the back of the queue, SIDRA can simulate more accurately than SYNCHRO while the degree of horizontal alignment can be represented more accurately in SYNCHRO than in SIDRA.

Acknowledgments

Conflict of interest

There is no conflict of interest.

Author Contribution Statement

All authors contributed to writing and editing this manuscript. The research problem was proposed by the author, Maryam L. Kareem, and the results of this work were supervised by Dr. Zainab A. Alkaissi. Maryam L. Kareem and Dr. Zainab A. Alkaissi developed the introduction and style of the manuscript. All authors discussed the results and contributed to the final manuscript.

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