Adewumi Augustine Adepitan
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Introduction

This study analyzes traffic conditions along a corridor near George Mason University, focusing on improving congestion at intersections during peak hours. Using Trans Modeler software, the study evaluates the effectiveness of various signal timing adjustments and control strategies under different scenarios. The primary objective is to enhance traffic flow and reduce delays while ensuring practical feasibility without adding new lanes due to the limited right-of-way.

The initial public feedback indicated significant delays during peak hours at two critical intersections. This study simulates and assesses proposed adjustments to traffic signals to address these concerns, aiming to develop actionable recommendations supported by quantitative analysis.

Study Objective and Method

Objective

The objective of this study is to optimize traffic signal control at intersections to alleviate congestion and minimize delays during peak traffic hours.

Method

1. **Data Collection**: Data on traffic flow, vehicle demand volume, and existing signal timings were collected.
2. **Model Calibration**: The existing traffic conditions were modeled using TransModeler, ensuring the accuracy of vehicle behavior and delays at intersections.
3. **Performance Measures**:
   - Delay by intersection
   - Intersection Level of Service (LOS)
   - Average vehicle delay and stops
4. **Scenarios and Proposed Solutions**:
   - Three iterations of signal timing adjustments were tested.
   - Each scenario aimed to optimize vehicle throughput by reducing Delays and improve LOS at key intersections (Node IDs: 3 and 1).

Figures and tables summarizing the results for each scenario are presented in the following sections.

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Results

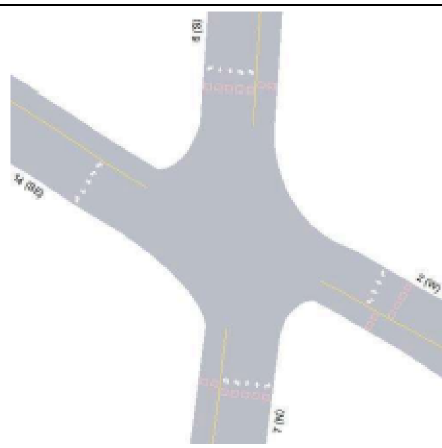
Scenario 1 (Initial Traffic Model)

For the Initial traffic model, after running to check the model analysis I have the following initial plan and result

TransModeler® Intersection Report

Site Information			
Intersection ID:	3	Site Name:	N 38.827431, W 77.316448
Cross Street:	14 (SE) & 7 (N)	Number of Plans:	1
Analysis Date:	2024/12/1 20:50:4		

Intersection Geometry

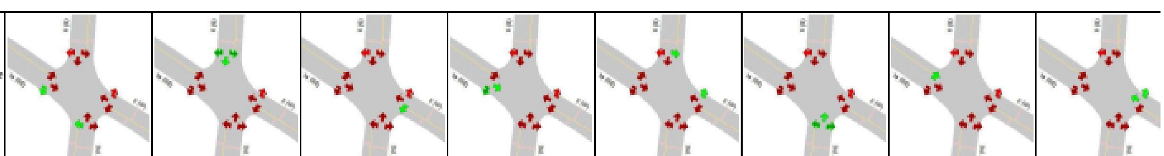


12/1/24, 4:49 PM Node3_Report.html

Signal Timing Plan - 1

Time of Day:	00:00:00 - 23:59:59
Plan Description:	00:00:00
Controller Type:	Pretimed (Concurrent Phasing)
Cycle Length:	160.0 sec
Offset:	116.0 sec
Coordinate Begin of:	Yellow

Phasing



Item Name \ Signal States								
ID	1	2	3	4	5	6	7	8
Green	16.0	41.0	25.0	50.0	23.0	34.0	15.0	60.0
Yellow	4.0	4.5	4.0	4.5	4.0	4.5	4.0	4.5
Red Clearance	3.0	2.5	3.0	2.5	3.0	2.5	3.0	2.5
Lost Time	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ped Walk + FDW	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Coordinated	No	No	No	Yes	No	No	No	Yes
Split	23.0	48.0	32.0	57.0	30.0	41.0	22.0	67.0
Opt Min Green	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	1, 2	3, 4
Ring - 2	5, 6	7, 8

Figure 1, Scenario 1Node 3(Initial Traffic Model)

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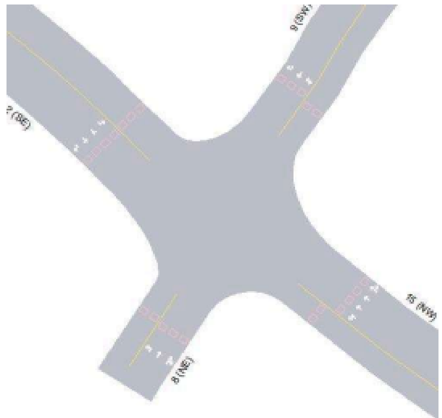
TransModeler® Intersection Report

Site Information			
Intersection ID:	1	Site Name:	N 38.825526, W 77.312536
Cross Street:	15 (NW) & 9 (SW)	Number of Plans:	1
Analysis Date:	2024/12/1 20:58:20		

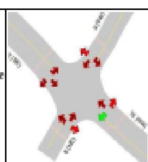
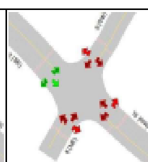
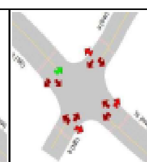
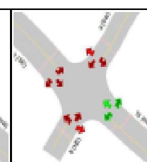
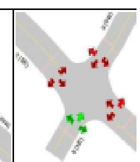
Intersection Geometry



Signal Timing Plan - 1

Time of Day:	00:00:00 - 23:59:59
Plan Description:	00:00:00
Controller Type:	Pretimed (Concurrent Phasing)
Cycle Length:	160.0 sec
Offset:	139.0 sec
Coordinate Begin of:	Yellow

Phasing

Item Name \ Signal States								
ID	1	2	3	4	5	6	7	8
Green	19.0	68.0	11.5	26.5	19.0	68.0	16.5	21.5
Yellow	4.5	4.5	3.5	3.5	4.5	4.5	3.5	3.5
Red Clearance	4.5	4.5	5.0	5.0	4.5	4.5	5.0	5.0
Lost Time	9.0	9.0	8.5	8.5	9.0	9.0	8.5	8.5
Ped Walk + FDW	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Coordinated	No	Yes	No	No	No	Yes	No	No
Split	28.0	77.0	20.0	35.0	28.0	77.0	25.0	30.0
Opt Min Green	17.0	17.0	16.5	16.5	17.0	17.0	16.5	16.5

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	1, 2	3, 4
Ring - 2	5, 6	7, 8

Figure 2, Scenario 1Node 1(Initial Traffic Model)

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Scenario 1 (Initial Traffic Model result)

Adjustments

- **Initial Condition**: No adjustments made; this was the baseline scenario to understand existing traffic conditions.
- Intersection 3 showed significant delays, with an LOS of F, indicating a poor performance.

Project: MyModel
Scenario: Scenario
Run(s): 12/04/24 01:13:17
Simulated: 12/04/24 01:13:17
Time: 08:10:00 - 09:00:00
Interval: Summary
Selection: --

Delay by Intersection - Summary

Node ID	Intersection	Number of Vehicles	Total Delay (hr)	Total Stpd Time (hr)	Total Num of Stops	Avg Delay (sec/veh)	Avg Stopped	Avg Stops /Veh
3	14, 7, 2 & 6	3,126	157.70	139.80	4,277	181.7	161.0	1.4
1	15, 9, 2 & 8	2,752	52.80	42.70	2,881	69.1	55.9	1.1

Table 1 scenario 1Delay Summary

Project: MyModel
Scenario: Scenario
Run(s): 12/04/24 01:13:17
Simulated: 12/04/24 01:13:17
Time: 08:10:00 - 09:00:00
Interval: Summary
Selection: --

Intersection Level of Service - Summary

Node ID	Intersection	Number of Vehicles	Total Control Delay (hr)	Avg Control Delay (sec/veh)	Level of Service	Control Type
3	14, 7, 2 & 6	3,126	151.70	174.7	F	Pretimed
1	15, 9, 2 & 8	2,752	47.40	62.0	E	Pretimed

Table 2 scenario 1 level of service

Observation

- Node 3 exhibited significant delays, with an average delay of **181.7 sec/vehicle** and an LOS of **F**.
- Node 1 had an average delay of **69.1 sec/vehicle** and an LOS of **E**.
- Observations indicated the need for signal coordination and green time adjustments.

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Scenario 2 (First Adjustment)

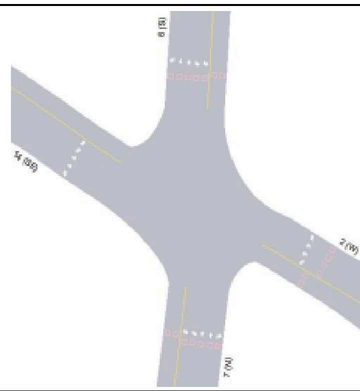
some adjustment with the following plan

12/4/24, 1:33 AM Node3_Report.html

TransModeler® Intersection Report

Site Information			
Intersection ID:	3	Site Name:	N 38.827431, W 77.316448
Cross Street:	14 (SE) & 7 (N)	Number of Plans:	1
Analysis Date:	2024/12/4 6:30:3		

Intersection Geometry



12/4/24, 1:33 AM Node3_Report.html

Signal Timing Plan - 1

Time of Day:	00:00:00 - 23:59:59
Plan Description:	00:00:00
Controller Type:	Pretimed [Concurrent Phasing]
Cycle Length:	160.0 sec
Offset:	60.0 sec
Coordinate Begin of:	Yellow

Phasing

Item Name \ Signal States								
ID	1	2	3	4	5	6	7	8
Green	16.0	41.0	25.0	50.0	23.0	34.0	15.0	60.0
Yellow	4.0	4.5	4.0	4.5	4.0	4.5	4.0	4.5
Red Clearance	3.0	2.5	3.0	2.5	3.0	2.5	3.0	2.5
Lost Time	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Ped Walk + FDW	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Coordinated	No	No	No	Yes	No	No	No	Yes
Split	23.0	48.0	32.0	57.0	30.0	41.0	22.0	67.0
Opt Min Green	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	1, 2	3, 4
Ring - 2	5, 6	7, 8

Figure 3 Scenario 2 node 3(first adjustment)

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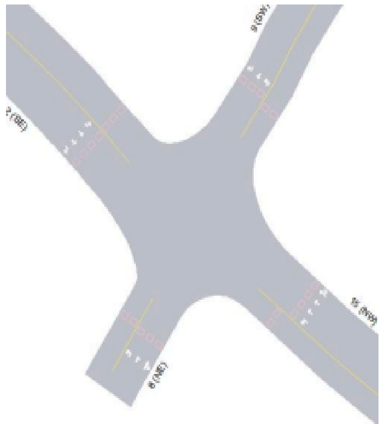
TransModeler® Intersection Report

Site Information			
Intersection ID:	*1*	**Site Name:**	*N 38.825526, W 77.312536*
Cross Street:	*15 (NW) & 9 (SW)*	**Number of Plans:**	*1*
Analysis Date:	*2024/12/4 6:34:20*		

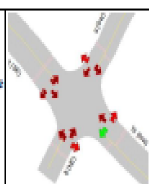
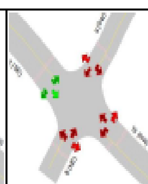
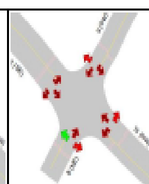
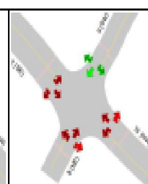
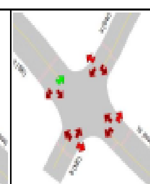
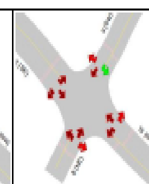
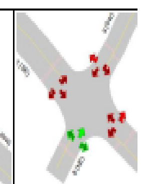
Intersection Geometry



Signal Timing Plan - 1

Time of Day:	*00:00:00 - 23:59:59*
Plan Description:	*00:00:00*
Controller Type:	*Pretimed [Concurrent Phasing]*
Cycle Length:	*160.0 sec*
Offset:	*139.0 sec*
Coordinate Begin of:	*Yellow*

Phasing

Item Name \ Signal States								
ID	1	2	3	4	5	6	7	8
Green	19.0	68.0	11.5	26.5	19.0	68.0	16.5	21.5
Yellow	4.5	4.5	3.5	3.5	4.5	4.5	3.5	3.5
Red Clearance	4.5	4.5	5.0	5.0	4.5	4.5	5.0	5.0
Lost Time	9.0	9.0	8.5	8.5	9.0	9.0	8.5	8.5
Ped Walk + FDW	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Coordinated	No	Yes	No	No	No	Yes	No	No
Split	28.0	77.0	20.0	35.0	28.0	77.0	25.0	30.0
Opt Min Green	17.0	17.0	16.5	16.5	17.0	17.0	16.5	16.5

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	1, 2	3, 4
Ring - 2	5, 6	7, 8

Figure 4 Scenario 2 node 1(first adjustment)

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Scenario 2 (first Adjustment result)

Adjustments Made

- Green Time: combination of possible green time was adopted also increased for through movements to improve flow along major corridors.
- Split Timing: Reallocated green times by reducing the duration for minor movements.
- Coordination: Introduced limited coordination between intersections to align phase changes.
- Priority was given to Node 3 because after studying the both node , node three had many issue with congestion compare to Node 1 which is performing better

Project:	MyModel
Scenario:	Scenario
Run(s):	12/04/24 01:24:27
Simulated:	12/04/24 01:24:27
Time:	08:10:00 - 09:00:00
Interval:	Summary
Selection:	--

Delay by Intersection - Summary

Node ID	Intersection	Number of Vehicles	Total Delay (hr)	Total Stpd Time (hr)	Total Num of Stops	Avg Delay (sec/veh)	Avg Stopped	Avg Stops /Veh
3	14, 7, 2 & 6	3,260	103.10	90.40	3,149	113.8	99.8	1.0
1	15, 9, 2 & 8	2,769	51.50	41.90	2,714	67.0	54.5	1.0

Table 3 scenario 2 delay summary

Project:	MyModel
Scenario:	Scenario
Run(s):	12/04/24 01:24:27
Simulated:	12/04/24 01:24:27
Time:	08:10:00 - 09:00:00
Interval:	Summary
Selection:	--

Intersection Level of Service - Summary

Node ID	Intersection	Number of Vehicles	Total Control Delay (hr)	Avg Control Delay (sec/veh)	Level of Service	Control Type
3	14, 7, 2 & 6	3,260	97.30	107.5	F	Pretimed
1	15, 9, 2 & 8	2,769	46.10	60.0	E	Pretimed

Table 4 scenario 2 level of service

Observations

- Adjusting the green times and introducing coordination significantly reduced delays at both intersections, especially at Node 3 from 181.7 to 113.8 sec/vehicle, though still in the same level of service F

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Scenario 3 (second Adjustment)

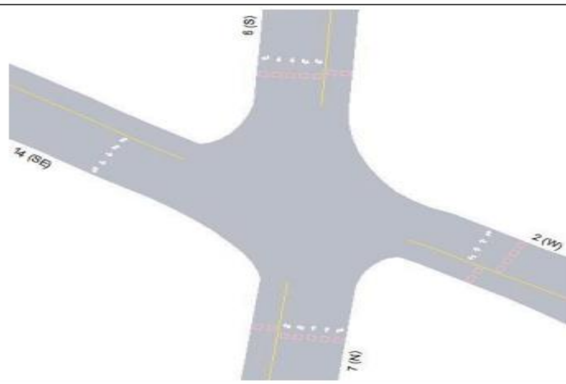
Having considered scenario 2, several iterations were again carried out which led to the further changes this was majorly made to node 3 as this is the underperforming Node with high delay, details in the Attached below

12/4/24, 2:13 AM Node3_Report.html

TransModeler® Intersection Report

Site Information			
Intersection ID:	*3*	**Site Name:**	*N 38.827431, W 77.316448*
Cross Street:	*14 (SE) & 7 (N)*	**Number of Plans:**	*1*
Analysis Date:	*2024/12/4 7:13:4*		

Intersection Geometry

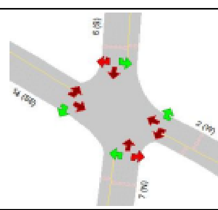
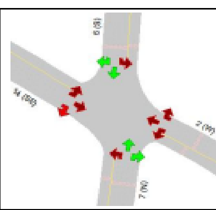
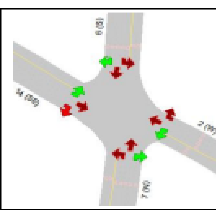
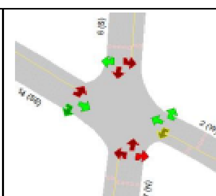


12/4/24, 2:13 AM Node3_Report.html

Signal Timing Plan - 1

Time of Day:	*00:00:00 - 23:59:59*
Plan Description:	*00:00:00*
Controller Type:	*Pretimed [Concurrent Phasing]*
Cycle Length:	*128.6 sec*
Offset:	*40.0 sec*
Coordinate Begin of:	*Yellow*

Phasing

Item Name \ Signal States				
ID	*1*	*2*	*3*	*4*
Green	*24.0*	*21.6*	*29.0*	*29.0*
Yellow	*4.0*	*4.5*	*4.0*	*4.0*
Red Clearance	*2.0*	*2.5*	*2.0*	*2.0*
Lost Time	*6.0*	*7.0*	*6.0*	*6.0*
Ped Walk + FDW	*15.0*	*15.0*	*15.0*	*15.0*
Coordinated	*No*	*No*	*No*	*Yes*
Split	*30.0*	*28.6*	*35.0*	*35.0*
Opt Min Green	*14.0*	*15.0*	*14.0*	*14.0*

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	*1, 2*	*3, 4*
Ring - 2		

Figure 5 scenario 3 node 3 (second Adjustment)

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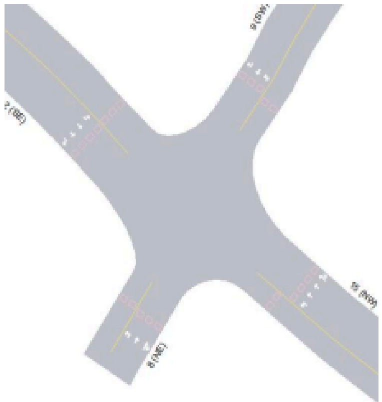
TransModeler® Intersection Report

Site Information			
Intersection ID:	1	Site Name:	N 38.825526, W 77.312536
Cross Street:	15 (NW) & 9 (SW)	Number of Plans:	1
Analysis Date:	2024/12/4 7:13:55		

Intersection Geometry

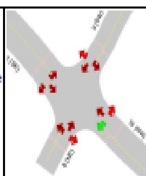
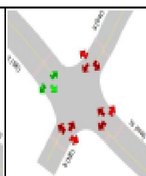
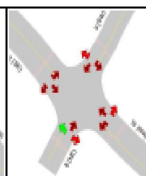
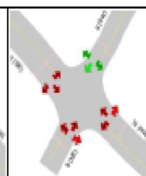
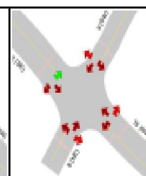
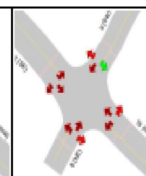
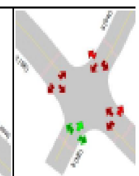


12/4/24, 2:14 AM Node1_Report.html

Signal Timing Plan - 1

Time of Day:	00:00:00 - 23:59:59
Plan Description:	00:00:00
Controller Type:	Pretimed [Concurrent Phasing]
Cycle Length:	160.0 sec
Offset:	139.0 sec
Coordinate Begin of:	Yellow

Phasing

Item Name \ Signal States								
ID	1	2	3	4	5	6	7	8
Green	19.0	68.0	11.5	26.5	19.0	68.0	16.5	21.5
Yellow	4.5	4.5	3.5	3.5	4.5	4.5	3.5	3.5
Red Clearance	4.5	4.5	5.0	5.0	4.5	4.5	5.0	5.0
Lost Time	9.0	9.0	8.5	8.5	9.0	9.0	8.5	8.5
Ped Walk + FDW	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Coordinated	No	Yes	No	No	No	Yes	No	No
Split	28.0	77.0	20.0	35.0	28.0	77.0	25.0	30.0
Opt Min Green	17.0	17.0	16.5	16.5	17.0	17.0	16.5	16.5

Phase Sequence and Concurrency Group

Ring \ Concurrency Group	CG - 1	CG - 2
Ring - 1	1, 2	3, 4
Ring - 2	5, 6	7, 8

Figure 6 Scenario 3 node 1 (second Adjustment)

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Scenario 3 (second Adjustment result)

Adjustments Made

- Green Time: Increased movements with the highest vehicle traffic volumes.
- Split Timing: Optimized splits to reduce delays for left-turn movements.
- Coordination: Strengthened signal coordination to better synchronize intersections.
- Red Clearance: Slightly reduced to improve traffic flow during phase changes.
- Reduction in Phases: Reduced total phases from 8 to 4 combined phases to optimize green times in order to increase flow within a coordinated signal thereby reducing the time delay. I actually did this to have an easy way of keeping my eye on the Traffic scenario with hope to improve the synchronization better

Project: MyModel
Scenario: Scenario
Run(s): 12/04/24 02:09:53
Simulated: 12/04/24 02:09:53
Time: 08:10:00 - 09:00:00
Interval: Summary
Selection: --

Delay by Intersection - Summary

Node ID	Intersection	Number of Vehicles	Total Delay (hr)	Total Stpd Time (hr)	Total Num of Stops	Avg Delay (sec/veh)	Avg Stopped	Avg Stops /Veh
3	14, 7, 2 & 6	4,519	82.70	64.30	3,781	65.9	51.2	0.8
1	15, 9, 2 & 8	3,115	56.00	44.70	2,887	64.7	51.7	0.9

Table 5 scenario 3 delay summary

Project: MyModel
Scenario: Scenario
Run(s): 12/04/24 02:09:53
Simulated: 12/04/24 02:09:53
Time: 08:10:00 - 09:00:00
Interval: Summary
Selection: --

Intersection Level of Service - Summary

Node ID	Intersection	Number of Vehicles	Total Control Delay (hr)	Avg Control Delay (sec/veh)	Level of Service	Control Type
3	14, 7, 2 & 6	4,519	74.90	59.7	E	Pretimed
1	15, 9, 2 & 8	3,115	49.90	57.7	E	Pretimed

Table 6 scenario 3 level of intersection

Observations

- Node 1 delay reduced and maintained performance even though this was not rigorously adjusted for optimization, because the traffic demand and delays is more generated from node 3, in this case, node 3 was adjusted more and this led to a significant improvement from 113.8 delay per sec to 65.9 which in turn improve the level of service from F to E .

Delay Reduction Efficiency

In other to know the percentage of delay achieved the delay reduction efficiency was calculated. To Quantify delay reduction efficiency between scenarios:

Efficiency = $\frac{initial\ Delay - optimized\ delay}{Initial\ delay} * 100$

- Initial delay: 181.7 sec/vehicle
- Final delay: 65.9 sec/vehicle

$$\text{Efficiency} = \frac{181.7 - 65.9}{181.7} * 100 = 63.7\%$$

I was able to reduce the average delay by 63.7%, this is a significant improvement in the traffic flow condition.

Conclusions

The observed reduction in delays through the iterative adjustments of signal splits and timings can be attributed to the factors below:

1. **Efficient Use of Green Time**: By reducing the split time for phases such as right turns, which may not require extended green times, the green time was reallocated to approaches with higher demand. This allowed for a more balanced allocation of time, leading to improved overall intersection performance and reduced unnecessary waiting for vehicles at other approaches.
2. **Shorter Cycle Lengths**: Reducing split times contributed to shorter overall cycle lengths. Shorter cycle lengths mean vehicles spend less time waiting during red phases, which in turn leads to a reduction in average delay per vehicle.
3. **Improved Signal Coordination**: For intersections that are part of a coordinated corridor, reducing and increasing split times depending on intersection traffic volume improved synchronization with adjacent intersections. This allowed for smoother vehicle progression and reduced stop-and-go conditions, contributing to a decrease in overall delays.

Through these iterative adjustments, this study successfully reduced delays and improved LOS at both intersections:

- Node 3: Delays reduced from 181.7 sec/vehicle to 65.9 sec/vehicle, reducing the delay by 63.7%, improving LOS from F to E.
- Node 1: Delays reduced from 69.1 sec/vehicle to 64.7 sec/vehicle, maintaining LOS E.

Key contributors to improvement include:

1. Efficient green time allocation based on traffic demand.
2. Shorter cycle lengths to reduce waiting times.
3. Enhanced signal coordination for smoother traffic progression.

The improvements in this study show how using simulation tools can help optimize traffic signal timing to ease congestion and reduce delays without expensive changes to physical infrastructure. This method allows for better traffic management by making informed decisions based on data.

While the reduction in delays and the improvement in LOS are promising, the LOS only improved to a certain point. Further attempts to optimize signal timing did not lead to better results, suggesting that the current traffic demand on these roads exceeds their capacity. This highlights the need for more comprehensive solutions, such as reducing demand or considering infrastructure changes in the long term.

Recommendations

Proper coordination and timing of signal phases are crucial to achieving effective and efficient traffic flow with a good Level of Service (LOS). Based on the findings of this study, it is recommended that the adjusted signal timings from Scenario 3 be implemented at both Node 3 and Node 1 to improve overall traffic flow and reduce waiting times at all phases of the intersections.

Additionally, implementing sensors with cameras at these intersections could further enhance the efficiency of traffic management. Such sensors would provide real-time data on the number of vehicles waiting and their respective waiting times, allowing for adaptive signal timing adjustments. By automatically prioritizing phases with higher traffic demand or adjusting green times when certain lanes are empty, these sensors would enable more responsive and dynamic control of traffic signals, thereby reducing overall delays.

More so, Regular monitoring of traffic conditions is also essential, particularly given the potential for changes in traffic volume over time. Continuous assessment will allow for periodic updates to signal timing splits, ensuring that high-traffic phases receive adequate green time and maintaining an optimal LOS even as conditions evolve.

In summary, implementing the optimized signal timings, using smart sensor technology for adaptive control, and maintaining ongoing traffic monitoring will create a more efficient, responsive, and effective traffic management system at these intersections.

Appendix