Criteria for Assessing the Effectiveness of a Non Real Time Coordinated Cluster of Signalized Intersections

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Abstract

Given the limited resources available for installing advanced signal controllers, many researchers and professionals believe that well-designed coordinated fixed-time signal control, combined with well-defined corridor coordination, is a cost-effective option. In this study, two closely spaced intersections were considered for analysis. It was identified that a subsystem consists of spatial elements (the link road that connects two signalized intersections) and temporal elements (the relative offset between the signals of the two intersections). Throughput, travel time, delay, queue length, and flow efficiency were considered basic performance measurement parameters. The traffic flow analysis was conducted using the Vissim model, with calibration parameters adjusted to suit Sri Lankan conditions based on previous research. Twenty demand models were evaluated, with volume-to-capacity (v/c) ratios ranging from 0.2 to 0.9 across the two intersections. The traffic flow was analyzed under three scenarios: Scenario 1 consisted of 60% through traffic, 20% left-turn traffic, and 20% right-turn traffic. In Scenario 2, the traffic distribution was 60% through traffic, 30% left-turn traffic, and 10% right-turn traffic. Scenario 3 featured 60% through traffic, 10% left-turn traffic, and 30% right-turn traffic. The Vissim model's link road geometry was kept at 500 meters, and both junctions were identical. The east-west direction was treated as the coordinated direction with three lanes, while the north-south cross streets had two lanes. Base saturation flows and offset optimization were calculated using Akcelik's (1981) method, and cycle timing was determined based on the Webster formula. The study extended its analysis to compare unsynchronized (Case 1) and synchronized (Case 2) models. Initially, travel time was plotted against throughput. Based on the Elbow method, three clusters were identified as the optimal cluster number and then K-means clustering was performed. Generally, Cluster 1 had low flow and moderate traffic, Cluster 2 had moderate to high flow but moderate travel time, and Cluster 3 had moderate flow and high travel time. When the mean values for each cluster were compared in the unsynchronized and synchronized models, signal synchronization improved all key metrics in each cluster, except for queue length on the link road in Cluster 3, and throughput and flow efficiency in Cluster 2. Based on the Independent-Samples T-Test p-value, statistically significant improvements were found in travel time, with an 8.74% improvement in Cluster 2 and a 14.34% improvement in Cluster 3. Delay improvements were 29% and 30% in Clusters 2 and 3, respectively. However, there was a 35.17% increase in queue length on the link road, suggesting that while flow efficiency and delays improved, congestion remained an issue. As a further performance check, the Min-Max Normalization and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods were used. Both methods ranked Cluster 3 as the highest performer, despite the increase in queue length. Finally, considering the Level of Service (LOS) criteria from the Highway Capacity Manual, Cluster 3 showed an improvement from LOS E and D to LOS C, whereas Cluster 2 showed an improvement from LOS C and B to LOS B and Cluster 1 remained at LOS B and A. The most notable result from this research is the identification of Cluster 3 as the best-performing cluster across multiple scenarios, while Cluster 2 provided moderate improvement

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and Cluster 1 showed no significant improvement. Therefore, this study suggests that to gain the benefits of synchronization, the intersections considered should initially fall within the range of Cluster 3 or Cluster 2. Further research is required to explore how intersection geometry and coordination direction affect synchronization.

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