Study on Flow Direction Changing Method of Reversible Lanes on Urban Arterial Roadways in China

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Abstract

A flow direction changing method of reversible lanes on urban arterial roadways is presented based on signal timing, coil detectors and overhead changeable lane-use signals, hoping that the safety of lane changing maneuvers on reversible lanes will be improved and the transition of periodic flow direction change will be smoother. First, a new layout of signalized intersection approaches along reversible lanes is proposed. That is, lane function of signalized intersection approach doesn’t change with the direction of reversible lanes. Then, direction changing method of reversible lanes on urban arterial roadways from off-peak periods to peak periods is provided. The method can change direction of reversible lanes in certain signal cycles.

Keywords: reversible lanes; coil detectors; overhead changeable lane-use signal; traffic direction changing method

1. Introduction

It is obvious that the level of traffic congestion on urban arterial roadways is still increasing. Endless stream of techniques have been developed to address this problem, including the reversible lane system. Reversible lanes are particularly effective because they take advantage of the unused capacity in the minor-flow direction lanes to increase the capacity in the major-flow direction lanes, thereby eliminating the need to construct additional lanes [1]. They have been used throughout the world for more than 80 years [2], most commonly to increase directional roadway capacity during peak commuter periods [3,4], planned events [5,6], temporary construction periods [7], and emergency events [8-10]. In other countries, most common applications of reversible lanes could be found on freeways, arterial roadways, bridges, and in tunnels. However in China, most common application of reversible lanes is on urban arterial roadways. Reversible lane operations in China are different from those in foreign...
countries. One of the reasons is that freeways, arterial roadways, bridges and tunnels which have implemented reversible lanes in foreign countries are uninterrupted-flow facilities, while urban arterial roadways are interrupted-flow facilities. Because of the intersections, reverse flow operation in urban arterial roadways are regarded to be more complex, especially in the vicinity of intersections where there is turning traffic, conflicting cross street and even pedestrians. Although the operation of reversible lanes on urban arterial roadways faces more difficulties, there are few literatures focusing on their control and management. The primary purpose of this paper is to provide a flow direction changing method of reversible lanes on urban arterial roadways from off-peak periods to peak periods based on signal timing, coil detectors and overhead changeable lane-use signals, hoping that the safety of lane changing maneuvers on reversible lanes will be improved and the transition of periodic flow direction change will be smoother.

2. Definition of Research Object

2.1. Reversible lanes

This paper mainly focuses on reversible lanes on urban arterial roadways in a typical urban commuter situation in China. Figure 1 shows an example of reversible lanes on a north-south urban arterial roadway with regularly spaced signalized intersections. The north-south urban arterial roadway consists of six travel lanes on the section including two center lanes which are reversible but are not physically separated. Each northbound or southbound approach at signalized intersections is widened to add one right-turn lane. Vehicles are allowed to make left turns at signalized intersections.

In order to see more clearly, green-colored pavement for two reversible lanes is used in Figure 1. The edge of each reversible lane is delineated by a double normal broken yellow line. The right reversible lane is called the "number 1 lane". The lane to the left of the "number 1 lane" is "number 2 lane".

During off-peak periods, the north-south urban arterial roadway operates as a bidirectional facility, with three travel lanes in each direction on the section. The number 1 lane is operated northbound and the number 2 lane is operated southbound. At signalized intersections, three travel lanes in each direction are converted into four lanes, including one left-turn lane and one right-turn lane. During the morning peak-period travel time, the predominant travel direction is southbound. Four lanes including two reversible lanes are operated southbound and two lanes northbound on the section. During the evening peak-period travel time, the predominant travel direction is northbound. Four lanes including two reversible lanes are operated northbound and two lanes southbound on the section.

There are four types of transitions: transition from the off-peak period to the morning peak-period, transition from the morning peak-period to the off-peak period, transition from the off-peak period to the evening peak-period and transition from the evening peak-period to the off-peak period. Taking reversible lanes shown in Figure 1 for example, this paper mainly studies the flow direction changing method of reversible lanes from the off-peak period to the morning peak-period. Direction changing methods of the other three types of transitions are similar to it.

2.2. Changeable lane-use signals

Changeable lane-use signals are installed above each reversible lane. There are four overhead changeable lane-use signals on each section of the north-south urban arterial roadway, as shown in Figure 1. Two are installed at the upstream of the intersection, called B₁ and F₁. B₁ is installed facing the northbound traffic in reversible lanes and instructing them. F₁ is installed facing the southbound traffic in reversible lanes and instructing them. The distance between B₁(or F₁) and corresponding downstream intersection stopping line is L. The other two are installed at the beginning of the departure leg, called B₂ and F₂. B₂ is installed facing the
northbound traffic in reversible lanes and instructing them. F_2 is installed facing the southbound traffic in reversible lanes and instructing them. That is to say, on each section of the north-south urban arterial roadway there are two overhead changeable lane-use signals in one direction. B_1 and B_2 provide instructions to northbound traffic in reversible lanes; while F_1 and F_2 provide instructions to southbound traffic in reversible lanes.

The overhead changeable lane-use signals display three different indications, which are the downward-pointing green arrow, the yellow "×" and the red "×". A downward-pointing green arrow positioned over a reversible lane indicates that drivers are permitted to drive in that lane. A yellow "×" positioned over a reversible lane indicates that a control change is about to occur and drivers should begin to leave the lane. A red "×" positioned over a reversible lane indicates that drivers are not permitted to drive in that lane. Each overhead changeable lane-use signal instructs two reversible lanes, as shown in Figure 1.

Fig. 1. General configuration of reversible lanes on urban arterial roadways in China
2.3. Coil detectors

Coil detectors are installed under the reversible lanes. There are eight coil detectors on each section of the north-south urban arterial roadway, as shown in Figure 1. Four are installed under the number 1 lane, called N_{11}, N_{12}, M_{11} and M_{12}. The other four are installed under the number 2 lane, called N_{21}, N_{22}, M_{21} and M_{22}. N_{12} and N_{22} are installed at the northern end of each section; N_{11} and N_{21} are installed near the northern end of each section. The distance between N_{11} and N_{12} (or N_{21} and N_{22}) is L_N. M_{12} and M_{22} are installed at the southern end of each section; M_{11} and M_{21} are installed near the southern end of each section. The distance between M_{11} and M_{12} (or M_{21} and M_{22}) is L_M.

3. Direction Changing Method of Reversible Lanes

3.1. Basic assumptions

The proposed flow direction changing method of reversible lanes on urban arterial roadways from the off-peak period to the morning peak period is based on the following key assumptions:

1. During the peak-periods, unbalanced flow occurring on north-south urban arterial roadway is caused by the heavy straight-going traffic, not the left-turning or right-turning traffic.
2. Install four overhead changeable lane-use signals and eight coil detectors on each section of the north-south urban arterial roadway, as shown in Figure 1.
3. During the morning peak-period, intersections along reversible lanes are operated by four phases (north-south through movement, north-south left turn, east-west through movement and east-west left turn). All intersections along reversible lanes have the same cycle length and the same effective green time for north-south through phase. The phase diagram is shown in Figure 2.

![Phase diagram of the intersections](image)

Fig. 2. Phase diagram of the intersections

4. North approach speed equals south approach speed on each section.
5. Use the new layout of intersection approach provided below. Drivers are only permitted to go straight through the intersection instead of making a left turn at the intersection when driving in reversible lanes.

3.2. The new layout of intersection approaches along reversible lanes

This paper provides a new layout of intersection approaches along reversible lanes. The new layout of intersection approaches is an important premise of the flow direction changing method of reversible lanes.

Current layout of intersection approaches along reversible lanes is shown in Figure 3. That is, lane function of signalized intersection approach changes with the direction of reversible lanes. During off-peak periods (shown in Figure 3(a)), the number 1 lane is operated northbound and the number 2 lane southbound on the section. The number 1 lane is served as the left-turn lane and the lane to the right of the number 1 lane is served as the through lane at the intersection. During the morning peak-period (shown in Figure 3(b)), the number 1 lane and the
number 2 lane are operated southbound on the section. The lane to the right of the number 1 lane is served as the left-turn lane. During the evening peak-period (shown in Figure 3(c)), the number 1 lane and the number 2 lane are operated northbound on the section. The number 2 lane is served as the left-turn lane, the number 1 lane is served as the through lane, and the lane to the right of the number 1 lane is served as the through lane. As we can see, functions of the number 1 lane and the lane to the right of the number 1 lane change with the direction of reversible lanes, which is likely to cause chaos and invite danger and accidents.

The new layout of intersection approaches along reversible lanes is shown in Figure 4. That is, lane function of signalized intersection approach doesn’t change with the direction of reversible lanes. During off-peak periods (shown in Figure 4(a)), the number 1 lane is operated northbound and the number 2 lane southbound on the section. The number 1 lane is served as the through lane and the lane to the right of the number 1 lane is served as the left-turn lane at the intersection. During the morning peak-period (shown in Figure 4(b)), the number 1 lane and the number 2 lane are operated southbound on the section. The lane to the right of the number 1 lane is still served as the left-turn lane. During the evening peak-period (shown in Figure 4(c)), the number 1 lane and the number 2 lane are operated northbound on the section. The number 2 lane and the number 1 lane are served as the through lanes and the lane to the right of the number 1 lane is still served as the left-turn lane. It is obvious that functions of the number 1 lane and the lane to the right of the number 1 lane don’t change with the direction of reversible lanes. However, it is noteworthy that one through lane is to the left of the left-turn lane during off-peak periods and two through lanes are to the left of the left-turn lane during the evening peak-period, different from common layout. Drivers may be confused. And it may increase clearance lost time at signalized intersection because of the conflict between north-south through movement and north-south left turn.

In this paper, the new layout of intersection approaches along reversible lanes is used. In this case, appropriate turn control signs should be used at the upstream of the intersections to mandate the movements of all traffic on the approach. Drivers are only permitted to go straight through the intersection when driving in reversible lanes. They are not permitted to make a left turn at the intersection when driving in reversible lanes.

![Fig. 3. Current layout of intersection approach](image1)

![Fig. 4. A new layout of intersection approach](image2)
3.3. Flow direction changing method of reversible lanes on urban arterial roadway

Because each section of the urban arterial roadways follows the same flow direction changing method of reversible lanes, we take the section between the two intersections shown in Figure 1 for example and establish the flow direction changing method of reversible lanes from the off-peak period to the morning peak-period. The two intersections are called intersection J\textsubscript{1} and intersection J\textsubscript{2}. The section between J\textsubscript{1} and J\textsubscript{2} is called section J\textsubscript{1}J\textsubscript{2}. The distance between J\textsubscript{1} and J\textsubscript{2} is L\textsubscript{0}, namely, the length of section J\textsubscript{1}J\textsubscript{2} is L\textsubscript{0}.

There are four overhead changeable lane-use signals (B\textsubscript{1}, F\textsubscript{1}, B\textsubscript{2} and F\textsubscript{2}) installed on section J\textsubscript{1}J\textsubscript{2}. B\textsubscript{1} is installed at the upstream of intersection J\textsubscript{2} facing northbound traffic in reversible lanes. F\textsubscript{1} is installed at the upstream of intersection J\textsubscript{1} facing southbound traffic in reversible lanes. The distance between B\textsubscript{1}(or F\textsubscript{1}) and the downstream intersection stopping line is L. B\textsubscript{2} is installed at the beginning of the departure leg of intersection J\textsubscript{1} facing northbound traffic in reversible lanes. F\textsubscript{2} is installed at the beginning of the departure leg of intersection J\textsubscript{2} facing southbound traffic in reversible lanes.

There are eight coil detectors (N\textsubscript{21}, N\textsubscript{22}, N\textsubscript{11}, N\textsubscript{12}, M\textsubscript{21}, M\textsubscript{22}, M\textsubscript{11} and M\textsubscript{12}) on section J\textsubscript{1}J\textsubscript{2}. N\textsubscript{11}, N\textsubscript{12}, M\textsubscript{11} and M\textsubscript{12} are installed under the number 1 lane; N\textsubscript{21}, N\textsubscript{22}, M\textsubscript{21} and M\textsubscript{22} are installed under the number 2 lane. N\textsubscript{12} and N\textsubscript{22} are installed at the northern end of section J\textsubscript{1}J\textsubscript{2}; N\textsubscript{11} and N\textsubscript{21} are installed near the northern end of section J\textsubscript{1}J\textsubscript{2}. The distance between N\textsubscript{11} and N\textsubscript{12} (or N\textsubscript{21} and N\textsubscript{22}) is L\textsubscript{N}. M\textsubscript{12} and M\textsubscript{22} are installed at the southern end of section J\textsubscript{1}J\textsubscript{2}; M\textsubscript{11} and M\textsubscript{21} are installed near the southern end of section J\textsubscript{1}J\textsubscript{2}. The distance between M\textsubscript{11} and M\textsubscript{12} (or M\textsubscript{21} and M\textsubscript{22}) is L\textsubscript{M}. L\textsubscript{N}(or L\textsubscript{M}) meets the following formula:

\[ L_N (or \ L_M) = \min \{L_q, v_a \cdot g_A \} \]

Where, L\textsubscript{N} = distance between N\textsubscript{11} and N\textsubscript{12} or distance between N\textsubscript{21} and N\textsubscript{22} (m); L\textsubscript{M} = distance between M\textsubscript{11} and M\textsubscript{12} or distance between M\textsubscript{21} and M\textsubscript{22} (m); L\textsubscript{q} = approach length at the intersection (m); v\textsubscript{a} = approach speed at the intersection (m/s); g\textsubscript{A} = effective green time for north-south through phase (sec).

During the morning peak-period, intersection J\textsubscript{1} and intersection J\textsubscript{2} have the same cycle length and the same effective green time for north-south through phase. Let the cycle length of intersection J\textsubscript{1} and intersection J\textsubscript{2} is C and the effective green time for the north-south through phase is g\textsubscript{A}. The first cycle during the morning peak-period is called C(1). The second cycle is called C(2), then C(3), etc.

"R×" represents the red "×" signal. "Y×" represents the yellow "×" signal. And "↓" represents the downward-pointing green arrow signal. B\textsubscript{1}(R×, Y×) means the red "×" signal and the yellow "×" signal are displayed by B\textsubscript{1}. The signal to the left of the comma in parentheses instructs the northbound traffic in the number 2 lane. The signal to the right of the comma in parentheses instructs the northbound traffic in the number 1 lane. In the case of B\textsubscript{1}(R×, Y×), "R×" instructs the northbound traffic in the number 2 lane and "↓" instructs the northbound traffic in the number 1 lane. The definitions of B\textsubscript{1}(R×, ↓), B\textsubscript{1}(R×, R×), B\textsubscript{2}(R×, ↓), B\textsubscript{2}(R×, R×), etc. are similar to that of B\textsubscript{1}(R×, Y×).

F\textsubscript{1}(R×, ↓) means the red "×" signal and the downward-pointing green arrow signal are displayed by F\textsubscript{1}. The signal to the left of the comma in parentheses instructs the southbound traffic in the number 1 lane. The signal to the right of the comma in parentheses instructs the southbound traffic in the number 2 lane. In the case of F\textsubscript{1}(R×, ↓), "R×" instructs the southbound traffic in the number 1 lane and "↓" instructs the southbound traffic in the number 2 lane. The definitions of F\textsubscript{1}(↓, ↓), F\textsubscript{2}(R×, ↓), F\textsubscript{2}(↓, ↓), etc. are similar to that of F\textsubscript{1}(R×, ↓).

During off-peak periods, the number 1 lane is operated northbound and the number 2 lane is operated southbound. During the morning peak-period travel time, the number 1 lane and the number 2 lane are operated southbound. From the off-peak period to the morning peak-period, the direction of the number 2 lane doesn’t need change while the direction of the number 1 lane needs change. The indications displayed by overhead changeable lane-use signals from the off-peak period to the morning peak-period are shown in Table 1.
Because the direction of the number 2 lane doesn’t need change while the direction of the number 1 lane needs change from the off-peak period to the morning peak-period, the flow direction changing method of reversible lanes is simplified to the flow direction changing method of the number 1 lane. In Table 1, for B₁ and B₂, the signal to the right of the comma in parentheses instructs the northbound traffic in the number 1 lane; for F₁ and F₂, the signal to the left of the comma in parentheses instructs the southbound traffic in the number 1 lane. According to Table 1, the flow direction changing method of the number 1 lane from the off-peak period to the morning peak-period is provided as follow:

1) Before the first cycle, a downward-pointing green arrow positioned over the number 1 lane is displayed by B₁ and B₂, indicating that drivers are permitted to drive northbound in the number 1 lane. A red "×" positioned over the number 1 lane is displayed by F₁ and F₂, indicating that drivers are not permitted to drive southbound in the number 1 lane. The number 1 lane is in the northbound direction.

2) From the first cycle to the nth cycle, a yellow "×" positioned over the number 1 lane is displayed by B₁, indicating that the direction of the number 1 lane is about to change and drivers driving northbound indicated by B₁ should begin to leave the number 1 lane. A red "×" positioned over the number 1 lane is displayed by B₂, indicating that drivers departing from signalized intersection J₁ and northbound entering the north-south urban arterial roadway are not permitted to use the number 1 lane. The red "×" positioned over the number 1 lane displayed by F₁ and F₂ indicates that drivers are not permitted to drive southbound in the number 1 lane.

It is necessary to be specific about the yellow "×" positioned over the number 1 lane displayed by B₁ from the first cycle to the nth cycle:

During the first cycle, the yellow "×" positioned over the number 1 lane displayed by B₁ indicates that drivers driving northbound in the influence area of B₁ during the first cycle should begin to leave the number 1 lane and that drivers driving northbound outside the influence area of B₁ during the first cycle are still allowed to drive northbound in the number 1 lane. The influence area of B₁ during the first cycle is the area in which drivers driving northbound are able to recognize B₁ during the first cycle; the outside of the influence area of B₁ is the area in which drivers are not able to see B₁ or recognize B₁ during the first cycle, including the upstream of influence area of B₁ and the downstream of influence area of B₁ (shown in Figure 5).

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Table 1. Indications displayed by overhead changeable lane-use signals

<table>
<thead>
<tr>
<th>Signal</th>
<th>B₁</th>
<th>B₂</th>
<th>F₁</th>
<th>F₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before C(1)</td>
<td>(R×,↓)</td>
<td>(R×,↓)</td>
<td>(R×,↓)</td>
<td>(R×,↓)</td>
</tr>
<tr>
<td>C(1)-C(n)</td>
<td>(R×, Y×)</td>
<td>(R×, R×)</td>
<td>(R×,↓)</td>
<td>(R×,↓)</td>
</tr>
<tr>
<td>After C(n)</td>
<td>(R×, R×)</td>
<td>(R×, R×)</td>
<td>(↓↓)</td>
<td>(↓↓)</td>
</tr>
</tbody>
</table>

Note: n is a positive integer; and n is greater than or equal to 2.
During the second cycle, the yellow "×" positioned over the number 1 lane displayed by B₁ indicates that drivers driving northbound in the influence area of B₁ during the second cycle should continue to leave the number 1 lane. Those driving in the downstream of influence area of B₁ in the number 1 lane during the first cycle are able to go straight through the intersection J₂ in the second cycle. Those driving in the upstream of influence area of B₂ during the first cycle and driving in the influence area of B₁ during the second cycle should leave the number 1 lane.

Until the end of the nth cycle, all drivers driving northbound in the number 1 lane have completely left the number 1 lane and the number 1 lane is clear of traffic.

3) After the nth cycle, a red "×" positioned over the number 1 lane is displayed by B₁ and B₂, indicating that drivers are not permitted to drive northbound in the number 1 lane. A downward-pointing green arrow positioned over the number 1 lane is displayed by F₁ and F₂, indicating that drivers are permitted to drive southbound in the number 1 lane. The number 1 lane is switched in the southbound direction.

As we can see, the flow direction changing method of the number 1 lane from the off-peak period to the morning peak-period can change direction of reversible lanes in n signal cycles. N is a positive integer, related to the length of section J₁J₂, the 85th percentile speed on section J₁J₂, cycle length of the intersection and effective green time for north-south through phase and so on.

3.4. Locational optimization of overhead changeable lane-use signals

In order to satisfy the condition that drivers driving northbound in the downstream of influence area of B₁ in the number 1 lane during the first cycle are able to go straight through the intersection J₂ in the second cycle, there are certain requirements for L. L is related to the disappearing distance, the effective green time for the north-south through phase, the approach speed, the cycle length, etc.

Driver perception of the overhead signal [11-13] is analyzed in order to calculate the disappearing distance. Figure 6 shows driver perception process of the overhead signal. The overhead signal is set in point G. Drivers discover the signal in point A, identify it and start recognizing it in point B, and finish reading it in point D. After the information was processed, drivers take action in point F and finish action in point K. In the disappearing point E, drivers cannot recognize the overhead signal because of the view angle limit. The disappearing distance of overhead signal is the length of EG segment. The influence area of overhead signal is in the upstream of point E. E is the boundary point between influence area of overhead signal and downstream of influence area of overhead signal.

Fig. 6. Driver perception process of the overhead signal

According to Figure 6, the disappearing distance can be calculated using Equation (2).

$$M = \frac{(H - H₀)}{\tan α} \quad (2)$$

Where, M = disappearing distance of overhead signal (m); H = height of overhead signal above roadway surface (m); H₀ = height of driver’s eye above roadway surface (m), general 1.2m in China [13]; α = view angle limit of overhead signal (°), general 7° in China [13].
In order to guarantee that drivers driving northbound in the influence area of B1 can change lanes and in order to satisfy the condition that drivers driving northbound in the downstream of influence area of B1 in the number 1 lane during the first cycle are able to go straight through the intersection J2 during the second cycle, L should meet the following formula:

\[ L_q < L + M < v_a (C + g_A) \] (3)

Where, \( L \) = distance between B1 and the downstream intersection stopping line (m); \( C \) = cycle length of intersection J2 (sec).

Giving the condition that L also needs to be greater than channelization length at signalized intersection, combining Equation (2) and Formula (3), the requirements for L are as follows:

\[ L_q < L < v_a (C + g_A) - (H - H_p) / \tan \alpha \] (4)

If the value of L calculated using Formula (4) doesn’t exist, which means drivers driving northbound in the downstream of influence area of B1 in the number 1 lane during the first cycle cannot completely go straight through intersection J2 during the second cycle, then let \( L > L_q \). If the maximum value of L calculated using Formula (4) is greater than \( L_0 \), then B1 and F1 don’t need to be installed on section J1J2. Two overhead changeable lane-use signals (B2 and F2) installed on section J1J2 are enough.

### 3.5. Calculation of \( n \)

In order to guarantee that the number 1 lane can be completely clear of traffic in n signal cycles, drivers driving in the upstream of influence area of B1 during the \((n-1)\)th cycle must be able to recognize B1 and leave the number 1 lane during the nth cycle. And drivers driving northbound in the downstream of influence area of B1 in the number 1 lane during the first cycle must completely go straight through intersection J2 in n cycles. \( n \) should meet the following formula:

\[ L_0 - L - M \leq n \cdot v \cdot C \]
\[ L + M \leq v_a \cdot [(n - 1)(C + g_A)] + 1 \] (5)

Where, \( L_0 \) = length of section J1J2 (m); \( n \) = number of signal periods required to change direction of reversible lanes; \( v \) = 85th percentile speed on section J1J2 (m/s).

Substituting Equation (2) and Formula (3) into Formula (5), we get:

\[ n \geq \left\lfloor \frac{L_0 - v_a (C + g_A) + L + (H - H_p) / \tan \alpha - v_a \cdot g_A + 1}{v \cdot C} \right\rfloor \] (6)

Considering that \( n \) is a positive integer and \( n \) is greater than or equal to 2, \( n \) can be calculated using Formula 7:

\[ n \geq \max \left\{ \left\lfloor \frac{L_0 - v_a (C + g_A)}{v \cdot C} \right\rfloor, \left\lfloor \frac{L + (H - H_p) / \tan \alpha - v_a \cdot g_A + 1}{v_a \cdot C} \right\rfloor, 2 \right\} \] (7)

To increase efficiency, the smaller the value of \( n \), the better it is. However, to ensure safety, the larger the value of \( n \), the better it is. In order to balance efficiency and safety, the final calculation of \( n \) is:

**Step 1: Initialization.**

Set \( n_0 = \max \left\{ \left\lfloor \frac{L_0 - v_a (C + g_A)}{v \cdot C} \right\rfloor, \left\lfloor \frac{L + (H - H_p) / \tan \alpha - v_a \cdot g_A + 1}{v_a \cdot C} \right\rfloor, 2 \right\} \)

**Step 2: Assignment.**

Let \( n = n_0 \).

**Step 3: Termination check.**

If coil detector N11 and N12 detect no cars during the nth cycle, stop; otherwise, set \( n_0 = n_0 + 1 \) and go to step 2.
4. Conclusion

This paper mainly presents a flow direction changing method of reversible lanes on urban arterial roadways from the off-peak period to the peak-period based on signal timing, coil detectors and overhead changeable lane-use signals. Only the requirements for $L_N$, $L_M$ and $L$ are both satisfied, can the method change directions of reversible lanes in $n$ signal cycles. The calculation of $n$ is also provided. However, traffic simulation isn’t used to evaluate the validity and reliability of the flow direction changing method.

A new layout of intersection approaches along reversible lanes is also proposed. That is, lane function of signalized intersection approach doesn’t change with the direction of reversible lanes. However, traffic chaos and increase of loss time at signalized intersection caused by this layout aren’t discussed.

In the next step, traffic simulation should be used to evaluate the validity and reliability of this method. Traffic chaos and increase of loss time at signalized intersection caused by the new layout of intersection approaches along reversible lanes should be discussed. Green wave coordinated control of reversible lanes could be considered in future.

Acknowledgments

This research is sponsored by National High-Tech R&D Program of China (Grant No. 2011AA110304). The authors gratefully appreciate the valuable suggestions from those who made this paper possible.

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