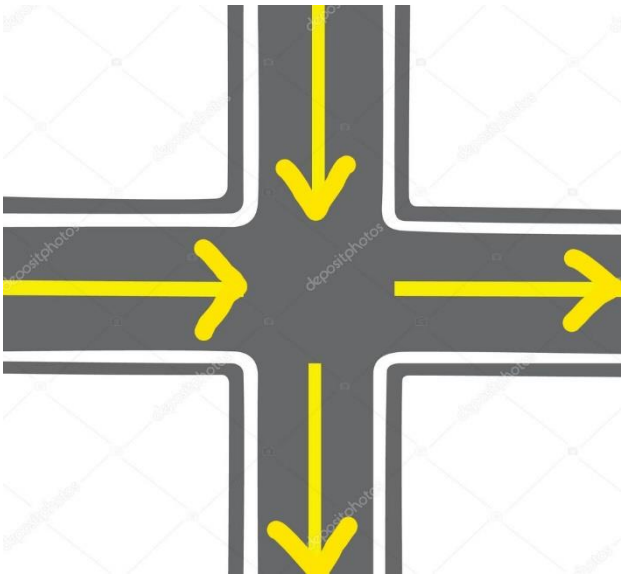
DFA Approach

The traffic control system using the DFA approach can be classified into 2 categories.

One Way Road intersection

Configuration of the road :

- Road directed from North to south direction
- Road directed from West to east direction



Traffic signal system:
For a one-way road intersection, there will be 2 traffic signals

- L1-Handles the signal for the vertical road(N-S)
- L2-Handles the signal for the horizontal road (W-E)

If L1 is green then traffic from the North will be allowed to move
If L2 is green then traffic from the West will be allowed to move

Rules:

1. If one signal is green then the other signal has to be red
2. Both signals can be red at the same time
3. Priority of signals is L1-L2
4. For a given period or lapse the state will not change.
5. While the given state is dealing with the traffic the input sensors are deliberating the next input symbol(traffic conditions)

Designing the DFA:

Finite Set of States (Q):
q_0 : L1 is green and L2 is red
q_1 : L2 is green and L1 is red
q_2 : Both L1 and L2 are red

Input Symbols:
V: Traffic is detected in the vertical(North) direction
H: Traffic is detected in the horizontal(West) direction
B: Traffic is detected in both(North-West) direction
N: Traffic is detected in none of the direction

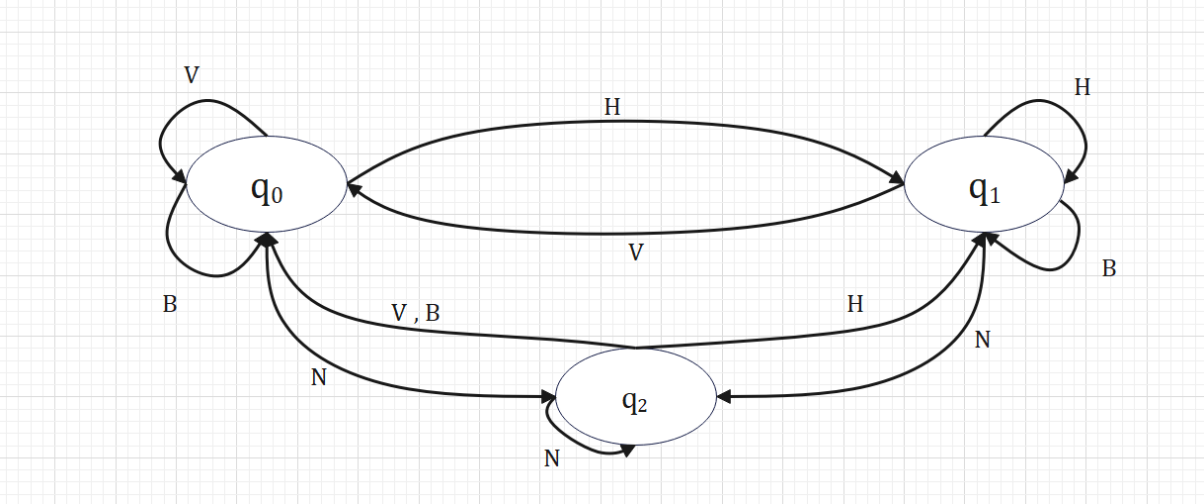
Working:

1. If traffic is detected in the same lane in which the signal was previously dealing, then the system will remain in the same state
   Eg: The L1(dealing with the vertical lane) signal was green and input symbol is V(Traffic is detected in the vertical lane) then the traffic system will remain in the same state(dealing with traffic L1)
2. If traffic is detected on the opposite road to which the signal was previously dealing, then the system will make a transition to the state dealing with that opposing road.
   Eg: If the L1(dealing with the vertical lane) signal was green and input symbol is H(Traffic is detected in the horizontal lane) then the traffic system will make a transition to the state making L2(dealing with horizontal traffic) green.
3. If traffic is detected in both the lanes then the system will remain in the same state to clear the traffic in that particular lane first so that traffic can be eliminated in at least one direction.
   Eg: The L1(dealing with the vertical lane) signal was green and input symbol is B(Traffic is detected in both lanes) then the traffic system will remain in the same state(dealing with traffic L1) to clear the remaining traffic as there is a greater probability that traffic in present lane is less as compared to the opposite lane.
4. If traffic is detected in none of the directions then the transition will be to the final state where none of the signals are green to ensure safety and avoid accidents for that particular time-lapse for which the state remains the same. From this state we can move to q_0 if input symbol is V or B(according to priority) and q_1 if input symbol is H again.

State Transition Table

States Vs Input Symbols	V	H	B	N
→ q_0	q_0	q_1	q_0	q_2
q_1	q_0	q_1	q_1	q_2
q_2 *	q_0	q_1	q_0	q_2

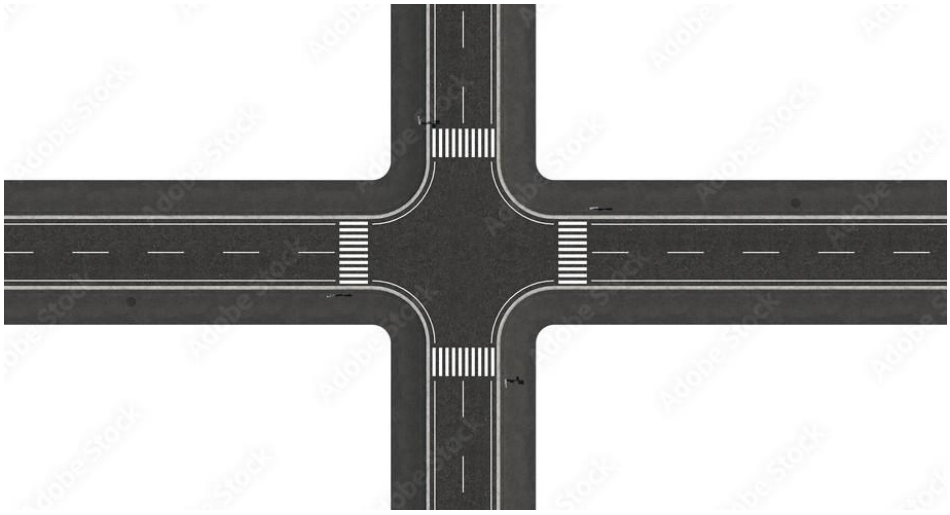
State transition diagram:



Two Way Road Intersection

Configuration of the road :

- Road directed from North to south direction
- Road directed from West to East direction
- Road directed from South to North Direction
- Road directed from East to West direction



Traffic signal system:
For the intersection of a Two-way road intersection, there will be 4 traffic signals

- L1-Handles the signal for the vertical road(N-S direction)
- L2-Handles the signal for the horizontal road (W-E direction)
- L3-Handles the signal for the vertical road (S-N direction)
- L4-Handles the signal for the horizontal road (E-W direction)

If L1 is green then traffic from the North will be allowed to move
If L2 is green then traffic from the West will be allowed to move
If L3 is green then traffic from the South will be allowed to move
If L4 is green then traffic from the East will be allowed to move

Rules:

1. If one signal is green then the other signals have to be red
2. All 4 signals can be red at the same time
3. Priority of signals is L1-L2-L3-L4
4. For a given period or lapse the state will not change.
5. While the given state is dealing with the traffic the input sensors are deliberating the next input symbol(traffic conditions)

Designing the DFA:

Finite Set of States (Q):
q_0 : L1 is green and rest all three are red
q_1 : L2 is green and rest all three are red
q_2 : L3 is green and rest all three are red
q_3 : L4 is green and rest all three are red
q_4 : All signals are red.

Input Symbols:

V: Traffic is detected in at least one vertical lane (North, South, North-South)

H: Traffic is detected in at least one horizontal lane (East, West, East-West)

B: Traffic is detected in at least one vertical and horizontal lane(North-East, East-South, North-East-South, North-East-West-South, etc.)

N: Traffic is detected in none of the direction

Working:

1. If traffic is detected on the same road in which the signal was previously dealing with, then the system will make a transition to the state that deals with the traffic on the same road but in the opposite direction.

   Eg: The L1(dealing with the N-S direction) signal was green and input symbol is V(Traffic is detected in any one of the vertical lanes) then the traffic system will make a transition to the state which deals with the traffic in the same direction(vertical direction) but in opposite direction(S-N) ie L3.
2. If traffic is detected on the opposite road to which the signal was previously dealing with, then the system will make a transition to the state dealing with that opposing road with higher priority.

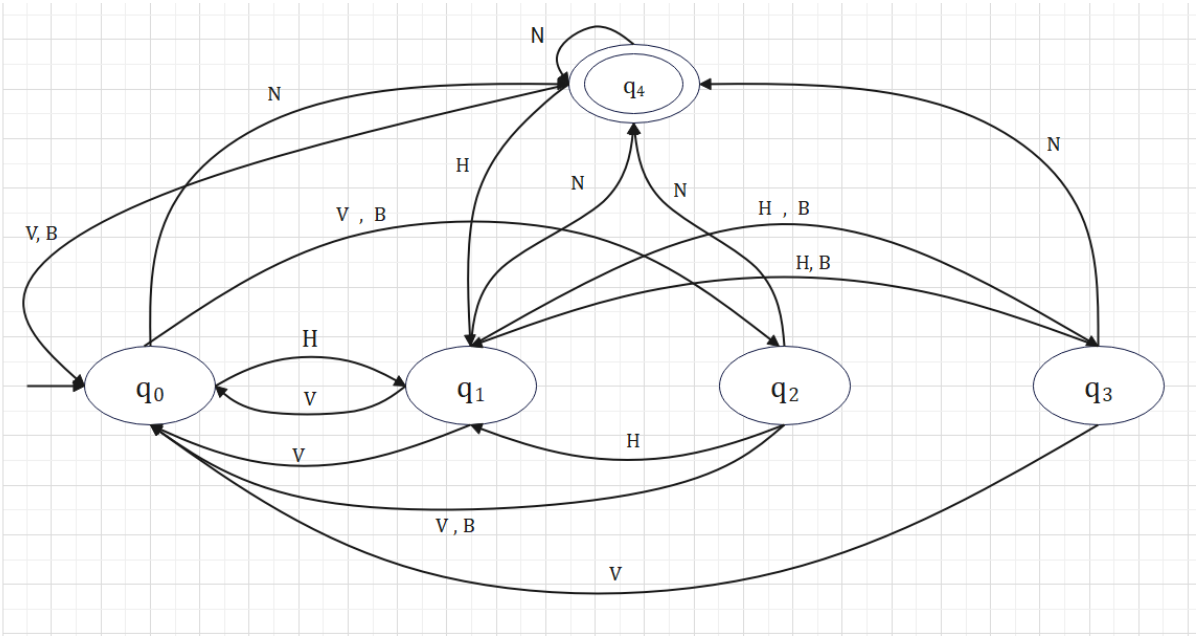
   Eg: The L1(dealing with the N-S direction) signal was green and the input symbol was H(Traffic is detected in any one of the horizontal lanes) then the traffic system makes a transition to the state dealing with that horizontal road with higher priority making L2(dealing with horizontal traffic in W-E direction) green as it is having higher priority.
3. If traffic is detected on both the roads then the system will make a transition to the state which deals with the traffic on the same road but in opposite direction because there is the need to clear the traffic in any one of the roads and it is the responsibility of the current state to give a chance to the opposite state to complete its traffic.

   Eg: The L1(dealing with the N-S direction) signal was green and input symbol is B(Traffic is detected in at least one vertical and horizontal direction) then the traffic system will make a transition to the state which deals with the traffic on the same road but in opposite direction L3(Dealing with S-N direction)
4. If traffic is detected in none of the directions then the transition will be to the final state where none of the signals are green to ensure safety and avoid accidents for that particular time-lapse for which the state remains the same. From this state we can move to q_0 if input symbol is V or B(according to priority) and q_1 if input symbol is H again.

State Transition Table

States Vs Input Symbols	V	H	B	N
→ q_0	q_2	q_1	q_2	q_4
q_1	q_0	q_3	q_3	q_4
q_2	q_0	q_1	q_0	q_4
q_3	q_0	q_1	q_1	q_4
q_{4*}	q_0	q_1	q_0	q_4

State transition diagram:



Example:

The initial state is q0 (L1 is green and the rest all are red)

Current Traffic Direction	**NE**	**W**	**S**	**NS**	**N_0**	**N_0**
Input symbol (current +previous traffic)	**B**	**H**	**B**	**V**	**V**	**N**
State Chosen	**q_2**	**q1**	**q3**	**q0**	**q2**	**q4**
Remaining Traffic direction	**E**	**W**	**S**	**N**	**N_0**	**N_0**

Advantages and disadvantages:

Advantages:

- Intelligent Management: The system effectively manages the flow of traffic by controlling traffic signals based on detected conditions, reducing congestion, and improving traffic efficiency according to traffic in the given direction.
- Simple to design: The system works on a finite state machine that simply makes the transition from one state to another state making it simple for programming.
- No Human Intervention: The system is automated and no human interference is required to make decisions.
- Safety: The system ensures safety if followed properly.

Disadvantages:

- Complexity: While the rules and state transitions are well-defined, implementing and maintaining the DFA for more complex road networks can become increasingly complex and error-prone.
- Sensor Reliability: The system depends on the reliability of traffic sensors for accurate detection. Sensor malfunctions or inaccuracies can lead to incorrect decisions.
- No Consideration of Advanced Features: The system may not consider advanced features like pedestrian crossings, emergency vehicle prioritization, or dynamic signal adjustments based on traffic volume.
- Looping: The system might stuck in a loop if traffic in any one of the directions doesn't end