# PREMIER UNIVERSITY CHATTOGRAM

DEPARTMENT OF **COMPUTER SCIENCE AND ENGINEERING**

# ASSIGNMENT

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|---|---|
| *COURSE NAME* | Artificial Intelligence |
| *COURSE CODE* | CSE 3317 |
| *ASSIGNMENT TOPIC* | **AI-Controlled Smart Traffic Management System** |
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**SUBMITTED TO**

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| **REMARKS** | **SUBMITTED BY** | |
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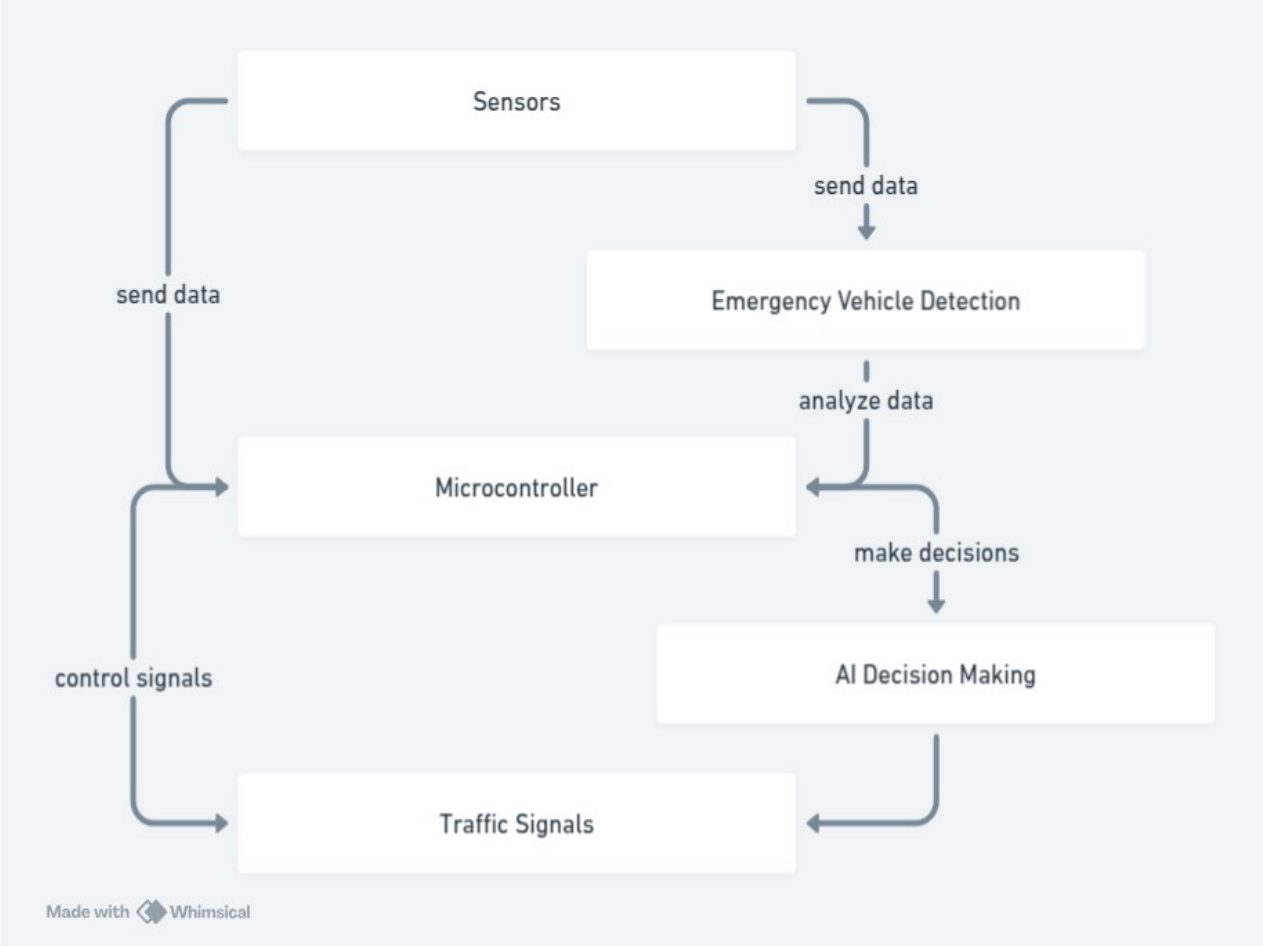
| | **SECTION** | A |

# 1. Introduction

In modern urban environments, traffic management is a critical challenge due to increasing vehicle density, road incidents, and the need for efficient emergency response systems. The city of Metropolis has implemented an AI-based traffic management system to regulate traffic flow, reroute vehicles during disruptions, and ensure emergency responders reach their destinations without delay. However, unforeseen disruptions such as road closures, malfunctioning traffic signals, and congestion have posed significant challenges. This assignment explores how the AI system should respond to such disruptions using First-Order Logic (FOL) to model the problem and derive solutions.

**Traffic Control System Overview Diagram:**



## 2. Problem Scenario

The city of Metropolis is facing the following traffic incident:

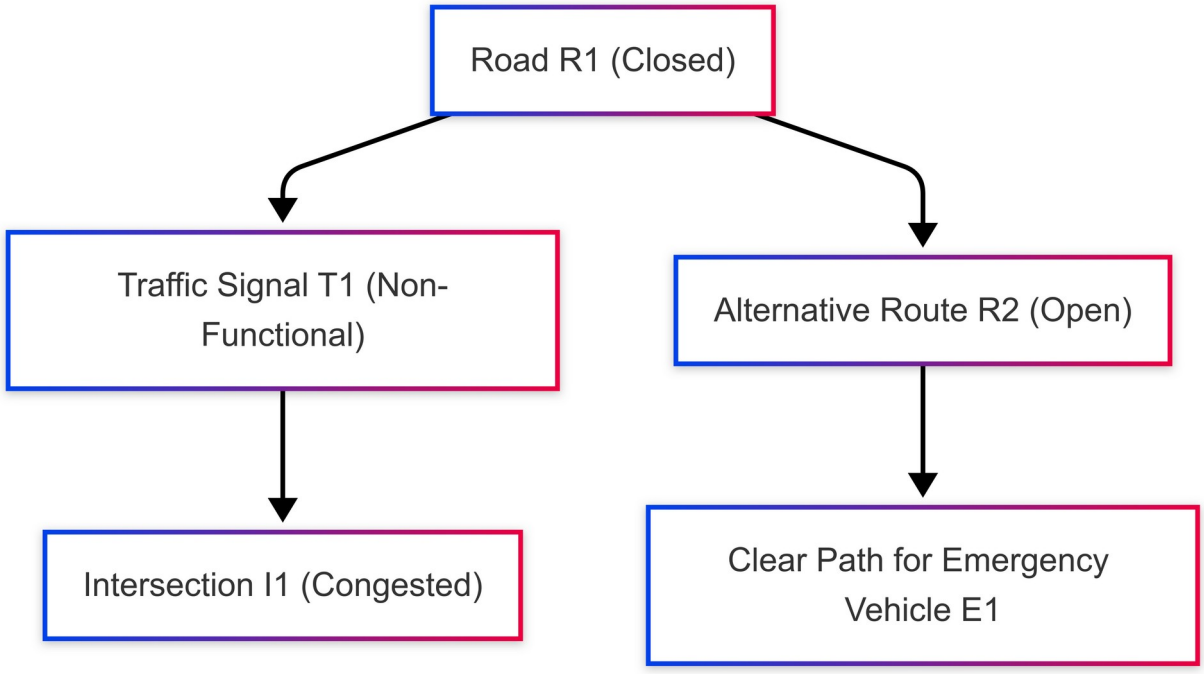
•Road R1 is unexpectedly closed due to an incident.
•Traffic Signal T1, which controls Road R1, is affected, leading to issues at Intersection I1.
•Increased congestion is reported around Intersection I1.
•Emergency Vehicle E1 is trying to reach the downtown hospital via Intersection I1.

The AI system must:

1.Determine the status of Traffic Signal T1.
2.Assess congestion at Intersection I1.
3.Ensure Emergency Vehicle E1 reaches the hospital on time.
4.Decide whether to reroute vehicles or activate manual traffic control.
5.Evaluate the impact of alternative routes on the overall outcome.

**Traffic Flow Diagram:**

Below is a diagram illustrating the traffic flow and rerouting process:

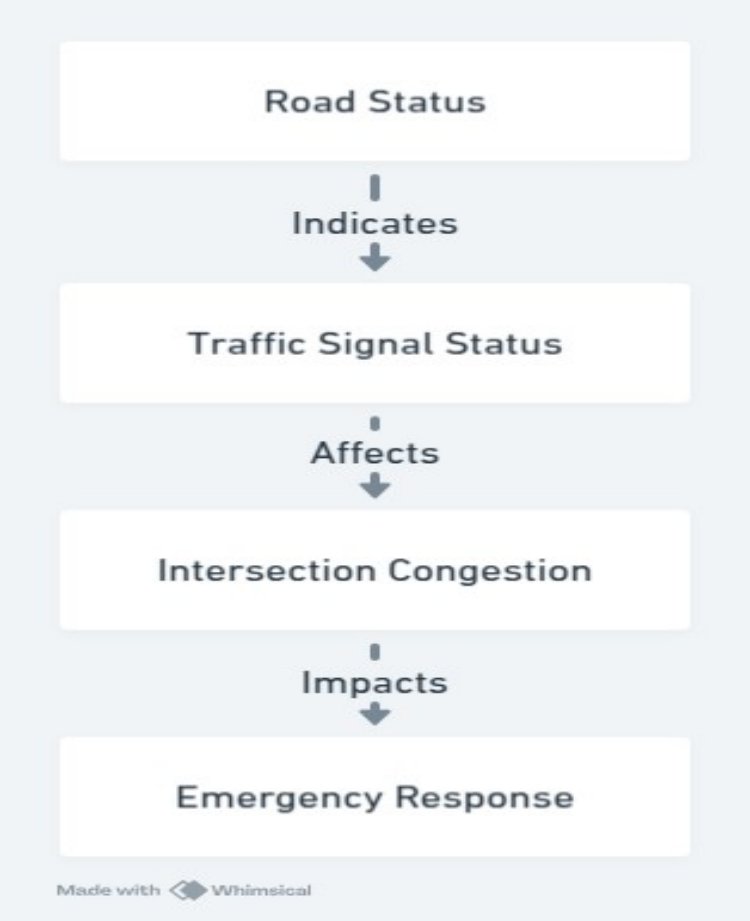


# 3. Background

The AI system operates based on the following Traffic Management Rules:

1.Traffic signals operate correctly only if the controlled road is open.
2.If a road is closed, vehicles must be rerouted when an alternative exists.
3.A non-functional traffic signal causes its controlled intersection to become congested.
4.Roads connected to a congested intersection also experience congestion.
5.Emergency vehicles must have an unobstructed route.
6.If no alternative route exists, manual traffic control must be activated at the intersection.

**Traffic Signal Dependency Flow Diagram:**



# 4. Logical Analysis Using First-Order Logic (FOL)

## 4.1 Defining Predicates

To model the problem, we define the following predicates:

- **Roads and Intersections:**
  - Open(R): Road R is open.
  - Closed(R): Road R is closed.
  - Congested(I): Intersection I is congested.
  - Affected(T, R): Traffic signal T controls road R.
  - Connected(R, I): Road R is connected to intersection I.
- **Traffic Signals:**
  - Functional(T): Traffic signal T is functional.
  - NonFunctional(T): Traffic signal T is non-functional.
- **Emergency Vehicles:**
  - ClearPath(E, R): Emergency vehicle E has a clear path on road R.
  - ReachesDestination(E): Emergency vehicle E reaches its destination.
- **Rerouting:**
  - AlternativeRoute(R1, R2): Road R2 is an alternative route for road R1.
  - Reroute(R1, R2): Vehicles are rerouted from road R1 to road R2.
  - ManualControl(I): Manual traffic control is activated at intersection I.

## 4.2 Traffic Management Rules in FOL

The traffic management rules are formalized as follows:

1. **Traffic Signal Functionality:**

- If a road is closed, its traffic signal becomes non-functional:

$$\forall T,R(Affected(T,R) \land Closed(R)) \rightarrow NonFunctional(T)$$

- If a road is open, its traffic signal is functional:

$$\forall T,R(Affected(T,R) \land Open(R)) \rightarrow Functional(T)$$

2. **Rerouting Vehicles:**

- If a road is closed and an alternative route exists, vehicles must be rerouted:

$$\forall R1,R2(Closed(R1) \land AlternativeRoute(R1,R2)) \rightarrow Reroute(R1,R2)$$

3. **Congestion at Intersections:**

- If a traffic signal is non-functional, its controlled intersection becomes congested:

$$\forall T,I,R(Affected(T,R) \land NonFunctional(T) \land Connected(R,I)) \rightarrow Congested(I)$$

- If an intersection is congested, all connected roads also experience congestion:

$$\forall I,R(Congested(I) \land Connected(R,I)) \rightarrow Congested®$$

4.**Emergency Vehicles:**

•Emergency vehicles must have a clear path:

$$\forall E,R(ClearPath(E,R)\land Open(R))\rightarrow ReachesDestination(E)$$

5.**Manual Traffic Control:**

•If no alternative route exists, manual traffic control must be activated:

$$\forall R1(Closed(R1)\land\neg\exists R2 AlternativeRoute(R1,R2))\rightarrow ManualControl(I)$$

## 4.3 Incident Conditions in FOL

The incident conditions are formalized as follows:

•Road R1 is closed:

$$Closed(R1)$$

•

•Traffic signal T1 controls road R1:

$$Affected(T1,R1)$$

•Emergency vehicle E1 requires a clear path to the hospital:

$$ClearPath(E1,R1)$$

•An alternative route R2 exists:

$$AlternativeRoute(R1,R2)$$

# 5. Step-by-Step Explanation of AI's Decision-Making Process

## Step 1: Analyze Road Closure

•Road R1 is closed:

$$Closed(R1)$$

•Traffic signal T1 controls R1:

$$Affected(T1, R1)$$

•From Rule 1, since R1 is closed, T1 becomes non-functional:

$$NonFunctional(T1)$$

## Step 2: Determine Congestion at Intersection I1

•Traffic signal T1 is non-functional:

$$NonFunctional(T1)$$

•From Rule 3, since T1 is non-functional, intersection I1 becomes congested:

$$Congested(I1)$$

•From Rule 4, all roads connected to I1 also experience congestion:

$$\forall R(Connected(R, I1) \rightarrow Congested(R))$$

## Step 3: Reroute Vehicles

•An alternative route R2 exists:

$$AlternativeRoute(R1, R2)$$

•From Rule 2, vehicles must be rerouted from R1 to R2:

$$Reroute(R1, R2)$$

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## Step 4: Ensure Emergency Vehicle Path

•Emergency vehicle E1 requires a clear path:

$$ClearPath(E1, R1)$$

•Since R1 is closed, E1 must use the alternative route R2:

$$ClearPath(E1, R2)$$

•If R2 is open and not congested, E1 can reach its destination:

$$Open(R2) \land \neg Congested(R2) \rightarrow ReachesDestination(E1)$$

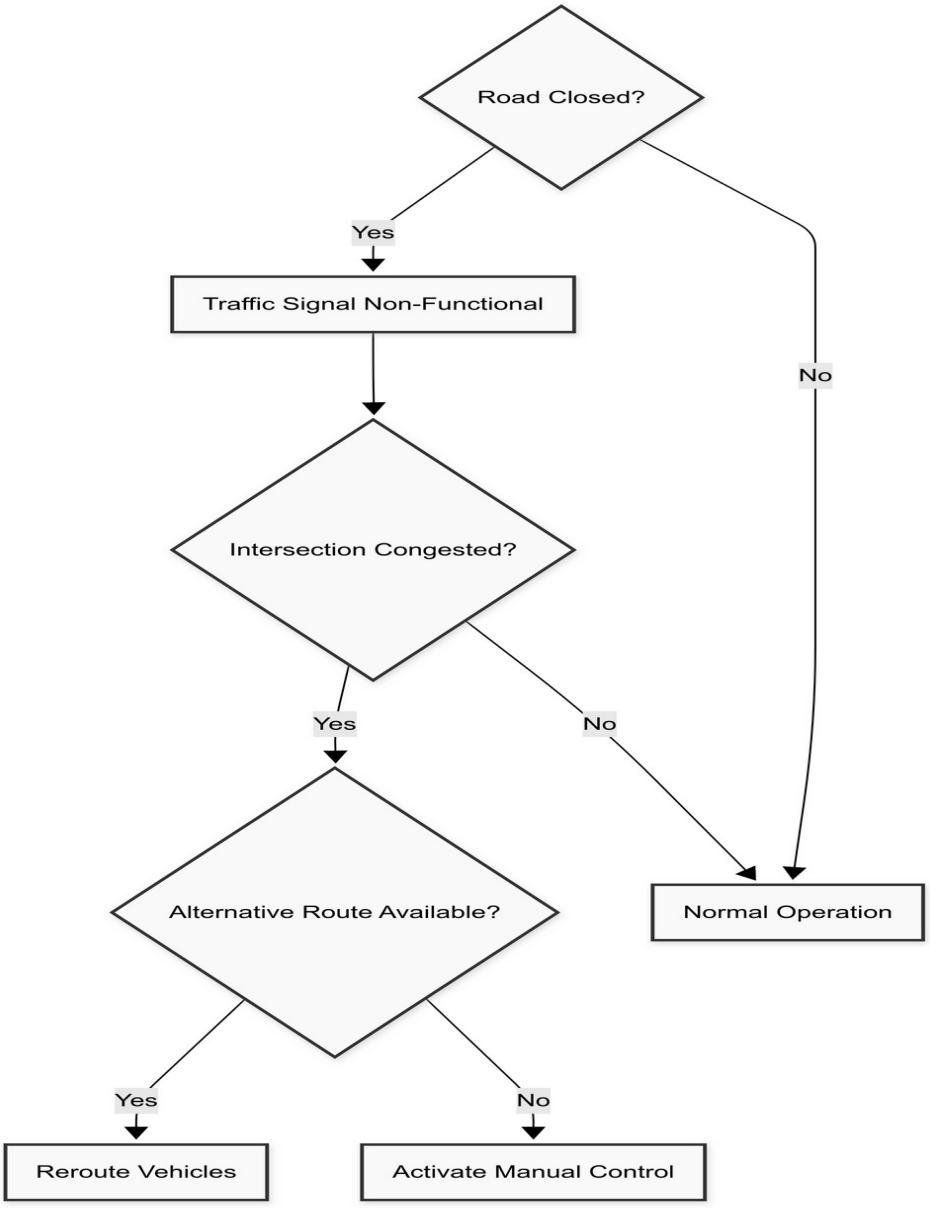
## Step 5: Check for Manual Control

•Since an alternative route R2 exists, manual traffic control is not required:

$$\neg ManualControl(I1)$$

## Decision-Making Flowchart:

The AI’s decision-making process can be visualized as follows:



# 6. Investigation and Analysis

The AI-controlled traffic management system is evaluated based on its ability to handle disruptions, optimize traffic flow, and ensure timely emergency response. Below is a detailed analysis of the system's performance and optimization strategies:

## i. Traffic Signal Functionality

•**Evaluation:** Traffic signal T1 will fail because road R1 is closed.

•**Justification**: From Rule 1, if a road is closed, its traffic signal becomes non-functional.

•**Optimization Strategy**:

- •Implement real-time monitoring of road conditions to detect closures instantly.
- •Automatically deactivate traffic signals on closed roads to prevent confusion and ensure safety.

## ii. Congestion at Intersection I1

•**Evaluation:** Intersection I1 will become congested due to the non-functional traffic signal T1.

•**Justification:** From Rule 3, a non-functional traffic signal causes its controlled intersection to become congested.

•**Optimization Strategy:**

- •Use predictive analytics to anticipate congestion and proactively reroute traffic.
- •Deploy dynamic traffic signal adjustments at nearby intersections to alleviate congestion.

### iii. Emergency Vehicle Response

•**Evaluation:** Emergency vehicle E1 can reach the hospital in time using the alternative route R2.

•**Justification:** E1 can use the alternative route R2, which is open and not congested.

•**Optimization Strategy:**

- •Prioritize emergency vehicles by creating dedicated lanes or granting them signal preemption.
- •Continuously update the AI system with real-time traffic data to ensure the fastest route is always selected.

### iv. Vehicle Rerouting Efficiency

•**Evaluation:** Vehicles will be effectively rerouted to R2, and manual traffic control is not required.

•**Justification:** Since an alternative route R2 exists, rerouting is possible, and manual control is unnecessary.

•**Optimization Strategy**:

- •Enhance the AI system's rerouting algorithms to consider multiple factors such as distance, traffic density, and road conditions.
- •Provide real-time rerouting suggestions to drivers via mobile apps or in-vehicle navigation systems.

### v. Impact of Alternative Routes

•**Evaluation:** The presence of an alternative route (R2) ensures that vehicles can be rerouted, congestion is minimized, and emergency vehicles can reach their destinations. Without an alternative route, manual traffic control would be required, leading to delays and potential failure to meet emergency response times.

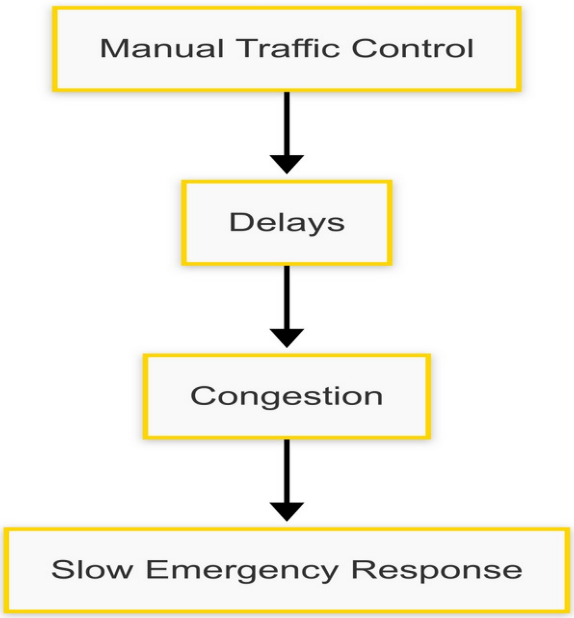
•**Justification**: Alternative routes provide flexibility and redundancy in the traffic network, enabling the system to handle disruptions effectively.

•**Optimization Strategy:**

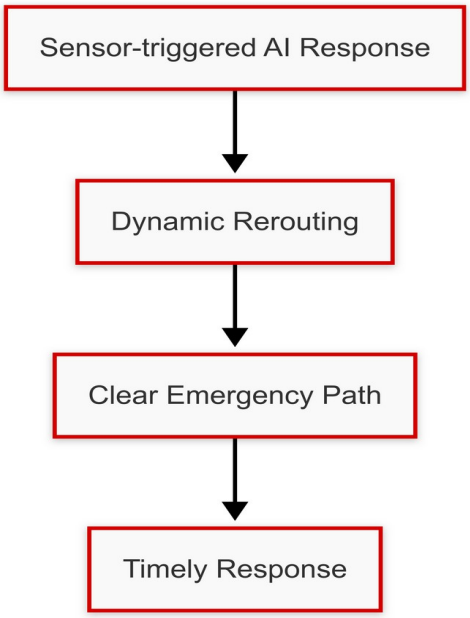
- •Identify and maintain multiple alternative routes for critical roads to ensure resilience.
- •Use machine learning to predict the impact of road closures and optimize alternative route selection dynamically.

**Before vs. After ATMS Implementation Diagram:**

**Before-**




**After-**



# 7.Conclusion

The AI-controlled traffic management system demonstrates strong capabilities in handling disruptions, optimizing traffic flow, and ensuring timely emergency response. By leveraging **First-Order Logic (FOL)** and advanced optimization strategies, the system can effectively manage complex traffic scenarios in Metropolis. Continuous evaluation and improvement of the system will ensure its resilience and efficiency in the face of future challenges.