Chandigarh University

Bachelor of Computer Application

Computing Aptitude- 23CAP-308

Mini Project

Submitted by:

Gorang Lamba

23BCA10245

Professor

23BCA-6'A'

Submitted to:

Mr.Arvinder Singh

Assistant

SMART TRAFFIC LIGHT CONTROL SYSTEM (C++)

Abstract

Traffic congestion is one of the most persistent and challenging problems in modern cities. As the number of vehicles increases every year, traditional fixed-time traffic lights are no longer efficient in managing the growing flow of vehicles. Long waiting times at red signals lead to driver frustration, fuel wastage, and environmental pollution.

This project, **Smart Traffic Light Control System**, aims to simulate an adaptive, intelligent traffic signal system using the C++ programming language. The system dynamically adjusts the green light duration based on the real-time density of traffic detected on two intersecting roads. The concept is inspired by modern smart city initiatives where real-time data from sensors and IoT devices are used to make efficient traffic management decisions.

The program takes input values (0–10) for two roads, representing traffic density, and then allocates green signal durations accordingly. If one road has higher traffic density, it is given a longer green signal time to ensure smoother traffic flow. The project uses C++ features such as loops, conditional statements, and functions, along with chrono and thread libraries to simulate time delays realistically.

This project not only demonstrates practical application of programming logic but also showcases how computational systems can mimic real-world solutions in smart transportation. It represents a foundational step toward understanding adaptive signal control and its benefits in reducing congestion, travel time, and fuel consumption.

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1. Introduction

1.1 Background

Traffic congestion has become a global concern, especially in rapidly developing urban areas. The increasing number of vehicles and limited road space have created severe traffic jams, particularly during rush hours. Traditional traffic control systems, which rely on fixed time intervals for green and red signals, often fail to respond to dynamic changes in traffic conditions.

As a result, one direction may remain empty while vehicles on the other road pile up unnecessarily. This inefficiency results in time loss, fuel wastage, and higher emissions. To overcome this problem, smart and adaptive systems are being developed and implemented in major cities like Singapore, London, and

New York. These systems can sense traffic in real-time and automatically adjust signal durations to maintain a balanced flow.

The Smart Traffic Light Control System developed in this project is a simplified simulation of such intelligent systems. By using user-provided inputs that represent vehicle density, the system decides which road should get a longer green light duration.

1.2 Motivation

The motivation behind this project is to create a realistic simulation that can help students and developers understand how adaptive traffic systems work. By implementing the project in C++, we can demonstrate how simple programming logic and mathematical reasoning can be applied to solve real-world urban problems.

Efficient traffic management is not just about saving time—it also contributes to energy conservation, reduction in air pollution, and overall improvement in the quality of life.

This project serves as a foundation for understanding how future technologies like artificial intelligence and IoT can be integrated into traffic systems to make cities smarter and more sustainable.

1.3 Problem Statement

Conventional traffic signal systems operate on fixed cycles, regardless of actual traffic flow. For instance, a green light might stay on for 30 seconds even if only a few cars are waiting, while the other road remains congested.

This leads to:

- Unbalanced traffic flow
- Long waiting times
- Unnecessary fuel consumption
- Increased carbon emissions

The problem can be addressed by using adaptive control logic that assigns green light durations based on real-time traffic density.

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2. Objectives and Scope

The main objectives of this project are:

1. To design and simulate a C++ program that adjusts signal timing based on real-time traffic conditions.
2. To understand the concept of adaptive signal control and implement it using basic programming constructs.
3. To simulate real-world delays using time-based libraries (chrono and thread).
4. To ensure fairness by giving a minimum green time to each road.
5. To develop modular, reusable code that can be extended in the future.

2.2 Scope of the Project

This project focuses on two intersecting roads, referred to as Road A and Road B. Traffic density is manually entered by the user as an integer value between 0 and 10. Based on these inputs, the system automatically decides which road should receive more green signal time.

While the project currently simulates a simple two-road intersection, it can easily be extended to multiple roads, sensor-based inputs, or even a network of coordinated signals in a city.

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3. Literature Review

3.1 Traditional Traffic Systems

Traditional traffic lights operate on fixed timers, usually pre-programmed based on historical data. While simple, they do not respond to real-time traffic changes. In many cities, these systems cause unnecessary waiting times and contribute to inefficiency.

3.2 Adaptive Traffic Systems

Adaptive systems dynamically adjust signal timing. For instance:

- **SCOOT (Split Cycle Offset Optimization Technique)** in the UK uses sensors to detect vehicles and continuously optimize signal timings.
- **SCATS (Sydney Coordinated Adaptive Traffic System)** in Australia coordinates multiple intersections in real-time.

These systems have shown significant improvements in reducing congestion and travel time.

3.3 Smart City Integration

In smart cities, traffic systems are integrated with data analytics and IoT. Sensors installed on roads send real-time data to central systems that make instant decisions. This creates smoother traffic flow and reduces environmental impact.

4. System Design and Working Principle

4.1 Working Concept

The Smart Traffic Light Control System uses adaptive logic to manage two roads based on input densities. The system follows these steps:

1. Accept user input for traffic density (0–10) on both roads.
2. Compare both values.
3. Assign green light durations based on density differences.
4. Simulate signal timing using real-time delays.
5. Switch signals cyclically.

4.2 Flow of Execution

1. System initializes and requests input.
2. Control logic compares density values.
3. Proportionate green signal times are allocated.
4. Real-time simulation occurs using sleep_for() delays.
5. Cycle repeats until terminated.

4.3 Design Logic

If traffic density of Road A is greater than Road B, Road A receives a longer green signal and vice versa. Minimum green time for both roads is maintained at 5 seconds.

6.Implementation

5.1 Tools Used

- **Language:** C++
- **Libraries:** iostream, chrono, thread
- **IDE:** Code::Blocks / Dev-C++ / Visual Studio

5.2 Source Code

(See previous code block — you can keep it same.)

5.3 Code Explanation

- The function controlTrafficLight() handles the decision-making and timing simulation.
- Conditional statements compare densities and assign times.
- Real-time behavior is simulated using sleep_for() to represent light durations.

- The program runs continuously in a loop until the user exits.

Code -:

```
#include <iostream>

#include <thread>

#include <chrono>

using namespace std;


void controlTrafficLight(int trafficDensityA, int trafficDensityB) {

    int baseTime = 10;

    int greenTimeA, greenTimeB;


    if (trafficDensityA > trafficDensityB) {

        greenTimeA = baseTime + (trafficDensityA - trafficDensityB);

        greenTimeB = baseTime - (trafficDensityA - trafficDensityB) / 2;
```

```
    } else if (trafficDensityB > trafficDensityA) {
        greenTimeB = baseTime + (trafficDensityB - trafficDensityA);
        greenTimeA = baseTime - (trafficDensityB - trafficDensityA) / 2;
    } else {
        greenTimeA = greenTimeB = baseTime;
    }

    if (greenTimeA < 5) greenTimeA = 5;
    if (greenTimeB < 5) greenTimeB = 5;

    cout << "\nSmart Traffic Light Control System Simulation\n\n";
    cout << "Traffic Light A (North-South) GREEN for " << greenTimeA << " seconds.\n";
    this_thread::sleep_for(chrono::seconds(2));
    cout << "Traffic Light A turns RED.\n";
    cout << "Traffic Light B (East-West) turns GREEN for " << greenTimeB << " seconds.\n";
```

```
    this_thread::sleep_for(chrono::seconds(2));
    cout << "Traffic Light B turns RED.\n\n";
    cout << "Cycle completed. Adjusting for next round based on new data...\n";
}

int main() {
    int trafficA, trafficB;
    char choice;

    cout << "===== SMART TRAFFIC LIGHT CONTROL SYSTEM =====\n";
    do {
        cout << "\nEnter traffic density for Road A (0–10): ";
        cin >> trafficA;
        cout << "Enter traffic density for Road B (0–10): ";
        cin >> trafficB;
```

```
        controlTrafficLight(trafficA, trafficB);

        cout << "\nRun another cycle? (y/n): ";
        cin >> choice;
    } while (choice == 'y' || choice == 'Y');

    cout << "\nSystem shutting down. Goodbye!\n";
    return 0;
}
```

<u>Code Inputs</u> –

✅ Example Inputs:

Example	Road A	Road B	Meaning
1	8	3	Road A is much busier, so it gets longer green time
2	2	7	Road B is busier, so it gets longer green time
3	5	5	Equal traffic → both get equal green time
4	9	1	Heavy traffic on A, so A's green time increases a lot

```
===== SMART TRAFFIC LIGHT CONTROL SYSTEM =====

Enter traffic density for Road A (0-10): 8
Enter traffic density for Road B (0-10): 8

Smart Traffic Light Control System Simulation

Traffic Light A (North-South) GREEN for 10 seconds.
Traffic Light A turns RED.
Traffic Light B (East-West) turns GREEN for 10 seconds.
Traffic Light B turns RED.

Cycle completed. Adjusting for next round based on new data...

Run another cycle? (y/n): y

Enter traffic density for Road A (0-10): 5
Enter traffic density for Road B (0-10): 10

Smart Traffic Light Control System Simulation

Traffic Light A (North-South) GREEN for 8 seconds.
Traffic Light A turns RED.
Traffic Light B (East-West) turns GREEN for 15 seconds.
Traffic Light B turns RED.

Cycle completed. Adjusting for next round based on new data...

Run another cycle? (y/n):
```

7.Testing and Results

6.1 Test Case 1

Input: Road A = 8, Road B = 3
Result: Road A gets a longer green time.

6.2 Test Case 2

Input: Road A = 4, Road B = 9
Result: Road B gets longer green time.

6.3 Test Case 3

Input: Road A = 6, Road B = 6
Result: Equal green time for both.

These results confirm that the system behaves correctly and adaptively.

7. Advantages

1. **Reduced waiting time** on busy roads.
2. **Improved fuel efficiency** by reducing idling time.
3. **Environmentally friendly** — reduces air pollution.
4. **Cost-effective simulation** — requires no hardware.
5. **Easy scalability** — can integrate sensors or AI in future.

8. Comparison: Fixed vs Adaptive Systems

Feature	Fixed Time System	Adaptive System
Signal Timing	Predefined	Dynamic based on traffic
Efficiency	Moderate	High
Implementation Cost	Low	Medium to High
Real-time Adjustment	No	Yes

Feature	Fixed Time System	Adaptive System
Fuel Efficiency	Poor	Improved
Scalability	Limited	High

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9. Sustainability and Environmental Benefits

Adaptive systems help reduce idle engine time, lowering fuel usage and emissions. Even small time savings can significantly impact air quality and energy efficiency in cities.

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10. Economic and Social Impact

1. Reduces travel time for commuters.
2. Improves logistics efficiency for businesses.
3. Enhances urban mobility and safety.
4. Encourages eco-friendly city planning.

11. Limitations

- Currently handles only two roads.
- Manual input instead of real sensors.
- Basic time simulation instead of full real-time accuracy.

12. Future Scope

1. **IoT Integration:** Real sensor data from infrared or cameras.
2. **AI and Machine Learning:** Predict traffic flow and adjust automatically.
3. **Emergency Vehicle Priority:** Automatically grant green to ambulances.
4. **Cloud-based Monitoring:** Real-time dashboards for city planners.
5. **Multi-intersection Coordination:** City-wide adaptive traffic network.

13. Ethical Considerations

Data from cameras and sensors must be handled responsibly to protect citizens' privacy. Smart systems should follow ethical guidelines to ensure transparency and safety.

14. Conclusion

The Smart Traffic Light Control System is a simple yet effective demonstration of adaptive signal management. It reflects how technology can be used to solve real-world urban problems efficiently. Using basic programming logic, this project simulates how real-time data can optimize traffic movement, save fuel, and reduce congestion.

In future implementations, the project can evolve into a complete IoT-enabled system integrated with AI for predictive control. It stands as a foundation for understanding the link between computer programming and smart city innovation.

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