TransitFlow: Traffic Light Controller

Software Requirements Specification (SRS)

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In Dedication to Froggy Froggerton

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1 Introduction

There are several software requirements that will need to be implemented to create a functional simulation of the traffic light control system, TransitFlow. The purpose of this document is to serve as an overview of each of these requirements so that we can create a comprehensive software package.

First, this document will provide a brief general description of the TransitFlow. Next, section 3.1 of this document, will give an overview of how our Light Controller System will handle inputs and outputs. Inputs will include various sensors that are able to detect cars, busses, and pedestrians. While outputs will be dynamically adjusted to control the flow of traffic while prioritizing pedestrian safety.

Section 3.2 will continue to specifically detail how each component will function along with its control logic. Included logic diagrams for each pedestrian, bus, and traffic light controllers detail how they will process inputs and outputs.

Design constraints will detail the physical and digital obstacles that will needed to be accounted for when creating the TransitFlow Controller.

Lastly, the final section is dedicated to the definition of terms that will be used throughout the document.

2 General Description

The TransitFlow software operates within the confines of the physical integration of public roadways, traffic signals, pedestrian crossings, and paths. Integration occurs through electronically powered and designed signals so the software communicates signals effectively with the public and maintains proper systems of organized traffic protocols. This system accommodates dynamic and complex traffic scenarios, promoting sustainability by reducing congestion and securing safety through seamless integration.

2.1 Physical Integration

- Overhead traffic lights communicate with vehicles at intersections. Intersections' traffic lights display left turn (left green arrow), right turn (right green arrow), go (green), slow down (yellow), and stop (red).
- Pedestrian crossing signals allow for the public walking on sidewalks and pathways to cross roads at the intersections. A signal (green) displays when to cross and for how long, and a signal to wait (red).
- Bus lane signals operate in separate parallel lanes to main roadways, but in conjunction with pedestrian crossing signals.

2.2 Systems Overview

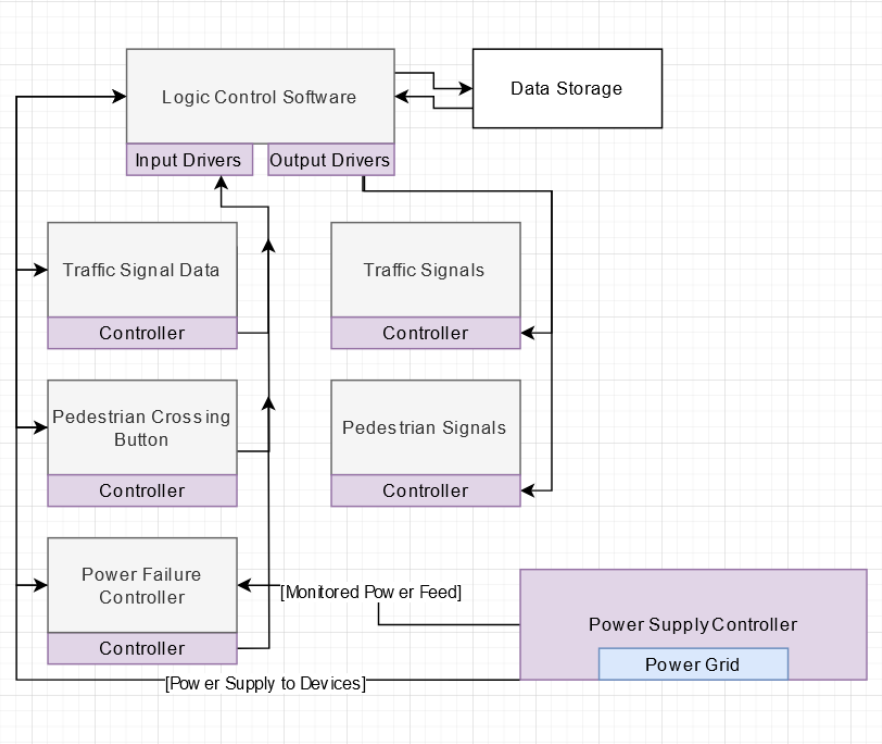

Figure 1: Overview of device controllers and power

Device drivers will provide the strategies to interact with TransitFlow through pedestrian buttons and sensors for bus lanes and traffic lights. These devices convert actor and sensor input of transportation paths into data packets usable by the TransitFlow Controller for traffic control procedures.

The input controllers facilitate communication of sensors and buttons with the TransitFlow Controller. The signals from these inputs assist in the decision making of the TransitFlow Controller, providing output data which directs the various subsystems within the traffic network. The outputs requiring controllers will communicate the expected behavior for users to follow. Data from user interaction is stored dynamically with the TransitFlow Controller, providing an adaptive framework to meet user needs while guaranteeing safety.

3 Specific Requirements

3.1 External Interfaces

As traffic and pedestrians begin to flow a series of inputs will be used to trigger events. These triggers will be used to change the state of the Traffic Light Controller. Allowing for more efficient light changes according to the traffic and pedestrian flow. This will reflect to the output devices to indicate a change has been made to affect traffic light instructions.

3.1.1 Light Controller Inputs

Car Detection Sensor An Electromagnetic Communication System will be used to interact with the Traffic Light Controller. The electromagnetic road sensors will respond to the vehicle's ferrous metal when the vehicle is directly over the sensor. When this happens the frequency of the wire will be increased, indicating a car is present. The system will be used in the left turn lanes to indicate to the Light Controller that a car is waiting. The Light Controller System will respond accordingly by starting a timer so that the traffic light will change.

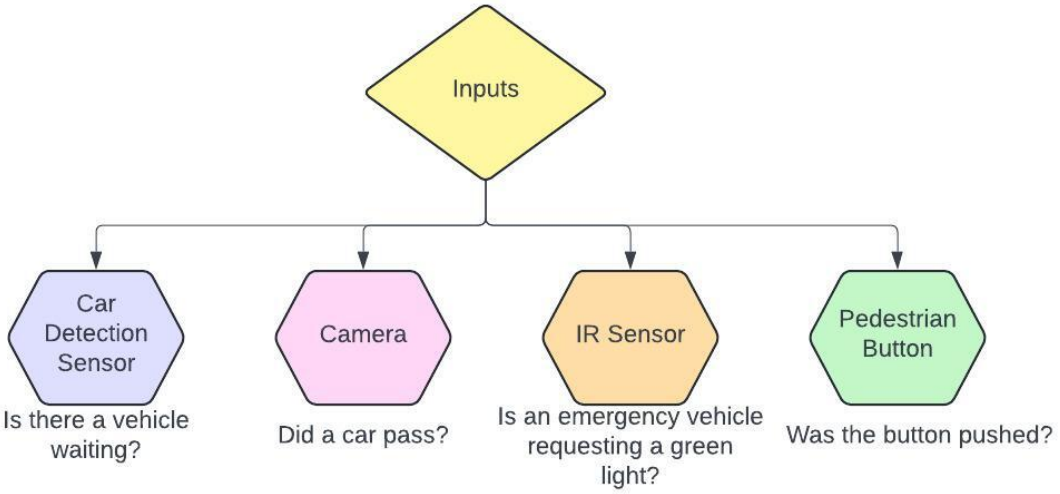

Figure 2: Light Controller Inputs

Camera A Traffic detection camera will be used to perform traffic counts. The camera will be using a Video Image Vehicle Detection System (VIVDS). VIVDS will determine the presence of vehicles passing through the intersection and adding to the car counter. The car counter sends transformed data packets from the Traffic Light Controller's devices to the TransitFlow Controller that sends back updated traffic cycle instructions.

IR Sensor Each Traffic Light will have an infrared receiver that will allow emergency vehicles to request a green light as they approach the intersection. Emergency vehicles are equipped with a forward-facing Mobile Infrared Transmitter (MIRT) which allow for these requests to happen. Emergency vehicles are able to request signal changes within 2,000 feet of an intersection. Once emergency vehicles have passed the intersection, traffic lights will resume normal operation. An IR sensor system will also be used for Bus lanes as it will allow for faster and safer traffic light changes for the intersecting traffic.

Pedestrian Button At each intersection pedestrians will have access to a button at the traffic light poles. Pressing this button will indicate to the TransitFlow Controller that a pedestrian is requesting to cross the intersection.

3.1.2 Light Controller Outputs

Traffic Light Traffic lights will be used to direct motor vehicles. The signals displayed will be determined by input triggering events or by the set timers built into the Traffic Light Controller.

1. SOLID RED
    - Indicates to traffic to stop before the intersection.
2. SOLID YELLOW
    - Indicates to traffic to slow down as the light will soon turn red.
3. SOLID GREEN
    - Indicates to traffic to proceed through the intersection.
4. LEFT GREEN ARROW
    - Indicates to traffic that its safe to make a left turn.

5. RIGHT GREEN ARROW
    - Indicates to traffic that it's safe to make a right turn.

Pedestrian Light The pedestrian light will be used to indicate when pedestrians are permitted to cross the intersection. The signals displayed will be determined by the pedestrian button's activation of a Pedestrian Light Controller subsystem, or preset timers built into the TransitFlow Controller.

1. RED HAND
    - Indicates to pedestrians that it's not safe to walk across the intersection.

2. GREEN WALKING MAN
    - Indicates to pedestrians that it's safe to walk across the intersection.

3.2 Control Logic

Depending on how dense traffic and pedestrian flow is it will adjust to the most efficient and safe set of instructions.

3.2.1 Top Level Traffic Controller System Diagram

The following diagram displays the top level design of the TransitFlow Controller. When the system boots, it will be initialized with existing starting data or previous stored data. For each labelled data set, the TransitFlow Controller will send out the instructions and information from that data set to the corresponding subsystems (Traffic Light Controller, Pedestrian Light Controller, and Bus Light Controller).

Each subsystem executes instructions in a constant loop of receiving data, processing the data, running the data, then sending back updated information. When the TransitFlow Controller receives updated information from a subsystem, the TransitFlow Controller will process data for that subsystem on a separate thread to prevent a scheduling bottleneck from the influxes of data packets. Data processing in the TransitFlow Controller will work as follows:

1. The TransitFlow Controller receives data from a subsystem on the network.
2. The TransitFlow Controller spawns a thread to process the data.
3. New updated data is sent back to the subsystem and to any other relevant subsystems within an intersection.

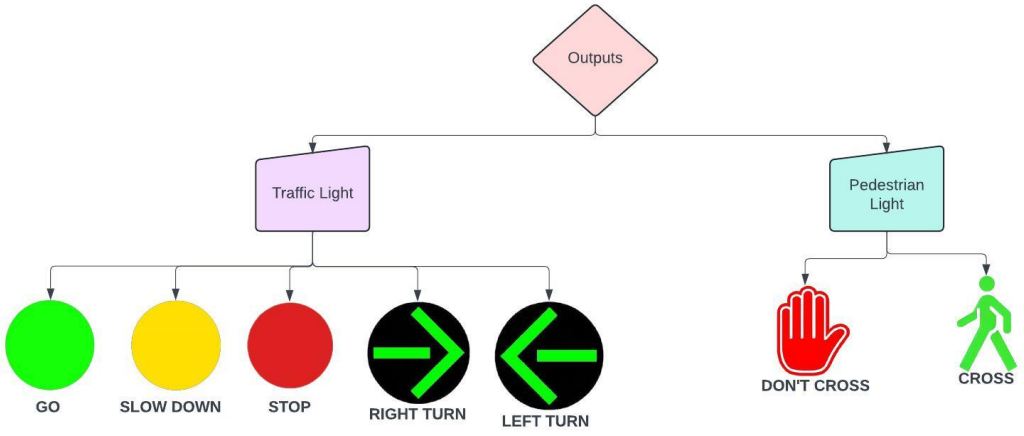

Figure 3: Traffic Lights

4. The thread finishes execution.

The steps above will allow the TransitFlow Controller to run a network of traffic intersections seamlessly. If there is a power outage or another type of system issue was to occur the TransitFlow Controller will attempt to restart the system which would repeat the initialization process.

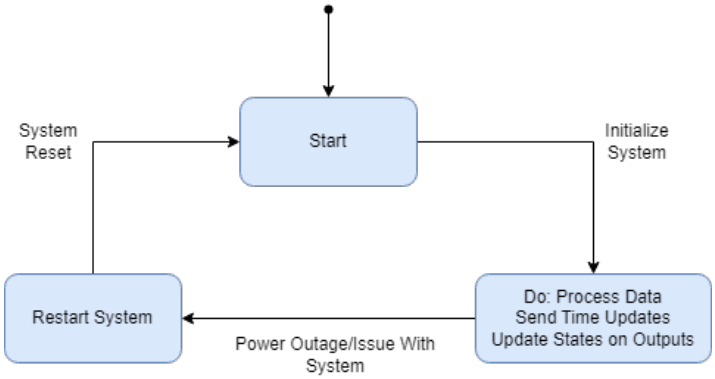

Figure 4: Simple view of the TransitFlow Controller loop. At system startup, it will process a set of previously saved traffic data used to instruct subsystems in the traffic network. After initialization, the system will loop, listening for and processing data from subsystems and responding appropriately. Upon power loss, the system will restart and cycle back to the start of the execution loop.

3.2.2 Traffic Light Controller Diagram

The Traffic Light Diagram describes the actions and events that will trigger different outputs of traffic lights. Initially the system is waiting for data from the TransitFlow Controller. Upon receiving the initial data, it will then parse this data packet and process it to the correct variables. It will then begin a new cycle dependent on the triggers and repeat the loop. During designated night time hours, traffic lights on side roads will be instructed to remain red until receiving car sensor data. Upon receiving data from the car sensor on the TransitFlow Controller, it will send new data to the TransitFlow Controller. The TransitFlow Controller will then parse the received data, instructing the Traffic Light Controller to schedule a state change.

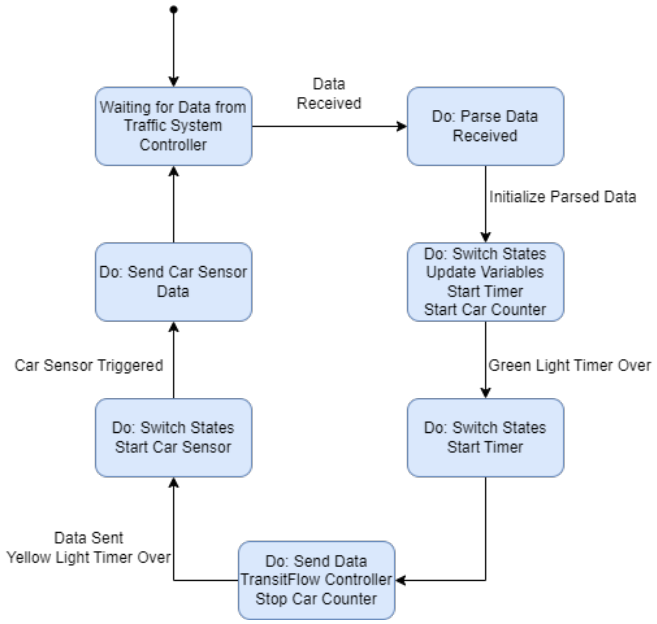

Figure 5: Traffic Light Logic Loop. Data received from the TransitFlow Controller will determine the state timings in the next cycle. During the cycle, the Traffic Light Controller will collect new data to send to the TransitFlow Controller upon state switches.

3.2.3 Pedestrian Light Controller Diagram

The Pedestrian Light handles the instructions for pedestrians crossing intersections. Pedestrian Lights will be scheduled by user input through activation of a button linked to a pedestrian light. When a pedestrian presses the button, data will be sent to the TransitFlow Controller letting it know that there is a pedestrian waiting to cross at that intersection. It will then send this data to perpendicular Traffic Lights along with the pedestrian light to allow the pedestrian to cross safely when the perpendicular Traffic Lights get a Green Light State.

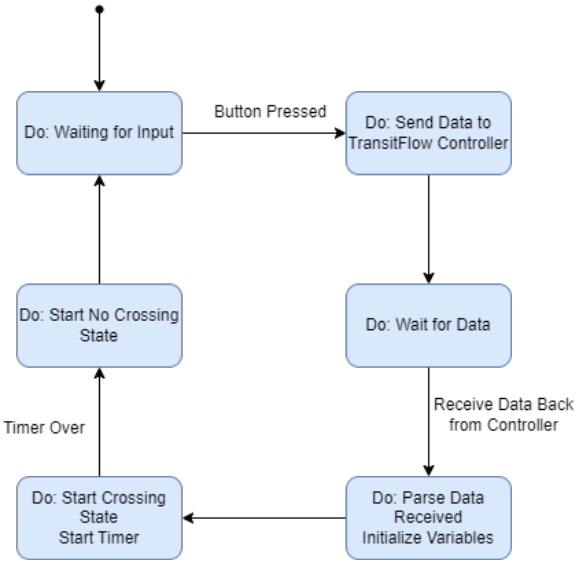

Figure 6: Control Logic

3.2.4 Bus Light Controller Diagram

The Bus Light handles the traffic on the separate bus lanes. Each bus lane shall be equipped with a sensor, at a calculated distance before a bus-lane intersection, which detects if a bus is approaching the intersection. This sensor will then send data to the TransitFlow Controller indicating that a bus has approached that intersection. Upon receiving a signal from one of these sensors, the TransitFlow Controller will schedule the upcoming perpendicular traffic lights to begin entering the red state, allowing the public transportation vehicle to proceed without stopping.

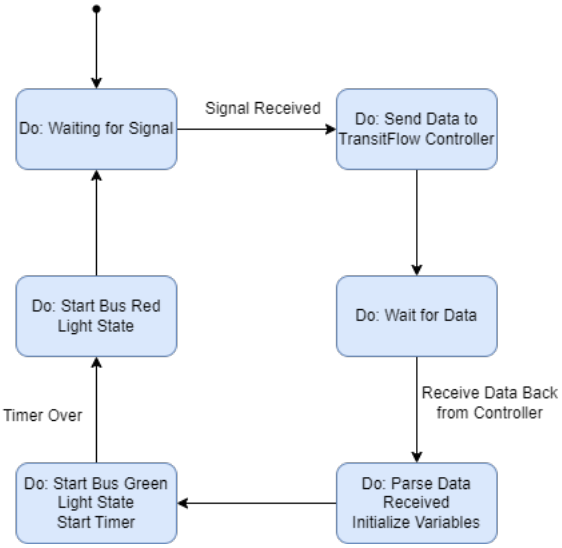

Figure 7: Control Logic

4 Design Constraints

TransitFlow requires control software that effectively communicates traffic directions, is maintainable, modifiable, efficient, allows the management of traffic data, and is secure. This section will detail those constraints in which the system must operate.

4.1 Software Language

All software for the control system must be written in Java. Designing the control system to function through the JVM leads to shortcomings in time and power efficiency which could otherwise be achieved with system-level languages.

- Java requires more sophisticated physical hardware due to being a higher level programming language which may not be supported on many low cost controller systems.
- The safe controller must be fast enough to respond to user inputs instantaneously. As such, the control software must be written efficiently to minimize the runtime.

4.2 Maintainable & Modifiable

The software is designed to grant public entities the flexibility to modify, maintain, and expand to accommodate evolving needs. Adaptability guarantees that the software can be enhanced to meet future requirements of traffic management without expensive development costs.

4.3 Efficient

The efficiency of TransitFlow is crucial, relying on it's ability to use sensors and signals to communicate with the public while managing data. Efficiency is important to prevent wasteful consumption of publicly supplied electricity.

4.4 Effective

For communication to be effective in maintaining proper flow of traffic while increasing safety for transportation on public roads, information must be understandable, clear, and practical. Intuitive presentation of directions and alerts are necessary to minimize the public's confusion.

4.5 Secure

The data used to manage and make decisions of directions given to the public will be safe from cybersecurity threats. TransitFlow employs safeguarding against unauthorized access, data breaches, and cybersecurity threats assuring the reliability and trust.

5 Definition of Terms

TransitFlow Controller: The main central system controller.
Traffic Light Controller: The controller for each individual traffic light.
VIVDS: Vehicle detection system for counting cars passing through intersections.
MIRT: Mobile infrared transmitter, used to detect incoming emergency vehicles.
Pedestrian: An individual, who is not driving a vehicle, that is walking on marked sidewalks and road crossings.
Cycle: Execution of a line of instructions by the computer.