Traffic System Controller Design and Implementation

2024-2025

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1 Introduction

1.1 Objective

The objective of this report is to design and implement a traffic control system for intersections as specified by the provided map. Key features include:

- Closed-loop controllers with dynamic delay handling.
- Tram stations, Bus stations, Tram lanes and priority car handling.
- Implementation of traffic lights for vehicles and pedestrians.

1.2 Scope

This report outlines the design, implementation, and specifications for the traffic control system, including OETPN models and UML component diagrams.

2 Specifications

2.1 Map Screenshots and Simplified Diagram

1. **Original Map:** Include a screenshot of the given map.

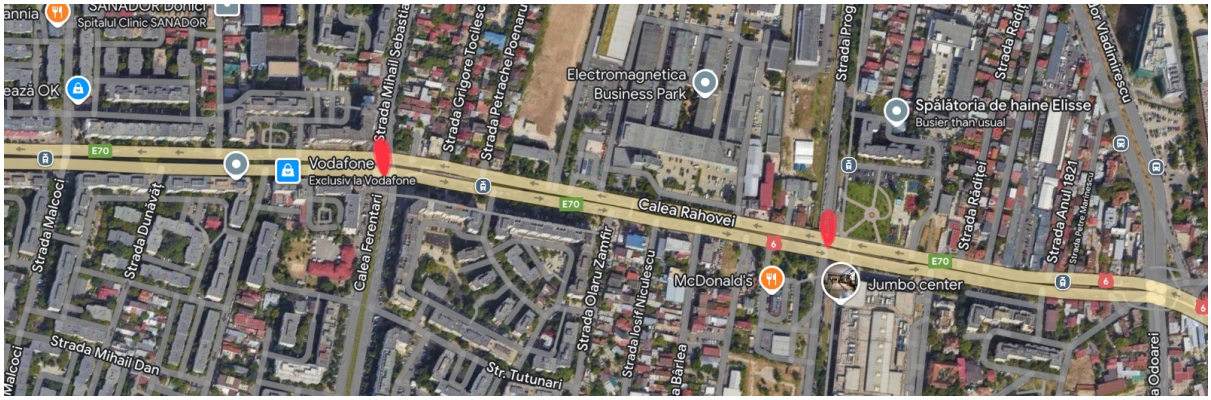

Figure 1: Given Map

2. **Simplified Diagram:** A simplified representation of intersections, lanes, and components.

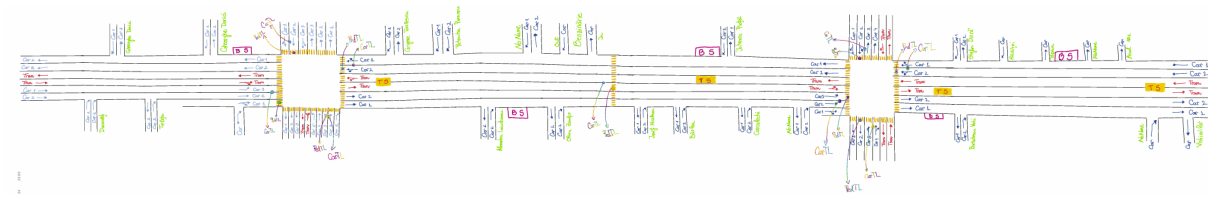

Figure 2: Simplified Map

3 System Design

3.1 Component Diagram

The following UML diagram represents the system's components and communication channels.

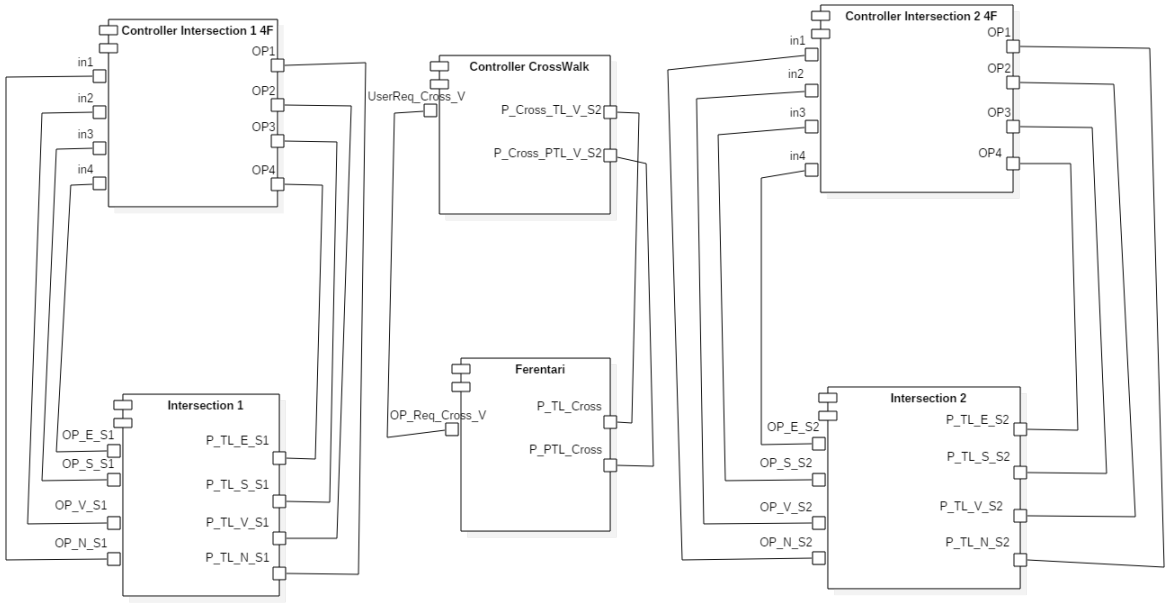

Figure 3: System Component Diagram

3.2 OETPN Model for the Plant

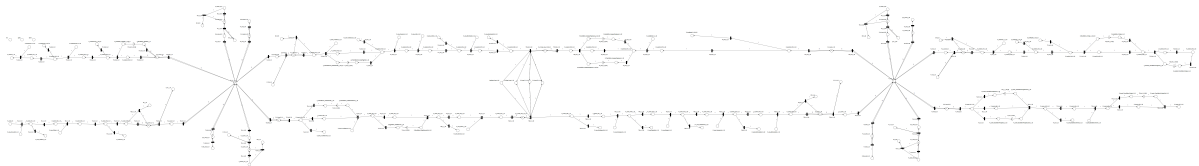

Figure 4: OETPN Model for the Plant

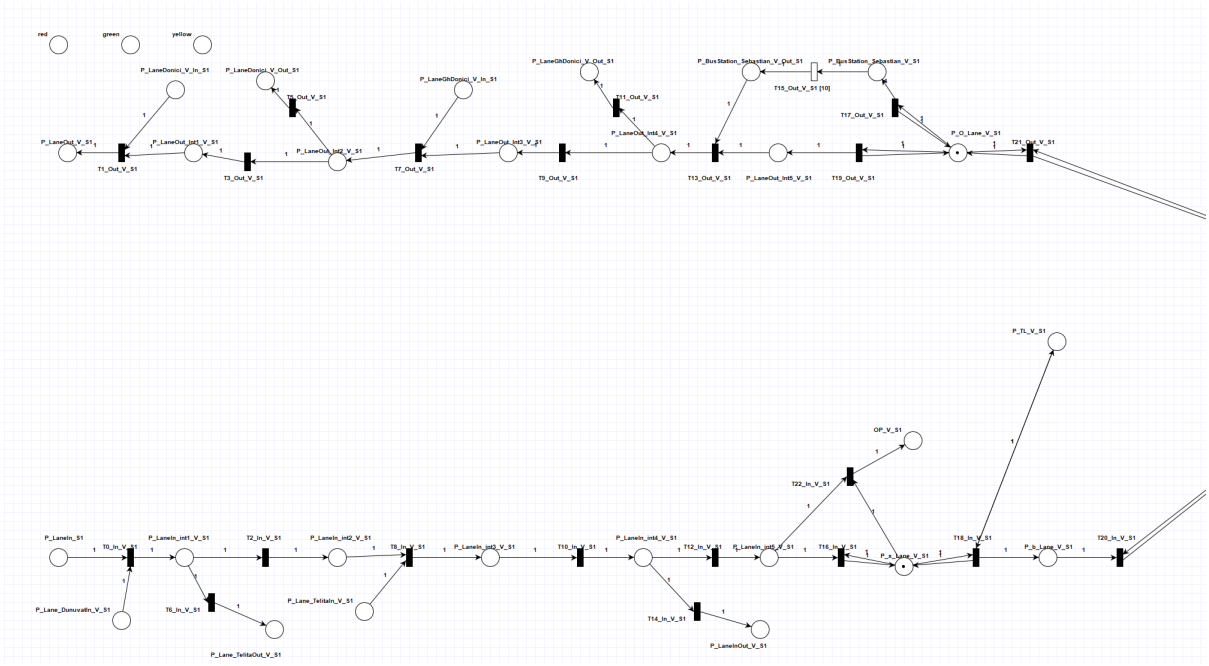

Figure 5: Calea Rahovei

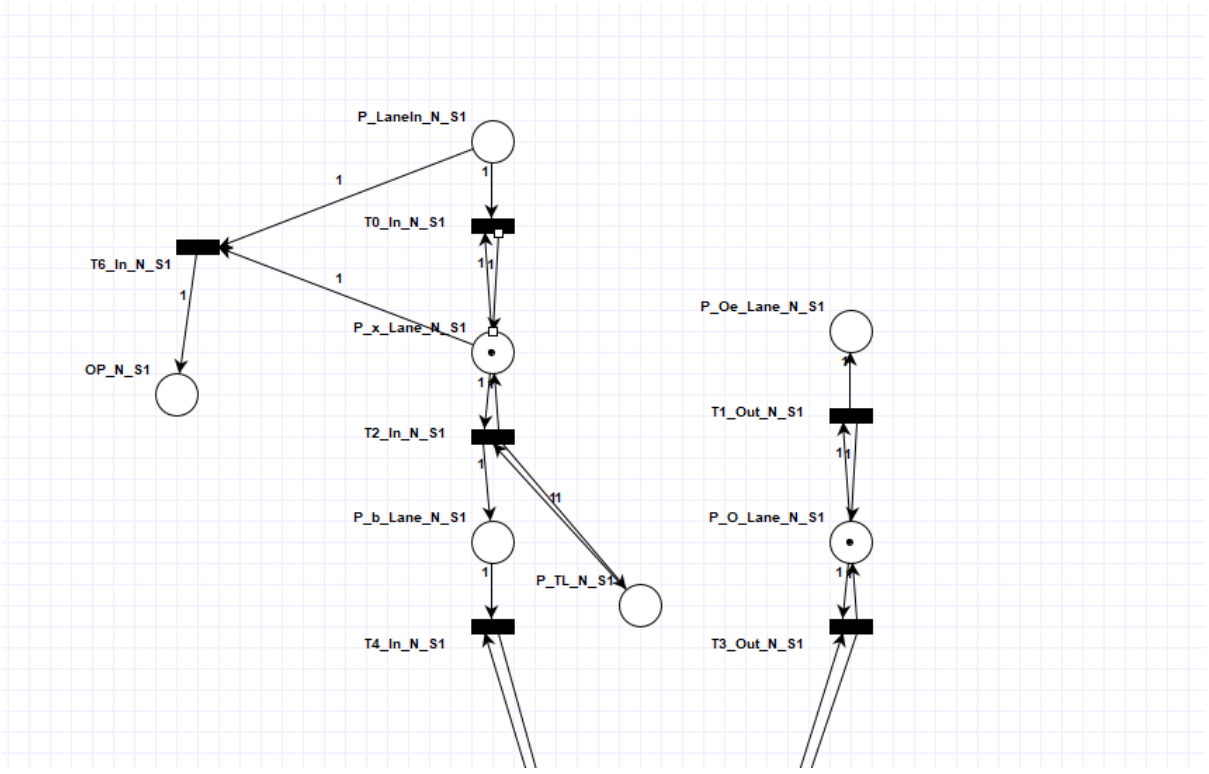

Figure 6: Mihail Sebastian Street

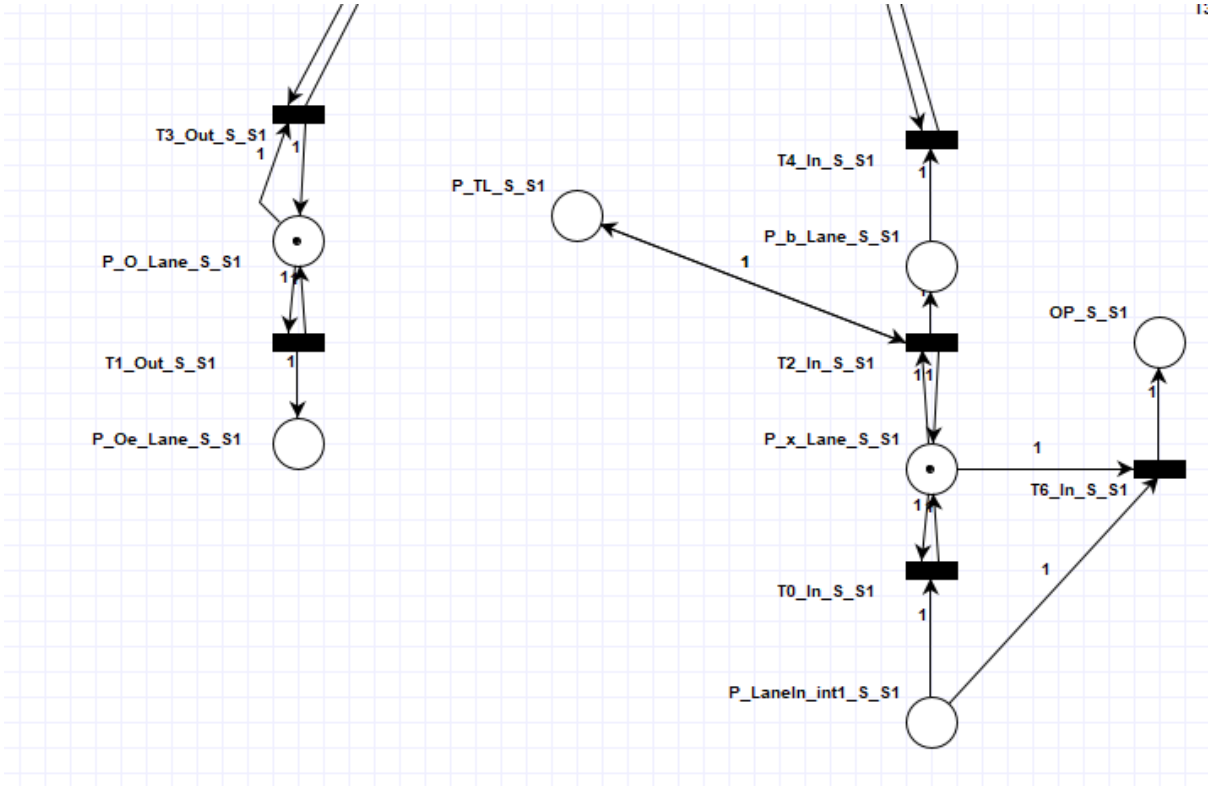

Figure 7: Calea Ferentari

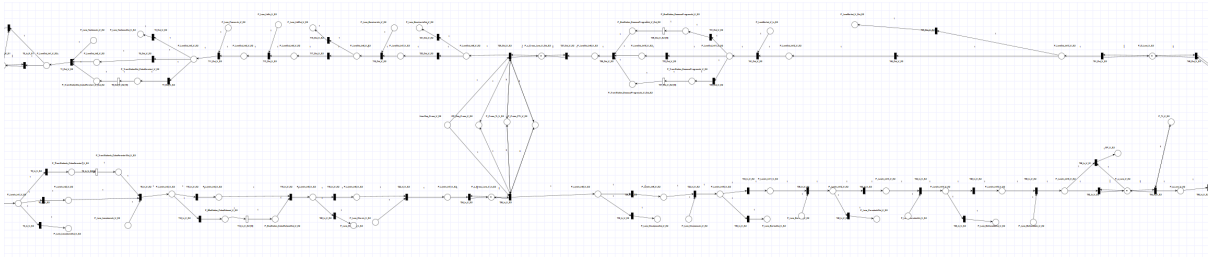

Figure 8: Calea Rahovei

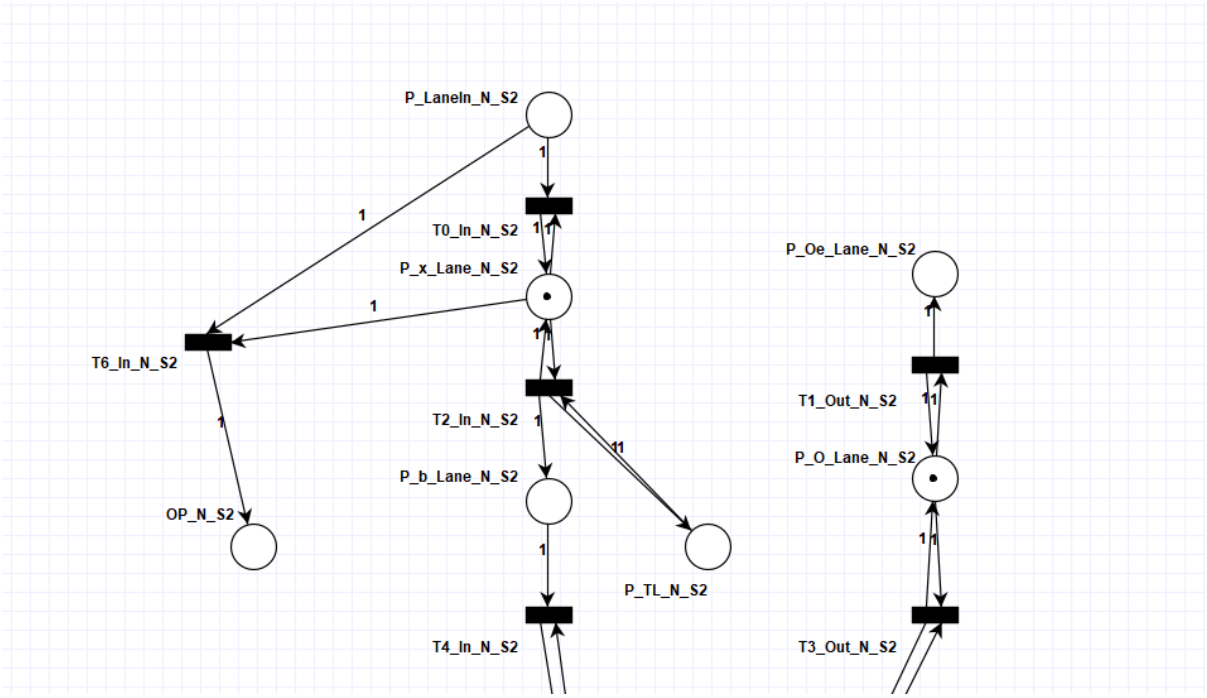

Figure 9: Progresului Street North

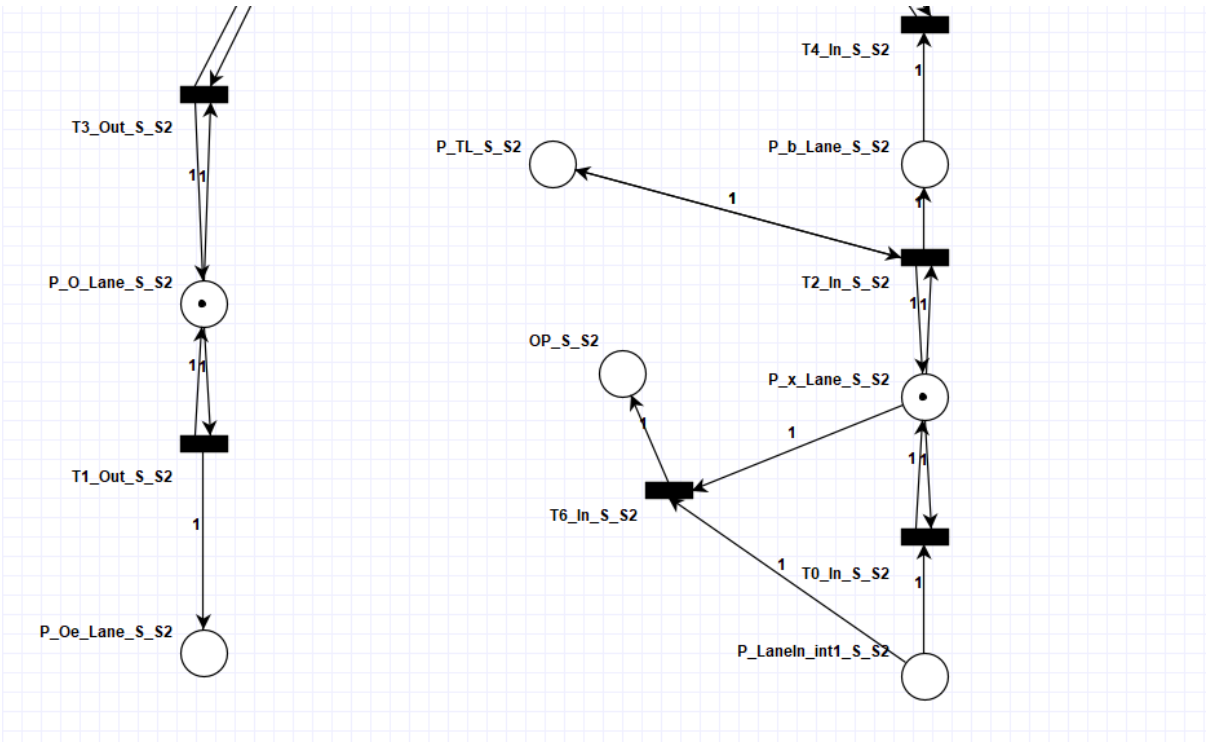

Figure 10: Progresului Street South

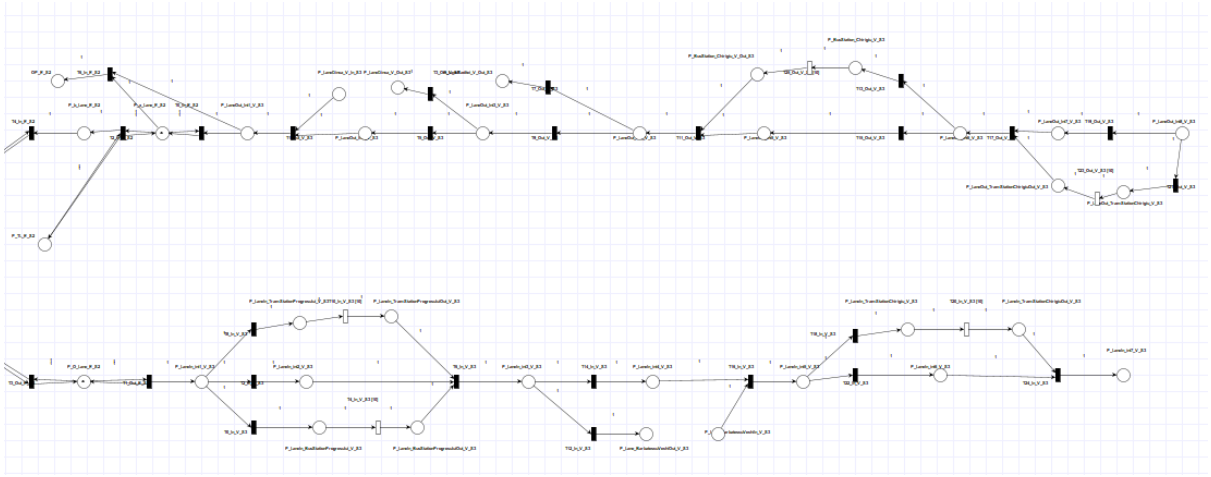

Figure 11: Calea Rahovei

3.3 Detailed Plant Places, Guards, and Mapping

Places Overview

Place Name	Type	Size	Initial Value
red	DataString	–	”red”
green	DataString	–	”green”
yellow	DataString	–	”yellow”
full	DataString	–	”full”
P_LaneIn_S1	DataCar	–	–
P_Lane_DunuvatIn_V_S1	DataCarQueue	2	–
P_LaneIn_int1_V_S1	DataCarQueue	3	–
P_LaneIn_int2_V_S1	DataCarQueue	3	–
P_Lane_TelitaOut_V_S1	DataCar	–	–
P_Lane_TelitaIn_V_S1	DataCar	–	–
P_LaneIn_int3_V_S1	DataCarQueue	3	–
P_LaneIn_int4_V_S1	DataCarQueue	3	–
P_LaneInOut_V_S1	DataCar		–
P_LaneIn_int5_V_S1	DataCarQueue	4	–
P_x_Lane_V_S1	DataCarQueue	4	–
OP_V_S1	DataTransfer	–	”target:in2, 1081”
P_b_Lane_V_S1	DataCar	–	–
P_LaneOut_V_S1	DataCar	–	–
P_LaneOut_Int1_V_S1	DataCarQueue	3	–
P_LaneDonici_V_In_S1	DataCar	–	–
P_LaneOut_Int2_V_S1	DataCarQueue	3	–
P_LaneDonici_V_Out_S1	DataCar	–	–
P_LaneOut_Int3_V_S1	DataCarQueue	3	–
P_LaneGhDonici_V_In_S1	DataCar	–	–
P_LaneGhDonici_V_Out_S1	DataCar	–	–
P_LaneOut_Int4_V_S1	DataCarQueue	3	–
P_LaneOut_Int5_V_S1	DataCarQueue	3	–
P_BusStation_Sebastian_V_Out_S1	DataCarQueue	2	–
P_BusStation_Sebastian_V_S1	DataCarQueue	2	–
P_O_Lane_V_S1	DataCarQueue	3	–
P_O_Lane_S_S1	DataCarQueue	4	–
P_Oe_Lane_S_S1	DataCar	–	–
P_x_Lane_S_S1	DataCarQueue	6	–
OP_S_S1	DataTransfer	–	”target:in3, 1081”
P_LaneIn_int1_S_S1	DataCar		–
P_b_Lane_S_S1	DataCar	–	–
P_x_Lane_E_S1	DataCarQueue	3	–
OP_E_S1	DataTransfer	–	”target:in4, 1081”
P_b_Lane_E_S1	DataCar	–	–
P_O_Lane_E_S1	DataCarQueue	3	–

Place Name	Type	Size	Initial Value
P_I_S1	DataCarQueue	3	–
P_TL_V_S1	DataString	–	–
P_TL_N_S1	DataString	–	–
P_TL_S_S1	DataString	–	–
P_TL_E_S1	DataString	–	–
P_LaneIn_N_S1	DataCar	–	–
P_x_Lane_N_S1	DataCarQueue	3	–
P_b_Lane_N_S1	DataCar	–	–
OP_N_S1	DataTransfer	–	”target:in1, 1081”
P_O_Lane_E_S1	DataCarQueue	3	–
P_Oe_Lane_E_S1	DataCar		–
P_LaneIn_int1_V_S2	DataCarQueue	3	–
P_LaneIn_int2_V_S2	DataCarQueue	2	–
P_LaneIn_int3_V_S2	DataCarQueue	3	–
P_LaneIn_int4_V_S2	DataCarQueue	3	–
P_LaneIn_int5_V_S2	DataCarQueue	3	–
P_LaneIn_int6_V_S2	DataCarQueue	3	–
P_LaneIn_int7_V_S2	DataCarQueue	3	–
P_Lane_LocusteanuOut_V_S2	DataCar	–	–
P_Lane_LocusteanuIn_V_S2	DataCar	–	–
P_Lane_OlaruOut_V_S2	DataCar	–	–
P_Lane_OlaruIn_V_S2	DataCar	–	–
P_TramStationIn_CaleaFerentari_V_S2	DataCarQueue	1	–
P_TramStationIn_CaleaFerentariOut_V_S2	DataCarQueue	1	–
P_BusStation_CaleaRahovei_V_S2	DataCarQueue	2	–
P_BusStation_CaleaRahoveiOut_V_S2	DataCarQueue	2	–
P_LaneOut_Int1_V_S2	DataCarQueue	3	–
P_Lane_TocilescuIn_V_S2	DataCar	–	–
P_LaneOut_Int2_V_S2	DataCarQueue	2	–
P_TramStationOut_CaleaFerentari_V_Out_S2	DataCarQueue	1	–
P_Lane_TocilescuOut_V_S2	DataCar	–	–
P_TramStationOut_CaleaFerentari_V_S2	DataCarQueue	1	–
P_LaneOut_Int3_V_S2	DataCarQueue	3	–
P_Lane_PoenaruIn_V_S2	DataCarQueue	2	–
P_LaneOut_Int4_V_S2	DataCarQueue	3	–
P_Lane_LidlIn_V_S2	DataCar	–	–

Place Name	Type	Size	Initial Value
P_LaneOut_Int5_V_S2	DataCarQueue	3	–
P_Lane_LidlOut_V_S2	DataCar	–	–
P_LaneOut_Int6_V_S2	DataCarQueue	3	–
P_Lane_BenzinarieIn_V_S2	DataCar	–	–
P_LaneOut_Int7_V_S2	DataCarQueue	3	–
P_Lane_BenzinarieOut_V_S2	DataCar	–	–
P_LaneOut_Int8_V_S2	DataCarQueue	3	–
P_x_Cross_Lane_V_Out_S2	DataCarQueue	3	–
P_LaneOut_Int9_V_S2	DataCarQueue	–	–
P_x_Cross_Lane_V_In_S2	DataCarQueue	3	–
P_LaneIn_int7_V_S2	DataCarQueue	–	–
P_LaneIn_int8_V_S2	DataCarQueue	–	–
P_LaneOut_Int8_V_S2	DataCarQueue	–	–
P_Cross_TL_V_S2	DataString	–	–
P_Cross_PTL_V_S2	DataString	–	–
UserReq_Cross_V_S2	DataString	–	–
OP_Req_Cross_V_S2	DataTransfer	–	”target:UserReq, 1083”
P_LaneIn_int8_V_S2	DataCarQueue	3	–
P_LaneIn_int9_V_S2	DataCarQueue	3	–
P_Lane_NiculaescuOut_V_S2	DataCar	–	–
P_Lane_NiculaescuIn_V_S2	DataCar	–	–
P_LaneIn_int10_V_S2	DataCarQueue	3	–
P_LaneIn_int11_V_S2	DataCarQueue	3	–
P_Lane_BarleaOut_V_S2	DataCar	–	–
P_Lane_BarleaIn_V_S2	DataCar	–	–
P_LaneIn_int12_V_S2	DataCarQueue	3	–
P_LaneIn_int13_V_S2	DataCarQueue	3	–
P_Lane_CarcalechiOut_V_S2	DataCar	–	–
P_Lane_CarcalechiIn_V_S2	DataCar	–	–
P_LaneIn_int14_V_S2	DataCarQueue	3	–
P_LaneIn_int15_V_S2	DataCarQueue	3	–
P_Lane_McDonaldsOut_V_S2	DataCar	–	–
P_Lane_McDonaldsIn_V_S2	DataCar	–	–
P_LaneIn_int16_V_S2	DataCarQueue	4	–
P_x_Lane_V_S2	DataCarQueue	4	–
P_b_Lane_V_S2	DataCar	–	–
P_I_S2	DataCarQueue	–	–

Place Name	Type	Size	Initial Value
OP_V_S2	DataTransfer	–	”target:in2, 1082”
P_LaneOut_Int9_V_S2	DataCarQueue	3	–
P_LaneOut_Int10_V_S2	DataCarQueue	2	–
P_BusStation_SoseauaProgresului_V_Out_S2	DataCarQueue	2	–
P_TramStation_SoseauaProgresului_V_Out_S2	DataCarQueue	1	–
P_LaneOut_Int11_V_S2	DataCarQueue	3	–
P_TramStation_SoseauaProgresului_V_S2	DataCarQueue	1	–
P_BusStation_SoseauaProgresului_V_S2	DataCarQueue	2	–
P_LaneMarket_V_In_S2	DataCar	–	–
P_LaneOut_Int12_V_S2	DataCarQueue	3	–
P_LaneMarket_V_Out_S2	DataCar	–	–
P_LaneOut_Int13_V_S2	DataCarQueue	3	–
P_O_Lane_V_S2	DataCarQueue	3	–
P_LaneIn_N_S2	DataCar	–	–
P_x_Lane_N_S2	DataCarQueue	3	–
P_b_Lane_N_S2	DataCar	–	–
OP_N_S2	DataTransfer	–	”target:in1, 1082”
P_O_Lane_N_S2	DataCarQueue	3	–
P_Oe_Lane_N_S2	DataCar	–	–
P_LaneIn_int1_S_S2	DataCar	–	–
P_x_Lane_S_S2	DataCarQueue	3	–
P_b_Lane_S_S2	DataCar	–	–
OP_S_S2	DataTransfer	–	”target:in3, 1082”
P_O_Lane_S_S2	DataCarQueue	3	–
P_Oe_Lane_S_S2	DataCar	–	–
P_x_Lane_E_S2	DataCarQueue	3	–
P_b_Lane_E_S2	DataCar	–	–
OP_E_S2	DataTransfer	–	”target:in4, 1082”
P_O_Lane_E_S2	DataCarQueue	3	–
P_I_S2	DataCarQueue	3	–
P_TL_V_S2	DataString	–	–
P_TL_N_S2	DataString	–	–
P_TL_S_S2	DataString	–	–
P_TL_E_S2	DataString	–	–
P_LaneIn_int1_V_S3	DataCarQueue	3	–

Place Name	Type	Size	Initial Value
P_LaneIn_int2_V_S3	DataCarQueue	3	–
P_LaneIn_BusStationProgresului_V_S3	DataCarQueue	2	–
P_LaneIn_BusStationProgresuluiOut_V_S3	DataCarQueue	2	–
P_LaneIn_TramStationProgresului_V_S3	DataCarQueue	1	–
P_LaneIn_TramStationProgresuluiOut_V_S3	DataCarQueue	1	–
P_LaneIn_int3_V_S3	DataCarQueue	3	–
P_LaneIn_int4_V_S3	DataCarQueue	3	–
P_Lane_BarbatescuVechiOut_V_S3	DataCar	–	–
P_Lane_BarbatescuVechiIn_V_S3	DataCar	–	–
P_LaneIn_int5_V_S3	DataCarQueue	3	–
P_LaneIn_TramStationChirigiu_V_S3	DataCarQueue	3	–
P_LaneIn_TramStationChirigiuOut_V_S3	DataCarQueue	3	–
P_LaneIn_int6_V_S3	DataCarQueue	3	–
P_LaneIn_int7_V_S3	DataCarQueue	3	–
P_LaneOut_Int1_V_S3	DataCarQueue	3	–
P_LaneDinca_V_In_S3	DataCar	–	–
P_LaneOut_Int2_V_S3	DataCarQueue	3	–
P_LaneDinca_V_Out_S3	DataCar	–	–
P_LaneOut_Int3_V_S3	DataCarQueue	3	–
P_LaneRaditei_V_Out_S3	DataCar	–	–
P_LaneOut_Int4_V_S3	DataCarQueue	3	–
P_LaneOut_Int5_V_S3	DataCarQueue	3	–
P_BusStation_Chirigiu_V_Out_S3	DataCarQueue	2	–
P_BusStation_Chirigiu_V_S3	DataCarQueue	2	–
P_LaneOut_Int6_V_S3	DataCarQueue	3	–
P_LaneOut_Int7_V_S3	DataCarQueue	2	–
P_LaneOut_Int8_V_S3	DataCarQueue	1	–
P_LaneOut_TramStationChirigiu_V_S3	DataCarQueue	1	–
P_LaneOut_TramStationChirigiuOut_V_S3	DataCarQueue	1	–

Transitions Overview (Conditions and Actions)

- **T0_In_V_S1**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_S1", NotNull
       * "P_Lane_DunuvatIn_V_S1", DontHaveCar
       * "P_LaneIn_int1_V_S1", CanAddCars
     - **Activations:**
       * "P_LaneIn_S1", AddElement, "P_LaneIn_int1_V_S1"
  2. **Guard 2**
     - **Conditions:**
       * "P_LaneIn_S1", IsNull
       * "P_Lane_DunuvatIn_V_S1", HaveCar
       * "P_LaneIn_int1_V_S1", CanAddCars
     - **Activations:**
       * "P_Lane_DunuvatIn_V_S1", PopElementWithoutTargetToQueue, "P_LaneIn_int1_V_S1"
  3. **Guard 3**
     - **Conditions:**
       * "P_LaneIn_S1", NotNull
       * "P_Lane_DunuvatIn_V_S1", HavePriorityCar
       * "P_LaneIn_int1_V_S1", CanAddCars
     - **Activations:**
       * "P_Lane_DunuvatIn_V_S1", PopElementWithoutTargetToQueue, "P_LaneIn_int1_V_S1"
       * "P_LaneIn_S1", AddElement, "P_LaneIn_int1_V_S1"
  4. **Guard 4**
     - **Conditions:**
       * "P_LaneIn_S1", NotNull
       * "P_Lane_DunuvatIn_V_S1", HaveCar
       * "P_LaneIn_int1_V_S1", CanAddCars
     - **Activations:**
       * "P_LaneIn_S1", AddElement, "P_LaneIn_int1_V_S1"
       * "P_Lane_DunuvatIn_V_S1", PopElementWithoutTargetToQueue, "P_LaneIn_int1_V_S1"

  - **Transitions Alike: T8_In_V_S1, T22_In_V_S2, T32_In_V_S2, T38_In_V_S2, T44_In_V_S2, T50_In_V_S2, T16_In_V_S3, T1_Out_V_S1,T7_Out_V_S1, T11_Out_V_S2, T13_Out_V_S2, T19_Out_V_S2, T41_Out_V_S2, T1_Out_V_S3, T11_Out_V_S3**

- **T2_In_V_S1**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int1_V_S1", HaveCarForMe
       * "P_LaneIn_int2_V_S1", CanAddCars
     - **Activations:**
       * "P_LaneIn_int1_V_S1", PopElementWithoutTargetToQueue, "P_LaneIn_int2_V_S1"
     - **Transitions Alike: T12_In_V_S1, T6_In_V_S2, T10_In_V_S2, T18_In_V_S2, T28_In_V_S2, T34_In_V_S2, T42_In_V_S2, T48_In_V_S2, T2_In_V_S3, T14_In_V_S3, T22_In_V_S3, T9_Out_V_S1, T5_Out_V_S2, T17_Out_V_S2, T23_Out_V_S2, T33_Out_V_S2, T45_Out_V_S2, T5_Out_V_S3, T9_Out_V_S3, T15_Out_V_S3, T19_Out_V_S3**
- **T6_In_V_S1**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int1_V_S1", HaveCarForMe
     - **Activations:**
       * "P_LaneIn_int1_V_S1", PopElementWithTarget, "P_Lane_TelitaOut_V_S1"
     - **Transitions Alike: T14_In_V_S1, T4_In_V_S2, T20_In_V_S2, T30_In_V_S2, T36_In_V_S2, T40_In_V_S2, T46_In_V_S2, T12_In_V_S3, T5_Out_V_S1, T11_Out_V_S1, T3_Out_V_S2, T15_Out_V_S2, T21_Out_V_S2, T43_Out_V_S2, T3_Out_V_S3, T7_Out_V_S3**
- **T10_In_V_S1**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int3_V_S1", HaveCar
       * "P_LaneIn_int4_V_S1", CanAddCars
     - **Activations:**
       * "P_LaneIn_int3_V_S1", PopElementWithoutTargetToQueue, "P_LaneIn_int4_V_S1"
     - **Transitions Alike: T1_In_V_S1, T1_Out_E_S1, T1_Out_E_S2, T51_Out_V_S2**
- **T16_In_V_S1**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int5_V_S1", HaveCar
       * "P_x_Lane_V_S1", CanAddCars

- **Activations:**
  - "P_LaneIn_int5_V_S1", PopElementWithoutTargetToQueue, "P_x_Lane_V_S1"
- **Transitions Alike: T0_In_S_S1, T0_In_N_S1, T0_In_E_S1, T24_In_V_S2, T27_Out_V_S2, T52_In_V_S2, T0_In_S_S2, T0_In_N_S2, T0_In_E_S2**

- **T22_In_V_S1**

1. **Guard 1**
   - **Conditions:**
     - "P_LaneIn_int5_V_S1", HaveCar
     - "P_x_Lane_V_S1", CanNotAddCars
   - **Activations:**
     - "full", SendOverNetwork, "OP_V_S1"
   - **Transitions Alike: T6_In_S_S1, T6_In_N_S1, T6_In_E_S1, T58_In_V_S2, T6_In_S_S2, T6_In_N_S2, T6_In_E_S2**

- **T18_In_V_S1**

1. **Guard 1**
   - **Conditions:**
     - "P_TL_V_S1", Equal, "green"
     - "P_x_Lane_V_S1", HaveCar
   - **Activations:**
     - "P_x_Lane_V_S1", PopElementWithoutTarget, "P_b_Lane_V_S1"
     - "P_TL_V_S1", Move, "P_TL_V_S1"
2. **Guard 3**
   - **Conditions:**
     - "P_x_Lane_V_S1", HavePriorityCar
   - **Activations:**
     - "P_x_Lane_V_S1", PopElementWithoutTarget, "P_b_Lane_V_S1"
     - "P_TL_V_S1", Move, "P_TL_V_S1"
   - **Transitions Alike: T2_In_N_S1, T2_In_S_S1, T2_In_E_S1, T54_In_V_S2, T2_In_N_S2, T2_In_S_S2, T2_In_E_S2**

- **T20_In_V_S1**

1. **Guard 1**
   - **Conditions:**
     - "P_b_Lane_V_S1", NotNull
     - "P_I_S1", CanAddCars
   - **Activations:**

        * "P_b_Lane_V_S1", AddElement, "P_I_S1"

    - **Transitions Alike: T4_In_N_S1, T4_In_S_S1, T4_In_E_S1, T36_In_V_S2, T4_In_N_S2, T4_In_S_S2, T4_In_E_S2**

- **T13_Out_V_S1**

    1. **Guard 1**
        - **Conditions:**
            * "P_LaneOut_Int5_V_S1", HaveCar
            * "P_BusStation_Sebastian_V_Out_S1", DontHaveBus
            * "P_LaneOut_Int4_V_S1", CanAddCars
        - **Activations:**
            * "P_LaneOut_Int5_V_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"
    2. **Guard 2**
        - **Conditions:**
            * "P_LaneOut_Int5_V_S1", DontHaveCar
            * "P_BusStation_Sebastian_V_Out_S1", HaveBus
            * "P_LaneOut_Int4_V_S1", CanAddCars
        - **Activations:**
            * "P_BusStation_Sebastian_V_Out_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"
    3. **Guard 3**
        - **Conditions:**
            * "P_LaneOut_Int5_V_S1", HavePriorityCar
            * "P_BusStation_Sebastian_V_Out_S1", HaveBus
            * "P_LaneOut_Int4_V_S1", CanAddCars
        - **Activations:**
            * "P_LaneOut_Int5_V_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"
            * "P_BusStation_Sebastian_V_Out_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"
    4. **Guard 4**
        - **Conditions:**
            * "P_LaneOut_Int5_V_S1", HaveCar
            * "P_BusStation_Sebastian_V_Out_S1", HaveBus
            * "P_LaneOut_Int4_V_S1", CanAddCars
        - **Activations:**
            * "P_BusStation_Sebastian_V_Out_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"
            * "P_LaneOut_Int5_V_S1", PopElementWithoutTargetToQueue, "P_LaneOut_Int4_V_S1"

- **Transitions Alike: T16_In_V_S2, T11_Out_V_S3**

- **T15_Out_V_S1**

  1. **Guard 1**
     - **Conditions:**
       * "P_BusStation_Sebastian_V_S1", HaveBus
       * "P_BusStation_Sebastian_V_Out_S1", CanAddCars
     - **Activations:**
       * "P_BusStation_Sebastian_V_S1", PopElementWithoutTargetToQueue, "P_BusStation_Sebastian_V_Out_S1"
     - **Delay:**
       * 10
     - **Transitions Alike: T14_In_V_S2, T39_Out_V_S2, T4_In_V_S3, T25_Out_V_S3**

- **T17_Out_V_S1**

  1. **Guard 1**
     - **Conditions:**
       * "P_O_Lane_V_S1", HaveBusForMe
       * "P_BusStation_Sebastian_V_S1", CanAddCars
     - **Activations:**
       * "P_O_Lane_V_S1", PopElementWithTargetToQueue, "P_BusStation_Sebastian_V_S1"
     - **Transitions Alike: T12_In_V_S2, T31_Out_V_S2, T0_In_V_S3, T13_Out_V_S3**

- **T19_Out_V_S1**

  1. **Guard 1**
     - **Conditions:**
       * "P_O_Lane_V_S1", HaveCarForMe
       * "P_LaneOut_Int5_V_S1", CanAddCars
     - **Activations:**
       * "P_O_Lane_V_S1", PopElementWithTargetToQueue, "P_LaneOut_Int5_V_S1"

- **T21_Out_V_S1**

  1. **Guard 1**
     - **Conditions:**
       * "P_I_S1", HaveCarForMe
       * "P_O_Lane_V_S1", CanAddCars
     - **Activations:**
       * "P_I_S1", PopElementWithTargetToQueue, "P_O_Lane_V_S1"

- **Transitions Alike: T3_Out_E_S1, T3_Out_N_S1, T3_Out_S_S1, T49_Out_V_S2, T3_Out_E_S2, T3_Out_N_S2, T3_Out_S_S2**

- **T0_In_V_S2**

  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int1_V_S2", HaveTramForMe
       * "P_TramStationIn_CaleaFerentari_V_S2", CanAddCars
     - **Activations:**
       * "P_LaneIn_int1_V_S2", PopElementWithTargetToQueue, "P_TramStationIn_CaleaFerentari_V_S2"
     - **Transitions Alike: T7_Out_V_S2, T35_Out_V_S2, T8_In_V_S3, T18_In_V_S3, T21_Out_V_S3**

- **T8_In_V_S2**

  1. **Guard 1**
     - **Conditions:**
       * "P_LaneIn_int2_V_S2", HaveCar
       * "P_Lane_LocusteanuIn_V_S2", IsNull
       * "P_LaneIn_int3_V_S2", CanAddCars
       * "P_TramStationIn_CaleaFerentariOut_V_S2", DontHaveTram
     - **Activations:**
       * "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
  2. **Guard 2**
     - **Conditions:**
       * "P_LaneIn_int2_V_S2", DontHaveCar
       * "P_Lane_LocusteanuIn_V_S2", NotNull
       * "P_LaneIn_int3_V_S2", CanAddCars
       * "P_TramStationIn_CaleaFerentariOut_V_S2", DontHaveTram
     - **Activations:**
       * "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S1"
  3. **Guard 3**
     - **Conditions:**
       * "P_LaneIn_int2_V_S2", HaveCar
       * "P_Lane_LocusteanuIn_V_S2", IsPriorityCar
       * "P_LaneIn_int3_V_S2", CanAddCars
       * "P_TramStationIn_CaleaFerentariOut_V_S2", DontHaveTram
     - **Activations:**
       * "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S2"

    * "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"

4. **Guard 4**
   - **Conditions:**
     * "P_LaneIn_int2_V_S2", HaveCar
     * "P_Lane_LocusteanuIn_V_S2", NotNull
     * "P_LaneIn_int3_V_S2", CanAddCars
     * "P_TramStationIn_CaleaFerentariOut_V_S2", DontHaveTram
   - **Activations:**
     * "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
     * "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S2"

5. **Guard 5**
   - **Conditions:**
     * "P_LaneIn_int2_V_S2", HaveCar
     * "P_Lane_LocusteanuIn_V_S2", IsNull
     * "P_LaneIn_int3_V_S2", CanAddCars
     * "P_TramStationIn_CaleaFerentariOut_V_S2", HaveTram
   - **Activations:**
     * "P_TramStationIn_CaleaFerentariOut_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
     * "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"

6. **Guard 6**
   - **Conditions:**
     * "P_LaneIn_int2_V_S2", DontHaveCar
     * "P_Lane_LocusteanuIn_V_S2", NotNull
     * "P_LaneIn_int3_V_S2", CanAddCars
     * "P_TramStationIn_CaleaFerentariOut_V_S2", HaveTram
   - **Activations:**
     * "P_TramStationIn_CaleaFerentariOut_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S1"
     * "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S1"

7. **Guard 7**
   - **Conditions:**
     * "P_LaneIn_int2_V_S2", HaveCar
     * "P_Lane_LocusteanuIn_V_S2", IsPriorityCar
     * "P_LaneIn_int3_V_S2", CanAddCars
     * "P_TramStationIn_CaleaFerentariOut_V_S2", HaveTram

- **Activations:**
  - "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S2"
  - "P_TramStationIn_CaleaFerentariOut_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
  - "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"

8. **Guard 8**
   - **Conditions:**
     - "P_LaneIn_int2_V_S2", HaveCar
     - "P_Lane_LocusteanuIn_V_S2", NotNull
     - "P_LaneIn_int3_V_S2", CanAddCars
     - "P_TramStationIn_CaleaFerentariOut_V_S2", HaveTram
   - **Activations:**
     - "P_TramStationIn_CaleaFerentariOut_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
     - "P_LaneIn_int2_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"
     - "P_Lane_LocusteanuIn_V_S2", AddElement, "P_LaneIn_int3_V_S2"
9. **Guard 9**
   - **Conditions:**
     - "P_LaneIn_int2_V_S2", DontHaveCar
     - "P_Lane_LocusteanuIn_V_S2", IsNull
     - "P_LaneIn_int3_V_S2", CanAddCars
     - "P_TramStationIn_CaleaFerentariOut_V_S2", HaveTram
   - **Activations:**
     - "P_TramStationIn_CaleaFerentariOut_V_S2", PopElementWithoutTargetToQueue, "P_LaneIn_int3_V_S2"

- **Transitions Alike: T1_Out_V_S2**

- **T25_Out_V_S2**
  1. **Guard 1**
     - **Conditions:**
       * "P_Cross_TL_V_S2", Equal, "green"
       * "P_x_Cross_Lane_V_Out_S2", HaveCar
     - **Activations:**
       * "P_x_Cross_Lane_V_In_S2", PopElementWithoutTarget, "P_LaneOut_Int8_V_S2"
       * "P_Cross_TL_V_S2", Move, "P_Cross_TL_V_S2"
       * "P_Cross_PTL_V_S2", Move, "P_Cross_PTL_V_S2"
  2. **Guard 2**
     - **Conditions:**
       * "UserReq_Cross_V_S2", NotNull
     - **Activations:**
       * "P_Cross_TL_V_S2", Move, "P_Cross_TL_V_S2"
       * "P_Cross_PTL_V_S2", Move, "P_Cross_PTL_V_S2"
       * "UserReq_Cross_V_S2", SendOverNetwork, "OP_Req_Cross_V_S2"
  3. **Guard 3**
     - **Conditions:**
       * "P_x_Cross_Lane_V_Out_S2", HavePriorityCar
     - **Activations:**
       * "P_x_Cross_Lane_V_Out_S2", PopElementWithoutTarget, "P_LaneOut_Int8_V_S2"
       * "P_Cross_TL_V_S2", Move, "P_Cross_TL_V_S2"
       * "P_Cross_PTL_V_S2", Move, "P_Cross_PTL_V_S2"
  - **Transitions Alike: T26_In_V_S2**
- **T29_Out_V_S2**
  1. **Guard 1**
     - **Conditions:**
       * "P_LaneOut_Int10_V_S2", HaveCar
       * "P_BusStation_SoseauaProgresului_V_Out_S2", DontHaveBus
       * "P_LaneOut_Int9_V_S2", CanAddCars
       * "P_TramStation_SoseauaProgresului_V_Out_S2", DontHaveTram
     - **Activations:**
       * "P_LaneOut_Int10_V_S2", PopElementWithoutTargetToQueue, "P_LaneOut_Int9_V_S2"
  2. **Guard 2**
     - **Conditions:**
       * "P_LaneOut_Int10_V_S2", DontHaveCar

    - "P_BusStation_SoseauaProgresului_V_Out_S2", HaveBus
    - "P_LaneOut_Int9_V_S2", CanAddCars
    - "P_TramStation_SoseauaProgresului_V_Out_S2", DontHaveTram
  - **Activations:**
    - "P_BusStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"

3. **Guard 3**
  - **Conditions:**
    - "P_LaneOut_Int10_V_S2", HaveCar
    - "P_BusStation_SoseauaProgresului_V_Out_S2", HaveBus
    - "P_LaneOut_Int9_V_S2", CanAddCars
    - "P_TramStation_SoseauaProgresului_V_Out_S2", DontHaveTram
  - **Activations:**
    - "P_BusStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"
    - "P_LaneOut_Int10_V_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"

4. **Guard 5**
  - **Conditions:**
    - "P_LaneOut_Int10_V_S2", HaveCar
    - "P_BusStation_SoseauaProgresului_V_Out_S2", DontHaveBus
    - "P_LaneOut_Int9_V_S2", CanAddCars
    - "P_TramStation_SoseauaProgresului_V_Out_S2", HaveTram
  - **Activations:**
    - "P_TramStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"
    - "P_LaneOut_Int10_V_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"

5. **Guard 6**
  - **Conditions:**
    - "P_LaneOut_Int10_V_S2", DontHaveCar
    - "P_BusStation_SoseauaProgresului_V_Out_S2", HaveBus
    - "P_LaneOut_Int9_V_S2", CanAddCars
    - "P_TramStation_SoseauaProgresului_V_Out_S2", HaveTram
  - **Activations:**
    - "P_TramStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
      "P_LaneOut_Int9_V_S2"

* "P_BusStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
"P_LaneOut_Int9_V_S2"

6. **Guard 7**
   - **Conditions:**
     * "P_LaneOut_Int10_V_S2", HaveCar
     * "P_BusStation_SoseauaProgresului_V_Out_S2", HaveBus
     * "P_LaneOut_Int9_V_S2", CanAddCars
     * "P_TramStation_SoseauaProgresului_V_Out_S2", HaveTram
   - **Activations:**
     * "P_BusStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
"P_LaneOut_Int9_V_S2"
     * "P_TramStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
"P_LaneOut_Int9_V_S2"
     * "P_LaneOut_Int10_V_S2", PopElementWithoutTargetToQueue,
"P_LaneOut_Int9_V_S2"
7. **Guard 9**
   - **Conditions:**
     * "P_LaneOut_Int10_V_S2", DontHaveCar
     * "P_BusStation_SoseauaProgresului_V_Out_S2", DontHaveBus
     * "P_LaneOut_Int9_V_S2", CanAddCars
     * "P_TramStation_SoseauaProgresului_V_Out_S2", HaveTram
   - **Activations:**
     * "P_TramStation_SoseauaProgresului_V_Out_S2", PopElementWithoutTargetToQueue,
"P_LaneOut_Int9_V_S2"

- **Transitions Alike: T6_In_V_S3**

3.4 OETPN Models for Controllers4F and PedestriansController

4 Controller Design

4.1 OETPN Model for Controllers

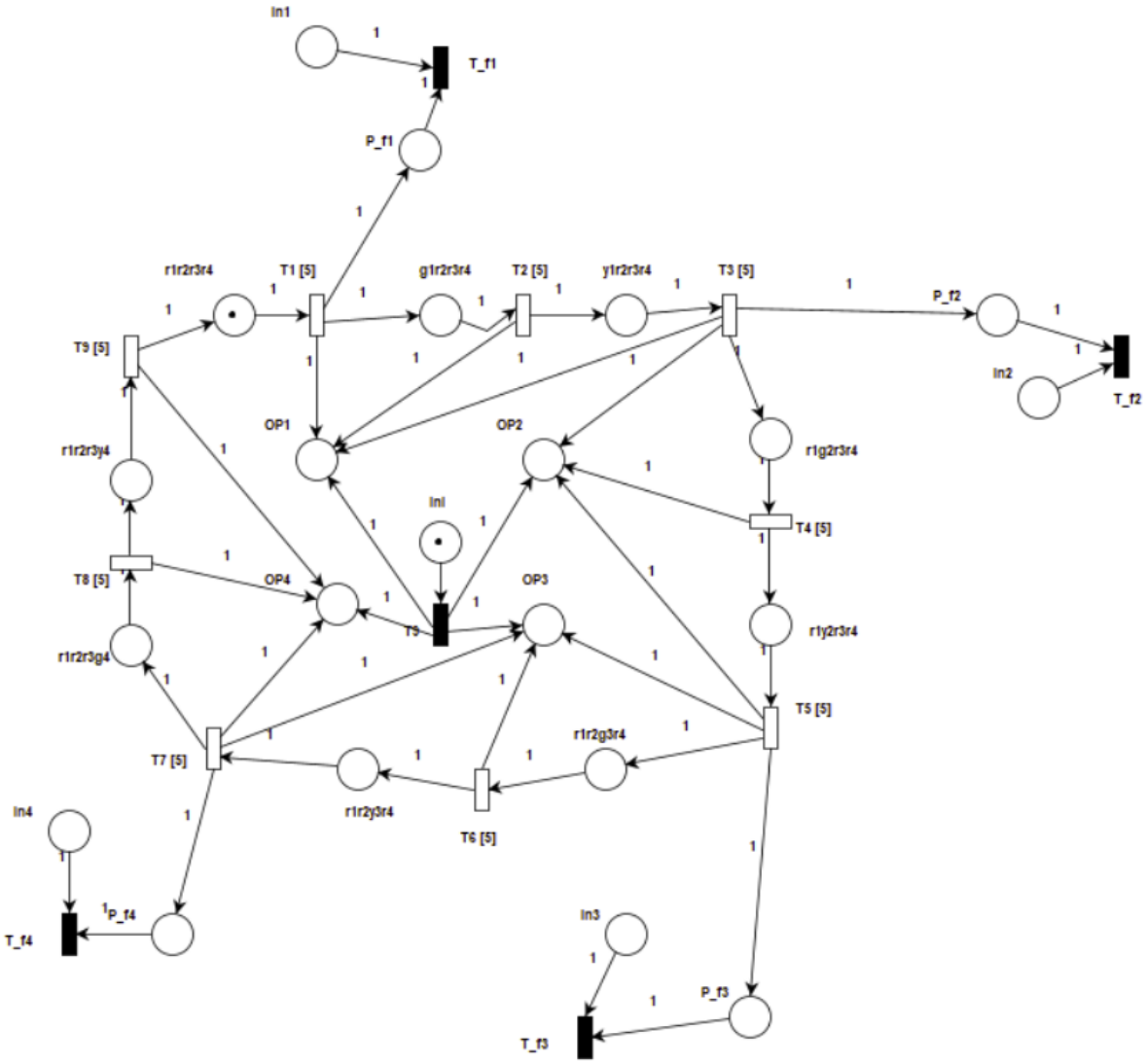

Figure 12: OETPN Model for Controller of Intersection 1 & 2

4.1.1 Controllers4F: Places and Transitions

Place Name	Type	Initial Value
ini	DataString	”red”
red	DataString	”red”
green	DataString	”green”
yellow	DataString	”yellow”
r1r2r3r4	DataString	”signal”
g1r2r3r4	DataString	–
y1r2r3r4	DataString	–
r1g2r3r4	DataString	–
r1y2r3r4	DataString	–
r1r2g3r4	DataString	–
r1r2y3r4	DataString	–
r1r2r3g4	DataString	–
r1r2r3y4	DataString	–
OP1	DataTransfer	(”localhost”, ”1080”, ”P_TL_N_S1”)
OP2	DataTransfer	(”localhost”, ”1080”, ”P_TL_V_S1”)
OP3	DataTransfer	(”localhost”, ”1080”, ”P_TL_S_S1”)
OP4	DataTransfer	(”localhost”, ”1080”, ”P_TL_E_S1”)
in1	DataString	–
in2	DataString	–
in3	DataString	–
in4	DataString	–
P_f1	DataString	–
P_f2	DataString	–
P_f3	DataString	–
P_f4	DataString	–
Five	DataInteger	5
Ten	DataInteger	10

- **iniT**
  1. **Guard 1**
     - **Conditions:**
       * "ini", NotNull
     - **Activations:**
       * "ini", SendOverNetwork, "OP1" (Delay: 0)
       * "ini", SendOverNetwork, "OP2" (Delay: 0)
       * "ini", SendOverNetwork, "OP3" (Delay: 0)
       * "ini", SendOverNetwork, "OP4" (Delay: 0)
       * "", MakeNull, "ini" (Delay: 0)
- **T1**
  1. **Guard 1**
     - **Conditions:**
       * "r1r2r3r4", NotNull
     - **Activations:**
       * "r1r2r3r4", Move, "g1r2r3r4" (Delay: 5)
       * "green", SendOverNetwork, "OP1" (Delay: 5)
       * "r1r2r3r4", Move, "P_f1" (Delay: 5)
- **T2**
  1. **Guard 1**
     - **Conditions:**
       * "g1r2r3r4", NotNull
     - **Activations:**
       * "g1r2r3r4", Move, "y1r2r3r4" (Delay: 5)
       * "yellow", SendOverNetwork, "OP1" (Delay: 5)
- **T3**
  1. **Guard 1**
     - **Conditions:**
       * "y1r2r3r4", NotNull
     - **Activations:**
       * "y1r2r3r4", Move, "r1g2r3r4" (Delay: 5)
       * "red", SendOverNetwork, "OP1" (Delay: 5)
       * "green", SendOverNetwork, "OP2" (Delay: 5)
       * "y1r2r3r4", Move, "P_f2" (Delay: 5)
- **T4**
  1. **Guard 1**
     - **Conditions:**

        * "r1g2r3r4", NotNull
    - **Activations:**
        * "r1g2r3r4", Move, "r1y2r3r4" (Delay: 5)
        * "yellow", SendOverNetwork, "OP2" (Delay: 5)

- **T5**

    1. **Guard 1**
        - **Conditions:**
            * "r1y2r3r4", NotNull
        - **Activations:**
            * "r1y2r3r4", Move, "r1r2g3r4" (Delay: 5)
            * "red", SendOverNetwork, "OP2" (Delay: 5)
            * "green", SendOverNetwork, "OP3" (Delay: 5)
            * "r1y2r3r4", Move, "P_f3" (Delay: 5)

- **T6**

    1. **Guard 1**
        - **Conditions:**
            * "r1r2g3r4", NotNull
        - **Activations:**
            * "r1r2g3r4", Move, "r1r2y3r4" (Delay: 5)
            * "yellow", SendOverNetwork, "OP3" (Delay: 5)

- **T7**

    1. **Guard 1**
        - **Conditions:**
            * "r1r2y3r4", NotNull
        - **Activations:**
            * "r1r2y3r4", Move, "r1r2r3g4" (Delay: 5)
            * "red", SendOverNetwork, "OP3" (Delay: 5)
            * "green", SendOverNetwork, "OP4" (Delay: 5)
            * "r1r2y3r4", Move, "P_f4" (Delay: 5)

- **T8**

    1. **Guard 1**
        - **Conditions:**
            * "r1r2r3g4", NotNull
        - **Activations:**
            * "r1r2r3g4", Move, "r1r2r3y4" (Delay: 5)
            * "yellow", SendOverNetwork, "OP4" (Delay: 5)

- **T9**

1. **Guard 1**
   - **Conditions:**
     * "r1r2r3y4", NotNull
   - **Activations:**
     * "r1r2r3y4", Move, "r1r2r3r4" (Delay: 5)
     * "red", SendOverNetwork, "OP4" (Delay: 5)

- **T_f1**
  1. **Guard 1**
     - **Conditions:**
       * "P_f1", NotNull
       * "in1", IsNull
     - **Activations:**
       * "Five", DynamicDelay, "" (Delay: 5)
  2. **Guard 2**
     - **Conditions:**
       * "in1", NotNull
     - **Activations:**
       * "Ten", DynamicDelay, "" (Delay: 5)

- **T_f2**
  1. **Guard 1**
     - **Conditions:**
       * "P_f2", NotNull
       * "in2", IsNull
     - **Activations:**
       * "Five", DynamicDelay, "" (Delay: 5)
  2. **Guard 2**
     - **Conditions:**
       * "in2", NotNull
     - **Activations:**
       * "Ten", DynamicDelay, "" (Delay: 5)

- **T_f3**
  1. **Guard 1**
     - **Conditions:**
       * "P_f3", NotNull
       * "in3", IsNull
     - **Activations:**
       * "Five", DynamicDelay, "" (Delay: 5)

2. **Guard 2**
   - **Conditions:**
     * "in3", NotNull
   - **Activations:**
     * "Ten", DynamicDelay, "" (Delay: 5)

- **T_f4**

1. **Guard 1**
   - **Conditions:**
     * "P_f4", NotNull
     * "in4", IsNull
   - **Activations:**
     * "Five", DynamicDelay, "" (Delay: 5)
2. **Guard 2**
   - **Conditions:**
     * "in4", NotNull
   - **Activations:**
     * "Ten", DynamicDelay, "" (Delay: 5)

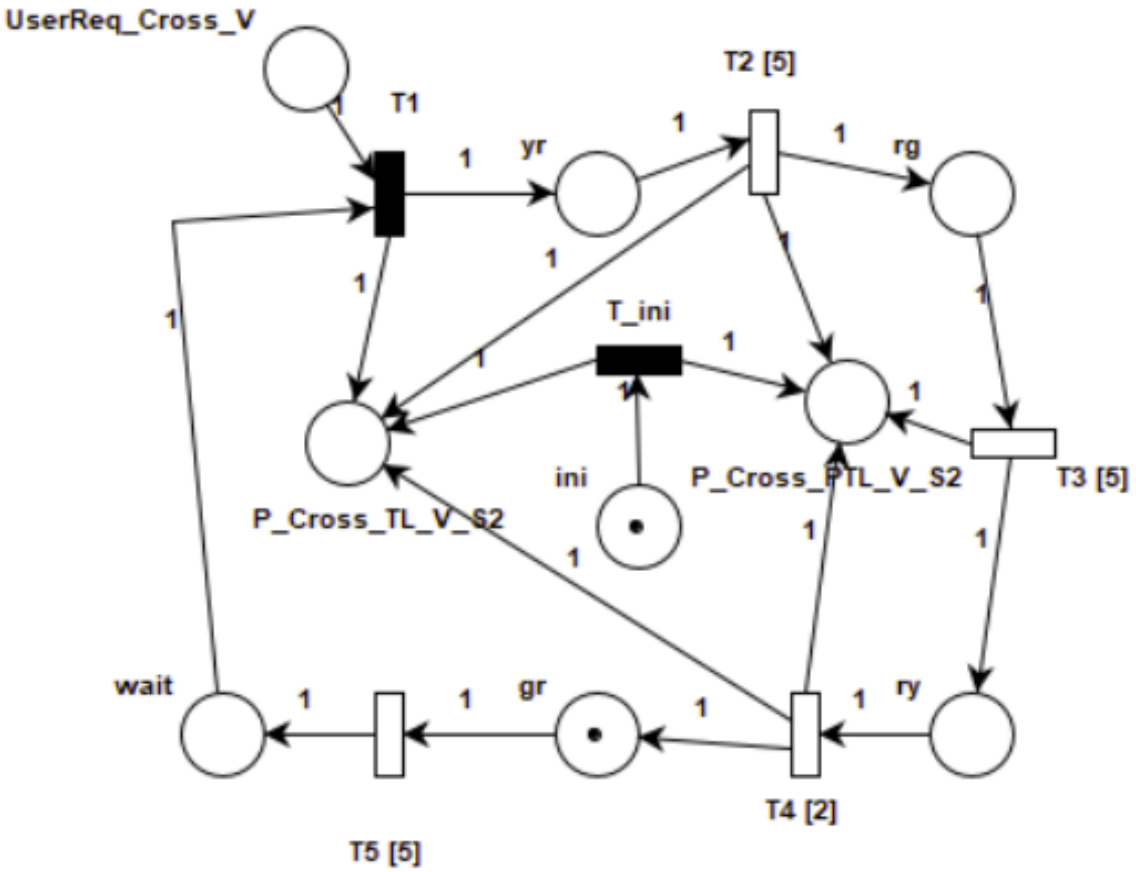

Figure 13: OETPN Model for Controller of Crosswalk

Place Name	**Type**	**Queue Size**	**Initial Value**
UserReq_Cross_V	DataString	–	–
P_ini	DataFloat	–	1.0
red	DataString	–	”red”
green	DataString	–	”green”
yellow	DataString	–	”yellow”
yr	DataString	–	–
rg	DataString	–	–
ry	DataString	–	–
gr	DataString	–	”signal”
wait	DataString	–	–
P_Cross_TL_V_S2	DataTransfer	–	(”localhost”, ”1080”, ”P_Cross_TL_V_S2”)
P_Cross_PTL_V_S2	DataTransfer	–	(”localhost”, ”1080”, ”P_Cross_PTL_V_S2”)

- **iniT**
  1. **Guard 1**
     - **Conditions:**
       - "P_ini", NotNull
     - **Activations:**
       - "green", SendOverNetwork, "P_Cross_TL_V_S2" (Delay: 0)
       - "red", SendOverNetwork, "P_Cross_PTL_V_S2" (Delay: 0)
       - "", MakeNull, "P_ini" (Delay: 0)
- **T1**
  1. **Guard 1**
     - **Conditions:**
       - "wait", NotNull
       - "UserReq_Cross_V", NotNull
     - **Activations:**
       - "wait", Move, "yr" (Delay: 0)
       - "yellow", SendOverNetwork, "P_Cross_TL_V_S2" (Delay: 0)
- **T2**
  1. **Guard 1**
     - **Conditions:**
       - "yr", NotNull
     - **Activations:**
       - "yr", Move, "rg" (Delay: 5)
       - "red", SendOverNetwork, "P_Cross_TL_V_S2" (Delay: 5)
       - "green", SendOverNetwork, "P_Cross_PTL_V_S2" (Delay: 5)
- **T3**
  1. **Guard 1**
     - **Conditions:**
       - "rg", NotNull
     - **Activations:**
       - "rg", Move, "ry" (Delay: 5)
       - "yellow", SendOverNetwork, "P_Cross_PTL_V_S2" (Delay: 5)
- **T4**
  1. **Guard 1**
     - **Conditions:**
       - "ry", NotNull
     - **Activations:**
       - "ry", Move, "gr" (Delay: 2)

        * "red", SendOverNetwork, "P_Cross_PTL_V_S2" (Delay: 2)
        * "green", SendOverNetwork, "P_Cross_TL_V_S2" (Delay: 2)

- **T5**

    1. **Guard 1**
        - **Conditions:**
            * "gr", NotNull
        - **Activations:**
            * "gr", Move, "wait" (Delay: 5)

Notes on Condition Keywords and Operations:

- **NotNull / IsNull**: Check if a place contains or does not contain a token.
- **SendOverNetwork**: Sends a traffic-light color (e.g. "red"/"green"/"yellow") to the specified `DataTransfer` place, which routes it to a remote Petri net.
- **Move / AddElement / PopElement**: Moves tokens from one place to another.
- **DynamicDelay**: Updates the target transition's firing delay depending on whether an input place (`inX`) is null or not (in these examples, it's either 5 or 10).
- **IsAsync**: Means the transition does not wait in ordinary Petri Net scheduling; it can fire based on external triggers or time events.

5 Testing of the Application

5.1 Testing the Priority Vehicle Handling System.

During the testing of the priority vehicle, all semaphore lights displayed red. This occurred because the controller had not beenactivated, and the semaphores are initialized with a default red light state.

- Tick 1
  - **Place**: P_LaneIn_S1
  - **Transition**: N/A
- Tick 2
  - **Place**: N/A
  - **Transition**: N/A
- Tick 3
  - **Place**: P_LaneIn_int1_V_S1
  - **Transition**: T0_In_V_S1
- Tick 4
  - **Place**: P_LaneIn_int2_V_S1
  - **Transition**: T2_In_V_S1
- Tick 5
  - **Place**: P_LaneIn_int3_V_S1
  - **Transition**: T8_In_V_S1
- Tick 6
  - **Place**: P_LaneIn_int4_V_S1
  - **Transition**: T10_In_V_S1
- Tick 7
  - **Place**: P_LaneIn_int5_V_S1
  - **Transition**: T12_In_V_S1
- Tick 8
  - **Place**: P_x_Lane_V_S1
  - **Transition**: T16_In_V_S1
- Tick 9
  - **Place**: N/A
  - **Transition**: T18_In_V_S1

- Tick 10
  - **Place**: P_I_S1
  - **Transition**: T20_In_V_S1
- Tick 11
  - **Place**: P_O_Lane_E_S1
  - **Transition**: T3_Out_E_S1
- Tick 12
  - **Place**: P_LaneIn_int1_V_S2
  - **Transition**: T1_Out_E_S1
- Tick 13
  - **Place**: P_LaneIn_int2_V_S2
  - **Transition**: T6_In_V_S2
- Tick 14
  - **Place**: P_LaneIn_int3_V_S2
  - **Transition**: T8_In_V_S2
- Tick 15
  - **Place**: P_LaneIn_int4_V_S2
  - **Transition**: T10_In_V_S2
- Tick 16
  - **Place**: P_LaneIn_int5_V_S2
  - **Transition**: T16_In_V_S2
- Tick 17
  - **Place**: P_LaneIn_int6_V_S2
  - **Transition**: T18_In_V_S2
- Tick 18
  - **Place**: P_LaneIn_int7_V_S2
  - **Transition**: T22_In_V_S2
- Tick 19
  - **Place**: P_x_Cross_Lane_V_In_S2
  - **Transition**: T24_In_V_S2
- Tick 20

  - **Place**: P_LaneIn_int8_V_S2
  - **Transition**: T26_In_V_S2
- Tick 21
  - **Place**: P_LaneIn_int9_V_S2
  - **Transition**: T28_In_V_S2
- Tick 22
  - **Place**: P_LaneIn_int10_V_S2
  - **Transition**: T32_In_V_S2
- Tick 23
  - **Place**: P_LaneIn_int11_V_S2
  - **Transition**: T34_In_V_S2
- Tick 24
  - **Place**: P_LaneIn_int12_V_S2
  - **Transition**: T38_In_V_S2
- Tick 25
  - **Place**: P_LaneIn_int13_V_S2
  - **Transition**: T42_In_V_S2
- Tick 26
  - **Place**: P_LaneIn_int14_V_S2
  - **Transition**: T44_In_V_S2
- Tick 27
  - **Place**: P_LaneIn_int15_V_S2
  - **Transition**: T48_In_V_S2
- Tick 28
  - **Place**: P_LaneIn_int16_V_S2
  - **Transition**: T50_In_V_S2
- Tick 29
  - **Place**: P_x_Lane_V_S2
  - **Transition**: T52_In_V_S2
- Tick 30
  - **Place**: N/A

  - **Transition**: T54_In_V_S2
- Tick 31
  - **Place**: P_I_S2
  - **Transition**: T55_In_V_S2
- Tick 32
  - **Place**: P_O_Lane_E_S2
  - **Transition**: T3_Out_E_S2
- Tick 33
  - **Place**: P_LaneIn_int1_V_S3
  - **Transition**: T1_Out_E_S2
- Tick 34
  - **Place**: P_LaneIn_int2_V_S3
  - **Transition**: T2_In_V_S3
- Tick 35
  - **Place**: P_LaneIn_int3_V_S3
  - **Transition**: T6_In_V_S3
- Tick 36
  - **Place**: P_LaneIn_int4_V_S3
  - **Transition**: T14_In_V_S3
- Tick 37
  - **Place**: P_LaneIn_int5_V_S3
  - **Transition**: T16_In_V_S3
- Tick 38
  - **Place**: P_LaneIn_int5_V_S3
  - **Transition**: N/A
- Tick 39
  - **Place**: P_LaneIn_int5_V_S3
  - **Transition**: N/A
- Tick 40
  - **Place**: N/A
  - **Transition**: N/A

5.1.1 Traffic Jam Intersection 1

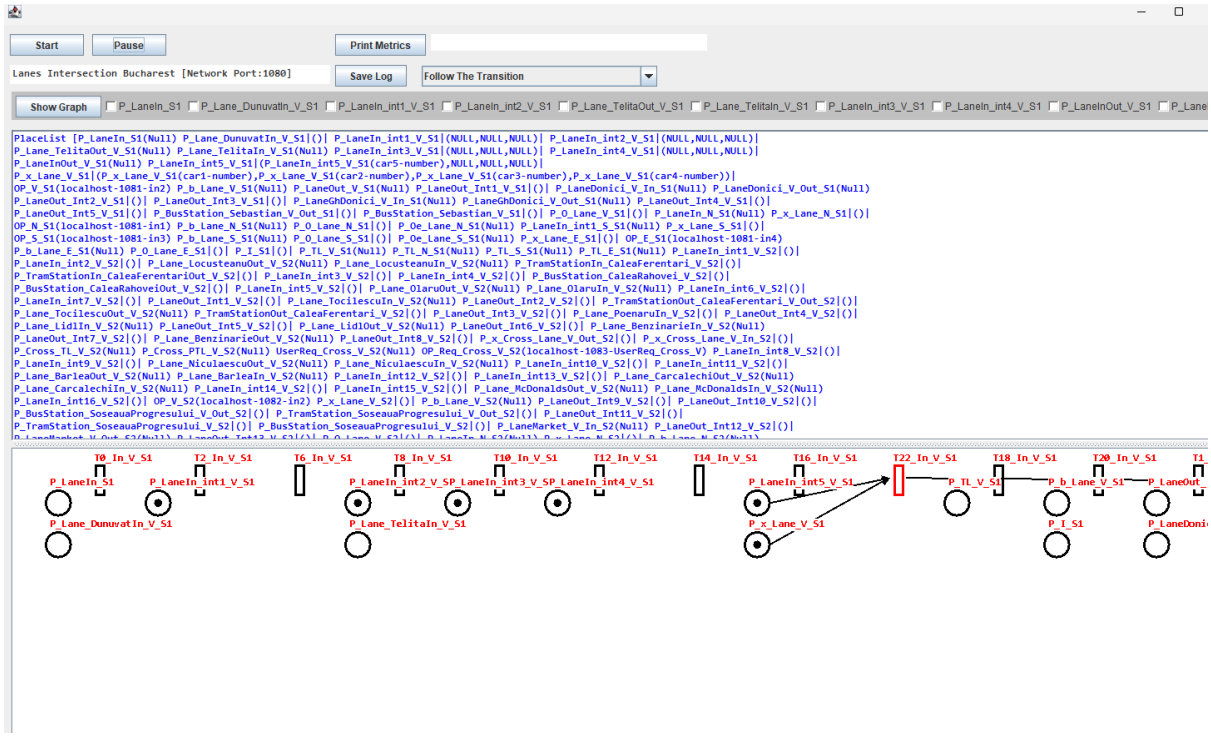

Figure 14: Intersection 1 at full vehicular capacity.

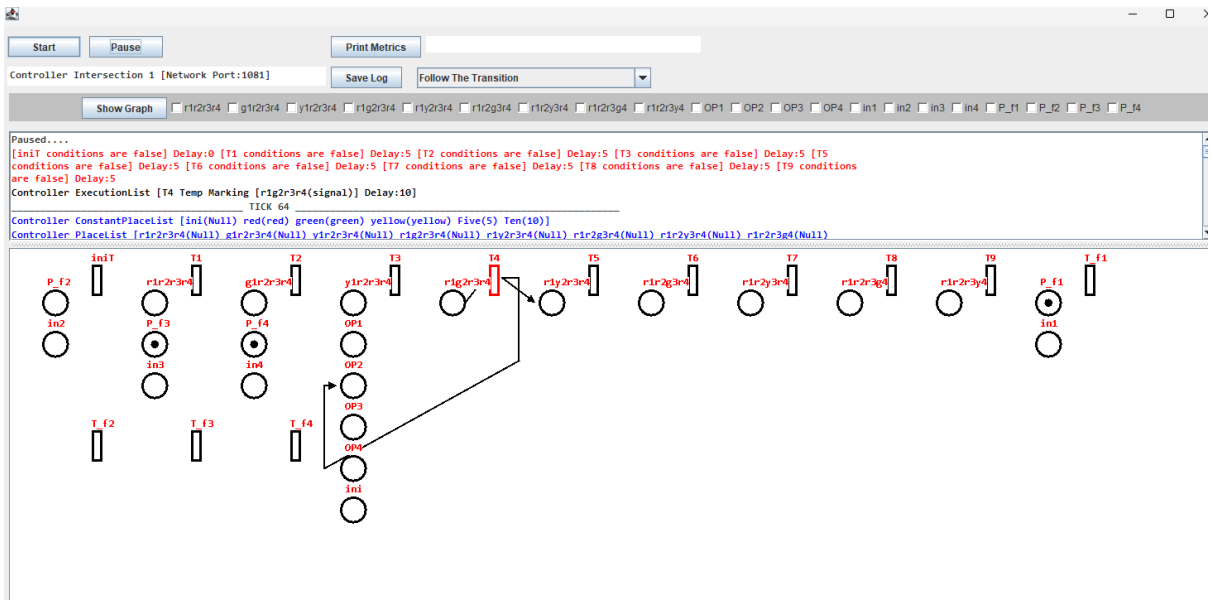

Figure 15: Representation of Controller4F adjusting the transition delay to 10 seconds in response to congestion signals.

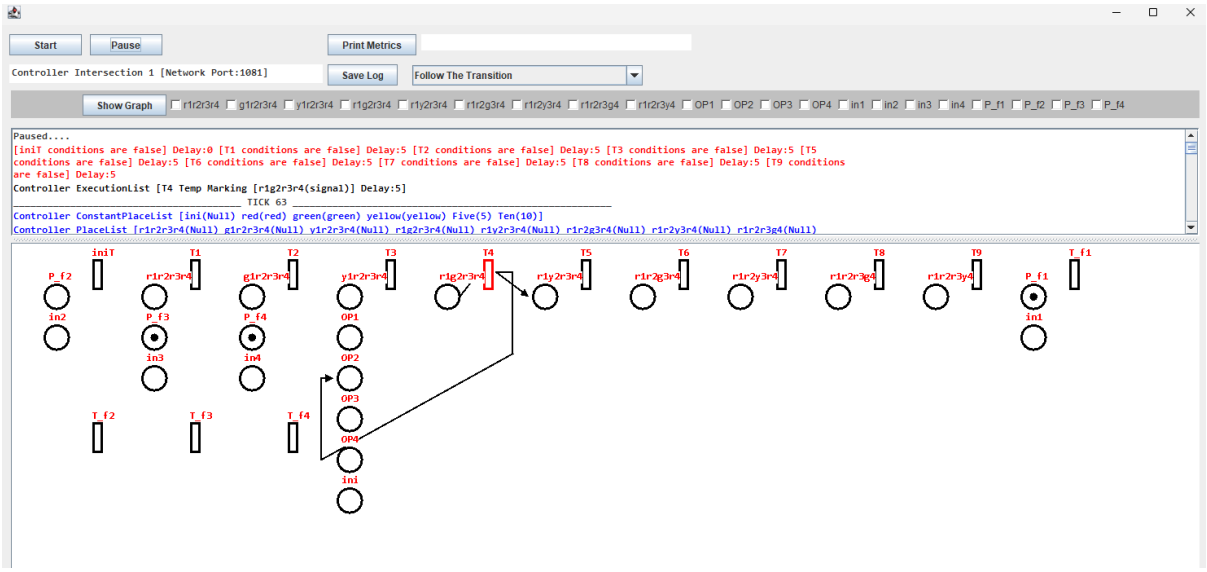

Figure 16: Visualization of Controller4F resuming standard transition delays after resolving congestion.

5.1.2 Traffic Jam intersection 2.

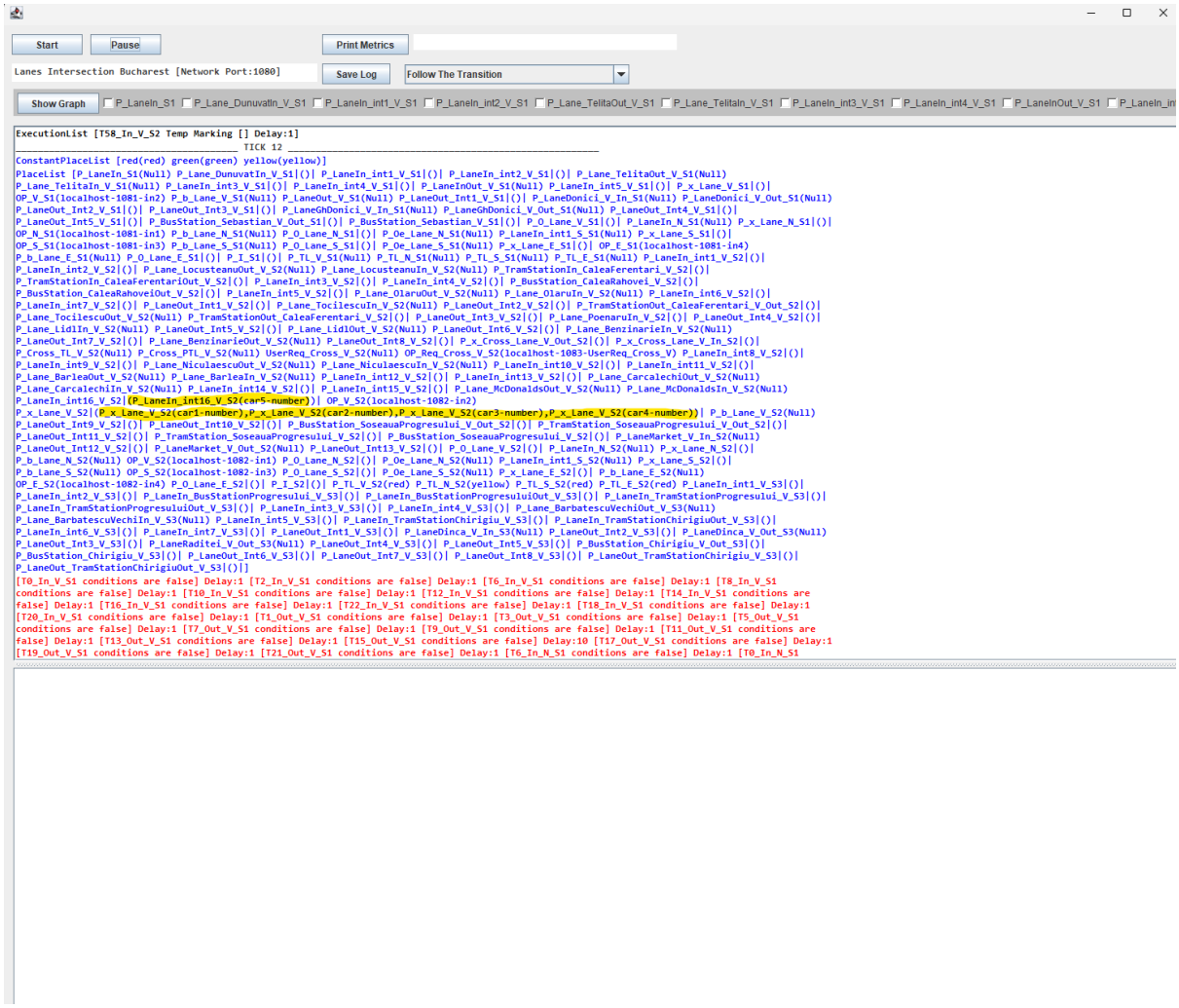

Figure 17: Intersection 2 at full vehicular capacity.

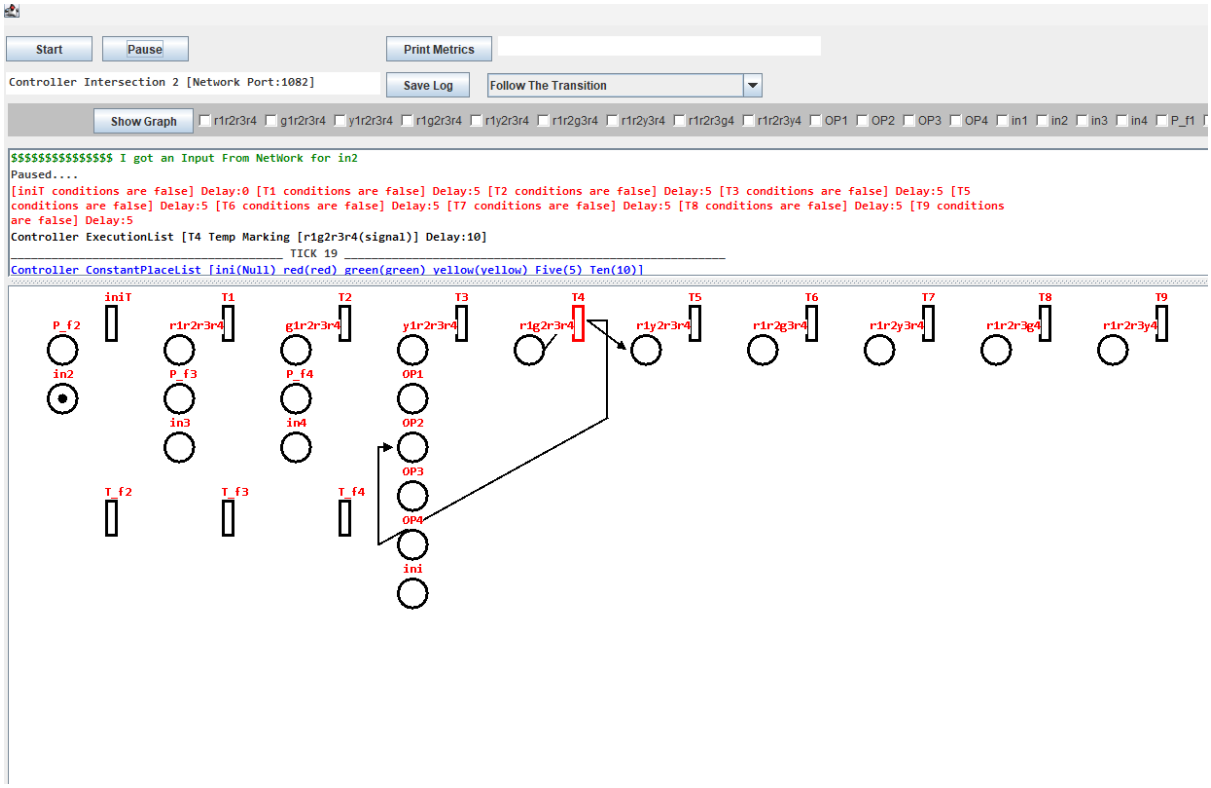

Figure 18: Visualization of Controller4F resuming standard transition delays after resolving congestion.

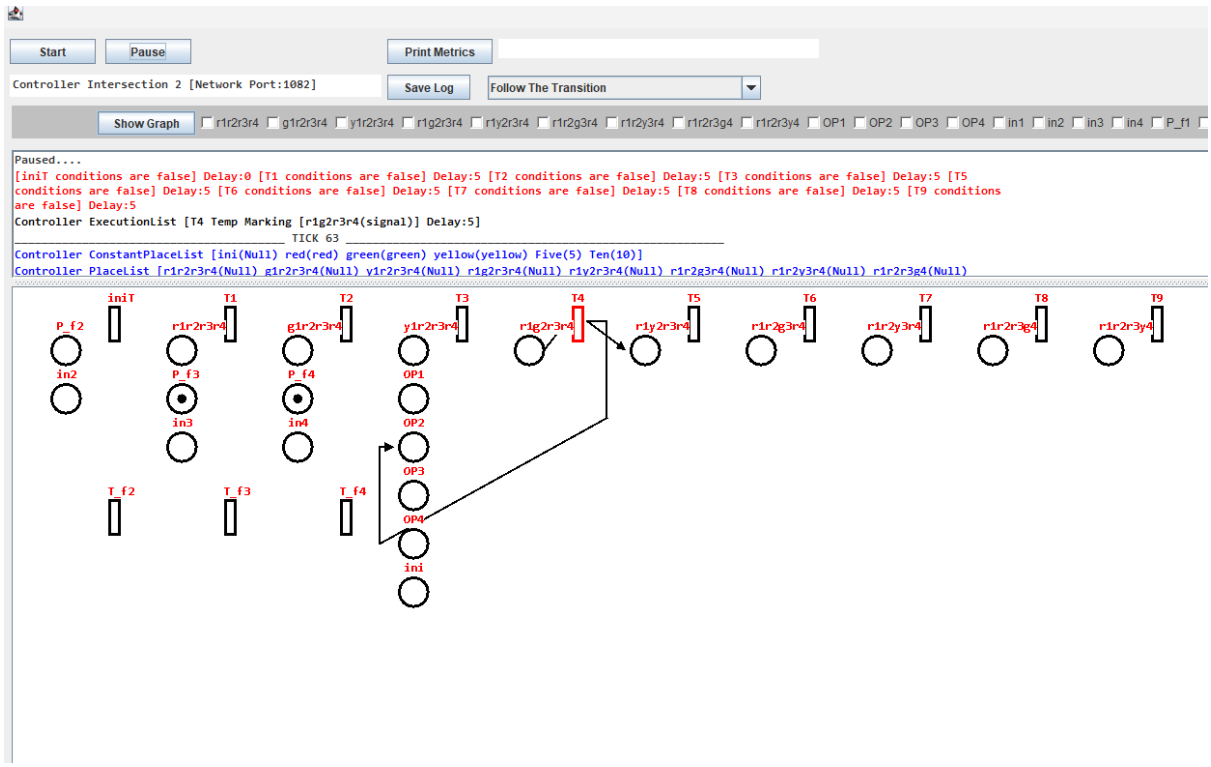

Figure 19: Visualization of Controller4F resuming standard transition delays after resolving congestion.

5.2 Testing the Bus Stations

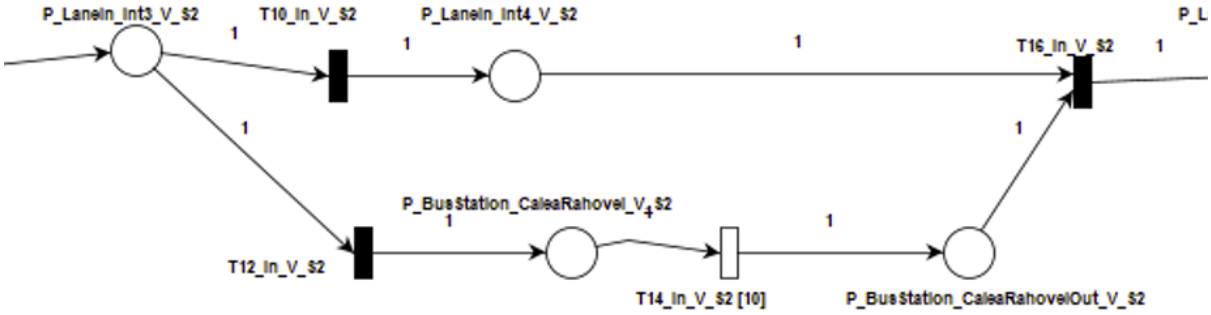

Figure 20: Bus station in question

Figure 21: Bus before entering the station

Figure 22: Bus in station

Figure 23: Bus leaving the station after 10 TICKS

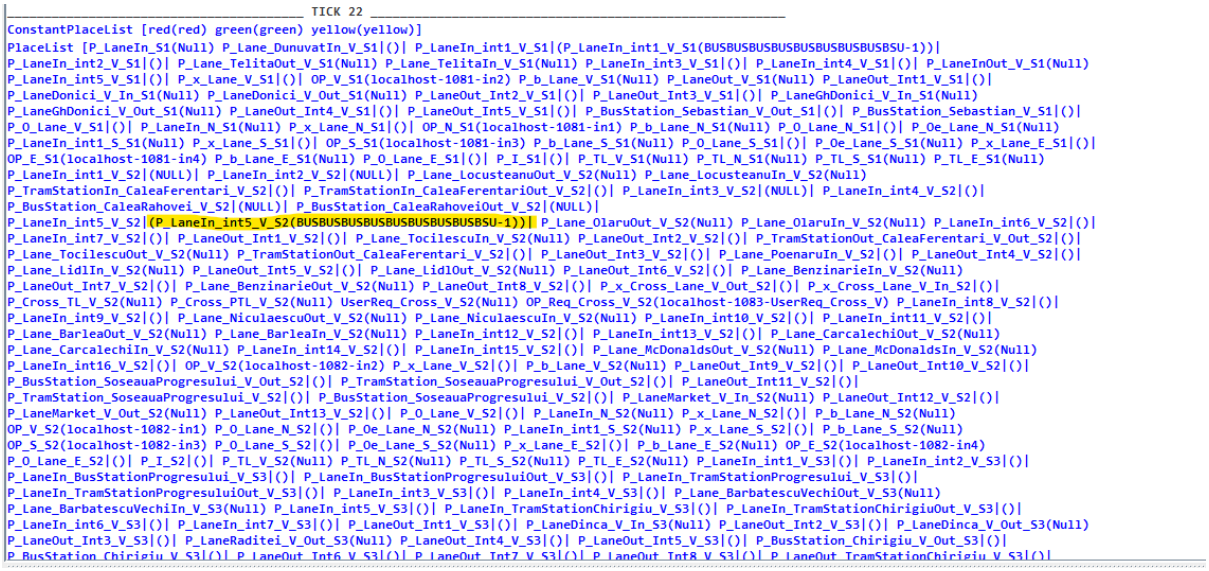

Figure 24: Bus out of station

5.3 Testing the Tram Stations

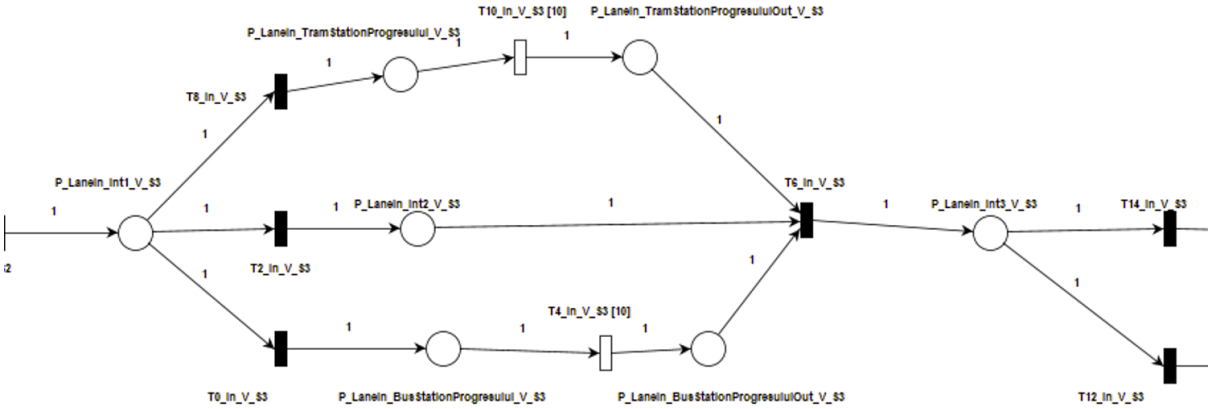

Figure 25: Tram Station in question

Figure 26: Tram before entering the station

Figure 27: Tram in station

Figure 28: Tram leaving the station after 10 TICKS

Figure 29: Tram out of station