Software Engineering, Department of Computer Engineering

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TRAFFIC LIGHTS FOR SAFETY AND EFFICIENCY

REQUIREMENT SPECIFICATION DOCUMENT

Contents

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1. INTRODUCTION

This document specifies the requirements for making traffic flow safe and efficient in a conjunction by using Axel's goal-oriented requirement engineering model. In this section, system-as-is and system-to-be will be depicted.

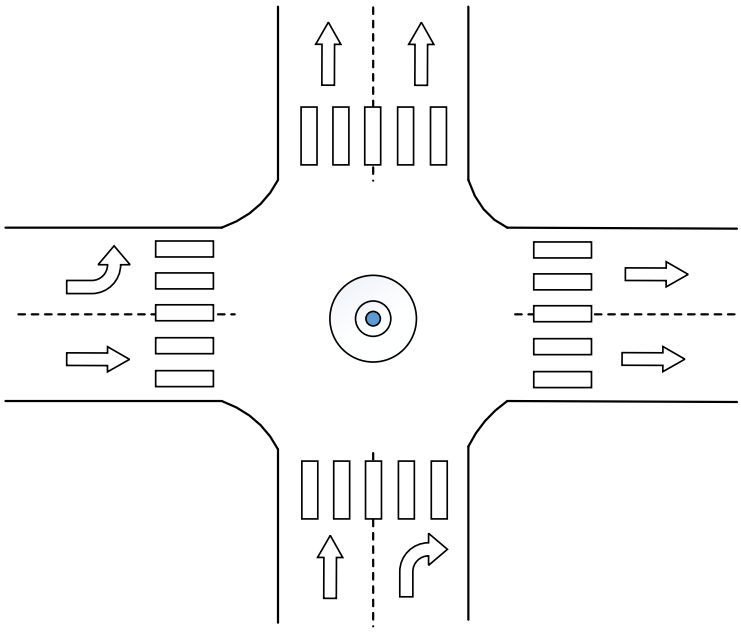


Figure 1 System-as-is

You can see a visual depiction of system-as-is above. It is quite obvious that the activities of drivers and pedestrians at this intersection will be ruled by disharmony. Trying to improve the experience at this intersection leads us to come up with a new system and we call this new system being talked of as system-to-be.

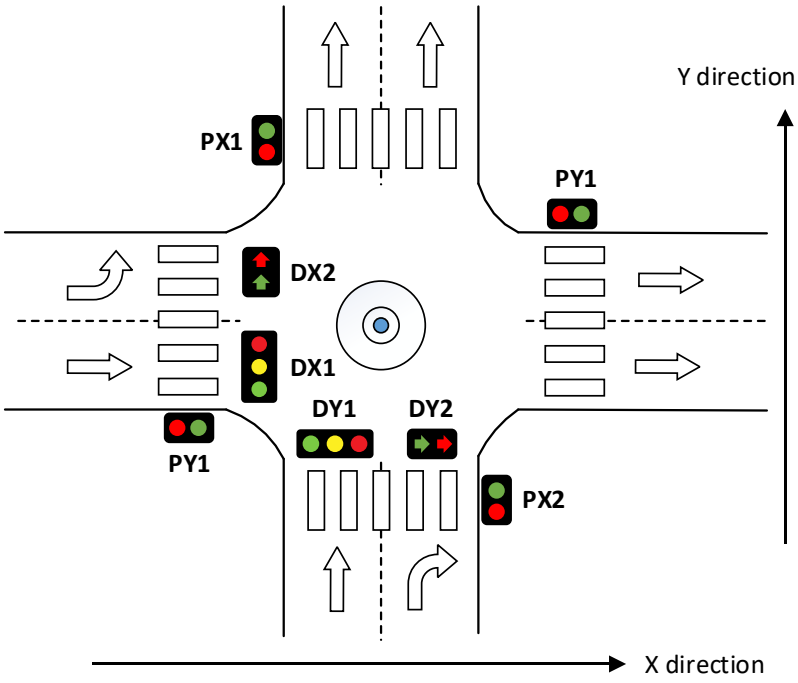


Figure 2 System-to-be

In system-to-be, traffic lights will be used to make the system-as-is safe and efficient. Traffic flow will be able to be controlled easily, correctly and fairly thanks to traffic lights. We will have 8 traffic light in the

system as actuators, and sensors to measure the count of pedestrians waiting for and congestions on the roads. Only green and red lights will be used as actuators, yellow lights will not be used in the system-to-be.

Each letter next to lights shows the name of the light (e.g. PX1 indicates the lights for the pedestrians waiting for crossing on X direction). The light-name for drivers starts with letter D and one for the pedestrians starts with the letter P. Arrows on the roads indicates the directions that the drivers can go.

The document will constitute of seven sections with the introduction. After the introduction section, you will find the section Goal Model that will give you details of the system goals from business ones to technical ones. In the third section, the obstacles of the system together with the solutions for some of them will be addressed. In the fourth section, you will find the agents and relationships of them each other. Fifth and sixth sections will identify conceptual and operation models that are necessary to carry out the system requirements. The seventh and last section is the conclusion part of the document that gives you a summary of what you read.

2. GOAL MODEL

We are going to address each sub goal separately because it is not possible to fit all of the goals into a single page. Annotations will be interleaved.

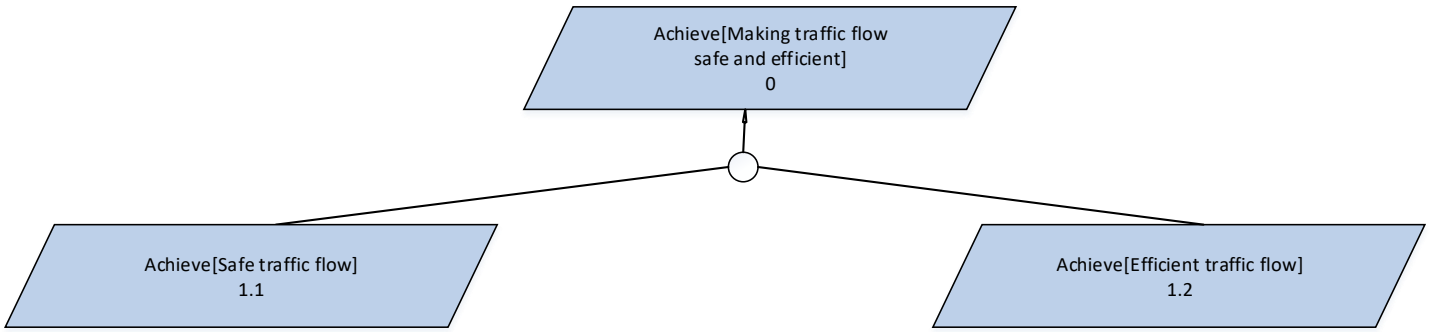


Figure 3 Main Goal - Making traffic flow safe and efficient

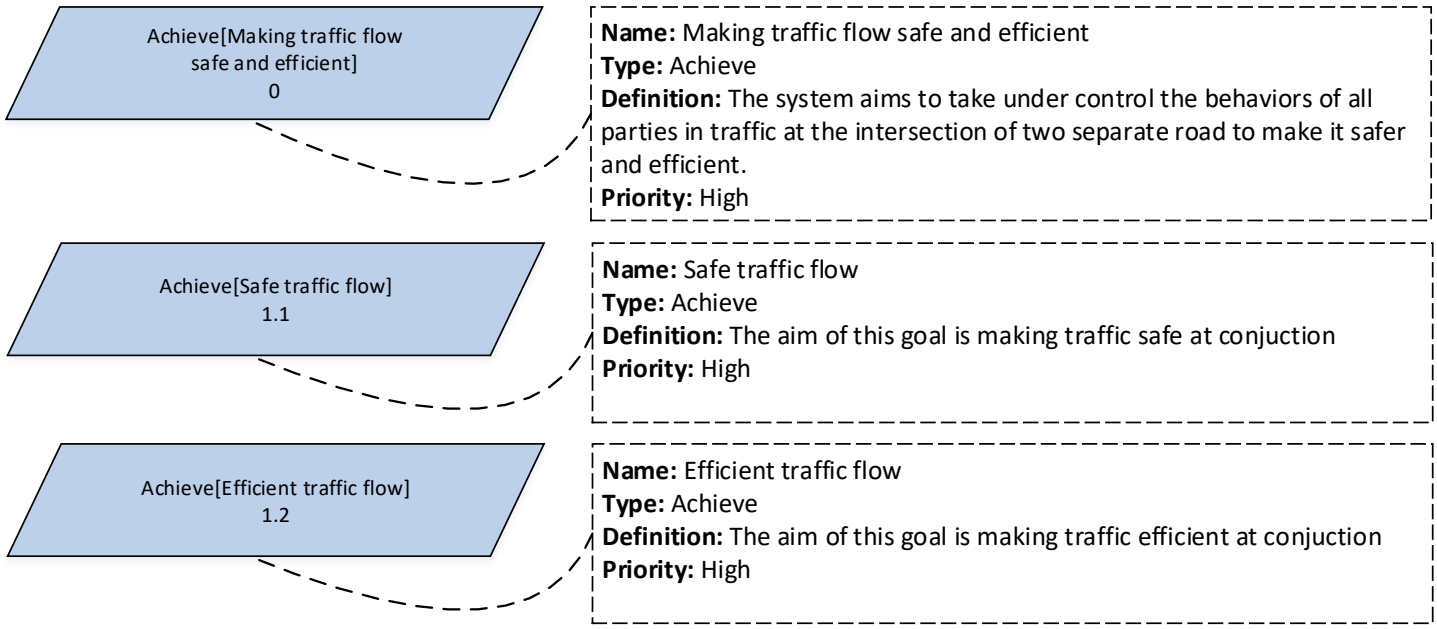


Figure 4 Annotation of Main Goal - Making traffic flow safe and efficient

2.1 Sub goal - Safe traffic flow

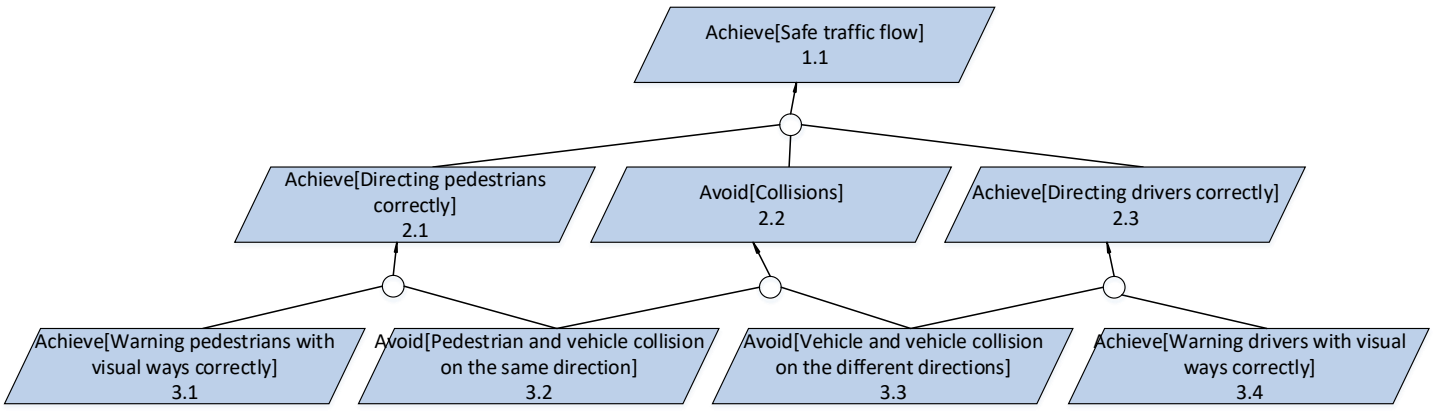


Figure 5 Sub goals of safe traffic flow

Achieve[Directing pedestrians correctly]
2.1

Name: Directing pedestrians correctly
Type: Achieve
Definition: The aim of this goal is directing pedestrians correctly.
Priority: High

Avoid[Collisions]
2.2

Name: Collisions
Type: Avoid
Definition: The aim of this goal is avoiding collision of pedestrians and vehicles.
Priority: High

Achieve[Directing drivers correctly]
2.3

Name: Directing drivers correctly
Type: Achieve
Definition: The aim of this goal is directing drivers correctly.
Priority: High

Achieve[Warning pedestrians with visual ways correctly]
3.1

Name: Warning pedestrians with visual ways correctly
Type: Achieve
Definition: The aim of this goal is warning pedestrians with visual ways to allow them to know whether they may cross or not.
Priority: High

Avoid[Pedestrian and vehicle collision on the same direction]
3.2

Name: Pedestrian and vehicle collision on the same direction
Type: Avoid
Definition: The aim of this goal is avoiding collision of pedestrians and vehicles on the same road.
Priority: High

Avoid[Vehicle and vehicle collision on the different directions]
3.3

Name: Vehicle and vehicle collision on the different directions
Type: Avoid
Definition: The aim of this goal is avoiding collision of vehicle and vehicles on going to different directions.
Priority: High

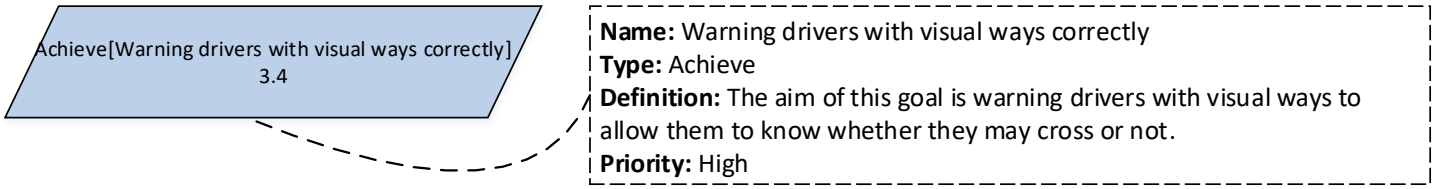


Figure 6 Annotations of sub goals of safe traffic flow

2.1.1 Sub goal - Warning pedestrians with visual ways correctly

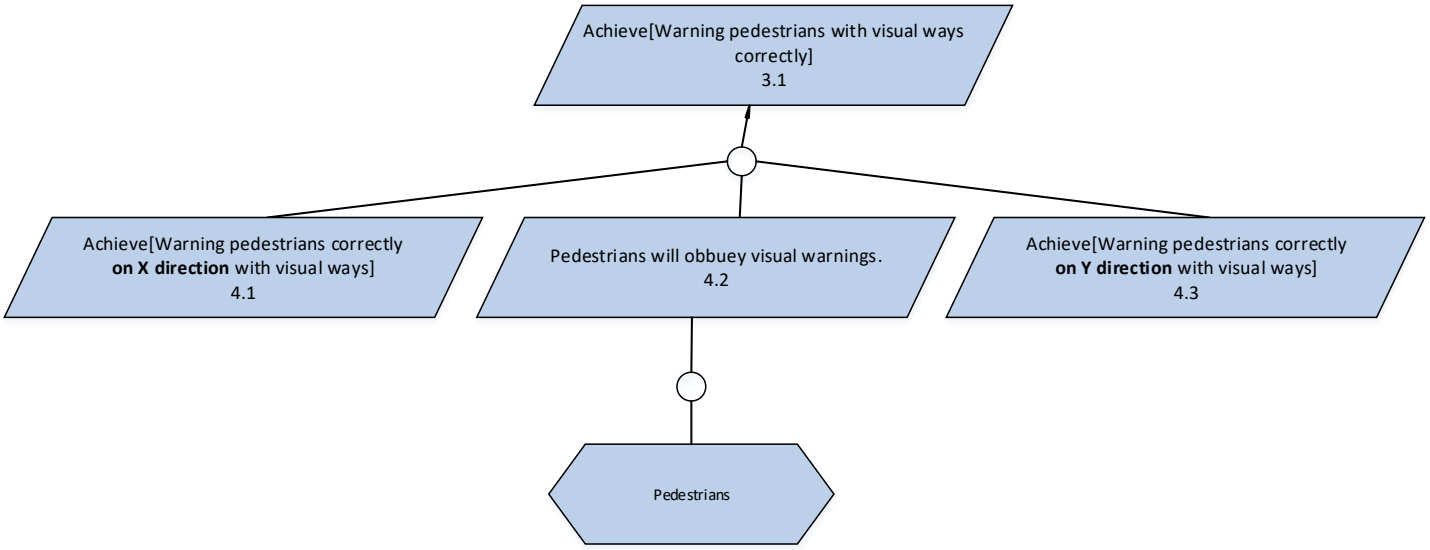


Figure 7 Sub goals of warning pedestrians with visual ways correctly

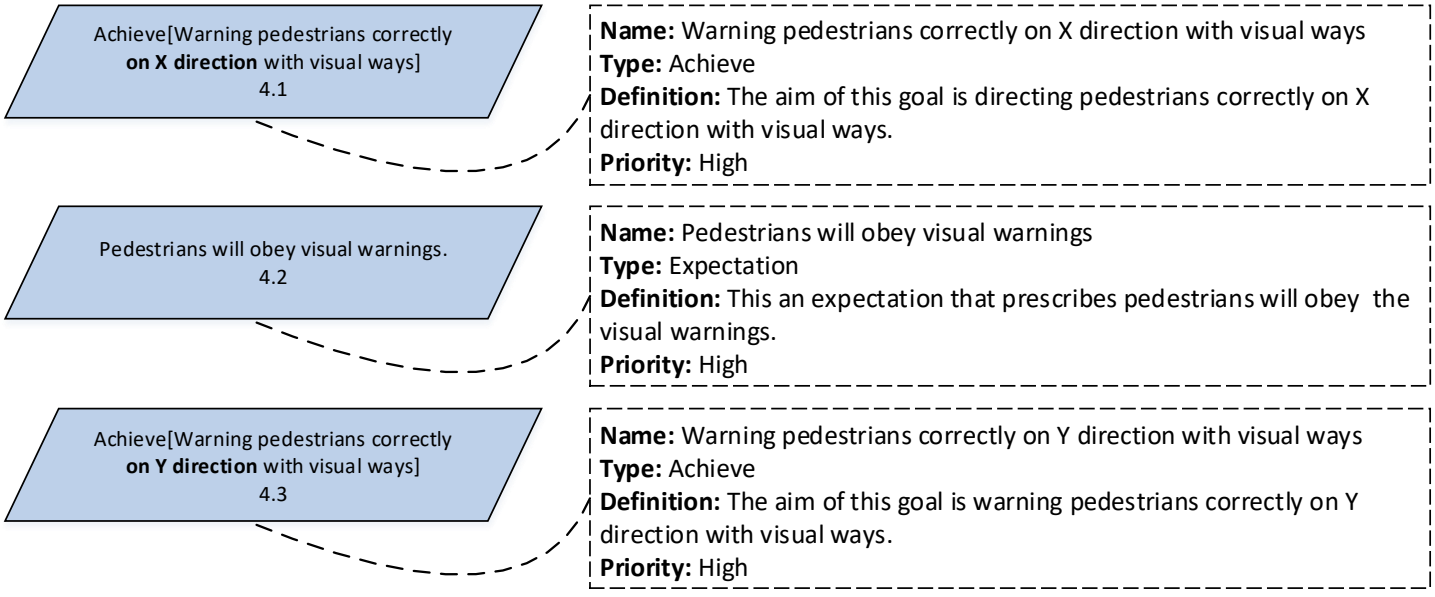


Figure 8 Annotations of sub goals of warning pedestrians with visual ways correctly

2.1.1.1 Sub goal - Warning pedestrians correctly on X direction with visual ways

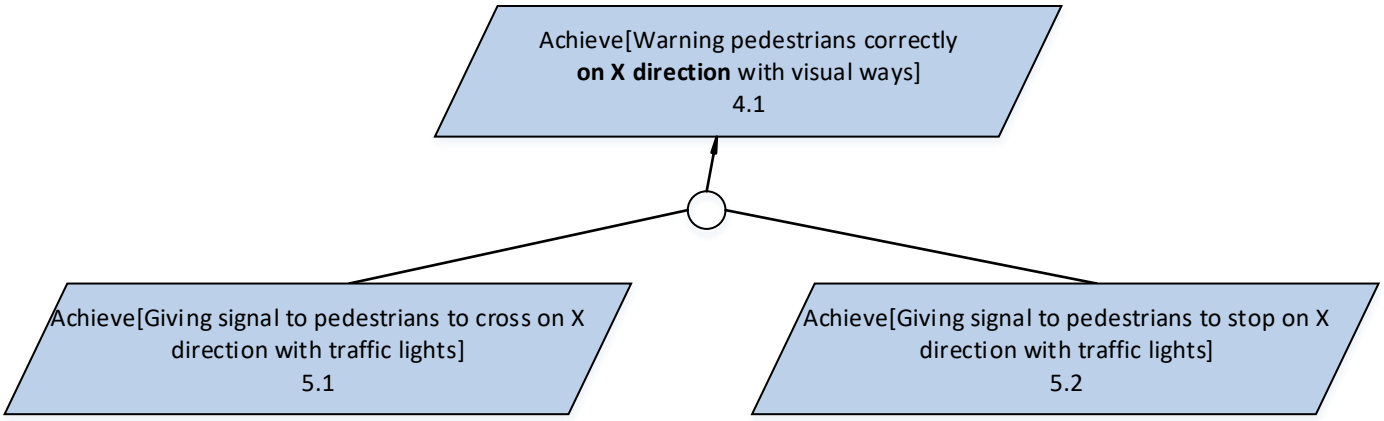


Figure 9 Sub goals of warning pedestrians correctly on X direction with visual ways

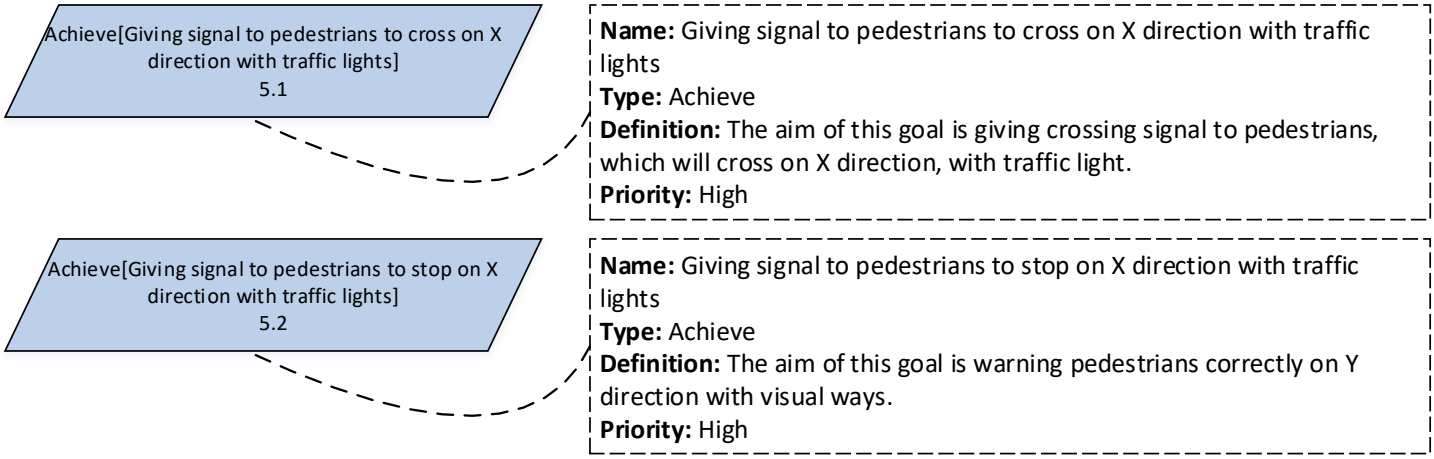


Figure 10 Annotations of sub goals of warning pedestrians correctly on X direction with visual ways

2.1.1.1.1 Sub goal - Giving signal to pedestrians to cross on X direction with traffic lights

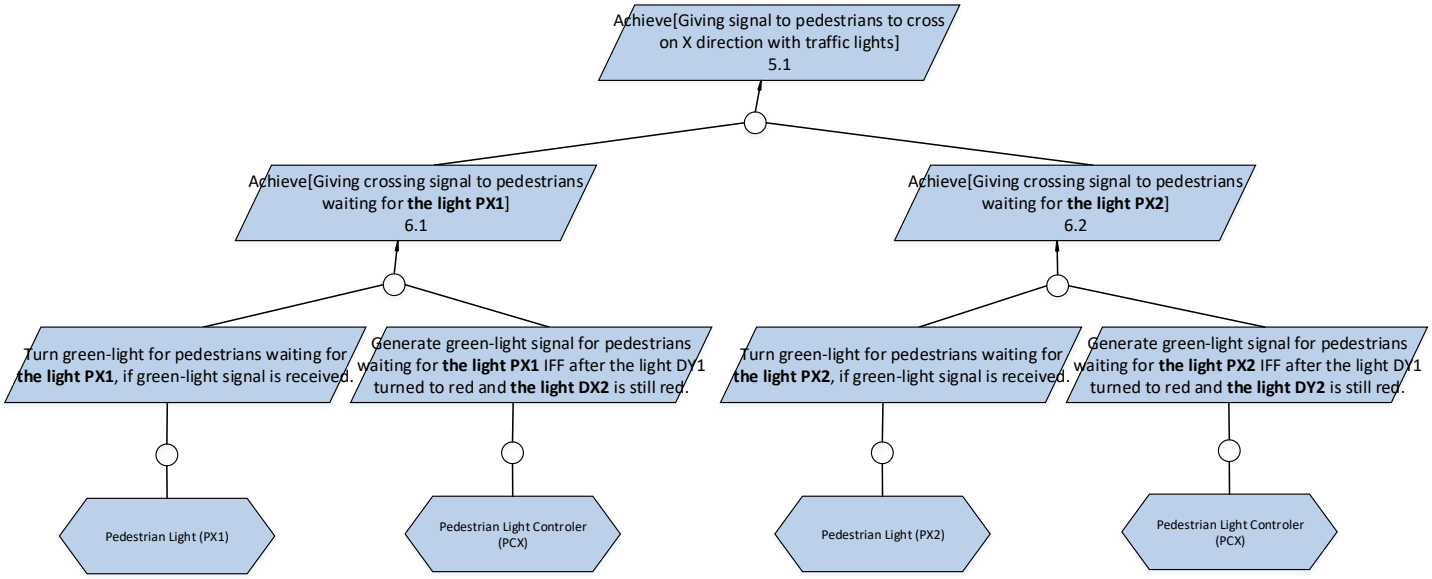


Figure 11 Sub goals of giving signal to pedestrians to cross on X direction with traffic lights

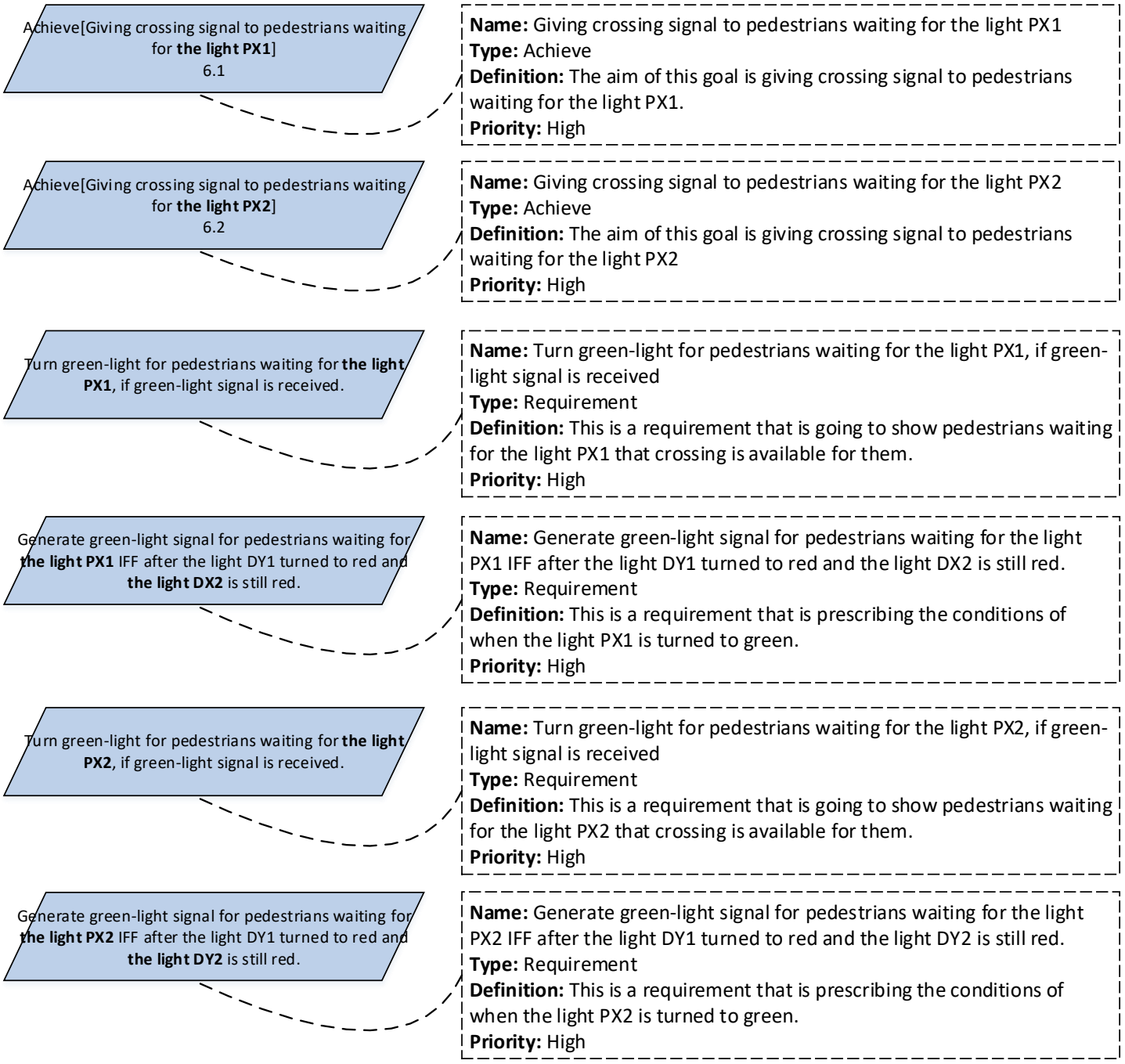


Figure 12 Annotations of sub goals of giving signal to pedestrians to cross on X direction with traffic lights

2.1.1.1.2 Sub goal - Giving signal to pedestrians to stop on X direction with traffic lights

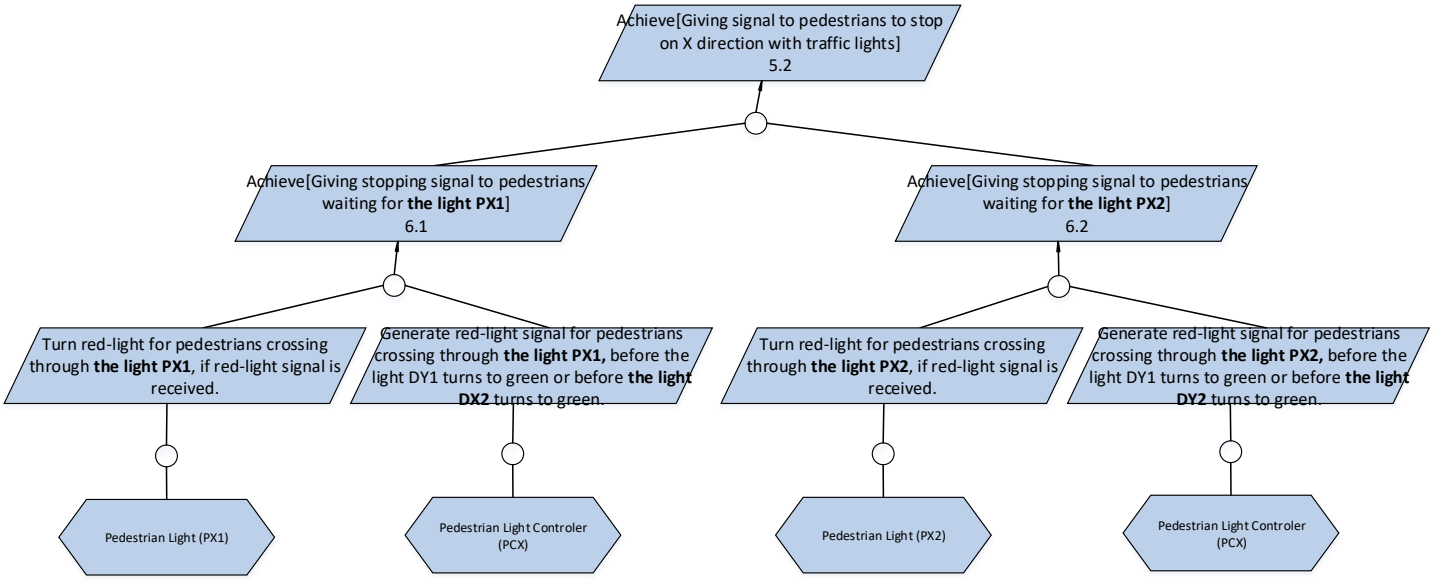


Figure 13 Sub goals of giving signal to pedestrians to stop on X direction with traffic lights

Achieve[Giving stopping signal to pedestrians waiting for **the light PX1**]
6.1

Name: Giving stopping signal to pedestrians waiting for the light PX1
Type: Achieve
Definition: The aim of this goal is giving stopping signal to pedestrians waiting for the light PX1.
Priority: High

Achieve[Giving stopping signal to pedestrians waiting for **the light PX2**]
6.2

Name: Giving crossing signal to pedestrians waiting for the light PX2
Type: Achieve
Definition: The aim of this goal is giving crossing signal to pedestrians waiting for the light PX2
Priority: High

Turn red-light for pedestrians crossing through **the light PX1**, if red-light signal is received.

Name: Turn red-light for pedestrians crossing through the light PX1, if red-light signal is received
Type: Requirement
Definition: This is a requirement that is going to show pedestrians crossing through the light PX1 that crossing is unavailable for them and stop.
Priority: High

Generate red-light signal for pedestrians crossing through **the light PX1,** before the light DY1 turns to green or before **the light DX2** turns to green.

Name: Generate red-light signal for pedestrians crossing through the light PX1, before the light DY1 turns to green and before the light DX2 turns to green.
Type: Requirement
Definition: This is a requirement that is prescribing the conditions of when the light PX1 is turned to red.
Priority: High

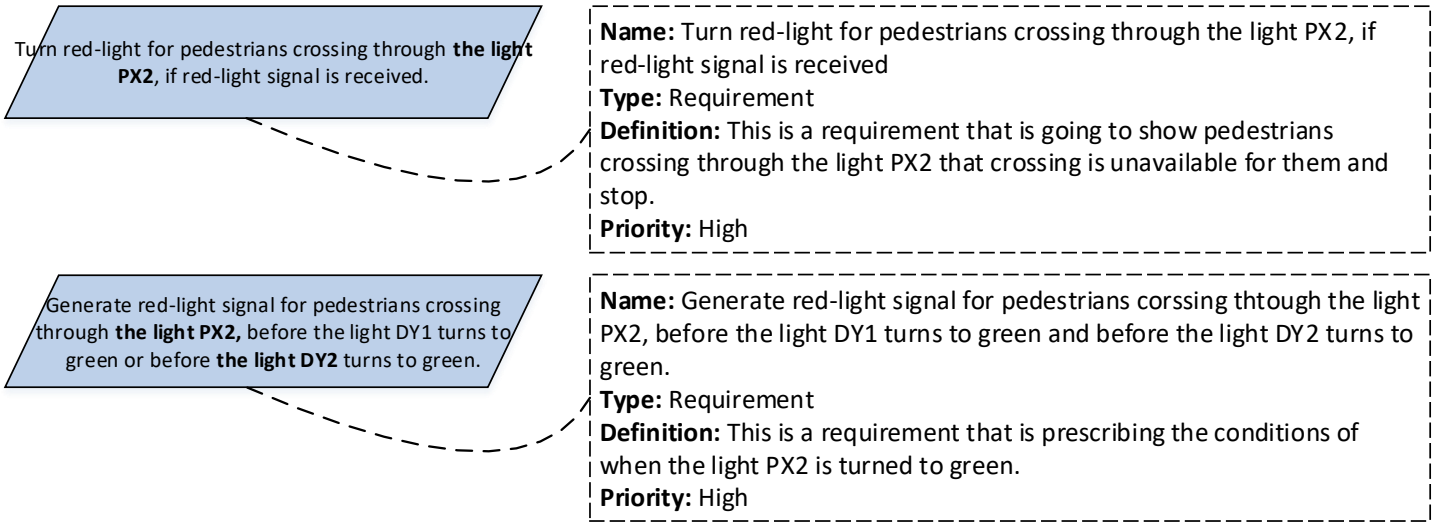


Figure 14 Annotations of sub goals of giving signal to pedestrians to stop on X direction with traffic lights

2.1.1.2 Sub goal - Warning pedestrians correctly on Y direction with visual ways

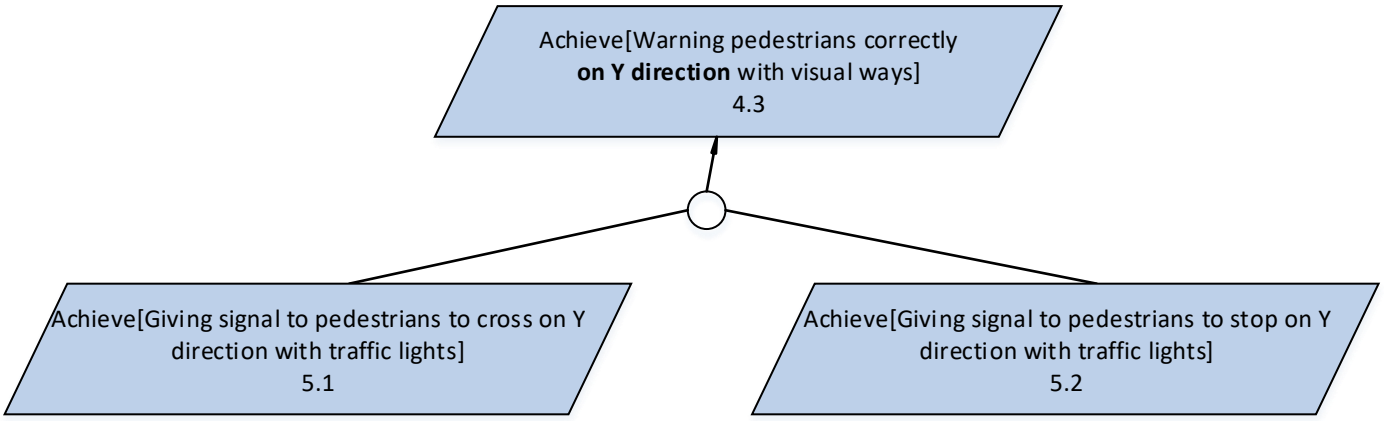


Figure 15 Sub goals of warning pedestrians correctly on Y direction with visual ways

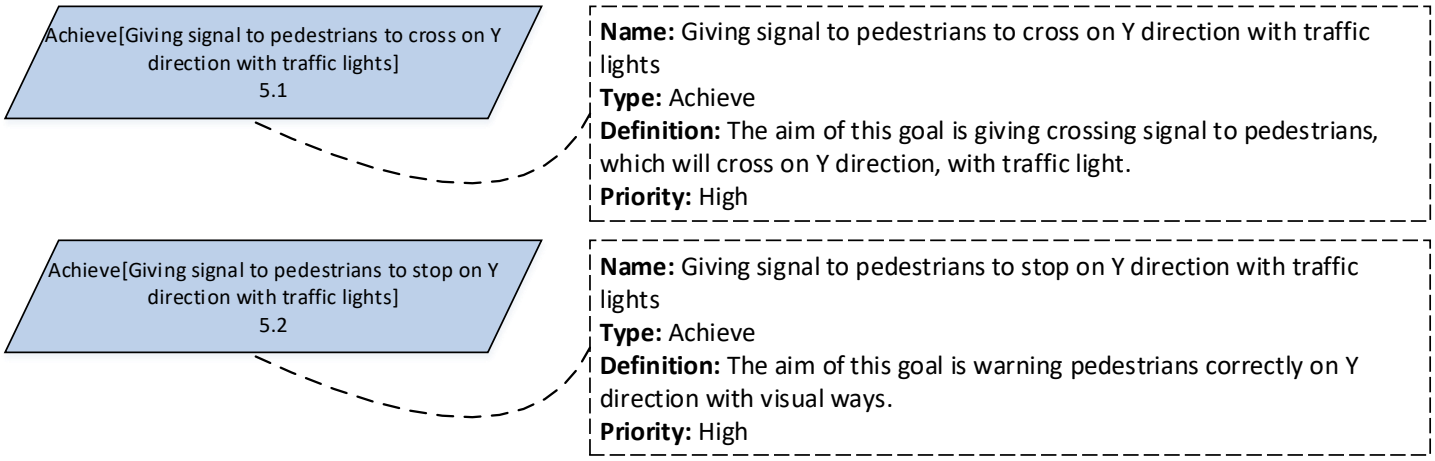


Figure 16 Annotations of sub goals of warning pedestrians correctly on Y direction with visual ways

2.1.1.2.1 Sub goal - Giving signal to pedestrians to cross on Y direction with traffic lights

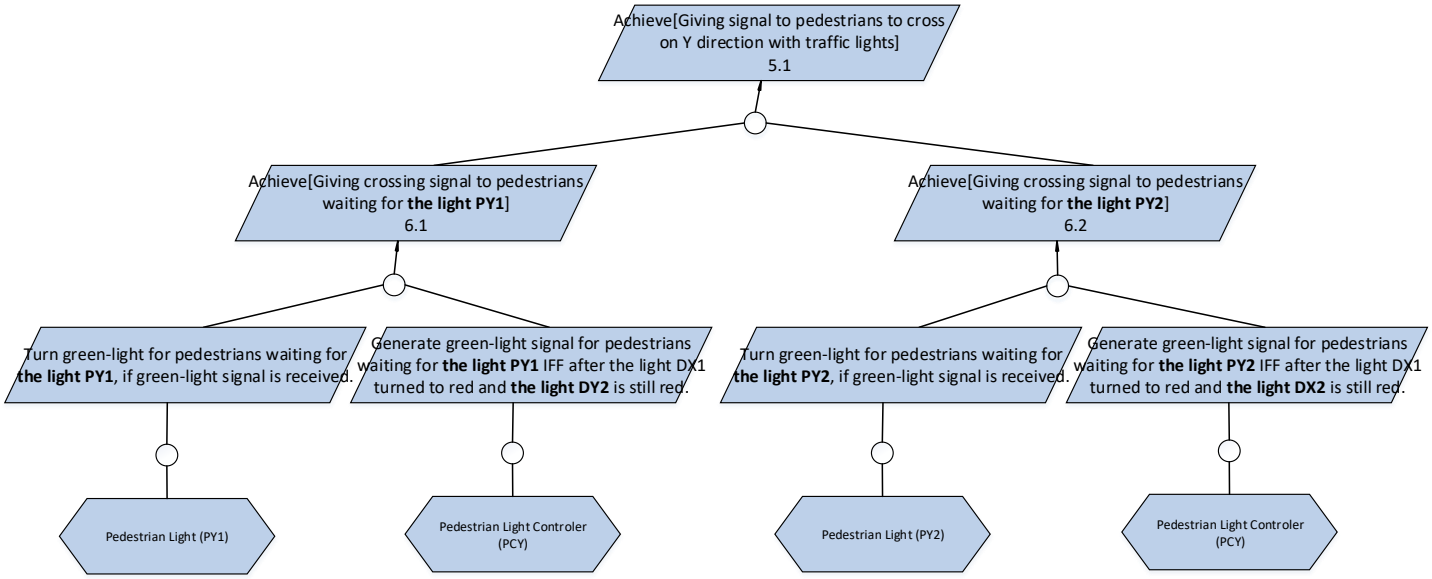


Figure 17 Sub goals of giving signal to pedestrians to cross on Y direction with traffic lights

Achieve[Giving crossing signal to pedestrians waiting for **the light PY1**] 6.1

Name: Giving crossing signal to pedestrians waiting for the light PY1
Type: Achieve
Definition: The aim of this goal is giving crossing signal to pedestrians waiting for the light PY1.
Priority: High

Achieve[Giving crossing signal to pedestrians waiting for **the light PY2**] 6.2

Name: Giving crossing signal to pedestrians waiting for the light PY2
Type: Achieve
Definition: The aim of this goal is giving crossing signal to pedestrians waiting for the light PY2
Priority: High

Turn green-light for pedestrians waiting for **the light PY1**, if green-light signal is received.

Name: Turn green-light for pedestrians waiting for the light PY1, if green-light signal is received
Type: Requirement
Definition: This is a requirement that is going to show pedestrians waiting for the light PY1 that crossing is available for them.
Priority: High

Generate green-light signal for pedestrians waiting for **the light PY1** IFF after the light DX1 turned to red and **the light DY2** is still red.

Name: Generate green-light signal for pedestrians waiting for the light PY1 IFF after the light DX1 turned to red and the light DY2 is still red.
Type: Requirement
Definition: This is a requirement that is prescribing the conditions of when the light PY1 is turned to green.
Priority: High

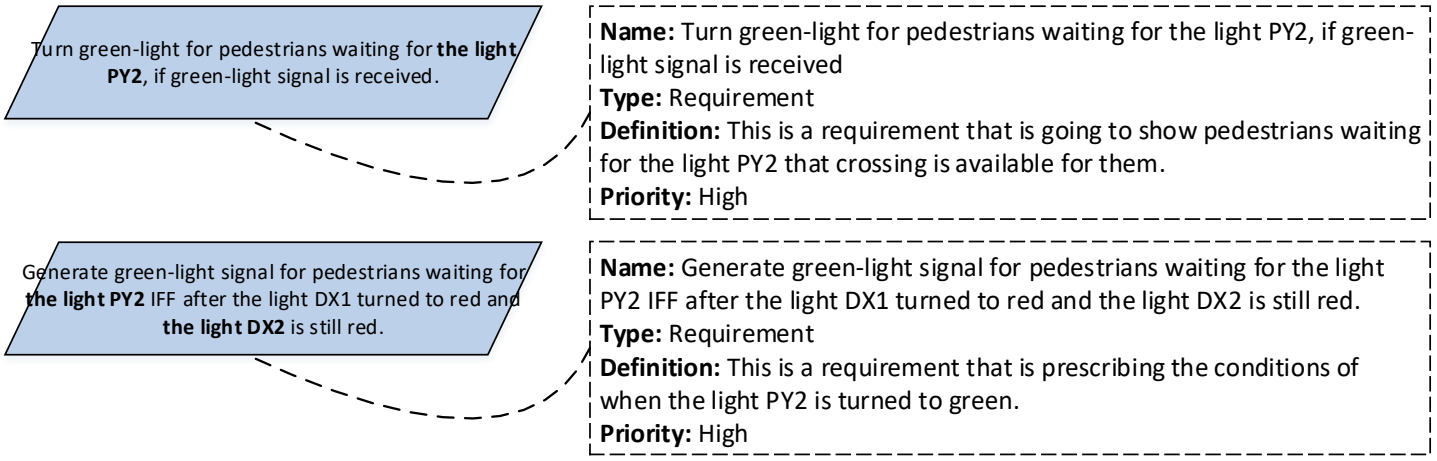


Figure 18 Annotations of sub goals of giving signal to pedestrians to cross on Y direction with traffic lights

2.1.1.2.2 Sub goal - Giving signal to pedestrians to stop on Y direction with traffic lights

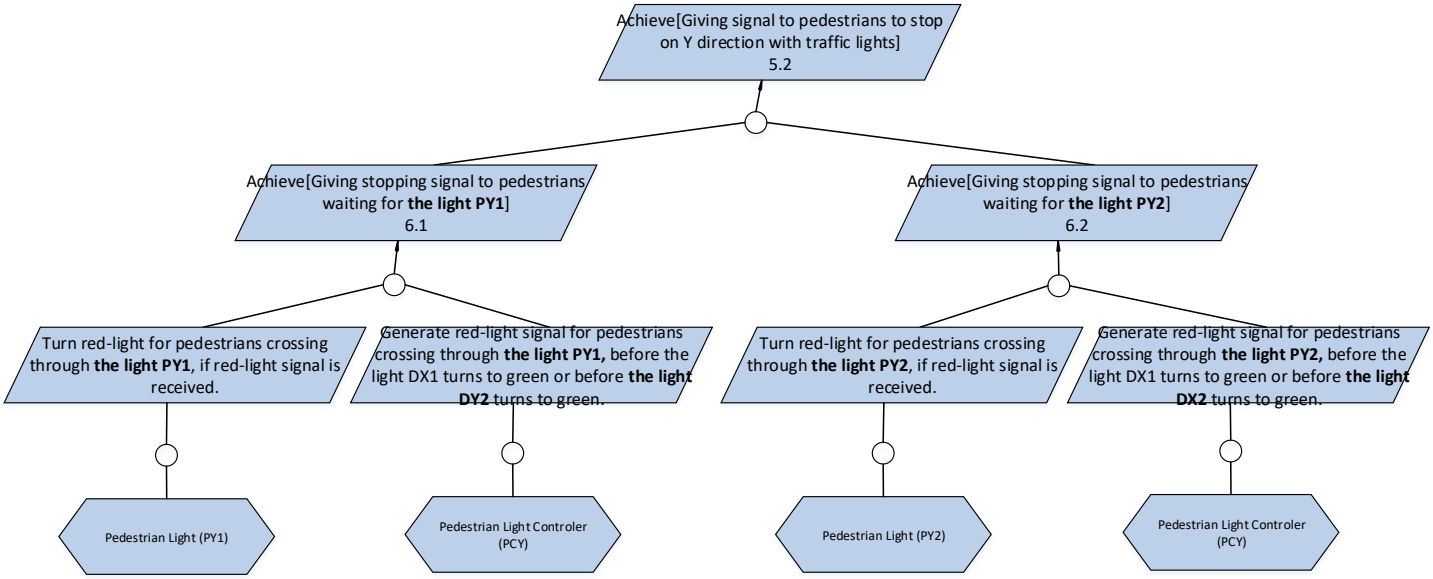
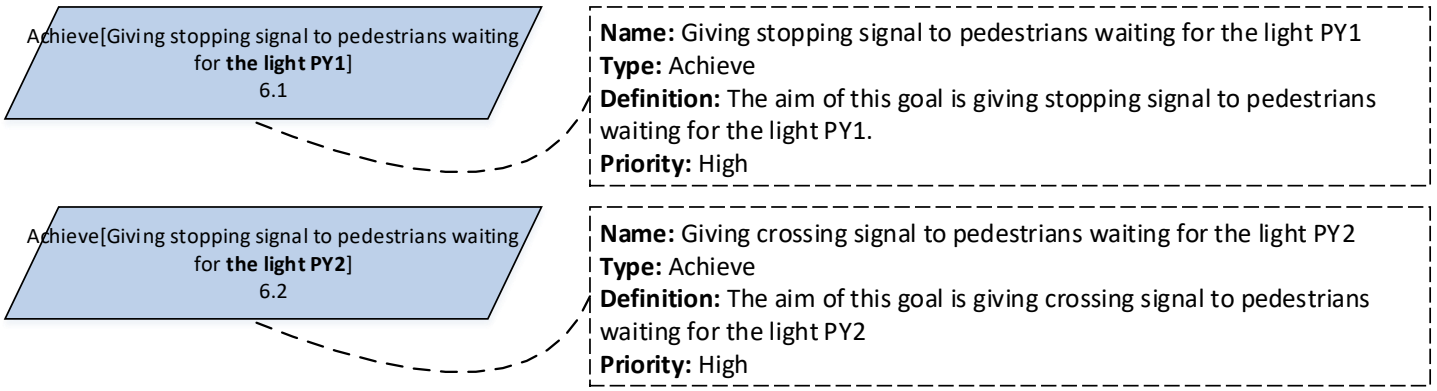


Figure 19 Sub goals of giving signal to pedestrians to stop on Y direction with traffic lights



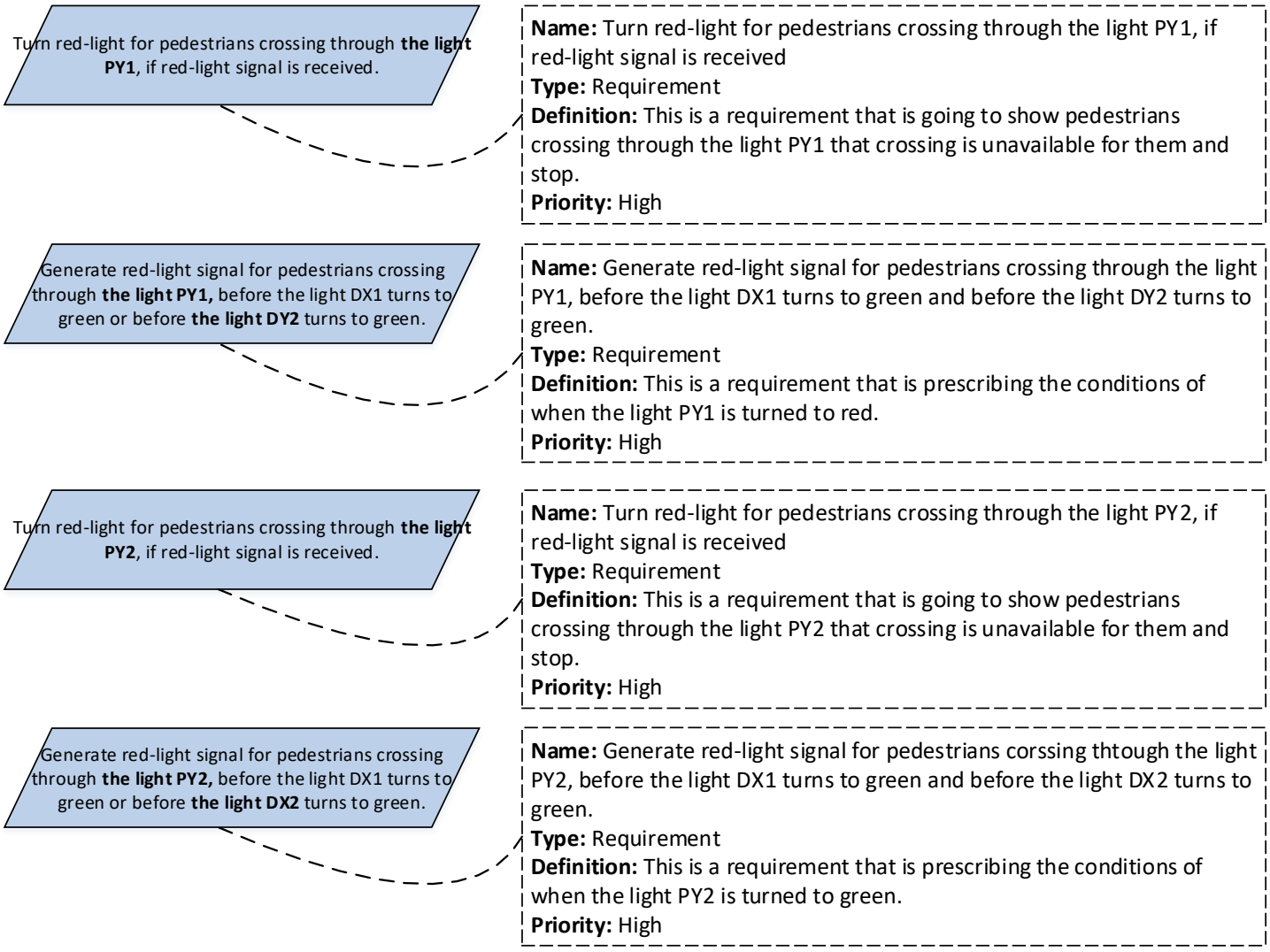


Figure 20 Annotations of sub goals of giving signal to pedestrians to stop on Y direction with traffic lights

2.1.2 Sub goal - Avoiding pedestrians and vehicles collision on the same direction

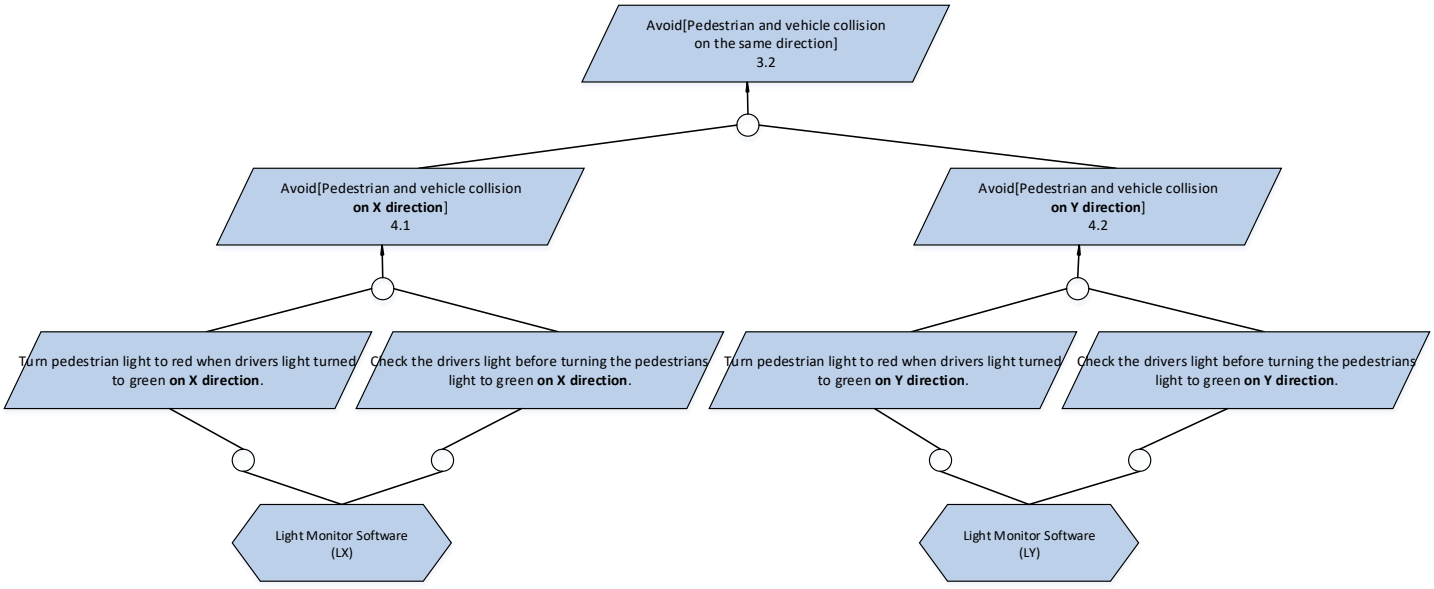


Figure 21 Sub goals of avoiding pedestrians and vehicles collision on the same direction

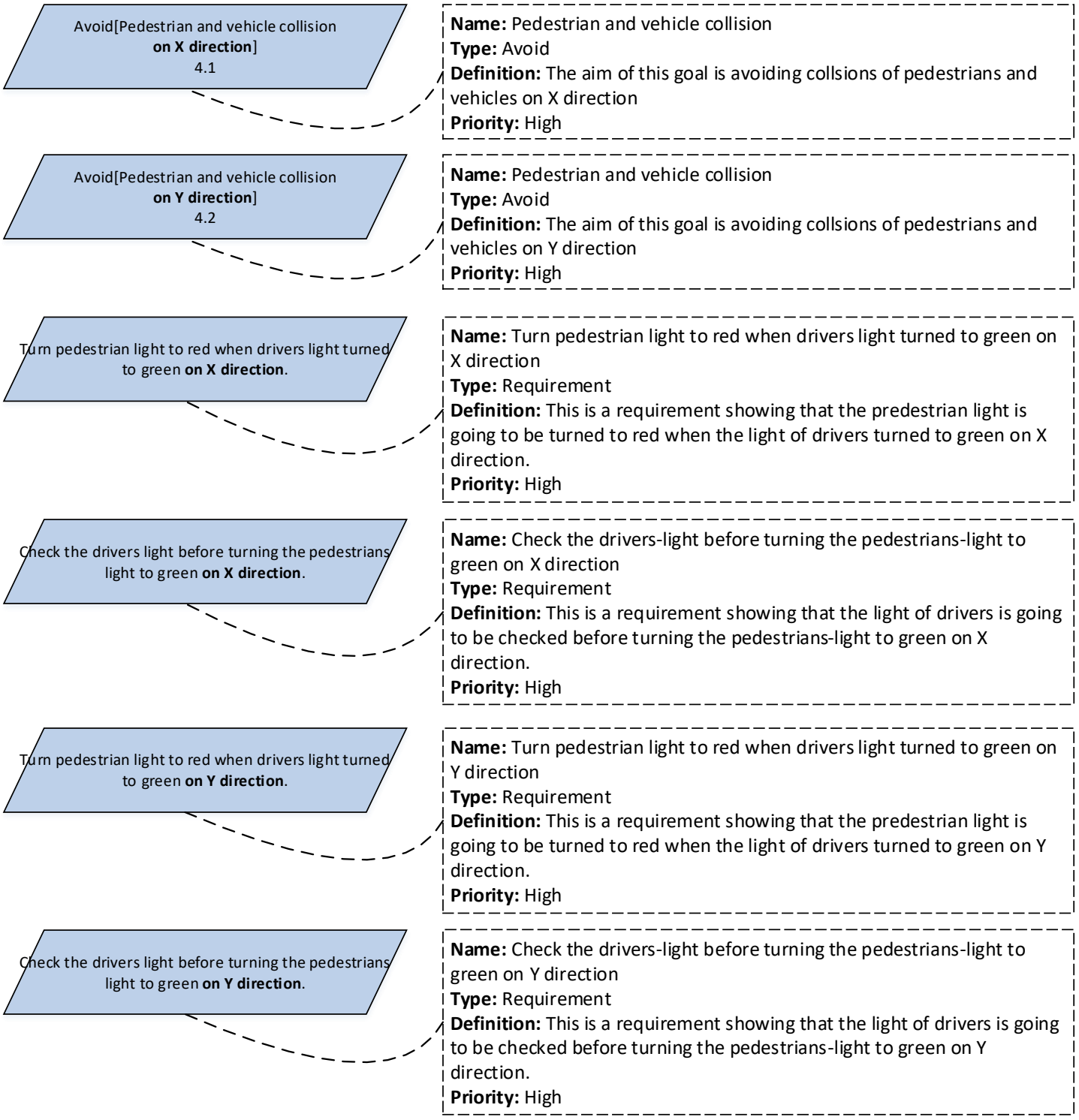


Figure 22 Annotations of sub goals of avoiding pedestrians and vehicles collision on the same direction

2.1.3 Sub goal - Avoiding vehicles and vehicles collision on the different directions

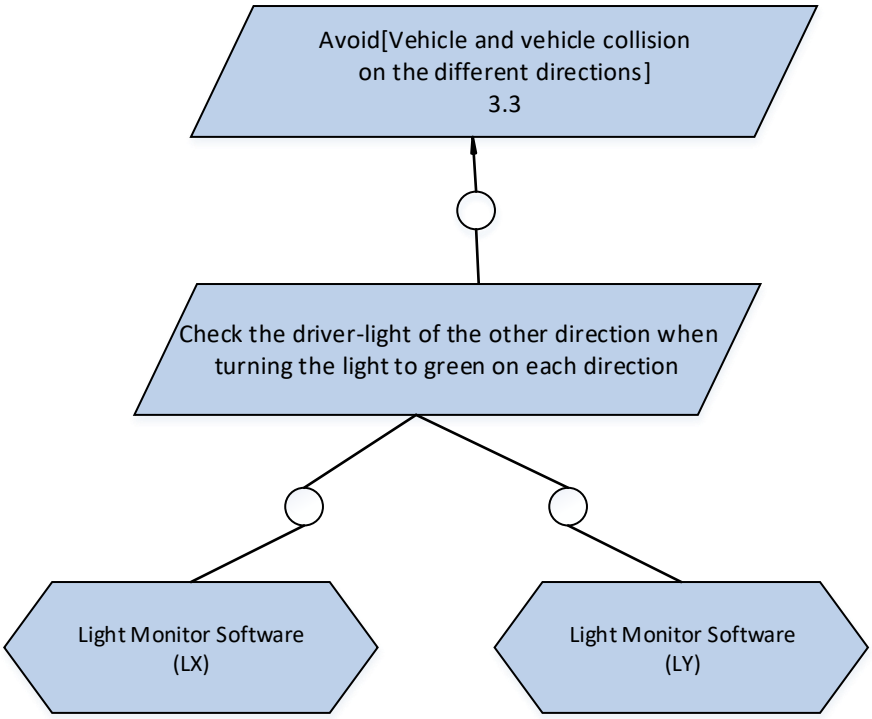


Figure 23 Sub goals of avoiding vehicles and vehicles collision on the different directions

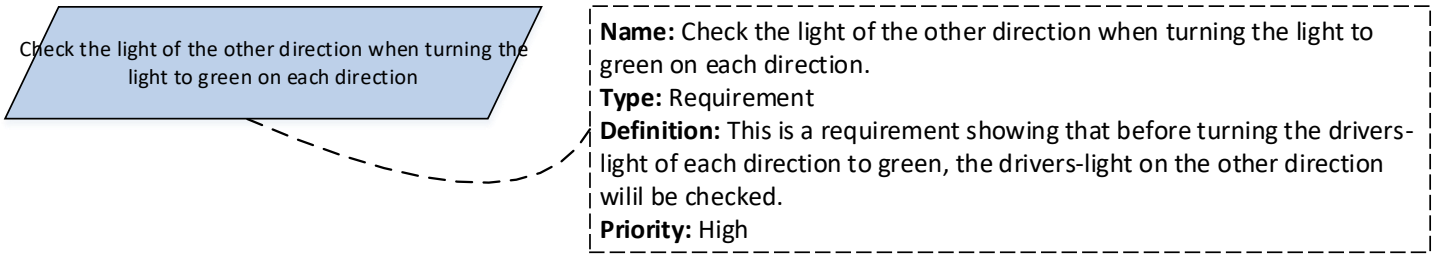


Figure 24 Annotations of sub goals of avoiding vehicles and vehicles collision on the different directions

2.1.4 Sub goal - Warning drivers with visual ways correctly

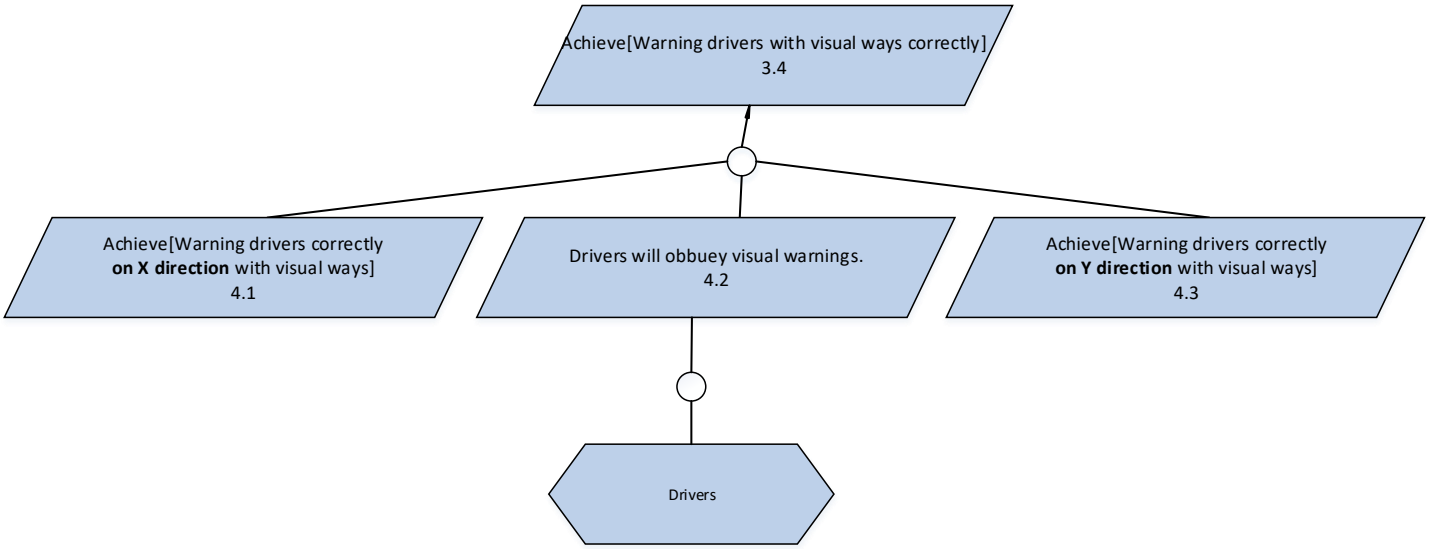


Figure 25 Sub goals of warning drivers with visual ways correctly

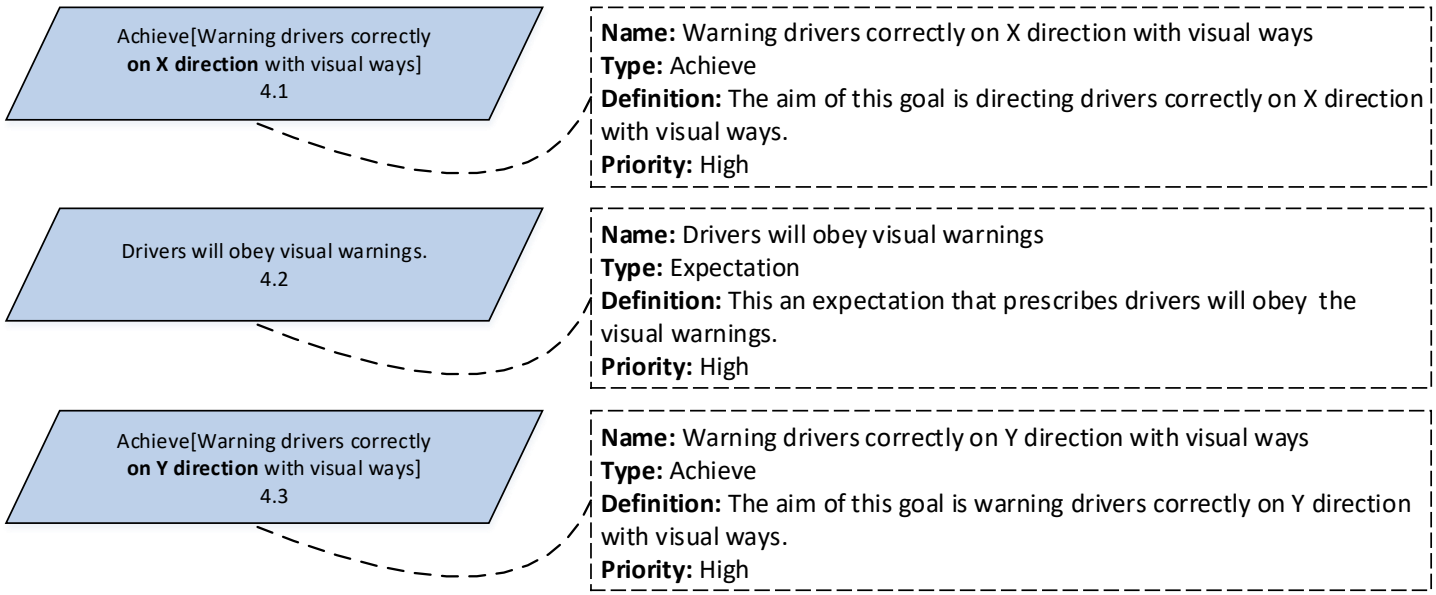


Figure 26 Annotations of sub goals of warning drivers with visual ways correctly

2.1.4.1 Sub goal - Warning drivers correctly on X direction with visual ways

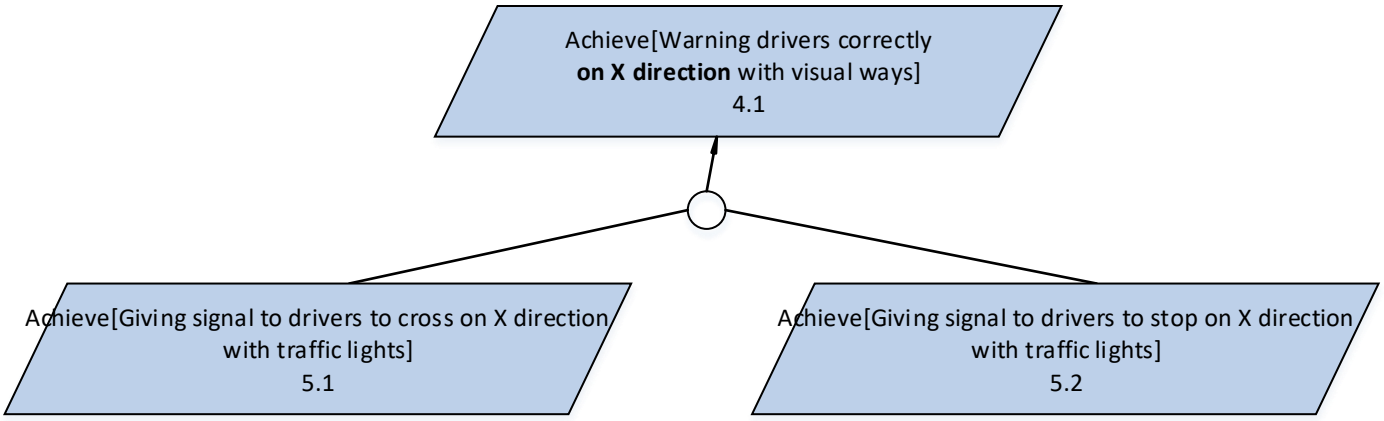


Figure 27 Sub goals of warning drivers correctly on X direction with visual ways

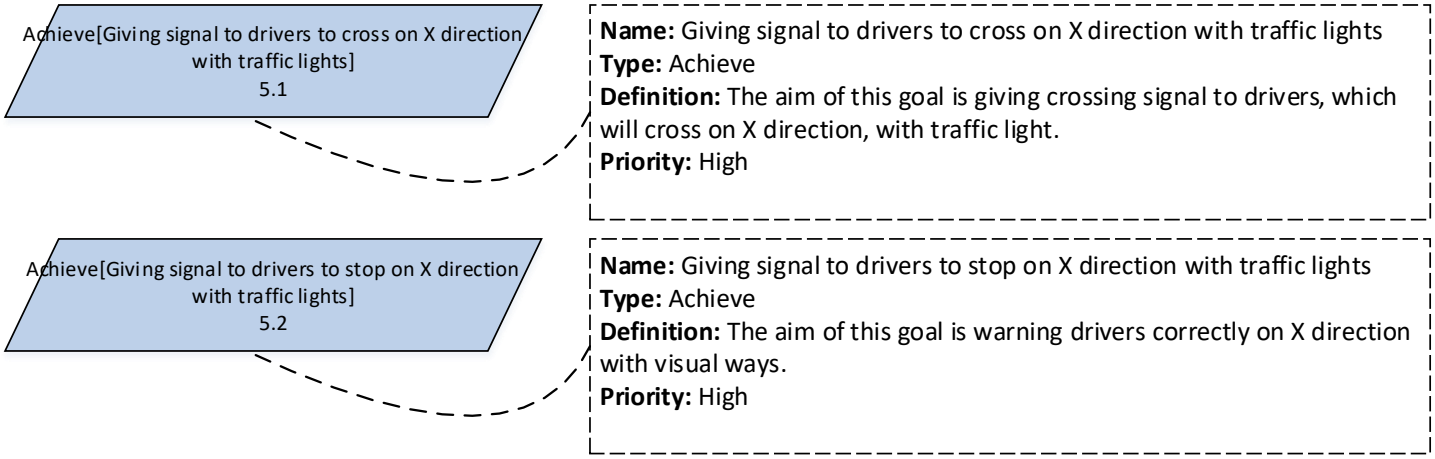


Figure 28 Annotations of sub goals of warning drivers correctly on X direction with visual ways

2.1.4.1.1 Sub goal - Giving signal to drivers to cross on X direction with traffic lights

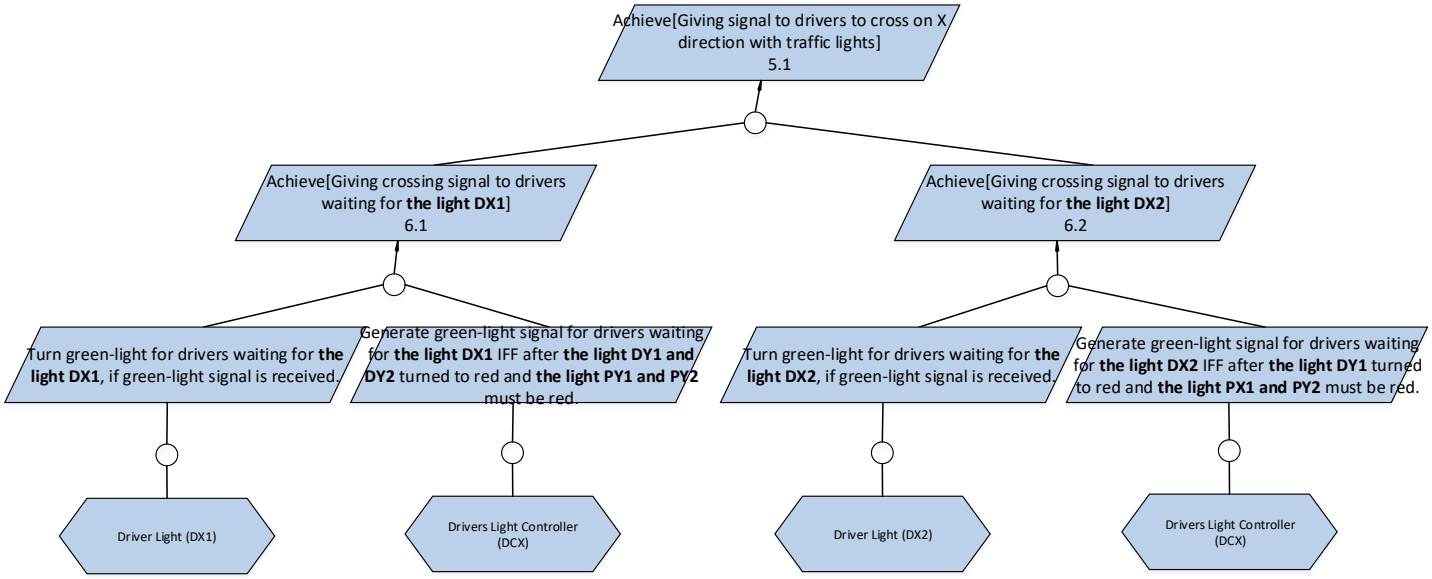


Figure 29 Sub goals of giving signal to drivers to cross on X direction with traffic lights

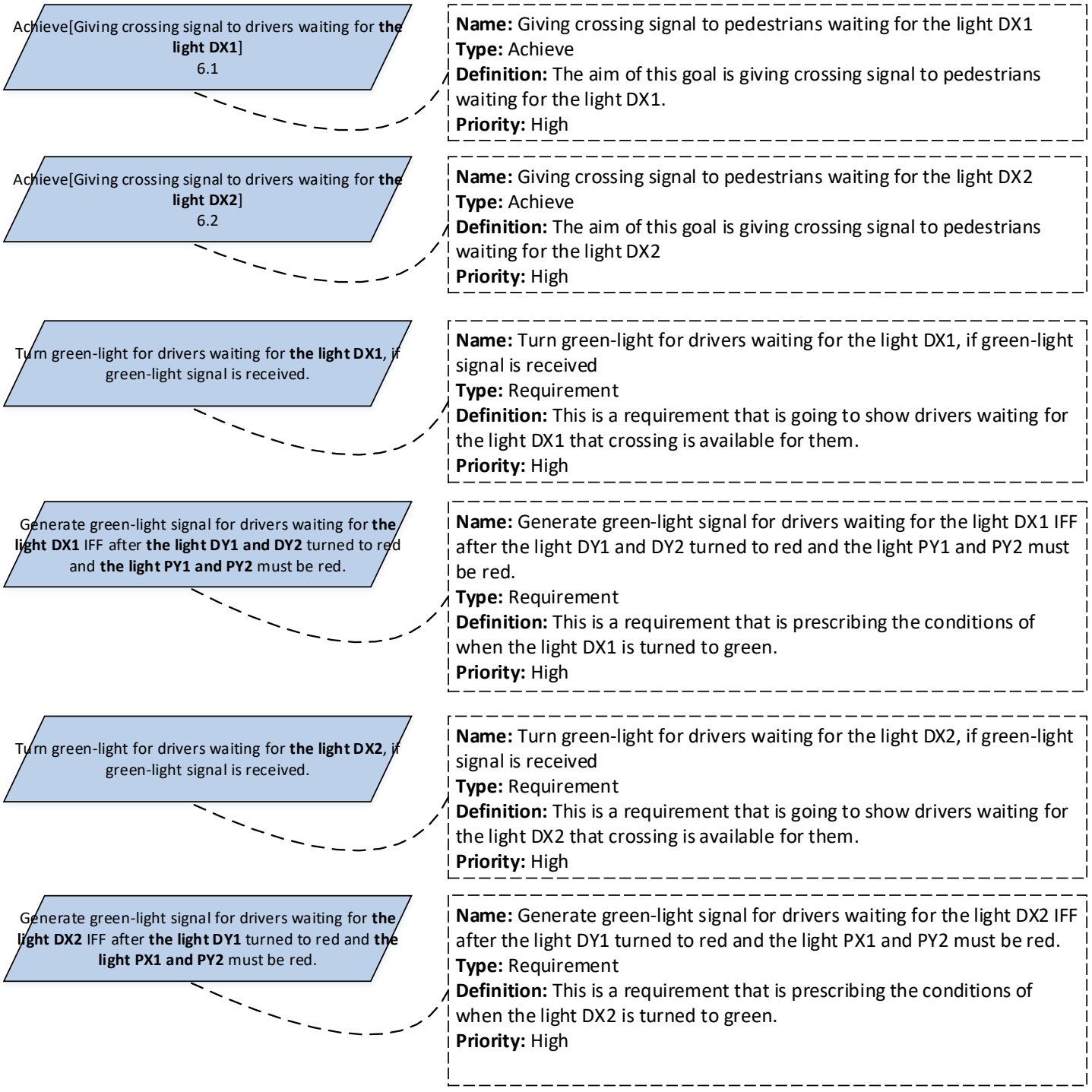


Figure 30 Annotations of sub goals of giving signal to drivers to cross on X direction with traffic lights

2.1.4.1.2 Sub goal - Giving signal to drivers to stop on X direction with traffic lights

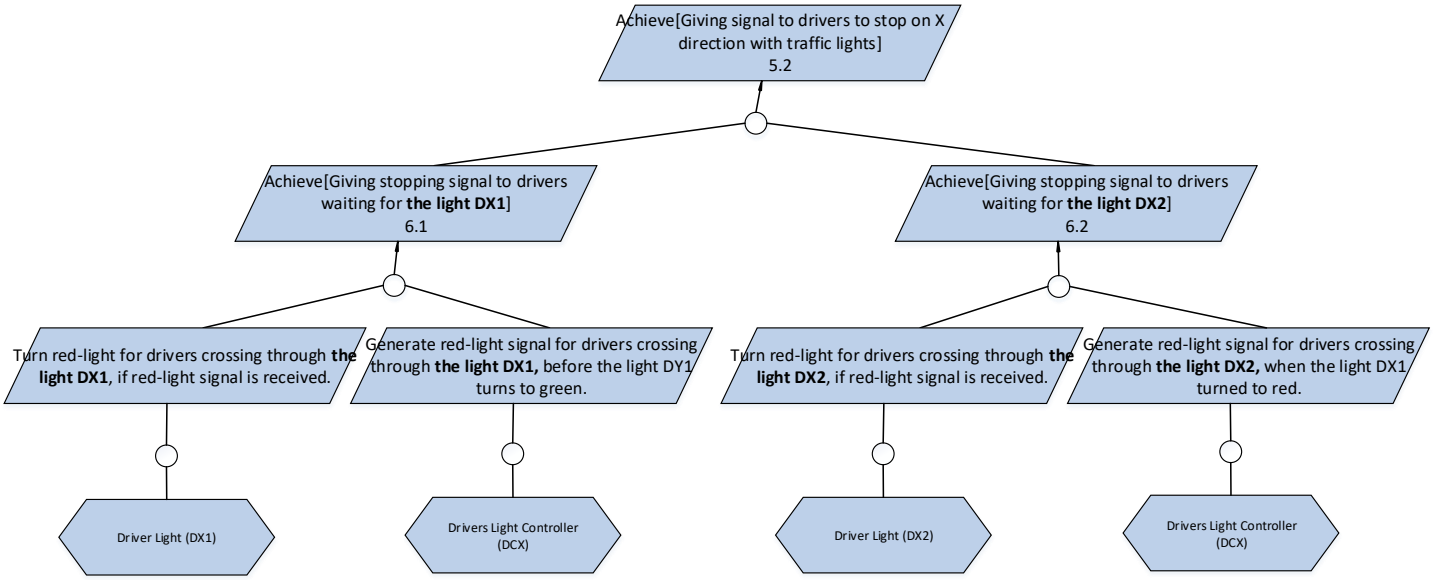


Figure 31 Sub goals of giving signal to drivers to stop on X direction with traffic lights

Achieve[Giving stopping signal to drivers waiting for **the light DX1**]
6.1

Name: Giving stopping signal to drivers waiting for the light DX1
Type: Achieve
Definition: The aim of this goal is giving stopping signal to drivers waiting for the light DX1.
Priority: High

Achieve[Giving stopping signal to drivers waiting for **the light DX2**]
6.2

Name: Giving crossing signal to drivers waiting for the light DX2
Type: Achieve
Definition: The aim of this goal is giving crossing signal to drivers waiting for the light DX2
Priority: High

Turn red-light for drivers crossing through **the light DX1**, if red-light signal is received.

Name: Turn red-light for drivers crossing through the light DX1, if red-light signal is received
Type: Requirement
Definition: This is a requirement that is going to show drivers crossing through the light DX1 that crossing is unavailable for them and stop.
Priority: High

Generate red-light signal for drivers crossing through **the light DX1,** before the light DY1 turns to green.

Name: Generate red-light signal for drivers crossing through the light DX1, before the light DY1 turns to green.
Type: Requirement
Definition: This is a requirement that is prescribing the conditions of when the light DX1 is turned to red.
Priority: High

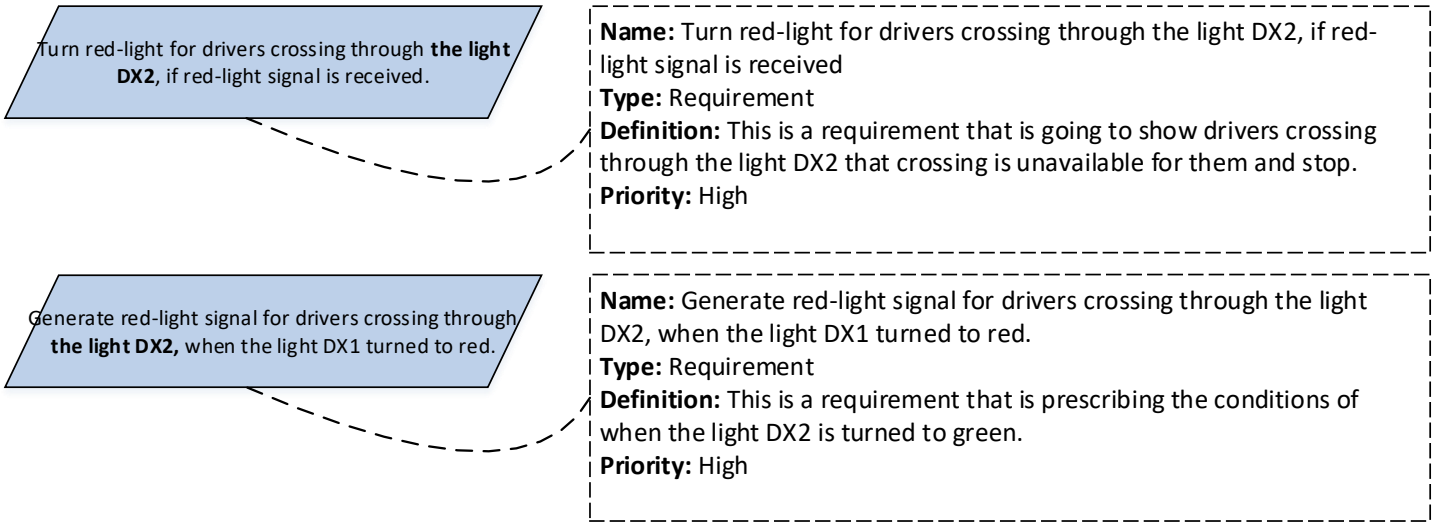


Figure 32 Annotations of sub goals of giving signal to drivers to stop on X direction with traffic lights

2.1.4.2 Sub goal - Warning drivers correctly on Y direction with visual ways

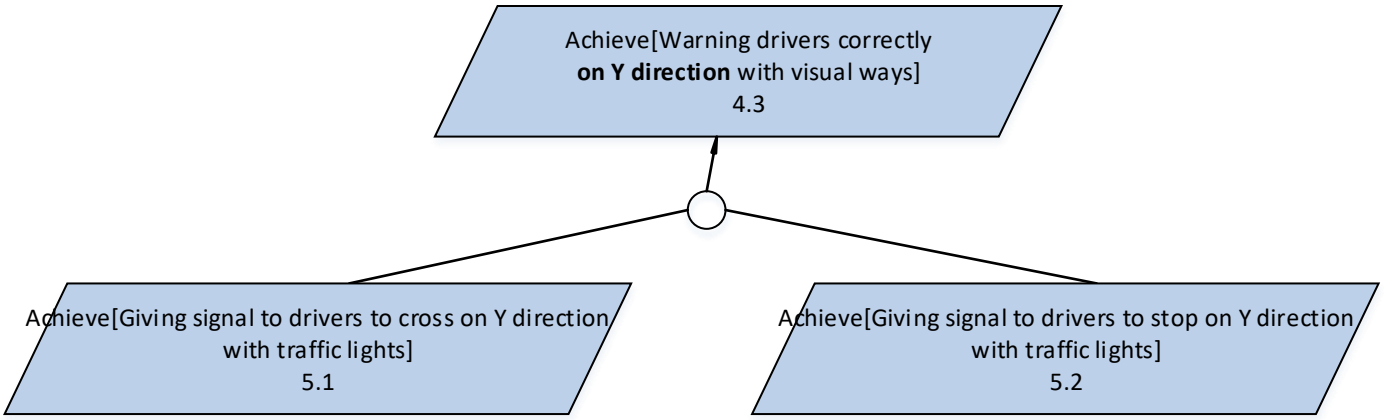


Figure 33 Sub goals of warning drivers correctly on Y direction with visual ways

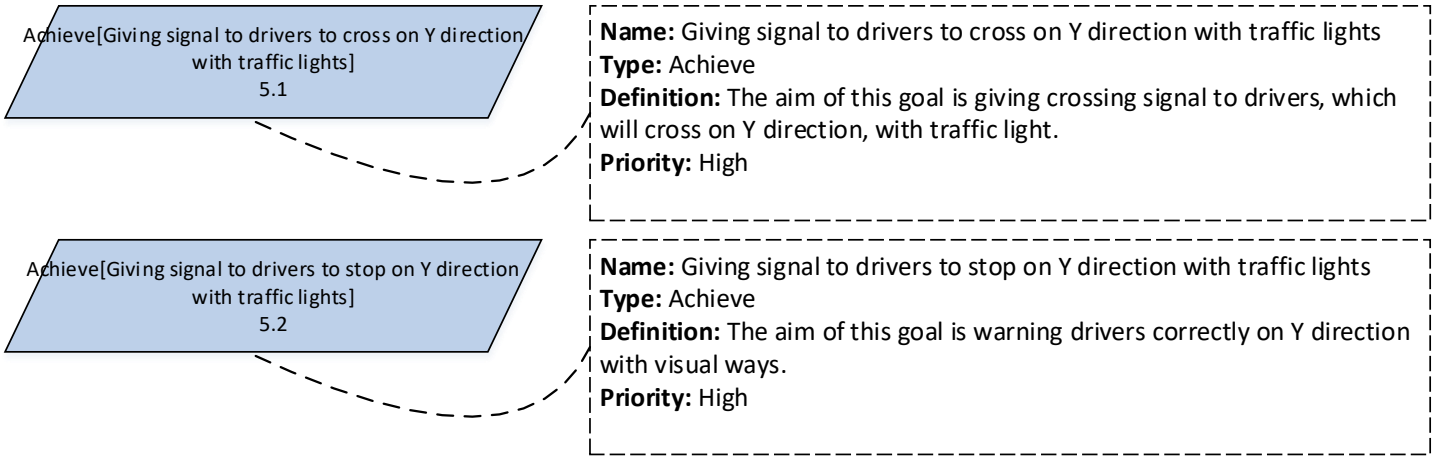


Figure 34 Annotations of sub goals of warning drivers correctly on Y direction with visual ways

2.1.4.2.1 Sub goal - Giving signal to drivers to cross on Y direction with traffic lights

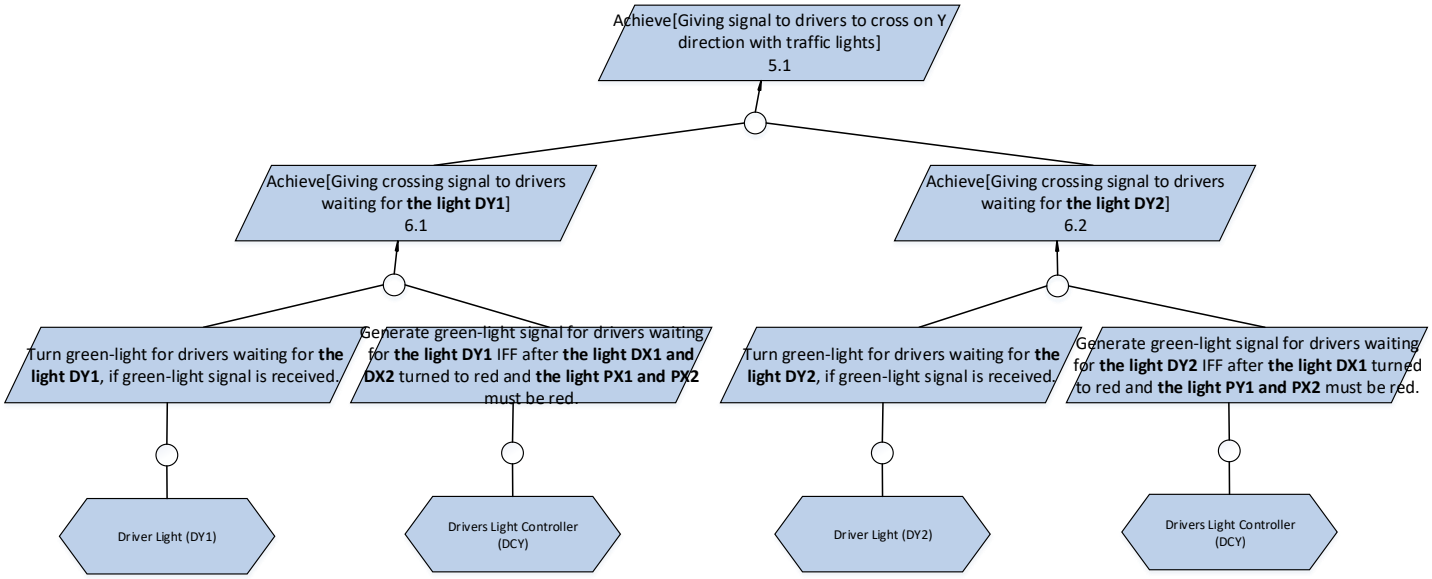


Figure 35 Sub goals of giving signal to drivers to cross on Y direction with traffic lights

Achieve[Giving crossing signal to drivers waiting for **the light DY1**]
6.1

Name: Giving crossing signal to pedestrians waiting for the light DY1
Type: Achieve
Definition: The aim of this goal is giving crossing signal to pedestrians waiting for the light DX1.
Priority: High

Achieve[Giving crossing signal to drivers waiting for **the light DY2**]
6.2

Name: Giving crossing signal to pedestrians waiting for the light DY2
Type: Achieve
Definition: The aim of this goal is giving crossing signal to pedestrians waiting for the light DX2
Priority: High

Turn green-light for drivers waiting for **the light DY1**, if green-light signal is received.

Name: Turn green-light for drivers waiting for the light DY1, if green-light signal is received
Type: Requirement
Definition: This is a requirement that is going to show drivers waiting for the light DY1 that crossing is available for them.
Priority: High

Generate green-light signal for drivers waiting for **the light DY1** IFF after **the light DX1 and DX2** turned to red and **the light PX1 and PX2** must be red.

Name: Generate green-light signal for drivers waiting for the light DY1 IFF after the light DX1 and DX2 turned to red and the light PX1 and PX2 must be red.
Type: Requirement
Definition: This is a requirement that is prescribing the conditions of when the light DX1 is turned to green.
Priority: High

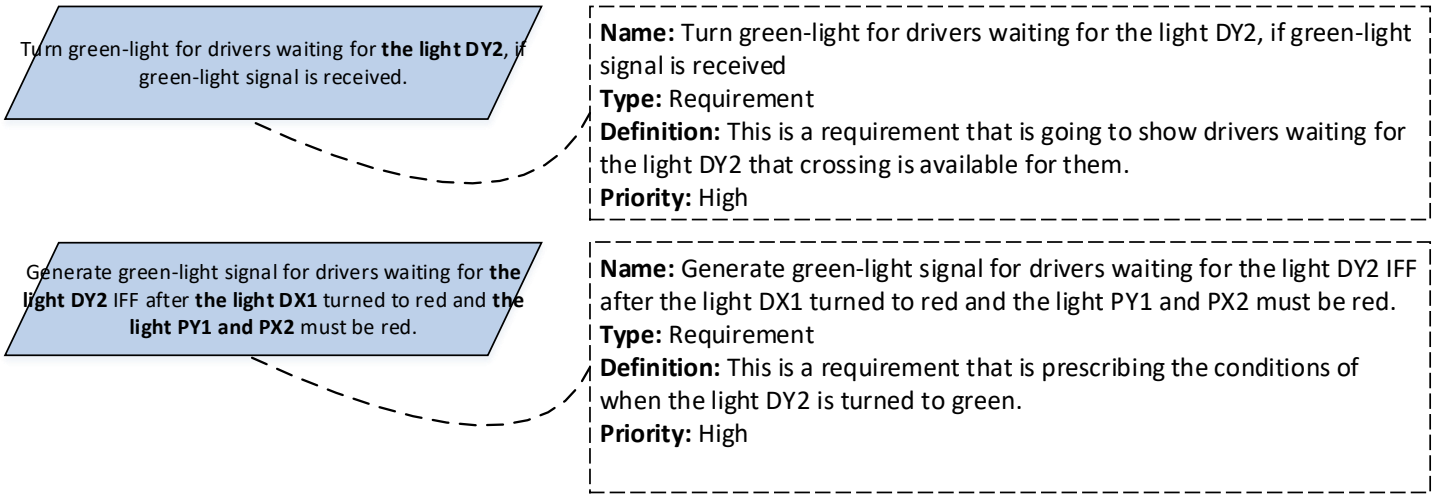


Figure 36 Annotations of sub goals of giving signal to drivers to cross on Y direction with traffic lights

2.1.4.2.2 Sub goal - Giving signal to drivers to stop on Y direction with traffic lights

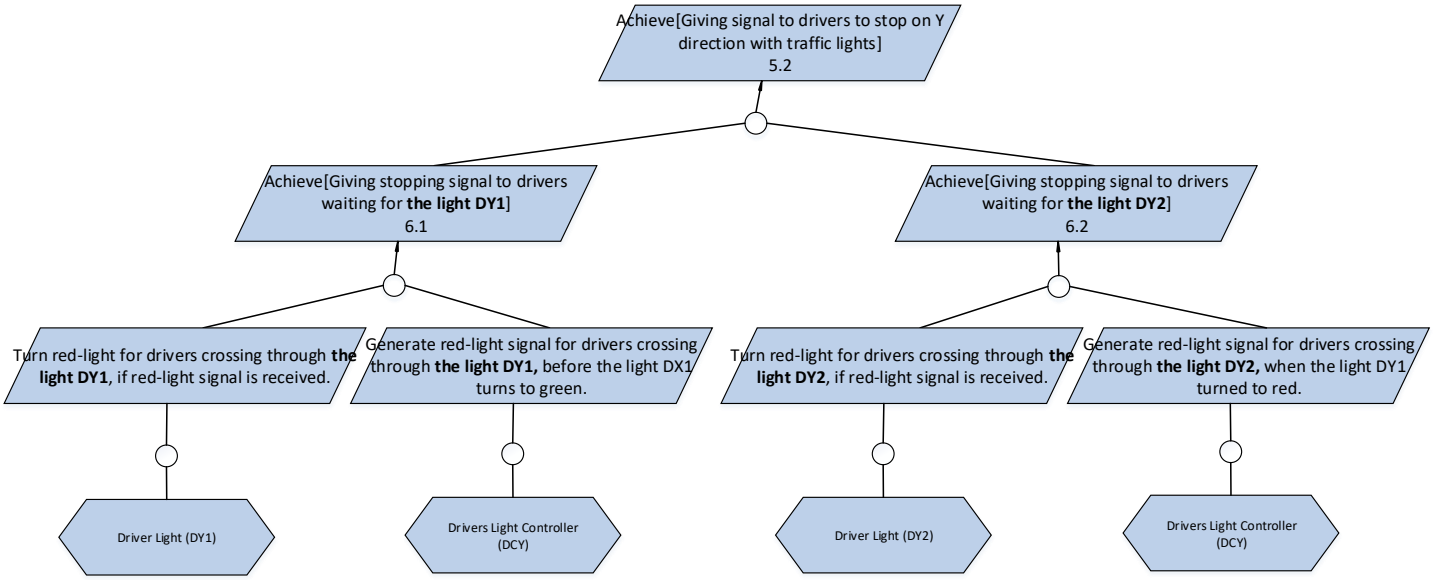
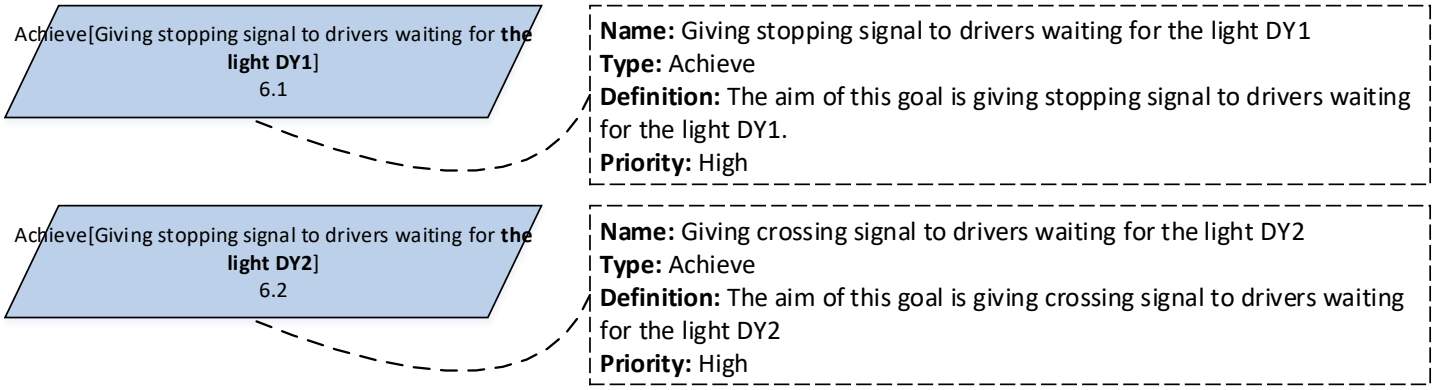


Figure 37 Sub goals of giving signal to drivers to stop on Y direction with traffic lights



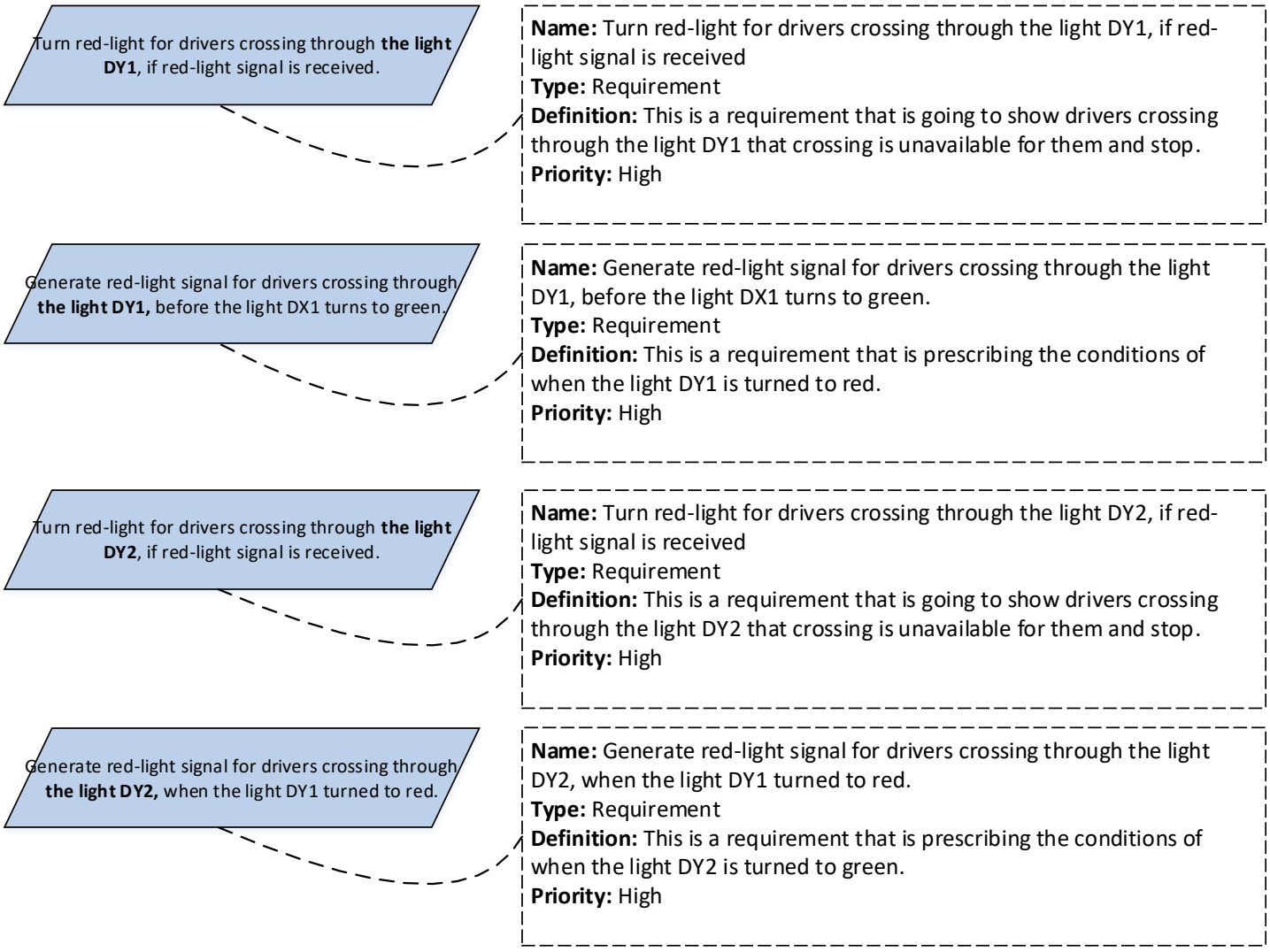


Figure 38 Annotations of sub goals of giving signal to drivers to stop on Y direction with traffic lights

2.2 Sub goal - Efficient traffic flow

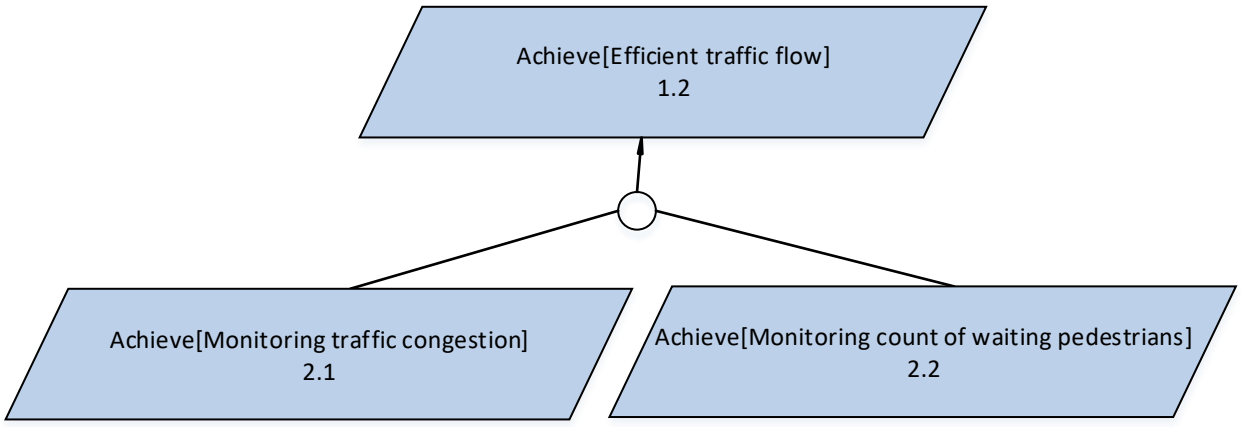


Figure 39 Sub goals of efficient traffic flow

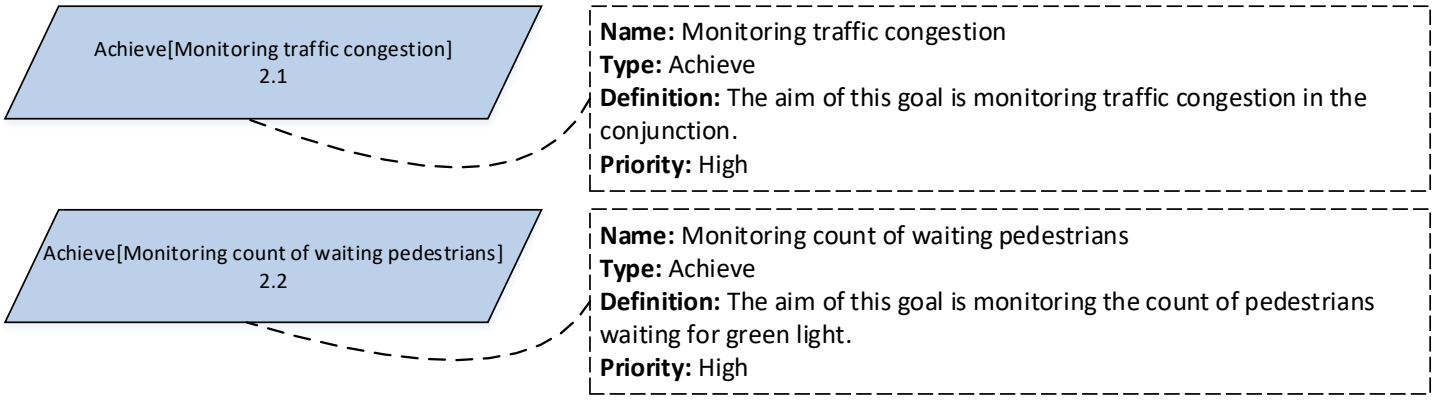


Figure 40 Annotations of sub goals of efficient traffic flow

2.2.1 Sub goal - Monitoring traffic congestion

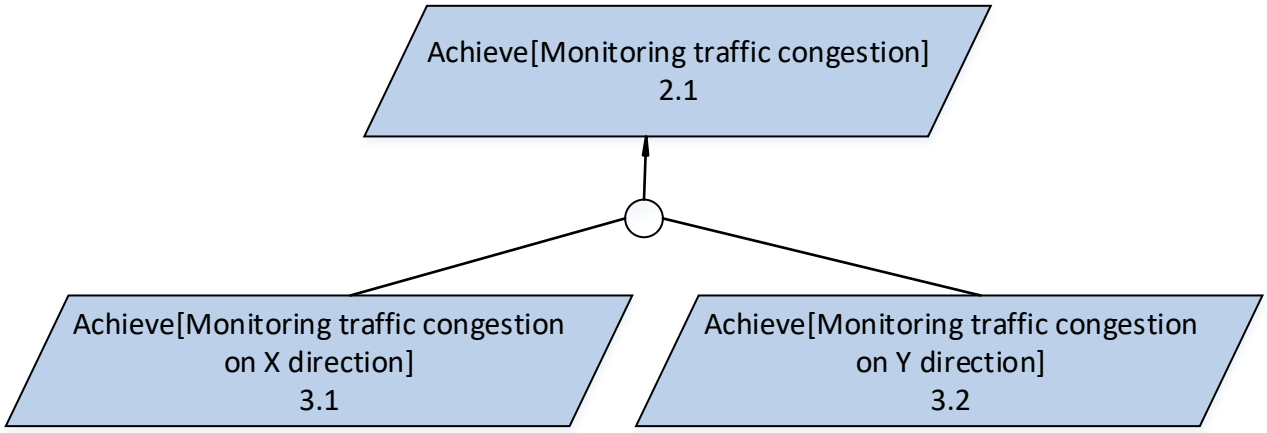


Figure 41 Sub goals of monitoring traffic congestion

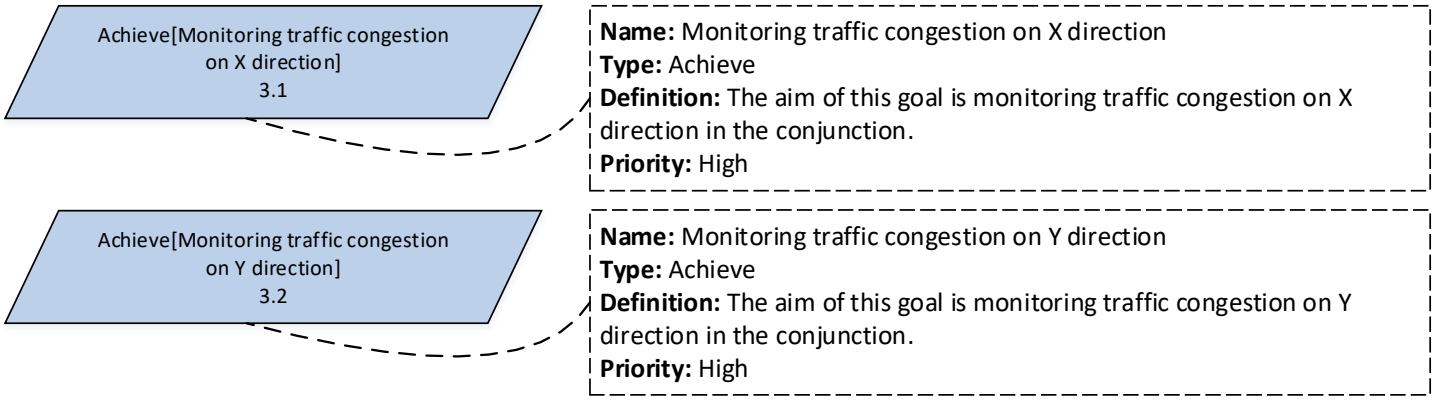


Figure 42 Annotations of sub goals of monitoring traffic congestion

2.2.1.1 Sub goal - Monitoring traffic congestion on X direction

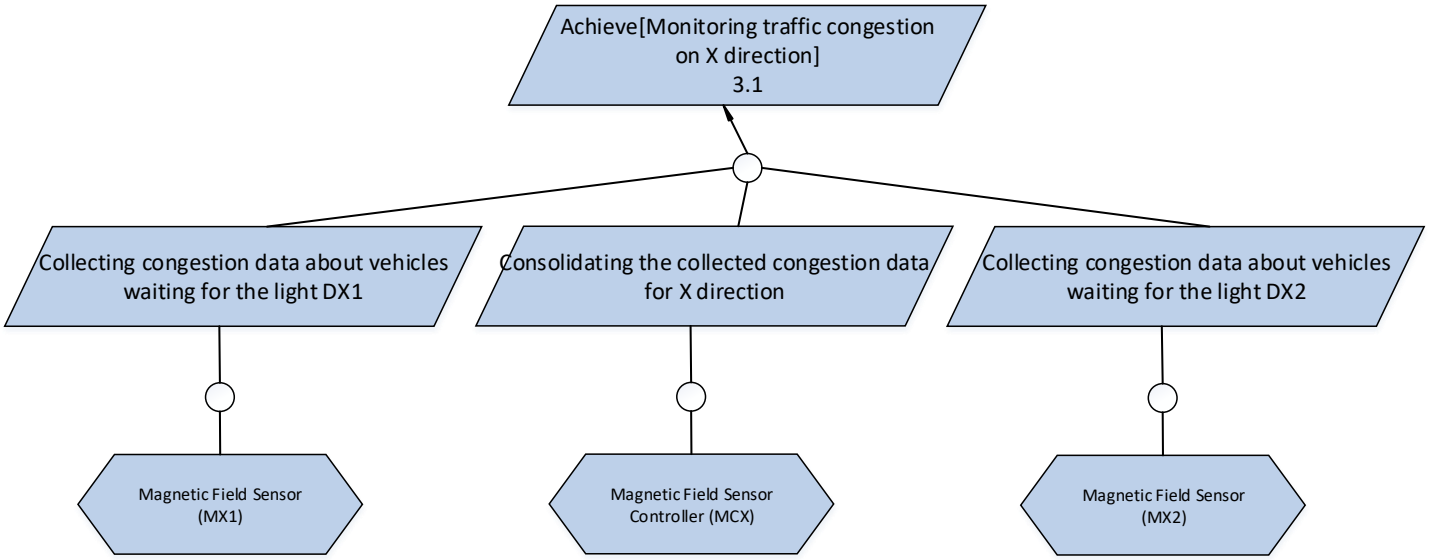


Figure 43 Sub goals of monitoring traffic congestion on X direction

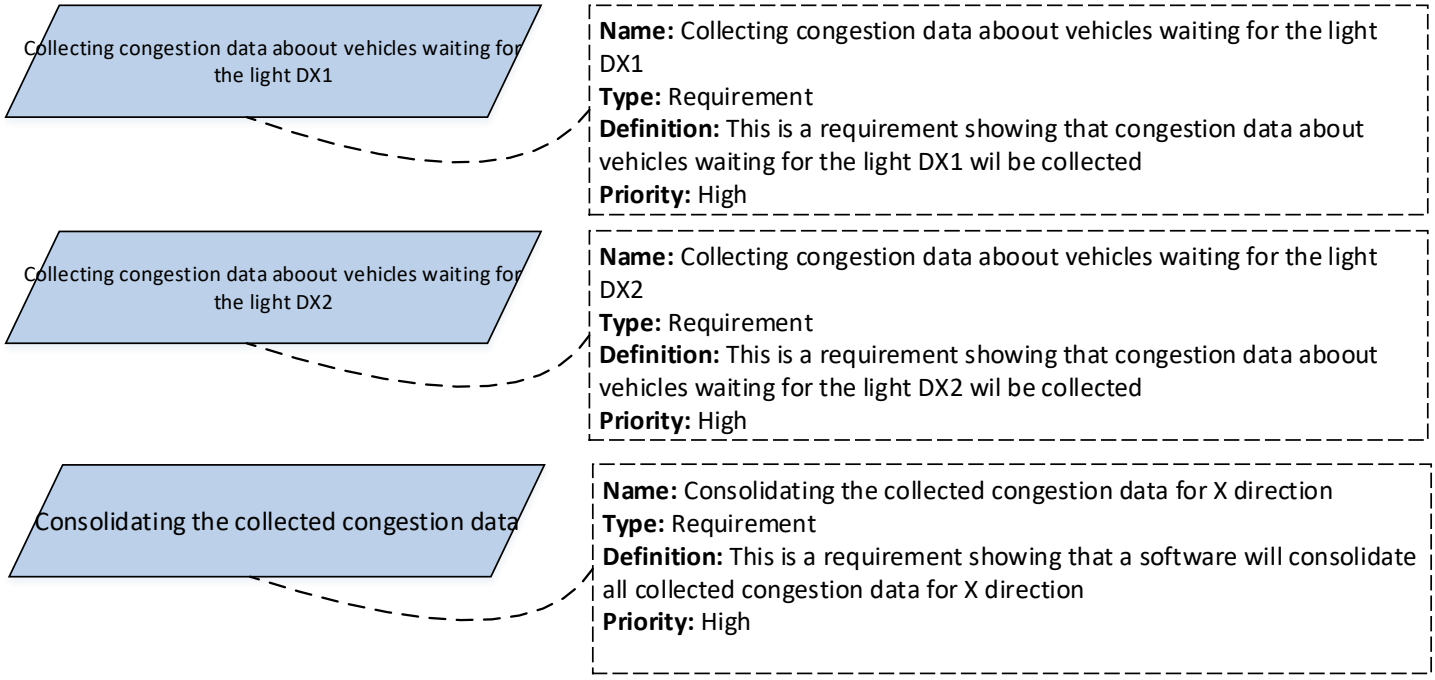


Figure 44 Annotations of sub goals of monitoring traffic congestion on X direction

2.2.1.2 Sub goal - Monitoring traffic congestion on Y direction

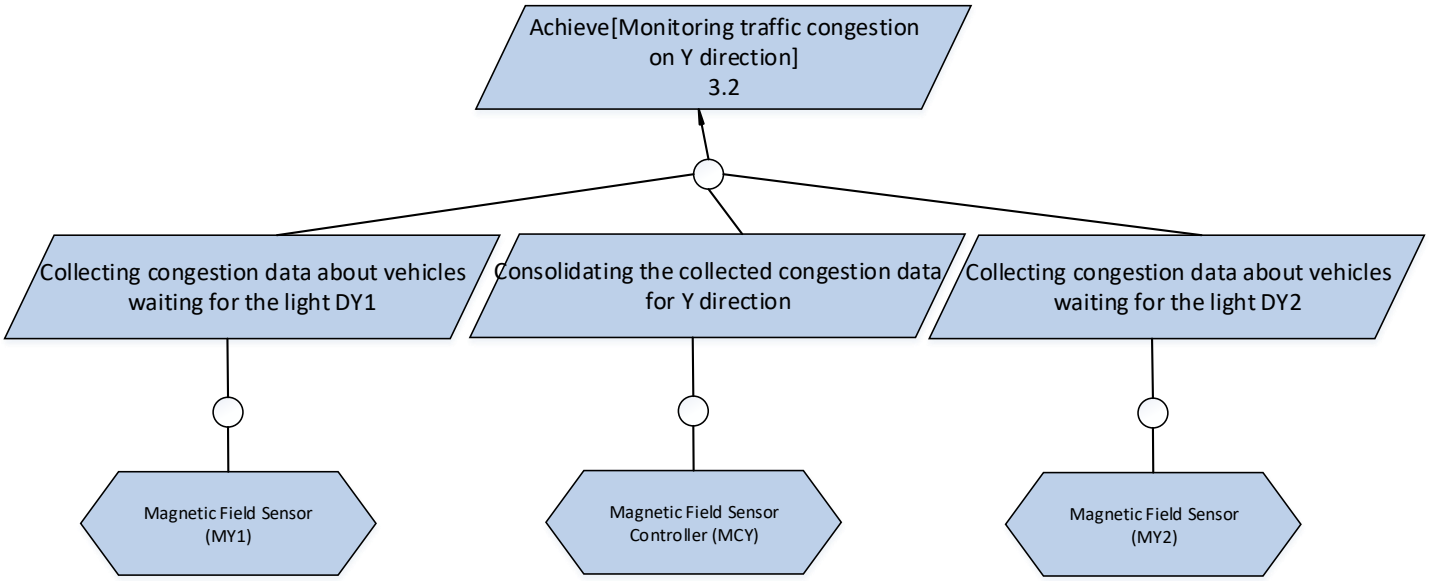


Figure 45 Sub goals of monitoring traffic congestion on Y direction

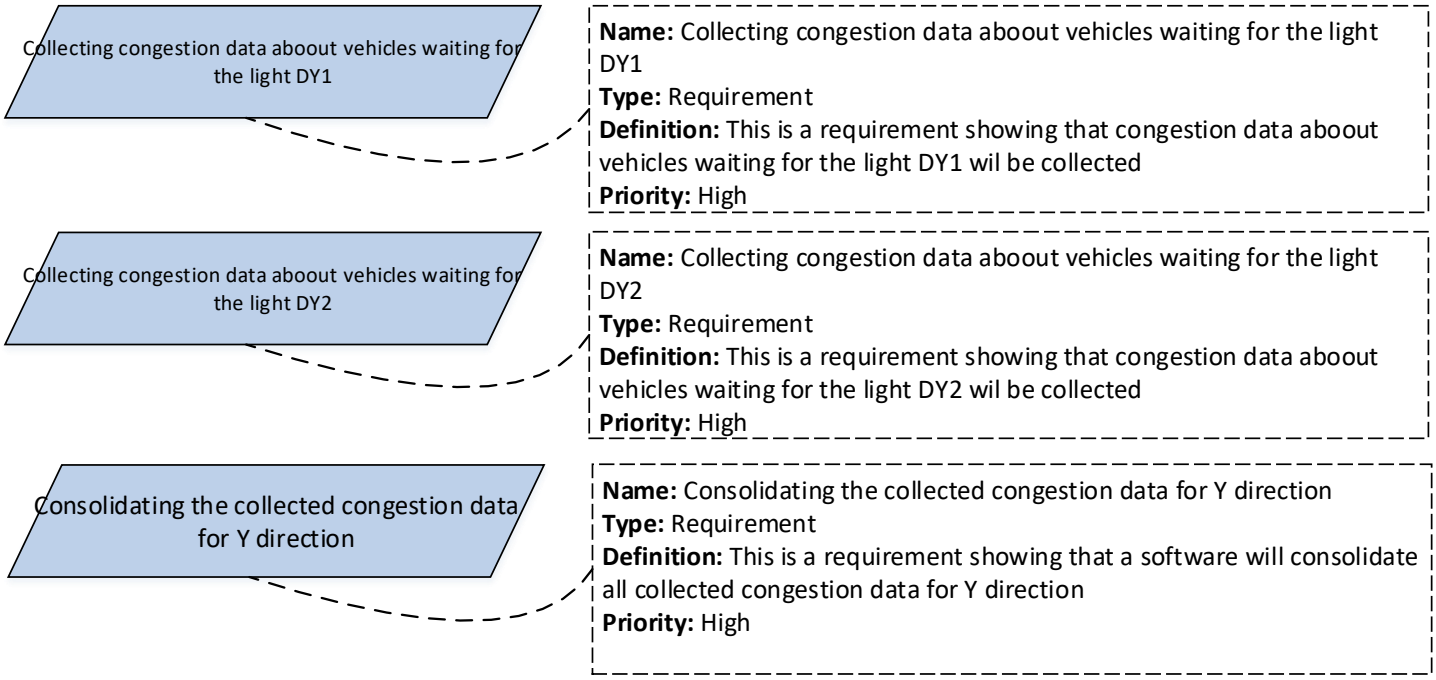


Figure 46 Annotations of sub goals of monitoring traffic congestion on Y direction

2.2.2 Sub goal - Monitoring count of waiting pedestrians

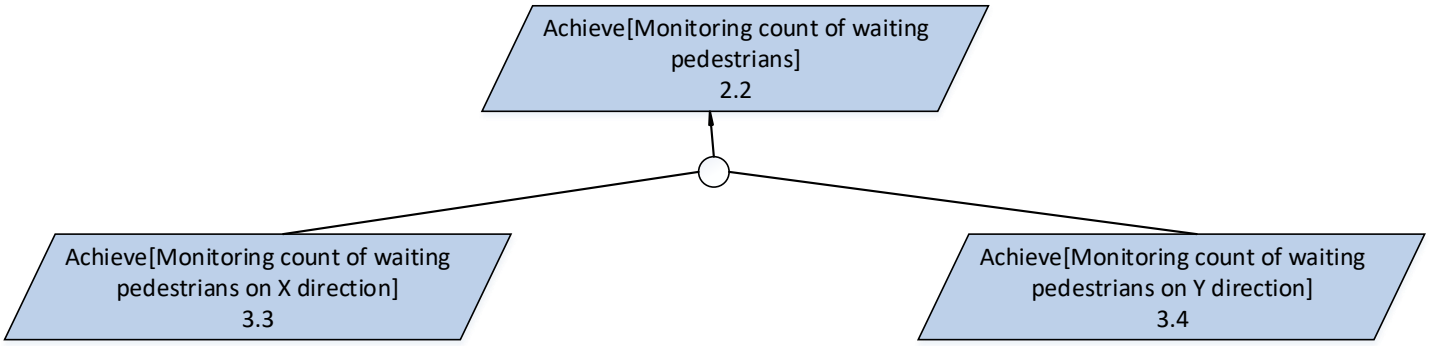


Figure 47 Sub goals of monitoring count of waiting pedestrians

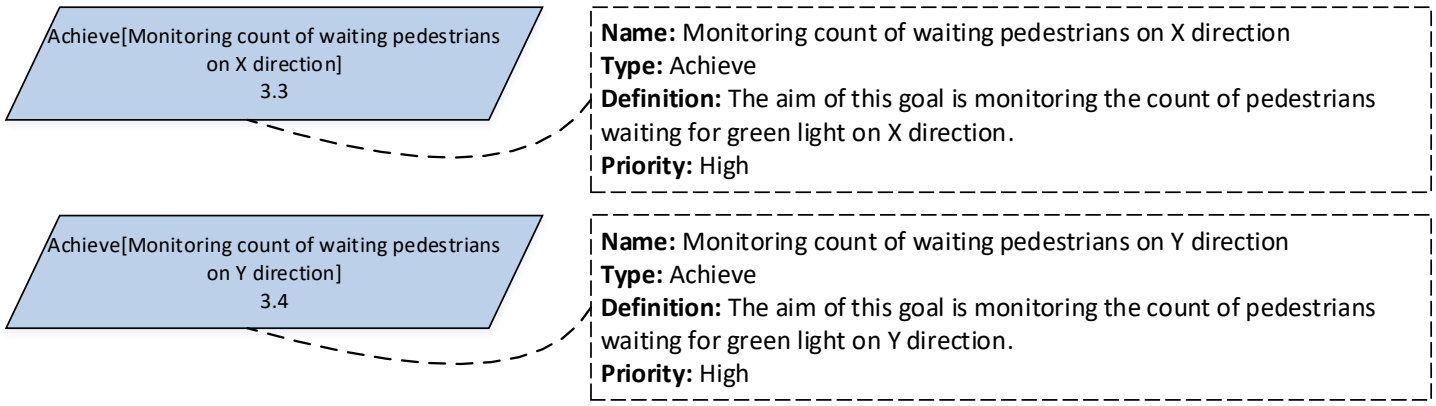


Figure 48 Annotations of sub goals of monitoring count of waiting pedestrians

2.2.2.1 Sub goal - Monitoring count of waiting pedestrians on X direction

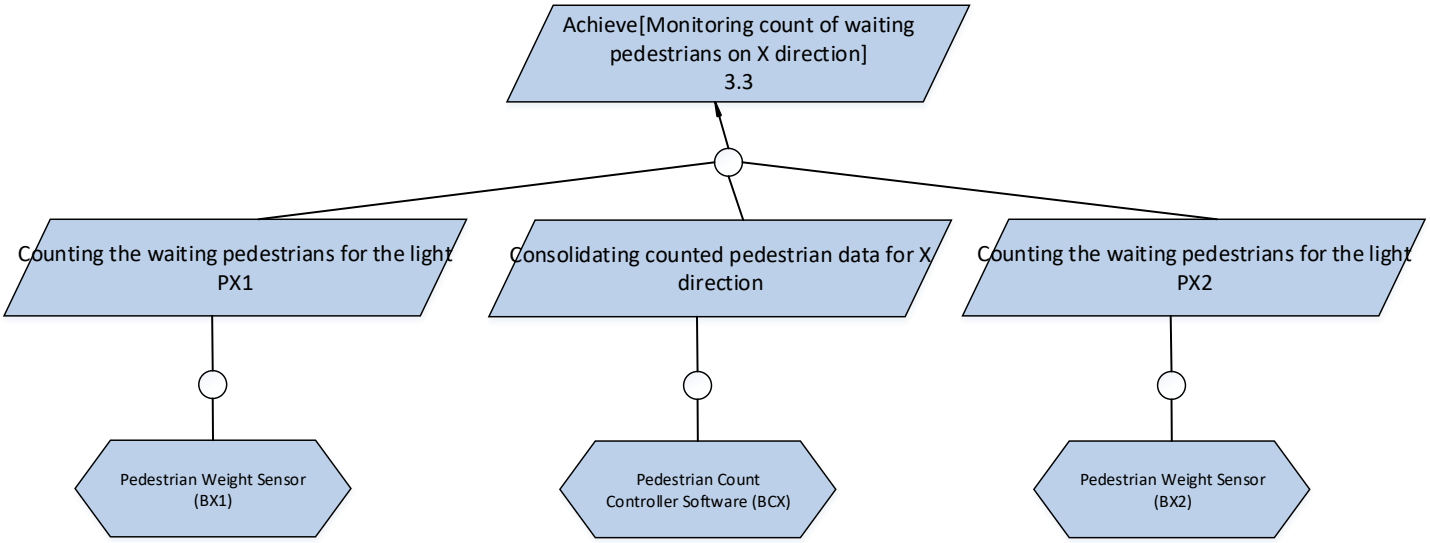


Figure 49 Sub goals of monitoring count of waiting pedestrians on X direction

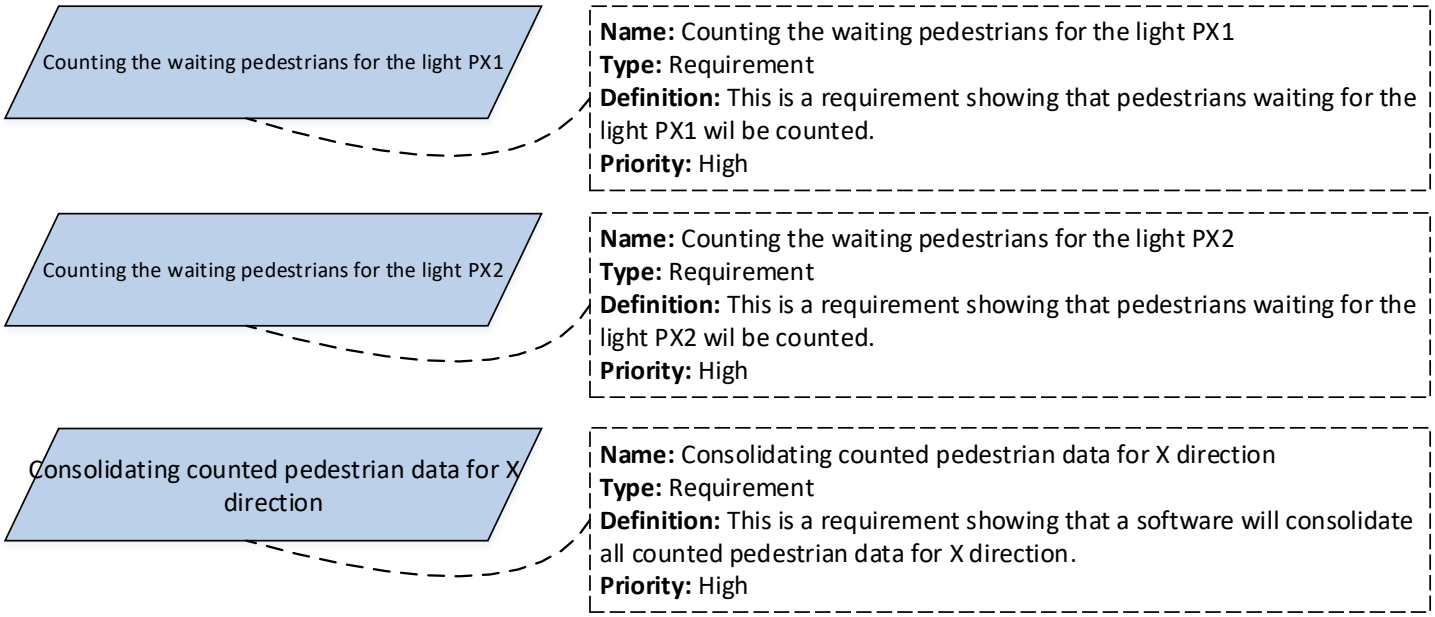


Figure 50 Annotations of sub goals of monitoring count of waiting pedestrians on X direction

2.2.2.2 Sub goal - Monitoring count of waiting pedestrians on Y direction

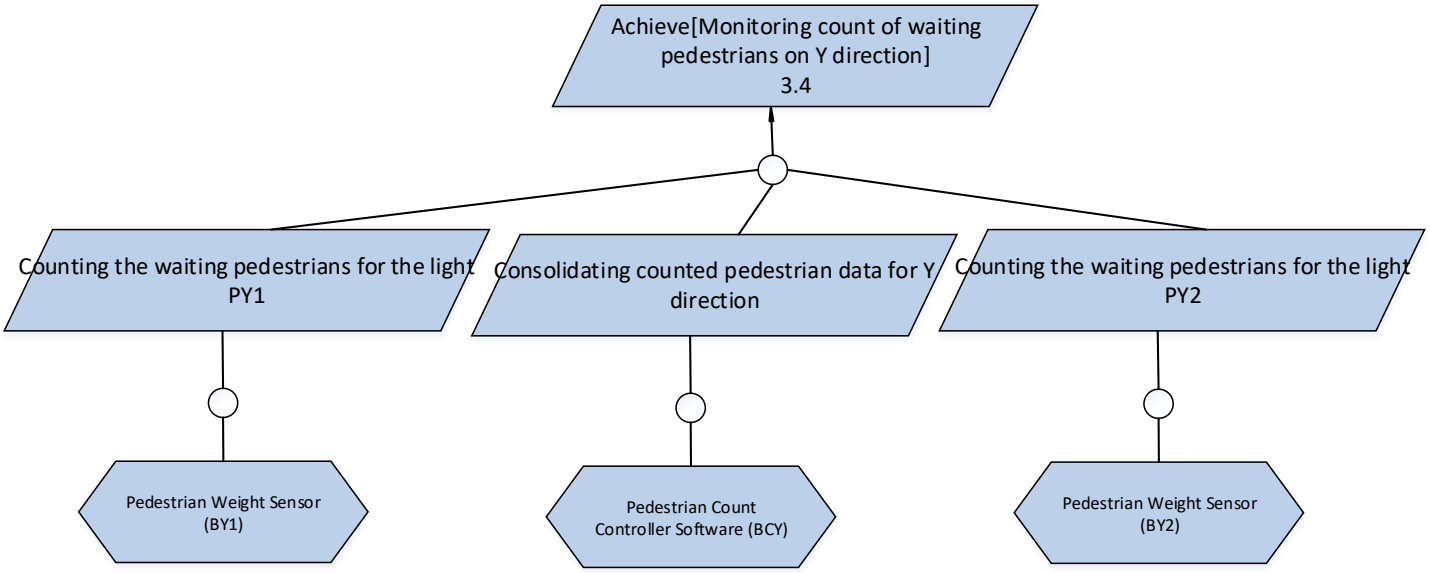


Figure 51 Sub goals of monitoring count of waiting pedestrians on Y direction

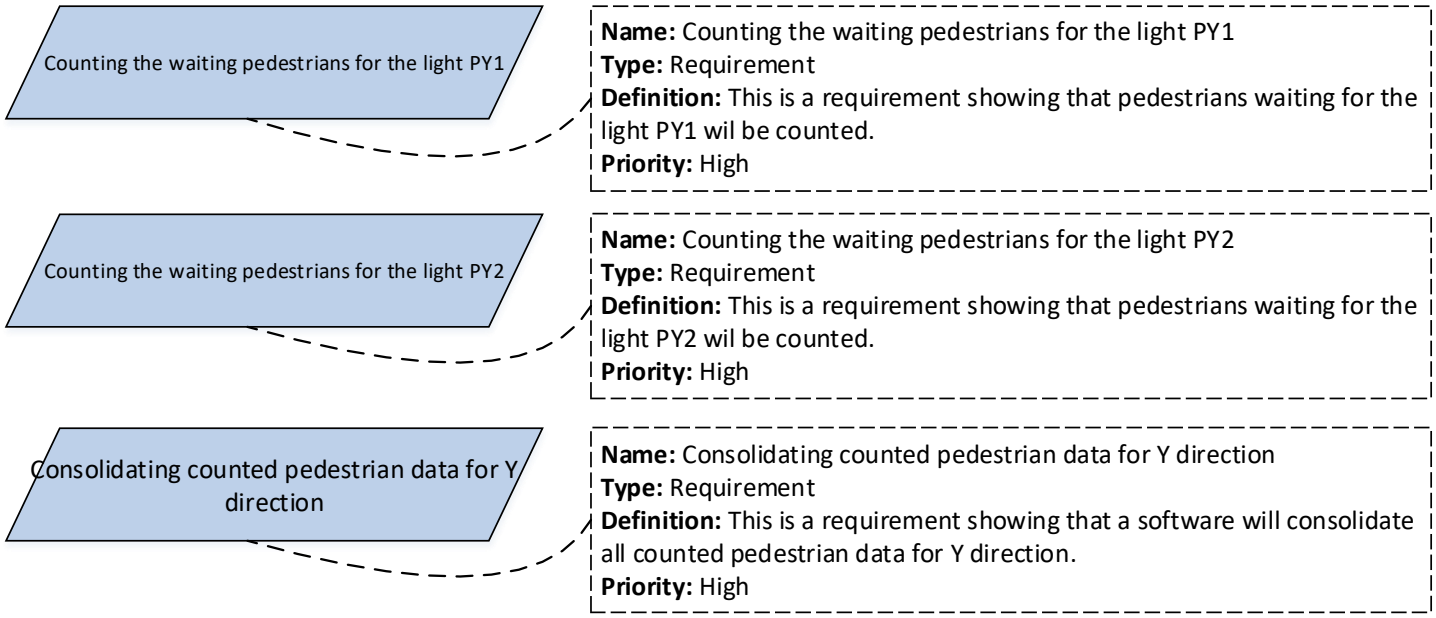


Figure 52 Annotations of sub goals of monitoring count of waiting pedestrians on Y direction

3. OBSTRUCTION MODEL

Obstruction modeling identifies the obstacles that cause the system not to work properly. Each agent might have the obstacles presented below, but to keep it simple, only two instances of them were given. First one will state the situation that if the system cannot be able to collect congestion data and the second one will state the situation of not changing the lights.

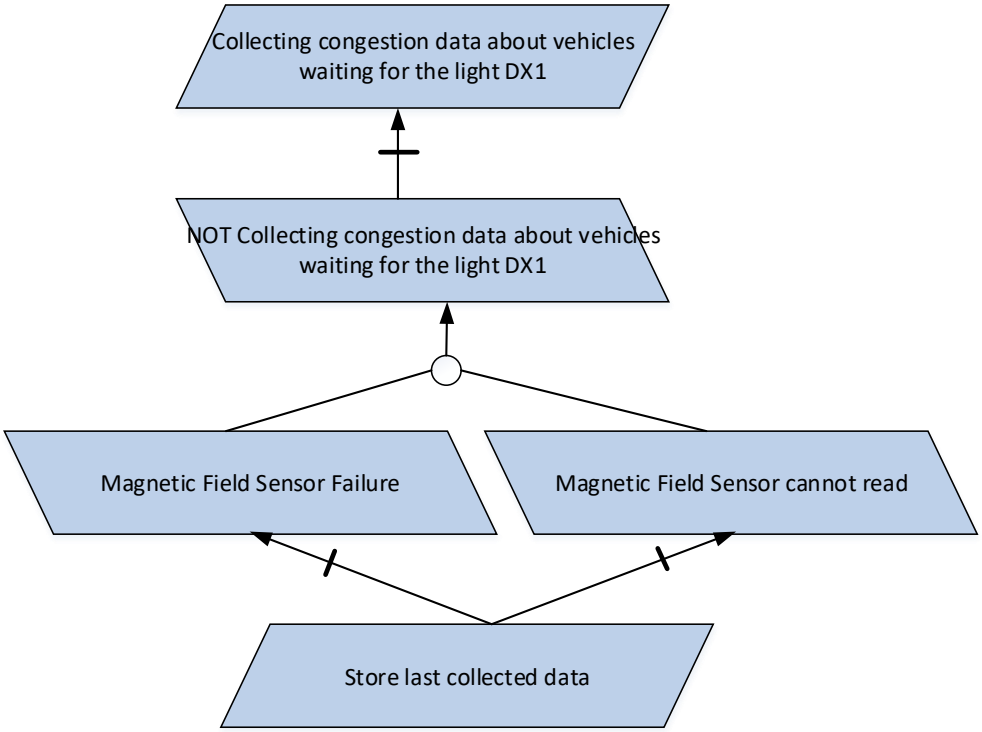


Figure 53 Obstacle of not collecting congestion data

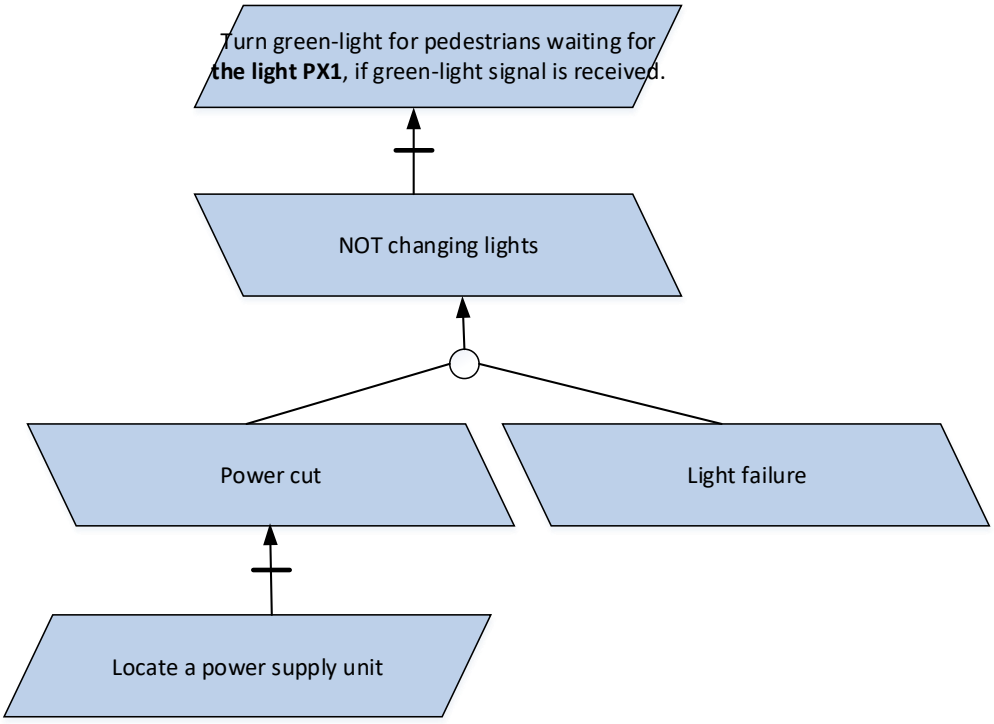


Figure 54 Obstacle of not changing lights

4. AGENT MODEL

The agents are responsible from the satisfaction of goals. They satisfies the goals by performing the operations (which will be identified in the conceptual model section).

4.1 Agent – Pedestrian light controller (PCX)

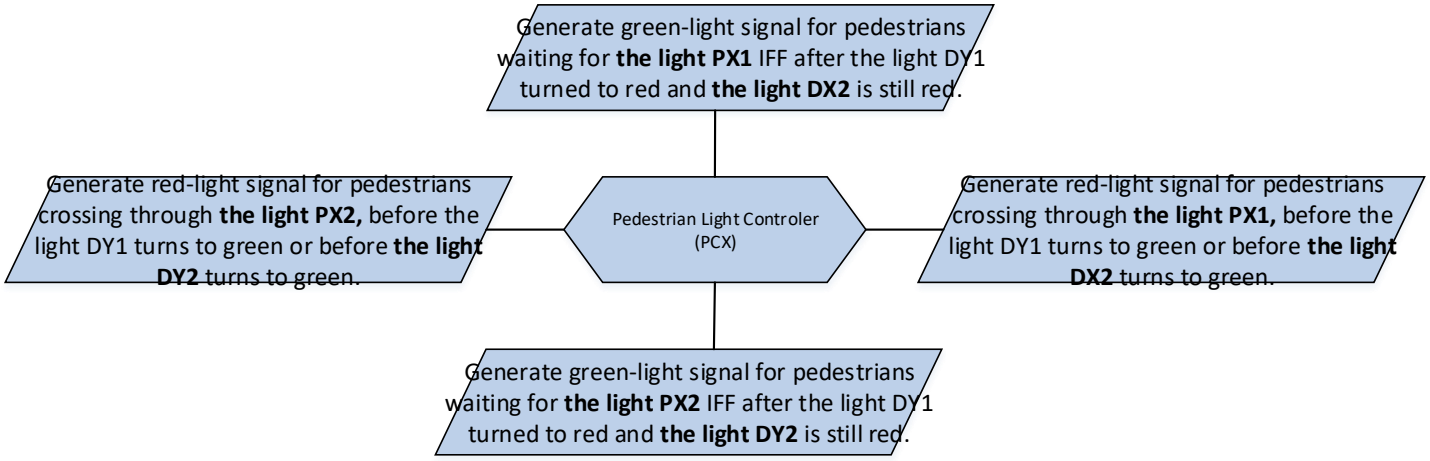


Figure 55 Pedestrian light controller (PCX) agent diagram

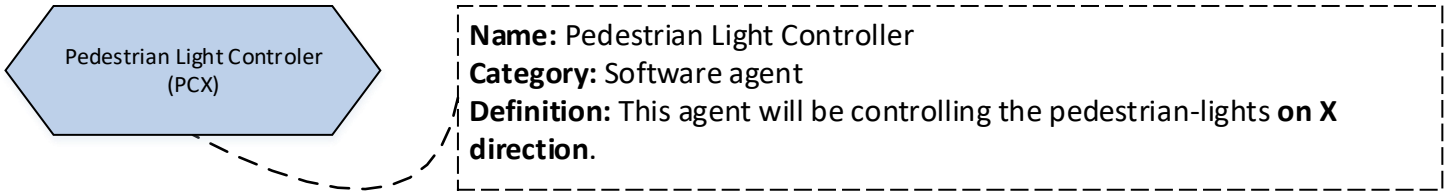


Figure 56 Annotations of pedestrian light controller (PCX) agent

4.2 Agent – Pedestrian light controller (PCY)

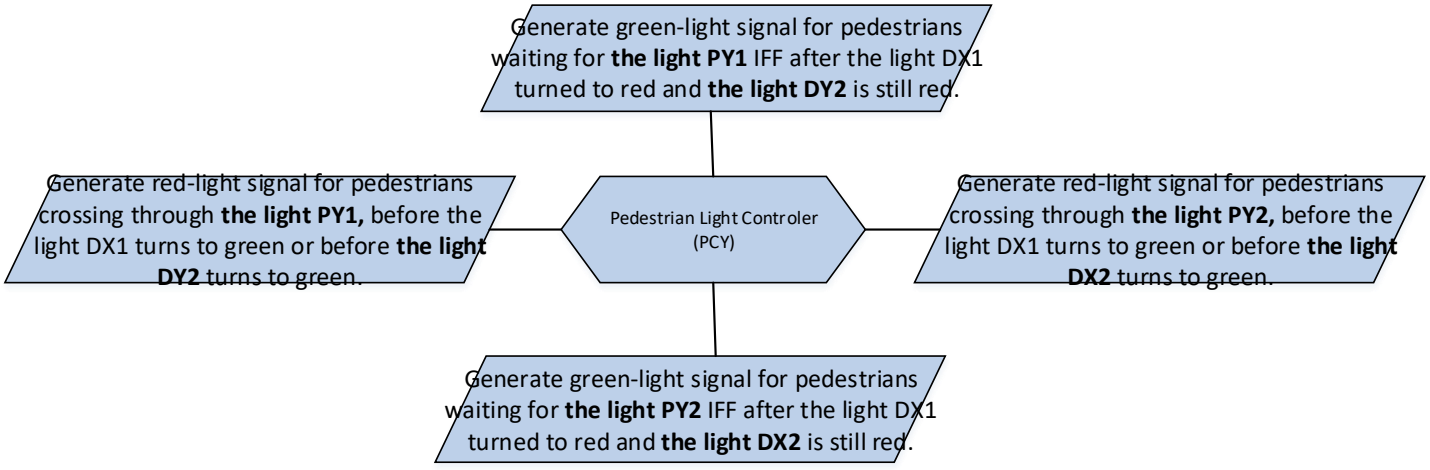


Figure 57 Pedestrian light controller (PCY) agent diagram

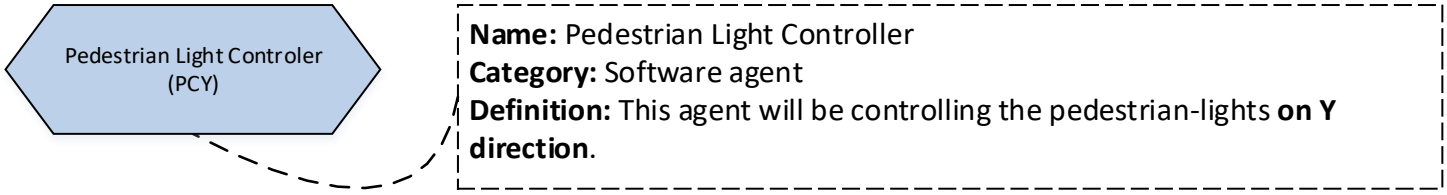


Figure 58 Annotations of pedestrian light controller (PCY) agent

4.3 Agent – Light Monitor Software (LX)

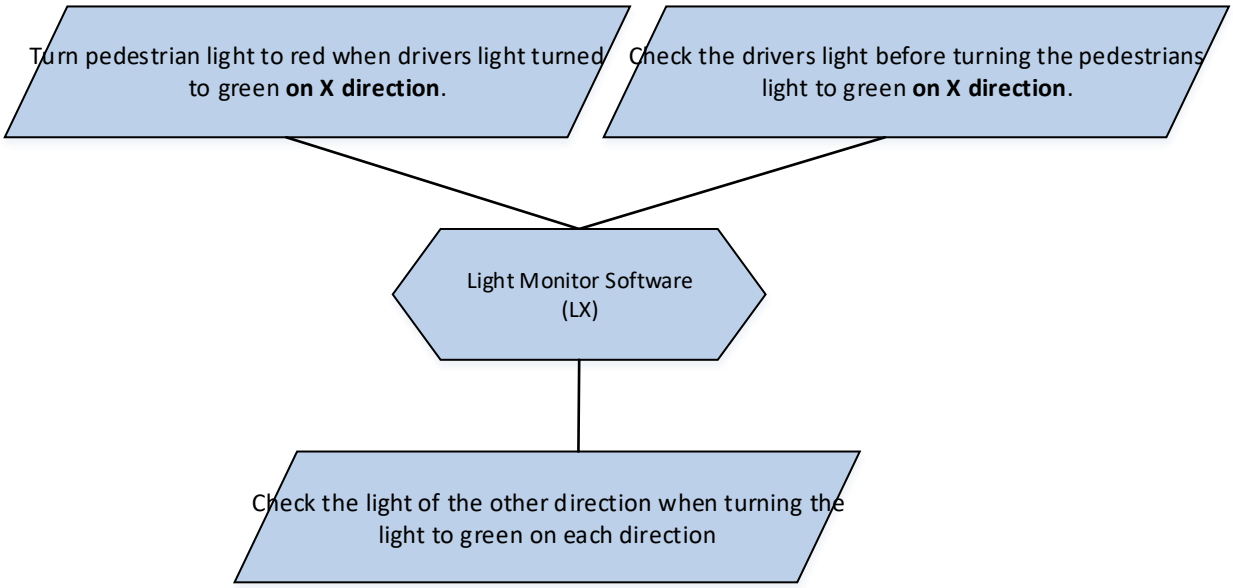


Figure 59 Light Monitor Software (LX) agent diagram

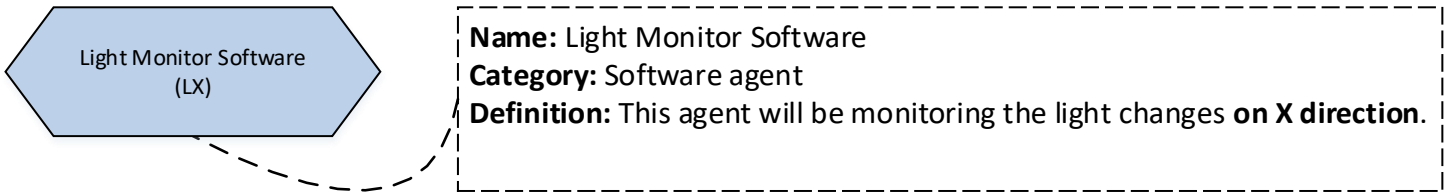


Figure 60 Annotations of Light Monitor Software (LX) agent

4.4 Agent – Light Monitor Software (LY)

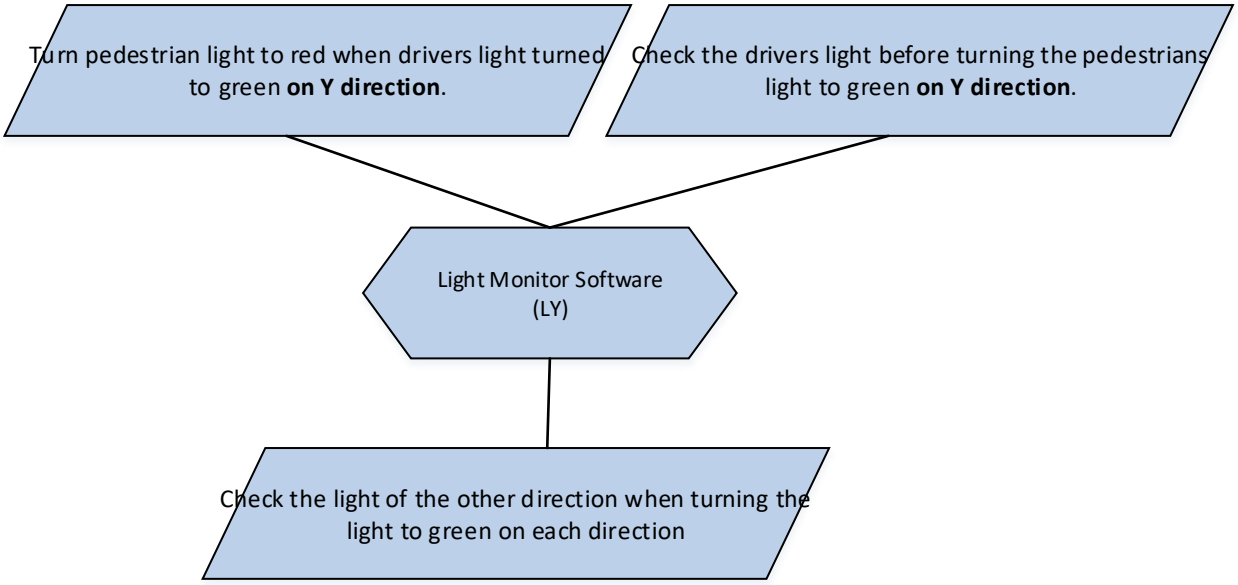


Figure 61 Light Monitor Software (LY) agent diagram

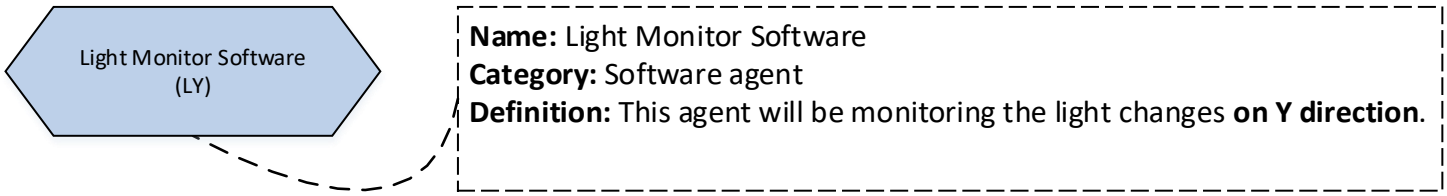


Figure 62 Annotations of Light Monitor Software (LY) agent

4.5 Agent – Drivers Light Controller (DCX)

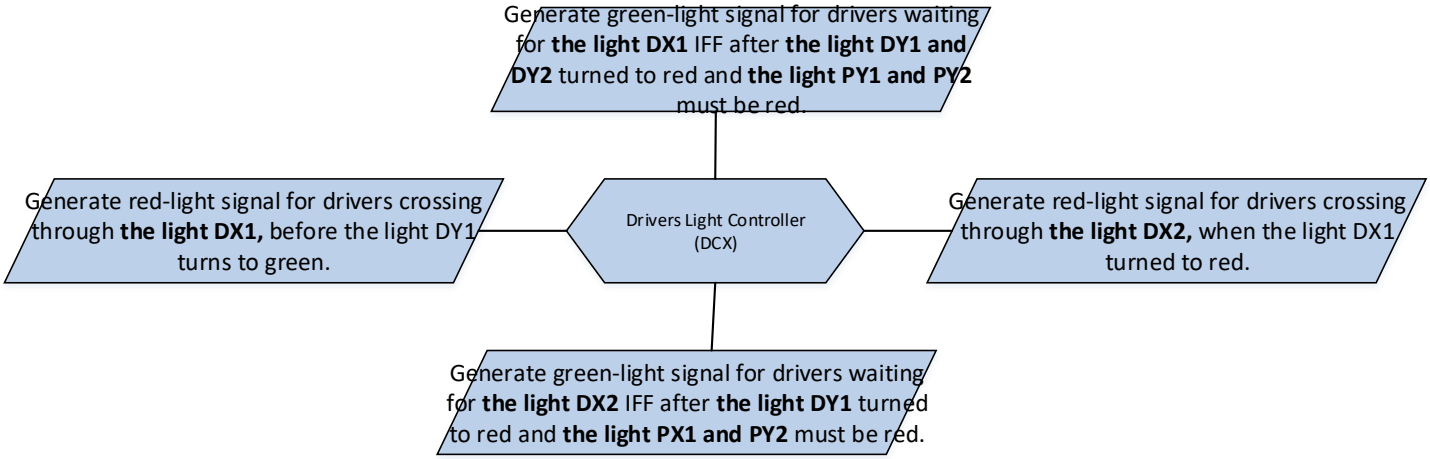


Figure 63 Drivers Light Controller (DCX) agent diagram

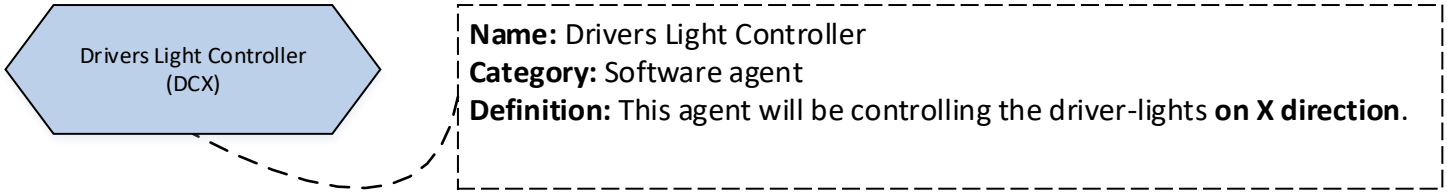


Figure 64 Annotations of Drivers Light Controller (DCX) agent

4.6 Agent – Drivers Light Controller (DCY)

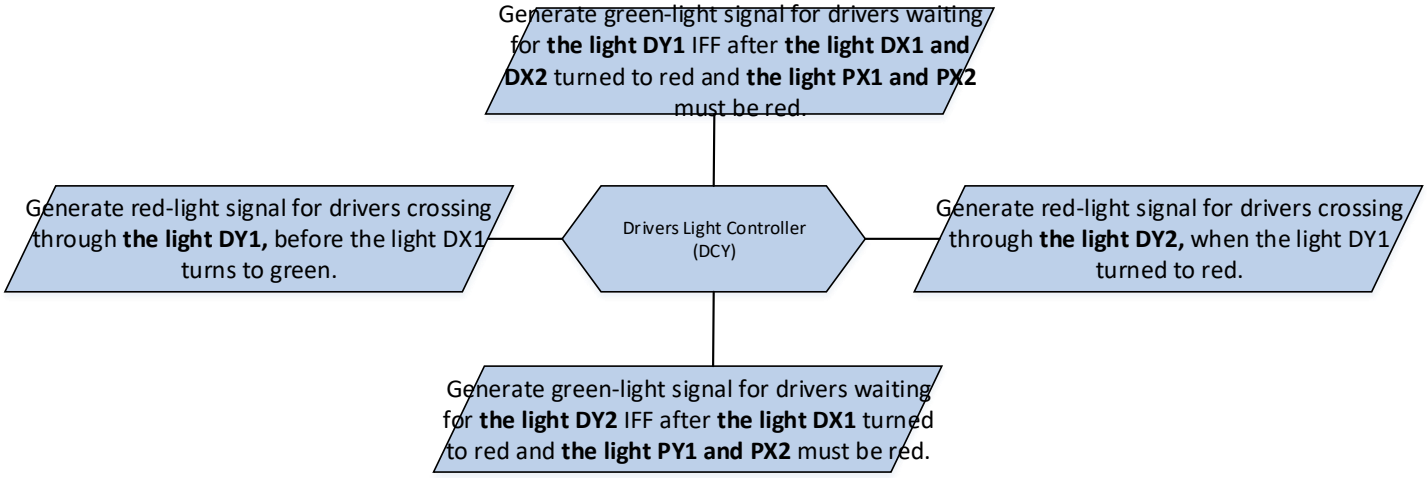


Figure 65 Drivers Light Controller (DCY) agent diagram

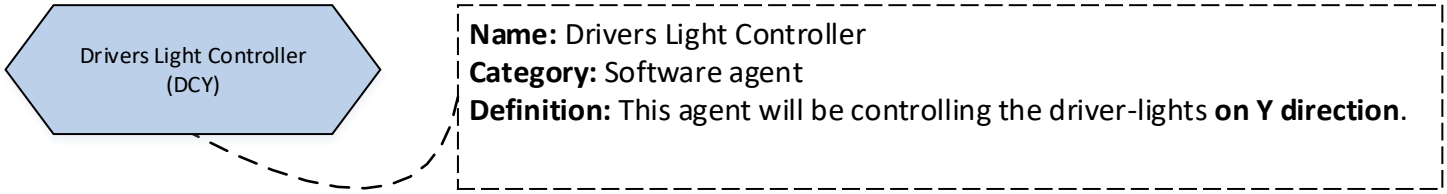
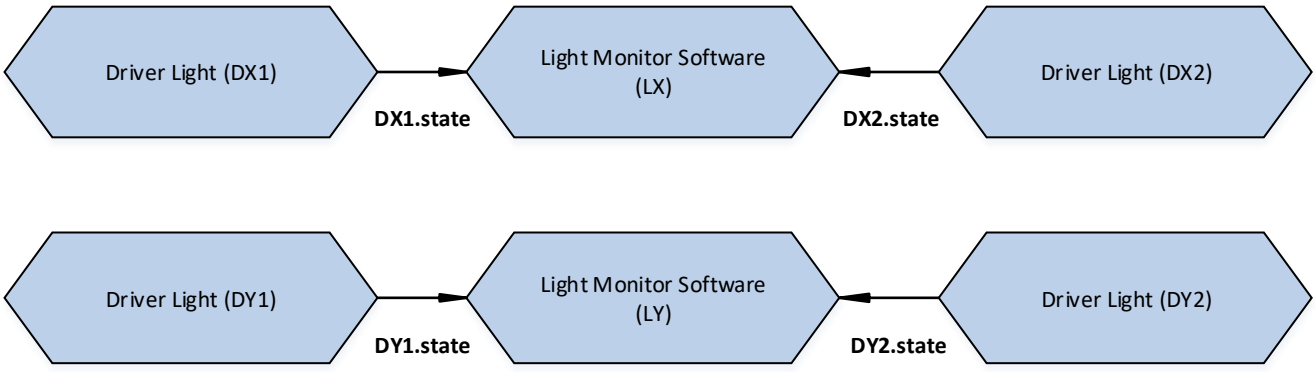
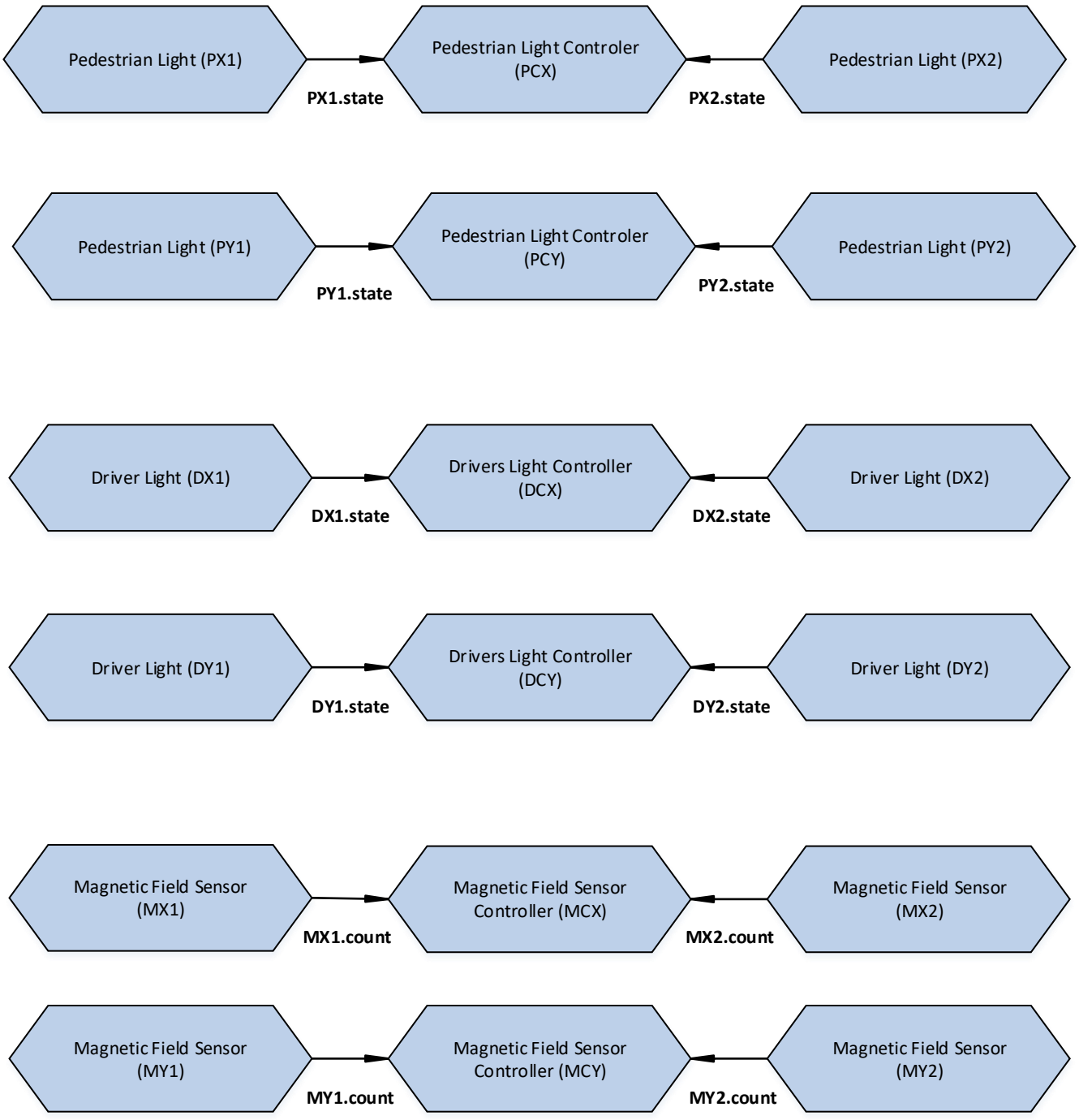


Figure 66 Annotations of Drivers Light Controller (DCY) agent

4.7 Agent – Context Diagrams

Context model of agents represents the agents and their relationships with each other.




Pedestrian Light (PX1)
PX1.state
Pedestrian Light Controler (PCX)
PX2.state
Pedestrian Light (PX2)
Pedestrian Light (PY1)
PY1.state
Pedestrian Light Controler (PCY)
PY2.state
Pedestrian Light (PY2)
Driver Light (DX1)
DX1.state
Drivers Light Controller (DCX)
DX2.state
Driver Light (DX2)
Driver Light (DY1)
DY1.state
Drivers Light Controller (DCY)
DY2.state
Driver Light (DY2)
Magnetic Field Sensor (MX1)
MX1.count
Magnetic Field Sensor Controller (MCX)
MX2.count
Magnetic Field Sensor (MX2)
Magnetic Field Sensor (MY1)
MY1.count
Magnetic Field Sensor Controller (MCY)
MY2.count
Magnetic Field Sensor (MY2)

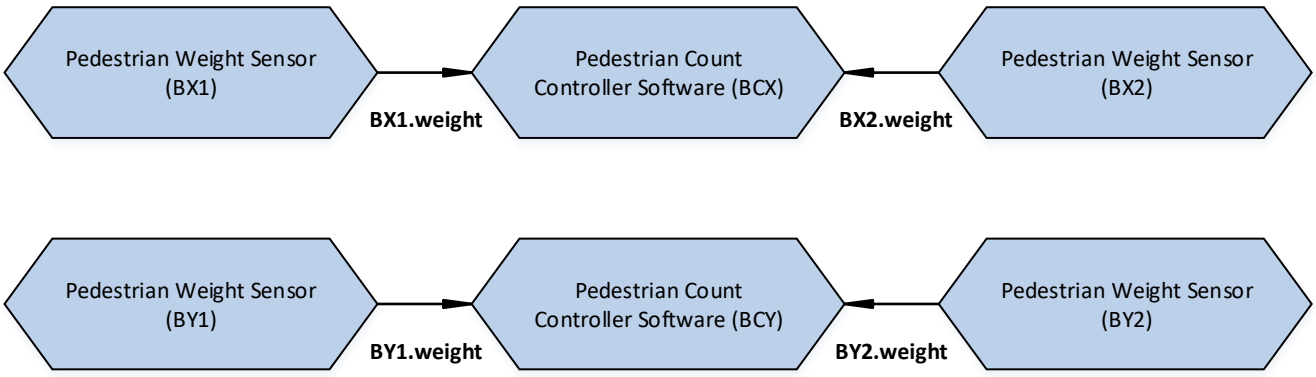


Figure 67 Context diagrams of agents

5. CONCEPTUAL MODEL

Conceptual modeling underpins software development process, especially in object-oriented software development. The conceptual model of given system is depicted as below.

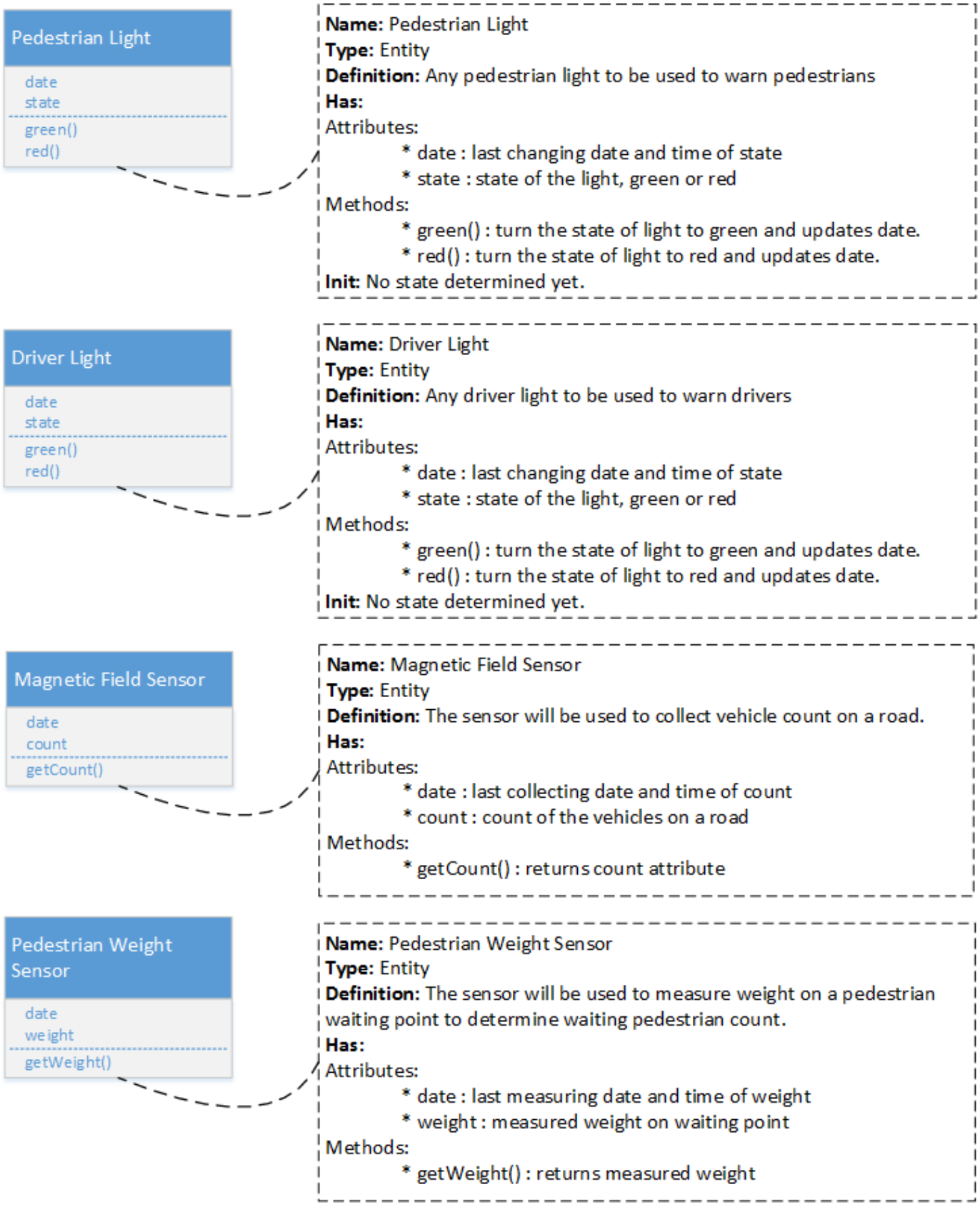


Figure 68 Conceptual diagram of agents

6. OPERATION MODEL

An operation is something that an agent will carry out to meet a requirement. Operation model will capture the operations with agents, which are responsible from the operations, objects, which will be monitored and/or controlled by the operations and the goal that the operations will be satisfied.

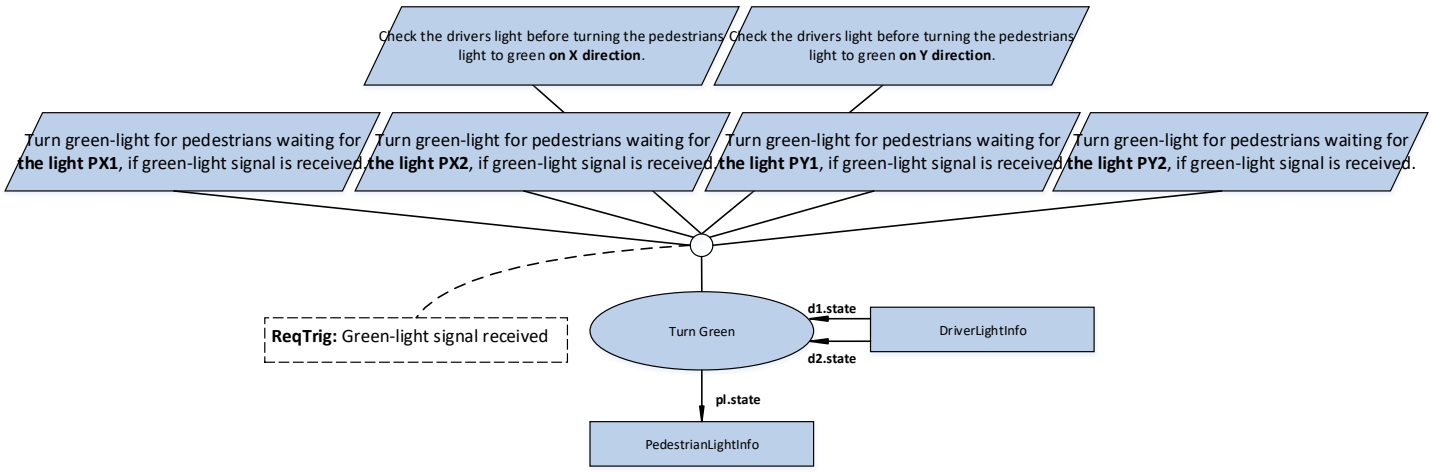


Figure 69 Operation - Turn pedestrian lights to green

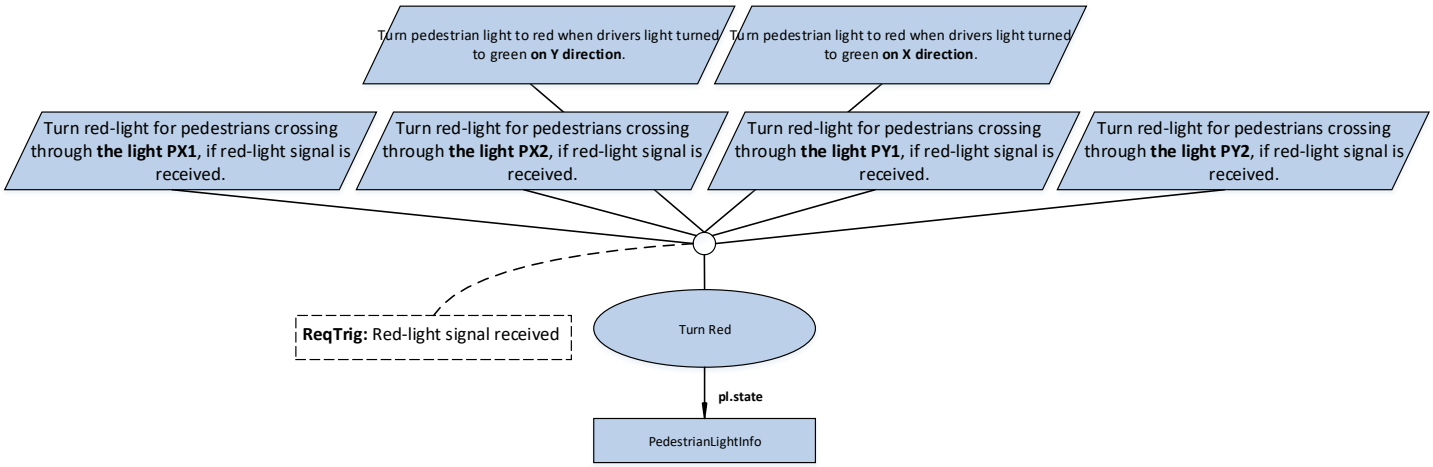


Figure 70 Operation - Turn pedestrian lights to red

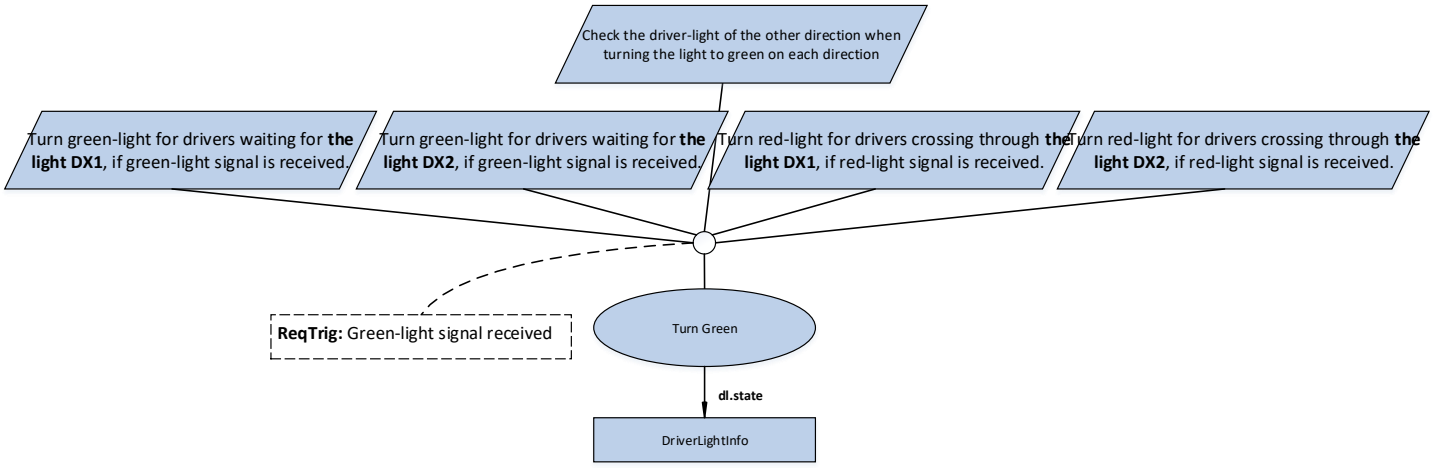


Figure 71 Operation - Turn driver lights to green

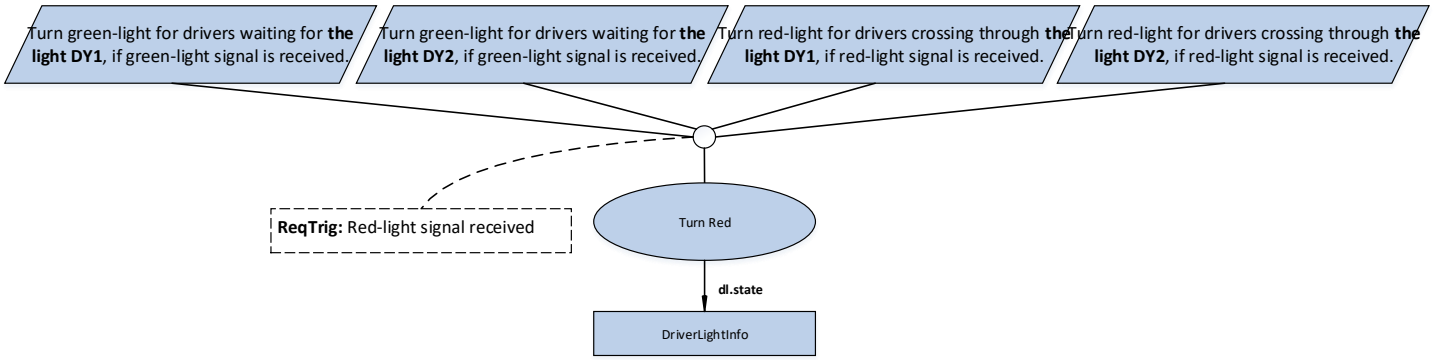


Figure 72 Operation - Turn driver light to red

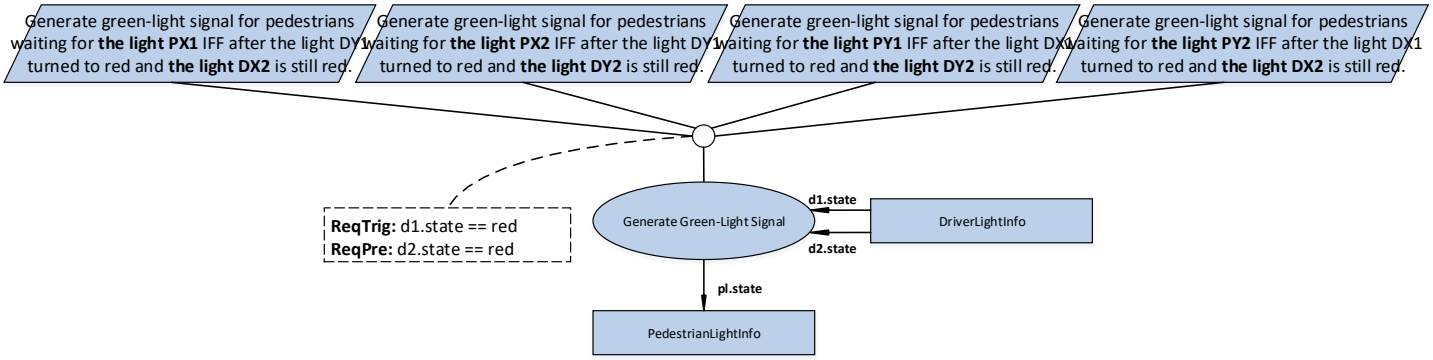


Figure 73 Operation - Generate green-light signal for pedestrian

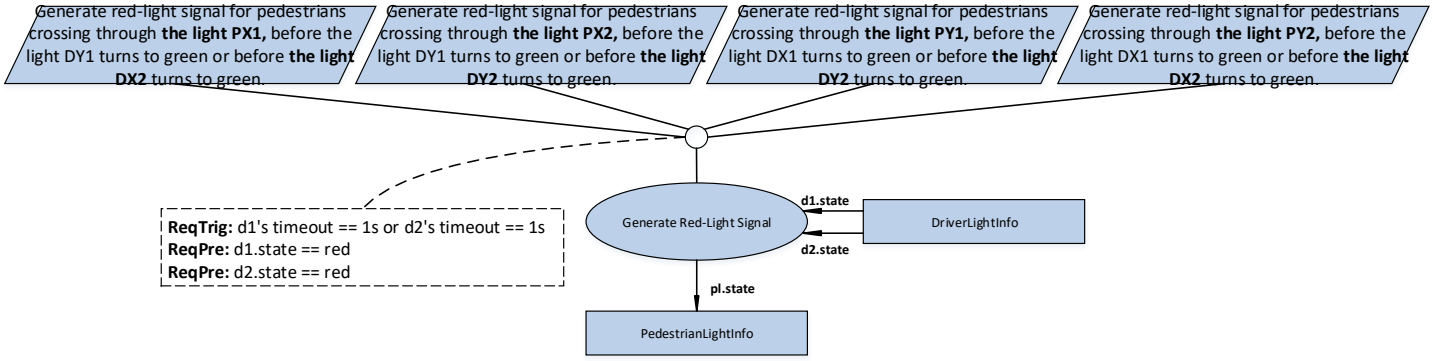


Figure 74 Operation - Generate red-light signal for pedestrian

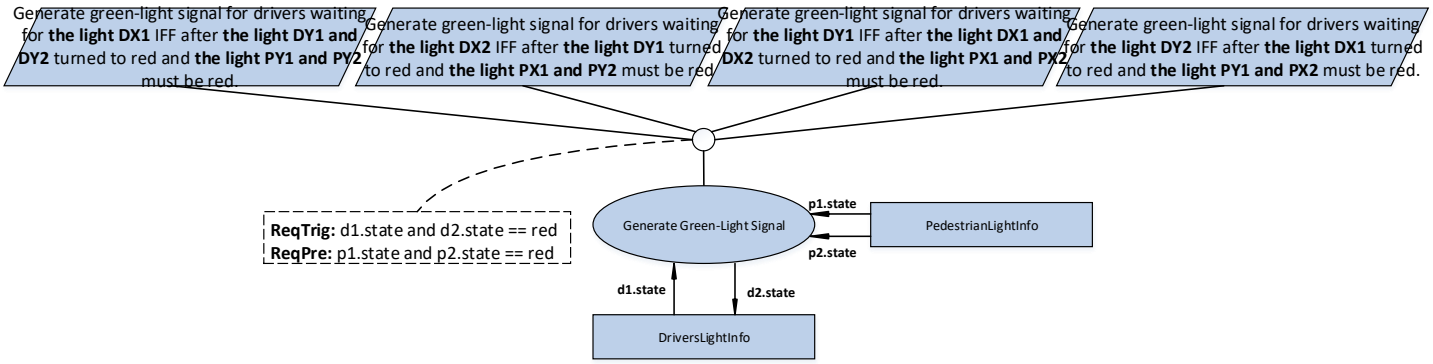


Figure 75 Operation - Generate green-light signal for driver

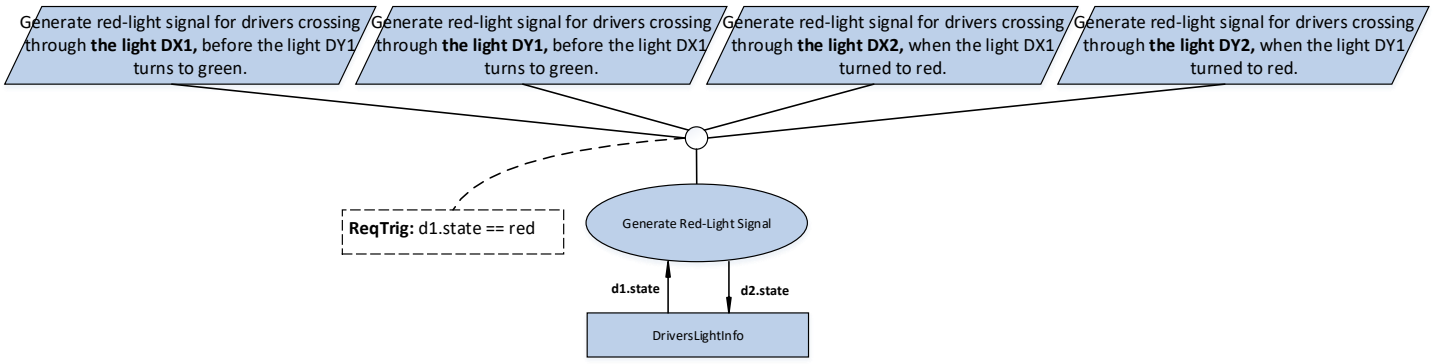


Figure 76 Operation - Generate red-light signal for driver

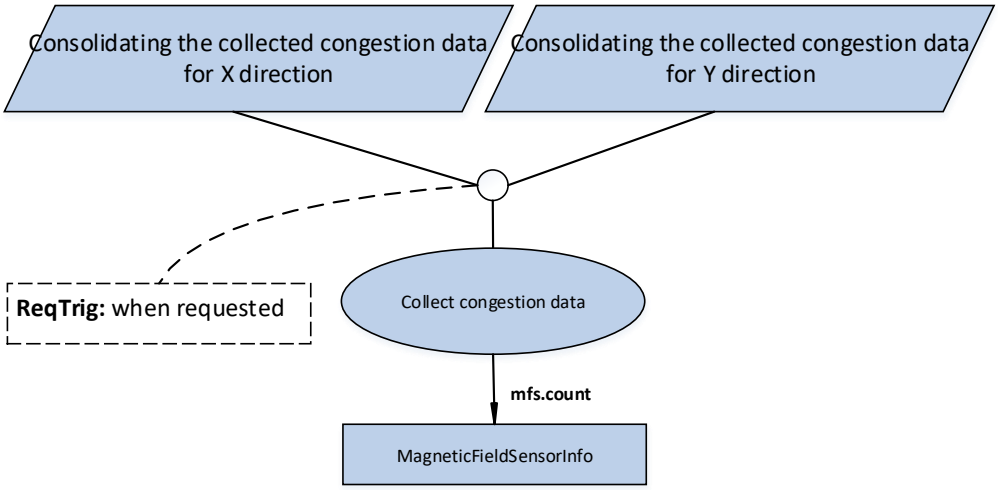


Figure 77 Operation - Collect congestion data

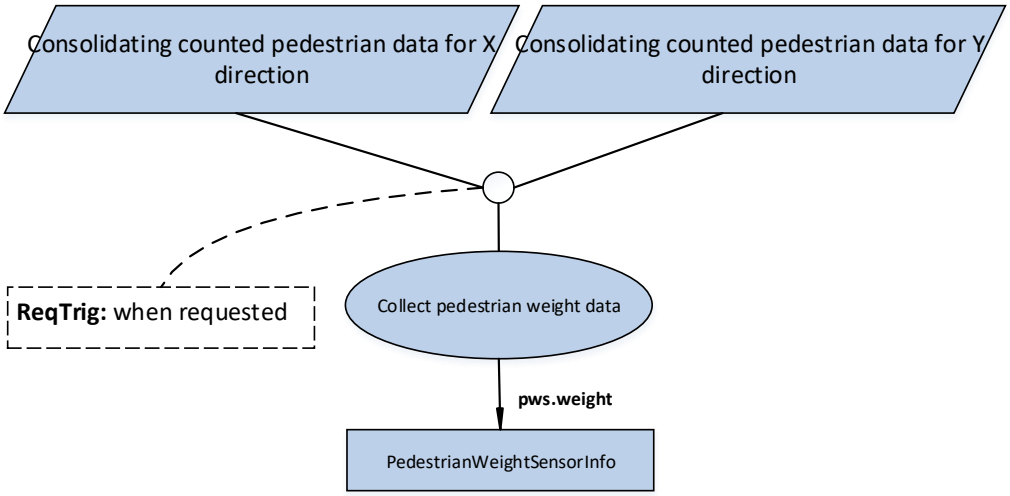


Figure 78 Operation - Collect pedestrian weight data

7. CONCLUSION

To conclude, traffic lights were used to make the traffic flow safe and efficient at the intersection. In our system-to-be, only two separate lights were utilized to direct pedestrian and drivers for satisfying safety-related goals and two separate sensors were used to satisfy the efficiency-related goals.

First of all, goal model was provided and addressed the obstacles against the system-to-be. The agent model, conceptual (object) model and lastly operation model were presented.