Implementation of Vehicle Dispatching and Monitoring in a Self-Driving Delivery Emulation System for Urban Areas

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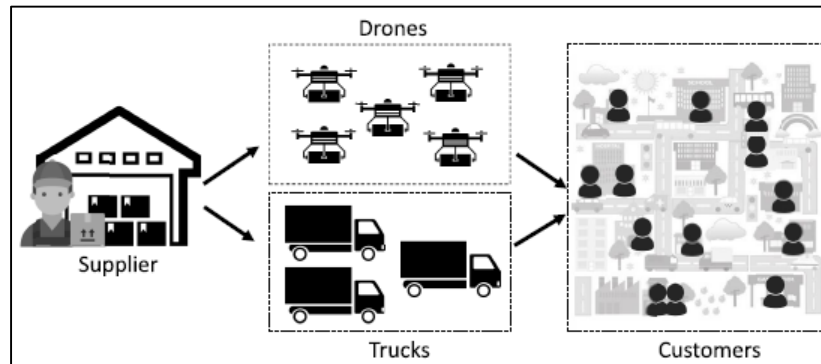
Unmanned Delivery of Takkyubin

Motivation

1. The **last mile delivery** is one of the most expensive stages of the entire e-logistic chain.

2. In the last mile delivery, the most widespread delivery mode is **home delivery**.

3. In the area of home delivery, there is no complete self-driving delivery system.

4. The thesis wants to develop the software part of a self-driving delivery emulation system.

5. Thus, the self-driving development company can apply the implementation into the actual self-driving cars for achieving the goal of system integration directly.

Related Work- Delivery Modes

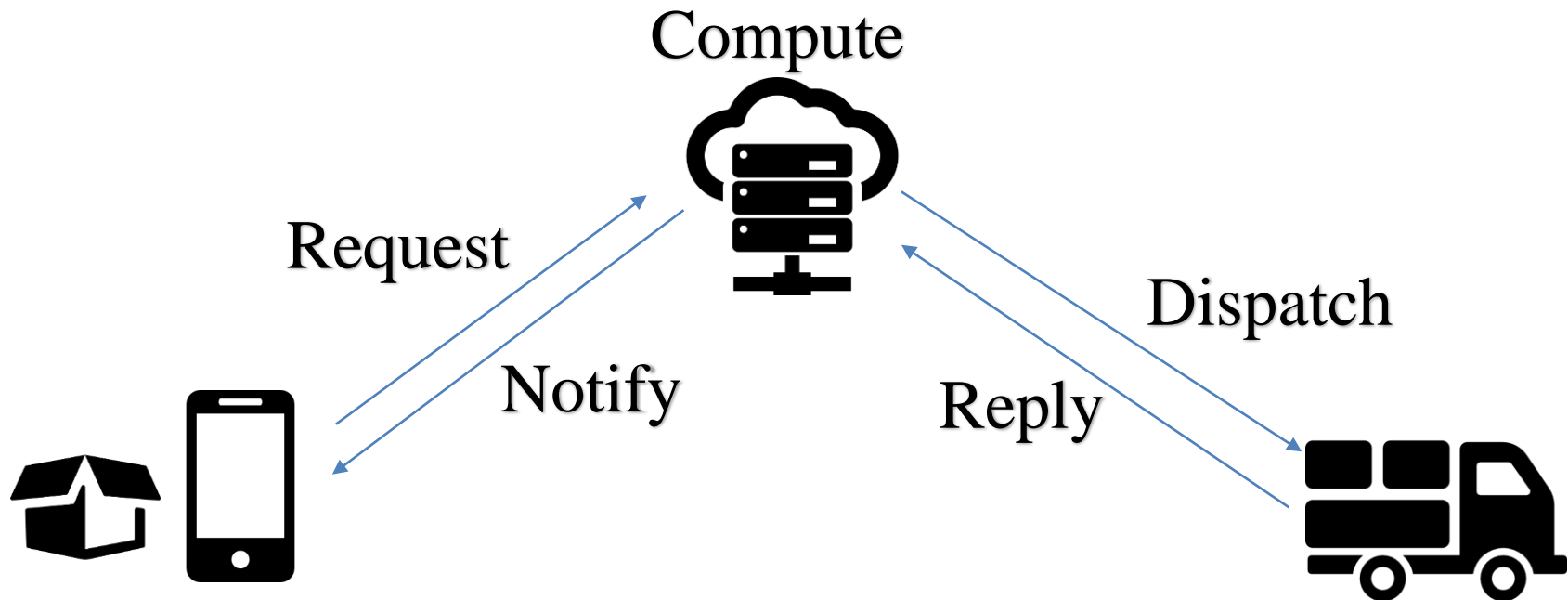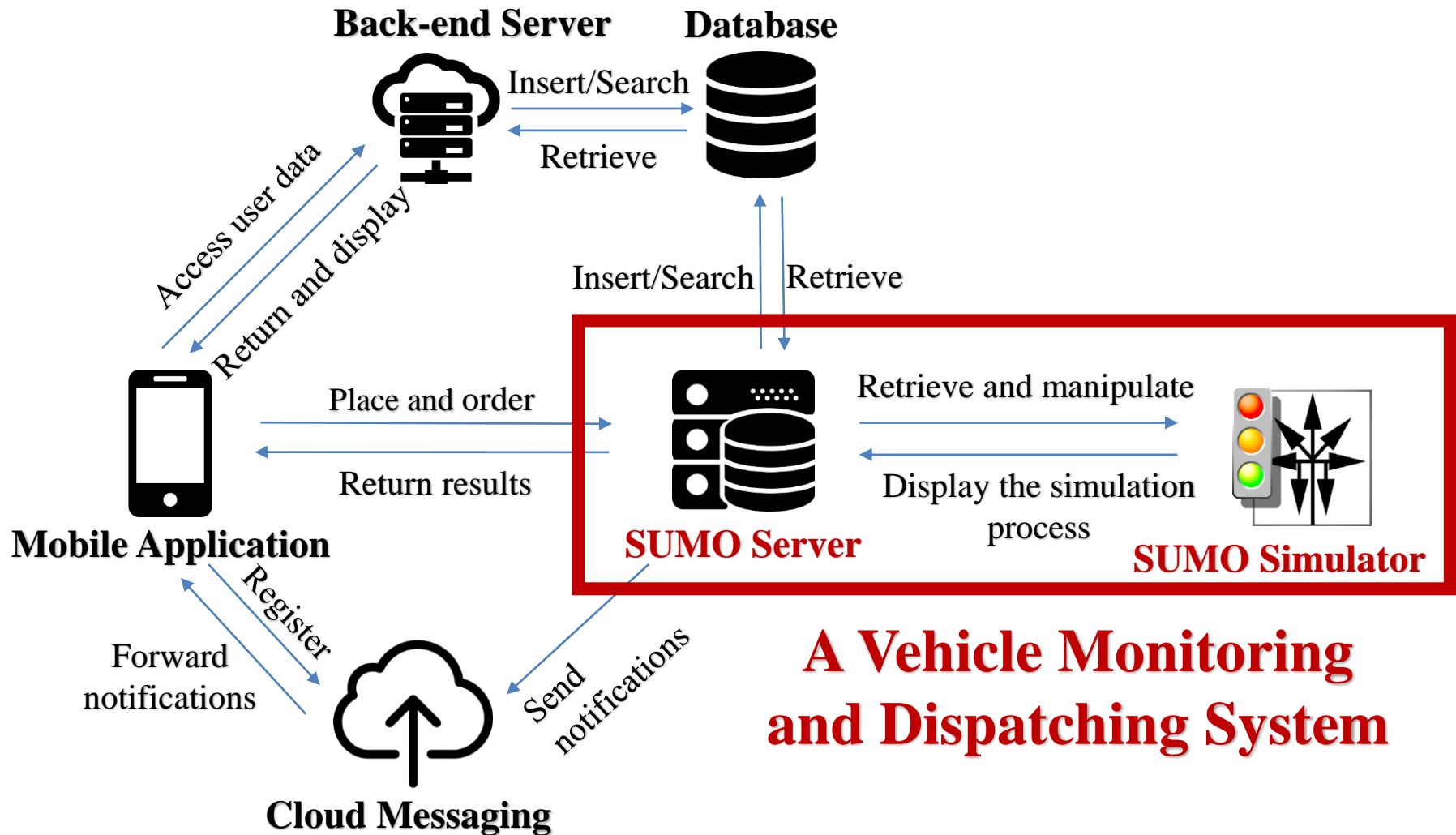|	Aerial vehicles [7]	A joint ground and aerial delivery service framework [8]	Cargo bikes [9]	Self-driving Vehicles [11]
Rapidity	◎	△	×	△
Scalability	×	△	×	◎
Reliability	×	◎	△	◎
Computation time	△	×	◎	△

◎ **Excellent, △Ordinary, ×Poor**

Introduction

1. The thesis implements a **vehicle dispatching and monitoring system** to simulate the parcel delivery process.

2. The system develops a dispatching mechanism to deal with the order requests and arranges the routes dynamically and immediately.

3. This study utilizes the SUMO simulator, and cleans up the map of the downtown area of Tainan.

4. It performs the simulation with five scenarios of the parcel delivery service.
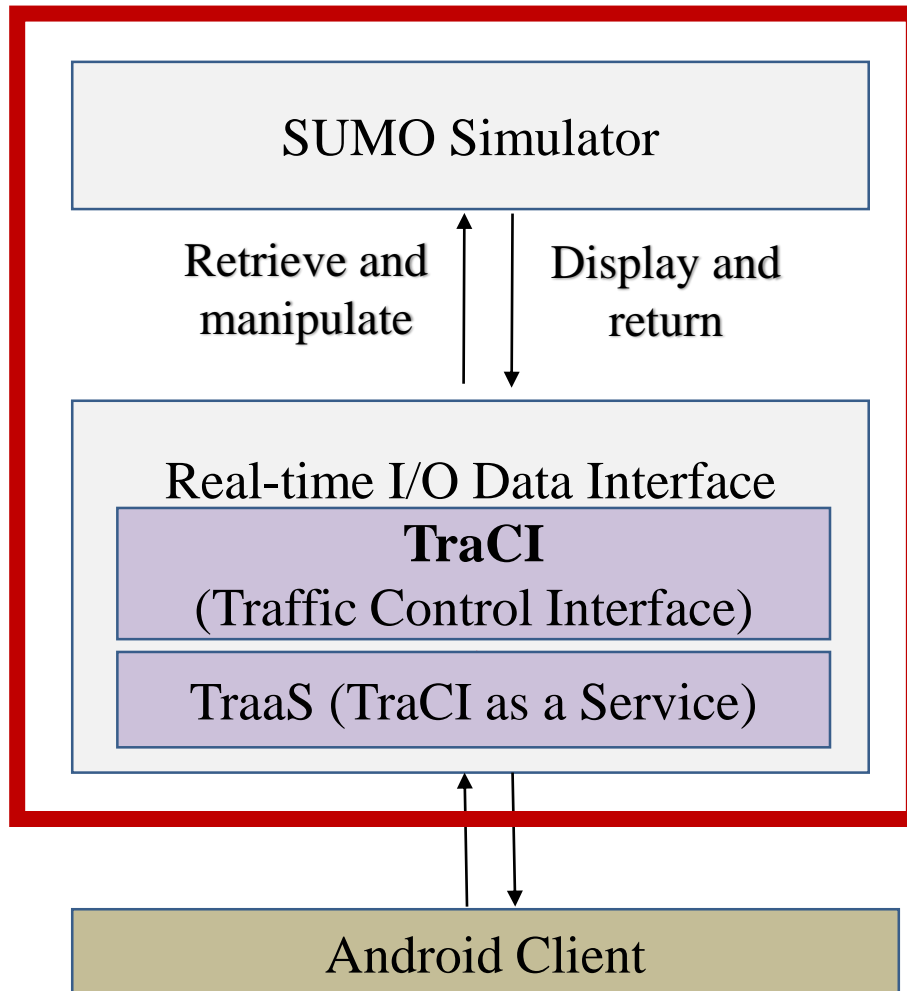
System Architecture with Self-Driving Truck

Compute

Request

Dispatch

Notify

Reply

A Whole System Overview

Back-end Server **Database**

Insert/Search

Retrieve

Access user data

Return and display

Insert/Search Retrieve

Place and order

Return results

Mobile Application

Register

Forward notifications

Send notifications

Cloud Messaging

Retrieve and manipulate

Display the simulation process

SUMO Server **SUMO Simulator**

A Vehicle Monitoring and Dispatching System

Traffic Control Interface

Vehicle Monitoring and Dispatching System

SUMO Simulator

Retrieve and manipulate ↑ ↓ Display and return

**Real-time I/O Data Interface**

TraCI
(Traffic Control Interface)

TraaS (TraCI as a Service)

Android Client

- Real-time I/O Interface offers a possibility to communicate between the simulation and the user application bi-directionally.

- TraCI can retrieve the values of vehicles and manipulate their behaviors.

- The service binds on a specific IP address and on a specific port.

- TraaS can communicate with the Android Client.

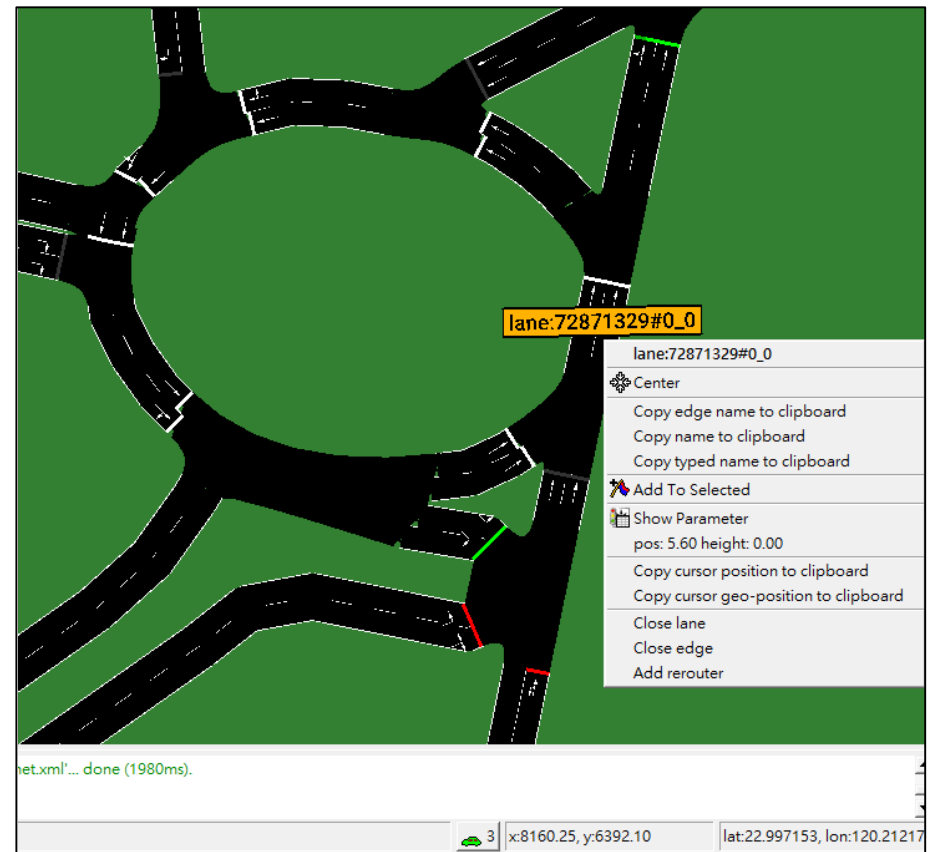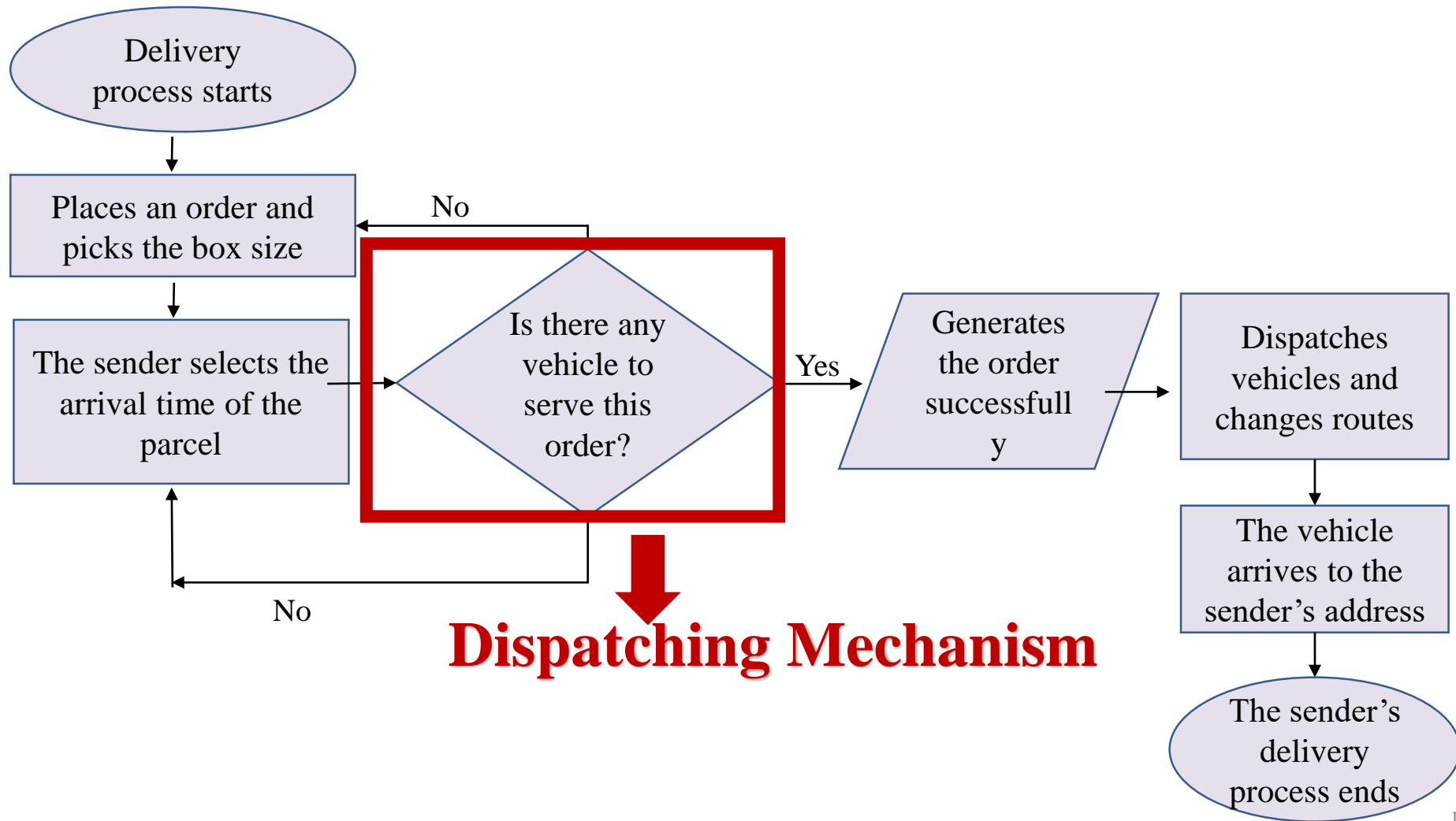# Manipulation of Vehicle Routing
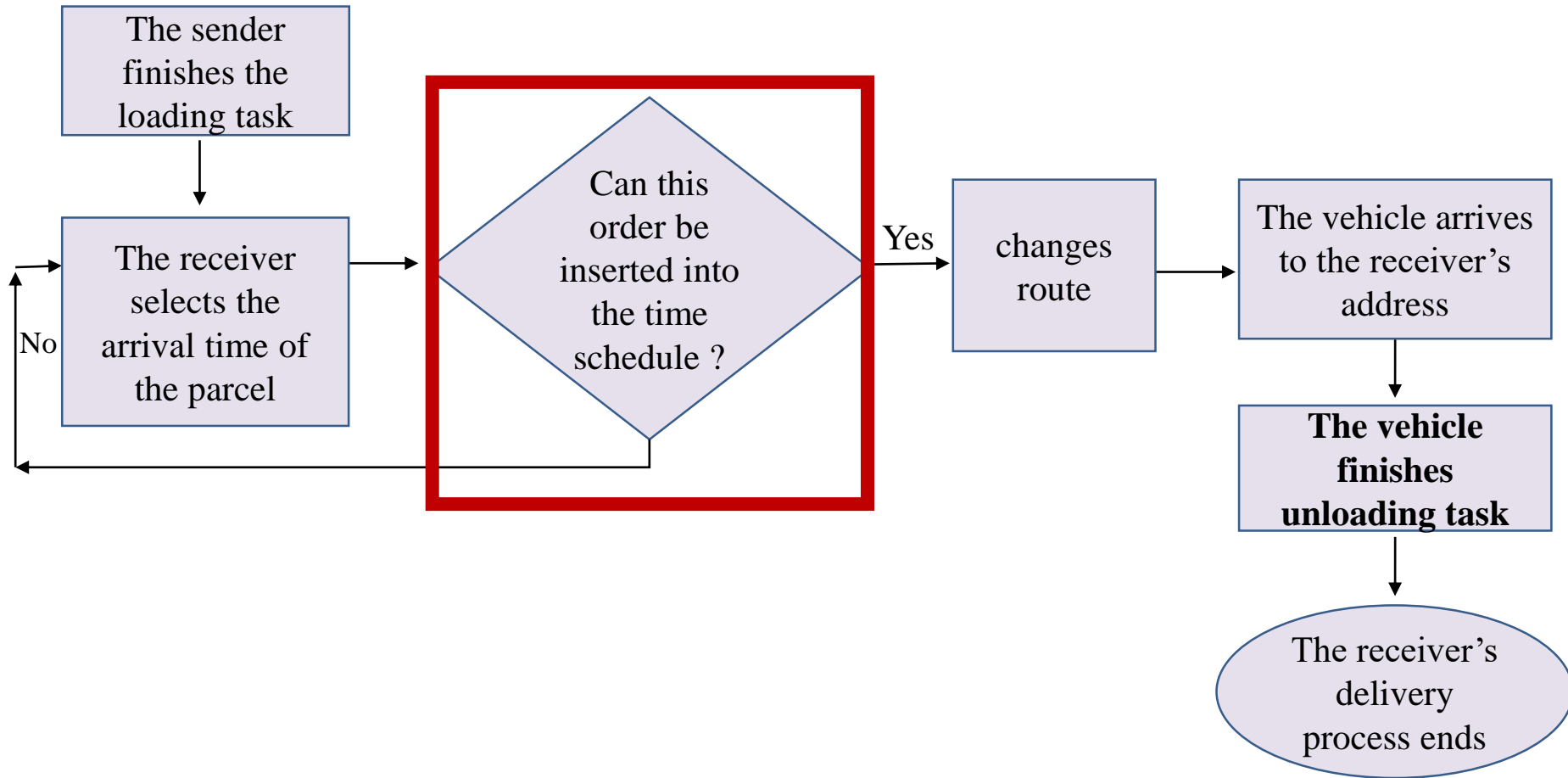
Before
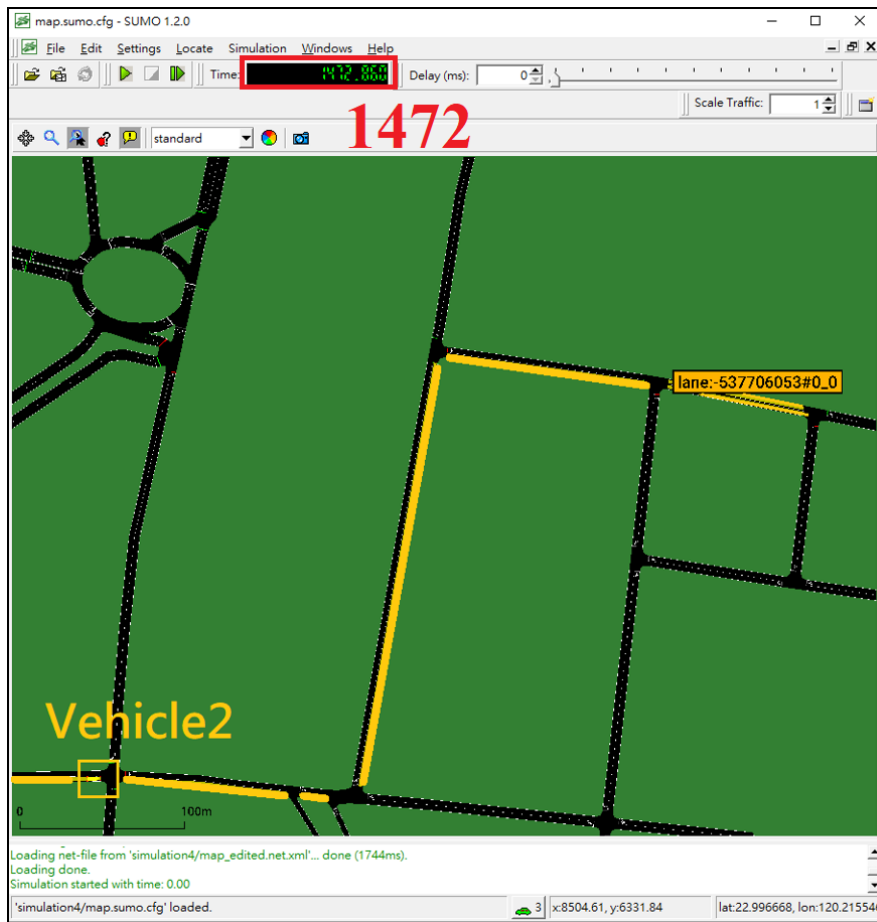
After
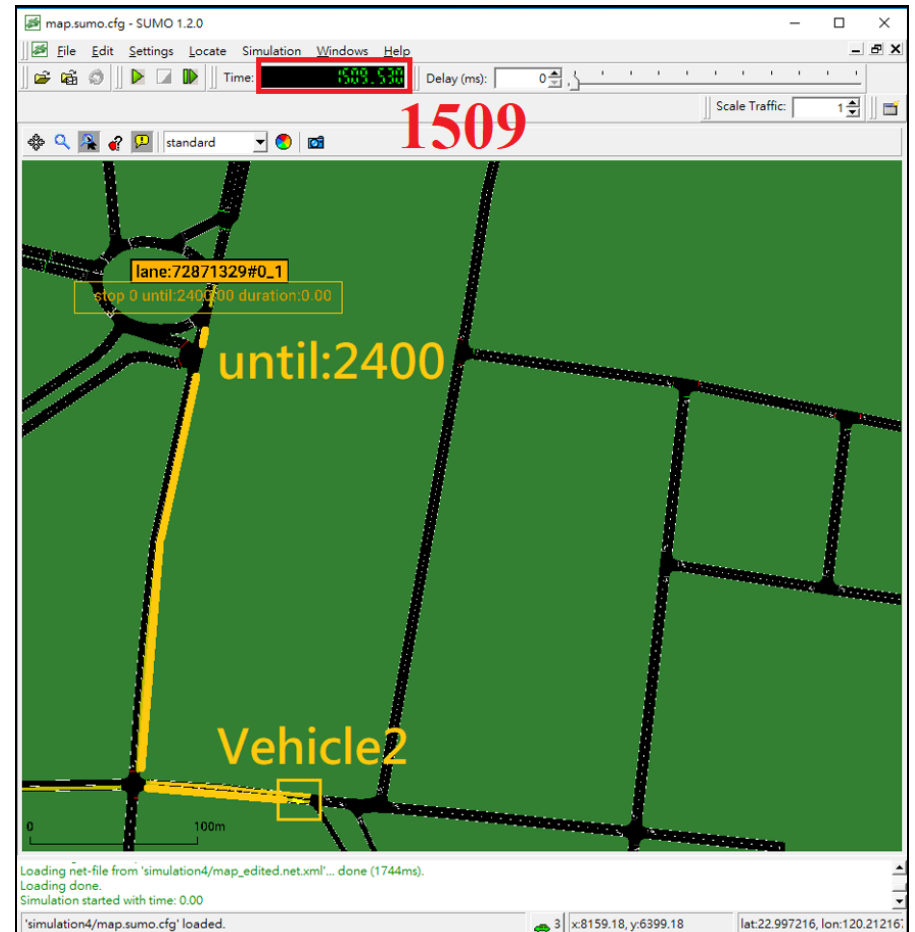
Map Address Conversion

Sender address → **Google Map API** → longitude, latitude → **convertRoad function in SUMO API** → Road ID of SUMO

Flow Chart of Parcel Delivery Process in Sender's Part

Delivery process starts

Places an order and picks the box size

No

The sender selects the arrival time of the parcel

No

Is there any vehicle to serve this order?

Yes

Generates the order successfully

Dispatches vehicles and changes routes

The vehicle arrives to the sender's address

Dispatching Mechanism

The sender's delivery process ends

Flow Chart of Parcel Delivery Process in Receiver's Part

The sender finishes the loading task

The receiver selects the arrival time of the parcel

No

Can this order be inserted into the time schedule ?

Yes

changes route

The vehicle arrives to the receiver's address

The vehicle finishes unloading task

The receiver's delivery process ends

Dispatching Mechanism
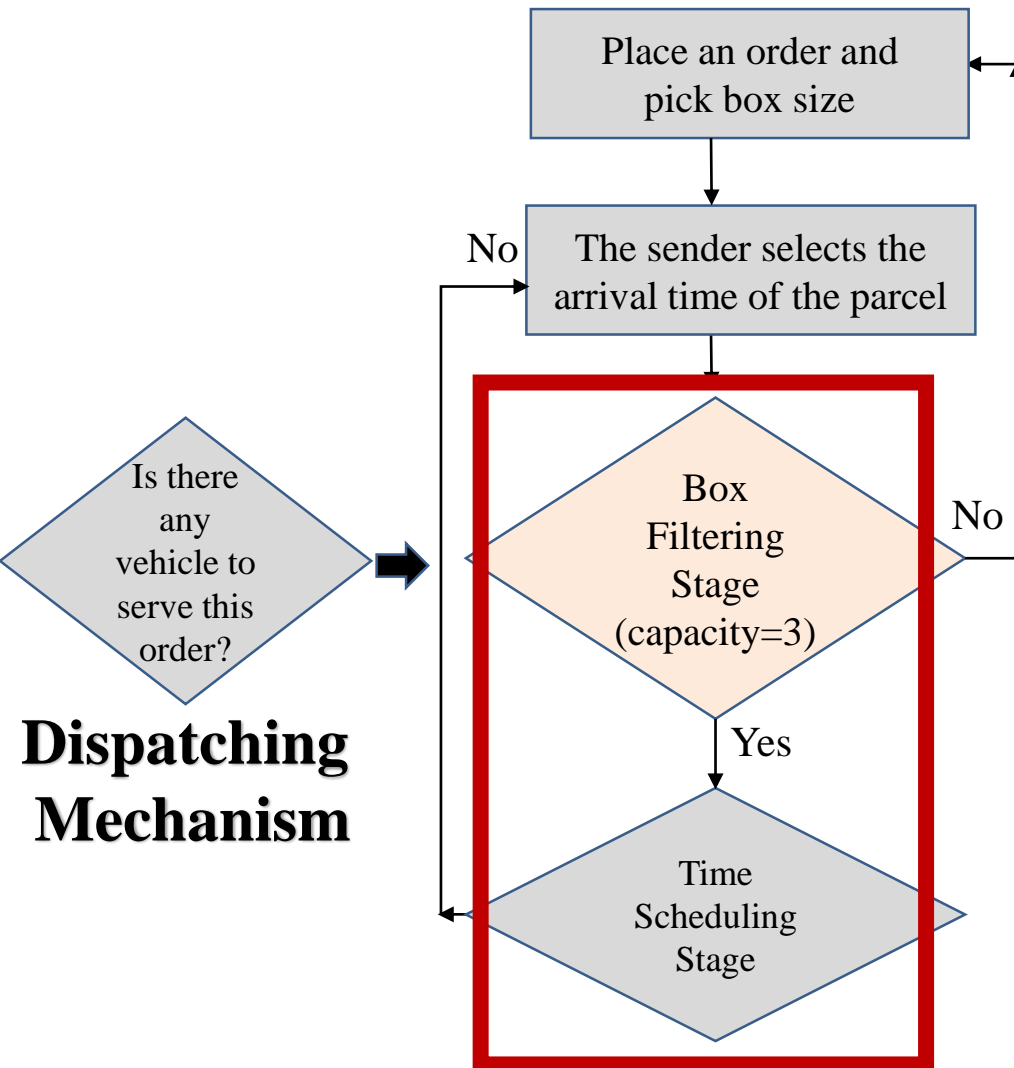
211

Vehicle ID   Small size   Container number

Place an order and pick box size

No — The sender selects the arrival time of the parcel

Is there any vehicle to serve this order?

Dispatching Mechanism

Box Filtering Stage (capacity=3) — No

Yes

Time Scheduling Stage

	V1	**V2**	**V3**
small	111 112		
medium		221	
large			

After the small box insertion,
v1,v2 and v3 exists

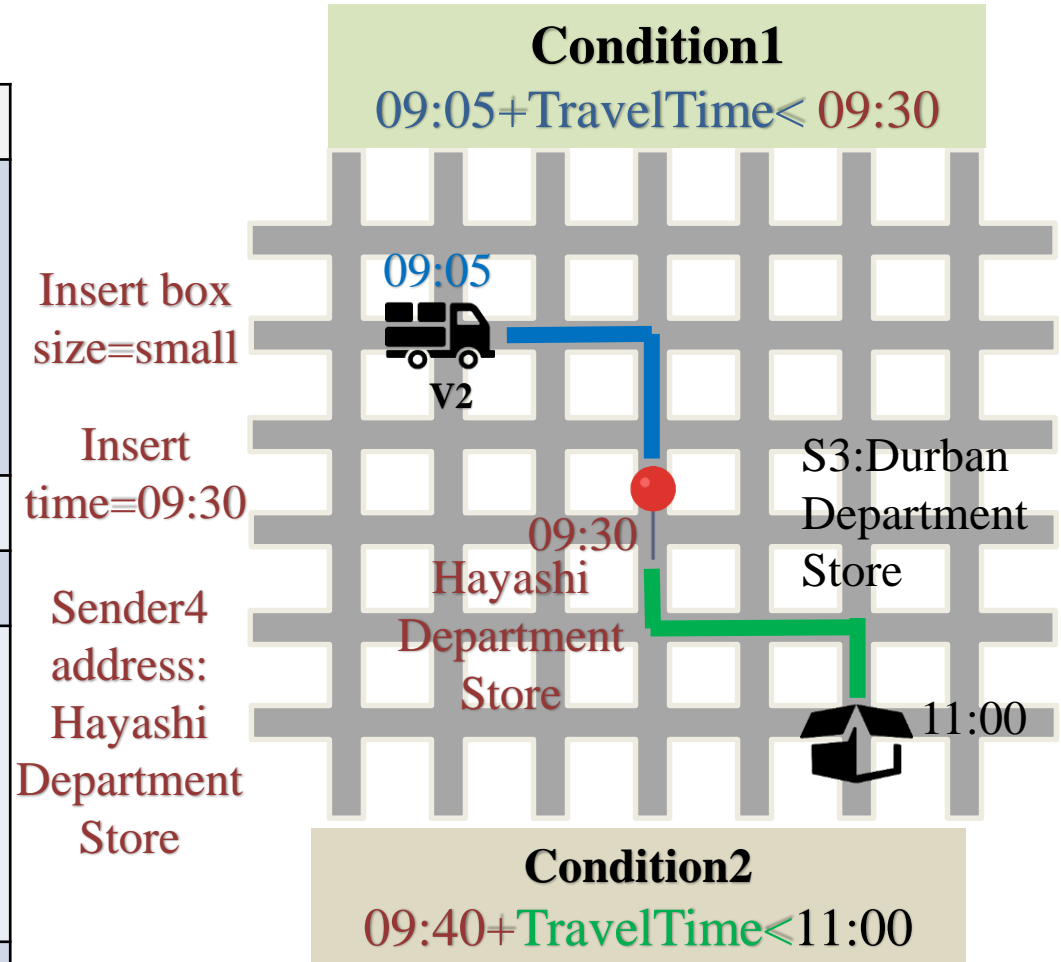|	**V1**	**V2**	**V3**	**V4**	**V5**
small	111				
medium	121 122 123	221	321 322 323	421 422	
large					

After the medium box insertion,
v2, v4 and v5 exists

13

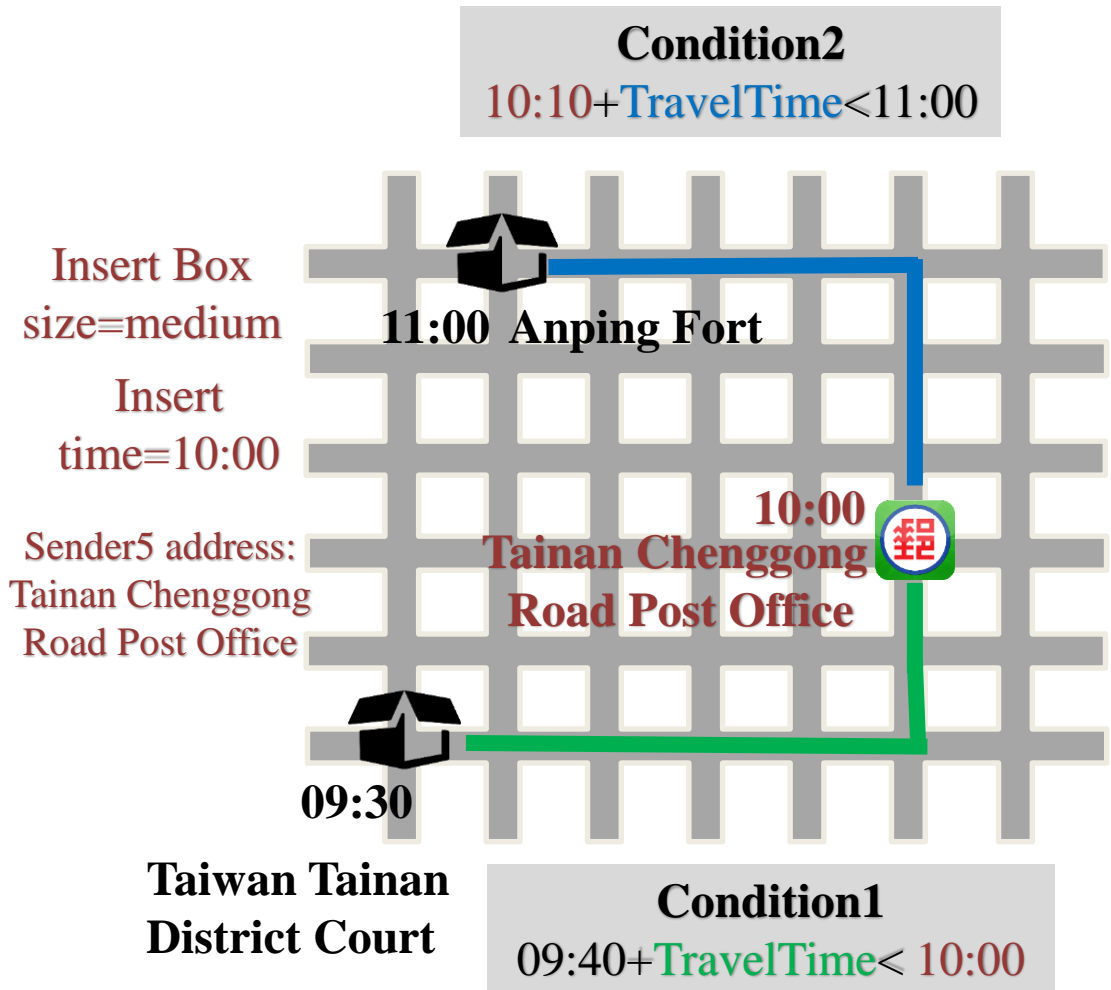# Case One: Simple Time Scheduling Stage (1)

Current Time=09:05

	V1	V2	V3
09:30	S1:Taiwan Tainan District Court, small(111)		
10:00			
10:30			
11:00	S2:Anping Fort, small(112)	S3:Durban Department Store, medium (221)	
11:30			

Condition1
09:05+TravelTime< 09:30

09:05

V2

S3:Durban Department Store

09:30 Hayashi Department Store

Insert box size=small

Insert time=09:30

Sender4 address: Hayashi Department Store

11:00

Condition2
09:40+TravelTime<11:00

Case Two: Simple Time Scheduling Stage (2)

Current Time:09:15

	V1	V2	V3
09:30	S1:Taiwan Tainan District Court, small(111)	S4:Hayashit Department Store, small (211)	
10:00			
10:30			
11:00	S2:Anping Fort, small(112)	S3:Durban Department Store, medium (221)	
11:30			

Condition2
10:10+TravelTime<11:00

Insert Box
size=medium

Insert
time=10:00

Sender5 address:
Tainan Chenggong
Road Post Office

11:00 Anping Fort

10:00
Tainan Chenggong Road Post Office

09:30

Taiwan Tainan District Court

Condition1
09:40+TravelTime< 10:00

Case Three: Simple Time Scheduling Stage (3)

Current Time:09:20

	V1	V2	V3
09:30	S1:Taiwan Tainan District Court, small (111)	S4:Hayashi Department Store, small (211)	
10:00	S5:Tainan Chenggong Road Post Office, medium (121)		
10:30			
11:00	S2:Anping Fort, small (112)	S3:Durban Department Store, medium (221)	
11:30			

Condition1

$09:20+TravelTime < 09:30$

V3

09:20

Insert time =09:30

Insert Box size=large

Sender6 address: T.S. Mall

T.S. Mall
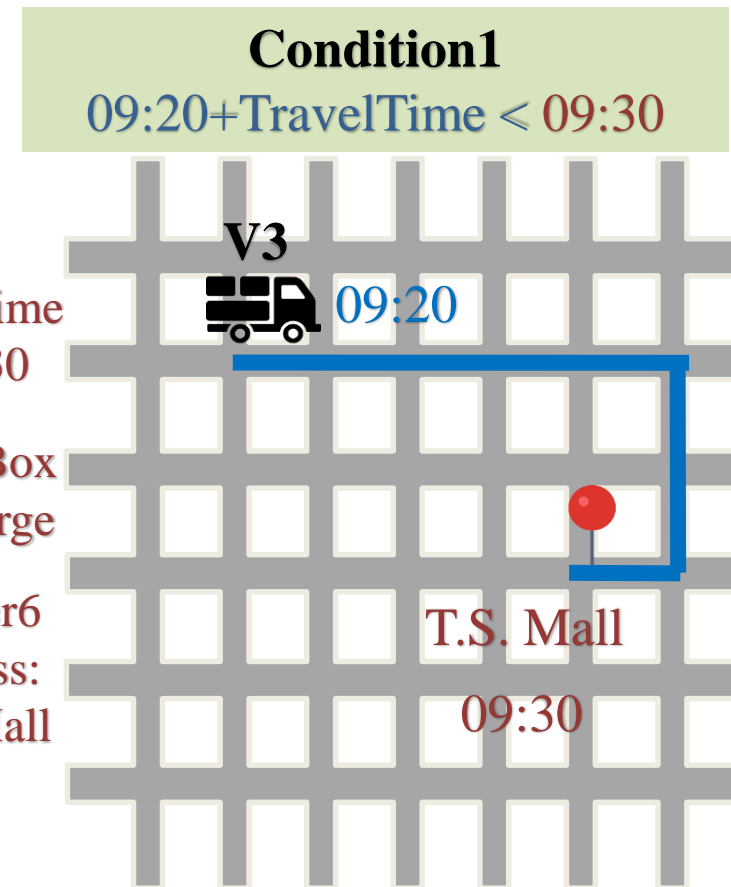
09:30

Sender Scenario

Time	V2
09:30	**S4:Hayashi Department Store**
10:00	
10:30	
11:00	S3:Durban Department Store
11:30	

Current Time:09:25

V2

09:30
Hayashi Department Store

Coming Notification (09:25)

Arriving Notification (09:30)

Finish Loading Process (09:35)

Ending Parking (09:40)

Receiver Scenario (1)

Time	V2
09:30	S4:Hayashi Department Store
10:00	**R4:National Cheng Kung University Hospital**
10:30	
11:00	S3:Durban Department Store
11:30	

Current Time:09:37

10:00

National Cheng Kung University Hospital

V2

Hayashi department store

Select the receiver's arrival time (09:37)

Forward to the receiver's address (09:40)

Get the coming notification (09:55)

Receiver Scenario (2)

Time	V2
09:30	S4:Hayashi Department Store
10:00	**R4:National Cheng Kung University Hospital**
10:30	
11:00	S3:Durban Department Store
11:30	

Current Time:10:00

National Cheng Kung University Hospital

V2

Arriving Notification (10:00)

Finish Unloading Process (10:05)

Ending Parking (10:10)

Parameters of Simulation

Parameters	Value
Simulation area	50.07 km^2
The number of junctions	6785
The number of roads	25069
The number of trucks	3
Vmax	5.0 [m/s]=18 km/hr
Average speed of truck	3.8 [m/s]=13.68 km/hr
Simulation time	09:00~15:00 (6 hours=21600 seconds)

Average Vehicle Speed Estimation
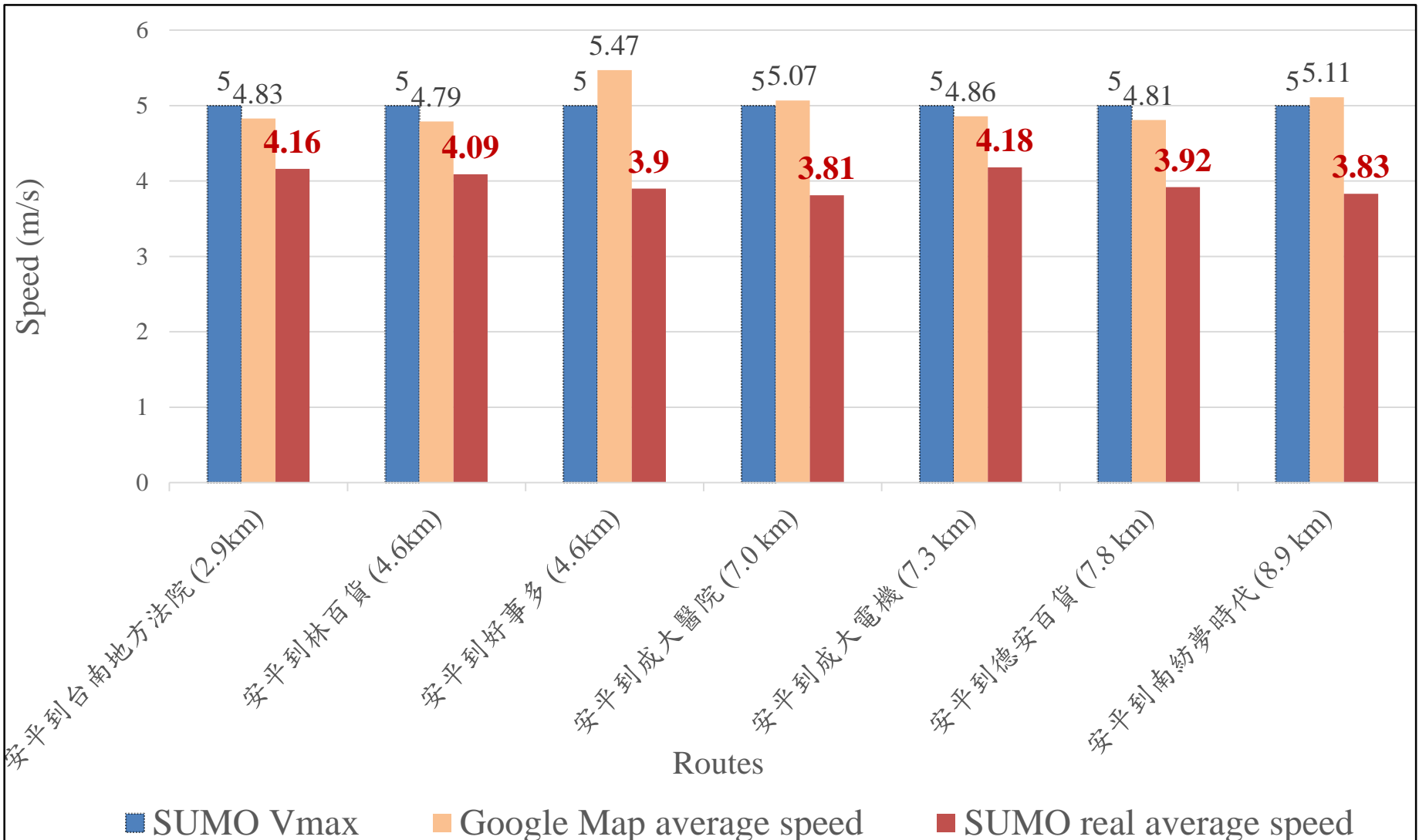
Simulation Result- Initialization

Time	V1	V2	V3
09:30	S1: Taiwan Tainan District Court		
10:00			
10:30			
11:00	S2: Anping Fort	S3: Durban Department Store	
11:30			
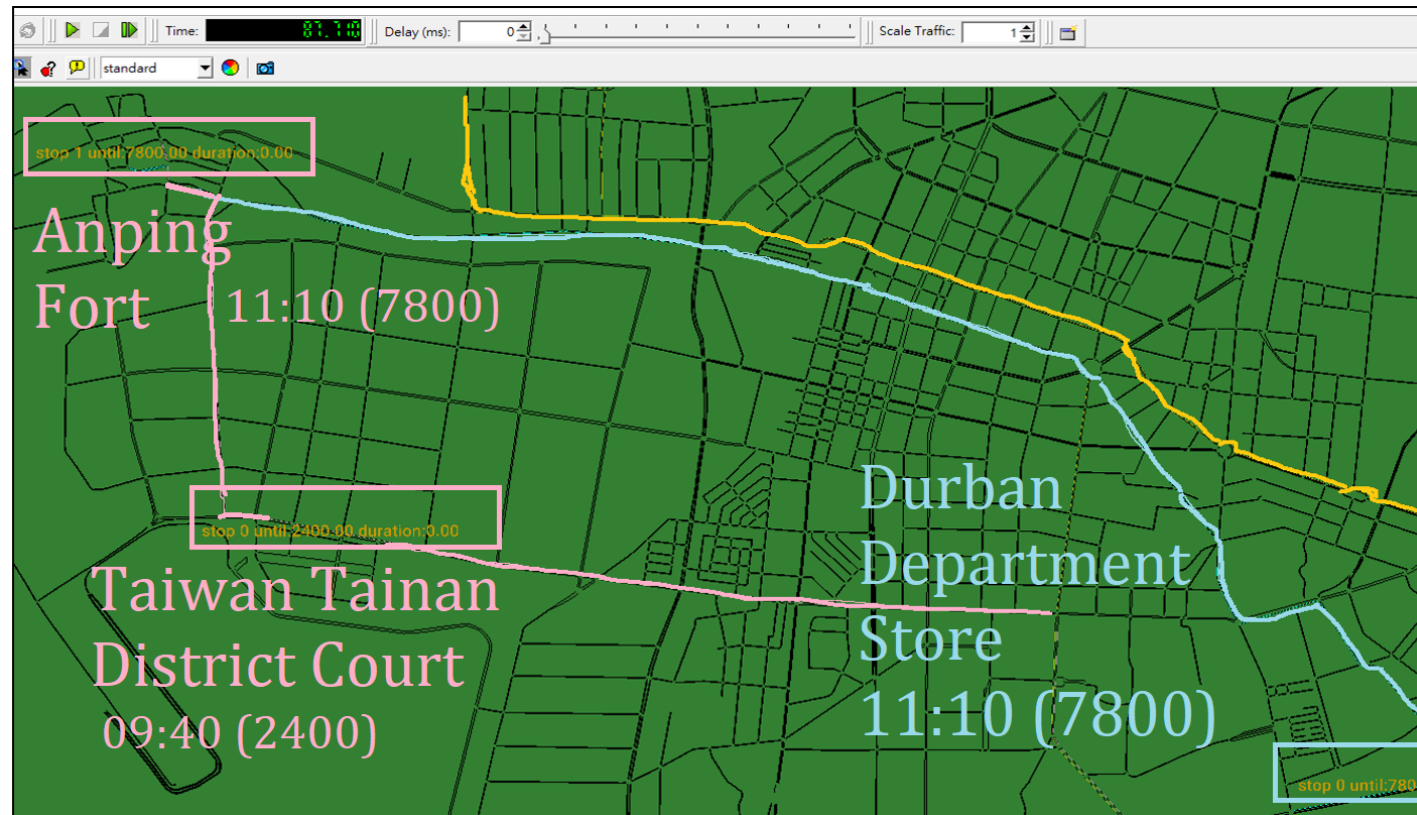
Simulation Result- Sender Request

Current Timeseconds:1203 (09:20:03)
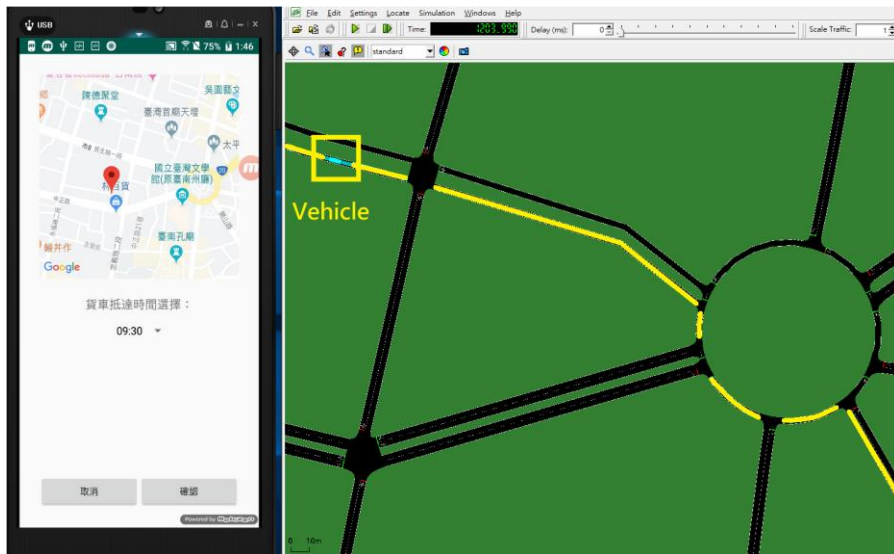
Current Timeseconds:1218 (09:20:18)
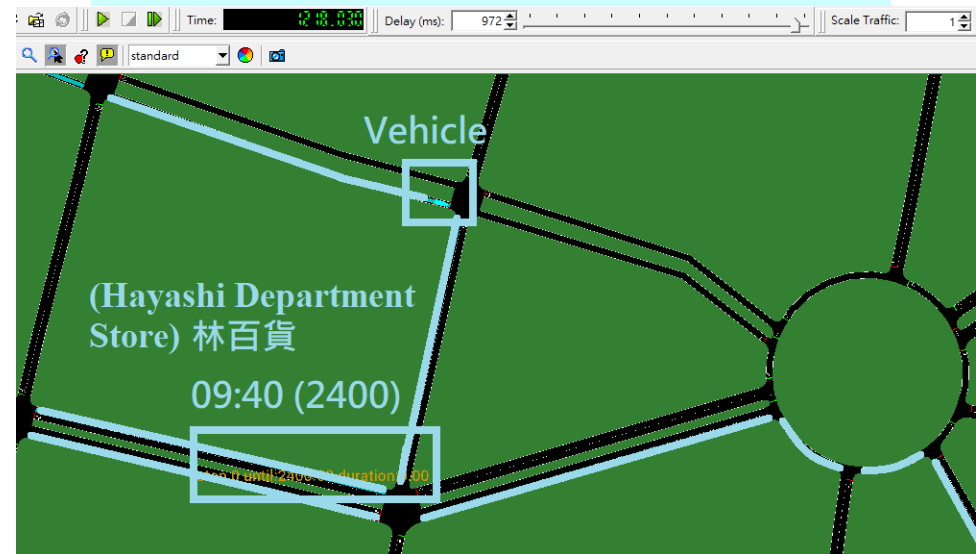
Simulation Result- Loading Process

Current Timeseconds:2104 (09:35)

1. The receiver would get the notification at 09:35 that the loading process finished.

2. The parameters of vehicle2 show that the "**box211**" has the container.

3. The vehicle2 cannot leave until 2400 (09:40).
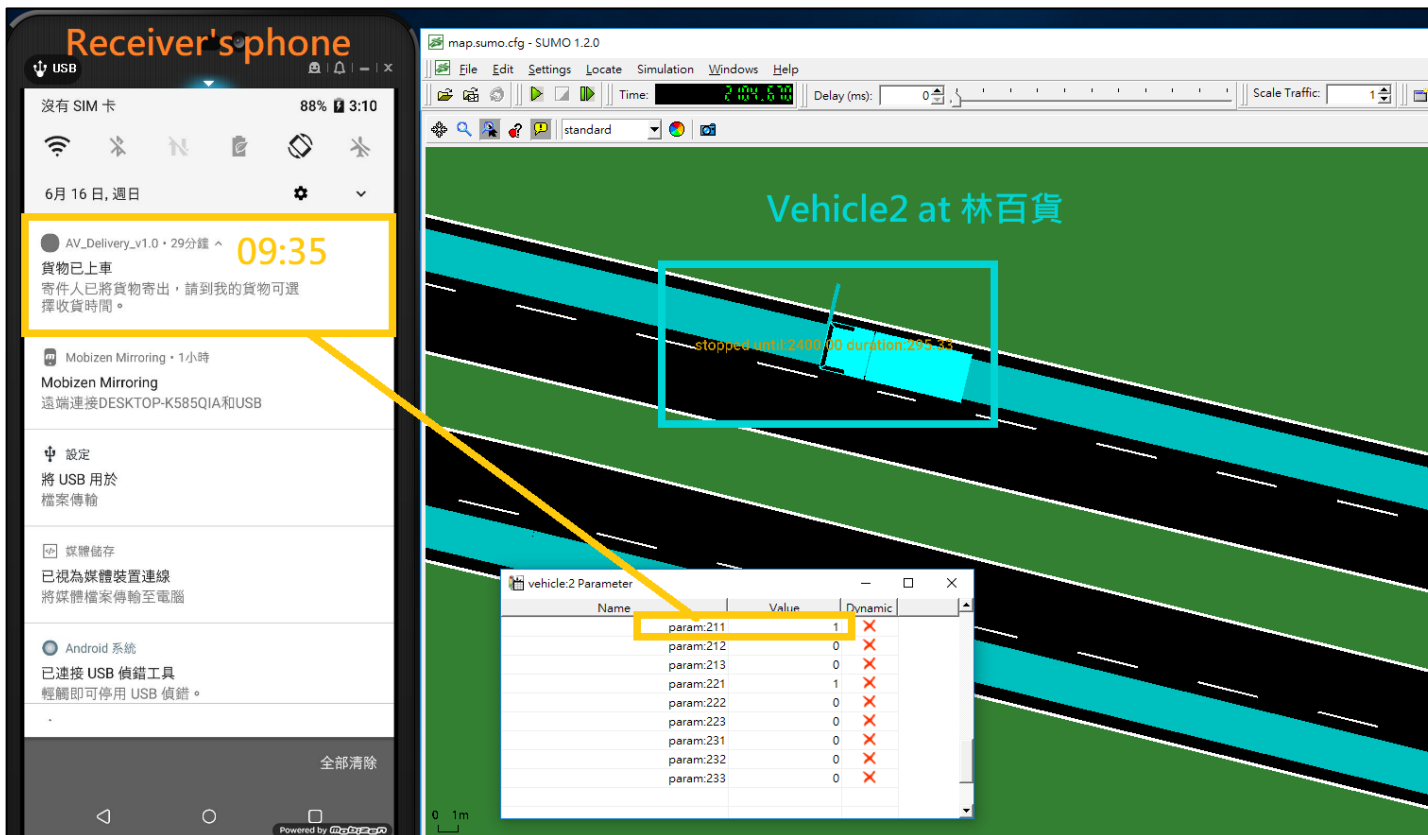
Simulation Result- Receiver Request

Current Timeseconds:2104
(09:35:04)

Current Timeseconds:2176
(09:36:16)
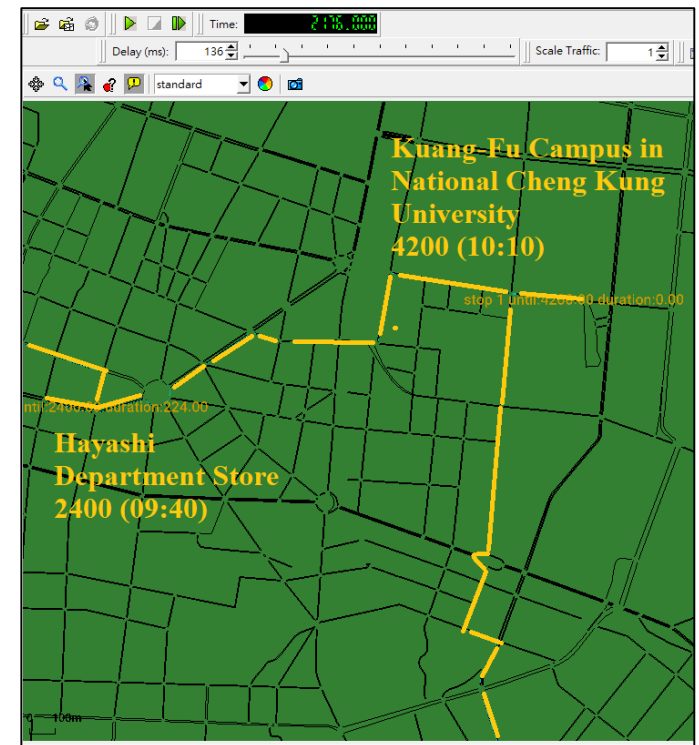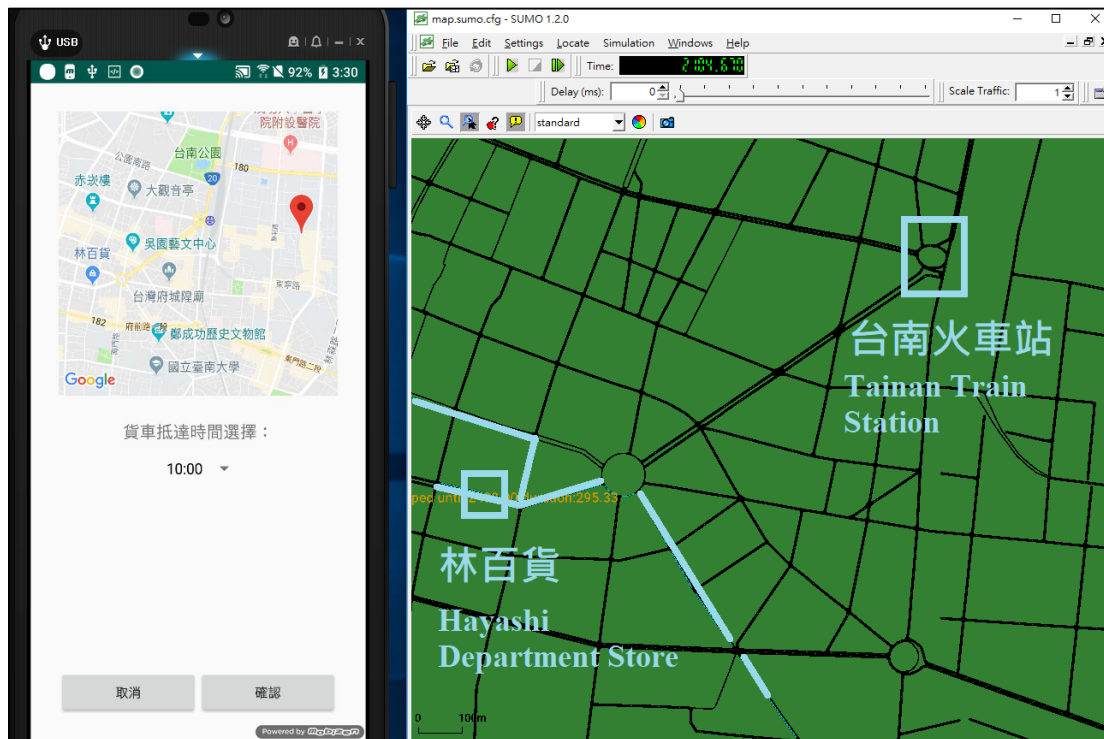
Simulation Result- Unloading Process

4069 (10:07:49)

The vehicle 2 would not leave until 4200 (10:10).

The parcel was unloaded.

Conclusion

1. The study implemented a vehicle dispatching and monitoring system to simulate the package delivery process.

2. This system used Traffic Control Interface to manipulate the vehicle's behavior and retrieve values in SUMO simulator.

3. With the proposed dispatching mechanism, the system can judge whether the order is established.

4. The simulation result showed the whole parcel delivery process with the parking scenario.

Future Work

Scalability: The system would be used in larger map and distribute more trucks into different areas according to the quantity of parcels.

Quantity: The system has to deal with a larger batch of orders in a brief period of time in the future.

Accuracy: The accuracy of the estimated vehicle speed should be actually measured by the real-time road conditions.