

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

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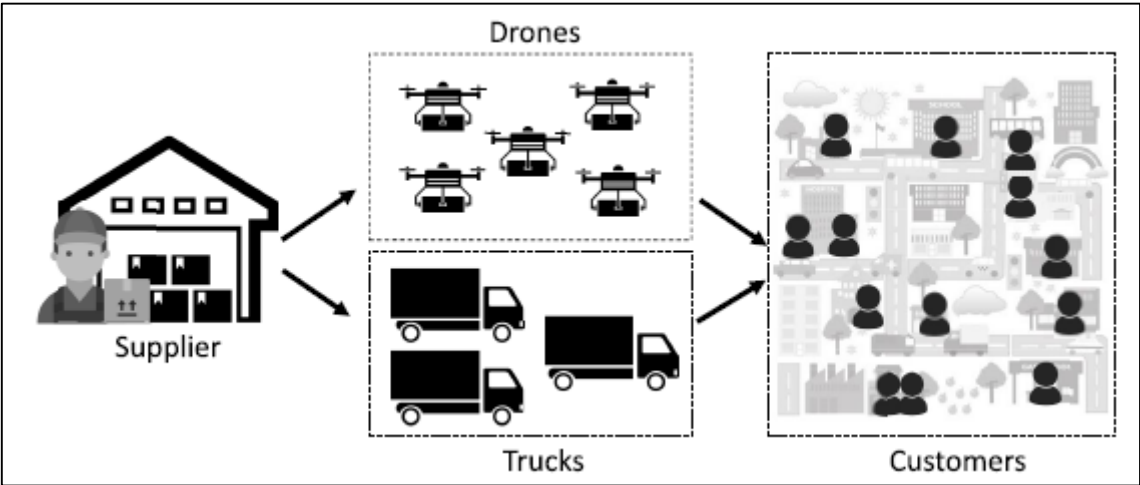
# Motivation

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 user can apply the implementation into the actual self-driving cars for achieving the goal of system integration directly.

# Related Work

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

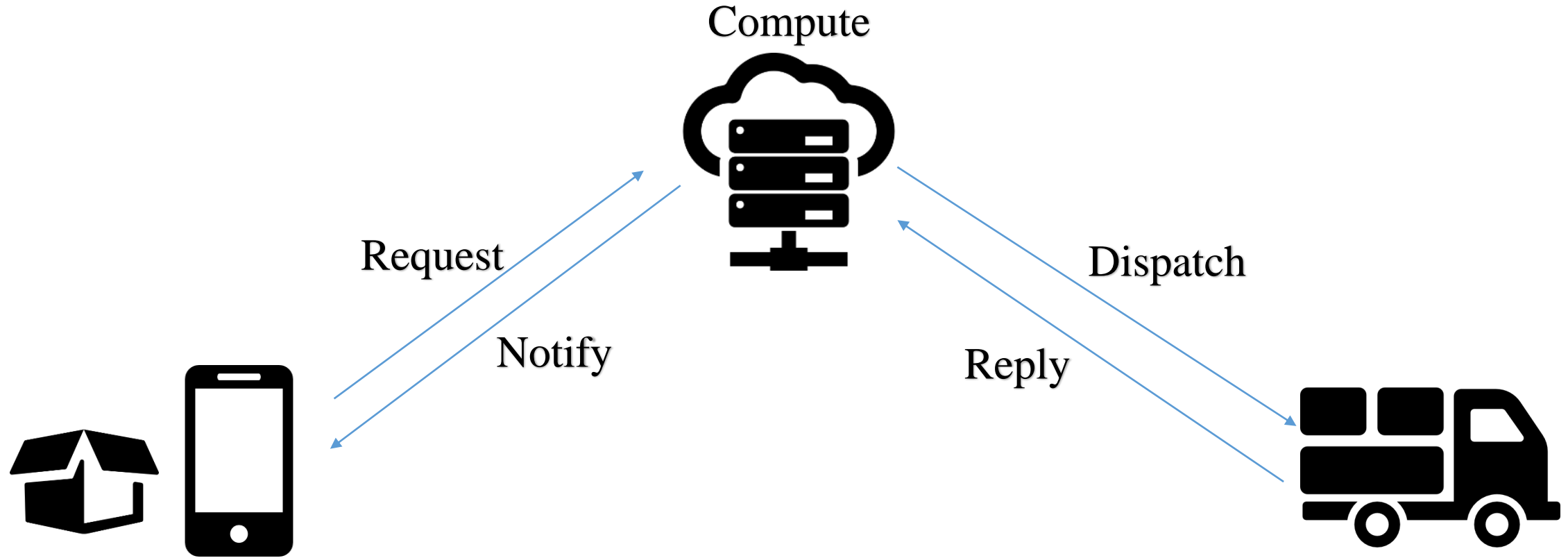
◎ Excellent, △Ordinary, ×Poor



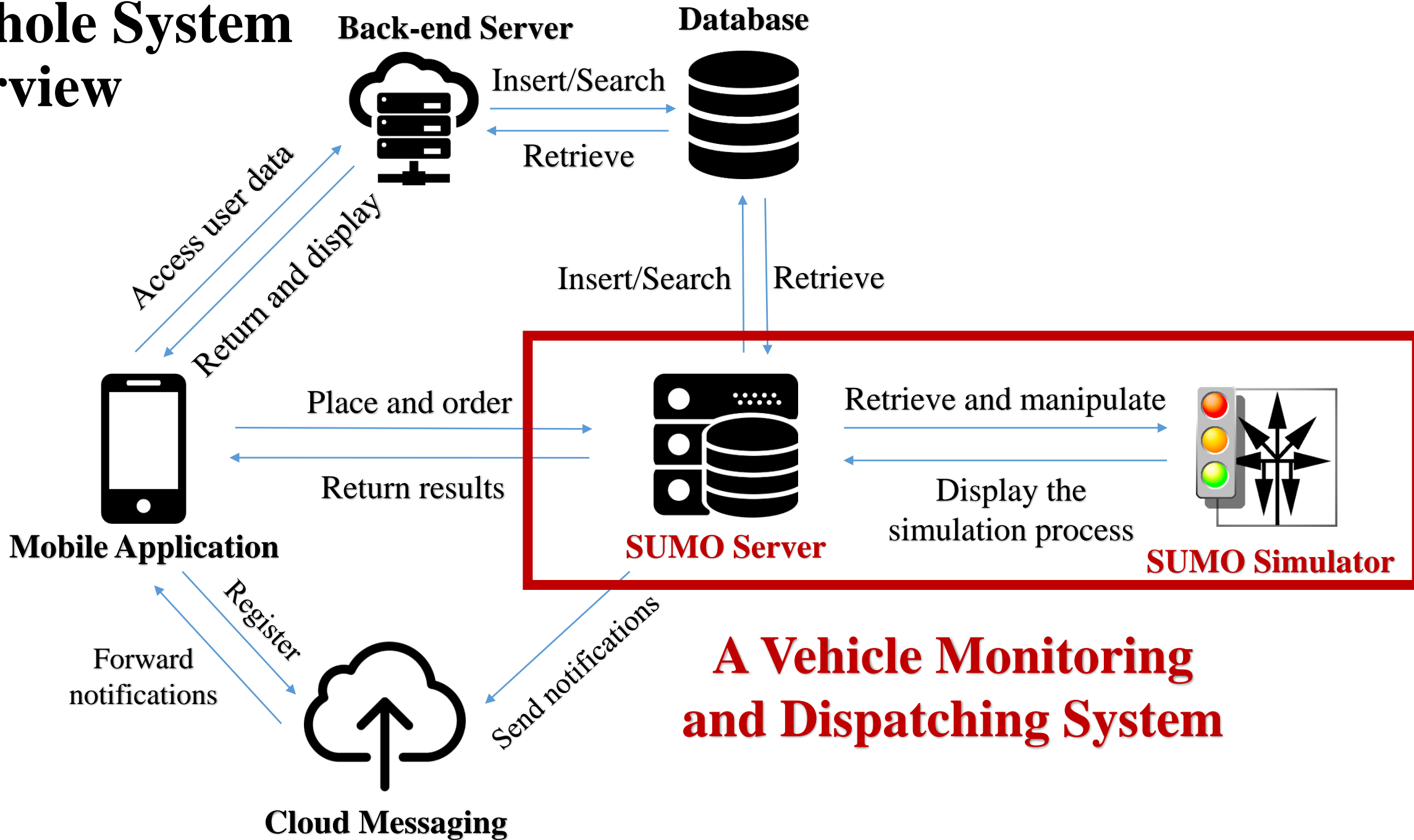
# Introduction

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 a Self-Driving Truck

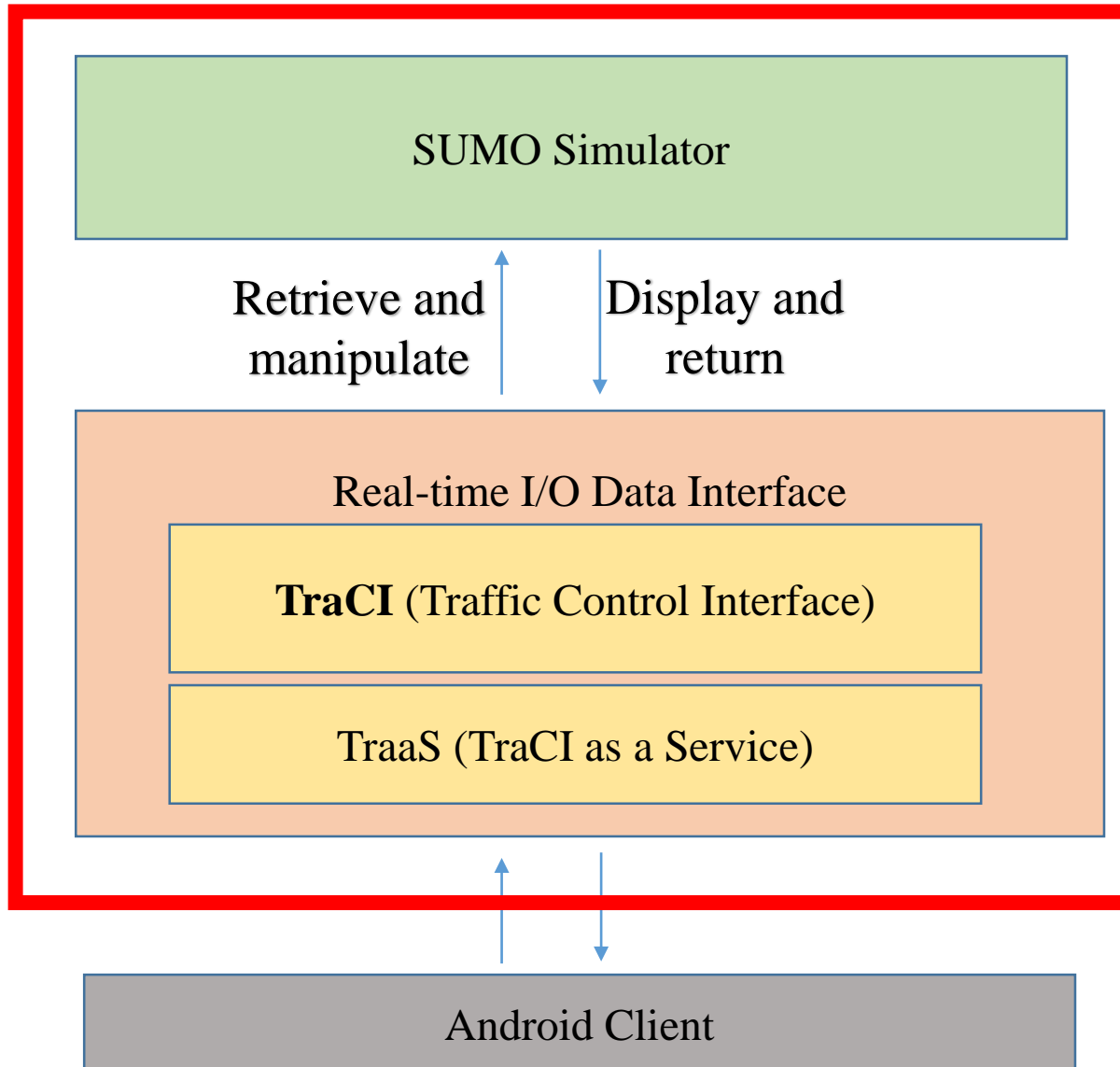


# A Whole System Overview



# Traffic Control Interface

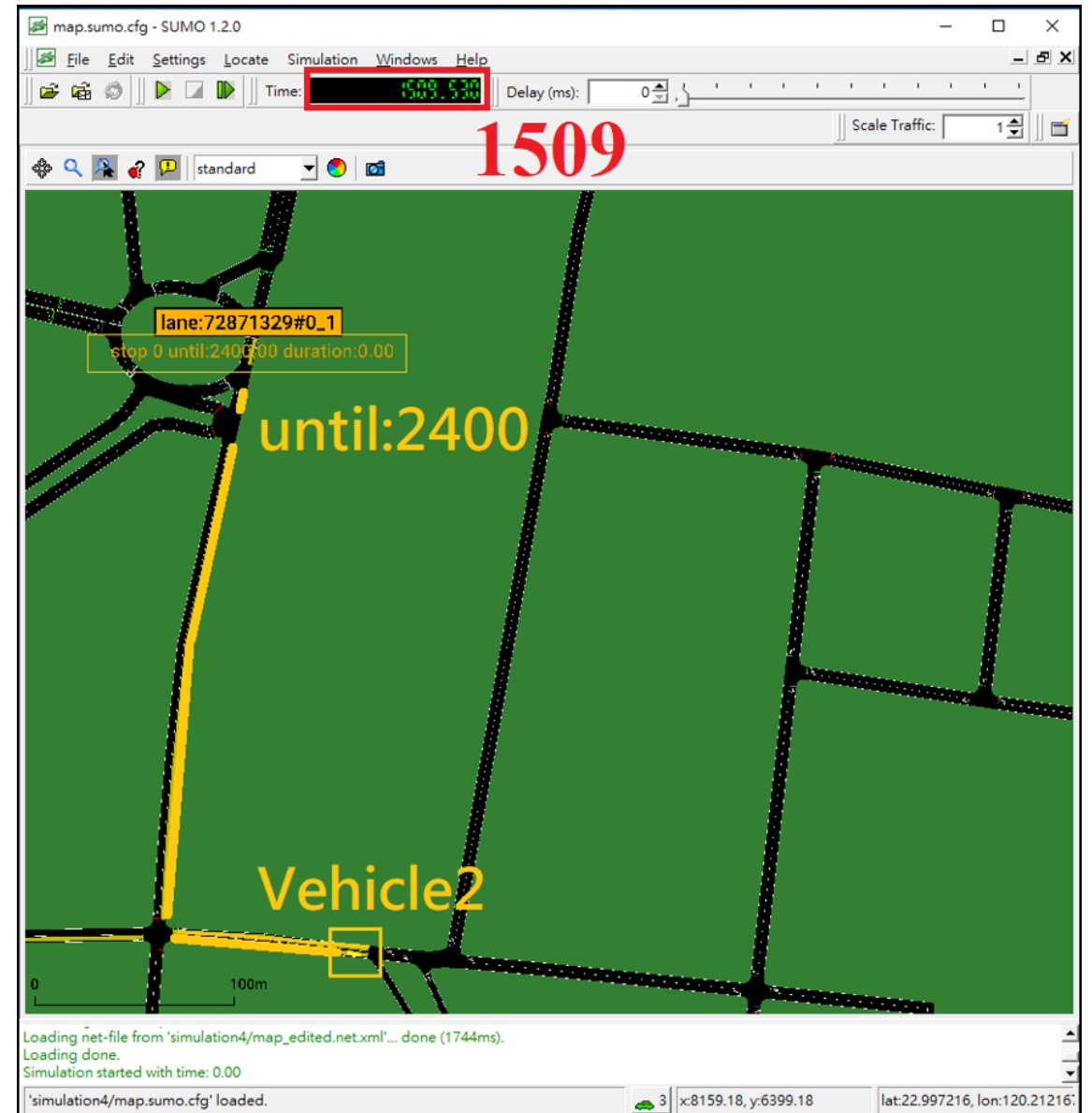
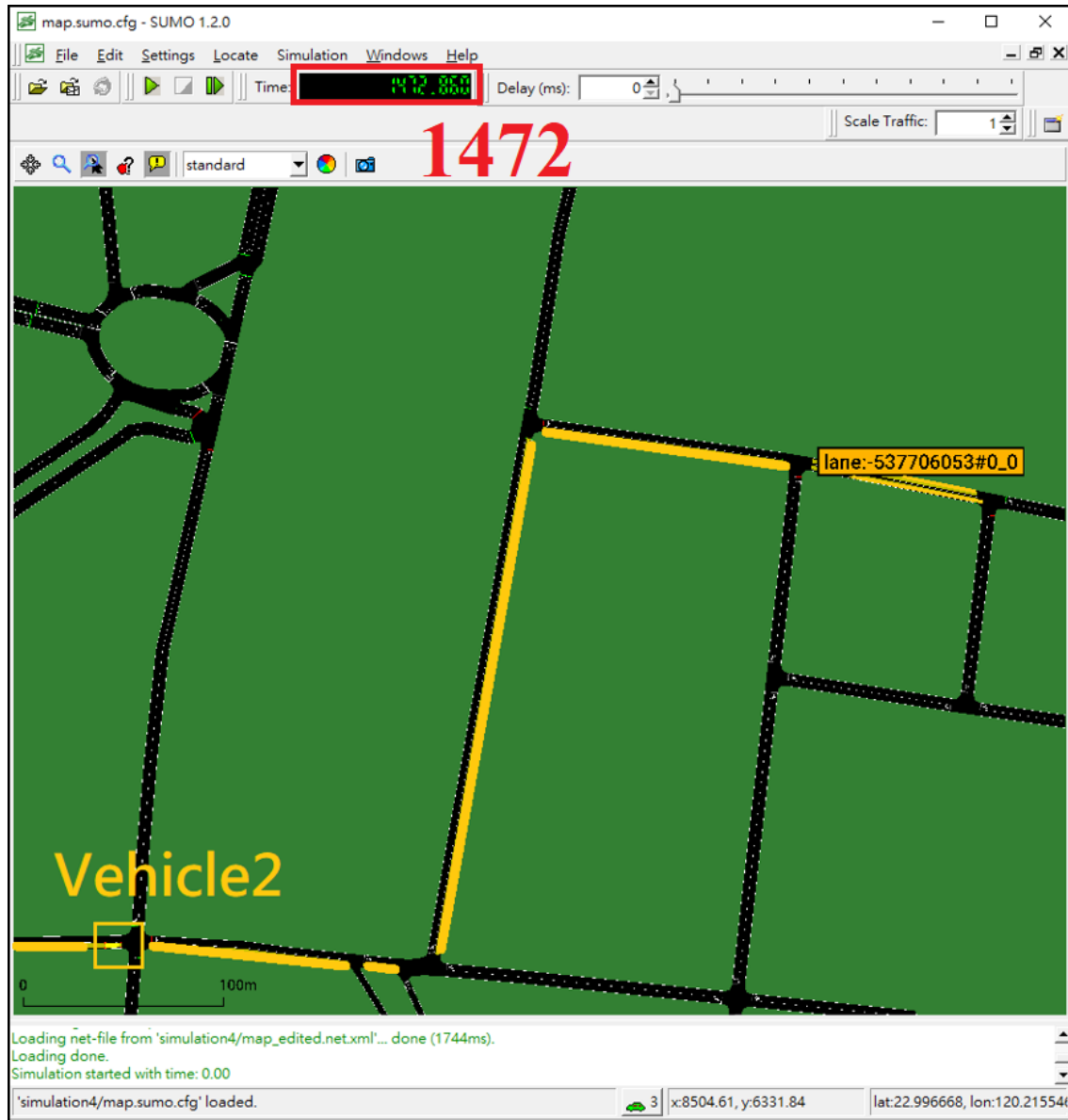
## Vehicle Monitoring and Dispatching System



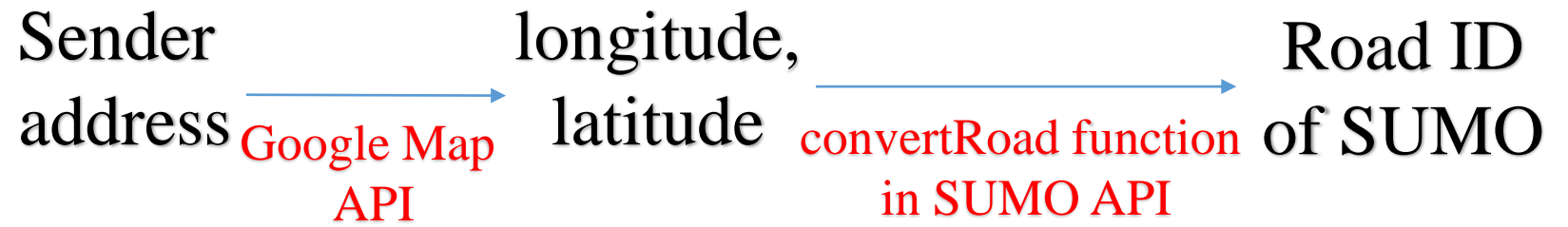
- Real-time I/O Interface offers a possibility to communicate between the simulation and the user application bi-directionally.
- TraCI can retrieve the values of vehicles and manipulate their behaviors.
- The service binds on a specific IP address and on a specific port.
- TraaS can communicate with the Android Client.



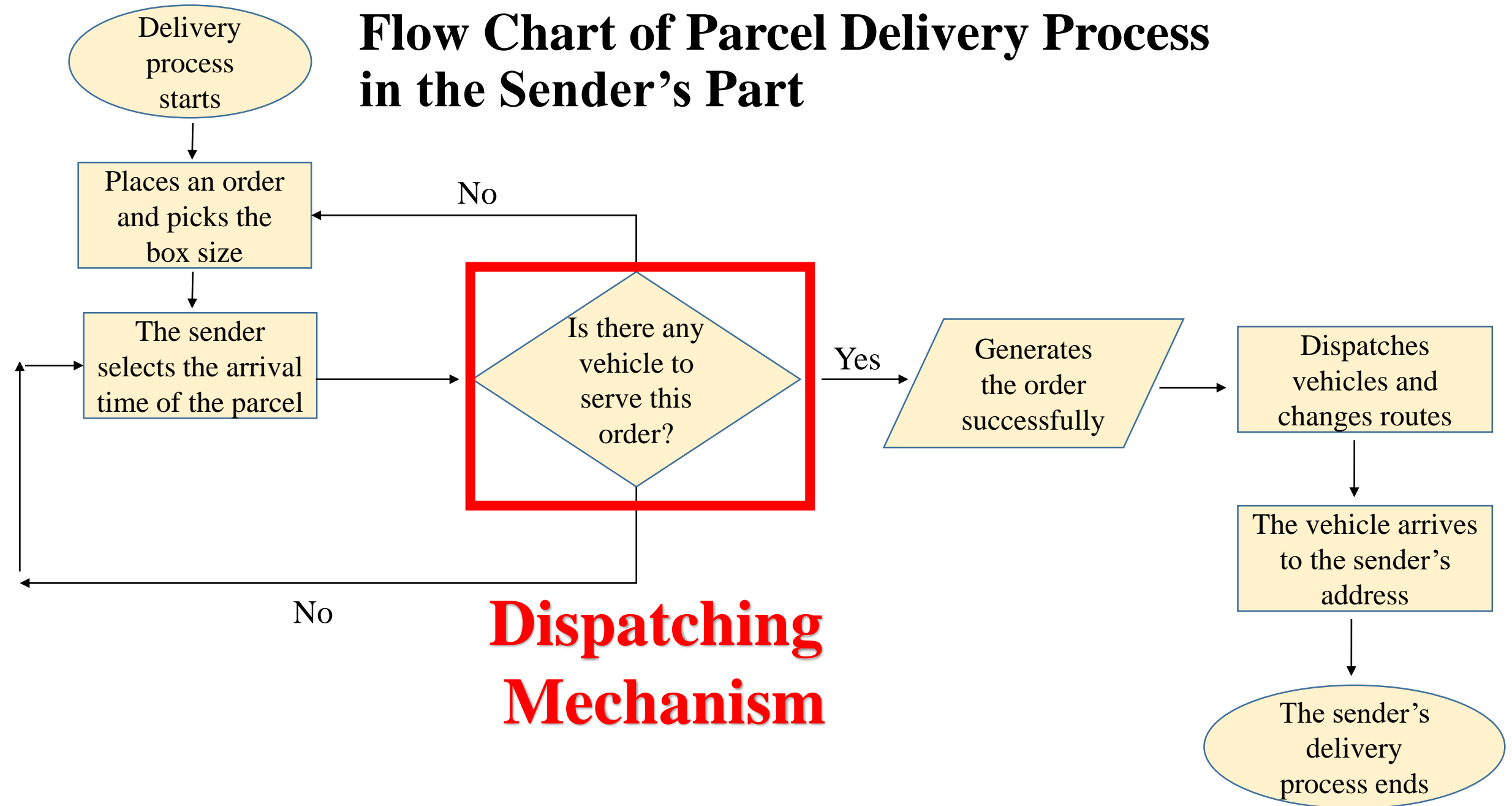
# Manipulation of Vehicle Routing



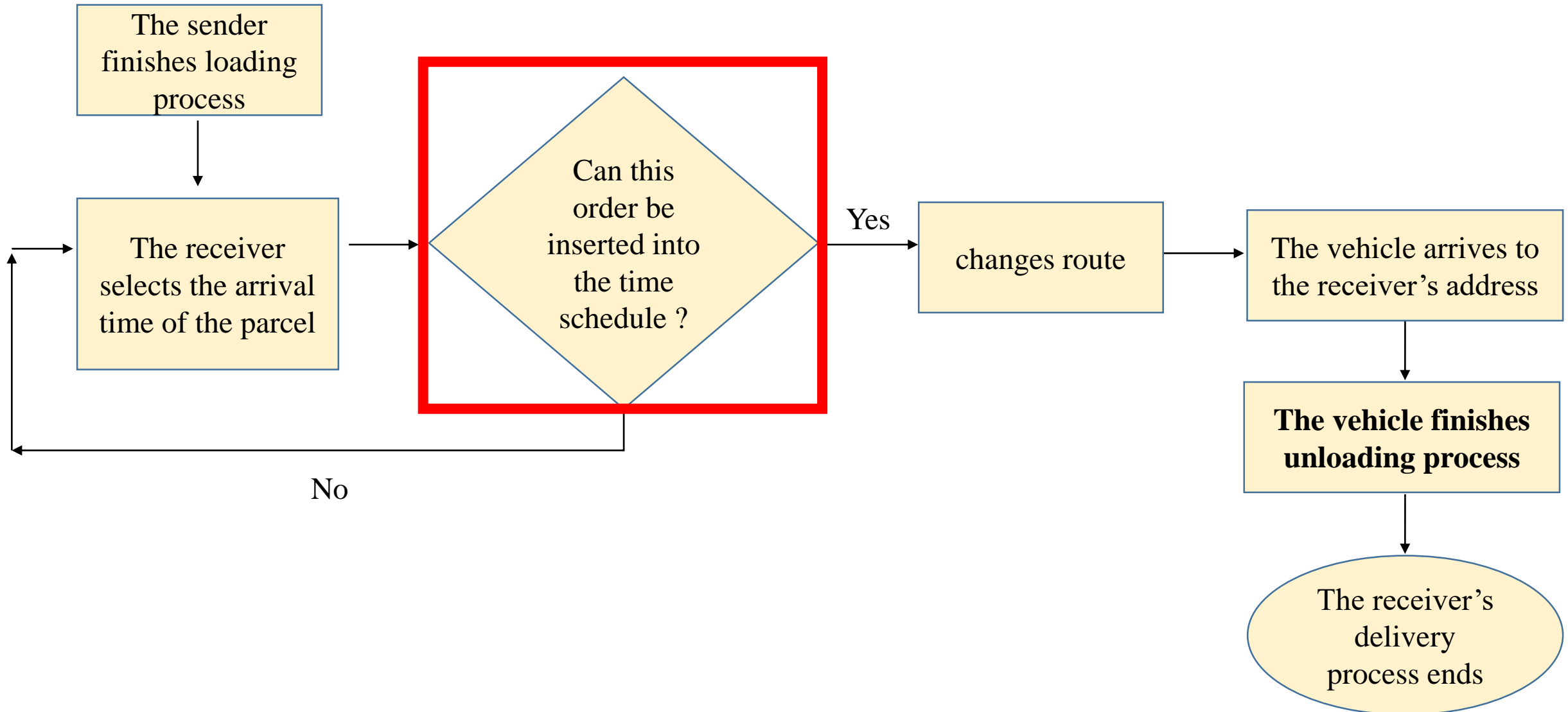
# Map Address Conversion



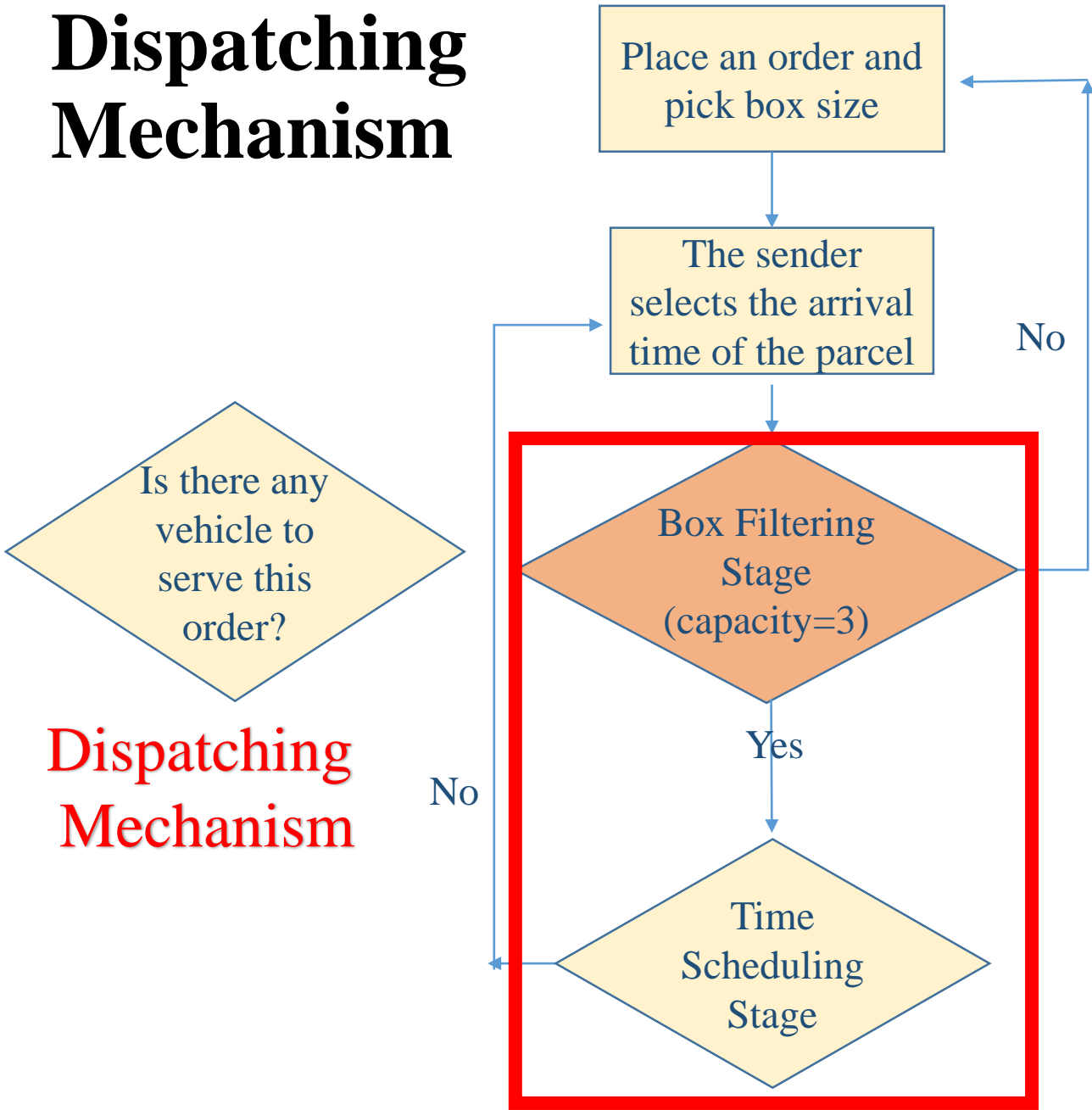
# Flow Chart of Parcel Delivery Process in the Sender's Part



# Flow Chart of Parcel Delivery Process in the Receiver's Part



# Dispatching Mechanism



	V1	V2	V3
small	111 112		
medium		221	
large			

Insert Box size=small,  
there are v1,v2,v3 after box filtering stage

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

Insert Box size=medium,  
there are v2,v4,v5 after box filtering stage

# Case One: Simple Time Scheduling

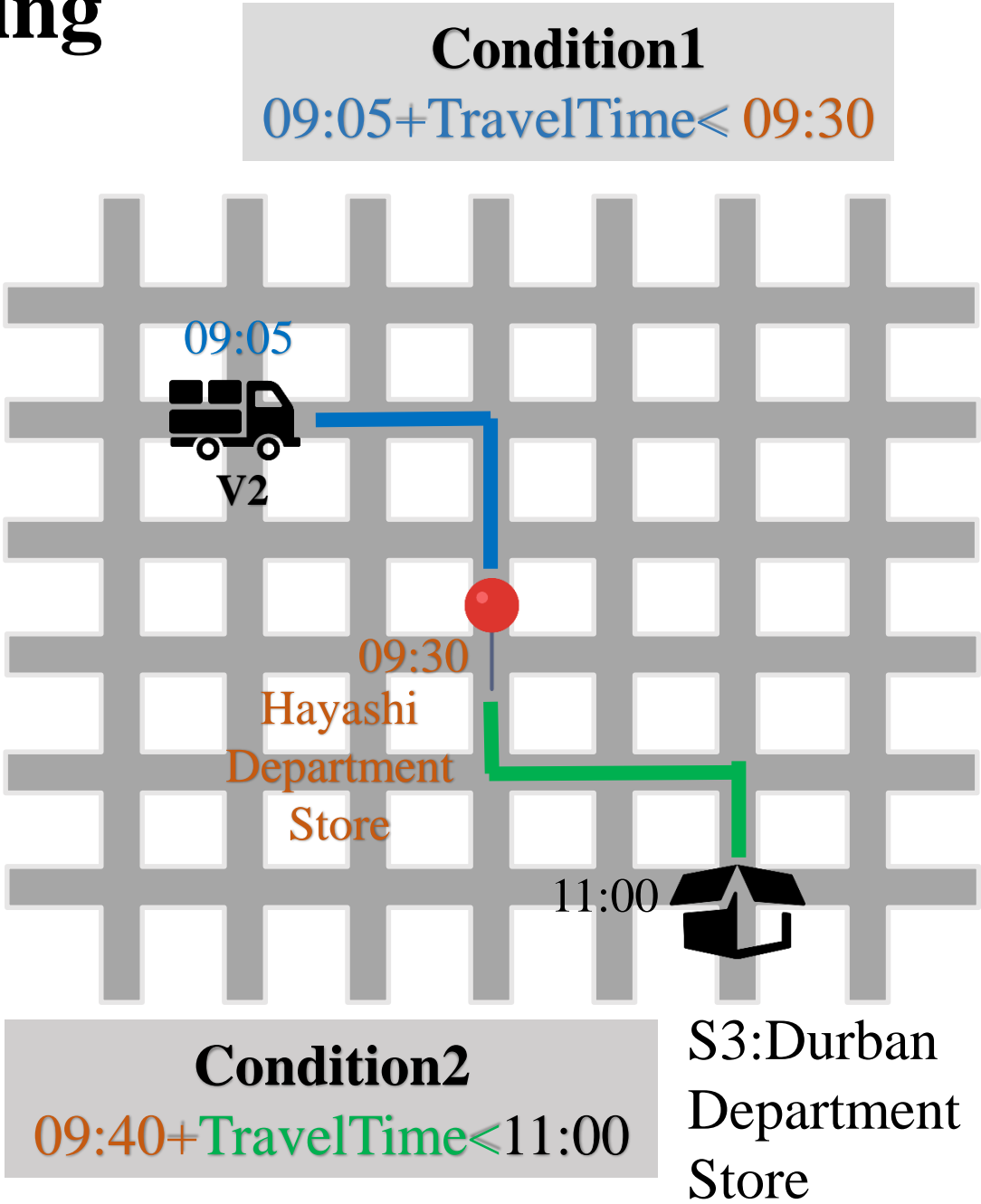
## Stage (1)

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			

Insert box  
size=small  
Insert  
time=09:30

Sender4  
address:  
Hayashi  
Department  
Store



# Case Two: Simple Time Scheduling

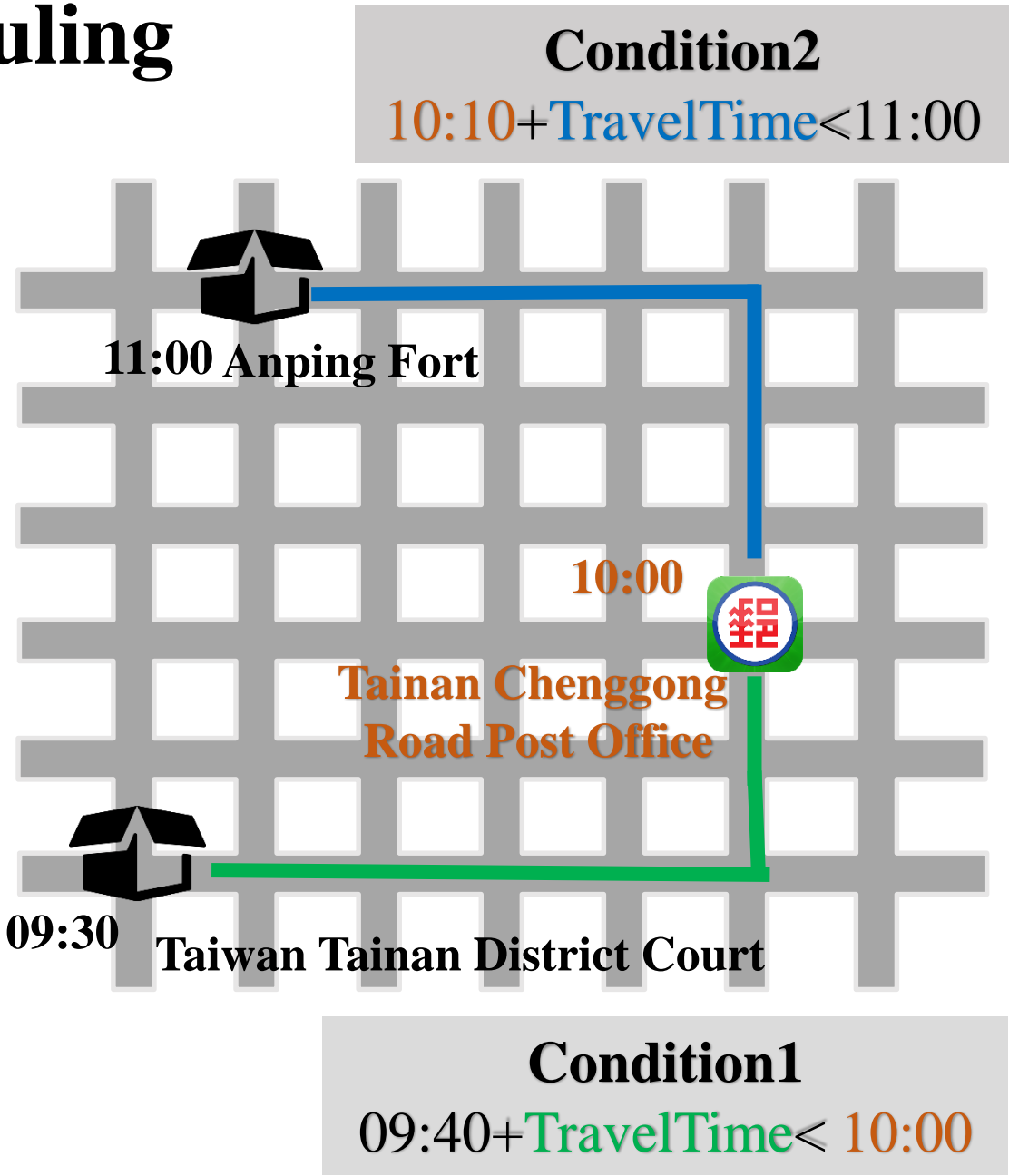
## Stage (2)

Current Time:09:15

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

Insert Box  
size=medium  
Insert  
time=10:00

Sender5 address:  
Tainan Chenggong  
Road Post Office



# Case Three: Simple Time Scheduling

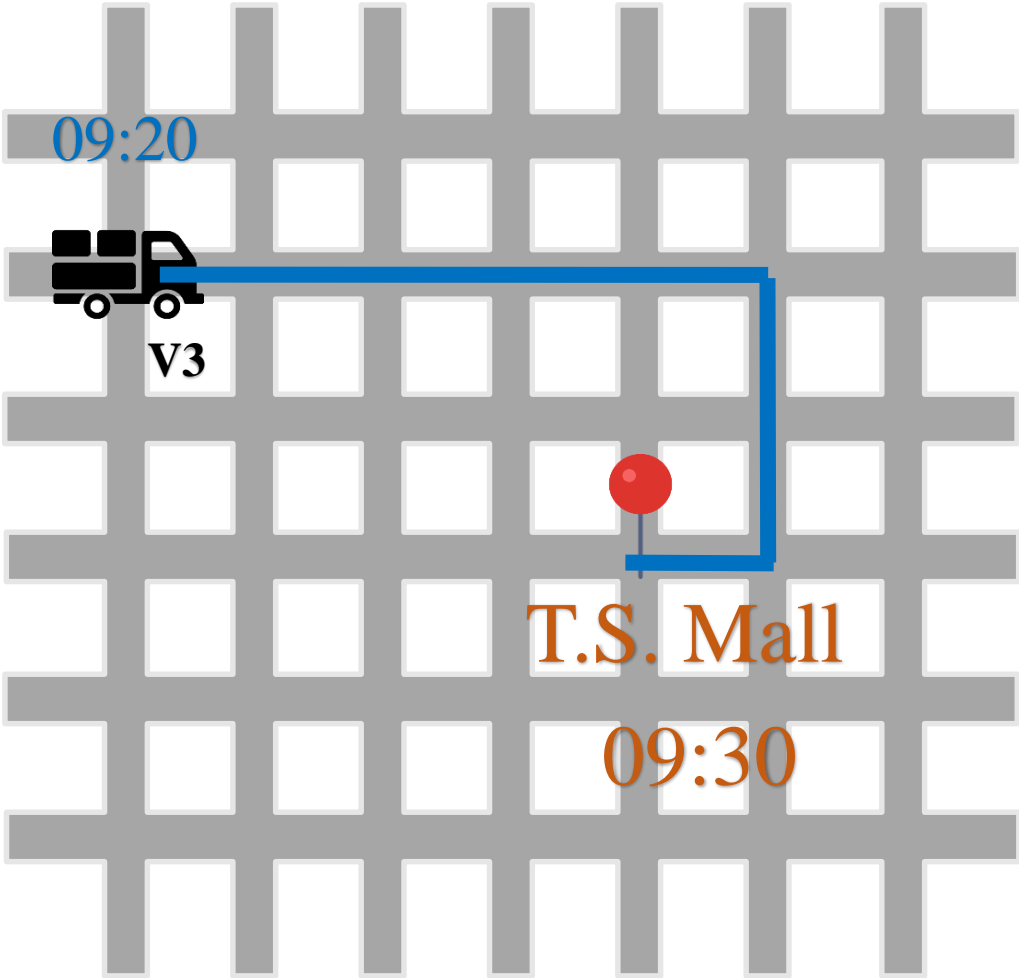
## Stage (3)

Condition1  
 $09:20 + \text{TravelTime} < 09:30$

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			

Insert time  
=09:30  
Insert Box  
size=large  
Sender6 address:  
T.S. Mall

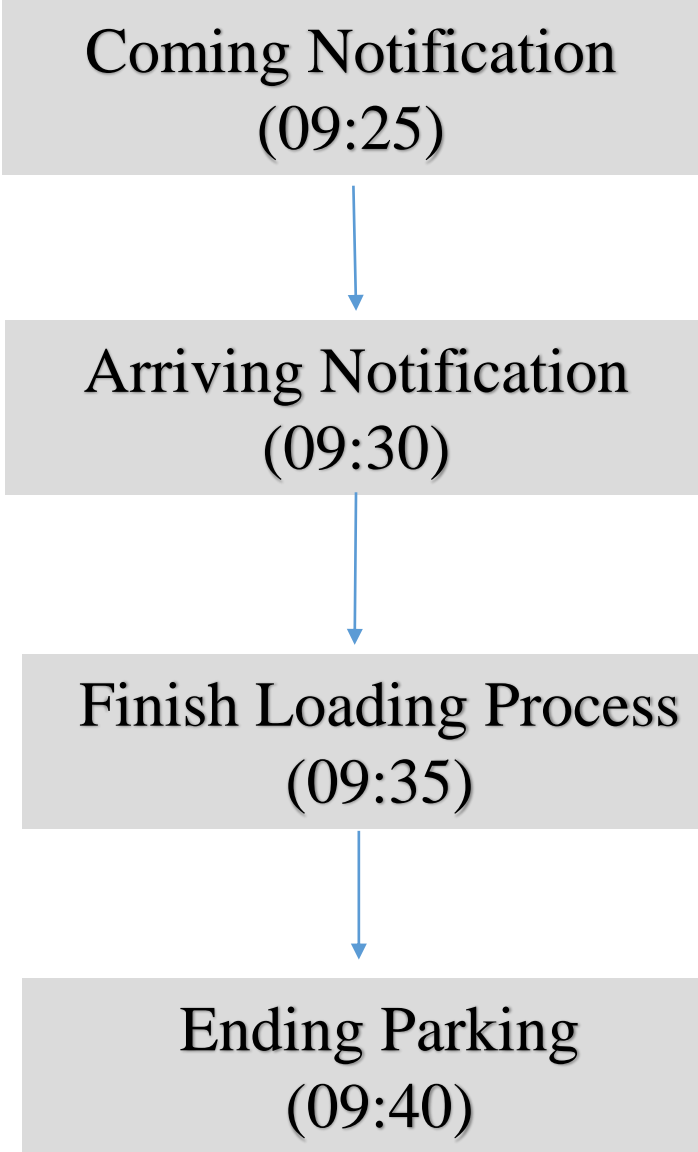
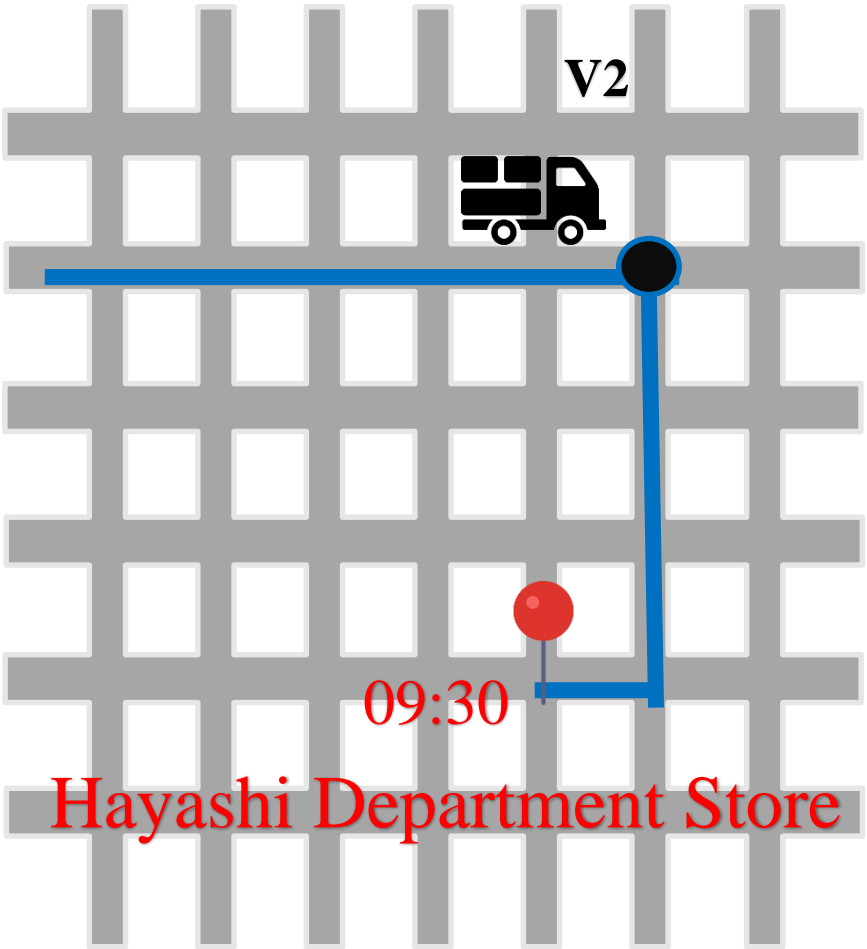




# Sender Scenario

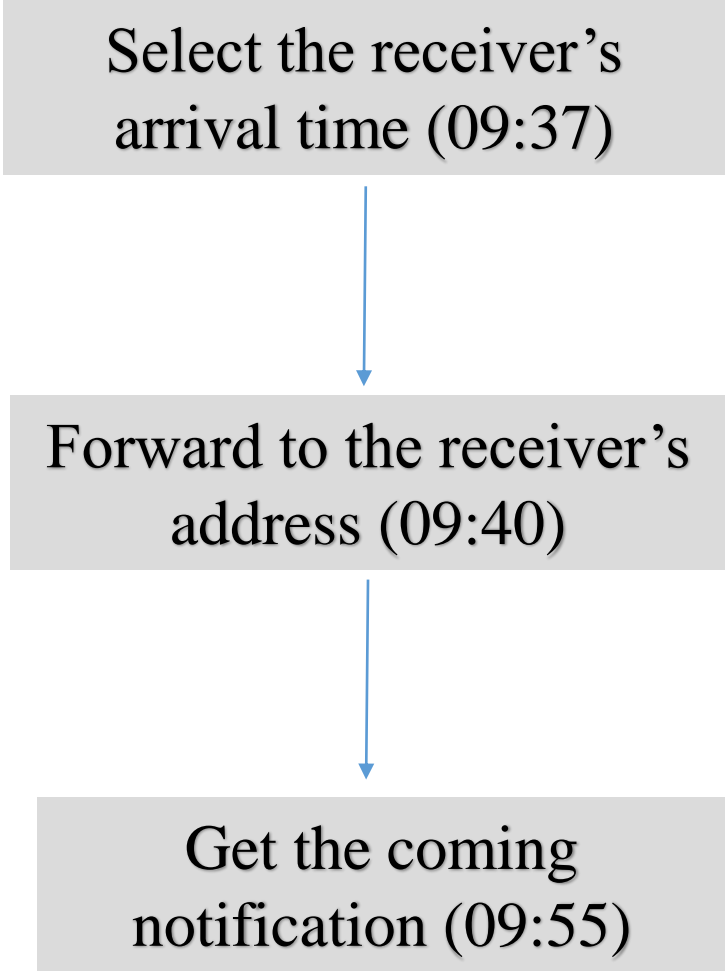
Time	V2
09:30	S4:Hayashi Department Store
10:00	
10:30	
11:00	S3:Durban Department Store
11:30	

Current Time:09:25



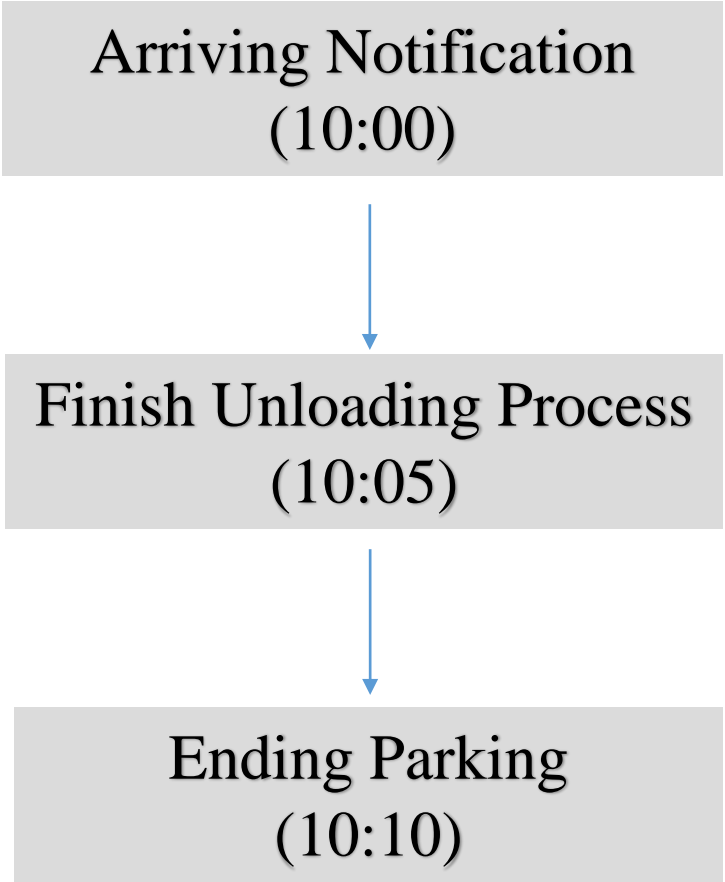
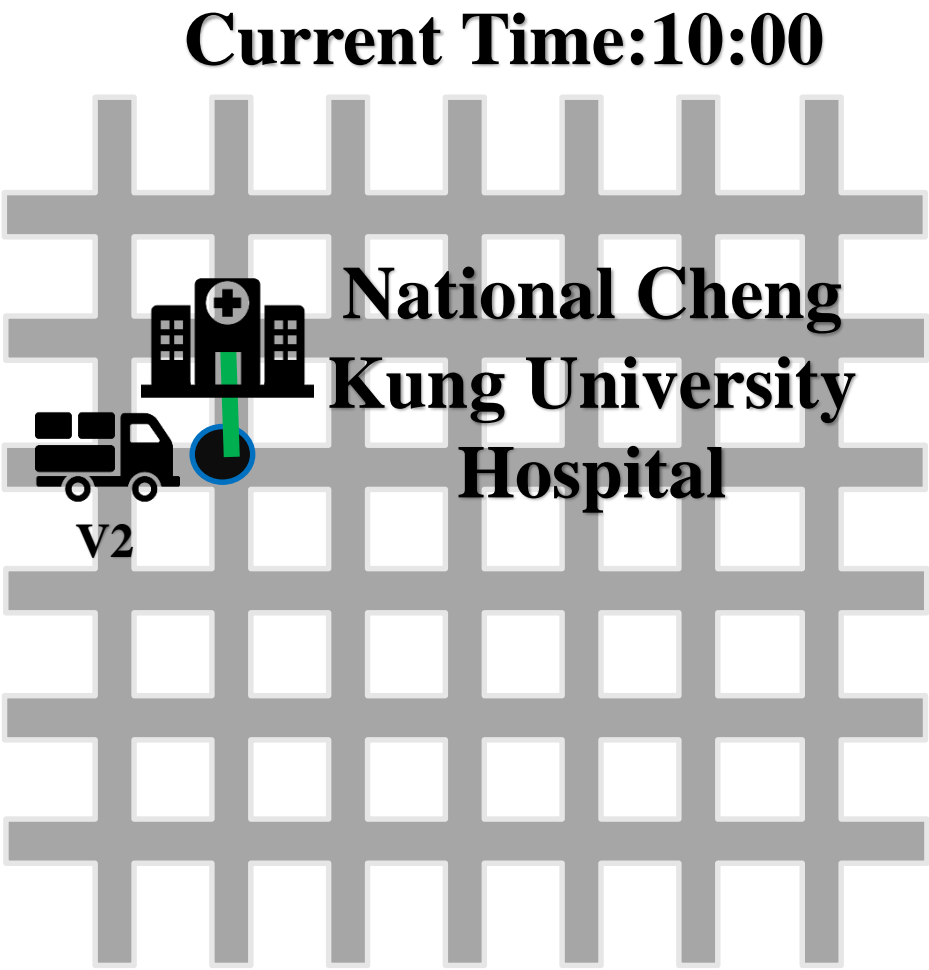
# Receiver Scenario (1)

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	

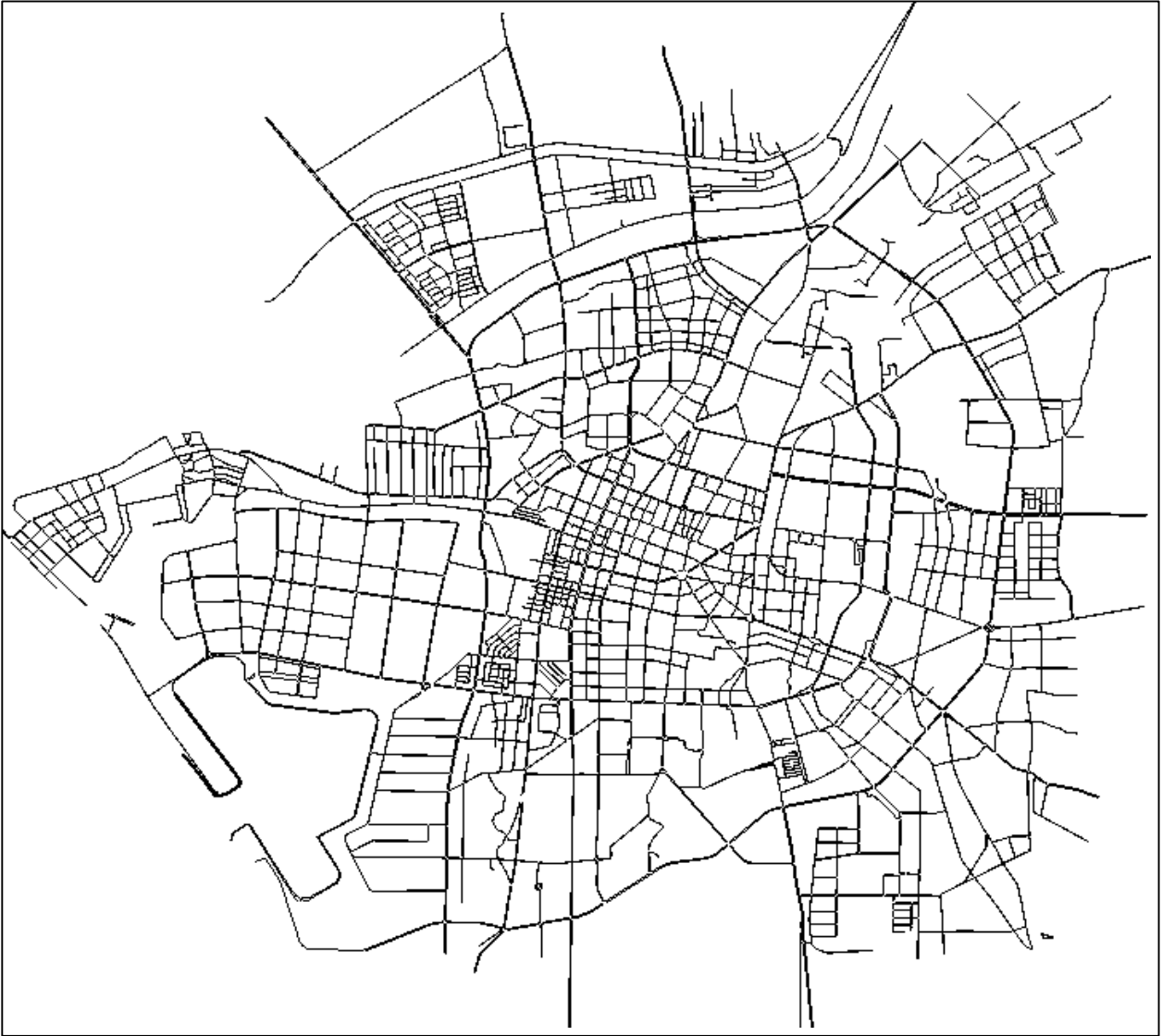
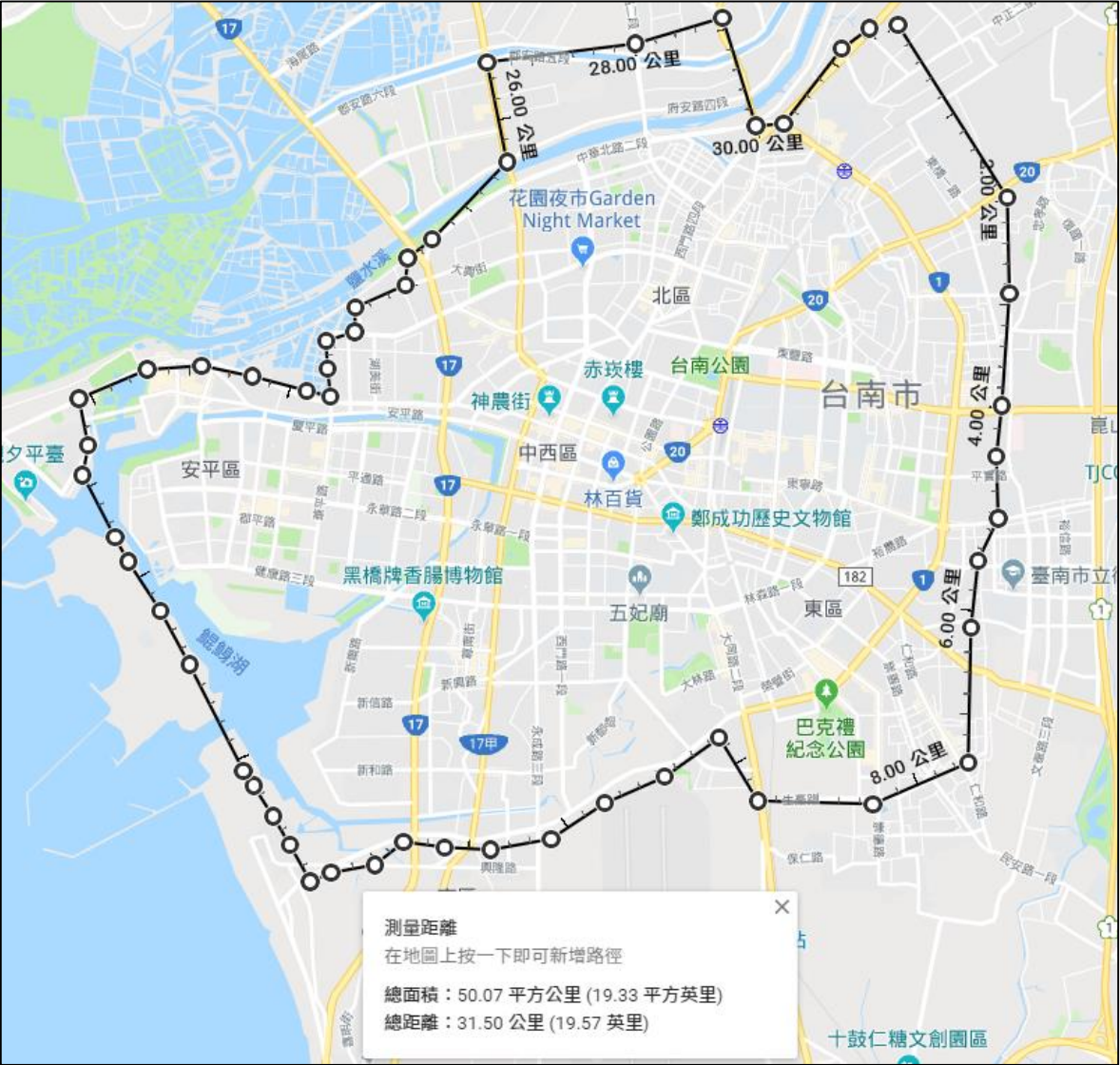


# Receiver Scenario (2)

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	



# Simulation Map

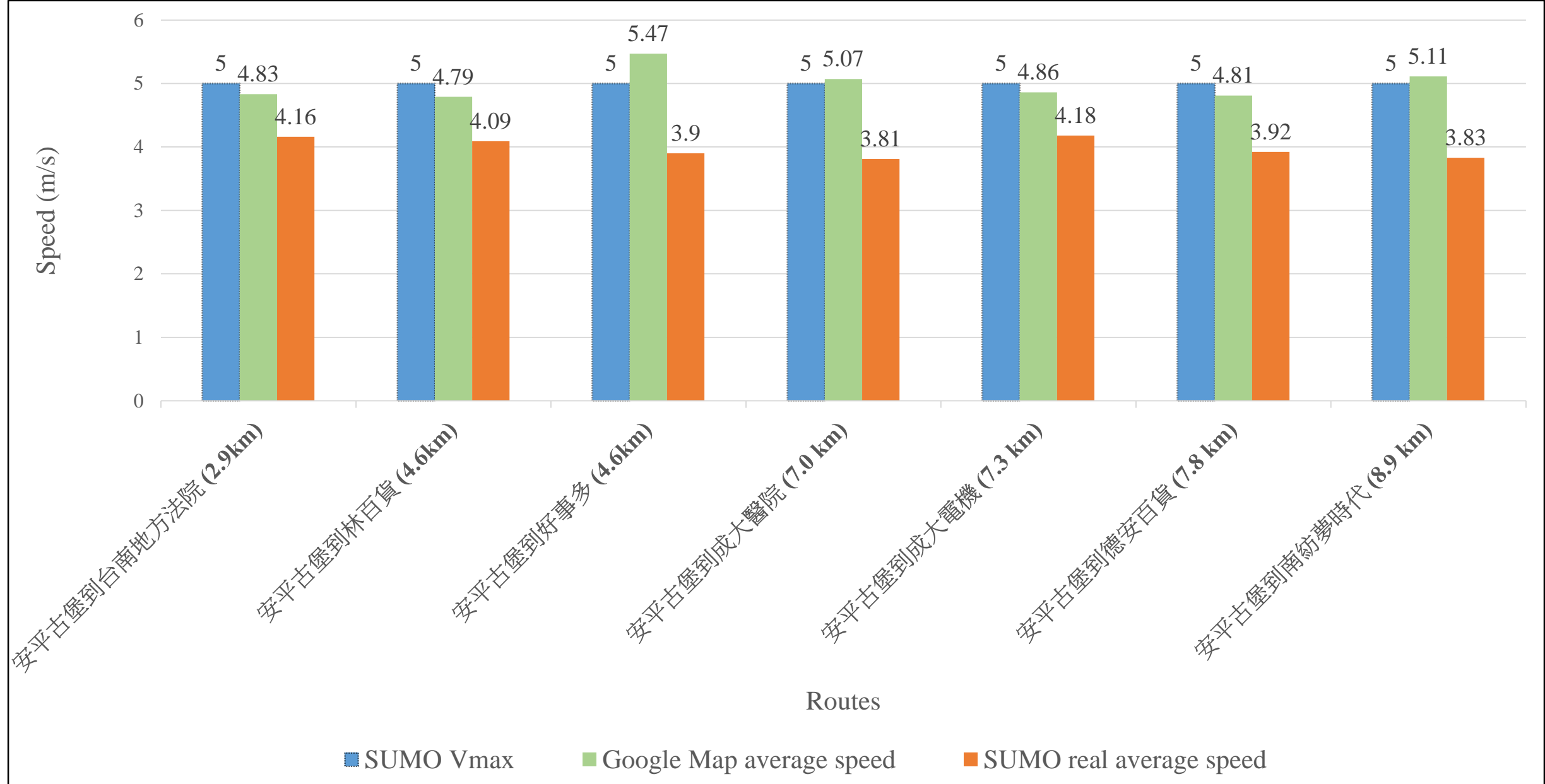


# Parameters of Simulation



Parameters	Value
Simulation area	50.07 km <sup>2</sup>
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)

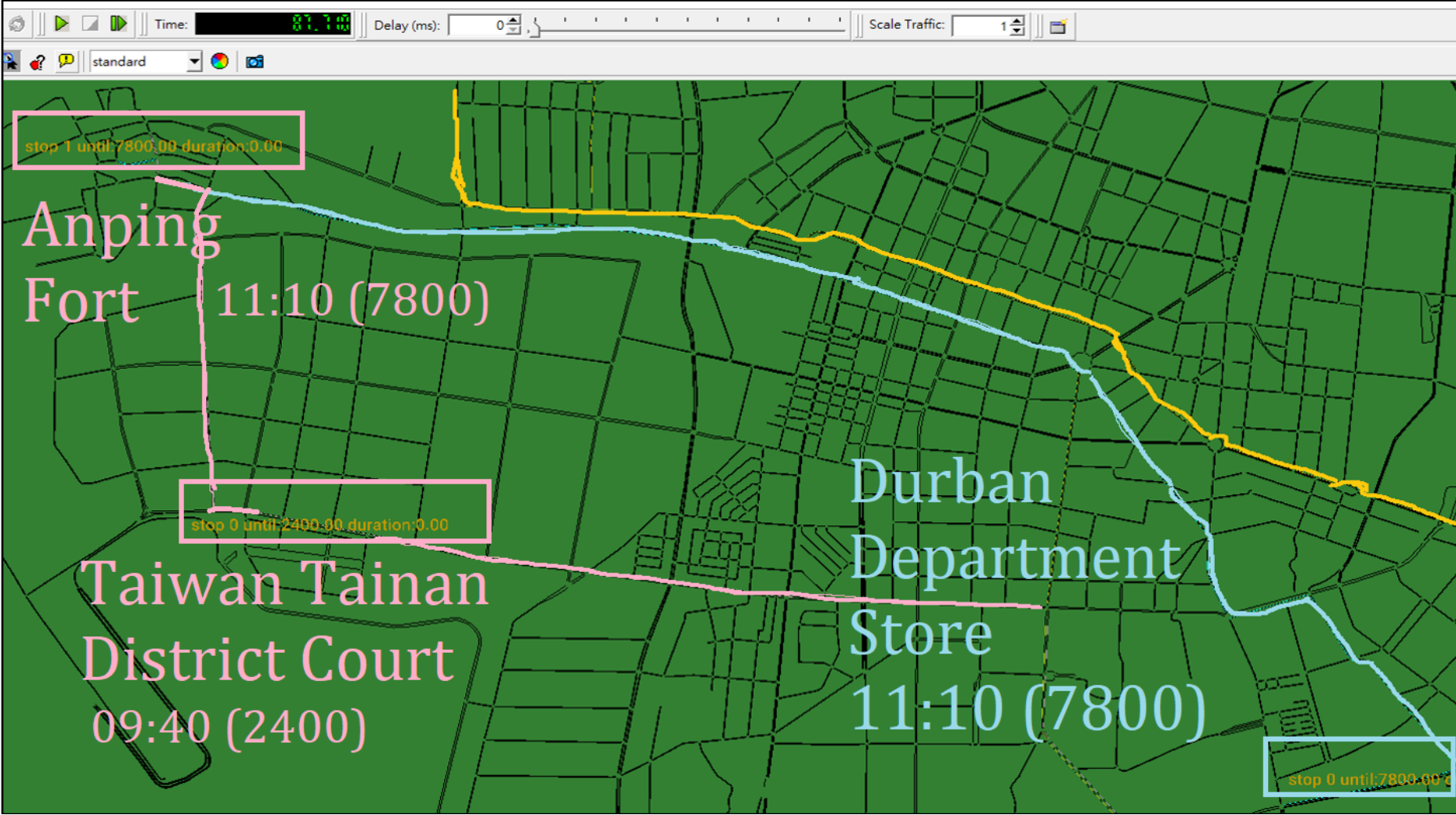
# Average Vehicle Speed Estimation





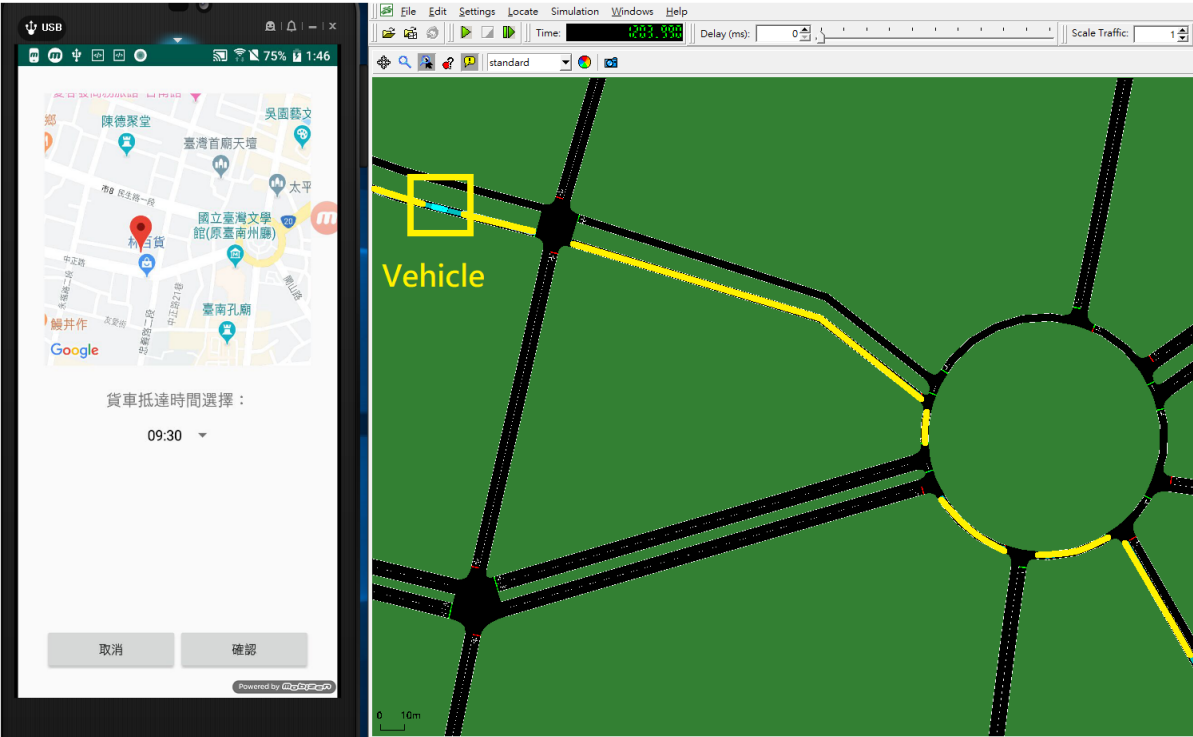
# Simulation Result-Initialization

Time	V1	V2	V3
09:30	S1: Taiwan Tainan District Court		
10:00			
10:30			
11:00	S2: Anping Fort	S3: Durban Depart- ment Store	
11:30			

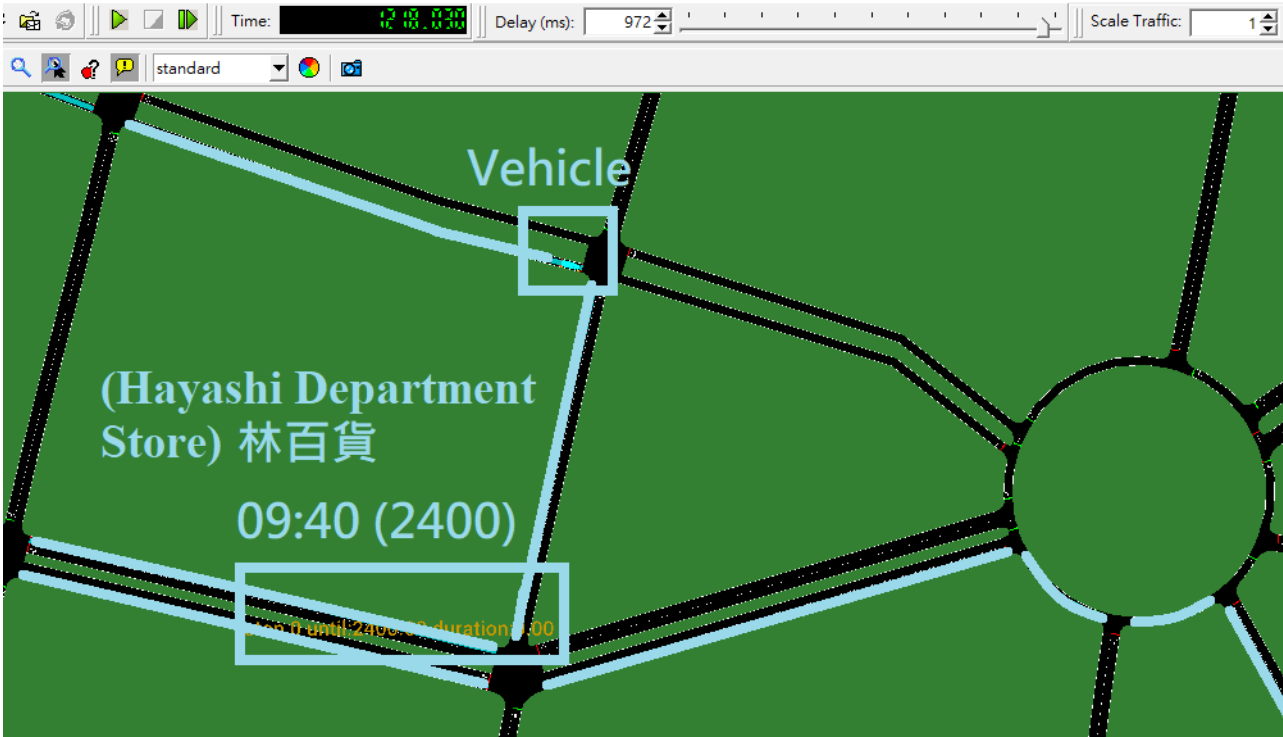


# Simulation Result- Sender Request

Current Timeseconds:1203 (09:20:03)



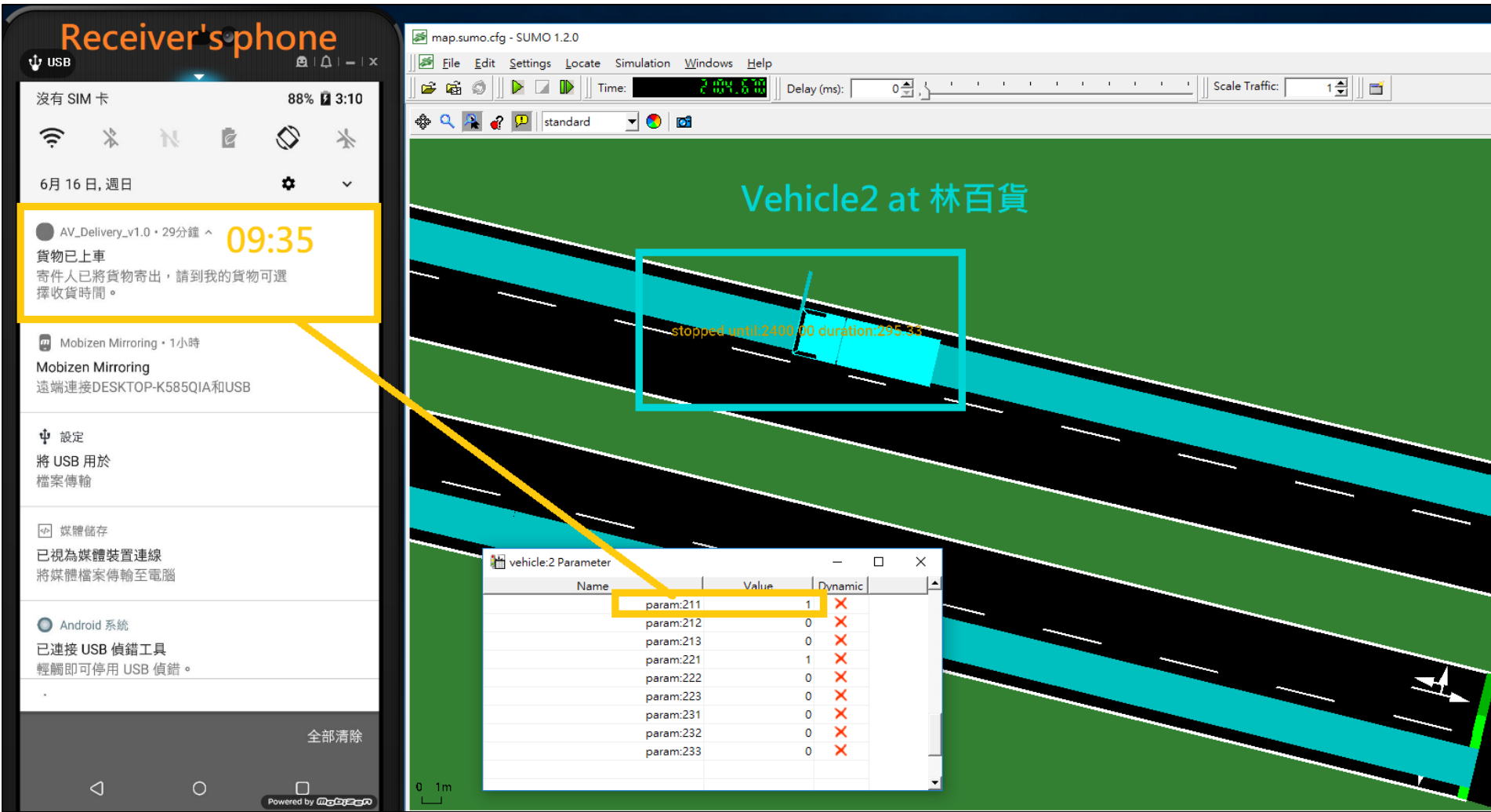
Current Timeseconds:1218 (09:20:18)





# Simulation Result- Loading Process

Current Timeseconds:2104 (09:35)



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

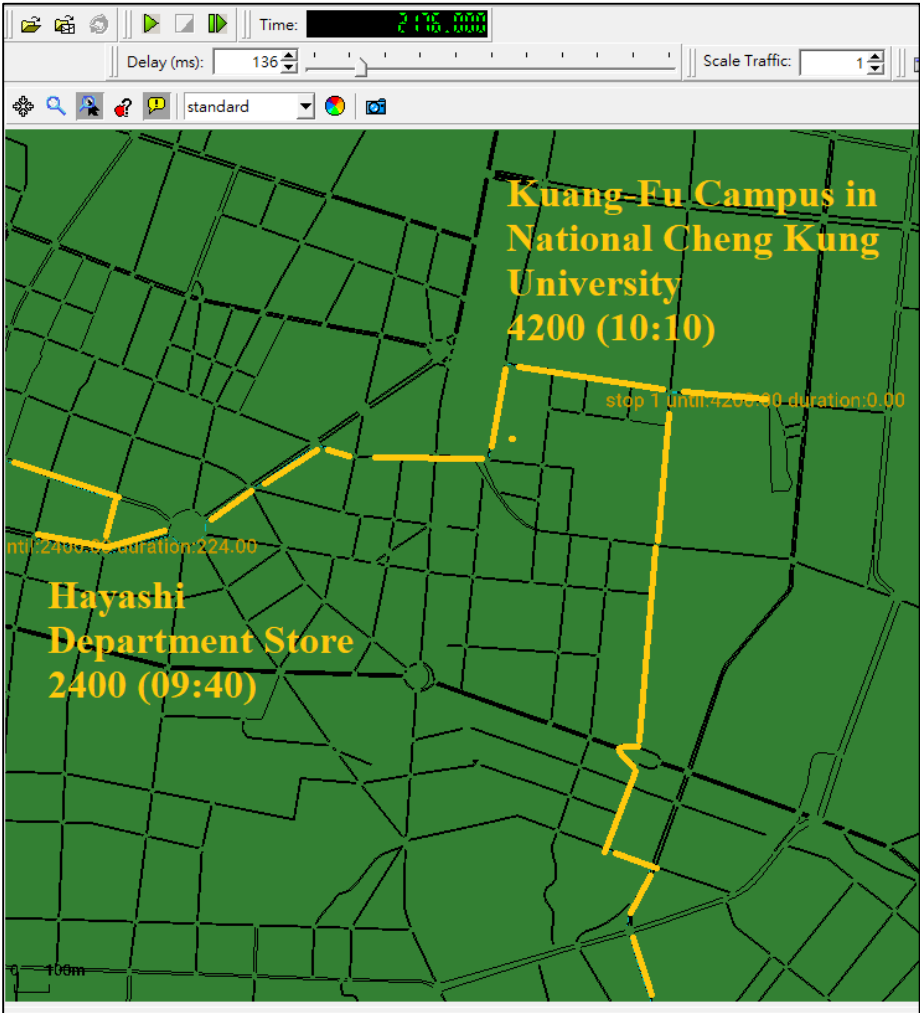
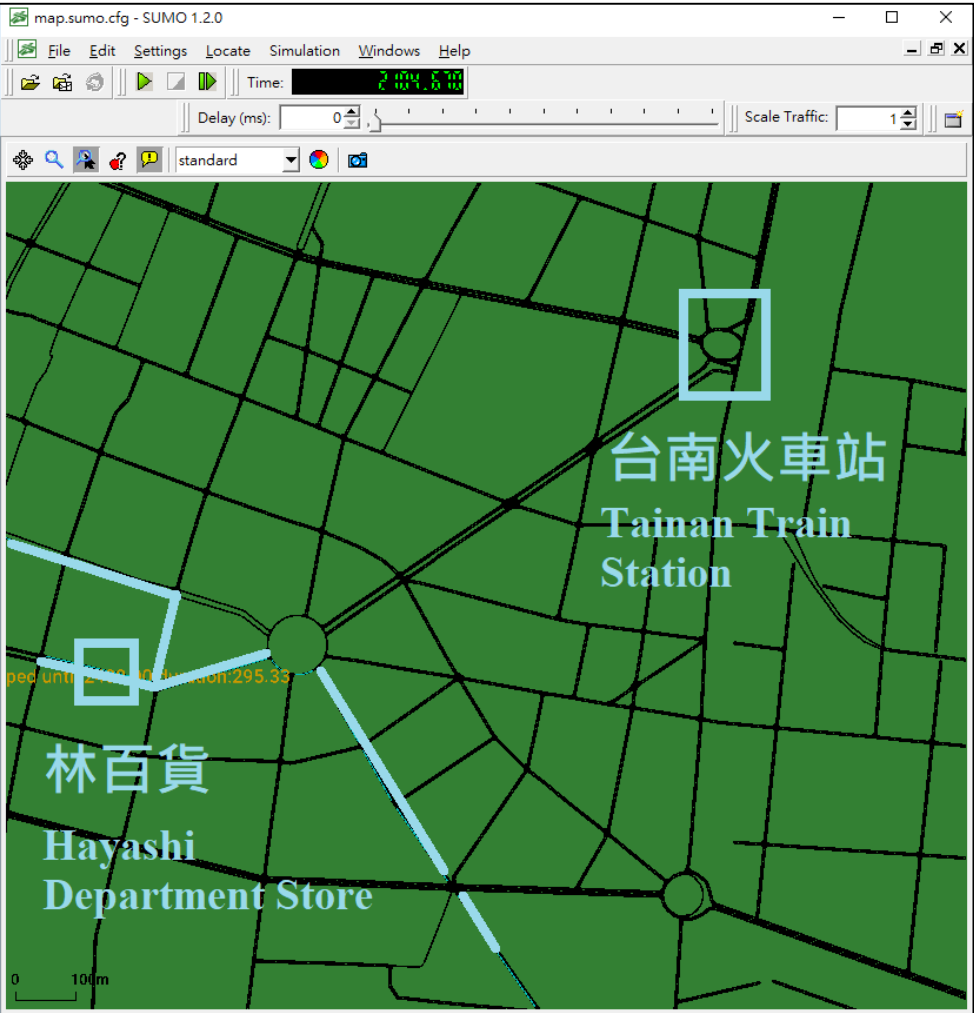
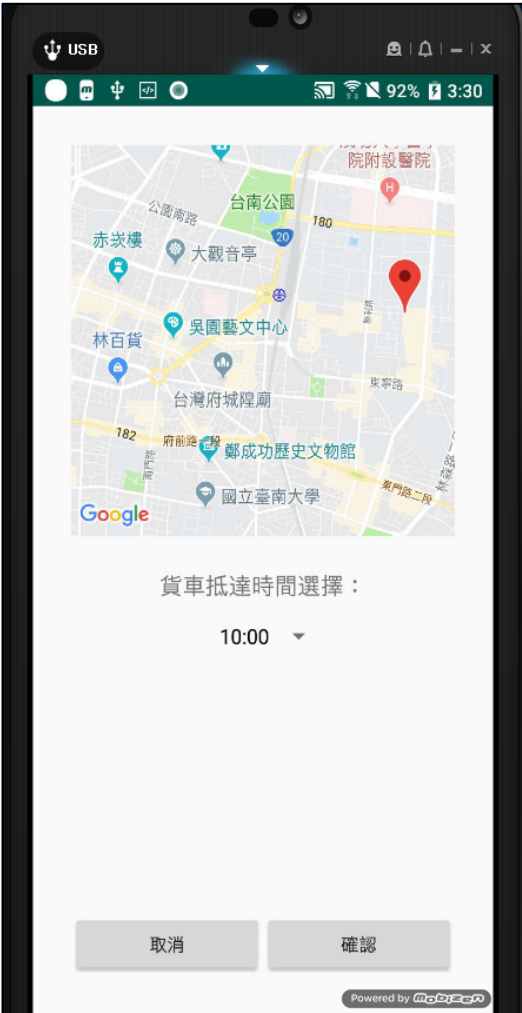
2.The parameters of vehicle2 show that the “box211” has the container.

3.The vehicle2 cannot leave until 2400 (09:40).

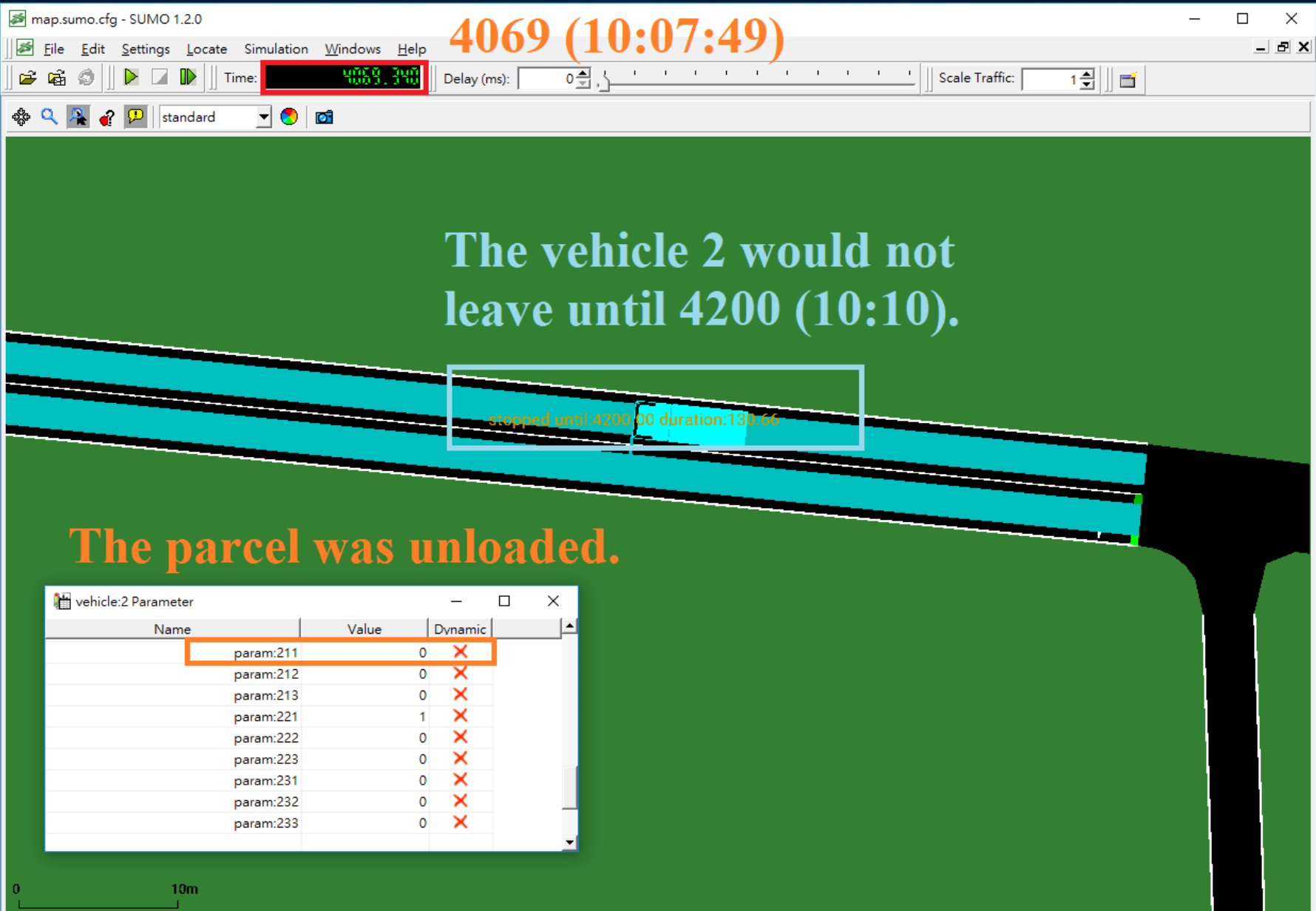
# Simulation Result- Receiver Request

Current Timeseconds:2104 (09:35:04)

Current Timeseconds:2176 (09:36:16)



# Simulation Result- Unloading Process



The parcel was unloaded.

Name	Value	Dynamic
param:211	0	X
param:212	0	X
param:213	0	X
param:221	1	X
param:222	0	X
param:223	0	X
param:231	0	X
param:232	0	X
param:233	0	X

# 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 runs the delivery simulation with a small amount of order requests. However, the system has to deal with a larger batch of orders in a brief period of time in the future.

**Accuracy:** When it comes to scheduling the task, the system has to calculate the travel time of the new route. Thus, the accuracy of the estimated vehicle speed should be actually measured by the real-time road conditions.