# 510 Project Presentation
# Bus Evacuation

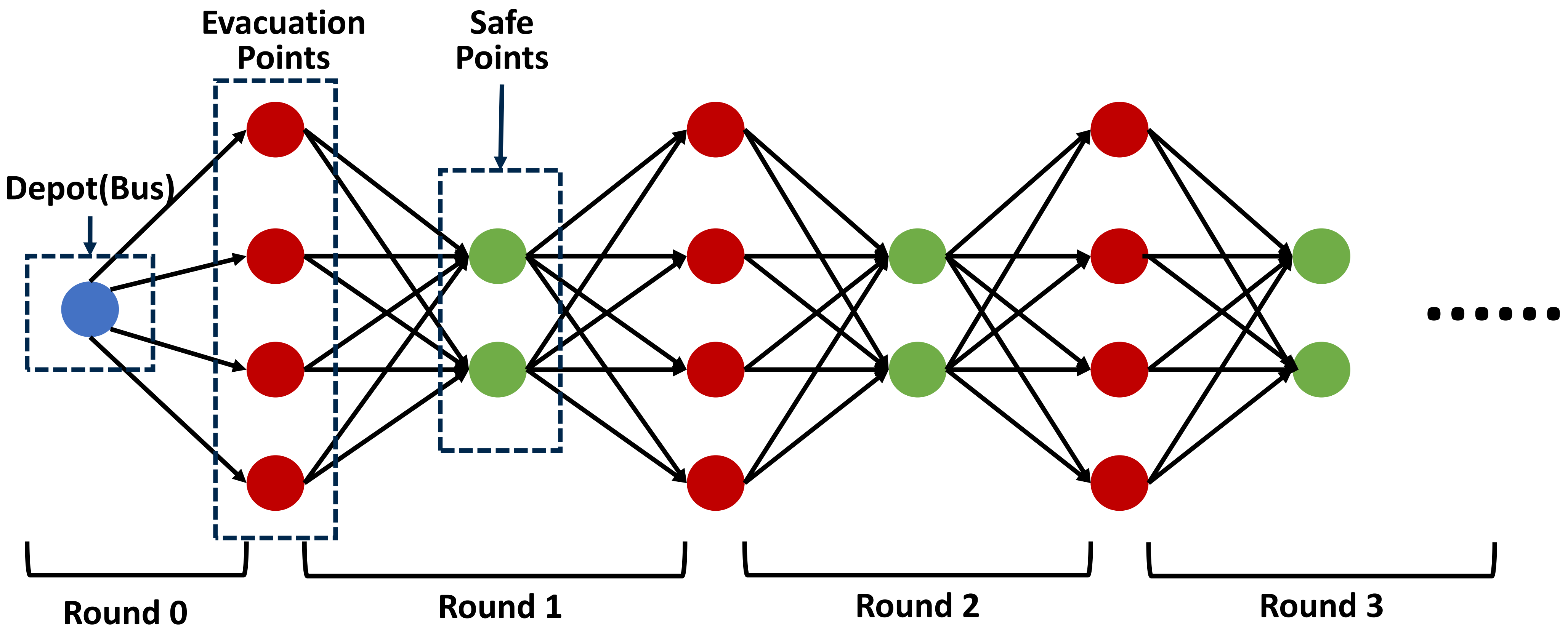
# Table of Context

# Problem Description

- Bus Evacuation Problem

Plan the evacuation of an urban zone using public transport.

- Model diagram



# Model Construction

## Set

- Set of buses: $buses$
- Set of depot: $depot$
- Set of evacuation points: $parking$
- Set of safe points: $safe$
- Set of evacuation rounds: $rounds$

## Parameters

- The capacity of buses:$Bus\_capacity$
- Distance between depots and evacuation points: $dist\_start[d, p]$
- Distance between evacuation points and safe points: $dist[p, s]$
- Demand of each evacuation points: $demands[p]$
- Capacity of each safe points: $capacities[s]$

## Decision variables

- $x_{bpsr}$:Binary variable
- $t\_to_{br}$:Time for reach the safe point
- $t\_back_{br}$: Time for return from the safe point
- $t_{\max}$ : The maximum time taken among all buses
- $b\_parking_{bpr}$: The number of evacuees get on bus b at evacuation point p in round r

## Objective function

$$\min t_{\max} \ \ or \ (average\ waiting\ time)$$

# Model Construction

Constraints:

- Pick up and delivery time: $t\_to_{br} \geq \sum_1^{park} \sum_1^{safe} dist[(p,s)] \cdot x_{bpsr} \quad \forall b \in buses \;\; r \in rounds$
- Next round evacuation: $t\_back_{br} \geq dist[p,s] \cdot \left(\sum_{i=1}^{park} x_{bisr} + \sum_{l=1}^{safe} x_{bpl(r+1)} - 1\right)$

  $\forall b \in buses,\ r \in rounds - 1,\ p \in park,\ s \in safe$
- Total time: $t_{\max} \;\; \geq \sum_1^{rounds} (t\_to_{br} + t\_back_{br}) + \sum_1^{park} \sum_l^{safe} dist_{start_p} \cdot x_{bpl0} \quad \forall b \in buses$
- One trip for every bus: $\sum_1^{park} \sum_1^{safe} x_{bpsr} \leq 1 \;\; \forall b \in buses,\ r \in rounds$
- Flow constraints: $\sum_1^{park} \sum_1^{safe} x_{bpsr} \geq \sum_1^{park} \sum_1^{safe} x_{bps(r+1)} \quad \forall b \in buses,\ r \in rounds - 1$
- Bus capacity: $b\_parking_{bpr} \leq Bus\_capacity \cdot \sum_1^{safe} x_{bpsr} \quad \forall p \in parking,\ b \in buses,\ r \in rounds$
- Demand: $\sum_1^{buses} \sum_1^{safe} \sum_1^{rounds} b\_parking_{bpr} \cdot x_{bpsr} \geq demands\,[p] \quad \forall p \in park$
- Safe points capacity: $\sum_1^{buses} \sum_1^{park} \sum_1^{rounds} b\_parking_{bpr} \cdot x_{bpsr} \leq capacities[s] \quad \forall s \in safe$

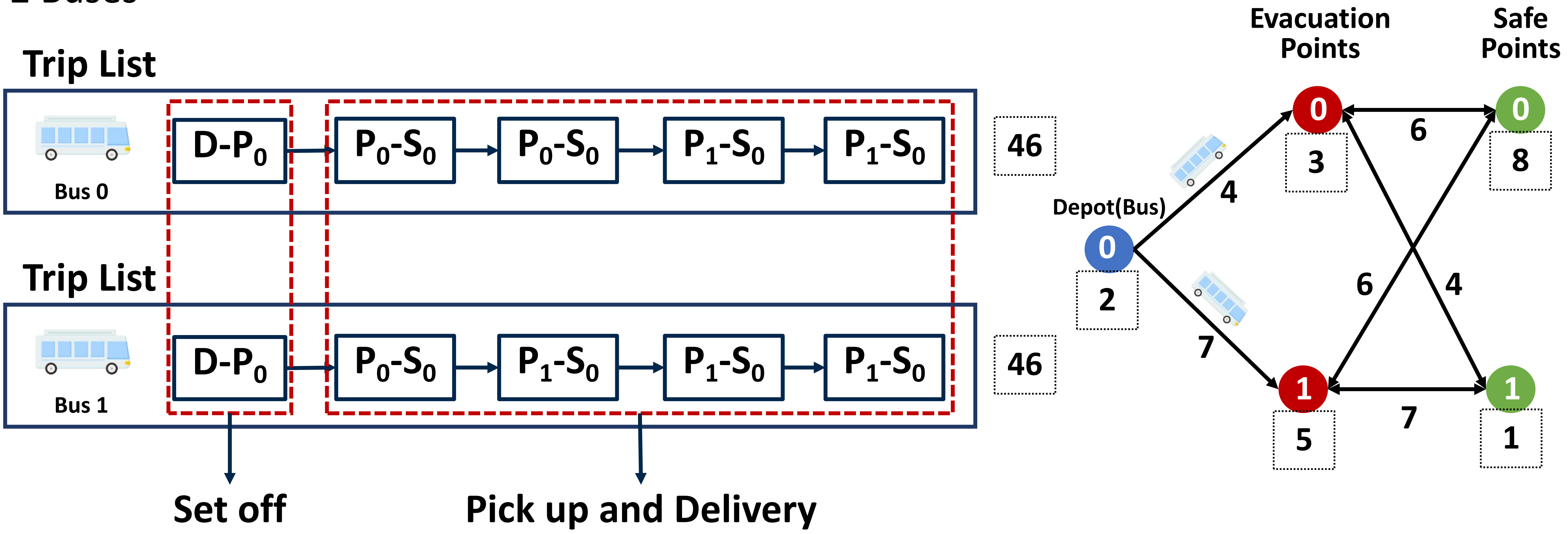
# Experiment and Results(1)

Bus Capacity: 1

Max Rounds: total Demands

T_max=46

2 Buses



# Experiment and Results(2)

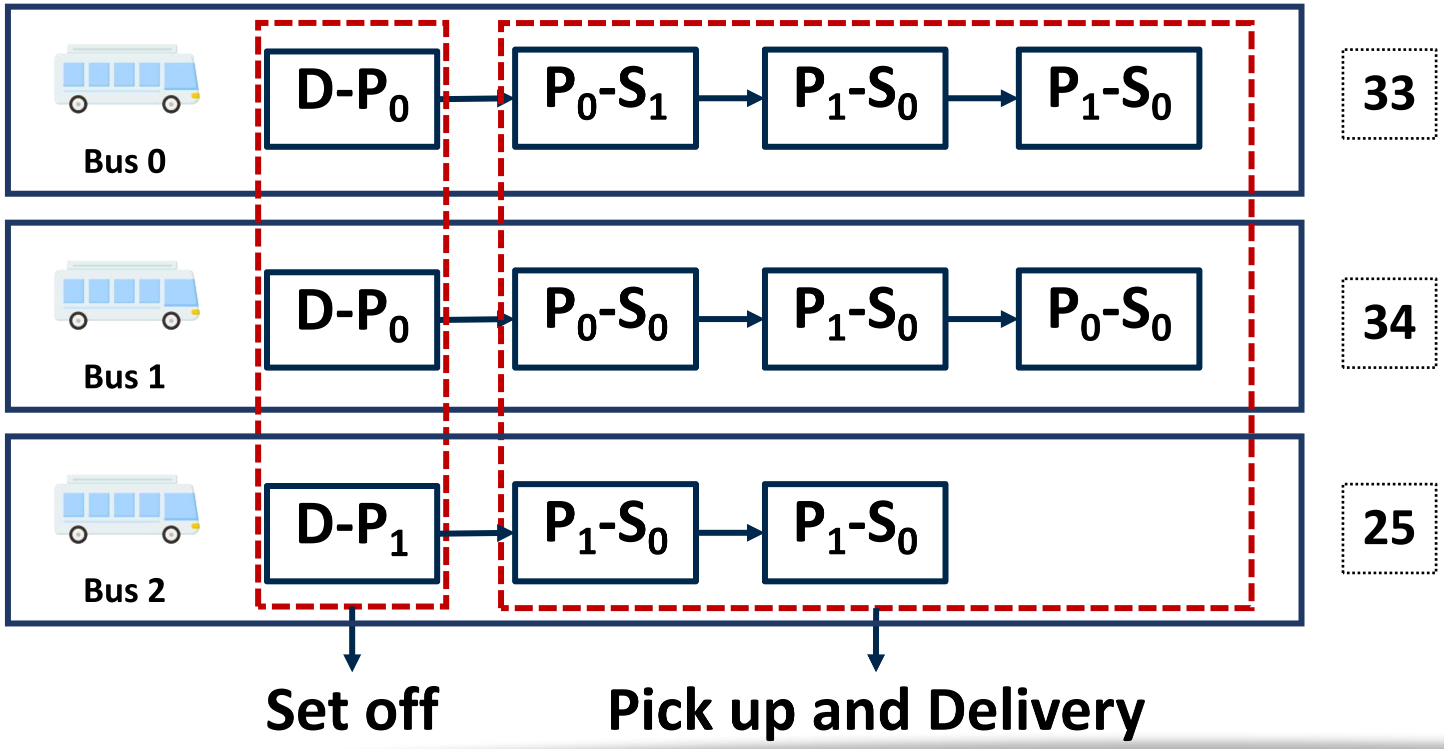
Bus Capacity: 1

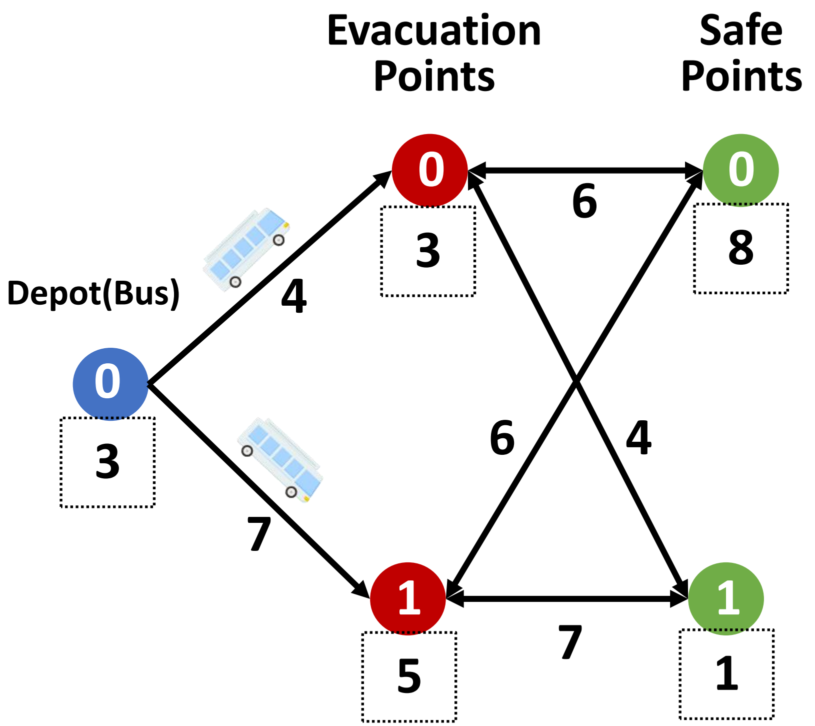
Max Rounds: total Demands

T_max=34

3 Buses

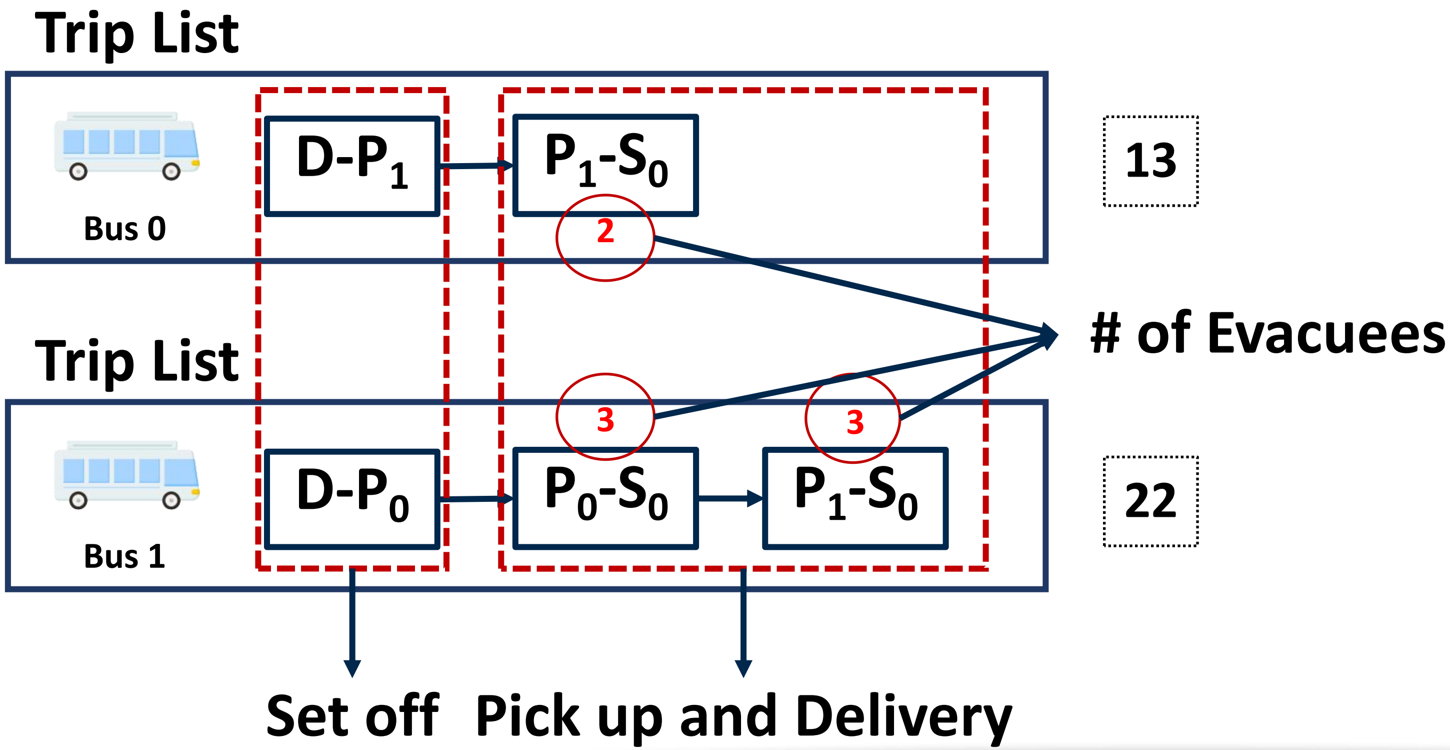
**Trip List**

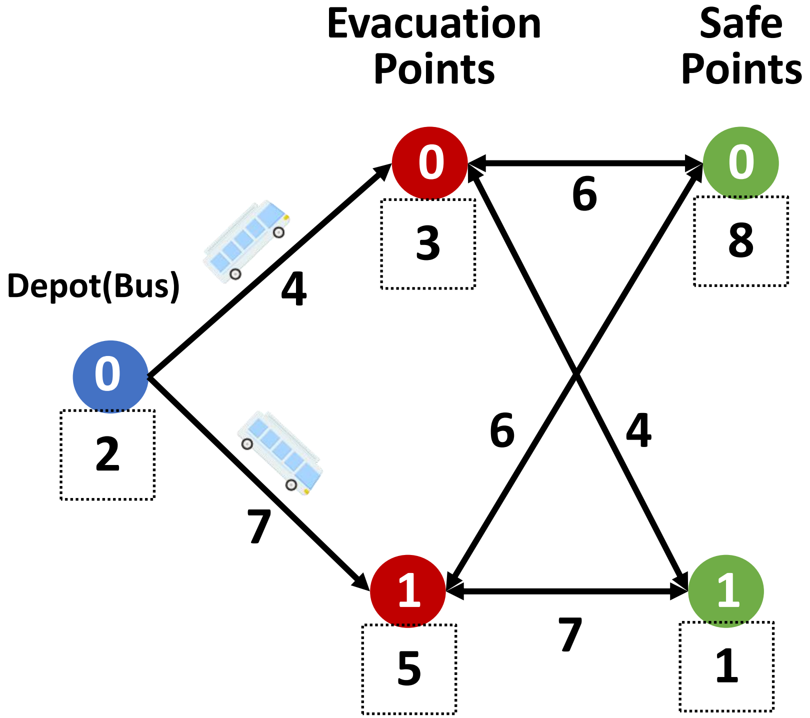


# Experiment and Results(3)

Bus Capacity: 3
Max Rounds: total Demands
T_max=22
2 Buses



# Conclusion

- We solved the Bus Evacuation Problem, using a model to minimize the total duration of the evacuation, building constraints for total evacuation time, flow-balance constraint for evacuation points and safe nodes, demand and capacity constraints, etc.

- For this we solve the model based on GUROBI. To test the model, we built the simple network with random values, and test the model with different settings of parameters. All the results showed that we found the optimal solutions for the model.

```
# Create a Gurobi model
m = gp.Model("evacuation_problem")

# Variables
x = m.addVars(Buses, Parking, Safe, Rounds, vtype=GRB.BINARY, name="x") #binary
t_to = m.addVars(Buses,Rounds, vtype=GRB.CONTINUOUS, name="t_to")
t_back = m.addVars(Buses,Rounds, vtype=GRB.CONTINUOUS, name="t_back")
t_max = m.addVar(vtype=GRB.CONTINUOUS, name="t_max")
b_parking=m.addVars(Buses, Parking, Rounds, vtype=GRB.CONTINUOUS,name="b_parking")

# Objective function
m.setObjective(t_max, GRB.MINIMIZE)
```

# Future Work

- To solve more complex problem instances considering, for example, cycles in graphs and asymmetric costs, to add different paths between evacuation and safe points

- GUROBI is still insufficient in solving actual large-scale evacuation problems. Solving algorithms suitable for large-scale planning can be considered.

- We can consider more combinations of self-evacuators and bus evacuation while taking into account road capacity.

- It Is important for considering fairness issues for all evacuees on the road.

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# Thanks! Question?