

GOALS

- **Support** electric transportation via electric vehicles (EVs).
- **Find** optimal locations for charging facilities on road networks.
- **Compare** charging pads vs. charging stations.

1. Charging station



2. Charging pad



FUNDAMENTAL QUESTIONS/CHALLENGES

- Consider the **driving range** of Electric Vehicles (EVs).
- Consider the **financial budget** with respect to the number of charging facilities to locate on the road network.
- **Scalability.** Large scale of candidate locations for charging facilities.
- **Safety concerns** with regard to charging stations.
 - Consider extreme weather impact on charging stations.
 - Ensure safety.

PROBLEM FORMULATION

- The planning problem is formulated as an **optimization problem** with
 - **Goal:** maximize the traffic flow served.
 - **Constraints:**
 - Fixed number of charging facilities to locate.
 - No overlap of charging stations and charging pads.
- **Feature** of this formulation:
 - Considers the limitation of EVs' driving range.
 - Assumes drivers go to charging stations on their pre-planned routes.

$$\text{maximize } Z = \sum_q f_q^T x_q$$

$$\text{s.t. } \sum_{h \in H} b_{qh} v_h \geq x_q, \forall q \in Q$$

$$a_{hp} y_p \geq v_h, \forall h \in H, \forall p \in P$$

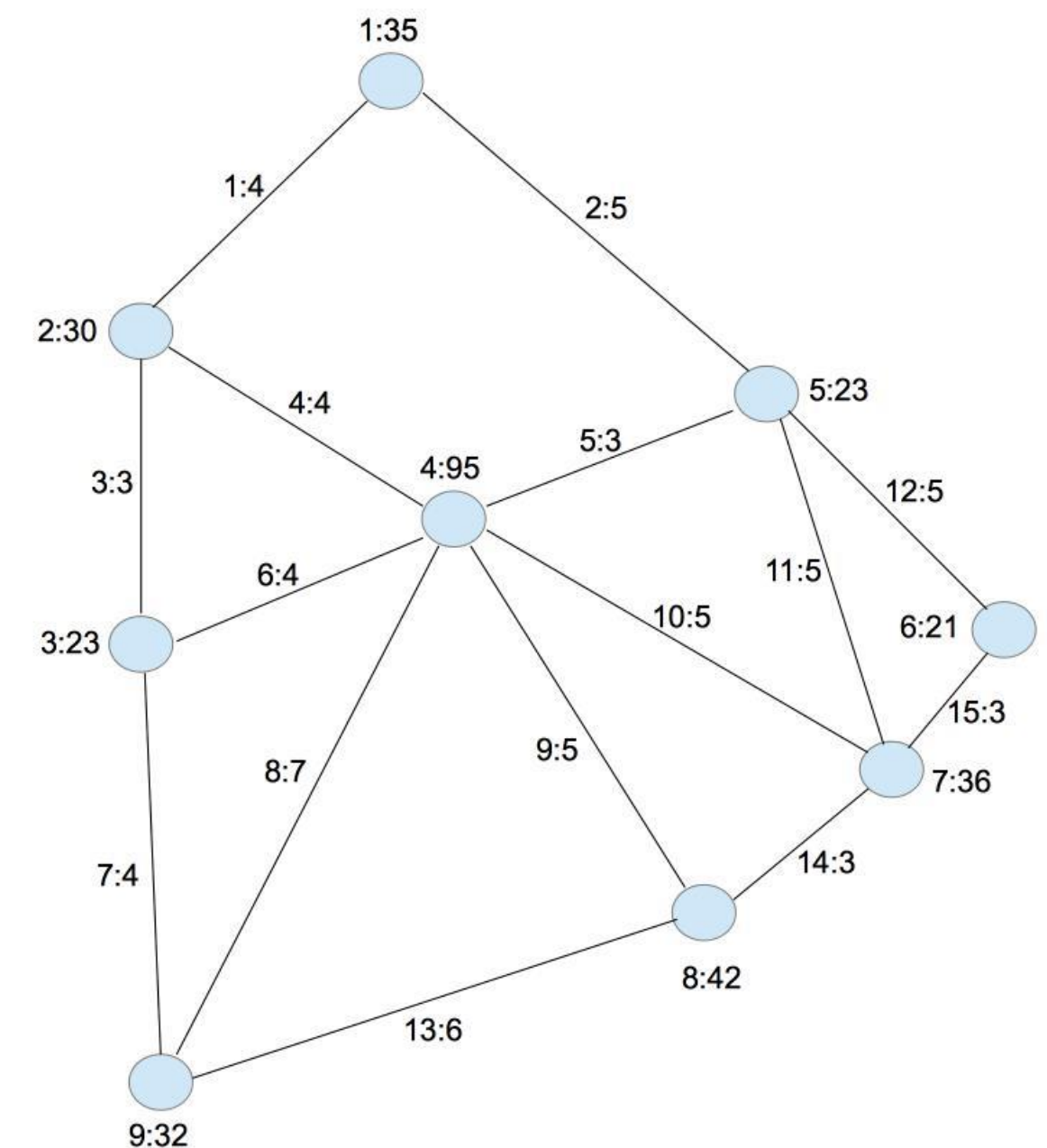
$$\sum_{p \in P} y_p = c,$$

$$y_{p_n} + y_{p_r} \leq 1, \forall p_n \in p_r, \forall p_n \in P, \forall p_r \in P$$

$$x_q, y_p, v_h \in \{0, 1\}, \forall q, \forall h, \forall p$$

EVALUATION

Test Road Network



REFUELED FLOWS WITH LINK 4, LINK 5, AND LINK 10 ASSIGNED WITH CHARGING PADS.

Flow ID	O	D	Distance	Path	Volume (veh/hr)
10	2	4	4	2 → 4	1068.8
11	2	5	7	2 → 4 → 5	147.86
13	2	7	9	2 → 4 → 7	180
22	4	5	3	4 → 5	1092.5
24	4	7	5	4 → 7	1026

Compare Charging Pad vs. Charging Station

1. Traffic flow served

MAXIMUM FLOW REFUELED UNDER VARIOUS SITUATIONS

# pad	# station	Configuration	Volume (veh/hr)
3	0	Link 4, Link 5, Link 10	3515.1
2	1	Link 4, Link 5, Node 1	2309.1
1	2	Node 1, Node 2, Link 5	2726.9
0	3	Node 1, Node 2, Node 4	1692.2

2. Charging time required

Example: Nissan Leaf. Driving from Node 2 to Node 7 (255 miles) with a speed limit of 70 miles per hour.

Requires 3.6 hours to complete the trip.

- **Charging station:** 32 hours of charging.
- **Charging pad:** No need to stop for charging.

RESEARCH RESULTS

- We **extended the charging facility planning problem** by taking into account charging pads in addition to charging stations.
- We proposed an **Extended Flow Refueling Location Model**.
- We show that by locating charging pads:
 - **More traffic flows** (veh/hr) are served/charged for the traffic system.
 - **Less charging time** is required for individual drivers.

FUTURE EFFORTS

- Study public transportation, e.g., electric buses.
- Study the effect of a located charging facility on traffic flows.