Outline

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1 Problem Description

- Background: The current infrastructure is old and not ready for EV.
- Interdependency problem: existing infrastructure is that we cannot satisfy the emerging charging demand for large proportion of the electrification of taxi fleet only through enhancing the current infrastructure.
- Example description. When we build a charging station, we need to consider two factors: economic efficiency, physical feasibility.
- From supply perspective, we want to provide the largest satisfaction under consideration of economic efficiency and physical feasibility. From demand perspective, by allowing autonomous vehicle in our system, we want to allocate the distribution of EV charging demand to fit the existing structure of networks better.
- In order to make optimal long-term decision and to operate and guide the charging route, we build two-stage model.

2 Case Study

2.1 Overview and Default Case Settings

- We use IEEE 33 and Sioux Falls transportation network
- Designed Structure of the network. In TN, we have two classes, downtown and uptown based on both geographic location and size of EV charging demand. In both classes, the demand is larger in East than West, and larger in South than North.
- In PDN, we build our root node in North uptown and make a deepest branch to support south uptown surrounding the whole city. Build two special line for west downtown and east down in middle and south of the city.
- Properties of Structure of the network. This structure will cause problem when considering the interdependence.

2.2 Existing Interdependence Impacts

- From TN perspective, we want to build large stations at southern and eastern uptown because the building cost is low and there will be high EV charging demand, and we want to avoid building stations at northern and western downtown because the demand is low and building cost is high.
- On the contrary, from PDN perspective, we want to avoid building large stations at southern and eastern uptown because there are located at the downstream and end of the longest branches. Instead, we want to build large station at northwestern area and the nodes on two special branches because it is easily to expand both physically and economically.

2.3 Solution for Interdependence From Supply Perspective

- We can change physical feasibility by changing the maximum number of line we can expand.
- We can change economical efficiency by changing cost of building Charging stations and cost of expansion line.
- Find more specific properties of the interdependent network system.

Changing Physical Feasibility

- Without any expansion, we still build some small station in downtown, southern and eastern uptown.
- Without expansion, we still need small station.
- If we can expand, we first expand for east and west downtown
- If southwest downtown is large enough, we dont need to southwest updown station.
- If we can expand as much as we want, we still have large amount of unsatisfied charging demand. Those unsatisfied demand is due to consideration of economically efficiency.

Changing PDN Cost

- If the cost of PDN expansion reduces, we want to build larger stations in eastern downtown and southeastern uptown.
- If eastern downtown is large enough, we don't build station in eastern uptown.
- Competition between eastern, southeastern, southwestern uptown.
- If the west downtown station is small, we build southwestern uptown station.
- Reduce PDN cost is useful but still not enough.

Changing TN Cost

- Less TN cost make more and larger stations. Higher TN cost make less stations.
- If we have incentive to build larger station, the first priority to expand is the east down.
- If we have to closed stations, the first priority to keep is also the east down.
- Reduce TN cost is more useful than PDN cost.

Changing Demand Pattern

- this shows the unsatisfied demand is mainly due to structure of network, not the demand pattern.
- larger station in uptown

2.4 Solution for Interdependence on Demand

- First possible result is that we can have larger satisfaction with more investment.
- We can have similar satisfaction but saving investment.

Changing K

- When we cannot enough physical feasibility, we can save cost and reach similar level satisfaction.
- When physical restriction is removed, we can invest more and reach much larger satisication.
- We build 3 small stations in uptown and large station in downtown.

Changing PDN cost

- If we can apply autonomous taxis, we dont need reduce PDN cost. Economical efficiency is high enough.
- Compared with the manually driving case, we are willing to invest more.

Changing TN cost

- If we can apply autonomous taxis, we dont need reduce TN cost. Economical efficiency is high enough.
- Compared with the manually driving case, we are willing to invest more.