An Algorithmic Approach to Designing an EV Stop-Gap Charging System

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With the depleting supply of petroleum worldwide, as well as concerns over global warming, the discussion to switch from motor vehicles to electric vehicles (EVs) is becoming increasingly relevant.

It’s expected that within the next 25 years, all motor vehicles in the United States will be replaced with EVs, with the total number replaced approaching 300 million. With this change, there are challenges regarding the infrastructure, as the rapid change from motor to EV will create bottlenecks at charging stations.

A stop-gap system has been suggested, which utilizes algorithms to efficiently allocate charging stations nationwide.

Before this system can be implemented, there are several requirements that need to be fulfilled:

a.) Every vehicles has an unique EV-ID which is connected to the charging station network

b.) A heirarchal networking system can be generated, which can be easily modified based on your primary residence. It categorizes your residence based on:

- Region (West, East Coast, Midwest, etc)

- State

- County

- City

-Block

c.) Based on the number of EV’s in a block against the # of charging station, an estimated wait time is calculated, and a possible transfer request is generated to the surrounding blocks.

d.) When an EV battery charge is <25%, it generates several request and approved vouchers within a reasonable distance and with a reasonable time

e.) Once a voucher is used, it is cleared from the system.

**Additional Context**

1.) The hierarchical networking system for determining location is established as a tree, where:

\* The U.S. is the root node, each branch from the U.S represents the regions (East Coast, West Coast, Midwest, etc)

\* Each branch of a region is a state

\* each branch of a state is a county

\* each branch of a county is a city

\* each branch of a city is a block

2.) A voucher (VCHR) contains the EV-ID of an EV, which can be sent to a charging station.

3.) Named the Array List Geographic Proximity System (ALGPS). The geographic proximity of one node to another has already been calculated beforehand in case the average wait time in a node is too long, and the (VCHR) needs to be sent to another local node instead.

The proximity is in an array list, sorted from least to greatest to quickly check the distances between neighboring nodes.

EX: There are 5 cities next to each others. Do note that “prox” doesn’t represent any particular measurement in this example:

[(city1, prox = 1.3), (city2, prox = 1.5), **(city3, prox = 1.8)**, (city4, prox = 2.4), (city5, prox = 2.7), …]

In this example, suppose we are the interested in the **city3**, looking for nearby cities. Because the array list is sorted, we can easily find the nearest cities by looking to the left and right of the element.

**Based on these requirements, and the additional context the following algorithmic system can be implemented, which is based on a system of trees, array lists, and queues:**

If an initial EV battery drops <25%, it sends a VCHR to the stop-gap system

The algorithm checks the local block for available charging stations.

If the charging station is occupied by another EV, the algorithm will use the following calculation to find the total wait time:

NOTE: TWT= Total Wait Time = (# of Evs in Block / # of Charging Stations in Block) x Charging Duration

The algorithm will use recursion to back trace to the city node, and will then calculate the average wait time (AWT) from the blocks in the city.

If the TWT at a certain block is less than the average wait time (TWT < AWT) , then the algorithm will generate a voucher for the charging station with the smaller wait time. Afterwards, the station which receives the EV-ID will add it to the back of its queue, and update the TWT.

Otherwise, if TWT > AVG, then the algorithm will use recursion to view and compare the AWTs of city nodes underneath the state node. It will use the (ALGPS) to prioritize finding the closest city nodes first.

Otherwise, if the charging station is empty, then the EV vehicle will immediately send the VCHR to be immediately added to the station’s queue.

Once a car has finished charging, the TWT for the block gets recalculated immediately.

After an established interval, the city, state, region, etc, nodes get their AWTs recalculated.