Individual research

Project S8 – Optimal Itinerary for Electric Vehicles

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Introduction

Thanks to their ecological and economic advantages, electric vehicles (EVs) are the ideal means of transportation to fight against the global warming by reducing the greenhouse gas emission. However, certain constraints bound to the battery's autonomy, the density of charging and the charging times slow down the adoption of these vehicles by a bigger quantity of users. The development of intelligent electricity networks (Smart Grids), improving the energy distribution between the suppliers and the consumers, could improve the experience of use of the EVs. *Achraf Bourass et al.* in ***« Secure Optimal Itinerary Planning for Electric Vehicles in the Smart Grid »*** suggest a system's architecture for establishing a secure communication between the Smart Grid and EVs, which will allow optimal itinerary planning.

In my synthesis, I will focus on the itinerary planning method and point out its advantages and inconveniences.

Suppositions and constraints

- **Suppositions** :
    - EVs communicate the following informations to the Smart Grid Operating System : state of charge (SoC), current position, destination
    - The most optimal routes are the most economic in terms of energy consumption and traveling time.
    - The most energy efficient route often corresponds to the shortest one
    - The nodes in the itinerary may be charging stations or not
    - All the charging stations have the same equipment
    - There are many EVs on the road

- **Constraints** :
    - Battery's autonomy : EVs have an autonomy of approximately 300 km, which is not suitable for long trips.
    - Charging stations' density : there is a low amount of charging stations and they are not well geographically distributed
    - Waiting times in charging stations : EVs have long charging times and there may have a queue at some charging points
    - Different speed limitations of route segments : this parameter is related to the energy consumption

Used approach and results.

Knowing the source (S), the destination (D) and the initial state of charge (SoCi) of the EV, the aim is to find a route allowing to keep a certain amount of charge SoCd after reaching D. This approach is broken down in two parts :

- **Part 1 : Finding a direct route between S and D.**
  First of all, the system determines the energy consumption of every possible route between S and D. Then, If the route with the lowest energy consumption allows to arrive at D with a level of battery upper than SoCd, it is chosen as being the most optimal one. However, if the previous condition is not respected, there is no direct path leading to D without stopping to charge the battery. The energy of the vehicle being insufficient, the method of the part 2 is then applied.

- **Part 2 : Planning an optimal itinerary including charging the battery in one or several stations.**

    Nodes that are not charging stations aren't considered in the calculations any more. The EVs will thus have to move from stations to stations until D. Therefore, the stations where the energy demand is superior to the charging capacity of the station, i.e. where the waiting queue is too long, are also discarded from the calculations and are considered as inaccessible. With the remaining nodes (accessible charging stations) in the graph representing the card of the route, Yen's algorithm is applied to find the **N** shortest paths in terms of energy consumption (N is chosen by the driver). For each of the previous paths, the most optimal waiting time is calculated. Finally the path followed by the EV will be the one with the best compromise between energy consuptiom and waiting time which satisfies the driver's need.

Advantages et inconveniences

Advantages :

- **Consideration of the level of battery on arrival** : the algorithm is made so that the driver has enough battery to go in a nearby station after his arrival at destination
- **Preferences of the driver are taken into account** : the driver of the EV interacts with the algorithm to generate a number of routes corresponding to his need
- **Consideration of waiting time in the charging stations** : it's a very relevant parameter because the charging time of an EV is an important factor and there is potentially a waiting line at charging points.
- **Charging the battery is not the priority** : the used method focuses on managing the energy consumed by the route rather than stopping in a station to recharge battery. It allows to minimize the traveling time.

Inconveniences :

- **Strong dependence on Smart Grid** : the vehicle does not possess its own navigating system and depends completely on Smart Grid.
- **Big loss of information** : in the 2nd part of the itinerary planning method, discarding the nodes which aren't charging stations lowers the precision of the final itinerary.
- **Difficulty of implementation** : the success of this method depends a lot on the communication between Smart Grid, charging stations and EVs. The current infrastructure of charging stations are not enough optimal to facilitate this communication.

Conclusion

Thanks to the communication between Smart Grid, charging stations and EVs, it would be possible to limit the impact of the constraints related to the EVs on the experience of the drivers. In spite of the lack of precision of the proposed route and the strong dependence on Smart Grid and on infrastructures of the charging stations, the proposed solution remains very relevant because it takes into account essential parameters such as the energy consumption of the route, the level of battery of the EV, the waiting time in stations and the driver's needs.