EV Charging Management and Coordination

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Table of Contents & Overview

The largest problem facing EV adaption currently is the lack of widely available charging infrastructure. In this presentation we will examine this issue and some new technologies that may help to relieve it in the future.

- Range Anxiety and Charging Coordination
- Battery Management System & Controller Area Network
- Vehicle Communications & Utilization of Radio Access Technology
- Charging Infrastructure & Charger Variations
- Charging Management Systems for EV Charges
- Open Charge Point Protocol & Interoperability of Chargers
- Overview & Connections to Coursework
**Range Anxiety**

Avg. Time to Gas Station = 4 min  
Avg. Time to EV Charger = 31 min

<table>
<thead>
<tr>
<th></th>
<th>2022 Models</th>
<th>Tesla Model 3</th>
<th>Chevrolet Bolt</th>
<th>Nissan Leaf S Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price ($)</td>
<td></td>
<td>46,990</td>
<td>32,495</td>
<td>32,400</td>
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<tr>
<td>Capacity (kWh)</td>
<td></td>
<td>60</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>EPA Range (miles)</td>
<td></td>
<td>272</td>
<td>259</td>
<td>226</td>
</tr>
</tbody>
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Fear of running out of charge without being able to locate a charging station
- Not an issue for ICEVs with current infrastructure
- Lack of charges in rural areas

Difficulty of long distance travel
- Recharges needed to cover full distance
- Significant time losses compared to EVs

General Lack of EV Infrastructure
- Less availability for repairs and higher costs
- Fast chargers are very expensive
- Adapters may be required at certain chargers
Charging Coordination

Long Distance Trips Require Planning
- Must ensure that EV can travel required distance
- Need to forecast charging stops
- Greatly limits routes available
- Some routes do not have DC fast chargers

EV Status Awareness
- State of Charge
- Vehicle Location
- Driving Conditions
- Charger Locations
Charging Considerations

Discharge Concerns
- Speed & Wind
- Temperature
- Road Conditions
- Cargo Load
- Hotel Load
- Battery Degradation

Recharge Concerns
- Battery Capacity
- Charger Type
- Recharge Rate
  - Safe Speed
  - SOC
**Battery Management Systems**

**Introduction:**

BMS is an electronic system that manages a rechargeable battery to ensure it operates safely and efficiently. BMS is designed to monitor the parameters associated with the battery pack and its individual cells, apply the collected data to eliminate safety risks and optimise the battery performance.
Main Functions of BMS

- Measurement and control of temperature
- Charge balancing (passive and active)
- Fault detection
- Data storage
Modular is preferred in EVs.
Controller Area Network (CAN)

The Controller Area Network (CAN) is a highly integrated system that was developed within the automotive industry to allow a number of electronic units on a single vehicle to share essential control data.
Utilization of Radio Access Technology

Vehicle to Vehicle
Vehicle to Infrastructure
Infrastructure to Vehicle

Requires Network Chips
- Utilize existing infrastructure
- Partner with cellular companies

New Opportunities
- Wireless charging methods
- Automated driving
- Improved load regulation
Issues for Charging Infrastructure

- Outside of the West Coast, EVs already suffer from a lack of abundant charging stations
  - Proprietary connectors exacerbate this problem further
- Charging stations without DCFC capability require a long time to charge
- Major shortage of EV charging stations
  - The United States is expected to reach 35 million EVs on the road by 2030
  - A study by the National Renewable Energy Laboratory estimates 3.4 DCFC and 40 Level 2 charging stations are needed for every 1,000 EVs
  - 50,000 DCFCs & 1.2 million Level 2 stations by 2030 need to be built
    - 380 EV charging stations per day to reach this mark
    - Built on average 30 stations per day from 2010-2020
  - Biden Administration allocated $15 billion to build 500,000 EV charging stations
Proprietary Charging Connectors

- Not all charging points provide every type of EV charging plug
  - Each type of charging plug is compatible with different EVs
  - Different charging points might not be available for certain EVs
- Most of the EV industry has agreed upon a single standard type of charging plug with the exception of Tesla
- Capable of different levels of charging
  - Level 1: 1 - 1.4 kW
  - Level 2: 3.9 - 19.2 kW
  - Direct Current Fast Charging (DCFC) 24 - 350 kW
    - Also called Level 3 charging
- 4 different types of EV charging plugs
Tesla Proprietary Plug

- The standard plug all Tesla charging stations use and are exclusive to Tesla EVs
  - No standard plug on the market when Tesla was founded
  - Much like how the charger for iPhones is to mini-USB chargers
- Capable of Direct Current Fast Charging (DCFC)
  - Supercharger stations owned by Tesla can reach up to a 250 kW charging rate
  - Tesla has announced plans to make these stations available to non-Tesla EVs
- Urban Supercharger locations limited to 75 kW and only have Tesla plugs
  - EVgo has outfitted most of their DCFC stations with Tesla plugs to reach a wider customer base
- Aftermarket charging adapter for non-Tesla vehicles exist
  - Lightning to mini-USB adapter
  - Limited to lower level charging stations
J1172

- The standard plug most of the EV industry has agreed upon
- For Level 1 and Level 2 charging
  - 1.5 - 10 kW charging rate
- All non-Tesla home EV charging stations come with it

Combined Charging System Combo

- iPhone chargers are to mini-USB chargers as Tesla plugs are to CCS plugs
- Advancement of the J1172 plug
  - Used for DCFC charging stations
  - Can reach charge rates of up to 350 kW
- High power output restricts it from being used as an at-home EV charger
ChaDeMo

- DCFC charging plug
- One of the earlier EV charging plugs on the market
  - Gained popularity in 2011-2012 with the introduction of the Nissan Leaf
- Is mostly being phased out in North America in favor of CCS plugs
  - Slower charge rate
    - Highest rate is 50 kW
- Only found on two EVs
  - Nissan Leaf
  - Mitsubishi Outlander PHEV
  - Both Japanese automakers
    - Still widely used in Japan
Local Charging Network

CMS

LAN

Charging Points

Electric Vehicles

Charging Management System (CMS)

Parking Database
Proprietary Charging Points

- Proprietary charging networks mean vendor dependent charging points within a network
  - Lack interconnectivity between CMS and chargers from different vendors
  - Drive up costs to own and maintain a charging network
Open Charge Point Protocol (OCPP)

- Open source protocol developed to allow interoperability between charging stations and CMS regardless of manufacturing vendor
- Draws similarities to cell tower networks and the interoperability of different manufacturer and generation towers [2]

**Open Charge Point Protocol**

*id*: User identification used to authorize and handle payment

*Transaction.Started()*: Initialize transaction handshake between charging point and CMS

*Transaction.Stopped()*: End transaction by handshaking between charging point and CMS

*Authorize()*: Authorization call used to make ensure the user is allowed to charge

*Authorize()*: Authorization call used to trigger the end of charging

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Economic Benefits of OCPP

- Flexibility
  - Network owners and operators can mix and match their network management software with their hardware from various vendors → reduces operational costs
- Competition
  - Vendors face direct competition from other vendors due to a lower barrier to replace charging points → reduces market prices

Reduced Costs → Incentivize more EV Charging Stations
Adoption of OCPP

- OCPP is widely adopted in Europe
  - OCPP is a requirement on any new charging point after 2019 in the UK
- OCPP is not as widely adopted in the United States
  - American charging market was kickstarted by the U.S. Department of Energy which allows each network provider to choose their own protocol
  - Tesla chargers notoriously do not feature OCPP and are considered closed networks
    - Tesla captures nearly 25%* of the charger market share within the United States

Implications for Future Innovations

- **EV Technology Advancements:**
  - BMS, CAN, EVCI, OCPP
  - EVs have gone from a novelty to a viable option for Transportation

- **EV Innovations to come:**
  - Autonomous Vehicles
  - Interconnected EV Grid
  - EV user becomes less and less involved as the technology automates tasks
Connections to ECE398GG

- Battery and Charging Management
  - BMS (Battery Management Systems)
  - Charging Connectors and Plugs
  - Connection to Lecture 5

- EV integration into today’s Grid
  - CAN (Controller Area Network), Radio Access Technology
  - Charging Coordination
  - Connection to Lecture 10

- Electric Vehicle Charging Infrastructure
  - Local Charging Network, Proprietary Charging Points
  - OCPP (Open Charge Point Protocol)
  - Connection to Lecture 13 with Professor Olga Mirroneko
Communication and Coordination of EVs

- Coordination:
  - BMS
  - Charging Connectors
  - Charging Infrastructure
  - Charging Coordination

- Communication:
  - CAN
  - Radio Access Technology
  - Adoption of Uniform EVCI
Acronyms

SOC - State of Charge
BMS - Battery Management System
CAN - Controller Area Network
RAT - Radio Access Technologies
CS - Charging Station
GA - Global Aggregator
DCFC - DC Fast Charger

CCS - Combined Charging System
ChaDeMo - Charge de Move
CMS - Charging Management System
LAN - Local Access Network
OCCP - Open Charge Point Protocol
ESS - Energy Storage System
EVCI - EV Charging Infrastructure
References


https://www.forbes.com/sites/breakingdotsak/2021/05/05/the-lack-of-ev-charging-stations-could-limit-ev-growth/?sh=699866786a13


