Presentation 3

Route Optimization for Amazon's Electric Delivery Vehicles

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Recap

Problem:

How can we add a charging station stop to an Amazon electric delivery vehicle (EDV) shipping route and maximize energy and time efficiency?

- Minimize distance of charging station detour
- Minimize wait time at charging station

Recap

- Rabbit: Amazon's current route optimization app
  - GPS/navigation system + shipment inventory log
- We will enhance Rabbit's algorithm/capabilities and the process of charging by:
  - Using Rabbit's currently collected data to find chargers en route to delivery
    - GPS map data
    - Time windows for deliveries
    - Traffic, weather, construction, accidents/hazards, etc
  - Using data from the EDV
    - Battery level
    - Driving range
  - Getting data from charging stations
    - Charging queue length
    - Queue order
    - Time stamps of NFC taps
    - Location of station

Synchronous analysis

Asynchronous analysis

Recap

- Beginning of shift: Rabbit will….
  - Predict at what point along the route the battery level would become low (i.e. 20%)
  - Suggest an initial route and charging stop for the day

- Throughout shift: driver can…
  - Choose an alternate charging station based on real-time updated queue lengths
  - Join the queue at a station, view their position in the queue, and receive a randomly generated number representing them
  - Use an open charger when they reach the first spot in the queue

Altered Proposal

Drivers will now use **NFC on their mobile device** (rather than an RFID tag) to tap onto an RFID reader

This is how they will join the charging queue and make a tap-to-charge payment at the charging stall

1. Current Technology

- NFC standards:
  - ISO/IEC 14443: pertains to ID cards used to store information
  - ISO/IEC 18000-e: pertains to RFID communication between NFC devices

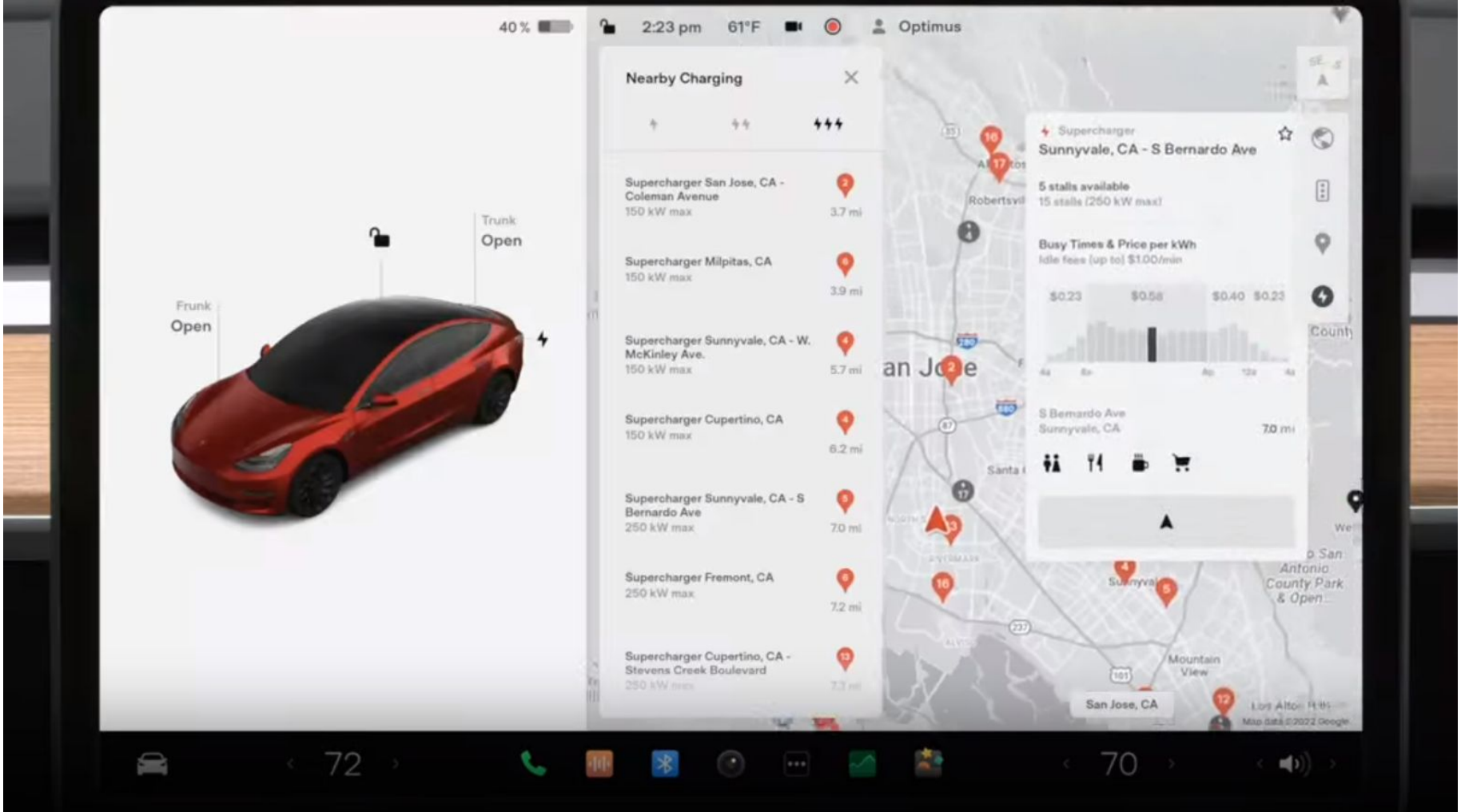
1. Current Technology

- Ex. ChargePoint stations
  - NFC tap-to-charge for payment/authorization, Apple and Android mobile devices
    - 13.56 MHz (High Frequency), transmits data up to 424 kbit/s
    - 2 devices are within a 10 centimeter range of each other
  - Taps against RFID reader mounted on charger
  - ChargePoint mobile app
    - Can join waitlist for nearby chargers
    - NFC and payment setup
    - Charging update notifications

1. Current Technology

- Ex. Tesla's built-in tablet dashboard
  - Map displays nearby charging stations & amount of "available stalls" at each
  - Can add Tesla charging station stop en route with navigation
  - Once the charger is plugged into Tesla, driver is automatically billed
  - Tesla app notifies the driver when car is almost fully charged
  - Restricted to Tesla owners / Tesla ecosystem

Photo on next slide


40 %
2:23 pm
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Optimus
Trunk
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Frunk
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Nearby Charging
Supercharger San Jose, CA - Coleman Avenue
150 kW max
3.7 mi
Supercharger Milpitas, CA
150 kW max
3.9 mi
Supercharger Sunnyvale, CA - W. McKinley Ave.
150 kW max
5.7 mi
Supercharger Cupertino, CA
150 kW max
6.2 mi
Supercharger Sunnyvale, CA - S Bernardo Ave
250 kW max
7.0 mi
Supercharger Fremont, CA
250 kW max
7.2 mi
Supercharger Cupertino, CA - Stevens Creek Boulevard
Supercharger
Sunnyvale, CA - S Bernardo Ave
5 stalls available
15 stalls (250 kW max)
Busy Times & Price per kWh
Idle fees (up to) $1.00/min
$0.23
$0.58
$0.40
$0.23
S Bernardo Ave
Sunnyvale, CA
7.0 mi
Mountain View
San Jose, CA
72
70

2. Hardware Used

01	NFC Chip (HF, short range)	• Already built into smartphones used by EDV drivers ○ Not included in cost estimate • Smartphones already used by 85% of American adults • No internet connection required
02	*Backup Option for NFC* RFID key fob tag	• Our initial proposal • Compatible w/ RFID readers in current proposal • For non-smartphone owners or if phone is low battery • Optional, therefore not included in cost estimate
03	RFID Reader	• IDEAS WAVE ID® Solo Keystroke V2 LEGIC® HF RFID Reader • Included in cost estimate
04	Digital Screen (Connected to central RFID reader)	• P6 Outdoor Full Color 40'' x 18'' Scrolling LED Display • Included in cost estimate

3. Role of Middleware

- Our middleware takes the form of software on the cloud and facilitates the flow/filtration of data
- Reduces amount of data processing that must occur on smartphone where Rabbit is installed

3. Role of Middleware: Charging Station Process

1

Driver conducts the first NFC tap with their smartphone on the central RFID reader to join the charging queue.

2

Middleware (on cloud) receives NFC chip UID (unique identifier).

3

Middleware adds UID to the bottom of the charging queue and augments the length of the queue by 1 to update queue length.

4

Middleware assigns UID a randomly generated number (#01 - #99) for privacy & transmits number to digital screen attached to central RFID reader.

5

Middleware sends Rabbit the position in the queue and the driver's random number. These will be displayed on the app.

6

Middleware notifies every charger of the UID at the top of the queue. The next available charger can have its own display signage to show that it is "available" (vacant).

7

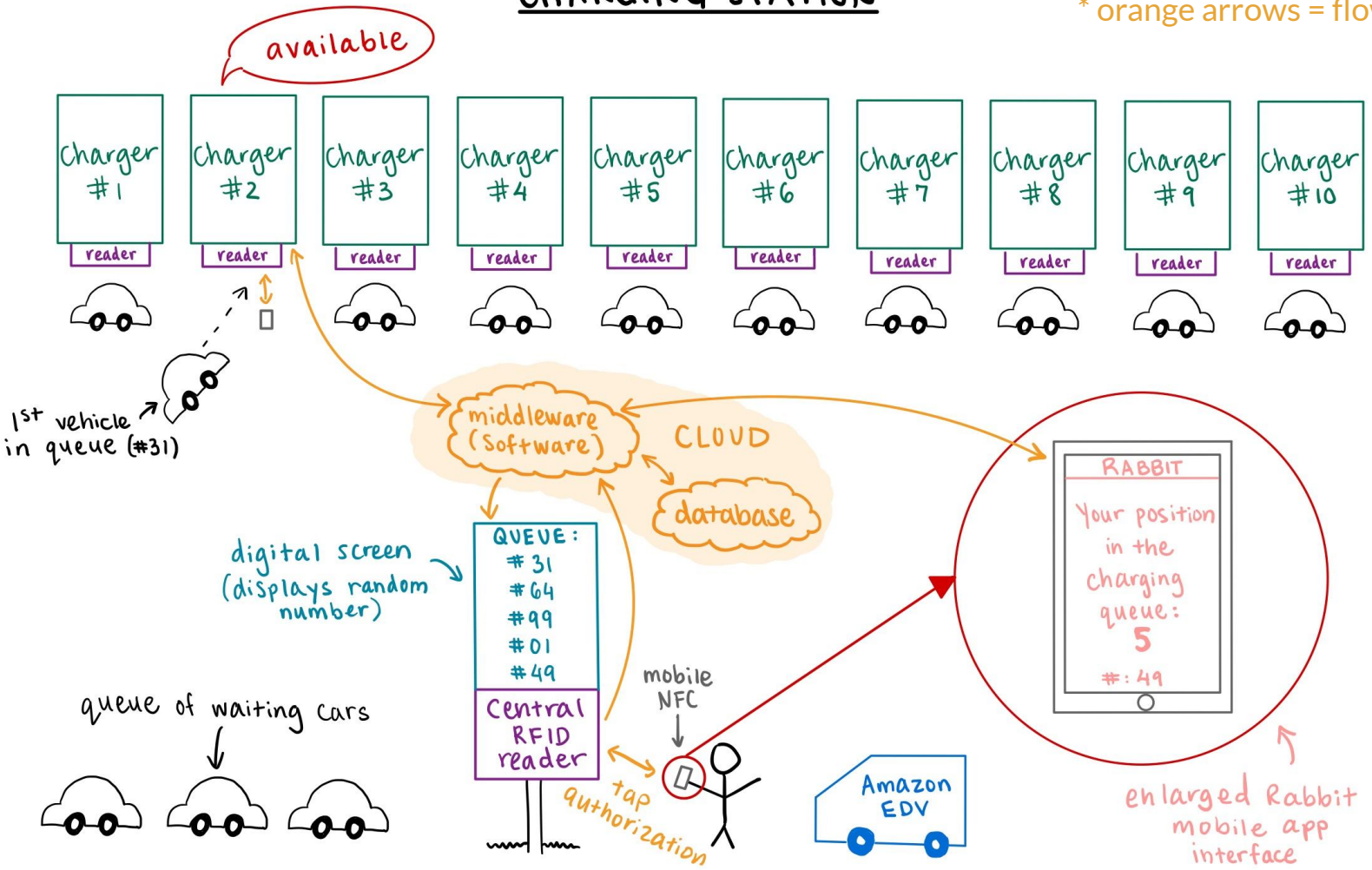
Middleware ensures that the correct driver is authorized at the next open charger when 1st driver in queue uses NFC tap-to-charge payment at RFID reader.

8

Middleware sends time stamps of taps and instantaneous queue lengths throughout the day to a database (on cloud) for long term trend analyses.

CHARGING STATION

* orange arrows = flow of data



4. Data Standards/Format and Memory

- EPC data standard isn't relevant -- EPC isn't used in NFC
- 64-bit memory on NFC chip should suffice
    - Used in TSMC A8 chip for iPhone 6 and 6+
    - Chip will store NFC UID when tap occurs
    - Chip does not need to store other data for our purposes -- cloud (middleware + database) will do so

5. Networking and Wireless Considerations

- NFC can function without an internet connection -- addresses concern in remote areas
- Middleware will likely require an internet connection to communicate with Rabbit and update the driver about their queue status
    - Solution: set up a WiFi network at each charging station
- Drivers need a cellular connection on the road to receive real-time updates relating to GPS traffic/construction/hazard updates, charging availability, queue times, etc
    - Solution: activate cellular data on drivers' phones

6. Tag/Hardware Security

- NFC Tag does need to be secure
- Inherent design supports this because communicating NFC devices are within ~10 cm range → short range means hard to obstruct data flow
- NFC tap-to-charge payment authorization occurs right before charging
    - Payment info may contain sensitive information
    - Security measures & encryption already built into smartphones (Apple Pay, Google Pay) make this reliable
- NFC UIDs are not displayed in public charging station
    - Instead use randomly assigned number to represent UID

7. Cost Estimate

- ~109,307 chargers in United States
  - Estimate about 10 chargers per charging station

- Cost of one charging station
  - 11 readers per station: (11 x $237) = $2,608
  - Media (digital screens) = $486
  - Ongoing Wifi cost = $20/month
  - Total: $3,093 + $20/month

- Cost of all charging stations
  - $3,093/station x 10,931 stations = $33,809,583
  - Ongoing WiFi cost (per month) = $20/month x 10,931 stations = $218,620/month

7. Cost Estimate

- Cost for Amazon
  - Rabbit App upgrades = $500,000
  - Cost estimate of middleware upgrades (new development): $1,000,000
  - Total cost for Amazon = $1,500,000

- Summary
  - Amazon would need to pay **$1.5 million for software implementation**
  - Other entities such as charging companies would need to pay **$33.8 million for hardware implementation** and **$218,620/month for WiFi**
  - For all costs across all companies: **$35,309,583 + $218, 620/month**

8. Cost Benefit Analysis

- Only overhead cost for Amazon is $1,500,000 software development and upgrade fees
- Ultimately, goal is to maximize efficiency so delivery drivers can deliver more packages per day
    - Challenge was determining estimated profit per package to calculate numeric ROI

8. Cost Benefit Analysis

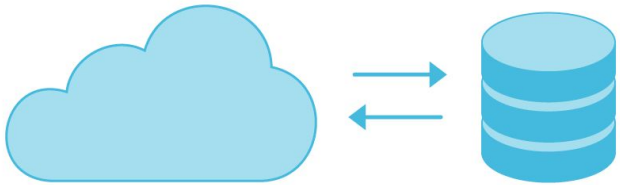
- Assumptions
  - Time saved using new IOT system
    - Estimate 30 minutes of saved delivery time
      - In LA: average of 10.2 minutes in traffic
      - Estimate drivers may wait up to 20 minutes for open charger
  - Driver Estimations
    - Estimate 4 additional stops per shift (based off data from Amazon driver forums)
    - 4 shifts a week (not 5 because contract workers)
      - Equates to ~ 80,000 drivers working in US each day
  - Charging stations don’t have WiFi (but many do)

8. Cost Benefit Analysis

- 4 additional stops x 80,000 drivers = **320,000 more packages** each day
- **Profit per package**: Amazon profit by delivery / packages delivered = $1.22/package
- Capability to process **$390,400 packages each day**
- Recuperate investment in 3.84 days (software costs on Amazon's end)
- First month ROI for software spending = 7.808
    - Very high: important to note it does not include hardware cost because it would be up to EV charging companies to implement these
- First month ROI also including hardware and other fees = 0.33
    - However, profitable by month 4 for all involved companies

9. Need for a Database

- Because long-term trend analysis needs to be performed, data needs to be stored
- Data can be stored in a cloud database
- Database would receive queue data
    - NFC UIDs
    - Length of the queue
    - Time stamps when the NFC taps are recorded
- Data in database provide insight into average wait times for given vehicles



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