DOORDASH

How Machine Learning Powers On-Demand Logistics at DoorDash

Gary Ren, Machine Learning Engineer

March 25, 2020

Last mile, on-demand logistics

Last mile, on-demand logistics

CNBC

DoorDash continues to lead in the food delivery wars

MORNING CONSULT

THE FASTEST GROWING BRANDS 2019

DoorDash, White Claw, Postmates, Impossible Foods & Venmo top this year's list

USA TODAY

Chase credit card holders can order DoorDash with no delivery fees

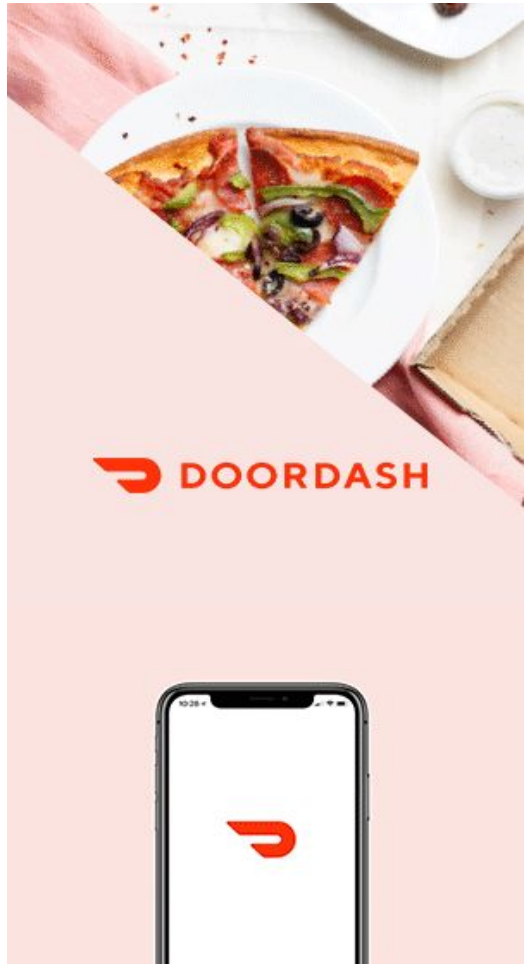
Outline

Machine Learning at DoorDash

Logistics Engine

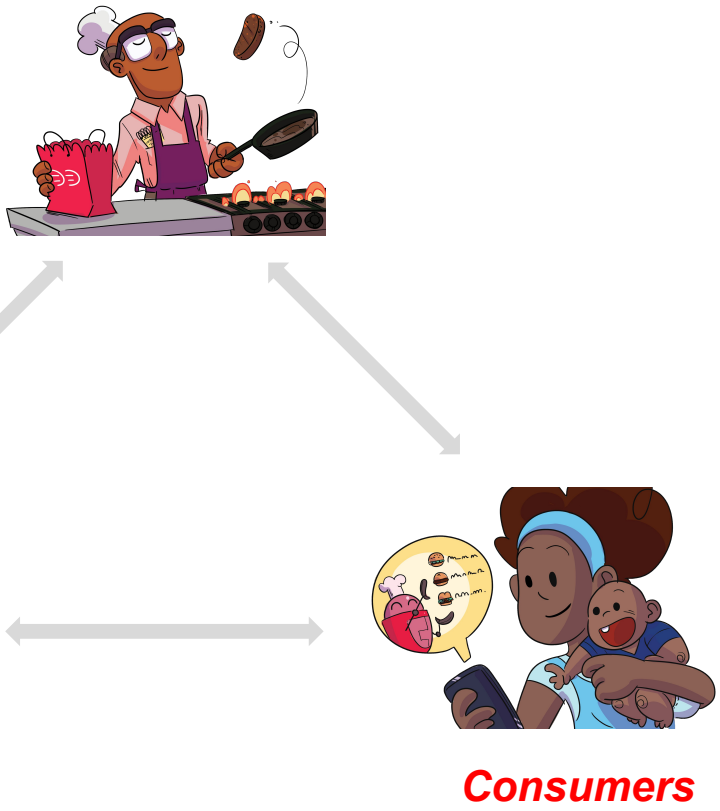
Reinforcement Learning for Logistics

Impact of GPUs



Machine Learning at DoorDash

Marketplace



Marketplace

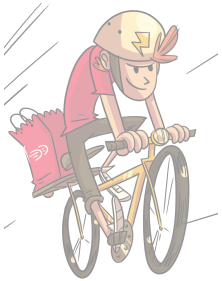
Merchants

Reach

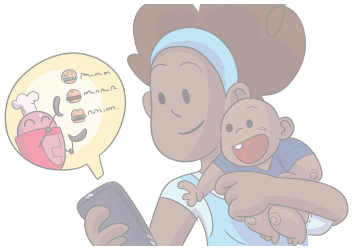
Revenue

Flexibility

Earnings



Dashers



Consumers

Convenience

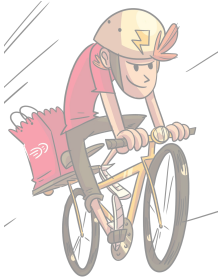
Selection

ML at DoorDash

Merchants

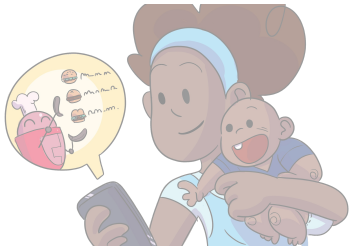
Assignments
Travel Estimates
Hotspots

Recommendations/Personalization
Search Ranking
Demand Distribution



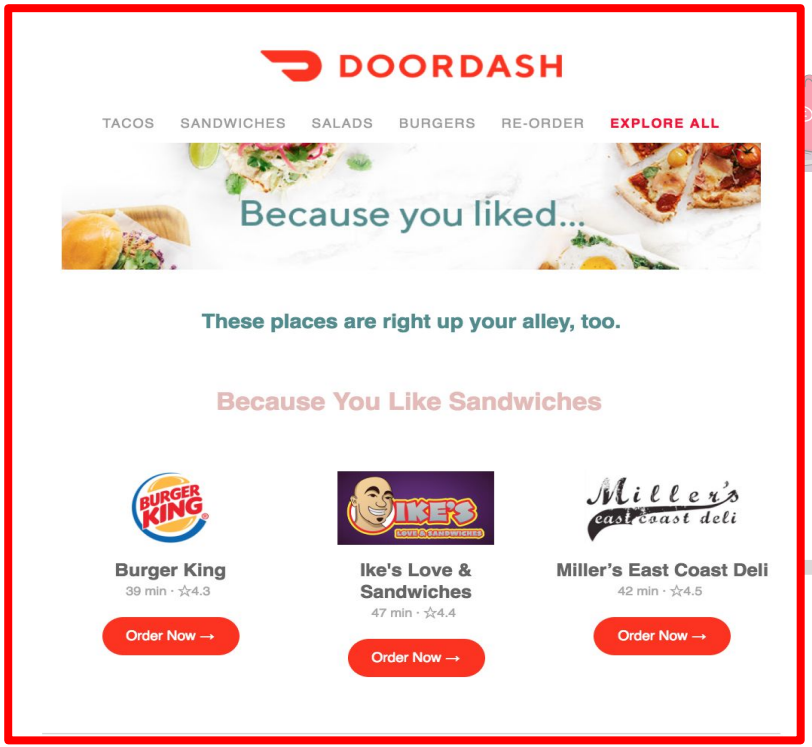
Dashers

Supply/Demand
Dynamic Pricing
Delivery Time



Consumers

ML at DoorDash

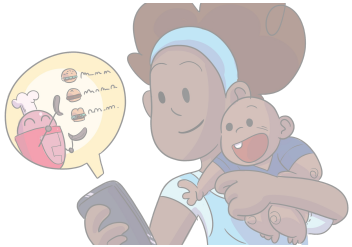


Merchants

Recommendations/Personalization

Search Ranking

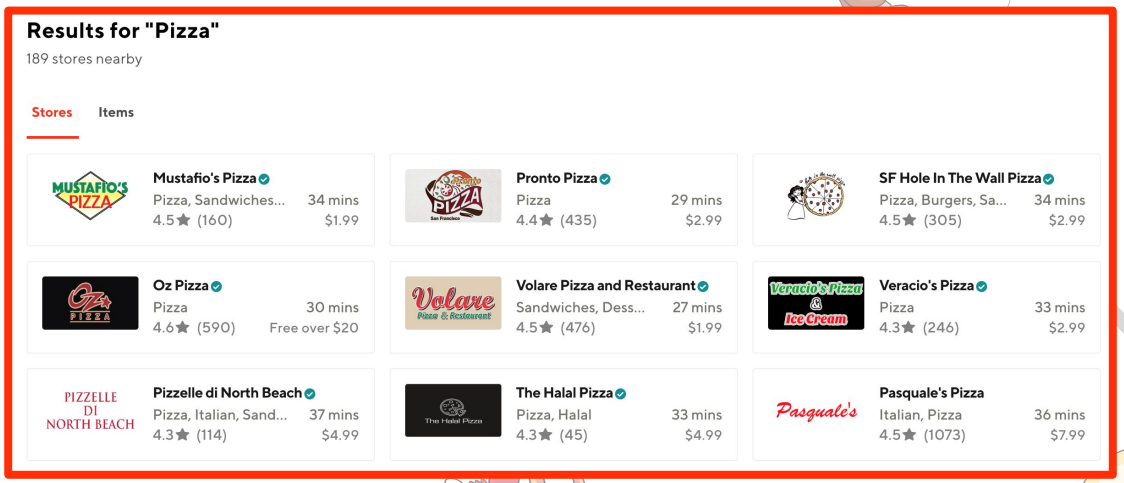
Demand Distribution



Consumers

ML at DoorDash

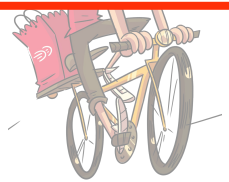
Merchants

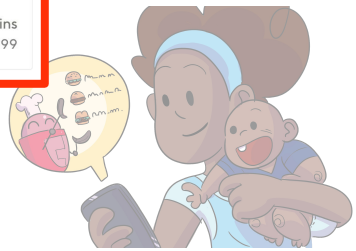


Recommendations/Personalization

Search Ranking

Demand Distribution



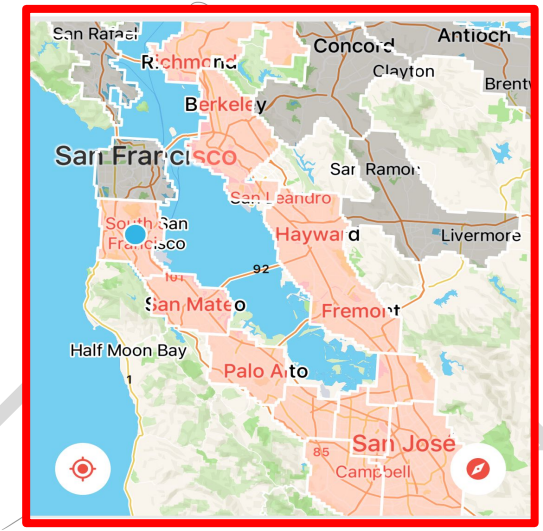


Dashers

Consumers

ML at DoorDash

Merchants

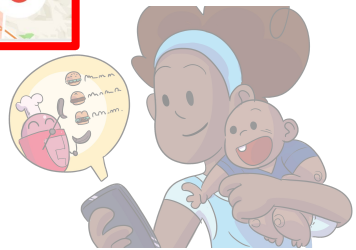


Dashers

Supply/Demand

Dynamic Pricing

Delivery Time



Consumers

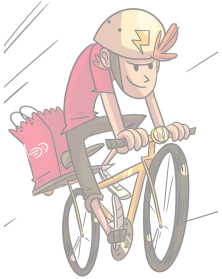
ML at DoorDash

Merchants

Assignments

Travel Estimates

Hotspots



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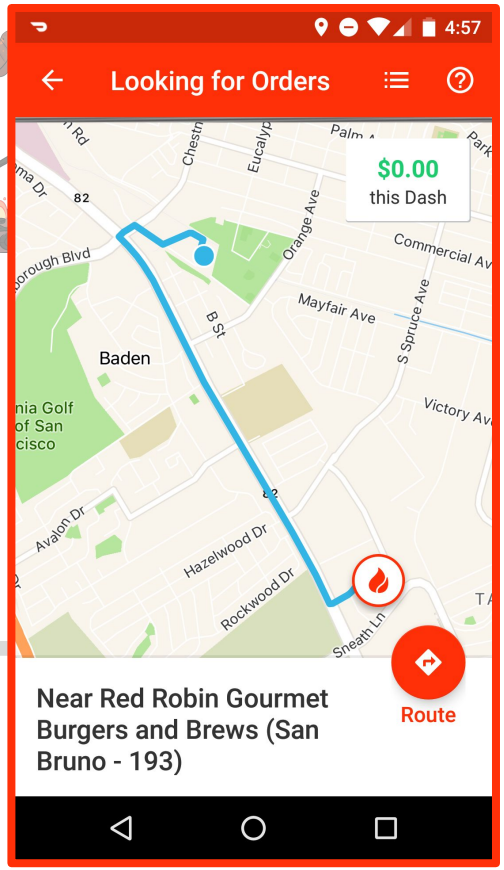


ML at DoorDash

Merchants

Food Prep Time
Selection Intelligence
Parking Prediction

Assignments
Travel Estimates
Hotspots

Recommendations/Personalization
Search Ranking
Demand Distribution

Pay Calculation
Supply Forecasting
Incentives

Dashers

Supply/Demand
Dynamic Pricing
Delivery Time

Consumers

Lifetime Value
Fraud
Promotions

Logistics Engine

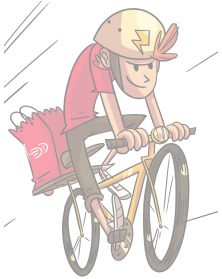
The AI system that powers deliveries on DoorDash

Logistics Engine

Merchants

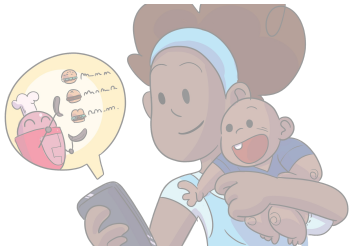
Assignments
Travel Estimates
Hotspots

Recommendations / Personalization
Search ranking
Demand distribution



Dashers

Supply/Demand
Delivery Time
Dynamic Pricing



Consumers

Logistics Engine

Merchants

Assignments
Travel Estimates
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Recommendations / Personalization
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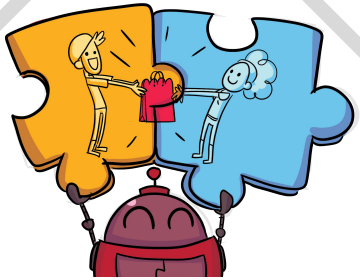
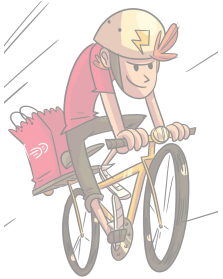
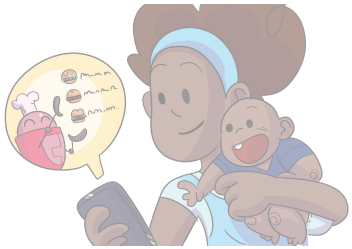
Demand distribution





Dashers

Supply/Demand
Delivery Time
Dynamic Pricing



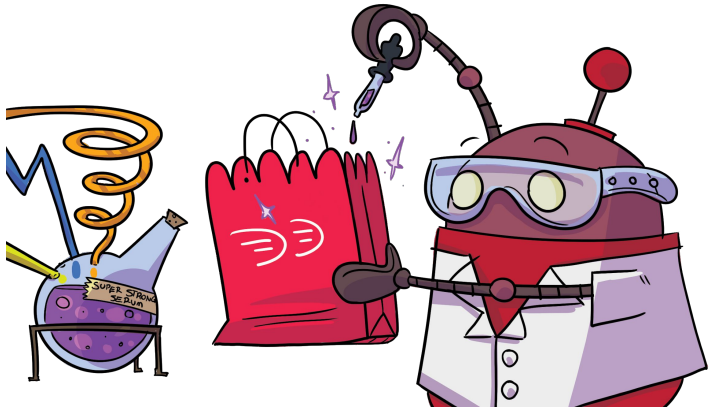
Consumers

Logistics Engine

Goal: **Fast and efficient** deliveries

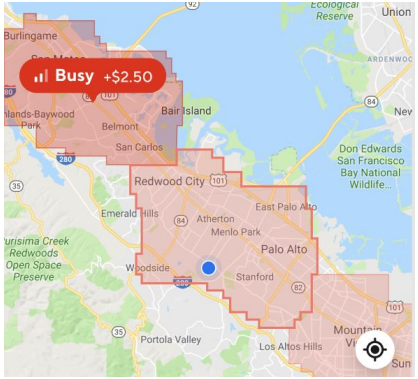
⏰ On-time delivery to consumer

⬆️ Increase marketplace efficiency

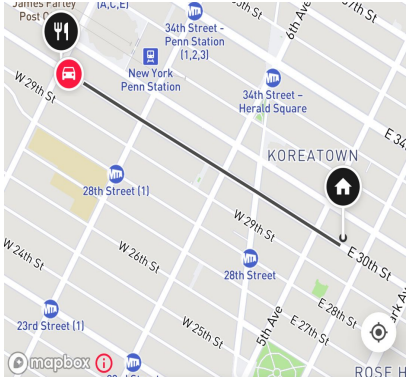


Logistics Engine

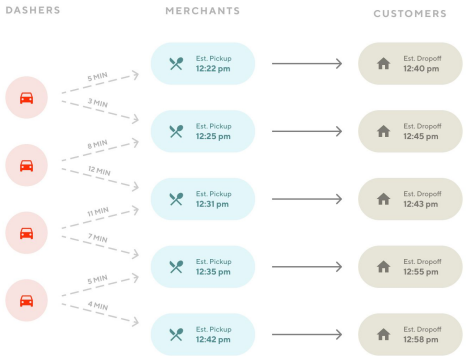
Balance Supply/Demand



Plan Routes

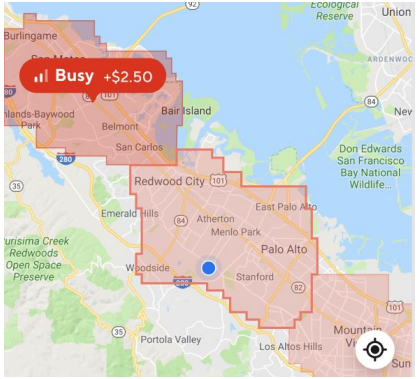


Dasher/Delivery Matching



Logistics Engine

Balance Supply/Demand



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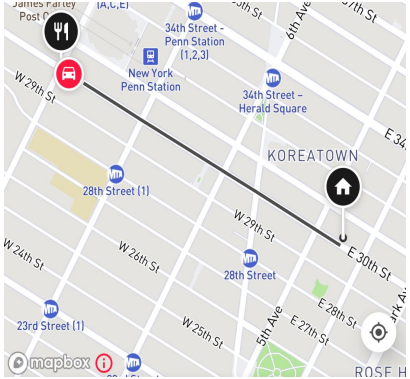

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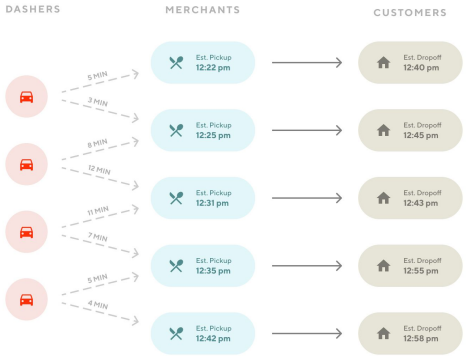


Supply Demand Balance

Undersupply

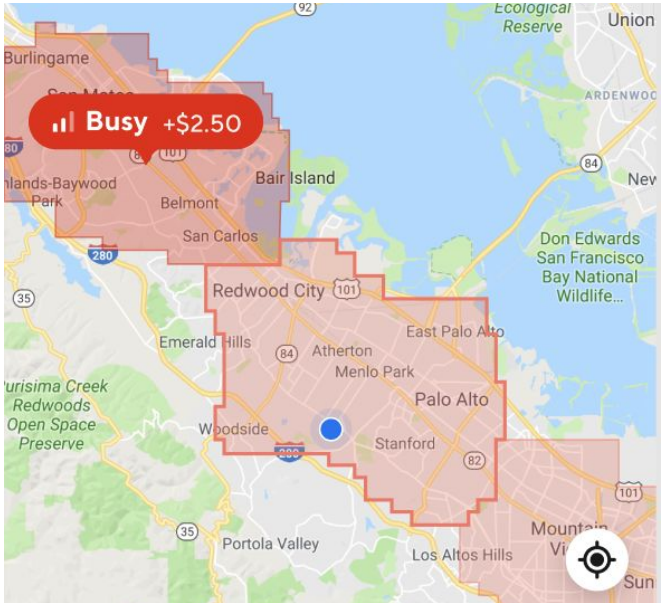
- More deliveries than Dashers

Dasher incentives

- Bonus $ per delivery

Upfront Dasher communications

- Dashers can plan ahead



Challenges

Complexity

Every region

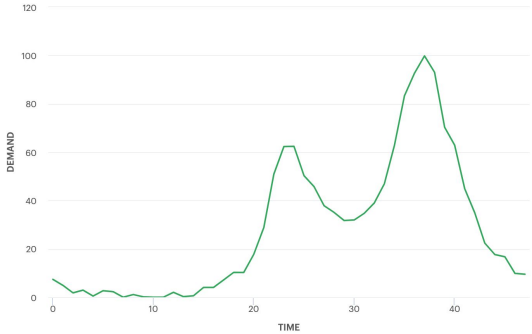
Every time of day

Region	$0	$1	$2	...
1				
2				
3				
...				

Forecasting

Future demand

Future supply



Variance

Weather, holidays

Promotions, events

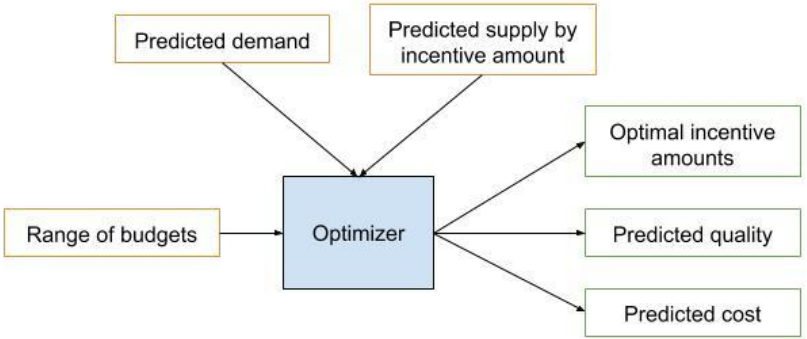
ML meets OR

Machine Learning (ML)

- Predict demand
- Predict supply by incentive amount

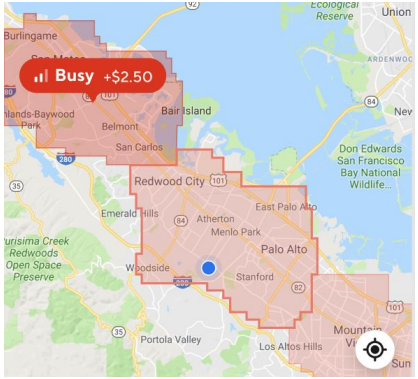
Operations Research (OR)

- Given predictions from ML and business goals
- Determine cost function
- Determine constraints
- Solve using mixed integer programing

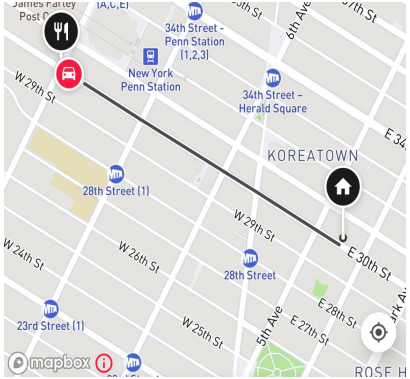


Logistics Engine

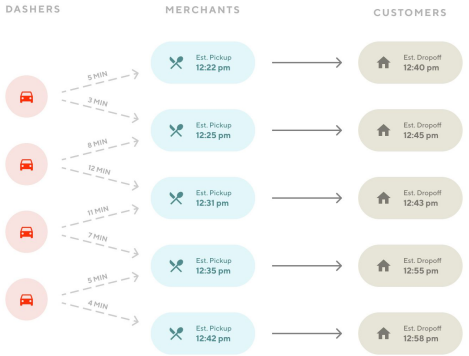
Balance Supply/Demand



Plan Routes

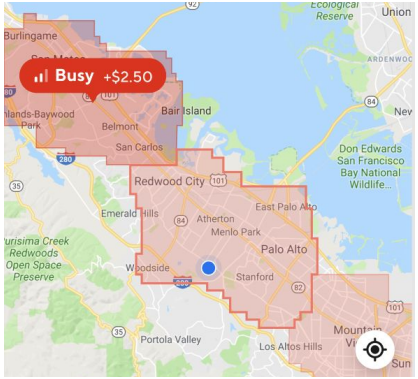


Dasher/Delivery Matching



Logistics Engine

Balance Supply/Demand



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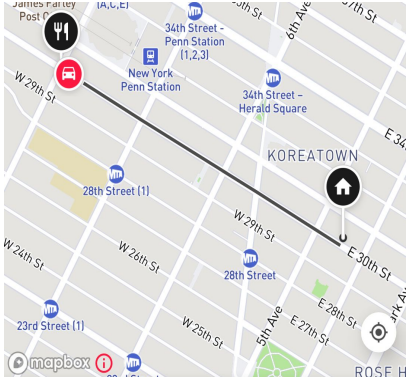

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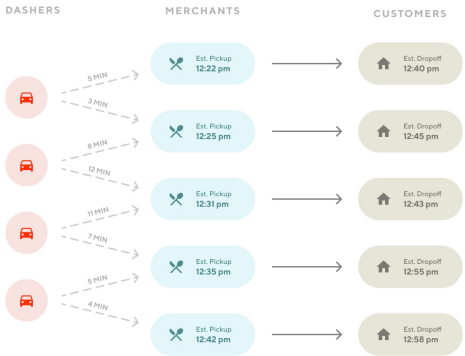


Optimal Matching

In plain English

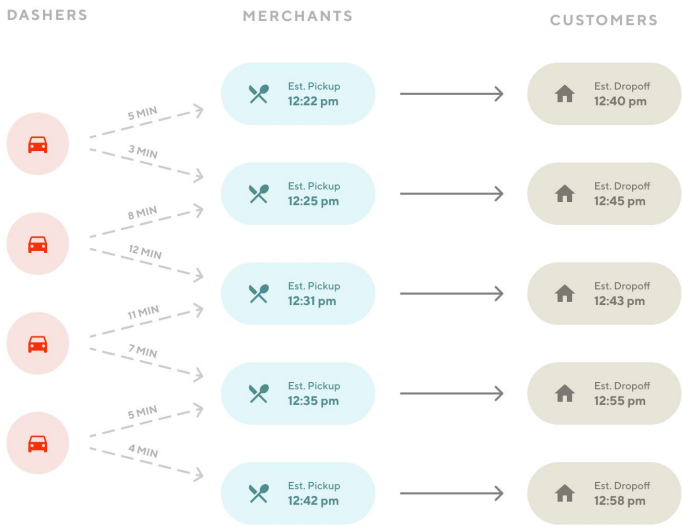
- Pick the best Dasher for each delivery

In canonical operations research

- Vehicle Routing Problem

DoorDash specific considerations

- Real-time fulfillment
- Optimize supply for future demand

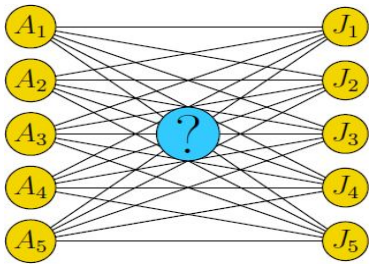


Challenges

Complexity

Combinatorics

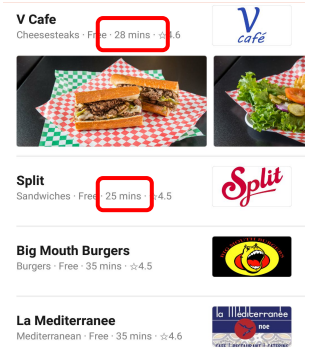
Delivery constraints



Time constraint

Asap delivery

Real-time demand



Variance

Merchant operations

Traffic, weather

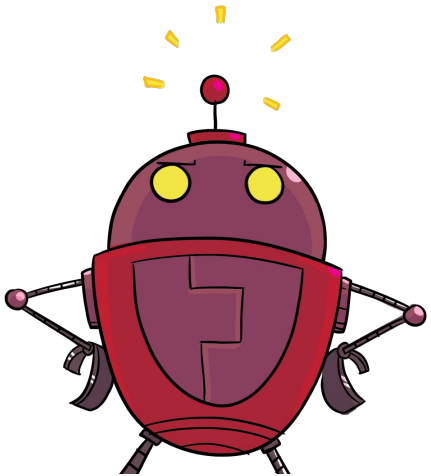
ML meets OR again!

Machine Learning (ML)

- Predict food prep times
- Predict travel times
- Predict delivery times

Operations Research (OR)

- Given predictions from ML, deliveries, Dashers, and business goals
- Determine cost function
- Determine constraints
- Solve using mixed integer programming



Optimal Matching: Summary

Data

Delivery data
- Location
- Type
- Size

Dasher data
- Location
- Capacity

Constraints
- Equipments

Predictions

Total delivery duration

Dasher travel duration

Food prep duration

Optimizations

Cost function

Constraints

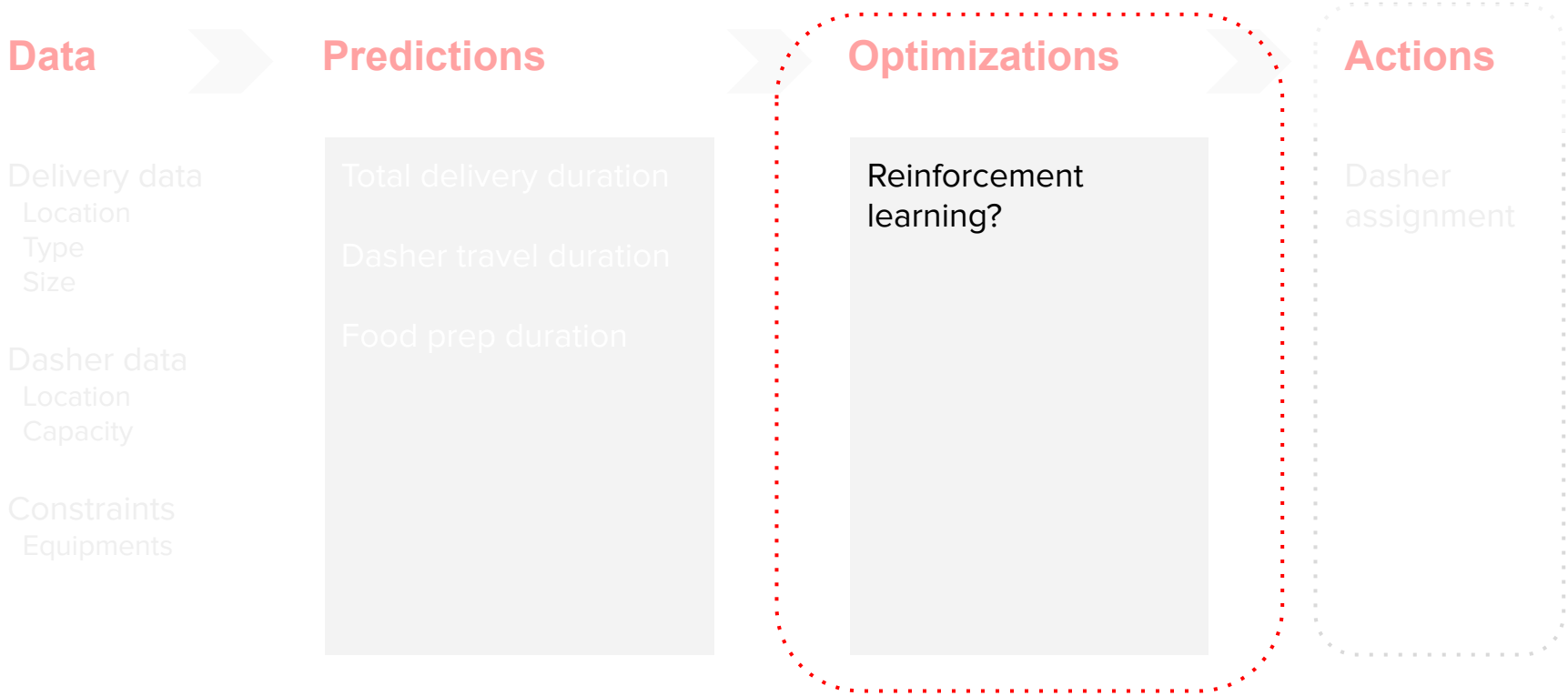
Mixed integer programming

Optimal matching

Actions

Dasher assignment

Self learning optimization?



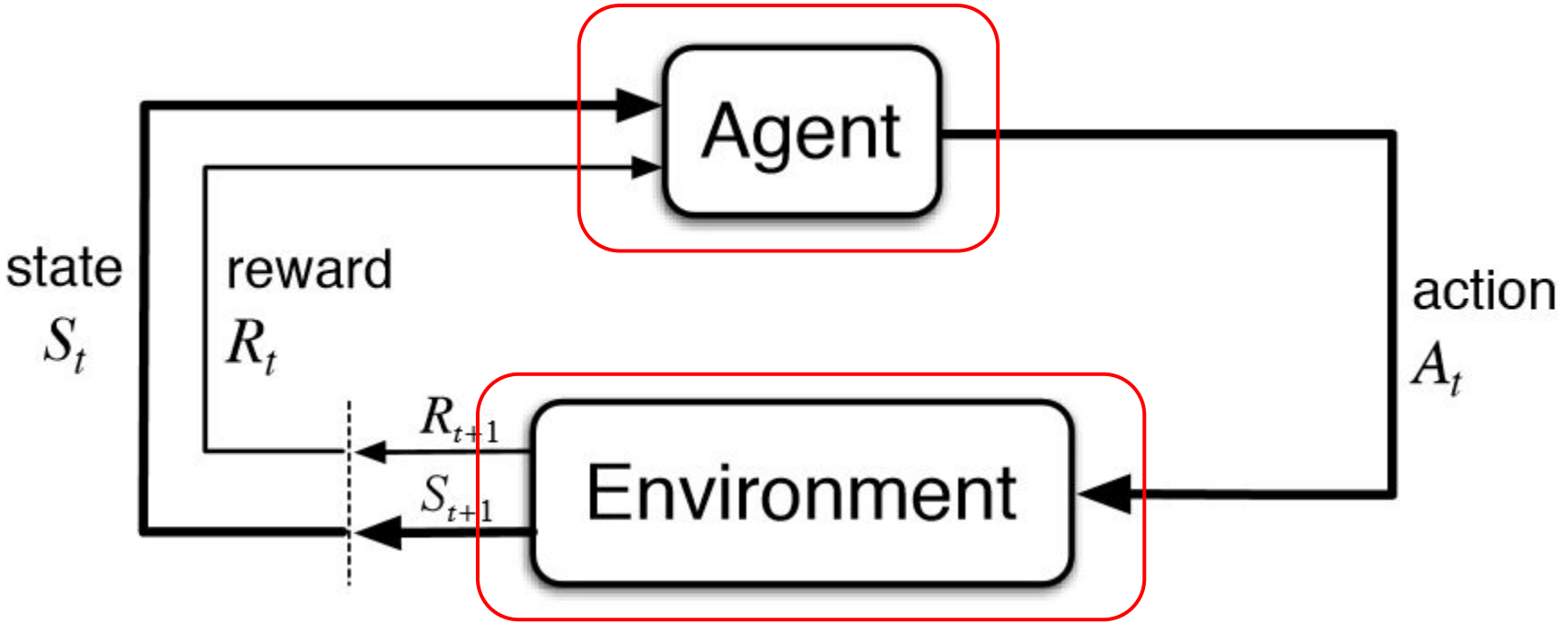
Reinforcement Learning for Logistics

Quick Context

- **Agent:** The entity that takes actions and tries to learn the best policy.

- **Environment:** The world that the agent interacts with.

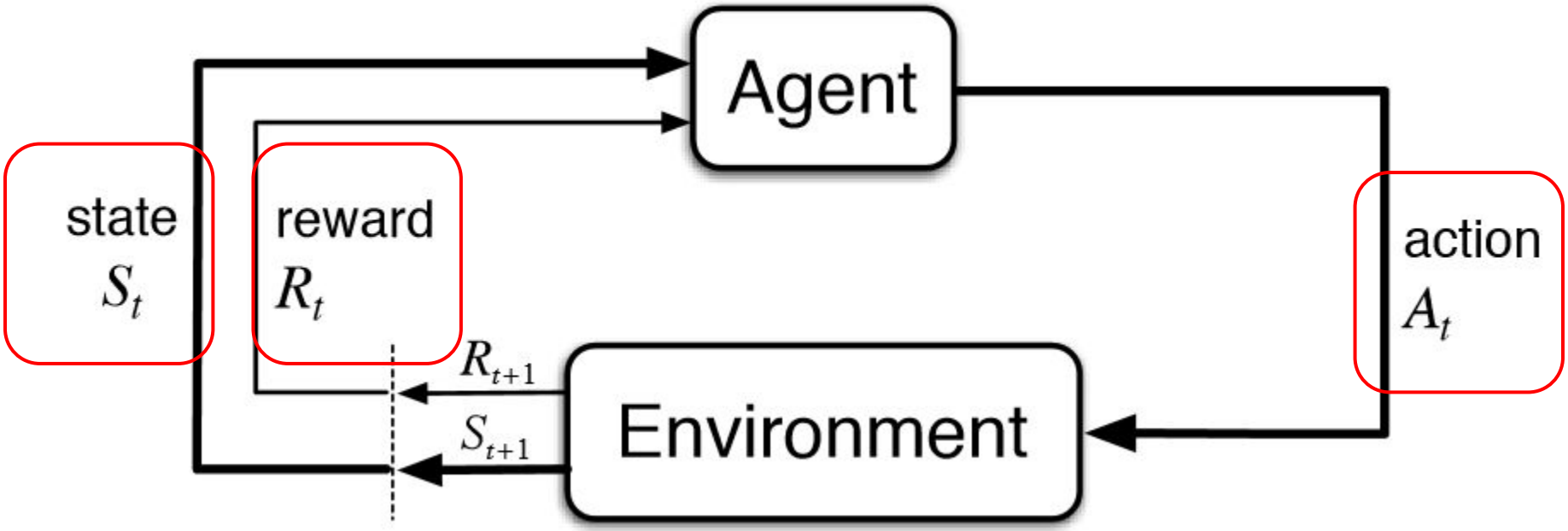
Quick Context



Quick Context

- **State:** The current status of the environment. It represents all the information needed to choose an action.
- **Action:** The chosen move out of the set of all possible moves at a state.
- **Reward:** The feedback as a result of the action. Note that rewards can be immediate or delayed.
- **Policy:** The strategy used to choose an action at each state.

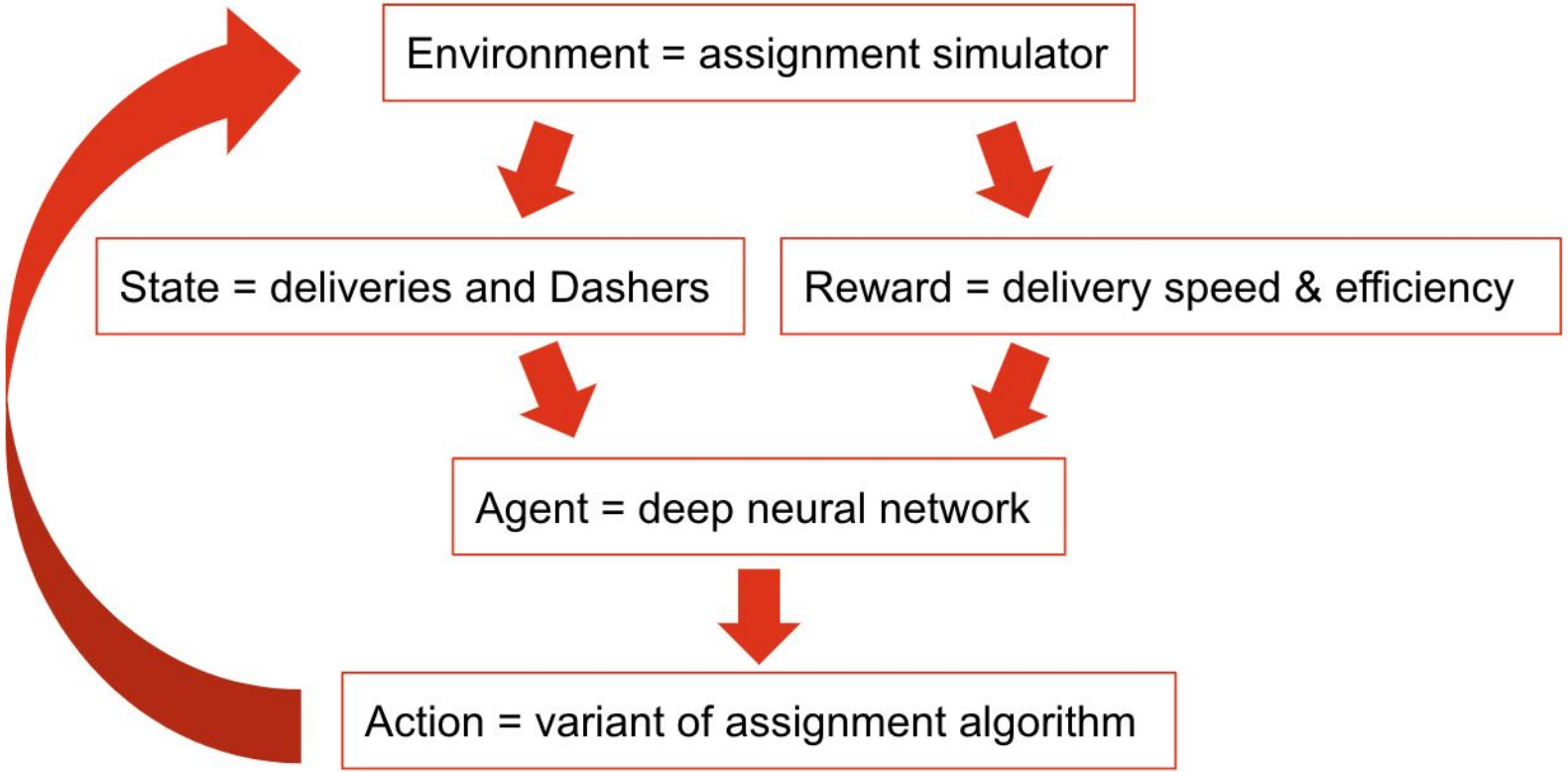
Quick Context



For DoorDash Logistics

- **State:** Deliveries and Dashers
- **Action:** Assignment algorithms
- **Reward:** Delivery speeds and Dasher efficiency
- **Agent:** Deep neural network
- **Environment:** Assignment simulator

For DoorDash Logistics



Results

- **6 second** improvement in delivery speed
- **1.5 second** improvement in Dasher efficiency

Impact of GPUs

Faster training speeds

- CPU ➜ GPU: **10x** improvement

- Single GPU ➜ Multiple GPUs: **3x** improvement

More Models
More Experiments

Merchants

Food Prep Time
Selection Intelligence
Parking Prediction

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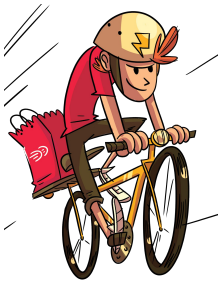
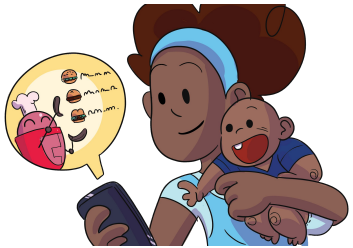
Incentives



Dashers

Supply/Demand
Dynamic Pricing
Delivery Time



Consumers

Lifetime Value
Fraud
Promotions

Takeaways

- Machine learning has **many use cases** at DoorDash
- Machine learning + operations research help **efficiently solve** supply demand balance and optimal matching problems
- **Reinforcement learning** fits well and has potential in logistics

Articles / Talks

- DoorDash Engineering Blog (doordash.engineering)
  - Optimal Matching
  - Reinforcement Learning
  - Personalization
  - Experimentation

- Other Talks
  - Software Engineering Daily
  - O'Reilly AI
  - QCon NY

We’re hiring!

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gary@doordash.com
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