Problem Statement
Amazon Transportation Services needs to anticipate vendor shipping demand to plan inbound transportation strategically.

Provided Data
One year (2020) of simulated inbound shipping data for a regional network in the Pacific Northwest.

Web App
The final product is a tool that allows users to fine tune forecasting and fleet size optimization with industry sensitive parameters.

Ship Modes
Shipments are classified into one of three shipmodes, based off pallet volume (53ft³):
- **Small Parcel (SP)**: Small handheld packages
- **Less Than Truckload (LTL)**: Multiple shipments in one truck
  - ½ Pallet < x < 10 Pallets
- **Full Truckload (FTL)**: One shipment per truck
  - > 10 Pallets

Solution

1. **Clustering**
   - Historic shipment locations were clustered by coordinates into regions using the k-means algorithm.
   - Clustering allows for allocation decisions to be made on a sub-regional basis, and mitigates variance in shipping demand.
   - The two optimization parameters that vary with cluster are distance to fulfillment centers and cost of trips.
   - Distances are measured from cluster centroid to fulfillment center centroid.

2. **Demand Forecasting**
   - Provided data was aggregated on a weekly basis, by cluster and ship mode.
   - Data was simulated for 2019 to allow Winter-Holt’s method to capture seasonality. Demand was forecasted for 2021, and data was simulated in 2021 to validate the forecast.

3. **Truckload Optimization**
   - **Inputs:**
     - Forecasted weekly truckloads for each ship mode in each cluster
     - Cost, distance, and truck availability
   - **Output:**
     - Quarterly truck fleet size.
     - Weekly allocation of fleet (storage, operating, or third party)
   - **Formulation:**
     - Minimize Total Cost
     - Total Cost = fleet storage cost (weekly) + acquisition cost + retirement cost + fleet operating cost (weekly) + outsourcing cost (weekly)
   - **Constraints:**
     - Available fleet hours meets forecasted demand
     - Fleet size for current period depends on the previous period
     - Positive integers for decision variables

Results

- **Comparison: Practical Worst Case Scenario vs Optimal Scenario**
  - **Practical:** Acquire the maximum total weekly fleet size at the beginning of the year, and maintain this fleet size throughout the entire year with no outsourcing or clustering.
  - **Optimal:** Dynamically adjust fleet size based on forecast and allow for outsourcing during demand spikes.

- **System Cost Savings With Simulated Data:** up to about 30%
  - This solution is scalable and can deliver substantial savings when informed with non-simulated data.
  - Simulated data includes 3,300 inbound shipments for PNW regional network in the US, while Amazon Freight reportedly shipped over 4 billion packages in the year 2020 for the United States.

- **Small Parcel**
  Amazon Freight outsources transport for SP shipments to 3P carriers

The team estimates a regional $289,390 in lost revenue in 2021 based off of forecasted demand.