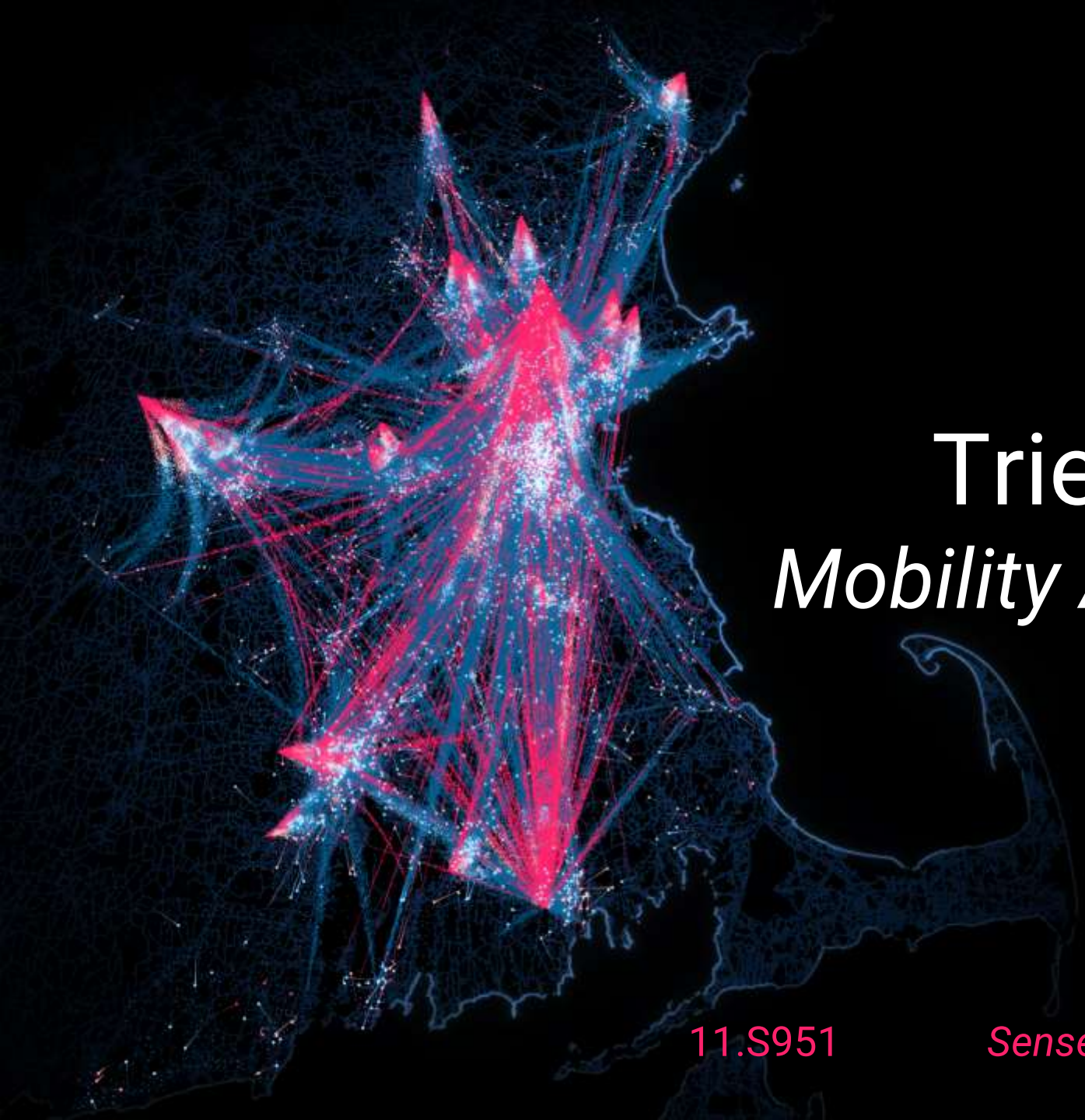


Week 7

Trieste and Mobility:
Mobility Asymmetry Matrices

Daniel Carmody, Sadegh (Sadi) Sabouri

IMPORTANT QUESTIONS TO ASK

- Where is public transit failing its riders?
- How many hours are wasted commuting when using modes of transport other than personal vehicles?
- How can city planners identify and prioritize the most important trips/routes to fix?

Image From Now

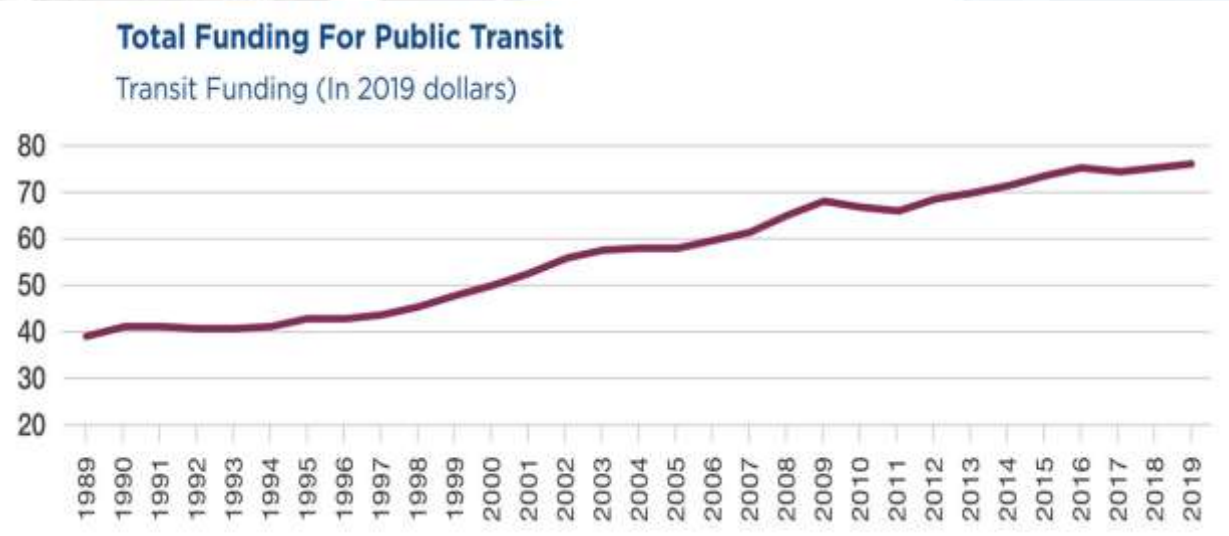
PUBLIC TRANSIT ROLE IN AN EFFICIENT TRANSPORTATION SYSTEM

- Traffic congestion
- Parking congestion
- Pollution emissions
- Excessive energy consumption
- Traffic accidents
- Rising fuel prices
- Rising roadway expansion costs
- Aging population
- Mobility for non-drivers

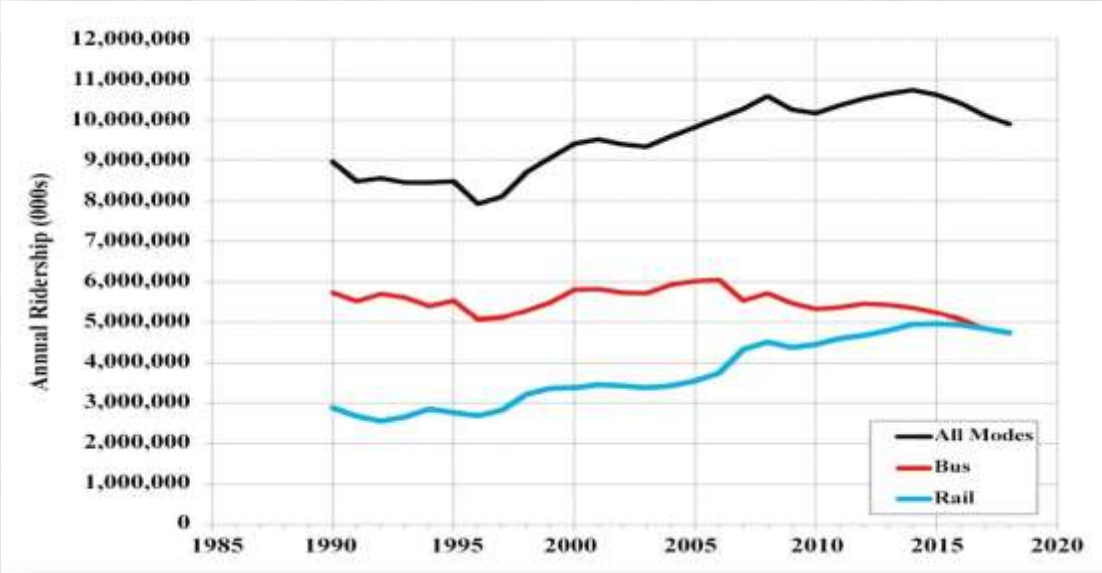
CITY	CONSTRUCTION COST PER SQUARE FOOT		CONSTRUCTION COST PER PARKING SPACE	
	UNDERGROUND $/SQ FT (1)	ABOVEGROUND $/SQ FT (2)	UNDERGROUND $/SPACE (3) = (1) x 330	ABOVEGROUND $/SPACE (4) = (2) x 330
Boston	$95	$75	$31,000	$25,000
Chicago	$110	$88	$36,000	$29,000
Denver	$78	$55	$26,000	$18,000
Honolulu	$145	$75	$48,000	$25,000
Las Vegas	$105	$68	$35,000	$22,000
Los Angeles	$108	$83	$35,000	$27,000
New York	$105	$85	$35,000	$28,000
Phoenix	$80	$53	$26,000	$17,000
Portland	$105	$78	$35,000	$26,000
San Francisco	$115	$88	$38,000	$29,000
Seattle	$105	$75	$35,000	$25,000
Washington, DC	$88	$68	$29,000	$22,000
Average	**$103**	**$74**	**$34,000**	**$24,000**

Source: Shoup, 2021. Quick review of his findings at this link

FALLING TRANSIT RIDERSHIP POSES AN ‘EMERGENCY’ FOR CITIES



Source: APTA Fact Book Analysis 2021



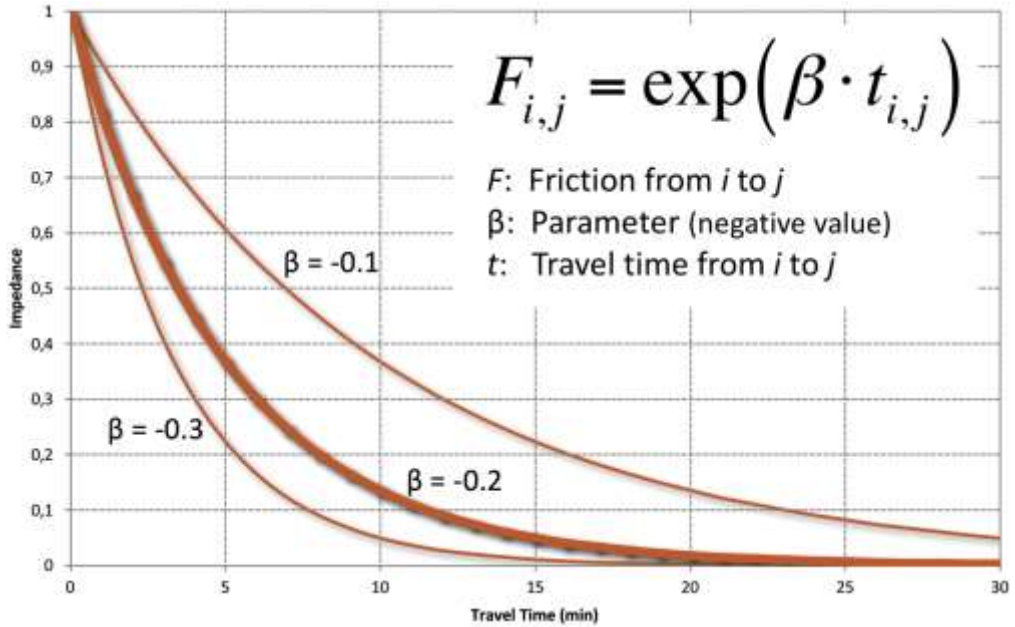
Source: National Transit Database

IMPORTANT TERMINOLOGIES

- Skim matrix (a.k.a network skimming):

  provides impedences between locations/zones/neighborhoods

Describes how difficult it is to get from one place to another place. Commonly calculated as travel time, distance, costs, or a combination thereof called generalized costs



Source: https://tfresource.org/topics/Impedance.html

IMPORTANT TERMINOLOGIES

- Highway Skims
  - Can be simple ‘generalized cost’ between each OD zone pair or complex taking into account single-occupancy vehicles, shared-ride 2,3+, time of the day (peak vs. non-peak hours)

- Transit Skims
  - Attributes to consider: travel time, route fare, schedule, headway, speed, etc.

IMPORTANT TERMINOLOGIES

- Traffic Analysis Zone (TAZ)
  - A special area delineated by state and/or local transportation officials for tabulating traffic-related data.
  - These TAZs (which also stands for travel, transportation, or traffic analysis zones) may have several uses, depending on how a travel model is structured, including: storing information about the people and places in each zone, serving as origins and destinations of trips, and calculating travel times between (and within) zones.

Source: tfresource.com

IMPORTANT TERMINOLOGIES

❖ Travel Demand Modeling/Forecasting

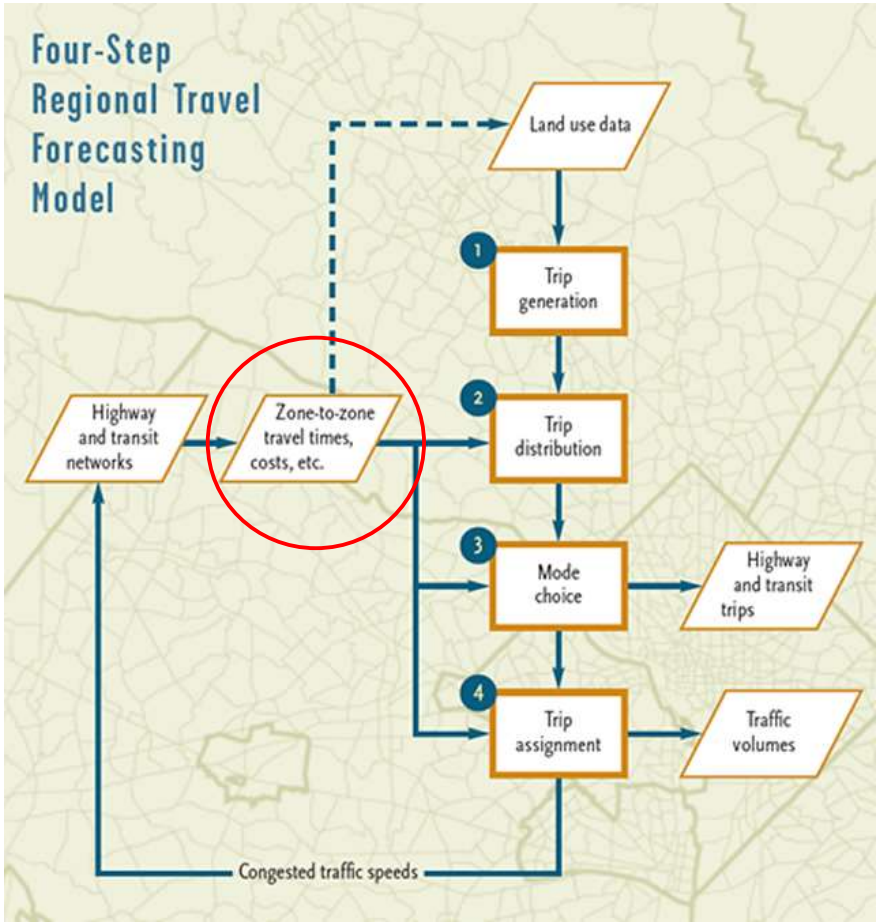
- Travel Demand Forecasting is the process used to predict travel behavior and resulting demand for a specific future time frame, based on assumptions dealing with landuse, the number and character of tripmakers, and the nature of the transportation system.

  Source: CDOT

  - How many trips will be made in the future?
  - Which transportation systems will become congested in the future?
  - How much ridership will a new transportation service attract?

IMPORTANT TERMINOLOGIES

- Travel Demand Modeling/Forecasting
  - Four-Step Travel Model
  - Activity-Based Model
- Main Sources of Data
  - Household Travel Survey
  - Transportation Metrics Providers



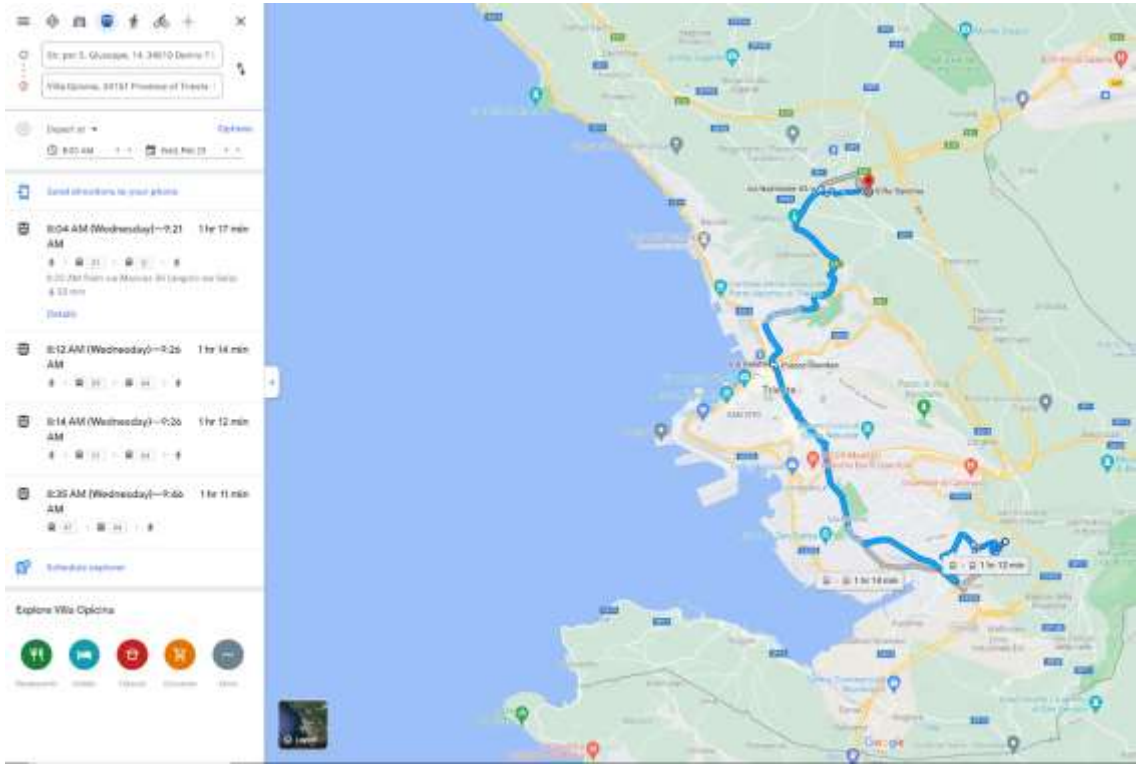
Source: MWCoG

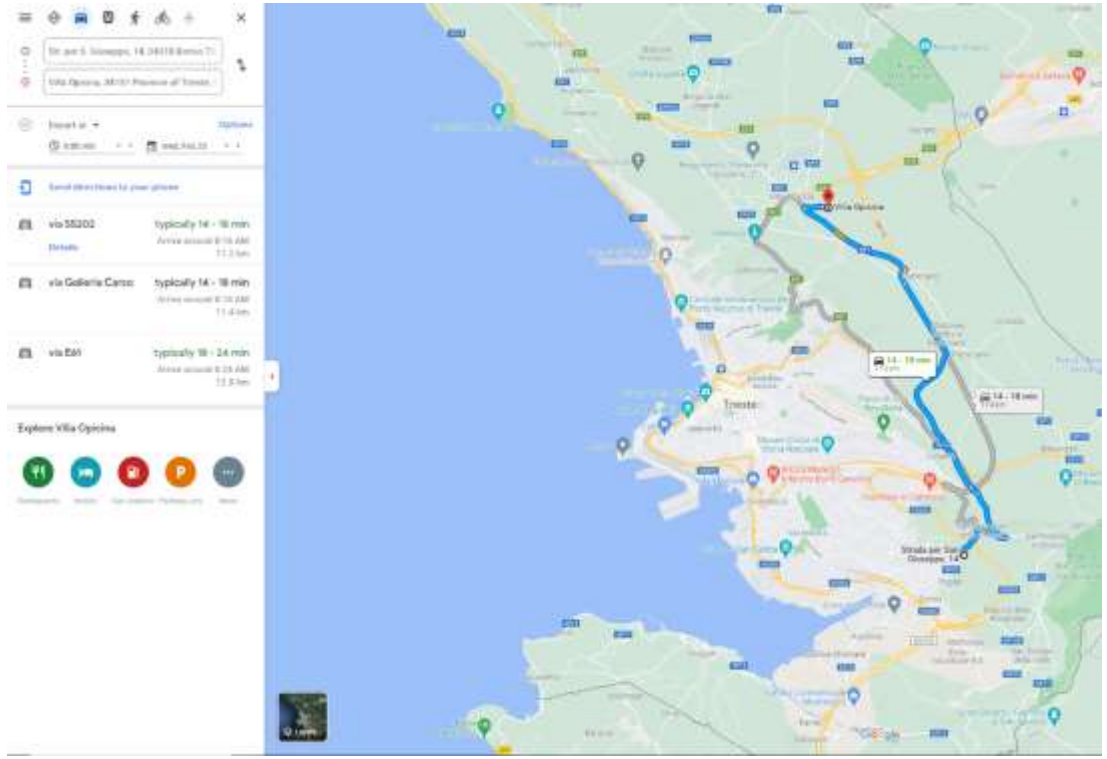
TRANSPORTATION METRICS SERVICE

STREETLIGHT DATA
Big Data for Mobility

IMPORTANT TERMINOLOGIES

- Mode Imbalance
  - The difference in travel time when using two different modes of transport (for example car vs. public transit).

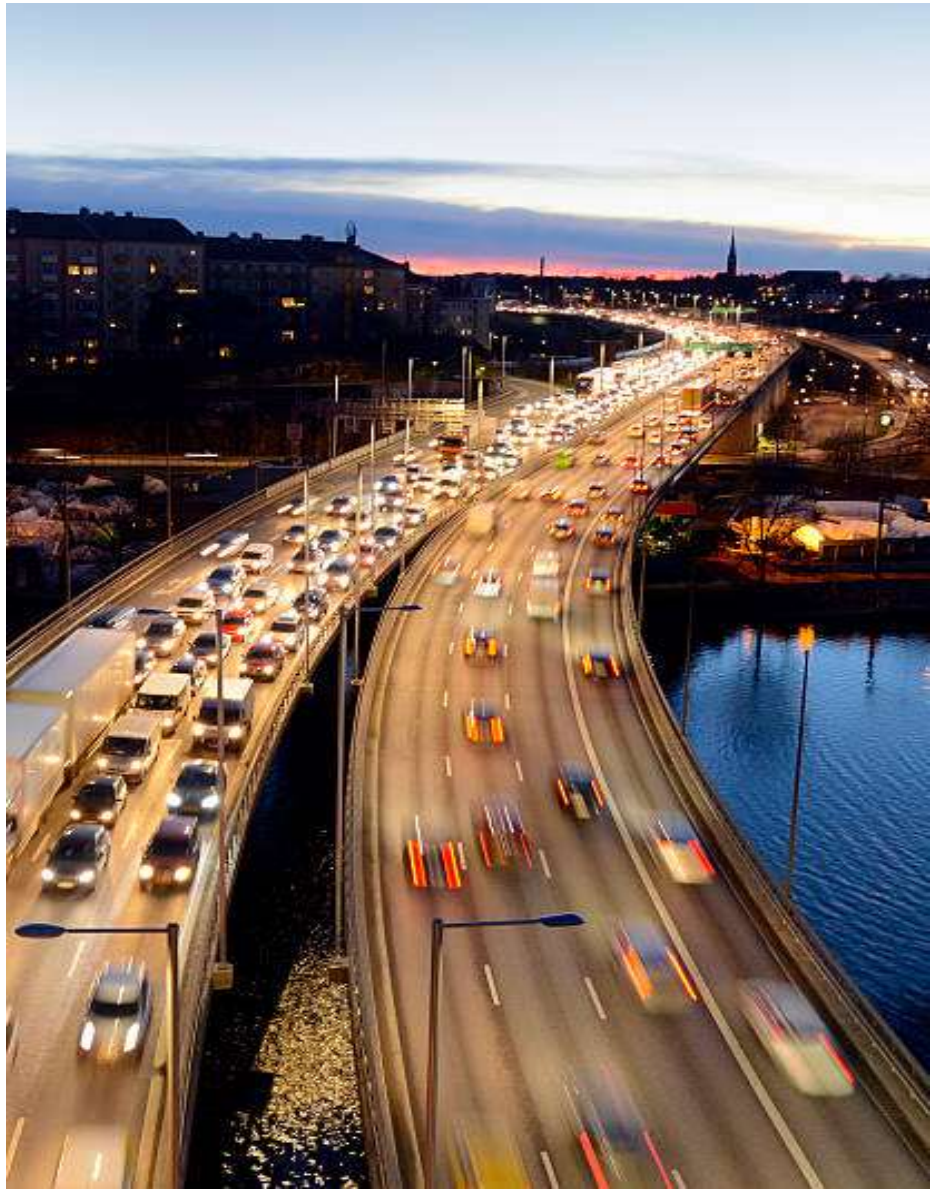




PROBLEM CAUSED BY MODE IMBALANCE

Those who can afford a car will be more likely to buy and use one. This leads to problems with:

- Sustainability
- Urban sprawl
- Higher segregation
- Traffic congestion
- Parking demand, …



PROBLEM CAUSED BY MODE IMBALANCE

Those who cannot afford a car will be limited in their choice of:

- Home location
- Jobs/hobbies
- Interpersonal relationships

DIAGNOSING MODE IMBALANCE

Mode Imbalance

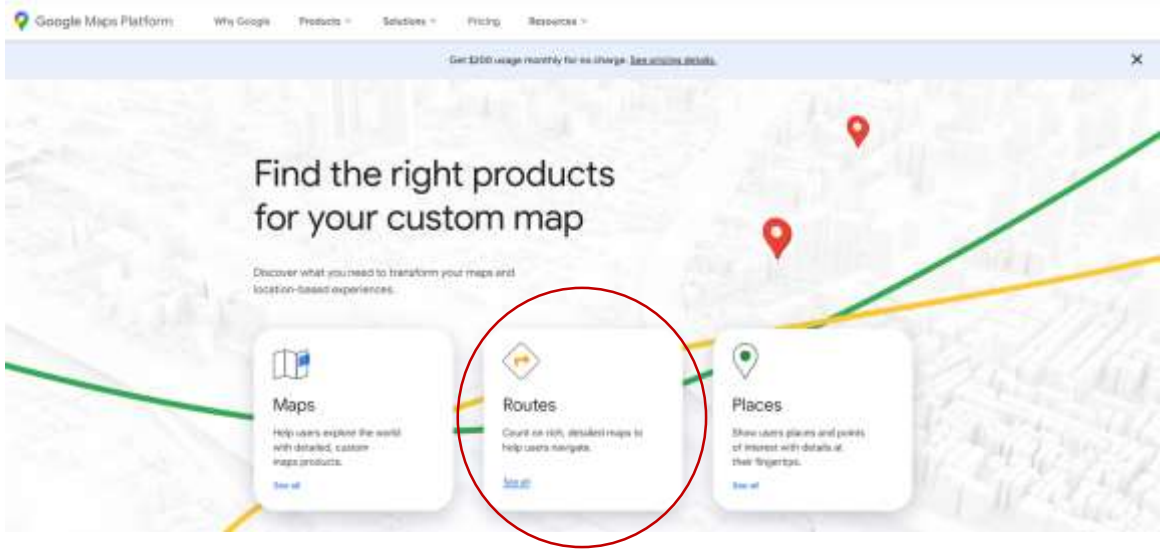
Steps to Get OD Matrices and Analyze Mode Imbalance

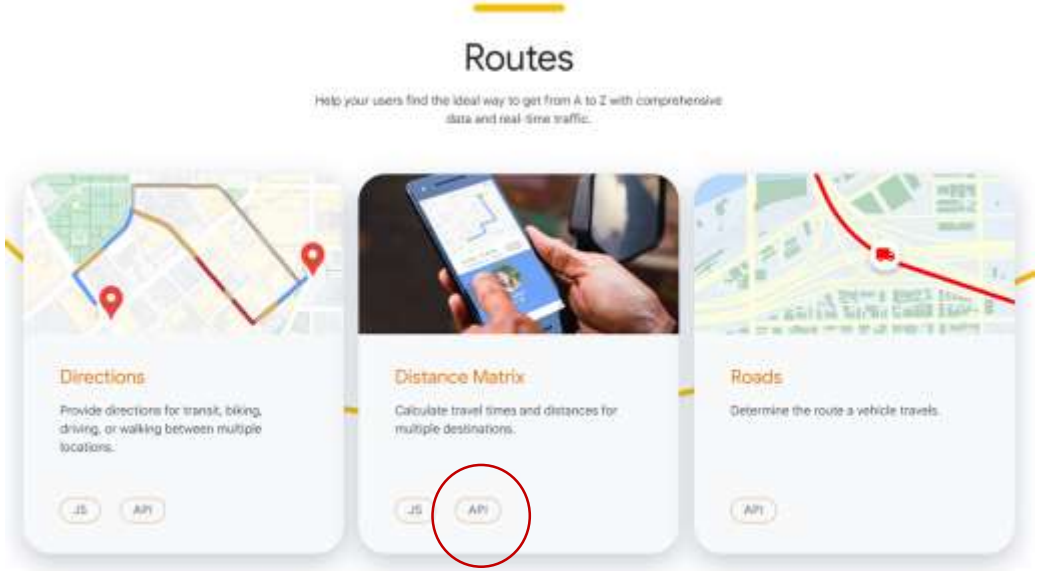
Overview

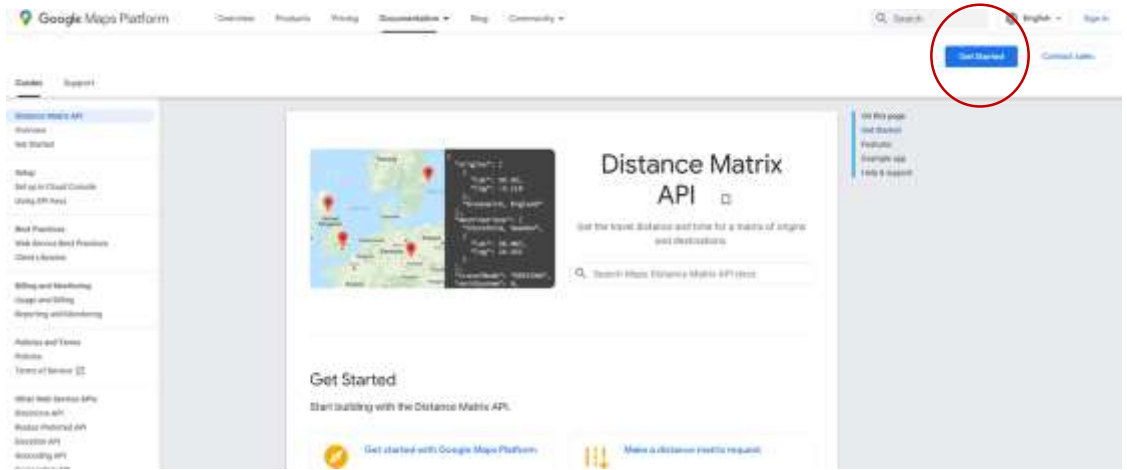
- How to get Google API key
- How to get OD matrices for transit and drive from Google Distance Matrix API
- How to create matrices
- Analyze asymmetry matrices and mode imbalance
- Compare travel time with demand data
- Use graph convolutional neural networks to understand how the travel mode imbalance for a given a trip is influenced by other nearby trips.

Getting Google API Key

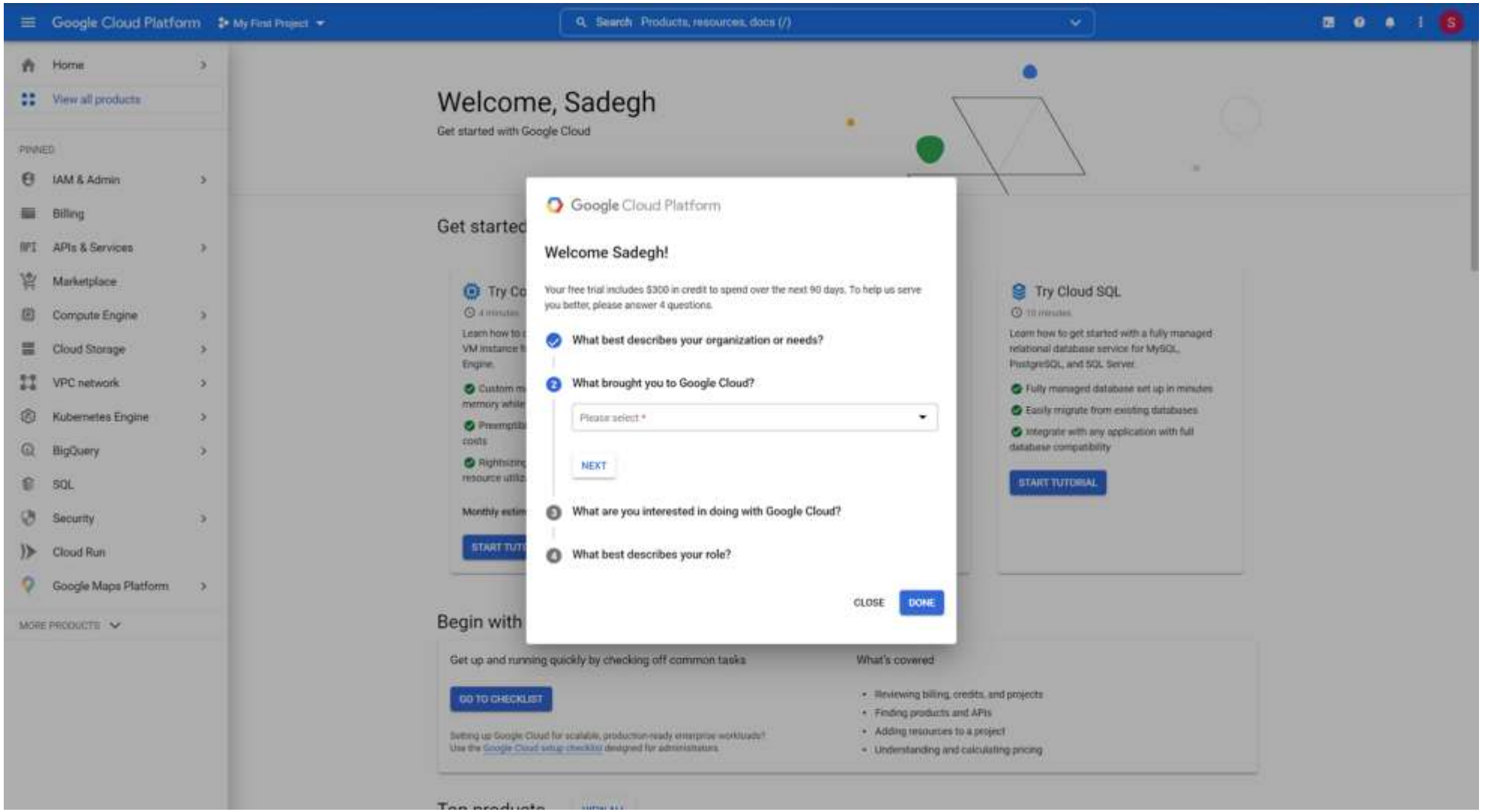
https://mapsplatform.google.com/maps-products/



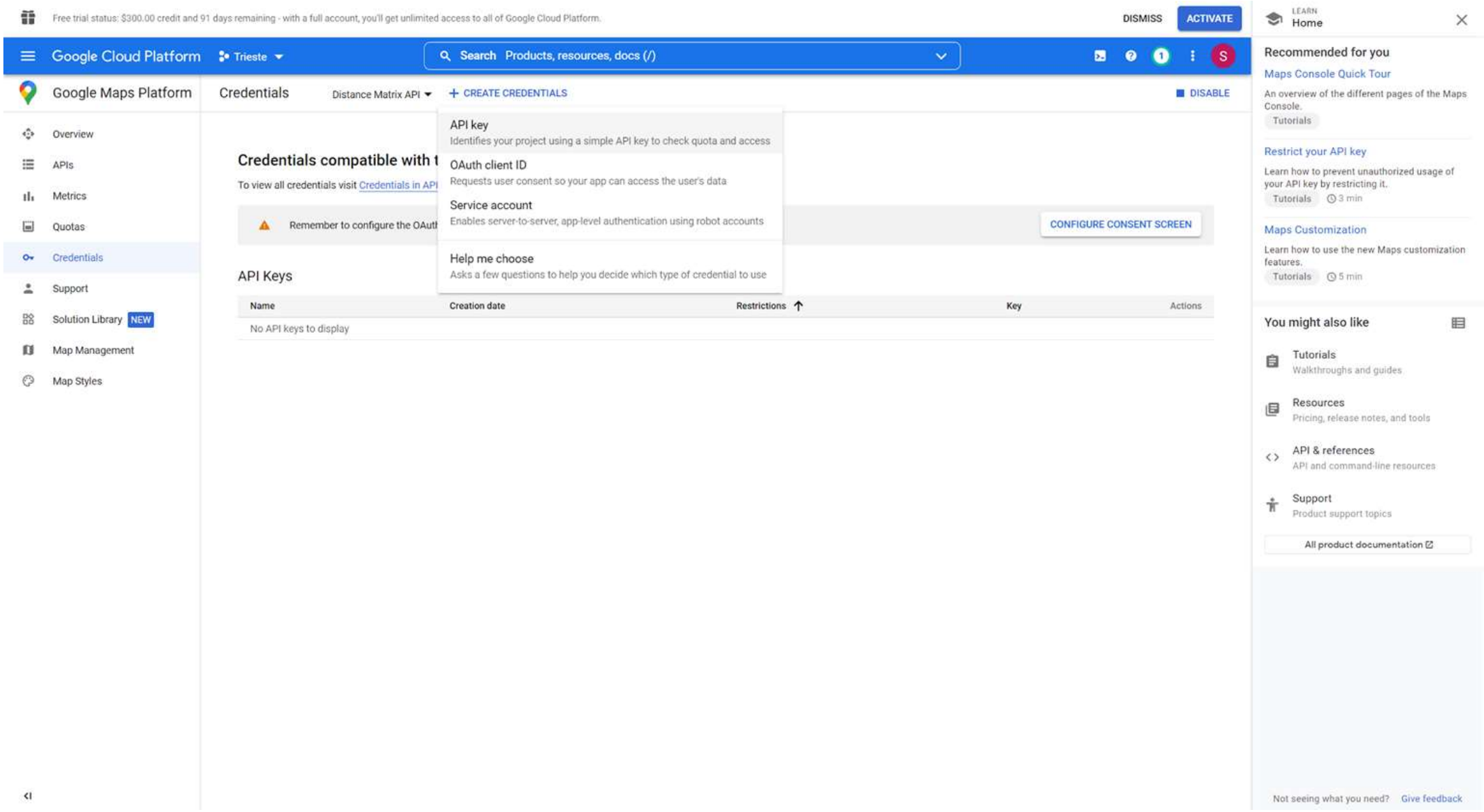




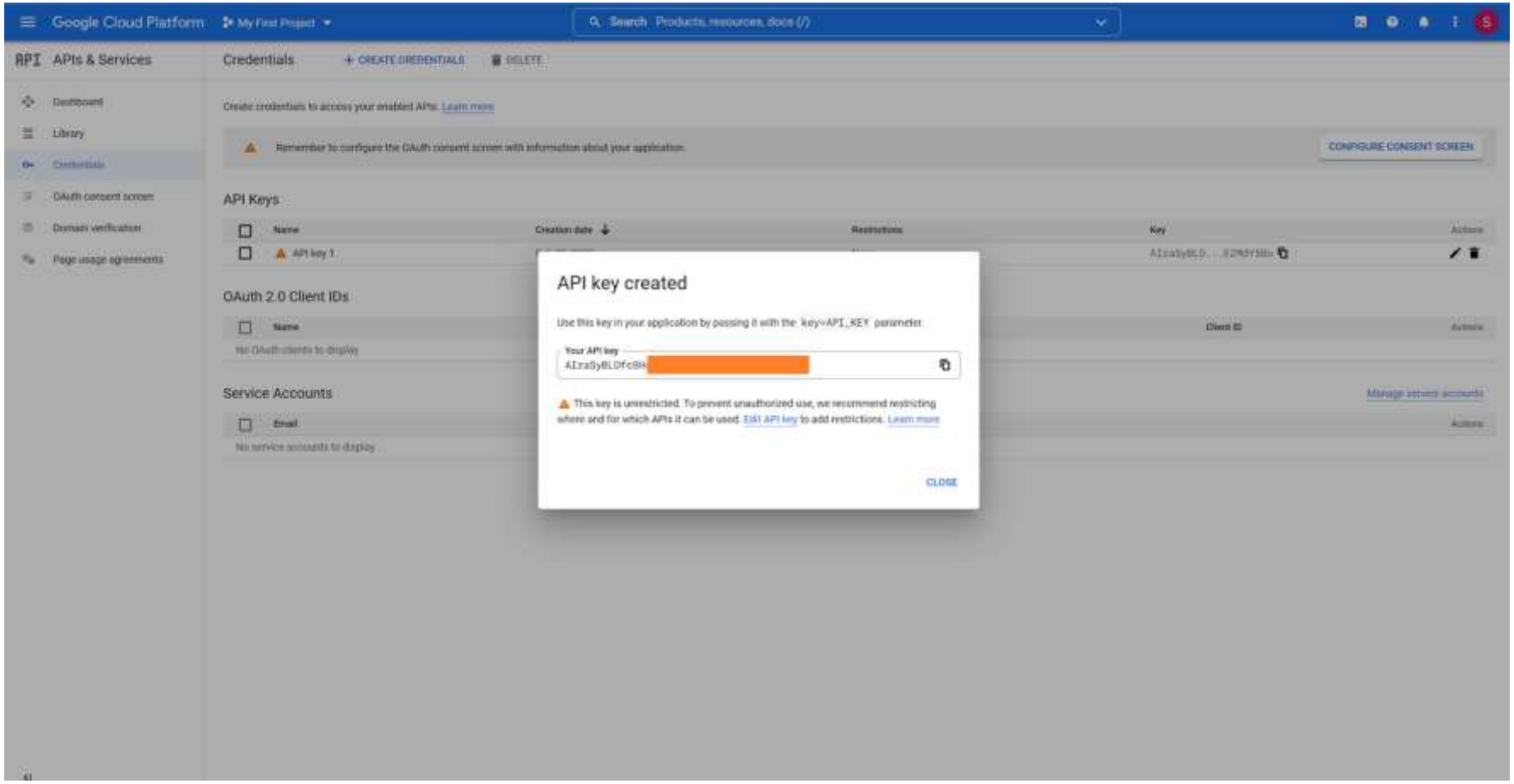
After Finishing with Payment Info Page



Creating a Project and API Key



Copying and Storing the API Key

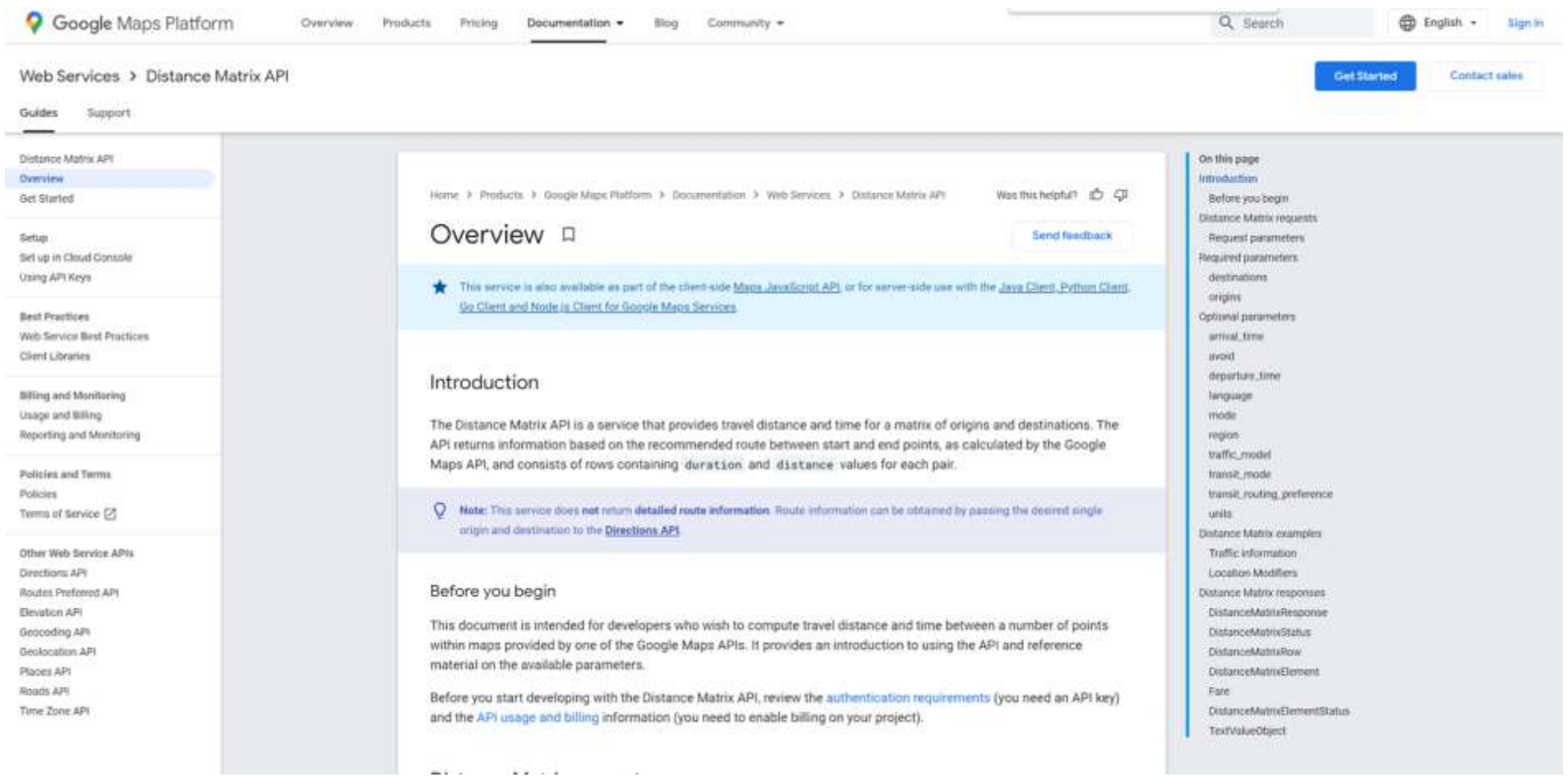


Distance Matrix API

Important Points to Know When Using Distance Matrix API

OVERVIEW OF HOW TO WORK WITH DISTANCE MATRIX API

https://developers.google.com/maps/documentation/distance-matrix/overview



FORMAT OF REQUESTING DATA

https://developers.google.com/maps/documentation/distance-matrix/overview

Distance Matrix examples

The following example uses latitude/longitude coordinates to specify the destination coordinates:

URL cURL JavaScript **Python** Java Ruby Go Postman

```
import requests

url = "https://maps.googleapis.com/maps/api/distancematrix/json?origins=40.6655101%2C-73.8918896999

payload={}
headers = {}

response = requests.request("GET", url, headers=headers, data=payload)

print(response.text)
```

Note: Snippets generated from OpenAPI specification on GitHub.

FORMAT OF REQUESTING DATA

https://developers.google.com/maps/documentation/distance-matrix/overview

```
import requests

url = "https://maps.googleapis.com/maps/api/distancematrix/json?origins=40.6655101%2C-73.89188969999998
&destinations=40.659569%2C-73.933783%7C40.729029%2C-73.851524%7C40.6860072%2C-
73.6334271%7C40.598566%2C-73.7527626&key=YOUR_API_KEY"

payload={}
headers = {}

response = requests.request("GET", url, headers=headers, data=payload)

print(response.text)
```

%2C means , (comma)
%7C means | (pipe character)

Learn more about URL Encoding:
https://www.w3schools.com/tags/ref_urlencode.asp

IMPORTANT CONSTRAINTS

1. Length of URL (see this link)

> **Note**: URLs must be properly encoded to be valid and are limited to 8192 characters for all web services. Be aware of this limit when constructing your URLs. Note that different browsers, proxies, and servers may have different URL character limits as well.

2. Time (same link)

Time should be in “Unix epoch” (or “seconds since epoch”), not human-readable date.

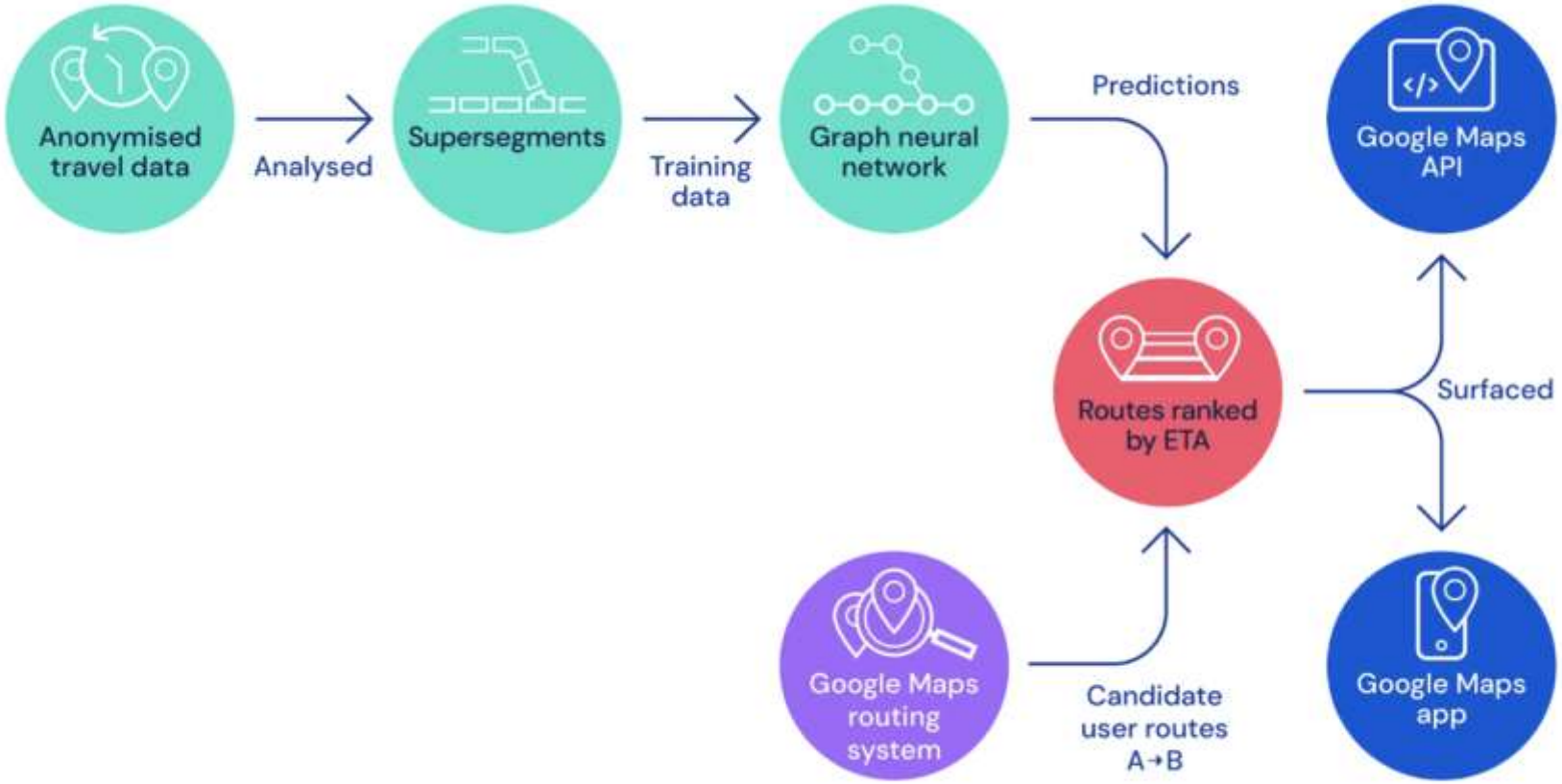
3. Number of Elements Per Request (see this link)

Maximum 100 elements per server-/client-side request

Maximum of 25 origins or 25 destinations per request

Graph neural networks

Estimated time of arrival prediction (Deepmind)



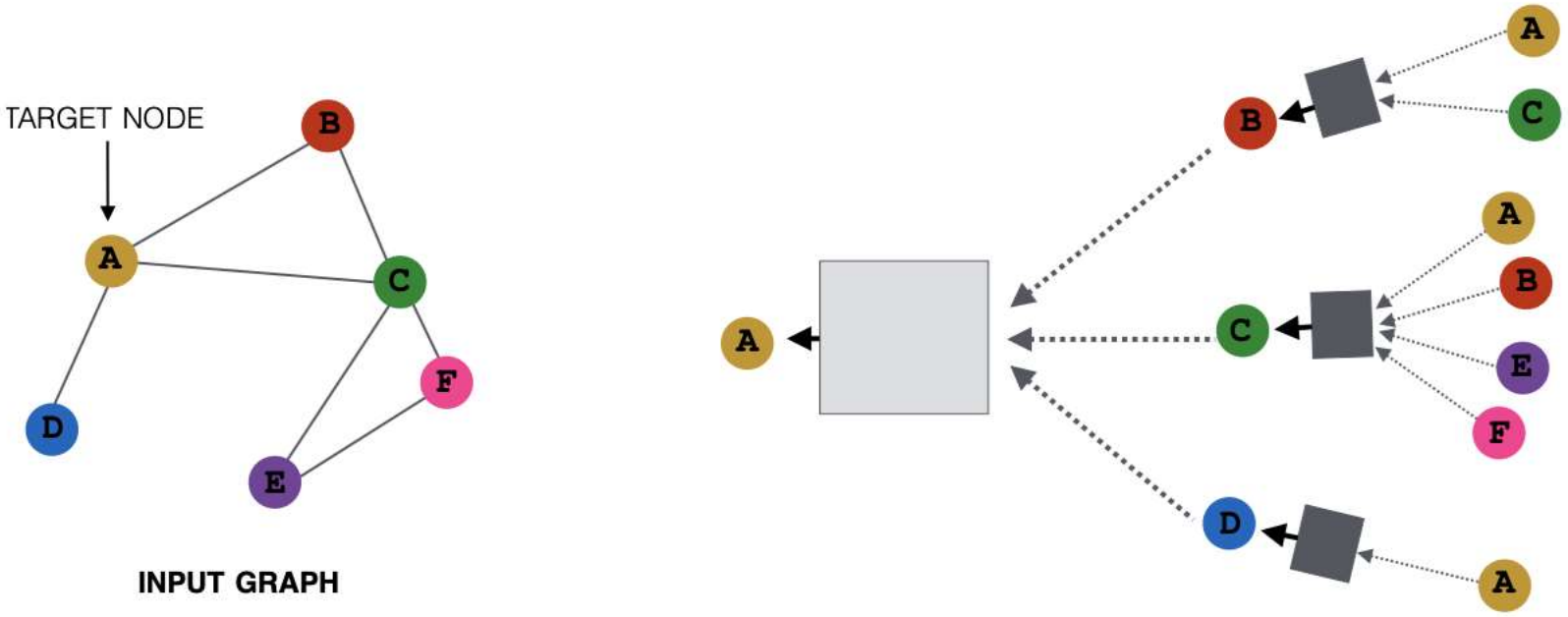
The model architecture for determining optimal routes and their travel time.

Estimated time of arrival prediction

https://deepmind.com/blog/article/traffic-prediction-with-advanced-graph-neural-networks

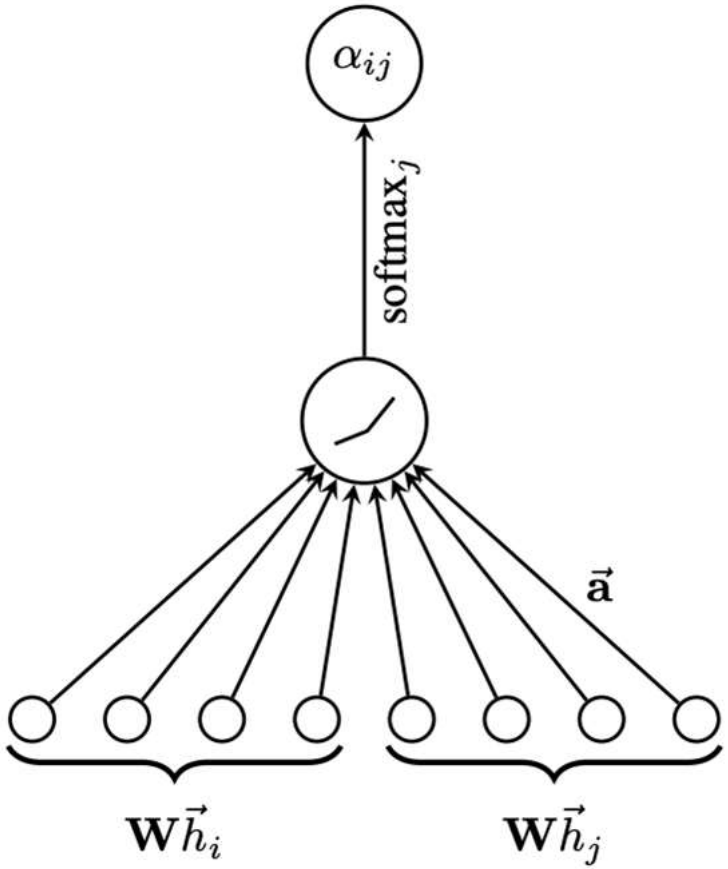
GNNs: The basics

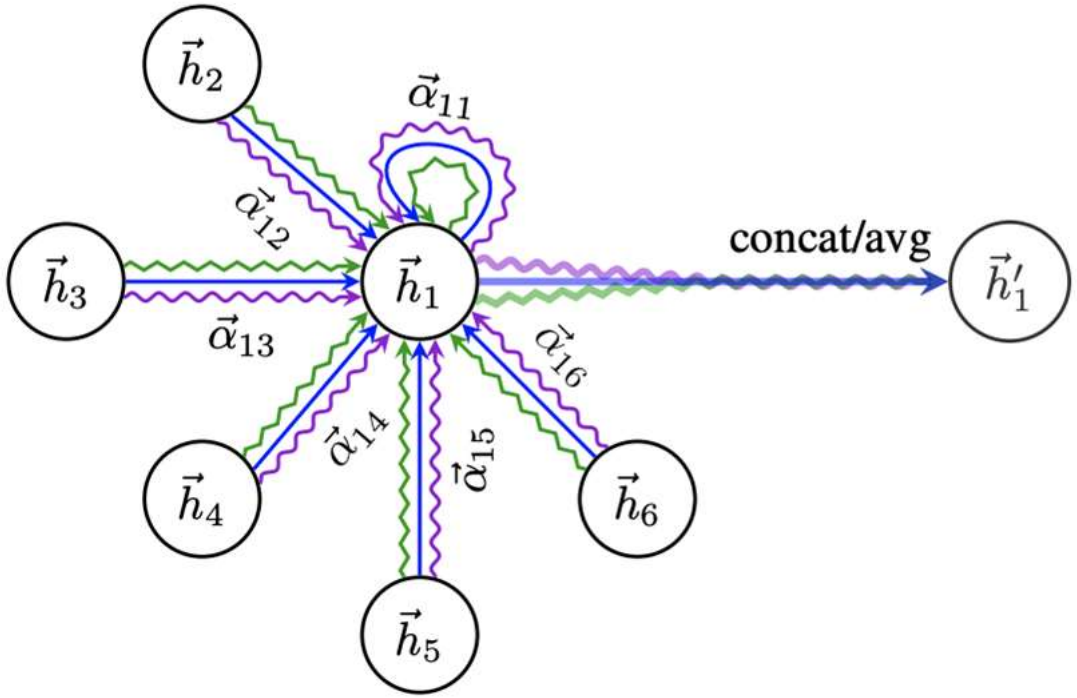
https://snap-stanford.github.io/cs224w-notes/machine-learning-with-networks/graph-neural-networks



Graph attention networks

https://arxiv.org/pdf/1710.10903.pdf

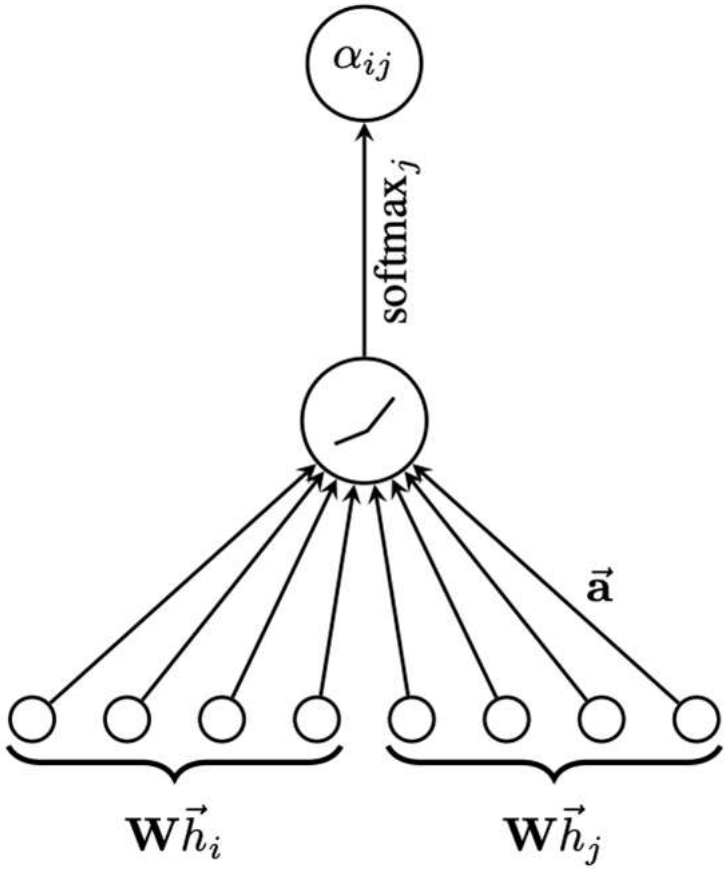


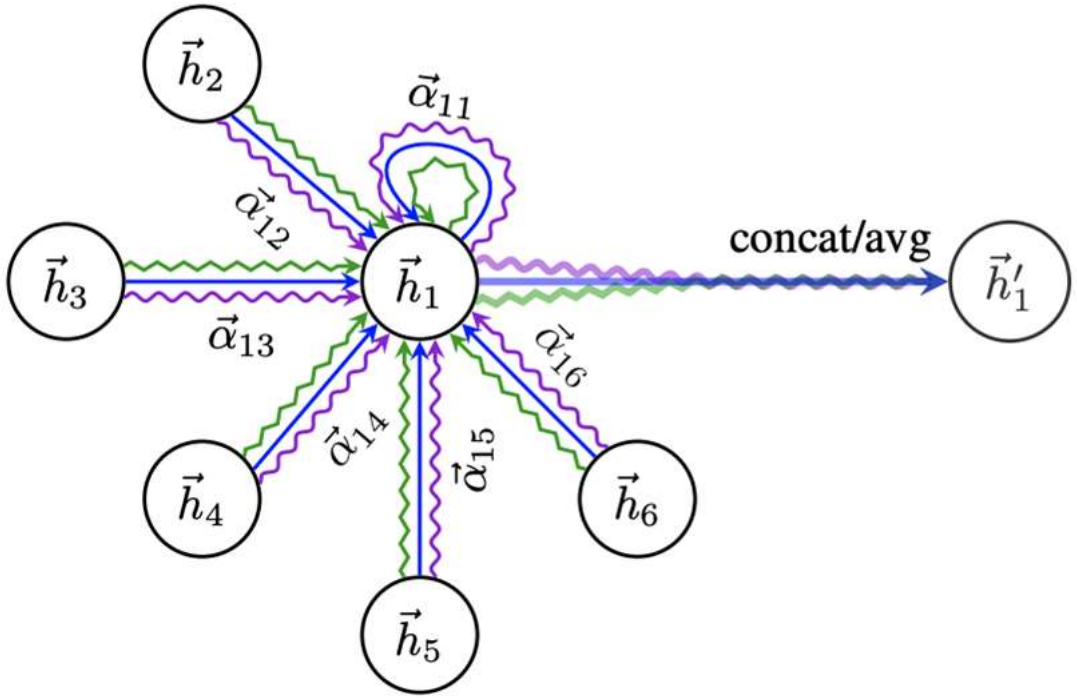


Graph attention networks as diffusion

https://arxiv.org/pdf/1710.10903.pdf

$$\frac{\partial}{\partial t}\mathbf{x}(t) = (\mathbf{A}(\mathbf{x}(t)) - \mathbf{I})\mathbf{x}(t) = \bar{\mathbf{A}}(\mathbf{x}(t))\mathbf{x}(t)$$





Estimating key links without demand data

https://arxiv.org/pdf/1710.10903.pdf

$$\frac{\partial}{\partial t}\mathbf{x}(t) = (\mathbf{A}(\mathbf{x}(t)) - \mathbf{I})\mathbf{x}(t) = \bar{\mathbf{A}}(\mathbf{x}(t))\mathbf{x}(t)$$