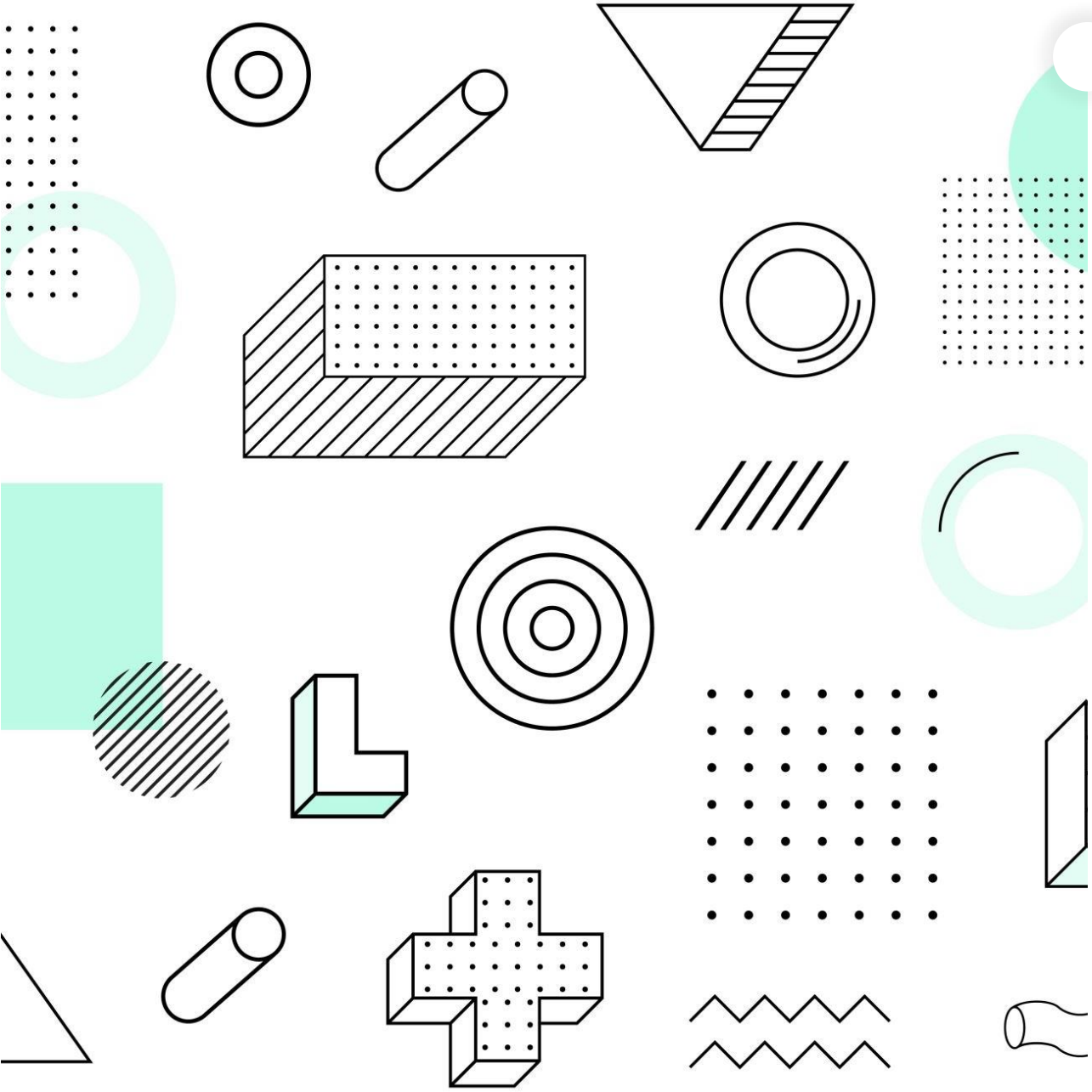


Performance evaluation and applications

Course @ Politecnico di Milano

Project A done by Davide Giannubilo

a.y. 2023 - 2024

The problem

- An electric car has to travel a distance which is slightly longer than the one allowed by its battery capacity: it must stop exactly once for recharging on the way.
- There are 4 road segments with 3 charging stations in between: each station has a number of chargers available, and a different loads in number of requests.
- The travelling time of the four segments is distributed according 4 traces where all times are expressed in minutes.
- Charging time is equal for all stations, and it is exponentially distributed with an average of 30 minutes.

The problem

- The request rate by other cars at the station, and the number of chargers, is given in the following table:

Station	Other traffic (car/hour)	Number of chargers
1	6	4
2	4	3
3	5	3

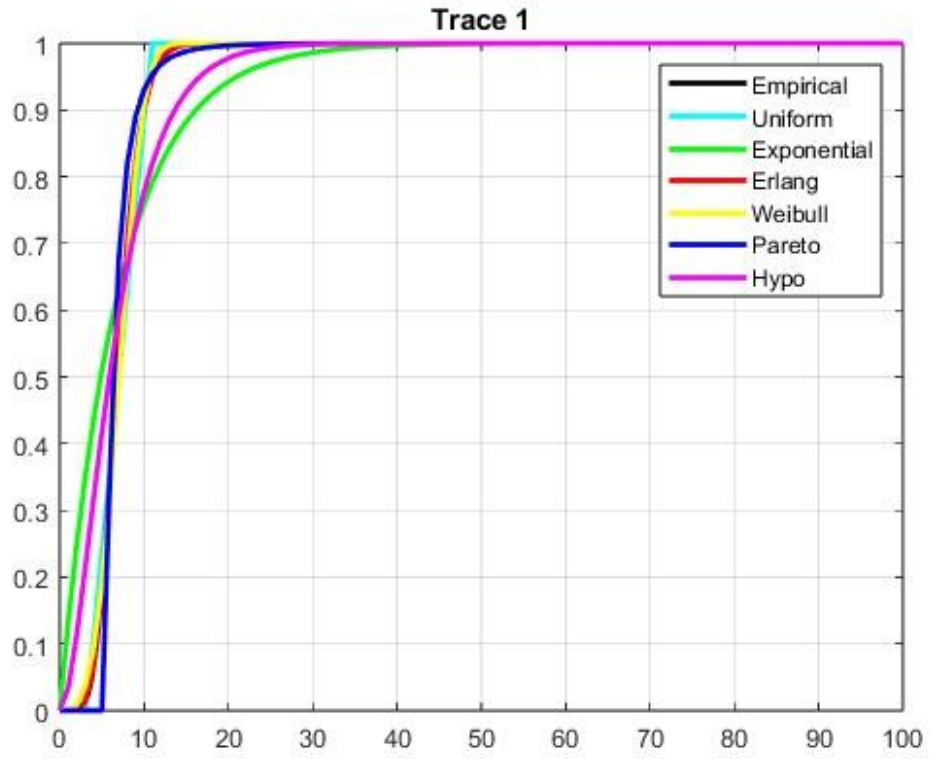
- Determine the **best stopping probability distribution**: test a few alternatives of probabilities of stopping at each station, and for each scenario determine the **average travelling time**.

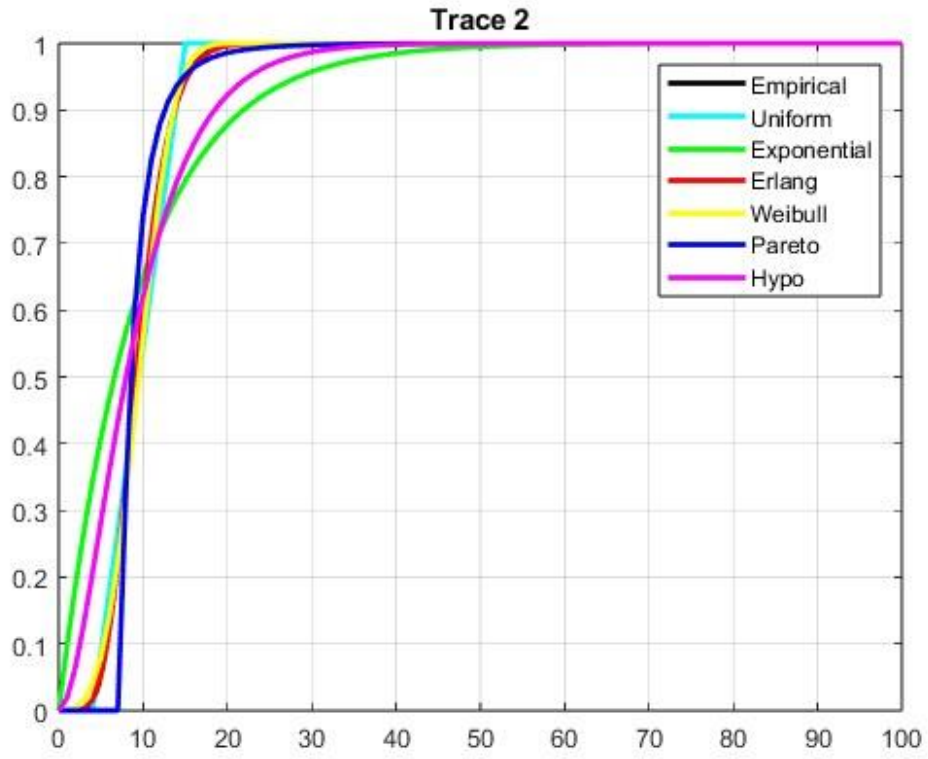
Proposed solution

- First of all, we have to understand which distribution has been used to generate those traces that represent the travelling time of each road segment. So, the first step is to fit the traces using Matlab.
- Distribution fitted:
  Uniform
  Exponential
  Erlang
  Weibull
  Pareto
  Hypo-exponential

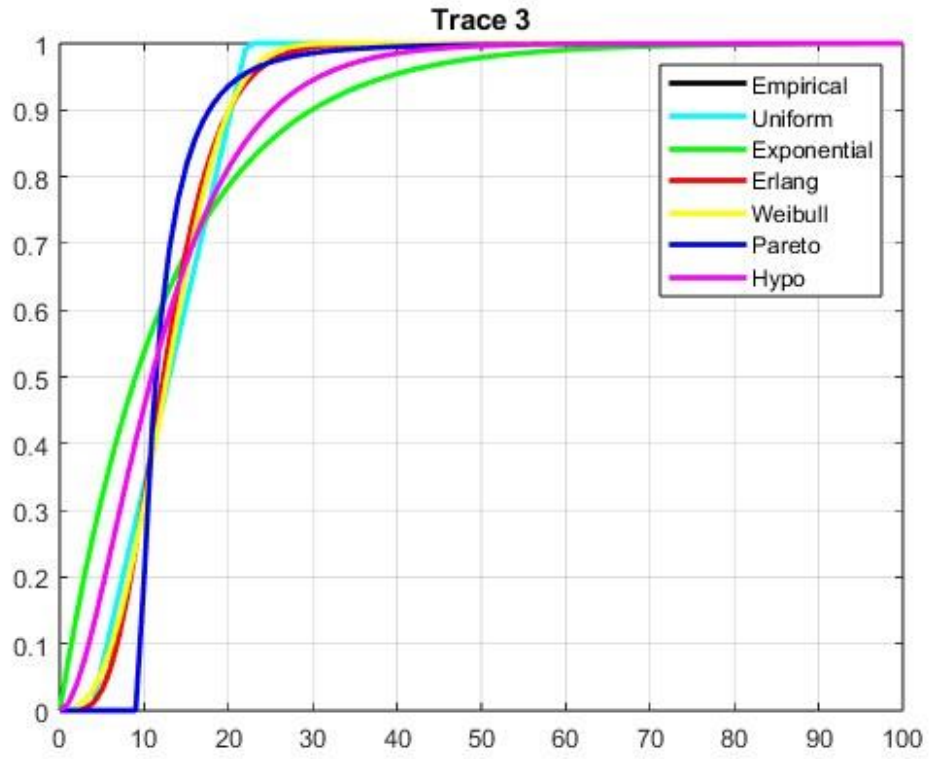
NO Hyper-exponential fitting because the Coefficient of Variations of the traces were less than 1.

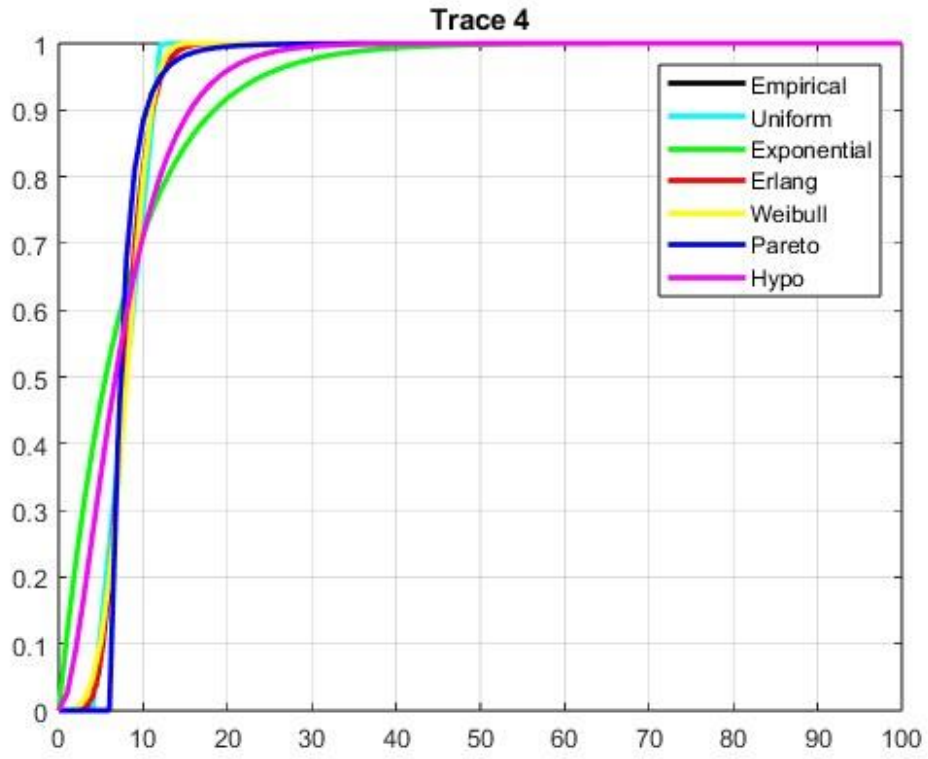
Proposed solution - Fitting process





Proposed solution - Fitting process





Proposed solution – Fitting process

- As we can see in the previous images, the traces have been created using an Erlang distribution. The parameters are the following:

Trace	Lambda	k
A	1.42658	10
B	0.94712	9
C	0.462514	6
D	1.49789	12

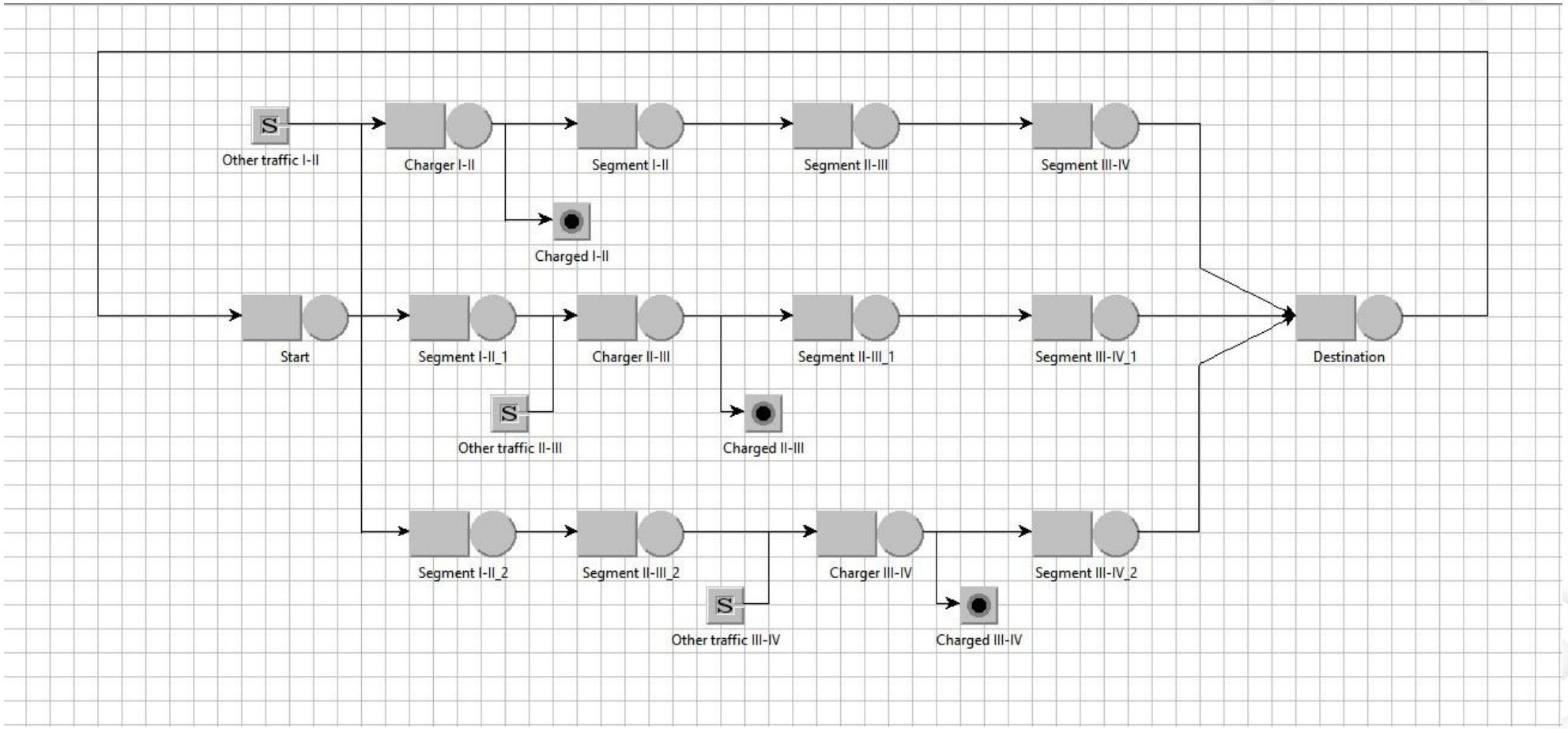
Proposed solution – JMT modelling

+ The flow of the car has been modelled using JSIMGraph Tool within JMT tool.

4 classes have been identified:

1) Electric car, a closed class with population equal to 1 that represents the electric car.
2) Cars I-II, an open class that represents the incoming cars at the first charging station.
3) Cars II-III, an open class that represents the incoming cars at the second charging station.
4) Cars III-IV, an open class that represents the incoming cars at the third charging station.

Proposed solution – JMT modelling



Just need to change the “routing probabilities” in the Start node and test it having built the model in this way.

Proposed solution - Results

- As we can see the **best** option is to stop at the **second charging station** since it has the lowest number of incoming cars between the three stations.
- The **worst option** is to stop at the **third one**.
- Anyway, also stopping at the **first station** is a **good idea**.

Probabilities	System response time
1.0 0.0 0.0	83.249
0.0 1.0 0.0	82.15
0.0 0.0 1.0	109.3978
0.33 0.33 0.33	91.2250
0.8 0.2 0.0	83.9063
0.2 0.8 0.0	82.6318
0.2 0.0 0.8	103.9143

All the results consider a confidence interval of 0.99 and maximum relative error of 0.03

Proposed solution - Results

- Imagine having 6 electric cars instead of 1.
- In this case the best distribution is to stop or in the first station or in the second since in the first we have 4 chargers and in the second the lowest arrival rate of concurrent cars.

Probability	System response time
100	183.2835
010	184.0263
001	354.8018
0.33 0.33 0.34	138.1308
0.8 0.2 0	150.3905
0.2 0.8 0	150.0368
0.5 0.5 0	123.8879

All the results consider a confidence interval of 0.99 and maximum relative error of 0.03

Thank you for the attention!