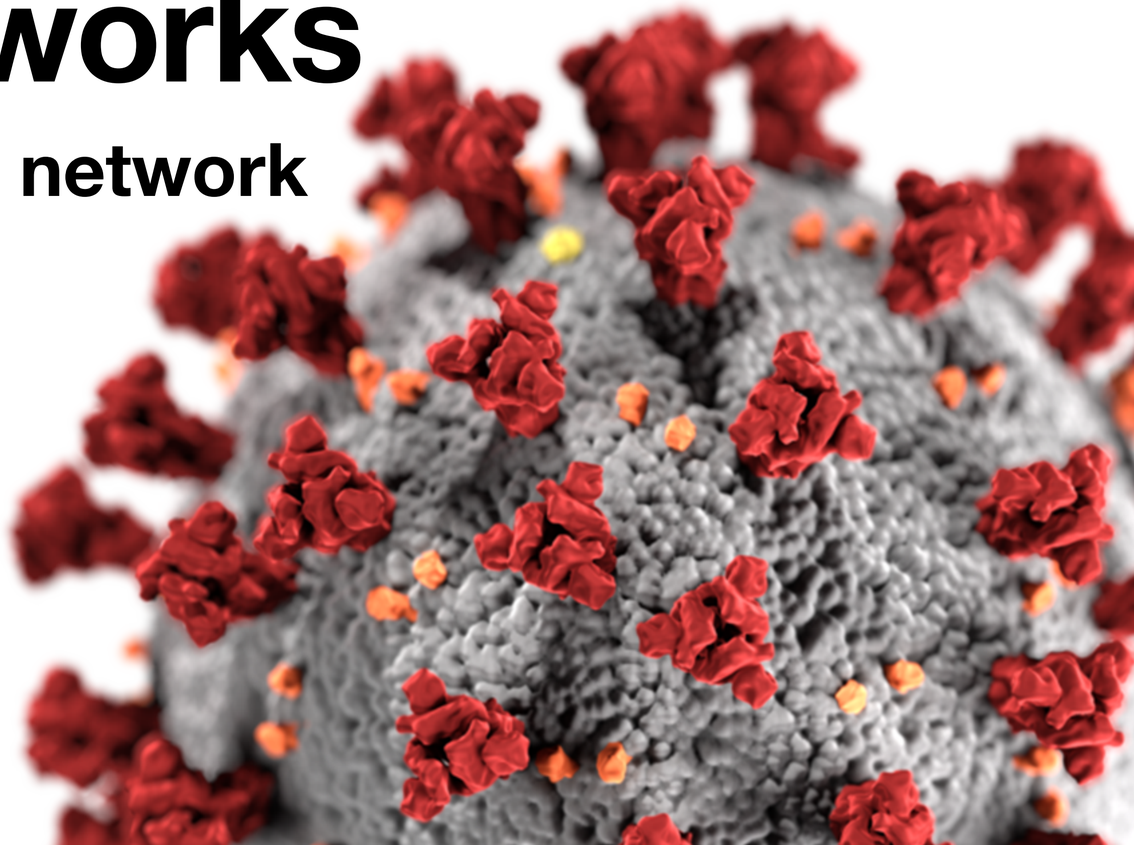
Data-Driven Epidemic Modelling in Public Transport Networks

A case study on Washington DC metro network



Panchamy Krishnakumari, 6 October 2020

Dutch coronavirus tracing app will undergo trials in Twente, tax office gets development role

Corona Tech & Media June 25, 2020

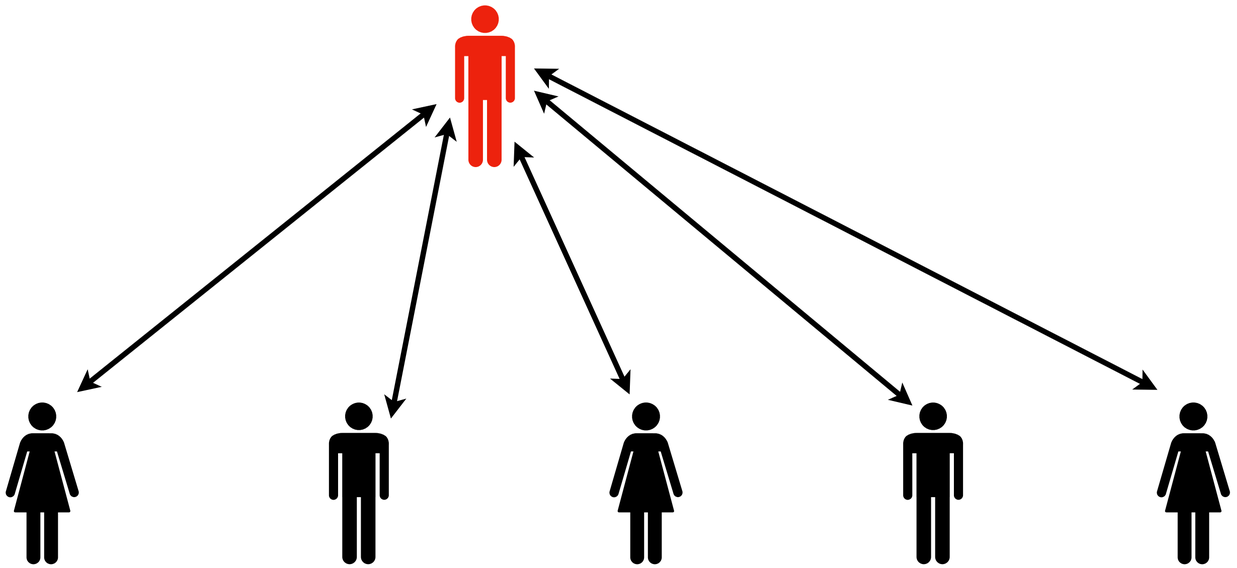
Opinion sharply divided about using an app to trace coronavirus cases

Corona Tech & Media June 9, 2020

Photo: Depositphotos.com

There is sharply divided support for a coronavirus tracing app among the Dutch and only one third say they would download it without question, according to research carried out by Delft, Maastricht and the VU universities.

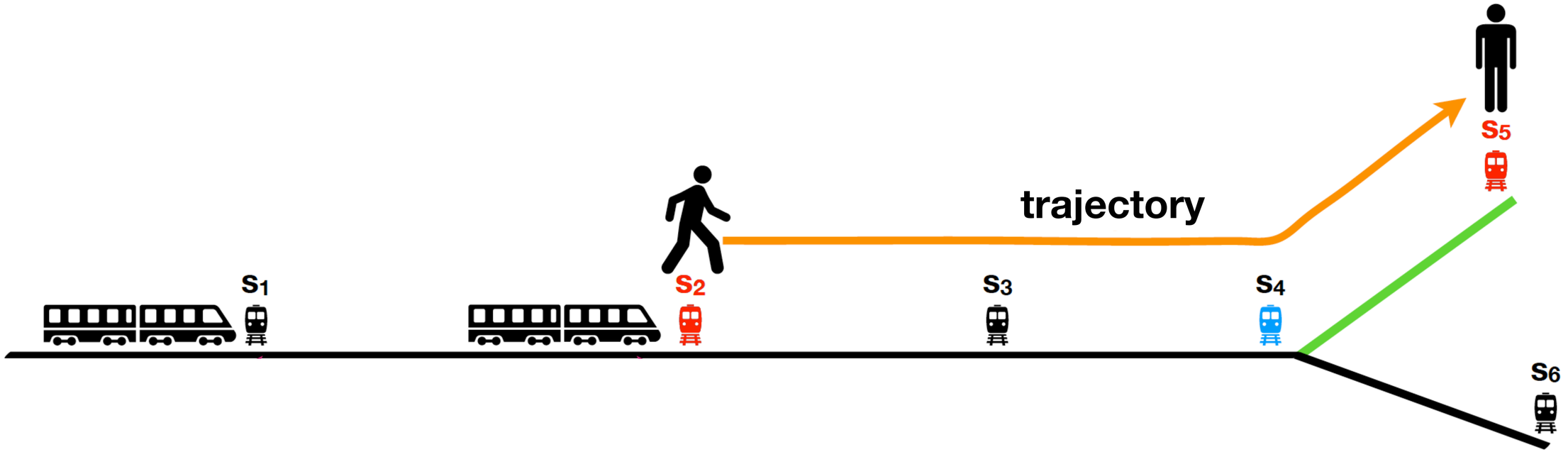
Contact graphs



Hypothesis

Contact graphs of public transport can be derived from smart card data and hence we can model the virus spread within the public transport!

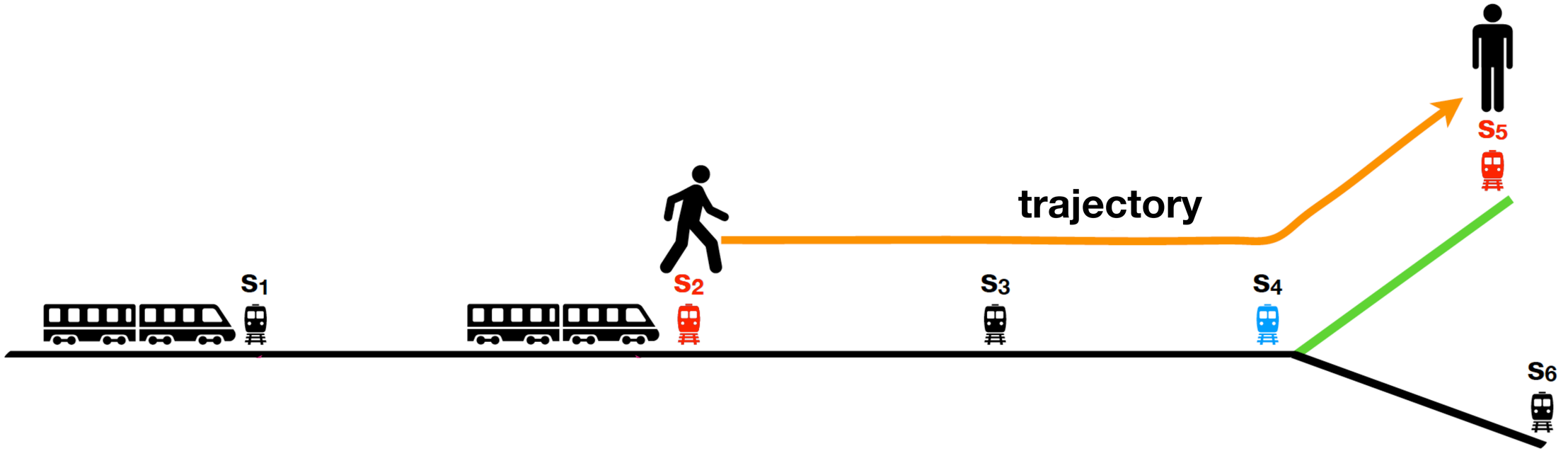
Public transport contact graphs



Four potential points of contact

- At the origin station
- Inside the train
- At transfer stations
- At the destination station

Public transport contact graphs



Given inferred passenger trajectory, tap-in location and time, tap-out location and time

Model parameters

1. Incubation period - **5 days**

2. Quarantine period - **21 days**

Six possible states for a passenger:

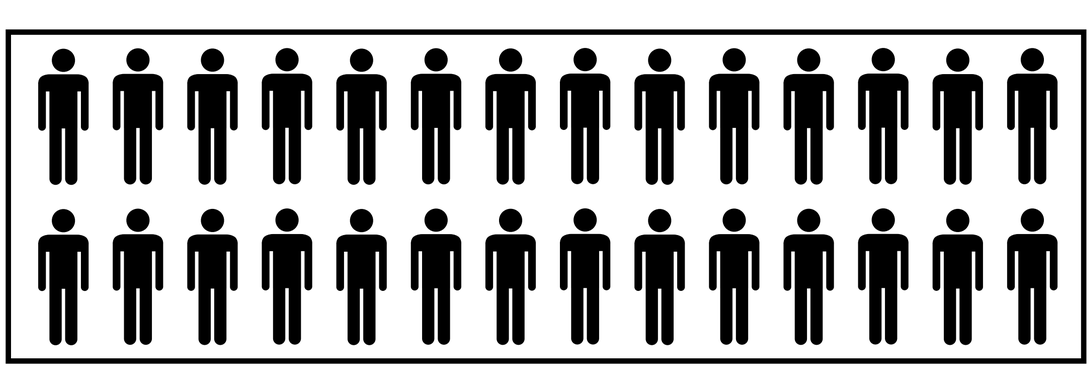
Susceptible —> Exposed —> Infected —> Infected and traveling —> Infected and quarantining —> Immune and traveling

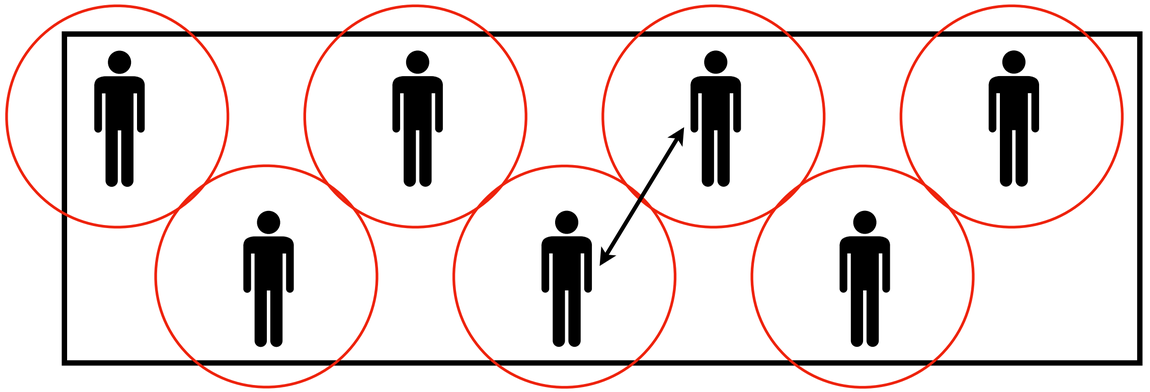
Model assumptions

1. Probability of infection based on proximity to infected person **P(A/B)**
2. Probability of proximity to an infected person **P(B)**

Model assumptions

1. Probability of infection based on proximity to infected person **P(A/B)**

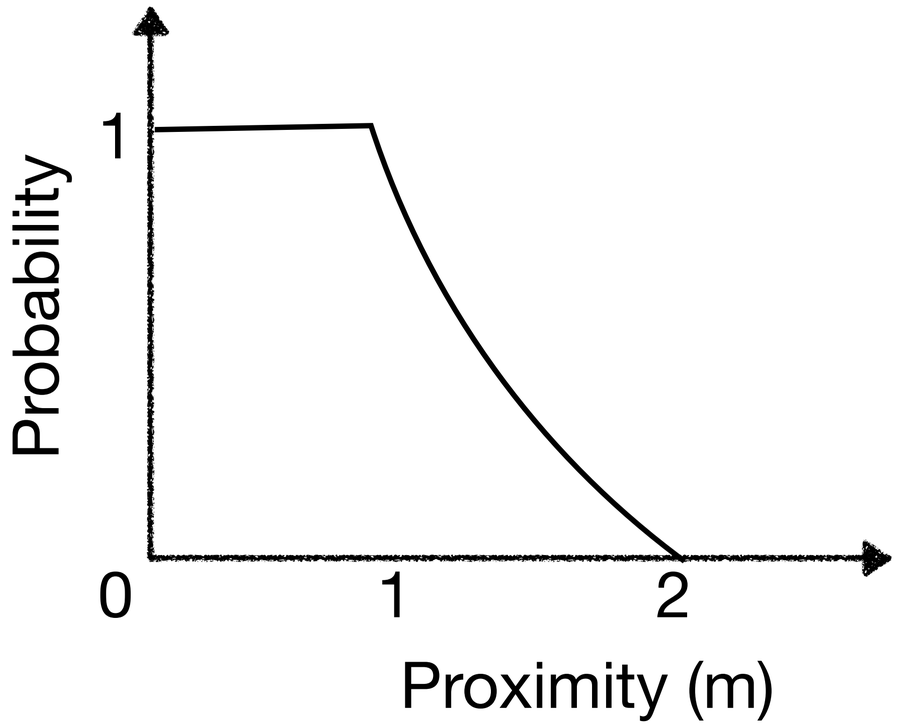




Depends on the number of passengers and the train/platform dimensions

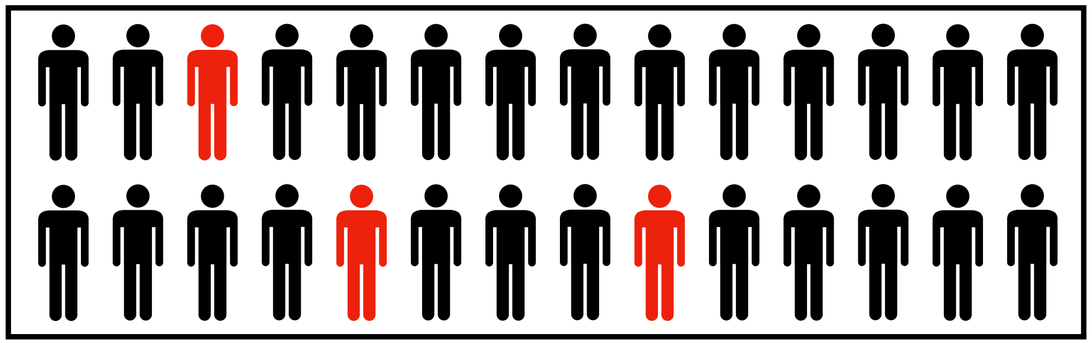
Model assumptions

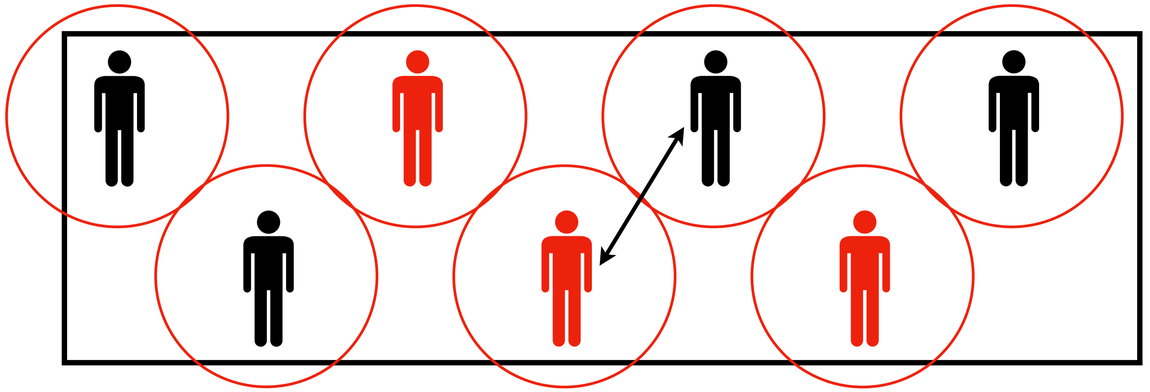
1. Probability of infection based on proximity to infected person **P(A/B)**



Model assumptions

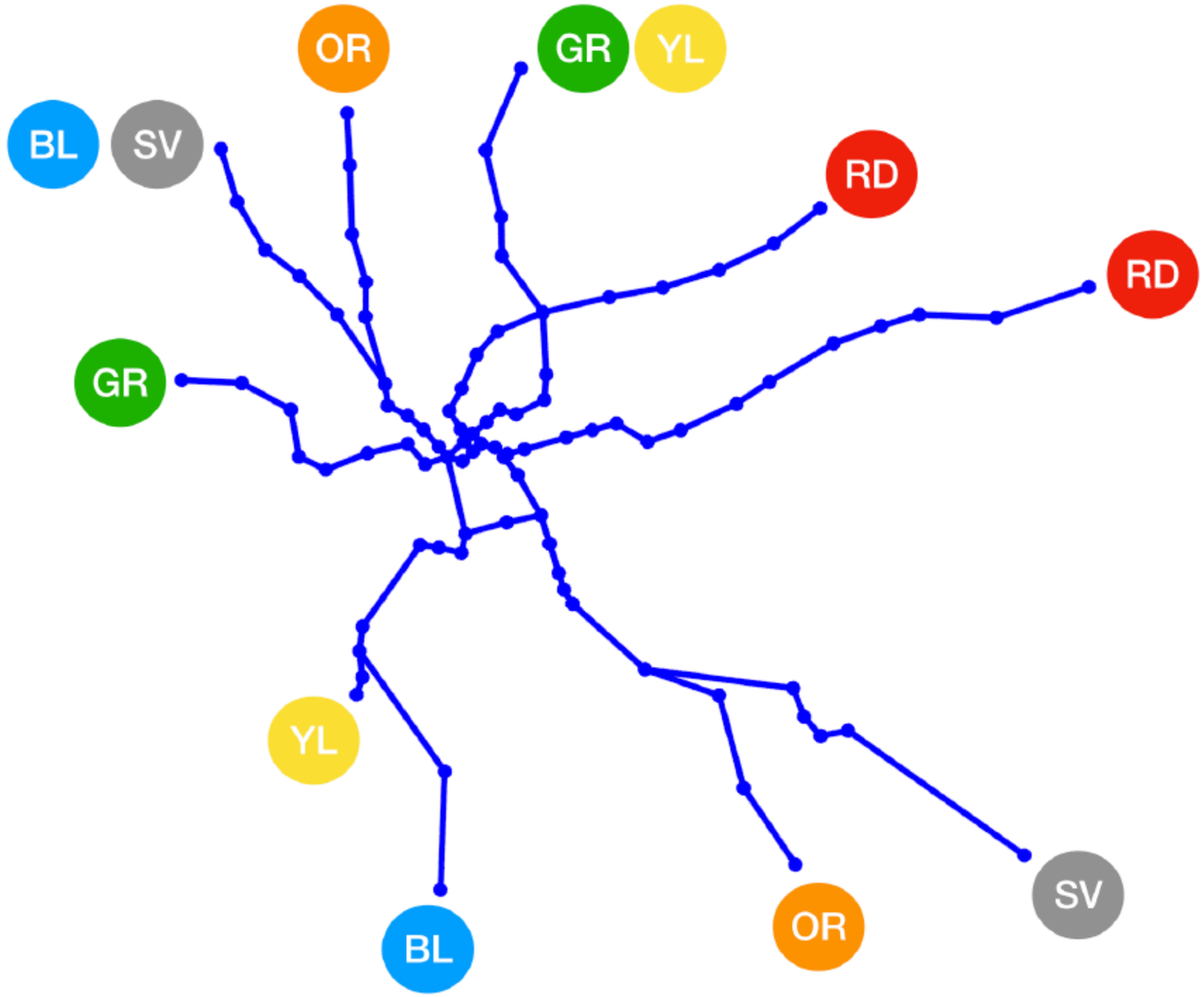
2. Probability of proximity to an infected person **P(B)**





Depends on the number of passengers and the number of infected passengers

Data



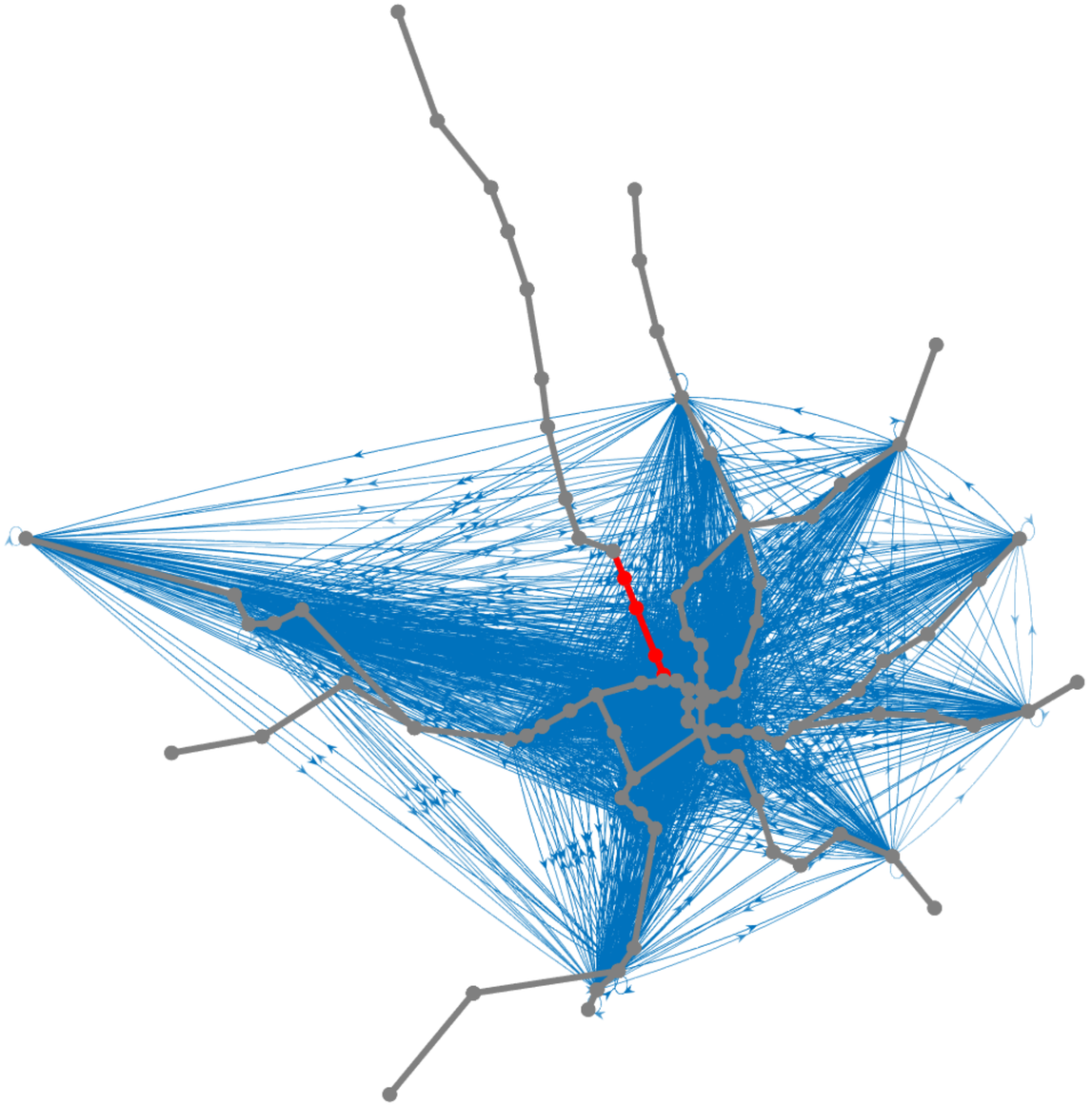
Average ridership per day

600 000

Average ridership in a train at a given time

133

Results



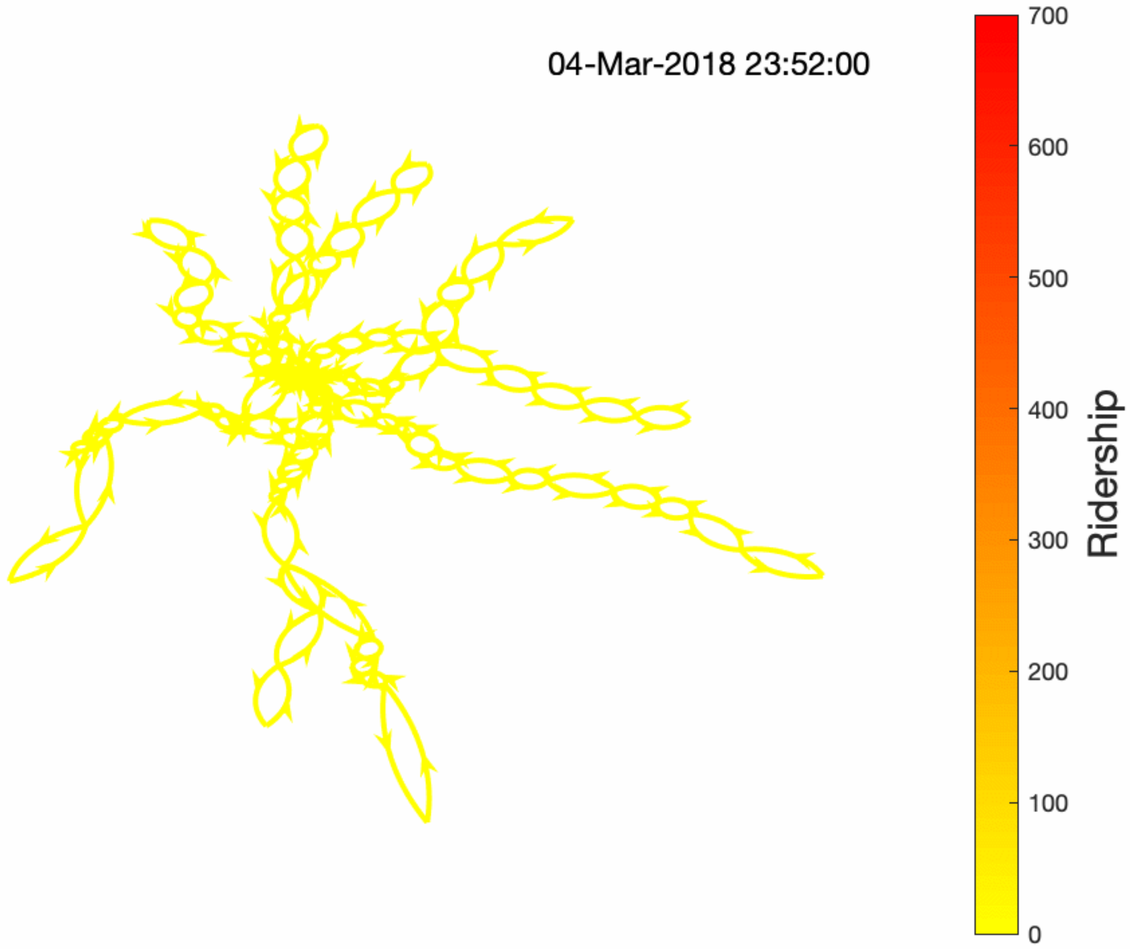
337 million person-person interactions during 5am - 12pm for 270 000 travelers

Results

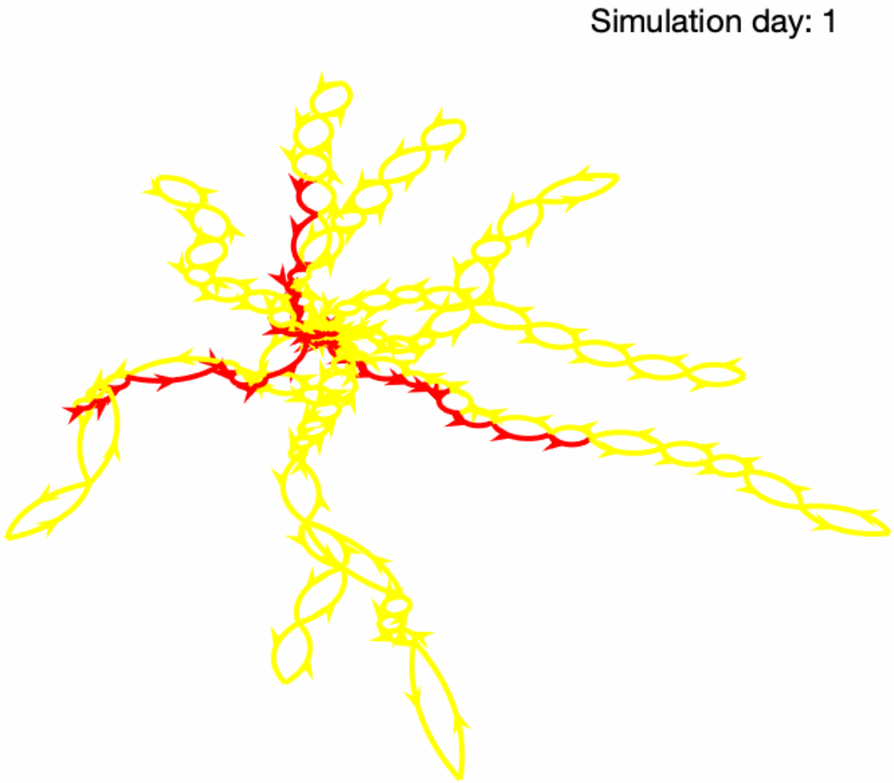
703 —> 1m

312 —> 1.5m

176 —> 2m

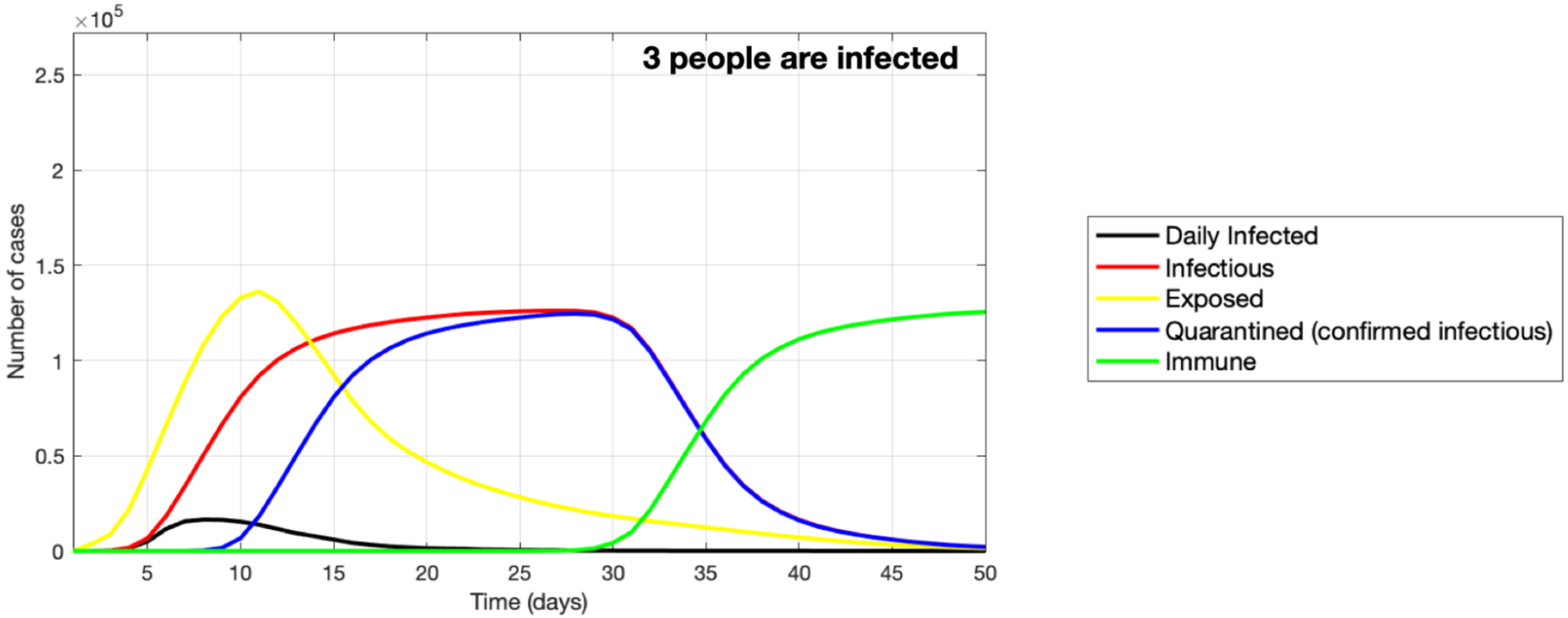


Results

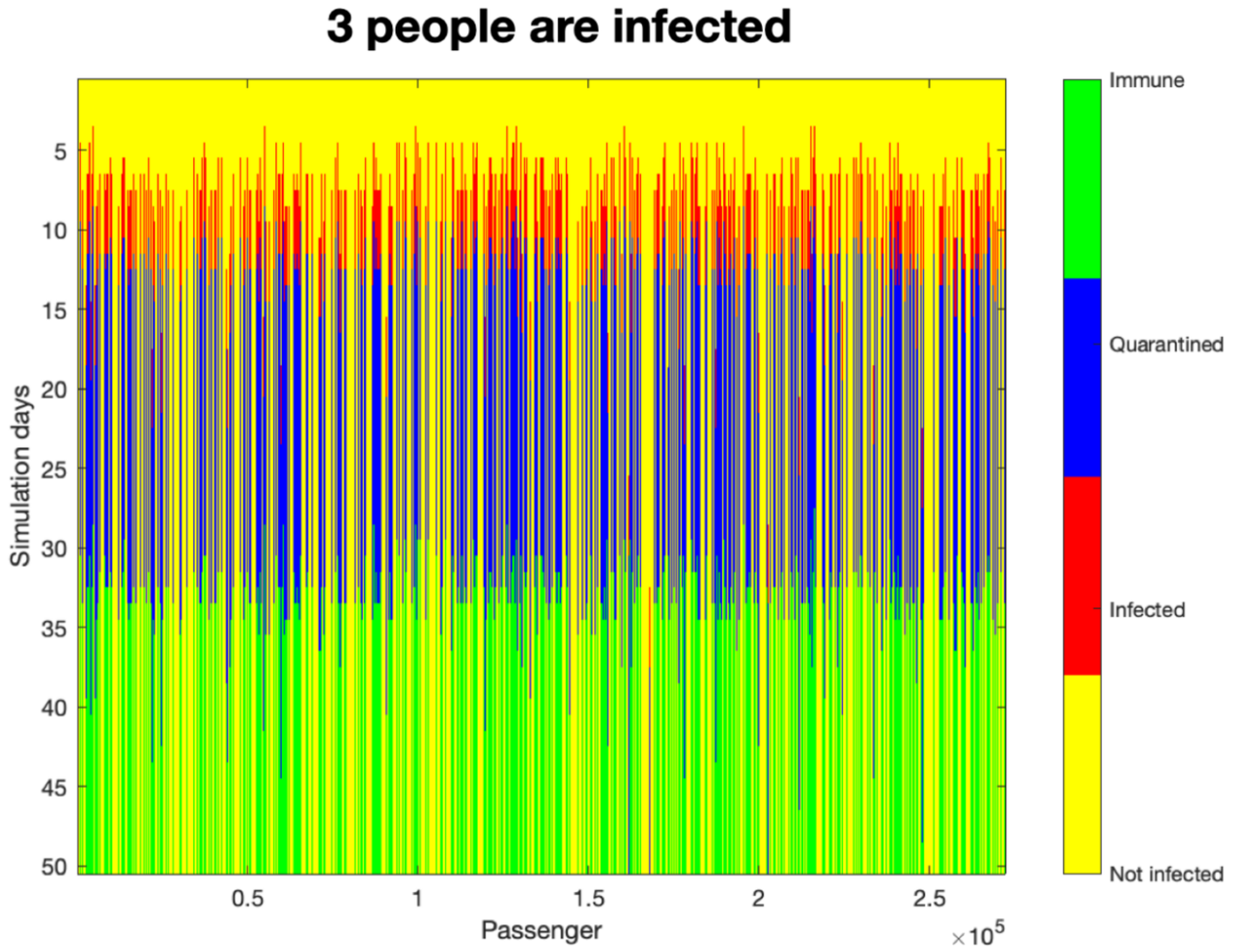


red implies an infected person has traversed the link

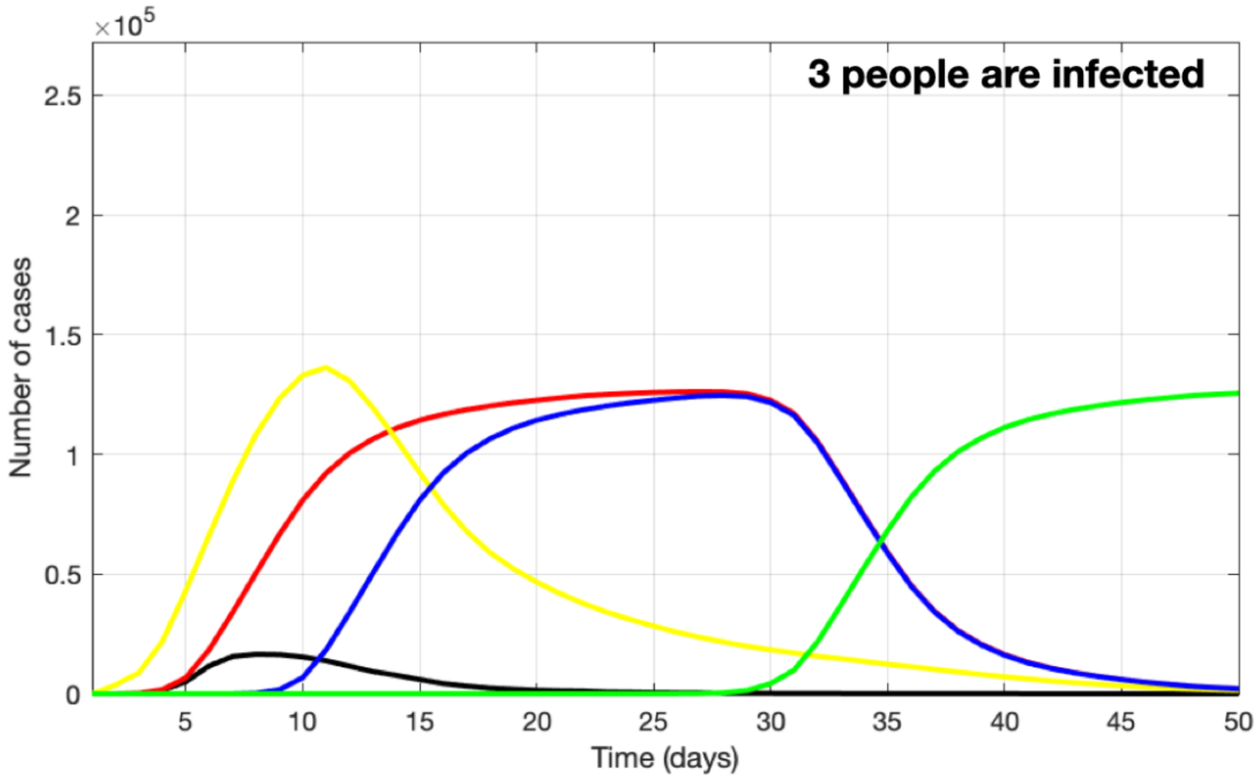
Results

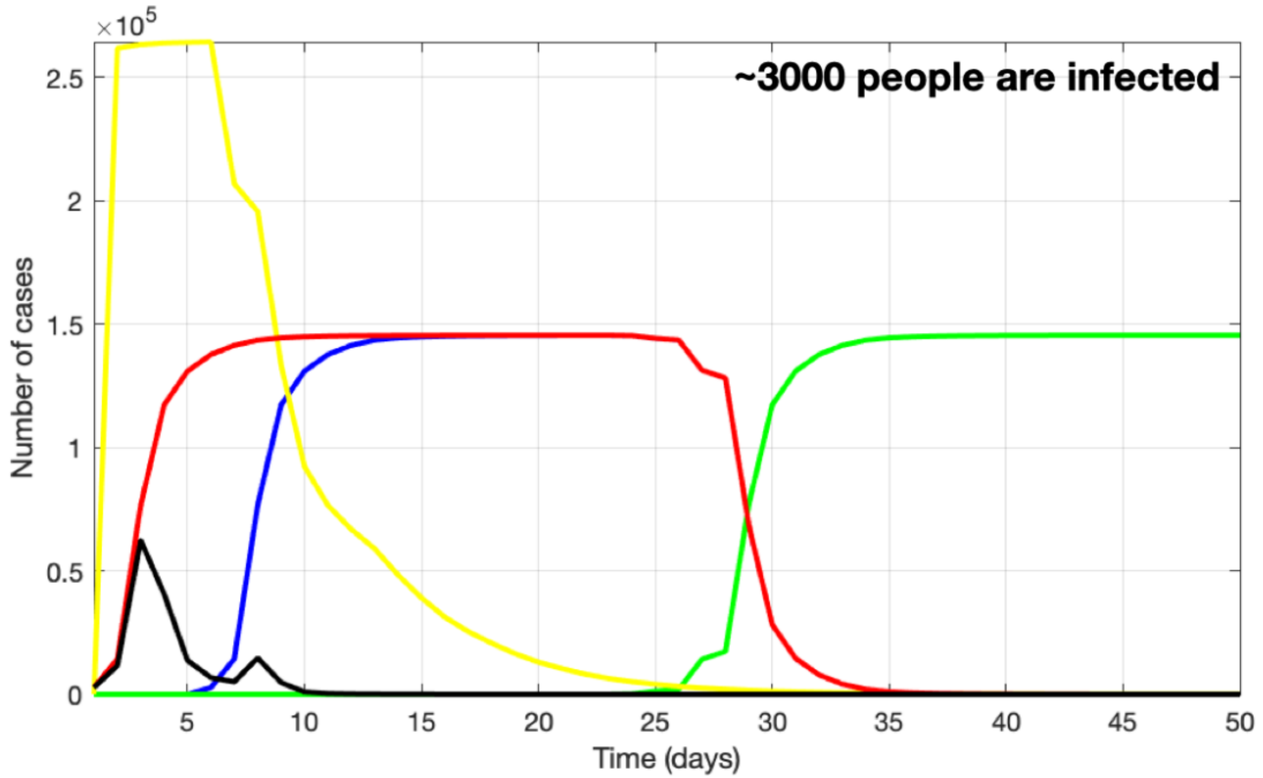

×10^5
3 people are infected
Number of cases
Time (days)
0
0.5
1
1.5
2
2.5
5
10
15
20
25
30
35
40
45
50
Daily Infected
Infectious
Exposed
Quarantined (confirmed infectious)
Immune

Results


3 people are infected
Simulation days
5
10
15
20
25
30
35
40
45
50
0.5
1
1.5
2
2.5
Passenger
×10^5
Immune
Quarantined
Infected
Not infected

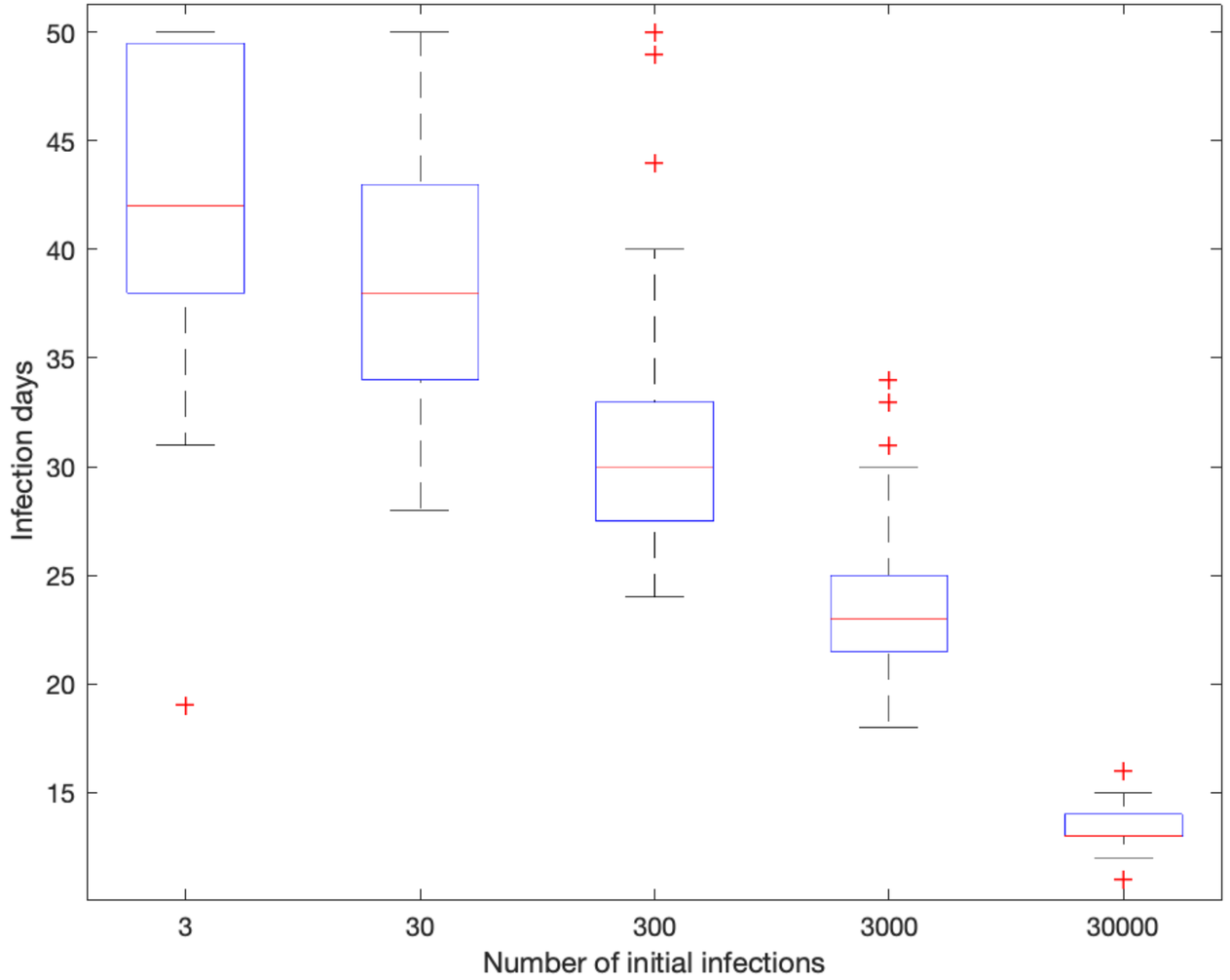
Results



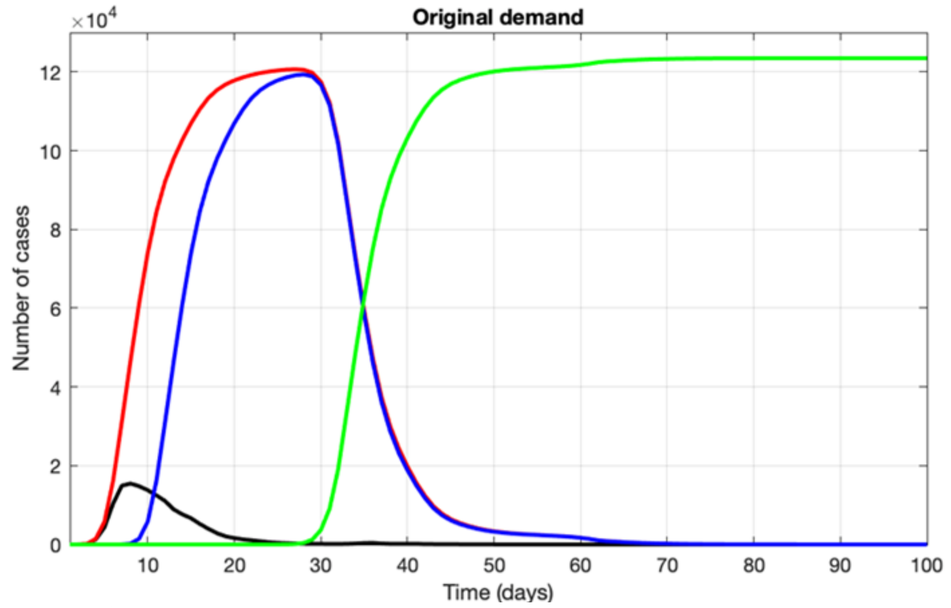


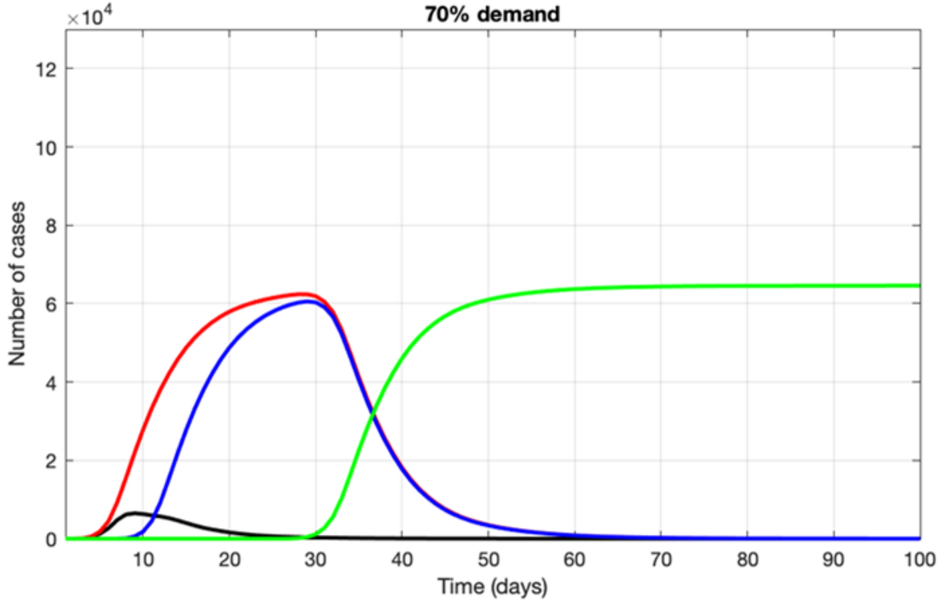
Daily Infected
Infectious
Exposed
Quarantined (confirmed infectious)
Immune

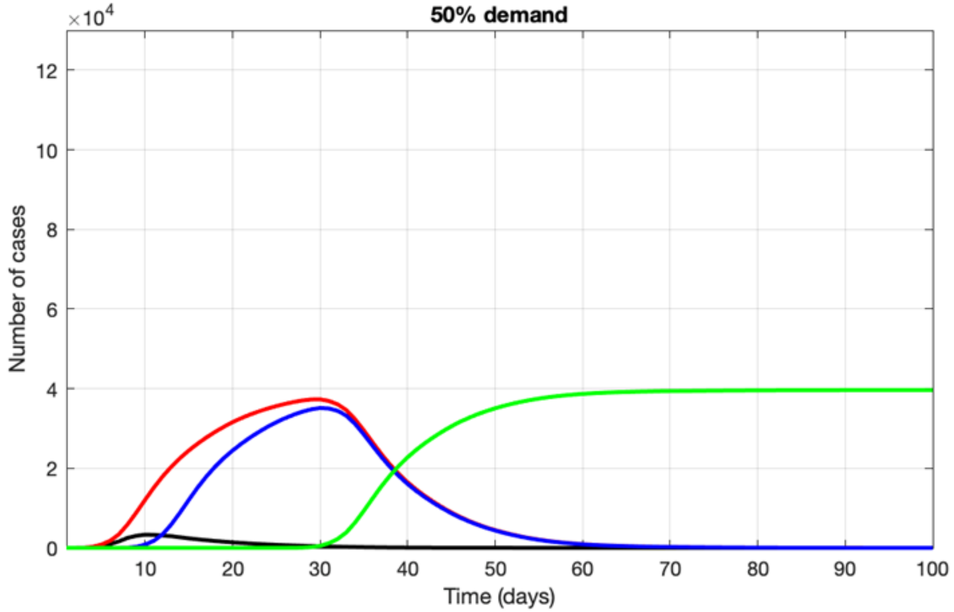
Results

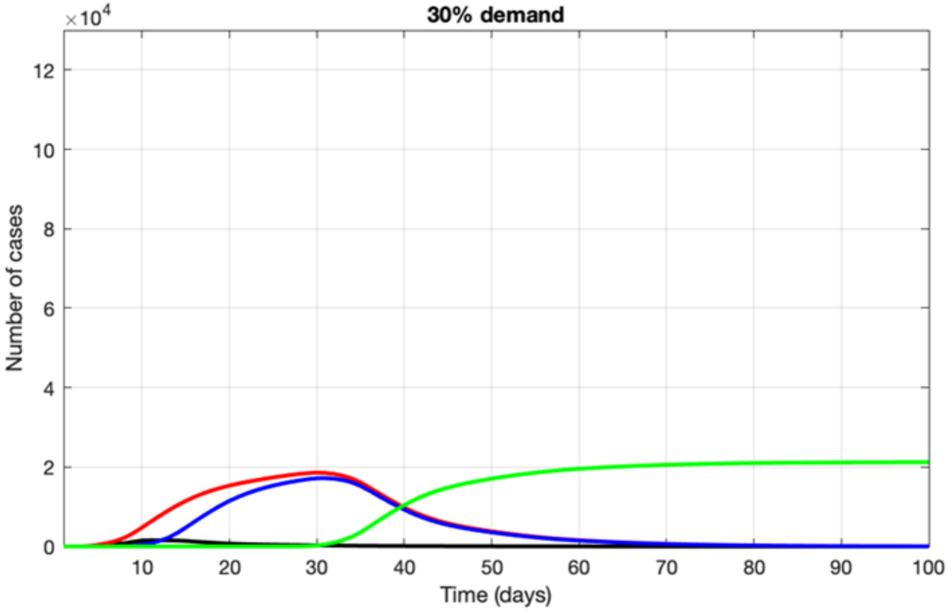

50
45
40
35
30
25
20
15
Infection days
3
30
300
3000
30000
Number of initial infections

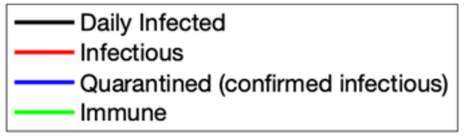
Results

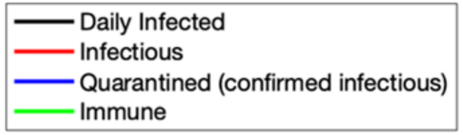

Original demand
×10^4
Number of cases
Time (days)


70% demand
×10^4
Number of cases
Time (days)

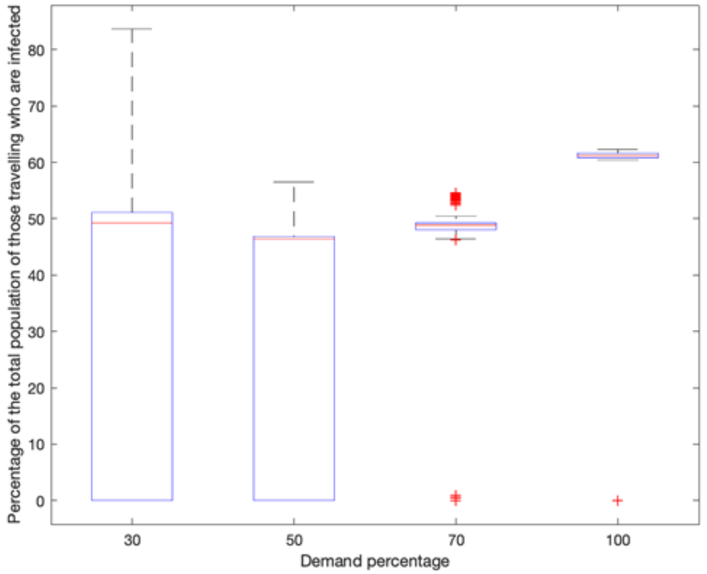

50% demand
×10^4
Number of cases
Time (days)

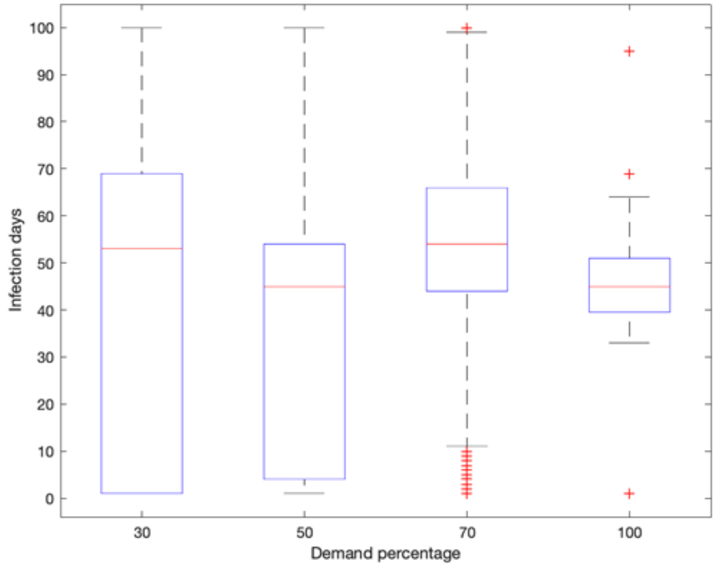

30% demand
×10^4
Number of cases
Time (days)

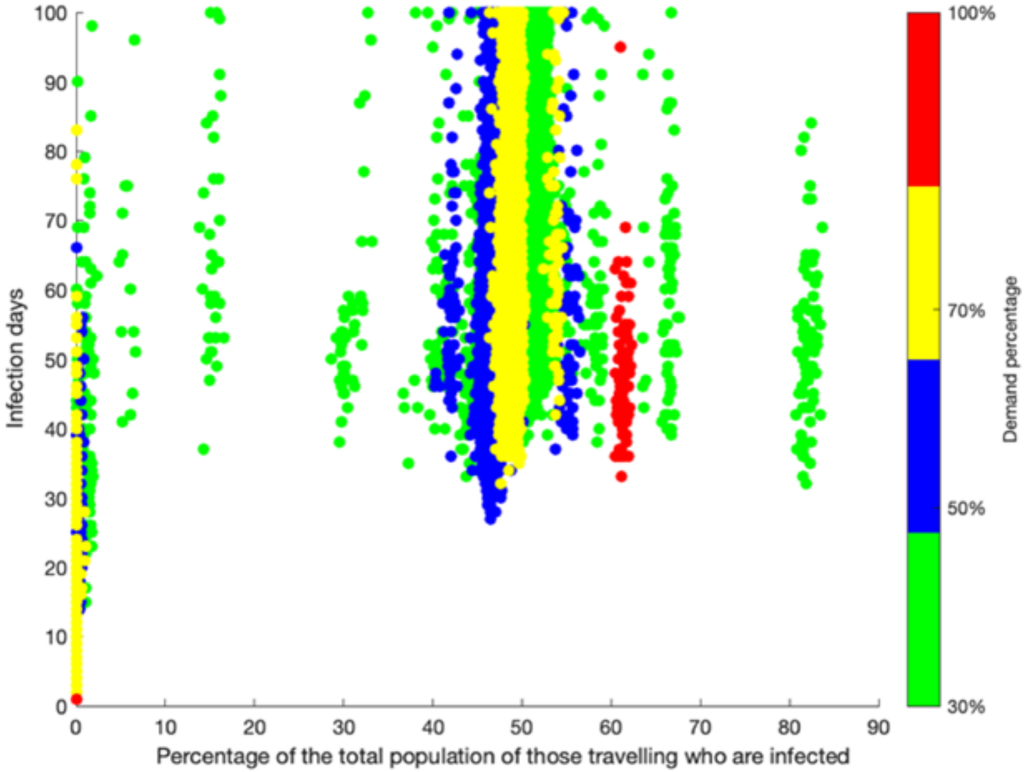

Daily Infected
Infectious
Quarantined (confirmed infectious)
Immune


Daily Infected
Infectious
Quarantined (confirmed infectious)
Immune

Results


Percentage of the total population of those travelling who are infected
Demand percentage
30
50
70
100


Infection days
Demand percentage
30
50
70
100


Infection days
Percentage of the total population of those travelling who are infected
Demand percentage
100%
70%
50%
30%

Questions ?

More info: *https://www.linkedin.com/pulse/virus-spreading-public-transport-networks-alarming-usual-krishnan/*