

Passenger Counting for Public Transport based on WiFi-Frames

Hung-Ju Wu Uroš Milenković Milan Cupać
Mladen Bašić Matija Dodović

RED!TECH

PIXIDA





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Status quo

Nightmare in public transportation

Everyone must have been through this...



Source: <https://mrpassenger.com/crucial-information-you-need-to-know-when-using-crowded-public-transportation/>

Problems

- Max capacity reached or exceeded during rush hour for certain high priority routes
 - ➔ Comfort and safety concerns, low quality
- Others have relatively low capacity
 - ➔ Low revenue for same operation costs

**Building new stations and railways
takes too much time and effort...**



Source: https://upload.wikimedia.org/wikipedia/commons/thumb/e/e4/U-Bahnhof_Unter_den_Linden_Nov_2012.JPG/1200px-U-Bahnhof_Unter_den_Linden_Nov_2012.JPG



Uncomfortable, Unsafe, Inefficient.

Is there a way to maximize the use of all facilities that we already have?



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Solution

Our Approach

1. Provide other suggestions for popular routes and cooperate with other companies (bike, e-scooter, etc.) to increase the amount of alternatives
2. Rearrange time schedules according to passenger flow

Alternative Route Suggestion

In general, give route suggestions based on current location and the destination

- Shorter travel distance: bikes, e-scooters
- Longer travel distance: metro, bus, tram
- To amusement parks: taxi, Uber
- ...

Alternative Route Suggestion

For regularly highly occupied routes:

- Other direct or 1x-transfer routes
- Suggestions based on weather and road conditions
- Suggestions to the public transport company to rearrange the buses from low-priority lines to the high-priority lines

Alternative Route Suggestion

For irregularly low-speed routes:

- Other routes that are not affected
- Vehicles with higher mobility (bikes, e-scooters)

Alternative Route Suggestion

Incentives for passengers

- Combi tickets
- Bonus Program

Alternative Route Suggestion

Combi tickets

- Discounts for vehicle transfer
- Monthly or annual packages

Alternative Route Suggestion

Bonus Program

- Earn points in exchange for ticket discount or free tickets (base on ticket price)
- Extra points for using public transport under bad weather conditions
- Extra points for riding bikes (health insurance)

Alternative Route Suggestion

Advantages for public transport operator

- Efficient use of all traveling capacities
- Higher quality of transportation → price ↑
- Increase the frequency of use
- Attracts new customers that used to use the services of the cooperation companies

Rearrangement of Time Schedules

- Regularly highly occupied routes
→ Frequency ↑
- Regularly low occupied routes
→ Frequency ↓

In order to achieve this...

Analyze the everyday passenger flow throughout the year



Find out the pattern on regular work days and holidays

Estimation of Passenger flow

- Our Approach:
Count passengers based on WiFi probe requests
through IoT gateway

Estimation of Passenger flow

Advantages

1. Near real-time
2. Efficient
3. Cost-effective

Why do it like this?

- Wi-Fi probe requests are constant and come from all mobile devices
- 1. A cheap way of capturing these signals
- 2. Everyone has a cell phone



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Solution-Data Analysis

Estimation of Passenger flow

Problems of counting:

1. Devices constantly share signals
2. Frequencies of these emissions are different
3. MAC-addresses of devices are randomized for safety measures
4. Raspberry Pi captures signals from all around the bus

Estimation of Passenger flow

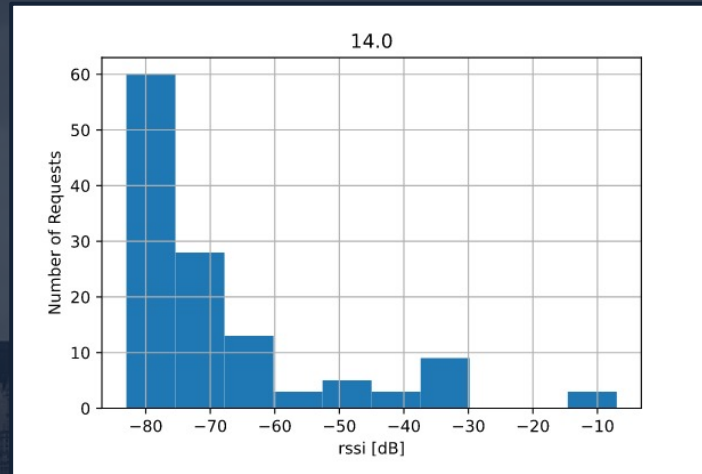
Approach:

1. First attempt was to derandomize the addresses
– we figured it isn't possible to do so
2. Each device shares signals with constant frequency – the second attempt is to catch all these different frequencies throughout one bus trip

Estimation of Passenger flow

Solution - consists of two parts:

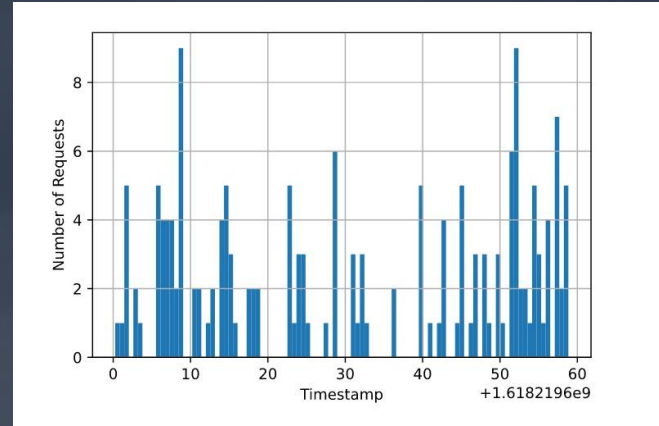
1. Filtering – We filter out the MAC-addresses with low strength, as they most likely come from outside of the bus – see picture



Estimation of Passenger flow

Solution - Consists of two parts:

2. Counting – convolutional neural network based on



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IoT Device Fingerprint using Deep Learning

Sandhya Aneja
Faculty of Integrated Technologies
Universiti Brunei Darussalam
Brunei Darussalam
sandhya.aneja@ubd.edu.bn

Nagender Aneja
Institute of Applied Data Analytics
Universiti Brunei Darussalam
Brunei Darussalam
nagender.aneja@ubd.edu.bn

Md Shohidul Islam
Faculty of Integrated Technologies
Universiti Brunei Darussalam
Brunei Darussalam
14b6057@ubd.edu.bn

Visualization of Passenger flow

Separate the number of passengers on the bus into categories:

1. Green – The bus is almost empty
2. Yellow – Recommended amount
3. Orange – Fairly crowded
4. Red – Full bus

Visualization of passenger flow

Bus on the map is moving in real time
GPS-data was used to define its position
See the provided video

Improvements to the model

1. Deeper network, as in the reference paper
2. Add noise to input data, as not to overfit the model
3. Smarter filtering



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Conclusion

Thank you for your
attention

