# Modelling Backward Traveling Holes in Mixed Traffic Conditions using an Agent Based Simulation

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# Agenda

1. Queue models
   - Why queue models?
   - Point queue model
   - Spatial queue model
2. Backward traveling holes
   - How does it work?
   - Queue model with holes
   - Fundamental diagrams
3. Sensitivity
   - Flow density contours
   - Average bike passing rate contours
4. Conclusion and outlook

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# Agenda



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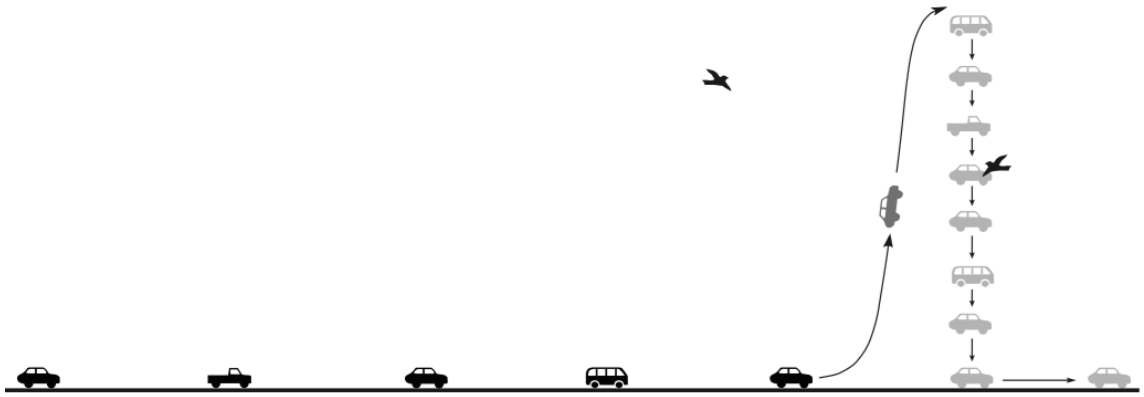
# Why queue models?

Queue models are –

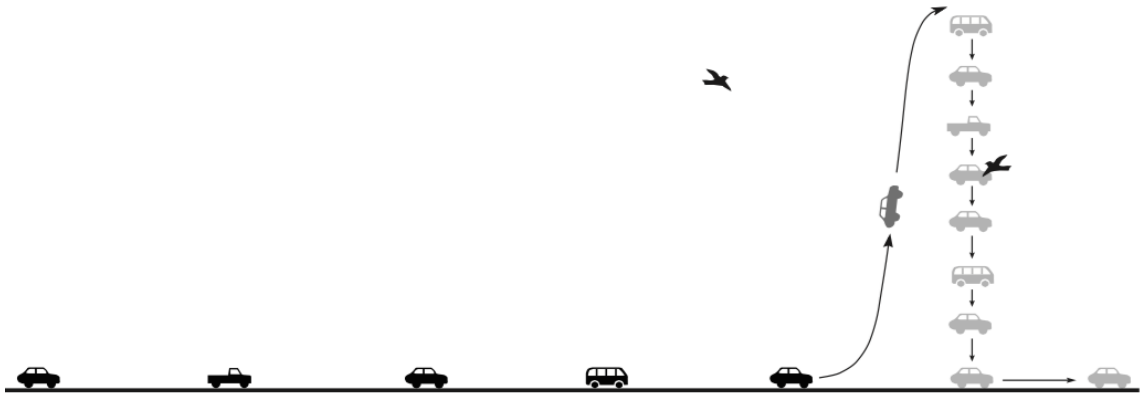
- Simple, fast, easy to implement
- Suitable for large scale scenario

# Point queue



(Hurdle and Son, 2001)

# Point queue



(Hurdle and Son, 2001)

- Unlimited storage capacity $\Rightarrow$ length of queue $= 0$
- No spill-back $\Rightarrow$ no inter-link interaction
- FIFO
- Space available on upstream *immediately* $\Rightarrow$ no intra-link dynamics

# Spatial queue

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## MATSim

- In the present study, a multi-agent transport simulation framework (MATSim) is used.
- Only spatial queue is used in MATSim

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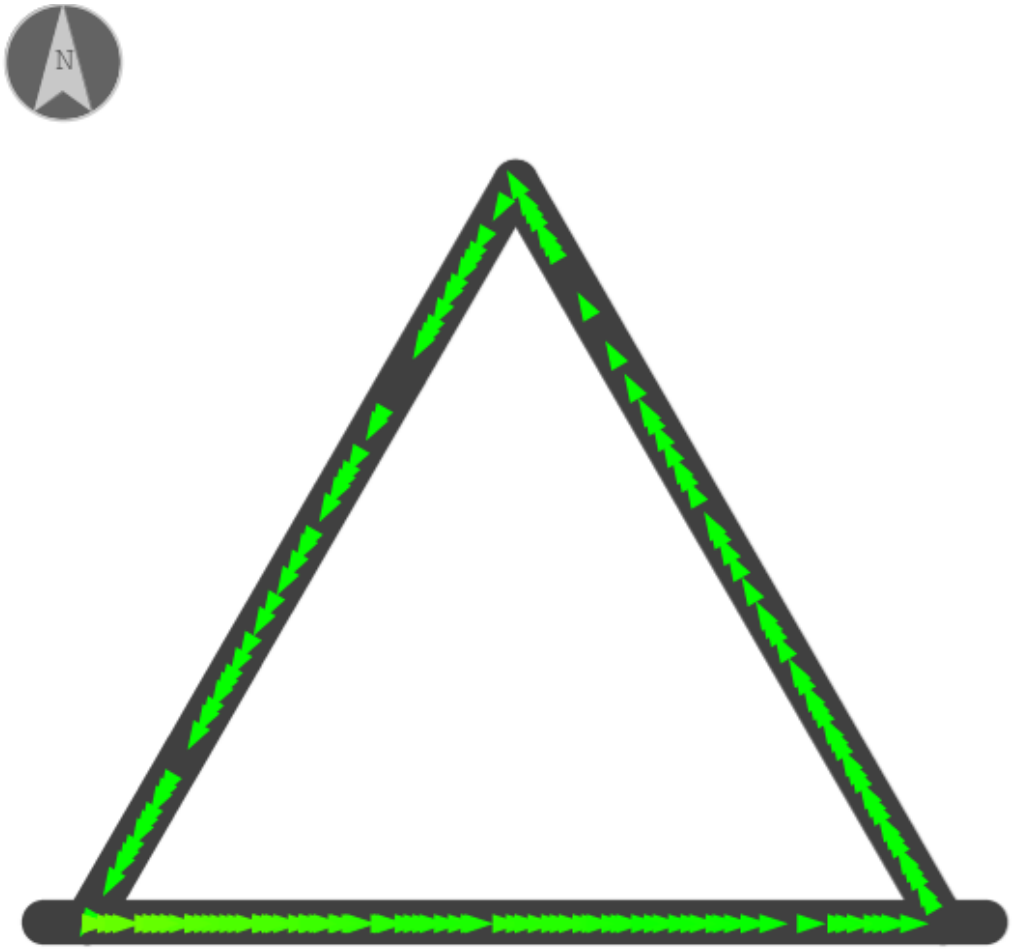
# Why MATSim?

- agent-based simulation framework
- suitable for large scale scenario [10 *min* to simulate 24 *h* of about 7 *million* persons of Switzerland (Balmer et al., 2009)]
- possible to simulate scenario with smaller sample size

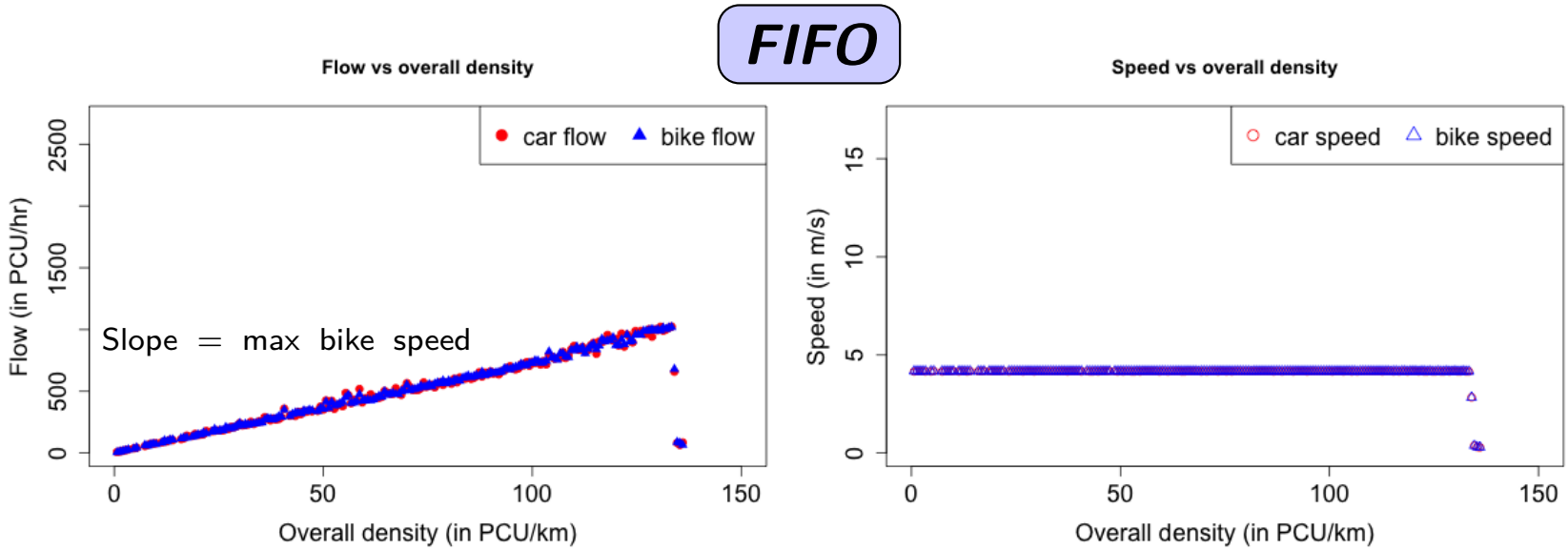
MATSim queue models -

| | Link dynamics | | |
|---|---|---|---|
| Queue model ... | FIFO | Passing | Seepage |
| ... without holes | Original | Agarwal et al. (2015) | |
| ... with holes | **in the present study** | | Agarwal and Lämmel (2015a,b) |

# Race track



# FIFO ⇒ Passing (Agarwal et al., 2015)



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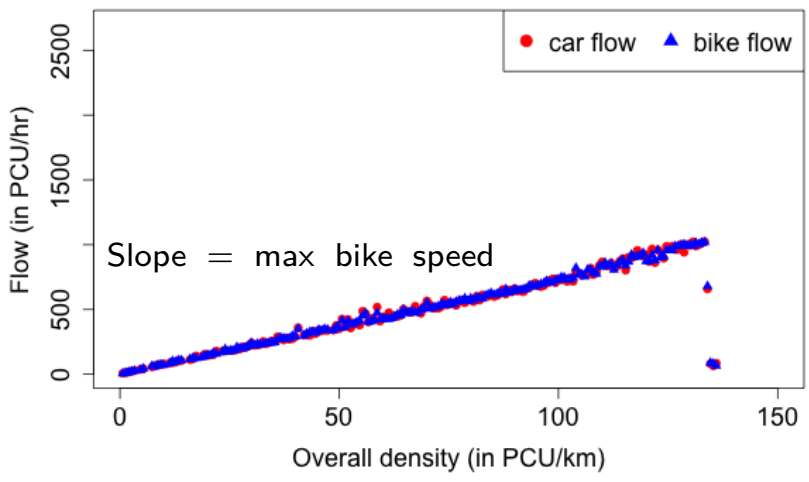
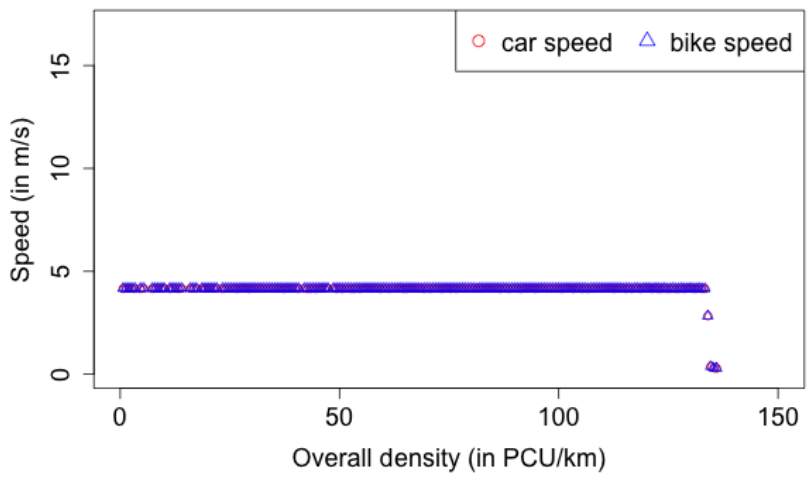
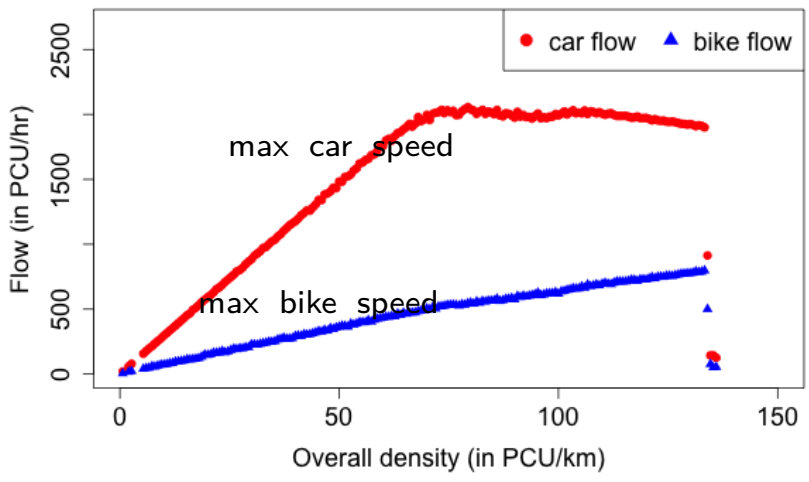
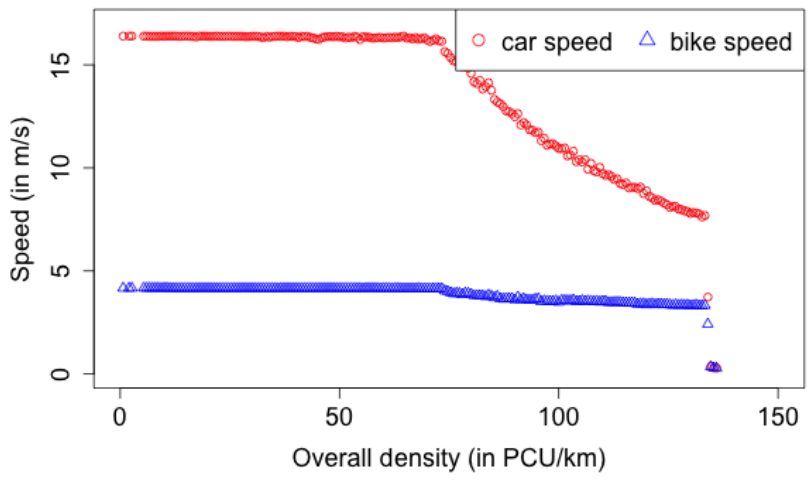
**FIFO**




**Passing**



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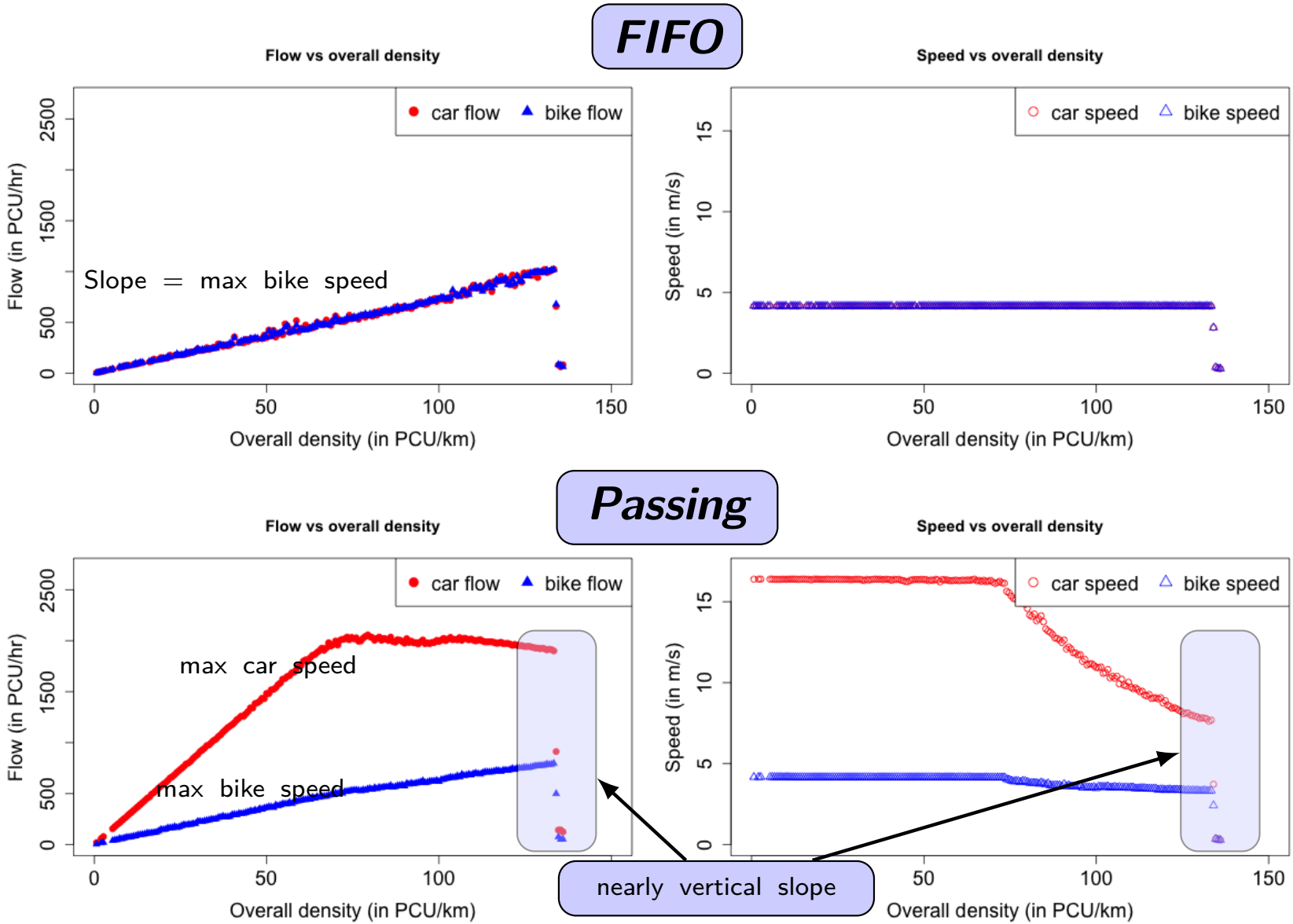

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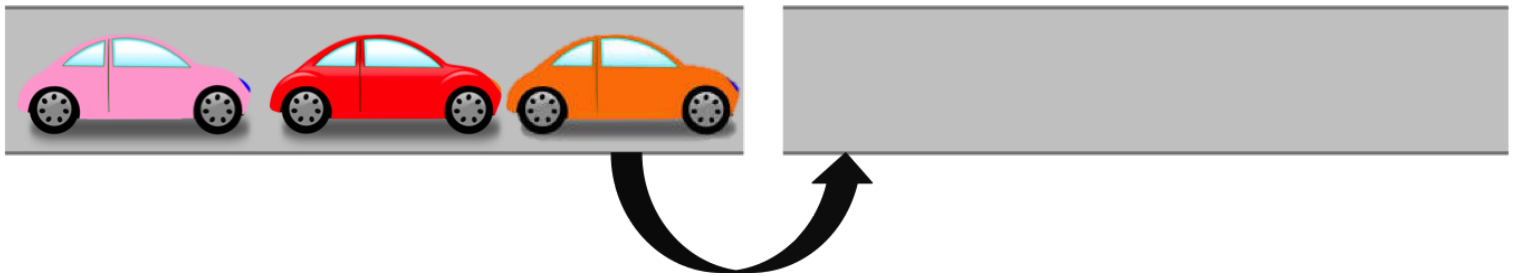
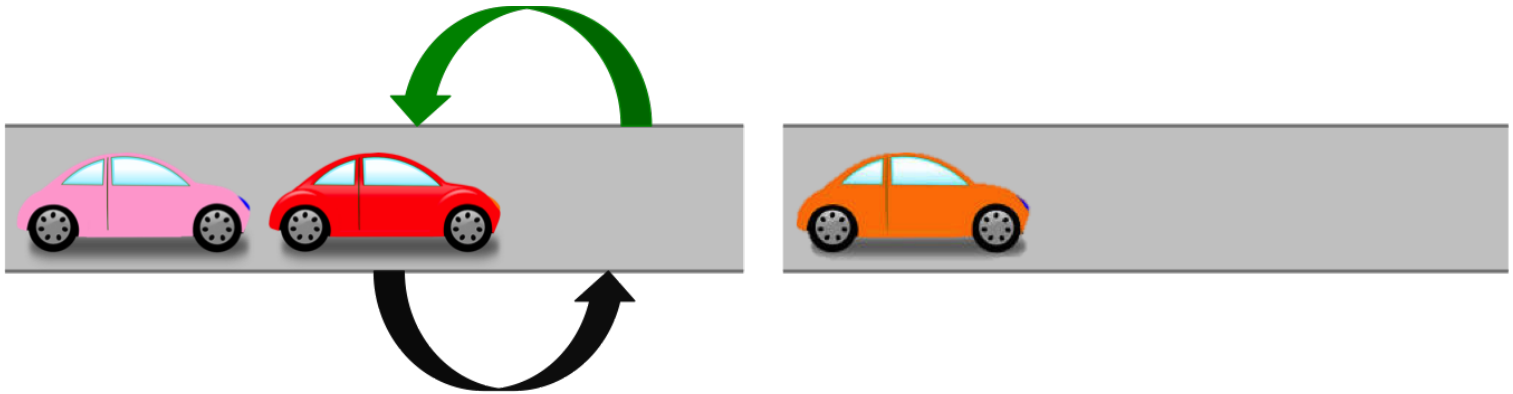
# Backward traveling holes

time step = 1



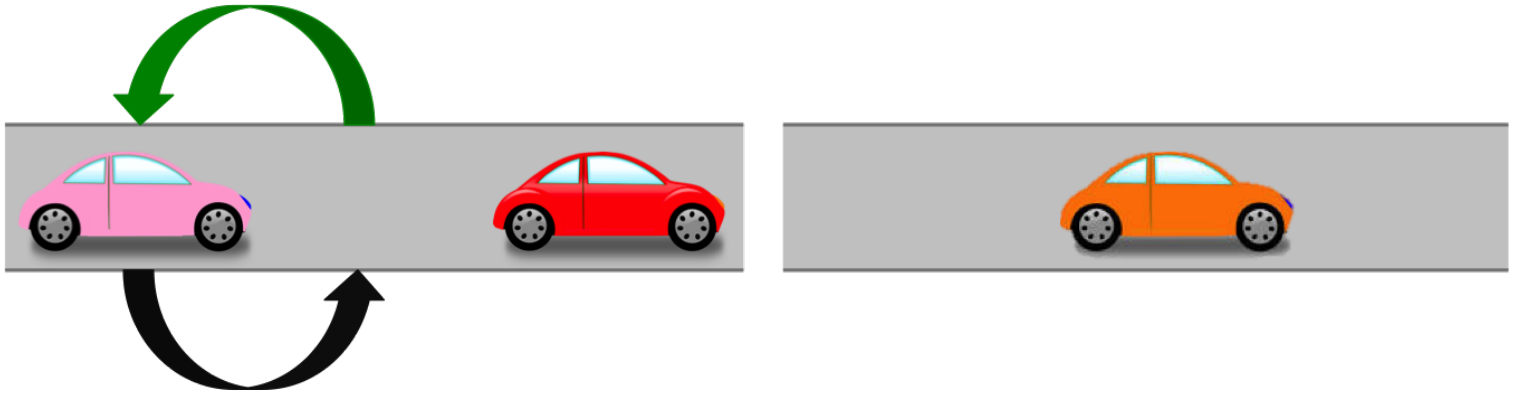
# Backward traveling holes

time step = 2



# Backward traveling holes

time step = 3



# Backward traveling holes

time step $= 4$

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- show movie

# Queue model with holes

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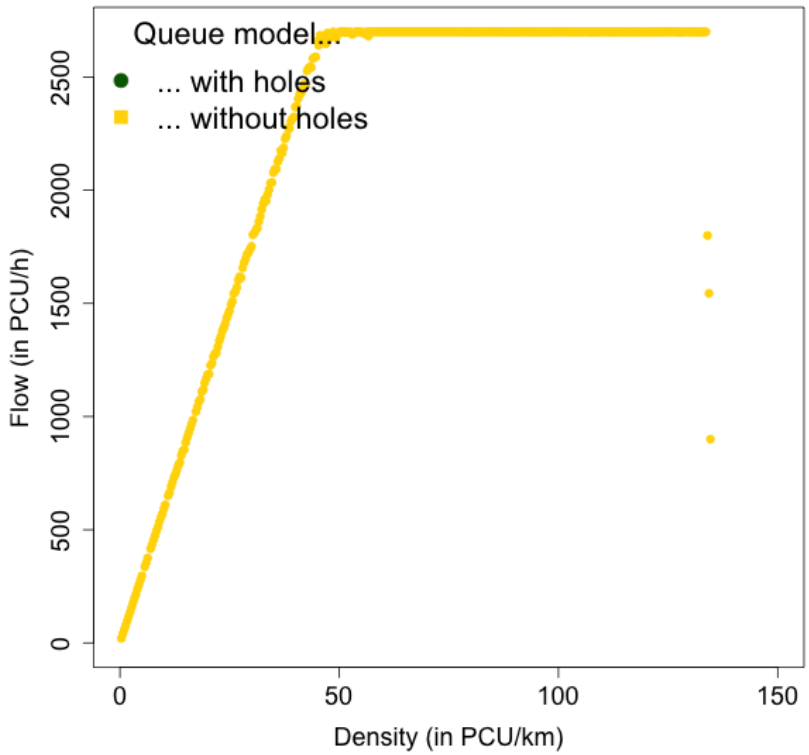
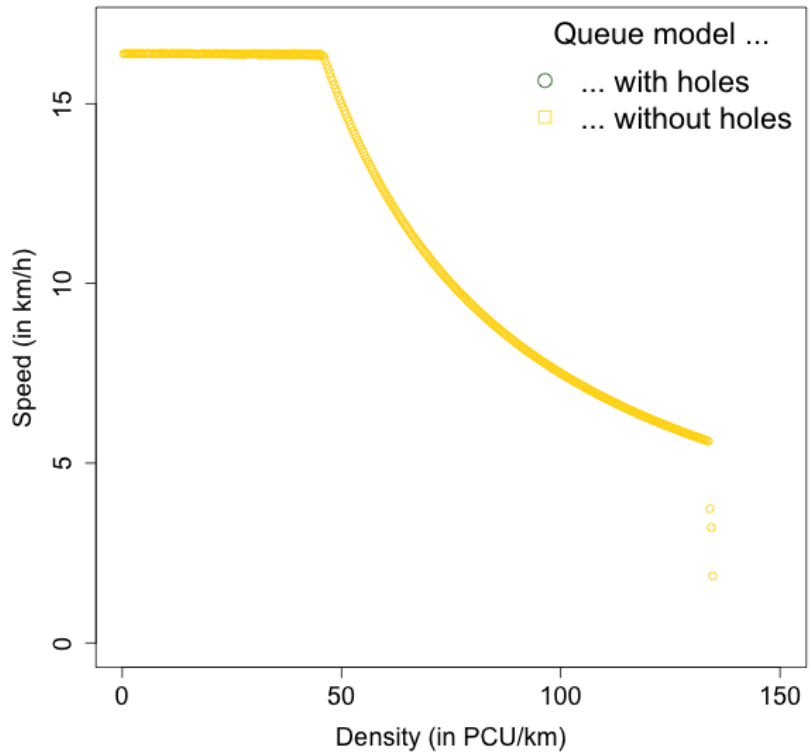
# with hole vs without hole – only car simulation



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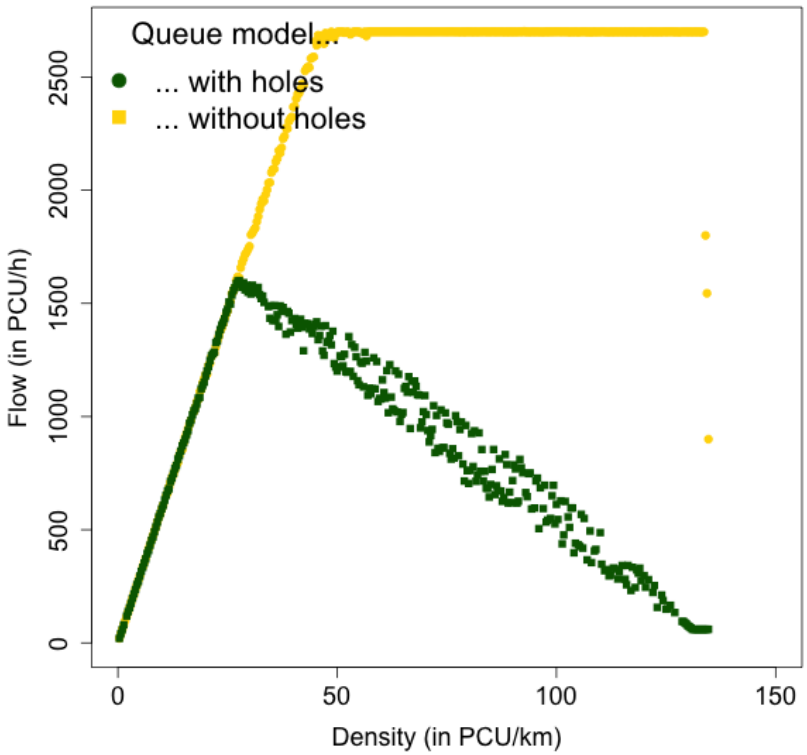


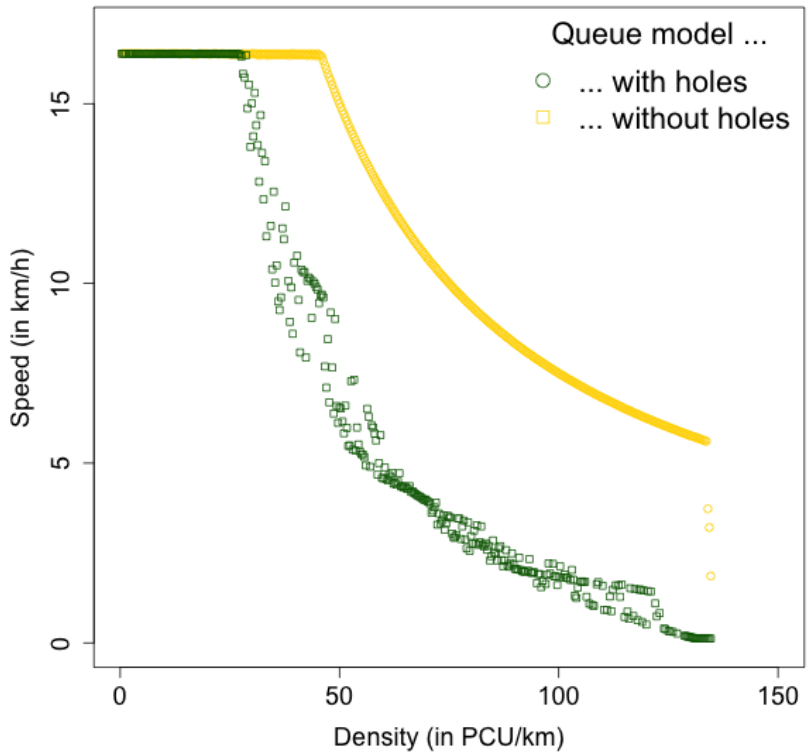

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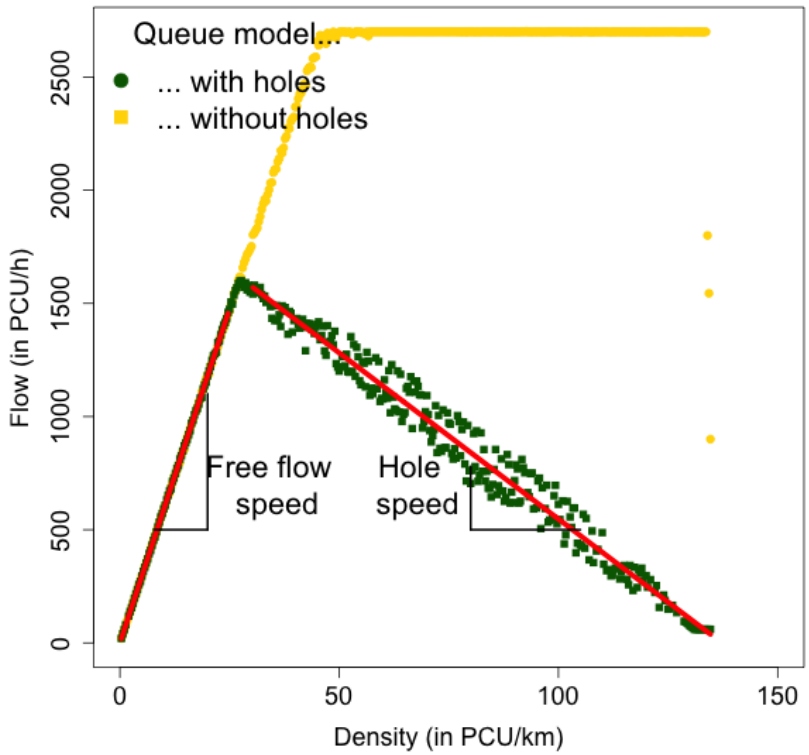
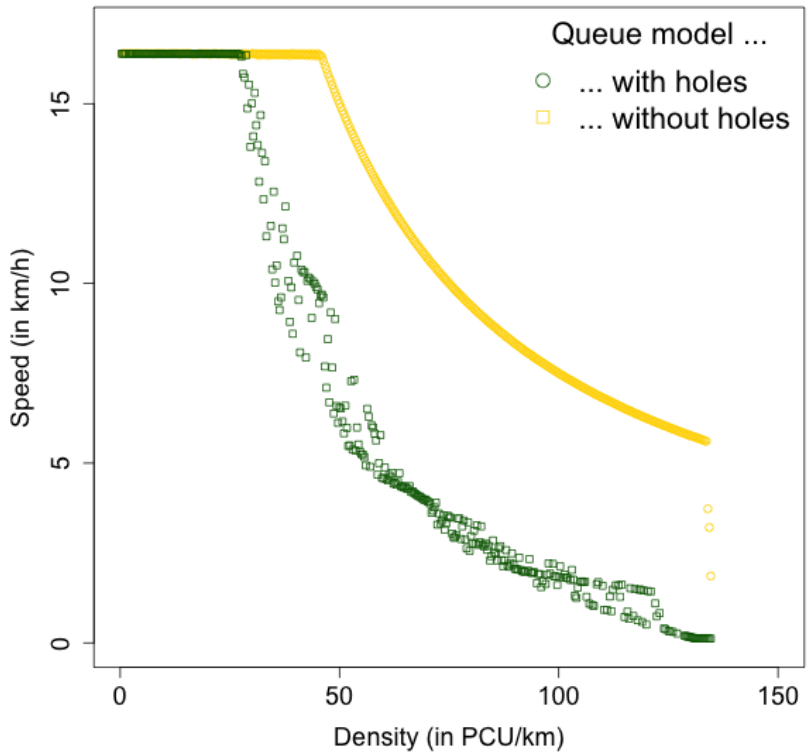
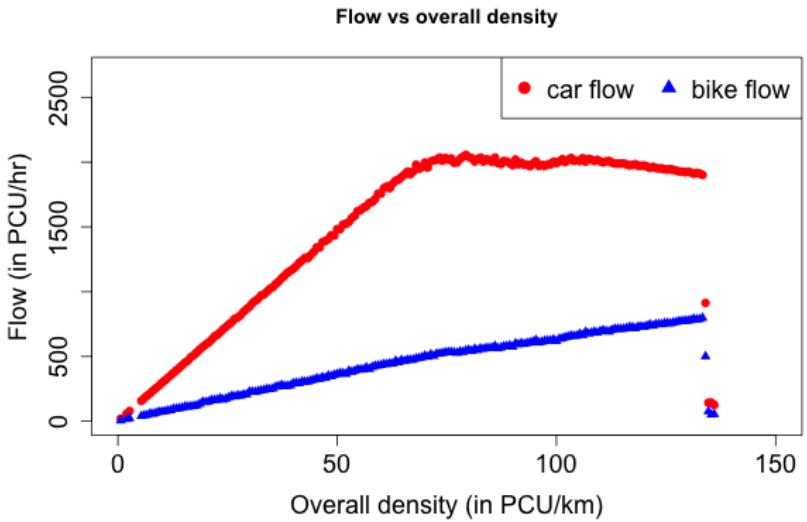
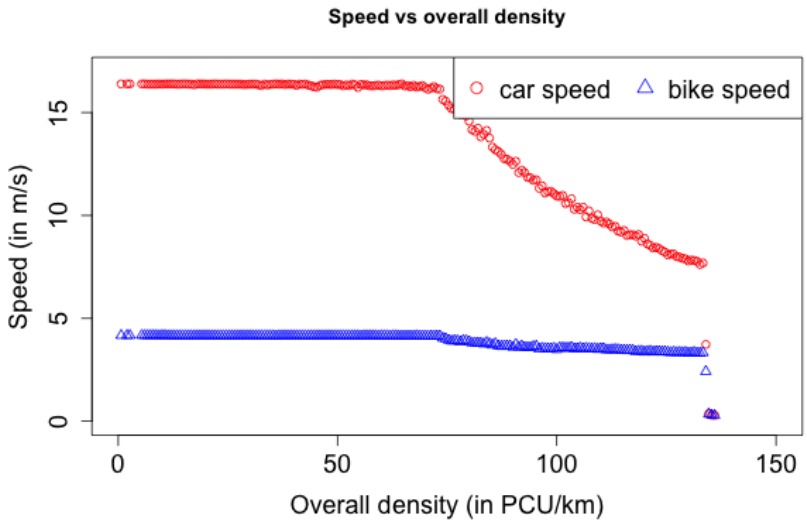


# Car bike simulation



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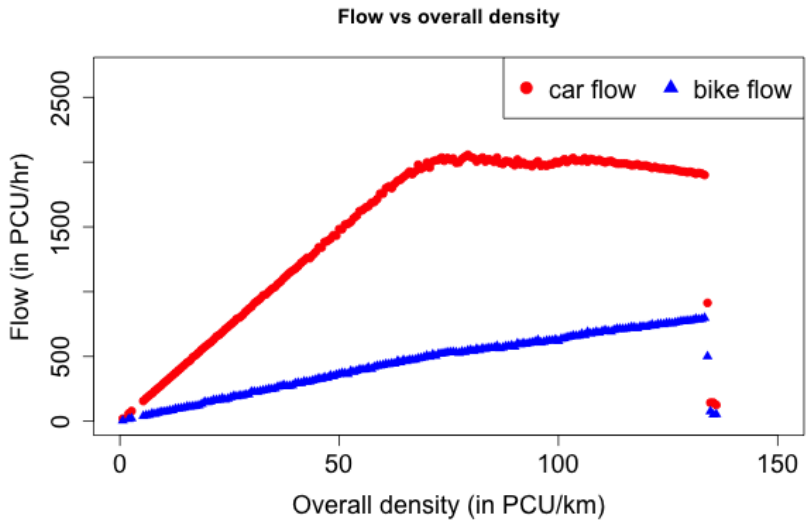


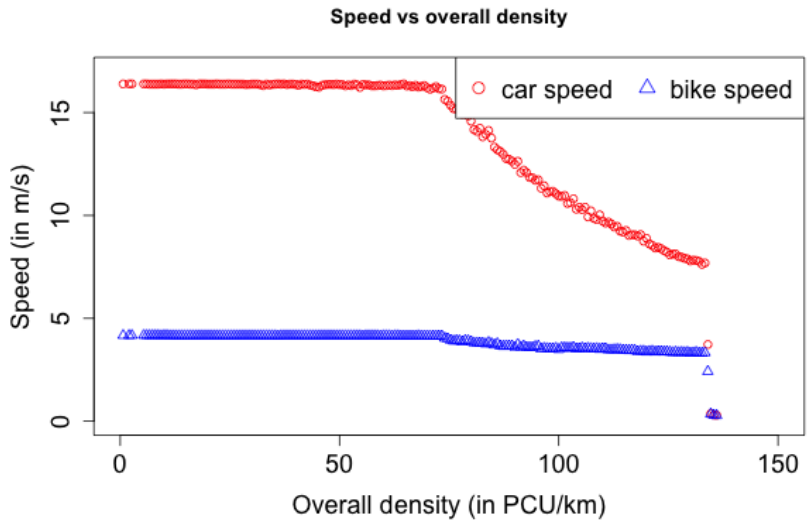


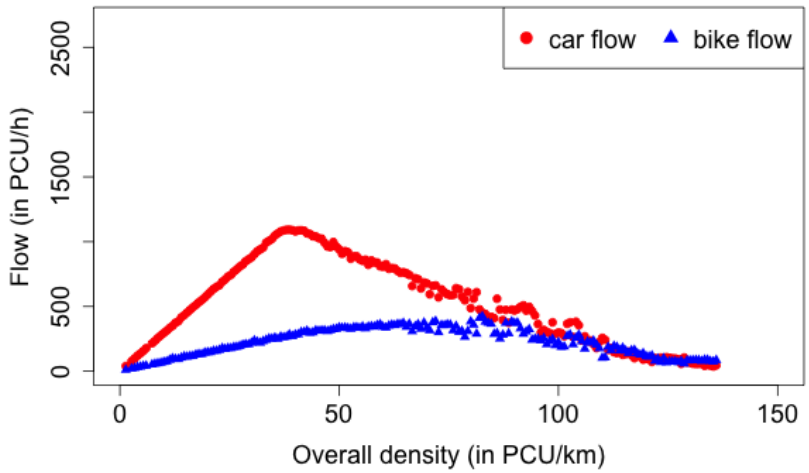


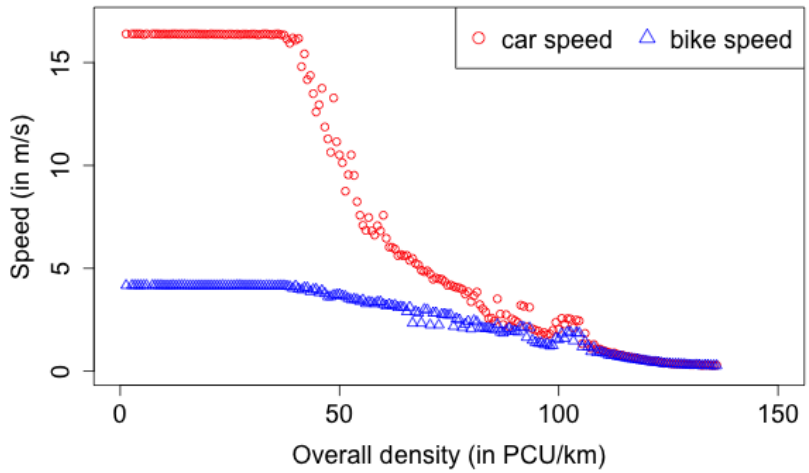

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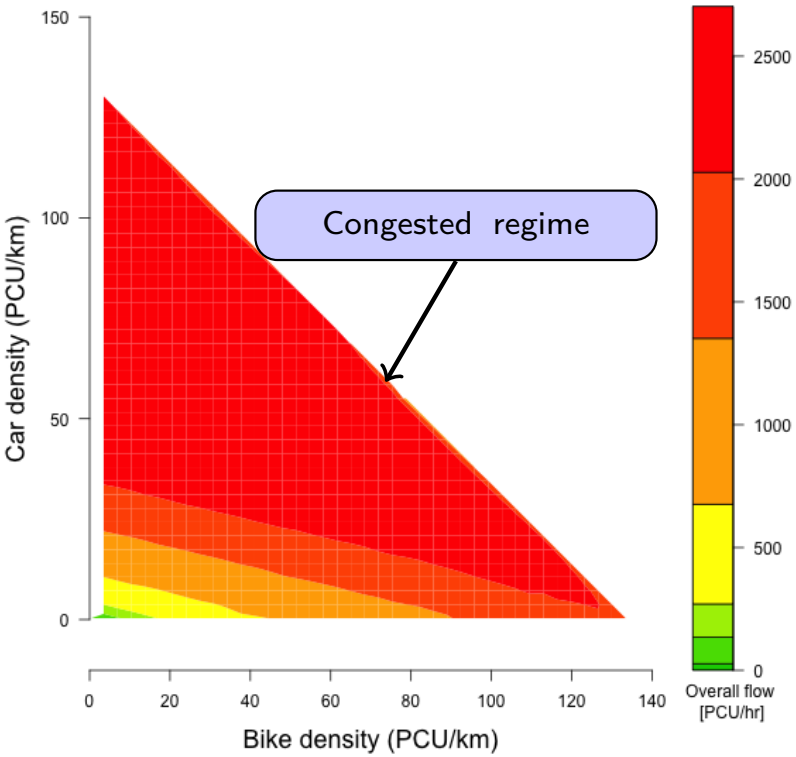
# Flow density contours

***without holes***



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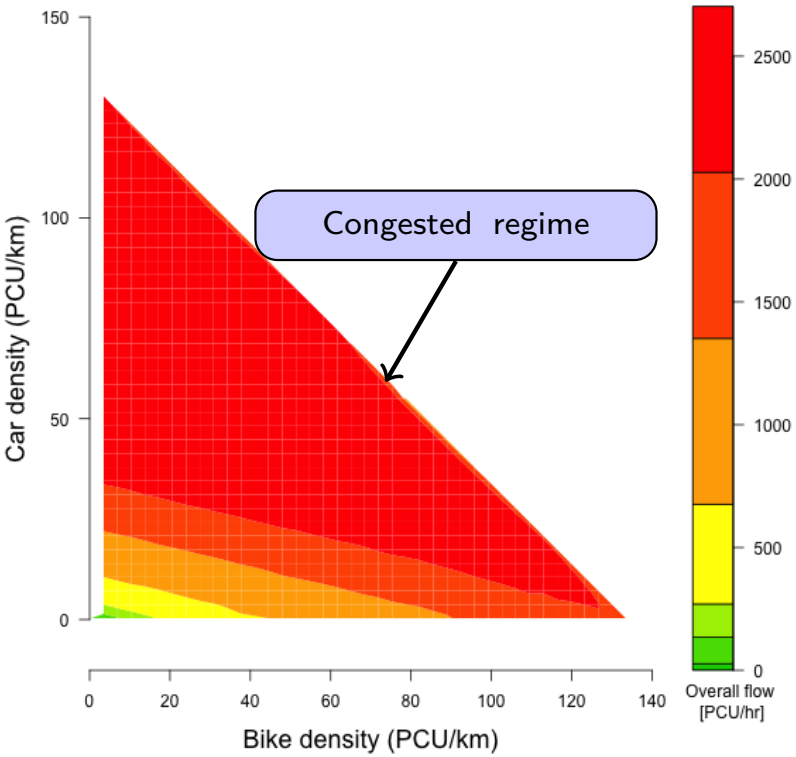
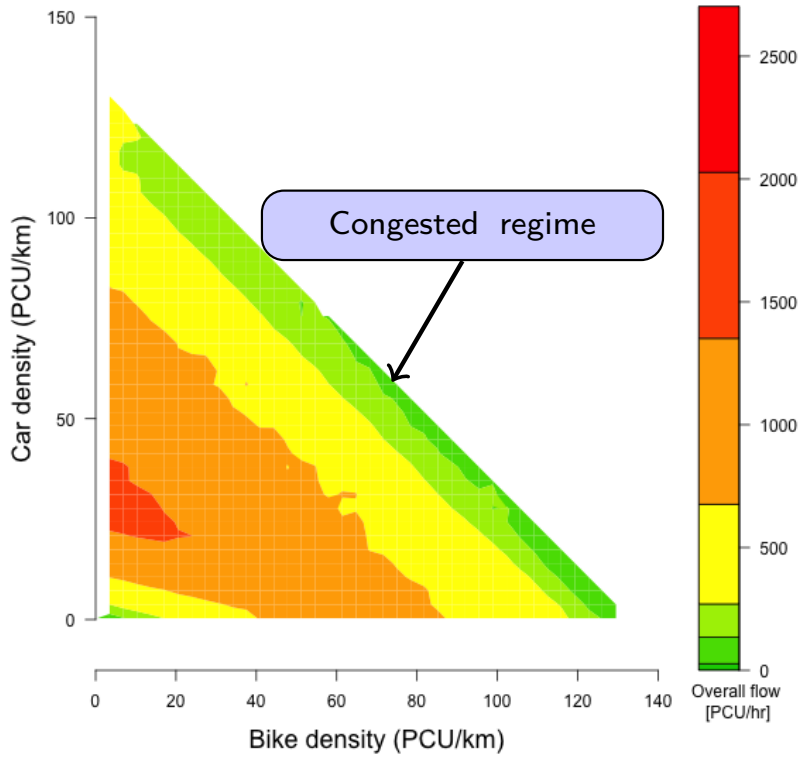
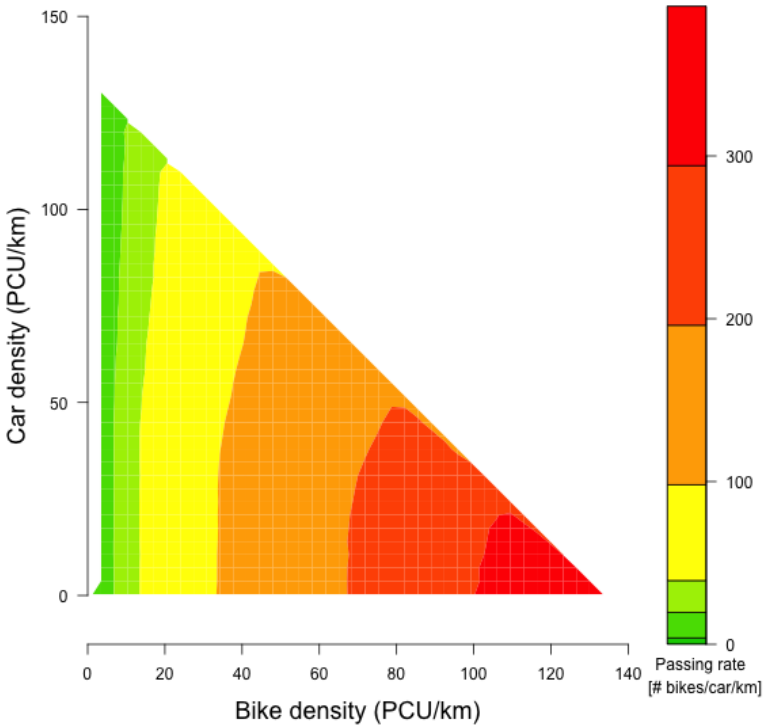



***with holes***



# Average bike passing rate contours

***without holes***



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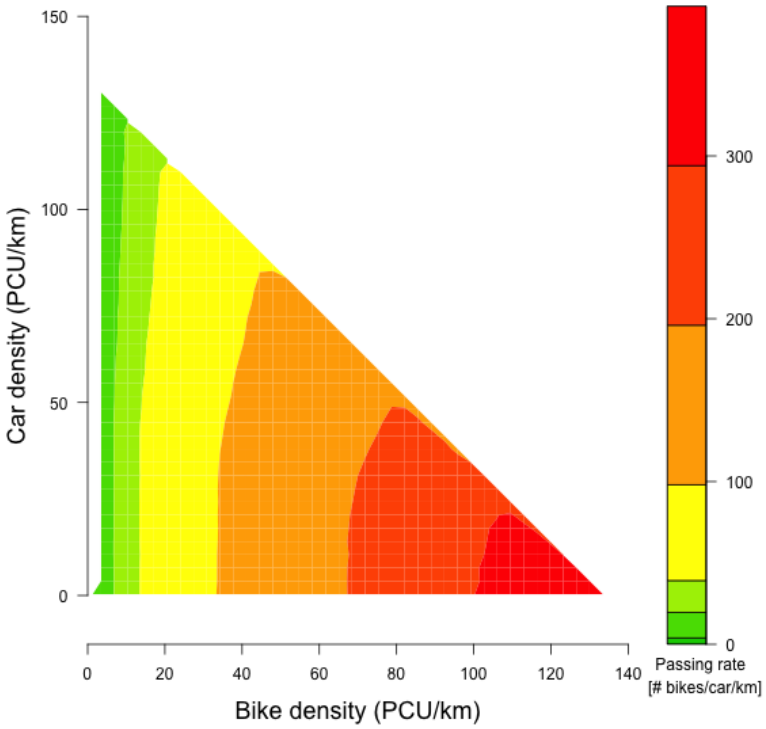
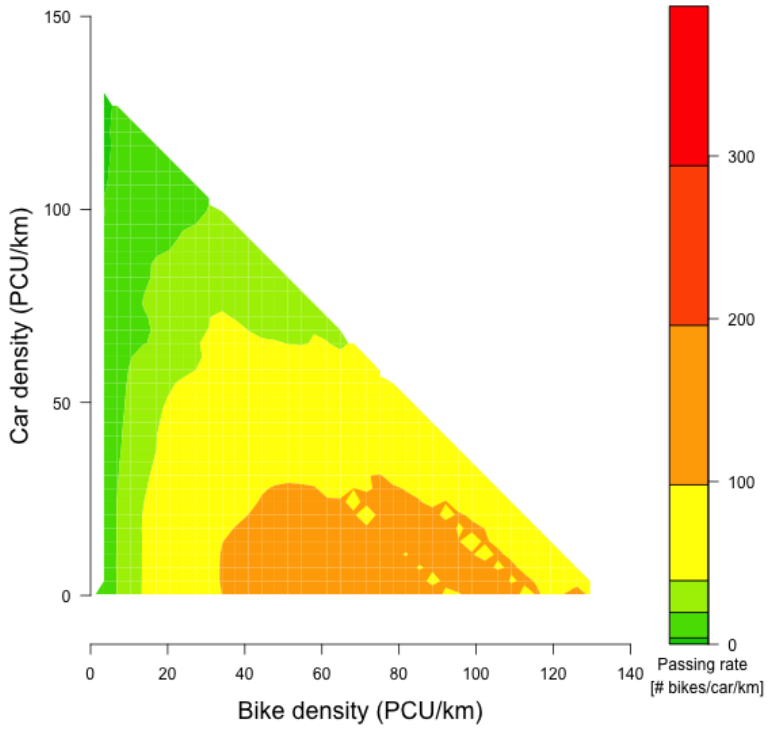



***with holes***

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## Conclusion

- Backward traveling holes in spatial queue models
- Suitable for mixed traffic and large scale scenarios
- Implicit inflow link capacity

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## Outlook

- Compare the computational efficiencies
- Apply it to a large scale real-word scenario

# References I


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# Thank you for your attention.

Questions / Comments / Suggestions ?

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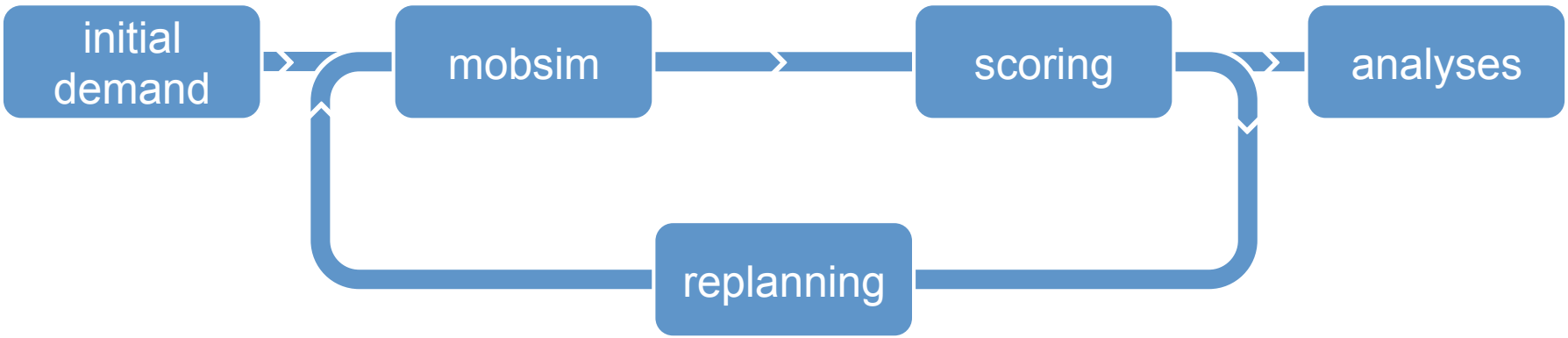
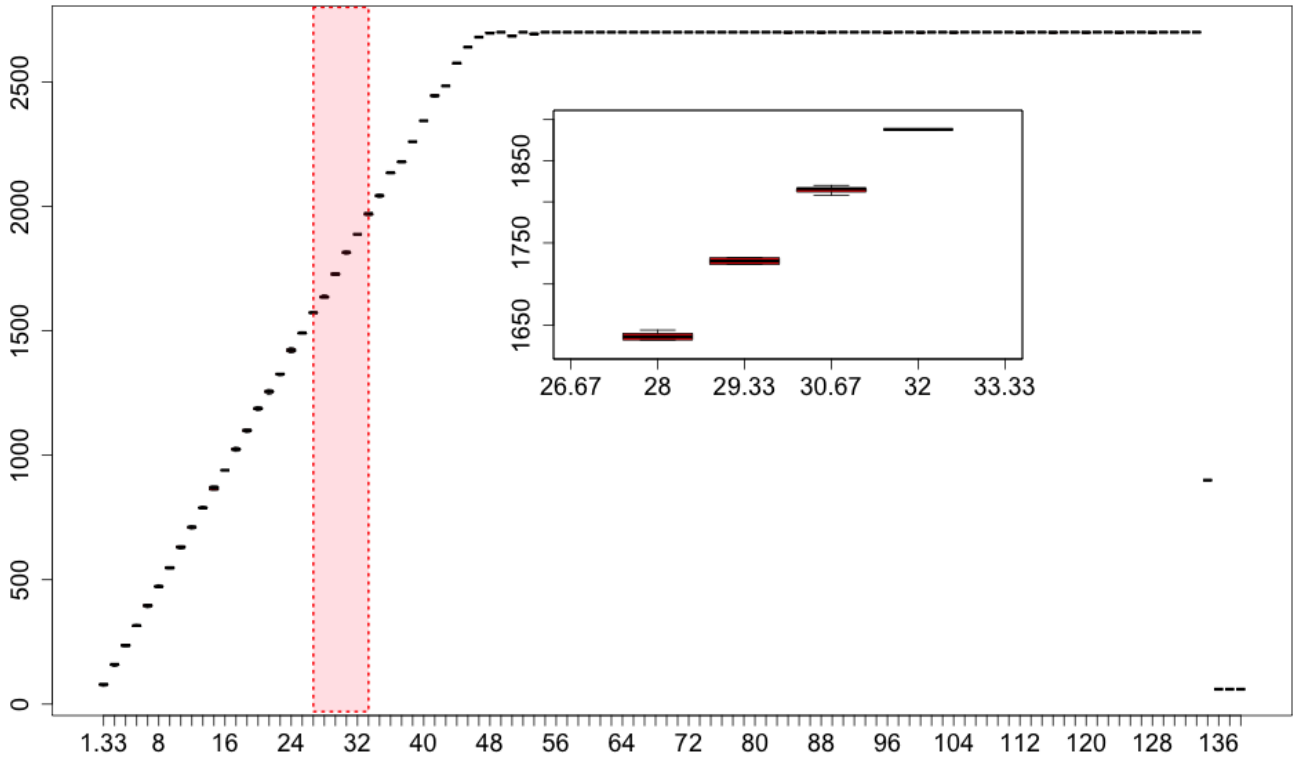
# Back up

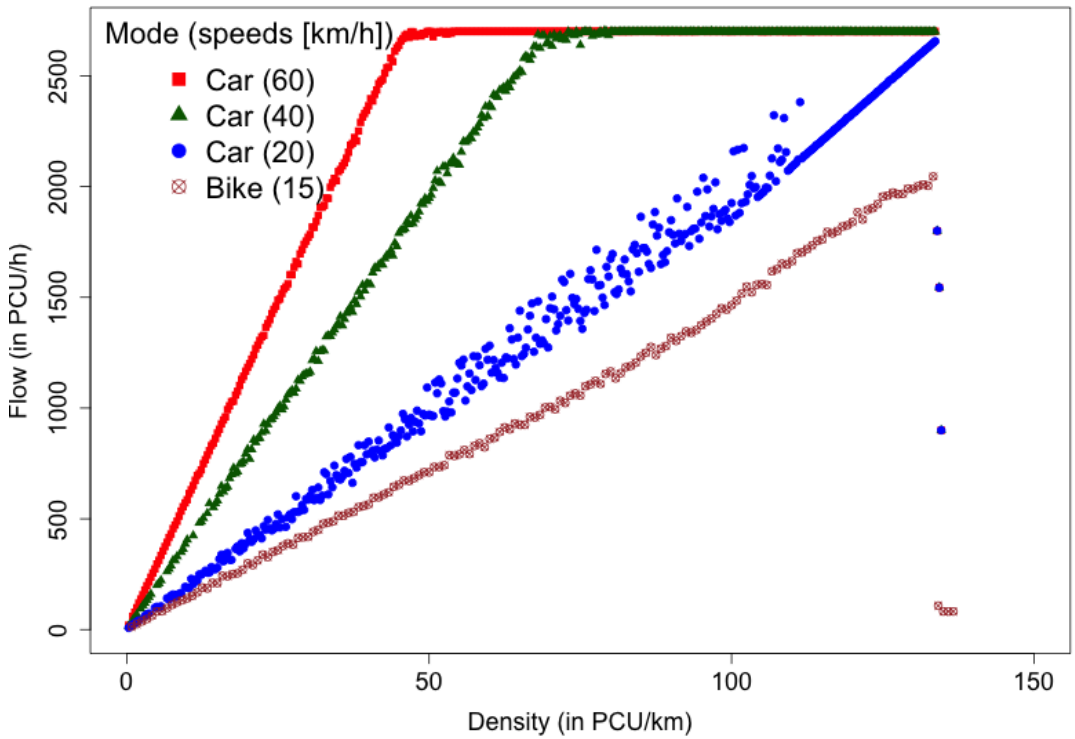
# MATSim



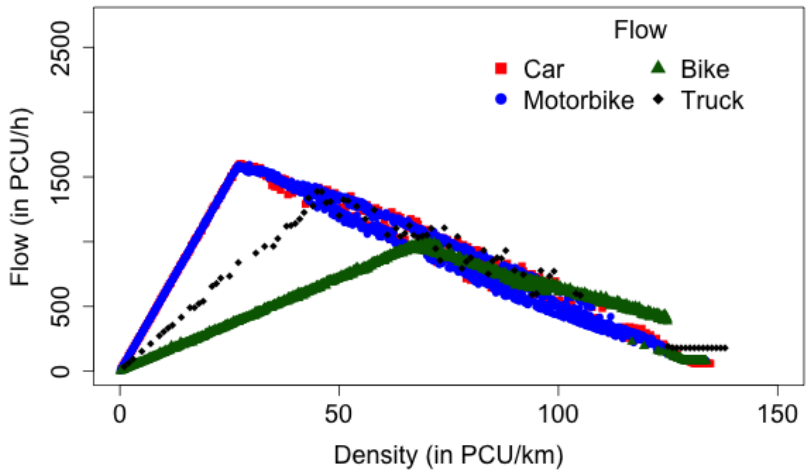
# Stead state in race track experiment

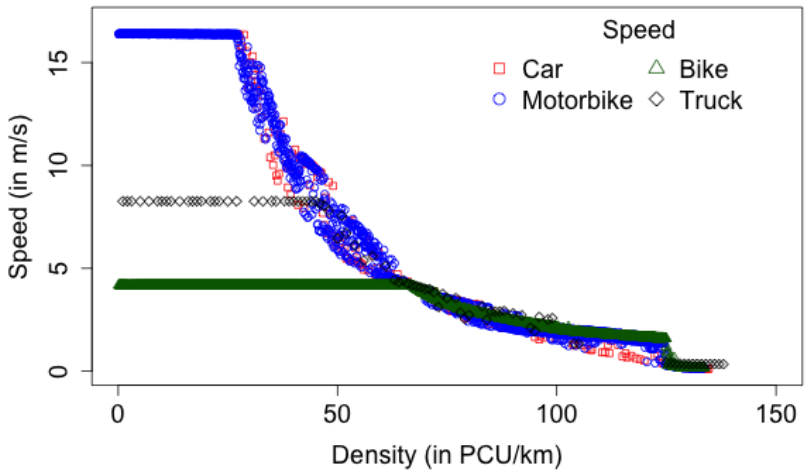


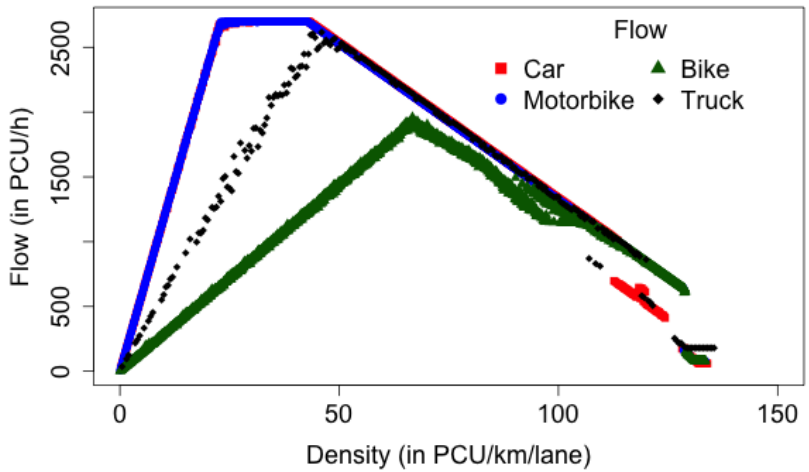
# Speed variation in queue model without holes

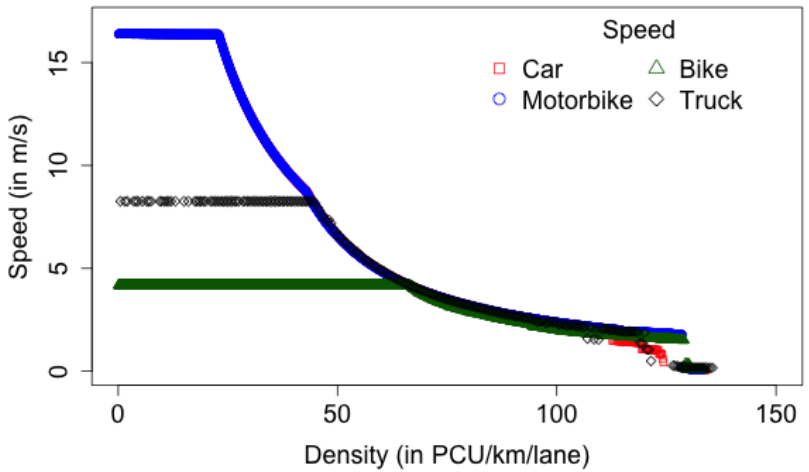


# Single modes

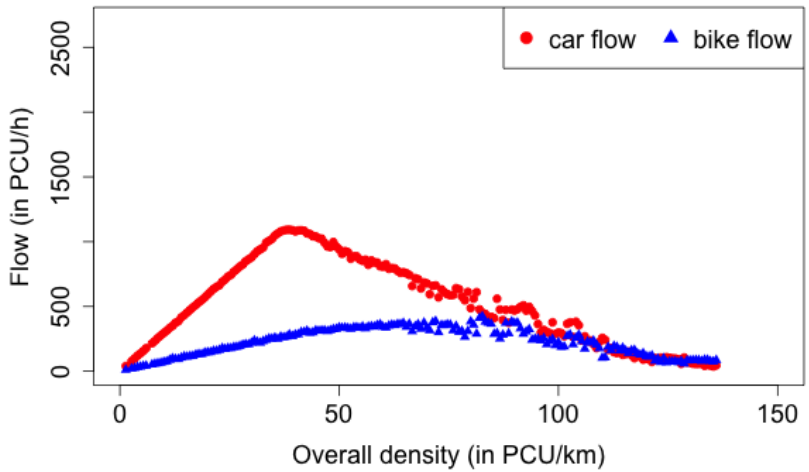


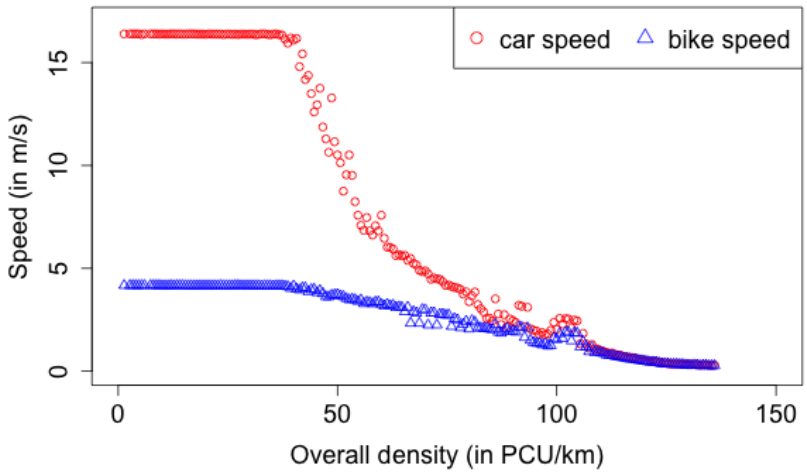



# Multiple modes



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