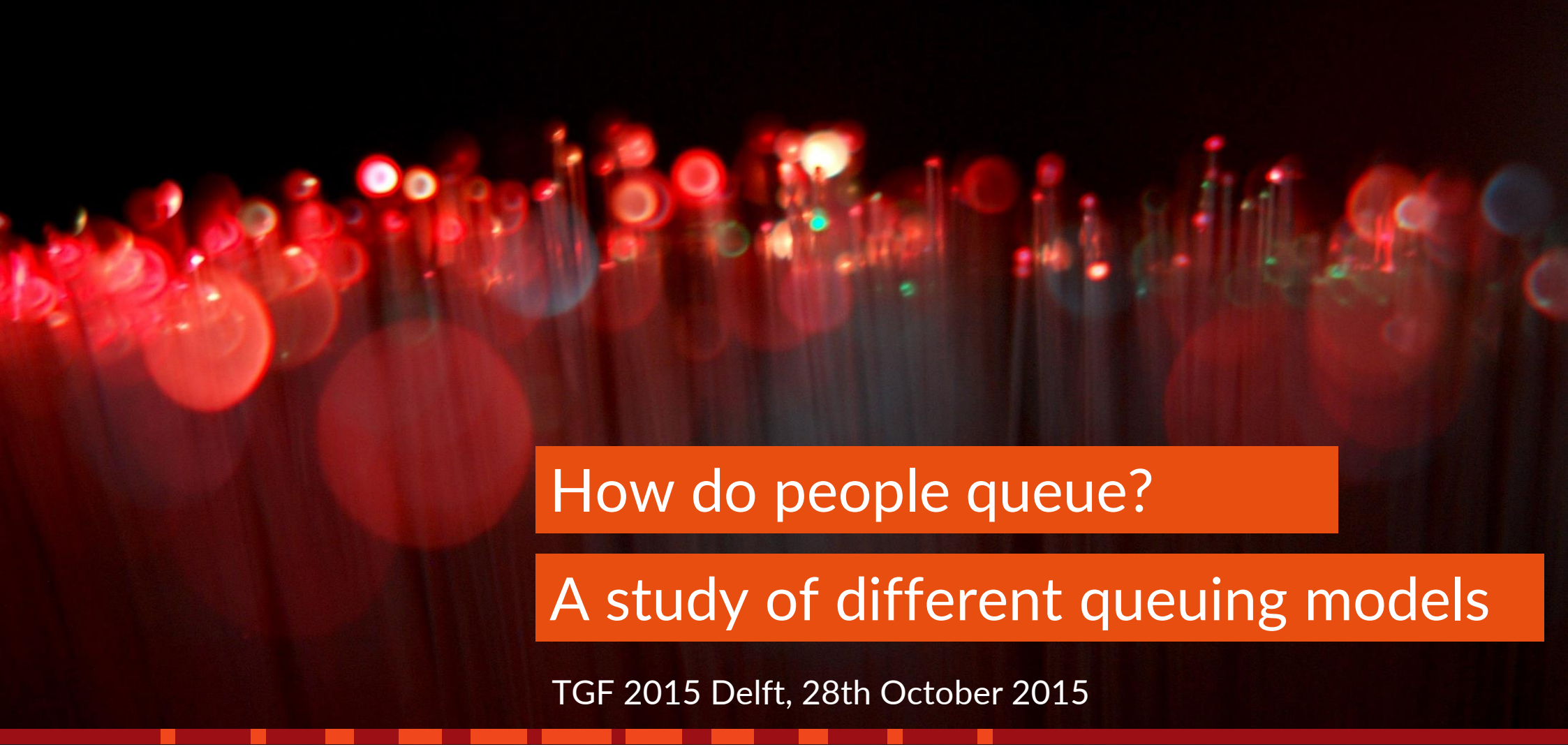

How do people queue?

A study of different queuing models

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Motivation

- Whenever there are crowded spaces, queuing occurs

- Such queuing evolves in many different ways, depending on:
  - situation
  - the reason for queuing
  - culture
  - geometry
  - …

- Simulation models have to cope with such different situations and behaviors

Queuing phenomena in real

Queuing in front of bottlenecks

Queuing in front of trains

Organized Queuing in front of service desks

Organized Queuing without demarcation tapes

Source: www.agbf.depdfHandreichung_Sicherheitsbehoerden.pdf

Queuing models at a glance

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Queue Type (Okazaki 1993)	Appearance	Characteristics	Simulation Model
Queuing in front of bottlenecks	In front of bottlenecks	Loosely queue formation	Navigational Fields with adjusted velocities
Queues in front of trains	At train boarding	Bulk of people next to opening doors	Definition of waiting zones
Organized Queuing (demarcation tapes)	In front of service points (e.g. at airports)	Queues formation and length is given by demarcation tapes	One-dimensional approach
Organized Queuing (no demarcation tapes)	In front of service points (e.g. at beer bar)	Queue width, length and form grows individually	Agent-based with knowledge about other queuing people

Queuing Models - Queuing in front of bottlenecks

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› Queuing Models uses dynamic floor fields with adapted velocities based on the Eikonal Equation (Zönnchen 2013, Köster 2014):

$$|\nabla\Phi(\vec{x})| \cdot F(\vec{x}) = 1, \Phi(\vec{x}) = 0 \text{ in } \Gamma$$

With

$$F(\vec{x}) = \frac{1}{c \cdot D(x)}$$

c will be chosen such that the pedestrians prefer to queue behind each other: pedestrians with same destinations do not slow down the wave.

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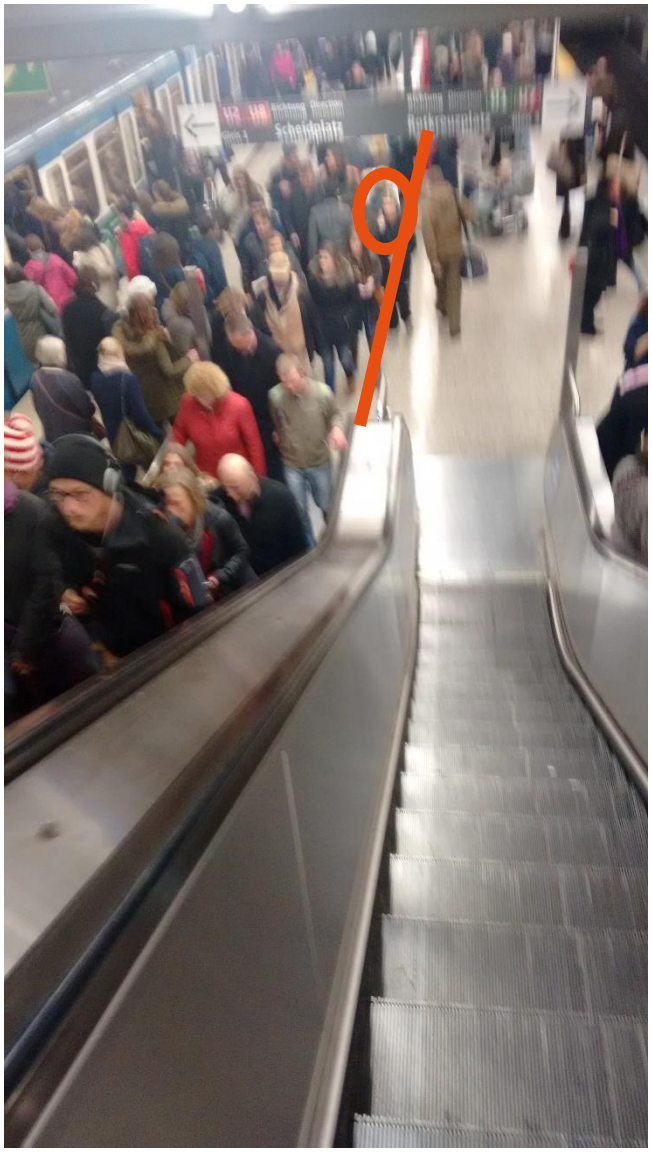
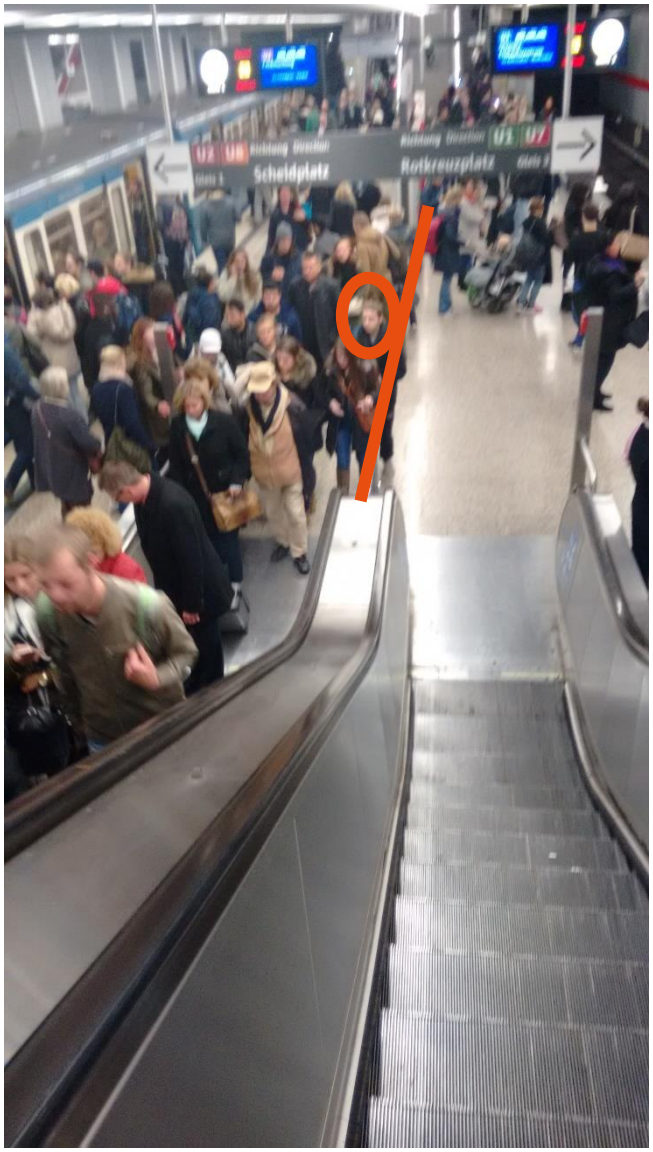
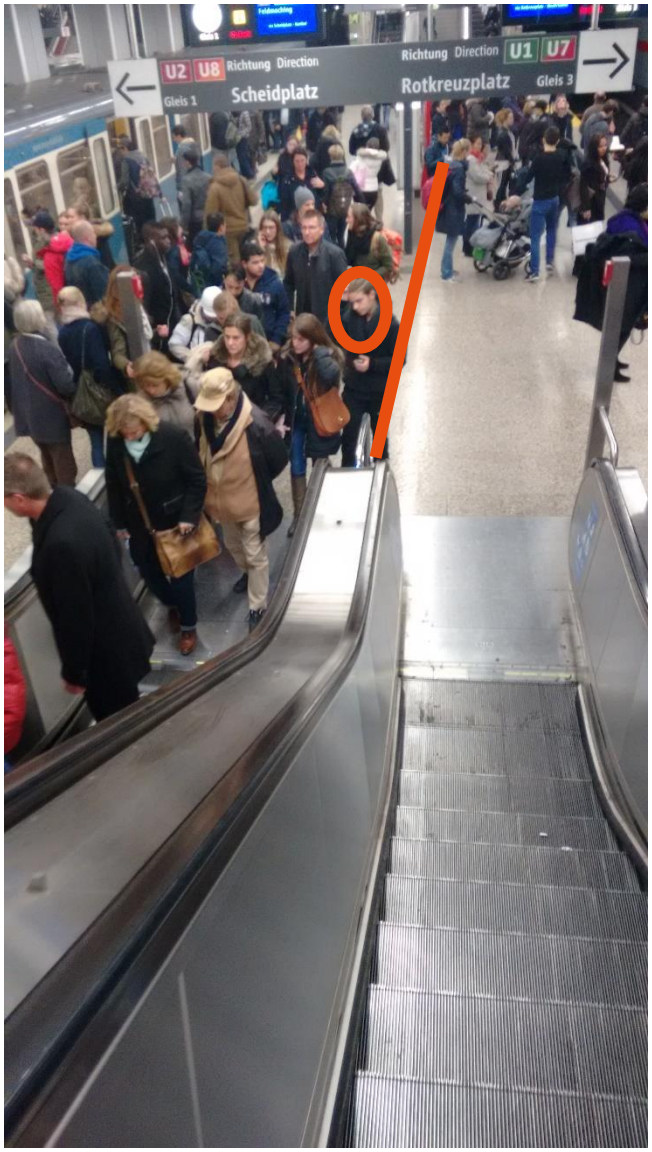
Queuing at an escalator

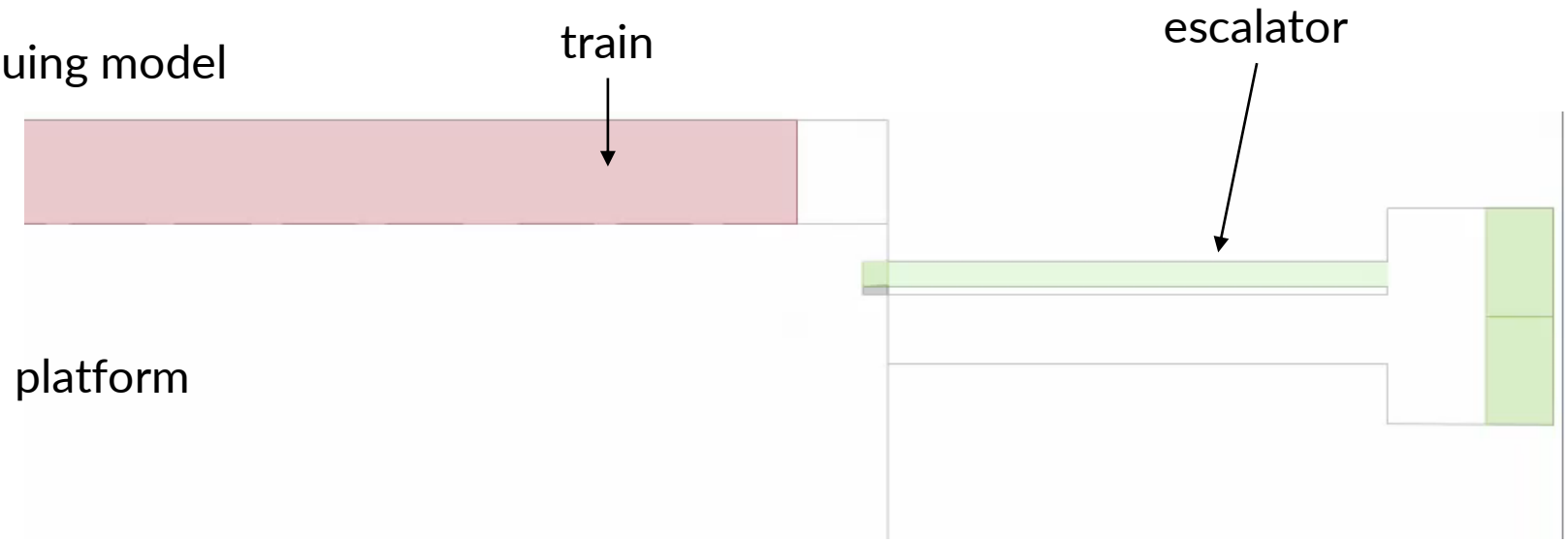




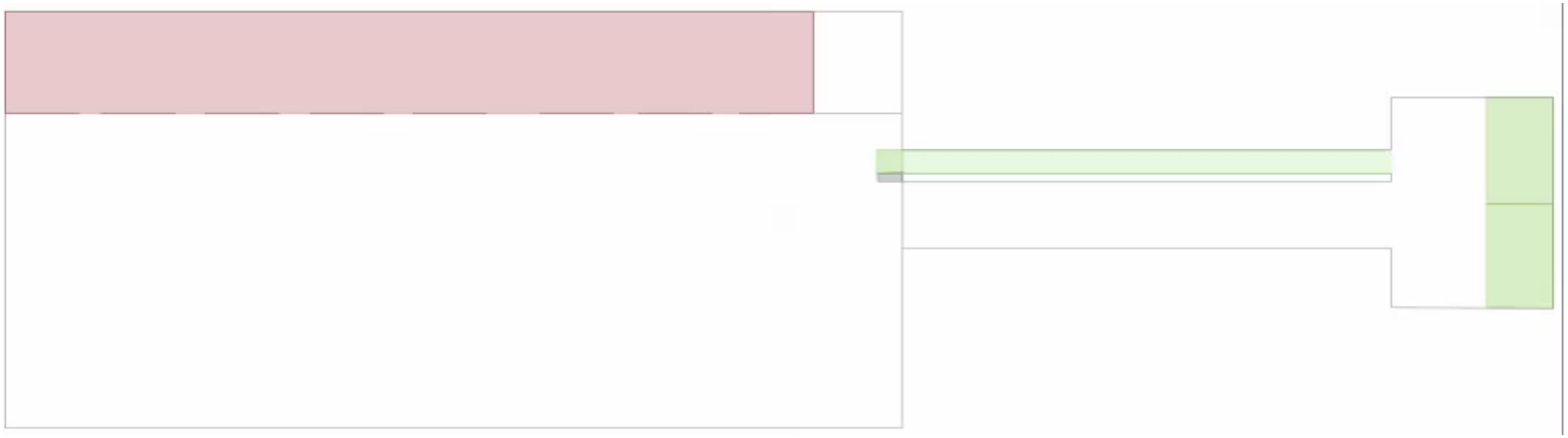


Simulation example

No queuing model

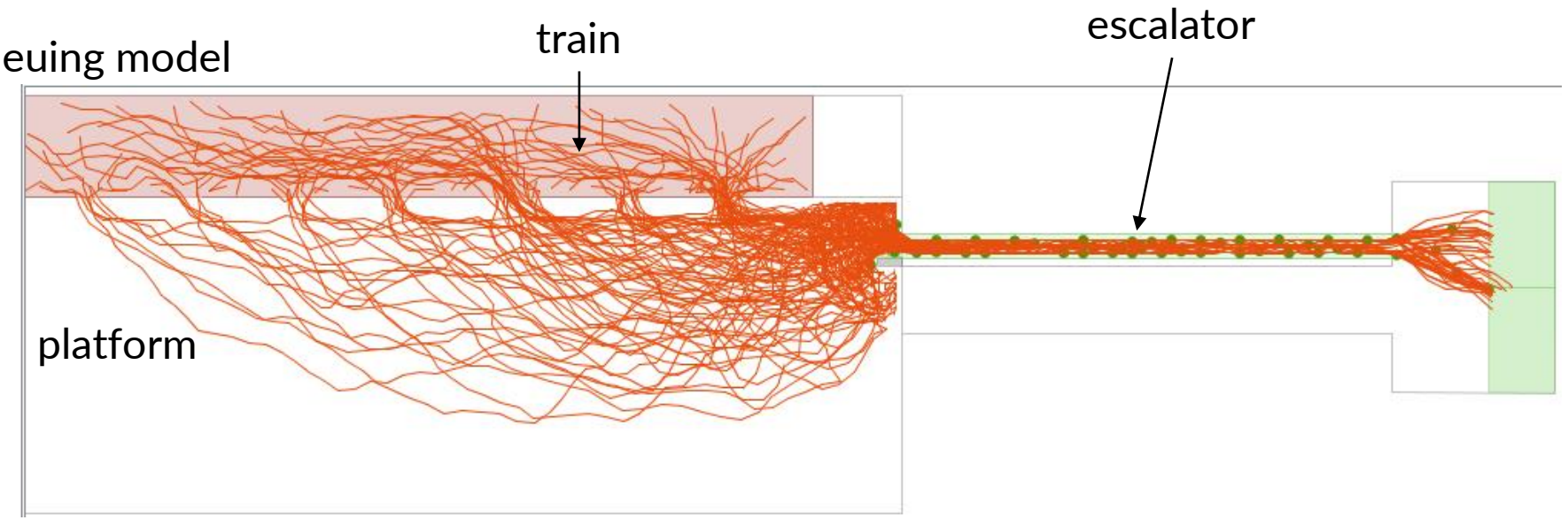


Queuing model with c=1

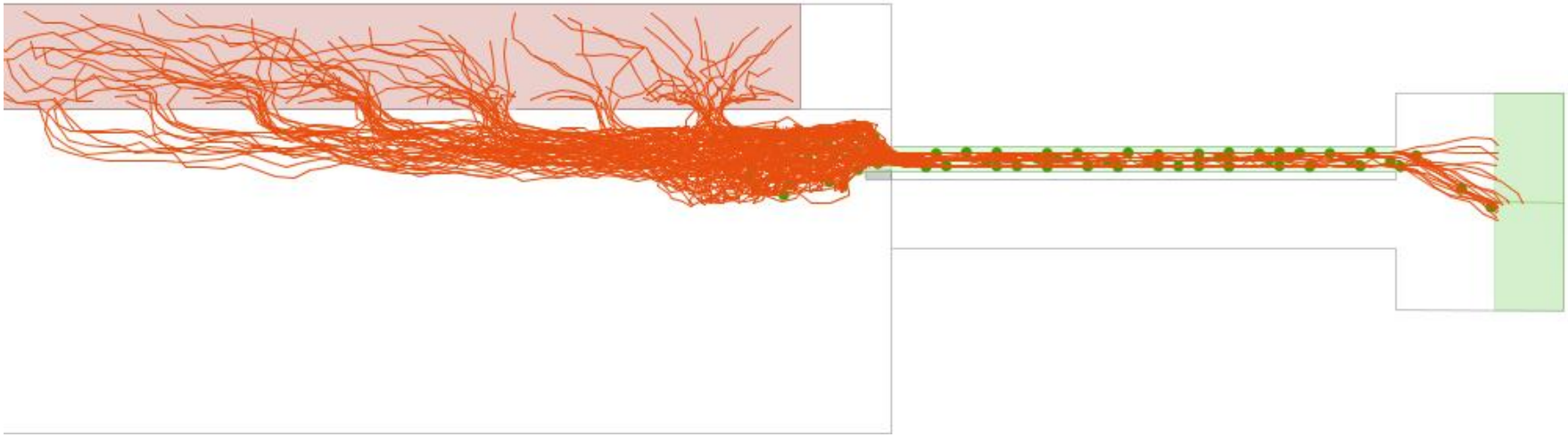


Simulation example

No queuing model



Queuing model with c=1



Queuing Models - Organized Queuing (no demarcation tapes)

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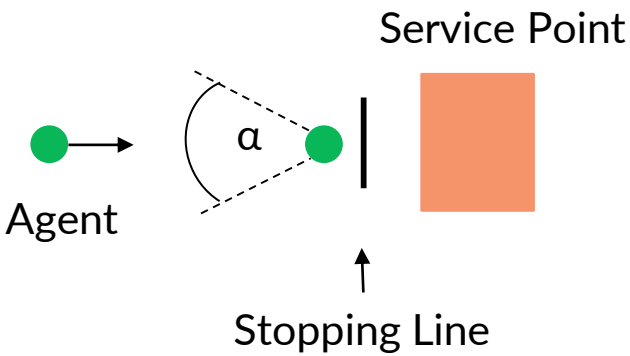
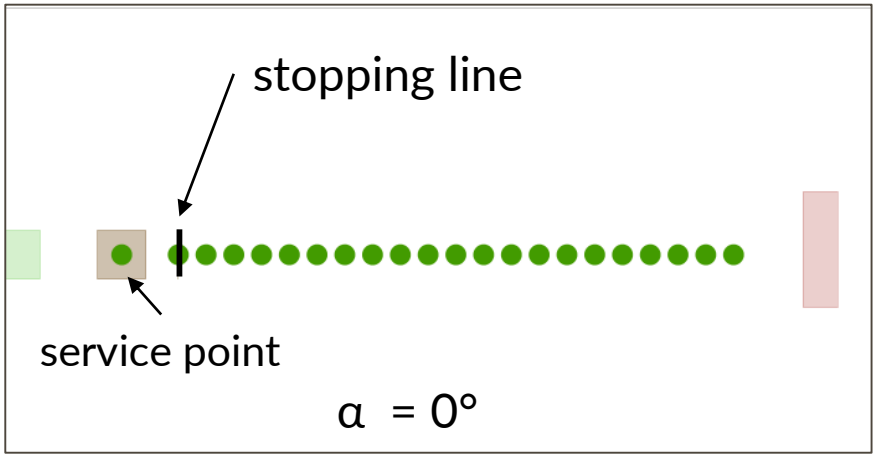
- Idea: agents stop at a defined stopping line
  - If agents already queue at this line, a spot behind the last agent is searched within a certain derivation angle.

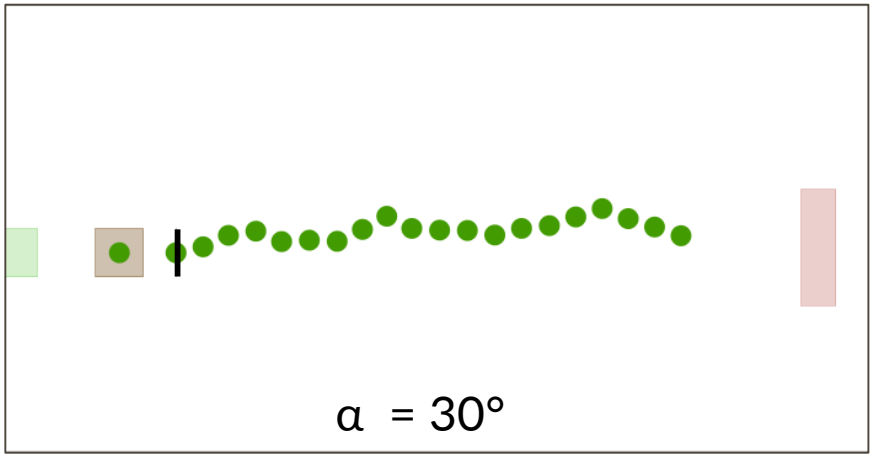
- agents start to queue as soon as the last agent in the queue is within their perception radius.
- groups tend to queue next to each other
- distances between queuing persons differs

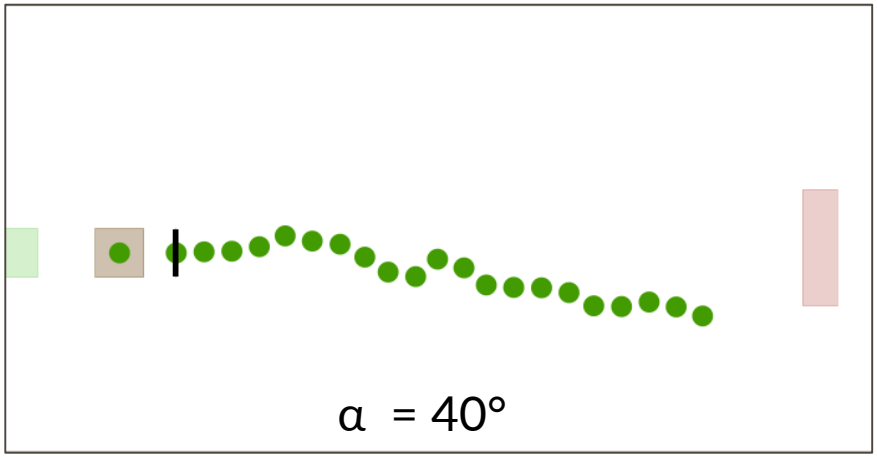
Example:

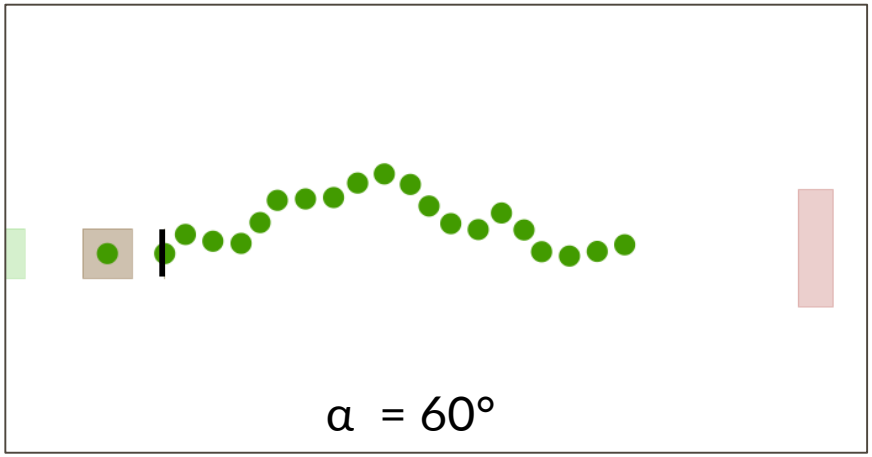


Simulation results for different derivation angles

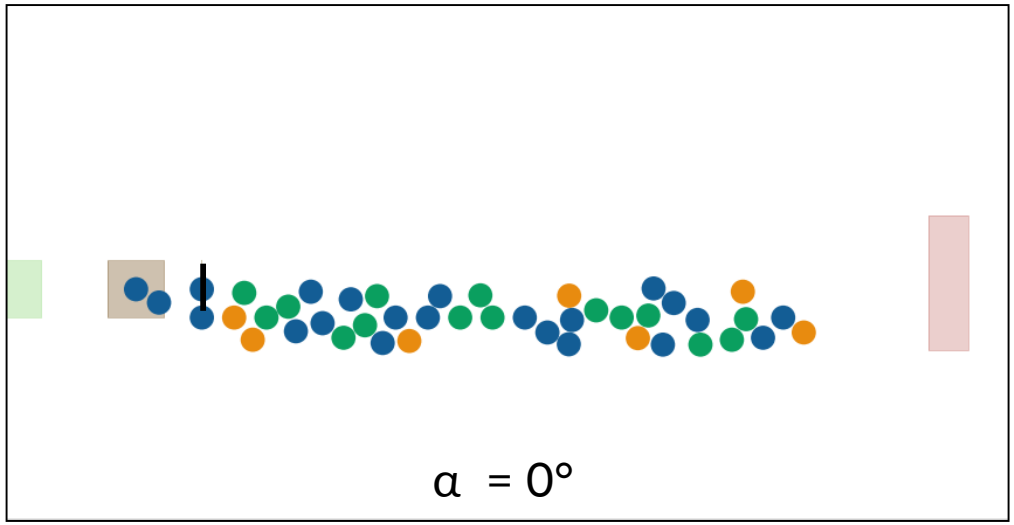


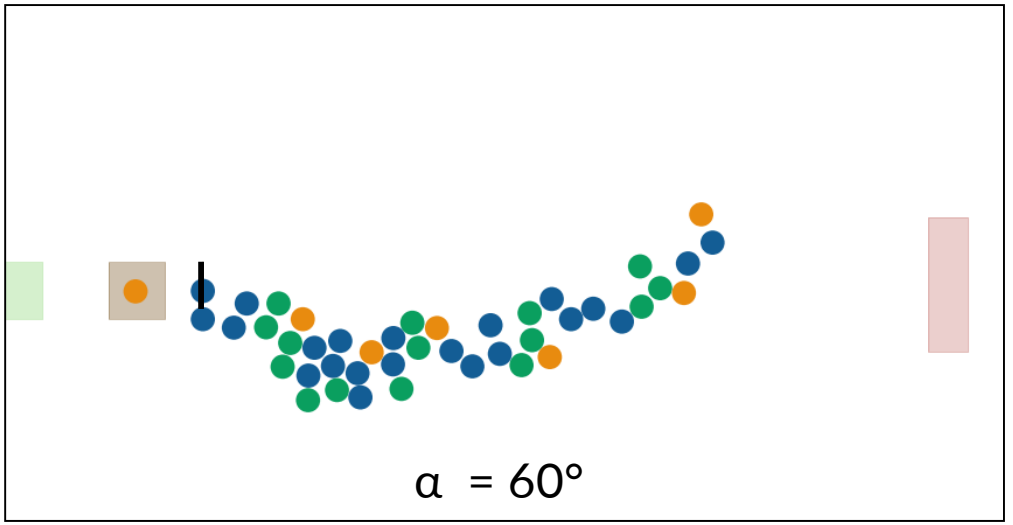






Simulation results for groups





service time at counter: 10 seconds

Group sizes:

- 3 persons (25 %)
- 2 persons (50 %)
- 1 person (25 %)

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Summary

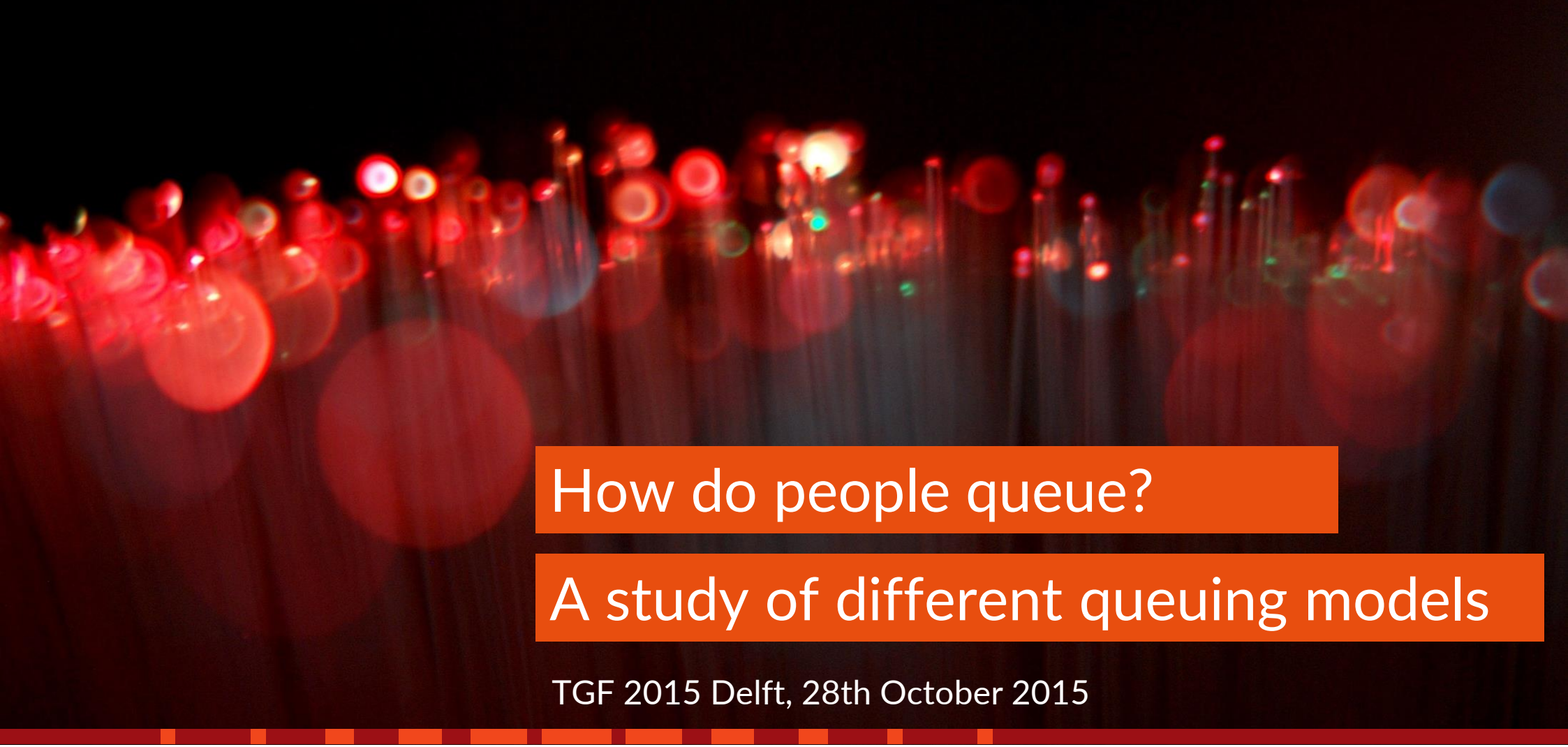
- People do queue differently depending on the situation
- Different models do exist and serve well for different occasions
- A new model was introduced for organized queuing without demarcation

Next Steps

- Further validation of the new queuing approach
- Combining different approaches in one scenario

Literature

- (Okazaki 1993) S. Okazaki, S.; Matsushita, International Conference on Engineering for Crowd Safety pp. 271–280 (1993)
- (Zönnchen 2013) B. Zönnchen, Navigation around pedestrian groups and queueing using a dynamic adaption of traveling times in the Fast Marching Algorithm, Bachelorthesis at University of Applied Sciences, Munich 2013
- (Köster 2014) G. Köster, B. Zönnchen, Queuing at bottlenecks using a dynamic floor field for navigation, Transportation Research Procedia 2(0), 344 (2014). The Conference on Pedestrian and Evacuation Dynamics 2014 (PED 2014), 22-24 October 2014, Delft, The Netherlands



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