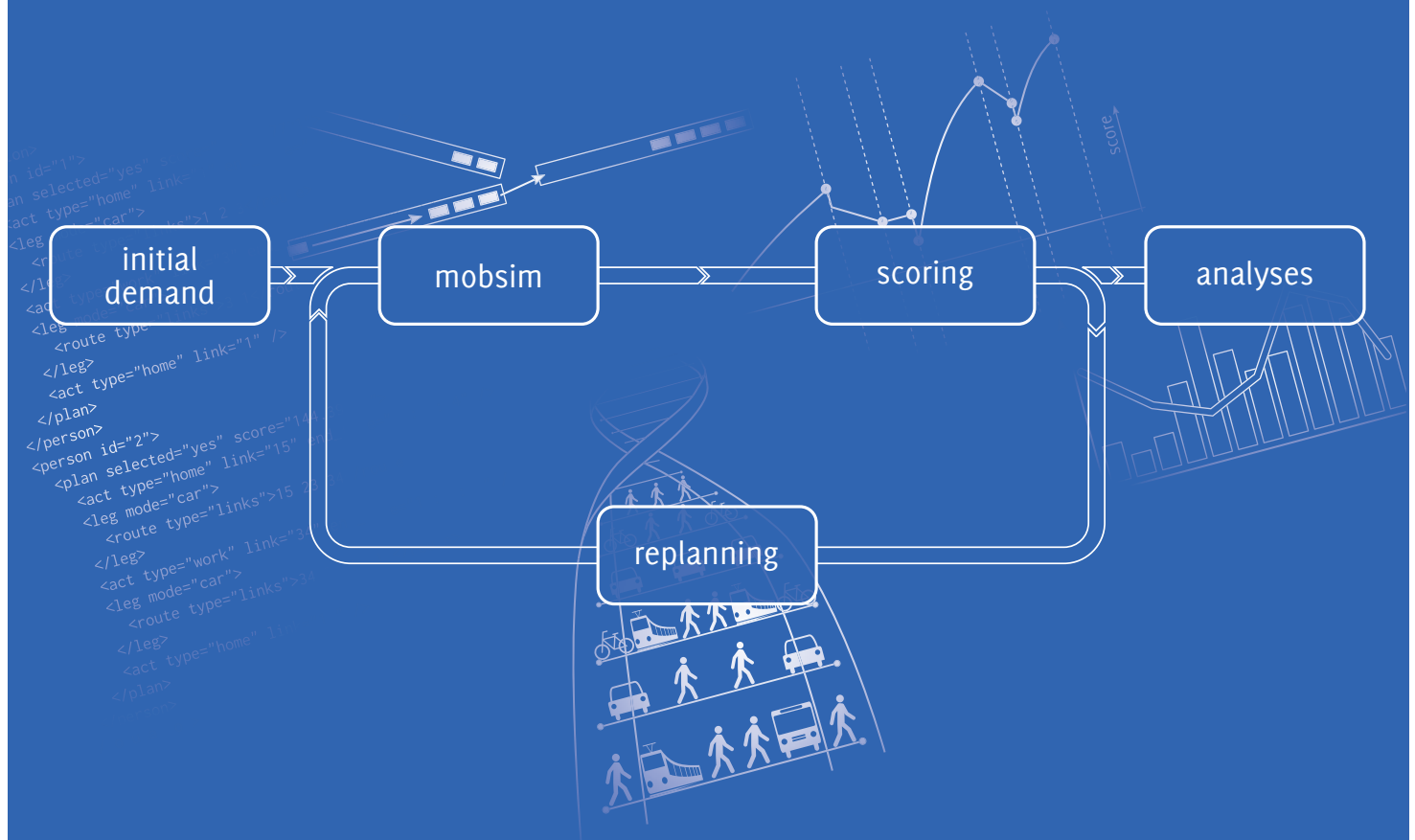# The Multi-Agent Transport Simulation MATSim

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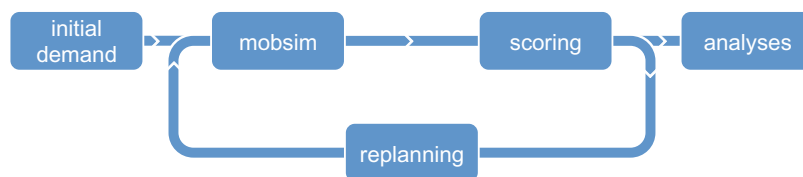
## Andreas Horni, Kai Nagel, Kay W. Axhausen



**MATSim**
**Multi-Agent Transport Simulation**

# The Multi-Agent Transport Simulation MATSim

Edited by
Andreas Horni, Kai Nagel, Kay W. Axhausen



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CHAPTER 21

# The "Multi-Modal" Contribution

## Christoph Dobler and Gregor Lämmel

## 21.1 Basic Information

**Entry point to documentation:**

http://matsim.org/extensions → multimodal

**Invoking the module:**

http://matsim.org/javadoc → multimodal → RunMultimodalExample class

**Selected publications:**

Dobler and Lämmel (2014)

## 21.2 Introduction

MATSim's standard mobsim, QSim, has recently been enabled to model multimodal scenarios as shown in Section 4.6.

In this chapter,[1] an earlier approach to handle multimodal scenarios, the multimodal link contribution, is presented. As shown below, it is a very efficient approach, that considers persons' biking and walking speeds to improve the teleportation estimates for these modes, whereas mode interactions are not taken into account.

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[1] Parts of this chapter are based on work published at the 6th International Conference on Pedestrian and Evacuation Dynamics in Zürich Dobler and Lämmel (2014).

## 21.3   Modeling Approach and Implementation

### 21.3.1   Multi-modal Link Contribution

Figure 21.1 shows the implementation's basic concept—a multimodal contribution is added to each link object in the mobsim.

While traffic flow dynamics are simulated by MATSim's mobsim using a queue model, these flows are not taken into account in the multimodal contribution. Examining typical pedestrian and cyclist traffic flows shows that congestion is very rare compared to vehicular traffic, justifying application of this simplistic approach over a scenario. For regions with higher traffic flows, this simple model loses accuracy, but still outperforms the teleportation approach, which MATSim uses by default.

Each multimodal link contribution uses a priority queue to manage all agents traveling on that link using a non-motorized mode. The queue orders the agents based on their scheduled link leave time (see Figure 21.2). This time is calculated when an agent enters a link and is based on parameters like the agent's age and gender, as well as the links' steepness. In each time step, it is checked whether the queue contains agents who have reached their link leave time and thus must be moved to their route's next link. An agent's position on a link is not determined by the model. However, under the assumption that agents move with constant speed, their position can be interpolated. This approach is computationally very efficient, because computation effort is created only when an agent enters or leaves a link but not when it is traveling along a link. Additionally, agents can travel at different speeds, so can overtake each other.

### 21.3.2   Travel Times

Walk travel time calculation is based on results of a comprehensive literature review by Weidmann (1992). Starting point is a normally distributed reference speed of 1.34 meters per second with a standard deviation of 0.26 meters per second, which leads to an individual reference speed for each person. FGSV (2009) and Transportation Research Board (2010) report comparable,
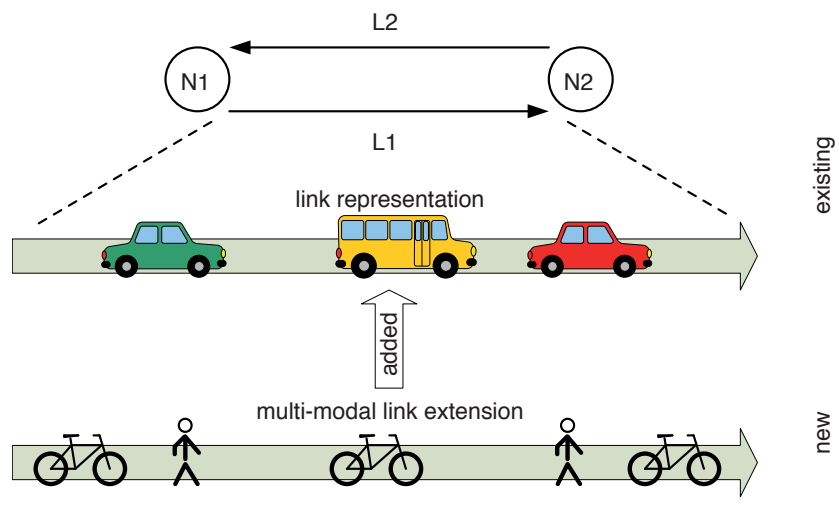


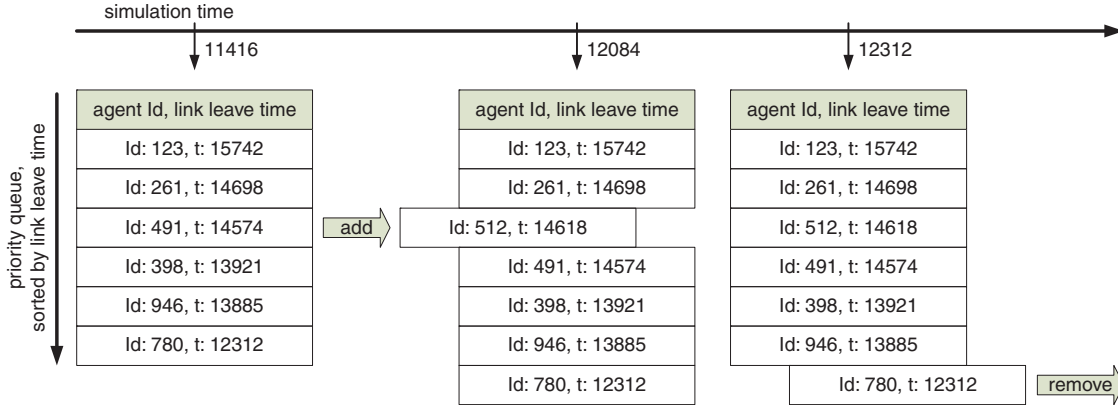**Figure 21.1:** Multi-modal link contribution.

**Figure 21.2:** Link representation in the simple model.
At time 12 084 seconds from midnight, agent 512 enters the link and is—based on its calculated link leave time 14 618 seconds from midnight—inserted into the queue. At time 12 312 seconds from midnight, agent 780 has reached its leave time and is then removed from the queue.

but less detailed data. If a trip's purpose is known, a person's reference value can be adjusted (commuting 1.49 meters per second, shopping 1.16 meters per second, leisure 1.10 meters per second; see FGSV, 2009). Using the reference speed and referencing a person's age, gender and statistical spreading, a personalized speed is calculated (see Figure 21.3(a)). Finally, to calculate the person's travel time on a specific link, influence of the link's steepness on the person's speed is taken into account (see Figure 21.3(b)). The combination of person-specific attributes and link steepness is shown in Figure 21.3(c).

As a result, a person's speed on plain terrain is calculated as:

$$f_{\text{person}} = f_{\text{statistical spreading}} \cdot f_{\text{gender}} \cdot f_{\text{age}} \tag{21.1}$$

$$v_{\text{person, walk}} = v_{\text{reference, walk}} \cdot f_{\text{person}} \tag{21.2}$$

A link's steepness is incorporated as:

$$v_{\text{person walks on link}} = v_{\text{person, walk}} \cdot f_{\text{steepness}} \tag{21.3}$$

The speed of cyclists is determined using results from Parkin and Rotheram (2010). Starting point is, again, an individual's speed based on a normal distributed ($\mathcal{N}(6.01, 1.17)$) reference speed. Once more, a person's speed is calculated by accounting for age and gender (see Figure 21.4(a)).

When calculating the steepness factor, one must define whether a link goes uphill or downhill. When going uphill, the person's speed is reduced by a factor based on the grade and a reference factor of 0.4002 meters per second, which is scaled by the same factor as the person's reference speed. i.e., the speed drop of slow people is lower than the drop of fast people. When bike speed drops below walk speed, which happens at a grade of approximately 12 %, it is assumed that the person switches to walking (see Equation (21.5)). For downhill links, a reference factor of
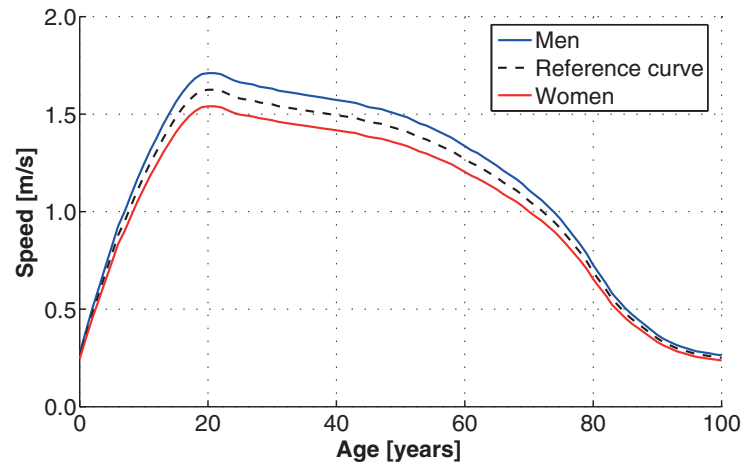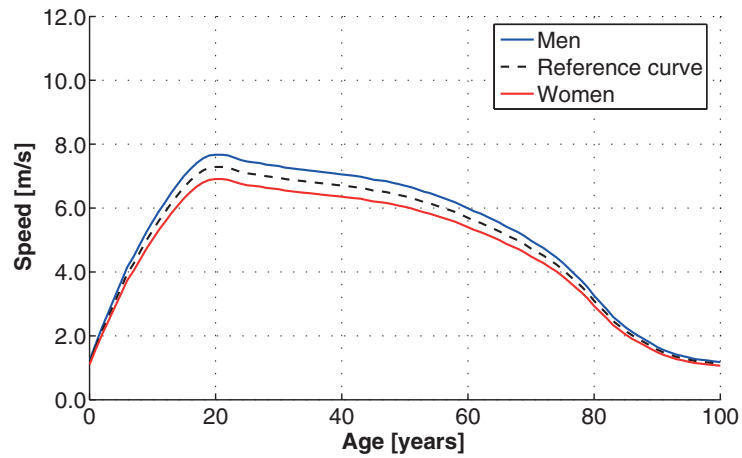
(a) Age dependent speed.
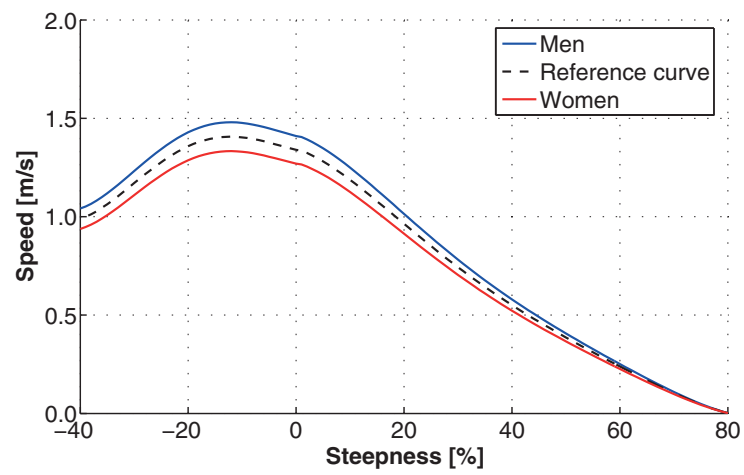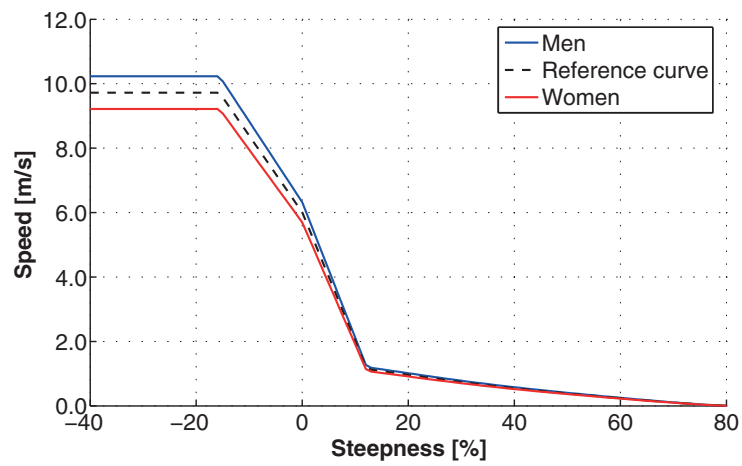


(b) Steepness dependent speed.
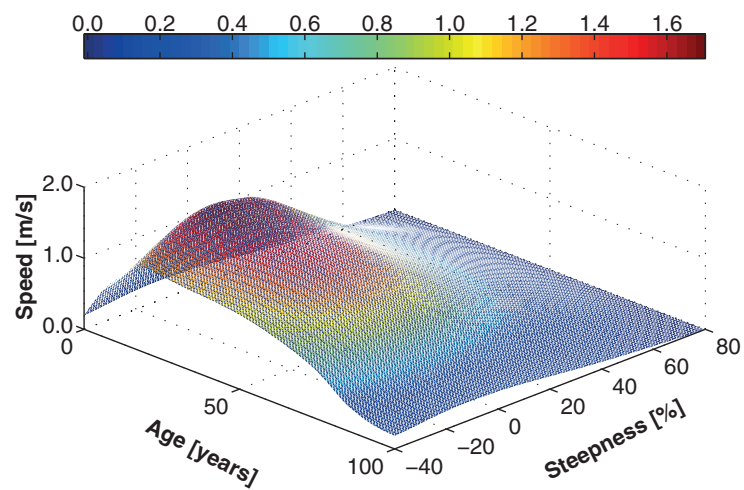


(c) Age and steepness dependent speed.
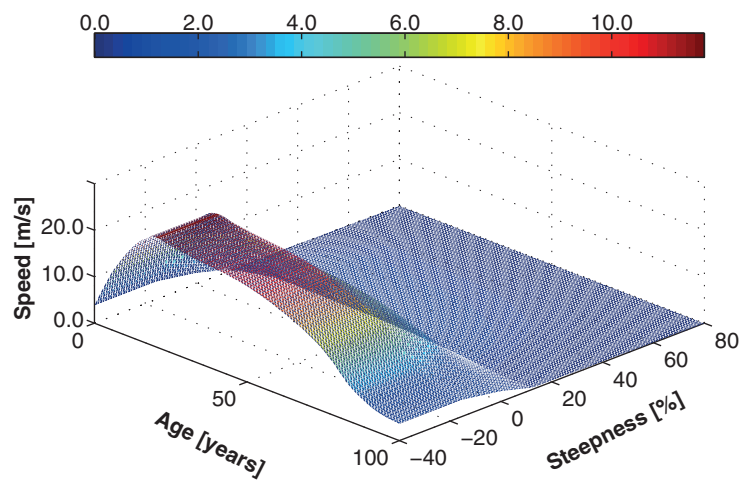
**Figure 21.3:** Age and steepness dependent speed of pedestrians.

(a) Age dependent speed.

(b) Steepness dependent speed.

(c) Age and steepness dependent speed.

**Figure 21.4:** Age and steepness dependent speed of cyclists.

0.2379 m/s is used. Additionally, it is assumed that cyclists limit their speed to 35 kilometers per hour (9.7222 meters per second; see Equation (21.6)).

$$v_{\text{person, bike}} = v_{\text{reference, bike}} \cdot f_{\text{person}} \tag{21.4}$$

$$v_{\text{person, uphill}} = \max \begin{cases} v_{\text{person, bike, flat}} - 0.4002 \cdot |\text{grade}| \cdot f_{\text{person}} \\ v_{\text{person, walk, uphill}} \end{cases} \tag{21.5}$$

$$v_{\text{person, downhill}} = \min \begin{cases} v_{\text{person, bike, flat}} + 0.2379 \cdot |\text{grade}| \cdot f_{\text{person}} \\ 9.7222 \end{cases} \tag{21.6}$$

Another parameter affecting pedestrian and cyclist speed is the crowd density of the link where they are physically present. Data to take this effect into account is, again, presented by Weidmann (1992). However, to calculate crowd density of a link, its geometry has to be taken into account, as discussed by Lämmel (2011).

## 21.4    Conclusions and Future Work

The multimodal contribution allows the tracking an agent's movement in detail, essential for studies related to topics like evacuations, e-bikes, car sharing or public transport. Experiments testing the implementation and demonstrating its capabilities are described by Dobler (2013).

An application's required level of detail strongly influences the modeling approach selection. A simple model including agents' age and gender, but not incorporating agent-agent interactions, might be detailed enough for some studies (e.g., e-bikes or public transport). However, for other studies, a more detailed model, also simulating agent interactions, might be necessary.

A first implementation of a pedestrian simulation module for MATSim, which also supports agent-agent interactions, was presented by Lämmel and Plaue (2014) introducing a force-base model. The agents' high-level planning (i.e., route and destination choice) was performed on a graph representing the transport system (e.g., a MATSim network), while the low level behavior (i.e., physical interaction between the participants) was simulated with a force-based model. Due to the intense computational effort of the underlying physical model, the scenario size was limited to a few thousand agents. An attempt to bypass this limitation was presented by Dobler and Lämmel (2012). They combined the force-based pedestrian simulation module with the multimodal link contribution, creating the opportunity to simulate large-scale scenarios, by staying highly resolved where needed and being more aggregated where possible.