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SELF-ORGANIZED NETWORK FLOWS

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Abstract. A model for traffic flow in street networks or material flows in supply networks is presented, that takes into account the conservation of cars or materials and other significant features of traffic flows such as jam formation, spillovers, and load-dependent transportation times. Furthermore, conflicts or coordination problems of intersecting or merging flows are considered as well. Making assumptions regarding the permeability of the intersection as a function of the conflicting flows and the queue lengths, we find self-organized oscillations in the flows similar to the operation of traffic lights.

1. **Introduction.** Material flows are found in many places of the world. This concerns, for example, traffic flows in urban areas or flows of commodities in logistic systems. There is also some similarity with material flows in production or biological systems, from cells over bodies upto ecological food chains. Many of these material flows are not of diffusive nature or going on in continuous space. They are often directed and organized in networks. In comparison with data flows in information networks, however, there are conservation laws, which can be used to set up equations for material flows in networks. It turns out, however, that this is not a trivial task. While there is already a controversial discussion about the correct equations representing traffic flows along road sections [6, 11, 33, 26], their combination in often complex and irregular networks poses further challenges. In particular, there have been several publications on the treatment of the boundary conditions at nodes (connections) of several network links (i.e. road sections) [25, 7, 28, 14, 10, 9, 4, 22, 23, 24]. In particular, the modeling of merging and intersecting flows is not unique, as there are many possible forms of organization, including the use of traffic lights. Then, however, the question comes up concerning how these traffic lights should be operated, coordinated, and optimized. In order to address these questions, in Sec. 2 we formulate a simple model for network flows, which contains the main ingredients of material or traffic flows. Section 3 will then discuss the treatment of diverges, merges, and intersections. Equations for the interaction-dependent permeability at merging zones and intersections will be

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