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EFFECTS OF PORT ATTRACTIVENESS ON LOGISTIC FLOWS IN A COMPETITION CONTEXT

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Abstract. In this paper, we present a model of logistic system with agents coupled with dynamic graph. We adopted a complex system approach to describe the local properties and functional rules of these organizations to understand how the macro properties emerge. As a result, we present how a local parameter, which represents the attractiveness of ports, affects the flow of goods over the territory.
Keywords. agent-based model, dynamic graph, logistic system, modeling, complex system

1 Introduction

The territory of a logistic system is composed of logistic infrastructures and a set of actors. The system is locally organized in order to support flows (of goods, of information, or financial), forming macro corridors between access nodes (maritime port, airport,...) and urban areas. The actors are numerous and heterogeneous (*e.g.* goods providers, logistics service providers, transporters, final consignees,...). But no actor has a complete decisional power on the transport of goods. Instead, each of them manages only a small part of it and they need to collaborate together. Moreover, a competition operates between close access nodes to be the one used to deliver the goods. According to the economical stakes of this competition, it is important to understand how the modifications of local decisions and of the structure of the territory can impact the performance of the system. The goal of this paper is to provide a model of logistic system in order to observe the effects of local parameters on the macro properties of such a system thanks to the simulation.

Choi *et al.*[1] proposed to see logistic systems as complex adaptive systems. In this context, agent-based approaches are often adopted since these models are spatially organized, and process disaggregated and heterogeneous data [2].

We propose a multi-scale approach, thanks to an agent-based model and dynamic graphs [3]. Our goal is to describe the complexity of these logistic systems: we model their local characteristics (actors and infrastructures, spatially spread over the territory) and its dynamics to explain the emergence of its macro properties. The first section describe the model while the second presents some results. We show that a local parameter, which represent the attractiveness of ports, affects the flow of goods over the territory.

2 Model

Actors as Agents The final consignee agents have local stocks which decrease each day according to a biased random number (according to the Huff's model [5] which considers population densities and accessibility to the network). The outsourced stocks of the final consignees are managed by logistics service providers (LSP). One final consignee has only one LSP (selected randomly, biased by the distance), but one LSP might have none or several final consignee(s). A LSP designs and manages a supply network made of warehouses connected to a goods provider and to its customers. Once the network is designed, the LSP monitors the stocks levels once a day, and orders a restock (if needed) from another warehouse of the network. During the simulation, a final consignee measures regularly the performance of his LSP. If the performance measured is too low, then the consignee can decide to choose another LSP. The foreign goods providers represent the access nodes. We consider that they aggregate every real foreign providers, and they can satisfy every orders of every kind of product. There are several provider agents only to model the different access nodes.

Transportation Network as Dynamic Graph The topology of the transportation network can be updated in real time (*e.g.* road works,...) [6]. Vehicle agents carry goods on the network. At their creation, these agents compute a path from their initial location to their destination. As they move along this path according to the speed limits, they leave, on each edge, a trace which is the amount of goods they carry. At each step, a coefficient makes decrease the trace on every edges, as the pheromones in ant colony optimization algorithms [4] which evaporate progressively. The trace is used to observe the traffic on the network: if an edge is no more

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used for some reasons, the evaporation process will dynamically highlight this change.

3 Results

We implemented this model into the agent-based simulation platform GAMA. In our simulation, we used real data of the Seine axis territory. To have two goods provider agents, we extended the transportation network to the Antwerp-Paris axis as in figures 1 and 2. Here, we study how a parameter (which represents the competition between the two ports) affects the flow of goods over the territory. This parameter is the probability that a LSP chooses a provider instead of the other one. Inspired by gravity models [7], we define this probability as:

$$F_{ij} = \frac{A_i}{d_{ij}^2}$$

Where F_{ij} is the force of attraction between the port i and the LSP j. A_i is the attractiveness of the port i. This parameter represents the competition between ports: a higher attractiveness value means that the port is more competitive than another one. And d_{ij} is the distance between i and j.

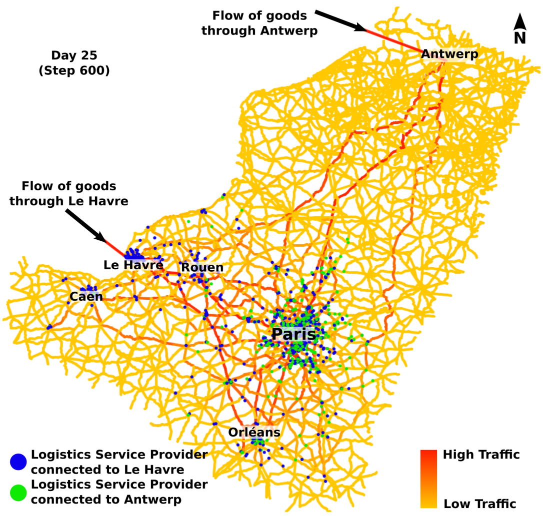

Figure 1: Scenario 1: The port of Antwerp is 3 times more attractive than the port of Le Havre.

To estimate the attractiveness, we looked at the ports statistics. In terms of TEU traffic, the traffic of Antwerp is around 3 times more important than Le Havre, so, we consider that a realistic scenario is to give an attractiveness of 3 for Antwerp and an attractiveness of 1 for Le Havre. The figure 1 represents this scenario on the 600 first steps of the simulation. On this figure, we observe three strong corridors on the Antwerp-Paris axis where the flow of goods are very important. After the 600$^{\text{th}}$ step, we updated the port attractiveness with a value of 5 for Le Havre, and a value of 1 for Antwerp. It allows us to study how the traffic is affected by the attractiveness with extreme (yet unrealistic) values. We observe on the figure 2 that there is only one strong corridor left on the Antwerp-Paris axis.

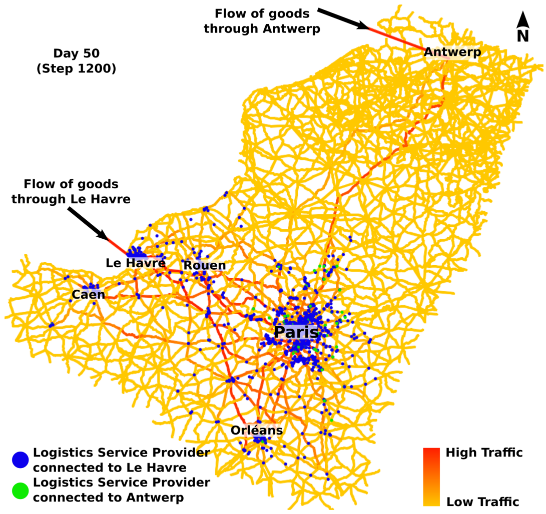

Figure 2: Scenario 2: The port of Le Havre is 5 times more attractive than the port of Antwerp

4 Conclusion

We highlighted with this model the importance of the port attractiveness on the traffic of a logistic system (and therefore its congestion). The dynamics of our model allows to define scenarios which will be activated at different moments in the same simulation. However, the simulation only include the road transport mode. So, as a perspective, we want to integrate a multi-modal transport network in the future.

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