Timing is Everything: an Agent-based Exploration of Last-Mile Freight Timed Delivery Behaviour

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Summary

We present an agent-based treatment of last-mile freight delivery, drawing upon data gathered in conjunction with partner organisations. In particular, we focus on the impact of timed deliveries on delivery statistics. Drawing upon previous work, we assess the interplay of these timed deliveries on the success of delivery drivers in meeting their targets..

KEYWORDS: Agent-based modelling, Freight, Parcel delivery, Timed deliveries.

1 Introduction

From scrappy start-ups to the Department for Transit, more and more people are turning to face the challenges of last-mile freight. In 2015, an estimated 1 billion parcels were delivered across the UK, representing a 15.7% growth over the previous year (IMR, 2015). Mintel (2016) forecast that that was likely to continue at an annual rate of 10-12%, suggesting that parcel freight transport?s transport emissions ? 15% of the UK?s total ? are only likely to grow (Department for Transport, 2016). This huge and changing system is particularly interesting in light of new environmental

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concerns, which have ushered in the era of the Ultra Low Emissions Zone, as well as new investments in delivery technology. Combinations of electric vehicles, parcel lockers, human porters, bikes, cargo-cycles, and even drones have been explored to try to cope with these changes (see Allen et al., 2018 for more).

The complex interplay of actors which characterise these delivery systems is often overlooked in wider conversations about freight. Freight companies must coordinate the actions of depots, delivery personnel, fleets of vehicles, and the relative unknown of consumer behaviour to try to bring the right parcels to the right people at the right time. They undertake this task in a changing policy environment with shared infrastructure, making use of the same parking spaces, road network, power grids, and more in an attempt to deliver an ever-increasing burden of parcels. Coordinating these diverse actors is no easy feat, especially in the face of rising competition.

To that end, we present here a piece of work which explores the interplay of different freight companies in a shared environment. We make use of an agent-based model (ABM) which allows us to capture the behaviours and interactions of the various moving parts of the parcel delivery system. This represents a valuable opportunity both to understand how the system currently functions and to explore how the system might be jointly influenced for the better. Gilbert writes that simulations can provide us with ?artificial laboratories? to test ideas and hypothesis, allowing us to harness some of the complexity of the real world and study it up close (2007). By understanding how drivers with different levels of experience handle the problem of timed deliveries, we can better help our industry partners explore potential solutions to their wicked problems.

2 Methods

The work presented here makes use of the ABM framework developed as part of the FTC 2050 Project (http://ftc2050.com; EPSRC grant agreement EP/N02222X/1). The overall project has been carried out in conjunction with industry partners. As a part of these partnerships, our team has had access to proprietary datasets capturing last-mile delivery logistics at the level of manifest entries and GPS traces of both individual vehicles and delivery personnel. The construction and validation of the overall model is presented in Wise et al. (under preparation; see also Wise et al., 2018), but this work will focus on an extension to the model.

In particular, the model we present here focuses on personnel making timed deliveries. This process is embedded within the larger model, which simulates delivery staff, depots, vehicles, and parcels as individual units. The model simulates movement at a granularity of meters and time in terms of minutes. It is situated, in this case, within the City of London, and utilises OpenStreetMap data to represent the transportation network of roads, pavement, and open spaces.

Broadly, the model works as follows: parcels are synthetically generated based on our real data for parcel delivery demand throughout neighbourhoods, then allocated to depots. Depots cluster parcels into groups based on a metric; in this paper, the parcels are simplistically bundled by cartesian distance from one another. Delivery staff enter the depots and wait to be assigned a set of parcels. Having spent a period of time collecting the parcels and potentially placing them within a vehicle, they exit the depot, making way for other delivery staff to collect their own parcels. Delivery personnel attempt (but sometimes fail) to distribute parcels, proceeding from one to the next based on a greedy heuristic. Once the delivery staff member has attempted to deliver every parcel, they return to the depot with the undelivered parcels and wait to be assigned a new round. This process continues until the end of their shift, allowing us to follow the routine of individual staff members

The extension presented in this work builds upon the base model by introducing a constraint of the delivery process in the form of timed deliveries. Delivery staff working as drivers adjust their route planning around the parcels which have required delivery times. For any given parcel, it may be necessary to deliver it within a range of hours. This puts constraints on how the parcel can be clustered into a route with other parcels, as well as how the delivery staff member must time their delivery. Delivery of the parcel outside of target hours is met with a lower level of success, while delivery of the parcel within target hours has higher success; any parcels the staff member attempt to deliver outside of target hours are recorded in order to be penalised. Delivery staff member attempt to minimise the number of out-of-target deliveries, and re-plan their route mid-round if they are poised to miss a timeslot.

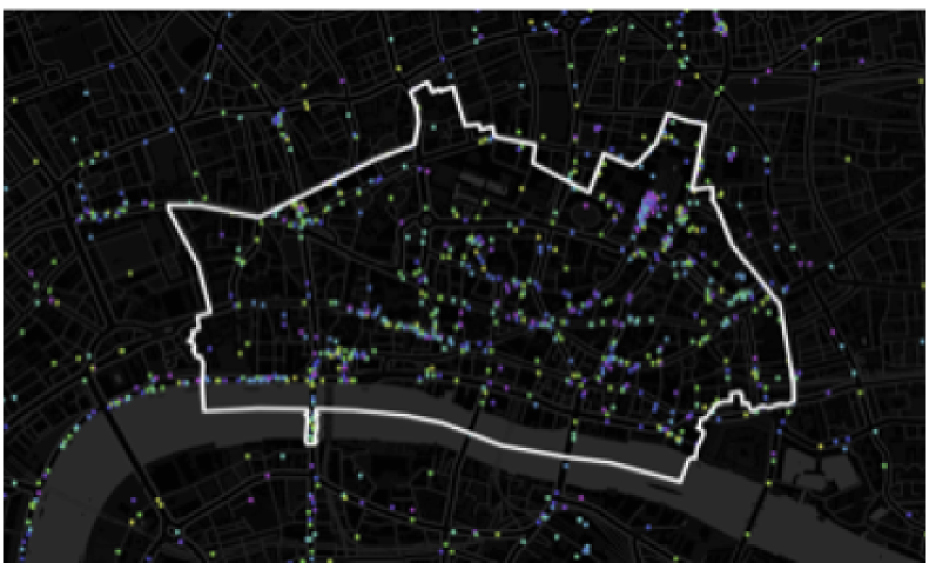

Figure 1: Gold standard data showing stopping locations

3 Results

Our efforts to validate the processes described here are aided by the datasets provided to us by our industry partners. The underlying model?s validation process is documented in Wise et al. (under preparation). Broadly, for the purpose of this case study we undertake a parameter sweep in order to explore the sensitivities and brittleness of the newly added parameters. In particular, we have attempted to fit the default case of business as usual, allowing us to compare the synthetic and true results. For this purpose, we utilise real manifest data and rounds.

The case study includes only drivers of vehicles, and we therefore compare the times at which drivers finish their rounds, the places they stop, the times at which they stop, the number of successful deliveries, the final distance driven, and the number of missed timeslots (see, for example, Figure 1). We also compare routes of real versus synthetic drivers. Based on this validation, we are able to more clearly explore scenarios, including the existence of tipping points for driver density in the area (an important question in light of increasing delivery density!) and the likely impact of various types of parking restriction.

4 Discussion

This work demonstrates how delivery timeslots influence the success of delivery staff in meeting their targets, and their impact on outcomes for both clients and delivery staff themselves. Further, it forms a beachhead from which more scenario exploration is possible. The impact of these kinds of deliveries and their mode are made visible and clear to interested non-specialists in modelling, allowing our industry partners to engage with the findings more clearly and immediately. By combining these outputs with the freight dashboard technology also developed in this project (see Cheliotis et al., under preparation), we can broaden access to the output of these kinds of techniques.

In doing so, we can enable industry and policymakers to explore futures in which, for example, parking policy changes can help us achieve better system-level results; to understand how investment in electric parking might help or hinder delivery; and to prioritise various interventions in the system. In particular, such a tool will better allow diverse industry representative to see how their different fleets of vehicles interact and influence one another, facilitating the process of collaborative working toward a mutual beneficial outcome. This cooperation is the ultimate goal of the project, and we hope that this contribution moves us one step closer to it.

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7 Biography

Sarah Wise is a lecturer for the Centre for Advanced Spatial Analysis of University College London. Her work deals with exploring and forecasting the development of systems involving people, infrastructure, and information, in particular by using agent based modelling.

Kostas Cheliotis is a Research Assistant at the Centre for Advanced Spatial Analysis. His research interests include computational simulations of spatial systems, the intersection of design and human spatial behaviour, and interactive visualisations as a tool for efficient communication and dissemination of information.

Fraser McLeod is a Research Fellow at the University of Southampton with over 30 years' experience on transport-related projects. Recent studies have focused on freight logistics, including servicing of charity donation banks, joint procurement and goods consolidation for large municipal organisations and parcel delivery operations in urban areas.

Tom Cherrett (BSc Hons, PhD, CMILT) is a Professor of Logistics and Transport Management within the Transportation Research Group at the University of Southampton. He teaches courses in transport planning and Logistics operations management. He researches last-mile logistics and how new technology and operational practice can reduce the negative transport impacts of delivery vehicles.

Julian Allen is based at the University of Westminster, where he is involved in research and teaching activities relating to freight transport and logistics. His research interests include freight transport and logistics operations, the role and formulation of freight transport policy, and the history of freight transport.

Oliver Bates is Senior Research Associate at Lancaster University looking at the role of people and digital technology in the demand placed on digital and physical infrastructures. His current work looks to leverage digital technology to redesign for environmental and social justice in homes, on campuses, and of urban freight.

Maja Piecyk is a Reader in Logistics at the University of Westminster. She leads research focusing on the environmental performance and sustainability of freight transport operations. Current projects focus on the optimisation of supply chain networks, the efficiency of last-mile urban freight operations, and long-term forecasting of logistics energy demand.

Tolga Bektas is Professor of Logistics Management at the University of Liverpool Management School. His research is on mathematical modelling and optimisation of problems arising in freight logistics, including network design, vehicle routing and location analysis, with a particular focus on reducing the environmental externalities of road transport.