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ALGORITHMIC MANAGEMENT

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AMAZON

Remote Control: Algorithmic Management of Circulation at Amazon

Armin Beverungen

This chapter examines how logistical media organize circulation at the online retailer Amazon. The chapter takes a look at the warehouse and the interaction of algorithmic management with architectural infra-structures and infrastructure space. Over the last decades of the 20th century, logistics became the ubiquitous science of managing circulation, with Amazon today considered the epitome of contemporary logistical intelligence. In the warehouse it becomes clear how a mundane and relatively simple tracing infrastructure in interaction with algorithmic management generates a chaotic material order and an opaque, widely networked system whose logics extend far beyond the warehouse. Lastly, I look at the fantasies and future scenarios that

drive the development of Amazon's logistics, which raises the following question: how can the circulation of labour, data and things be decoupled from the circulation of capital and how can its logistical media be reassembled?

Media, Management and Circulation

If logistics offers "a vital political history of the economic space of our present" (Cowen 2014, 11), then focusing on Amazon as one of its key actors provides insights into how its logistics – its operations, economies and media – characterize digital cultures today. Logistics, as a "ubiquitous management science of the government of circulation" (Cowen 2014, 10) which emerged during the "logistics revolution" (Cowen 2014, 23-52) of the last three decades of the 20th century, asserted its authority over the management of circulation across the entire system of production and distribution. Media, and in particular calculative media distributed in environments, play an essential role, at least according to Thrift: "the rise of continuously computed environments has made logistics perhaps the central discipline of the contemporary world – though one curiously unsung" (2008, 95; see also Schabacher 2008; Dommann 2011). Logistics is increasingly based on software that can be used to model the world of circulation: "Logistics is increasingly a programmer's game. Its use of software systems, from enterprise resource planning (ERP) to cloud computing, provides a means of modeling the world as a series of economically valued objects and relationships" (Neilson 2012, 332).

An understanding of logistics as a "calculative logic and spatial practice of circulation" (Chua et al. 2018, 617) highlights how logistical media which "arrange people and property into time and space" (Peters 2012, 40), and especially digital logistical media that traffic in "organization, power and calculation" (Peters 2015, 7) are of particular importance for contemporary logistics. While Peters is more concerned with elementary and ancient media, which "have always been in the business of recording, transmitting, and processing culture; of managing subjects, objects, and data; of organizing time, space, and power" (2015, 19), Rossiter has focused on how logistical media "as technologies, infrastructure and software – coordinate, capture, and control the movement of people, finance, and things" (2016, 4-5). Rossiter emphasizes the interaction of infrastructure, software and

algorithms: "If infrastructure makes worlds, then software coordinates them… algorithms play a vital role in arranging the material properties and organizational capacities of infrastructure. Algorithms thus register a form of infrastructural power" (2016, xv).

In what follows, then, the focus is on the algorithmic management of circulation in the infrastructural spaces shaped by Amazon. Chua et al. (2018, 617), in outlining current debates around logistics in geography and elsewhere, name three directions for a critical approach: logistics is not to be understood as apolitical management science but as a political project; attention should be paid to the irrationalities and vulnerabilities of logistical regimes; and work should be oriented towards resistance and struggles within logistical networks. I would like to contribute to this endeavor with a critical exploration of the media at work in the algorithmic management of circulation at Amazon. This also includes emphasizing that – especially in the case of Amazon, which produced the richest man in the world – the circulation of people, things and data is also conditioned by the circulation of capital.

Amazon: Prediction, Experimentation, Contingency

Amazon is the largest and most popular online retailer in the world and a "master planner" (Phillips and Rozworski 2019, 77). In Lyster's view, Amazon represents "the epitome of contemporary logistical intelligence" (2016, 119), since it not only owns one of the largest integrated logistical networks of the world including almost everything from warehouses and data centers to airplanes and delivery trucks, but is also at the forefront of developments in areas such as robotics and predictive analytics (see e.g. Pöchhacker and Nyckel 2020; Simon 2019). Amazon is present in Germany with its online trading, a large number of fulfillment centers and locations for delivery to end customers. There are also data centers near Frankfurt and development centers in Munich and Berlin. Yet the infrastructure that enables the circulation of goods at Amazon remains largely unnoticed. Hill describes Amazon (with reference to Chun 2016) as an example of "the disappearing from consciousness of 'habitual media'", and as "a process of withholding from awareness what ought to be at the center of our attention." (Hill 2019, 4). Amazon's platform infrastructure, Hill suggests, "acts as a central nervous system", and thereby enables a "seemingly frictionless and omnipresent marketplace" which "hides its weight behind interfaces" (2019, 5).

Even if we subtract Amazon's other businesses from view, in particular Amazon Web Services with platforms like Amazon Mechanical Turk, then Amazon's logistical operations can still hardly be grasped as a whole: they are not only largely invisible or unseen, but also often opaque, as well as vastly expansive, complex and integrated. Consider for example the way in which the optimization of circulation relies not only on data centers and algorithmic operations as well as spatial and architectural infrastructure, but also on getting closer to customers. The optimization of circulation has always been based on the calculated needs of potential customers; now, with predictive analytics the storage and distribution of goods are continuously adapted to these predictions. As Pöchhacker and Nyckel note, the "logistics of probability" at Amazon is characterized by an "entanglement of anticipatory shipping with algorithmic logistical infrastructures" (2020, 1). This entanglement also includes Amazon's recommender system, which, based on "item-to-item collaborative filtering" and the collective and social labour of recommendation, attempts to calculate our wishes and needs using data about our purchases and other online activities tracked. The result: "The chaos of individual tastes and opinions is condensed into something usable" (Phillips and Rozworski 2019, 83). Ultimately, Amazon promises that it can read our thoughts, and thus delivers a standard algorithmic imaginary (Natale 2019).

At the same time, the system already generates a spatial-medial order close to us, because it is the Amazon Echoes and the Dash Buttons (now banned in Germany) which provide us with recommendations (in the case of the Echoes) and enable us to place orders (in both cases), thereby allowing us to stay at home. Through these logistical media, Amazon's infrastructure enters our homes: "These are the artefacts, devices and procedures that we rub up against each day and they offer a fleeting access to the larger abstract world of logistics" (Lyster 2018, 27). Crawford and Joler (2018) describe the extractive operations and labour processes which sustain a device such as the Echo Dot. Yet it is these operations and processes which are concealed, Hill suggests, when "consumption becomes this unthinking, when our products are only a one click or a 'Hello Alexa' or the push of a button away" (2019, 5). Even if these gadgets at home, the expansive spatial and architectural infrastructure they are integrated with, as well as the predictive analytics deployed, are meant to assure a certain plannability of circulation – logistics also at Amazon still cannot evade the need for a certain flexibility, usually negotiated via the terms "agility" and "resilience" (Bernes 2013, 185).

On the one hand, this flexibility is generated by a developmental and experimental order through which logistical infrastructure is constantly updated. In Germany, for example, there are now two eighth-generation fulfillment centers, in Winsen (Luhe) and in Mönchengladbach, where robots from Amazon Logistics are used. The refashioning of infrastructure space in this way requires an undefined, smooth ground, as is for example provided by greenfield or brownfield sites on which fulfillment centers are erected. Ideally, this ground is already smart, thereby guaranteeing the data flows of the control infrastructure: "Ground is the canvas of logistics, and in lieu of dripped paint and cigarettes, it hosts embedded data" (Lyster 2016, 157; and 153-158). Logistics is "generalizing in tendency" in that it potentially unifies space, while distribution centers in particular can be seen as "circumscribed 'laboratory' spaces" (Toscano and Kinkle 2015, 203) in which the spatial and architectural infrastructures of logistics are continuously refined. The city is equally an experimental space for logistics, in which, contrary to the inertia of materiality, logistical infrastructures can be re-inscribed again and again – as described below and made clear, in particular, by Amazon's numerous patents, from Amazon Go shops to drones to zeppelins-come-warehouses.

On the other hand, the flexibility that contingency requires, despite prediction and planning, is also inscribed in the work in fulfillment centers and beyond. The precarious working conditions and the strict control of work processes at Amazon have long been the focus of trade union industrial action (see e.g. Cattero and D'Onofrio 2018; Apicella and Hildebrandt 2019). Amazon's warehouses are still very much dominated by seasonal work, while delivery staff at Amazon Logistics are usually self-employed or outsourced.

The Disorder of Things and the Opacity of Control

When visiting a fulfillment center, common and not so common media of circulation catch the eye: docks for trucks, workstations for workers, pallets, trolleys for a variety of parcels, a lot of brown parcels, the ubiquitous yellow "totes" (conveyable transport boxes that can hold up to 15kg and 50 individual items), miles of conveyor belts, chutes for parcels, "SLAM"-machines ("scanning-labelling-addressing-machines"), a variety of different shelves, and in the more recent fulfillment centers, robots that carry shelves. All these logistical media contribute to circulation in the warehouse. Yet even if fulfillment centers are not traditional warehouses

– they are supposed to "fulfill" our wishes as quickly as possible, after all – even Amazon's goods must come to a standstill at some point: circulation is interrupted and there is friction and resistance. Planned friction balances out the different temporalities and rhythms of logistical circulation: "There is purposeful pausing, or interruption, of flow that is most visible in the spatialities of storage that are critical to the achievement of coordination" (Gregson et al. 2017, 390).

So how are goods sorted and stowed, and what kind of order is there as things rest so that they can circulate again as quickly as possible? Lyster reports: "over the years, Amazon has conducted its own zoning studies that attempt to optimize the tricky relationship between time and space in the warehouse" (2016, 89). This has resulted in a number of organizational modes that are still visible in today's fulfillment centers, such as "fast pick zones" for very popular goods like Amazon Kindles, or "batches" distributed throughout the centers where popular products are made available for fast picking anywhere (ibid.). Probably the most important element of Amazon's storage principles is "chaotic storage". In chaotic storage, the same goods are not stored together but in different places, on the one hand to save space – "stowers" simply put the goods in compartments with suitable free space, meaning there are no empty reserved shelves – and on the other hand so that "pickers" on their way through the warehouse always have the goods somewhere nearby and therefore need to walk less. The principle of chaotic storage regulates storage both in older warehouses – for example in Rheinberg, a fifth-generation warehouse, where in one area, on three separate floors, shelves are loaded by stowers and emptied by pickers – and in new warehouses, such as those of the eighth-generation – for example in Winsen (Luhe), where over three floors the roughly 30,000 shelves are moved around by around 2,700 robots and brought to the stowers and pickers at the stations.[1]

This disorder of things could give the impression that things could quickly become untraceable and thus elude circulation. There are certainly instances, observed and reported during guided tours of two warehouses, when things do escape the order of things, for example when they fall off the trolleys of stowers or pickers, or when abrupt movements of the robots make them fall from shelves. A curious incident was also observed when a packaging machine was yet to be properly calibrated, and things packaged in plastic by these machines would hit conveyor belts at the wrong speed and land in between tippers integrated into the conveyor belt,

1 This data was gathered during two guided tours of the fulfillment centers.

thus unable to be tipped into chutes for further circulation, and doomed to journey in circles before being retrieved manually. But, apart from such instances, orderly chaos prevails, and chaotic storage reflects, at least in certain respects, the logic of newer, post-relational databases, in which the structure of rows and columns no longer dominates (Biedebach 2017). People can't find anything in the storage system without machine help or instructions, while the warehouse management system has recorded where all things are located. Delfanti sees this as a form of "machinic dispossession", as workers' knowledge of the order of things is taken away and integrated into a remote algorithmic system: "this process generates an inventory that no individual human being can navigate without the aid of Amazon's system algorithm" (Delfanti 2021, 45).

Even if – or rather, because – things do not always circulate, the flow of data must not be interrupted, and this requires capture: "It is not the flow of commodities that must be seamless, but the flow of data streams, RFID codes, and location trackers" (Pöchhacker and Nyckel 2020, 5). In Amazon's fulfillment centers, this capture of things (and of labour, as we will see shortly) is achieved through a mundane, perhaps surprisingly old, paper-based logistical medium: the barcode. While the Universal Product Code (UPC) is the most commonly used type of barcode and is widely used in logistics (see LeCavalier 2016, 63-75 for a history of the barcode), Amazon does not rely on UPCs. UPCs only allow the identification and tracking of identical, not individual products. But Amazon wants to track things individually; therefore, all goods that are in Amazon's supply chain in the warehouse are equipped (usually in addition to their UPC) with an individual barcode. At the same time, all containers for goods – the totes, the shelf compartments, the compartments at packing stations, the packages not yet addressed – are also equipped with individual barcodes. And every time a product – which is tracked as a digital "item" – changes location or container, the product and container must be scanned.

The barcode as the key logistical medium of capture in the fulfillment center acts here as a translator, "to translate physical objects into information to be managed" (LeCavalier 2018, 105). The barcode as translator is one of many "coupling technologies that facilitate the internal compatibility within logistical systems" (ibid.) – others are, for example, basic protocols of data transfer or even the standardized container – which thus contribute to the smooth circulation of data and the controlled interruption of the circulation of goods. It might have been expected that Amazon would make use of other logistical sensor media, such as radio-frequency identification (RFID) chips (as insinuated e.g. by Lyster 2019, 102), or even

augmented video surveillance that can detect people and objects and track their movements, as is the case in Amazon Go stores.[2] Yet the scanning of individual barcodes generates all the data essential for tracking goods in the warehouse which the algorithmic control system relies on. The system can then, as soon as orders for delivery arrive, instruct pickers and packers to collect and pack goods. Via barcode scanners, whether in hand or at the station, the algorithmic system intervenes in the warehouse.

And the barcode does even more: the labor process of the receivers, stowers, pickers and packers is traced through interaction with barcodes. Since Amazon is often portrayed as a prime example of a despotic, digital Taylorism (e.g. Staab and Nachtwey 2016; Altenried 2017), one might have expected that even newer logistic sensor media would be in use here, allowing labor processes to be tracked, traced, monitored and evaluated even more meticulously. For example, it was noted that Amazon monitors workers via "wearable" and "arm-mounted terminals" (Moore and Robinson 2016, 2779; see also Moore and Piwek, 2017). Yet these terminals merely scan barcodes, leaving digital traces of steps in the labor process, so that Amazon does not have to use any sensors that attach to bodies – gathering bodily data from movement to heart rate – to trace and control labor processes. Although Amazon has a patent for an "ultrasonic bracelet and receiver" (Cohn 2017), which, attached to a worker's wrist, is supposed to track exact arm movements, this is currently not used. Neither is a cage carried by robots and used to transport workers through the robot area of the warehouse (Wurman et al. 2015), which would represent an even more intensive and restrictive form of control.

Even though the design of the various stations, corridors and scanners very much dictates certain movements and labor processes, Amazon does not have to deal with the micro-management of laboring bodies, but leaves room for self-discipline, as Taylorism rarely does. Nevertheless, a control system is created which is described as total in practically all reports. This sense of total control is not least due to the fact that Amazon's assessment of logistical labor is highly opaque. Performance is assessed by only one metric, which cannot be reconstructed from various productivity indicators even by trade unions, and is therefore incomprehensible. Delfanti also describes that managers only report performance in terms of percentages

2 During the summer of 2020 Amazon did actually introduce "distance assistants," due to the Covid-19 crisis, which were meant to help workers with social distancing, and are based on augmented video surveillance. They could therefore potentially be repurposed later for new forms of tracking and tracing in the warehouse (see Vincent 2020). Thanks to Eva-Maria Nyckel for this reference.

based on a benchmark, the nature of which is not disclosed (2021, 51). In addition, on the basis of these evaluation mechanisms, which seem to operate automatically, decisions on hiring and firing are also automatically, if not taken (because this is often illegal), then at least prepared (Lecher 2019). With this in mind, it is not surprising that managers on the ground are attributed little power to act or decide. To quote Rossiter: "Who really needs a manager when decisions become computational calculations?" (2016, 125). This is the essence of remote control, and it is thoroughly opaque to those affected by it.

And it is not only algorithmic control but circulation itself which becomes opaque. With regard to the fulfillment centers in which robots operate, LeCavalier (2019, 54) notes: "These buildings provoke a crisis of legibility in that we cannot understand the behavior of their machines even though we created the instructions that guide them. When observing the RDUs in action, one is tempted to assign a kind of intelligence to these machines because they seem to operate with such unpredictable purpose".

From the Warehouse Into the City

What happens to logistics when it leaves the warehouse? LeCavalier already noted that in the case of Walmart, architectural edges between warehouses and their outsides are slowly eroding, and that the edges of warehouses are only necessary "to keep the vast material handling system protected from the elements" (LeCavalier 2016, 96). Rather than asserting strict boundaries, the distinction between interior and exterior "only obscures the more active process of connecting one interior to another" (ibid.). In a sense then, circulation becomes indifferent to architectural edges; the smoothness of infrastructure space trumps architectural distinction. Lyster similarly observes that "the spaces that serve logistics… accommodate so much infrastructural paraphernalia and computer technology that their architectural aspects are hard to detect" (2016, 149). Yet, rather than architecture being superseded or disappearing, "it has been synthesized into a flow field, such that conduit (flow) and node (space) merge into a single seamless artifact" (Lyster 2016, 152) – both within and beyond the warehouse.

Amazon precipitates these developments in logistical urbanism, for example in its focus on delivery. Since 2018, Amazon has been developing a "last mile" delivery service in Germany, which, like Amazon Flex in the USA, is based on hiring outsourced or self-employed drivers with often rented vans for delivery. Both the handling of parcels and navigation through

the city of "last mile" delivery is in turn controlled by an app, similar to the app used by companies like Uber or Deliveroo (see Altenried 2019). Amazon thus operates beyond its fulfillment centers in our cities, and that requires an expansion of logistical infrastructures in the city. Amazon has already set up distribution centers at various locations, for example in the ports of Duisburg and Hamburg or on the border between Herne and Bochum, which serve as contact points for delivery drivers shipping to end customers. These distribution centers are very different from fulfillment centers. They are largely empty halls that receive pre-sorted parcels collected in transport trolleys – parcels that are seemingly chaotically stacked yet pooled in trolleys for optimized delivery routes. The parcels and trolleys remain only for a very short period of time (hours or less) before they are picked up by drivers and distributed to end customers. The infrastructural spaces that Amazon seeks out here are closer to city centers, compared to fulfillment centers which are usually located at urban edges close to nodal points in transportation networks. The integrity of the logistics chain and thus the safeguarding of circulation is also achieved here through barcode scans.

The logistical logics of the fulfillment centers and their media thus migrate from the warehouse to the city. LeCavalier has also identified another logic that explains Amazon's expansive activities, especially the many patents that work towards the reorganization of urban space and its infrastructure. According to LeCavalier, the breakthrough of Kiva, today's Amazon Robotics, was to granularize the logistic system, "to make storage and inventory the same thing, and to make storage mobile": "Instead of machine buildings populated with robot-like humans, as familiar science-fiction tropes might lead us to anticipate, Kiva creates a machine landscape of building-like robots" (LeCavalier 2019, 53). This logic of mobile storage units points beyond the warehouse, and this is precisely the logic that is followed by the many logistical media that Amazon has patented, from delivery drones to flying warehouses (see Lisso 2017; Berg et al. 2016). These logistical media circumvent the materialities of urban space as they slowly inscribe themselves into it.

"Last mile" delivery to end customers completes the circulation of goods and data: from the media of recommendation and order, via the calculations of anticipatory shipping and the logistical operations in warehouses to actual dispatch and customer feedback. Throughout, the opacity of the system and its algorithmic, remote control, with support from the barcode, is maintained (Altenried 2019, 125). Amazon is also working on a different ending: Amazon Go stores, currently only experimentally operating in the

UK and USA, as spaces which eliminate the requirement for "last mile" delivery as customers come to Amazon to pick up their goods. Here, the continuity of logistical logics also becomes apparent, as Amazon moves further into the heart of cities and as customers are reimagined as picking agents: "Amazon makes little distinction between a customer in a shop or picking agent working at their fulfillment centers. In fact, it stresses the similarities between the two: both locate items from an inventory". (Stewart 2018). In Amazon Go stores, customers check-in with their NFC-enabled smartphones, and there is no need for a check-out as picked-up goods are traced not via scanning or RFID chips but via cameras, and are automatically charged to the customers' Amazon accounts. Here the barcode is potentially replaced by other logistical media: "deep learning algorithms, sensors and cameras in the ceiling control the selection, placement and replacement of all the goods, rendering obsolete the iconic barcode" (Lyster 2019, 102). Thus, we all become potential (unpaid) employees of Amazon, and the world around us is mapped and captured sensorially by Amazon.

Disassembly, Reassembly

Amazon has recently seen a lot of contestation, from union struggles and movements such as *Make Amazon Pay* or *Berlin vs Amazon*, to Amazon's withdrawal of plans to establish its second headquarter in New York City after public opposition. The analysis here suggests that there are two directions in which a critique of and opposition to Amazon could proceed. This could be logistical media theory's contribution to reckoning with Amazon's logistical operations as they characterize and sustain digital cultures. While this chapter largely tries to develop a critique of Amazon in the vein of reverse engineering its operations, it may also enable a "reverse of engineering" – a project Neilson (2020: 78) proposes for repurposing Amazon's planning powers, and which "entails the subordination of data to qualitatively rich futures rather than planning processes that work from the merely evidential and measurable".

One direction would be to explore how Amazon remakes our cities. Where movements such as *Berlin vs Amazon* largely focus on the prevention of Amazon's administrative or research and development facilities gentrifying cities and exacerbating housing crises, the analysis here suggests that the much more immanent effect of Amazon on our cities is already here to reckon with. The opacities of infrastructural power gains import here, since, as Schabacher emphasizes, "insofar as infrastructures as much as

architectures actively structure, organize, limit or distribute space, and at the same time occupy it aesthetically-symbolically, they are genuinely linked to the question of power relations" (2015, 88, my translation). Exploring Amazon's urbanism, its architectural and infrastructural spaces, might both show where contestations are possible and lead to a speculative practice imagining even a logistical urbanism in opposition to what Amazon and other dystopias have to offer (Lyster 2016 182-196; Graham et al. 2019).

Another direction would be to explore how Amazon could be reassembled. Phillips and Rozworski ask how one could take over the "logistics and planning powerhouses" like Walmart and Amazon for an "egalitarian, ecologically rational civilization" (2019, 239). Focusing in detail on anticipatory shipping, chaotic storage or algorithmic management, there seems to be little that is not focused on bending "the production of the future around market positions" (Neilson 2020, 78), and thus little to be repurposed for, say, a circulation divorced from capital that would take reproduction or ecology seriously. Rather, "fulfillment" individualizes and distracts from collective political decision making: "by isolating consuming subjects through gestures of personalization, fulfilment industries claim to free us from confronting either the abstract but shared responsibilities related to, for example, the 'slow violence' of global warming or the collective immediate action required by contemporary crises of government, economy, or environment" (LeCavalier 2018, 108). Could we imagine fundamentally reassembling Amazon's logistical media collectively, against fulfillment?

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