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# Orchestrating scalability: how patents render cloud imaginaries in CAV innovation

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**ABSTRACT**

This article explores how cloud computing enables and shapes the scaling of connected and autonomous vehicles (CAVs), positioning cloud infrastructure as a technology, strategy, and imaginary central to the scaling of AI. Using a dataset of 69,421 global patent families, we analyse how diverse actors – including automotive manufacturers, chipmakers, electronics companies, autonomous vehicle firms, and telecom/mapping providers – mobilise cloud technologies to expand AI capabilities, manage resources, and coordinate complex socio-technical systems. Approaching patents through ‘sociotechnical imaginaries’, we show how they simultaneously codify technical innovations while projecting visions of scalable, cloud-enabled CAV futures. Our analysis identifies four thematic clusters – vehicle communication, machine vision, network architectures, and edge computing – through which cloud technologies are operationalised and imagined. We argue that the cloud functions as a *technology of orchestration*, with cloudification exemplifying AI’s industrialisation as it moves from laboratory research to globally scalable systems. The article contributes to debates on scale by highlighting the interplay between technical, organisational, and imaginative dimensions in shaping AI-enabled mobility.

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## Introduction

Connected and autonomous vehicles (CAVs) depend on cloud computing infrastructures largely controlled by dominant platform companies (Van der Vlist et al., 2024). These firms monopolise access to computational resources, which are critical for scaling AI-driven systems (Narayan, 2022). This article investigates how cloudification – the growing reliance of industries on cloud-based infrastructures and logics – shapes the scaling of AI in the CAV field, a key site of AI innovation.

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This 'industrialisation' marks AI's transition from research setting to commercial deployment, including within the automotive industry (Van der Vlist et al., 2024). To make sense of this shift, we map elements of the emerging technological and industrial landscape. Our guiding research question is: *How do patents render cloud imaginaries in CAV innovation?* We approach this through the lens of sociotechnical imaginaries and an exploratory study of over 69,000 global patent filings related to CAVs. Patents allow us to trace how innovation narratives around AI and cloud infrastructure unfold in this domain, and how they are tied to scalability.

Through the analysis, we show that the cloud – in all its diverse forms – emerges as a *technology of orchestration*: a means of coordinating computation, mediating data flows, and enabling scalability across distributed systems. It appears variously as a data *prioritiser*, trust *validator*, resource *threshold*, and latency *spectrum*. The patents demonstrate the non-linear scaling of CAVs, in which specific cloud computing strategies are required.

CAVs offer a compelling case where AI is developed and implemented *at scale* (Hind et al., 2022), requiring accompanying investments in cloud infrastructures. The category incorporates automated driver-assistance technologies, vehicles capable of communication with other vehicle (V2 V), roadside infrastructure (V2X), and cloud platforms; and 'autonomous' vehicles (e.g., 'robotaxis'). The automotive industry also warrants particular attention: historically a site of significant technological innovation (Hind, 2024), structured by complex global supply chains shaped by geopolitical dynamics, and marked by pervasive data extraction and profiling (Caltrider et al., 2023; Hill, 2024). CAVs illustrate a broader process in which AI scales – moving beyond narrowly-defined applications to take on infrastructural significance across entire sectors. This process is uneven: Big Tech reshapes automotive practices through its provision of scalable cloud computing, while traditional automakers, consumer electronics firms, and telecom providers pursue their own strategies within the emerging ecosystem.

Our analysis draws together work from platform studies, science and technology studies (STS), and innovation studies. First, we build on research into hyperscale cloud infrastructures (Narayan, 2022), 'cloudification' (Kotliar & Gekker, 2024), and the growing infrastructural dependence of contemporary AI systems (Ferrari, 2023; Van der Vlist et al., 2024) to examine how cloud logics structure economic relationships between Big Tech and industry-specific firms. Second, we engage with scholarship on the platformisation of automobility (Hind et al., 2022), exploring how cloud-based models are being implemented in CAVs. Third, we contribute to critical debates on AI innovation by analysing the transition of AI from laboratory research to large-scale, publicly deployed systems (Hind, 2024; Jaton, 2021; Pfotenhauer et al., 2021).

Patents form our empirical entry point. As legal instruments, patents grant temporary exclusive rights to produce, use, or commercialise an invention in exchange for public disclosure of how it works. Patents function as critical innovation tools in a digital age: protecting intellectual property rights, shaping competitive dynamics, codifying future technological claims, and enabling claimants to assert market power (Damásio et al., 2025). Patents are therefore both descriptive – detailing what firms claim to be novel – and speculative, projecting visions of commercially viable futures (cf. Iliadis & Acker, 2022). As such, they offer a useful proxy for studying innovation trajectories, indicating where firms anticipate value, how they frame new technologies, and how they position themselves within evolving industrial ecosystems. Crucially, patents do not simply reflect technological developments but help to shape and *orchestrate* them.

We begin by situating the scaling of AI in CAVs within the broader context of cloud industrialisation and power. We then detail the methodology for analysing patents and their key actors. Finally, we zoom in on four central thematic clusters – vehicle communication, machine vision, network architectures, and edge computing – to show how cloud imaginaries are encoded in patent filings.

## Automotive innovation, cloud industrialisation, and infrastructural power in AI

### *Automotive innovation*

In recent years, the automotive industry has become a key site where cloud computing, AI, infrastructural power, and innovation have converged. Connected and autonomous vehicles (CAVs) depend on an assemblage of cloud-based technologies – including data storage, connectivity, and machine vision – that increasingly require support from Big Tech firms and AI providers. Yet efforts to deliver CAVs have faced persistent obstacles, shaped by three principal challenges.

First, geopolitical and geoeconomic disruptions have destabilised the automotive industry's complex supply chains. Chip shortages during the pandemic (Brinley, 2023), followed by trade war disputes have led to strategies of 'onshoring' and 'friend-shoring' in semiconductor production (Aoyama et al., 2024), which are reshaping the foundations of global automotive supply chains.

Second, automotive firms have struggled with digitalisation. Processes of datafication (Hind, 2021), 'chipification' (Forelle, 2022), and platformisation (Hind et al., 2022) have transformed everything from how customers purchase vehicles to how faulty models are recalled (Shakir, 2025). These developments have stretched the expertise of many automotive firms, forcing them to rely on new kinds of partnerships to deliver digital innovations (Hind et al., 2022). One example is Polestar, an 'asset-lite' brand owned by Volvo, which became the first to integrate Google Gemini (Hawkins, 2025). As Volvo have stated, 'accelerating the pace of innovation' through such partnerships is intended to 'not only improve the driving experience' for customers, but also 'set new benchmarks for the automotive industry' (Brady, 2025).

Third, legacy automakers face mounting competition from Chinese entrants. Firms such as BYD, Geely, and Xiaomi are rapidly expanding into European and US markets, with BYD surpassing Tesla in global electric vehicle sales in 2023 (Gerbaudo, 2024). Backed by state subsidies and vertically integrated supply chains, BYD produces chips and batteries in-house, while Xiaomi leverages expertise in consumer electronics to advance software integration. In contrast, Western automakers remain dependent on outsourced battery production and software partners, leaving them at a cost disadvantage (European Commission, 2024).

Overall, these dynamics underscore the automotive industry's growing reliance on cloud and AI services provided by Big Tech companies. For example, the Volkswagen Automotive Cloud (VW.AC) is the result of a strategic partnership between Volkswagen and Microsoft, signed in 2018, to develop a foundational dedicated service for all future vehicle features, such as intelligent parking and over-the-air-updates (Volkswagen, 2018). The company has since secured multiple partnerships for infrastructural, cloud-based services needed for digital and AI-driven automobility (Cariad, 2023).

### Cloud industrialisation and AI

CAVs' dependence on large-scale cloud infrastructures can be situated within AI's broader industrialisation: the transition from experimental, research-driven projects to large-scale, commercial deployment (Van der Vlist et al., 2024). This scalar shift signals a broader reconfiguration of AI (Pfotenhauer et al., 2021), fuelled by economic narratives of an 'AI-first world' (e.g., Pichai, 2017), and structurally underpinned by the cloud computing platforms of Amazon (AWS), Microsoft (Azure), and Google (Cloud). These 'Big Three' US cloud giants dominate around 65% of the global cloud market and provide the computational backbone required to train and scale contemporary AI systems (Rikap, 2024).

The result is a structural convergence between AI and Big Tech infrastructure, conceptualised as 'Big AI' – a model of innovation where AI's development, deployment, and scaling are fundamentally dependent on hyperscale cloud infrastructure (Van der Vlist et al., 2024). Realising the potential of scaled AI applications, particularly in demanding areas such as large language models (LLMs), requires enormous computational capacity, favouring a small set of firms with the capital and infrastructure to meet such demands (Luitse, 2024; Luitse & Denkena, 2021; Rikap, 2024). This concentration fuels rentier and monopolistic dynamics, prompting growing scholarly interest in the political economy of AI, the emergence of 'cloud empires' (Lehdonvirta, 2022), and critiques of the computing industry's oligopolistic structure (e.g., Narayan, 2022). Firms that control cloud infrastructure not only enable AI development but also extract value from their position as infrastructural intermediaries – renting access to compute power, data pipelines, and proprietary software.

Hyperscalability – a defining feature of cloud computing – thus functions as both enabler and constraint, fuelling rapid expansion of AI capabilities while entrenching infrastructural asymmetries and new forms of dependency. Pfotenhauer et al. (2021) have termed this dynamic the 'politics of scaling', capturing how a scalar imperative dominates contemporary innovation discourse and shapes broader economic imaginaries – at all costs (Hanna & Park, 2020). Empirically examining specific sectors, such as the automotive industry, allows examining such dynamics beyond industry-native framings.

Importantly, these narratives do not simply describe technological progress; they actively shape it. In this, patents become places where cloud technologies are presented, described, visualised, and imagined. The cloud is rendered differently in each patent, while maintaining shape, form and general knowability to this noted wider audience across many instances of these patents. The conceptualisation of 'the cloud' allows easy communication and interpretation across patent applicants, patent evaluators, and patent readers, in addition to enabling the conceptualisation, organisation, and scaffolding of follow-on development work at the organisational level.

Within platform capitalism, firms strategically build ecosystems around their core technologies, mobilising resources such as open datasets and developer challenges to attract external innovators – 'complementors' – and cultivate wider innovation ecosystems (Hind et al., 2024; Luitse et al., 2024; Widder et al., 2024). Furthermore, technology firms partner with automotive manufacturers, infrastructure providers, and cloud services to scale AI applications (Hind et al., 2022).

### *Infrastructural power in AI*

The infrastructural backbone of AI is itself a major source of corporate power, shaping how future systems are deployed. Big Tech's dominance rests not only on capital and talent, but also on privileged access to critical computational infrastructures. These advantages allow firms to entrench their positions through rentier strategies (Dyer-Witheford et al., 2019; Kak & West, 2023; Luitse, 2024; Van der Vlist et al., 2024). Smaller players, dependent on access to these infrastructures, risk long-term lock-in effects.

This dominance also has material and spatial dimensions, with these 'infrastructural geographies' (e.g., Ferrari, 2023; Klinge et al., 2023) highlighting the uneven global distribution of socio-technical systems that underpin AI – from hyperscale data centres to chips. As noted in the automotive case, supply chain fragilities have pushed automakers into closer alliances with Big Tech to secure access to computational infrastructure.

Cloud-dependent AI is also embedded in geopolitical structures of digital dependence. Mayer and Lu (2025) show how the US and China have consolidated dominance across three critical vectors – hardware, platforms, and patents – qualifying them as global 'technopoles'. These positions confer not only technological autonomy but also infrastructural power, enabling both countries to steer innovation trajectories, regulatory standards, and potentially weaponise dependency relations.

Against this backdrop, two competing innovation imaginaries emerged. The first celebrates hyperscalability (scaling up). The second, increasingly visible in Europe and elsewhere, emphasises 'digital sovereignty': reclaiming autonomy over strategic infrastructures (Baur, 2024). In automobility, these imaginaries collide. Analysing how such imaginaries are articulated, for example in patent filings, provides an important lens into the ongoing restructuring of industrial and infrastructural power.

## Cloud imaginaries in CAV patents

### *Patents and cloud imaginaries*

Patents provide both legal descriptions of technological inventions, as well as speculative imaginaries of future technological shifts (Egliston & Carter, 2022; Jasanoff & Kim, 2015; Shapiro, 2020). Iliadis and Acker's (2022) study of Palantir's intellectual property highlights this dual character, where patents first 'trace processes of imagination' (Iliadis & Acker, 2022, p. 344), serving as representations of how a patent applicant 'wishes to appear' (ibid) to a wider, prospective audience which includes the tech press, who regularly report on patent applications to indicate possible future product releases (e.g., George, 2023). Yet, patents are not works of fiction, and when analysed in relation to a firm's actual capabilities they constitute 'a realistic representation, or at least a close approximation' (Iliadis & Acker, 2022, p. 344). Patents, then, both document *ongoing* development work, as rationalised and constituted for public patent application, as well as *future* developable, viable technologies. In this sense, patents offer a viewpoint into cloud imaginaries: these documents not only codify technical developments but also inscribe visions of how cloud-based AI might unfold in practice (cf. Hlongwa & Talamayan, 2023).

Patents are also instruments of economic capture. Their legal status enables firms to secure claims over potential revenue streams, shape acquisition or merger prospects, and establish market power (Damásio et al., 2025), even if the patented product is never commercialised. In the tech industry especially, this has produced a tendency to 'patent everything' (Watkins, 2022). In internet studies and STS patent data has been used to trace emerging technological trends (e.g., Bucher, 2020). Industry analysis, meanwhile, focuses on patent holders as maintaining particular 'patent power' – a metric that helps understand companies' impact beyond just financial reports (Mendelsohn & Rak, 2025).

Drawing on STS, we understand patents within the framework of sociotechnical imaginaries. As Richter et al. (2023, p. 218) argue, imaginaries – collective visions of desirable futures – are a powerful lens for analysing emerging technologies. They are co-produced by corporations, policymakers, and the media, and take shape both discursively and materially. Patents are a particularly consequential site of this co-production: they formalise speculative technological futures and institutionalise innovation trajectories. Moreover, imaginaries are sustained across multiple channels, from strategic storytelling and promotional materials to formal legal instruments such as global patent filings. Further, as Brause et al. (2025) note, imaginaries always involve discursive strategies that define desirability, specify spatio-temporal horizons of deployment, and naturalise certain futures while foreclosing others.

By analysing patents, then, our intention is not to simply catalogue technical artefacts. Instead, we trace how *cloud imaginaries* – the embedding of AI development and deployment into the infrastructures of cloud computing – are encoded, circulated, and contested within the specific industry of connected and autonomous vehicles (CAVs).

### Patent analysis: a four-step process

Our study undertook a large-scale analysis of patents relating to CAVs in order to map emerging topics around cloud-based AI. The aim was not to provide an exhaustive inventory of the field but to develop an exploratory, mixed-methods account of how cloud imaginaries surface within patenting activity.

We rely on computational topic modelling to highlight key topics and themes. Our methodology consisted of four steps. First, building the dataset. Using Lens, a non-profit patent search and analysis platform, we constructed a broad query ['connected vehicles' OR 'connected vehicle' OR 'connected and autonomous vehicles' OR 'connected and autonomous vehicle' OR 'autonomous vehicles' OR 'autonomous vehicle'] which yielded 168,033 results.[1] To deal with duplicate patents we used Lens' 'Extended Patent Families' tool, identifying collections of patents 'covering the same or similar technical content' (European Patent Office, n.d.). This approach yielded 69,421 results.[2]

Second, computational topic modelling. We applied the BERTopic tool (Grootendorst, 2022) to identify latent themes across the dataset. This tool uses an embedding model to map text within a multi-dimensional space. This allowed us to perform topic modelling based on the semantic meaning identified in patents, expressed as a mathematical vector. We selected Hugging Face's all-MiniLM-L6-v2 model (Hugging Face, n.d.) as it is lightweight and capable at capturing semantic similarity. The model itself was trained on a vast range of textual material, including Stack Exchange questions and scientific research papers, making it well-suited for parsing patent abstracts.

The third stage involved identifying topic clusters. The tool's topic modelling analysis produced dozens of topic clusters, not all of which were interesting for our focus on AI and cloudification. After manually reviewing patent listings we selected four clusters for closer examination: (1) *vehicle communication* (375 total patents); (2) *machine vision* (470); (3) *network architectures* (1264); and (4) *edge computing* (765). We tabulated the most frequent applicants and examined patent titles and abstracts in order to select representative patents – those typical of the cluster – for deeper reading. Our analysis adopts a panchronic approach, clustering patents filed across all time periods to identify persistent thematic patterns. This approach revealed stable imaginaries across the dataset but did not capture temporal shifts over time.

Fourth and finally, we conducted detailed qualitative analysis of the selected patents, including full texts and diagrams. This enabled us to establish cluster narratives and to highlight illustrative examples.

This four-step process enables a methodological integration of quantitative mapping and qualitative interpretation. By combining large-scale computational mapping with close interpretive work, we sought to chart how cloud imaginaries materialise across thousands of patents, while also grounding these patterns in the close analysis of specific artefacts.

## Mapping patent dynamics in the CAV field

### *Key actors and patent trends*

Our top-level dataset contains 69,421 unique CAV-related patent families, demonstrating the exponential rise of CAV-related innovation since 2013 (Figure 1), when only 501 patent applications were submitted. By 2017 the number of yearly patents surged to 3,277, marking the beginning of a feverish growth in the development of CAVs, with various autonomous vehicle firms (e.g., Uber, Waymo) beginning to test their vehicles on public roads and increasing patent applications. Only three years later, in 2020, annual applications had risen to 12,865. Although the industry faced turbulence in 2018, patenting activity quickly rebounded, eventually reaching 17,883 in 2023, with a similar total in 2024 (17,866). The slowing of growth from 2020 onwards suggests a maturing – and scaling – of these innovations. In 2024, the last complete year in the dataset, there were only a few hundred more total patents than in 2023.

The dataset also shows a highly concentrated distribution of ownership (Figure 2). The five most active applicants are: Ford (5,273), LG Electronics (4,771), Toyota (3,727), Waymo (3,255) and GM (3,064) followed by Qualcomm (2,691), Intel (2,545), Nvidia (2,338), Samsung (2,205) and Hyundai (1,837).

The top 20 patent owners can be grouped according to five general categories: automotive manufacturers (Ford, Toyota, GM, and Hyundai), chipmakers (Qualcomm, Intel, and Nvidia), electronics companies (LG Electronics, Samsung, IBM, and Bosch),

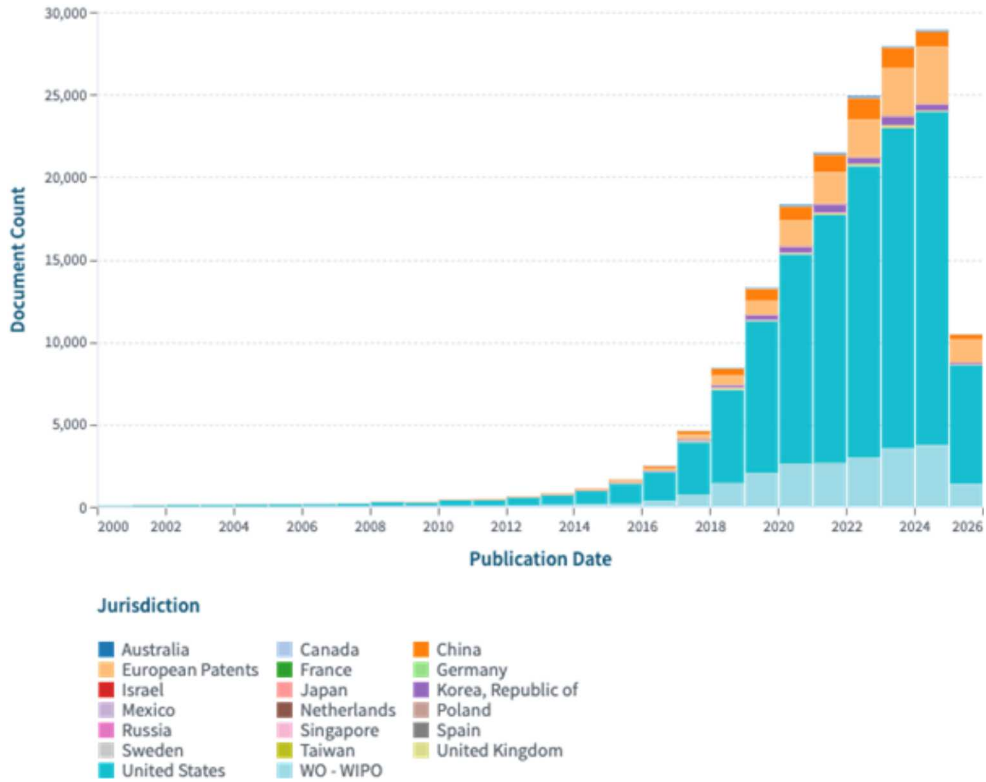


**Figure 1.** Patents per year since 2000, including subdivision by jurisdiction of filing. This shows that most patents are filed under the USA, with a small but visible percentage of Worldwide, European, Chinese, and South Korean patent files.


**Figure 2.** Top owners (with exact name).

autonomous vehicle firms (Waymo, Zoox, GM Cruise, Uber, and UATC), and telecom/mapping providers (Ericsson, AT&T, Here, and Huawei). State Farm – a major insurance firm – is the only one of these patent owners that does not fit neatly within these categories. Despite the recent surge, no Chinese patent owners found their way into the overall top 10, although as discussed below, some firms are represented in specific categories (i.e., vehicle communication and machine vision).

Ford is the single largest patent owner in the dataset, though its activity has slowed. The company peaked in 2020 with over 370 applications; by 2024, filings had dropped to around 280. A portion of these are attributable to Argo AI (~136 filings), Ford's AV subsidiary shuttered in 2022. Most applications were categorised in the Cooperative Patent Classification (CPC) system as relating to the 'autonomous decision making process, e.g., artificial intelligence, predefined behaviours using knowledge based models' (GO5D1/0088) that is, through machine learning.

Taken together, this overview of CAV patents highlights four points that frame our subsequent analysis: (1) an exponential growth in CAV-related patent applications from 2013 to 2023, before plateauing in 2024; (2) concentrated ownership, with a relatively small set of firms in five categories dominating filings; (3) AI and cloud centrality, with the majority of patents classified in domains tied to AI and machine learning; and (4) innovation maturation, through the maturation of CAV-related innovations across the noted timeframe.

This macro-level analysis provides the backdrop for a more granular view. In the next section, we detail four specific patterns of cloud imaginaries in CAV innovation that emerged through topic modelling. These clusters reveal not only the ubiquity of these imaginaries but also how the cloud is collectively depicted as a *technology of orchestration*.

## Cloud imaginaries in CAV innovation: four emerging patterns

### (1) Cloud as data prioritiser: scaling vehicle communication

The first topic cluster centred around patents for *vehicle communication*. This cluster encompasses patents that treat the cloud as a prioritisation system for vehicle communication, determining the relative importance of different data streams for CAVs. This cluster was not dominated by any one particular firm or grouping, and included applications from US automotive manufacturers such as GM (17 patents), Ford (14) and Toyota (6), as well as Chinese tech firms such as Baidu (9) and also lesser-known entities such as CAVH (14), who work with clients to develop integrated 'Vehicle-Road-Cloud' (VRC) systems to 'expedite the commercialisation of automated driving' (CAVH, n.d., n.p.).

Typical patent applications in this cluster described innovations that concerned systems and methods for communicating and processing vehicle data. Patents submitted by GM, for example, included methods for operating scenario-planning and route-generating systems for autonomous vehicles,[3] cloud-based road traffic event and condition systems,[4] and a crowd-sensed fuel estimation system.

The scaling of vehicle communication and data processing, in this automotive context, typically concerned the construction and operation of systems or architectures capable of sending and receiving different kinds of sensor/vehicle data to and from a CAV in question. In essence, the patents included different methods for enabling the kind of

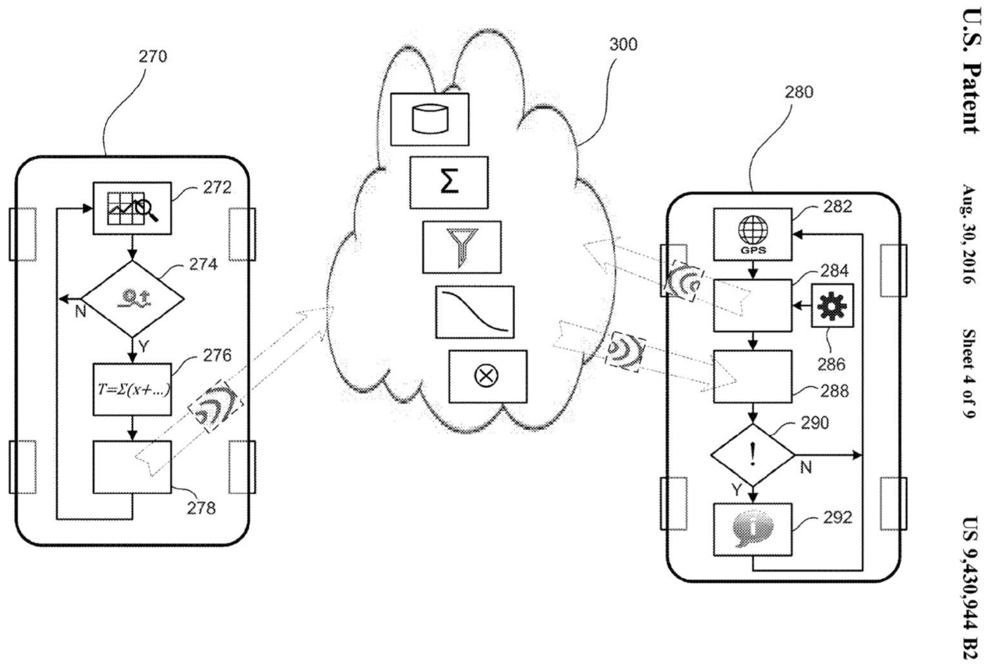


**Figure 3.** This patent by GM offers a method for determining traffic safety events using 'vehicular participative sensing systems', whereby vehicles collect data (left box) that is then processed through a centralised cloud and then distributed as an 'advisory' to other vehicles (right box). Source: https://www.lens.org/lens/patent/120-947-641-692-071.

environmental awareness and perception deemed central to CAVs themselves, aided by the respective connective and sensory qualities of other vehicles out in a wider driving environment. As one patent describes (Figure 3):

> Although … telematics systems have been used to gather some limited types of vehicle data for specific purposes much more data could be collected from a large number of vehicles, and this data could be used to identify a wide range of traffic and road conditions which can be disseminated to and beneficial to other vehicles in a certain geographic locale.[5]

Extrapolating from this thematic category, it becomes evident that that cloud is being imagined as a data *prioritiser*. Rather than a technology with limitless storage space, the cloud is instead envisioned as a technology where, as multiple data sources and streams are integrated, the relative importance of each must be determined, establishing when (and how) they should be processed. Accordingly, the cloud is conceived as capable of enabling prioritisation at different levels from specific vehicle actions to wider environmentally-sensed phenomena and events. Here, the cloud must facilitate multiple purposes, flexible enough to accommodate all kinds of data necessary for delivering AI-dependent features and functions.

### *(2) Cloud as trust validator: scaling machine vision*

The second cluster contained patents for *machine vision*. This cluster comprises patents that conceptualise the cloud as a validation system for sensor data inputs. This cluster was also varied, but was led by autonomous vehicle companies, including Zoox (18), Waymo (18) and Cruise (13) as well as chipmakers (Nvidia, 17) and telecom providers (Huawei, 12).

Typical patent applications in this cluster described innovations for handling sensor data for autonomous vehicles. While similar to the previous category, patents in this cluster described methods for handling sensor data used specifically for ensuring the decision-making capacities of autonomous vehicles, rather than wider communication capabilities of only connected vehicles. Patents submitted by Zoox, for example, include methods for determining depth data,[6] generating data in 'voxel space' (i.e., in 3D),[7] and modelling objects in simulated environments.[8] The scaling of machine vision, in these patents, typically involved dealing with the limitations of particular modes of sensing (e.g., camera or lidar), and the necessities of devising additional methods for accounting for these limitations, whether concerning their (in)ability to capture depth or render environments in full-3D form.

Drawing on this second thematic category around the scaling of machine vision, the cloud is being imagined as a technology for *validating* trust. In these cases, the cloud is imagined as the enabler of the translational processes necessary to turn raw camera and lidar data into reliable, and faithful, representations of reality. In these patents, the question was not how to prioritise or store different data streams but how to *verify* and *trust* them for (time-sensitive) control-specific decisions and actions. The cloud is thus being conceived as the infrastructure that helps facilitate this process – whether by checking against established 'ground truths' (Jaton, 2021) or comparing discrepancies between sensor data sources (Figure 4.).

### *(3) Cloud as resource threshold: scaling network architectures*

The third cluster included patents centred on *network architectures*. This cluster encompasses patents that conceptualise the cloud as a threshold-based system for network resource management. This cluster was dominated by Japanese automotive manufacturer Toyota (92), alongside Ford (84), US chipmaker Qualcomm (73) and South Korean multinational LG Electronics (44). Autonomous vehicle firms including Cruise, Waymo and Lyft were also present, albeit with fewer overall patent applications.

Typical patent applications in this cluster described systems for establishing technical thresholds at which vehicle data is shared with a wider network (Figure 5),[9] 'misbehaviour' management systems to identify inaccurate, corrupt, or hacked data,[10] and systems for generating multiple vehicle communications in response to certain events.[11] As one patent describes,

> Distributed data storage and computing by a cluster of connected vehicles is a promising solution to cope with an increasing network traffic generated for and by connected vehicles. Vehicles collaboratively store (or cache) data sets in their onboard data storage devices and compute and share these data sets over vehicle-to-vehicle (V2 V) networks as requested by other vehicles. Using clusters removes the need for connected vehicles to access remote cloud servers or edge servers by vehicle-to-network (V2N) communications (e.g., by cellular networks) whenever they need to get access to computing resources …[12]

Across these patents, the scaling of network architectures involves the development of technical protocols for how – and where – data should be sent, shared, and stored.

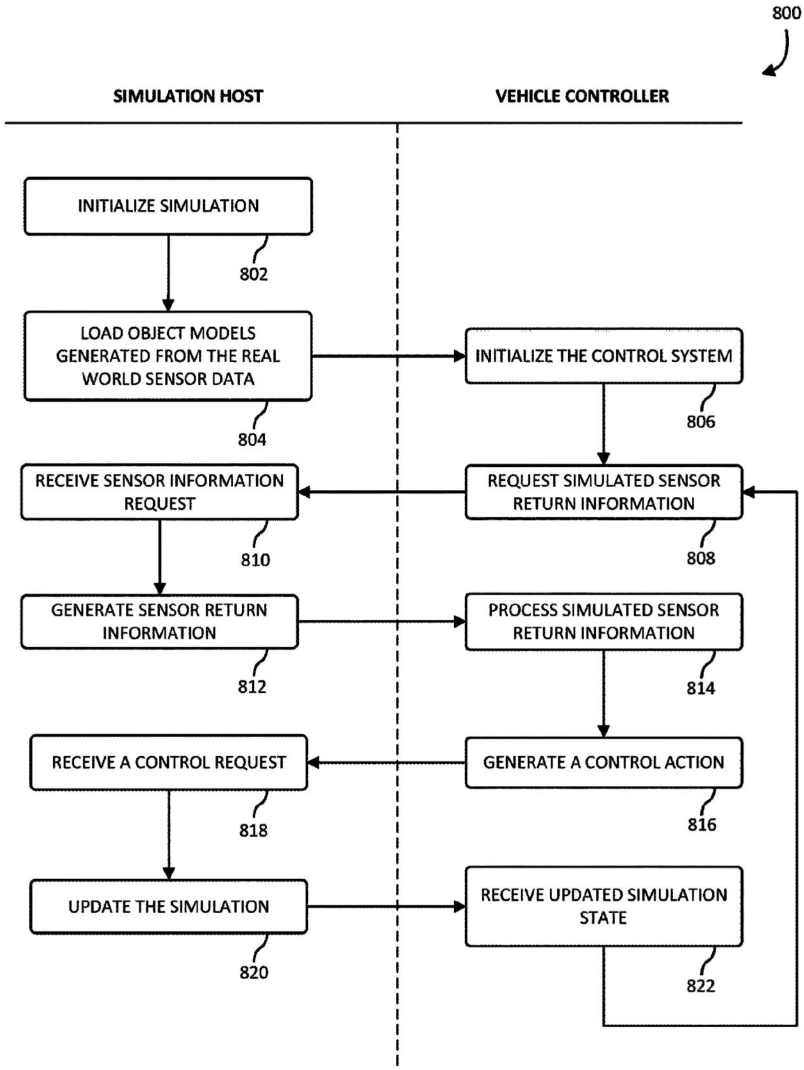


**Figure 4.** This patent by Zoox Inc., a subsidiary of Amazon, envisions the use of the cloud to generate live simulated representations of the world. These would then be used for vehicle decision-making. This would augment the vehicle itself, improving its capacity to act on the world and ensuring control actions are valid. Source: https://www.lens.org/lens/patent/055-376-539-214-362.

This is because the cloud is understood as a computationally finite resource, rather than the capacious, limitless environment. Managing exactly how and when data is sent to cloud servers from specific vehicles, as the patent above contends, is an important task if innovations like V2V are to be realised. Rather than cloud resources assuming the role of storing and processing entirely localised actions, the scaling of network architectures concerns the enrolment of other vehicles and roadside infrastructures as possible data stores.

In this third cluster, the cloud is being envisioned as a set of resource *thresholds* over which data is sent and other forms of communication are actioned. Conceiving of the

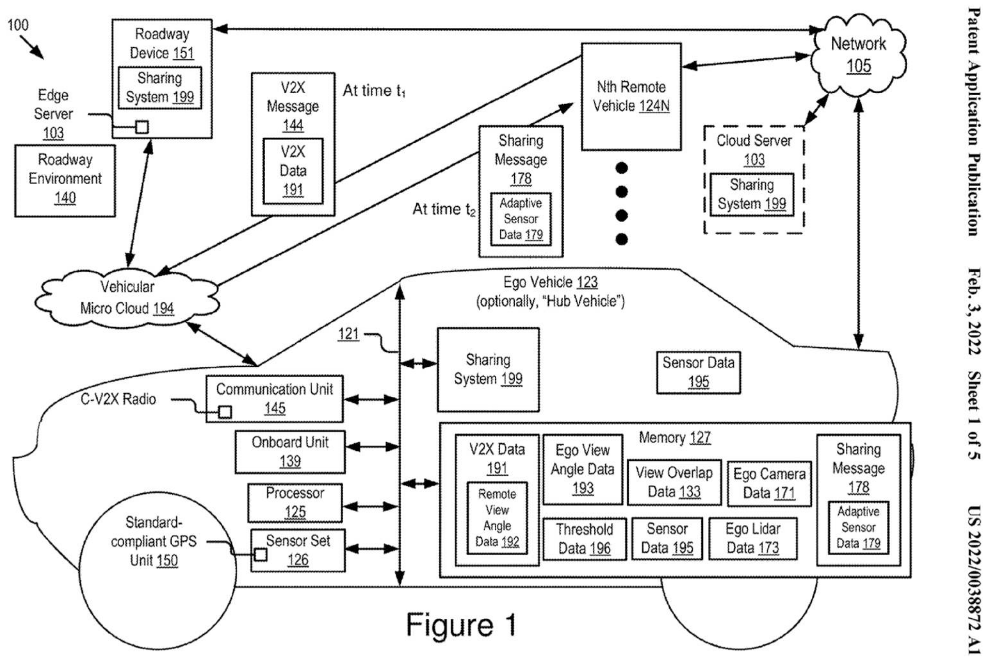


**Figure 5.** This patent by Toyota depicts the vehicle as a variable generator of data, from lidar data to GPS. However, not all of this data needs to leave the car and be sent to the cloud. Some of this data is kept local, some is shared only with other vehicles (the 'vehicular micro cloud'), while other data is sent to the cloud infrastructure. Source: https://www.lens.org/lens/patent/134-324-723-086-021.

cloud in this way allows patent applicants to establish protocols through which the cloud is mobilised or 'stood down'. This imaginary is central to the resource management quandary that comes with scaling: how best to optimise the computational resources at hand? Our example patents demonstrated that innovations did not envision the cloud as just a big computational 'bucket' into which everything could be put. Instead, imaginaries portrayed the cloud as a technology requiring complementary storage and processing locations. Establishing thresholds at which the cloud should be operationalised was key to this imaginary.

### *(4) Cloud as latency spectrum: scaling edge computing*

The final topic cluster for our analysis contained patents related to *edge computing*. This cluster comprises patents that conceptualise the cloud as a spectrum of distributed computing resources across multiple edge layers with varying latencies and proximities. This category was dominated by a mix of applicants ranging from US chip firms (Intel, 93) and telecom firms (Verizon, 51) to Swedish telecom multinationals (Ericsson, 30) and autonomous vehicle firms (Uber, 26). While automotive manufacturers and AI-specific entities were also present, they numbered far fewer.

Typical patent applications in this cluster described innovations that concerned systems and methods for managing edge computing resources. Patents submitted by Intel, for example, included AI/machine learning techniques for the acceleration of resource allocation through the use of telemetry data,[13] the automation of resource allocation, and the 'attestation' (i.e., verification) of data from edge devices.[14]

The scaling of edge computing in this context requires grappling with how to best optimise computational resources, developing methods that efficiently 'schedule' and 'commit' such resources at the most appropriate time. Patents in this cluster typically described the need to handle large amounts of data variously referred to as telemetry data or 'event data'. Figure 6 provides an illustration of the relations across this edge computing spectrum, from devices (e.g., vehicles) to cloud data centres. In between, as the patent describes, different layers in the edge computing network might be referred to as 'close edge', 'local edge', or 'far edge', complicating relations between edge devices and the cloud. As the method describes, taking account of the latencies in each edge computing layer is critical – and a key feature of the patent being submitted.

This final cluster makes clear that the cloud is being conceived of as a latency *spectrum* where differences between the cloud and local devices are not binary. Instead, the cloud is understood as pluri-locational, with different operational latencies, and with varying proximities to either end of the spectrum. In these cases, the capabilities to deliver AI are distributed throughout these locations in order to manage resources as best as possible – with innovations like 'edge clouds' being proposed to solve extant operational issues. Here, AI is both being proposed as a technique for managing these computational resources more efficiently as well as a deliverable technology itself requiring the effective management of computational resources throughout the cloud.

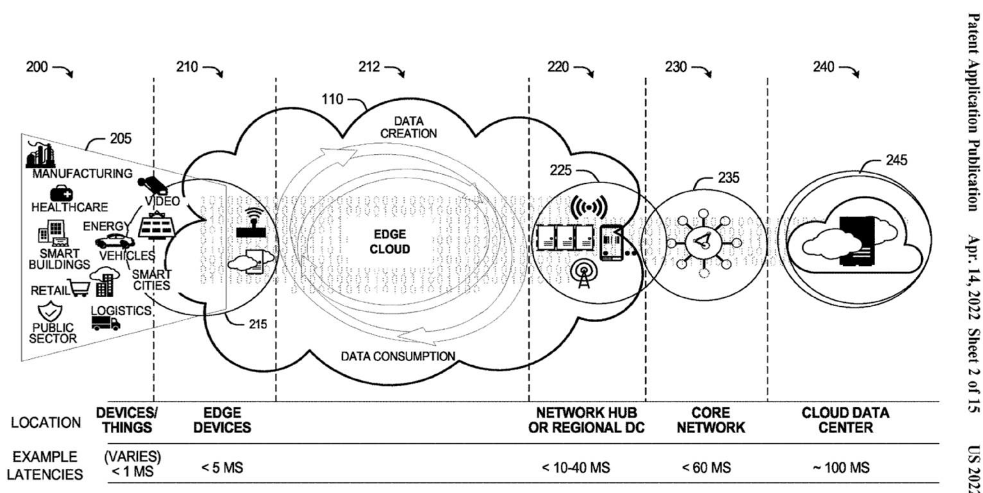


FIG. 2

**Figure 6.** This patent by Intel focuses on edge computing. It develops a method to enable a constellation of edge devices to communicate together, creating an 'edge cloud' for computing that is closer to users and their devices. The image depicts this edge cloud, therefore, as having a lower latency in milliseconds (ms) when compared to the 'cloud data center'. Source: https://lens.org/043-869-262-380-965.

## Orchestrating scalability in CAV innovation

The trade-offs of cloud centralisation in CAV-related innovation are manifold. On one hand, the cloud – as a technology of orchestration – concentrates power in the hands of providers; on the other, its presence in patents shows that this concentration is never total – never simply a case of 'capture it all'. It shows how the cloud is not a uniform thing, neither materially nor rhetorically. Across the dataset we analysed, the cloud is everywhere: 'possess[ing] a material existence that far exceeds the data center realm' (Narayan, 2022, p. 923), but a closer reading shows that it is, in fact, a multiplicity of technologies that envisions scaling different aspects of CAVs through various practices of remote storage and processing. In every case, the cloud remains recognisable as the organising, *orchestrating*, reference point (Figure 7).

In our analysis, we found that the scaling of the cloud, and the scaling of CAVs specifically, is principally concerned with both managing and maximising resources. Following previous work on cloud and AI technologies' industrialisation and distribution (Luitse, 2024; Van Der Vlist et al., 2024) the patents show how broad computing infrastructures encounter specific issues when being implemented in a particular industry. The cloud, as we have found, is not always the solution: many patents we studied depicted innovations designed to lessen the burden on central cloud computing systems by shifting responsibility for computational processes back to vehicles and other local, 'edge' devices. In such cases, tension between the promise of hyperscalable regimes (Pfotenhauer et al., 2021) and the reality of its implementation is evident (Hind, 2024).

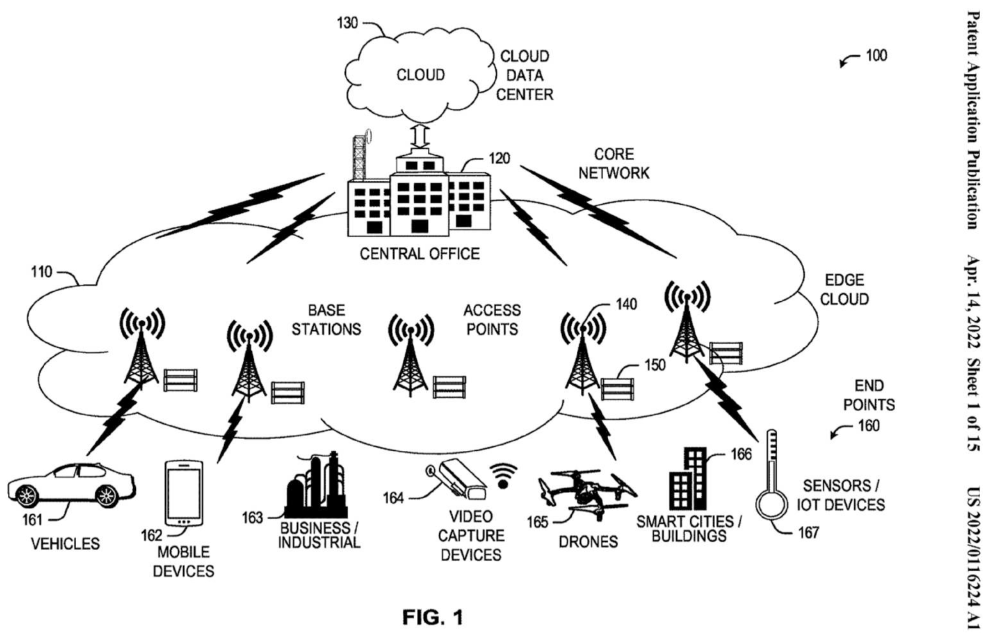


**Figure 7.** A typical depiction of the 'cloud-as-orchestrator' found in the dataset. The 'cloud data center' sits at the top of the pyramid, orchestrating control over devices and networks. Source: https://www.lens.org/lens/patent/043-869-262-380-965.

This helps us reconceptualise the cloud not simply as a centralised processing facility but as a *technology of orchestration*. Its power lies in controlling, managing, and optimising data flows across distributed systems: not always doing the heavy work of processing data, but key to 'orchestrating' flows of data and decisions. This is seen in how different patent applicants appear in various clusters. While traditional automotive firms might try to render the cloud as an auxiliary service to their main goal of manufacturing vehicles with embedded services (clusters 1 and 3), technology upstarts and chip companies profiting from the scaling economy might focus instead on the cloud's availability for complex compute tasks (cluster 2). Telecoms firms, in contrast, might use their ownership and knowledge of communications infrastructure to shift computational resources around, from cloud to edge (cluster 4). Although we often think that the power of the cloud is consolidating technical power in distant servers (Ferrari, 2023), we can see through these patents that the cloud, in this sense, does not substitute other infrastructures, but rather *orchestrates* the system as a whole.

Two critical implications follow. First, the centrality of the cloud is inescapable: across thousands of patents, none could imagine CAVs without invoking the cloud – whether as concept, symbol, or technical resource. Second, the patents reveal a paradox: even as they attempt to mitigate dependence on cloud infrastructures, they reinforce the imaginary centrality of the cloud itself. Efforts to manage strain on the cloud end up consolidating its role as the essential organising infrastructure.

From this perspective, the cloud is more than a technical infrastructure but also a discursive one (Iliadis & Acker, 2022). The concept of the cloud in these patents works to *render* and *consolidate* respective imaginaries. It is through the cloud as a concept that different patent applications crystallise and communicate visions of a future of connected and autonomous vehicles. These imaginaries are certainly not always the same, and do not render the same kind of world as envisioned by certain Big Tech firms and cloud computing leaders. Regardless, they all, either by using different techniques or employing the same tactics, tie these respective imaginaries to the concept of the cloud itself. While this might be expected in the dataset we have studied, it is nonetheless evident in the patents we have examined that neither 'connected' nor 'autonomous' vehicles are being made possible without the cloud, both as concept and as technology.

Taken together, these dynamics highlight how patents do more than document technical solutions. They actively shape the cloud imaginaries through which CAV innovation is rendered thinkable, legitimate, and scalable. The patents make visible how the cloud is imagined as both a technical bottleneck and a solution; as both centralised and distributed; as both limiting and enabling. It is not possible – at least as reflected in the patents we studied – to imagine CAVs without imaging the cloud in some sense playing a role. Each patent application in the CAV industry is thus concerned with how to reduce the reliance, strain, or computational burden on the cloud itself. In so doing, they consolidate the cloud's position not just as a technical infrastructure, but as the infrastructural condition of possibility for CAVs.

Finally, what the patents do not show is also interesting: the geopolitical struggles over the future of AI technologies and the growing financialisation of CAVs. Unlike documented anxieties around digital sovereignty (Baur, 2024), we saw little evidence of one country's domination over particular (subsets of) technologies. This is most likely due to how CAVs – like traditional cars – are reliant on global production and supply chains, making national concentration difficult. While our findings corroborate the ongoing platformisation of automobility (Hind et al., 2022), the patents we reviewed lack the particular financial and rentier component observed as part of this platformisation (Shapiro & Forelle, 2024), such as subscription and leasing arrangements.

## Conclusion

This article has examined how the cloud – as a *technology of orchestration* – has become central to the scalar development of connected and autonomous vehicles (CAVs). By coordinating computation, mediating data flows, and enabling scalability across distributed systems, the cloud underpins how CAVs are envisioned and built. Our focus on patents – documents that both record technical innovations and project imaginaries of technological futures – has shown how the cloud is mobilised as a critical infrastructural condition for imagining and realising AI-driven mobility.

We analysed a large dataset of over 69,000 patent families to map the actors involved in filing CAV-related patents. This revealed an exponential rise in patenting activity: from just 501 applications in 2013 to 17,866 in 2023 (a 3,569% increase in a single decade). Rather than being dominated by Big Tech, filings were concentrated among five groups – automotive manufacturers, chipmakers, electronics companies, autonomous vehicle firms, and telecom/mapping providers. These coalitions indicate that CAV innovation is distributed across several industries rather than located in a single sector.

Geographically, patenting did not show strong 'technopoles' (Mayer & Lu, 2025). Despite narratives of Chinese disruption, filings remained heavily skewed toward the US, where over 20,000 CAV-related patents were filed in 2024, compared with just over 3,400 in China. Established US, Japanese, and South Korean firms such as GM, Toyota, and Samsung continue to dominate patent filings across multiple technological domains, while Chinese entrants like Huawei, Baidu, and TuSimple have been gradually building a presence – especially in machine vision technologies. Patenting, we suggest, reflects not only innovation capacity but also the institutional infrastructures that enable firms to translate R&D into formalised intellectual property.

On a more granular level, we demonstrated how cloud-related technologies are articulated across patents by identifying four thematic categories. This shows the sheer variation in how patents seek to manage the burden of cloud infrastructures. Some depict the cloud as a data *prioritiser* that determines which data flows are processed centrally; others as a trust *validator* that confirms the accuracy of locally processed outputs; still others treat it as a resource *threshold* or latency *spectrum* – dynamically allocating resources depending on network load, proximity, and latency. Despite these differences, the cloud remains ever-present – visually symbolised in patent diagrams by a stylised depiction of a cumulus cloud.

The broader implication is that cloudification is not simply an industry trend but a structural transformation. CAV patents show how diverse firms, across markets, are invested in building AI-enabled infrastructures that are globally scalable. Cloudification offers a developmental logic linking innovations in communication, perception, and computation to a broader industrial logic of scalability. Yet this also reinforces structural dependencies: by embedding cloud services as indispensable intermediaries, the field risks consolidating the infrastructural dominance of Big Tech – even where these firms are not the primary patent holders. Through CAV-related patents, Big Tech firms are a spectral presence, represented as chipmakers (e.g., Nvidia) or autonomous vehicle firms (Waymo), competing alongside automotive manufacturers, electronics, and telecom companies to bring new technologies to market.

Three conclusions follow. First, patents underscore the oligopolistic structure of CAV innovation. While Big Tech platforms are powerful, they are not alone; automotive, chip, electronics, and telecom firms collectively shape the direction of CAVs. Second, patenting highlights a paradox: attempts to reduce dependence on the cloud (through edge computing or distributed architectures) often reaffirm its imaginary centrality. Working around the cloud's limits serves to reassert its indispensability. Third, while the cloud operates as a technology of orchestration, it is also a fix that holds together disparate innovation trajectories around computation, latency, and scalability. However, this reliance risks entrenching bottlenecks, long-term dependencies, and infrastructural lock-ins at a time when states and regions are asserting new claims to 'technological sovereignty' (Rikap & Lundvall, 2021).

In conclusion, the cloudification of CAVs illustrates the broader industrialisation of AI. As patents show, AI systems are moving from the laboratory into commercial infrastructures – scaled through factories, fleets, and networks, and formalised through intellectual property (i.e., the patent). Cloud infrastructures sit at the heart of this transformation, orchestrating not just technical possibilities but the imaginaries through which future mobility is envisioned, legitimised, and governed.

## Notes

1. The query cut-off point was 12/05/2025.
2. The query is available on Lens.org: https://link.lens.org/upkBd9nT3nh Note there may be different results as the service may index new patents through time.
3. https://www.lens.org/102-669-882-826-624.
4. https://lens.org/120-947-641-692-071.
5. https://www.lens.org/lens/patent/120-947-641-692-071/fulltext.
6. https://www.lens.org/lens/patent/158-228-075-383-247.
7. https://www.lens.org/lens/patent/189-539-218-412-395.
8. https://www.lens.org/lens/patent/055-376-539-214-362.
9. https://www.lens.org/lens/patent/134-324-723-086-021.
10. https://www.lens.org/lens/patent/117-647-306-162-53X.
11. https://www.lens.org/lens/patent/075-182-901-104-386.
12. https://www.lens.org/lens/patent/134-324-723-086-021.
13. https://lens.org/168-925-260-725-372.
14. https://lens.org/043-869-262-380-965.

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## Author contributions

CRediT: **A. (Alex) Gekker:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing; **S. (Sam) Hind:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing; **G. (Gabriel) Pereira:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing; **F. N. (Fernando) van der Vlist:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.

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## Data availability statement

The data that support the findings of this study are openly available in the Open Science Framework (OSF) at https://osf.io/5pj9b/.

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## References

Aoyama, Y., Song, E., & Wang, S.-Y. (2024). Geopolitics and geospatial strategies: The rise of regulatory supply chain controls for semiconductor GPN in Japan, South Korea and Taiwan. *ZFW – Advances in Economic Geography*, *68*(3-4), 167–181. https://doi.org/10.1515/zfw-2024-0046

Baur, A. (2024). European dreams of the cloud: Imagining innovation and political control. *Geopolitics*, *29*(3), 796–820. https://doi.org/10.1080/14650045.2022.2151902

Brady, P. (2025, May 21). Volvo Cars and Google expand partnership with Gemini integration and accelerated automotive innovation. *Volvo*. https://www.media.volvocars.com/global/en-gb/media/pressreleases/349455/volvo-cars-and-google-expand-partnership-with-gemini-integration-and-accelerated-automotive-innovati

Brause, S. R., Schäfer, M. S., Katzenbach, C., Mao, Y., Richter, V., & Zeng, J. (2025). Sociotechnical imaginaries and public communication: Analytical framework and empirical illustration using the case of artificial intelligence. *Convergence: The International Journal of Research into New Media Technologies*, *31*(4), 1267–1287. https://doi.org/10.1177/13548565251338192

Brinley, S. (2023, July 12). The semiconductor shortage is—mostly—over for the auto industry. *S&P Global: Mobility*. https://www.spglobal.com/mobility/en/research-analysis/the-semiconductor-shortage-is-mostly-over-for-the-auto-industry.html

Bucher, T. (2020). The right-time web: Theorizing the kairologic of algorithmic media. *New Media & Society*, *22*(9), 1699–1714. https://doi.org/10.1177/1461444820913560

Caltrider, J., Rykov, M., & MacDonald, D. (2023, September 6). It's official: Cars are the worst product category we have ever reviewed for privacy. *Mozilla Foundation*. https://www.mozillafoundation.org/en/privacynotincluded/articles/its-official-cars-are-the-worst-product-category-we-have-ever-reviewed-for-privacy/

CARIAD. (2023). *Press release: Structural and personnel realignment at CARIAD*. https://cariad.technology/de/en/news/stories/structural-and-personnel-realignment-at-CARIAD.html

CAVH. (n.d.). *About CAVH*. https://cavhllc.com/#about

Damásio, B., Silva, E., & Mendonça, S. (2025). Patents and the business strategies of digital platforms: A comparative analysis of the patent portfolios of large digital platforms. In *ITS 33rd European Conference 2025: Digital Innovation and Transformation in Uncertain Times*. https://hdl.handle.net/10419/331264

Dyer-Witheford, N., Kjøsen, A. M., & Steinhoff, J. (2019). *Inhuman power: Artificial intelligence and the future of capitalism*. Pluto.

Egliston, B., & Carter, M. (2022). 'The metaverse and how we'll build it': The political economy of Meta's Reality Labs. *New Media & Society*, *26*(8), 4336–4360. https://doi.org/10.1177/14614448221119785

European Commission. (2024, October 29). EU imposes duties on unfairly subsidised electric vehicles from China while discussions on price undertakings continue. *European Commission*. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_5589

European Patent Office. (n.d.). *Patent families*. Retrieved September 1, 2025, from https://www.epo.org/en/searching-for-patents/helpful-resources/first-time-here/patent-families

Ferrari, F. (2023). Neural production networks: AI's infrastructural geographies. *Environment and Planning F*, *2*(4), 459–476. https://doi.org/10.1177/26349825231193226

Forelle, M. C. (2022). The material consequences of "chipification": The case of software-embedded cars. *Big Data & Society*, *9*(1), 1–12. https://doi.org/10.1177/20539517221095429

George, P. (2023, March 3). Ford's self-repossessing car patent is a nightmare of the connected-car future. *The Verge*. https://www.theverge.com/2023/3/3/23624328/ford-self-repossessing-car-patent-connected-car-nightmare

Gerbaudo, P. (2024, April 11). The electric vehicle developmental state. *Phenomenal World*. https://www.phenomenalworld.org/analysis/byd

Grootendorst, M. (2022). *BERTopic: Neural topic modeling with a class-based TF-IDF procedure*. arXiv. https://doi.org/10.48550/arXiv.2203.05794

Hanna, A., & Park, T. M. (2020). *Against scale: Provocations and resistances to scale thinking*. arXiv. http://arxiv.org/abs/2010.08850

Hawkins, A. (2025). Volvo will be the first to install Google's Gemini in its cars. *The Verge*. https://www.theverge.com/news/670954/volvo-google-gemini-ai-cars-android-automotive

Hill, K. (2024). Automakers are sharing consumers' driving behavior with insurance companies. *New York Times*. https://www.nytimes.com/2024/03/11/technology/carmakers-driver-tracking-insurance.html

Hind, S. (2021). Dashboard design and the 'datafied' driving experience. *Big Data & Society*, *8*(2), 1–14. https://doi.org/10.1177/%2F20539517211049862

Hind, S. (2024). *Driving decisions: How autonomous vehicles make sense of the world*. Palgrave Macmillan.

Hind, S., Kanderske, M., & van der Vlist, F. (2022). Making the car "Platform ready": How Big Tech is driving the platformization of automobility. *Social Media + Society*, *8*(2), 1–13. https://doi.org/10.1177/20563051221098697

Hind, S., van der Vlist, F., & Kanderske, M. (2024). Challenges as catalysts: How Waymo's open dataset challenges shape AI development. *AI & Society*, *40*, 1667–1683. https://doi.org/10.1007/s00146-024-01927-x

Hlongwa, L., & Talamayan, F. (2023). Patenting sociality: Uncovering the operational logics of Facebook through critical patent analysis. *Media, Culture & Society*, *45*(6), 1135–1155. https://doi.org/10.1177/01634437231154759

Hugging Face. (n.d.). Sentence-transformers/all-MiniLM-L6-v2. *Hugging Face*. https://huggingface.co/sentence-transformers/all-MiniLM-L6-v2

Iliadis, A., & Acker, A. (2022). The seer and the seen: Surveying Palantir's surveillance platform. *The Information Society*, *38*(5), 334–363. https://doi.org/10.1080/01972243.2022.2100851

Jasanoff, S., & Kim, S.-H. (2015). *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power*. University of Chicago Press.

Jaton, F. (2021). *The constitution of algorithms: Ground-truthing, programming, formulating*. MIT Press.

Kak, A., & West, S. M. (2023). 2023 Landscape: Confronting Tech Power. *AI Now Institute*. https://ainowinstitute.org/publications/2023-landscape-confronting-tech-power

Klinge, T. J., Hendrikse, R., Fernandez, R., & Adriaans, I. (2023). Augmenting digital monopolies: A corporate financialization perspective on the rise of Big Tech. *Competition & Change*, *27*(2), 332–353. https://doi.org/10.1177/10245294221105573

Kotliar, D., & Gekker, A. (2024). Migrating the state into corporate clouds. *Information, Communication & Society*, *27*(14), 2566–2586. https://doi.org/10.1080/1369118X.2024.2343816

Lehdonvirta, V. (2022). *Cloud empires: How digital platforms are overtaking the state and how we can regain control*. MIT Press.

Luitse, D. (2024). Platform power in AI: The evolution of cloud infrastructures in the political economy of artificial intelligence. *Internet Policy Review*, *13*(2), 1–44. https://doi.org/10.14763/2024.2.1768

Luitse, D., Blanke, T., & Poell, T. (2024). AI competitions as infrastructures of power in medical imaging. *Information, Communication & Society*, *28*, 1735–1756. https://doi.org/10.1080/1369118X.2024.2334393

Luitse, D., & Denkena, W. (2021). The great transformer: Examining the role of large language models in the political economy of AI. *Big Data & Society*, *8*(2), 1–14. https://doi.org/10.1177/20539517211047734

Mayer, M., & Lu, Y.-C. (2025). Global structures of digital dependence and the rise of technopoles. *New Political Economy*, 1–20. https://doi.org/10.1080/13563467.2025.2497766

Mendelsohn, K., & Rak, G. (2025). These companies were the patent powerhouses of 2024. *IEEE Spectrum*. https://spectrum.ieee.org/patent-power-2025
Narayan, D. (2022). Platform capitalism and cloud infrastructure: Theorizing a hyper-scalable computing regime. *Environment and Planning A: Economy and Space*, *54*(5), 911–929. https://doi.org/10.1177/0308518X221094028
Pfotenhauer, S., Laurent, B., Papageorgiou, K., & Stilgoe, J. (2021). The politics of scaling. *Social Studies of Science*, *52*(1), 3–34. https://doi.org/10.1177/03063127211048945
Pichai, S. (2017). *Google I/O Keynote '17*. https://www.youtube.com/watch?v=Y2VF8tmLFHw
Richter, V., Katzenbach, C., & Schäfer, M. S. (2023). Chapter 18: Imaginaries of artificial intelligence. In S. Lindgren (Ed.), *Handbook of critical studies of artificial intelligence* (pp. 1–19). Elgar.
Rikap, C. (2024, May 15). Dynamics of corporate governance beyond ownership in AI. *Common Wealth*. https://www.common-wealth.org/publications/dynamics-of-corporate-governance-beyond-ownership-in-ai
Rikap, C., & Lundvall, B-Å. (2021). *The digital innovation race*. Palgrave Macmillan.
Shakir, U. (2025, January 10). Tesla recalls 200,000 vehicles with faulty on-board computers. *The Verge*. https://www.theverge.com/2025/1/10/24340689/tesla-rearview-camera-recall-self-driving-computer-short-circuit
Shapiro, A. (2020). 'Embodiments of the invention': Patents and urban diagrammatics in the smart city. *Convergence: The International Journal of Research into New Media Technologies*, *26*(4), 751–774. https://doi.org/10.1177/1354856520941801
Shapiro, A., & Forelle, M. C. (2024). Driving into a paywall: The subscriptionization of consumer vehicles. *Engaging Science, Technology, and Society*, *10*(3), 147–180. https://doi.org/10.2139/ssrn.4955964
Van der Vlist, F., Helmond, A., & Ferrari, F. (2024). Big AI: Cloud infrastructure dependence and the industrialisation of artificial intelligence. *Big Data & Society*, *11*(1), 1–16. https://doi.org/10.1177/20539517241232630
Volkswagen. (2018, September 28). Volkswagen and Microsoft announce strategic partnership. *Volkswagen Newsroom*. https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-and-microsoft-announce-strategic-partnership-4234
Watkins, N. (2022, March 15). Inside Big Tech's race to patent everything. *Wired*. https://www.wired.com/story/big-tech-patent-intellectual-property/
Widder, D. G., Whittaker, M., & Myers West, S. (2024). Why 'open' AI systems are actually closed, and why this matters. *Nature*, *635*, 827–833. https://doi.org/10.1038/s41586-024-08141-1