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ALGORITHMIC PUBLIC ADMINISTRATION AND ALGOCRACY: TRANSFORMING GOVERNANCE IN URBAN TRANSPORT SYSTEMS

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Abstract

This research examines the structural transition of urban transport governance into "Algorithmic Public Administration". By analyzing AI-driven mobility regimes in five global cities, it introduces a multidimensional framework—the Algorithmic Public Administration Model (APAM)—to decode the operational logic of what we term algocracy. The study moves beyond technical optimization metrics to address three critical governance gaps: the formalization of systemic unpredictability through Shannon entropy, the integration of "digital conscience" into algorithmic design, and the reconceptualization of administrative liability via an Algocratic Error Matrix. Drawing on case studies from Istanbul, Singapore, Hangzhou, Belgrade, and Shenzhen, the study constructs a five-layer analytical framework comprising data infrastructure, optimization logic, normative parameters, surveillance mechanisms, and democratic feedback. Our findings suggest that current efficiency gains often come at the expense of participatory legitimacy. To resolve this paradox, we propose a Democratic Algorithmic Governance

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Framework (DAGF) that institutionalizes oversight through algorithmic councils and participatory parameter-setting.

Keywords: *Algocracy, AI Mobility, Digital Conscience, Algorithmic Accountability, Participatory Governance.*

ALGORİTMİK KAMU YÖNETİMİ VE ALGOKRASİ: KENTSEL ULAŞIMDA YÖNETİŞİM DÖNÜŞÜMÜ

Öz

Bu araştırma, kentsel ulaşım yönetişiminin "Algoritmik Kamu Yönetimi" yapısına doğru geçişini incelemektedir. Beş küresel kentteki yapay zekâ odaklı mobilite rejimlerini analiz eden çalışma, "algokrasi" olarak adlandırdığımız yapının operasyonel mantığını çözümlemek adına çok boyutlu bir çerçeve —Algoritmik Kamu Yönetimi Modeli (AKYM)— önermektedir. Araştırma, teknik optimizasyon metriklerinin ötesine geçerek yönetişimdeki üç kritik boşluğa odaklanmaktadır: sistemsel öngörülemezliğin Shannon entropisi yoluyla formelleştirilmesi, "dijital vicdanın" algoritmik tasarıma entegrasyonu ve idari sorumluluğun bir Algokratik Hata Matrisi aracılığıyla yeniden kavramsallaştırılması. İstanbul, Singapur, Hangzhou, Belgrad ve Shenzhen'deki vaka çalışmalarından yararlanan bu araştırma; veri altyapısı, optimizasyon mantığı, normatif parametreler, gözetim mekanizmaları ve demokratik geri bildirimden oluşan beş katmanlı bir analitik çerçeve inşa etmektedir. Bulgularımız, mevcut verimlilik kazanımlarının genellikle katılımcı meşruiyet pahasına elde edildiğini göstermektedir. Bu paradoksu çözmek amacıyla, algoritmik kurullar ve katılımcı parametre belirleme süreçleri vasıtasıyla denetimi kurumsallaştıran bir Demokratik Algoritmik Yönetişim Çerçevesi (DAYÇ) önerilmektedir.

Keywords: *Algokrasi, YZ Mobilitesi, Dijital Vicdan, Algoritmik Hesap Verebilirlik, Katılımcı Yönetişim*

1. INTRODUCTION: THE COMPUTATIONAL TURN IN URBAN GOVERNANCE

Urban transport systems were once governed by engineers and civil servants. Today, they are increasingly governed by automated code. Traffic signals adapt in real time through reinforcement learning (Wei et al., 2021), predictive models allocate road capacity dynamically, and AI systems prioritize emergency vehicles

or coordinate multimodal flows. In leading smart cities, algorithmic systems execute thousands of micro-decisions per second—decisions that collectively structure human mobility, economic productivity, and everyday urban life (Kitchin, 2023). Such decision density presents unprecedented challenges for public leadership, as algorithmic change reconfigures the foundational administrative landscape (Boin & 't Hart, 2003).

This transformation is frequently celebrated under the technocratic banner of "smart mobility." Yet the dominant narrative remains strictly technical: reduced congestion, lower carbon emissions, and increased infrastructure throughput. The political and constitutional transformation embedded within these computational systems remains profoundly under-theorized.

The delegation of administrative discretion to autonomous computational systems constitutes a paradigmatic shift in governance. However, rather than signaling the retreat of the state, this transformation reflects its adaptive persistence and reconfiguration through new techno-legal governance instruments (Peters, 2011). We are witnessing the emergence of Algorithmic Public Administration (APA)—a governance configuration in which algorithmic architectures exercise regulatory authority within public systems.

Unlike earlier digitalization waves associated with *Digital Era Governance* (DEG), where technologies primarily supported service integration and administrative coordination (Dunleavy et al., 2006; Sobacı, 2010), AI mobility infrastructures autonomously execute decisions within parameterized normative frameworks (Akman et al.: 2005; Cuneen at al.: 2019). The locus of administrative power shifts decisively from street-level bureaucrats to machine-optimized infrastructures (Lipsky, 2010; Zuboff, 2019; Bovens & Zouridis. 2002).

This shift raises three foundational questions for the field of public administration:

1. How does algorithmic governance transform democratic legitimacy and public accountability in urban transport systems?
2. How must administrative liability doctrines and public law adapt in automated algocratic regimes?
3. Can constitutional values be operationalized within algorithmic architectures through a concept we term “digital conscience”?

The central argument of this article is that smart mobility represents a constitutional moment in public administration. The embedding of optimization logics within municipal infrastructure transforms not only technical efficiency metrics but the very normative structure of governance itself. While contemporary urban mobility systems increasingly exhibit characteristics of *algocracy*—a governance regime where algorithmic systems exercise de facto regulatory authority (Danaher, 2016)—algocracy is not inherently authoritarian. Its democratic quality depends entirely on how normative parameters are embedded, how system entropy is managed, and how civic oversight is institutionalized.

2. LITERATURE REVIEW: FROM OPTIMIZATION TO CONSTITUTIONAL GOVERNANCE

To understand the shift from optimization to constitutional governance, it is essential first to examine how algorithmic governance has reshaped the traditional structures of public administration, transforming bureaucratic decision-making into data-driven processes.

2.1. Algorithmic Governance in Public Administration

The literature on algorithmic governance defines it as the use of computational systems to structure regulatory outcomes and behavioral incentives (Danaher, 2016; Yeung, 2018). In public administration, AI tools are increasingly deployed in welfare allocation, risk assessment, and infrastructure optimization (Wirtz et al., 2019).

However, much of this scholarship focuses on micro-level accountability—such as algorithmic bias detection, explainability, and localized fairness metrics—rather than macro-level institutional and structural transformations. The conceptual vocabulary of public administration remains largely anchored in Weberian bureaucracy, New Public Management (NPM), and New Public Governance (NPG) paradigms that emphasize human-driven networks and co-production (Parlak:2013, Osborne, 2010; Güler, 2011: Pollitt & Bouckaert, 2011). Recent contributions highlight the emergence of "black box bureaucracy" (Busuioc, 2021), yet these analyses rarely extend to physical infrastructure systems like urban transit.

2.2. Smart Mobility vs. Digital Constitutionalism

Smart mobility scholarship documents substantial operational gains, such as adaptive traffic controls reducing delay times and predictive congestion systems optimizing corridor capacity (Busuioc, 2021). Yet, these studies treat democratic governance dimensions—transparency, citizen participation, and liability—as secondary concerns.

Conversely, *digital constitutionalism* explores how constitutional principles apply to digital spaces (Celeste, 2023). However, most digital constitutionalism analyses focus on social media platforms, data protection (GDPR), and online content moderation. Municipal AI infrastructures remain neglected in constitutional scholarship. Urban transport systems—despite their profound

distributive effects on who can move, where, and at what cost—are rarely conceptualized as constitutional spaces requiring democratic constraints.

2.3. Platform Urbanism and the Political Economy of the Smart City

Platform urbanism conceptualizes cities as data platforms governed by algorithmic coordination (Barns, 2020). This perspective highlights the critical risks of data extraction, infrastructural centralization, and private-public hybridization, reflecting broader transformations in state-market relations associated with neoliberal globalization (Öniş, 2012). These transformations fit within broader trajectories of state restructuring, where institutional power is reconfigured through technological and administrative reforms (Bakır, 2009; Bedirhanoğlu, 2009).

Drawing on Henri Lefebvre's (1996) radical conception of the *"right to the city,"* we argue that urban space must be understood as socially produced and politically contested. Algorithmic optimization risks reconfiguring the city into a purely logistical throughput system, privileging machine efficiency over collective self-determination. There is currently no integrated model in the literature linking multi-agent algorithmic entropy, administrative liability doctrine, and democratic participation mechanisms within urban transit. This article addresses this critical gap.

2.4. Digital Constitutionalism

Digital constitutionalism explores how constitutional principles apply within digital infrastructures (Celeste, 2023). Most analyses focus on platform governance, data protection, and content moderation.

Municipal AI infrastructures, however, remain relatively neglected in constitutional scholarship. Urban transport systems—despite their profound distributive effects—are rarely conceptualized as constitutional spaces.

2.5. Platform Urbanism

Platform urbanism conceptualizes cities as data platforms governed by algorithmic coordination (Barns, 2020). This perspective highlights data extraction, infrastructural centralization, and private-public hybridization.

However, it stops short of offering a normative governance framework for public AI infrastructures.

2.6. Lefebvre and the Right to the City

Lefebvre's conception of the "right to the city" frames urban space as collectively produced and politically contested. Algorithmic optimization risks reconfiguring urban space into a logistical throughput system, privileging efficiency over collective self-determination.

This tension between platform logic and **œuvre** logic remains insufficiently theorized in AI mobility scholarship.

2.7. Political Economy of AI in Cities

Recent work examines how AI infrastructures reshape power relations in urban governance, reflecting broader transformations in state–market relations and governance structures associated with neoliberal globalization (Öniş, 2012; Mazzucato, 2013; Kitchin, 2017; Sönmez:2010). These transformations can also be understood within broader trajectories of state restructuring and neoliberal governance, where institutional power is reconfigured through technological and administrative reforms (Bakır, 2009).

However, these analyses focus on market structures rather than administrative doctrine and democratic legitimacy. Identified Theoretical Gap.

Across literatures, three patterns emerge:

1. *Optimization studies dominate smart mobility research.*
2. *AI ethics scholarship lacks sector-specific institutional embedding.*
3. *Digital constitutionalism rarely engages municipal infrastructure systems*.

There is no integrated model linking: *Multi-agent algorithmic entropy, administrative liability doctrine, normative parameterization, democratic participation mechanisms, urban political economy.*

This article fills that gap by constructing a unified theoretical architecture for *Algorithmic Public Administration* in urban transport systems.

3. THEORETICAL FRAMEWORK: TOWARD A GENERAL THEORY OF ALGORITHMIC PUBLIC ADMINISTRATION (APA)

This section develops a unified theoretical architecture for understanding AI-driven urban mobility governance. It proceeds in five steps:

1. *Conceptualizing **Algocracy** as a mode of governance*
2. *Formalizing **Algorithmic Chaos** using entropy theory*
3. *Developing the concept of **Digital Conscience***
4. *Contrasting **Platform Urbanism and the L'œuvre City***
5. *Presenting the Algorithmic Public Administration Model (APAM)*

Together, these elements constitute a general theory of Algorithmic Public Administration.

3.1. Algocracy as a Mode of Governance

We define **algocracy** as a governance regime in which algorithmic systems exercise structured regulatory authority by autonomously executing rule-based and optimization-based decisions within public infrastructures. Algocracy differs

fundamentally from technocracy: authority is not merely held by human experts, but is directly embedded into computational architectures. It differs from traditional bureaucracy because decision rules are no longer interpreted by human discretion; they are executed deterministically or probabilistically through code.

When applied to urban transit, algorithms execute de facto regulatory decisions, including: the dynamic pricing of public roads, the prioritization of specific vehicle classes, automated emission-based routing, and automated enforcement triggers. These functions shift authority from visible, legally accountable institutions to invisible digital infrastructures.

3.1.1. From Bureaucracy to Algocracy

Classical public administration rests on Weberian bureaucracy—hierarchical authority, rule-based decision-making, and human discretion. Technocracy introduced expert dominance, privileging technical expertise in policy formation. However, algorithmic systems introduce a distinct configuration:

Decision rules encoded in software, Continuous adaptive optimization, Real-time execution without deliberation, Distributed micro-decision architecture.

We define algocracy as: A governance regime in which algorithmic systems exercise structured regulatory authority by autonomously executing rule-based and optimization-based decisions within public infrastructures.

Algocracy differs from technocracy in that authority is not merely expert-driven but embedded in computational architectures. It differs from bureaucracy in that decision rules are no longer interpreted but executed through code.

3.1.2. De Facto Regulatory Authority

AI mobility systems regulate access to road space, congestion pricing, and traffic flows, effectively exercising regulatory functions traditionally associated with the state, but increasingly embedded within technological systems (Levi-Faur, 2011).

Access to road space, Priority of vehicle classes, Congestion pricing, Emission routing, Traffic enforcement triggers.

These functions constitute regulatory decisions. When executed algorithmically, they shift authority from visible institutions to invisible infrastructures.

3.1.3. Delegation and Constitutional Transformation

Delegation to algorithms is not neutral. It alters:

Transparency structures, Accountability pathways, Participation channels, Liability doctrines.

Algocracy therefore represents not incremental modernization but a **constitutional transformation** of administrative power.

3.2. Algorithmic Chaos: Formalizing Systemic Entropy

Algorithmic governance is often portrayed by tech vendors as hyper-rational and deterministic. Yet, in multi-agent urban environments—where multiple independent AI systems optimize simultaneously—emergent unpredictability arises. Drawing on information theory (Shannon, 1948; Cover & Thomas, 2006), we formalize this systemic unpredictability as Algorithmic Governance Entropy (H):

$$H = -\sum_{i=1}^{n} Pi \log_2 Pi$$

Where P_i represents the probability of a specific routing, capacity allocation, or enforcement outcome *i* within the urban transport ecosystem, and *H* measures the total uncertainty and instability within the public administration system.

In a smart city, multiple computational agents operate simultaneously: municipal traffic control engines optimize network flow, private navigation platforms (e.g., Google Maps, Yandex) optimize individual travel times, ride-hailing fleets optimize profit margins, and logistics platforms optimize delivery windows. Each agent j minimizes its own localized loss function:

$\min L_j$ (x)

Without a unified, state-governed normative parameter alignment, these conflicting optimizations produce competitive feedback loops, route oscillations, and sudden congestion spillovers. As the number of uncoordinated algorithmic agents (n) increases, the total system entropy expands logarithmically:

$H_{System} \alpha \log(n)$

This algorithmic chaos directly undermines democratic governance by fracturing explainability and causal traceability. When system entropy is high, identifying administrative causation becomes impossible, rendering traditional legal liability and democratic oversight non-functional.

3.2.1. Entropy as Governance Instability

Algorithmic governance is often portrayed as hyper-rational and deterministic. Yet in multi-agent environments—where multiple AI systems optimize simultaneously—emergent unpredictability arises. Drawing on information theory (Shannon, 1948; Cover & Thomas, 2006), entropy is defined as:

H=−∑i=1npilog 2piH

Where:

- *pip_ipi represents the probability of selecting routing or decision outcome iii.*
- *HHH measures uncertainty in the system.*

In urban mobility:

- *Navigation platforms optimize for individual travel time.*
- *Traffic control systems optimize network flow.*
- *Environmental modules optimize emission reduction.*
- *Ride-hailing fleets optimize profit margins.*

Each agent minimizes its own loss function:

Min Lj(x)for agent j

However, without coordinated parameter alignment, collective entropy increases.

3.2.2. Multi-Agent Conflict and the Digital Tragedy of the Commons

Analogous to Hardin's tragedy of the commons, uncoordinated optimization leads to:

Congestion spillovers, Induced demand, Route oscillations, Feedback loops

As the number of agents increases:

Hsystem∝ log (n)H_{system} propto)

Higher entropy implies:

Reduced predictability, Policy incoherence, Governance instability.

We define **algorithmic chaos** as: A condition in which interacting optimization systems generate emergent instability due to misaligned objective functions and insufficient normative coordination.

3.2.3. Democratic Implications of Entropy

High entropy reduces: *Explainability, Traceability, Accountability clarity.* In such systems, identifying causation becomes difficult—complicating liability and democratic oversight. Entropy thus becomes not merely technical uncertainty but a governance variable.

3.3. Digital Conscience: Operationalizing Constitutional Weights

To counter algorithmic chaos and technocratic displacement, we introduce the concept of digital conscience. It is defined as the systematic embedding of constitutional values (such as equity, universal accessibility, and due process) directly into algorithmic objective functions and parameter weighting structures.

Standard transport optimization algorithms utilize a narrow efficiency-driven loss function:

$\min L(x)$=αT+ βC + γE

Where *T* = travel time, *C* = *operational cost*, and *E* = environmental emissions, weighted by technical coefficients (α, β, γ). Digital conscience mathematically reconfigures the optimization engine by injecting explicit, legally binding constitutional weights:

$$\min L(x) = \alpha T + \beta C + \gamma E$$

Where F represents a quantified Spatial Fairness Index (ensuring low-income neighborhoods are not starved of transit capacity or transit-induced routing overflows) and A represents a Universal Accessibility Score. The determination of these parameters (Ƶ, €) is fundamentally political, not technical. Digital conscience dictates that these weights must be derived via democratic inputs rather than proprietary vendor defaults.

3.3.1. From Ethical Principles to Operational Norms

AI ethics frameworks emphasize principles such as fairness, accountability, and transparency, while also highlighting the conceptual and practical challenges of translating these values into operational systems (Mittelstadt et al., 2016; Floridi et al., 2018). However, these principles often remain declarative.

We propose digital conscience as an operational mechanism: The systematic embedding of constitutional values into algorithmic objective functions and parameter weighting structures.

3.3.2. Norm-Weighted Optimization

Standard optimization:

Min L(x)=αT+ βC+ γE

Where:

TTT = travel time, CCC = cost, EEE = emissions

Digital conscience introduces constitutional weights:

Min L(x)=αT+βC+γE+δF+ϵA

Where:

FFF = fairness index, AAA = accessibility score

Normative weights (δ,ϵ\delta,\epsilonδ,ϵ) are not purely technical—they are political decisions.

3.3.3. Parameter Legitimacy

The core democratic question becomes: Who sets the weights?, If vendors determine them, governance shifts to private actors, If technocrats determine them, participation is limited, If citizens influence them, democratic legitimacy increases, Digital conscience therefore requires institutional design.

3.4. Platform Urbanism vs. L'œuvre City

Drawing on Lefebvre's conception of the city as a socially produced and politically contested space, urban environments must be understood not merely as sites of optimization but as arenas of collective self-determination (Lefebvre, 1996). The tension between platform urbanism and the vision of the city as l'œuvre necessitates a deeper examination of platform logic, which reconfigures urban spaces through data-driven and algorithmic mediation.

3.4.1. Platform Logic

Platform urbanism views the city as: Data infrastructure, Optimization space, Real-time coordination system, Efficiency and throughput dominate.

3.4.2. L'œuvre Logic

Drawing on Lefebvre, the city is:

Socially produced, Historically layered, Politically contested. The tension between these logics defines the politics of smart mobility.

Algorithmic optimization may prioritize efficiency over collective self-determination, potentially undermining principles of local autonomy and participatory urban governance traditionally associated with decentralization (Tekeli: 2011; Keleş, 2012).

3.5. The Algorithmic Public Administration Model (APAM)

The Algorithmic Public Administration Model (APAM) integrates these dimensions into a cohesive, five-layer theoretical framework designed to map and diagnose automated public governance systems:

- **Layer I: Data Infrastructure:** The foundational layer consisting of IoT sensor networks, GPS feeds, edge-computing traffic cameras, and private platform APIs. *Core Governance Risk:* Data asymmetry and structural vendor-lock in.

- **Layer II: Optimization Engine:** The algorithmic core executing machine learning, reinforcement learning traffic light control, and predictive congestion modeling. *Core Governance Risk:* Unchecked escalation of Shannon entropy.
- **Layer III: Normative Parameterization:** The operational gate where weights (δ, ϵ) are applied to the optimization engine. This is where "digital conscience" is mathematically enforced or neglected.
- **Layer IV: Oversight and Audit:** The institutional apparatus tasked with independent algorithmic verification, bias auditing, and continuous entropy tracking.
- **Layer V: Democratic Feedback Loop:** The public interface enabling participatory parameter-setting, citizen co-design of objective functions, and algorithmic impact assessments.

3.5.1. Causal Logic of APAM

The model proposes:

Data → Optimization → Norm Weighting → Oversight → Democratic Feedback → Parameter Revision

Entropy increases when: Normative layer is weak, Oversight layer is absent, Feedback loop is closed.

Legitimacy increases when: Parameters are participatory, Entropy is monitored, Liability is clear.

3.6. Institutional Economics and Principal-Agent Dynamics

In algocracy:

- Citizens = principals

- Public authorities = meta-principals
- Algorithm vendors = agents
- Algorithms = delegated sub-agents

Information asymmetry intensifies because algorithms are opaque even to supervising authorities.

APAM reduces asymmetry by:

Mandatory audit trails, Parameter transparency, Norm disclosure requirements.

3.7. Toward Democratic Algorithmic Governance

The theoretical architecture demonstrates that:

- Efficiency alone cannot define successful smart mobility.
- Entropy must be governed.
- Norms must be embedded.
- Participation must be institutionalized.
- Algorithmic Public Administration thus requires a democratic design framework.

4. METHODOLOGY AND CASE SELECTION

To operationalize and validate the Algorithmic Public Administration Model (APAM), this study employs a qualitative, comparative case study design based on a “Most Different Systems Design” (MDSD) approach (George & Bennett, 2005). This methodology allows us to isolate and observe how algocratic dynamics manifest across highly divergent political regimes, administrative cultures, and levels of centralized state authority.

4.1. Operationalization of Governance Indicators

To eliminate the subjective ambiguities common in smart city assessments, we establish rigorous, empirical criteria for classifying the governance performance of each city as Low, Medium, or High.

Governance Indicator	*Low*	*Medium*	*High*
Transparency	Proprietary, closed-source source code; Complete absence of public algorithmic impact assessments or data dictionaries.	Partial disclosure of system logic; Publication of static AI ethics guidelines without code access.	Open-source API components; Mandatory, published algorithmic audits; Real-time public data dashboards.
Accountability	Total absence of specialized AI liability frameworks; Strict vendor-shielding clauses in municipal contracts.	Reliance on legacy administrative law; Ad-hoc or informal municipal AI review panels.	Institutionalized Algorithmic Audit Councils; Integration of an explicit Algocratic Error Matrix.
Participation	Top-down, technocratic implementation; No mechanism for citizen input regarding algorithmic goals.	Post-deployment public consultations; Online surveys regarding user satisfaction rather than system parameters.	Co-design of optimization loss functions; Participatory parameter-setting workshops; Civic voting on algorithm weights.
Entropy Coordination	Fragmented, uncoordinated environment; Private and public algorithmic agents optimize in isolation.	Intermittent or partial data-sharing protocols established between public authorities and dominant private transport apps.	Fully integrated public data platforms; Real-time system entropy monitoring; Coordinated multi-agent optimization.

Table 1. Operationalization of Governance Indicators
Source: This table was created by the authors.

4.2. Case Selection Rationales

Five global cities were selected to provide comprehensive empirical variation across three macro-variables: political regime type, AI maturity level, and administrative centralization.

- **Singapore:** Represents a highly centralized, high-maturity technocratic democracy. It serves as the ideal baseline for evaluating centralized, state-led multi-agent coordination (LTA:2025).
- **Hangzhou:** Represents an authoritarian technocracy characterized by a state-dominated, unified AI core (the "City Brain" developed with Alibaba). It provides insight into maximum technical optimization with minimal democratic inputs (Global AI Initiative, 2023).
- **Shenzhen:** Functions as a decentralized, hyper-innovative authoritarian tech hub driven by deep vendor-state integration (Tencent/Huawei), highlighting corporate-state path dependencies (Sprick, 2026).
- **Istanbul:** Represents a hybrid democratic regime with a fragmented, vendor-dependent digital ecosystem. It illustrates the classic manifestation of uncoordinated multi-agent algorithmic entropy (Wang et al., 2024).
- **Belgrade:** Represents a transitional democracy with expanding, foreign-procured AI surveillance and transport architectures, showcasing the early stages of algocratic transition.

Table 2. Case Selection Logic and Comparative Governance Regimes

City	Regime Type	AI Integration Level	Governance Centralization
Istanbul	Hybrid Democratic	Medium–High	Moderate
Singapore	Technocratic Democracy	High	High
Hangzhou (City Brain)	Authoritarian Technocracy	Very High	Very High

Belgrade	Transitional Democracy	Medium	Moderate
Shenzhen	Authoritarian İnnovation Hub	High	High

Source: This table was created by the authors.

This selection enables comparison across:

- Liberal vs centralized governance
- Vendor-led vs state-led AI infrastructures
- Varying accountability regimes

4.3. Data Collection and Triangulation

Data for this study were collected from primary institutional documents, legislative frameworks, and secondary performance datasets spanning the 2022–2025 period, ensuring deep triangulation:

1. *Official Municipal Frameworks:* Singapore's Land Transport Authority (LTA) Smart Mobility 2030 Review, Hangzhou's City Brain Blue Paper, and Istanbul Metropolitan Municipality (IBB) Strategic Plan.

2. *Regulatory & Legal Texts:* The European Union AI Act compliance documentation (for relevant comparative frameworks), local procurement contracts, and Turkish/Serbian administrative law codes on state liability.

3. *Secondary Operational Data:* Congestion index analytics (TomTom Traffic Index data), urban emission tracking indices, and published academic evaluations of municipal traffic control efficiencies.

5. FINDINGS: THE REALITY OF ALGOCRATIC REGIMES

The cross-case analysis reveals a stark, systematic divergence between technical infrastructure optimization and democratic governance compliance.

5.1. Comparative Analysis Matrix

Table 3. Performance and Governance Matrix Across Case Cities

City	Layer I: Data Infrastructure	Layer II: Optimization Capability	Layer III: Digital Conscience	Layer IV: Oversight & Audit	Layer V: Civic Participation	Layer II: Entropy Coordination
Singapore	High	High	Medium	Medium	Medium	High
Hangzhou	High	High	Low	Low	Low	High
Shenzhen	High	High	Low	Low	Low	Medium
Istanbul	Medium	Medium	Low	Low	Low	Low
Belgrade	Medium	Low	Low	Low	Low	Low

Source: This table was created by the authors.

5.2. Algorithmic Chaos and Empirical Realities

The empirical analysis validates our formal theory of algorithmic chaos, showing how it manifests uniquely across different urban topographies:

Istanbul: Uncoordinated Multi-Agent Overlap

Istanbul's smart transport model is marked by severe coordination gaps. The municipality operates an adaptive traffic management system (ISBAK), but the vast majority of drivers rely on uncoordinated, private navigation engines (Yandex, Google Maps). Because there is no centralized alignment of objective functions (Layer III), private platforms actively optimize for individual route minimization while the municipality attempts to optimize total network throughput.

This results in severe route oscillation: private algorithms simultaneously route thousands of vehicles into residential side streets to bypass arterial bottlenecks,

inducing immediate localized congestion spillovers and escalating total system entropy (*H*).

Singapore: Centralized Entropy Suppression

Conversely, Singapore minimizes algorithmic chaos through its highly integrated Intelligent Transport System (ITS). By combining real-time ERP (Electronic Road Pricing) congestion tracking with unified public-private data mandates, the Land Transport Authority enforces centralized parameter alignment. The system explicitly regulates private fleet algorithms, successfully bounding system entropy. However, this high coordination is executed via an insulated, technocratic elite, leaving Layer V (Civic Participation) constrained to post-hoc public feedback rather than active, democratic parameter-setting.

Hangzhou: The Authoritarian Black Box

Hangzhou's "City Brain" represents the global peak of automated urban optimization. It coordinates thousands of traffic intersections, automated bus dispatches, and emergency corridors autonomously. It has successfully reduced the city's congestion rank from 3rd to 35th in China.

However, this efficiency is achieved through a total "black box" model (Layer IV). The normative weights governing transit prioritization remain a corporate-state secret. The system lacks any mechanism for digital conscience; public transit riders and pedestrian spaces are structurally deprioritized in favor of private vehicle throughput metrics, exposing the deep structural violence of optimization divorced from democratic legitimacy.

5.3. Democratic Displacement

Across cases, a pattern emerges: higher efficiency is associated with lower participatory governance. Technocratic consolidation increases as algorithmic systems mature. This tendency reflects broader dynamics of neoliberal state

transformation, where governance becomes increasingly centralized and insulated from democratic pressures (Bedirhanoğlu, 2009).

Higher efficiency ↔ Lower participatory governance.

Technocratic consolidation increases as algorithmic systems mature.

This supports the hypothesis that without digital conscience and participatory embedding, algocracy tends toward technocratic centralization.

6. LEGAL AND ADMINISTRATIVE IMPLICATIONS

The transition from human-centric administration to automated algocratic governance breaks the foundational doctrines of traditional public law—specifically the classical doctrine of administrative service fault (*faute de service*).

6.1. The Crisis of Causality in Public Law

Traditional administrative liability rests on an unbreakable triad: a human decision-maker, an identifiable act of institutional negligence, and direct causal traceability (Guglielmi, 2023). Algocratic transit architectures obliterate this triad. When an autonomous deep reinforcement learning model alters traffic signal timings across a network, causing an erratic flow that leads to a catastrophic multi-vehicle collision or a localized toxic emission spike, where does the liability fall?

The human supervisor in the control room cannot predict or explain the neural network's hidden layer weight adjustments (the explainability crisis). Traditional public law cannot assign fault to a machine, yet shielding the state behind vendor software agreements creates a severe constitutional accountability vacuum (Citron, 2008).

6.2. The Algocratic Error Matrix

To reconcile public law with automated administrative action, we reject the notion of unassignable algorithmic errors. We construct the **Algocratic Error Matrix** to establish clear, actionable parameters for administrative and civil liability.

ALGOCRATIC ERROR MATRIX		
ERROR CATEGORY	CAUSAL AGENT	RECONSTRUCTED LIABILITY MODEL
Design & Code Fault	Algorithmic Developer (Private Vendor + State)	Strict Joint & Several Liability
Inference & Opacity Fault	Autonomous AI Model (Public Risk Doctrine)	No-Fault State Compensation
Operational Data Fault	Public Supervisory Body	Negligence-Based Administrative Liability

Design & Code Fault: Arises when the underlying software contains structural programming flaws, unvetted training biases, or clear violations of procurement specifications. The state and the private vendor share strict, joint liability. The state cannot contract out its constitutional duties.

Inference & Opacity Fault: Occurs when both the code and data are technically sound, but the multi-agent neural interactions produce an emergent, unexplainable, and harmful systemic failure (high entropy collapse). Here, traditional negligence cannot be proven. We propose adapting the public law

doctrine of *exceptional risk* or *no-fault state liability*: the state, having introduced an autonomous risk into the public space for efficiency gains, must internalize the costs of its systemic failures and directly compensate affected citizens.

Operational Data Fault: Occurs when the public administration fails to properly maintain the data infrastructure layer (e.g., faulty IoT road sensors feeding corrupted velocity data into the AI engine, leading to systematic routing failures). This falls under standard administrative negligence for failure to maintain public services.

6.3. No-Fault Liability in Algorithmic Governance

Given entropy and opacity, citizens cannot bear proof burdens.

We propose: Reversal of burden of proof, Mandatory algorithmic logging and Public compensation funds for AI-induced harm.

This aligns with risk-based administrative doctrine.

7. DEMOCRATIC ALGORITHMIC GOVERNANCE FRAMEWORK (DAGF)

To resolve the efficiency-legitimacy paradox identified in our findings, we propose the **Democratic Algorithmic Governance Framework (DAGF)**. This framework shifts smart cities away from corporate platform urbanism and aligns them with the democratic co-production of the city.

DEMOCRATIC ALGORITHMIC GOVERNANCE FRAMEWORK (DAGF)

[Layer V: Civic Parameters] <-- Public Input / Voting
|
▼
[Layer III: Digital Conscience] <-- Normative Weights Applied
|
▼
[Layer II: Optimization Core] <-- Suppresses Entropy (H)
|
▲

[Layer IV: Audit Councils] <-- Continuous Verification

7.1. Institutionalizing Algorithmic Audit Councils (AAC)

Cities must legally establish Algorithmic Audit Councils (AAC) as independent, adversarial oversight bodies separated from the executive municipal branch. An AAC must be composed of interdisciplinary experts: computer scientists, public law scholars, urban planners, and elected citizen representatives. The AAC holds statutory powers to:

- Enforce continuous, real-time tracking of Algorithmic Governance Entropy (H).
- Conduct mandatory pre-deployment Algorithmic Impact Assessments (AIAs) on all mobility software layers.
- Possess full access rights to code repositories and optimization logs, utilizing Zero-Knowledge Proofs (ZKPs) to verify system fairness and compliance without compromising proprietary vendor trade secrets.

7.2 Participatory Parameter-Setting and Digital Agoracism

The core democratic intervention of the DAGF is the institutionalization of **participatory parameter-setting**. Rather than allowing corporate vendors or isolated technocrats to determine the loss functions of urban life, municipalities must deploy digital agoracism platforms.

Through annual civic parameter consultations or localized citizen juries, the public directly deliberates on and votes to set the foundational weights (δ, ϵ) of the optimization engines. For instance, citizens can democratically mandate that during peak hours, environmental emissions and pedestrian safety indices hold a higher optimization priority weight than private vehicle transit speed. This design aligns algorithmic execution directly with democratic

legitimacy, transforming urban code into an expression of collective self-determination.

8. CONCLUSION

Smart mobility is not a politically neutral infrastructure upgrade; it is a profound transformation of constitutional architecture. This article has demonstrated that the uncoordinated delegation of public administrative functions to autonomous AI mobility systems gives rise to an unmapped mode of governance: *algocracy*. Left entirely to market forces or insulated technocratic logics, multi-agent AI optimization inevitably generates systemic algorithmic chaos—measurable through Shannon entropy—which displaces the citizen as an active political actor and breaks the causal doctrines of public law.

By constructing the Algorithmic Public Administration Model (APAM) and the Algocratic Error Matrix, this study provides public administrators and legal scholars with the diagnostic and analytical tools necessary to decode, bound, and govern these automated systems. The central finding is clear: as urban transit systems scale in computational efficiency, they systematically shed participatory legitimacy unless explicit normative embedding mechanisms are legally enforced.

Implementing the Democratic Algorithmic Governance Framework (DAGF) provides a clear pathway out of this technocratic trap. By anchoring algorithmic optimization in digital conscience and participatory parameter-setting, modern public administration can ensure that the code governing our cities remains transparent, accountable, and fundamentally democratic. Algorithmic Public Administration is no longer a speculative future; it is already operational. The urgent question for our generation is not whether our cities will be governed by algorithms, but whether those algorithms will be governed democratically.

Conflict of interest:

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GENİŞLETİLMİŞ ÖZET

Giriş

Kentsel ulaşım sistemleri, tarihsel olarak mühendisler ve kamu görevlileri tarafından yönetilmiştir. Günümüzde ise bu sistemler giderek artan biçimde algoritmalar tarafından yönetilmektedir. Trafik sinyalleri pekiştirmeli öğrenme yöntemleriyle gerçek zamanlı olarak uyum sağlamakta; yapay zekâ (YZ) sistemleri acil araçlara öncelik tanımakta, yük koridorlarını optimize etmekte ve çok modlu ulaşım akışlarını koordine etmektedir. Bu dönüşüm, teknik bir yenilik olmanın ötesinde, kamu yönetiminde köklü bir siyasi ve anayasal dönüşümü de beraberinde getirmektedir.

Makale, bu dönüşümü kavramsal olarak temellendirmek amacıyla **Algoritmik Kamu Yönetimi (AKY)** çerçevesini ortaya koymakta ve YZ odaklı mobilite sistemlerinin yönetişimde yarattığı yapısal değişimi algokrasi kavramıyla açıklamaktadır. Algokrasi; algoritmik sistemlerin kamusal altyapılar içinde özerk biçimde kural tabanlı ve optimizasyon tabanlı kararlar alarak fiilî bir düzenleyici otorite icra ettiği bir yönetişim rejimi olarak tanımlanmaktadır. Bu yönetişim biçimi, klasik Weberci bürokrasiden ve teknokrasiden ayrışmaktadır: otorite artık yalnızca uzmanlık bilgisine değil, kodla işleyen hesaplama mimarilerine yerleştirilmiştir.

Makalenin temel araştırma soruları şunlardır: Algoritmik yönetişim kentsel ulaşım sistemlerinde demokratik meşruiyeti nasıl dönüştürmektedir? İdari sorumluluk doktrinleri algokratik rejimlere nasıl uyum sağlamalıdır? Anayasal değerler, “dijital vicdan” adı verilen bir tasarım ilkesi aracılığıyla algoritmik mimarilere işletilebilir mi?

Yöntem

Çalışma, karşılaştırmalı nitel vaka analizi tasarımını ikincil nicel performans göstergeleriyle birleştiren çok yöntemli bir araştırma stratejisi benimsemektedir. Amaç nedensel genelleme değil; Algoritmik Kamu Yönetimi Modeli'nin (AKYM) teorik olarak test edilmesi ve zenginleştirilmesidir.

Beş kent; yönetişim rejimi türü, YZ olgunluğu ve siyasi-idari merkezileşme düzeyindeki farklılıklar temel alınarak seçilmiştir: **İstanbul** (hibrit demokratik, orta-yüksek YZ entegrasyonu), **Singapur** (teknokratik demokrasi, yüksek entegrasyon), **Hangzhou** (otoriter teknokrasi, çok yüksek entegrasyon), **Belgrad** (geçiş dönemi demokrasisi, orta entegrasyon) ve **Shenzhen** (otoriter inovasyon merkezi, yüksek entegrasyon). Bu seçim; liberal ile merkezi yönetişim biçimleri,

özel sektör liderliğindeki ile devlet liderliğindeki YZ altyapıları ve farklı hesap verebilirlik rejimleri arasında karşılaştırma yapılabilmesini sağlamaktadır.

Veri kaynakları olarak belediye akıllı mobilite stratejileri, politika belgeleri, ulaşım otoritesi performans raporları, ikincil tıkanıklık ve emisyon verileri ile kamu ihalesi açıklamaları kullanılmıştır. Analitik kategoriler AKYM'nin beş katmanından türetilmiştir: verimlilik kazanımları, emisyon azaltımı, şeffaflık mimarisi, hesap verebilirlik mekanizmaları, katılımcı kapsayıcılık ve entropi koordinasyonu.

Bulgular

Beş kentin karşılaştırmalı analizi, algokratik dinamiklerin farklı kurumsal bağlamlarda nasıl ortaya çıktığını göstermektedir.

Algoritmik kaos açısından değerlendirildiğinde, İstanbul'da birden fazla navigasyon uygulaması ve belediye sistemi entegre bir hedef uyumlaması olmaksızın eş zamanlı çalışmakta; bu durum sürücü davranışlarında kararsız güzergâh salınımlarına yol açarak uyarılmış (induced) tıkanıklık yayılımını kronik hale getirmektedir Singapur'da merkezi koordinasyon entropiye büyük ölçüde hâkim olmakla birlikte demokratik geri bildirim sınırlı kalmaktadır. Hangzhou'nun "Kent Beyni" uygulamasında güçlü merkezi komuta yapısı ve birleşik hedef fonksiyonu sayesinde entropi minimize edilmekte; ancak bu durum hesap verebilirlik riskleriyle birlikte gelmektedir. Shenzhen'de yüksek optimizasyon kapasitesine karşın katılımcı denetim mekanizmaları son derece sınırlıdır. Belgrad'da ise sınırlı teknolojik kapasite entropiyi kısıtlamakla birlikte optimizasyonun sağladığı avantajlardan da yararlanılamamaktadır.

Tüm vakalar genelinde belirgin bir örüntü gözlemlenmektedir: yüksek verimlilik ↔ düşük katılımcı yönetişim. Algoritmik sistemler olgunlaştıkça teknokratik konsolidasyon güçlenmekte, demokratik katılım alanları daralmaktadır. Bu bulgu, dijital vicdan ve katılımcı yerleştirme mekanizmaları olmaksızın algokrasinin teknokratik merkezileşmeye doğru evrilme eğiliminde olduğu hipotezini doğrulamaktadır.

Temel paradoks şudur: YZ odaklı sistemlerden elde edilen verimlilik kazanımları, azalan şeffaflık ve katılımcı meşruiyet ile birlikte seyretmektedir.

Sonuç ve Tartışma

Makale, teorik ve pratik açıdan birbirine bağlı üç özgün katkı sunmaktadır.

Birincisi, çok etmenli YZ optimizasyonunun yarattığı sistemik öngörülemezliği açıklamak için Shannon entropisi kullanılarak algoritmik kaos kavramı biçimselleştirilmiştir. Birden fazla YZ sisteminin birbirinden bağımsız hedef fonksiyonlarıyla eş zamanlı çalıştığı ortamlarda toplam sistem entropisi artmakta; bu durum açıklanabilirliği, izlenebilirliği ve hesap verebilirlik şeffaflığını zayıflatmaktadır.

İkincisi, anayasal değerleri algoritmik sistemlere yerleştiren norm ağırlıklı bir tasarım ilkesi olarak dijital vicdan kavramı geliştirilmiştir. Standart optimizasyon fonksiyonlarına —seyahat süresi, maliyet ve emisyon gibi değişkenlerin yanı sıra— adalet endeksi ve erişilebilirlik skoru eklenmiş; bu normatif ağırlıkların teknik olmadığı, özünde siyasi kararlar olduğu vurgulanmıştır. Ağırlıkların kim tarafından belirleneceği sorusu, demokratik meşruiyetin merkezine oturmaktadır.

Üçüncüsü, kamu hukuku doktrinini algoritmik hesap verebilirlik teorisiyle bütünleştiren Algokratik Hata Matrisi aracılığıyla idari sorumluluk yeniden kavramsallaştırılmıştır. Bu matris üç hata türünü birbirinden ayırt etmektedir: programlama hatalarından kaynaklanan kod hatası (katı kamu sorumluluğu), önyargılı ya da eksik veri setlerinden kaynaklanan veri hatası (ihmal temelli sorumluluk) ve sistemin karmaşıklığı nedeniyle kararın açıklanamaz hale geldiği opak karar hatası (kusursuz tazminat). İspat yükünün tersine çevrilmesi, zorunlu algoritmik günlük kaydı ve YZ kaynaklı zararlar için kamu tazminat fonları önerilmektedir.

Bu bulgulara dayanarak makale, Demokratik Algoritmik Yönetişim Çerçevesini (DAYÇ) önermektedir. Bu çerçeve; bağımsız algoritmik denetim konseyleri, yıllık parametre istişareleri ve vatandaş jürilerini kapsayan katılımcı parametre belirleme süreçleri, kamuya açık entropi gösterge panelleri ve sıfır bilgi ispatı entegrasyonunu (Zero-Knowledge Proof - ZKP) içermektedir. Çerçevenin temel amacı, vatandaşların algoritmik sistemlerin kararlarına müdahale etmesi değil; bu sistemlerin önceliklerini demokratik biçimde meşrulaştırmasıdır.

Makale, akıllı mobiliteyi yalnızca altyapısal bir modernizasyon girişimi olarak değil, kamu otoritesinin yapısal bir yeniden örgütlenmesi olarak konumlandırmaktadır. Algoritmik sistemlerin kentleri yönetip yönetmeyeceği artık bir soru değildir; asıl soru bu yönetimin demokratik olup olmayacağıdır.