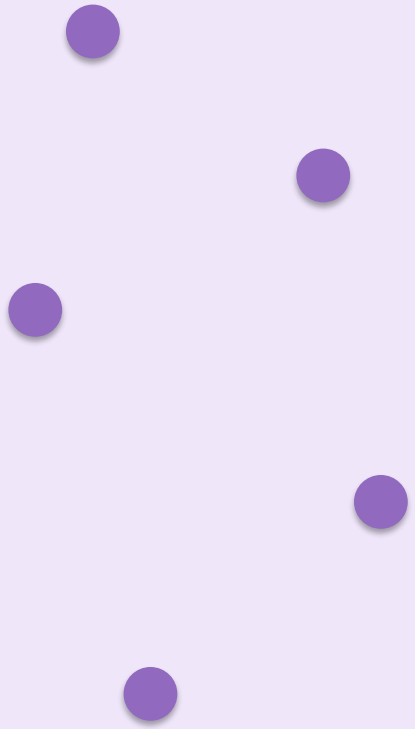
Systematic Review of AI Models for Vehicle-to-Everything (V2X) Communication Systems



FACULTY OF ENGINEERING

International Conference Presentation

Presenter: Ogunrinde Tosin

Why this research matters

V2X is the connective tissue of intelligent transportation systems.

V2X connects road users

V2V, V2I, V2P and V2N links support cooperative perception, traffic management and automated driving.

Rule-based methods fall short

Millisecond latency and up to 99.999% reliability are hard to meet in fast-changing vehicular networks.

AI is a data-driven alternative

DL, DRL, FL and transformers learn from data, but the evidence is fragmented.

The research gap

Existing surveys cover one layer or one technique, few follow a reproducible protocol, and little is said about how solutions were validated.

This review maps AI methods across the communication, intelligence and application layers of the V2X stack.

Research focus and questions

Five research questions frame the review.

RQ1–2 | Problems and models

Which V2X problems have been addressed with AI, at which layer of the stack, and with which models?

RQ3–4 | Gains and validation

What gains over conventional baselines are reported, and how and where were the solutions validated?

RQ5 | Gaps and trends

What persistent gaps and emerging trends are evident?

Contribution: a protocol-driven synthesis across the communication, intelligence and application layers, with attention to evaluation environment and network architecture.

Review methodology

PRISMA 2020-guided systematic review of peer-reviewed, English-language studies.

510
database records

544
incl. snowballing

442
screened

153
full-text assessed

75
studies included

Sources searched

IEEE Xplore • Scopus • ScienceDirect • SpringerLink • Web of Science • ACM DL • Google Scholar

Quality screening

Checklist: objectives, reproducibility, baselines, evaluation set-up and quantitative results. Simulation-only studies with little detail were excluded.

Of 544 records: 102 duplicates, 289 excluded on title/abstract and 78 at full text. Results are a narrative synthesis; no meta-analysis was possible.

A three-layer view of AI-enabled V2X

The reviewed studies span the full V2X stack.

1 | Communication layer

RESOURCE ALLOCATION

Decentralised DRL agents select sub-bands and power from local observations.

BEAM PREDICTION

DL cuts pilot and beam-search overhead.

2 | Intelligence layer

COOPERATIVE PERCEPTION

Feature-level and transformer-based fusion extend sensing range and overcome occlusion.

Also here: edge offloading, federated learning, intrusion detection and privacy protection.

3 | Application layer

TRAFFIC-SIGNAL CONTROL

DRL agents learn phase-selection policies and reduce delay in simulation.

COOPERATIVE DRIVING

Multi-agent learning supports lane changing, intersections and platooning.

Key point: all three layers share demanding QoS needs—millisecond latency and up to 99.999% reliability.

RQ3 findings | Benefits and limits by AI paradigm

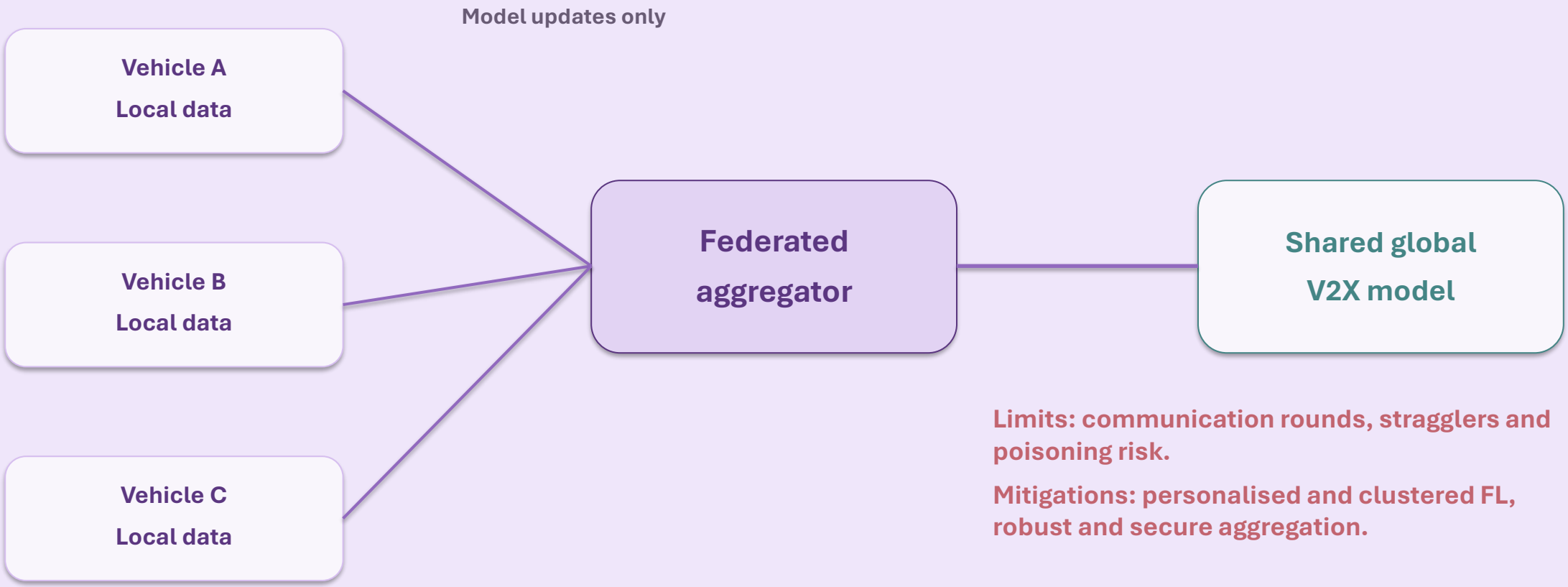
Narrative synthesis of 75 studies; no meta-analysis was possible.

PARADIGM	REPORTED BENEFITS	PRINCIPAL LIMITATIONS
DL	Captures non-linear patterns; fast inference after training	Needs large labelled datasets; sensitive to distribution shift
DRL / MARL	Adapts online; higher V2V reliability and spectral efficiency than heuristics	Unstable, sample-inefficient training; sim-to-real gap
FL	Raw data stay on the vehicle; lower uplink load	Communication rounds, stragglers, non-IID data and poisoning risk
Hybrid / generative	Combines complementary strengths; robust fusion under delay and pose error	Higher complexity and energy demand; little field validation

AI beats traditional approaches on the metrics studied, but largely in simulation.

Federated learning: fleet-wide learning without raw data

Raw data stay on the vehicle; only model updates are shared.



Limits: communication rounds, stragglers and poisoning risk.

Mitigations: personalised and clustered FL, robust and secure aggregation.

Vehicles see different roads, sensors and behaviours; this non-IID data slows or destabilises convergence.

RQ4 findings | Validation is dominated by simulation

Most reviewed solutions are validated in simulation rather than on real roads.

SIMULATION

Traffic simulators (SUMO), co-simulation (Veins) and driving simulators (CARLA) dominate.

HARDWARE & FIELD

Hardware-in-the-loop tests, digital twins and field trials were rare.

Important limitation

Simplified channels and synthetic traffic can overstate gains; learned policies often degrade in the real world.

75 / 544

records yielded studies for synthesis

99.999%

reliability target for the most demanding use cases

3

layers: communication, intelligence, application

4

dimensions used to classify the studies

Baselines and KPIs were not standardised, and few studies released code or data.

Persistent gaps | From simulation to deployment

Conclusions rest largely on simulation; four gaps recur across the studies.

VALIDATION

Can simulated gains survive real roads and traffic?

HARDWARE & DATA

Can models fit in-vehicle limits and cope with non-IID data?

SECURITY & STANDARDS

Can systems resist attacks and interoperate across DSRC, C-V2X and vendors?

CLOSE THE GAP BETWEEN SIMULATION AND DEPLOYMENT

Scalable, resilient AI-enabled intelligent transportation

Implications | Sustainable, resilient infrastructure

Benefits depend on how well AI-enabled V2X fits local conditions.

SAFER ROADS

Fewer collisions, smoother flow and, indirectly, lower emissions.

RESILIENT BY DESIGN

Edge-resident models degrade gracefully when roadside units, backhaul or power fail.

FIT FOR LOCAL CITIES

Lightweight, locally trainable models suit mixed traffic and patchy connectivity.

SPECTRUM, STANDARDS AND DATA GOVERNANCE

Policy support will decide whether these benefits are realised

Research priorities and emerging trends

From promising simulations to scalable, real-world deployment.

1. Validate beyond simulation	Hardware-in-the-loop testing, digital twins and field trials, with shared benchmarks and open data.
2. Fit the vehicle	Lightweight, quantised models and edge offloading that suit in-vehicle compute, memory and energy limits.
3. Harden federated learning	Personalised and clustered FL with robust and secure aggregation, for non-IID data and poisoning.
4. Standardise	Common interfaces, standard KPIs and datasets, and standard-aligned AI functions across DSRC and C-V2X.
5. Watch emerging trends	6G-enabled V2X, reconfigurable intelligent surfaces, generative AI and privacy-preserving decentralised learning.

Conclusion | From models to real deployments

The paper’s central message.

AI-enabled V2X improves latency, reliability and traffic efficiency, but the evidence rests largely on simulation.

Communication layer

DRL and DL prediction improve reliability and spectral efficiency.

Intelligence layer

Perception, FL and intrusion detection must cope with non-IID data and attacks.

Application layer

DRL signal control cuts delay; fuel and emission gains remain inferred.

Future direction: hardware-in-the-loop and field validation with open benchmarks, lightweight and robust models, secure federated learning, and standard-aligned AI functions.

Thank you | Questions and discussion