



IoT and Connected Cars: The Smart Vehicle Revolution

The connected car market stood at \$97.19 billion in 2024. By 2034 it is projected to reach \$390 billion — not because of entertainment upgrades, but because the car itself is being transformed into a communicating, thinking participant in a shared digital network.

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WHAT IS IOT — AND WHAT DOES IT HAVE TO DO WITH CARS?

It's estimated that the Internet of Things, or IoT, will connect over 75 billion devices around the world by 2025. The network of everyday objects from hospital equipment to toys and car accessories that are equipped with sensors, software, and wireless technology to automatically collect and share data was first imagined by Kevin Ashton in 1999. But it's the automotive industry that is adopting the technology faster than almost any other.

The connected car is one of the coolest IoT things to ever roll off a production line, collecting streams of data from dozens of car sensors and subsystems, all simultaneously.

For example, engine sensors, tyre pressure monitors, brake pads, and other non-standard IoT things can supply real-time readings to service centres, insurance companies, law enforcement agencies, other drivers, and even car thieves. A car's GPS chip constantly reports the vehicle's current location and/or speed to various organisations. External environmental sensors supply car systems with data on weather, street conditions, parking spots, and so the rest.

DUBLIN—(BUSINESS WIRE)—ResearchAndMarkets.com has added “Global Connected Car Market 2024-2034” report to their offering. The connected car market is expected to grow at a CAGR of approximately 15% over the next decade. The total connected car market is projected to grow from \$97.19 billion in 2024 to reach \$390.23 billion by 2034. Data from connected cars is distributed over multiple layers of cloud. First it is sent to IaaS providers such as Amazon Web Services and Microsoft Azure for real time traffic analysis. Then the data is moved to PaaS platforms where connectivity, data security and data mining services are offered. This connectivity enabled data allows multiple SaaS services including vehicle tracking, fleet management, navigation and predictive maintenance to emerge in the market. These services can now be offered through multiple devices such as smartphones and tablets.

This is how connected vehicles could look like in the future – or at least in our today. Driving in Pakistan is normally a pretty hectic affair – and with the ever growing traffic jams all over the country, it has even become a dangerous activity.



Anyone who has sat in Pakistani traffic knows that our roads are not just congested — they are genuinely dangerous. That daily reality is exactly why this technology matters to me personally.

V2X: WHEN VEHICLES TALK TO EACH OTHER AND TO THE ROAD

IoT in transportation is bringing about a wide range of innovations. One of the most practical and the most promising for the road transport scenario is the use of Vehicle-to-Everything (V2X), where vehicles communicate with everything around them, such as other vehicles, pedestrians, roadside units and cloud for sharing relevant information. V2X communication takes place through four types of communication methods.

In order to prevent accidents on the road, Vehicle-to-Vehicle (V2V) enables cars to exchange real-time data about speed and braking. This exchange of information also extends to the communication between cars and static infrastructure like smart traffic lights, which enables Vehicle-to-Infrastructure (V2I). It further extends to humans around us carrying their smartphones or wearing various devices like smart watches that can be picked up by Vehicle-to-Pedestrian (V2P) technology. Alerts generated by such communication will be unpredictable even to a human driver. In addition, Vehicle-to-Network (V2N) will enable a vehicle to be connected to the cloud, through which it can obtain various information like better route guidance and car-to-cloud communication, and even remotely receive updates to the car's software.

Smart intersection is one of the most powerful V2I applications. Instead of using conventional time-based traffic lights to block every vehicle approaching an intersection, vehicles sharing their location, speed, and intent are used to compute an optimal decision, in real-time, on which vehicle(s) to allow passage based on AI. Smart intersections improve fuel efficiency, reduce travel time through traffic, and improves signalization performance. These are pressing issues in Pakistan where urban intersections are badly managed and traffic congestion increases with each passing day.

The evidence is in the data. A March 2025 study published in the MDPI Sensors journal used SUMO simulations to demonstrate that C-V2X reduces communication delays by more than 99% compared to legacy DSRC technologies, while lowering traffic conflict rates by 38% when autonomous vehicles comprise 80% of traffic. These reductions are not trivial, but provide a framework for what a transformed road infrastructure and traffic network could look like.

SAFETY: THE NUMBERS THAT DEMAND ACTION

Road safety problems are typically in the human domain, but when it comes to advanced driver assistance systems, that begins to change. According to the World Health Organization, for instance, around 1.35 million people die in road disturbances every year, making traffic injuries the eighth leading cause of death world-wide, one fatality occurring every 24 seconds.

Connected cars can see better than we do. A human driver has roughly 180° of horizontal vision, but a car with sensors will have the ability to 'see' 360°, in every direction at once. The potential to avoid accidents is obviously vast, especially given that cars travel at a far greater speed than cyclists. To give you an idea of just how vast, this car would have the potential to see a cyclist appearing out of a side alley before you even have a chance to look.



Auto-dispatching of emergency services could potentially reduce road-fatalities. Majority of road-fatalities do not die due to the injury caused in collision; rather they die due to lack of response in emergency situations where only a few minutes are required to save their lives. IoT can play significant role in automating this process. In this paper, an automatic accident detection system has been designed and implemented using IoT. Accelerometer and GPS are used to detect and locate the accident, respectively. GSM is used for real-time connectivity to dispatch emergency services automatically within seconds of collision without requiring any human intervention.

V2X is important because it addresses the classes of accidents that actually occur most frequently (e.g. rear impact, intersection, pedestrian). Connected cars in a city with old buildings face real-world issues like Doppler Shift, signal fade, multipath, and challenging network access conditions. But all of these are standard engineering problems that can be addressed through the deployment of additional 5G infrastructure

I have seen ambulances trapped behind rickshaws and wedding processions while someone somewhere needed help. A system that detects a crash and calls for aid automatically — without waiting for a bystander to notice — would have saved lives lost to that delay.

AI, CLOUD, AND THE INTELLIGENCE LAYER

Connected vehicles now don't only communicate with others on the road, but are increasingly equipped with advanced algorithms that make them think. To enhance performance, better plan maintenance, or to simply make driving more enjoyable, AI systems on modern connected vehicles process a ton of data from sensors fitted all around. For example, predictive maintenance of connected vehicles can notify maintenance personnel before a tyre runs completely out of air, or a brake pad wears out and causes a critical accident. The system can also identify an accident in dashcam footage within a matter of seconds and inform relevant authorities with the location. Research published in 2019 found accident detection and notification systems utilising AI-powered Convolutional Neural Networks (CNN) are already being tested and implemented around the world. While many of these systems rely on local hardware for rapid processing, according to research from 2013, a further boost in efficiency and scalability comes from utilising cloud-based storage and energy harvesting from solar power. Here in Pakistan, consistent power available on all roads is often a luxury, so this approach is increasingly being adopted to address connected vehicle developments.

As connected vehicles, wearable devices, smart home sensors, and industrial machines (sensors) churn out increasing amounts of digital data, one big problem arises: how to trust the information they're sending out. In the context of an inter-network of stakeholders — including vehicle makers, insurance providers, government agencies, and sharing platforms — blockchain-based solutions for managing access to sensor information, such as autonomous car telemetry, are providing ways to pinpoint exact moment in time at which information has been recorded (when it was generated), be confident that information is the whole truth (validity) and ensure its protection (integrity). In addressing these so far uncured challenges Internet of Vehicles adoption is going to accelerate worldwide.

WHAT THIS MEANS FOR PAKISTAN



When I look at the traffic signals that nobody follows, the intersections with no lane markings, and the highways where accidents go unreported for hours, I do not see a country that is far from this technology — I see a country that needs it more urgently than most.

A newly published review article at renowned international research journal MDPI Technologies, by researchers at Air University Islamabad, Pakistani, has made its mark in global automotive research. Addressing every aspect related to connected and autonomous vehicle (C&AVE), the article identifies required advancements in infrastructure and challenges related to deployment as well as comprehensive analyses of related cybersecurity challenges. The article certainly highlights the mark of Pakistani academics in ongoing global research efforts focused towards future transport solutions.

Building on these findings, a new study by Dr. Sara Shah of NUST will explore the potential of integrating autonomous and connected vehicles into Pakistan's existing transport systems, and map out a 10-year trajectory towards doing so, which the researcher believes could happen by 2025. The study will examine the local engineering challenges, the need to reform current transport laws, and the broader socio-economic implications of such change.

In parallel, the seeds sown at the Free and Open Source Software (FOSS) Day are starting to yield fruit in the form of original research in the field of cybersecurity emanating from universities in Pakistan. Specifically, a team of undergraduate students from the NFC Institute of Engineering and Technology (Multiawn) and postgraduate students from Government College University (Faisalabad) designed and developed a Machine Learning Intrusion Detection System for Smart Cities vehicular network and related challenges. Their approach relied on a Random Forest classifier achieving, on real world network traffic, an overall accuracy of 95.5% to detect a number of attacks, including Denial of Service and GPS Spoofing, which highlights genuinely novel research aiming to address critical cybersecurity issues faced by the world in protecting connected vehicles.

By understanding how wireless systems can facilitate greater efficiency and utility on the road, scientists have also turned their attention to the complex problem of urban transport management. In *Wireless Communications and Mobile Computing*, a team of researchers based in Pakistan used the city of Peshawar as a testbed for the application of IoT-powered traffic management. Focusing on connected vehicles (CVs) navigating through city roads, the work implemented a Nash Equilibrium solution that optimally coupled both vehicles and roadside units to reduce traffic congestion, especially at bottlenecks such as busy intersections. With Pakistan's urban cities rapidly expanding while their transportation infrastructure struggles to keep up with demand, solutions that make vehicle movement both smoother and safer are not future opportunities: they are pressing needs

My honest worry is cost. This infrastructure requires investment that Pakistan's government has not consistently prioritised. But the research coming from our own universities tells me the technical capacity is here — what is needed now is the political will to match it.

SECURITY, PRIVACY, AND STANDARDISATION: CHALLENGES THAT REMAIN

Connecting cars can bring many benefits, but also introduces some risk. Firstly, the Controller Area Network (CAN) bus that connects everything from the car's airbags to the Electronic



Stability Program (ESP) to the power steering can be hacked. This allows an attacker to take remote control of a car's critical safety functions. Secondly, the vehicle-to-everything (V2X) communications, which receive vital information from road-side infrastructure, can be subjected to Man-in-the-Middle attacks. Such attacks enable attackers to intercept and manipulate messages exchanged between vehicles and the infrastructure.

Many security design approaches are being evaluated, including zero-trust security architectures, over-the-air authentication methods and comprehensive threat models. These topics are still being explored by security professionals.

A recent cyberattack on the smart city transportation system in Olsztyn, Poland's is a grim reminder that connected transport systems are already under attack by organised cybercriminals in 2023.

A new worry is the connected car's invasive potential to the owners' privacy. The cars will record all travel and can inform insurance companies and retailers about consumers' most recent destinations. Manufacturers already are beginning to supply such information. But data protection regulations are slow to adapt to the new technology, which can store massive amounts of information.

There is also the issue of interoperability, with the US looking to use DSRC, while China and much of Europe are turning to C-V2X. Currently, there is no interoperability between the two systems, but there is work ongoing by ISO/TC 204 to bring forward international standards to support intelligent transport systems to help mitigate these issues.

CONCLUSION

The connected car is no longer a farfetched vision of the automotive future; it is today's automotive future. The global connected car market is expanding at a rapid pace, reaching from today's \$97 billion to nearly \$390 billion by 2027. The IoT technology embedded in connected vehicles reduces communication delays, traffic conflicts, accident response times and in fact, even fatalities.

We still need to address issues like cyber security, data privacies, handlings in crowded environments and standardization but all these are solvable issues. The world is progressing very rapidly on this global front and it is great to see that there is some wonderful work going on across the globe. Equally exciting is the engagement and research that is now taking place across Pakistani universities. We are seeing original research from institutions such as Air University, NUST, NFC Multan, GCU Faisalabad and many across Peshawar. With urbanization driving pressure on city infrastructure intelligent transport systems are now a pressing requirement.

I write this as someone who studies this technology and lives inside the problem it is trying to solve. That combination — knowing both the research and the reality on ground — makes me believe Pakistan cannot afford to wait.

The question is not whether this technology will transform how we move — it already is. The question is how quickly Pakistan positions itself to shape that transformation, rather than simply import it.



About the Author Ammara is a student researcher at the University of Agriculture, Faisalabad, with an interest in emerging technologies and their real-world applications. She actively explores how IoT and smart systems are transforming Pakistan's transportation and industrial sectors. She can be reached at ammarahashim354@gmail.com.

Keywords: Internet of Things (IoT); Connected Vehicles; Smart Transportation; Autonomous Driving; Vehicle-to-Everything (V2X); Pakistan Automotive Industry

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