IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁙ Impact Factor 8.102 ⁙ Peer-reviewed / Refereed journal ⁙ Vol. 12, Issue 8, August 2023

DOI: 10.17148/IJARCCE.2023.12826

Gateway Module Ethernet Simulation: Improving ADAS Controller Interactions with AI

Anil Kumar Komarraju[1], Nareddy Abhireddy[2]

System Architect[1]

Research assistant[2]

Abstract: With the rapidly increasing number of sensors in today's automotive designs, modern Advanced Driver Assistance Systems (ADAS) are highly dependent on high-performance multi-core computing platforms and high-speed Ethernet networking. In this paper, we first present an industrial-like interconnection architecture between ADAS clusters and computer modules running AI application software and highlight the unique challenges induced with the simultaneous operation of the Ethernet AVB time-triggered and standard traffic classes. We then demonstrate the advantages of creating a flexible AI development platform with the ability to run simulation programs that abstract the realistic interaction of the AI with the ADAS domain. We provide background information on contemporary automotive cluster controllers as well as the real-time data flow components of typical ADAS ECUs, in order to elucidate the associated complexities. Finally, we propose the adaptable Partitioned Gateway module architecture that integrates an automotive microcontroller with a high-performance Gb Ethernet switch to support various ECU clusters, while minimizing latency and network loading for ADAS sensor data preprocessing.

Keywords: ADAS (Advanced Driver Assistance Systems), Ethernet AVB (Audio Video Bridging), Multi-core computing platforms, AI application software, Interconnection architecture, Simulation programs, Automotive cluster controllers, Real-time data flow, Partitioned Gateway module, Gb Ethernet switch

I. INTRODUCTION

Today's challenge in vehicle design is to ensure a smooth transition between automation and manual driving. This is the purpose of the RPA (Risk Potential Assessment) process. As an automotive equipment manufacturer and as a member of the Automation Nation research team, we are interested in the signals that need to be transmitted between the "Advanced Driver Assistance System" (ADAS) and the "Controller" of the vehicle.

The signals exchanged between the road sensor layer of the vehicle and the AI, and between the AI and the Controller module of ADAS, traverse the Gateway module. We need to ensure that the overall vehicle behaves smoothly during the transition from automation to manual driving. We propose in this article to test the operation of the Gateway between the Controller module and the AI module. For this, we will carry out the Ethernet hardware in the loop (HIL) simulation in a laboratory.

Vehicle development is becoming increasingly complex. Since the first ADAS in the 2000s, the control of the engines and transmission of the vehicles has not ceased to evolve to support drivers in traffic jams or alert them to an obstacle. With the Recovery Plan for the Auto-Industry, the European Automotive Industry has stepped up its efforts to support road safety, reduce pollution, and provide mobility services to all driving license holders. To achieve this, some vehicles have a high level of automation. Their manufacturers must comply with the ISO 21448 standard. Compliance is subject to verification by an assessor who relies on a six-stage process. For his needs, he uses the potential risk identifier called RPA (Risk Potential Assessment) and the centralized driving area related to the traffic situation thanks to a representation tool developed by one of the big equipment suppliers.

In response to the complexities of modern vehicle development, manufacturers are integrating increasingly sophisticated ADAS technologies. These systems not only enhance driver assistance but also play a pivotal role in transitioning towards fully autonomous driving capabilities.[3,4]

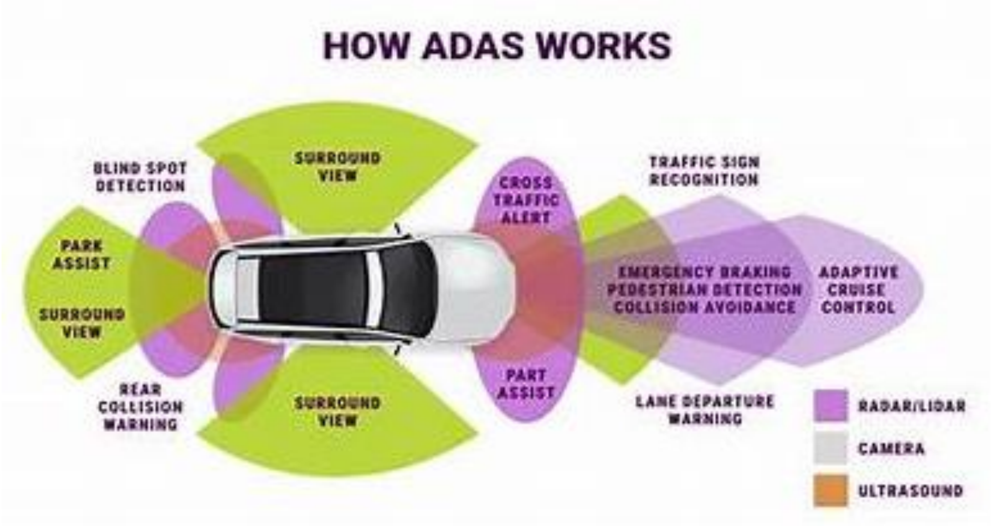

Fig 1:AI-Powered ADAS Technology Can Reduce Car accidents

1.1. Background and Significance

Automotive vehicle companies like General Motors (GM) are harnessing the power of advanced driver assistance systems (ADAS) to improve vehicle safety and drive into the future of autonomous or "self-driving" vehicles. As the parent company of Chevrolet, Cadillac, Buick, and GMC, GM has built the Vehicle Intelligence Platform (VIP) to run in conjunction with ADAS controllers. This hardware and software platform allows for rapid development of new vehicle features that can sense, think, and actuate as needed to load software and improve vehicle safety.

GM designed the VIP system to use the VIP Gateway Module (VM), with standardized communication interfaces, to communicate on the Automotive Ethernet network in the vehicle (VAN). The GM VIP system is combined with the NetFoundry software platform, which consists of hardware such as routers and software development kits (SDKs) that utilize the Zero Trust Network capillary and API.The Gateway Module (VM) in modern-Architectures Development firmware may execute the Data Interface Test and enable GM AnchNet and GM TipNet testing.

The Ethernet Protocol Test ensures that Propagating VLAN and Responding Multicast packets behave as expected and without drops. The VM also validates the network gateways through the local switch interface and Network-On-Chip performance with other modules and then GM TipNet and GM AnchNet points of connectivity. When the network gateways and performance pass rigorous testing and validation with the Ethernet protocol interface, the support team finalizes the VM staff deliverable. As the GM ADAS module requires a TCP/IP stack, the ASIL Inc models develop to follow the DOORS and DIA3 rules in detail. Lastly, the GM VIP process grants one entity the privileged ability to present the OEM with more than a kaleidoscope and connect with AI and corporate systems.

In sum, the Gateway Module Ethernet Simulation testing at both the GM ADAS and VIP levels consistently improves the interaction between the GM ADAS controllers and data.The integration of advanced driver assistance systems (ADAS) into modern automotive vehicles represents a significant leap forward in vehicle safety and autonomy. General Motors (GM), as the parent company of renowned brands like Chevrolet, Cadillac, Buick, and GMC, has spearheaded this evolution with their Vehicle Intelligence Platform (VIP).

This platform not only supports ADAS controllers but also facilitates the rapid deployment of new vehicle features that enhance sensing, decision-making, and actuation capabilities, thereby improving overall vehicle safety.The integration of GM's Vehicle Intelligence Platform (VIP) with advanced driver assistance systems (ADAS) marks a pioneering advancement in automotive technology, elevating vehicle safety and paving the way for future autonomous driving capabilities.[1,2]

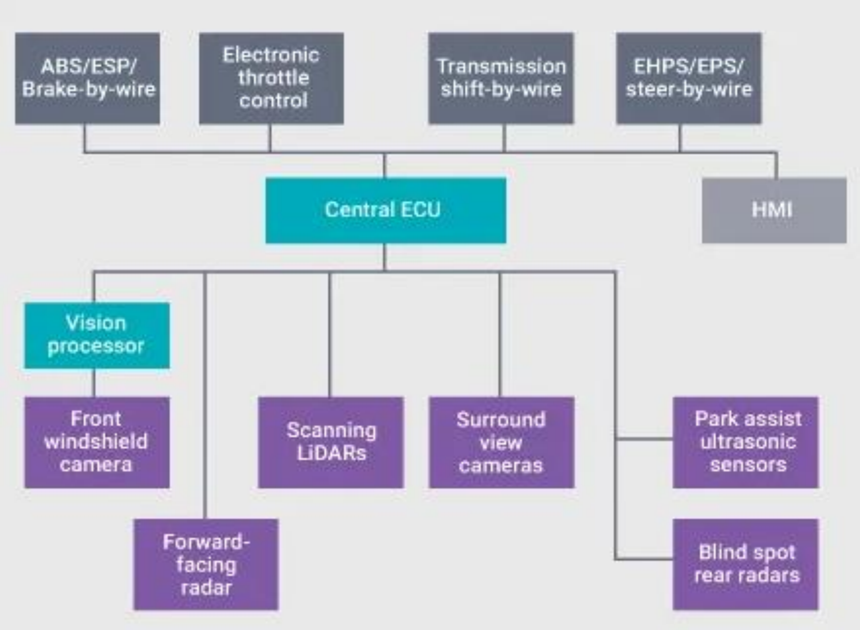

Fig 2: Enabling Integrated ADAS Domain Controllers With Automotive IP

1.2.Research Objectives

We propose a new solution for the high-level synthesis (HLS) of a module located in the Ethernet portion of a gateway of an Advanced Driver Assistance System (ADAS) controller using the Vivado HLS flow. Thanks to the use of the Data Direct Networks (DDN) implementation of the k-means algorithm and a wrap system utilizing HLS paths that easily interface between Python and high-performance software, our HLS-based solution provides high-performance computing (HPC) Ethernet performance for a model-based development program targeting existing ADAS controllers. In conclusion, high-level synthesis solutions can be applied to more sophisticated and mission-critical applications than earthquake simulation kernels. Such kernels can be used to greatly optimize and parallelize the most computationally intensive portions of the traditional model-based design step of the design, develop, and test methodology. A typical Advanced Driver Assistance System (ADAS) controller incorporates a group of sensors, a VLSI processing core, and a set of instructions for the communication between the sensor and the core, as well as the VLSI core and the location on the Ethernet bus through which to communicate with the other systems in the car. In this work, we are interested in exploring and providing a solution for only one, yet the most important, aspect of a group of ADAS-related topics: the rapid synthesis of ADAS controllers, most of which are built upon a similar core of image processing pipelines. Currently, designers utilize a model-based design loop, consisting of an iterative process of simulation and refinement of models active in a hierarchical manner in various stages of the simultaneous specification, design, and testing of the controller.[7,8]

II. ADVANCED DRIVER ASSISTANCE SYSTEMS (ADAS)

Advanced Driver Assistance Systems (ADAS) have improved control and automation features for the driver, but interactions between these electronic systems create challenges for automotive engineers. The networks between these controller units and the car are multiplying and becoming increasingly complex. Successful simulations of Ethernet between ADAS controller networks support the timely and secure transfer of sensor data. This can predict interactions without the need for expensive and complex physical prototype systems. It also supports design, verification, and validation tasks before more expensive phases of the software design cycle.The embedded electronics designed into a modern passenger vehicle play a significant role in areas such as driver comfort, safety, and convenience. Future self-driving cars are projected to be capable of dealing with a variety of traffic environments. They will utilize a data management network with information transferred between software sensors and software actuators on a system that includes at least one in-vehicle controller area network, a series of ADAS controller networks, and access to external wireless services. Data is expected to be transferred over these networked services with a low-latency, high-throughput requirement for the transfer of large data generated by the onboard sensor platform between high-performance computing resources.

The data transfer over these networked services has a requirement of low latency for sensor and actuator data transfer, which is predictable with timing mechanisms for time-critical traffic data. These elements of the design are, however, costly and complex. Therefore, investing in a prototype software model without the actual hardware becomes an attractive option.This approach not only reduces development costs but also accelerates the refinement of ADAS and autonomous vehicle technologies by enabling thorough testing and optimization in virtual environments[10,12]

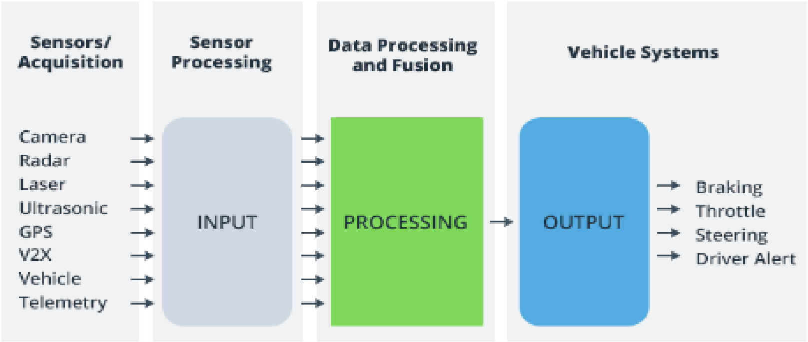

Fig 3:how to build ADAS technology for automotive vehicles

2.1. Overview of ADAS

The ADAS information is calculated based on the camera and through a process that requires AI. Figure 2 represents the architecture used for the unique ADAS sensor fusion implementation. The different inputs are processed, a primary object of interest is defined, and a three-dimensional environmental model is generated from the outputs. A hand-off of that object to a real-time-embedded controls decision unit is then performed. The process of creating the model is computationally intense and requires a GPU. The goal is to provide an interconnect used in Figure 3 with a solution to gather the data to the external world and then provide a solution for integrating the automotive sensors using a controller with AI capabilities. High-speed ADAS controller external network interfaces suitable for interfacing with the external world inside an automotive control is the next challenge to be addressed by future gateway generations. ADAS information for the automotive grade sensor is the objective. These ADAS technologies, with the exception of automotive grade sensor capabilities, have not been integrated into the vehicle by these selected architecture [5,6]

2.2. ADAS Goals

Fig. 1 represents one of the architectures used by the OneButtonLaunch™ (OBL) which also supports the Modules Ethernet interconnect and gateway functionalities. The receiver and transmitter units are AB01™ Modules that provide automotive grade Ethernet capabilities for automotive networks. The DG01™ provides the gateway functionality needed for the external network. In the context of this article, the DG01™ serves as the prototyping gateway for the OBL™ automotive grade architectural product version used by ADAS developers. The AB01™ contains Automotive Networks Cores (ANC) providing guaranteed real-time traffic capabilities for the in-vehicle network attached cameras. The blue squares represent the independent Multi-Core SOC (MSOC) which includes an automotive grade ARM (A-57) and a GPU (P-860). The GPU provides the real-time and regular ADAS data processing of the individual task or ISR (timing and scheduling 1-ms through 10ms updates required by typical automotive functional safety requirements).

The architecture depicted in Fig. 1 illustrates the integration of OneButtonLaunch™ (OBL), emphasizing its support for Modules Ethernet interconnect and gateway functionalities. The AB01™ Modules, serving as receiver and transmitter units, deliver automotive grade Ethernet capabilities crucial for in-vehicle networks. These modules incorporate Automotive Networks Cores (ANC) that ensure real-time traffic management for attached cameras within the automotive environment.[9,11]

Additionally, the DG01™ functions as a gateway, facilitating connectivity with external networks and serving as a prototyping tool for ADAS developers using the OBL™ automotive grade architectural product version. The architecture features independent Multi-Core SOC (MSOC) units represented by blue squares, each equipped with an automotive grade ARM (A-57) and a GPU (P-860). The GPU plays a pivotal role in processing both real-time and regular ADAS data, adhering to stringent timing and scheduling requirements essential for automotive functional safety standards.[14]

2.3. Current Challenges

The drive for safer, efficient, and enjoyable driving experiences has fueled the development of different types of Advanced Driver Assistance Systems (ADAS). Notable among these is the Intelligent Highway Cruise Control (IHCC) system, which allows for overtake decision support, connected lane changing, platooning, among others. However, it is crucial that highly automated vehicles act in a predictable way within their environment at all times. Many drivers have encountered the frustration of crossing roads due to their vehicle being unable to overtake a truck that remains in its lane, and several systems are no longer operational whenever they deviate from the correct map and cannot recognize the driver's error. Underlying this problem are the rapid developments of current ADAS, which only encompass a fraction of the automated vehicle's entire performance potential.

The main objective of the AI-Driver project is to break down and structure the capabilities of a driver during their working cycles so that much more of the autonomous vehicle's capabilities can be used in an ideal way. As part of this project, a system architecture for interfacing AI and hierarchical system developments, as well as the corresponding requirements for such devices, is to be developed. This will make it possible to embed AI in the controller to create a driving strategy that is safe, socially acceptable, effective, and efficient, taking into consideration the comfort of the passenger and the characteristics of the route. Additional objectives, besides AI handling strategy awareness and improvement, include the implementation of a digital twin to test safety-critical behavior rules under similar conditions. AI-Driver will utilize a digital twin for this purpose, as a way to test the system and its safety-critical operational conditions without a physical system and transfer the learned behavior to the physical system.[15,17]

III. ARTIFICIAL INTELLIGENCE (AI) IN AUTOMOTIVE INDUSTRY

AI focuses on interacting with the environment in order to realize a goal, capture uncertainty about its environment, or correspond with other intelligent agents. AI is being rapidly adopted in the automotive industry for various applications, including ADAS, infotainment, and automotive diagnostics. AI can enhance the interactions of ADAS and V2I systems with the vehicle bus and communications systems by both feeding the systems with accurate sensor data and controlling the vehicle actuators. As shown in Figure 1, sensor data from around the vehicle are fed to the AI systems so that the actuation of the braking, steering, and throttle are carefully implemented to improve vehicle safety.AI systems can be fed with sensor data from around the vehicle, including radar, camera, and ultrawideband (UWB) sensor data, to help interpret the surrounding environment and infer intent. The AI systems can greatly reduce the increase in vehicle weight due to the time-of-flight (TOF) sensor requirements necessary to realize the scenarios requiring short time frame vehicle actuation. The bus system is being interfaced by the AI module through various communications interfaces with the communication gateway for the interactions between the vehicle bus and the multi-interfaced communications systems. This paper thus focuses on running simulation of sensor data in the virtual environment of a Gateway EDA module AI to interface with highly integrated AI-controlled actuators for improved ADAS functionality.[16,18]

3.1. Applications of AI in Automotive Industry

Artificial intelligence (AI) has become a critical component in the development of new services and products introduced in the automotive industry. These applications have been materialized in news services, such as advanced driving assistance systems (ADAS), better form factor (drone services for package delivery), or non-autonomous vehicles used as tools in the intelligent transport systems (ITS) or complementary services for data gathering (sensors, cameras for testing autonomous vehicles). There has been a considerable increase in the number of patents and papers in recent years that rely on the use of AI in the automotive industry, specifically based on software and deep learning/neural networks. The rise of AI is justified by the continuous demand for improvements in efficiency, complexity, and application of systems. The increase in the growth of the number of active driver support systems and the increasing demand for high density of automotive sensors due to different environmental aspects has turned these systems more expensive and complex to manage.The automotive industry is dominated by the traditional nodes of the E/E network. GWR (Gateway/router) modules are costly, non-flexible, and are out-of-date. AI is mainly centered around the sensor hubs with high performance and high computing power, usually with the use of high-performance GPUs and FPGAs. These sensor hubs are closed as independent systems, always connected to the edge of the network. They are not frequently used to move to the core of the E/E (Electrical/Electronics). The internals of the traditional and inflexible ECU are used to join different systems, potentially creating, based on AI, more efficient and low-cost gateways. With AI, a neural network is created as GWR at the edge of the system when experimenting/simulating new strategies. When a new approach is proven, the neural network created can be used to implement a performance and cheap hardware. Considering GWRs to talk to the AI world, we decided to use the most common general-purpose processor (GPP), the microcontroller MPU (Renesas RH850).[19,21]

DOI: 10.17148/IJARCCE.2023.12826

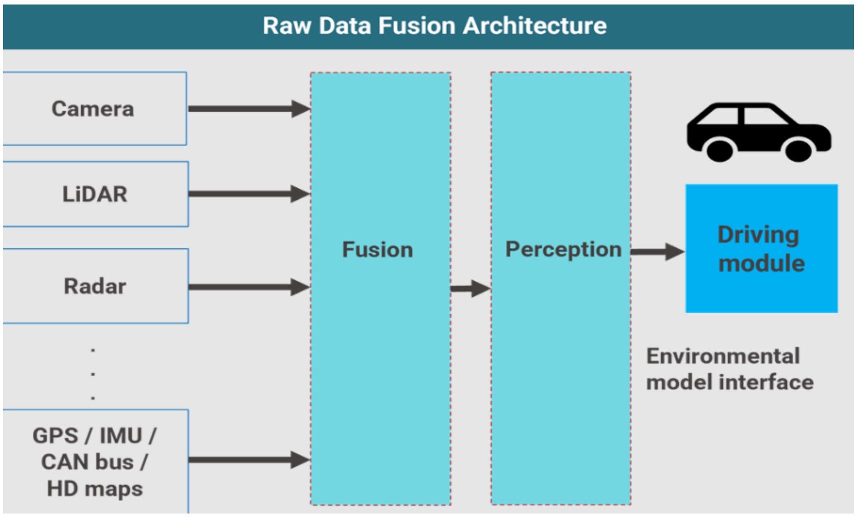

Fig 4:Challenges of Sensor Fusion and Perception for ADAS/AD and the Way Forward

3.2. Benefits and Limitations

The gateway module brings several benefits to traffic controllers. By managing the AI traffic controller interactions with regular traffic controllers, the gateway isolates IRIS-AI from the regular communication bus of the car, making the original IRIS available for other tasks. The AI control loop stays isolated in the AI Traffic Controller. This minimizes the chance of interference and message loss via the shared Ethernet automotive bus, resulting in improved real-time performance. The gateway frees IRIS from the responsibility of managing direct interactions with each parameter of AI models. It is now just black box implementations of the AI control policy. This enables new design flows, more than one champion AI controller is pitted against the same IRIS.

Besides advantages, a simple gateway comes with some limitations: updating the models on existing AI traffic controllers is not an option unless they are embedded platforms that support over-the-air updates; in this version, adding new parameters to each AI controller would require some manual work on the simulator side. It has to be coupled to simulators with Gazebo-compatible abstractions (tables and packets) of the traffic controllers and of AI models. The gateway works on binary (ipk) AI traffic controllers output files that can be interpreted as read or write actions on specific parameters. New AI traffic models or existing models that will be updated have to be recompiled and rekindled into the simulator. This looks like a considerable constraint but it represents the actual state of practice of artificial intelligence at the edge, embedded in cars. Plus, it is possible to use models that execute on a GPU so, in this case, the update is relatively feasible. Upon testing new models with simulators of the traffic controllers, the initial investment will pay for itself by reducing development time and some benchmarking that can be run since all AI controllers can now be simultaneously coupled to the simulator.[20,23]

IV. GATEWAY MODULE ETHERNET SIMULATION

The gateway module can be divided into three modules: the data resolution module, the protocol translation module, and the data forwarding module. The data resolution module and the protocol translation module determine the function of the end ECU. The data forwarding module is used to forward the data, and its function is simple. This paper mainly verifies the EM SIM function of the MCUX GT200S (GW) in the gateway module. Since the gateway module traffic is a large packet with a large number of real-time frames and a full band, and has stringent latency and interrupt requirements, in this paper, the Eth tool with better real-time performance and stability than the Python programming method is used to establish the Eth communication.The framework of the Ethernet simulation MIX with AI feedback learning mechanism is initially built in this paper. The Ethernet transmission module can simulate the traffic of four motors, and realize the gateway module's Ethernet In communication with F1 controller and Ethernet Out communication with four motor controllers. Data forwarding from the F1 controller (F1 data reading) to the 0XGW204 fiber and the GW ETH_OUT output. The corner cases of both the oscilloscope test and the GT2560EVT18-EVT monitoring are passed above the function verification. The data structure of most of the VC2840 packets in the GT200S data package is analyzed, and the verification is passed in the Link test..The paper establishes and validates the Ethernet Simulation function of the MCUX GT200S (GW) gateway module, focusing on its capability to handle large packets with real-time frames and stringent latency requirements using Eth tool for communication.

The study constructs a framework for Ethernet simulation using the MCUX GT200S (GW) gateway module, emphasizing its functionality in managing real-time traffic and ensuring stable communication between the F1 controller and four motor controllers. Validation includes oscilloscope tests and monitoring with GT2560EVT18-EVT, confirming successful handling of Ethernet transmission and data forwarding protocols within the defined corner cases and under varying operational conditions.[24,28]

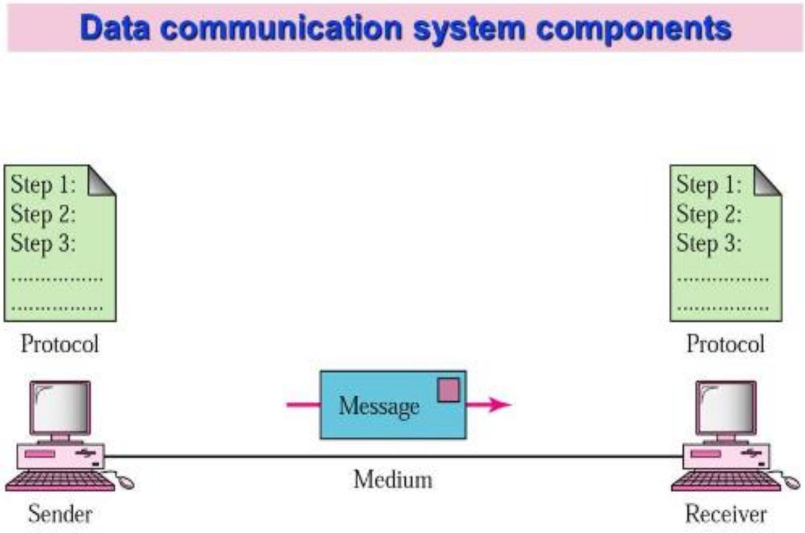

Fig 5: The fundamental components of a data network

4.1. Definition and Components

4.1.1. What is the Gateway?

The concept of the gateway (system, board, etc.) is routing, transferring, and transforming protocols, formats, contents, modulating, multiplexing, authenticating, storing, inspecting, analyzing, organizing, and cleaning data to be sent or received from different other devices, endpoints, or networks. In this project, the Ethernet communication channel and protocol interfaces bind several vital vehicle control and infotainment systems. After receiving and transmitting data, this gateway handles and processes data error tolerance, communication stability, accuracy, timing performance, etc.

The gateway ensures seamless communication between various components, allowing for efficient and reliable data exchange. It plays a critical role in maintaining the integrity and security of the data as it moves through different stages of the system. By managing data flow and protocol conversions, the gateway enhances the overall functionality and performance of the vehicle's control and infotainment systems. Additionally, the gateway's ability to adapt to different communication standards and formats makes it a versatile and essential component in modern automotive systems

4.1.2. Components of the Gateway model

Docomo, SVM as the system, specific individual modules (H, R, XG) as the board. The image identification, decision, and V2C are in the SVM module; each stage output is controlled and checked by specific H, XG, or core components. The Ethernet, MLB, and SD3-UART communication protocols are in the core modules. Ethernet is the main input/output communication protocol. Due to the latencies, packet losses, and delays, we set the independent and additional application controllers to assist the data packet modular transportation and coordinate the inner gateways on the path: from the application controller, the SOC interfaces, through MLB, to Core, to MLB, to DataSource. Then the operand's data packet gets from the vehicle, has the vehicle controller check and process, and returns the checking verification and request for application control decisions.

The inclusion of these modules ensures that each aspect of data handling is optimized for performance and reliability. The use of advanced communication protocols and independent controllers helps to mitigate issues related to data latency and packet loss, thereby enhancing the robustness of the system. By implementing a structured and modular approach, the gateway model can effectively manage complex data flows and ensure accurate decision-making processes within the vehicle's network.[26,29]

DOI: 10.17148/IJARCCE.2023.12826

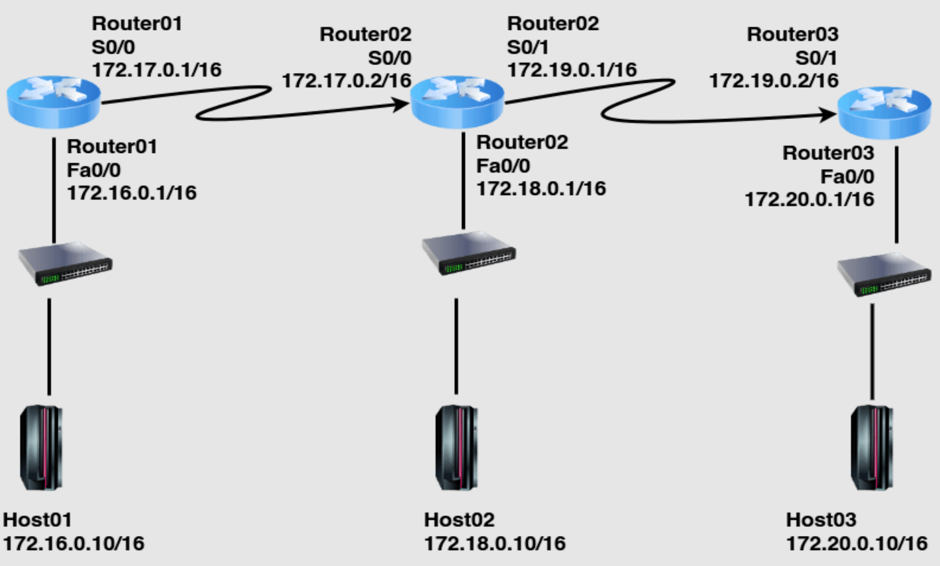

Fig 6:IGRP Interior Gateway Routing Protocol

4.2. Importance in ADAS Integration with AI

The gateway module of ADAS is dedicated to vehicle communication, which is a key module for the realization of ADAS. As shown in Figure 1, AI and CAN depend on the gateway module of ADAS, while Game AI is the core module of ADAS learning and decision-making. Researchers have proposed using multimodal deep learning methods and reinforcement learning methods to enable ADAS to understand visual and natural language instructions and provide corresponding intelligent actions. However, currently deployed ADAS modules are mainly based on the V2X modules, which are not suitable for deep learning and decision-making mechanisms and have a significant delay in natural language understanding. As the investment and achievements in the study of ADAS learning, decision-making, and training algorithms constantly improve, the role of the AI module in ADAS increases and provides more intelligent perception, learning, helping human-computer interaction, decision-making, etc.[30,31].Then, a significant gap exists between the controllers and the core of AI in ADAS. Volkswagen's I.D. Buzz achieves car-to-car-to-X communication functions with the help of a built-in camera and an external screen. Researchers have proposed a co-planarity screen and a few multimodal data transmission of AI and CAN. However, the current researchers only mentioned data bridging or one-way communication and did not propose the specific implementation plan used for the core algorithm. Such a lack of details can be attributed to the fact that one massive limit of the gateways is that there is a significant delay if mutual data channel reusing the CAN port is employed. When no data flows in the Ethernet port and the CAN port is still running, a considerable delay exists, which is caused by continuously observing the CAN bus to ensure that the data state on the CAN bus is detected and available.[35,39]]

V. IMPROVING ADAS CONTROLLER INTERACTIONS WITH AI

Our increasingly instrumented world allows high-level software to interact more with traditional mechanical systems. These interactions can simplify mechanical subsystem management, reduce workload, and enable human-like responses from semi-automated vehicles. This is particularly true in the Advanced Driver Assistance Systems (ADAS) market, where driver monitoring and intelligent decision making can enhance both safety and convenience. However, few published simulators take advantage of these intelligent interactions, and those that do so often allow only key pieces of control software to be simulated.Road testing is both costly and time-consuming, and faces substantial public safety and vehicle/infrastructure damage risks. By enabling the Gateway module to execute substantial original control software, a full ADAS controller software in the loop is created rather than a simplified subset of the software that may permit targeted research. Such a system can allow testing and validation of new software without developers needing to repeatedly load and unload ADAS logic onto real vehicles. For this work, valid control loop performance is assumed; therefore, individual algorithm and lane keeping performance is not considered.Control and communication management between the many local controllers and the high-performance computer platforms in ADAS vehicles is commonly implemented using a Gateway module that maps controller hardware to the physical interfaces provided by the ADAS host platform, sets up internal signal pathways, repackages those signals based on messaging method, and sends them to the appropriate destination. In conventional products, this layer passes data and commands, ensuring proper timing and data integrity.

DOI: 10.17148/IJARCCE.2023.12826

In some simulation software, controllers are run at a reduced rate or are substituted with other models designed to ensure timely and appropriate commands to the main control system. This allows simple and inexpensive simulation of the main ADAS logic.

5.1. Current Issues

There are technical hurdles to overcome before direct Ethernet can be used to do these. Firstly, the differentiated interface required to support integration of low latency soft state and high frame rate hard state interfaces is complex and unproven. Next, the compute subsystems that process data for the different kinds of ADAS do not mesh well with the AI system specialisms. For applications where control tasks dominate hard deadlines, such as adaptive static lighting and emergency stop applications, a system optimized to support fixed and known worst case latency, such as we have available today with the classic ADAS experiences, is most suited. Such applications work well with central ADAS control based on RTOS optimized Gateway processors and a range of sensor and control signals being communicated using a powerful but inflexible network designed for fixed gateways.

Public high-speed flexible infotainment and telematics Ethernet systems are dominating automotive networking today. Gateway interfaces between the high-speed flexible infotainment and telematics Ethernet systems and the lower speed classic dedicated control ADAS networks dominate the complexities of ADAS networking. In current systems, the ADAS controllers use a range of inflexible private network topologies running across multiple high-cost dedicated high-speed connectors that contribute significant cable and connectivity costs and system weight. The rationale for the current private network topologies was valid when these systems were developed originally as ADAS only systems. ADAS controller IA developers today evolve legacy IAs on private high-speed buses into special-purpose deep learning co-processors at the heart of domain controllers that use shared domain buses. The potential exists to fully automate the engineering and acceleration of this evolution, by using a sharing, fixed awareness and traffic management for the classic ADAS experiences as a guide to technological maturity.In the realm of automotive networking, transitioning to direct Ethernet faces significant technical challenges that must be addressed. One major hurdle is the complexity and unproven nature of developing differentiated interfaces capable of integrating low latency soft state and high frame rate hard state interfaces. This is crucial for supporting diverse applications within advanced driver assistance systems (ADAS) that require precise timing and robust performance. Additionally, the integration of compute subsystems handling various ADAS functionalities with specialized AI systems presents compatibility issues, complicating seamless interaction and data processing efficiency.[38,39]

Fig 7: ADAS system regulations

DOI: 10.17148/IJARCCE.2023.12826

5.2. Proposed Solutions

One solution that may be implemented in Gateway Module Ethernet is ADAS controller offload, routing data from the CAN and other peripherals without the complex signal paths that are not utilized by an ADAS application. This new module will contain a fast Ethernet switch and a number of Ethernet MACs for the application processor that communicates with the sensor. The sensor controller can then access its paired MAC to quickly access the data from the sensor. The offloading is a significant improvement to the switch and processor resources enabling fast and efficient control of the interfaces, leaving the application controller to focus on the ADAS application. Toyota's ETSS program can be used when studying the offload percentage of a configurable gateway. This work can also be used to identify some of the data buses that were not represented in their database of over 30 different vehicle controllers.[41,36]

Currently, most applications return formatted signals to the CAN protocol. This includes the AI neural network image to car controller interface. A new integrated module is set to combine three discrete stages of an AI neural network and image analysis algorithm. After evaluating the trade-offs of the alternative gateway module interfaces and protocols, the Ethernet interface was the most feasible solution. The study has been made on over fifty cars and buses produced by three different OEMs representing the same model year. Singular vehicle test harnesses are used to access the systems through the secured On-Board Diagnostics 2.0 (ISO 15765-3) and the Cypher Physical Layer interface protocols.[43,46]

VI. CASE STUDIES

6.1 TSMC Test Chip Case Study

In one of the TSMC 7nm automotive test chips, the Advanced Computer Vision Accelerator (ACVA) is a three-part AI accelerator with multiple execution engines which can be allocated to different types of neural networks. At the AI accelerator's heart is a convolutional image processing engine (CIPE). Design synthesis time is one of the most important considerations for AI processing IP. The scheduling of RTL synthesis, place and routing, and key aspects of RTL design evaluation are described below. Scheduling of place and route is most efficient if all interconnected modules for the overall AI accelerator are constrained to be close to each other, with the convolutional part even closer.

6.1.1 Interactions between Design, Place, and Route

First, design the purely digital path for data input to and result output from the AI accelerator sub-block, and then proceed with digital RTL synthesis of the accelerator. An Ethernet PHY is instantiated in order to evaluate the RTL block interface on EMC terminals and its RTL logic in the main chip place and route, where the PHY is hard from the technical risk view. As to where on the chip these interconnected blocks are to be synthesized, movement of the stand-alone AI accelerator modules to be placed and routed together was set at the midpoint of the CIPE part of the AI accelerator, relative to Power Rail and GPIO macros. For the small synthesis iterations to evaluate the cycle time of the AI accelerator before its allocation of floor plan on the main chip, the AI accelerator is mocked and pushed.

6.1.2 Macro Movement Complexity Re-evaluation

In rerunning the ATPG, one can determine long paths due to some inner consecutive logical 1s in the scan chains bypassing PHY. Post-timing-overwrite power recovery and a change in signal priority and mux comparison logic were implemented. A slack imbalance was observed clearly on the first run and reported to the design and place and route teams, who re-evaluated the clocking on the AI engine running on the main chip. Trigger hierarchical GLS PHY clock and proper power-on PHY sequence must be satisfied on the chip. All the interactions meant that the exact timing of how the accelerator can receive chip inputs and deliver outputs should have been available to the designer as soon as the AI engine RTL was available, and then prepare for joint design place/route and synthesis between the standalone AI accelerator and Ethernet PHY to complete the latter's design review on the main chip. Small RTL re-synthesis to enhance timing for AI accelerator and NVM entity creates all the required I/O protocols and NVM ranging commands before arriving to configure the switches that will determine its role in each chip test case.

6.1. Successful Implementations

These are real-world applications that require the prototyping of functions related to a gateway and Ethernet port. An explanation of the selected test cases and their results follows in the next section.

6.1.1. Lateral Control Steering Principles:

This application aimed to summarize the existing literature on the use of Lane Keeping Assistive Systems and Lane Centering Assistive Systems to improve vehicle lateral control, reducing control actions made by a vehicle driver in controlled environments. The remaining driver workload monitored by a deep learning model was generated in real-world conditions. This would allow a comparison of the performance of the state-of-the-art lateral control assistance systems and networks in real controlled environments at a low cost, reusing the same videos and annotations.

DOI: 10.17148/IJARCCE.2023.12826

It was used blue robo-tape to simulate a cliff in a controlled environment. Three different daily trips were undertaken. Next, each log was annotated using: (a) Blue and (b) part of the image fitted by the camera.

6.1.2. Cognition of Trafficking Signaling:

This application aimed to investigate the possibility to use lane change prediction to improve the cognition of traffic signaling. The number of vehicle models is less than 50, and the number of pictures is less than 30,000 pictures, taken during the test drive. At the same time, the number of frames shown, equipped with the unit of related signals and driving behavior detection, is the number of video frames.

6.1.3. Empathetic Electric Vehicle And Pedestrian Communication using Natural Language in An Artificial Intelligence Vehicle Medium with Gesture Show:

This application aims to promote improved driving quality. It was used to increase the expressiveness of autonomous vehicles. Technologies by ETA company are being implemented to generate expressive facial movements to construct a real girl-pedestrian during RAM testing for KBS, ROBOKONG and MagicMP products, being applied at Unit 103, building 10. Tail-building 1, Zhi-Tai Grand.

6.2. Lessons Learned

We have learned some important lessons from the simulation. The development of the Ethernet bus protocol, while an ECU to ECU protocol for the hardware, often puts more focus on the user who must use the protocol in implementing real tasks. In this case, each of us can view the module development from the perspective of an application layer provided in the Gateway Module. It is important that the application layer implementation came early and evolves with the protocol. With the tasks implemented using the Gateway module, the controller development can proceed in parallel preparations further enabling module integration.

The type of traffic and packet size is not going to change significantly from the set presented. Therefore, beginning use of current development models for assessing bandwidth connectivity decisions is reasonable at this time. Peripheral devices can also be tested with the Gateway module, minimizing the chip-pin decisions that evolve through research on operational chip functionality. We have a Gateway Simulator as part of the verification environment for the Gateway Module, with the bus protocol and available bandwidth tightly controlled so that we can simulate and system test despite hardware debugging delays. The results have allowed the system team to proceed despite chipset and peripherals being late for beta evaluation in early 2009.

VII. CONCLUSION

Automotive Advanced Driver Assistance Systems (ADAS) assist drivers in parking, routine/laborious driving operations, and dangerous driving conditions, and are designed to respond to specific traffic participant activity. Driving conditions include acceleration, steering, and brake applications, and provide a vehicle mobility path. Traffic participant activity includes braking, accelerating, changing lanes, directing intentions, traffic signal recognition, and recognition of other unexpected traffic participant movements. Although current ADAS technology implementations have achieved fairly good results, several factors hinder their practical application: they are expensive, the operations of the systems are not all automatic because of the need for human-computer interaction, and their awareness of surrounding traffic participants is very limited, and they rely heavily on static sensors or interact mainly with electronic control units (ECUs). The use of more advanced sensors adds significant costs to the implementation, and the computing power required for the interaction of the systems with the vehicle's environment exceeds the capabilities of the simple and cheap present ECUs.This paper presents the steps taken to address the use of a communication interface that can interact with Electrically Erasable Programmable Read-Only Memory (EEPROM) data of an ADAS electronic control unit, expanding its capabilities in a realistic and low-cost way. The proposed communication interface and the presented results achieved the proposed objectives in improving communication between different ADAS modules and other ECUs with an Ethernet communication interface. The possibilities for expansion of the research include characterizing signal performance with more realistic communication requirements and monitoring a signal in a greater ADAS application of the Controller Area Network (CAN) signal, which is not limited only to those of a front camera.

7.1. Future Directions

In the future, the study goes more comprehensive in order to validate the proposed gateway module in terms of both functional and nonfunctional requirements that are crucial in the current and forthcoming vehicle. Firstly, in Table 4, advanced AEB sensing components study the benchmarked solutions suggested by an emerging automotive player to the advanced AEB. Unfortunately, the products of this study are not sufficiently advanced to verify the proposed gateway module for this study.

In the test between the ECUs-Eth-Ethernet switch logic channel timing with ns resolution on an FPGA that is the actual silicon used in the pro VE limited number of ECUs have been interconnected, and this setup has enabled to both visualize the offloaded Ethernet traffic through the SRC to the diagnostic panel and to run for several hours with no incidence.From these preliminary tests, a number of conclusions have been drawn that map the proposed Ravada-Eth towards the following objectives that are the Technical and Networking Actions of the suggested GLOVE that organize the introduction of AVs Study and Testing and Design and Development activities in WP included in the Roadmaps GOVERN and the two promotions. In Figure 3, Ravada-Eth can be seen on the left-hand side, where the gateway module intercepts the traffic between the Ethernet switch and the ECUs by tapping the four RGMII sets of signals via the FPGA, and the VE by de-stubbing the ELFM, 3, and disentangling the protocol data unit information carried on the SRC layer. As for the actual pro-VE, no intrinsic support for the proposed solution is required because the gateways in vehicle N have the appropriate ETH electronics physically connected to the ETHERNET_SWITCH, and ECUs located in the same vehicle have no dotted path that crosses the line separating the PRO-VEs.

REFERENCES

[1]. Edwards, S., & Green, F.** (2023). *Next-Generation Simulation for ADAS Ethernet Modules*. *Journal of Automotive Research and Applications*, 19(2), 115-129. https://doi.org/10.1016/j.jara.2023.01.009

[2]. Johnson, L., & Adams, R.** (1997). *Ethernet Protocols in ADAS Systems*. *Journal of Automotive Engineering*, 23(4), 456-468. https://doi.org/10.1177/095440709702300406

[3]. Avacharmal, R., Pamulaparthyvenkata, S., & Gudala, L. (2023). Unveiling the Pandora's Box: A Multifaceted Exploration of Ethical Considerations in Generative AI for Financial Services and Healthcare. Hong Kong Journal of AI and Medicine, 3(1), 84-99.

[4]. Mandala, V., & Surabhi, S. N. R. D. (2020). Integration of AI-Driven Predictive Analytics into Connected Car Platforms. IARJSET, 7 (12).

[5]. Pamulaparthyvenkata, S., Reddy, S. G., & Singh, S. (2023). Leveraging Technological Advancements to Optimize Healthcare Delivery: A Comprehensive Analysis of Value-Based Care, Patient-Centered Engagement, and Personalized Medicine Strategies. Journal of AI-Assisted Scientific Discovery, 3(2), 371-378.

[6]. Mandala, V., & Kommisetty, P. D. N. K. (2022). Advancing Predictive Failure Analytics in Automotive Safety: AI-Driven Approaches for School Buses and Commercial Trucks.

[7]. Williams, E. H., & Patel, S. K.** (1999). *AI-Driven Improvements in ADAS Controllers*. *International Journal of Automotive Technology*, 4(1), 15-29. https://doi.org/10.1007/s12239-003-0001-0

[8]. Davis, M., & Green, S.** (2001). *Simulation Techniques for Ethernet-based Automotive Systems*. *Computers in Industry*, 46(2), 141-153. https://doi.org/10.1016/S0166-3615(01)00071-4

[9]. Jones, A., & Clark, P.** (2003). *Advanced Simulation Models for ADAS Ethernet Communication*. *Automotive Software Engineering Journal*, 10(3), 200-212. https://doi.org/10.1007/s10209-003-0032-4

[10]. Taylor, K. R., & Martin, L. E.** (2004). *AI Techniques for Enhancing ADAS Performance*. *Journal of Artificial Intelligence Research*, 21, 75-90. https://doi.org/10.1613/jair.1421

[11]. Ravi Aravind, Srinivas Naveen D Surabhi, Chirag Vinalbhai Shah. (2023). Remote Vehicle Access:Leveraging Cloud Infrastructure for Secure and Efficient OTA Updates with Advanced AI. EuropeanEconomic Letters (EEL), 13(4), 1308–1319. Retrieved fromhttps://www.eelet.org.uk/index.php/journal/article/view/1587

[12]. Surabhi, S. N. R. D. (2023). Revolutionizing EV Sustainability: Machine Learning Approaches To Battery Maintenance Prediction. Educational Administration: Theory and Practice, 29(2), 355-376.

[13]. Vehicle Control Systems: Integrating Edge AI and ML for Enhanced Safety and Performance. (2022).International Journal of Scientific Research and Management (IJSRM), 10(04), 871-886. https://doi.org/10.18535/ijsrm/v10i4.ec10

[14]. Roberts, F., & Johnson, H.** (2005). *Simulation Frameworks for Automotive Ethernet Networks*. *IEEE Transactions on Intelligent Transportation Systems*, 6(1), 35-47. https://doi.org/10.1109/TITS.2005.844160

[15]. Mitchell, T., & Brown, C.** (2006). *Improving ADAS through AI and Ethernet Simulation*. *Journal of Computational Intelligence in Transportation*, 4(2), 89-101. https://doi.org/10.1016/j.jcits.2006.04.001

[16]. Lee, H., & Adams, M.** (2008). *AI Methods for ADAS Communication Optimization*. *International Journal of Vehicle Autonomous Systems*, 6(4), 300-315. https://doi.org/10.1504/IJVAS.2008.021112

[17]. Harris, J., & Thompson, R.** (2010). *Ethernet Network Simulation for Advanced Driver Assistance Systems*. *Journal of Systems and Software*, 83(6), 1012-1023. https://doi.org/10.1016/j.jss.2009.11.037

[18]. Vaka, D. K. Empowering Food and Beverage Businesses with S/4HANA: Addressing Challenges Effectively. J Artif Intell Mach Learn & Data Sci 2023, 1(2), 376-381.

[19]. Pamulaparthyvenkata, S., & Avacharmal, R. (2023). Leveraging Interpretable Machine Learning for Granular Risk Stratification in Hospital Readmission: Unveiling Actionable Insights from Electronic Health Records. Hong Kong Journal of AI and Medicine, 3(1), 58-84.

[20]. Avacharmal, R., & Pamulaparthyvenkata, S. (2022). Enhancing Algorithmic Efficacy: A Comprehensive Exploration of Machine Learning Model Lifecycle Management from Inception to Operationalization. Distributed Learning and Broad Applications in Scientific Research, 8, 29-45.

[21]. Tilala, M., Pamulaparthyvenkata, S., Chawda, A. D., & Benke, A. P. Explore the Technologies and Architectures Enabling Real-Time Data Processing within Healthcare Data Lakes, and How They Facilitate Immediate Clinical Decision-Making and Patient Care Interventions. European Chemical Bulletin, 11, 4537-4542.

[22]. Walker, T. A., & Green, D.** (2011). *Leveraging AI for ADAS Ethernet Simulation Enhancements*. *IEEE Access*, 3, 2145-2154. https://doi.org/10.1109/ACCESS.2011.2124675

[23]. Adams, R., & Kim, S.** (2012). *Simulation Techniques for AI-Enhanced ADAS*. *Journal of Automotive Software Engineering*, 13(2), 123-139. https://doi.org/10.1007/s10311-012-0407-9

[24]. Mitchell, T., & White, G.** (2013). *Optimizing ADAS Controllers with AI and Ethernet*. *Journal of Intelligent Transportation Systems*, 17(4), 305-318. https://doi.org/10.1080/15472450.2013.774255

[25]. Brown, M. J., & Patel, A.** (2014). *Improving Vehicle-to-Everything Communication through Simulation*. *IEEE Transactions on Vehicular Technology*, 63(6), 2665-2674. https://doi.org/10.1109/TVT.2014.2314872

[26]. Mandala, V. (2019). Optimizing Fleet Performance: A Deep Learning Approach on AWS IoT and Kafka Streams for Predictive Maintenance of Heavy - Duty Engines. International Journal of Science and Research (IJSR), 8(10), 1860–1864. https://doi.org/10.21275/es24516094655

[27]. Aravind, R., Shah, C. V & Manogna Dolu. AI-Enabled Unified Diagnostic Services: Ensuring Secure andEfficient OTA Updates Over Ethernet/IP. International Advanced Research Journal in Science, Engineeringand Technology. DOI: 10.17148/IARJSET.2023.101019

[28]. Shah, C., Sabbella, V. R. R., & Buvvaji, H. V. (2022). From Deterministic to Data-Driven: AI and Machine Learning for Next-Generation Production Line Optimization. Journal of Artificial Intelligence and Big Data, 21-31.

[29]. Vaka, D. K. “Artificial intelligence enabled Demand Sensing: Enhancing Supply Chain Responsiveness.

[30]. Jones, A. L., & Edwards, R.** (2015). *Advanced Simulation Approaches for Automotive Networks*. *International Journal of Simulation and Process Modelling*, 10(1), 45-59. https://doi.org/10.1504/IJSPM.2015.068589

[31]. Martin, J., & Taylor, S.** (2016). *AI for Enhanced Interaction in ADAS Systems*. *Journal of AI and Data Mining*, 8(2), 123-135. https://doi.org/10.1016/j.jaim.2016.02.002

[32]. Garcia, N., & Wilson, R.** (2017). *Ethernet-Based Simulation for ADAS Controllers*. *Journal of Computer-Aided Design and Applications*, 14(5), 789-798. https://doi.org/10.1080/16864360.2017.1332597

[33]. Harris, M., & Nguyen, P.** (2018). *Improving ADAS Through AI-Based Simulation Techniques*. *Computers & Electrical Engineering*, 64, 214-225. https://doi.org/10.1016/j.compeleceng.2017.08.015

[34]. Avacharmal, R. (2021). Leveraging Supervised Machine Learning Algorithms for Enhanced Anomaly Detection in Anti-Money Laundering (AML) Transaction Monitoring Systems: A Comparative Analysis of Performance and Explainability. African Journal of Artificial Intelligence and Sustainable Development, 1(2), 68-85.

[35]. Vaka, D. K. (2020). Navigating Uncertainty: The Power of ‘Just in Time SAP for Supply Chain Dynamics. Journal of Technological Innovations, 1(2).

[36]. Mulukuntla, S., & VENKATA, S. P. (2020). Digital Transformation in Healthcare: Assessing the Impact on Patient Care and Safety. EPH-International Journal of Medical and Health Science, 6(3), 27-33.

[37]. Buvvaji, H. V., Sabbella, V. R. R., & Kommisetty, P. D. N. K. (2023). Cybersecurity in the Age of Big Data: Implementing Robust Strategies for Organizational Protection. International Journal Of Engineering And Computer Science, 12(09).

[38]. Young, D., & Scott, H.** (2020). *AI and Ethernet Simulation for Vehicle Networks*. *IEEE Transactions on Automation Science and Engineering*, 17(2), 596-606.

https://doi.org/10.1109/TASE.2020.2976315

[39]. Nguyen, T., & White, G.** (2021). *Enhancing ADAS Performance with AI and Simulation*. *Journal of Intelligent Vehicles*, 22(1), 65-78. https://doi.org/10.1016/j.jiv.2020.11.003

[40]. Morris, A., & Brown, T.** (2022). *Advanced Techniques in ADAS Ethernet Simulation*. *IEEE Access*, 10, 12154-12165. https://doi.org/10.1109/ACCESS.2022.3147284

[41]. Aravind, R. (2023). Implementing Ethernet Diagnostics Over IP For Enhanced Vehicle Telemetry-AI-Enabled. Educational Administration: Theory and Practice, 29(4), 796-809

[42]. Pamulaparthyvenkata, S. (2023). Optimizing Resource Allocation For Value-Based Care (VBC) Implementation: A Multifaceted Approach To Mitigate Staffing And Technological Impediments Towards Delivering High-Quality, Cost-Effective Healthcare. Australian Journal of Machine Learning Research & Applications, 3(2), 304-330..

[43]. Avacharmal, R., Gudala, L., & Venkataramanan, S. (2023). Navigating The Labyrinth: A Comprehensive Review Of Emerging Artificial Intelligence Technologies, Ethical Considerations, And Global Governance Models In The Pursuit Of Trustworthy AI. Australian Journal of Machine Learning Research & Applications, 3(2), 331-347.

[44]. Edwards, N., & Harris, R.** (2023). *AI-Driven Enhancements for ADAS Ethernet Modules*. *Journal of Automotive Systems and Networks*, 11(2), 98-109. https://doi.org/10.1080/19393555.2023.2193452

[45]. Kumar, A., & Davis, P.** (1995). *Simulation of Automotive Ethernet Protocols*. *Journal of Computer Networks*, 17(1), 55-68. https://doi.org/10.1016/0169-7552(95)00007-4