Title: Agentic AI Architecture for Predictive Maintenance and Personalized In-Vehicle Experience

Abstract: This paper proposes a novel end-to-end system architecture that integrates vehicle telematics, edge computing, cloud-based AI, and agentic automation to provide predictive maintenance, proactive service scheduling, and personalized advertisements within the vehicle's infotainment system. The design bridges data from in-vehicle sensors to cloud services such as AWS IoT, SageMaker, and calendar/location APIs, orchestrated by an LLM-based Agentic AI. This holistic system enhances user convenience, vehicle health, and OEM monetization strategies.

Keywords: Predictive Maintenance, Agentic AI, Automotive Telematics, AWS Cloud, Infotainment Advertisement, Edge AI, Vehicle E-commerce

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1. Introduction

Modern vehicles are equipped with advanced sensors, ECUs, and infotainment systems capable of capturing real-time behavioral and operational data. While existing telematics systems perform basic diagnostics, this paper proposes an agentic AI-driven architecture that automates predictive maintenance, user interactions, and retail/e-commerce suggestions using a personalized and context-aware approach.

2. System Overview

The system comprises five key layers:

2.1 Edge Layer (Vehicle Side):

- **Telematics ECU:** Collects data from CAN bus and vehicle sensors (speed, acceleration, engine temperature).
- **Onboard AI Module:** Runs lightweight ML models for real-time anomaly detection and driver behavior profiling.
- **Infotainment System:** Displays alerts, contextual ads, and allows user interaction.

2.2 Connectivity Layer:

- **IoT Gateway:** Handles secure data transmission to the cloud and supports OTA firmware/model updates.

2.3 Cloud Layer (AWS):

- **AWS IoT Core** and **Kinesis** for ingesting telemetry.
- **Data Lake (S3)** for long-term storage.
- **AWS Lambda** for serverless event handling.
- **SageMaker** for ML model inference (e.g., predicting component failures).
- **Agentic AI Service:** Interfaces with APIs and orchestrates decisions and interactions.
- **Ad/Personalization Engine:** Recommends products based on terrain, weather, and driving style.

2.4 Integration & User Services:

- **Maps and Calendar APIs:** Used for scheduling service at nearby OEM centers.
- **E-commerce API:** Enables infotainment-based ordering of vehicle parts (e.g., oil).
- **Email/Payment Services:** Sends updates and confirms orders.

2.5 Security & Compliance:

- Implements TLS encryption, AWS IAM, and GDPR-compliant user data handling.

3. Use Case Scenarios

- **Predictive Maintenance:** Vehicle detects early signs of engine wear and notifies the user.
- **Agentic Service Scheduling:** AI finds a nearby service center, checks user calendar, and proposes booking.
- **Infotainment Ads:** Based on location (e.g., hilly terrain), AI suggests suitable engine oils.
- **Parts Purchase:** User can order recommended items directly via infotainment system.

4. Innovations & Contributions

- Introduction of an **agentic AI orchestration layer** integrating predictive diagnostics, scheduling, and e-commerce.
- Contextual product recommendation engine embedded within **vehicle infotainment**.
- Tight integration of **cloud services (AWS)** with **edge telematics**.

5. Implementation Considerations

- **ML Inference:** Trained on real-world driving behavior using SageMaker.
- **Latency Management:** Hybrid edge-cloud processing for critical alerts.
- **Fail-safes:** Manual override and user consent mechanisms.

6. Conclusion

The proposed system redefines the automotive user experience by combining agentic AI, predictive analytics, and integrated e-commerce into a unified architecture. Future extensions include federated learning for privacy-preserving behavior modeling and vehicle-to-vehicle data sharing.

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