AI-Enabled Green Energy Harvesting and Management System

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Abstract: The transition from non-renewable to renewable energy sources is driven by the need to reduce carbon emissions. Renewable resources such as wind power, solar energy and electric vehicles (EVs) are increasingly being developed and widely deployed. As a fast-growing part of the automotive market, EVs are crucial in addressing the carbon issue. Thanks to bidirectional charging technology, EVs not only serve as eco-friendly consumers, but also as an effective solution to energy shortages and peak demand. This research focuses on energy harvesting and management based on distributed electric vehicles, exploring new methods to improve grid reliability and facilitate the use of renewable energy.

❑ AI-Enabled Blockchain-based Electric Vehicle Integration System (AEBIS):

AEBIS leverages the dual role of the EV fleet, acting both as a consumer and a supplier of electrical energy within a virtual power plant (VPP) platform. The system enhances power management within smart grid platforms by utilizing artificial neural networks and federated learning to accurately predict the energy consumption of electric vehicles. The prediction is then used to control the vehicle's charging/discharging process. This integration enables optimized energy harvesting and distribution.

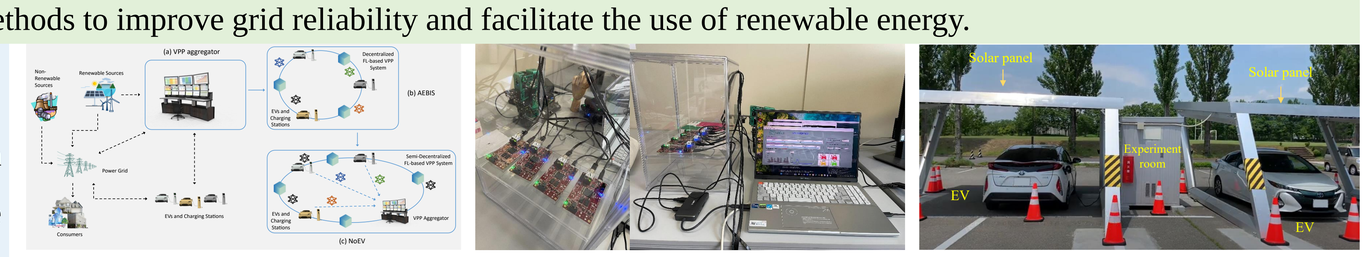
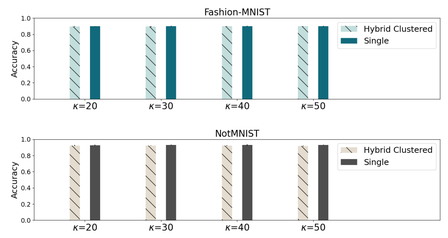
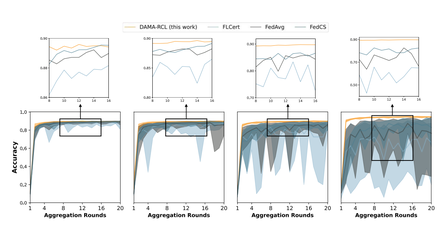


Figure 1. AEBIS Illustration, demo, and on-site experiment (UoA, 2021).





Name	BRAM_18K	DSP48E	FF	LUT
Expression	-	-	0	493
Instance	-	5	414	950
Memory	2	-	320	20
Multiplexer	-	-	-	627
Register	-	-	454	-
Total	**2**	**5**	**1188**	**2090**
Available	120	80	35200	17600
Utilization (%)	**1**	**6**	**3**	**11**
Weights	**Memory required**			
Weights	568 Bytes			
Biases	60 Bytes			
Inputs	44 Bytes			
Total	**672 Bytes**			

Figure 2. Evaluation of the AEBIS in terms of accuracy and robustness of blockchain-based learning, and AI hardware complexity.

❑ Reference

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❑ Vehicle-to-Grid Network (V2GNet)

The V2GNet system is a trustworthy campus energy trading platform that uses blockchain technology within a vehicle-to-grid (V2G) network. It incorporates two blockchain networks:

- Blockchain of Energy Exchanges (BoE): Collects energy requests from energy consumers.
- Blockchain of Electric Vehicles (BoEV): Collects energy offers from electric vehicles (EVs) that participate as energy suppliers.

A control system serves as an intermediary between the two blockchains. The control system has three main roles: (1) Organizing demand and supply data, (2) making energy dispatch decisions, and (3) broadcasting result notification. This structure supports secure, transparent and efficient energy trading within the V2G network and ensures data integrity in all transactions.

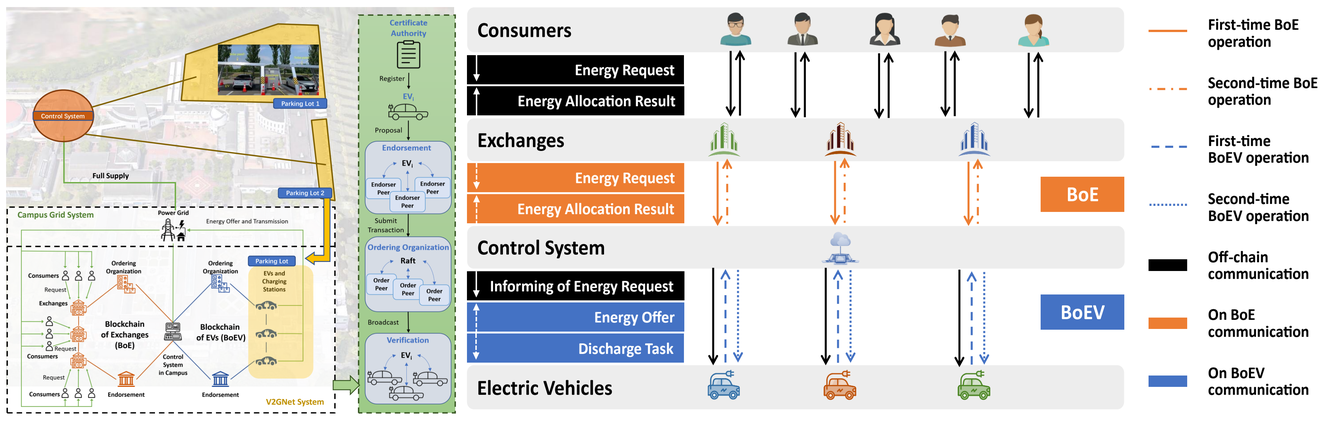

Figure 3. Illustration of V2GNet and detailed energy trading process.

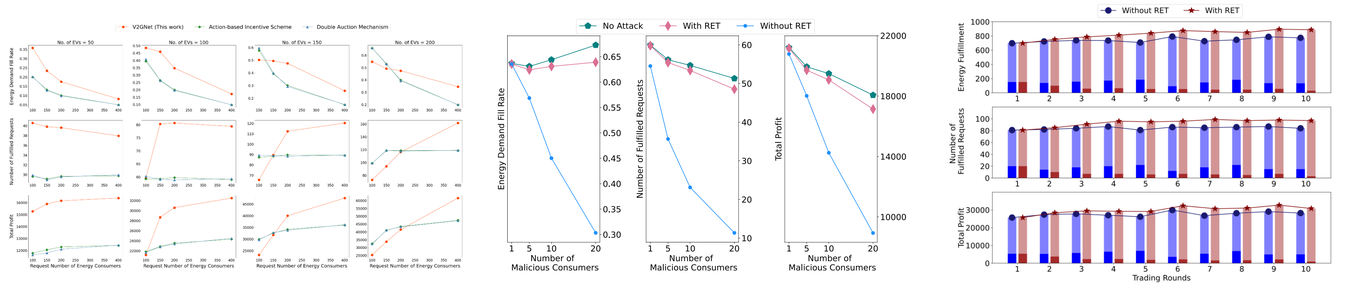

Figure 4. Evaluation of the V2GNet in terms of three indicators, including total profit, number of fulfilled requests, and energy fulfillment.

❑ Reference

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❑ AI-Enabled Automotive Edge Computing

Driven by the advances in AI, computer architecture, and sensor technologies, automobiles, including electric vehicles (EVs) and Self-driving cars are transforming into sophisticated automotive computing platforms. As the advancement of these computing systems accelerates, they will be running a wide variety of applications, including sensing, navigation, etc., using specialized deep neural network systems and complex communication protocols (i.e., Ethernet, SDVs) with safety and reliability support.

Currently, we are focusing on the following research themes: (1) Lightweight Gen AI for automotive, (2) Energy management software platform based on renewable energy (i.e., EVs, etc.), (3) Advanced SoCs for automotive (i.e. EV power prediction, solar system power prediction, etc.), (4) Distributed EV energy trading system with BC and AI-chip.

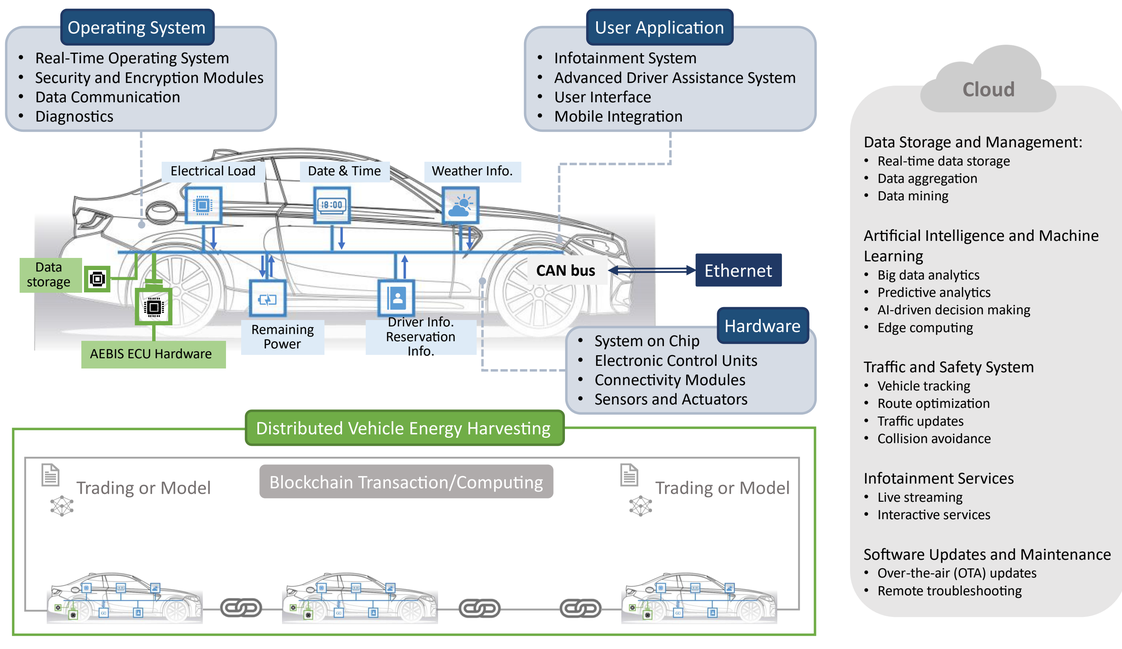

Figure 5. Integration of AI-enabled edge and automotive computing in software-defined vehicles (SDV).

❑ Reference

1. https://web-ext.u-aizu.ac.jp/misc/neuro-eng/aebis.html