A Cluster-based Hierarchical Faster Consensus Mechanism for Safety Services in the DLT-based Cellular Vehicular Network

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DLT 기반 셀룰러 차량 네트워크의 안전 서비스를 위한 클러스터 기반 계층적 고속 합의 메커니즘

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Abstract

This paper presents a cluster-based hierarchical faster consensus mechanism designed to enhance safety services in Distributed Ledger Technology (DLT)-based cellular vehicular networks. In these environments, ensuring low-latency and high-reliability communication is critical for safety-focused applications such as collision avoidance and emergency alerts. The proposed mechanism groups vehicular nodes into clusters managed by Roadside Units (RSUs), Base Stations (BSs), or Routers, with each cluster governed by a leader responsible for handling consensus within the group. A multi-level consensus approach is adopted to accelerate decision-making, minimize communication overhead, and improve fault tolerance. This approach significantly enhances the trustworthiness of emergency blocks, speeds up block delivery, and boosts the scalability of consensus, effectively overcoming the latency and computational challenges that traditional DLT-based mechanisms face in high-mobility vehicular networks.

Ⅰ. Introduction

Recent advances in DLT highlight the potential of hierarchical and cluster-based consensus mechanisms to tackle high-reliability, scalability and latency issues in high-mobility networks. A hierarchical PBFT algorithm [1] was proposed for IoT, while [2] introduced a clustered blockchain consensus for mobile wireless sensor networks (MWSNs). Building on these ideas, this paper presents a cluster-based hierarchical faster consensus mechanism for DLT-based cellular vehicular networks. By clustering vehicular nodes under RSUs, BSs, or Routers in different layers, and using a multi-level clustered consensus approach, the decision-making process speeds up, ensuring fast, reliable block delivery for vehicular safety services.

Ⅱ. Method

Figure 1 shows an architecture for a hierarchical and faster consensus mechanism, highlighting the distinct layers involved. In the first layer, vehicles are connected directly to an RSU, forming a cluster under its control. The second layer consists of RSUs connected to a BS, with some vehicles also directly linked to the BS. The third layer incorporates routers and other network devices that manage communication between clusters. Each of these layers follows a cluster-based organization, managed by RSUs, BSs, or routers, to facilitate efficient consensus formation. The mechanism is designed to ensure that emergency or safety messages achieve consensus quickly. It verifies both the content and its source, preventing unauthorized or fake emergency messages from disrupting the dynamic vehicular network. Devices within and across layers collaborate to authenticate and authorize source information, ensuring secure and reliable communication throughout the network.

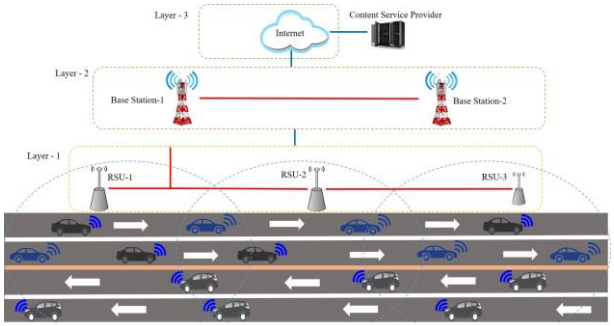

Figure 1: An architecture for hierarchical faster consensus

Ⅲ. Conclusion

In conclusion, the proposed cluster-based hierarchical faster consensus mechanism ensures rapid, reliable, and secure communication for safety services in DLT-based vehicular networks by leveraging multi-layered consensus and efficient source verification. This approach addresses scalability, latency, and authentication challenges in high-mobility environments.

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