National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Radio Resource Allocation Strategies for High-Reliability and Safety in Vehicular Ad Hoc Networks (VANETs)
Speaker	: Biraja Prasad Nayak (Rollno : 519cs1005)
Supervisor	: Arun Kumar
Venue	: Convention Hall - CS323
Date and Time	: 07 Apr 2025 (4:30PM)
Abstract	: Vehicular Ad Hoc Networks (VANETs) play a pivotal role in ensuring road safety through the timely dissemination of safety-critical messages. Effective radio resource allocation is crucial to meet the requirements of high reliability and low latency communication in VANETs. This thesis proposes innovative approaches to address key challenges in resource allocation, message prioritization, and real-time communication for vehicular networks. The first contribution introduces an Analytical Hierarchy Process (AHP)-based prioritization mechanism for Vehicle-to-Vehicle (V2V) communication. By ranking Vehicular User Equipment (VUE) pairs based on critical attributes, the best resource blocks are allocated to high-priority pairs, ensuring faster delivery of safety-critical data. Simulation results demonstrate that the proposed method outperforms existing algorithms in reducing latency and enhancing the reliability of critical message dissemination. The second contribution addresses the categorization and handling of messages based on their criticality using 5G numerology. Safety-critical messages, such as accident notifications, are assigned numerologies with low delay requirements, whereas non-critical messages, like infotainment data, prioritize high throughput. An efficient algorithm for bandwidth part allocation, combined with a priority queue system, is developed to optimize resource usage. Results indicate that the proposed algorithm significantly improves throughput and reduces delays for safety-critical messages, thereby fulfilling V2X communication quality of service (QoS) requirements more effectively than existing methods. A key challenge in VANETs is the management of bursty traffic scenarios, such as those occurring after large events. The third contribution addresses this issue with a Reinforcement Learning-based resource allocation strategy for Mode 2 communication, where resources are allocated without a base station&rsquos involvement. By incorporating the Age of Information (AoI) to prioritize messages and discard outdated packets, the proposed scheme mitigates congestion and ensures efficient resource utilization during high traffic loads. This approach significantly reduces packet delays and enhances system reliability under bursty traffic conditions. The fourth contribution explores the real-time application of resource allocation in vehicular networks using Large Language Models (LLMs). Potential applications of LLMs in V2X communication are discussed, along with the challenges and key performance indicators associated with their implementation. An auction-based resource sharing mechanism, enabled by LLMs, is proposed to maximize revenue while minimizing latency. A learning-based optimization framework is demonstrated to effectively balance resource allocation and QoS requirements, highlighting the transformative potential of LLMs in enhancing vehicular communication networks. Collectively, these contributions advance the state-of-the-art in VANET resource allocation and message prioritization, addressing critical challenges of reliability, latency, and scalability. The proposed methods offer practical solutions for improving safety-critical communication, resource utilization, and adaptability in dynamic vehicular environments.