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**Paper Title: UAV-Assisted Task Offloading in Vehicular Edge Computing Networks**

**Introduction**  
Vehicular Edge Computing (VEC) is increasingly viewed as a critical element for the future of 6G communications, supporting various emerging applications such as mobile augmented reality and autonomous driving. These applications are computing-hungry and delay-sensitive, meaning they demand quick and intensive data processing, which is often beyond the capabilities of vehicles’ onboard resources. The introduction of VEC systems, where roadside units (RSUs) assist in processing tasks, helps mitigate this issue by pushing computational resources closer to the vehicle.

However, in dense urban areas, RSUs often become overloaded due to the high volume of computational requests, reducing their efficiency. This paper introduces a novel solution: UAV-assisted task offloading. The UAVs serve as airborne edge computing devices that assist overloaded RSUs, thereby reducing vehicular task delays and maintaining service quality. The study formulates an online problem-solving approach based on Lyapunov optimization and Markov approximation, aiming to minimize vehicular task delay under a UAV’s long-term energy constraint. The proposed solutions demonstrate effectiveness through extensive simulations.

**Novelty of the Paper**  
The primary novelty of this paper is its introduction of UAVs into vehicular networks to alleviate the overload experienced by RSUs in urban areas. While UAV-assisted mobile edge computing (MEC) systems have been studied before, this paper is among the first to focus specifically on the vehicular context. It presents a UAV-assisted offloading scheme that solves two key challenges: the long-term energy constraint of UAVs and the complexity of making real-time offloading decisions.

To address these challenges, the authors employ advanced techniques such as Lyapunov optimization, which allows the system to be optimized in real-time without requiring future information. The Markov approximation technique is used to handle the intractability of the offloading decision-making process, transforming the vehicular task delay minimization problem into a more manageable format. By focusing on VEC networks and UAVs’ role in addressing RSU overload, the paper presents a solution with real-world applicability in dense urban environments.

**Main Contributions**

**UAV-Assisted VEC Offloading Framework**: The paper proposes a novel framework that integrates UAVs to help with task offloading in overloaded RSUs. UAVs are equipped with edge servers that offload tasks from RSUs to reduce computational pressure and vehicular task delay.

**Long-Term Energy Constraint Handling**: One of the primary challenges for UAVs is limited battery life. The paper introduces a method to manage UAV energy consumption over time by constructing an energy deficit queue and optimizing real-time offloading strategies using Lyapunov optimization.

**Markov Approximation**: The paper solves the UAV-assisted offloading problem using a Markov chain-based approach. This allows the authors to determine close-to-optimal strategies for UAVs to assist RSUs in minimizing vehicular task delays, even as task loads vary across time slots and locations.

**Extensive Simulation**: To validate the proposed method, extensive simulations were performed with real-world data. These simulations show that the method outperforms existing baseline solutions by reducing vehicular task delays while adhering to UAV energy constraints.

**Pros**

The paper addresses the practical need for real-time task offloading decisions. By not requiring future information, the system is highly adaptable to changing network conditions. The proposed solution is scalable and can be applied to large vehicular networks in urban areas. The use of UAVs as mobile edge devices also provides flexibility in dealing with dynamic task loads. The energy deficit queue mechanism ensures that UAVs do not overuse their limited energy, making the solution practical for long-term deployment in real-world scenarios. The simulations conducted in the study are based on real-world vehicular trajectory data from Shenzhen, China, making the results more credible and applicable to real urban environments.

**Cons**

While the paper addresses UAV energy constraints, its reliance on renewable energy sources such as solar or wind energy may not always be feasible in urban areas, especially in densely populated zones with limited exposure to these resources. The proposed framework assumes that a UAV can assist a single RSU at any given time. This approach might become less efficient in scenarios where multiple RSUs are simultaneously overloaded in geographically dispersed locations. The paper assumes that UAVs can adjust their location to follow overloaded RSUs in a timely manner. However, in practice, the time required for a UAV to reposition itself could introduce additional delays, reducing the efficiency of task offloading.

**Summary**  
The paper presents a highly innovative solution to the problem of overloaded RSUs in vehicular edge computing networks. By introducing UAVs as mobile edge servers, the authors propose a novel task offloading scheme that significantly reduces vehicular task delays, even in heavily congested urban areas. The use of Lyapunov optimization to handle long-term energy constraints and Markov approximation to determine real-time offloading strategies is highly effective in achieving the paper’s objectives.

The simulations demonstrate the proposed method’s superiority over baseline methods, particularly in reducing task delays while staying within the UAV’s energy limits. The study contributes significantly to the growing field of UAV-assisted mobile edge computing, particularly in the context of vehicular networks, and offers a practical solution that could be implemented in future smart cities.

While the paper does offer a compelling framework, there are some limitations, such as the potential inefficiencies in UAV movement and the reliance on energy harvesting. However, these limitations do not overshadow the paper’s contributions, and future research could address these concerns by improving UAV mobility or exploring alternative energy sources.

**Conclusion**

In conclusion, the paper presents a forward-looking solution to a critical problem in vehicular networks, and its findings are likely to be of significant interest to researchers and practitioners in the fields of mobile edge computing, vehicular networks, and UAV technology. Adding on to this the increased popularity of machine learning techniques and applications in IoT enable devices such as UAVs will be an interesting research direction in the future.

**References**

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