Offloading Optimization in MEC and Vehicular-Fog Federated Systems: A Reinforcement Learning Approaches

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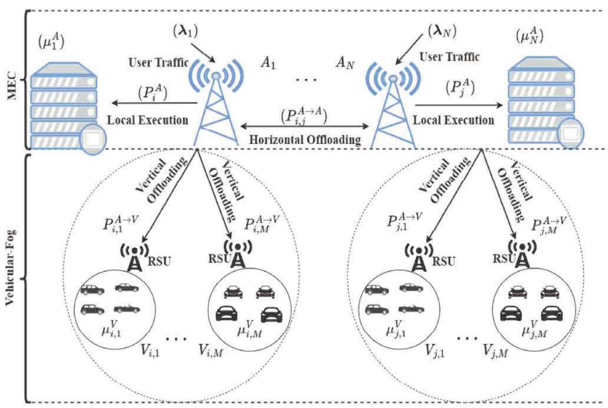
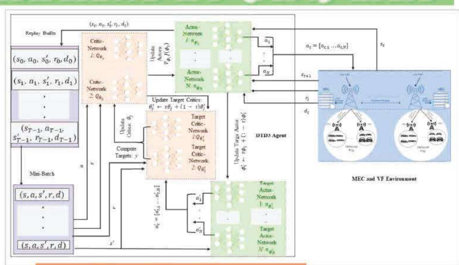
Abstract

The innovation of 5G networks has enabled the deployment of a two-tier edge and vehicular-fog network, consisting of Multi-access Edge Computing (MEC) and Vehicular Fogs (VFs) positioned closer to the Internet of Things (IoT) devices. This reduces propagation latency and enhances quality of service (QoS) compared to cloud-based solutions. However, MEC sites can become overloaded during high-traffic events like concerts or sports contests. Offloading techniques transfer computationally intensive tasks from resource-constrained devices to those with sufficient capacity, improving task performance and extending device battery life. This research explores offloading within a two-tier MEC and VF architecture, focusing on offloading from MEC to MEC and from MEC to VF. The primary objective is to minimize system costs by reducing latency and energy consumption. A multi-objective optimization problem is formulated, and a Distributed-TD3 (DTD3) approach, building on the TD3 algorithm, is proposed. The approach demonstrates faster convergence and higher efficiency in extensive simulations compared to benchmark solutions.

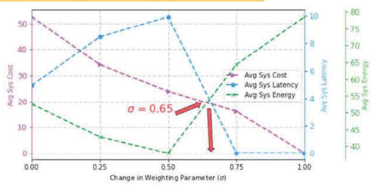
MEC and vehicular-fog Architecture

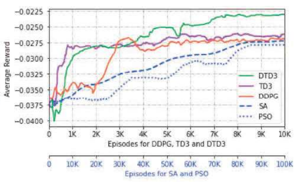


Distributed-TD3 (DTD3) Model

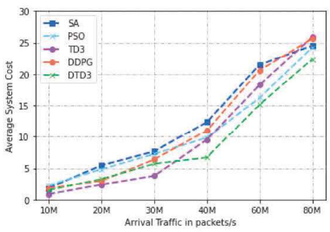


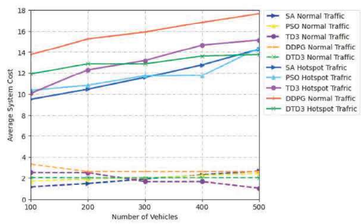
Results





- The weighting parameter (σ) is set to 0.65, where both average system latency and energy contribute equally to the overall system cost
- DTD3 converges faster and performs better than the TD3, DDPG, SA, and PSO algorithms.





- DTD3 has a low average system cost both with changes in arrival traffic or with changes in the number of vehicles.

Conclusion

- We addressed computational offloading of hotspot traffic in MEC and VF networks to minimize latency and energy consumption.
- A Distributed-TD3 algorithm was proposed for optimal offloading decisions using an RL environment representation.
- Our approach achieves faster convergence and better performance in simulations compared to benchmarks.

Paper:(1) F. G. Wakgra, B. Kar, S. B. Tadele, S. -H. Shen and A. U. Khan, "Multi-Objective Offloading Optimization in MEC and Vehicular-Fog Systems: A Distributed-TD3 Approach," in IEEE Transactions on Intelligent Transportation Systems, doi: 10.1109/TITS.2024.3409367.