

Efficient Framework for Analysis of 5G Network Slicing Optimization Using Advanced Deep Learning Techniques

Kiran Joshi ^a, Seema Bedi ^b

^a *Department of Mechanical Engineering, Shiva School of Technology, Kanpur, India.*

^b *Department of Mechanical Engineering, Shiva School of Technology, Kanpur, India.*

Abstract

Network slicing makes it possible to design customized networks that may accommodate various use cases. Each slice can be customized to meet certain needs regarding security, mobility, latency, bandwidth, and dependability. Unmanned aerial vehicle (UAV)-based Mobile Edge computational (MEC) for 5G/6G networks is a new paradigm that unites the capabilities of UAVs with the computing capability and low-latency connectivity of MEC. To facilitate real-time processing of data, analysis, and provision of services on the network edge, it involves placing MEC servers or alternative computing resources on board UAVs. The term "IIoT" denotes an industrial setting's network of equipment, sensors, and systems connected to one another, communicating and sharing data in order to optimize operational efficiency. We considered the Industrial Internet of Things (IIoT) scenario in our study, which links IoTs to systems deployed in industrial manufacturing. We utilized to assign the resources to the slices to cater to the needs of the 5G/6G slices. We even used UAV in our system model, which can hold base stations. We developed the disaster situation in which outside connection of the ground base station has been disrupted, and using UAV-based mMTC, we are establishing ground device connections via the outside devices in a bid to communicate and exchange data. Another situation we used as UAV-enabled IIoT which is 5G/6G compliant and given that UAV are battery-scarce devices we want to minimize the power usage and decrease the overall latency.

Keywords: Network Slicing, Deep Learning, Neural Network.

Introduction

Network slicing, a crucial component of 5G networks that enables effective resource management and allocation, is probably going to be expanded upon and enhanced further in 6G networks. A network slice is a technique that enables the creation of several virtual networks, each tailored to meet certain service requirements, above a shared physical infrastructure (Zhang, 2019). With specialized resources and unique features, each network slice functions as a separate logical network that offers customized connectivity and services to various users and applications. For achieving best possible performance and efficient utilisation of network resources, UAV-based IIoT applications can be benefitted with efficient resource allocation schemes in the 5G/6G context. UAVs can make meaningful contributions to mMTC in a variety of ways. UAVs can make valuable contributions to mMTC in the form of dynamic coverage and connectivity, load balancing, energy efficiency, QoS and latency management etc. Within the IIoT applications context, mMTC stands for the communication among a large number of low-cost, low-power devices (Li et al., 2017).

Coupling IIoT with industrial manufacturing systems leads to the creation of the Industrial Internet of Things (IIoT). In addition, Unmanned Aerial Vehicles (UAVs) have been gaining significance as useful instruments in a variety of applications in industry, such as IIoT. UAV-enabled Federated Edge Learning (FEEL) Based on the capabilities of 5G and 6G networks, IIoT combines edge computing and federated learning techniques with UAVs in industrial use cases. In UAV-enabled IIoT networks, energy consumption and latency are significant factors that can restrict FEEL performance. Nevertheless, plenty of research has been conducted in minimizing latency and enhancing energy efficiency in UAV-enabled IIoT networks (Foukas et al., 2017).

Proposed Architecture

New application scenarios and service ideas were continually studied and presented by researchers, scholars, and industry experts because 6G was in the initial research and development phase at that time. New application usage cases and service demands might emerge in order to fulfill the evolving needs of society and the rising requirements of future applications as 6G development and technology evolve. Three further 5.5G vision application scenarios were recently unveiled by (Debbabi et al., 2020).

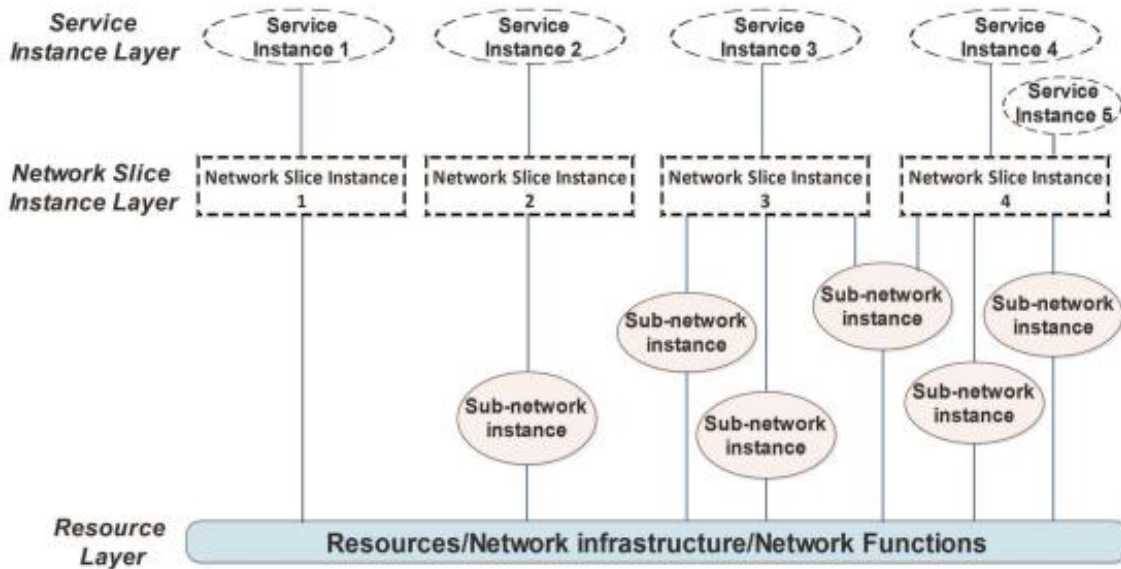


Fig. 1: Proposed Architecture

As shown in figure 2, three new application services were created especially for 6G. It looks into three key aspects of 5.5G wireless networks: harmonized communication and sensing (HCS), real-time broadband communication (RTBC), and uplink centric broadband communication (UCBC). These characteristics capture the changing requirements of future apps, such as more uplink capacity, real-time responsiveness, and unifying communication and sensing functions. It offers an introduction to UCBC, RTBC, and HCS, featuring their technical background, possible use cases, and research challenges entailed in deploying them in 5.5G networks (Afolabi et al., 2018).

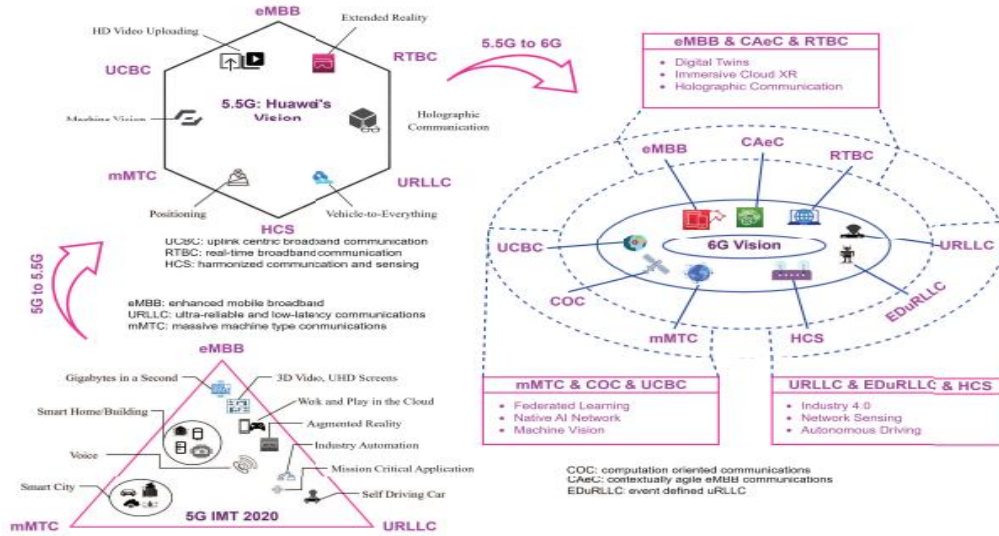


Fig. 2: Towards 6G: The Evolution of Use Cases from 5G to 6G.

Network Slicing with The Contribution of NN and DBN

Being part of network slicing contributes to designing solutions that address the specific needs of these industries, allowing for groundbreaking innovation. UAV-assisted MEC brings together the capabilities of Unmanned Aerial Vehicles (UAVs) and the computing capability of MEC, allowing for enhanced wireless connectivity and services. Through your work on this technology, you help shape future-proof solutions to advance wireless communication, providing faster, more secure, and low-latency connectivity. UAV-assisted MEC helps bring computing resources near users by placing MEC servers on UAVs. This mobile and dynamic edge computing model provides real-time data processing, content caching, and service offloading features (Song et al., 2019).

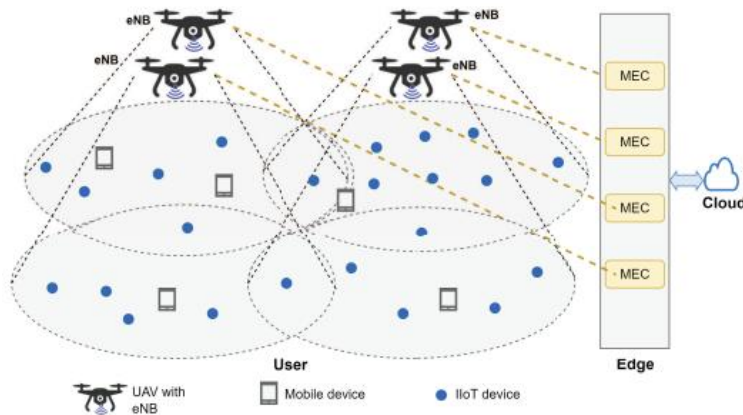


Fig. 3: The UAV-Enabled IIoT based 5G/6G Wireless Networks.

UAV assisted MEC finds its applications in various industries. It is applicable in real-time video analytics, disaster response, remote sensing, precision agriculture, and smart city implementations. UAV-based MEC poses special technical challenges that need innovative solutions. They are managing resources, mobility, energy consumption, and interaction with existing network infrastructure (Li et al., 2019, Wang et al., 2019).

Experimental Results and Discussion

Figure 4 illustrates the impact of the different learning rates of the Adam optimizer on the suggested scheme on the average latency convergence. We took the total number of episodes to 1200 and the various learning rates as like 0.001, 0.01 and 0.1. The figure 4 illustrates that the learning rate 0.01 performs with overall low latency which reported

converging after 600 episodes. While the learning rate 0.001 converges with total relatively high latency, and the learning rate 0.1 does not converge at all.

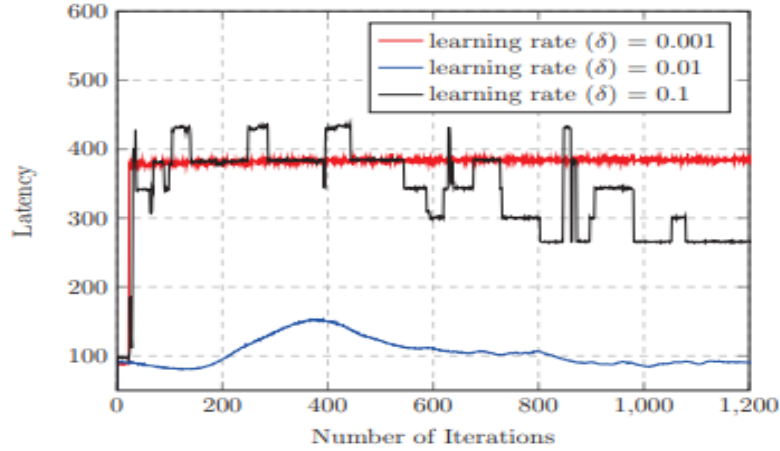


Fig. 4: Learning Rate Convergence

The effect of different discount factor parameters on the proposed scheme's average latency convergence is shown in Figure 5. We employed 1200 iterations with different discount factors of 0.99, 0.79, and 0.59. In this, figure 5 discount factor 0.99 converges nicely after 800 episodes with overall low latency, while the discount factor 0.59 and 0.79 takes overall relatively high latency for performance conversion.

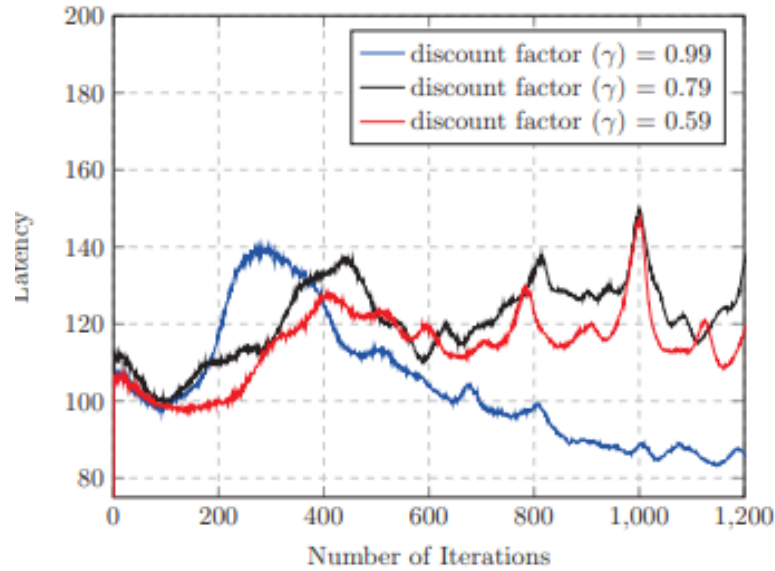


Fig. 5: Discount Factor Convergence

According to simulation results, the suggested approach can effectively stop devices from evading FL training and reduce system costs by minimizing latency and energy consumption.

Conclusions

Beyond mobile internet, 6G is expected to enable ubiquitous Internet of Everything (IoE) applications and artificial intelligence (AI) services, including digital twins, brain-computer interfaces, extended reality (XR) and metaverse, e-health, connected autonomous systems, sustainable cities, tactile and haptic internet, and more. In this paper, we investigate FEEL in UAV-based IIoT networks for 5G/6G through deep reinforcement learning methods. We initially develop joint latency and energy consumption models in the Markov decision process (MDP) form. The optimization problem is then solved using a deep deterministic policy gradient (DDPG) based method. where the trade-off between

energy use and a combination of latency is used to calculate the system cost. According to the simulation results, our suggested strategy outperforms the traditional approach.

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