Ph.D. Research Proposal

Doctoral Program in "Department Name"

Authentication Vertical Handover for Multi-Tier Networks in Video Transmission

by

<Name of the Candidate>

<Reg. No of the Candidate>

<Supervisor Name>

<Date of Submission (DD MM 20YY>

I. INTRODUCTION / BACKGROUND

Heterogeneous Network (HetNets) is a new technology in mobile communication that provides more applications to the end-users. It consists of multi- tier networks (GSM, EDGE, UMTS, WLANs, and LTE etc.) with different such as hardware, protocols, operating systems and mobility applications. Global System for Mobile Communication (GSM) is a second generation cellular system, which is used to digital modulation technique for accessing teleservices, data services and voice services. Enhance Data Rates of GSM Evolution (EDGE) is used to improve the data transmission rate, which is an extension of GSM. Then, Universal Mobile Telecommunication Service (UMTS) is a third generation broadband packet based transmission, which provides the many services to mobile users (text, digitalized voice, video and multimedia) at data rates up to 2Mbps. Long Term Evolution (LTE) is a fourth standard wireless speed technology, which is next level after UMTS 3G technology. It increases the data transfer speed at data rate 100Mbps.

HetNets provides the many available resources compared with individual networks. It allowing many users can efficiently connect, at any time and any place to access the technology with best connectivity. Its specified ranges between 2.75G and 4G, expected to go above the range. HetNets are typically collected of many formats of radio access technologies, transmission solutions, power levels and base station. HetNets are multi-layer, multi-RAT, multi-server and multi-operator networking, which all are integrated into HetNets. In recent years, the uses of interconnected mobile devices are increased, which result in growth of data traffic. HetNets provides the optimal solution for broadband traffic with its multi access networks, low power and terminals. HetNets application contains many Quality of Service requirements such as strict time deadline to best effort only, downtime is not acceptable to random disconnections tolerable, Error cannot accept to high error rates tolerable. HetNets is considered as the resolution for the data explosion in the mobile networks. HetNets has many advantages as follows,

- HetNets provide the Optimized radio interface by using Multi-RATS

- It supports Multi-service to reduce the performance complexity and increase throughput when less mobility is needed.
- It provides higher performance of cellular system by using small cells and efficient link capacity.
- HetNets allows sharing the better resources for different network usages.

Radio Access Technology (RAT) is defined as physical connection method for a radio that is based on the communication network. Single Radio Controller was introduced for supporting Multi-RAT network. This Single Radio Controller (SRC) is capable to coordinate with multi-RAT base stations as GSM/ UMTS/ LTE. Multi-RAT meets the following targets,

- Guarantee users to get consistent service experience
- Reduces Difficulties in network management
- Highly improves the radio resource utilization

VHO in HetNets can performed with three steps such as,

- ***Initiation phase***: in this phase, gather the required information for handover decision such as networks (latency, throughput), user preferences (security, cost) and access terminals.
- ***Decision phase***: Select the best RATs based on the gathered information.
- ***Execution phase***: in this phase, end users maintain the new RATs after that the old RATs released.

The authors in [3] have introduced the RAT selection mechanism where the user select the best RAT service based on the user and network based parameters. The video encoding is one of the significant processing the transmission of video in the 5G network. The video encoding is subjected to improve the video quality during the transmission. In this paper [4] have proposed H.264 algorithm to encode the video packets before going to transmit it to the destination. This paper also discussed the adjustment of the encoding parameters in order to get the better video quality during the transmission. The authors in [5] have adaptively controlled the bit rate of the encoding algorithm in order to enhance the quality of the video.

The authors in [6] have introduced path selection mechanism where the data priority is estimated before transmitted data to the destination. In order to reduce the latency and packet losses during the video transmission, buffer management process is emerged. In [7], authors have controlled the buffered by scheduling the data present in the buffer. The scheduling the video packet in the buffer reduces the delay incurred during the video transmission. The authors in [8] have introduced the QoE aware scheduling in cross layer based wireless network. Here, the scheduling process is achieved by the maximum buffer filling algorithm by considering the QoE constraints.

1.1 Research Outline & Scope

Network selection in HetNets has several impacts such as handover failures, packet loss and delay. Network selection is an importance performance in handover decision, if the selected network is breakable, then the handover is failure.

1.2 Research Objectives

VHO can be performed in mobile initiated handover and network- initiated handover. The best path between source and destination is essential to achieve the low packet loss rate during the video transmission in the multi-tier network.

II. RESEARCH GAPS

2.1 Common Problem Statement

The dynamic users move either closer or far away from the access, due to which the received signal strength (RSS) is varied. The user with poor RSS is required to handover from the current connectivity. Thus handover introduces difficulties during video transmission. In this network, video packet is transmitted through the air medium which is highly affected by the network environment factors such as bit error rate, SINR and more. Transmitting video over HetNets is a challenging task. Since wireless network has multipath fading and interference issues that tends to reduction in video quality, packet losses and delay during video transmission. Most of the works have utilized H.264 to encode the video packets. However, these methods consume more bandwidth and require high processing power. These network environment factors affect the

video transmission greatly such as quality reduction and packet losses. However, most of the works doesn't utilized network environmental and user preference factors for video transmission. Thus reduces the QoE performance and also video quality.

2.2 Problem Definition

A multi constraint QoE-centric routing (MCQR) [16] algorithm is proposed to select optimal path for video streaming in MANET. The multi constraint includes link stability, SNR, and link delay. Based on multiple constraints each node is given with a weight value in the network. Then optimal next hop node is selected for video transmission based on weight value. The video is transmitted through optimal route which has nodes with highest weight value.

Problems

- This method fails to guarantee QoE since QoE is fully depends on video quality experienced by destination.
- Transmission of raw video increases bandwidth consumption

Proposed Solutions

- Video quality is improved by QA-SVC algorithm and optimal route is selected by EPSO-MS algorithm
- Involvement of QA-SVC method minimizes bandwidth consumption through multi-layer video transmission

Authors propose a vertical handover mechanism [17], denoted Proxy MIPv6-based Mobile Internal Vertical Handover (PMIP-MIVH), which uses a logical interface and a Distributed PMIPv6 scheme in order to improve the handover performance and consequently the overall network's performance. Numerical model analysis show that our proposed solution (PMIP-MIVH) performs well in terms of handover connection durations, handover latency and session continuity

Problems

- Frequent handover affects the system efficiency and also result poor transmission performance
- Packet loss rate is very high and also it results high handover latency

Proposed Solutions

- Video quality is very high since QoE is verified in destination
- Packet loss rate is very less

In [18] author presents energy and goodput optimized CMT (EPOC) solution for multimedia streaming over heterogeneous wireless networks. In order to satisfy the goodput performance, joint forward error correction coding and rate allocation scheme is utilized. The major idea behind this work is to combine stream control transmission protocol (SCTP) with concurrent multipath transfer (CMT) with FEC and rate allocation scheme. Rate allocation scheme minimizes the energy consumption without loss in goodput while FEC balances delay and recoverability.

Problems

- This method is not able to handle congested network environment
- Absence effective scheduling scheme degrades the QoE experienced by destination

Proposed

- Network congestion can be handles by QA-SVC based encoding and EPSO-MS based path scheduling
- Involvement of IANN and DWRR algorithm helps to achieve target QoE

In [19] author presents a priority aware and TCP oriented coding (PATON) by adapting forward error correction coding scheme. Initially, an analytical model is developed for FEC coding based real-time video transmission with TCP over wireless networks. Then a heuristic solution is proposed for prioritized frame selection, FEC redundancy adaption, and packet size adjustment to maximize real-time video quality.

Problems

- This method involves with high bandwidth consumption

Proposed Solutions

- Involvement of layer based adaptive encoding scheme minimizes bandwidth consumption for data transmission

Energy –quality aware bandwidth aggregation (ELBA) scheme is proposed [20] in this paper for video transmission over wireless networks. In ELBA scheme, a bandwidth aggregation framework is designed by integrating energy minimized rate adaption, delay-constrained unequal protection, and quality aware packet distribution. For enabling energy-minimized quality guaranteed video transmission ELBA leverages wireless channel diversity and video frame priority.

Problems

- Not able to guarantee QoE even with large energy consumption
- Due to fixed coding rate, energy consumption is high

Proposed

- QoE guaranteed with the involvement of QA-SVC method, EPSO-MS method, IANN algorithm, DWRR algorithm, and T2Fl scheme.

III. RESEARCH CONTRIBUTIONS

To overwhelm all above problems involved in video transmission over wireless network, we proposed a novel cross-layer based priority scheduling approach to guarantee QoE. Proposed cross-layer approach involves with following processes for video transmission: *(i) video encoding, (ii) path scheduling, (iii) priority based scheduling, and (iv) video quality estimation.* Each significant process is explained as follows,

Video encoding

Initially source node encodes the video before transmitting it to destination. In video encoding, Quality based Adaptive SVC (QA-SVC) scheme is employed. Here, the parameters of SVC are adjusted dynamically based on feedback about video quality from destination and network states obtained from physical layer. This process is performed in application layer since our work is based on cross-layer approach; application layer is able to communicate with physical layer and network layer. In our work, QA-SVC can adjust the parameters (such as number of enhancement layers, and rate of group of pictures (GOP)) accordance to congestion and video quality.

Path scheduling

Path scheduling is involved in network layer and obtains information from application layer to guarantee QoS required by each layer of the video. In path scheduling, the optimal number of paths are selected by Entropy based Multiple Thresholding Solutions (E-MTS) algorithm. Each layer of encoded video is scheduled with optimal path based on QoS requirement. Fitness function in EPSO-MS algorithm is formulated by considering link stability, link duration, delay and residual energy of the path.

Priority based scheduling

The encoded video is further scheduled based on packet type, GOP rate, packet size, and deadline. This process is supported by *Modified Real-time Transport Protocol (M-RTP)* header. All packets are provided with priority value through Convolutional Neural Network (CNN) in which each layer of the video also scheduled to support video streaming. Then the packets buffered in the queue are scheduled by Deficit Weighted Round Robin (DWRR) algorithm. Then the video is transmitted to next hop in the route based on priority. Here DWRR algorithm is also adaptive which adjusts the weight value according to number of packets in the queue.

Video quality estimation

Finally, the encoded video is received in the application layer of destination. Then the video is decoded and the quality of video is estimated by Fuzzy AHP scheme. In Fuzzy AHP, peak to signal to noise ratio (PSNR), frame loss rate, and packet size difference are considered to

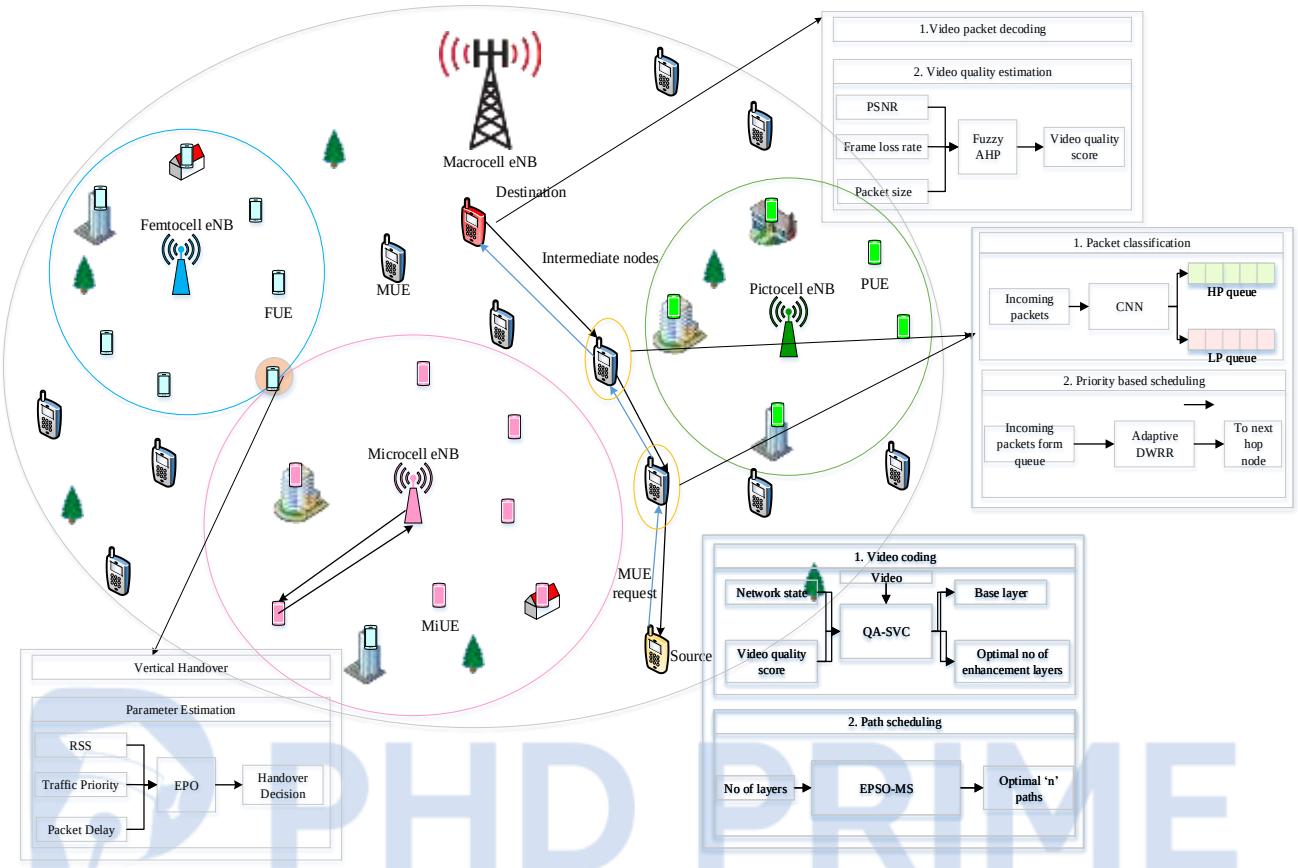
estimate the quality of the video. After, estimation, the *Video Quality Score (VQS)* is sent to source through *Real-time Transmission Control Protocol (RTCP)*.

Performance Evaluation

Finally our proposed cross-layer based priority scheduling approach is evaluated in terms of following parameters,

- Throughput & Goodput
- Delay & Jitter
- PSNR
- Packet drop
- Bandwidth utilization
- Mean opinion score

SYSTEM ARCHITECTURE



IV. RESEARCH NOVELTIES

The highlights of our proposed works are discussed as follows:

- In our work, we have adaptively changed the encoding parameters such as bit rate and QP. Here, the bit rate is adaptively changed by considering the network environmental factors such as attenuation, bit error rate, SNR, throughput and bandwidth.
- We optimally select the network parameter using EPO algorithm which considers the three parameters that are RSS, Traffic Priority and Packet Delay.

V. PREVIOUS WORKS & LIMITATIONS

Paper 1

Title: Multipath Routing to Improve Quality of Service for Video Streaming Over Mobile Ad Hoc Networks

Concept

This paper discusses the challenges and issues involved in multimedia transmission over mobile networks. Then two multipath routing protocols namely M-AODV and MDSDV are evaluated. QoS provision is highlighted as major issue in mobile networks due to dynamic nature, bandwidth limitations, and so on. In mobile networks, bandwidth, infrastructure, radio links, and communication range of nodes affect the video streaming. For QoS provisioning, QoS based routing protocols are introduced as major solution.

Paper 2

Title: SDN-Based Handover Authentication Scheme for Mobile Edge Computing in Cyber-Physical Systems

Concept

Load balancing in MEC was addressed using handover. SDN-based Handover authentication Scheme (SHAS) was proposed with an authentication handover module (AHM). This module distributes one-time session key (OSK) using which mutual authentication was performed based on 3-way handshake protocol. The handover request was initiated to AHM with OSK and then handshake protocol was established by exchanging messages of response, acknowledgement and agreement.

Paper 3

Title: Smart Virtualization Packets Forwarding During Handover for Beyond 5G Networks

Concept

In this paper, packet forwarding was presented by creating unique tag of each users based on the standard E.164 numbering, MAC address and identity. The switches verify packet prefix and then it matches tag of the user, if the tag was not true then the request from the user was

dropped. Here, the illegitimate users with the tag will also be allowed into the network which degrades the network.

Paper 4

Title: SDN/NFV-based handover management approach for ultradense 5G mobile networks

Concept

In this paper, a Software-Defined Handover Management Engine (SDHME) was developed for future 5G networks. The handover in this system was proposed by evaluating bandwidth, delay, packet loss using the measurements of received signal strength (RSS).This method was majorly based on QoS, and however the absence of authentication fails to support ultra-dense future 5G networks.

Paper 5

Title- Two-sided matching framework for optimal user association in 5G multi-RAT UDNs

Concept

The authors in this paper have proposed the two sided matching algorithm in the 5G multi-RAT network. Here, the user selects the best RAT network for their association with the 5G multi-RAT network. For this purpose, this paper proposed the matching theory algorithm which is stable matching algorithm. It estimates the utility function for the candidate the access points. And, then it selects one RAT network based on the estimated utility function. The utility function is estimated based on the SINR and RSSI factors. By considering these factors each user in the network selects the optimal access point.

Paper 6

Title: Blockchain-enabled Authentication Handover with Efficient Privacy Protection In SDN-based 5G Networks

Concept

A new authentication approach that utilizes blockchain and software defined networking (SDN) techniques to remove the unnecessary re-authentication in repeated handover among heterogeneous cells. The proposed approach is designed to assure the low delay, appropriate for the 5G network in which users are replaced with the least delay among heterogeneous cells using their public and private keys provided by the devised blockchain component while protecting their privacy. In our comparison between Proof-of-Work (POW)-based and network-based models, the delay of our authentication handover is shown to be less than 1ms.

Paper 7

Title: CPPHA: Capability-based Privacy-Protection Handover Authentication Mechanism for SDN-based 5G HetNets

Concept -

This paper integrates user capability and Software Defined Network (SDN) technique, and proposes a capability-based privacy protection handover authentication mechanism in SDN-based 5G HetNets. Our proposed scheme can achieve the mutual authentication and key agreement between User Equipments (UEs) and BSs in 5G HetNets at the same time largely reduce the authentication handover cost. We demonstrate that our proposed scheme indeed can provide robust security protection by employing several security analysis methods including the BAN logic and the formal verification tool Scyther.

Paper 8

Title- A Multi-objective Optimization Data Scheduling Algorithm for P2P Video Streaming

Concept

A distributed data scheduling algorithm is proposed for video streaming. Here each video is divided into multiple segments and each segment is weighted to assign priority. Weight value computation is performed based on emergency (time), rarity (number of senders), and segment quality (PSNR). Then the receiver selects sender based on time required for receiving segments. The optimal sender schedules the segment requested by receiver based on segment weight value.

Limitations

- This method only suitable for single layer video transmission which increases bandwidth consumption

Paper 9

Title- Optimizing Stored Video Delivery For Wireless Networks: The Value of Knowing the Future

Concept

In this paper, video delivery is optimized in the wireless networks in cross layer based mechanism. This paper performs the video delivery based on the two different techniques that are scheduling the transmission and future capacity variations. This paper mainly aims to avoid the re-buffering during the video delivery in the wireless networks. Here, the receiver buffer capacity is considered afore to the video transmission. It schedules the video packets by considering the status of the buffer.

Paper 10

Title- PO-MPTCP: Priorities-Oriented Data Scheduler for Multimedia Multipathing Services

Concept

This paper proposes the priorities aware data scheduling in order to provide the multimedia services. Here, the Multi Path based TCP protocol is utilized which is used to transmit the prioritized packet to the destination without any loss. Here, the priority is allocated for each data to be processed. Based on the priority of the data, this paper performs routing in the wireless networks. In this, the multi-attribute based multipath is selected to transmit the multimedia data to the end user.

Paper 11

Title- A Hybrid Unicast-Multicast Network Selection for Video Deliveries in Dense Heterogeneous Network Environments

Concept

In this paper proposes a hybrid unicast-multicast utility-based network selection algorithm (HUMANS), which offers the additional option of selecting multicast transmissions in the network selection process during video delivery. By serving users with good channel conditions via unicast transmissions and users with poor channel quality conditions via multicast, HUMANS allows outperforming other solutions in terms of outage percentage and average quality of transmission, in both low- and high-density scenarios. Most importantly, at the same time it guarantees operators more efficient resource utilization.

Paper 12

Title- Video encoding adaptation for QoE maximization over 5G cellular networks

Concept

The authors in this paper have introduced the video encoding procedures in the 5G cellular networks. The main objective of this paper is to provide high QoE to the user requesting the video service. Here, the encoding is performed using the H.264 encoding algorithm. Here, the user request is processed with the aid of the 5G base station which transmits request to the service provider in order to provide requested video service to the user. During video encoding, this paper adjusted the encoding parameters such as QP and frame rate.

Paper 13

Title- Context-Aware Radio Access Technology Selection in 5G Ultra Dense Networks

Concept

This paper proposes the radio access technology based communication in 5G network. In this, paper user selects the best radio access network in order to gather better communication performance in the 5G network. For this paper, this paper considered the two different criteria

that are network and user based parameters. Here, the user criteria's are jitter delay and packet loss rate. And then, network parameters are considered as the data rate and received signal strength information.

Paper 14

Title: Robust distributed video coding for wireless multimedia sensor networks

Concept

This paper proposes a robust distributed video coding (RDVC) framework for optimizing video quality over wireless multimedia network. Based on Wyner-Ziv coding (WZC), a error-resilient key frame coding scheme is presented. Here the additional Wyner-Ziv bits play a significant role to attain better resilient and better rate/distortion performance. Furthermore, group puncture rate adaptive IRA code based on distributed joint channel coding scheme is presented.

Limitations

- However, here all coding schemes are not able to adjust their parameters which increases transmission time and bandwidth consumption for video transmission

Paper 15

Title- Streaming High-Quality Mobile Video with Multipath TCP in Heterogeneous Wireless Networks

Concept

This paper introduces quality driven multipath TCP (ADMIT) algorithm for video streaming in wireless networks. Error correction and rate adaption are involved in ADMIT algorithm for video streaming. In this method following algorithms are executed for video streaming: forward error correction algorithm, FEC packet size adaption algorithm, and flow rate allocation algorithm. Transmission control protocol (TCP) is utilized for reliable data transmission.

Limitations

- Perhaps TCP protocol is reliable; it increases delay for video transmission. In addition, it is not suitable for real time data transmission in congested network
- It increases energy consumption to achieve target QoS

BIBLIOGRAPHY

Lal, Chhagan & Laxmi, Vijay & Gaur, Manoj & Conti, Mauro. (2016). Enhancing QoE for video streaming in MANETs via multi-constraint routing. Wireless Networks. 24.

Tuyisenge, L., Ayaida, M., Tohme, S., & Afilal, L.-E. (2020). A mobile internal vertical handover mechanism for distributed mobility management in VANETs. Vehicular Communications, 100277.

Jiyan Wu, Bo Cheng, Ming Wang, and Junliang Chen, "Energy-Aware Concurrent Multipath Transfer for Real-Time Video Streaming over Heterogeneous Wireless Networks", IEEE Transactions on Circuits and Systems for Video Technology, Vol 28, No 8, pp 2007-2023, 2018.

Jiyan Wu, Bo Cheng, Ming Wang, and Junliang Chen, "Priority-Aware FEC Coding for High-Definition Mobile Video Delivery Using TCP", IEEE Transactions on Mobile Computing, Vol 16, No 4, pp 1090-1106, 2017.

Jiyan Wu, Bo Cheng, Ming Wang and Junliang Chen, "Energy-Efficient Bandwidth Aggregation for Delay-Constrained Video over Heterogeneous Wireless Networks", IEEE on Selected Areas in Communications, Vol 35, No 1, pp 30-49, 2017.

Sedrati, M., & Benyahia, A. (2017). Multipath Routing to Improve Quality of Service for Video Streaming Over Mobile Ad Hoc Networks. Wireless Personal Communications, 99(2), 999–1013.

Wang, C., Zhang, Y., Chen, X., Liang, K., & Wang, Z. (2019). SDN-based Handover Authentication Scheme for Mobile Edge Computing in Cyber-Physical Systems. IEEE Internet of Things Journal, 1–1.

Yaseen, F. A., & Al-Raweshidy, H. S. (2019). Smart Virtualization Packets Forwarding During Handover for Beyond 5G Networks. IEEE Access, 7, 65766–65780.

Gharsallah, A., Zarai, F., & Neji, M. (2018). SDN/NFV-based handover management approach for ultradense 5G mobile networks. International Journal of Communication Systems, e3831.

Amine, M., Kobbane, A., Ben-Othman, J., & Walid, A. (2020). Two-sided matching framework for optimal user association in 5G multi-RAT UDNs. International Journal of Communication Systems, e4346.

Yazdinejad, A., Parizi, R. M., Dehghantanha, A., & Choo, K.-K. R. (2019). Blockchain-enabled Authentication Handover with Efficient Privacy Protection in SDN-based 5G Networks. IEEE Transactions on Network Science and Engineering, 1–1.

Cao, J., Ma, M., Fu, Y., Li, H., & Zhang, Y. (2019). CPPHA: Capability-based Privacy-Protection Handover Authentication Mechanism for SDN-based 5G HetNets. IEEE Transactions on Dependable and Secure Computing, 1–1.

Liu, Pingshan & Xiong, Xiaoyi & Huang, Guimin. (2017). A Multi-objective Optimization Data Scheduling Algorithm for P2P Video Streaming. 184-197.

Lu, Zheng & Veciana, Gustavo. (2013). Optimizing stored video delivery for mobile networks: The value of knowing the future. Proceedings - IEEE INFOCOM. 2706-2714.

Lu, Wei & Yu, Dandan & Huang, Minghe & Guo, Bin. (2018). PO-MPTCP: Priorities-Oriented Data Scheduler for Multimedia Multipathing Services. International Journal of Digital Multimedia Broadcasting. 2018. 1-9.

Araniti, G., Scopelliti, P., Muntean, G., & Iera, A. (2019). A Hybrid Unicast-Multicast Network Selection for Video Deliveries in Dense Heterogeneous Network Environments. IEEE Transactions on Broadcasting, 65, 83-93.

Yu, Ya-Ju & Pang, Ai-Chun & Yeh, Ming-yu. (2018). Video encoding adaptation for QoE maximization over 5G cellular networks. Journal of Network and Computer Applications. 114.

Habbal, Adib & Goudar, Swetha & Hassan, Suhaidi. (2017). Context-Aware Radio Access Technology Selection in 5G Ultra Dense Networks. IEEE Access. PP. 1-1.

Jiyan Wu, Chau Yuen, Bo Cheng, Ming Wang, and Junliang Chen, "Streaming High-Quality Mobile Video with Multipath TCP in Heterogeneous Wireless Networks", IEEE Transactions on Mobile Computing, Vol 15, No 9, pp 2345-2361, 2016.

Hong Yang, Linbo Qing, Xiaohai Hel, Xianfeng Ou, and Xiaojuan Liu, "Robust distributed video coding for wireless multimedia sensor networks", Multimedia Tools and Applications, Springer, Vol 77, No 4, pp 4453-4475, 2018.