Guest editorial: Cognitive models for peer to peer networking in 5G and beyond networks and systems

Anil Kumar Budati[1] · George Ghinea[2] · Dileep Kumar Yadav[3] · Hafeez Basha Ranipet[4]

The problem of integrated cognition devices belongs to a multi-disciplinary area of advanced 5G and beyond networks. The multi-disciplinary focusing on cognitive models at Base Transceiver Stations (BTS) and Mobile Switching Networks (MSN), such as system architectures, Device Sensors, computing techniques, computation intelligence algorithms, mobile devices, Multiplexing devices, helps to reveal a broader and deeper understanding of system architecture and signal processing are part of everyday life and society. Over the past decades many cognitive architectures have been proposed and steadily developed, based on different approaches and computational intelligence methodologies for the network up-gradations, but still current cognitive architectures are far from the goal of covering the requirements for general intelligence in the area of Advanced networks like 5G and beyond wire/wireless Networks. Recent research in the area of evolutionary computational algorithms and genetic programming is used in this study as an inspiration for developing the new version of integrated cognitive architecture devices for advanced communication networks are the knowledge applied to the architecture as well for Industry 4.0 requirements.

A cognitive architecture models and computing algorithms specifies the underlying infrastructure for an intelligent communication networks. Briefly, architecture includes those aspects of developments in Latest BTS, MSN, computing algorithms and Computational intelligent techniques that are constant over time and across different application domains like Cognitive Radio Networks, Software Defined Networks and all wireless Ad hoc Networks. The cognitive devices must have the capacity typically include, the short-term and long-term memories that store content about the user's information, nodes information, computational evolutionary algorithms, and knowledge about data transmission along with the speed of the Network transmissions. The advanced on chip boards, Artificial Intelligence, Deep Learning and Machine Learning models are expecting to give the solutions for the problems involved in the advanced wireless networks.

This special issue aims to address the various issues on cognitive architectures, computational intelligence algorithms like Hardware Description Languages, Signal processing, Communication devices, Artificial Intelligence (AI) algorithms, Machine Learning, Deep Learning on 5G and beyond Networks and the papers contributed high quality theoretical and practical works. The proposed submissions and presentations should be original and unpublished works.

This article is part of the Topical Collection: *Special Issue on Cognitive Models for Peer-to-Peer Networking in 5G and Beyond Networks and Systems*
Guest Editors: Anil Kumar Budati, George Ghinea, Dileep Kumar Yadav and R. Hafeez Basha

✉ Anil Kumar Budati
anilkumar@griet.ac.in; anilbudati@gmail.com

George Ghinea
George.Ghinea@brunel.ac.uk

Dileep Kumar Yadav
dileep.yadav@galgotiasuniversity.edu.in

Hafeez Basha Ranipet
drhafeez@basharesearch.com

[1] Department of ECE, GRIET (Autonomous), Hyderabad 500090, India

[2] Department of Computer Science, Brunel University London, Uxbridge, UK

[3] Department of CSE, Galgotias University, Greater Noida, Uttar Pradesh, India

[4] Basha Research Corporation, Station-H Corporation (Non-Profit), Block 690 B, # 05 - 170, Woodlands Drive:75, Woodlands 732690, Singapore

1 Papers in the special issue

The Special Issue is composed of seven contributions.

Bhawna Chaudhary et al. proposes the immense need for improving road safety and demand for enhancing the overall driving experience, the utility of vehicular ad-hoc networks technology (VANET) becomes well pronounced. But, the major setbacks of VANET are centralized architecture and the lack of privacy-preserving mechanisms. As it is evident, blockchain technology is gaining attention because of the features like decentralization, distributive, cooperative maintenance and non-tampering nature. This paper presents a decentralized architecture of VANET comprising block chain technology. The proposed blockchain-based model for VANET works in four stages: blockchain network initialization, vehicle registration, pseudonym upload, and blockchain maintenance. This can efficiently solve the problems emerging in centralized architectures and helps in resolving trust issues between the entities. We propose an algorithm for protecting location privacy and providing anonymity. Experimental analysis proves that the given architecture performs better than the existing solutions.

Anh-Tu Le et al. focus to implement machine type communications (MTCs) in next generation mobile networks, Narrowband -Internet of Things (NB- IoT) need be studied. Such NB- IoT has been released by the third-generation partnership project (3GPP) as a promising method to exhibit extended coverage and low energy consumption, especially for cheap MTC devices. However, the existing NB- IoT using orthogonal multiple access (OMA) scheme cannot provide connectivity for a massive MTC devices. In this paper, we consider NB- IoT using non-orthogonal multiple access (NOMA). We find that power allocation factors for devices in clustering users are necessary to exhibit differences in term of performance of devices which belong to clustering MTC devices. The worse situation of imperfect successive interference cancellation (SIC) is further studied due to main reason of degraded system performance. We derive closed-form expressions of outage probability for devices in a cluster to highlight main parameters affecting quality of devices. We verify our mathematical analysis via Monte-Carlo simulations.

Usman Rauf Kamboh et al. describes about the objective of the study is to consider the foremost high-tech issue of mobile radio propagation i.e. path loss for an outdoor and indoor environment for mmWave in a densely populated area.60[GHz] mmWave is a win-win for the 5th Generation radio network. Several measurements and simulations are performed using the simulator" Smart Cognitive 3D Ray Tracer build in MATLAB. Two of the main parameters (pathloss and received signal strength (RSS)) of the radio propagation are obtained in this study. To compute the pathloss and RSS, 5G 3GPP mobile propagation model is selected due to its flexibility of scenario and conditions beyond 6GHz frequency. For indoor simulations, we again chose 5G 3GPP mobile propagation model. It is evident from the recent previous studies that there is still not enough findings in the ray tracing specially cognitive 3D ray tracing. The suggested alternative cognitive algorithm here deals with less iterations and effective use of resources. The conclusions of this work also comprise that the pathloss is reliant on separation distance of base station and receiver. The abovementioned frequency and interconnected distance reported here provide better knowledge of mobile radio channel attributes and can be also used to design and estimate the performance of the future generation (5G) mobile networks.

Vivek Gupta *et. al* focus on wireless communication technology is used in various applications and therefore the availability of wireless spectrum is a serious concern. The number of cellular users is increasing rapidly. The 5G network will be able to cater to the requirements of the increasing users. However, the spectrum efficiency needs to be improved. Cooperative spectrum sensing is being widely used by cognitive radios for utilizing the available spectrum in an efficient manner. Evolutionary Algorithm based optimization methods are used in various applications and have proved to be very efficient. These algorithms can also be used for optimizing the cooperative spectrum sensing in cognitive radios. In this paper, two methods are proposed for optimal Cooperative Spectrum Sensing for5G cognitive networks. The optimization algorithms are designed using whale optimization algorithm (WOA) and Particle Swarm Optimization (PSO). The objective is to increase the probability of detection by optimizing the 'weighting vector'. In the first method, WOA is used for cooperative spectrum sensing optimization in cognitive radios. In the second method, WOA method is improved using the PSO algorithm. A hybridized WOA-PSO algorithm is proposed to further improve the probability of detection. The results obtained are compared with other existing algorithms. The proposed methods perform better than the existing methods.

S B Goyal *et. al* deals with the Spectrum sensing (SS) is a concept of cognitive radio systems at base transceiver stations that can find the white space i.e. licensed spectrum owned by primary users (PU), for transmission over a wireless network without any channel interference. The cognitive radio network is designed to overcome the problem of the limited radiofrequency spectrum as most of the applications are dependent on wireless devices in5G. The major concern that arises here is the detection of spectrum availability. The traditional approaches can solve this issue but consume a large amount of time and prior information about PU and spectrum. The objective of this paper is to give a solution to resolve such issues. In this paper, we have used the learning capabilities of deep learning algorithms such as Convolution neural network (CNN) and Recurrent neural network (RNN) for spectrum sensing without prior knowledge of PU. The proposed model

is termed ensemble CNN and RNN (ECRNN) to learn the features of spectrum data and predict the spectrum availability at base transceiver stations in 5G. The simulation result of the ECRNN showed the improvement of accuracy of the system with a reduction in losses that occurred during the false alarm of prediction as well as an improvement in the probability of detection. ECRNN had analyzed PU statistics and result in better spectrum sensing. This paper also supported multiple Sus that would increase the speed of spectrum sensing and data transmission over the available limited spectrum at the same time.

Wali Ullah Khan *et. al* proposes a Non-orthogonal multiple access (NOMA) is expected to play a critical role in heterogeneous networks (HetNets) for beyond fifth-generation (5G) wireless systems. The unrivaled benefits of NOMA along with the multi-tier architecture of HetNets has the potential to significantly improve the performance of cellular networks. Motivated by such possibilities, this article provides a new resource optimization scheme for efficient cellular device association and optimal power control in NOMA-enabled HetNet. Our objective is to maximize the energy efficiency of the proposed HetNet while guaranteeing the signal decoding and minimum rate of each cellular device. The problem of cellular device association and power control is jointly formulated as a non-convex optimization. Since the problem of energy efficiency is coupled with both devise association and power control, it contains high complexity and, hence, it is very difficult to obtain the joint solution. To obtain an efficient solution and reduce the complexity, we decouple the original problem into two subproblems for efficient device association and optimal power control. For any given power allocation of base stations (BSs), we first adopt dual theory for cellular device association, and then a new sequential quadratic programming (SQP) is employed to calculate the optimal power control. Later, we also present the benchmark suboptimal power control method which is based on Karush-Kuhn-Tucker conditions. Monte Carlo simulation results unveil that the proposed NOMA resource optimization scheme in HetNet can significantly improve the system performance compared to the benchmark NOMA and orthogonal multiple access (OMA) schemes.

Haythem Bany Salameh et al. explores his research on adaptive routing and spectrum assignment protocol for heterogeneous Full-duplex (FD) and half-duplex (HD) cognitive radio (CR) networks. The key design goal of the developed protocol is to select a path between a source destination pair, and to optimally assign channels to each hop along the selected path. One main feature of the proposed protocol is that it takes into account the dynamic activity of Primary Users (PUs) over radio channels. To that end, radio channels are characterized in terms of their average availability-time, and the proposed protocol selects the channels with maximum availability-time. Another main feature of the proposed protocol is considering network heterogeneity, where the connected devices may have HD or FD transmission capabilities. The proposed protocol follows a segmentation strategy that relies on the existence of HD nodes. It choses the path with least number of path-segments (and hence minimum HD nodes) to minimize the likelihood of time-shared transmissions, and hence improves network throughput. Compared to existing FD-based schemes, simulation results show that the proposed routing scheme provides considerable enhancement on the overall network performance.

Acknowledgements We would like to express our gratitude and congratulations to all the authors of the selected papers in this Special Issue of Peer-to-Peer Networking and Applications Journal (Springer Publisher) for their contributions of great value in terms of quality and innovation.

We would like to thank also all the reviewers for their contribution to the selection and improvement process of the publications in this special issue. Our hope is that this Special Issue will stimulate researchers in both academia and industry to undertake further research in this challenging field. We are also grateful to the Peer-to-Peer Networking and Applications Journal Editor in Chief and the Editorial office for their support throughout the editorial process.

Anil Kumar Budati is a full time Associate Professor in the Gokaraju Rangaraju Institute of Engineering & Technology (GRIET-Autonomous), Hyderabad, India. His research interests mainly focus on wireless communications, signal processing and cognitive radio networks. He has published more than 30 peer reviewed international journal and conferences papers, delivered guest lectures and acted as various committee chairs in national and international conferences. He acts as Guest Editor for various highly indexed and high impact factor journals He acts as Editor for the book of Cognitive Computing, Taylor and Francis Publisher (CRC Press). He is a member of IEEE, IEI and IAENG from 2018, and has served as a reviewer for various international journals. He has received the B.Tech degree from (VYCET) JNTU, Hyderabad in 2007 and Master of Technology from (LBRCE) JNTUK, Kakinada University in 2010 and the Ph.D. degree from GITAM Deemed to be University, India in 2019 respectively

George Ghinea was a Professor in the Department of Computer Science at Brunel University London. I obtained my BSc. Degree with Computer Science and Mathematics majors from the University of the Witwatersrand, South Africa. I later went on to obtain BSc. (Hons.) and MSc. Degrees, both in Computer Science, from the same university. I was awarded my PhD – Quality of Perception: An Essential Facet of Multimedia Communications from the University of Reading, UK, in 2000. In it, I proposed the Quality of Perception metric, a precursor of the Quality of Experience (QoE) concept now widely known. However, whilst QoE is still a concept, QoP is a concrete metric. Thus, recognising the infotainment duality of multimedia, QoP not only characterises the subjective enjoyment associated with experiencing multimedia presentations, but also how such presentations aid a person\'s ability to assimilate informational content.

My research activities lie at the confluence of Computer Science, Media and Psychology. In particular, my work focuses on the area of perceptual multimedia quality and how one builds end-to-end communication systems incorporating user perceptual requirements. I have applied my expertise in areas such as eye-tracking, telemedicine, multi-modal interaction, and ubiquitous and mobile computing. I am particularly interested in building human-centred e-systems, particularly integrating human perceptual requirements. My work has been funded by both national and international funding bodies – all of it being collaborative work with other teams and stakeholders I have been privileged to be involved with. I have also been honoured to supervise 21 PhD students to completion and to have published over 250 high-quality research articles with them and other research collaborators.

Dileep Kumar Yadav received the Engineering degree (B. TECH. in Computer Science & Engineering) from Uttar Pradesh Technical University, Lucknow, UP, India and masters degree (M.TECH. in Computer Science & Technology) from School of Computer & Systems Sciences, Jawaharlal Nehru University, New Delhi, India. Dr. Yadav has earned Ph.D. (Computer Science & Technology) degree from School of Computer & Systems Sciences, Jawaharlal Nehru University New Delhi, India. His primary research interests are in image processing and computer vision. He is Sun Certified Java Programmer. He is author of several research publications (Patent, Journals, and National/International conferences). He has also written Books and many Book Chapters for internationally reputed publishers. Dr. Yadav is also associated with many international journals as Associate Editor, Member, or Int. Editorial Board member etc. He has more than 10 years of working experience in industry as well as academic. Currently, Dr. Yadav is working an Associate Professor in Dept. of CSE, SCSE, Galgotias University, Greater Noida, India.

Hafeez Basha, Ranipet attained Bachelor of Technology (B. Tech) in Electrical and Electronics Engineering (EEE) from Jawaharlal Nehru Technological University Hyderabad (JNTUH) in 2007, Master of Technology (M. Tech) in Computer Science and Engineering (CSE) from Acharya Nagarjuna University, Guntur in 2010 with sponsorship from Thomson Reuters, Doctor of Philosophy (Ph. D) in Advanced Technology / Renewable Energy from Kumamoto University, JAPAN with Monbukagakusho Scholarship from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Govt. of Japan. He was also presented Dean's Award for Research Excellence during convocation in 2016. He did his Summer Internship at Ho Chi Minh City University of Technology, VIETNAM and Winter Internship at Polytech Clermont-Ferrand, Université Blaise Pascal, FRANCE. He was Waste-to-Energy Consultant at Peepal Renewables Pvt. Ltd. where he deployed biogas plants around 10,000+ in Adilabad, Telangana and 15,000+ in Jabalpur, Madhya Pradesh with CSR funding from France based TOTAL Gas and Energy Ltd. He is also Career Counsellor for higher education abroad and promotes Government Scholarships and free education programs of French and Japanese Universities through their Embassies. He visited 13+ countries with full funding, delivered Guest Lectures at 70+ Institutions in India and abroad including BITS Pilani, NIT-Karnataka, NIT-Rourkela, etc. He is Editor and Reviewer at various SCI / SCOPUS Indexed Journals published by Elsevier and Springer as well as Technical Chair for IEEE Conferences. He served as IEEE Branch Chairman and IEEE Branch Counsellor. He is also two times recipient of Young Scientist Award in 2009 and 2014 respectively.