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# Program

	Sunday, December 13	Tuesday, December 15	Wednesday, December 16	Thursday, December 17
8:00				
-	T1: <i>Test1</i>			
8:15				
8:15				
-				
9:30				
9:30			<i>Women in Engineering Track-1</i>	
-				
11:00				
11:00				
-				
11:30				
			<i>TS 7</i>	
11:30			<i>TS 8</i>	
-			<i>TS 9</i>	<i>TS 16</i>
13:00			<i>Women in Engineering Track-2</i>	<i>TS 17</i>
				<i>TS 18</i>
13:00				
-				
14:00				<i>Workshop: Internet of X-Things (X-IoT)</i>
14:00				
-				
15:00				
	<i>TS</i>	<i>Women in</i>		
15:00	<i>1</i>	<i>Engineering</i>	<i>TS</i>	<i>TS</i>
-	<i>TS</i>	<i>Track-3</i>	<i>12</i>	<i>19</i>
16:15	<i>2</i>		<i>TS Workshop:</i>	<i>TS</i>
	<i>TS</i>		<i>11 Fog</i>	<i>20</i>
	<i>3</i>		<i>Networks</i>	
16:15	<i>Workshop: 5G and Future Wireless Technology</i>			<i>Workshop: New Advances on Vehicle-to-Everything (V2X) Communications and Networking</i>
-				
16:30				
16:30				
-				
16:45				
16:45			<i>TS 13</i>	
-			<i>Women in</i>	
17:30			<i>Engineering</i>	



### **15:18 Beamformed Sensing using Dominant DoA in Cognitive mmWave Network...7**

Madhuri Latha, Sai Krishna Charan Dara and Sachin Chaudhari (International Institute of Information Technology, India)

In this paper, we propose spectrum sensing schemes for a secondary user (SU) with multiple antennas to detect a primary user (PU) transmission in a cognitive mmWave network. The channel model considered at mmWave carrier frequencies is the clustered Rician fading channel, which has few multipaths. For the considered scenario, we propose three beamformed energy detection (BFED) schemes where beamforming is done in the dominant direction of arrival (DoA) at the SU and then energy detection (ED) is applied. The three schemes differ in the amount of information assumed about the DoAs at the SU. The performance of these schemes has been compared with the traditional ED and maximal ratio combining (MRC) schemes for multi-antenna systems. It is shown through simulations that the proposed BFED approaches provide significant performance gains over the ED and negligible loss as compared to the MRC, which makes an impractical assumption of the channel between the PU and the SU to be exactly known.

### **15:37 Leveraging Multi-cell NOMA for Cell Edge...13**

Zhanwei Yu (Uppsala University, Sweden); Lei You (Independent Researcher, Sweden); Di Yuan (Uppsala University, Sweden)

Non-orthogonal multiple access (NOMA) is a promising technique for performance enhancement in cellular networks. This paper investigates how much NOMA can offer for cell edge in multi-cell scenarios. We consider the joint optimization problem of time-frequency resource allocation, user pairing, and power split, for scaling up the demand delivered for edge users. Our approach for problem solving consists in iteratively applying a fixed-point method to the cells, and, for each cell, deriving an algorithm guaranteeing optimum for single-cell optimization. By embedding the fixed-point method into bi-section search, we are able to show the overall approach guarantees global optimality. Numerical results demonstrate that multi-cell NOMA optimization has much more to offer over orthogonal multiple access for the experience of edge users, in particular for high-demand and resource-limited scenarios.

### **15:56 One Bit Imperfect Feedback Based Antenna Cluster Selection for MIMO System over Nakagami-m Fading Channels...19**

Ankit Garg (Jaypee Institute of Information Technology Noida, India); Sunil Malik and Manav Bhatnagar (Indian Institute of Technology Delhi, India)

In this paper, we analyze the performance of the cluster selection scheme employing one-bit feedback for multiple-input multiple-output (MIMO) wireless communication system. The selected cluster of transmit antennas will encode the input symbol-stream with the help of generalized orthogonal space-time block codes to provide full diversity order. The channel between the transmitter and receiver are assumed to follow Nakagami-m distribution to accurately characterize different fading scenarios in the practical wireless systems. It is not always possible to have perfect feedback information over an unguided feedback link and since the imperfect information deteriorates the overall performance of the system. Therefore, the error-tolerant optimized power allocation scheme is proposed. The closed-form expressions of exact and asymptotic symbol-error-rate (SER) are derived for the considered MIMO system under erroneous feedback bit employing M-quadrature amplitude modulation (M-QAM) constellation. The optimized transmit weights are obtained by minimizing the derived SER expression. Further, the exact closed-form expression of the outage probability of the considered system is also derived under imperfect feedback bit over the considered MIMO system. Simulation results validate the derived mathematical expressions of

the investigated performance metrics.

## TS 2

### **15:00 Two Laser Selection Scheme for FSO Communication...25**

Pranav Sharda (Indian Institute of Technology-Delhi, India); Anshul Jaiswal (Indian Institute of Technology Roorkee, India); Manav Bhatnagar (Indian Institute of Technology Delhi, India); Ankit Garg (Jaypee Institute of Information Technology Noida, India)

In order to send the information bits, a conventional transmit laser selection (CTLS) scheme selects the best transmit aperture. Due to the optimal transmit aperture selection, CTLS offers the best possible error performance in a free-space optical (FSO) communication system. Moreover, this optimal error performance is observed under the perfect feedback link scenario. However, a slight error in the feedback information can cause a significant loss in the diversity order. This deteriorates the error performance. To overcome this problem, we propose and analyze a novel grouping-based TLS scheme, called two TLS (TTLS) scheme. In the proposed TTLS scheme, the transmit apertures are divided into two groups and the best aperture in each group is used for transmission of the data. Furthermore, it is observed by the intensive analysis that the proposed TTLS scheme offers a lesser loss in the diversity order as compared to CTLS under the erroneous/imperfect feedback link. Therefore, a significant amount of performance gain can be achieved by the proposed TTLS scheme as compared to the CTLS scheme under a practical (erroneous feedback) scenario.

### **15:18 Design of transmitter communication module for nanosatellite optical communication terminal...31**

Nirlesh Singh (LEOS-ISRO & IIT DELHI, India); Ravikumar Keshavappa (Indian Space Research Organisation, India); Sonali Sonali (IIT Delhi, India); Abhishek Dixit (Indian Institute of Technology Delhi & IBBT, India); Umesh S b (LEOS-ISRO, India)

In the present world of satellites, miniaturization of satellite subsystems plays a vital role in launch capacity and operational maintenance. Free-space optical communications with lasers offer an attractive alternative to traditional radio frequency (RF) communications and enable a reduction in size, weight, and power (SWaP). In this work, we have studied and designed the transmitter module for nanosatellite-optical communication terminal (NOCT) to provide power-efficient and high data rate downlink using infrared lasers from low earth orbit satellites. In this paper, we present the requirements for the functional design of the transmitter system. We design an optical link for low-earth orbit (LEO) satellites and evaluate the relation between the bit error rate (BER) and receiver sensitivity for the pulse position modulation (PPM) systems. We also characterize the Erbium-doped fiber amplifier (EDFA) for validation of design using the free-space optical link.

### **15:37 Reactive Hitless Hop tuning based defragmentation algorithm for enhanced spectrum efficiency in Elastic optical networks...37**

Sai Kiran Posam (Sri Sathya Sai Institute of Higher Learning, India); Sai Kishore Bhyri (Cisco Systems Inc., India); Gowrishankar R, Venkata Narasimha Reddy Challa and Siva Sankara Sai Sanagapati (Sri Sathya Sai Institute of Higher Learning, India)

With ever-increasing bandwidth requirements, telecom operators have to rely heavily on technologies, which use the same infrastructure but increase the capacity keeping in mind both Opex and Capex. Elastic optical networks is one such technology, which assigns spectrum tailored to the demand in terms of 6.25/12.5 GHz granularity and thereby increasing the spectrum

utilization. When the traffic is dynamic, there will be frequent setting up and tearing down of demands, which will lead to the isolated fragments of the spectrum that cannot be allocated for further demands. There are various approaches to group these fragments of the isolated spectrum and we have proposed a Reactive Hitless Hop tuning based defragmentation algorithm that defragments the spectrum by retuning the minimum number of demands. The proposed algorithm was implemented on different fragmented scenarios on NSFNET and USNET topologies and concluded that the algorithm was able to free spectrum by retuning a minimal number of existing demands.

### **15:56 On the Performance of Hybrid FSO/RF System Over Generalized Fading Channels...43**

Narendra Vishwakarma and Swaminathan Ramabadran (Indian Institute of Technology Indore, India)

In this paper, we analyze the performance of a single-threshold-based switching scheme for hybrid free space optics/ radio frequency (FSO/RF) system over generalized FSO and RF fading channels. The turbulence induced fading in FSO link is modeled using generalized Malaga distribution and the RF channel fading is modeled using recently proposed generalized  $\alpha$ - $\eta$ - $\kappa$ - $\mu$  distribution. In addition, the effect of pointing errors and atmospheric attenuation are also taken into consideration to evaluate the system performance assuming heterodyne detection (HD) and intensity modulation/direct detection (IM/DD) techniques. The unified closed-form expression for average symbol error rate (SER) is derived. Further, the asymptotic expression is also derived in closed-form to obtain the diversity gain of the hybrid system. The effect of various FSO and RF channel parameters on the system performance has been investigated and the coding gain obtained due to RF backup link over single-link FSO system has also been reported. Finally, all the derived expressions are validated using Monte-Carlo simulations.

## **TS 3**

### **15:00 Availability Comparison of 5G Network Service...49**

Priyatosh Mandal (Centre for Development of Telematics, New Delhi, India)

5G network service is a set of virtual network functions (VNFs), which are connected to each other. A complete network slice can be virtualized with the use of a network service. VNFs of a network service can be deployed with the use of OpenStack, which is an open source cloud computing platform. In OpenStack, all the vnfs of a network service can be deployed in one compute node or in different compute nodes. In this present work, we derive closed form expression to analyze the availability of network service considering the deployment of vnfs of a network service in one and different compute nodes. In the availability analysis, we consider the failure perspective of compute node(s). Further, we compare the availability of network service considering these two deployment strategies.

### **15:18 On the Availability of 5G VNF from Initialization Perspective...55**

Priyatosh Mandal (Centre for Development of Telematics, New Delhi, India)

Virtual network function (vnf) can be useful for efficient use of cloud resources, specially for 5G networks, where dynamic creation, modification and deletion of virtual network functions are of special need. OpenStack is an open source cloud computing platform, where it is possible to create any virtual network function on demand. During creation of virtual network function, using Tacker or Mistral interface of OpenStack, the problem can arrive with respect to the reachability of vnf,

which triggers the OpenStack to recreate the vnf. In this present work, we derive a closed form expression to analyze the availability of vnf considering the reachability problem during or after creation of virtual network function. Further, we compare availability of vnf considering two vnf creation procedures.

### **15:37 Dynamic Resource Allocation of eMBB-uRLLC Traffic in 5G New Radio...61**

Muhammed Al-Ali, Elias Yaacoub and Amr Mohamed (Qatar University, Qatar)

5G technology is intended to support three promising services with heterogeneous requirements: Ultra-Reliable and Low Latency Communication (uRLLC), enhanced Mobile Broadband (eMBB) and massive Machine Type Communication (mMTC). The presence of these services on the same network creates a challenging task of resource allocation to meet their requirements. Given the critical nature of uRLLC applications, uRLLC traffic will always have the highest priority which causes a negative impact on the performance of other types of applications. In this paper, the problem of uRLLC/eMBB resource allocation is formulated as an optimization problem aiming to maximize the Average throughput of eMBB User Equipment (UE) while satisfying the latency demands of uRLLC applications. A Dynamic programming approach is used to achieve an optimal resource allocation for uRLLC traffic on a TTI level that minimizes its impact of eMBB Average Throughput in addition to preserving an acceptable level of fairness among eMBB UE. This approach is applied on top of heuristic scheduling algorithms where uRLLC traffic punctures pre-allocated resources of eMBB UE upon arrival. The effectiveness of this approach is evaluated using numerical simulation and the results show how it minimizes the impact of uRLLC traffic on the performance of these algorithms in terms of Data rate, Spectral Efficiency and Fairness.

### **15:56 PPSE: Privacy Preservation and Security Efficient AKA Protocol for 5G Communication Networks...67**

Balu Laxman Parne (Academician & SVNIT, Surat, India); Shubham Gupta (Visvesvaraya National Institute of Technology Nagpur, India); Kaneesha Gandhi and Shubhangi Meena (SVNIT, Surat, India)

The authentication and key agreement (AKA) protocol strengthens the security of mobile communication networks. The 5G-AKA protocol is standardized by the 3rd generation partnership project (3GPP) for future mobile communication networks. However, it is observed that this protocol is vulnerable to numerous security weaknesses. Moreover, the protocol suffers from huge computation and communication overhead. To overcome these issues, several AKA protocols were introduced by the researchers. However, none of the protocols took care of the identity preservation and single key disclosure issue over the communication channel. In this article, we propose the Privacy Preservation and Security Efficient (PPSE-AKA) protocol that preserves the user's identity and protects the shared secret key. The mutual authentication is formally verified by using the AVISPA tool. The security analysis demonstrates that the protocol fulfills all the privacy requirements and dodges the potential attacks. The performance of the protocol is evaluated for the previously established schemes and observed that the PPSE-AKA protocol exhibits a cutting edge competition to them.



**Tuesday, December 15 15:00 - 18:30**

**Workshop: 5G and Future Wireless Technology**

**15:00 Automated Symbol Rate Estimation Over Frequency-Selective Fading Channel by Using Deep Neural Network...73**

Mahesh Shamrao Chaudhari and Sudhan Majhi (Indian Institute of Technology, India)

The adaptive communication system is going to play a major role for fifth-generation (5G) and beyond wireless communication where the physical layer signal parameters need to be changed at the transmitters as per system requirement and the receiver needs to estimate them to recover the signal. The symbol rate is an important parameter that often needs to be changed for a variable data rate system and thus requires estimating it at the receiver before recovering the signal. In this paper, we have proposed an efficient and robust automated symbol rate estimation model for single carrier system over frequency-selective fading environment, by using deep neural network (DNN) approach. The estimation can be carried out on both intermediate frequency (IF) data or baseband data. The proposed scheme carries out estimation of symbol rate without having any prior knowledge of bandwidth which was a main assumption for the existing statistical methods. In the proposed scheme, no additional knowledge such as channel state information (CSI), timing, and frequency offset are required to estimate the symbol rate. The training and testing data for the proposed model have been generated in the presence of different symbol rate signal with random symbol timing offset (STO) and carrier frequency offset (CFO) in the presence of Rayleigh and Rician channel fading environment. The DNN model is trained by generated data, then the trained DNN model is tested by estimating the symbol rate. The performance of the DNN model is compared with the statistical model based on conventional theory. The proposed model outperforms the statistical model in terms of performance. The performance of the symbol rate estimator is depicted by the normalized mean square error (NMSE) and bit error rate (BER).

**15:35 Performance of iterative Successive interference cancellation receiver for LDPC coded OTFS...79**

Suvra Sekhar Das, Shashank Tiwari and Vivek Rangamgari (Indian Institute of Technology Kharagpur, India); Subhas Chandra Mondal (Wireless & Wipro Technologies, India)

Orthogonal Time Frequency Space (OTFS) modulation is a recently developed transmission technology, in which symbols from complex constellation are placed in the delay Doppler lattice. It is shown in literature that OTFS is more resilient to inter carrier interference, caused due to high Doppler, than OFDM. However, the required signal processing complexity of OTFS at the receiver side is much higher than that of OFDM. In this work we present the performance of an iterative SIC receiver for LDPC coded OTFS based on an earlier developed MMSE receiver. It is observed that improvement up to 7.5 dB can be achieved using the proposed receiver. It is also shown that the proposed SIC receiver has lower complexity than a message passing receiver available in literature, yet provides comparable performance for lower order modulation and low SNR. For higher order modulations and at high SNR the proposed receiver achieves better reliability, i.e. coded block error rates up to  $10^{-5}$ , which is aligned with the higher reliability requirement of 6G mobile communication systems.

**16:10 Analysis of downlink NOMA in full duplex-half duplex mixed cell PPP system with interference...85**

Sudharsan Parthasarathy (National Institute of Technology Tiruchirappalli, India); Abhay Kumar

Sah (IIT Roorkee, India); Satya Kumar Vankayala (Samsung R&D Institute Bangalore, India)  
In this paper we derive the outage probability and average spectral efficiency of downlink users in a mixed cell full duplex (FD)-half duplex (HD) non orthogonal multiple access (NOMA) system in the presence of inter-cell interference. Despite increase in rate achieved in a complete full duplex system as the available bandwidth increases, there is an increase in outage probability due to the additional interference from uplink users. Instead, a mixed cell system with half duplex and full duplex base stations can be used along with NOMA. Though there is a decrease in rate achieved when compared to a complete FD-NOMA system, outage probability also reduces. This trade-off gives the designers flexibility to choose the fraction of full duplex base stations to deploy, choose the ratio of power split in NOMA to achieve a target rate at a given outage.

#### **16:45 A Novel Front-haul Bandwidth Compression Method for RAN Systems...91**

Satya Kumar Vankayala (Samsung R&D Institute Bangalore, India); Gaurav Potnis (Indian Institute of Technology, Madras, India); Konchady Gautam Shenoy (Indian Institute of Science (IISc), India); Seungil Yoon (Samsung Electronics, Korea (South)); Swaraj Kumar (Samsung R&D Institute, India)

Recently, there has been a significant increase in users as well as user data requirements in mobile communications. This is attributed to advances in mobile communication systems and networking, along with the advent of fifth generation (5G) mobile systems. As a result, front haul data compression techniques have become necessary to meet QoS requirements. In this paper, we resort to contemporary machine learning techniques and provide algorithms to, respectively, dynamically predict and compress the front haul data. The proposed scheme involves evaluating the Error Vector Magnitude (EVM) metric and comparing the performance with existing schemes. Furthermore, these algorithms can be deployed on contemporary C-RAN as well as O-RAN architectures. From simulations, we are able to demonstrate a compression of about 65%.

#### **17:20 Performance Evaluation of Multipath VLC Links for Different Transmitter Configurations...96**

Sonu Jaiswal (Indian Institute of Technology, India); Rishu Raj (Indian Institute of Technology Delhi, India); Abhishek Dixit (Indian Institute of Technology Delhi & IBBT, India)

Visible light communication (VLC) is an optical wireless communication technology in which light-emitting diodes (LEDs) used for illumination are also used for communication. Due to its numerous advantages, it is being actively researched for implementation in 5G cellular systems. In VLC, signals from transmitter panels can reach the receiver through numerous paths because of the reflections from walls. Consequently, these signals suffer from time dispersion, thereby imposing an upper limit on the achievable data rate. This time dispersion depends on a number of factors like wall reflectivity, receiver location, transmitter position, detector area, LED semi-angle etc. So, there is a need to include the effect of multiple reflections (occurring in the practical indoor environment) in the performance evaluation of indoor VLC link. We obtain various channel parameters like mean excess delay, RMS delay, coherence bandwidth etc. by simulations in MATLAB to characterize the multipath channel for different transmitter configurations. We also study the error performance of the multipath VLC system in the presence of inter symbol interference (ISI). Moreover, we analyze the effect of LED semi-angle on the channel characterization and error performance of multipath VLC links.

#### **17:55 Cost-efficient Mobile Backhaul Network Design over TWDM-PON...102**

Shahbaz Akhtar and Pramit Biswas (Indian Institute of Technology Patna, India); Aneek Adhya

(Indian Institute of Technology Kharagpur, India); Sudhan Majhi (Indian Institute of Technology, India)

In recent times, time and wavelength division multiplexed passive optical networks (TWDM-PONs) are recognized as promising transport network technology for mobile backhaul design. TWDM-PON is a multi-wavelength PON technology that offers high reliability, low maintenance cost, high capacity, and long transmission reach. In this paper, we propose a recursive clustering algorithm (RCA) to design cost-efficient TWDM-PON architecture for providing backhaul connectivity to the macro-cell base stations (BSs). Based on the geographical locations of BSs, RCA explores the optimal number of BS clusters, the size of each cluster, the most suitable location of remote nodes for passive device placement, and the best fiber route from operator's central office to the BS's locations. The primary objective is to reduce the total cost by minimizing the total length of deployed fibers. We also employ cable-conduit sharing, where the cable-conduits deployed for existing fiber links are utilized to place a new fiber link. We introduce two-stage cable-conduit sharing to maximize sharing of cable-conduits for last-mile fiber and distribution fiber so as to further tune down the cost. We compare the performance of our proposed RCA scheme with the existing benchmark studies, viz., BS clustering technique and random-cut sectoring approach. The simulation result confirms that our scheme substantially reduces the backhauling cost compared with the existing studies.

## **Tuesday, December 15 17:30 - 18:45**

### **TS 4**

#### **17:30 Buffer-Aided AF Cooperative Relaying Network with NOMA Transmission Scheme...108**

Sandeep Joshi (Birla Institute of Technology & Science (BITS), Pilani, India); Manoj B. R. (Linköping University, Sweden); Soumya P. Dash (Indian Institute of Technology Bhubaneswar, India)

A buffer-aided cooperative communication network employing non-orthogonal multiple access (NOMA) with fixed gain amplify-and-forward relaying is considered in this paper. Using NOMA scheme the mobile user which acts as a relay and is a strong user transmits the information to the two destination devices which are the weak users. The strong user is aided with a data buffer and it amplifies and forwards the superposed signal received from the source. The buffer at the relay has the potential to offer flexible scheduling of data reception and transmission by utilizing the channel resources and also helps in offloading data servers. The approximate upper bound expressions for the successful transmission probabilities at the two weak users is derived considering that the device acting as a relay (strong user) has global channel state information. By adopting a Markov chain approach to model the evolution of the strong user's buffer status, the closed-form expression for the outage probability and the average packet delay of the system are also derived.

#### **17:48 Low Complexity Based QR-LRL OSIC Detector for Downlink NOMA-MIMO Systems...114**

Rahul Makkar (The LNM Institute of Information Technology & Rupa Ki Nangal, Post-Sumel, Via-Jamdoli, India); Kotha Venugopalachary (Shiv Nadar University, India); Divyang Rawal (LNMIIT, India); Vijay Kumar Chakka (Shiv Nadar University Greater Noida, India); Nikhil Sharma (The LNM Institute of Information Technology, Jaipur, India)

Power domain NOMA SISO system achieve more capacity compared to OMA system for a given power. To enhance the overall system capacity, NOMA-MIMO based downlink system with superposition coding (SC) coding is considered in this work. With the incorporation of MIMO, the

detector subject to interuser as well as interantenna interference. Conventionally, after receiving the signal from the base station (BS), each user eliminates the interantenna interference using zero-forcing (ZF) based linear detector. This paper proposes low-complexity based QR-LRL detector to overcome jointly the interuser interference and interantenna interference. The performance of the proposed detector under BER and capacity metrics compared with ZF-SIC and ML detectors. Simulation results show that the proposed receiver guarantees near ML performance with lower complexity for NOMA-MIMO downlink systems. It presents the sumrate improvement for various MIMO configurations with different modulation orders. It also provides optimal power allocation factor to experience the same BER at both the near user (NU) and the far user (FU) using ZF and QR-LRL detector.

#### **18:07 Qos Aware and Fair Resource Distribution for Uplink NOMA Cellular Networks...119**

Priya Gupta (Indian Institute of Technology Roorkee & IIT, India); Debashis Ghosh (Indian Institute of Technology (IIT) Roorkee, India)

Non-orthogonal multiple access (NOMA) technique achieved a lot of interest due to its extraordinary spectral efficiency and ready to become the best possible solution for fifth-generation (5G). In this paper, system throughput maximization is analyzed under the uplink NOMA scenario. The scarcity of resources motivates the researchers for finding some optimal way to allocate or share the resources among users. This paper focuses on the objective of system throughput maximization under the optimal channel and power allocation constraint. Our problem is mixed-integer nonlinear programming (MINLP) problem and NP-hard to solve. Consequently, it is solved in two sequential steps. The first is channel assignment through different schemes and second is power allocation that has been done (while satisfying constraints such as power budget and quality of service (QoS)) to the optimal channel paired users. The simulation results are discussed, analyzed and the considered performance metric is system throughput.

#### **18:26 On Energy Harvesting in Hybrid Massive MIMO Cooperative NOMA in a Multiuser Cell...125**

Suraj Dhar (IIT Kanpur, India); Adrish Banerjee (Indian Institute of Technology, Kanpur, India); Pradip Sircar (Indian Institute of Technology Kanpur, India)

In this paper we have considered an energy harvesting hybrid massive MIMO cooperative NOMA scheme using hybrid SWIPT protocol in a multiuser cell. Semi-orthogonal User Selection- Receive Antenna Selection Algorithm (SUS-RAS) algorithm is used to create the zero-forcing user set and select the receive antennas of each user for signal reception. Then User Matching-Receive Antenna Selection Algorithm (UM-RAS) is used to group the matched users with the users in the zero-forcing user set and also to select the antennas for signal reception. Max-Max algorithm is used to select the antenna pair for relaying between the users in each cluster. Finally, some numerical studies are shown that demonstrate the advantage of massive MIMO concept, cooperative NOMA along with hybrid SWIPT protocol for energy harvesting.

TS 5

#### **17:30 A CPW fed Super Wideband Dielectric Resonator Antenna...131**

Sachin Agrawal (NIT Delhi, India)

In this paper, a CPW fed super wideband (SWB) dielectric resonator antenna (DRA) is proposed. It consists of a rectangular DR situated at the center of the rectangular slot both excited by a tapered feedline. In addition, a circular stub is added at the top portion of the feed in such a way that it

excites the DR efficiently. From simulation results, it is found that the presence of DR in the proposed antenna design improves the impedance matching throughout the band and hence enhances the impedance bandwidth by downshifting the lower cutoff frequency from 3 GHz to 1 GHz. It is observed that the proposed antenna achieved an impedance bandwidth of more than 175% ranging from 1 GHz to 15 GHz with a bandwidth ratio of more than 15:1. Besides, it is investigated that the presence of DR raises the peak gain from -5.6 dBi to 1.24 dBi at 1 GHz. It achieved a maximum gain of 7.2 dBi at 5.1 GHz. Further, the proposed antenna exhibits an almost stable radiation pattern in the entire frequency range.

#### **17:55 Design of Defected Ground Structure in Planar Array for Cross Polarization Reduction...136**

Rajalakshmy G (Amrita Vishwa Vidyapeetham, Bangalore, India); Arpita Thakre (PES University, Bengaluru, India)

A simple configuration of defected ground structure is proposed for suppressing the H plane cross polarization in a line fed planar array. A 1x2 and a 2x2 array having defects in ground plane have been designed in X-band. The designs show around 10-14 dB suppression in the H-plane cross polarization level with improved gain. The design and simulation process is accomplished by using AWR simulator.

#### **18:20 Advanced Mechanisms for Satellite and Terrestrial Co-existence in 26/28 GHz mmWave spectrum...142**

Dattaraj Raut Mulgaonkar (Samsung Research Institute, India); Diwakar Sharma (Samsung Semiconductor India Research, India); Rakesh Mehrotra (Samsung Research Institute, India); Tushar Vrind (Samsung, India)

Availability of wide bandwidth makes mmWave spectrum in 26 and 28 GHz an attractive candidate for terrestrial cellular and satellite services. Dividing the spectrum into parts for each service proportionally shrinks the available resources for each service, thus co-existence of competing service in mmWave band is an indispensable subject to maximize usage of the spectrum. However, in the available literature co-existence has not been explored adequately for deployed technologies in satellite and terrestrial cellular communication. We have evaluated interference on satellite services in 26/28 GHz, which originates from the 5G terrestrial cellular network. To the best of our knowledge, for the first time in this paper, we have proposed interference mitigation mechanism for operating satellite communication in both space to earth (S-E) and earth to space (E-S) scenarios. In the S-E scenario, where 5G stations (base station and User Equipment (UE)) create interference on satellite earth stations, we have proposed applying (a) site shielding, and (b) beam nulling and power adaptation (BNAP) at 5G base stations to mitigate interference. In E-S scenario, where 5G stations create interference at the satellite space station, we have proposed applying (i) BNAP at the UE, (ii) Transmit Time Interval (TTI) bundling with reduced uplink transmission power at the UE, and (iii) localized deployment for the 5G base station to mitigate interference. Through extensive analytical modelling and simulations, we show that the proposed interference mitigation techniques can provide 10-20 dB interference reduction and offer better co-existence for satellite and terrestrial services in the mmWave spectrum.

### **17:30 A Novel On-demand Trust-based Access Control Framework for Resource-constrained IoT System...148**

Anjana Prabhakar (IIIT-B, India); Tricha Anjali (International Institute of Information Technology - Bangalore, India)

Access control mechanism in IoT is a challenge in itself owing to the massive scale and heterogeneity of IoT devices that are connected. The task becomes more difficult when there are resource-constrained devices in the network. Employing a resourceful trusted third party as a centralized authority for access control and storage of data is no more an ideal solution due to possible breach of privacy and single point of failure. It also hampers the scalability of the IoT system. The On-demand Trust-based Access Control (OTAC) framework proposes a distributed trust-based blockchain model optimized for access control in resource-constrained environments. OTAC offers a differential level of security and privacy on a demand basis. The hierarchical structure of OTAC framework gives it a decentralized architecture. OTAC uses a customized trust-based consensus, immune to Byzantine attack and hence gives it an edge over other blockchain-based access control schemes.

### **17:48 Fine-grained Frequencies to Combat Cross Technology Interference in IoT: A Measurement Study...154**

Chandra Shekhar and Sudipta Saha (Indian Institute of Technology Bhubaneswar, India)

In this paper we show a possible way to deal with the problem of severe WiFi interference in low power WSN/IoT-edge in the 2.4 GHz ISM band. Through extensive multi-frequency link-measurement experiments we demonstrate that under heavy congestion when the frequency band is fully occupied by WiFi channels, the multi-channel protocols for low power ZigBee communication should try to exploit all the 1 MHz separated 80 different frequencies instead of sticking to only the 16 standard channels. Through an in-depth analysis of the outdoor link measurement data we observe that the availability of the usable frequencies follows a well-known levy characteristics. Exploiting this special property, we propose an efficient frequency searching mechanism that can quickly find a suitable frequency when the current operating frequency degrades. Our trace-based simulation results show that the proposed strategy can perform upto 80% faster compared to the naive random probe based searching.

### **18:07 IoT-Blockchain Enabled Yield Advisory System (IBEYAS) for Rubber Manufacturers...160**

Shajulin Benedict (Indian Institute of Information Technology Kottayam, India & Earlier - TUM-Germany, Germany); Bill Jose Sibi (Summer Internee, IIITKottayam, India); Vinaya Balakrishnan (Technical Assistant, IIITKottayam, India)

IoT, Blockchain, Cloud, and other ICT technologies have more to offer to overcome the ongoing economic crisis of the rubber industry and reflect the adequate regard for boosting the economy of manufacturers. This paper proposes an IoT-Blockchain enabled Yield Advisory System (IBEYAS) for natural rubber manufacturers. IBEYAS connects IoT-enabled sensors of agricultural land, assesses the yield value of rubber trees at different time intervals, and notifies the anomalies to rubber manufacturers and the associated involving participants. The anomaly record of IBEYAS advises manufacturers to opt for appropriate rubber yielding procedures. For experiments, sensors were mounted on three different agricultural locations and the blockchain network was set up at the IoT cloud research laboratory. Experimental results revealed how IBEYAS recorded the anomalies after the entries consented from i) rubber manufacturers, ii) landowners, iii) rubber board

authorities, and iv) rubber tappers; the results showcased the yield opportunities suggested by IBEYAS to the rubber manufacturers.

### **18:26 Data Quality Improvements for Internet of Things Using Artificial Neural Networks...166**

Chafiq Titouna (Paris University, France); Farid Nait-Abdesselam (University of Missouri Kansas City, USA)

The Internet of Things has gained considerable attention due to its potential applications in multiple domains. However, some deployment environments may be hostile and this may affect the quality of data (QoD) and alter its accuracy. In order to ensure a high level of reliability, an IoT system should be able to clean its own sensed data by discarding those instances that are erroneous or incoherent. To achieve the data quality improvements, this paper suggests a new approach based on Artificial Neural Network (ANN). The proposed scheme can prematurely and efficiently detect outliers before forwarding them to a central processing unit. The performance of this proposed solution is validated through simulations, using a real dataset, and compared with other well-known models. Our findings demonstrate that the proposed approach outperforms the compared models in terms of accuracy, f-score, recall and precision metrics.

**Wednesday, December 16**

**Wednesday, December 16 9:30 - 11:00**

**Women in Engineering Track-1**

### **9:30 On Improving the Fairness of NOMA-Based Indoor Visible Light Communication System...172**

Kumud Jindal (Indian Institute of Technology (IIT), Delhi, India); Rishu Raj (Indian Institute of Technology Delhi, India); Abhishek Dixit (Indian Institute of Technology Delhi & IBBT, India)

In this paper, we improve the fairness of non-orthogonal multiple access (NOMA) by proposing a power allocation scheme that ensures all users experience the same bit error rate (BER) irrespective of their channel conditions. We also derive analytical expressions for the BER obtained using this novel power allocation scheme by applying it to a downlink NOMA-based visible light communication (VLC) system. The numerically simulated results for different scenarios match the analytical results, thereby validating the derived power allocation expression. Finally, we demonstrate a significant improvement in the fairness of NOMA for our novel power allocation scheme compared to the existing gain ratio power allocation and normalized gain difference power allocation schemes.

### **9:52 Study of Performance Enhancement in Underwater Optical Wireless Communication System...178**

Pooja Singh (Indian Institute of Technology Delhi, India); Ch Krishna Chaitanya (Indian Institute of Technology, Delhi, India); Sonali Sonali (IIT Delhi, India); Abhishek Dixit (Indian Institute of Technology Delhi & IBBT, India); V K Jain (IIT Delhi, India)

Underwater optical wireless communication has many plausible applications, but the biggest challenge for this is the communication medium that is water. Water characteristic changes from place to place. Due to high absorption and scattering, link length is limited to a few meters. In this work, we increase the link length under different channel conditions. For achieving this, we use a semiconductor optical amplifier (SOA) at the receiver and also, error-correcting codes (ECCs) in

various water types to mitigate the effects the channel effects. SOA decreases the power required at the receiver, thus, increasing the link length for the same bit error rate (BER). But, SOA fails to perform as water quality degrades too much such as in turbid harbor. In contrast to this, the use of ECCs can significantly reduce the power requirement and increase the link length. We have also employed the combination of both the models in order to achieve desired performance at a lower power and to attain more link length. Simulation is done using MATLAB. Analytical results for SOA assisted system are also plotted along with the simulation results.

#### **10:15 Millimeter Wave Wireless System Modeling with Best Channel Selection Policy...184**

Tooba Mukarram and Kartik Shrivastava (BITS Pilani, Rajasthan, India); B. Sainath (BITS Pilani, India)

Millimeter-wave (mmWave) technology is one of the most popular enabling technologies in the fifth-generation and beyond wireless systems. MmWave technology provides substantial extra bandwidth to address high data rate requirements for various terrestrial mobile systems. The main challenges in technology include high propagation attenuation and channel fading. In this paper, we consider mmWave non-cooperative and cooperative system models and propose the best mmWave channel selection policy (BMCSP). For these systems, we study the performance of the proposed BMCSP. Specifically, we present useful mathematical analysis for the average spectral efficiency (SE) of both non-cooperative and cooperative mmWave systems. To quantify the gains delivered by BMCSP, we compare the average SE performance with that of the randomly selected channel. We find that the proposed policy provides superior performance in terms of average spectral efficiency.

#### **10:37 A Novel Framework for Misbehavior Detection in SDN-based VANET...190**

Rukhsar Sultana (Malaviya National Institute of Technology, India); Jyoti Grover (Malaviya National Institute of Technology Jaipur, India); Meenakshi Tripathi (MNIT Jaipur, India)

In Vehicular Ad Hoc Networks (VANET), internal attacks are performed by insider nodes. Effective Misbehavior Detection System (MDS) can detect such misbehaving insider nodes. MDS monitors the transmitting messages constantly to detect incorrect data packets through plausibility and consistency checks and thus detects the misbehaving vehicle. Existing detection systems are not adaptive to network statistics. Therefore, we propose a framework for misbehavior detection in Software-Defined Networking (SDN)-based VANET. SDN-based VANET is provided with programmability and flexibility so that proposed framework can be adjusted according to the present network scenario on order to provide effective and accurate detection performance.

**Wednesday, December 16 11:30 - 13:00**

TS 7

#### **11:30 An Anycast Service with Cognitive DTN Routing...196**

Ricardo Lent (University of Houston, USA)

The use of anycast routing in challenged networks, such as space networks, can help to alleviate the impact of the regular network partitioning and large communication delays that characterize such an operational environment. With the anycast service, a data bundle can be delivered to any member of the anycast group. This work is motivated by the observation that the bundle routing could be optimized to reach the group member that offers the lowest end-to-end delivery time from the node where the routing decision is being made. This possibility is explored in this study by a proposed



extension to the Cognitive Space Gateway (CSG) approach to DTN routing. The advantage of the method is that it adaptively determines the path for each bundle, which will depend on the network congestion, while dynamically deciding the (near) optimal member as the destination node. This process allows for achieving low bundle response times and high throughput. Testbed experiments are reported which confirm the performance advantages of the proposed method over unicast routing.

### **11:52 ArsPAN: Attacker Revelation Scheme using Discrete Event System in 6LoWPAN based Buffer Reservation Attack...202**

Dipojjwal Ray (Indian Institute of Technology Guwahati, India); Pradeepkumar Bhale (IIT Guwahati, India); Santosh Biswas (Indian Institute of Technology Bhilai, India); Sukumar Nandi (Indian Institute of Technology Guwahati, India); Pinaki Mitra (IIT Guwahati, India)  
6LoWPAN, an adaptation layer designed by IETF, is meant for IPv6 connectivity over lossy links and low power resource constrained devices using the IEEE 802.15.4 networks. Of late, the growing emergence of Internet of Things (IoT) enabled devices in areas such as industrial Cyber Physical Systems (CPS) and home automation has mobilized extensive implementation of 6LoWPAN. However, absence of authentication mechanisms render the adaptation layer prone to various attacks arising out of duplicated or fabricated fragments. Buffer Reservation Attack targets the vulnerability induced due to fictitious allocation of the buffer, which then denies new packets from occupancy till timeout. Existing research works to mitigate such attacks resort to cryptographic solutions and split buffer approaches to intelligently guarantee buffer reservation. In this paper we propose an attacker revelation scheme using Discrete Event Systems (DES) in the framework of Finite State Machines (FSM). The motivation behind our countermeasure is that no work has addressed identification of the adversary in 6LoWPAN setting before. We detect the attack using Wireshark analytics and identify the malicious node from responses to probe packets using a DES based state estimator which ensures correctness too. Our approach is tested on Contiki OS and experimental results show that the proposed scheme provides energy efficient solutions with lesser response times compared to the state of the art solutions.

### **12:15 Detection and Verification of Decreased Rank Attack using Round-Trip Times in RPL-Based 6LoWPAN Networks...208**

Abhay Deep Seth, Santosh Biswas and Amit Kumar Dhar (IIT Bhilai, India)  
The IPv6 over Low-power Wireless Personal Area Network (6LoWPAN) supports IP over Lossy networks. RPL (Routing Protocol for Low-power and Lossy Networks) routing protocol has been developed for 6LoWPAN routing. RPL is vulnerable to various types of attacks namely external and internal. One of the internal attacks for the RPL-based IoT Network is Rank Attack. A spiteful node advertises false decreased rank information to disturb the topology of the network. This attack creates network disruption, loop formation, and degrades network performance in terms of packet delivery ratio, packet delay, and throughput. This paper proposes a novel mechanism to detect and verify the decreased rank attack and exclude the spiteful node from the network using the round trip time (RTT).

### **12:37 On-Node Correlation Based Data Reduction in WSN for Smart Agriculture...214**

Christian Salim and Nathalie Mitton (Inria Lille - Nord Europe, France)  
Nowadays, climate change is one of the numerous factors affecting the agricultural sector. Optimizing the usage of natural resources is one of the challenges this sector faces. For this reason,

it could be necessary to locally monitor weather data and soil conditions to make faster and better decisions locally adapted to the crop. Wireless sensor networks (WSNs) can serve as a monitoring system for these types of parameters. However, in WSNs, sensor nodes suffer from limited energy resources. The process of sending a large amount of data from the nodes to the sink results in high energy consumption at the sensor node and significant use of network bandwidth, which reduces the lifetime of the overall network. In this paper, for data reduction, a data correlation and prediction technique is proposed both at the sensor node level and at the sink level. The aim of this approach is to reduce the amount of transmitted data to the sink, depending on the degree of correlation between different parameters. In this work we propose the Pearson Data Correlation and Prediction (PDCP) algorithm to detect this correlation. This data reduction maintains the accuracy of the information while reducing the amount of data sent from the nodes to the sink. This approach is validated through simulations on MATLAB using real meteorological data-sets from Weather- Underground sensor network. The results show the validity of our approach by reducing the amount of data by a percentage up to 69% while maintaining the accuracy of the information. The humidity values prediction based on the temperature parameter is accurate and the deviation from the real value does not surpass 7% of humidity.

TS 8

### **11:30 Position based Throughput Maximization of Multi-UAV-assisted Relay Networks...220**

Sandeep Kumar Singh (National Sun Yat-sen University, Kaohsiung, Taiwan); Kamal Agrawal (Indian Institute of Technology Delhi, India); Keshav Singh (National Sun Yat-sen University, Kaohsiung, Taiwan); Chih-Peng Li (National Sun Yat-sen University, Taiwan); Wan-Jen Huang (National Sun Yat-Sen University, Taiwan)

In this work, we investigate the performance of best downlink signal to noise ratio (BDS) based unmanned aerial vehicle (UAV) selection scheme in multi-UAV relaying network, where multiple UAVs assist the communication between two ground users (GUs). Firstly, the best UAV is selected using BDS based selection criterion, then, the closed form expressions for the outage probability and throughput of the multi-UAV assisted relay network are derived considering Nakagami-m distributed fading channels. Furthermore, an optimization problem is formulated to ensure maximum system throughput performance by finding the optimal 3D-coordinates (position) of the selected UAV. In addition to this, we derive an upper bound to the system throughput which simplifies the optimization problem and is used in finding a sub-optimal solution to the optimization problem. By Monte Carlo simulation, we validate all the results.

### **12:00 Pano2RSSI: Generation of RSSI maps for a room environment from a single panoramic image...226**

Nibin Raj and D V V Sai Teja (Indian Institute of Space Science and Technology, India); Vineeth Bala Sukumaran (Indian Institute of Space Science and Technology, Trivandrum, India)

We consider the feasibility of predicting received signal strength indicator (RSSI) map for a room environment from a single 360 RGB panoramic image of the room using deep learning (DL). We are motivated by significant applications in rapid and automated deployment of indoor wireless sensor networks. In our knowledge, this is the first work that addresses the feasibility of RSSI prediction from visual input using DL. As a first step towards this, we propose a system, Pano2RSSI, that consists of two deep neural network (DNN) based subsystems in cascade. A single RGB panoramic image of the room environment is fed as input to the first subsystem (Pano2Layout). Pano2Layout predicts the layout of the room as well as detects objects and their

sizes within. This layout information is the input to the second subsystem (RSSI-Net) which predicts a 2D RSSI map for a given 2D transmitter location within the room. In this initial proposal of the system, RSSI-Net assumes that some parameters about the wireless propagation environment are fixed (such as antenna gains, path loss exponent, material permittivities.) We illustrate the end-to-end performance of Pano2RSSI and identify several challenges and possible improvements for this problem.

### **12:30 A Location-Aware Energy-Efficient Scheme for M2M Communications by Resource Efficiency Optimization...232**

Sree Krishna Das (Military Institute of Science and Technology (MIST), Bangladesh); Ratna Mudi (World University of Bangladesh & Jahangirnagar University, Bangladesh)

Fifth-generation (5G) permits user equipments (UEs) to communicate directly with one another for providing better service to the increasing number of UEs by reducing power consumption and improving resource efficiency (RE). As machine-to-machine (M2M) UEs (MUEs) use resource blocks (RBs) and produce interference, therefore how to assign the RBs properly is crucial. Hence, to locate an unknown machine (UM) in 5G is essential for facilitating the proper spectrum reuse in M2M communications. This paper proposes a location-aware mode selection based RE and energy efficiency (EE) optimization process for M2M communications over cellular networks using orthogonal resource sharing scheme. Firstly we develop a location-aware water filling algorithm based RE optimization process for cellular user equipments (CUEs) and EE optimization process for MUEs. RE optimization process provides available resources for CUE and then M2M pair reuses the residual spectrum in the proposed network. As a result, the water filling algorithm reduces the power consumption of UE as well as ensures satisfactory data rate which improves the EE. The proposed network is evaluated using extensive MATLAB simulation results in terms of EE which show that the proposed scheme can improve the system performance significantly.

## **TS 9**

### **11:30 On Collaborative Radio Frequency Observatory in India...238**

Prabhu Chandhar (Chandhar Research Labs Pvt Ltd, India); Vinay U Pai (BITS Pilani, Pilani, India)

In this paper, we describe a national level collaborative radio frequency observatory (CRFO) for maintaining a collection of RF measurement data from various Indian states. The online observatory will be primarily used for monitoring and analyzing the national spectrum usage as well as for the development of machine learning based radio signal classification and identification techniques for anti-jamming, interference management, and cognitive radio (CR) systems. Initial results on national spectrum usage analysis observed from different parts of India show that only a small percentage of GSM spectrum is utilized due to service migration of cellular users to 4G networks. It is also seen that the 4G bands are under-utilized during low traffic conditions. The results suggest that depending on the location, the under-utilized spectrum can be used for CR based services.

### **11:52 Interference-Constrained Power Adaptive Decode-and-Forward Relaying Policy: Design and Performance Analysis...244**

Rahul Sharma (BITS Pilani, Rajasthan, India); B. Sainath (BITS Pilani, India)

Power adaptation is a feasible and promising solution to avoid interference at the primary, caused

by transmissions of secondary underlay cooperative spectrum sharing systems. For it, we propose a novel interference-constrained power adaptive decode-n-forward (IC-PADnF) relaying policy jointly with a simple probabilistic relay selection (PRS) policy. The proposed IC-PADnF relaying policy apart from acting as a regenerative relay, adaptively sets its transmit power and gain to optimize the underlay cooperative spectrum sharing system's performance. Further, the relay selection policy considered is easy to implement due to less channel state information (CSI) requirements. To evaluate the proposed IC-PADnF policy's performance, we derive analytical expressions for optimal fading averaged spectral efficiency, and optimal fading averaged energy efficiency. We also obtain upper-bound to these essential performance measures. We perform Monte-Carlo simulations to validate the derived analytical results. Furthermore, we compared the proposed policy with benchmark policies to explicitly show the performance improvements and its applicability for cooperative spectrum sharing systems and networks.

### **12:15 Noise Analysis and Comparison of an 'M' Repeated/Regenerator Link...250**

Manivasakan R (IIT, Chennai, India); Fredy Francis (Indian Institute of Technology Madras, India)  
The advent of optical amplifiers have revolutionized optical communications, facilitating (Wavelength Division Multiplexed) WDM systems and leading to an explosion in bandwidth and data rates. But long amplified links degrades the optical Signal to Noise Ratio (SNR) with each stage of amplification due to the addition of Amplified Spontaneous Emission (ASE). This is overcome by using regenerators which does the Optical-Electrical and back to Optical (OEO) conversion to detect the signal and regenerating it anew thereby removing all the noise and hence restoring the SNR. But this electrical conversion introduces delays and prohibitively increases the cost of the link. A potential solution for this is the use of all optical regenerators, which does the amplification and reshaping in the optical domain itself. This paper undertakes a BER analysis proving the unconditional superiority of regenerators over repeaters for given link parameters. It also demonstrates the better power savings and extra reach of all optical regenerators. Further, a few approximations are used to represent the Q function analytically and the corresponding expressions are used for comparing the performance of repeaters and regenerators.

### **12:37 Dynamic Relay Selection using a Greedy Cluster Strategy...256**

Raja Mukhopadhyay, Sarmistha Neogy and Samiran Chattopadhyay (Jadavpur University, India)  
One of the primary challenges of relay assisted communications in ad hoc network and device-to-device (D2D) communications in cellular network is sustenance of QoS requirements of mobile users. This paper proposes a relay selection technique based on a greedy clustering scheme that takes relay load and willingness into consideration during relay selection. With a dynamic selection imperative in a mobile environment this technique aims at optimizing the number of selected relays of a node by monitoring the current status of the relays. We compare our proposed technique with the relay selection technique of Optimized Link State Routing (RFC 7181) over two scenarios: the first in an ad hoc scenario with a collection of mobile nodes and the second in D2D communication over cellular scenario. Simulation results show an overall improvement in performance in terms of average network throughput, packet loss rate and end-to-end delay for our proposed technique.

## **Women in Engineering Track-2**

### **11:30 Security vs. Flexibility: Striking a Balance in the Pandemic Era...260**

Vaishali Soni and Deepika Kukreja (Netaji Subhas University of Technology, India); Deepak

Kumar Sharma (Netaji Subhas Institute of Technology, University of Delhi, India)

An organization's reputation is largely dependent on the work culture it provides to its employees. This is the reason, "flexibility" is becoming an inherent part of an employer's support to its employees. Due to the unprecedented outbreak of novel corona virus (COVID-19), most companies have adapted flexibility of working from anywhere, for their employees. This digital transformation took place almost instantaneously. Hence, neither the employees, nor the companies were fully prepared for this situation. This definitely makes our lives convenient. But there exists another side of the coin which is concerned with the security issues pertaining to use of personal networks and devices. The home network devices have not been configured to be secure in line with the company's requirements. That is the reason, attackers have a larger surface to get their hands dirty on. This paper emphasizes on the cybersecurity threats which have emerged in this pandemic era. The work presents the challenges faced by the employees as well as their companies in these tough times. Then this paper discusses the sudden rise in volumes of cyber-attacks between January 2020 to March 2020. Next, it describes the risks which might occur in the near future of the COVID-19 world. The paper proposes some of the ways in which companies can strike an efficient balance between flexibility for employees and security of their assets.

#### **12:00 A Simple Approximation of FSO Link Distribution and its Applications...265**

Arti Mk and Aarti Jain (AIACTR, India)

We consider a wireless free space optical (FSO) communication system. The FSO link is assumed to follow the gamma-gamma distribution. It is shown in literature that the probability density function (PDF) of the gain of FSO link has complicated form, it is in the form of modified Bessel function. Due to its complicated nature, the analytical expressions of FSO communication system has very high computational complexity. In this paper, we derive an approximate expression of PDF of gain for FSO link in terms of series expansion. It is shown in the paper that the derived approximate expression is very accurate and easy to deal. The performance of the FSO communication system is analyzed in terms of bit error rate by using the derived PDF expression.

#### **12:30 Two-Tier Architecture for Heterogeneous Public Safety Wireless Networks...268**

Pimmy Gandotra (Indian Institute of Technology, Delhi, India); Vimal Bhatia (Indian Institute of Technology Indore, India)

Device-to-device (D2D) communication and Heterogeneous networks (HetNet) in wireless communication networks (WCNs) are known to enhance system capacity, coverage and energy efficiency. A key area where these can improve the overall performance during partial and complete infrastructure unavailability, and ensure coverage, along with essential information broadcasting is the public safety communication systems. Looking for an appropriate architectural solution for the 5G WCNs and beyond, during an emergency, this paper proposes a two-tier architecture for achieving guaranteed Quality of Service (QoS). Under appropriate availability from the macro base station (BS), public-safety users are serviced by it directly, which forms Tier 1. However, under the situation of loss of infrastructure and/or for offloading public-safety traffic from the macro BS, the public-safety users are serviced by the Tier 2 elements, i.e small cell BSs and D2D links. As far as possible, use of D2D or cooperative communication is braced, as it provides higher system throughput. Also, D2D supports much lower power consumption, thereby making it more suitable during emergency situations where users may not be able to recharge handsets frequently

**Wednesday, December 16 14:00 - 16:15**

**Women in Engineering Track-3**

**14:00 On the fly classification of traffic in Anonymous Communication Networks using a Machine Learning approach...273**

Lalitha Chinmayee MaheshKumar Hurali (Ramaiah Institute of Technology, India); Annapurna P Patil (M S Ramaiah Institute of Technology, India)

Anonymous Communication Networks (ACNs) provide privacy and anonymity to the users of the Internet. Traffic classification in ACNs is an emerging area of research due to its benefits in network management tasks like network security, Quality of Service provisioning, and in Research and Development of ACNs. Out of the well-known traffic classification approaches available, Machine Learning (ML) based approach has proven to be advantageous over the port-based and payload based approach. Using a publicly released Anon17 dataset, this work presents an ML-based traffic classification technique in ACNs. The proposed technique performs on the fly classification, which involves the classification of traffic as early as possible using the first few packets of traffic flow. The proposed on the fly classification technique outperforms the state of the art technique in ACNs with increased classification accuracy, F measure and requires less number of packets in traffic flow to achieve highest possible performance metrics.

**14:45 Detection and Prevention of Black Hole Attack in SUPERMAN...279**

Kratika Sharma (ABV-IIITM GWALIOR, India); Saumya Bhadauria (ABV-IIITM Gwalior, India)  
MANETs are wireless networks, providing properties such as self-configuration, mobility, and flexibility to the network, which make them a popular and widely used technique. As the usage and popularity of the networks increases, security becomes the most important factor to be concerned. For the sake of security, several protocols and methodologies have been developed for the networks. Along with the increase in security mechanisms, the number of attacks and attackers also increases and hence the threat to the network and secure communication within it increases as well. Some of the attacks have been resolved by the proposed methodologies but some are still a severe threat to the framework, one such attack is Black Hole Attack. The proposed work integrates the SUPERMAN (Security Using Pre-Existing Routing for Mobile Ad-hoc Networks) framework with appropriate methodology to detect and prevent the network from the Black Hole Attack. The mechanism is based on the AODV (Ad-hoc On-demand Distance Vector) routing protocol. In the methodology, the source node uses two network routes, from the source to the destination, one for sending the data packet and another for observing the intermediate nodes of the initial route. If any node is found to be a Black Hole node, then the route is dropped and the node is added to the Black Hole list and a new route to send the data packet to the destination is discovered.

**15:30 Low PAPR Waveform Design for OFDM Systems Based on Convolutional Autoencoder...285**

Yara Huleihel (Ben Gurion University, Israel); Haim H Permuter (Ben-Gurion University of the Negev, Israel); Eilam Ben-Dror (Huawei Technologies Ltd., Israel)

This paper introduces the architecture of a convolutional autoencoder (CAE) for the task of peak-to-average power ratio (PAPR) reduction and waveform design, for orthogonal frequency division multiplexing (OFDM) systems. The proposed architecture integrates a PAPR reduction block and a non-linear high power amplifier (HPA) model. We apply gradual loss learning for multi-objective optimization. We analyse the model's performance by examining the bit error rate (BER), the PAPR and the spectral response, and comparing them with common PAPR reduction algorithms.

**Wednesday, December 16 15:00 - 16:15**

**TS 11**

**15:00 Deep Reinforcement Learning based Traffic Signal Optimization for Multiple Intersections in ITS...291**

Ananya Paul (IEST, India); Sulata Mitra (Indian Institute of Engineering Science and Technology, India)

The number of vehicles is drastically increasing worldwide, especially in large cities. Thus there is a need to model and enhance the traffic management to help meet this rising requirement. The primary purpose of traffic management is to reduce traffic congestion by optimizing traffic signal, which is currently one of the main concerns. Reinforcement Learning (RL) approaches in Intelligent Transportation System (ITS) are infeasible for traffic management of large road networks. However, Deep Reinforcement Learning (DRL) is capable of handling this enlarged problem. In order to manage the traffic flow of a large road network, there is a strong need for coordination between traffic signals of the intersections, enabling vehicles to pass through intersections more easily. In this paper, a single DRL agent manages the traffic signal of multiple intersections using policy gradient algorithm. In particular, the agent is trained with spatio-temporal data of the environment that allows it to perform action in different deep neural network models. The simulation experiment is studied in terms of three different simulation metrics. The proposed system outperforms while comparing it with the baseline i.e. fixed signal duration systems.

**15:25 Deep Learning based Symbol Detection for Molecular Communications...297**

Sanjeev Sharma (IIT (BHU) Varanasi, India); Dharmendra Dixit (Indian Institute of Technology Bhubaneswar & REC Sonbhadra, India); Kuntal Deka (IIT Goa, India)

Molecular communication (MC) can play an indispensable role in nanonetworks and Internet of Bio-nano Things based applications. However, inter-symbol interference (ISI), due to slow diffusion of molecules can severely degrade system's performance. In this paper, we propose a deep learning (DL)- based receiver design to decode the data symbols in MC. The proposed DL-based receiver (DLR) does not require the channel state information and threshold value(s) implicitly to decode the data symbols. The DLR is trained offline by applying the data symbols generated from simulation based on diffusion channel statistics, then it is used for recovering the online transmitted data symbols directly. Impact of various system parameters such as diffusion coefficient, noise and ISI level, and frame duration are analyzed for DLR. DLR's performance is also compared to conventional detection methods. Results show that DLR can be a viable and practical choice in MC system design.

**15:50 Artificial Intelligence-based Approach for Gait Pattern Identification Using Surface Electromyography (SEMG)...303**

Sri Sai Madhu Vinay Chowdary Y and Jaswanth Tokala (The LNM Institute of Information Technology, India); Sanjeev Sharma (IIT (BHU) Varanasi, India); Vikas Sharma and Abhishek Sharma (The LNM Institute of Information Technology, India)

Internet of Things (IoT) is gaining significant development for various applications, including healthcare and medical field. The connectivity of sensor nodes using IoT enables the possibility of extracting more features from the data gathered. This information can be used to prepare real-time

assistive technology and help in supervision, alert generation, training, and logging the activity for future purposes. In this work wearable Electromyography (EMG) based system is being presented to measure gait parameters in everyday life. EMG is implemented for recording the electrical activity of muscle tissue. Therefore, surface EMG (SEMG) is employed in most research works to get information related to muscle movements in health and posture recognition. We use gait prediction of a person using SEMG to monitor daily living activities, which includes climbing, walking, jogging, and jumping. The MyoWare muscle sensor is used for the experiment. The fetched data is processed using a deep neural network model to recognize the above-mentioned activities. The 98.44 percent accuracy is observed with the convolutional neural network model.

TS 12

**15:00 An Analysis on the Impact of Utility Functions on the Performance of Game Theory Based Channel Allocation in Cognitive Radio Wireless Sensor Network...309**

Prativa Rai (Sikkim Manipal Institute of Technology, India); M. K. Ghose (SMIT, India); Hiren Kumar Deva Sarma (Sikkim Manipal Institute of Technology, India)

Cognitive Radio enabled Wireless Sensor Network has attracted researchers in present time. Channel allocation in such a network is a challenging task. Game Theory may also be applied to solve such issues and limited literature is available on this. However, while designing games for channel allocation, choice of utility function plays an important role in order to meet higher performance level by the channel allocation algorithm. In this paper, impact of various utility functions which may be used in GT based channel allocation algorithms is explored. Entire process of assigning channels to different nodes through game based allocation has been detailed. Simulations results are reported showing performance of three different utility functions which may be used in game based channel allocation. Future scopes of the work are outlined.

**15:18 A Hybrid Approach for Fast Anomaly Detection in Controller Area Networks...315**

Jerin Sunny (Amrita Vishwa Vidyapeetham & Center for Cybersecurity Systems and Networks, India); Sriram Sankaran (Amrita University, India); Vishal Saraswat (Robert Bosch Engineering and Solutions Pvt Ltd, India)

Recent advancements in the field of in-vehicle network and wireless communication, has been steadily progressing. Also, the advent of technologies such as Vehicular Ad-hoc Networks (VANET) and Intelligent Transportation System (ITS), has transformed modern automobiles into a sophisticated cyber-physical system rather than just a isolated mechanical device. Modern automobiles rely on many electronic control units communicating over the Controller Area Network (CAN) bus. Although protecting the car's external interfaces is an vital part of preventing attacks, detecting malicious activity on the CAN bus is an effective second line of defense against attacks. This paper proposes a hybrid anomaly detection system for CAN bus based on patterns of recurring messages and time interval of messages. The proposed method does not require modifications in CAN bus. The proposed system is evaluated on real CAN bus traffic with simulated attack scenarios. Results obtained show that our proposed system achieved a good detection rate with fast response times.

**15:37 An Efficient Probabilistic Model for Anomaly Prediction in Aerial Ad Hoc Networks...321**

Chafiq Titouna (Paris University, France); Farid Nait-Abdesselam (University of Missouri Kansas City, USA)



The increasing use of Unmanned Aerial Vehicles (UAVs) in various applications of Aerial Ad Hoc Networks, such as precision agriculture and aerial remote sensing, is fast contributing to their adoption in many civilian applications. Generally equipped with multiple sensors, such as cameras and movement detectors, UAVs are also deployed in hostile environments such as disaster zones or military fields. Therefore, and in order to ensure the success of any deployment of Aerial Ad hoc Networks, detecting and isolating failures is of great importance to allow a high level of security and reliability. In this research, we first introduce a model using a Bayesian network that copes with this type of issues and tries to detect any faulty UAV. Second, we develop a probabilistic predictive scheme to avoid the unexpected failure of a UAV. The proposed approach is validated using realistic synthetic datasets provided by the UAV laboratory at the University of Minnesota.

### **15:56 A Novel Frame model for Cluster Head Selection and Codeword Detection in the 5G Cellular Networks...327**

Venkata Sunil Reddy Timmareddy, SatyaJaswanth Badri and Vijay Bhaskar Reddy Chintakunta (Sree Vidyanikethan Engineering College, India); Rishabh Mohta (Illinois State University, USA); Kalpana Vattikunta (Sree Vidyanikethan Engineering College, India)

4G communications were ruling the entire world with its high-speed network; however, if the users increased, then its speed gets decreased. The 5G model developed, and its rate of data is higher than the 4G frame model. Also, the dense weight node in the cellular network consumed more energy that tends to signal failure. So to make the 5G mobile communications efficient, the present article aimed to develop a novel Grey Wolf (GW) clustering model to choose the cluster head. Moreover, the codeword selection refined by a novel Generalized Intelligent Fuzzy (GIF) mode. Finally, the predictive model as a novel African Buffalo-based Recurrent Model (ABRM) deep learning model developed as the predictive model for continuous multi-user (MU) prediction and monitoring. Subsequently, the data transferred effectively, and its success rate is evaluated with existing models our proposed model gained an excellent outcome by attaining 98.8% of accuracy and reduced complexity rate as 17%.

## **Wednesday, December 16 15:00 - 16:30**

### **Workshop: Fog Networks**

### **15:00 Application-Specific Service Function Chain Provisioning in Heterogeneous Fog Networks...333**

A. Jaesim (University of Mount Union, USA); Nazli Siasi, Majdi Ababneh and Mohamed Elkourdi (University of South Florida, USA); Amro A. Nour (American University of Kuwait, Kuwait)

Cloud architectures provide abundant resources, albeit with prolonged link delays. Meanwhile, fog architectures provide limited resources at the expense of limited resources. Hence, hybrid fog-cloud solutions have been proposed to combine the benefits of both architectures. However, users demand low latency and high processing still cannot be accommodated using the hybrid model. Therefore, this paper presents a heterogeneous single-tier fog architecture suitable for data-intensive and delay-sensitive requests, which represents the worst-case scenario for the type of incoming requests from the network perspective. Moreover, an efficient service function chain provisioning scheme is implemented here on the proposed architecture. The scheme leverages coordinated generalized pattern search algorithm and yields reduced network delays and energy consumption as opposed to the hybrid solution.

**Wednesday, December 16 16:45 - 18:00**

**TS 13**

**16:45 Quality of Experience Aware Medium Access Control in Attocell Network...339**

Kshitiza Singh (Indian Institute of Technology Delhi, India); Abhishek Dixit (Indian Institute of Technology Delhi & IBBT, India); V K Jain (IIT Delhi, India)

With the development of converged optical-wireless networks, the mobile users can access a very high bandwidth, any time and anywhere, for the upcoming real-time applications. In the modern digital world, quality-of-experience (QoE) has become the central area of concern to ensure end-to-end user satisfaction. In this paper, we analyze the quality-of-service (QoS) for different traffic classes for a radio-over-fiber (RoF) based attocell network. For this, we use a simple polling algorithm with dynamic weighted queuing for grant sizing and maintains a delay within the maximum bounds for high and medium priority traffic classes with high channel utilization. Further, we propose a model to map QoE with the QoS parameters, like delay, jitter, and packet loss rate, and quantify QoE by representing the degree of user satisfaction by a mean opinion score.

**17:03 On the average and peak age-of-information for Berkeley-MAC protocol...345**

Govind Ajith Mydhili (Indian Institute of Space Science and Technology, India); Vineeth Bala Sukumaran (Indian Institute of Space Science and Technology, Trivandrum, India)

We consider a remote monitoring and estimation scenario, where multiple sensors sample processes of interest and transmit their measurements to a power-constrained base station over a single-hop wireless network. We are motivated by applications in unmanned aerial vehicle (UAV) data collection networks where the base station is a power-constrained UAV. The objective of the base station is to remotely estimate the processes with minimum error from the received measurements and to optimize power consumption. The sensors use a preamble-sampling medium access control protocol to improve base station power efficiency. Recently, the Age-of-Information metric has been used to study network performance for minimum error remote estimation objective. Therefore, we consider the Age-of-Information performance of a widely used preamble sampling protocol, Berkeley-MAC (BMAC), for a single-hop wireless network. We analytically characterize the average and peak Age-of-Information for BMAC in a low-contention regime. We also analyse the average and peak Age-of-Information using simulations.

**17:22 CSMA/SR Decentral Spatial Reuse Channel Access Algorithm for Wireless LAN...351**

Michael Knitter (University of Dortmund, Germany); Wolfgang Endemann and Ruediger Kays (TU Dortmund University, Germany)

The upcoming IEEE 802.11ax standard renews the discussion on spatial reuse by parallel transmitting links. The standard uses carrier sense threshold level and transmit power adjustments to potentially improve performance of the network. Related work shows that allocating dedicated transmit power and rate settings per link is key to fully utilize spatial reuse potential. This paper discusses how to best apply such spatial reuse concepts to a decentral channel access protocol. A state time model reflects fundamental performance drivers and limits of the approach. The proposed CSMA/SR algorithm shows up as a good compromise between needed protocol overhead and achieved throughput improvement. An IEEE 802.11ax based simulation demonstrates a CSMA/SR system performance improvement up to 46 % compared to standard CSMA/CA.

### **17:41 Jamming on Throughput Improvement in Cognitive Radio Networks...357**

Avik Banerjee (Madanapalle Institute of Technology & Science, India); Santi Prasad Maity (Indian Institute of Engineering Science and Technology, Shibpur, India)

This work considers a cognitive radio (CR) system model containing a set of transmit-receive node pairs, one fusion center (FC), one primary user emulation attack (PUEA) node, an eavesdropper node (Eav) and a set of jammers. The CR operation is governed by repetitive time frame wherein at the initial time slot, simultaneous energy harvesting (EH) and spectrum sensing (SS) are done through power splitting (PS) mode. Based on SS decision at the FC, CR transmitters and jammers either perform EH from primary user (PU) signal over the remaining slot or make an opportunistic data transmission. Eavesdropping is prevented by selecting the best friendly jammer that minimizes the signal to interference ratio at the Eav. Sum secondary throughput of the network is maximized under the constraints of meeting the sensing reliability of PU, energy causality of SU node and friendly jammer, interference at PU receiver, individual secondary and secrecy outage probability. Simulation results show ~4.5% and ~14.79% gain in sum secondary throughput and residual energy, respectively.

## **TS 14**

### **16:45 Capacity of Ligand Receptor Channel with Markovian Symbol Detection...363**

Muskan Ahuja (IIT Campus, Hauz Khas, India); Manav Bhatnagar and Ankit Ankit (Indian Institute of Technology Delhi, India)

Stochastic representation of ligand receptor binding is important to provide a receiver modeling of the molecular communication system. In this paper, we model the binding of a finite number of ligand receptors on the receiver with discrete time Markov chains. A novel Markov chain model is introduced for the final output which considers the combined effect of responses received on each ligand receptor. Moreover, the maximum rate at which the proposed chemical binding can operate is presented by analytically quantifying the discrete time capacity of the ligand channel for a binary source. The derived capacity analysis clearly articulates the advantage obtained by employing multiple receptors over a single receptor in a biological signaling scenario with a threshold detector giving the final output.

### **17:10 Spectral Efficiency in Poisson Cluster Based HetNets with Users-Basestations Correlation...369**

Nitish Vikas Deshpande and Sandeep K Routray (Indian Institute of Technology, Kanpur, India); Abhishek K Gupta (Indian Institute of Technology Kanpur, India)

In this paper, we consider a realistic K tier heterogeneous cellular network (HetNet) consisting of two types of coexisting tiers: Poisson cluster process (PCP) based tiers with base-stations (BSs) and users (UE) distributed as PCP and are coupled, and Poisson point process (PPP) based tier with BSs and UEs distributed as mutually-independent PPPs. We derive the spectral efficiency (SE) for a typical user belonging to one of the tier under max-power association and open access. An important intermediate step involves deriving expressions for the Laplace transforms (LT) of total received power and interference which also opens new avenues for computation of other performance metrics. We also investigate the impact of clustering over the performance of both type of users via numerical simulation and provide important design insights.

### **17:35 Increasing Cell Throughput and Network Capacity in a Real-world HetNet Environment...375**

Haijun Gao, Japjot Bawa and Raman Paranjape (University of Regina, Canada)

Wireless cellular networks have been extensively developed for the past decades from 3G to 5G. In this paper, a novel algorithm is proposed to increase the cell throughput in a small cell indoor environment. The algorithm combines k-means clustering and cell-splitting technique. Instead of solely using k-means clustering to cluster locations of users and small cells, an indicator is assisted to help identify potential antennas that are useful for increasing cell throughput in the optimization process. In addition, simulations and a series of data collections for verifying our algorithm are performed in a real-world LTE-A HetNet (heterogeneous network). The simulation results indicate that our algorithm can boost cell throughput of the whole system by up to 43% compared to the initial setting of directly using cell-splitting. The results of the measured data show that the algorithm can improve the cell throughput of the hotspot by about 36% in terms of basic cell-splitting settings. This algorithm will be beneficial for the network when it does not have enough capacity for users in small cell environments.

TS 15

#### **16:45 An Efficient Edge Analytical Model on Docker Containers for Automated Monitoring of Public Restrooms in India...381**

Rajasi Gore (Motilal Nehru National Institute of Technology & MNNIT Allahabad, India); Shashwati Banerjea (MNNIT Allahabad, India); Neeraj Tyagi (Motilal Nehru National Institute of Technology Allahabad, India); Sanu Saurav, Deepesh Acharya and Vishesh Verma (Motilal Nehru National Institute of Technology, India)

The government of India proposed "Clean India Mission" in 2014 that has led to the establishment of many public restrooms across the country. The purpose of this mission is to provide hygienic toilets to prevent open defecation and eradicate water-borne diseases. These restrooms are assigned human resources. However, the majority of them are in bad condition for usage. For increasing the availability of toilets, there is a requirement of a smart sanitation system for its automated monitoring. Moreover, rural and semi-urban restroom locations suffer from limited network connectivity. Thus, restroom state analysis needs to be performed near to the sites for seamless monitoring. This paper proposes an edge analytics framework based on the Internet of Things (IoT) and fog computing to analyze restroom data at the network edge and provide intelligent decisions. The machine learning model runs over Docker containers for analyzing data due to resource-constraint fog nodes. The choice of a machine learning model for analysis depends on the model's performance in classification and on Docker containers over Raspberry Pi. Results show Adaptive Neuro-Fuzzy Inference System (ANFIS) is suitable over Docker containers for handling restroom data at the edge of the network.

#### **17:10 Fully Homomorphic Encryption based Privacy-Preserving Data Acquisition and Computation for Contact Tracing...387**

Koushik Sinha (Southern Illinois University, Carbondale, USA); Pratham Majumder (CMR Institute of Technology, India); Subhas Kumar Ghosh (Commonwealth Bank of Australia & Corporate Technology India, Australia)

For public health surveillance systems, privacy is a major issue in storing and sharing of personal medical data. Often, patients and organizations are unwilling to divulge personal medical data for fear of compromising their privacy because although the data may be encrypted, the encrypted values typically need to be first decrypted to perform any computation on the data. Unfortunately, such a barrier in easy sharing of data can severely hamper the ability to respond in a timely and effective manner to a crisis scenario, as evident in the case of the ongoing COVID-19 pandemic. To

overcome this critical obstacle, we propose in this paper a novel privacy-preserving encryption mechanism for storage and computation of sensitive healthcare data. Our scheme is based on the use of a secure fully homomorphic encryption scheme, so that the required computations can be performed directly on the encrypted data values without the need for any decryption. The ability to execute queries or computation directly on encrypted data, without the need for decryption, is not present in any existing public-health surveillance system. We propose a novel computational model and also develop an algorithm for contact tracing with COVID-19 pandemic as a case study. We have simulated our proposed approach using the ElGamal encryption algorithm to check the correctness and effectiveness of our proposed approach. The results show that our proposed solution is effective in providing adequate security while supporting the computational needs for contact-tracing. Besides contact-tracing, our new data-encryption technique can have a much broader impact in the field of healthcare. By executing queries or computations directly on encrypted data, our innovative solution would make the sharing of data in healthcare-related research and industry significantly simpler and faster. The use of such a data encryption scheme to store and transmit sensitive healthcare data over a network can not only allay the fear of compromising sensitive information but also ensure HIPAA-compliance.

### **17:35 Network Security Systems Log Analysis for Trends and Insights: A Case Study...393**

Amit Kumar Meena and Neminath Hubballi (Indian Institute of Technology Indore, India); Yogendra Singh (IIT Indore, India); Vimal Bhatia (Indian Institute of Technology Indore, India); Katrin Franke (NTNU, Norway)

Network perimeter security appliances like firewalls, intrusion detection systems mediate communications and log details pertaining to various events. Logs generated by these systems are used to identify security compromises, vulnerable systems, mis-configurations, etc and serve as a valuable asset for a network administrator. In this paper, we report on a study conducted using logs generated by production level security appliances deployed in our university network. In particular, we process the logs generated by firewall, intrusion detection/prevention system and domain name system service to identify trends and gain insights. We process 71 million network connection records which includes 95.7 thousand alerts generated by an open source intrusion detection system collected over a period of 31 days and derive statistics to understand end host level behavioral trends. In our analysis we compare hosts which are known to be infected with malware or running Peer-to-Peer applications and remaining using a set of relevant parameters and identify clearly differentiated behavioral trends.

## **Women in Engineering Track-4**

### **16:45 Robust Maximum Likelihood Algorithm-based Mitigation technique for impulsive noise in MIMO-OFDM systems...399**

Girija Prabhakar Sakimalla (Kakatiya Institute of Technology & Science, Warangal); Rameshwar rao R (Osmaniya, India)

Non-Gaussian impulsive noise impacts the equalizers and signal detectors directly in the wireless system. The major problem in the MIMO-related applications is the blind source equalization and separation, where the users transmit multiple digital signals in a linear channel that is received using the array of antennas. The noise in the received signals are impulsive in nature, which is mitigated in the research by implementing Robust Maximum Likelihood Algorithm (RMLA) for handling the degradation of the performance in the wireless system. The constant modulus cost function formulated using RMLA is used for modelling the equalizer to adaptively suppress the influence of

the impulsive noise. The effectiveness of the proposed RMLA based impulse noise mitigation is evaluated based on the evaluation metrics, such as Bit Error Rate (BER), Mean Square Error (MSE) and Symbol Error Rate (SER) corresponding to the Signal-to-Noise Ratio (SNR) and dissimilar antenna array size. The proposed RMLA based BE method provided a minimum BER values of 0.0021, 0.0044, 0.0142 and minimum MSE value of 0.0006, 0.0012, and 0.0037 with the Rayleigh channel, minimum BER values of 0.0006, 0.0012 and 0.0013 and provided minimum MSE value of 0.0003 with the Rician channel.

#### **17:10 Priority Order-Based Key Distribution in QKD-secured Optical Networks...405**

Purva Sharma (Indian Institute of Technology, Indore, India); Vimal Bhatia (Indian Institute of Technology Indore, India); Shashi Prakash (Devi Ahilya University, India)

In quantum key distribution (QKD)-secured optical networks, blocking increases with the number of QKD lightpath requests as well as with the number of times modification required to improve the security level of QKD lightpath requests. The blocking is severe problem in such networks because of the limited number of resources (wavelengths and time-slots) in each fiber link. In this paper, we propose a priority order-based routing wavelength and time-slot allocation (POB-RWTA) scheme to reduce the blocking of QKD lightpath requests. In the proposed POB-RWTA scheme, the QKD lightpath requests are served according to their priority order. The priority order of each QKD lightpath request is based on the security level. The blocking of high priority lightpath requests (HPLRs) and total incoming QKD lightpath requests due to limited resources can be reduced using the above criterion of priority order. The performance analysis of the proposed POB-RWTA scheme is made in terms of the success probability of QKD lightpath requests considering different wavelengths for QSch and the probability of secret key update failure. We compared the proposed POB-RWTA scheme with a non-priority order-based routing wavelength and time-slot allocation (NPOB-RWTA) scheme. Simulations performed on NSFNET topology show that by using the POB-RWTA scheme, the success probability of HPLRs and total incoming QKD lightpath requests are significantly improved as compared to NPOB-RWTA.

#### **17:35 Virtual Network Function Embedding under Nodal Outage using Reinforcement Learning...411**

Swarna Bindu Chetty (University College Dublin, Ireland); Hamed Ahmadi (University of York, United Kingdom (Great Britain)); Avishek Nag (University College Dublin, Ireland)

With the emergence of various types of applications such as delay-sensitive applications, future communication networks are expected to be increasingly complex and dynamic. Network Function Virtualization (NFV) provides the necessary support towards efficient management of such complex networks, by disintegrating the dependency on the hardware devices via virtualizing the network functions and placing them on shared data centres. However, one of the main challenges of the NFV paradigm is the resource allocation problem which is known as NFV-Resource Allocation (NFV-RA). NFV-RA is a method of deploying software-based network functions on the substrate nodes, subject to the constraints imposed by the underlying infrastructure and the agreed Service Level Agreement (SLA). This work investigates the potential of Reinforcement Learning (RL) as a fast yet accurate means (as compared to integer linear programming) for deploying the softwarized network functions onto substrate networks under several Quality of Service (QoS) constraints. In addition to the regular resource constraints and latency constraints, we introduced the concept of a complete outage of certain nodes in the network. This outage can be either due to a disaster or unavailability of network topology information due to proprietary and ownership issues. We have analyzed the network performance on different network topologies, different capacities of the nodes and the links, and different degrees of the nodal outage. The computational time escalated with the

increase in the network density to achieve the optimal solutions; this is because Q-Learning is an iterative process which results in a slow exploration. Our results also show that for certain topologies and a certain combination of resources, we can achieve between 70-90% service acceptance rate even with a 40% nodal outage.

**Thursday, December 17**

**Thursday, December 17 11:30 - 13:00**

**TS 16**

**11:30 Network failure assessment based on graph signal processing...417**

Anurag Prakash (Indian Institute of Technology Delhi & Ciena, Canada); Subrat Kar (Indian Institute of Technology, Delhi, India)

Network fault analysis is done to assess network degradation and pursue network planning. A real-time assessment of the extent of degradation is usually provided corresponding to the forwarding capacity of the failed routing node or link. However, the network operates in a diminished capacity and reroutes services to cope up with the faults. This introduces congestion on certain flows, or latency on services and functions, which are many hops away from the faults. The spread of such failures is referred to as the blast radius. To assess network degradation, existing methods use correlation of flows, link utilization and routing schemes to services and network functions, which are time-consuming. In this work, we propose a new method to assess the spread of such failures, which follows the progression of flows with network topology. This new method is based on sequential estimation and graph signal processing. The method provides an estimate of the blast-radius and eventual flow distribution in the network. We simulate one or multiple faults in different network topologies to verify our method. The simulation results show that our method provides an effective way to assess network degradation due to node or link failures.

**11:52 Performance Evaluation of Integrated XG-PON and IEEE 802.11ac based EDCA Networks...423**

Akshita Gupta and Hritik Goel (Indraprastha Institute of Information Technology, India); Vivek A Bohara (Indraprastha Institute of Information Technology, Delhi (IIIT-Delhi), India); Anand Srivastava (Indraprastha Institute of Information Technology Delhi, India)

The increase in demand for multimedia services and real-time applications has led to the increasing deployment of telecommunication services all over the world. However, this also necessitates the requirement for the enhanced performance in the quality of service (QoS) parameters of the network, such as throughput, packet loss rate (PLR), and end-to-end delay. In this paper, we investigate an integrated fiber-wireless (FiWi) network composed of a 10-Gigabit-capable passive optical network (XG-PON) and IEEE 802.11ac based wireless local area network (WLAN). The paper aims to enhance the throughput of the FiWi network such that each user is granted an uplink bandwidth of 100 Mbps. At the optical line terminal (OLT), the deficit dynamic bandwidth allocation (DBA) algorithm is incorporated to provide the necessary QoS at the users. It has been shown through intensive simulations the proposed work is able to achieve an improvement in the QoS parameters like average throughput, end-to-end delay, PLR, and aggregate throughput within an acceptable range of International Telecom Union-Telecommunication Standardization Sector (ITU-T) standards.

### **12:15 Real-time Spatio-Temporal based Outlier Detection Framework for Wireless Body Sensor Networks...429**

Ali Haj-Hassan (Université de Bourgogne Franche-Comté, France); Carol Habib (Junia, France); Jad Nassar (HEI - Yncréa HdF, France)

Wireless body sensor networks (WBSNs) are threatened by many issues like anomalies in collected data and failure in their hardware components. An outlier detection approach applied on online monitoring of vital signs can both prevent collection of outlier data and detect emergent health degradation. In this paper, we propose an outlier detection framework for real time sensed data by WBSNs. Our proposed solution is twofold: Robust z score algorithm is executed at first step on the sensor nodes level to detect abnormal values and send them to the coordinator. After that, Isolation Forest is executed at the coordinator to distinguish between a faulty measurement and a critical health state. Correlation among vital signs are exploited to differentiate between an emergent healthy event and an anomaly in the measured data. Experiments conducted on real physiological datasets show that our proposed method is able to achieve a good detection accuracy with a low false alarm rate. Complexity and energy efficiency studies demonstrate the low complexity and lightness of our proposed solution.

### **12:37 Geometric Sequence Technique for Effective RTO Estimation in CoAP...435**

Vishal Jitendrakumar Rathod (National Institute of Technology Karnataka Surathkal, India); Mohit P. Tahiliani (National Institute of Technology Karnataka, Surathkal, India)

Internet of Things (IoT) is a network where physical objects with Internet connectivity can interact and exchange information with other connected objects. IoT devices are constrained in terms of power and memory, and have limited communication capabilities. The Constrained Application Protocol (CoAP) is a lightweight messaging protocol which is widely used by various IoT applications in low power and lossy wireless networks. CoAP provides reliability and minimal congestion control via a fixed Retransmission TimeOut (RTO) and Binary Exponential Backoff (BEB). It does not maintain end-to-end connection information and therefore, cannot adapt RTO based on the network conditions. Moreover, CoAP resets the RTO to its default value after having received the ACK for the retransmitted packet. This approach of resetting the RTO degrades the performance in a network with high latency and leads to spurious retransmissions. In this paper, we propose a Geometric Sequence Technique (GST) for effective RTO estimation in CoAP. GST retains the previous RTO value after having received the ACK for the retransmitted packet and eventually returns to the default value by decreasing the RTO depending on the number of consecutive successful transmissions. The proposed technique is implemented in Contiki OS and validated against the existing mechanisms. The experiments have been conducted using the Cooja simulator and the FIT/IoT-LAB testbed to verify the effectiveness of the proposed technique. The results show that GST minimizes the Flow Completion Times (FCT), reduces the number retransmissions and improves the network throughput.

TS 17

### **11:30 Collaborative learning-based Schema for Predicting Resource Usage and Performance in F2C Paradigm...441**

Souvik Sengupta (Fundacio i2CAT, Spain); Jordi Garcia (UPC BarcelonaTech (CRAAX), Spain); Xavier Masip-Bruin (Universitat Politècnica de Catalunya (UPC) & Advanced Network Architectures Lab (CRAAX), Spain)

Better resource utilization is a continuous demand for smart computing paradigm. Fog-to-Cloud



(F2C) is emerging to satisfy that need. Adopting machine-learning (ML) techniques help F2C to priorly forecast system resource usage and performance, for keeping its promise towards better resource management. Performing ML techniques for predicting the resource usage and performance needs historical data of system resources. Processing over that data for extracting the knowledge is one of the essential steps in ML techniques. Based on the obtained knowledge, prediction model is built to perform forecasting operation. This course can be done either in a logically centralized location (cloud) or distributed locations. Due to data privacy issues and bandwidth limitation, it is often an impractical and massive resource-consuming job to continuously send resources statistical data to the centralized location. Also, the local execution of these operations reduces service latency for any time-sensitive applications. Considering these and observing F2C computing facilities, we realize to build a new architectural framework for adaptively managing F2C resources. In this framework, we implemented a globally coordination-based distributed learning and prediction mechanism for accurately forecasting the resource usage (i.e., RAM, CPU, Disk) and execution-time (performance) for achieving some tasks. Finally, performing comparative tests between our proposed framework and centralized learning and prediction based computing framework, shows our proposed framework outperforms over the centralized framework, in terms of prediction accuracy. Also, we found that in our proposed framework, the overall bandwidth utilization reduces by one-third, and data transmission time becomes lower by half to the centralized framework.

#### **11:48 Group based Publisher-Subscriber Communication Primitives for ndnSIM...447**

Ananthakrishnan S (National Institute of Technology Karnataka, India); Mohit P. Tahiliani (National Institute of Technology Karnataka, Surathkal, India); Deepaknath Tandur (Hitachi ABB Powergrids, India); Hariram Satheesh (ABB, India)

Named Data Networking (NDN), an information centric network architecture, aims to provide an efficient and scalable alternative for content distribution. Modern Internet applications have more emphasis on data, and are less concerned about the location from where data is retrieved. NDN's communication primitives being strictly pull based help in bringing this focus shift from location of data to the data itself. A concern for NDN is to enable the support of other popular communication primitives, such as the Publisher-Subscriber (Pub-Sub) model, seamlessly. The Pub-Sub model is well suited for applications that require periodic retrieval of data or event triggered data, such as in Industrial Automation Control Systems (IACS). This paper presents the design and development of a model to support the group based Pub-Sub communication primitives in ndnSIM, a popular ns-3 based network simulator for NDN. The functionality of the proposed model is tested by developing an end-to-end simulation environment in ndnSIM, that is representative of the popular use cases of Pub-Sub communication primitives.

#### **12:06 Testing Smart DTN Routing Using CloudLab...453**

Ricardo Lent and Gandhimathi Velusamy (University of Houston, USA)

A series of experiments were conducted using both CloudLab and a dedicated laboratory testbed to test the performance of the Cognitive Space Gateways (CSG)--an approach to DTN routing that exploits a spiking neural network as a learning element to discover and dynamically forward data bundles. The experiments focus on evaluating the average response time of bundles and throughput of a data flow sent at given traffic intensity over an emulated space network. The same topology and identical, repeatable tests were run on both facilities. The results help to validate the performance of the CSG routing approach compared to the Contact Graph Routing algorithm using independent experimental settings. Furthermore, the experiments reveal some of the challenges

associated to the use of network virtualization, as done in CloudLab, when applied to network performance measurements.

#### **12:24 Machine Learning and Caching based Efficient Data Retrieval Framework...457**

Shashwat Mishra (BITS-Pilani, KK birla Goa Campus, India); Rahul Bajpai (BITS-Pilani, KK Birla Goa Campus, India); Naveen Gupta (BITS Pilani Goa, India); Vibhutesh Kumar Singh (University College Dublin, Ireland)

The explosive growth of wireless data and traffic, accompanied by the rapid advancements in intelligence and the processing power of user equipments (UEs), poses a very difficult challenge to the data providers to maintain the high data rate with sustainable quality-of-service (QoS). A lot of data can be saved by using caching based communication techniques, which would save the service providers a fortune and will make internet connectivity even more affordable. Also, there is room for saving bandwidth and using the limited number of servers and towers efficiently outputting a steadily healthy QoS. We propose an efficient data retrieval framework that uses caching based on the popularity of the pages where the popularity of pages is determined by the number of hits it gets over a month, which is the learning phase of the model and how frequently a given web page is requested. The proposed framework uses a causal decision tree in the background to determine the popularity of pages according to which the algorithm decides whether a given page is worthy of being cached or not. Results show that our proposed model outperforms the conventional data retrieval models in terms of cache missed probability.

#### **12:42 E-Governance: A Tendering Framework Using Blockchain With Active Participation of Citizens...461**

Yashita Goswami and Ankit Agrawal (BITS Pilani, India); Ashutosh Bhatia (Birla Institute of Technology and Science, Pilani, India)

E-governance, i.e., the use of information technology for government activities to provide services, exchange information, etc. are becoming increasingly popular. One such area of e-governance is e-tendering. While e-tendering makes the tendering process more efficient, a trust deficit remains between the citizens and the government, due to the centralized management of the whole tendering process. Several research works provide a decentralized solution to make the process of e-tendering more secure, transparent, and fair. However, in the present time, the government posts the problems/issues currently they are dealing with; and seems interested in taking the suggestions from the citizens to make the better solution for the problem. Thus, in this paper, a permissioned blockchain-based approach to provide a transparent and fair tendering system with citizens' active participation and tracking of funds is presented. In the proposed scheme, the citizens can see the tendering activities transparently and give ideas and suggestions to solve the government's posted problems and receive a due credit of that contribution in a fair manner.

**TS 18**

#### **11:30 A Modular Hybrid Simulator for LoRaWAN...465**

KM Poonam Maurya (IIT Bhilai, India); Arzad Kherani (Indian Institute of Technology, Bhilai, India)

Low Power Wide Area Network (LPWAN) is considered as a prime choice for Internet of Things (IoT) connectivity as they provide low power data transmission over a wide range of communication. A simulation analysis gives an idea of how the deployed IoT network is going to

behave and what kind of challenges it can face. A simulation-based study to assess the performance before deployment of IoT network is preferable. We have developed a discrete event, scalable, and open-source LoRaWAN network simulator, called Modular Hybrid Simulator for LoRaWAN. The script of the developed simulator is written in Python. The designed simulator consists of multiple modules for the required actions of LoRa communication. These modules are easy to understand and can be adapted to the application requirements. As the developed simulator deals with the IQ (in-phase and quadrature-phase) samples, it gives a better understanding of the LoRaWAN (MAC) and LoRa (PHY) interaction.

### **11:52 Identity Based Security Framework For Smart Cities...469**

Gokul Nb (Amrita Vishwa Vidyapeetham, India); Sriram Sankaran (Amrita University, India)

A smart city is a next generation city where it uses information and communication technologies (ICT) to improve the quality of life a person by smartly providing different services and basic amenities with efficiency and reliability. It is very critical to secure the privacy of a person in each system the user interacting with. In this project we are coming up with an identity based security framework for smart cities. The framework is an alternate yet efficient solution to the existing PKI security requirements the smart cities. Proposed solution implements identity based cryptography technique that uses known identities as public keys. Our solution could replace the traditional Public Key Infrastructure in smart cities to reduce the infrastructure overhead a PKI could impose. The goal of this framework is to provide three main points namely security, reliability and efficiency.

### **12:15 Performance Analysis of SIMO-UWOC System...473**

Nabajyoti Nath (Indian Institute of Information Technology Guwahati, India); Sanya Anees (Indian Institute of Information Technology - Guwahati, India)

A  $T \times R$  multiple-input-multiple-output (MIMO) based underwater wireless optical communication (UWOC) system employing Intensity Modulation (IM) / Direct Detection (DD) with On-Off keying (OOK) is considered, where underwater optical turbulence (UOT) is modeled by Exponential Generalized Gamma (EGG) distribution. The performance of UWOC system is highly dependent on the effect of absorption, scattering and UOT. The EGG underwater channel model efficiently described the optical irradiance induced due to air bubbles, temperature gradient and salinity, thus works well for the entire weak to strong turbulence regimes. The study of bit error rate (BER) performance of UWOC links with spatial diversity is investigated and the expressions are expressed in terms of Meijer-G function. The information are sent by  $M$  transmit apertures and received by  $N$  receiver apertures. A novel analytical expressions for single-input single-output (SISO), single-input multiple-output (SIMO), multiple-input single-output (MISO) and MIMO configuration of considered system are derived. The BER of different SIMO configuration is plotted and both numerical and analytical results conveys the behavior of our system for different channel parameters.

### **12:37 PCRF: On the blocking probability of LTE-A...477**

Priyatosh Mandal (Centre for Development of Telematics, New Delhi, India)

Policy and charging rule function (PCRF) is a node in LTE-A network for provisioning of policy and charging resources to policy and charging enforcement function (PCEF) of PDN gateway (PGW). During policy allocation the PCRF allocates bandwidth to a call, depending on the total bandwidth available between PGW and the external packet data network (PDN). In this paper we

analytically find the blocking probability of voice and video call from the policy provisioning perspective. Further we show that, if the available bandwidth between PGW and PDN is not sufficient, it can create blocking of calls. Not only that, for a given value of arrival rate, we can find the optimal bandwidth between PGW and packet data network to decrease the blocking probability.

## **Thursday, December 17 11:30 - 16:15**

### **Workshop: Internet of X-Things (X-IoT)**

#### **11:30 Hardware Design of Multi-Layer Coil For Magnetic Induction Communication in Non-Conventional Media...481**

Abhilash Vensiyani (Visvesvaraya National Institute of Technology, Nagpur, Maharashtra, India); Shashank Vadalía (Visvesvaraya National Institute of Technology Nagpur Maharashtra, India); Tanvi Kamble (Visvesvaraya National Institute of Technology, Nagpur, Maharashtra, India); Vinay Kumar (MNNIT Allahabad, Prayagraj, India); Sadanand Yadav (RGM College of Engineering and Technology, Kurnool, India)

Magnetic Induction (MI) communication is an appropriate alternative of radio wave communication in the non-conventional medium due to bearing a less propagation attenuation in such a medium. In MI based communication, single layer coil structure generates a limited range magnetic field. So to overcome this limitation, this paper incorporating a multi-layer coil structure of square shape on-chip, in that multiple single layer coils are stacked and wire-connected in series and result are analyzed in terms of power received by transceiver coils at receiver side. Further the effect of increment of the number of coil layers on the received power are also analyzed. The results show that the multi-layer square transceiver coil geometry provides better performance in comparison to other shapes of coil structure.

#### **13:52 Data rate-based grouping using machine learning to improve the aggregate throughput of IEEE 802.11ah multi-rate IoT networks...487**

Mahesh Miriyala and Badarla Sri Pavan (National Institute of Technology Puducherry, India); V P Harigovindan (NIT Puducherry, India)

IEEE 802.11ah, a standard for Internet of Things (IoT), uses restricted access window (RAW) mechanism to minimize the impact of collisions and to improve the aggregate utility of the network. However, in IEEE 802.11ah based multi-rate IoT networks, it is observed that throughput of higher data rate devices degrades below the level of lower data rate, due to performance anomaly. To overcome this problem, we propose data rate-based grouping using machine learning (DGML) in this paper. The proposed scheme exploits the self-organizing map neural network to classify the devices according to the data rate of devices, and to assign each group with a dedicated RAW slot. Analytical and simulation results show that, the DGML scheme significantly improves the aggregate throughput with minimal overhead, when compared with the default uniform grouping scheme.

**Thursday, December 17 14:00 - 18:10**

**Workshop: New Advances on Vehicle-to-Everything (V2X) Communications and Networking**

**14:00 A Survey on Blockchain and Edge Computing applied to the Internet of Vehicles...492**

Anderson Apolonio Lira Queiroz, queiroz. a. a. l. (Federal University of Pernambuco & Federal Institute of Pernambuco, Brazil); Eduardo Oliveira, Kelvin Lopes Dias and Maria Barbosa (Federal University of Pernambuco, Brazil)

With the advent of Intelligent Transportation Systems (ITS), data from diverse sensors either embedded into the vehicles or present along with the smart city infrastructure, are of utmost importance and require both processing power and efficient trust mechanisms for information exchange in vehicular-to-everything (V2X) communications. To accomplish these requirements, both edge computing and blockchain have been recently adopted towards a secure, distributed, and computation empowered Internet of Vehicles (IoV). This paper surveys prominent solutions for blockchain-based vehicular edge computing (VEC), provides a taxonomy, highlights their main features, advantages, and limitations to provide subsidies for further proposals.

**14:50 Sub-meter scale Node Positioning using Hybrid Time-Angle Measurements in an Asynchronous V2X Communication Network...498**

Mayur Katwe (Visvesvaraya National Institute of Technology Nagpur, India); Pradnya Ghare (Dr, India)

An accurate and robust positioning of nodes under 1m is a crucial aspect for future vehicular network applications involving location and context aware communication. In this paper, a novel hybrid range-angle based localization algorithm is proposed to achieve sub-meter scale positioning of multiple user nodes in a time-asynchronous V2X communication network. A closed-form solution based on hybrid asynchronous time and angle measurements is formulated using Cartesian-spherical coordinate relationship which combinedly estimate the 3-dimensional location and clock parameters i.e., clock skew and clock offset of all user nodes. Simulation results examine the performance analysis of the proposed method and confirms its optimality under various network scenarios. The proposed method achieves sub-meter node localization by maintaining clock frequency and phase synchronization accurately upto 10ppb and 10ns, respectively.

**15:40 PAPR Minimization Technique in MIMO V2V Transmission using SVM-based Channel Estimation...504**

Sonam Jain (Indian Institute of Technology Delhi, Hauz Khas, India); Ranjan Bose (Indian Institute of Technology, India)

In this paper, linear support vector machine (SVM), a well known machine learning algorithm is exploited for estimating the channel. Further, a linear precoding scheme for peak to average power ratio (PAPR) reduction in orthogonal frequency division multiplexing (OFDM) based multiple-input multiple-output (MIMO) system is proposed for V2V transmission. The key idea of the scheme is to generate the precoded signal by the use of the estimated channel information. Selection of the optimum precoding matrix criteria directly relates to minimizing the probability of symbol error rate, whereas, codebook designing is based on Grassmannian subspace packing. Theoretical analysis and simulation result validate that the proposed scheme has the ability to provide large PAPR reduction and low computational complexity in space time block code (STBC) based MIMO-OFDM system, and therefore, leads to improvement in the system performance.

**16:30 Real-Time Geometric Representation of Lane-Change Decision for Autonomous Vehicles using Dynamic Optimization Algorithm...509**

Ahmed Ibrahim (Nile University, Egypt); M. Saeed Darweesh (School of Engineering and Applied Sciences, Nile University, Egypt); Tawfik Ismail (Cairo University & Nile University, Egypt)

This paper develops a lane-change geometric representation that can be used in an on-road vehicle. The design of the proposed system uses the data collected from active a host vehicle and measures the relative speed between host vehicle and obstacle vehicles in real-time. The available distance to the target lanes measures the separated distance between the host and obstacle vehicles in real-time. These data are generated automatically using a dynamic environment and updated using time and object dynamics laws. The main algorithm uses the data to test the availability of using lane-change while checking if there is a slight break applied not to waste the testing time of the testing, then the smart searching algorithm applies to find the most suitable solution to change the lane safely as fast as possible. The desired system has been achieved with accepted real-time results that exceed the standard driver response time. Also, full accepted safety results allow the vehicle to get out of the lane with particular speed and steering angles to avoid collisions and avoid crashes in the host vehicle.

**17:20 A Visible Light Communication based predictive system for the height and location estimation of an obstacle...513**

Aranya Chakraborty (IISc Bangalore, India); Anand Singh (Indraprastha Institute of Information Technology Delhi, India); Vivek A Bohara (Indraprastha Institute of Information Technology, Delhi (IIIT-Delhi), India); Anand Srivastava (Indraprastha Institute of Information Technology Delhi, India)

This paper presents a visible light communication (VLC) -based predictive system for estimating an obstacle's height and location in an indoor environment. Two types of indoor environments having one and four LED's respectively are considered for the simulation. In each of the above environments, the system is first simulated using an infinitely thin obstacle and then using an obstacle having a radius of 0.05m. Linear Regression is applied to the results to develop a predictive algorithm to obtain the location and height of an obstacle from the received power profile. Finally, the accuracy of the predictive system for each of the above scenarios is also measured.

**Thursday, December 17 15:00 - 16:15**

**TS 20**

**15:00 Low Complexity Convolutional Neural Networks for Wireless Receiver Chain Optimization...519**

Mohammed Radi (TU Dresden, Germany); Emil Matus and Gerhard P. Fettweis (Technische Universität Dresden, Germany)

Technologies for 5G and beyond open up new chances for enabling new applications, which leads to an increasing variety of requirements, possible scenarios, and possible engineering decisions for wireless systems. Thus, having dynamic and robust techniques that can adapt to this huge variety has become more important than ever. One of the challenging adaptations is to select the most appropriate receiver architecture i.e. the architecture that gives the required performance with the least possible complexity, while modifying it dynamically based on the effects of having an instantaneous mix of a data sequence, channel effects, noise, and transmitter/receiver chains imperfections and impairments. One of the most innovative techniques is using convolutional

neural networks (CNNs) as an initial pre-process that is capable of predicting the best receiver architecture. The technique depends on using offline pre-trained CNNs that can classify every incoming packet dynamically and assign it to the most appropriate receiver architecture. The technique shows high performance and accuracy that leads to higher certainty of the required resources and processing time, and consequently, better scheduling for the processes in the available receiver architectures and processing elements. Despite that, the technique adds an extra complexity due to the added CNNs. Although CNNs operations as multiplications have lower complexity than the operations in the receiver blocks, the added complexity due to using the CNNs is so high that they lead to total higher complexity than just using a higher complexity receiver in many cases. Here we propose a low complexity approach that gives an equivalent performance of the state of the art technique. Our approach here depends on reducing the size of the used CNNs by introducing parts of the incoming packet to the input layers of the CNNs instead of introducing the whole packet as in literature state of art, which reduces the added complexity due to the CNNs while keeping the advantage of the pre-knowledge of the required resources and the corresponding processing time. We show different approaches of how to extract enough information from the packet without the need to use all of it as input for the CNN, and analyzing the performance for every approach; then showing the total complexity reduction due to our new proposal.

#### **15:25 A Hybrid Anomaly Based Intrusion Detection Methodology Using IWD for LSTM Classification...525**

Anita Venugopal and Mukesh Madanan (Dhofar University, Oman); Nitha C Velayudhan (Noorul Islam Centre for Higher Studies & Universal Engineering College, India)

The Network Intrusion Detection based on Anomaly is one of the best ways to identify the spam users and activities in cyber security. In present era, the Intrusion Detection System resources are increased due to inappropriate features that effect the detection rate of systems. To ensure better detection rate, a feature selection approach is utilized for the elimination of dissimilar and unemployable features in Intrusion Detection Systems. In addition, the time-consuming for the detection process also needs to be augmented for the process of classification. The paper introduces a method that avails the IWD algorithm for the feature subset selection in conjunction with LSTM to predict the malicious activity on that network. KDD CUP'99 dataset is employed for the judgement of performance on the intrusion detection in comparison with extant techniques. The performance estimate of the proposed model with previous methodologies depicts that the intended model is prominent by means of Higher Detection Rate, Low False Alarm Rate, and time consumption.

#### **15:50 A Study on MIMO Channel Estimation by 2D and 3D Convolutional Neural Networks...530**

Ben Marinberg and Haim H Permuter (Ben-Gurion University of the Negev, Israel); Eilam Ben-Dror (Huawei Technologies Ltd., Israel); Ariel Cohen (Ben-Gurion University of the Negev, Israel)

In this paper we study the usage of Convolutional Neural Network (CNN) estimators for the task of Multiple-Input-Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) Channel Estimation (CE). Specifically, the CNN estimators interpolate the channel values of reference signals for estimating the channel of the full OFDM resource element (RE) matrix. We have designed a 2D CNN architecture based on U-net, and a 3D CNN architecture for handling spatial correlation. We investigate the performance of various CNN architectures for a diverse data set generated according to 5G NR standard, and in particular we investigate the influence of spatial correlation, Doppler and reference signal resource allocation. The CE CNN estimators are then integrated with MIMO detection algorithms for testing their influence on the system level Bit Error

Rate (BER) performance.

## TS 19

### **15:00 Outage Analysis of D2D-based Ultra-Reliable Low Latency Communication System under Nakagami- $m$ Fading Channel...536**

Abhishek Kumar (Bharat Institute of Engineering and Technology); Jeswin Eldho and Shikhar Pandey (BITS Pilani KK Birla Goa Campus, India); Rahul Bajpai (BITS-Pilani, KK Birla Goa Campus, India); Naveen Gupta (BITS Pilani Goa, India)

This paper investigates an outage probability of device-to-device (D2D) based ultra-reliable low latency communications (URLLC) network. A D2D transmitter accesses the radio resource of a cellular user's opportunistically and transmits short packets data to the D2D receiver directly, without causing interference to the cellular user. Here, the maximum achievable rate for the D2D user, for a given interference power constraint under imperfect channel state information condition is used to find the outage probability under the Nakagami- $m$  fading channel. Next, a closed-form expression of outage probability for D2D users is derived under the Nakagami- $m$  fading channel. The outage probability is simulated for multiple values of channel gain, D2D rate, and interference threshold to validate the derived theoretical results.

### **15:25 On the Importance of Traffic Control Subsystem in ICN-based Industrial Networks...540**

Athreya H Nagaraj (National Institute of Technology Karnataka, Surathkal, India); Bhaskar Kataria (National Institute of Technology Karnataka, India); Aditya Chandrashekar Sohoni and Mohit P. Tahiliani (National Institute of Technology Karnataka, Surathkal, India); Deepaknath Tandur (Hitachi ABB Powergrids, India); Hariram Satheesh (ABB, India)

The Industrial Automation Control Systems (IACS) are currently dominated by IP-based protocols. Industry 4.0 demands an efficient and scalable networking infrastructure that facilitates data sharing to drive operational improvements and develop business intelligence. The deterministic requirements in industrial networks have led to the emergence of a new IEEE standard in the form of Time-Sensitive Networking (TSN). TSN enables having an upper bound on the latency of data communication, thereby partially fulfilling the requirements of Industry 4.0. However, TSN alone cannot provide the level of determinism required in industrial networks. The efficiency of the layers above TSN can significantly affect the network performance. Information Centric Networking (ICN), which contrasts with IP-based protocols by focusing on the data rather than on the end-points, is emerging as a promising network layer paradigm. In this paper, we evaluate what it takes for ICN to be integrated with TSN, and thereby meet the requirements of industrial networks.

### **15:50 Deploying Visible Light Communication for Alleviating Light Pollution...544**

Yash Gupta (IIITD, India); Anand Singh (Indraprastha Institute of Information Technology Delhi, India); Ashutosh Bansal (IIITD, India); Vivek A Bohara (Indraprastha Institute of Information Technology, Delhi (IIIT-Delhi), India); Anand Srivastava (Indraprastha Institute of Information Technology Delhi, India)

This paper aims at providing a solution to alleviate light pollution using visible light communication (VLC). The motivation behind the work lies in the outrageous expansion of already existing night lights which primarily use light-emitting diodes (LEDs) for illumination. Most of them are not in use simultaneously. We present a futuristic approach in automating these redundant lights. To automate the redundant LEDs, we propose using a wireless feedback mechanism for the



received signal-to-noise ratio (SNR) from the user to the LEDs and object localization techniques. Specifically, a reduction of 32% in LED usage for the simulation parameters as per the designed indoor VLC testbed has been observed. Moreover, the developed model can be employed both in indoor and outdoor lighting systems.