DEPARTMENT OF ELECTRICAL COMMUNICATION ENGINEERING

M.Tech (ECE) PROJECTS

The following projects are being offered to the M Tech (Electrical Communication Engineering) stream, 2022-2024 batch.

B SUNDAR RAJAN

BSR – 1. High-rate and Low-latency modulation and coding for 6G and beyond.
BSR – 2. Cache-aided communication for next generation wireless systems
BSR – 3. Broadcasting with side-information for content delivery networks.
BSR – 4. Security and Privacy in Caching Networks
BSR – 5. Private Information Retrieval (PIR) and Private Information Delivery (PID)

A CHOCKALINGAM

AC – 1. OTFS 2.0: Zak-OTFS Modulation for 6G and Beyond
AC – 2. RIS-Aided Joint Modulation and Beamforming
AC – 3. Deep Learning for Wireless Transceivers Design
AC – 4. Hybrid RIS-VLC Wireless Systems

K J VINOY

KJV – 1. Design of 5G mmwave frontend (Modify existing design of the antenna tile to incorporate a new generation beam steering IC. Requires modification of a multilayer PCB.)
KJV – 2. Development of a hybrid beam steering scheme for 5G mmwave antenna (Python + FPGA programming of the frontend board to study various strategies for hybrid (analog + digital) beam steering)
KJV – 3. Detection and neutralization of drones (programming of software defined radio (SDR) modules and design of RF amplifiers to engage with drones).

The following two Analog VLSI projects are being offered jointly with Dr. Manikandan R.R., who is a visiting faculty in the ECE Dept:

KJV-MRR – 1. Sub-50 ppm/^{o}C, 1 micro-Ampere quiescent current CMOS voltage reference circuit with current sourcing capability

Description: Sensor frontend circuits used in Internet of Things (IoT) sensor nodes are designed under low supply voltage and low Quiescent current constraints due to the limited energy available from the energy harvesting power sources. The wide range and variation of output voltage from the harvesting sources demands the use of voltage regulator however its power consumption needs to be minimized. The sub 1 micro-Ampere quiescent current voltage regulators with sub-50 ppm/^{o}C temperature coefficient and < 0.1%/V line sensitivity serve as a potential solution to these applications. In this project, ultra-low power voltage

regulator circuit techniques with current sourcing capability and improved line sensitivity will be explored.

KJV-MRR – 2. Second order curvature compensation circuit with Delta-VBE based process sensor and on-chip process trimming to support a sub-10 ppm/^{o}C voltage reference performance.

Description: High precision voltage reference circuits are used in high resolution ADC's (> 16 bit), voltage regulators and to generate current references. VBE nonlinearity and process variations limit the achievable minimum temperature coefficient performance. In this project second order compensation circuits with Delta-VBE based process sensors and its low power implementation will be explored to meet sub-10 ppm/^{o}C temperature coefficient voltage reference circuits

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UTPAL MUKHERJI

UM – 1. Low delay file transmissions over power constrained quasi-static fading channels.

T SRINIVAS

TS – 1. Quantum computing using photonic integrated circuits.
TS – 2. Optical Biosensors using photonic integrated circuits.

BHARADWAJ AMRUTUR

BA – 1 Optimization Techniques for Large Scale, Real-Time Network Management

Description: The project will involve studying and implementing a few approaches to network resource allocation - across L1/L2 and higher layers in 5G and advanced networks, by formulating the problem jointly across multiple base stations and using high performance compute to implement the algorithms. These will be tested out in a simulated network.

Prerequisites: Linear Algebra, Probability, Communications and Network Systems, Topics to be studied in sem 2: Optimization, C++/Python programming and High Performance Computing Libaries for Linear Algebra/optimization, NS3 simulation framework.

(Up to 2 students).

RAJESH SUNDARESAN

RS-AK – 1. Short term unfairness in decentralised WiFi systems (Joint with Prof Anurag Kumar)

Description: Scaling up of WiFi access systems has been possible due to the decentralised nature of medium access. The very decentralised nature of these systems makes them suffer from unfair access issues if the system is not designed properly. We will systematically study such phenomena and design protocols to increase fair access.

RS – 2. Information design using deep reinforcement learning

Description: We will explore reinforcement learning strategies associated with optimal signaling in information sharing games.

NEELESH B MEHTA

Projects are related to cutting-edge topics in 5G and beyond wireless communication systems.

NBM – 1. Ultra-reliable low latency communications
NBM – 2. Network slicing for supporting heterogeneous wireless services
NBM – 3. Any other topic in 5G/6G of interest to the student

Projects require a background in digital communications and a willingness to learn about new tools and techniques.

NAVIN KASHYAP

NK – 1. Quantum Error-Correcting Codes
NK – 2. Coding for fault-tolerant computing (on quantum as well as classical computing architectures)
NK – 3. Storage Codes on Graphs

CHANDRA R. MURTHY

CRM – 1. Advanced modulation schemes for beyond 5G and 6G
CRM – 2. System-level performance evaluation and analysis of 5G communication systems
CRM – 3. Deep unfolding based receiver designs
CRM – 4. Intelligent reflecting surface-assisted MIMO-OFDM communications
CRM – 5. Optimization of cell-free massive MIMO with dynamic time division duplexing

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GAURAB BANERJEE

GB – 1. Integrated beamformer chip design using CMOS and GaN technologies
GB – 2. CMOS based Up/down-converter circuit design with integrated phase locked loop.
Both the projects require prior exposure to chip design concepts and CAD tools (LTSPICE will do).

SUDHAN MAJHI

SM – 1. Artificial Intelligence-Based based Network slicing and Edge learning for 6G communication
SM – 2. Artificial Intelligence-Based Resource Allocation for 6G communication
SM – 3. Designing coding, beamforming, and modulation for an autoencoder system
SM – 4. End-to-End 5G security, privacy and challenges

PARIMAL PARAG

PP – 1. Network workload characterisation for Machine Learning and AI pipelines. ML/AI model training relies on massive data sets, and is computationally intensive. Thus, the data and computation is spread over multiple nodes, and model training workflow involves massive I/O over the network. Characterising the network traffic will help developing optimised network architecture and protocols.

PP – 2. End-to-end application performance tracing. Today's distributed applications following cloud-native platform depend on multiple nodes and various architectural components that are shared by multiple tenants and applications. Performance tracing of the application through various layers of the OS and network will help diagnose and optimise end-to-end performance issues. Given the scale of the infrastructure, such tracing also needs to ensure that the overheads of tracing are minimal.

PP – 3. In-band telemetry (INT), traffic classification, and inferencing at the data plane of DCNs. Gathering per-packet information is practical only if it is performed at the data plane of high-throughput low-latency networks such as Data Center Networks. Recent advancements in programmable data plane also allow embedding custom telemetry information within payload packets. However, due to the INT overheads and limited capabilities of the network devices, a selective INT strategy is preferred. Real-time traffic classification within the memory and compute constraints of switch data plane is a use case for per-packet measurement. We also wish to explore ML for traffic classification and inference within the data plane.

PP – 4. Performance evaluation of transport protocols for Internet and Data Center traffic. This project involves evaluating a performance of a few transport-layer proposals for improving east-west traffic within data centers (e.g., DC-TCP, HOMA, dcPIM) as well as north-south traffic across wide area network (e.g., QUIC, BBR, etc) for dominant applications. On the basis of the analysis, we can suggest improvements in existing congestion control algorithms.

PP – 5. Scheduling and placement in cloud-native architecture. Cloud-native architecture is popular for use cases such as bursty cloud services or 5G network functions. However, scheduling and placement of microservices and network functions has huge impact on the performance and resource utilisation due to factors such as data locality, job completion deadlines, and compute/power profile of heterogeneous servers. The project can also explore host-side optimisation of data path and offloading I/O to Data Processing Unit (DPU).

PP – 6. Load balancing. We are interested in the scheduling and load balancing techniques for traffic models that better fit realistic traffic over modern networks, in cases when the model parameters are known and unknown or time varying.

PP – 7. Distributed trust systems. When there is no single trusted party, distributed nodes have to reach a consensus for the network to accept a transaction. We are interested in the modelling, design, and performance analysis of such systems.

VARUN RAGHUNATHAN

VR – 1. Spatial Modulation in Optical Wireless Communication

RAJIV SOUNDARARAJAN

RSO – 1. Rendering Novel Views of Human Poses using Neural Radiance Fields for Augmented Reality and Telepresence

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SUNDEEP P. CHEPURI

SPC – 1 . AI/ML for wireless communications
SPC – 2. 5G/6G simulations
SPC – 3. Integrated sensing and communications
SPC – 4. Reconfigurable intelligent surfaces

VAIBHAV KATEWA

VK – 1. 5G applications for Robotics and Autonomous Systems

This project will explore how 5G technology can help in designing real-time systems like autonomous cars, drone delivery systems, warehouse robotics etc. We will look at issues like latency, determinism, reliability etc. which are crucial for these real-time applications, and how can 5G help in ensuring that these specifications are met. There will be an opportunity to simulate the 5G technology on a team of ground robots.

VK – 2. Reinforcement Learning based Inference and Control

This project involves applying RL techniques for problems related to decision making, inference and control. We will begin by studying how optimal policies are derived for a given problem setting. Then, we will explore the following question: Can we use the optimal policy 1 derived for setting 1 to compute the optimal policy 2 for setting 2, without computing policy 2 from scratch? This problem is related to transfer learning in the context of RL.

VK – 3. Security and Privacy in Cyber-Physical Systems

This project involves studying various security and privacy mechanisms that can be implemented in CPS. We will explore different attack detection and identification algorithms to detect presence of malicious attacks. We will also look at attack design problems where the goal is to attack the system in the worst possible manner and then develop countermeasures against such attacks.

VK – 4. Design of Communication Protocols for Networked Control Systems This project involves developing communication protocols for routing, congestion control and medium access that are custom made for control applications. These applications have stricter requirements in terms of latency and bandwidth. We will explore how can we adapt the existing protocols to make them more efficient and suitable for such applications.

VK – 5. Vulnerability Analysis of Smart Grids

This project is sponsored by PowerGrid Corporation of India which manages the transmission grid of India and is setting up a Center of Excellence at IISc. It will involve identifying various vulnerabilities in smart grid and develop mechanisms to measure their severity. We will first develop a graphical model of the grid with different devices as nodes and transmission/communication links as edges. Then, we will measure how attacks on a particular node spread in the whole network. It will also involve developing a GUI for visualizing the network and attack spread.

RAHUL SINGH

RHS – 1. Reinforcement Learning.

PRATHOSH A.P.

PAP – 1. Low resource Speech Recognition (Project with DRDO)

PAP – 2. Domain Adaptation for Automatic speech Recognition (Project with Polizybazar)

PAP – 3. NLP for Indian Language translation with Sanskrit (NLTM)

All three projects need the candidates to have proficiency in Python programming for Deep Learning.

(NAVIN KASHYAP)
For Projects Committee