NGCN

Center for Next - Generation Communication and Networking

The LNM Institute of Information Technology

2020

Contents

About the Center

Prof. R. Banerjee, Director, LNMIIT has taken a bold and unique initiative by establishing various centers of excellence dealing with several cutting-edge research areas. One such centre is the "Centre for Next Generation Communication and Networking (C-NGCN)" in the Department of ECE. It is a multi-disciplinary Centre working at the intersection of Communication Technology, Radio Physics and Computer Science mainly focusing on xG Wireless Systems and Networks, Software Defined Networking and Wireless Data Analytics.

Through this centre, a strong team comprising interested/ involved faculty, research scholars, and students is being developed for interactive, jointly steered and highly coordinated research efforts to undertake next generation challenges in the converged areas of Communication, Computing and Networking.

Welcome

Welcome to the newly formed Centre for Next Generation Communication and Networking (C-NGCN) in the Department of Electronics and Communication Engineering at The LNM Institute of Information Technology, Jaipur.

For over a decade, the department emphasizes its undergraduate program and later the postgraduate program started with specializations in Mobile communication, VLSI and embedded system. Currently, there is a worldwide interest in 5G/ 6G wireless technologies. In tune with this trend, there is a strong feeling at the department to create a centre for next generation communication and networking. This will accelerate the research enthusiasm among the faculty as well as create a considerable momentum through team ship and dedicated approach for facing the challenges in the new horizon of next generation wireless research.

In the near-term research strategy, the centre would focus its activities in the following major areas:

- Device-to-Device Communication: Algorithms, Protocols and Resource Optimization
- Signal Processing for 5G: Beamforming, Precoding and Multi-user Scheduling
- Ultra-reliable and Low-latency Communication
- Optical Wireless Backhauling and UAV Assisted Communication in 5G
- Data Analytics for 5G Wireless Network Design and Optimization
- SDN and NFV Technologies for Sat-Com Integration into 5G Ecosystem

VISION STATEMENT

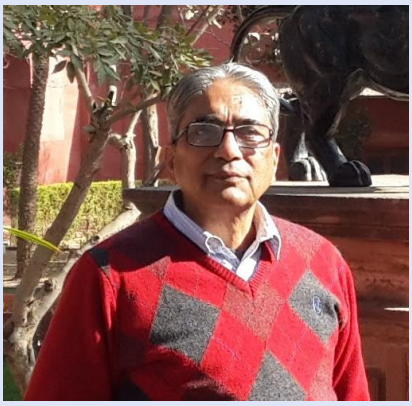
Leading research and development in next-generation wireless communication and networking, pioneering new concepts, technologies and applications for better living experiences.

MISSION STATEMENT

The Centre will pursue the immediate challenges of 5G and beyond 5G communication and networking that would be required for niche applications such as D2D, M2M, V2V, V2X along with IoE in relation to SDN enabled 5G.

People

FACULTY MEMBERS



Prof. Ranjan Gangopadhyay

Centre Lead

Dr. Nikhil Sharma

Co-Lead

Mr. Akash Gupta

Dr. Anirudh Agarwal

Dr. Divyang Rawal

Dr. Joyeeta Singha

Prof. Raghubir Tomar

Dr. Soumitra Debnath

Dr. Maroor Vikraraman Deepak Nair

Mr. Purnendu Karamkar

STUDENT MEMBERS

Aditya Singh Sengar

Bhupendra Sharma

Monika Jain

Monika Jain

Rahul Kumar Garg

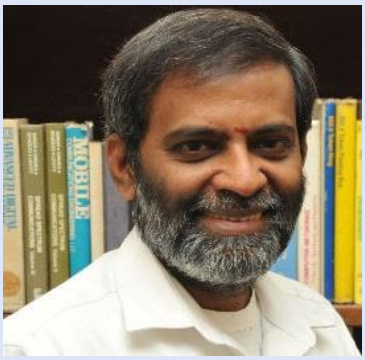
Rahul Makkar

Sandhya Soni

Shweta Saboo

MENTORS

Mr. Prem Jain
Former Senior VP, Cisco, USA



Prof. A. Chockalingam
IISc, Bangalore

Prof. Giancarlo Prati

Director, SSSUP, Pisa, Italy

Prof. Subhrakanti Dey

University of South Australia

Prof. Hwang-Cheng Wang

National Ilan University, Taiwan

Prof. Peter Cochrane

University of Suffolk, UK

Technical Activities

JAN 2018-DEC 2018

Workshop on 5G and IoT- The New Internet Perspective

A two-day national workshop on "5G and IoT - The New Internet Perspective" was organized by the Centre for Next Generation Communication and Networking (C-NGCN), Department of ECE, in association with ITRA, MeitY, Government of India during December 8-9, 2018.

Two most disruptive technologies viz. 5G - the new Radio, the next generation wireless, and IoT/ IoE, the next generation Internet, have made a dramatic influence on individuals' and societies' perspective towards digital transformation and world economy. The main objective behind organizing this workshop was to provide the learning platform and research motivational opportunities to the participants on key enabling technologies and challenges in 5G wireless networks and IoT systems, by the eminent experts from academia and industries in India with their vast expertise, domain knowledge and future vision.

The first day of the workshop was dedicated to the research exposure on 5G networks and the potential major enabling techniques. The key current research topics and applications in IoT systems and networking was focused upon the next day.

The number of seats for the Workshop participation was limited to 70 for researchers, postgraduate students and faculty/ officials from the Government and Engineering Institutions in and outside Rajasthan.

Sr. No.	Name	Institution	Talk Title
1	Prof. A. Chockalingam	IISc Bangalore	Novel Modulation Schemes for 5G
2	Prof. R. Gangopadhyay	LNMIIT	5G and IoT: A Vision Perspective
3	Prof. S. Prakriya	IIT Delhi	Energy Harvesting in 5G
4	Mr. N. Bykampadi	Nokia Labs	Security in 5G-Architecture and Standards Perspective
5	Prof. A. D. Barman	Kolkata University	Network Densification and Interference Management in Femto - cells
6	Mr. A. Nigam	Samsung Research	5G-The Connectivity Fabric for the Society
7	Prof. S. De	IIT Delhi	Data-Driven Performance Optimization for IoT Communications
8	Prof. M. Sharad	IIT Kharagpur	IoT Applications in Agriculture
9	Dr. P. Rajalakshmi	IIT Hyderabad	IoT for Non-invasive Healthcare Technologies
10	Dr. S. Ramakrishan	ITRA, Meity, GoI	5G, IoT and More Making of Technology and Society


LNMIIT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5G and IoT
New Internet
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Sponsored by

Workshop on 5G Specification and Standardization

A two-day national workshop on "5G Specification and Standardization" was held at LNMIIT during April 23-24, 2019. Experts for Industry were invited to sensitize student on the 5G standardization activity in India. As a direct outcome of the workshop, 4 LNMIIT students were offered internship.

Sr. No.	Name	Position	Organization
1	Dr. V. James	Associate Director-Technical Standards	Qualcomm
2	Dr. S. Kumar	Standardization Engineer	Ericsson Communication
3	Dr. S. Selvaganapathy	Specification Architect	Nokia Networks

JAN 2020 ONWARDS

Skype Talk by Prof. Mark Flanagan

A Skype talk by Prof. M. Flanagan from the University College Dublin was organized by the Centre for Next Generation Communication and Networking (C-NGCN) on 20th February 2020. Prof. Flanagan presented his recent research work related to various technologies related to 5G like Non - Orthogonal Multiple Access (NOMA), Ultra-Reliable Low - Latency Communications (URLLC), and wireless communications assisted by Reconfigurable Intelligent Surfaces (RIS).

SPONSORED PROJECTS

Completed Projects

The project entitled "Mobile Broadband Service Support over Cognitive Radio Networks" was successfully completed in December 2018, which was supported by ITRA, Digital-India Corporation, MeitY, Govt. of India; for a total funding of INR 1.06 crores. It was a collaborative project with IIT Delhi, IRPE Kolkata, and NERIST Arunachal Pradesh as the other partner institutions.

The project rendered significant contributions to the following areas:

1. Advanced Spectrum Sensing Techniques
2. Capacity Analysis for TVWS Networks
3. Learning based Models for Spectrum Occupancy Prediction for Efficient DSA
4. Interference Mitigation in Cognitive Radio MIMO-OFDM Systems
5. Radio Environment Map Creation and Utilization

Sanctioned Projects:

1. **Name:** Multimodal User Interface for Assisting Elderly People in Indoor Environment

   Grant Received from: DST under SEED

   Duration: 3 years, Funding **Amount:** 32.20 Lakhs

2. **Name:** Energy Efficient RF/VLC Networks for IoT Applications

   Grant Received from: SERB (Core Research Grant Scheme)

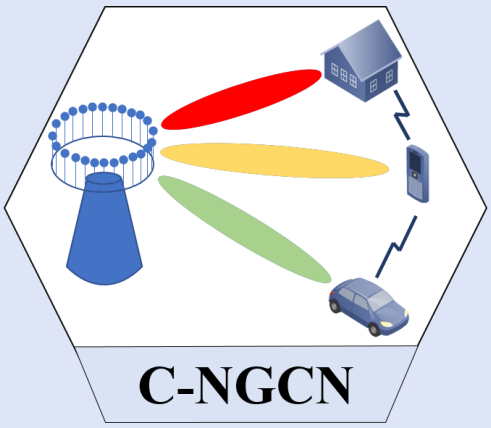
   Duration: 3 Years, Funding **Amount:** 60 Lakhs

Project Proposals under Development

Project Title	People Involved
Cognitive D2D Technologies for Next-Generation 5G Networks	Prof. R. Gangopadhyay, Dr. S. Debnath
Green RF Amplifier Design Meeting 5G Standards	Dr. M. V. D. Nair
Smart Solutions for Optical Backhaul: Design, analysis and implementation	Dr. N. Sharma, Mr. A. Gupta
Wireless Powered UAV Assisted Intelligent Green IOT Networks	Dr. A. Agarwal, Prof. R. Gangopadhyay

ONGOING RESEARCH

- Cooperative D2D Communication for 5G
- Optical Wireless including Visible Light Communication
- Green RF Amplifier Design and mm Wave Technology
- Assistive Technologies for Elderly Persons
- Data Analytics for Wireless Resource Optimization
- Advanced Interference Cancellation for Dense Cellular Networks
- Radio Environment Map: Creation and Applications



ENVISIONED RESEARCH

Wireless Data Analytics for resource optimization for 5G

As wireless systems are evolving, it is becoming increasing to reliably describe them analytically. Hyper dense hetnets have led to a situation of complete chaos in both physical and network layers. Deep Learning offers a fresh perspective to realize various communication scenarios. A deep learning enabled system is adaptable and requires minimum human intervention. It is however not without its challenges, which includes a considerable information and processing overheads, mathematically difficult abstraction of components leading to probable performance gains and exact architecture of the deep learning system are a few of the issues and quite relevant research areas for contemporary research.

Optical Wireless Backhaul for 5G

The future activity on 5G will investigate new high capacity and low-latency architecture for backhauling 5G networks, by engineering UDWDM technology as well as long-reach PONs, to provide connectivity to a dense-cell population. Design issues and algorithms at both physical and network layers need to be addressed.

D2D Communication and Networks

Device to device (D2D) has emerges as a hot research area for next gen cellular network. It leverages the physical proximity of communication devices to extend cellular coverage mostly in sparse deployment scenarios as well as providing advantages like offloading, improved spectrum reuse and system throughput. However, it poses new problems and challenges which must be addressed, this includes admission control, power control, relay selection, resource allocation and interference management for upcoming 5G deployment needs through research attention similarly for the realization of potential D2D relaying in underlay cellular system practical consideration for cooperation and coordination is needed in a given D2D system model. Finally, the security aspects of D2D communication and the trust management in D2D network are very interesting and challenging areas which need to be addressed with new approaches.

Massive MIMO

Massive-MIMO is a promising technology to meet the high data rate and QoS requirements of 5G wireless systems. The envisioned project will address several challenges in Massive MIMO system design that include robust channel estimation techniques, low-complexity receiver design that leverages the Massive MIMO spatial degrees of freedom and energy efficiency in base station design.

RESEARCH COLLABORATIONS

1. Prof. Abhirup Das barman, Institute of Radio Physics, Kolkata University
2. Prof. Hwang-Cheng Wang, National Ilan University, Taiwan
3. Dr. Rocco Giofre, University of Roma Tor Vergata, Italy
4. Prof Shankar Prakriya, IIT Delhi
5. Prof. Parul Garg, NSIT, Delhi
6. Dr. Sangram Ganguly, CTO, Rhombus Power Inc, San Jose, California, USA
7. Prof. Marc Flanagan, Department of EE, University College, Dublin, Ireland

Outcome and Outreach Activities

RESEARCH OUTCOMES

PhD Thesis completed

Name: **Anirudh Agarwal**
Title: **Spectrum Occupancy Modeling and Prediction for Efficient Dynamic Spectrum Access in Cognitive Radio Networks**

Ongoing PhD Research

Sr. No.	Names of Scholars	Research Topics (Tentative)
1.	Aditya Singh Sengar	D2D Communication
2.	Bhupendra Sharma	Intelligent Surface Assisted Communication
3.	Monika Jain	Cognitive Radio
4.	Monika Jain	Under- water Visible Light Communication
5.	Rahul Kumar Garg	Miniaturized Ultra-wideband Microstrip Antenna Design
6.	Rahul Makkar	Cooperative Communication
7.	Sandhya Soni	Cooperative Communication
8.	Shweta Saboo	Gesture Recognition

M.Tech. Thesis Completed

1.: Akshita Gupta (Pursuing PhD at IIIT Delhi)
Title: **Performance Analysis of Decode and Forward Protocol based Cooperative Systems over TWDP Fading**

2.: Justin Jose (Pursuing PhD at IIT, Indore)
Title: **Resource Allocation for Underlay Full-Duplex D2D Communication**

OUTREACH ACTIVITIES

- Dr. Divyang Rawal and Dr. Nikhil Sharma, organized a 3-day workshop on "Simulation of wireless systems using Matlab + Simulink" at JNEC, Royal University of Bhutan, between March 8 -10, 2019
- Dr. Nikhil Sharma chaired two sessions at IEEE VTC 2019, held in Kuala Lumpur
- Dr. Divyang Rawal chaired a session at IEEE PIMRC 2018, Bologna, Italy
- Dr. Nikhil Sharma was Special-session- tutorial Chair, and was one of the core organizing committee members for ETIC 2019, Bhutan
- Dr. Divyang Rawal conducted a workshop on "Future Wireless Communication Systems: Theory and Practice on Wicomm Trainer and SDR Kit" at GEG, Gandhinagar, India 2018
- Prof. R. Gangopadhyay as Guest of Honour addressed the students of Purnima Engineering College, Jaipur on the Annual Event
- Prof. R. Gangopadhyay delivered an invited Talk in FDP on ICT tools for Teaching, Learning and Institutes on 16th January 2020 at MNIT, Jaipur.

Budget

2019-2020

A. Recurring Expenditure: OPEX

S. No.	Head of expenses	Qty.	Purposes of expenses with complete details and specifications	Date/ Month of requirement	Estimated cost (Rs.) (Including all)	Name of the Indenter
1	Contingency	1	Procurement of consumables/components	May	50,000	C-NGCN Member
2	Seminar/ Activity Related		Inviting Experts from Industry/Academia involved in National Project Development in 5G	June'19-Feb'20	1,50,000	Prof. R Gangopadhyay
	TOTAL Rs. (including all like taxes, transportation, testing, everything)				**2,00,000**	

B. Capital Expenditure (like fixed assets, equipment, computers, printers etc.) CAPEX

S. No.	Head of expenses	Qty.	Purposes of expenses with complete details and specifications	Date/ Month of requirement	Estimated cost (Rs.) (Including all)	Name of the Indenter
1	Equipment (NetSim S/W)	1	See ANNEXURE-B	May	6,00,000	Dr. S. Debnath/ Prof. R Gangopadhyay
2	Equipment (Koruza Pro)	1	See ANNEXURE-C	April	1,40,000	Dr. N. Sharma/ Prof. R Gangopadhyay
3	Equipment (Experimental Board)	1	See ANNEXURE-D	May	60,000	Dr. D. Rawal/ Dr. Nikhil Sharma
4	Computer/ Printer/ Scanner	2	See ANNEXURE-E	April	2,00,000	Dr. A. Agarwal/ Dr. S. Debnath
	TOTAL Rs. (including like all taxes, transportation, testing, everything)				**10,00,000**	

2020-2021

A. Recurring Expenditure: OPEX

S.No.	Head of expenses	Qty.	Purposes of expenses with complete details and specifications	Date/ Month of requirement	Estimated cost (Rs.) (Including all)	Name of the Indenter
1	Contingency	NA	Purchase of components and accessories and other petty purchases	April 2020 onwards	50,000	Dr. N. Sharma
2	Invited Talk/ Workshop	NA	Provision for holding a two-day workshop on 5G and related topics	September - November 2020	2,00,000	Prof. R. Gangopadhyay
	TOTAL Rs. (including all like taxes, transportation, testing, everything)				**2,50,000**	

B. Capital Expenditure (like fixed assets, equipment, computers, printers etc.) CAPEX

S.No.	Head of expenses	Qty.	Purposes of expenses with complete details and specifications	Date/ Month of requirement	Estimated cost (Rs.) (Including all)	Name of the Indenter
1	Furniture, Electrical Wiring	NA	To furnish the C-NGCN laboratory	Apr-20	35,00,000	Dr. N. Sharma
2	USRP Boards	6	To setup a Software Defined Radio Laboratory	Apr-20	10,00,000	Dr. N. Sharma, Dr. D. Rawal
3	Li-Fi Test beds	4	To support B.Tech. research projects and C-NGCN laboratory development	Apr-20	3,00,000	Dr. N. Sharma, Mr. A. Gupta
4	LoRa Modules	4	To support B.Tech. research projects	Apr-20	50,000	Dr. A. Agarwal
5	Netsim Advanced Emulator Modules	2	To support networking experiments related to 5G/ LTE	Apr-20	6,00,000	Dr. A. Agarwal, Mr. A. Gupta
	TOTAL Rs. (including like all taxes, transportation, testing, everything)				**54,50,000**	

Publications

January 2018-December 2018

1. S. Soni, D. Rawal, N. Sharma, D. N. K. Jayakody “Selective DF Based Multiple Relayed Cooperative System with M-QAM Signaling”, 2018 IEEE 29th Annual International Symposium on Personal, Indoor and Mobile Radio Communication. (PIMRC-2018), Bologna, Italy, 1-6.
2. A. Agarwal, R. Gangopadhyay, S. Dubey, S. Debnath, and M. A. Khan, “Learning based Predictive Dynamic Spectrum Access Framework in Cognitive Radio Networks: A Practical Perspective for Enhanced QoE of Secondary Users," in IET Communications, DOI: 10.1049/iet-com.2018.5407.
3. A. Agarwal, and R. Gangopadhyay, “Predictive Spectrum Occupancy Probability based Spatio-Temporal Dynamic Channel Allocation Map for Future Cognitive Wireless Networks," in Transactions on Emerging Telecommunications Technologies, vol. 29, no. 8, p.e3442, June 2018.
4. A. Agarwal, A. S. Sengar, and R. Gangopadhyay, “Spectrum Occupancy Prediction for Realistic Traffic Scenarios: Time Series versus Learning based Models," in Journal on Communication and Information Networks, vol. 3, no. 2, pp. 44-51, June 2018. (Springer)
5. A. Agarwal, and R. Gangopadhyay, “Generalized Statistical Spectrum Occupancy Modelling and Its Learning Based Predictive Validation,” in 24th IEEE National Conf. Commun. (NCC), Feb. 2018, DOI: 10.1109/ncc.2018.8600244.
6. A. S. Sengar, R. Gangopadhyay, and S. Debnath. "On the construction of radio environment map for underlay device-to-device networks." 2018 24th Asia-Pacific Conference on Communications (APCC). IEEE, 2018.

January 2019-December-2019

1. J. Jose, A. Agarwal, R. Gangopadhyay, and S. Debnath, “Outage Analysis based Channel Allocation for Underlay D2D Communication in Fading Scenarios,” in IEEE International Conference on Wireless Communication, Signal Processing and Networking (WiSPNET), Mar. 2019.
2. J. Jose, A. Agarwal, A. S. Sengar, R. Gangopadhyay, and S. Debnath, "Multi-channel Allocation for Full-Duplex Underlay D2D Communication," in Transactions on Emerging Telecommunication Technologies, DOI: 10.1002/ett.3852, Dec. 2019.
3. A. Gupta, N. Sharma, P. Garg, D. N. K. Jayakody, C. Yury and J. Li, “Asymmetric Satellite-Underwater Visible Light Communication System for Oceanic Monitoring” in IEEE Access, vol. 7, pp. 133342-133350, 2019.
4. A. Gupta, N. Sharma and P. Garg, “Hard Switching Based Hybrid RF/VLC System and Its Performance Evaluation” in WILEY Transaction on emerging telecommunications technologies, Vol. 30, no.2, Feb. 2019.

5. M. Jain, S. Soni, N. Sharma, D. Rawal “Performance analysis at far and near user in NOMA based system in presence of SIC error”, Elsevier AEU-International Journal of Electronics and Communications, 152993, Dec. 2019.
6. R. Makkar, D. Rawal, N. Sharma and D. N. K. Jayakody,” Multi-Antenna Based Selective DF Cooperative Relaying Scheme over TWDP Fading” in IEEE WCNC 2019, 15-19 April 2019, Marrakech, Morocco.
7. S Soni, M Jain, D. Rawal, N. Sharma, R. Liyanapathirana “Performance Analysis of DF Cooperative-NOMA System with QPSK-BPSK Scheme in the Presence of SIC Errors.” 2019, ICEERP-2019, Sydney, Australia.
8. S. Soni, D. Rawal, N. Sharma, D. N. K. Jayakody, J. Li, “Performance Analysis of UAV-Aided Wireless Communication Systems with Ubiquitous Coverage”. 2019, IEEE 90th Vehicular Technology Conference (VTC2019-Fall), 1-6, September 2019, Honolulu, Hawaii, USA.
9. A. Gupta, R. Makkar, D. Rawal, N. Sharma, D. N. K. Jayakody, “Performance of M-QAM Scheme over TWDP Fading for Multiple Receive Antennas System.” 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), 1-5, 28 April-1 May 2019, Kuala Lumpur, Malaysia.
10. S. Soni, D. Rawal, N. Sharma and D. N. K. Jayakody,” M-QAM Based MRC Receiver with Selective DF Relaying”, in ETIC 2019, Bhutan, 8-10 March 2019.
11. M. Jain, N. Sharma and D. Rawal, “Performance Analysis at Near and Far Users of a Noma System Over Fading Channels”, in IEEE Indicon-2019, Rajkot, India, Dec. 2019.
12. S. Soni, M. Jain, D. Rawal and N. Sharma, “DF Cooperative-NOMA Scheme in Presence of SIC Errors for Ubiquitous Coverage”, in IEEE ANTS-2019, BITS Pilani, Goa, India, Dec. 2019.
13. R. Makkar, S. Soni, A. Bachkaniwala, D. Rawal and N. Sharma, “Pilot Interpolation Based Channel Estimation for LTE Systems”, in IEEE CoCoNet-2019, Trivandpuram, Kerela, India, Dec. 2019.
14. K. Yadav and J. Singha, "Facial Expression Recognition using Modified Viola- John's Algorithm and KNN classifier", accepted in Multimedia Tools and Applications (Springer), Nov 2019.

January 2020 onwards

1. A. Agarwal, and D. Mishra, “Wireless Powered Protocol Exploiting Energy Harvesting During Cognitive Communications," in IEEE Wireless Commun. Lett., DOI: 10.1109/LWC.2020.2970715, Jan. 2020.
2. A. Agarwal, and D. Mishra, “Hovering Localization and Power Allocation for UAV assisted DF Relaying Ad Hoc Network,” in IEEE Int. Conf. on Communications (ICC), Mar. 2020.
3. M. Jain, A. Agarwal, D. Rawal and R. Gangopadhyay, “Adaptive Bit and Power Allocation for Dual-mode Index Modulation”, Physical Communication, vol.40, 2020
4. A. S. Sengar, R. Gangopadhyay and S. Debnath, “Interference Modelling for and Underlay D2D Network for Efficient Resource Allocation”, in IEEE 3rd 5G World Forum (5GWF’20) (***Communicated***)

Resources

The resources provided below reflect a few selected choices of industry, academia and governmental agencies which are engaged, involved, and sponsoring various initiatives and projects in the core areas of 5G communication and networking. Detailed information in each category can be gleaned by clicking the icons.

INDUSTRY (LOCAL, GLOBAL)

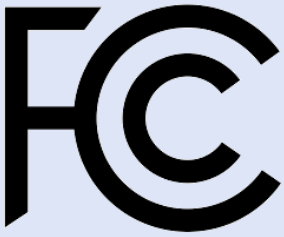
A few corporate houses are listed below which are generating vital research and development in 5G.

ACADEMIA

Within the academia, there are many universities across the globe which are giving are steering advanced level research and development in the thrust areas of 5G. A selected few has been put in the present resource.

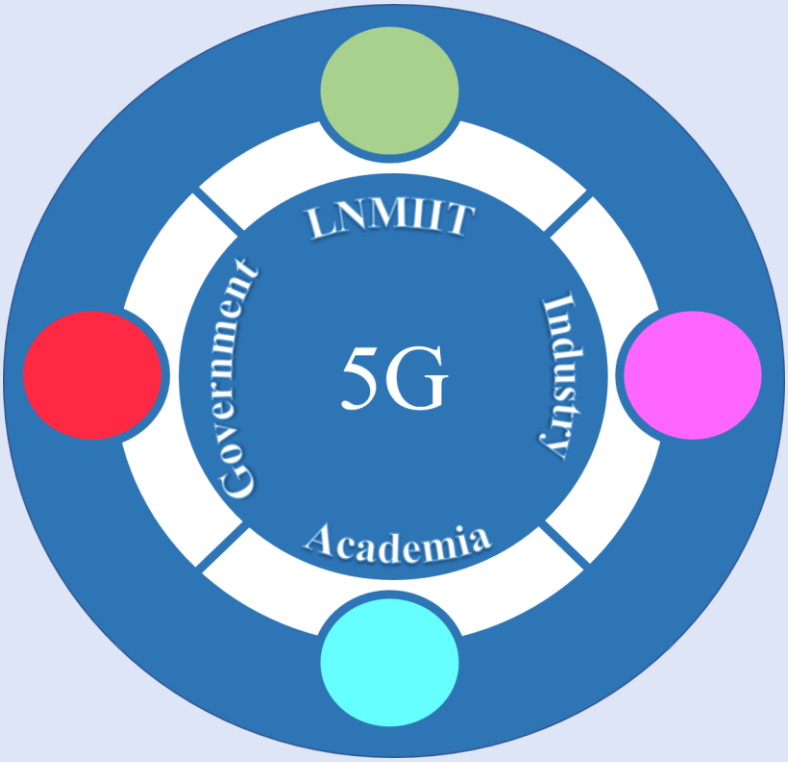
GOVERNMENT

Of the governmental initiatives, we specify a few like National Science Foundation and Federal Communication Commission (USA), International Telecom Union and European Union (Europe), 5G Forum (South Korea) and IMT-2020 (People's Republic of China) etc.



Contact Details

We are seeking collaborations from interested partners across several sectors like Academia, Industry and Government.



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