

Bio of Prof. Abhay Karandikar for non-official Directors on the Boards of CPSEs

1. Name and surname (in full): Abhay Karandikar
2. Director Identification Number (refer note 1): 00477659
3. Income Tax PAN: ADMPK3420H
4. Gender: Male 4. Nationality: Indian
5. Father's name and mother's name and Spouse's name (if married): Keshav Karandikar (Father)
Lata Karandikar (Mother)
Aruna Karandikar (Wife)
6. Date of Birth: 15th June, 1965
7. Present Position/Occupation: Professor and Head
Department of Electrical Engineering
Indian Institute of Technology Bombay,
Powai, Mumbai 400 076
8. Full address (present and permanent) with PIN code, Phone number, Mobile Number, E-Mail address
- B-290, Nilgiri,
Indian Institute of Technology Bombay,
Powai, Mumbai 400 076
- Office: +91 22 2576 7439
Mobile: +91 9820347269
Residence: +91 22 2576 7439
Email address: karandi@ee.iitb.ac.in
9. Educational & Professional Qualification (Graduation onwards)

S.No.	Course	Subjects	University/Institute	Year of Passing
1.	BE	Electrical Engineering	Jiwaji University, Gwalior	1986
2.	MTech	Electrical Engineering	Indian Institute of Technology Kanpur	1988
3.	PhD	Electrical Engineering	Indian Institute of Technology Kanpur	1995

10. Work Experience Please refer to attach CV.
11. Whether SC/ST/OBC/Minorities/Women (if yes, indicate the relevant category): NA
12. Area of Specialization (Finance, Law, Management, Sales, Marketing, Administration, Research, Corporate Governance, Technical Operations or any other):
Technology (Electrical Engineering, Wireless Communications, Communications Networks)
13. Indicate how you fulfill the laid down criteria (Refer Annex)
Academia, Head of Department and Professor having more than 10 years of teaching in technology.

14. (a) Have any legal proceedings initiated or are pending against you: No

(b) If yes, please furnish the details: NA

15. (a) Have you been or are designated partner in limited liability partnerships (LLP): No

(b) If yes, please furnish the following details: NA

16. Directorship/held/presently being in companies (both CPSEs and Private)

Name of company	Nature of Industry	Nature of directorship	Duration (with dates)
Center for Innovation VNIT, Nagpur	a Section 25 Company	Board Member	February 2012- till date



Abhay Karandikar

Date: 10th September, 2014

Abhay Karandikar

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Date of Birth: 15th June, 1965

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EDUCATIONAL QUALIFICATION:

- PhD (1995) (Electrical Engineering)
Indian Institute of Technology Kanpur
- MTech (1988) (Electrical Engineering)
Indian Institute of Technology Kanpur
- BE (1986) (Electrical Engineering)
Jiwaji University, Gwalior
First Rank in BE (Electronics Engineering)

ACADEMIC AND PROFESSIONAL EXPERIENCE

1. Professor & Head (January 2012 - till date),
Professor (April 2007 - till date),
Associate Professor (February 2001 - March 2007),
Assistant Professor (April 1997 - January 2001),
Department of Electrical Engineering, Indian Institute of Technology Bombay
Involved in teaching and research in Wireless Communications Networks, Computer Communications Networks, Communications System Theory and Digital System Design.
2. Team Coordinator (October 1994 - April 1997), High Performance Computing and Communications Group, Centre for Development of Advanced Computing (C-DAC), Pune.
As lead member of PARAM 9000 Super Computer design team, I was responsible for the design of Interconnection Networks for PARAM 9000.
3. Visiting Fellow (April 1995 - June 1995) (on leave from C-DAC), Department of Information Engineering, Chinese University of Hong Kong, Hong Kong.
Research in ATM Flow Control and design of large ATM switches.
4. Scientist/ Engineer (July 1988 - July 1989), System Engineering and Integration Division, Earth Station and Ground Hardware Group, Space Application Center, ISRO Ahmedabad.

ADMINISTRATIVE EXPERIENCE

Leadership Administrative Roles at IIT Bombay

1. Head (Department of Electrical Engineering, IIT Bombay) (January 2012- till date)
The department of Electrical Engineering of IIT Bombay, today, is one of the largest departments in the institute with 64 faculty members and about 1200 students. The

department has grown rapidly in terms of number of faculty and students; and sponsored research funding during the last 5 years. Some of my major achievements as Head of the department are the following-

- With support from department colleagues and faculty search committee, I played a significant role in Faculty Hiring - the department added 10 faculty members during my tenure as Head taking the total strength to 64. Earlier, as Convener, faculty search committee, I contributed in setting up a process for aggressive faculty hiring. As a result, the department's faculty strength has multiplied by 1.5 times (from 39 to 64) in last 5 years.
- I re-vamped the PhD and MTech admission process for improving the quality of intake and introduced the system of PhD qualifier. These and several other measures have been put in place to improve the graduate research program.
- Brought significant improvement in department infrastructure at various levels.
- Improved various administrative and academic processes in the department with regard to teaching assistant, academic mentorship, faculty advisor etc.

2. Head (Computer Center) (August 2008- July 2011)

As Head Computer Center, I was responsible for formulating policies, design and operations of the IIT Bombay's computing and network infrastructure including Internet, campus wide network and data center. Some of the major achievements were-

- Revamped hostel network with about 5000 nodes with state of the art switches with 1 Gbps access port and 10 Gbps backbone speed. Implemented several access control features.
- Revamped campus wide networking with network kiosks throughout the campus with improved architecture. Extended campus wide networking to all staff quarters (about 875).
- Commissioned the high performance computing facility—"SpaceTime Supercomputing.

3. Convener, Institute Admissions Committee, 2012, 2013.

I was responsible for formulating structure for operational aspects of MTech/PhD admissions including admission rules at institute level and conduct of tests/interviews procedures.

4. Convener, Institute Core Curriculum Committee 2012.

As Convener, I steered in bringing comprehensive changes in undergraduate curriculum of the institute. After 2007, this was an exercise to review the modifications made in 2007. The committee made several significant changes in curriculum including introduction of Biology course in first year undergraduate.

5. Member, Institute Faculty Advisory Committee, 2012-13

I participated in bringing new faculty assessment and promotion policy with Dean (Faculty) as Convener.

6. Convener, Faculty Search Committee, EE Dept, IIT Bombay, 2006-2009.

As Convener, Faculty Search Committee, I played a major role in focusing on aggressive faculty hiring. The faculty search committee spent significant efforts in identifying potential faculty candidates and following up with them. It is due to these efforts that the department registered an impressive increase in faculty strength in the last five years. The committee also set up a process for faculty search.

Other Administrative Experience in IIT Bombay-

1. **Member, Advisory Board Desai-Sethi Entrepreneur Center, IIT Bombay 2013.**
2. **Member, Institute Dandi Memorial Committee 2012.**
3. **Member, IIT Bombay Center for Urban Science 2012.**
4. **Member, Committee on academic data security, 2011-12.**
The committee suggested guidelines for security of degree certificates etc. and improvement to academic data base.
5. **Member, Committee on institute policy and guidelines on distance education, 2011.**
Comprehensive guidelines and policy recommendations were suggested for distance education program of IIT Bombay.
6. **Member Committee on establishment of science and technology park in IIT Bombay, 2011.**
7. **Member, C-DEEP Advisory Committee, 2008-11**
8. **Member Faculty Search Committee, 2009-12, 2003-4.**
9. **Convener Department BTech and DD Curriculum Committee, 2007.**
10. **Member, Department Policy Committee, EE Dept, 2004- 2008.**
11. **Member Technical Advisory Committee, Telephone Exchange, IIT Bombay 2011-14, 2009-11, 2003-2004, 1999-2000.**
12. **Member, Technology Business Incubator Policy Committee, IIT Bombay, 2004.**
The committee set-up the policies and procedures for IIT Bombay's business incubator SINE in its formative years.
13. **Convener, Communications Group, EE Dept, IIT Bombay, 2001-2003.**
14. **Professor in Charge, Department Computer Lab, Intranet Server and Department Network, 1999-2005.**
15. **Professor in Charge, Microprocessors and MDS Lab, 1998-2000.**
16. **Member, Department Undergraduate Committee, 1999-2000, 2003-2005.**
17. **Member, Post Graduate Committee of Kanwal Rekhi School of Information Technology, 1999-2003.** This was in formative years of the school and I was involved in designing curriculum and structure of the program.

Leadership Roles at National Level

1. **Secretary, Telecom Standards Development Society India (TSDSI)**
I played a leadership role in nation-wide effort for setting up India's telecom standards development organization (SDO) with participation of all stakeholders-telecom operators, equipment vendors, academia and research labs. Telecom Standards Development Society India was registered in June 2013 and recognized by the Department of Telecom, Govt of India as national SDO. As Secretary, Governing Council, I am coordinating the overall operations in formative years of this national organization.
2. **Coordinator, National Centre for Excellence in Technologies for Internal Security (NCETIS)**
For the past two years, I spearheaded an effort along with colleagues from IIT Bombay in setting up a Homeland security center. The center is expected to address the technology innovations gap for internal security requirements specially for state and central police forces of our country. I coordinated the effort for preparing Detailed Project Report (DPR). The same has been approved in principle by the

Department of Electronics and Information Technology (DeitY), Govt of India and it is now pending approval of grant. The center is expected to begin its operations from October 2014.

3. Member, Committee for the formulation of “Spectrum Act”, June 2011.

The committee was chaired by Retired Supreme Court Judge, Justice Shivraj V. Patil. I contributed to writing a draft of National Radio Spectrum Management Act to replace Indian Wireless Telegraphy act 1933.

4. Member, Working Group on Telecom for 12th Five year Plan of India, Planning Commission, Govt of India

I contributed to several drafts of various sub-groups created under this working group on Telecom R&D, IPR and manufacturing, spectrum and licensing, and broadband.

Apart from the above, I have been contributing to several national level committees. Some of these roles are--

5. Member, Academic Committee for funding PhD Scheme, Department of Electronics and Information Technology (DeitY), 2014.
6. Member SEBI Technical Advisory Committee since 2013.
7. Member, Expert Group on Creation of Telecom Entrepreneurship Development, Telecom R&D and Telecom Manufacturing Promotion Fund by Department of Telecom during 12th Five Year Plan, December 2012.
8. Member, Working Group for Development of Innovation and IP in ESDM sector, DeitY, Gol, 2012.
9. Chairman sub-group on Telecom R&D Fund setup by DoT. (drafted the entire report on TRDF. Report submitted in March 2013)
10. Member, Telecom Sector Innovation Council to draw roadmap for telecom sector of the country during Decade of Innovations 2010-2020, DoT, 2011-12.
11. Member Oversight Committee, Millworkers’ Online Lottery (chaired by Retd Uplokayukta), Maharashtra Government, 2012.
12. Member, Oversight Committee (chaired by Retd UpLokayukta), MHADA Online Lottery 2012. (Suggested comprehensive changes in Online Lottery system and oversaw the complete operations of online Lottery).
13. Member, Oversight Committee (chaired by Retd High Court Judge), MHADA Online Lottery, 2011. (Successfully helped MHADA implement Online Lottery of flats).
14. Member of the committee set up to draft blue print of Telecom Entrepreneurship Development Council by DoT 2011.
15. Co-Chair of drafting group on new technology for National Frequency Allocation Plan 2011.
16. Key member of the committee (chaired by Joint Secretary, DoT) set up by government to consider TRAI recommendations for measures to improve telecom infrastructure in rural India, 2009. (Drafted the entire report. Report submitted in September 2009).

BOARD AND ADVISORY LEVEL POSITIONS IN INDUSTRY

1. Board Member, Board of Directors, Center for Innovation VNIT (CIVN), a Section 25 company, VNIT, Nagpur, 2012.
2. Member, Telecom Center of Excellence Coordination Center Executive Council, a Registered Society, 2012-2013.
3. Member, Experts Panel, Aditya Birla Private Equity Capital, 2012.

NUMBER AND NAMES OF REPUTED AWARDS AND RECOGNITIONS

Number of reputed Awards/Recognitions : 14

Finalist/Best Paper Awards in Conferences
1. Best Paper award in Workshop on Indoor and Outdoor Small Cells, Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt) 2014 held in Hammamet, Tunisia, May 12-16, 2014.
2. Finalist for the Best Paper award in National Conference on Communications (NCC) 2014 held in IIT Kanpur, February 28 - March 2, 2014.
3. Finalist (one of the three) for the Best Paper award in IEEE Local Computer Networks (LCN) 2012 held in Florida, USA, October 22-25, 2012.
4. Best Paper Award in ACM Mobile Ad Hoc Networking and Computing (MobiHoC), 2009 held in Louisiana, USA, May 18-21, 2009.
Excellence in Teaching Awards in IIT Bombay (based on 5 years' course evaluation feedback of students)
5. Award for Excellence in Teaching, IIT Bombay 2011.
6. Award for Excellence in Teaching, IIT Bombay 2006.
Significant Awards
7. VASVIK Industrial Research award 2013 for Electrical and Electronics Sciences and Technology.
8. National Academy of Sciences of India (NASI)-Reliance Industries Platinum Jubilee Award 2012 for Application oriented Research.
9. Hari Om Ashram prerit Dr Vikram Sarabhai Research Award 2009.
10. Prof K Sreenivasan Memorial Award of IETE, 2006.
11. Prof SVC Aiya Memorial Award by Prof SVC Aiya Trust, 2006.
12. Dr PK Patwardhan Technology Development Award of IIT Bombay, 2004.
Other Honors
13. Fellow of IETE.
14. Nominated member of academic senate of IIT Bombay (during the tenure of Associate Professor) in 2004.

TECHNOLOGY DEVELOPMENT, COMMERCIALIZATION AND LICENSING

1. Significant Technology Licensing in Telecom Center of Excellence

I played a leadership role in establishing Telecom Center of Excellence in IIT Bombay. The center in IIT Bombay is being sponsored by Tata Teleservices Ltd. As a part of this center, I am directing the following major technology development efforts.

(a) Network OPEX Optimization

Power & Fuel (P&F) expenses constitute majority of operating expenses, and Diesel alone constitutes ~40% of overall Power & Fuel (P&F) expenses! As part of the continuous efforts by the industry to bring down these costs, several initiatives are being tried. However performance of these initiatives is heavily dependent on site characteristics (tenancy, weather, asset-health, grid availability etc.), technology evolution and fuel costs. Implementation of identified initiatives is typically done at a group-level and given the diversity in site characteristics, the actual benefits reduce. A site-specific decision making can significantly reduce the Operational Expense (OPEX). Given the large (>10K) sites and individual site characteristics, there is a need of a data analytics driven approach for site-specific decision making. We have developed an innovative tool using advanced machine learning, analytics and optimization techniques in providing focused decisions that bring benefit at every site, while operators retain the flexibility in introducing new initiatives. The technology has been field tested in several sites and shown up to 30% reduction in OPEX.

The technology is now being commercialized by Panchsheel Research Pvt Ltd. See <http://www.panchsheel.biz>

(b) Mobile Social Networking Platform (MSNP)

We developed an innovative concept for facilitating and analyzing social contexts for providing targeted recommendations. Our group has patented this concept and based on this, has developed a complete platform for mobile social networking. This platform offers many rich features which are very distinct from traditional social networking platforms. Mobile Social Networking Platform (MSNP) offers service providers an effective framework to develop personalized applications and send targeted advertisements to a user in the network. These advertisements are based on user's demographic profile, call detail records, buddy list and interests. Thus, instead of flooding the user advertisements, MSNP directs only relevant information to him.

Any application that uses the social networking can be launched on this platform. Few applications which were deployed and field tested on Tata Teleservices Network are listed below.

- **SmartPicks**

SmartPicks is the Handset bundle-offer from Tata DOCOMO that gives customers interesting package offers including:

- Free Video Calling Minutes
- Free Mobile TV Minutes
- Free Data Usage

MSNP identifies the SmartPicks base. The algorithm then identifies social clusters and sends targeted recommendations.

- **User Driven Health Care (UDHC)**

User-Driven Health Care (UDHC) is an SMS platform that supports patient's health care needs through a community based online collaborative work.

- **Targeted Caller Tune Recommendation**

This application aims at selectively recommending to a user, those caller tunes that she might like depending on analysis of social cluster.

This platform is being deployed on Tata Teleservices Network.

(c) Low Cost Cellular Backhaul for Rural Access (CeBRA)

Our group has been focusing on developing an innovative solution for cellular backhaul based on a modified optimized version of long distance free band radio. This leverages physical layer of IEEE 802.11 WiFi standard and uses an innovative media access control protocol. About 300 such links have been deployed in Tata Teleservices Network. This technology is being licensed to a company for commercialization.

2. Incubation of Company- Eisodus Networks Private Limited (Ethernet Based Broadband Access Networks)

During the beginning of year 2000, our group worked on the development of Ethernet based Broadband access technology for converged telecom sector with specific emphasis on emerging India and Asia specific markets. Our team architected an innovative architecture that leverages the potential of Ethernet for providing Quality of Service (QoS) based triple play services. We also developed a novel method of transporting voice over packet switched networks like Ethernet and developed unique algorithms for enhancing the performance of packet voice communication.

Based on these ideas and with a vision to develop technology for Indian telecom markets indigenously, I mentored and incubated a company called Eisodus Networks Private Limited in IIT Bombay's business incubator in 2003. The company successfully secured a funding of US\$ 1 Million from investors and set up the engineering team to develop the products based on these unique innovations. The field trial of the technology was carried out in Tata Communications, one of the largest Telecom operators in India. The products were also deployed in Tata Communication's live network in Mumbai. The technology was also tested by Sify Broadband, Bharti, Reliance Infocomm and a host of other service providers. The technology also attracted attention in world's telecom circles and top telecom business magazines featured it. Eisodus team is now part of Tejas Networks. I served as Technology Advisor to Tejas Networks during 2007-09.

The company was featured in Light Reading--

http://www.lightreading.com/document.asp?doc_id=85645&WT.svl=news1_2

3. Emergency Communication System for Force 1 Anti-Terrorist Commando

Our group has developed a state of the art emergency communication system for Force 1, an elite force formed to tackle terrorists in Maharashtra. This technology enables commandos' movements inside a building to be monitored in a remote control and command center through live video streaming over wireless. The system comprises of a base station located in control vehicle and commando unit which has a mini camera built into the commando's spectacle. The entire system has been developed and

prototyped by our group including the packaging by Industrial Design Center of IIT. This development has been covered in press news item-

http://articles.timesofindia.indiatimes.com/2011-10-07/mumbai/30257234_1_research-centre-anti-terror-security-forces

4. Open Source Software Development (Multiprotocol Label Switching (MPLS) Router)

In my early years of research, I led a major project in open source software development in the area of Linux based Layer 3 router based on MPLS. I successfully supervised efforts of about 7 Masters Theses. The carefully planned effort of the team led to the development of Linux based MPLS router and the source code was made available worldwide in open source. I also started the effort of developing Linux based MPLS emulator for research and development purposes. The Linux based source code has been downloaded by thousands of researchers and developers worldwide and is extensively used in various universities and research groups.

5. Contributions to International Standards in 4G Wireless (3GPP Standards) (IEEE 802.16m Mobile WiMAX) and IEEE 802.1 (Carrier Ethernet Standard)

I have made significant contributions in international standards- namely 3GPP, IEEE 802.16m and IEEE 802.1. We have recently started contributing to 3GPP Standards based on our research in the area of fourth generation (4G) wireless technology, namely, Long Term Evolution (LTE) and WiFi Offload. We also contributed to ITU-R's Working Party 5D in the area of TV white space.

Our research in next generation wireless communications has been incorporated into Mobile WiMAX standard-IEEE 802.16m. This standard forms one of the technologies for IMT-Advanced (official name of 4G) Wireless Standard. Specifically, our group's several ideas on Media Access Control (MAC) layer Quality of Service (QoS) including a novel idea in bandwidth reservation for QoS have been accepted and now forms part of the future 4th Generation wireless. Our group has also made several contributions on Relay architectures, Automatic Repeat Request (ARQ) protocol, Self Organizing Network and QoS in collaboration with leading technologist from Intel and others. (See the attached list for all contributions).

As a part of national effort, we also participated in evaluating the technologies for IMT-Advanced by International Telecommunications Union (ITU). ITU has recognized this group as one of the few registered evaluators in the world. Our innovative ideas in point to multi point protection and segment protection in carrier Ethernet were well received in 802.1 working group. As a result of these contributions to the working group, a new amendment to IEEE 802.1Q (called IEEE 802.1Qbf- Infrastructure Segment Protection) was initiated.

TEACHING

Development of New Courses

I introduced the following new courses in IIT Bombay-

- Communications Network (EE 706)
- Wireless and Mobile Communications (EE 764)
- Advanced Data Networks (EE 740)
- Advanced Internet Technologies (IT 641)- in Kanwal Rekhi School of IT

Development of New Lab

I developed a new lab called Information Networks Laboratory for research in communications network. The lab is equipped with about 40 Linux and Windows platforms, 3 high power compute servers, Linux based MPLS Test-Bed, Intel's Network Processor Test-Bed, Spirent's Protocol Analyzer, QUALNET/OPNET Simulation tools, WiFi measurements/development Test-Bed, Rohde & Schwarz Digital Storage Oscilloscope, Rohde & Schwarz Hand-held Spectrum Analyzer, Texas Instruments & Freescale LTE development platforms, Broadband Wireless Simulator.

Distance Education

Developed a video course on "Broadband Networks" under National Program on Technology enhanced Learning (NPTEL). The course is now available on YouTube's NPTEL channel.

LIST OF PhD THESES SUPERVISED

- Number of PhD theses completed : 10
Number of PhD theses in progress : 4

PhD Theses (completed)

1. Punit Rathod, Performance Characterization of Hybrid Wireless Network with WiFi Access and WiMAX Backhaul Links for Rural Broadband Applications, July 2014
2. Mahima Mehta, Radio Resource and Mobility Management Techniques in Heterogeneous Cellular Network, May 2014.
3. Ranjan Bala Jain, On Tele-traffic analysis of Cellular OFDM Network, February 2013.
4. R A Patil, On throughput Performance of Retransmission Protocols with Packet combining over Lossy Link, July 2012. (Co-advisor: Prof. Prasanna Chaporkar)
5. Brijesh Kumar Rai, On Network Coding for Communicating the Sum of Symbols from Multiple Sources, July 2010. (Co-advisor: Prof. Bikash Dey)
6. Sanjay S Pawar, Performance Analysis of Spectral Amplitude Coded Optical Code Division Multiple Access System, January 2010. (Advisor: Prof. R. K. Shevgaonkar)
7. Hemant Kumar Rath, On Channel and Transport Layer Aware Scheduling and Congestion Control in Wireless Networks, July 2009.
8. Nitin Salodkar, Online Algorithms for Delay Constrained Scheduling over a Fading Channel, May 2008.
9. Ashutosh Gore, On Wireless Link Scheduling and Flow Control, December 2008.

10. R. Manivasakan, Correlated Inter-arrival Time Poisson Process (CIPP) for Modeling Broadband Teletraffic, June 2000. (Advisor: Prof. U. B. Desai)

PhD Theses (in progress)

1. Akshay Mishra
2. Anshu Mittal
3. Arghyadip Roy
4. Shubhada Gadgil

Apart from PhD theses, I have supervised 106 MTech theses and 52 BTech projects.

SPONSORED RESEARCH AND CONSULTANCY

Number of Ongoing Sponsored Projects	: 5
Number of Completed Sponsored Projects	: 11
Number of Consultancy Projects	: 27

I have received total research funding of about Rs 20 crores through sponsored research and consultancy projects.

Sponsored Research Projects

I have undertaken large number of research projects sponsored by industries as well as government funding agencies. Following is a list of various projects undertaken by me as principal investigator.

Ongoing Projects-

1. **Test-Bed for affordable Broadband in India using Backhaul in TV White Space, Ford Foundation, 2013-16.**
Funding - USD 530K.

This project aims to setup test-beds in multiple Indian semi-urban/rural regions and determine technical parameters required for TV white space based operation of broadband services. We propose to investigate cost-effective affordable broadband services for urban and rural areas in sub-GHz TV band either in the unlicensed-spectrum scenario or in the lightly licensed regime for fixed backhaul applications. The research results of the test-bed are expected to provide concrete guidelines for developing a regulatory framework for TV white space operation in India

2. **Dual Connectivity LTE-WiFi Solution for Broadband Wireless Networks, Department of Electronics and Information Technology (DeitY), 2013-15.**
Funding - INR 3 crore

Wireless broadband technology is being seen as the key to providing ubiquitous broadband connectivity in the country. Effective use of the cellular 4G network in conjunction with the WiFi network gives several advantages to the operators and the mobile users. The objective of this project is to design and develop solutions for interworking of LTE-WiFi networks that can address the key challenges like network discovery, mobility, quality of experience and energy efficiency. The project will also

develop prototypes for the solutions arrived at and demonstrate in a LTE-WiFi test-bed. The test-bed will allow interworking of LTE and WiFi access networks at Layer 3.

3. Indo-UK Advanced Technology Center of Excellence in Next Generation Networks, Systems and Services, Phase-II, Department of Science and Technology, 2012-2015. Funding - INR 1.47 crore

This is a multi-institution project with several IITs, IISc and UK universities. The project has three groups and each group has several work packages. In our work package, we propose to address research challenges in radio resource and mobility management in next generation heterogeneous wireless networks. In addition, we also address energy efficient resource allocation algorithms.

4. Village Communications Network, MHRD, 2012-14. Funding - INR 1 Crore

The objective of this project is to develop wireless mesh network using commodity WiFi devices. The project envisages investigating multi-hop mesh network to address the problem of broadband access for low density rural subscribers with low average revenue per user.

5. Tata Teleservices-IITB Center for Excellence in Telecom, TTSL, 2008-2016. Funding - INR 12.0 crores

Telecom Centers of Excellence have been set up in IITs, IIM Ahmedabad and IISc Bangalore in public-private partnership mode with support from various telecom service providers. I played a leadership role in establishing the center in IIT Bombay. The center is being funded by Tata Teleservices. Under this center, I have been directing many technology development projects in areas of broadband access, network optimization and next generation wireless networks standardization.

Completed Projects

6. Technical Feasibility of TV White Space operation in India, Ford Foundation, 2012-13.
Funding - USD 125K
7. 4G Emergency Communications System, Force 1, Maharashtra Police, 2010.
Funding - INR 30 lakh
8. Next Generation Scalable Wireless Infrastructure for Broadband in India, Intel, 2010.
Funding- USD 33760
9. Indo-UK Advanced Technology Center of Excellence in Next Generation Networks, Systems and Services, Department of Science and Technology, 2009-2012.
Funding - INR 1.22 crores
10. Cross Layer Design for Next Generation Wireless Networks, Department of Science and Technology (DST), 2005-2008.
Funding- INR 23.84 lakh
11. Teletraffic Modeling and QoS Guarantees in Internet, DST, 2001-2004.
Funding- INR 9.48 lakh
12. Quality of Service in CDMA Mobile Networks, L&T InfoTech 2003-2004.
Funding- INR 1.0 lakh

13. Interactive Multimedia Communications over Cable TV Networks, Ministry of Human Resources, 1999-2001.
Funding- INR 9 lakh
14. GPRS Simulator, Tata InfoTech Ltd, 1999.
Funding- INR 1.2 lakh
15. Layer 3 Switching and Packet Filtering Systems, Texas Instruments, USA, 2000-2002.
Funding - USD 22600
16. Layer 3 Switching for High Performance Routers, RIMO Technologies, 1999.
Funding - INR 50K

Consultancy Projects

I have provided consultancy to many industries in network planning and design including advice on technology choice, procurement, installation; performance analysis and audit of networks, design and implementation of network protocols, due-diligence of technical capabilities for investment, taxation and validation matters. Some of my major consultancy projects have been with the following list of clients.

1. **Gujarat Informatics Ltd 2013-14**
Advising Gujarat Police on modernizing police communications network, RFP preparations, technical evaluations of bids, spectrum advice etc.
Funding - INR 17.9 lakh
2. **Urban Design Research Institute 2013-14**
Advised UDRI on planning strategies for city broadband towards Mumbai Development Plan 2030
Funding - INR 4.5 lakh
3. **Reliance Jio Infocomm 2013**
Advised the company on 4G mobile towers specifications.
Funding - INR 1.25 lakh
4. **Tejas Networks 2011-12**
Advised the technical team on algorithms towards LTE base station design
5. **Ericsson India and Economic Laws Practice 2011**
Advised the company on technical interpretation of base station components
Funding - INR 1.05 lakh
6. **Aditya Birla Capital Advisors 2011**
Detailed technical due-diligence of PON company for possible investment
Funding - INR 0.75 lakh
7. **Municipal Corporation of Greater Mumbai 2011-12**
Advised Municipal corporation in automating Octroi collection system
Funding - INR 13.5 lakh
8. **Tata Teleservices Ltd 2010.**
Technical help on taxation matters
Funding - INR 3.1 lakh
9. **Tejas Networks, Bangalore, 2007-2009.**
Advised the standards and technology team on Carrier Ethernet; authored patents and wrote technical contributions to standards.
Funding - INR 14.38 lakh
10. **Metanoia Inc, USA, 2008.**

Advised Metanoia team on IP QoS and Carrier Ethernet for international clients of Metanoia.

Funding - INR 4.33 lakh

11. Municipal Corporation of Greater Mumbai, 2008.

Advised MCGM for preparing RFP, technical evaluation of bids for deploying PMR radio communications system.

12. Reliance Communications, 2007-2008.

Validated their strategy for Broadband access networks and reviewed the deployment architecture.

Funding - INR 15.0 lakh

13. Sterlite Technologies, 2006.

Funding - INR 0.55 lakh

14. CMC Limited, Hyderabad, 2005.

Funding - INR 0.37 lakh

15. Larsen and Toubro InfoTech, 2003-2004.

Funding - INR 2.79 lakh

16. Tata Consultancy Services, 2002-2003.

Advised the technical team on embedded software for communications technology
Funding - INR 4.0 lakh

17. Cradle Technologies, USA, 2001-02.

Provided technology input on UMS platform

Funding - INR 2.2 lakh

18. Switch ON Networks, USA, 2000-2001.

Closely interacted with their architects on algorithms for packet classification for their classification engine.

19. Tata Consultancy Services, 2001.

Funding - INR 1.54 lakh

20. Axes Technologies, 2001.

Funding - INR 1.5 lakh

21. National Securities Depository Ltd, 2000.

Conducted a security audit of NSDL network.

22. Feedback Electronic System Ltd, 2000.

Performed due-diligence of technical capabilities of their CTI products.

23. MTNL, 2000.

24. Cirrus Logic Software India, Pune, 1999-2000.

Advised the team on implementation of TCP/IP stack and Router proof of concept on their UMS platform.

Funding - INR 4.2 lakh

25. Tata InfoTech Ltd, Mumbai, 1999.

26. BSES Telecom, 1999.

27. Cirrus Logic Software, India Pune, 1998.

LIST OF RESEARCH PUBLICATIONS

Number of US Patents Awarded	: 5
Number of Patents Filed	: 12
Standards Contribution	: 17
Referred Journals	: 24
Conference Proceedings	: 66
Book Chapters	: 2

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1. Abhay Karandikar, Prateek Kapadia, Animesh Kumar, Sanjay Kumar, Somya Sharma, Dhanshree Deval - Parakh, "Method for Facilitating and Analyzing Social Interactions and Context for Targeted Recommendations in a Telecom Service Provider's Network", US Patent issued in 2014.
2. Siddharth Shetty, Punit Rathod and Abhay Karandikar, "An Approach for Enabling Coexistence for Radio Technologies", **US Patent (8,725,078)** issued on May 2014.
3. Prateek Kapadia, B Srinadh, Abhay Karandikar and Harshad Maral, "Differentiating Wireless Uplink Bandwidth Request by Connection Priority", **US Patent (8,509,210)**, issued on August 2013.
4. Abhay Karandikar and M Vinod Kumar, "A Method to Develop Hierarchical Ring based Tree for Unicast and/or Multicast Traffic", **US Patent (8,391,180)** issued on March 2013.
5. Rohit Ramani and Abhay Karandikar, "Technique for Improving Transport Protocol Performance over Lossy Networks", **US Patent (7, 394, 764)** issued on July 01, 2008.

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2. Abhay Karandikar, Prateek Kapadia, Animesh Kumar, Sanjay Kumar, Somya Sharma, Dhanshree Deval - Parakh, "Method for Facilitating and Analyzing Social Interactions and Context for Targeted Recommendations in a Telecom Service Provider's Network", Patent filed, February 2010 (India).
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3. Gaurav Varshney, Punit Rathod, Akshay Mishra and Abhay Karandikar, "Interference Management in Heterogeneous Networks by Resource Block Prioritization", Patent filed, April 2012 (India).
4. Suman Khakurel, Abhay Karandikar and Mahima Mehta, "Uplink Bandwidth Request based on Connection Priority and Access Delay", Patent filed, March 2012 (India).
5. Suman Khakurel, Abhay Karandikar and Mahima Mehta, "A Novel Scheme of Buffer Status Reporting in Relay Assisted Cellular Networks", Patent filed, September 2011 (India).
6. Suman Khakurel, Abhay Karandikar and Mahima Mehta, "A Method of Buffer Status Reporting for Relay Nodes in Cellular Networks", Patent filed, September 2011 (India).
7. Gauri Joshi, B Srinadh, Prateek Kapadia and Abhay Karandikar, "A Relay ARQ Method to Minimize Packet Loss during Handover", Patent Filed, September 2011 (India).
8. M Vinod Kumar and Abhay Karandikar, "Segment-based Protection Switching with Traffic Engineering (SPS-TE) for Point-to-Point and Point to Multipoint Traffic Engineered Service Instances by Correlation of Fault Information", Patent filed, March 2009 (India).
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One of the working group members for the new standard-

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4. Prateek Kapadia and Abhay Karandikar, "Relay Datapath clarifications (16.6.2)", March 2010, IEEE C802.16m-10/0392.
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6. Siddharth Shetty and Abhay Karandikar, "Opportunities for India in Sub-1 GHz Spectrum and International Standardization", Technical Report, November 2010.
7. Siddharth Shetty, Akshay Mishra and Abhay Karandikar, "Proposal for TV White Space towards NFAP 2010", January 2011, contributions to National Frequency Allocation Plan 2011.
8. Siddharth Shetty, Akshay Mishra and Abhay Karandikar, "Proposal for Spectrum for PSDR and PPDR towards NFAP 2010", January 2011, contributions to National Frequency Allocation Plan 2011.

Book Edited

1. Vijay P Bhatkar and Abhay Karandikar, PARAM 9000: Towards a National High Performance Information Infrastructure, *CDAC India*, 1996.

LIST OF MEMBERSHIPS IN SOCIETIES & PROFESSIONAL ACTIVITIES

Memberships in Societies

1. Member, Institute of Electrical and Electronics Engineers (IEEE)
2. Fellow, The Institution of Electronics and Telecommunication Engineers (IETE)

Editorial Board

1. Associate Editor, *Sadhana*, Springer Verlag, 2012-13.
2. Member, Editorial Board, *International Journal of Network Management*, July 2008-December 2011.
3. Member, Editorial Board, *International Journal of Communications Network and Distributed System* 2009-11.

Technical Program Committee Member

1. Track Chair, iConnect, Computer Society of India 45th Annual Convention, November 2010.

2. Chair, National Conference on Communications, 2008.
3. Technical Program Committee of ADCOMP 1998 and 1999.
4. Technical Program Committee of HiPC 2002, 2003, 2004.
5. Technical program Committee of CIT 2002, 2003.
6. Technical Program Committee of ICBN 2003, 2004, 2006.
7. Technical program Committee of IEEE WCNC 2005, 2006, 2007, 2013.
8. Technical Program Committee of IEEE GLOBECOM 2008, 2009, 2010.
9. Technical Program Committee of WISARD 2009.
10. Technical Program Committee of IEEE ICC 2010.
11. Technical Program Committee of IEEE ANTS 2008 (Tutorial Chair), 2009.
12. Technical Program Committee of IEEE VTC 2010.
13. Working Group Member, IEEE 802.1 Standards WG, 2009-10.
14. Reviewers for IEEE Communications Letters, IEEE Transactions on Networking, IEEE Transactions on Wireless Communications, IEEE Transactions on Mobile Computing, IEE Proceedings and IEEE Communications magazine, Computer Communications, INFOCOM, ACM MobiHoc, GLOBECOM, SPCOM, Electronic Letters, International Journal on User-Driven Healthcare.

Other Professional Activities

1. Expert for evaluating Technology Development and Investment Promotion (TDIP) scheme of Department of Telecom, October 2013.
2. Member, Expert Committee, Indo-US Science & Technology Forum, 2013-14.
3. Member, Project Review & Steering Group (PRSG) for the project "Next Generation (4G Advanced) Wireless Technology Research" by CEWiT, Chennai DeitY, Gol, 2013.
4. Project Review & Steering Group (PRSG) for the project "Development of Broadband Wireless Communication System using Terahertz Technology by SAMEER, DeitY, Gol, 2013.
5. Member, Advisory Board, Bharti School of Telecommunications Technology and Management, IIT Delhi, 2013.
6. Member, Academic Committee, College of Military Engineering, Pune 2013.
7. Chair, Working Group 3, ITU-T Focus Group on "Bridging the gap: From Innovations to Standards", 2012-13, International Telecommunications Union (ITU-T)
8. Member, TCOE, sub-committee on self-sustainability, Department of Telecom, Government of India, 2012-13 (chaired by Joint Secretary, DoT).
9. Contributing author, Technology Vision 2035 on ICT and Telecom, TIFAC, 2013.
10. Jury member, Indian Semiconductor Association (ISA) Techno vision awards 2013.
11. Chairman, Project Review & Steering Group (PRSG) for the project Technology development for Autonomic Energy Aware Management of Network & Cloud by C-DAC, DeitY, Gol, 2012.
12. Member, Project Review & Steering Group (PRSG) for the project Text to Speech System in Indian Language, DeitY, 2012.
13. Member, CAREL sub-committee on Smart Phone set-up by Principal Scientific Advisor to Gol, 2012.
14. Jury Member, Economic Times Telecom Awards 2012.
15. Member, Technology Appraisal Committee, TIFAC Innovation Program, DST, 2012.
16. Selection committee member, CDAC, 2012.

17. Member, Research and Recognition Committee of Board of Studies, Mumbai University, 2012-13.
18. Working Group Member, IEEE 802.1 Standards WG, 2009-10.
19. Chairman, WG-4 Broadband Wireless Consortium of India.
20. Member, Technical Advisory Committee, Center for Excellence in Wireless Technology, Chennai 2008.
21. Member, Expert Group TEC, Ministry of Communications.
22. External Expert on the Review Committee and Selection Committees of CDAC, Pune.
23. Member, Vision Group in Information Technology, University of Pune.
24. Expert, Design Review Committee, Hybrid Satellite Internet System, ISRO, Ahmedabad, 1999-2000.
25. Member, Board of Studies, Amravati University.
26. Member, Sub Group formed by DoE, Government of India, in Jan-April 1997 to study IT Man Power requirements in India and IT education. The group comprised of top executives from IT companies and academicians.
27. PhD/MS theses examiner for IISc, IIT Delhi, Kanpur, Madras, Kharagpur, Guwahati, NIT Calicut, Trichy, Bhopal, DA-IICT, Mumbai University, IIITM Gwalior.

INVITED TALKS / TUTORIALS IN CONFERENCES

Tutorial in Tier-1 International Conferences

1. 'Elements of Cross-Layer System and Network Design for QoS Enabled WiMAX Networks', IEEE MILCOM, Orlando Florida, USA, October 2007.
2. 'Unraveling QoS in IEEE 802.16 Wireless Broadband Access Networks: The Role of MAC, Cross-Layer Design and Scheduling', jointly with Dr Vishal Sharma, IEEE GLOBECOM, San Francisco, November 2006.

Tutorial in National Conferences

1. 'Metro Ethernet: Understanding Key underlying Technologies', Metanoia Workshop, Bangalore, July 2007.
2. 'Appreciating Key Design Aspects of QoS in WiMAX', Metanoia Workshop, Bangalore, July 2007.
3. 'QoS in IEEE 802.16 Broadband Wireless Access: The Role of MAC, Cross-Layer Design and Scheduling', National Conference on Communications, IIT Kanpur, January 26-28th 2007.
4. 'Next Generation Optical Networks', half day tutorial, jointly with Dr Kumar Sivarajan of Tejas Networks, National Conference on Communications, IIT Madras, 2003.
5. 'Multiprotocol Label Switching', half day tutorial, National Conference on Communications, IIT Bombay, January 25-27th 2002.
6. 'Quality of Service Guarantees in Internet: Recent Trends', jointly with Prof Dheeraj Sanghi of IIT Kanpur, National Conference on Communications, IIT Delhi, January 29-30th 2000.

Selected Invited Talks in Industry and Academic Forums

1. 'Broadband Public Safety Communications', Distinguished Speaker in FICCI Workshop on Homeland Security, July 2014.
2. 'Issues in Spectrum Management and Future of Telecom', Leadership Lecture series, Vodafone, May 2014.
3. 'Broadband Wireless in India: Addressing Radio Spectrum Efficiency', Keynote address in TechFest, AD Patel Institute of Technology, Anand, March 2014.
4. 'Telecommunications Standards Development Society India: Role of Academia' Panel Discussion, National Conference on Communications, IIT Kanpur, March 2014.
5. 'Broadband Wireless Networks', Key note address in short term course 'Fundamentals and Applications of Wireless Communications Systems', SGS Institute of Technology, Indore, January 2014.
6. 'Innovations in Rural Broadband for Inclusive Telecom Growth' Telecom Summit in Convergence, 2014, New Delhi, January 2014.
7. 'Affordable Backhaul for Broadband in Rural India: Opportunities in TV White Space', Invited Talk in IEEE ANTS, Chennai, December 2013.
8. 'Wireless Broadband in India: Challenges, associated solutions and technology research directions', Invited talk in Intel Academic Forum, Goa, September 2013,
9. 'Spectrum Management Issues', Workshop on Activities and R&D Roadmap for the Next Five Years of TCOEs: Achieving the Objectives of NTP 2012, IIM Ahmedabad, July 2013.
10. 'Regulation in Spectrum Management', Invited talk in Workshop on International Spectrum Management, National Institute of Communications Finance, DoT, April 30th, 2013.
11. 'Next Generation Wireless Networks: Research Challenges and Opportunities', NASI-Reliance Industries Platinum Jubilee award Lecture, 82nd Annual Congress of NASI, December 01, 2012.
12. 'Building Eco-system for Smart Phones in India-Key Challenges', 3rd CAREL Workshop, Office of PSA to Government of India, Delhi, October 22nd, 2012.
13. 'Building Next Generation Large-Scale Mobile Backhaul Network', Indo-Japan 60th Anniversary Workshop on Large Scale Networks, Chennai, August 7th, 2012
14. 'Next Generation Wireless Networks: Tele-traffic and QoS Aspects', 4th Indo-German Frontiers of Engineering Symposium, Merseburg, Germany, June13-16, 2012.
15. 'Driving Innovations for Telecom in India: Role of IPR', Innovate India 2012, Mumbai, organized by DSIR, Ministry of Science and Technology, March 23rd 2012.
16. 'Driving Research Agenda for Telecom in India: Role of IPR', Plenary Session Talk, Regional International Telecommunications Society (ITS) Conference 2012, Delhi, February 23rd 2012.
17. 'Wireless Broadband Infrastructure in India', India Research Network Meeting, Samsung, Bangalore, November 4th 2011.
18. 'Towards 4G+', 2nd Bholanath Saikia Memorial Lecture, NIST Mirza, Guwahati, Assam, October 23rd 2011.
19. 'Trends in Wireless Networks' Invited Talk, FlyTxt, Trivandrum, July 2011.
20. 'Next Generation Wireless Networks: Research Challenges' ASET colloquium Tata Institute of Fundamental Research, June 10th 2011.

21. 'Next Generation Networks', Invited talk in TCS Technical Architects' Conference Kolkata, February 22nd, 2011.
22. 'Trends in Wireless Networks', CIO Meet, Computer Society of India, January 2011.
23. 'Incubating Next Generation Telecom Technologies', TCOE IPR in 4G, Telecom Export Promotion Council Meeting, New Delhi, December 8th 2010.
24. 'Next Generation Mobile Broadband', iConnect Track, Computer Society of India (CSI) 45th Annual Convention, Mumbai, November 27th 2010.
25. 'Role of National Institutions in Telecom Standards', Mobile Broadband: Igniting the Service Revolution, workshop by IITCOE - IIM Ahmedabad, New Delhi, November 26th 2010.
26. 'Opportunities for Sub-1 GHz Frequency Spectrum in India', Mobile Broadband: Igniting the Service Revolution, IITCOE - IIM Ahmedabad, November 26th 2010.
27. 'Scheduling in Wireless Networks', Institute Colloquium, NCRA, TIFR, Pune, October 15th 2010.
28. 'Next Generation Wireless Networks: Research Challenges and Opportunities', Hari Om ashram prerit Dr Vikram Sarabhai award Lecture, Physical Research Laboratory, Ahmedabad, August 12th 2010.
29. 'Opportunities and Challenges in India's Growing Computing and Wireless Broadband Market', Intel, Santa Clara USA, July 15th 2010.
30. 'Delay Constrained Scheduling over Fading Channel', Qualcomm Research, San Diego, July 13th 2010.
31. '4G MAC Layer: TICET contributions to standards', Tata Teleservices Limited (TTSL), Mumbai, June 21st 2010.
32. 'Next Generation Wireless Networks', Maharashtra Institute of Technology, Alandi, Pune (Inauguration of Research Center), July 9th 2010.
33. 'Research Agenda for Next Generation Wireless Networks', Wireless Technology in Emerging Markets, Intel, Bangalore, June 11th 2010.
34. 'Broadband Internet: Technology Development and Challenges', National Broadband Initiative Workshop, IITCOE - IIM Ahmedabad, New Delhi, April 16th 2010.
35. 'IEEE 802.1Qbf: Infrastructure Segment protection', Global Standards at IEEE, IEEE-SA Seminar, Bangalore, March 9th 2010.
36. 'Next Generation Wireless Networks: Challenges and Opportunities', 1st GISFI Standardization Event, Lonavala, February 26-27th 2010.
37. '4G MAC Layer: TICET Contributions to IEEE 802.16m', Plenary talk on Indian Contributions to Global Standard, National Conference on Communications, IIT Madras, January 29th 2010.
38. 'IPv6 over WiMAX', BSNL's IPv6 workshop, Mumbai, 27th November 2009.
39. 'Next Generation Wireless Networks', Invited talk in C-DOT's 25th Silver Jubilee event, Bangalore, August 2009.
40. 'Trends in Networking', Tejas Networks Engineering Conference, August 2008.
41. 'On-Line Learning Algorithm for Power Optimal Scheduling under Fading Channel', International Conference on Stochastic Processes and Applications, IISc Bangalore, July 2007.
42. 'Challenges for Broadband Deployment in India and Role of Metro Ethernet', keynote address in National Conference on Emerging Trends in Electronics and Communications Engineering, PCE, Goa.

43. 'Challenges for Broadband Deployment in Emerging Economies', Indo-Australia Broadband and Information Technology Workshop, Australian Academy of Technology and Sciences, July 2006.
44. 'QoS and Resource Allocation in Wireless Networks', Indo-US Frontier on Engineering Workshop, US Academy of Engineering and Indian Academy of Engineering, Agra, March 2006.
45. 'Efficient Scheduling under Fading Channel', Indo-UK Workshop on Next Generation Networks, Chennai, January 31st 2006 - February 2nd 2006.
46. 'Metro Ethernet Access Networks', MTNL Mumbai, October 15th 2005.
47. 'Equitable Information Society: Time for Action', World Telecom Day, MTNL, May 17th 2005.
48. 'On Scheduling Transmission under QoS Constraints', Polytechnic University, Brooklyn, July 2003.
49. 'Ethernet based Access Networks', International Conference on Broadband Networking, ICBN, 2003, May 2003.
50. 'MPLS Performance Engineering and MPLS Emulator', MPLS/GMPLS World Asia Pacific Conference, Seoul, Korea, March 24-26th 2003.
51. 'Overview of MPLS Traffic Engineering', International Conference on Information Technology 2002, December 2002.
52. 'Demystifying MPLS' IEEE ComSoc Invited Lecture series, Mumbai, September 24th 2001.
53. 'Packet Scheduling Algorithms for Quality of Service Guarantees', N Rama Rao Distinguished Lecture, IIT Kanpur, September 6th 2001.
54. 'IP Switching', Sasken Communications Technologies, Bangalore, April 2001.
55. 'Issues in providing Internet Services over Cable TV Networks', Commsphere 2000, February 2000.
56. 'Technology Convergence and Information Infrastructure', National Workshop of Advertising and Communications Industry held to discuss Broadcasting Bill 1997, Mumbai, July 1997.
57. 'High Performance Computing in India with specific reference to CDAC's PARAM', 30th Annual Convention of Computer Society of India (CSI), Hyderabad, November 1995.

CONTINUING EDUCATION PROGRAM (CEP)

I have conducted a large number of CEP and short term courses for industry professionals, government officers and university teachers. A list is given below.

CEP Courses Conducted (as Principal Investigator)

1. '(Dynamic) Spectrum Management', January 2014.
2. 'Role of Technology in Crime and Crime Prevention', IPS Officers, November 2011.
3. 'Technology for Law Enforcement', Mumbai Police, June 2010.
4. 'Role of Technology in Crime Prevention and Detection for IPS officers', October 2007.
5. 'CDMA Mobile Communication', CEP/DEP course, June 2005.
6. 'Signal Processing in Networking', Short Term course, August, 2004 (sponsored by DST).
7. 'Broadband Networks', Motorola, New Delhi, February, 2004.

8. `GSM and CDMA', Larsen & Toubro InfoTech, Mumbai, April 2003.
9. `Wireless Networks', Motorola, New Delhi, November 2002.
10. `CDMA', Persistent Systems, Pune, September 2002.
11. `VoIP', Hughes Tele.com, Mumbai, August 2002.
12. `Communications Technologies', Global Tele Systems, Mumbai, July 2002.
13. `Voice over IP', Usha Martin Communications, Calcutta, May 2000.
14. `Voice over IP', Usha Martin Communications, Calcutta, November 1999.
15. `Telematics', IIT Bombay, Mumbai, June-July 1998.

Participation in the form of lectures in CEP (as Co-I)

1. `Spectrum Regulations and TV White Space Scenario in India', CEP course on (Dynamic) Spectrum Management, January 2014.
2. `GSM', CEP course on Role of Technology in Crime and Crime Prevention, November 2012.
3. `GSM and 3G' CEP course on Role of Technology in Crime and Crime Prevention, November 2011.
4. `Public Safety Communications', CEP course on Role of Technology in Crime Prevention and Detection for IPS officers, November 2010.
5. `GSM and CDMA', CEP course on Role of Technology in Crime Prevention and Detection for IPS officers, November 2009.
6. `Air Interface for Mobile Communications', CEP course for GTL Systems, Mumbai, January 2007.
7. `Wireless Communications', CEP course on Role of Technology in Crime Detection and Prevention for IPS Officers, November 2004.
8. `Wireless Communications', CEP course on Role of Technology in Crime Detection and Prevention for IPS Officers, November 2003.
9. `Internet Concepts', CEP course on Data Communications, VSNL, January 2003.
10. `ATM Technology', CEP course on Switching, VSNL, Jan 2003.
11. `QoS for IP Telephony', short course for Tata Teleservices organized by UACT, December 2002.
12. `Voice over IP', Short term course in UACT, June 2002.
13. `QoS in Internet', Short Term course on IP Telephony, UACT and IISc, February, 2002.
14. `High Speed Network', CEP course on Communications Module, VSNL, December 2001.
15. `Internet and ATM', CEP course on Corporate training, VSNL, November 2001.
16. `ATM and High Speed Network', CEP course on Corporate training, VSNL, October 2001.
17. `Voice over IP', 5th Finishing School Program, UACT, November 2001.
18. `Digital Communications and Noise', Short Term course on Telematics, August-September 2001.
19. `Voice over IP', 4th Finishing School Program, UACT, July 2001.
20. `GSM' and `CDMA', IEP course on Mobile Computing, July 2001.
21. `Embedded Wireless Device', CEP course on Embedded System IEP, June 2001.
22. `TCP/IP and QoS in Internet', CEP course on Communications Network for Reliance Infocom, December 2000.

23. CEP course on Telecom Fundamentals for Eftia OSS Solutions, Mumbai, October 2000.
24. `High Speed Network', CEP course on Communications Module, VSNL, September 2000.
25. `High Speed Network', CEP course on Communications Module, VSNL, June 2000.
26. `Signaling in B-ISDN, ATM and GSM', CEP course on SS7 Signaling, Usha Martin Communications, Calcutta, May 16-19, 2001.
27. `High Speed Network', CEP course on Communications Module, VSNL, Pune, February 2000.
28. `High Speed Network', CEP course on Communications Module, VSNL, Pune, October 1999.
29. `High Speed Network', CEP course on Communications Module, VSNL, Pune, August 1999.
30. `High Speed Network', CEP course on Communications Module, VSNL, Pune, July 1999.
31. `Microprocessor', CEP course, Railway Engineers in IRIEN, Nasik, January 1999.
32. `High Speed Network', CEP course on Communications Module, VSNL, Pune, October 1998.
33. `Multimedia Networks', CEP course on Multimedia and Visual Special effects, September 1998.
34. `High Speed Network', CEP course on Communications Module, VSNL, Pune, September 1998.
35. `High Speed Network', CEP course on Communications Module, VSNL, Pune, August 1998.
36. `Microprocessors', CEP course, Railway Engineers in IRIEN, Nasik, July 1998.
37. `High Speed Network', CEP course on Communications Module, VSNL, Pune, February, 1998.
38. `Microcontrollers', CEP course on Mechatronics, October 1997.
39. `DSP Processors', CEP course on Current Topics in Digital Signal Processing, August 1997.
40. `High Speed Network', CEP course on Communications Module, VSNL, Pune, June 1997.