

Date: Wednesday, April 26, 2017 8:00 AM to 6:00 PM

Venue: The E Hotel Banquet & Conference Center
3050 Woodbridge Avenue, Edison, NJ 08837

5G Learning Series: 5G Tutorial – Chair’s Report

by

Amruthur Narasimhan Ph.D., CISSP

The IEEE 5G Education Working successfully conducted our first 5G Learning Series on April 26, 2017 at the Edison Hotel and conference center, Edison, NJ. We had an entire day full of invigorating presentations by invited speakers, who provided cutting edge information on 5G key areas. A large number of attendees, around 200 registrants (115 registrants at the location and 85 web attendees), filled the conference hall to its capacity. The tutorial had also strong student participation, both as attendees and volunteers. Participants made it successful by their participation and interactions with invited speakers and professional colleagues... We received excellent feedback from the attendees along with requests to conduct a similar learning series on 5G in 2018 to benefit IEEE members and other professionals in the area.

On behalf of the IEEE, I am pleased that you attended the IEEE 5G Learning Series – NJ Edition Tutorial and many of you gave good feedback about professionalism with which the tutorial was conducted and the expertise of invited speakers. The Chair thanks our volunteers, and IEEE OC staff who helped to make this a successful 5G Tutorial.

The day began with a social breakfast at 8:00 AM. The tutorial started with 5G Basics given by Dr. Sudhir Dixit, who is the Fellow and Evangelist, Basic Internet Foundation. The tutorial had two tracks: Track 1 covering 5G core topics and Track 2 covering 5G applications. Dr. Sudhir Dixit scheduled on Track 1 with 5G core and the role of Network Function Virtualization (NFV) and Software Defined Network (SDN) gave an excellent background and fundamentals of 5G to attendees. After lunch, Track 1 continued with Importance of Millimetric waves in 5G by Dr. K Raghunandan, who is Lead Wireless Analyst at New York Transit. After the coffee break in afternoon, Dr. Xiaoxiong (Kevin) Gu from IBM spoke about mmWave Silicon Integration and Packaging Challenges for 5G Communication. Track 1 concluded with Prospect of 5G Air Interface from Dr. Yongxing Zhou VP of Huawei /Dr. Lingjia Liu Assoc Professor of Univ. of Kansas.

Track 2 continued after the morning coffee break by Prof Jennifer Chen from Stevens Institute of Technology covering topic on “Friend or Foe? Security Issues in IoT Devices Empowered by 5G Networks.” Dr. Jaichen Chen of Rutgers WINLAB spoke about 5G IoT Network – Service Oriented Communication with Global Reachability. Dr. Amruthur Narasimhan spoke on “Critical issues of IOT empowered by 5G – A case study on self-driving vehicles.” This was followed by Akshay Sharma on Newer Low Code Back Office Capabilities for 5G, how a new BSS can enable 5G Innovations.

All tutorial topics were up to the minute, exciting, informative, and thought-provoking.

Attendees at the 5G learning series were pleased to interact with each other and participate in lively discussions with the invited speakers and peers during the breaks for breakfast, lunch and afternoon snack – which were included in the modest registration fee. Concluding the conference, prizes and awards were presented to speakers and volunteers...

You can review the updated Agenda on the IEEE website <http://5g.ieee.org/education/ieee-5g-learning->

IEEE 5G Learning Series – 5G Tutorial- NJ Edition



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series/new-jersey-edition

We have published the presentation slides (conditioned on the approval of speakers/organizations) on the 5G learning series for the attendees after the event.

Attendees were given the option to get Continuing Education Units (CEUs) if they did register earlier and

- (a) Attend the full day conference and (b) Submit the completed CEU evaluation form at the Registration Desk at the close of conference.



SPEAKERS IEEE 5G Tutorial Chair

VOLUNTEERS IEEE 5G Tutorial Chair

Sincerely,

Dr. Amruthur Narasimhan,
Chair of the NJ 5G Tutorial

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TUTORIAL SPEAKERS



Dr. Sudhir Dixit
Fellow and Evangelist,
Basic Internet Foundation



Dr. K Raghunandan
Lead Wireless,
New York Transit



Yongxing Zhou
Vice President,
Huawei



Dr. Lingjia Liu
Associate Professor, EECS,
University of Kansas



Prof. Jennifer Chen
EECS, Stevens Institute of
Technology



Dr. Jiachen Chen
Rutgers WINLAB



Dr. Xiaoxiong (Kevin) Gu
IBM T.J. Watson Research
Center



Akshay Sharma
VP at Beesion



Dr. Amruthur Narasimhan
Information Security
Consultant

IEEE 5G Initiative Learning Series – New Jersey Edition

5G is not just the next evolution of 4G technology; it is a paradigm shift. 5G is not only evolutionary (providing higher bandwidth and lower latency than current-generation technology); more importantly, 5G is revolutionary, in that it is expected to enable fundamentally new applications with much more stringent requirements in latency (e.g. real time) and bandwidth (e.g. streaming). 5G should help solve the last-mile problem and provide broadband access to the next billion users on earth at much lower cost because of its use of new spectrum and its improvements in spectral efficiency. 5G is an enabler of exciting use cases that will transform the way people live, work, and engage with their environment. In the short term, 5G can support exciting use cases such as the IoT, smart transportation, eHealth, smart cities and smart homes, industrial automation, and entertainment services.

The IEEE 5G Learning Series is designed to demystify 5G technologies and train technology and industry teams with the knowledge of 5G technologies. This tutorial will provide an understanding of the following topics:

- Introduction to 5G
- 5G RAN
- 5G IOT
- 5G Hardware
- 5G Application
- 5G Core
- 5G Standards
- 5G Security
- 5G OSS
- 5G Business

Attendee Registration (in-person or remote online access via Webex): <https://events.vtools.ieee.org/m/44054>

Earn 0.7 CEU Credits with additional \$9 charge and separate online registration.

Patron/Exhibitor Registration:

<https://meetings.vtools.ieee.org/m/44174>

Dr. Amruthur Narasimhan, IEEE 5G New Jersey Tutorial Chair,
anarasimhan@ieee.org

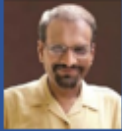
Dr. Ashutosh Dutta, IEEE 5G Initiative Co-Chair, ashutosh.dutta@ieee.org

Dr. Rulei Ting, IEEE 5G Education Working Group Co-Chair, rt@ieee.org

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IEEE 5G Initiative Learning Series – New Jersey Edition- 5G Tutorial

TUTORIAL SPEAKERS



Dr. Sudhir Dixit
 Fellow and Evangelist,
 Basic Internet Foundation



Dr. K Raghunandan
 Lead Wireless,
 New York Transit



Yongxing Zhou
 Vice President,
 Huawei



Dr. Lingjia Liu
 Associate Professor, EECS,
 University of Kansas



Prof. Jennifer Chen
 EECS, Stevens Institute of
 Technology



Dr. Jiachen Chen
 Rutgers WINLAB



Dr. Xiaoxiong (Kevin) Gu
 IBM T.J. Watson Research
 Center



Akshay Sharma
 VP at Beesion



Dr. Amruthur Narasimhan
 Information Security
 Consultant

AGENDA

Time	Track 1- Core	Track 2- Applications
8-9 AM	Registration/Breakfast	
9-11 AM	5G Basics - Dr. Sudhir Dixit	
11-11.15AM	Coffee Break	
11.15 – 1:15 AM	5G Core and the role of NFV and SDN Dr. Sudhir Dixit	Friend or Foe? Security Issues in IoT Devices Empowered by 5G Networks Prof. Jennifer Chen
1:15-2:15	Lunch	
2:15-3:15 PM	Importance of Millimetric waves in 5G Dr. K Raghunandan	5G IoT Network – Service Oriented Communication with Global Reachability Dr. Jiachen Chen
3:15-3:30 PM	Coffee Break	
3:30 –4:30 PM	mmWave Silicon Integration and Packaging Challenges for 5G Communication Dr. Xiaoxiong (Kevin) Gu	Critical issues of IOT empowered by 5G – A case study on self-driving vehicle Dr. Amruthur Narasimhan
4:30-5:30 PM	Prospect of 5G Air Interface Dr. Yongxing Zhou /Dr. Lingjia Liu	Newer Low Code Back Office Capabilities for 5G, how a new BSS can enable 5G Innovations Akshay Sharma

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<http://5g.ieee.org/education/ieee-5g-learning-series/new-jersey-edition>

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2017 5G Tutorial Program Highlights

Dr. Amruthur Narasimhan, 5G Tutorial Chair, opened the conference by greeting all the participants, speakers, and volunteers. He spoke about the program for the whole day of full of invigorating presentations by invited speakers. He emphasized that 5G wireless and mobile communication networks supports 100s of Mb/sec to 1 Gb/sec of data throughput. He introduced that 5G mobile communications will have 1000 times the capacity increase in comparison to networks deployed last decade. Millimetric waves (30GHz – 300 GHz) are poised as a great contributor towards phenomenal data rates, which are critical component of 5G radio access.

With proliferation of IoT devices, a communication network with global reachability, mobility, and richer communication are required. With approximately 20 billion IOT devices being forecast to be deployed by 2020, security is an important challenge along with privacy. This brings in the social and legal challenges of IoT deployment a critical issue that needs to be tackled.

Dr. Ashutosh Dutta gave a brief description of 5G initiative from IEEE, conducting 5G conferences, 5G tutorials and involving industries, universities and other organization in developing and deploying 5G.



Dr. Amruthur Narasimhan, IEEE 5G Tutorial Chair



Dr. Ashutosh Dutta, IEEE 5G Initiative Co-Chair

Invited Speakers

TRACK 1: 5G Core:

The chair introduced the first invited speaker Dr. Sudhir Dixit, Fellow Evangelist, Basic Internet Foundation, described the basics of 5G. The foremost requirement of 5G wireless and mobile communication networks is the ability to support transmission speeds of the order of 100s of Mb/sec to 1Gb/sec (at times with very low latency). The networks of future (towards 2025) would be required to cater for an overall 1000x capacity increase in comparison to the systems deployed during the earlier part of the present decade. These objectives will be achieved through the introduction of new technologies in Radio Access Networks (RANs). He explained that Enhanced MIMO (Multi Input Multi Output) and Large Scale Antenna Systems (or Massive MIMO) are two important PHY layer “capacity/coverage” enhancement technologies. Further, he described how HetNets (Heterogeneous Networks) will help 5G deployment. Air interface

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adaptations required for very high energy efficiency and massively parallel nature of transmissions from IoT devices will form an integral part of the 5G design.



Dr. Sudhir Dixit

Further, in module 2 of his talk on “5G core and the role of NFV and SDN, described major new RAN technologies for 5G systems. His presentation went into the details of virtualization and SDN by covering such topics as the benefits of virtualization, consideration of planning and deployment of a 5G eco-system, potential architectures and ecosystems, standards activities targeting the 5G systems, and some selected use cases of (and roadmap towards) NFV deployments. He concluded with a brief description of open research and technology challenges for implementation of future generation networks.

Next, Dr. K. Raghunandan, Lead wireless Engineer, NY Transit, spoke on “Importance of Millimetric waves in 5G” that are (30GHz – 300 GHz) are poised as a great contributor towards phenomenal data rates. He described several challenges to implement this technology. With the initial implementation yielding encouraging results, industries are gearing up to the task of producing Millimetric wave components, circuits and systems. He provided an overview of what this involves not only in terms of producing equipment, but also how to deploy and optimize the radio network. He spoke about current deployments in the Millimetric wave bands (both unlicensed and licensed) and moves to possible large scale deployments in future. Are the expectations of high data rates real? How much of this is practical were addressed in the tutorial.



Dr. K Raghunandan

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Next Dr. Xiaoxiong (Kevin) Gu, IBM T. J. Watson Research Center, spoke on “mmWave Silicon Integration and Packaging Challenges for 5G Communication.” mmWave technology is rising as a crucial component for 5G radio access and other emerging ancillary wireless networks including Gb/s device-to-device communication and mobile backhaul. The tutorial covered recent advances in state-of-the-art mm-wave silicon technology, packaging and integrated antenna design in the context of 5G communications. The main challenges in 5G hardware development and the corresponding mitigation strategies are discussed with a focus on RFIC, antenna and packaging integration technologies. The talk emphasized the following key enablers for the commercial scale deployment of mm-wave technology in the 5G era: 1) highly integrated and complex circuits in silicon technologies, and 2) strategies for IC, package, antenna and board co-design and integration. Through various examples of mmWave transceivers with antennas-in-package demonstrated in hardware, this talk illustrates how these challenges can be addressed for a variety of potential 5G usage scenarios, from PAN to backhaul.



Dr. Xiaoxiong (Kevin) Gu

Next, Dr. Yongxing Zhou, Vice President of Huawei and Dr.Lingjia Liu, Head of MIMO and Spectrum Research Competency Center spoke on “Prospect of 5G Air Interface: Opportunities and challenges.” The new connected digital society with varieties of heterogeneous services (MBB and the IoT) provision has brought unprecedented challenges to future radio access and mobile core networks. Technology and spectrum innovations have to meet those diversified requirements for specific application scenarios within an integrated/unified radio access technology framework. This tutorial illustrates how the transformation from spectrum efficiency to service-specific and user experience based evaluation metrics is needed. Key technology enablers were analyzed and evaluated to accelerate business success of 5G and the IoT. 5G New Radio (NR) standard progress were introduced in this tutorial and how this paradigm shift is becoming reality.

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Dr. Yongxing Zhou

TRACK 2: 5G Applications:

Dr. Amruthur Narasimhan introduced next speaker for track 2 on applications – Prof. Yingying (Jennifer) Chen, Professor, EECS Stevens Institute of technology who spoke on “Friend or Foe? Security Issues in IoT Devices Empowered by 5G Networks.” 5G networks will offer data speeds 10 to 100 times faster than current 4G networks. In addition to increased speed, 5G networks will offer lower latency, increased reliability, and fast connectivity from more places, and greater capacity, allowing more users and more devices to be connected at the same time. The resulting infrastructure will finally make the Internet of Things (IoT) scalable, with more than 20.8 billion “things”—including buildings, cars, machines, appliances and wearable devices—expected to be online by the time 5G rolls out in 2020, up from 4.9 billion things in 2015. The IoT presents numerous benefits to consumers, but security and privacy could be a serious concern preventing the wide deployment of IoT. In this tutorial, two examples in wearable devices and smartphones to demonstrate the security concerns in IoT deployment were used. In the first example, while the embedded sensors in wearable devices (such as smartwatches and activity trackers) have the capability of monitoring and inferring human daily activities, they could also be utilized to reveal user’s sensitive information. In particular, she demonstrated a serious security breach of wearable devices in the context of divulging secret information (i.e., key entries) while people accessing key-based security systems. Existing methods of obtaining such secret information relies on installations of dedicated hardware (e.g., video camera or fake keypad), or training with labeled data from body sensors, which restrict use cases in practical adversary scenarios. In this tutorial, a wearable device can be exploited to discriminate mm-level distances and directions of the user’s fine-grained hand movements, which enable attackers to reproduce the trajectories of the user’s hand and further to recover the secret key entries. In the second example, she explored the limits of audio ranging on mobile devices in the context of a keystroke snooping scenario. Acoustic keystroke snooping is challenging because it requires distinguishing and labeling sounds generated by tens of keys in very close proximity. Existing work on acoustic keystroke recognition relies on training with labeled data, linguistic context, or multiple phones placed around a keyboard — requirements that limit usefulness in an adversarial context. In this tutorial, mobile audio hardware advances can be exploited to discriminate mm-level position differences and that this makes it feasible to locate the origin of keystrokes from only a single phone behind the keyboard.

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Prof. Yingying (Jennifer) Chen

Next Dr. Amruthur Narasimhan introduced Dr. Jiachen Chen, Rutgers University, who spoke on “5G IoT Network – Service Oriented Communication with Global Reachability.” The advent of new Internet of Things (IoT) devices has posed challenges to the underlying network design. He spoke about the 5G network for IoT devices that would in future support: 1) global reach-ability – the devices need to be identified and located from any place in the network, 2) mobility support – the devices need to have seamless connection even in presence of device mobility, 3) richer communication patterns – the devices need communication patterns like query/response, pub/sub, anycast, etc., and 4) resource efficiency – a large proportion of IoT devices are severely constrained in energy, computation, and/or network capacity.

MobilityFirst (MF) is a future Internet architecture that has the potential to satisfy the requirements of the new IoT network – persistent globally unique identifiers (GUID's) provides global reach-ability; late-binding based on global name resolution service (GNRS) supports mobility in an efficient manner; communication patterns like unicast, multicast and anycast are also supported natively. To extend the coverage of MF to devices with power, computation and network constraints, MF-IoT is proposed as a light-weight variant (but is still compatible with) MF. Concept of “service-oriented communication” is also encouraged to satisfy the communication widely used in IoT world.

He described the design and implementation of both MobilityFirst and MF-IoT to explain how different communications will be realized in the 5G IoT network. To help understand the concept of service-oriented communication, he used several typical IoT applications to show the benefits that the users and devices can get. He also spoke about potential new IoT applications that can be supported in the new environment

Next, Dr. Amruthur Narasimhan, IEEE 5G Tutorial Chair, spoke on “Critical issues of IOT empowered by 5G – A case study on self-driving vehicle.” The proliferation of Internet of Things (IoT) devices in connected automobile systems creates challenges of harnessing large data empowered by 5G while maintaining security and confidentiality, as well as business, social and legal challenges. The sheer scope of IoT carries countless security and privacy implications for businesses, individuals and organizations. The proliferation of IoT devices creates challenges of harnessing large data empowered by 5G while maintaining security and confidentiality, as well as business, social and legal challenges.

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Dr. Amruthur Narasimhan

Dr. Narasimhan spoke about one of the use cases of autonomous vehicles in depth for their implications on security, privacy, social and legal challenges.

Proliferation of large-scale deployment of IoT devices without proper design for solutions to security, privacy and big-data challenges has attracted the auto industry's attention. Proper administrative, social and legal changes are needed by people, government and businesses.

Next Dr. Amruthur Narasimhan introduced Akshay Sharma, Former Tech analyst at Gartner, current VP at Beesion, who spoke on “Newer Low Code Back Office Capabilities for 5G, how a new BSS can enable 5G Innovations.” 5G holds the promise of providing newer services like UltraHD video, leveraging unlicensed spectrum, enhanced support of M2M and IoT applications, holistic security, and with distributed cloud RAN architectures. Newer service chaining of functions with open APIs will occur, blending the cloud with the network. However, as in any new innovation, the legacy back office Business Support System (BSS) often becomes the bottleneck to rapid deployments within carriers. He discussed these issues and possible solutions, using novel DevOPs, Low Code model-driven and cloud-based approaches to BSS, opening the door to further 5G innovations.



Akshay Sharma

Closing Remarks

What should the 5G industry and research plan in 2018 and beyond to address the basic requirements and standards of 5G? What 5G applications will we see in the near future including IOT etc.? What is in store for this industry in 2018 and beyond?

ACKNOWLEDGEMENTS

The Chair thanks Dr. Manu Malek, for providing helpful comments and editing the Tutorial Chair report.

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About IEEE:

The IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through its highly cited publications, conferences, technology standards, and professional and educational activities.

Through its more than 430,000 members in 160 countries, the organization is a leading authority on a wide variety of areas ranging from aerospace systems, computers and telecommunications to biomedical engineering, electric power and consumer electronics. Dedicated to the advancement of technology, the IEEE publishes 30 percent of the world's literature in the electrical and electronics engineering and computer science fields, and has developed nearly 1,500 active industry standards. The organization annually sponsors more than 1,300 conferences worldwide. Additional information about the IEEE can be found at www.ieee.org.

Tutorial Scope:

The IEEE 5G Learning Series is designed to demystify 5G technologies and train technology and industry teams with the knowledge of 5G technologies. This tutorial will provide an understanding of the following topics: Introduction to 5G, 5G RAN, 5G IOT, 5G Hardware, 5G Application, 5G Core, 5G Standards, 5G Security, 5G OSS, and 5G Business