Getting Ready for 5G:

Preparing a Skilled Workforce for Future Wireless Networks

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Content

Abstract

New technologies will be needed to bring the next generation of wireless services to market. The physics of using licensed and unlicensed radiofrequencies for coexistence and convergence will require advanced training and skills development in the field of RF engineering. Massive Multiple Input Multiple Output (MIMO) antenna propagation, millimeter-wave technologies, Centralized Radio Access Networks (C-RAN), Software Defined Networks (SDN), advances in Wi-Fi technologies and more are just some of the tools that will be used to deploy fifth-generation (5G) networks and services. This report, which builds on a 2016 Wireless Infrastructure Association paper, identifies training and educational needs across a broad swath of technologies as the network moves closer to the end user. While candidate technologies and use cases are being evaluated for 5G, which is scheduled to be standardized by 2020, this report aims to address the need for effective on-the-job training, classroom, and online education to help the industry create a skilled labor workforce to build future generations of heterogeneous networks.

Introduction

Fifth-generation (5G) mobile communications networks are expected to disrupt nearly every job sector and ecosystem across the world as deployment of these technologies enables more robotics and automation, adding to productivity throughout the world where advanced network services are deployed. While the definition of 5G technology is not yet standardized, the lack of formal definitions has not discouraged interest, investment, or declarations of deployments throughout the telecommunications sector.

Ahead of the first phase of standardization, expected to be completed in 2018, academia and operators have started showcasing some of the key capabilities of 5G through trials and business cases. Companies are focused on new air-interface transmission schemes, higher frequency bands, and advanced antenna technologies such as Massive MIMO and beamforming. Many experts predict that large-scale commercial deployments will start in 2020. ReportsnReports estimates that 5G networks will generate nearly $250 billion in annual service revenue by 2025.[1]

The sea change expected from the deployment of 5G networks can only happen with a sufficiently skilled labor force trained to design, install, and monitor these networks. Further, 5G deployments will require other new skillsets as industries adapt their workforces to exploit changes driven by 5G adoption.

Mobile Data Demand and Driving Forces of 5G

Subscribers on fourth-generation LTE (4G) networks today are demanding more bandwidth as streaming video, augmented reality, peer-to-peer gaming, and other bandwidth-intensive services are popular. Data consumption on smartphones is expected to grow from less than 6 Gigabytes (GB) per month to 26 GB per month in North America in the next five years, according to the Ericsson Mobility Report 2017.[2]

While Mobile Network Operators (MNOs) are experiencing the greatest amount of data flowing across their networks, revenues from that data flow have not followed the same trajectory. As such, operators are seeking new ways to profit from their networks — and 5G opens the capability to offer new applications and services. A new generation of applications — from the Internet of Things (IoT) to self-driving cars to virtual reality — are, or soon will be, in use. Nearly every industry and job sector will be disrupted, enhanced or otherwise changed from the deployment of 5G networks. Operators are willing to invest in next-generation technologies to be able to charge for those services and applications.

5G and the Subsequent Shift in Skillsets Needed

More automation and disruption across industries is expected to shift skillsets as people adapt to new realities. Autonomous vehicles could negate the need for truck drivers, for example. However, up to 3 million jobs could be created from 5G wireless deployments, according to a report from Accenture. Deploying next-generation 5G wireless networks could add approximately $500 billion to the U.S. gross domestic product (GDP) through direct and indirect benefits, Accenture said.[3]

5G Use Case

Smarter Grids

The consumption and distribution of energy, including heat or gas, is becoming highly decentralized, creating the need for automated control of a very distributed sensor network. A smart grid interconnects such sensors, using digital information and communications technology to gather and act on information. This information can include the behaviors of suppliers and consumers, allowing the smart grid to improve the efficiency, reliability, economics and sustainability of the production and distribution of fuels, such as electricity, in an automated fashion. A smart grid is another sensor network with low delays.

The power grid should become more distributed in the future with more small producers (wind turbines and solar panels) and fewer large energy producers (coal and nuclear plants). In addition, the power grid will have to cope with the changing energy production and coordinate it with dynamic power consumers (e.g., power to gas). This coordination effort needs to exchange lots of data and is an important requirement to creating a smart grid. 5G technology is a promising candidate that provides a single standardized interface for all this communication. In the past, power-grid operators have used their own communication networks to exchange the data from the few sources that provided them. When the number of devices connected to the power grid increases, this strategy becomes expensive. Using the 5G infrastructure provides a cost-efficient alternative, assuming it is reliable and secure enough for the power grid.

Accenture breaks down its 5G wireless job creation estimate into two categories. The research firm expects the wireless industry to invest up to $275 billion in 5G over seven years — an investment that would yield about 850,000 U.S. jobs, including jobs at supplier and partner companies. In addition, Accenture predicts an additional 2.2 million jobs will be created because of 5G economic benefits that would boost GDP by $420 billion.

The Accenture report, "How 5G Can Help Municipalities Become Vibrant Smart Cities," also notes that 5G could provide high-speed broadband to the 5 percent of Americans who currently do not have access. If localities embrace 5G and citizens who are not already online become adopters, an additional 870,000 jobs could be created and GDP could be boosted an additional $90 billion, researchers estimate. "Because faster Internet connections allow users to utilize video applications for telecommuting, or participate in e-learning courses that give them additional skill sets or certifications, their employability and earning power increases, thus creating a more competitive workforce," the report notes.

Smart City Benefits

One of the reasons Accenture expects to see substantial investment in 5G is that the technology is expected to rely on large numbers of small cells, which will need to be deployed to augment the macrocellular network, which transmits wireless signals for miles. Once deployed, the infrastructure will be well suited to supporting smart-city technology, which Accenture sees providing strong economic benefits. Among these are energy-saving smart grid technology, fuel-saving vehicle-to-vehicle technology, revenue-generating smart-parking technology, crime-reducing gunshot detection technology and more.

Qualcomm Inc., a leading mobile technology company, commissioned a study that predicts that the 5G value chain will generate up to $3.5 trillion in revenue in 2035 and create up to 22 million jobs worldwide by then. The study, "The 5G Economy," includes an economic impact study conducted by IHS Markit and validated by Dr. David Teece, director of the Tusher Center for the Management of Intellectual Capital at the University of California at Berkley's Haas School of Business.[4]

Changes Needed to the Network

However, none of these visions can be realized until the 5G network is built. The International Telecommunication Union (ITU) is the United Nations agency that develops technical standards so networks and technologies can seamlessly connect worldwide. The ITU Radio Communications unit (ITU-R) outlined the minimum technical performance requirements to achieve a consistent definition, specification, and evaluation of the candidate IMT-2020 radio interface technologies (RITs)/Set of radio interface technologies (SRIT).[5] Recommendation ITU-R M.2083 defines eight key capabilities for IMT-2020, which form a basis for the technical performance requirements.

Key requirements include:

- 1 Gigabit per second speeds in the field.
- 1 Millisecond or less end-to-end latency.
- Support for 1,000 times increase in bandwidth per unit area.
- Support for up to 100 times as many connected devices.
- The perception of 100% coverage.
- 90% reduction in network energy usage, which could be done in part using C-RAN technology.
- Up to 10-year battery life for low-power, machine-type devices.

In order to achieve these requirements, changes will need to be made to the radio access and backhaul networks, along with greater network densification and more spectrum brought to market.

Areas Where Training Will be Needed to Make the Workforce Ready for 5G

As the telecommunications ecosystem sets standards for 5G, it is apparent that the major shifts in deploying the new technology will require new skillsets to address the new radio network, core network, backhaul techniques, densification efforts and new spectrum brought to market.

Specifically, training and education will be needed in the following areas:

1) RF Principles and Fundamentals
2) Spectrum
    a. Allocation
    b. Licensed vs. Unlicensed Band Assignment
    c. Spectrum Refarming Impacts

3) Millimeter-wave Spectrum

4) RF Conditioning Products at Existing Macro Towers

5) LTE and LTE-Advanced

    a. Spectral Efficiency and Variable Channels

    b. Latency, OFDM

    c. Air-Interface Standard

    d. Carrier Aggregation

6) Small Cells and Frequency Reuse Concept of Densification

    a. 100% In-building RF Propagations

    b. Cabling and Antenna Placement for Indoor Coverage

    c. 100% Backhaul Requirements for Small Cells (Fiber, Copper, Microwave)

7) Network Functions Virtualization (NFV)

8) Software Defined Networking (SDN)

9) Network Slicing Concepts; Control Plane and User Plane Splitting

10) Basic understanding of connectivity requirements for Internet of Things (IoT)

11) Multi Antenna Transmission (MIMO) and Massive MIMO

12) C-RANs (Centralized Radio Access Networks) and Cell Virtualization

5G Use Case

Smarter Society

Smart cities and smart homes, often referred to as smart society, will be embedded with dense wireless sensor networks. Like the smart home in Lake Nona, Florida, distributed networks of intelligent sensors will identify conditions for cost- and energy-efficient maintenance. Gigabit-speed fiber connectivity fosters a myriad of applications for the community and its residents. Each home in the community will have the bandwidth to support temperature sensors, window and heating controllers, smart kitchen islands, burglar alarms and home appliances, all connected wirelessly. Many of these sensors use low data rates and are low power and low cost. High-speed applications are available as well, including real-time high-definition (HD) video for surveillance and high-speed broadband for streaming entertainment. Fifth-generation services must be able to integrate the management of these very diverse connected devices in the home, the community, and across the city itself.

Training Options

A Hands-on Approach with On-the-Job Training

Employers can prepare training for and start educating their employees in key technical areas of the radio network, core network, and backhaul space. Many of these topics, such as C-RAN, are no longer just a concept on paper; they are being exercised in the field. Success likely includes emphasizing the importance of on-the-job training as it is likely the most effective way to train the future workforce if coupled with classroom training.

Employees are often trained away from where they work, whether it's down the hall or across the country. This traditional approach puts a wall between what employees learn and what they do. On-the-job training can break down this wall.

Learners and teachers work shoulder to shoulder and develop a feeling of pursuing the same goal when training on the job. Training becomes something not simply given to employees, but something in which they participate.

Benefits of Hands-on Approach:

- Employees can give immediate feedback about what they don't understand and offer suggestions about how to improve lessons and processes.
- On-the-job training improves learning retention.
- When learning and everyday work are combined, an employee's mind is processing and associating the sights and sounds of the environment with the skills being developed.
- On-the-job training also helps instructors. They can see how their lessons work in practice and then fine-tune them.
- The process lets instructors field-test the ideas and techniques they teach. Sometimes, this testing leads not only to better teaching, but also to better processes, improving efficiencies and safety for the field jobs.

Apprenticeship Model

Apprenticeship is a model that promotes on-the-job training. It heavily relies on approaches defined by subject matter experts to train new workforces. Apprenticeship reduces the learning curve for new employees by teaching lessons learned from experienced workers.

The Telecommunications Industry Registered Apprenticeship Program (TIRAP) is a joint venture of telecommunications companies, industry associations and the U.S. Department of Labor (DoL) that develops DoL-credentialed apprenticeship programs available to qualified employers for career development of the telecommunications workforce.[6]

TIRAP's mission is to partner with stakeholders to promote safety, enhance quality, and enable education and advancement opportunities in the telecommunications workforce that will meet network infrastructure buildout needs. The Wireless Infrastructure Association (WIA) is the national sponsor of TIRAP.

Since its inception, TIRAP has outlined an Apprenticeship Framework and credentialed a total of nine occupations through DoL. TIRAP brings together a diverse group of industry experts and apprenticeship programs that companies can implement voluntarily to provide telecommunications professionals quality education and on-the-job training.

Classroom-Based Technical Instructions

Education programs can achieve the best results by blending classroom teaching with on-the-job training. The classroom is a great starting point for learning, but the practical application of that learning is essential as the employee works toward mastering the skill.

An apprenticeship framework also includes a considerable amount of classroom-based learning before the apprentice can start practical, hands-on learning. Blending classroom work with on-the-job training requires a clear message along with good processes and tools. On-the-job training is most effective when employees play an active role. Organizations send this message by asking for participation and by truly listening when people share their thoughts.

New technologies, such as e-learning tools, can help organizations integrate teaching into everyday activities. These tools put training guidance at employees' fingertips, letting them look up key points when their jobs demand it.

Classroom-based technical training also needs to be vendor neutral. The wireless industry has many players — products from different vendors might have the same functionality but they manufacture their equipment in different ways. By focusing on providing conceptual training, quality technicians and engineers can be trained to work on products from many vendors.

With this goal in mind, WIA has launched the Telecommunications Education Center (TEC).

TEC is a dynamic learning program and online portal devoted to improving education, quality of work standards, and safety within the telecommunications industry. TEC was developed by WIA with significant contributions from academia, subject matter experts, and members. Additionally, education is supported through partnerships with Virginia State University, the TIRAP, the U.S. DoL, and the FCC to provide applicable contact hours earned with course and training completion.

The goal of TEC is to improve career development opportunities for members of the telecommunications workforce and to support the growth and penetration of wireless deployments. WIA experts work with individuals, businesses, and training facilities to offer customized training courses, tailor curriculum that supports new technologies and ways of doing business, design programs specific to individual employer needs, and provide consultation services. TEC training is available via classroom, field, and online learning environments.

5G Use Case

Medical Services

Next-generation cellular services will benefit the healthcare industry as well, including wearable gadgets that report vital signs to a central health command center, remotely monitoring potential health risks before they are likely to occur; doctors using medical robots and the 5G network to operate on patients with minor procedures or during emergencies; and the ability to diagnose and prescribe medication for ear and sinus infections.

The TEC Advantage

TEC courses that are designed to train the workforce needed to build the 5G network include the following topics:

- Wireless Site Safety
- Wireless101
- 5G Outlook
- DAS and Small Cell Basics
- Wi-Fi Fundamentals
- Macro Site Fundamentals
- Advanced DAS And Small Cells: Hardware and Components and Design Considerations

Allowing companies and individuals to invest in the industry with job training creates a valuable pipeline of workers who exhibit the critical skillset needed to support network deployment. TEC provides immediate benefit to the employer by assisting with new employee onboarding and professional development programs, which frees up internal, and often limited, training resources to focus on business-specific topics critical to employee success.

Successful completion of TEC courses results in WIA certification. Workers earn certification in a specific area, and they can take that certification and skills to improve their careers with them. Companies benefit from knowing their workers have met the highest standards and proven that they have the skills required to support their customers' needs. Companies are also able to recruit new employees who hold desired certifications, knowing that they don't need to spend time and money training them on certain tasks.

Conclusion

The demand on wireless networks is set to grow exponentially as consumers increasingly rely on their wireless devices for a variety of data-driven tasks and as machines and communities are increasingly connected in an effort to improve efficiency and lower costs. These developments require not only continual upkeep and upgrades to the macro network, but a massive densification of wireless networks as the industry moves toward 5G.

The next generation of wireless technology will change the way network infrastructure is designed and deployed, with RAN network functions being centralized and the cloud taking a more important role as virtualization gains momentum. To handle increasing traffic demands, large numbers of small cells will need to be deployed, along with more macrocell towers. Additional spectrum will be required, which will introduce new signal propagation patterns and network design considerations.

Already facing a limited supply of qualified engineers and technicians to address current network buildouts, the wireless industry must focus on training and educating the next generation of employees to handle new technologies and spectrum characteristics. On-the-job training, apprenticeships and certification programs, such as the Telecommunications Education Center, are essential to supplying a trained and skilled workforce to meet the requirements of future network buildouts.

About the Authors

Dr. Rikin Thakker, MMTC & University of Maryland

Dr. Rikin Thakker possesses over 15 years of experience in the field of cellular and wireless communications. He has helped design, deploy, and maintain cell sites with 3G and 4G technologies for major cellular operators in the United States. He also advises operators, regulators, OEMs, and vendors around the world on 5G strategies including densification and broadband deployment. Dr. Thakker is a co-founder of RF Academics—an initiative started by a group of elite professors to cater to the industry's need of quality education and consulting services at corporate speed.

Dr. Thakker is also a faculty member in the Department of Electrical and Computer Engineering at the University of Maryland, College Park (UMD). In addition to developing the Wireless Infrastructure Association's course content, he has designed several graduate level courses related to Cellular Network Infrastructure, Wi-Fi Technologies, and DAS/ Small Cells for the Master's in Telecommunication program at UMD. He received Instructor of the Year award for the program in 2014. He is also an Adjunct Assistant Professor at

George Washington University's (GWU) Ph.D. program for the Engineering Management and Systems Engineering (EMSE) department. Dr. Thakker also serves as Vice President of Telecommunications and Spectrum Policy at the Multicultural Media, Telecom and Internet Council (MMTC), where he evaluates MMTC's policy positions and the impact of telecom policies on minorities and women. He is also the lead content developer for MMTC's joint Department of Labor (DoL) contract with the National Urban League and the Wireless Infrastructure Association under the ApprenticeshipUSA initiative. Dr. Thakker chairs the Education and Training Working Group at the Innovation and Technology Council of WIA. He also serves on the Editorial Review Board for the International Journal of System Dynamics Application (IJSDA). Dr. Thakker earned his Ph.D. in Systems Engineering with a concentration in Mobile Communications and Spectrum Management from GWU, and his M.S. in Telecommunications from UMD.

Matthew DeGino, Crown Castle

Matthew DeGino is an RF engineer with 10 years focused on DAS and small cells. He started with NextG Networks in 2007 helping deploy the first large-scale outdoor greenfield DAS networks in the United States. He has spent the last 6 years with the Fiber and Small Cell team at Crown Castle, establishing a nationwide leading portfolio of nodes. Matthew lives in San Francisco and is a graduate of California Polytechnic State University San Luis Obispo with a degree in Electrical Engineering.

Nate Fuentes, CommScope

Nate Fuentes is business development manager, North America, for CommScope's Distributed Coverage and Capacity Solutions team, responsible for technical sales and strategic partnerships for distributed antenna system (DAS) and small cell solutions. Nate joined CommScope through the acquisition of TE Connectivity's Broadband Network Solutions business in 2015. He has served the wireless industry for 10 years in previous engineering roles at TE Connectivity and ADC. Nate has proven technical expertise and business acumen providing advanced product application solutions to all tiers of customers. He has a bachelor's degree in electrical engineering from the University of Texas–Austin and holds many industry certifications.

Ray Hild, JMA Wireless

Ray Preston Hild is an accomplished senior management and strategic partnership professional with over 26 years of experience in the wireless industry. He has consulted on several major government and enterprise initiatives and co-authored several industry white papers. Ray has been a member of the WIA Innovation and Technology Council for several years. In addition, he has served on a variety of wireless committees and boards for major industry associations on such topics as: Unified Communications, DAS in mid-tier markets, oDAS, Mobile Broadband, Wireless as the 4th utility, Enterprise Wireless Systems, 5G education, Rural Broadband and Network Densification. Lastly, Ray has created the Public Safety Code Guidebook which is meant to track the changing landscape of first responder wireless requirements across the United States.

Ray has held management and leadership positions with several prominent corporations over the years. Those include Sprint-Nextel, Corning, Galtronics and most recently JMA Wireless. He has won dozens of awards over several decades for service and performance. Ray is involved in the Johns Hopkins Mentorship Academy working with teenagers needing guidance in their career choices. He is also invested in supporting those who served through 185 for Heroes, an organization that hosts events for Operation 2nd Chance to help our warriors when they return from duty. Currently Ray is an Area Vice President for JMA Wireless, a global supplier of world class telecommunications equipment and solutions.

Kurt Jacobs, JMA Wireless

Kurt Jacobs holds 17 years of leadership experience in business integration, product management and market development. He is involved in multiple business functions in fast paced, leading technology industry including IoT. Kurt is mission oriented to achieve marketplace dominance and satisfy customers. He is corporate ambassador to the industry and channel for multiple solutions and product lines. Kurt is passionate about spearheading the forging and establishment of strategic partnerships, setting up business infrastructures, formulating go-to-market plans, and implementing integrated sales and marketing across international markets. Conversant with the entire enterprise software market with a focus on unified communication and collaboration applications (contact center control, unified messaging, computer telephony integration, CEBP, IoT, security, mobility, collaboration, voice and video teleconferencing, etc.). Working to implement solutions with US and International government, defense and public-sector system integrators for next generation communication systems.

He is a graduate of the University of Wisconsin-Madison with a Bachelor of Science Degree in Engineering Mechanics and holds an Master's Degree in Business Management from the Wisconsin School of Business.

Endnotes

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