

# SHAH NAWAZ KHAN

Ph.D.  
Resume

› **Position:** Senior Researcher: BTEB. NAP. Network Orchestration & Automation

› **Profile:** I am an experienced researcher in the field of wireless communication and networks with particular interest and expertise in 5G Programmable Cloud & Radio Access Network, Software-Defined Networking, Network Function Virtualization and Edge-Cloud Architectures. I have professional experience and strong interest in cross industry-academia research projects on future wireless communication networks.



## ››› Employment Record

6/18 - Permanent

### Senior Researcher: 5.5G Wireless Networks

- Ericsson Research, SW

- › Working on 5.5G Network evolution and multi-cloud and RAN resource orchestration
- › Working on standardization in ETSI NFV on multi-cloud network service specification and on multi-domain VNF orchestration. Also involved with joint industry academia research projects on 5G network evolution towards 5.5G. I also manage a group of researchers spread across Ericsson offices in Brazil, Germany and Sweden

1/2016 - 6/2018

### Researcher: Programmable 5G Networks

- Fondazione Bruno Kessler, IT

- › Involved in several EU Horizon 2020 projects dedicated to 5G mobile networks research.
- › Recent & ongoing EU H2020 projects:: 5G-ESSENCE, SESAME, COHERENT, VITAL. Research Focus: Joint RAN and Cloud Resource Orchestration, RAN programmability & control, Spectrum Sharing in heterogeneous 5G networks, Multi-tenancy and Isolation

1/2014 - 12/2015

### Research Associate/Post-doc

- TU Ilmenau, DE

- › Carried out R&D activities in EU FP7, Carl Zeiss Foundation and DFG funded research projects.
- › Developed system level simulation model for cognitive radio ad hoc networks, prototype implementation of Radio Environment Map for demos and carried out teaching and advising duties for Masters level university students.

9/2010 - 12/2013

### Project Associate

- TU Ilmenau, DE

- › Responsible for R&D activities in the department of Integrated Communication Systems.
- › Carried out research on self-organization in wireless networks for disaster scenarios, supporting placement of disjoint services inside the network infrastructure. Also carried out joint research work within the scope of International Graduate School on Mobile Communications.

1/2009 - 1/2010

### Visiting Lecturer

- Sarhad University, PK

- › Taught graduate courses to Masters level students and supervised MS student projects
- › Taught courses on Wireless Sensor Networks, Graph Theory and C/C++ Programming. Also gave tutorials on simulations and modeling techniques in OMNeT++ simulator.

## ››› Educational Record

2009 - 2014

### Doctor of Philosophy (Ph.D.)

- GIK Institute of Engineering, PK

- › **Major:** Computer System Engineering **Thesis:** *Performance Optimization Algorithms for Future Wireless Networks*. Focused on Disjoint Service Placement & Management in future wireless networks. Self-Organized algorithm was presented for service placement with the aim of overall network performance optimization.
- › **Research focus:** Self-Organized algorithms, service placement in disjoint services scenario, network performance optimization.

2006 - 2008 **Master of Science (MS)**  - [GIK Institute of Engineering, PK](#)

- » **Major:** Computer System Engineering **Thesis:** Cost-based Data Centric Routing in Wireless Sensor Networks **Description:** Developed a data-centric routing protocol with minimum energy usage overhead and provided a parametric reliability control knob.
- » **Research focus:** Wireless Sensor Networks, Routing Protocols in WSNs, Network topology and Resiliency optimization

2002 - 2006 **Bachelors of Science (BS)**  - [Alama Iqbal Open University, PK](#)

- » **Major:** Information Technology **Thesis:** Server-side DB and Web front-end development for National Book Foundation, Pakistan
- » Main subjects taken: Operating systems, Data structures, Software Engineering, Digital Communication networks, Object Oriented Programming, Business Communications, Web Development & Design, Digital Logic Design.

## »»» Research Experience

6/2017 - Ongoing **EU ICT-7-2016 Project: ESSENCE**  - [at FBK, Italy](#)

- » The project focuses on Edge Cloud computing and Small Cell-as-a-Service provisioning.
- » Within the scope of 5G-ESSENCE, I work on the LightMANO framework which aims at developing lightweight virtualization and MANO solutions specific to distributed & heterogeneous edge cloud architecture. This includes supporting network access, control and service function orchestration in the context of multi-tenancy and resource isolation requirements.

1/2016 - Ongoing **EU Horizon 2020 Project: COHERENT**  - [at CREATE-NET, Italy](#)

- » This project focuses on heterogeneous network abstraction and on developing a centralized architecture for programmable network control and radio resource management.
- » I worked on abstracting heterogeneous network environment and generating networks graphs for modeling the radio environment. The developed abstraction are used for spectrum management and sharing using the project's centralized network control framework. Demos for multi-tenancy in RAN have been developed based on these abstractions.

1/2016 - Ongoing **EU Horizon 2020 Project: SESAME**  - [at CREATE-NET, Italy](#)

- » This project focuses on developing small-cell 5G networks where the small cells can be offered as-a-service to virtual network operators together with lightweight data-center capabilities for mobile edge-computing
- » I have worked to the design of the virtualized SESAME architecture and on developing resource awareness in the lightweight edge data-center environment using self-organization principles. Edge cloud supporting content caching has been demoed during this project.

2014 - 2015 **EU FP7 Project: CREW**  - [at TU Ilmenau, Germany](#)

- » As CREW open call partners, the main task was to reduce the spectrum sensing latency and its impact on Software Defined CSMA link layer protocols.
- » I worked on the initial call for proposals and its subsequent development at the labs in Ilmenau University of Technology. Used the developed Radio Environment Map prototype for profiling Primary User channels based on sensed activity and adapting secondary user access decisions.

2011 - 2015 **Cognitive Radio Networks Lab**  - [at TU Ilmenau, Germany](#)

- » Funded by Carl-Zeiss foundation, this project was focused on developing a Cognitive Radio laboratory in Ilmenau University of Technology for basic technological research
- » I was responsible for different lab activities related to developing a Software Defined Radio test-bed for general experimentation and demonstrators. I contributed to several research directions on Cognitive Engine, Radio Environment Mapping and Medium Access Control protocols as well as supporting student projects.

2010 - 2015

### Int. Graduate School on Mobile Communications

 - at [TU Ilmenau, Germany](#)

- › I was associated with the International Graduate School as research scholar and participated in its workshops, research groups, demonstrators, and joint publications
- › Topics to which I contributed included future Internet architecture, Software Defined Networking, and Dynamic Spectrum Access

## ››› Project Proposals, Research Funding & Scholarships

2016-2018

### Funded Project Proposals

at [CREATE-NET, Italy](#)

- › Worked on several research proposals in the area of wireless network, SDN/NFV and 5G networks. For the EU Horizon H2020 program, contributed to idea conception, consortium building and proposal writing of five research proposal submission including the successful 5G-CARMEN and 5G-ESSENCE project proposal.
- › Funding worth 24 Million Euros by European Commission under Horizon 2020 program

2009-2015

### Research Funding

at [TU Ilmenau, Germany](#)

- › 2011: A research scholarship from Carl Zeiss foundation Germany. Funding for research and development of a test-platform/laboratory for software defined and dynamic spectrum access networks.
- › 2010: Funding for the DFG qualification program at Ilmenau University of Technology in Germany. Focus on qualification for research position at International Graduate School on Mobile Communications.

2009

### Research Scholarship

at [TU Ilmenau, Germany](#)

- › 2009: Scholarship for participation in a 3-weeks summer academy program at TU Ilmenau in Germany, organized by Integrated Communication Systems group. Focused on the advancements in wireless communication systems.
- ›

## ››› Developed Software & Demos

2017 - 2018

### Edge Cloud SDN/NFV Orchestrator

at [FBK Create-Net, Italy](#)

- › Developed a joint hardware and software resources orchestrator that pro-actively scales (up/down) the hardware and software resources of the cluster in response to edge services deployment. The edge cloud comprise heterogeneous hardware (x64 & ARM) and the orchestrator can deploy NFV instances on the nodes in an architecture-aware manner. Considered edge services include RAN provisioning, Video encoding & streaming and Web-hosting.
- › Tools used: Golang, Kubernetes, Bash, Docker, Yaml, Weave

2016 - 2017

### MEC specific Lightweight SDN/NFV MANO Platform

at [FBK Create-Net, Italy](#)

- › Called LightMANO, the platform converges SDN/NFV and MANO stack at the network edge on top a hybrid (ARM + x64) Kubernetes cluster consisting of Raspberry Pi, Virtual Machines and Linux Hosts. The cluster serves as 5G network edge hosting service functions (Video Streaming, Encoding) and access functions (Radio Access). Docker containers used as VNFs for WiFi and LTE Access provisioning.
- › Tools used: Kubernetes, Docker, Bash, SRS-LTE, VMs+Raspberry Pi 3, Yaml

2013 - 2014

### Distributed Resource Map

at [TU Ilmenau, Germany](#)

- › A database driven application that collected data from spectrum sensing algorithm at the MAC layer and developed a radio environment map for predictive channel access. Implemented learning algorithm for abstraction of collected inputs into channel maps for secondary user access.
- › Tools used: C++, SQL, ZeroMQ, Iris SDR

2014 - 2014

### Dynamic Spectrum Access Demo

at [TU Ilmenau, Germany](#)

- ▶ A prototype Cognitive Radio ad hoc network where a cognitive Tx/Rx pair sensed the Primary User channels and selected the most valuable channel based on derived statistics of of the Primary Users activities.
- ▶ Tools used: C++, ZeroMQ, SQL, USRP2 interfaced with Linux machines

2012 - 2013

### Cognitive Radio Simulator "crSimulator"

at TU Ilmenau, Germany

- ▶ A simulation model developed in OMNeT++ platform. This model can be used to test different aspects of Cognitive Radio ad hoc network including primary and secondary user network performance
- ▶ Tools: OMNeT++, C++, SQLite, Linux

## Theses Supervised

9-2017

### Masters Thesis: University of Trento, Italy

Shahriar Hasan

- ▶ **Title:** Active Radio Resource Sharing in Multi-Tenant 5G Radio Access Networks
- ▶ The thesis presents an active approach to fine-grained spectrum sharing among LTE based RAN tenants. A centralized controller actively monitors the load of tenant networks and facilitates sharing radio resources based on spectrum exchange favors. Final-Grade: 1-Excellent

## Invited Talks

- **Converging SDN and NFV at the Network Edges: The lightMANO Approach**, talk given at IEEE 5G-Summit organized by University of Trento Italy in March 2018
- **Bringing Virtualization, Control and Intelligence to the Network Edge**, talk given at a Summer School organized by 5G-CHARISMA project in University of Athens, Greece June 2016

## Book Chapters

- **Towards Spectrum Sharing in Virtualized Networks: A Survey and an Outlook** in Cognitive Radio, Mobile Communications and Wireless Networks
- **Radio Spectrum Aspects in 5G Networks** in 5G Networks: An European Vision

## Hands-on Experience

- Programming: C, C++, Golang, Python, Bash, Yaml
- Prototyping: USRP, LimeSDR, Raspberry Pi, OMNeT++, OpenWRT

What keeps me and my computers busy these days?

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## Research Publications

- **RAN Orchestration: A New Approach to Spectrum Management in Multi-Tenant 5G Networks**, Shah Nawaz Khan, Leonardo Goratti, Shahriar Hasan, R. Riggio, IEEE Int. Symposium on Personal Indoor & Mobile Communications (PIMRC) Bologna Italy 2018
- **On Edge Cloud Architecture and Joint Physical Virtual Resource Orchestration for SDN/NFV**, Shah Nawaz Khan, R. Riggio, 5G-PINE Workshop, 14th International Conference on Artificial Intelligence Applications and Innovations (AIAI18), Rhodes, Greece 2018.
- **Network Graphs Reflecting Transmission Policies**, L. Kulsaz, A. Kliks, Shah Nawaz Khan, U.R.S.I Baltic Symposium, Microwave & Radar Week, Poznan Poland 2018.
- **LightMANO: Converging NFV and SDN at the Edges of the Network**, R. Riggio, Shah Nawaz Khan, T. Subramanya, I. G. B. Yahia, D. Lopez, IEEE/IFIP Network Operations and Management Symposium (NOMS) Taipei, Taiwan 2018.

- **On Active, Fine-Grained RAN and Spectrum Sharing in Multi-Tenant 5G Networks**, Shah Nawaz Khan, L. Goratti, R. Riggio, S. Hassan, IEEE Int. Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC) Montreal, Canada 2017.
- **SDEC: A Platform for Software Defined Mobile Edge Computing Research and Experimentation**, T. Subramanya, L. Goratti, Shah Nawaz Khan, E. Katetzakis, I. Giannoulakis, R. Riggio, IEEE Conference on Network Function Virtualization and Software Defined Networks, Berlin, Germany 2017.
- **A Practical Architecture for Mobile Edge Computing**, T. Subramanya, L. Goratti, Shah Nawaz Khan, E. Katetzakis, I. Giannoulakis, R. Riggio, IEEE Conference on Network Function Virtualization and Software Defined Networks, Berlin, Germany 2017.
- **Virtualization of RF Spectrum Resources for 5G Networks**, Shah Nawaz Khan, A. Kliks, T. Chen, M. Mustonen, R. Riggio, L. Goratti, IEEE 26th European Conference on Networks and Communications (EUCNC) Oulu, Finland 2017.
- **An Architecture for Spectrum Management and Coordinated Control in 5G Heterogeneous Networks**, A. Kliks, B. Bossy, Shah Nawaz Khan, R. Riggio, L. Goratti International Symposium on Wireless Communication Systems (ISWCS) 2016.
- **Hypertexts based Radio Spectrum Profiling in Cognitive Radio Networks** Shah Nawaz Khan, Andreas Mitschele-Thiel, EAI endorsed transactions on cognitive communications, Vol. 15, No. 12, April 2015
- **Evolutionary hypertexts based radio spectrum profiling in cognitive radio ad hoc networks**, Shah Nawaz Khan, Andreas Mitschele-Thiel, 9th IEEE International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM) pp. 191–196, Oulu Finland. 2014
- **Evolving Hypertexts based Channel Prediction for Secondary Access in Cognitive Radi Ad hoc Networks** Shah Nawaz Khan, Andreas Mitschele-Thiel 4th Workshop of COST Action Cognitive Radio and Networking for Cooperative Coexistence of Heterogeneous Wireless Networks Rome, Italy. 2013
- **Database-assisted Coordinator-based Spectrum Mobility in Cognitive Radio Ad-hoc Networks**, A. Puschmann, Shah Nawaz Khan, M. A. Kalil, A. Mitschele-Thiel, Tenth IEEE International Symposium on Wireless Communication Systems (ISWCS) Ilmenau, Germany. 2013
- **A Lightweight Message-based Inter-Component Communication Infrastructure**, T. Simon, A. Puschmann, Shah Nawaz Khan, A. Mitschele-Thiel 5th IEEE International Conference on Computational Intelligence, Communication Systems and Networks (CICSyN) Madrid, Spain. 2013
- **crSimulator: A discrete simulation model for cognitive radio ad hoc networks in OMNeT++**, Shah Nawaz Khan, M. A. Kalil, A. Mitschele-Thiel, 6th Joint IFIP/IEEE Wireless and Mobile Networking Conference (WMNC) pp. 1–7, Dubai, UAE. 2013
- **Distributed Resource Map: A Database-driven Network Support Architecture for Cognitive Radio Ad hoc Networks**, Shah Nawaz Khan, M. A. Kalil, A. Mitschele-Thiel, IEEE International Congress on Ultra-Modern Telecommunications (ICUMT) Saint Petersburg, Russia. Oct, 2012
- **An Architecture for Cognitive Radio Ad-Hoc Network Nodes**, A. Puschmann, Shah Nawaz Khan, A. H. Mahdi, M. A. Kalil, A. Mitschele-Thiel 12th IEEE International Symposium on Communications and Information Technologies (ISCIT) Queensland, Australia, Oct. 2012
- **Self-Organized Disjoint Service Placement in Future Mobile Communication Networks**, Shah Nawaz Khan, A. Diab, C. Brosch, M. Ahmad International Journal of Communication Networks and Information Security, Vol. 4, No. 2, Aug. 2012
- **Distributed Spectrum Map for Cognitive Radio Ad hoc Networks**, Shah Nawaz Khan, M. A. Kalil, A. Mitschele-Thiel, 4th ACM International Conference on Cognitive Radio and Advanced Spectrum Management (Cog-ART) Barcelona Spain, Oct. 2011
- **Increasing Network Lifetime and Data Transfer through Node Vulnerability Aware Routing in Wireless Sensor Networks**, R. Khan, Shah Nawaz Khan, T. Mohammed, M. Ahmad IEEE International Conference on Information and Emerging Technologies (ICIET) Jun. 2010
- **A Robust and Energy Efficient Global Gradient Setup Mechanism for Gradient Based Routing in Wireless Sensor Networks**, Shah Nawaz Khan, N. M. Khan, M. Ahmad 14th IEEE Asia-Pacific Conference on Communications APCC'08 Tokyo Japan, Oct. 2008
- **Project Report**: EU2020 COHERENT: First report on physical and MAC layer modelling and abstraction. Deliverable 3.1
- **Project Report**: EU2020 COHERENT: Report on enhanced LSA, intra-operator spectrum-sharing and micro-area spectrum sharing. Deliverable 4.1




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- **Project Report:** EU2020 SESAME: Cloud-Enabled Small Cell (CESC) Prototype design specifications and initial studies on Self-X and virtualization aspects. Deliverable 3.1
- **Project Report:** EU2020 SESAME: Orchestrator Architecture Design and Interfaces Specification. Deliverable 6.1

## »» Contact & Social Media

Social Media

### Online Accounts

- »  LinkedIn,  Twitter,  Facebook
- » Personal email: [shazmailz@gmail.com](mailto:shazmailz@gmail.com), Skype: shazchatz, WhatsApp: +393391314480

Other Info.

### Bio-Data

- » **Birthday:** 29th January, 1983, **Nationality:** Pakistan, **Passport:** AM4117953, **Driving License:** B-German
- » **Language Proficiency:** English-Fluent, German-Basic, Urdu/Pashto: Fluent

## »» References: References available on request