



Towards NFV-based Mobile Video Delivery: Challenges and Opportunities

**TGI Course,
Dept. of Computer Science,
University College Cork**

**4th – 5th May 2016
TGI Module Code: TGI_N11**

**Dr. Rittwik Jana
Dr. Emir Halepovic
Dr. Vijay Gopalakrishnan
AT&T Labs--Research**

This 1 ½ day course is designed for Ph.D. students and post-doctoral researchers who are working in areas related to network function virtualization, cellular mobile networks, or video streaming and quality of experience. It is also open to industry partners of TGI institutions. Registration is required but there is no fee to attend. Coffee breaks and lunches are included. The course is not-for-credit, but UCC will be happy to provide a certificate of attendance on request.

Abstract

Cellular networks are quickly becoming the access network of choice for Internet connectivity. Yet, cellular network technology, even LTE (the latest generation of cellular technology) carries its voice heritage in all its facets. In this tutorial, we provide an overview of how the cellular network works, its components and the new applications that are central to its evolution. The tutorial is split into three sessions: The first session will provide an overview of various wireless technologies, both from a theoretical and practical perspective. We will highlight some of the recent advances and hot topics in wireless research. The second session will start off with an introduction to adaptive video streaming technologies (DASH, HLS, etc.). We will then provide a fairly broad overview of Quality of Experience (QoE) issues including measurement and modeling QoE and recent advances therein. The final session will introduce network function virtualization (NFV), the forces that are driving this direction, and the enabling technologies. We will then focus on topics around orchestration, high performance and reliability using NFVs.

Day 1 (May 4) 10am-5pm

Introduction and Background to Wireless Technologies (Rittwik Jana)

- Historical context
- LTE in the mobile landscape
- Overall cellular architecture
 - Radio Access Network
 - Core Network architecture (EPC)
 - Roaming
- Protocol Architecture
 - User plane
 - Control plane
- Cellular radio access
 - 3G
 - LTE
- Multiuser Scheduling and interference coordination in wireless:
 - Scheduling algorithms
 - Exploiting mobility in proportional fair scheduling – measurements and algorithms (30 mins)
- Research Directions in radio/wireless technology
 - 5G
 - IoT
 - Cloud-RAN
 - Wifi and Full Duplex radios (30 mins)
 - Picocells, HETNETs

Adaptive Streaming Video and QoE (Emir Halepovic)

- Introduction to HTTP Adaptive Streaming (HAS)
 - Motivation
 - Architecture
 - Standards and protocols: HLS, DASH
 - Challenges and issues
- Quality of Experience
 - What is QoE?
 - QoE for video streaming
 - Components of QoE in HAS
 - Measurement and monitoring of QoE
- Prediction-Based Adaptation
 - Adaptation algorithms
 - Impact of network bandwidth on HAS
 - Special issues in wireless networks
 - Prediction of bandwidth and use in HAS
- Estimating QoE using machine learning

- Network vs. user-level performance
- Inferring user-level QoE from network metrics
- A system for QoE estimation using machine learning

Day 2 (May 5) 10am-2pm

Network Function Virtualization (Vijay Gopalakrishnan)

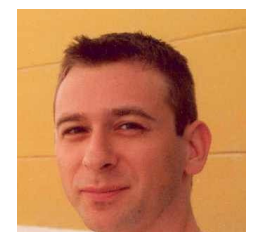
- Challenges with Appliance-based Cellular Core
- Introduction to Network Function Virtualization
 - Benefits offered by NFV
 - Emerging technologies that make NFV possible (DPDK, SRIOV, etc)
- Challenges with NFV
 - Performance of virtualized elements
 - Performance limitations of existing implementations
 - New approaches to improving performance
 - Flexibility and Manageability of virtualized elements
 - Limitations of existing virtual element designs
 - Rethinking how network elements are designed
 - Orchestration of virtualized network elements
 - Composing services
 - Placement of network elements

Biographies:

Rittwik Jana is a Lead Inventive Scientist at AT&T Labs Research. His research interests span Internet technologies, networked video streaming, cellular networks and systems, intelligent service composition using VNFs in Domain 2.0. Rittwik holds a Bachelor of Engineering in Electrical and Electronics from the University of Adelaide, Australia, and a Ph.D. in Telecommunications Engineering from the Australian National University, Canberra, Australia.



Emir Halepovic received his B.Sc. and M.Sc. degrees in computer science from the University of Saskatchewan, Canada in 2002 and 2004, respectively, and he received his Ph.D. from the University of Calgary, Canada in 2010. His research work was supported by several prestigious scholarships and awards, including Canada Graduate Scholarship from the Natural Sciences and Engineering Research Council of Canada, Alberta Ingenuity Scholarship and PhD Graduate Scholarship from the Informatics Circle Of Research Excellence in Canada, as well as Killam Memorial Scholarship from University of Calgary.



After spending a year as a Post-Doctoral Research Fellow at the University of Calgary, Emir has joined AT&T Labs - Research, where he currently holds a position of Principal Inventive Scientist. His research interests are in the areas of networking, including measurement, modelling, performance evaluation, content-defined dynamic caching, as well as building large-scale network measurement and management systems. Most of his previous and current research seeks to understand the impact of mobile and wireless environment on user-perceived performance and performance of network protocols and applications, as well as cross-layer interactions involving mobile applications, especially adaptive video over HTTP. Emir conducted one of the first measurement-oriented performance characterizations of live CDMA2000 and WiMAX networks in Canada, with focus on Transmission Control Protocol (TCP) performance and multimedia application performance. Emir is a member of the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE). His services include chairing of IEEE Workshop on Network Measurements.

Vijay Gopalakrishnan is a Director in the Network and Service Quality Management Center in AT&T Labs – Research. His research interests fall broadly in the areas of networked systems and protocols, distributed systems and content delivery. He leads a team of ten researchers focused on various systems aspects of networking including network management, network function virtualization, software defined networking, network protocols, mechanisms for efficient content delivery, etc. As part of AT&T’s ECOMP initiative, he leads an effort to policy enable the control and management of networks. Vijay got his MS and PhD in Computer Science from the University of Maryland, College Park in 2003 and 2006 respectively. He is a member of the ACM and the IEEE.



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