

Tutorial T-3: Advanced Ad Hoc and Mesh Networks: From Theoretical to Practical

Presenter: Jiajia Liu (Xidian University)

Tutorial Overview

Ad hoc and mesh networks have been of significant importance among various networking techniques, and have received a great deal of attention from both academia and industry in the last decades. Recently, extensive research interests in ad hoc and mesh networks have been further sparked around the newly emerging concepts of Internet-of-Things (IoT), LTE-A and 5G networks, D2D communication, machine type communication (MTC), cognitive radios, smart vehicle, unmanned aerial vehicles (UAVs), etc. Therefore, we provide a tutorial for the latest research progress in advanced ad hoc and mesh networking techniques, from both theoretical side and practical side.

The target audience of this tutorial will be researchers, engineers, and regulators in the networking industry, who are interested in understanding the latest research progress in theoretical modeling and evaluation as well as prototype design and implementation of advanced ad hoc and mesh networks.

As motivated by the skyrocketing number of communicationable devices and unprecedented consumer demand for cyber-physical information exchange, intensive research efforts have been taken towards developing advanced communication and networking techniques, to improve the spectrum efficiency, the network reliability, as well as the energy efficiency, to provide efficient communication service recovery and QoS provisioning in emergency response, etc. In this tutorial, we aim to provide an introduction to the advanced ad hoc and mesh networking techniques, from theoretical modeling, analytical evaluation, to prototype design and field experiment.

We are going to cover the following important technical issues:

- (1) **Interference modeling:** it is one of the most difficult yet important parts in analytical modeling and evaluation of communication networks, including ad hoc networks, mesh networks, as well as cellular networks. We introduce the latest research progress, in particular utilizing the theory of stochastic geometry, in modeling the distribution of accumulated interference, as well as the derivation of outage and ergodic rate.
- (2) **End-to-end information delivery:** it corresponds to the essential information propagation process, which includes a lot of network dynamics such as the user distributions, buffer occupations, battery usages, etc. How to accurately characterize the information delivery process has attracted a lot of research attention. We utilize the theory of Markov chain to model such dynamic process in DCF, V2I, as well as DTNs/MANETs.
- (3) **Network reliability:** it is never too much to emphasize the importance and necessity of network reliability modeling and evaluation, especially under the correlated network failures, such as those caused by malicious attacks, natural disasters, etc. Furthermore, how to efficiently provide communication service in post-disaster recovery is also of great importance. We introduce the latest techniques in building mesh networks via deploying moveable and deployable resource unit (MDRU).

Detailed organization:

1. Theoretical modeling and evaluation
 - 1.1 Interference in large-scale ad hoc networks (40min)
 - Poisson point process
 - Interference in Poisson networks
 - Random channel access
 - CSMA modeling
 - Outage and ergodic rate
 - Applicability to LTE-A multi-tier heterogeneous networks
 - 1.2 End-to-end information propagation (40min)
 - Network dynamics and Markov chain
 - Operations of distributed coordination functions
 - V2V and V2I communication
 - Message relaying in DTNs/MANETs
 - Derivations of throughput and delivery delay
 - 1.3 Network reliability evaluation (40min)
 - Independent vs. correlated failures
 - Deterministic failure models
 - Line failure model
 - Circular failure model
 - Probabilistic failure models
 - Reliability assessment and estimation
2. Practical design and field experiment (40min)
 - Relay-by-smartphones for post-disaster relief
 - Integrations with UAVs
 - Moveable and deployable resource unit (MDRU) for disaster recovery
 - Field experiment for mesh network building with MDRU
3. Discussions and Future Directions (20 min)

Presenter Biography

Jiajia Liu (S'11-M'12-SM'15) received his B.S. and M.S. degrees both in computer science from Harbin Institute of Technology in 2004 and from Xidian University in 2009, respectively, and received his Ph.D. degree in information sciences from Tohoku University in 2012. He was a JSPS special research fellow in Tohoku University from Apr. 2012 to Oct. 2013, and a data analytics engineer in Aviation Industry Corporation of China from Jul. 2004 to Aug. 2006. He has been a Full Professor at the School of Cyber Engineering, Xidian University, since 2013, and has been selected into the prestigious "Huashan Scholars" program by Xidian University since 2015. He has published more than 50 peer-reviewed papers in many high quality publications, including prestigious IEEE journals and conferences. He has received the Best Paper Awards from many international conferences including IEEE flagship events, such as IEEE WCNC in 2012 and 2014. He was the recipient of the prestigious 2012 Niwa Yasujiro

Outstanding Paper Award due to his exceptional contribution to the analytics modeling of two-hop ad hoc mobile networks, which has been regarded by the award committees as the theoretical foundation for analytical evaluation techniques of future ad hoc mobile networks. He was also a recipient of the Tohoku University President Award 2013, Graduate School of Information Sciences Dean Award 2013, Professor Genkuro Fujino Award 2012, Chinese Government Award for Outstanding Ph.D. Students Abroad 2011 and the RIEC Student Award 2012. His research interests cover a wide range of areas including load balancing, wireless and mobile ad hoc networks, Fiber-Wireless networks, Internet of things, cloud computing and storage, network security, LTE-A and 5G, SDN and NFV. He has been actively joining the society activities, like serving as associate editors for IEEE Transactions on Computers (Oct. 2015-present) and IEEE Transactions on Vehicular Technology (Jan. 2016 - present), editor for IEEE Network (July 2015-present), guest editors of top ranking international journals like IEEE Transactions on Emerging Topics in Computing (TETC), IEEE Network Magazine, IEEE Internet of Things (IoT) Journal, etc., and serving as technical program committees of numerous international conferences like the leading symposium co-chair of ad hoc and sensor networking symposium for GLOBECOM 2017. He is a Distinguished Lecturer of the IEEE Communications Society.