

Tutorial Submission for IEEE 5G World Forum

Title

Cellular Internet of Things: Framework, Optimization, and Challenges of NB-IoT

Abstract

Along with the evolution towards 5G, massive machine-type communications (mMTC) are expected to play a prominent role in the Internet of Things. mMTC is about connecting a massive number of low-power devices over very large areas, with low data rates. As recently standardized by 3GPP, NB-IoT largely fulfills the 5G mMTC requirements by adapting and leveraging the existing LTE technology.

In this tutorial, we present recent advances in cellular IoT technologies with focus on NB-IoT. We analyze the link level and system level design aspects. We further focus on NB-IoT link budget analysis and radio network dimensioning. Precisely, we present best practices in the network design and deployment of NB-IoT. Acquiring such best practices is of paramount importance for the engineering and optimization of cellular IoT technologies. We also provide a comparative scientific analysis of NB-IoT and concurrent technologies such as LoRaWAN and evaluate their performance in terms of coverage and capacity. Finally, we cover the research directions and scientific challenges particularly for radio resource management in NB-IoT.

Speaker/s Name and company/University

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For 5G core/Fundamentals or 5G applications track

5G core/Fundamentals

Tutorial Outline

IoT services and applications that foster mMTC; Samer Lahoud; 10 minutes
Requirements and characteristics of mMTC; Samer Lahoud; 10 minutes
5G and cellular IoT technologies; Melhem El Helou; 10 minutes
NB-IoT design rationale - how NB-IoT leverages and adapts 3GPP LTE infrastructure and mechanisms to meet 5G mMTC requirements?; Melhem El Helou; 15 minutes
NB-IoT standard: radio interface, physical architecture, protocol architecture; Melhem El Helou; 15 minutes
Radio models and link budget analysis for NB-IoT; Melhem El Helou; 10 minutes
Bandwidth-based dimensioning for NB-IoT; Samer Lahoud; 15 minutes
Performance comparison of NB-IoT and LoRaWAN; Melhem El Helou; 10 minutes
Research directions for radio resource management in NB-IoT; Samer Lahoud; 25 minutes

Intended Audience

This tutorial is of strong interest to the IEEE 5G World Forum community working in the fields of communications technology. First, engineers and professionals will benefit from an overview on NB-IoT, the major technology proposed by 3GPP to tackle the challenges of cellular Internet of Things. They will

acquire a deep understanding of NB-IoT major design choices and best practices in capacity and coverage planning. Second, academic and industry researchers will benefit from a scientific overview on the state-of-the-art and the promising research perspectives for radio resource management in NB-IoT. Finally, graduate students will benefit from a technology overview on the radio interface, and the physical and protocol architectures for NB-IoT. This tutorial is accessible to a broad audience in the IEEE 5G World Forum community as it only requires familiarity with communication and networking concepts.

Short Bio of speaker/s

Samer Lahoud is an Associate Professor at the Saint-Joseph University of Beirut where he lectures computer networking courses at the Faculty of Engineering (ESIB). His research activities focus on routing and resource allocation algorithms for wired and wireless communication networks. Mr. Lahoud received the Ph.D. degree in communication networks from Telecom Bretagne, Rennes, in 2006. After his Ph.D. degree, he spent one year at Alcatel-Lucent Bell Labs Europe. From 2007 to 2016, he was with the University of Rennes 1 and with IRISA Rennes as an Associate Professor.

Melhem El Helou received the engineer's degree and a master's degree in telecommunications and networking engineering from the Ecole Supérieure d'Ingénieurs de Beyrouth (ESIB), Faculty of Engineering at the Saint Joseph University of Beirut, Beirut, Lebanon, in 2009 and 2010, respectively and the Ph.D. degree in computer and telecommunications engineering from IRISA Research Institute, University of Rennes 1, Rennes, France and Saint Joseph University of Beirut, in 2014. He joined ESIB in September 2013 where he is currently an Assistant Professor (*fr*: Maître de conférences). His research interests include wireless networks, radio and energy resource management, Internet of Things, and quality of service.

Past Iteration(s) and Average Turnout/Impact

The authors have previously delivered related tutorials in multiple scientific events. They chose to make the tutorial sources available under Creative Common license CC BY-NC-SA 4.0 on the public repository <https://github.com/samerlahoud/tutorial-lpwan-iot>. The different versions are the result of a continuous effort to keep the tutorial material up to date.

- 25th International Conference on Telecommunications, ICT 2018, Saint-Malo, France, June 2018, <http://ict-2018.org/tutorials/>, 30 attendees
- International Symposium on Performance Evaluation of Computer and Telecommunication Systems, Bordeaux, France, July 2018, <http://atc.udg.edu/SPECTS2018/>
- Seminar of the Faculty of Engineering at Saint-Joseph University of Beirut, June 2018, <https://bit.ly/2NJmvGb>, 30 attendees
- Labex DigiCosme Seminar on Future Access Networks: Cloud-RAN and Optimization problems, Paris Saclay, June 2017, <http://bit.ly/2B2ak1f>, 20 attendees
- Course on Internet of Things Technologies, ESIB, Saint-Joseph University of Beirut, <http://bit.ly/2BcXU7I>, a total of 42 students from 2016 to 2018
- The speakers are leading scientific and experimental studies for measuring, assessing, and modelling the coverage, capacity, and quality of service of LoRaWAN networks. The tutorial will also be an occasion to present the latest results of these scientific studies published in the IEEE Internet of Things Journal.