

Course Introduction

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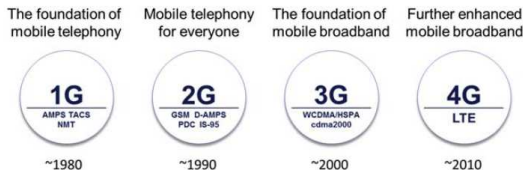
Simulation-Based Design of 5G Standards

Brief history of wireless standards (1)



- 1G – based on analog transmission with the main technologies being
 - AMPS (Advanced Mobile Phone System) developed within North America,
 - NMT (Nordic Mobile Telephony) jointly developed by network operators of Nordic countries
 - TACS (Total Access Communication System) used in, for example, UK
- Limited to voice services and, for first time, made mobile telephony accessible to ordinary people

Brief history of wireless standards (2)



- 2G – saw the introduction of digital transmission on the radio link
- Target service was still voice – digital transmission allowed limited data services e.g., SMS
 - GSM - jointly developed by European countries
 - D-AMPS (Digital AMPS) developed within North America
 - PDC (Personal Digital Cellular) developed and solely used in Japan
 - CDMA-based IS-95 technology – developed at a somewhat later stage

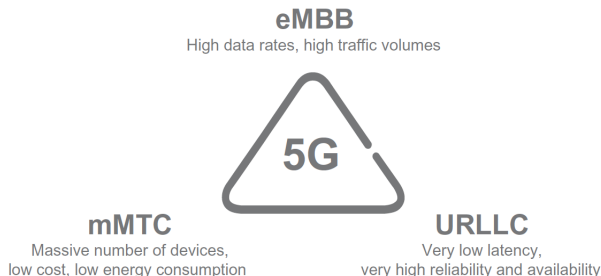
Brief history of wireless standards (3)



- 3G – true step to high-quality mobile broadband was taken, enabling fast wireless internet access
 - HSPA (High Speed Packet Access) – FDD, TD-SCDMA – TDD
 - CDMA-2000
- 4G – LTE supports both FDD and TDD operation
 - Unlike 3G which had two different technologies
 - OFDM enables wider transmission bandwidths and advanced MIMO techniques

What Is 5G?

- 5G is being designed for the following use cases



- mMTC – remote sensors, and monitoring of various equipment
- URLLC – automatic control, factory automation

Evolving 4G LTE to 5G

- LTE technical specifications were (Release 8) introduced in 2009.
- Since then, LTE has evolved (through Release 9 to 14) to provide enhanced performance/features
 - Higher data rate by increasing number of tx/rx antennas
 - Enable truly low-cost devices with very long battery life, in line with massive MTC applications
 - Significant steps taken to reduce the LTE air-interface latency
- With these ongoing, and future evolution steps, LTE will be able to support a wide range of the use cases envisioned for 5G.

NR – The New 5G Radio-Access Technology

- Why are we developing 5G NR
 - Despite LTE being a capable technology, certain requirements cannot be met by LTE or its evolution.
 - LTE technical development was initiated a decade ago – advanced technical solutions are available
- To meet these requirements and to exploit new technologies, 3GPP initiated the development of a new radio-access technology known as NR (New Radio)
- First version of NR specifications was available by the end of 2017
 - to meet commercial requirements on early 5G deployments already in 2018
- NR reuses many of the structures and features of LTE
- Since NR serves broad use cases than LTE, uses a partly different set of technical solutions

Standardization of mobile communication (1)

- Multi-national technology specifications and standards – key to success of mobile communication.
 - Allows deployment and interoperability of devices and infrastructure of different vendors
 - Enables devices and subscriptions to operate on a global basis
 - 1G NMT technology was created on a multinational basis
 - Allowed for devices and subscription to operate over the national borders between the Nordic countries
- 2G GSM was jointly developed between European countries within ETSI (European Telecommunications Standards Institute).
 - GSM devices able to operate over a large number of countries – covering a large number of users
- True global standardization of mobile happened with 3G technologies, especially WCDMA

Standardization of mobile communication (2)

- Work on 3G was initially also carried out separately within
 - Europe (ETSI),
 - North America (TIA) – Telecommunication Industry Association
 - Japan (ARIB) – Association of Radio Industries and Businesses
- Although work was being done separately within different standard organizations
 - e.g., ETSI, TIA, ARIB – similar underlying technologies were being pursued
- Especially true for Europe and Japan – both were developing similar flavors of WCDMA

Standardization of mobile communication (3)

- Different regional standardization organizations came together and jointly created the Third-Generation Partnership Project (3GPP)
 - task of finalizing the development of 3G technology based on WCDMA
- A parallel organization (3GPP2) was later created to develop an alternative 3G technology,
 - cdma2000, as an evolution of second-generation IS-95.
- For a number of years, 3GPP and 3GPP2, with their respective 3G technologies (WCDMA and cdma2000) co-existed
- Over time 3GPP came to completely dominate and has,
 - despite its name, continued into the development of 4G (LTE, and 5G) technologies.
- Today, 3GPP is only significant organization developing specifications for mobile communication

Books

- 5G NR: The Next Generation Wireless Access Technology
 - Erik Dahlman, Stefan Parkvall, and Johan Skold, Elsevier 2018 [ErikD]
- 5G NR Architecture, Technology, Implementation, and Operation of 3GPP New Radio Standards
 - Sassan Ahmadi, Elsevier 2019[SassanA]
- Reference for today's lecture: Chap1 of ErikD

Course evaluation and attendance

- MATLAB simulation assignments based on class material - 15%
- Two mid-term exams 30%
- End-sem 40%
- Take home tutorials – not graded, will hold tutorial classes to clarify doubts
- Attendance - 15