Aalto University
Comnet

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Mobile Communication systems and services

Lecture 9a: Services and Generations

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Services in Mobile Communication Systems

Services & Evolution

- The concepts discussed above sufficient for a taxonomy of Mobile Communication Systems (MCSs)
- To understand evolution, services need to be addressed
- Changes in services drive evolution of MCSs
  - realized and projected
  - increased/decreased popularity
  - characteristics of projected future services
- In the beginning:
  - MCSs were all about speech
- In the future:
  - everyhing is IP, including speech
    - the MCS is transparent to service, no special design needed

Services and Applications

- Most important attributes of services offered over mobile systems
  - data rate
    - average
    - variability
  - delay
    - tolerance (round-trip time)
    - setup time
  - symmetry (UL/DL)
  - Quality of Service requirement
- Most important service characteristic from core and RAN p.o.w. is amenability to different *switching* methods

  ➔ Core network: different architectures

  ➔ RAN: different channel structures and performance measures

Typical Services

preference
CS
PS
P/CS

- speech
  - constant ~10 kbs, delay tolerance 100 ms, symmetric
- video call
  - constant >100 kbs, delay tolerance 100 ms, symmetric
- video streaming/broadcast
  - constant >100 kbs, delay toler upper limited by buffer size, ~no UL
- best-effort data; background file up- and download
  - e.g. email download
  - rate up to Mbps, no delay constraints, asymmetric
- interactive file up- and download (e.g. web browsing)
  - rates up to Mbps, delay tolerance ~100 ms, asymmetric, short setup
- real-time gaming
  - rates ~100 kbs, delay tolerance < 100 ms, symmetric

Mobile Communication System Generations

Taxonomy of Mobile Comm Systs

- Rudimentary classification and history of mobile communication systems
- Can be understood on a high level using
  - analog vs. digital transmission methods
  - Synchronization
  - multiplexing and multiple access principles
  - duplexing
  - service palette and corresponding preferred switching method
    - Voice ➔ increasing role of data

Generations

- Mobile network development characterized in terms of generations
- Good overview: http://en.wikipedia.org/wiki/Mobile_telephony_standards

- 1st generation (1G)
  - analog modulation & voice processing
  - voice almost only application
    - normal telephony, emergency calls, voice mail

  - AMPS (Advanced Mobile Phone System), in the Americas
  - NMT (Nordic Mobile Telephone), in the Nordic countries
    - variants for 450 MHz and 900 Mhz bands
  - TACS (Total Access Communication System), in Europe

Why Digital Cellular?

- Digitalization:
  - digital source code
  - digital air interface
- Digital source coding allows compression
  - narrowing the bandwidth by removing redundancy of speech
  - Example: Nyqvist sampled, almost distortion free: ISDN 64 kbps ➔ GSM voice 13 kbps
  - ➔ spectrum efficiency: less resources used per call
- Digital air interface allows
  - error detection and error correction
    - ➔ robustness against noise and interference
    - ➔ QoS can be guaranteed independently of location
  - TDMA & CDMA possible
    - ➔ more flexibility in resource usage, multiplexing of different kinds of data
  - adaptation to radio conditions
  - security (digital encryption)
- Drawbacks of digital:
  - processing & delays
  - application specific (voice) codecs

2nd generation (2G)

- Digital modulation and voice processing
- Services:
  - Voice
  - SMS
  - Some circuit switched data (GSM < 9.6 kbps)
- GSM (Global System for Mobile Communications / Groupe Special Mobile)
  - almost worldwide
  - variants for 900 MHz and 1800 MHz, 1900 MHz bands
- PDC (Personal Digital Cellular)
  - a.k.a. JDC (Japanese Digital Cellular)
  - in Japan
- DAMPS (Digital AMPS)
  - a.k.a. IS-54 (Interim Standard 54), a.k.a. TDMA in the US
  - in Americas
- IS-95 (Interim Standard 95)
  - a.k.a. cdmaOne
  - in Americas, South Korea, India, China

2G evolution (2.5G)

- Services: higher data rates and packet switched data
- GSM evolution
  - HSCSD (High Speed Circuit-Switched Data)
    - Circuit switched data up to 4x14.4 = 57.6 kbps
  - GPRS (General Packet Radio Services)
    - packet switched data up to 100 kbps
  - EDGE (Enhanced Data rates for GSM Evolution)
    - packet switched data up to 296 kbps
- IS-95 evolution
  - cdma2000 1x uses one 1.25 MHz band, in Americas

Why 3G?

- Success of 2G digital cellular ➔ capacity exhaustion ➔ need for systems with higher spectral efficiency
- 2G radio interfaces optimised for voice
  - only low-rate data services

  ➔ Need system supporting high-speed multirate data services with asymmetric radio links

➔ 3G optimized for circuit switched voice and packet switched data
  - WCDMA up to 1.92 Mbps

3rd generation (3G)

- cdma2000 family
  - cdma2000 3x uses three 1.25 MHz bands, not deployed
  - cdma2000 1xEV-DO (Evolution-Data Optimized)
  - in Americas, Japan, South Korea
  - CDMA, synchronous UL
- UMTS (Universal Mobile Telecommunication System)
  - The radio access of UMTS is called UTRA (UMTS Terrestrial Radio Access). There are three versions of UTRA:
    1. UTRA-FDD
    2. UTRA-TDD HCR (High Chip Rate) a.k.a. TD-CDMA
       - Based on WCDMA (Wideband CDMA) technology
         - CDMA, 5 MHz band, asynchronous UL
         - Used almost worldwide
    3. UTRA TDD LCR (Low Chip Rate)
       - Based on TD-SCDMA (Time Division Synchronous CDMA)
         - 1.6 MHz band, TDD, CDMA and TDMA
         - Used in China
  - The Radio Access Network is accordingly UTRAN

3G evolution (3.5G)

- Further enhanced packet switched data
- Increased network capacity
- HSPA (High Speed Packet Access)
  - extension of WCDMA
  - HSDPA (High Speed Downlink Packet Access)
    - Up to 10 Mbps
  - HSUPA (High Speed Uplink Packet Access)

4th Generation (4G)

- WiMAX (Worldwide interoperability for Microwave Access)
  - IEEE standard 802.16
  - a standard for wireless metropolitan area networks
  - Support for mobility
- LTE (UTRA Long Term Evolution)
  - packet switched only
    - Voice, up to 100 Mbps data
  - increased coverage & network capacity, decreased latency
  - different access principle for DL & UL
  - winning technology battle in 4G
- LTE is marketed as 4G, but does not fulfill all official 4G targets
- Full 4G targets will be fulfilled by LTE Advanced

Generations, Overview

	System	multiple access	duplexing	carrier separation	time division/ spreading factor	launched
1G	AMPS NMT450 TACS NMT900	all FDMA	all FDD	30 kHz 12.5 kHz 30 kHz 12.5 kHz		1979 1982 1985 1987
2G	GSM DAMPS PDC IS95	T/FDMA T/FDMA T/FDMA DS-CDMA	all FDD	200 kHz 30 kHz 25 kHz 1.25 MHz	8 3 3 64	1991 1992 1993 1995
3G	WCDMA cdma2000 1x cdma2000 3x TD-SCDMA	DS-CDMA DS-CDMA MC-CDMA T/CDMA	FDD/TDD FDD FDD TDD	5 MHz 1.25 MHz 3.75 MHz 1.6 MHz	256 64 3 x 64 16	2001 2002 not deployed 2007
4G	LTE	OFDMA/SC-FDMA	FDD/TDD	1.4, 3, 5, 10, 15, & 20 MHz		2010

Mobility vs. data rate (DL)