Mobile Communications

Mobile Communications Evolution

AMPS

❖ **AMPS (Advanced Mobile Phone System)**

- 1st Generation (1G) mobile cellular phone
- Analog standard using FDMA (Frequency Division Multiple Access)
- Developed by Bell Labs
- Introduced in North America in Oct. 1983

GSM

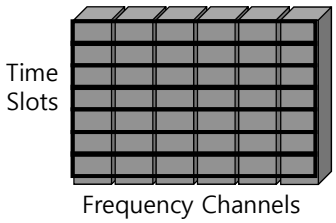
❖ GSM (Global System for Mobile Communications)

- 2nd Generation (2G) mobile cellular phone: Digital system
- Introduced in Finland in 1991
- Dominant global standard
  - Over 90% market share
  - Operated in over 219 countries & territories

GSM

❖ GSM

- GSM uses FDMA & TDMA combined
  - FDMA (Frequency Division Multiple Access)



  - TDMA (Time Division Multiple Access)

GSM

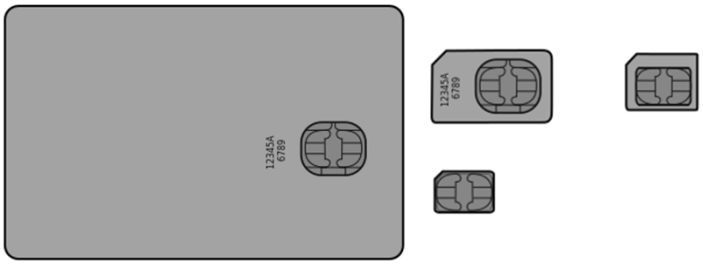
❖ GSM Services

- Voice calls
- Data transfer speeds up to 9.6 kbps
- SMS (Short Message Service)
- SIM card technology

GSM

❖ SIM (Subscriber Identity Module)

- SIM is a detachable smart card
- SIM contains user subscription information and phone book



GSM

❖ SIM Advantages

- SIM enables a user to maintain user information even after switching cellular phones
- By changing ones SIM a user can change cellular phone operators while using the same the mobile phone

IS-95: cdmaOne

❖ IS-95

- IS-95 (Interim Standard 95) is the first CDMA based 2G digital cellular standard
  - Why CDMA?
  - CDMA performs well against (narrow band) interference and (multipath) signal fading
  - cdmaOne is the brand name for IS-95 that was developed by Qualcomm

IS-95: cdmaOne

❖ **IS-95**

- Hutchison launched the first commercial cdmaOne network in Hong Kong in September 1995
- IS-95 traffic channels support voice or data at bit rates of up to 14.4 kbps

UMTS

❖ **UMTS (Universal Mobile Telecommunications System)**

- 3rd Generation (3G) mobile cellular system
- Evolution of GSM
- UTRA (UMTS Terrestrial Radio Access) supports several different terrestrial air interfaces

UMTS

❖ UMTS (Universal Mobile Telecommunications System)

- Multiuser Access in UTRA can be supported by UTRA-FDD or UTRA-TDD
  - FDD (Frequency Division Duplex)
  - TDD (Time Division Duplex)

UMTS: WCDMA

❖ WCDMA (Wideband Code Division Multiple Access)

- 3rd Generation (3G) mobile cellular system that uses the UTRA-FDD mode
- 3GPP (3rd Generation Partnership Project) Release 99
  - Up to 2 Mbps data rate

UMTS: WCDMA

❖ WCDMA

- First commercial network opened in Japan is 2001
- Seamless mobility for voice and packet data applications
- QoS (Quality of Service) differentiation for high efficiency of service delivery
- Simultaneous voice and data support
- Interworks with existing GSM networks

CDMA2000

❖ CDMA2000

- 3G mobile cellular system
- Standardized by 3GPP2
- Evolution of IS-95 cdmaOne standards
  - Uses CDMA & TDMA
    - CDMA (Code Division Multiple Access)
    - TDMA (Time Division Multiple Access)

CDMA2000

❖ CDMA2000

- Initially used in North America and South Korea (Republic of Korea)

CDMA2000

❖ CDMA2000 1xEV-DO

- CDMA2000 1xEV-DO (Evolution-Data Optimized) enables 2.4 Mbps data rate
- CDMA2000 1xEV-DO network launched in South Korea on January 2002

CDMA2000

❖ CDMA2000 1xEV-DO

- Regarded as the first 3G system based on ITU standards
  - ITU (International Telecommunication Union) is the specialized agency for information and communication technology of the UN (United Nations)

HSDPA

❖ HSDPA (High-Speed Downlink Packet Access)

- Enhanced 3G mobile communications protocol
- Evolution of UMTS for higher data speeds and capacity
- Belongs to the HSPA (High-Speed Packet Access) family of protocols

HSDPA

❖ HSDPA (High-Speed Downlink Packet Access)

- HSDPA commercial networks became available in 2005
- Peak Data Rate
  - Downlink: 14 Mbps (Release 5)

EV-DO Rev. A

❖ EV-DO Rev. A (Revision A)

- Peak Data Rate
  - Downlink: 3.1 Mbps
  - Uplink: 1.8 Mbps
- Launched in the USA on October 2006
- VoIP support based on low latency and low bit rate communications

EV-DO Rev. A

❖ EV-DO Rev. A

- Enhanced Access Channel MAC
  - Decreased connection establishment time
- Multi-User Packet technology enables the ability for more than one user to share the same timeslot
- QoS (Quality of Service) flags included for QoS control

HSPA+

❖ HSPA+ (Evolved High-Speed Packet Access)

- HSPA+ all IP network first launched in Hong Kong in 2009
- WCDMA (UMTS) based 3G enhancement
- HSPA+ is a HSPA evolution

HSPA+

❖ HSPA+ (Evolved High-Speed Packet Access)

- Peak Data Rate
  - Downlink: 168 Mbps
  - Uplink: 22 Mbps
- MIMO (Multiple-Input & Multiple-Output) multiple-antenna technique applied
  - Why MIMO?
  - MIMO uses uncorrelated multiple antennas both at the transmitter and receiver to increase the data rate while using the same signal bandwidth as a single antenna system

HSPA+

❖ HSPA+ (Evolved High-Speed Packet Access)

- Higher Date Rate Accomplished by
  - MIMO multiple-antenna technique
  - Higher order modulation (64 QAM)
  - Dual-Cell HSDPA is used to combine multiple cells into one

EV-DO Rev B

❖ EV-DO Rev. B (Revision B)

- EV-DO Rev. B was first deployed in Indonesia on January 2010
- Multi-Carrier evolution of Rev. A
- Higher data rates per carrier
  - Downlink Peak
    - 4.9 Mbps per carrier
  - Uplink Peak
    - 1.8 Mbps per carrier

EV-DO Rev B

❖ EV-DO Rev. B

- Reduced latency from statistical multiplexing across channels
  ➔ Reduced delay ➔ Improved QoS
- Longer talk-time & standby time
- Hybrid frequency re-use & Reduced interference at Cell Edges and Adjacent Sectors ➔ Improved QoS at the Cell Edge

EV-DO Rev B

❖ EV-DO Rev. B

- More Efficient Asymmetric Data Rate Support
  - Downlink ≠ Uplink Data Rates
- Asymmetric Service Examples
  - File transfer
  - Web browsing
  - Multimedia content delivery
  - etc.

LTE

❖ LTE (Long-Term Evolution)

- LTE launched in North American on September 2010 with the Samsung SCH-R900

- Deployed on both GSM and the CDMA mobile operators

LTE

❖ LTE (Long-Term Evolution)

- Peak Data Rate (Release 8)
  - Downlink: 300 Mbps
  - Uplink: 75 Mbps

LTE-A

❖ LTE-A (LTE-Advanced)

- Considered as a 4G technology based on the ITU-R IMT-Advanced process

- Peak Data Rate (Release 10)
  - Downlink: 3 Gbps
  - Uplink: 1.5 Gbps

LTE-A

❖ LTE-A (LTE-Advanced)

- LTE-A incorporates higher order MIMO (4×4 and beyond) and allows multiple carriers to be bonded into a single stream

Mobile Communications

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