

Wireless Cellular Networks II: 2.5G and 3G

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Audio/Video recordings of this lecture are available at:

<http://www.cse.wustl.edu/~jain/cse574-08/>



- Wireless Generations: 2.5G, 3G
- CDMA
- GSM
- CDPD
- GPRS, EDGE
- EV-DV, EV-DO
- WCDMA, CDMA2000, TD-SCDMA
- HSDPA

3G Technologies

- ❑ Wideband CDMA (W-CDMA): Next Generation GSM.
Uses 5 MHz channel width \Rightarrow 2 Mbps
- ❑ CDMA2000: Next Generation CDMA (IS-95)
1.25 MHz Channels \Rightarrow 144 kbps
 - 3x, 6x, 9x, and 12x in future
 - 3x (3XRTT): 3.75 MHz channel \Rightarrow 2 Mbps
- ❑ UWC-136: Next Generation TDMA (IS-136)
200 kHz Channels \Rightarrow 384 kbps or
1.6 MHz Channels \Rightarrow 2 Mbps
Developed by Universal Wireless Communications Consortium (UWCC)

Goal: Provide high-speed packet based Voice and Data

3G

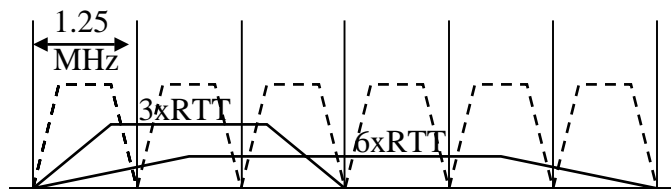
- ❑ Also known as ITU IMT-2000 Project.
Started in 1980.
- ❑ Goal: To have one world-wide standard and a common frequency band for mobile networking
- ❑ Result:
 - Three frequency bands: Below 1 GHz, 1.7GHz, 2.5GHz
 - Three different technologies: W-CDMA (Europe) CDMA2000 (North America) , and TD-SCDMA in China.

WCDMA

- ❑ Wideband CDMA
- ❑ Proposed by European Telecom Std Inst (ETSI) Alpha group
- ❑ WCDMA has 5MHz single carrier system w Freq Div Duplexing and direct sequence (FDD-DS) \Rightarrow 2 Mbps data
- ❑ 3rd Generation Partnership Project (3GPP.org)
- ❑ 2.5G:
 - HSCSD (High-Speed Circuit Switched Data)
 - GPRS (General Packet Radio Service)
144 kbps data only
 - EDGE (Enhanced Data for GSM Evolution)
384 kbps data
 - HSDPA (High-speed downlink packet access)
Asymmetric. 2 Mbps+ downlink.

CDMA2000

- ❑ Proposed by Third Generation Partnership Project 2 (3GPP2.org).
- ❑ 3GPP2: Partnership of 5 Telecom standards bodies: ARIB and TTC in Japan, CWTS in China, TTA in Korea and TTA in North America
- ❑ Full backward compatibility with IS-95B (CdmaOne)
- ❑ CDMA2000 is also known as CDMA-MC (multi-carrier)
- ❑ It uses n carriers of 1.2288 MHz each. 1x, 3x, 6x, 9x, 12x

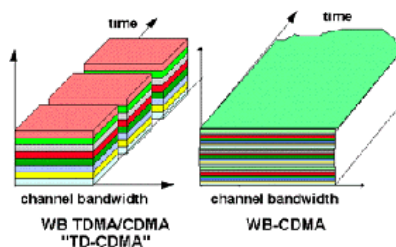


CDMA2000 (Cont)

- ❑ 625 kHz guard band between carriers
- ❑ Single carrier or multi-carriers
- ❑ 2.5G: Operators can overlay CDMA2000 1x now over CdmaOne. Also known as CDMA2000 1xEV.
Implemented in 2 steps:
 - 1xEV-DO (Evolution data only),
 - 1xEV-DV (Evolution data and voice on one carrier).

TD-SCDMA

- ❑ Time Division Synchronous CDMA
- ❑ Proposed by China Wireless Telecommunication Standards group (CWTS)
- ❑ Uses Time Division Duplex (TDD)
- ❑ Synchronous \Rightarrow All base station clocks are synchronized
- ❑ <http://www.tdsdma-forum.org/>



2.5 G

Data services over 2G networks

- ❑ GSM
 - High-speed circuit-switched data (HSCSD)
 - General Packet Radio Service (GPRS)
 - Enhanced Data Rate for GSM Evolution (EDGE)
- ❑ CdmaOne:
 - 1xEV-DO
 - 1xEV-DV

HSCSD

- ❑ High-Speed Circuit Switched Data (HSCSD)
- ❑ First attempt to get high-speed data over GSM
- ❑ Allows data users to get 1 to 8 slots
 - Data rates up to 115 kbps
- ❑ Circuit switched \Rightarrow Constant data rate
 - Not suitable for bursty data
 - Not widely implemented
 - GPRS is more widely implemented

GPRS

- ❑ General Packet Radio Service (GPRS)
- ❑ Standard GSM has 8 slots per 200 kHz channel
 - ⇒ 9.6 kbps data
- ❑ GPRS allows any number of slots to a user
 - 4 different codings used depending upon channel condition
 - 9.05 kbps to 21.4 kbps per slot
 - 76-171 kbps using all 8 slots.
- ❑ GPRS user can hop channels (as in CDPD). 2.5G Technology

G_i = GSM User

G_{pi} = GPRS User

| | t_0 | t_1 | t_2 | t_3 | t_4 | t_5 | t_6 | t_7 | t_0 | t_1 | t_2 |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Uplink 1 | G1 | | G2 | | GP2 | | | GP1 | G1 | | G2 |
| Uplink 2 | | | | GP1 | | | GP2 | | | | |
| Downlink 1 | G1 | GP1 | G2 | | GP2 | | | GP1 | G1 | | G2 |
| Downlink 2 | GP1 | | | | GP1 | | | | | GP2 | |

GPRS (Cont)

- ❑ Supports intermittent and bursty data transfers
 - Point-to-multipoint also supported
- ❑ Need to add two new elements to GSM networks:
 - Service GPRS support node (SGSN)
 - Security, Mobility, Access control
 - Gateway GPRS support node (GGSN)
 - Connects to external packet switched networks
- ❑ Standardized by ETSI

EDGE

- ❑ Enhanced Data Rates for GSM Evolution (EDGE)
- ❑ Standard GSM uses Gaussian Minimum Shift Keying (GMSK) modulation
- ❑ EDGE changes to 8-PSK modulation \Rightarrow 3 bits/Hz
- ❑ GPRS+EDGE \Rightarrow 384 kbps
- ❑ Need better radio signal quality

Data Rates

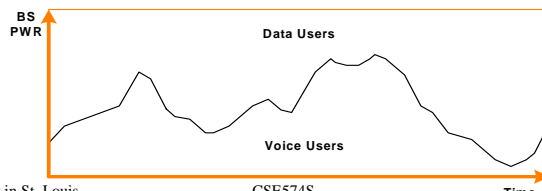
| Technology | Bandwidth | Data Rate/User (Theory) | Data Rate/User (Realistic) |
|-------------|-----------|-------------------------|----------------------------|
| GSM | 200 kHz | 9.6 kbps | 9.6 kbps |
| GPRS | 200 kHz | 172 kbps | 40 kbps |
| EDGE | 200 kHz | 474 kbps | 100 kbps |
| CDMA2000 3x | 3.75 MHz | 2 Mbps | 384 kbps |
| WCDMA | 5 MHz | 2 Mbps | 1 Mbps |

HSDPA

- ❑ High-Speed Downlink Packet Access for W-CDMA
- ❑ Improved spectral efficiency for downlink P Asymmetric
- ❑ Up to 10 Mbps in theory, 2Mbps+ in practice
- ❑ Announced by Siemens, then by Ericsson, Alcatel, Fujitsu
- ❑ Adaptive modulation and coding (AMC)
- ❑ Multi-code (multiple CDMA channels) transmission
- ❑ Fast physical layer (L1) hybrid ARQ (H-ARQ)
- ❑ Packet scheduler moved from the radio network controller (RNC) to the Node-B (base station)
 - ⇒ advanced packet scheduling techniques
 - ⇒ user data rate can be adjusted to match the instantaneous radio channel conditions.

1xEV-DV

- ❑ 1x Evolution to Data and Voice (1xEV-DV)
- ❑ Single 1.25 MHz bandwidth shared between voice and data users
- ❑ 3.1 Mbps peak data rate on Forward Packet Data Channel
- ❑ Voice users are usually scheduled first
- ❑ Dynamic allocation of the unused BS power to data users every slot cycle (1.25 ms)



1xEV-DV vs. 1xEV-DO

- ❑ EV-DV uses 1 RF channel for data and voice while EV-DO requires separate carrier frequencies
- ❑ Fully compatible with CdmaOne and CDMA2000 allowing all types of handoff between those systems \Rightarrow economical, incremental deployment; uninterrupted voice and data coverage
- ❑ EV-DV provides smooth coexistence between voice and data services
- ❑ IS-2000 Rel 0 BS can be upgraded to support EV-DV Rel C by addition of channel card and SW upgrade
- ❑ To upgrade the same BS to support EV-DO in addition to 1x, a separate RF path (from antennas through PA's to channel card) is needed

Data Rates

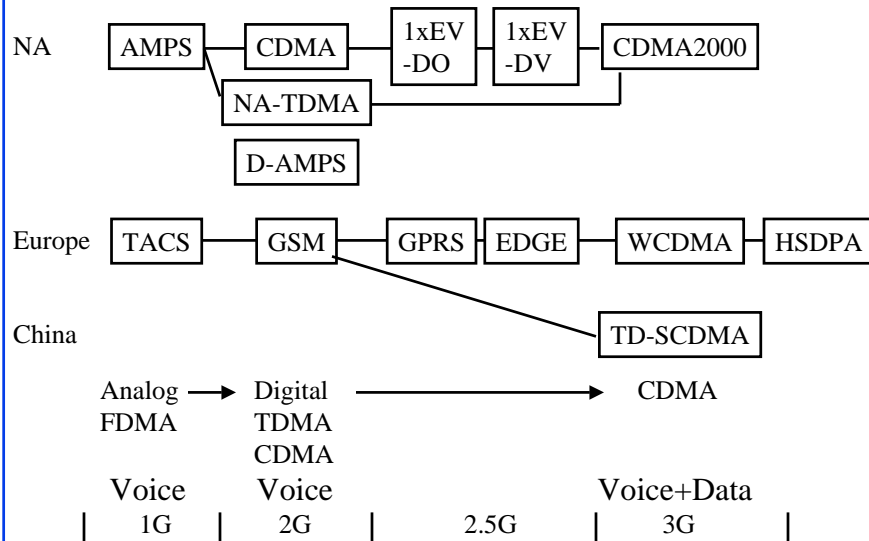
| | Down Link | Up Link |
|----------------|-----------------------|-----------------------|
| 1x | 9.6 kbps – 614.4 kbps | 9.6 kbps – 460.8 kbps |
| 1xEV-DV Rel. C | 9.6 kbps – 3.09 Mbps | 9.6 kbps – 460.8 kbps |
| 1xEV-DV Rel. D | 9.6 kbps – 3.09 Mbps | 9.6 kbps – 1.5 Mbps |
| 1xEV-DO | 38.4 kbps – 2.45 Mbps | 9.6 kbps – 450.8 kbps |
| 1xEV-DO Rel. A | 38.4 kbps – 2.45 Mbps | 9.6 kbps – 1.5 Mbps |

3G Deployments

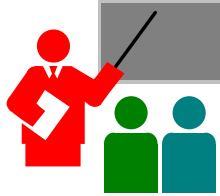


- ❑ 3G deployments are finally happening.
- ❑ UMTS forum lists statistics (Jan 2008)
 - Ref: <http://www.umts-forum.org/>
 - Total cell phones 3.3B
 - GSM based 2.6B = 80%
 - 3G = 300 M (50% in Europe, 43% in Asia Pacific)
 - 3G + HSPA = 200 M

Evolution of Cellular Technologies



Summary



- ❑ Three systems for 3G: W-CDMA (ROW), CDMA2000 (NA), TD-SCDMA (China)
- ❑ GPRS and EDGE = 2.5 G path for GSM systems
- ❑ 1xEV-DO and 1xEV-DV = 2.5G CDMAone systems
- ❑ CDMA2000 allows many channel width: 1xRTT, 3x, 6x
- ❑ HSDPA provides a high-speed asymmetric data on 3G systems

Homework 15

- ❑ Read chapters 1, 4, and 5 from Harte, et al.
- ❑ Draw a diagram showing the constellations of 8PSK modulation used in EDGE systems

Thank You!

