

Wireless Networks

Lecture 25: 1G, 2G, and 3G

Part 2

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Outline

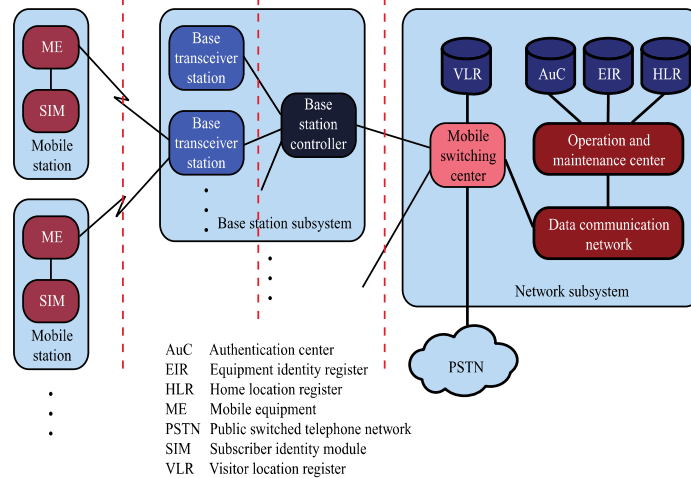
- **1G: AMPS**
- **2G: GSM**
- **2.5G: EDGE, CDMA**
- **3G: WCDMA**

Some slides based on material from
“Wireless Communication Networks and Systems”
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Global GSM System



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GSM Multiple Access

- **Combination of FDMA and TDMA**
- **890-915 MHz for uplink**
- **935-960 MHz for downlink**
- **Each of those 25 MHz bands is sub divided into 124 single carrier channel of 200 KHz**
 - » Each with a data rate of 270.833 kbps
- **In each uplink/downlink band there is a 200 KHz guard band**
- **Each 200 KHz channel carries 8 TDMA channels**

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Additional GSM Features

- **GSM uses GMSK modulation**
 - » Gaussian Minimum Shift Keying
- **Slow frequency hopping: successive TDMA frames are sent over a different frequency**
 - » Switches every 4.615 msec
 - » Spreads out effect of multipath fading
 - » Also helps with co-channel interference
- **Delay equalization**
 - » Mobile stations sharing a frame can be at different distances from the base station
 - » Tail bits and guard bits provide margin to avoid overlap

Generalized Packet Radio Service (GPRS)

- **Packet-oriented data transport service**
 - » Bursty, non-periodic traffic typical for Internet access
- **Uses a new architecture for data traffic**
 - » Allows users to open a persistent data connection
 - » Sending data traffic over a voice connection would add too much setup and teardown overhead
- **Uses the same frame structure as voice**
 - » 21.4 kbps from a 22.8 kbps gross data rate
 - » Can combine up to 8 GSM connections
 - Overall throughputs up to 171.2 kbps
 - » Enhanced Data Rates for GSM Evolution (EDGE) further increased rates using a more aggressive PHY

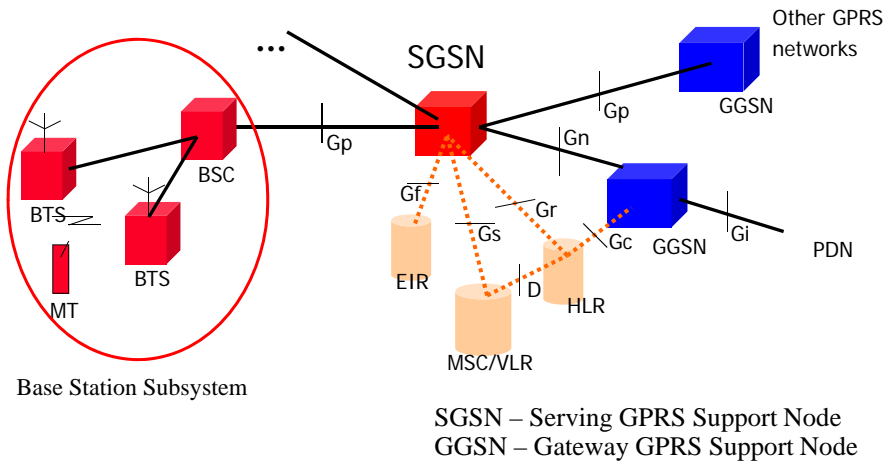
GPRS Architecture

- **Network Subsystem includes several new entities:**
 - **Serving GPRS Support Node (SGSN):** data transfer between Base Station and Network Subsystem
 - **Gateway GPRS Support Node:** connects to other GPRS networks and the packet data network (Internet)
 - **New interfaces between the various entities**
- **Transmission plane**
 - Data packets are transmitted by a tunnel mechanisms
- **Control plane**
 - Protocol for tunnel management: create, remove, ...
 - GPRS Tunnel Protocol
- **Radio interface**
 - Changes the logical channels and how they are managed

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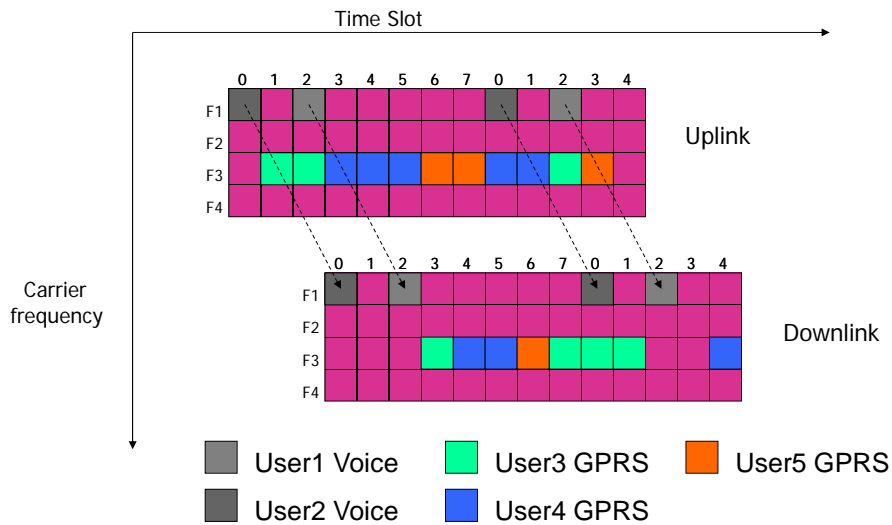
GPRS Architecture



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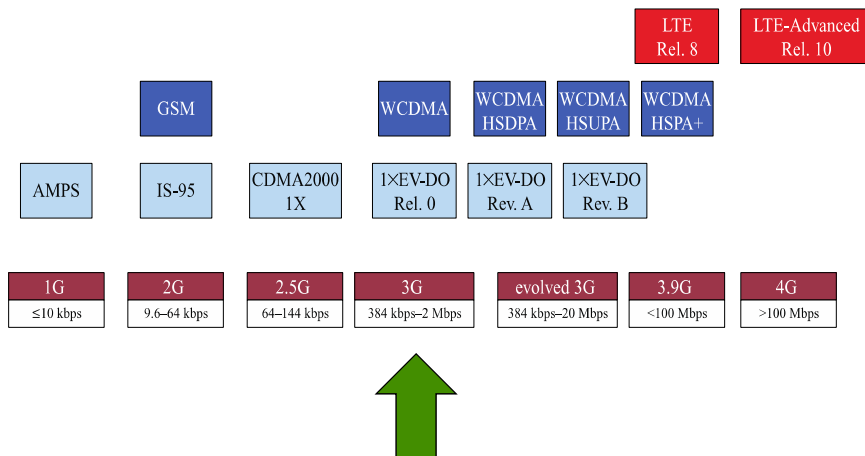
GPRS Radio Interface



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Evolution of Cellular Wireless Systems



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Who is Who

- **International Telecommunications Union (ITU) - agency of the United Nations responsible for:**
 - » Assisting in the development and coordination of world-wide standards
 - » Coordinate shared use of the global spectrum
 - » Defined the International Mobile Telecommunications 2000 (IMT-2000) project for 3G telecommunications
- **Third Generation Partnership Project (3GPP)**
 - » A group of telecommunications associations that represent large markets world-wide
 - » Defined a group of 3G standards as part of the IMT-2000 framework in 1999
 - » Originally defined GSM, EDGE, and GPRS
 - » Later defined follow-on releases and also LTE (4G)

UMTS and WCDMA

- **Part of a group of 3G standards defined as part of the IMT-2000 framework by 3GPP**
- **Universal Mobile Telecommunications System (UMTS)**
 - » Successor of GSM
- **W-CDMA is the air interface for UMTS**
 - » Wide-band CDMA
 - » Many GSM functions were carried over WCDMA
 - » Originally 144 kbps to 2 Mbps, depending on mobility
- **Basically same architecture as GSM**
 - » But they changed all the names!

Later Releases Improved Performance

- **High Speed Downlink Packet Access (HSDPA):**
1.8 to 14.4 Mbps downlink
 - » Adaptive modulation and coding, hybrid ARQ, and fast scheduling
- **High Speed Uplink Packet Access (HSUPA):**
Uplink rates up to 5.76 Mbps
- **High Speed Packet Access Plus (HSPA+):**
Maximum data rates increased from 21 Mbps up to 336 Mbps
 - » 64 QAM, 2x2 and 4x4 MIMO, and dual or multi-carrier combinations
- **Many GSM functions were carried over WCDMA**
- **Eventually led to the definition of LTE**

Advantages of CDMA for Cellular systems

- **Frequency diversity – frequency-dependent transmission impairments have less effect on signal**
- **Multipath resistance – chipping codes used for CDMA exhibit low cross correlation and low autocorrelation**
- **Privacy – privacy is inherent since spread spectrum is obtained by use of noise-like signals**
- **Graceful degradation – system only gradually degrades as more users access the system**

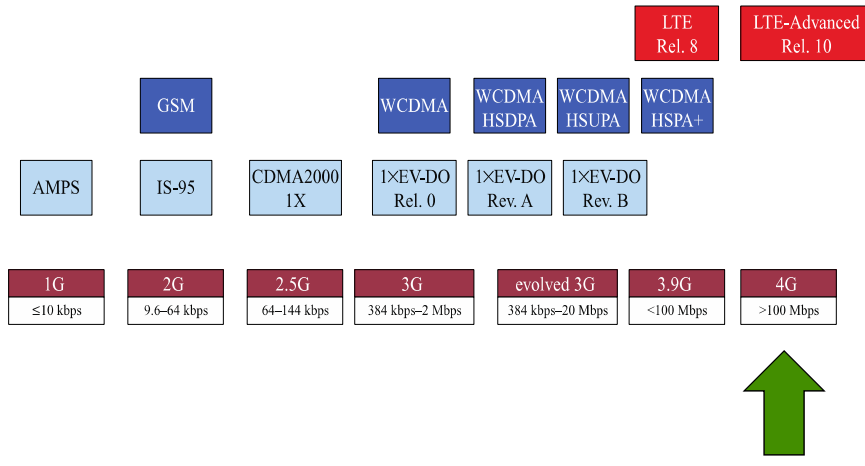
Mobile Wireless CDMA Soft Hand-off

- **Soft Handoff – mobile station temporarily connected to more than one base station simultaneously**
- **Requires that the mobile acquire a new cell before it relinquishes the old**
- **More complex than hard handoff used in FDMA and TDMA schemes**

Drawbacks of CDMA Cellular

- **Self-jamming – arriving transmissions from multiple users not aligned on chip boundaries unless users are perfectly synchronized**
- **Near-far problem – signals closer to the receiver are received with less attenuation than signals farther away**
 - » **Need power control**

Evolution of Cellular Wireless Systems



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