

# **Intro to 3G Cellular Systems and UMTS overview**

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**2720 Slides 11**

## **Second Generation Cellular Systems**



- Motivation for 2G Digital Cellular:
  - Increase System Capacity
  - Add additional services/features (SMS, caller ID, etc..)
  - Reduce Cost
  - Improve Security
  - Interoperability among components/systems (GSM only)
- 2G Systems
  - Global System for Mobile (GSM)
  - IS-95 (cmdaone)
  - Pacific Digital Cellular (PDC)



## 2.5 G Systems



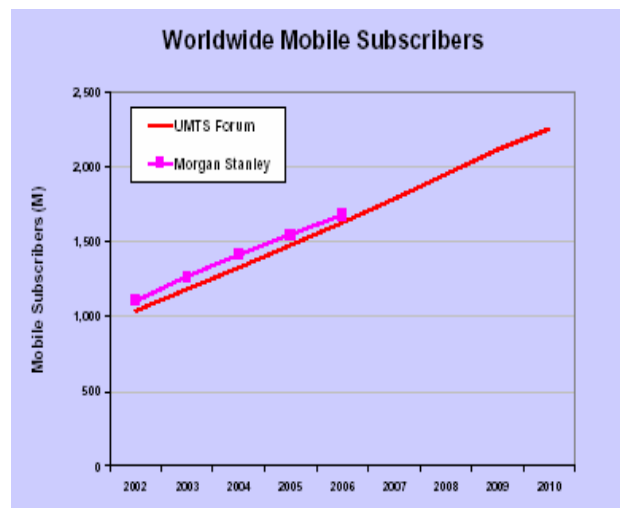
- 2G Systems provide slow speed data service
  - 9.6 Kbps – 14.4 Kbps
- 2.5G
  - Attempt to improve data services from 2G and build customer base for wireless data service
  - GPRS, EDGE, *cdma 2000 1x-rtt*
  - Basically overlay network of data service on 2G networks (voice still circuit switched)
  - Max data rate 57 Kbps – 384 Kbps
  - Typical data rates 30-70 Kbps – similar to dialup modem service



## 3G Driving Factors



- Voice traffic continues to grow  
1 billion wireless subscribers occurred in 2002
  - wireless users more than number of wired lines users
- Predict 2 billion by 2008
- Mobile voice is in part the killer app for 3G



# 3G Applications



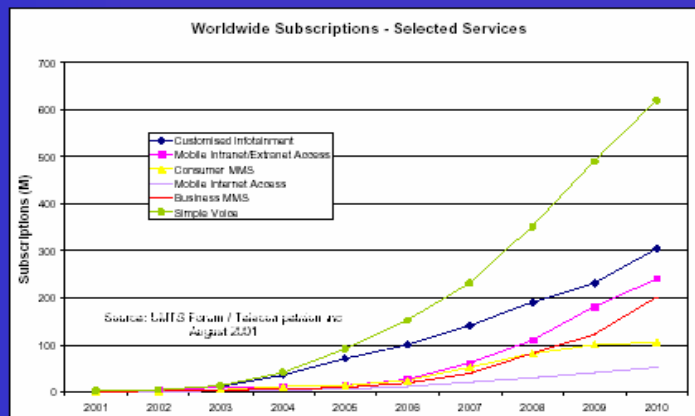
- Focus on data service and value added applications
  - Mobile Internet Access
  - Mobile Intranet/Extranet Access
  - Personalized Infotainment
    - Video, audio, interactive games, TV, etc.
  - Multimedia Message Service (MMS)
  - Location Based Services (LBS)
  - Rich Voice (video telephony, text + audio, etc.)
- Theme
  - Multi-mode (multi-media) service
  - Community and identity



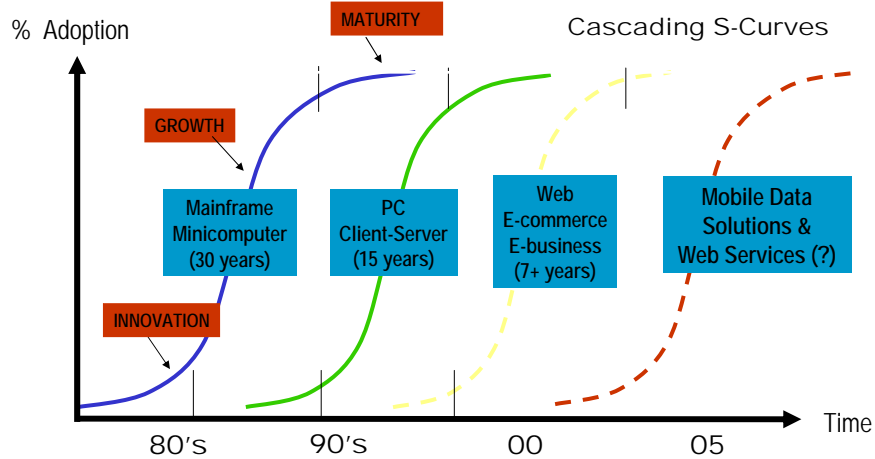
# 3G Driving Factors



## Worldwide demand for 3G services by subscriptions – 2001-2010



## Next Innovation – Mobile Data Services?



## 3G Development

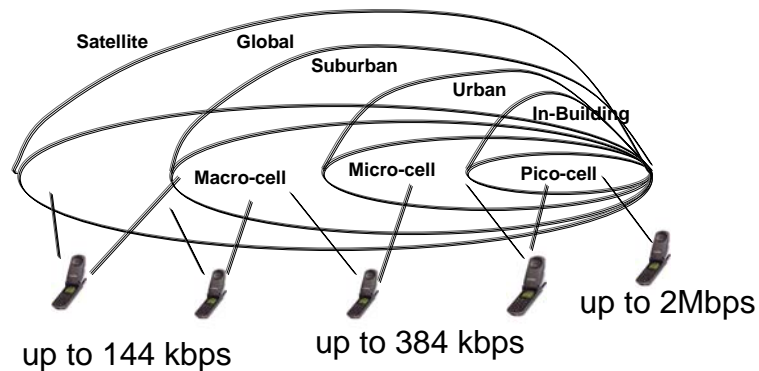


- 1986 ITU began studies of 3G as:
  - Future Public Land Mobile Telecom. Systems (FPLMTS)
  - 1997 changed to IMT-2000 (International Mobile Telecom. in Year 2000)
  - ITU-R studying radio aspects, ITU-T studying network aspects (signaling, services, numbering, quality of service, security, operations)
- IMT-2000 vision of 3G
  - **1 global** standard in **1 global frequency band** to support wireless data service
  - Spectrum: 1885-2025 MHz and 2110-2200 MHz worldwide
  - Multiple radio environments (phone should switch seamlessly among cordless, cellular, satellite)
  - Support for packet switching and asymmetric data rates
- Target data rates for 3G
  - Vehicular: 144 kbps
  - Pedestrian: 384 kbps
  - Indoor office: 2.048 Mbps → roadmap to > 10Mbps late
- Suite of four standards approved after political fight

## 3G Requirements



Seamless End to End Service with different data rates



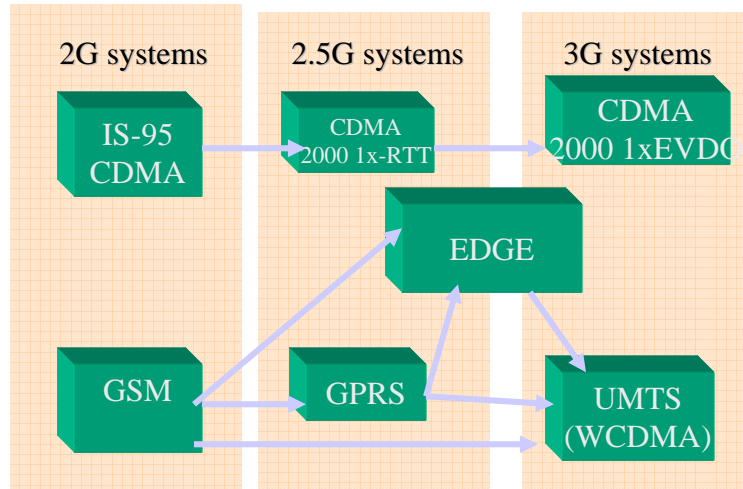
## Third Generation Standards



- ITU approved suite of four 3G standards
- **EDGE** (Enhanced Data rates for Global Evolution)
  - TDMA standard with advanced modulation and combined timeslots
  - Provides unification of NA-TDMA and GSM
  - Only meets some of the 3G requirements (2.75G?)
- **UMTS** (Universal Mobile Telephone Service) also called **WCDMA** (wideband CDMA)
  - Dominant standard outside of US and leading standard for 3G worldwide
  - Viewed as 3G migration path for GSM/TDMA systems
- **CDMA 2000**
  - Also called (3X and cdma three): competes directly with W-CDMA up to 2 Mb/s
  - Evolutionary path for IS-95 which is the dominant standard in the US
- **TD-SCDMA** : Stand alone standard developed in China



## Evolution Path to 3G



## Current status of 3G



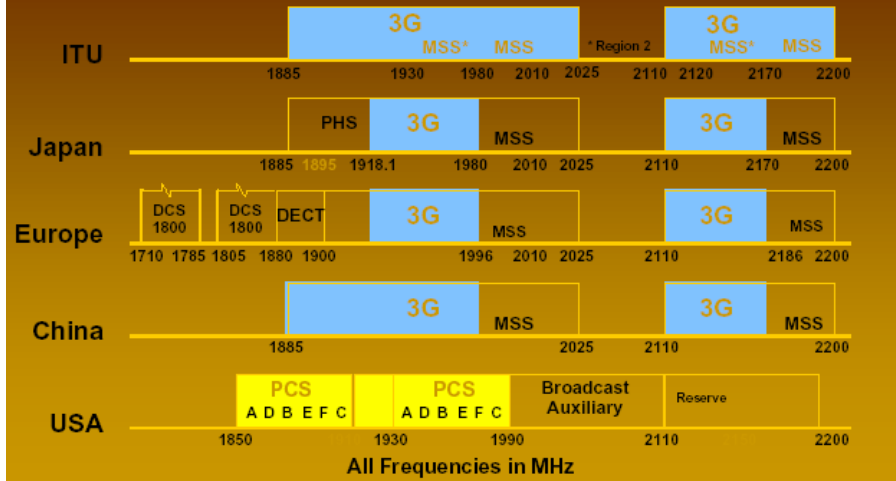
- Two partnership projects to harmonize and standardize the two main 3G standards
  - 3GPP that deals with the UMTS standard
    - <http://www.3gpp.org>
    - FDD and TDD mode
  - 3GPP2 that deals with the US cdma2000 proposal
    - <http://www.3gpp2.org>
    - Multicarrier CDMA
  - 3G spectrum allocated in over 100 countries
    - spectrum not consistent throughout the world
  - Deployments occurring slower than expected
    - Service providers strapped for cash (spectrum too expensive)
    - Equipment delays
    - Many carriers going with 2.5 G first to build data market



# 3G Spectrum Allocations



## 3G Spectrum Availability [2]



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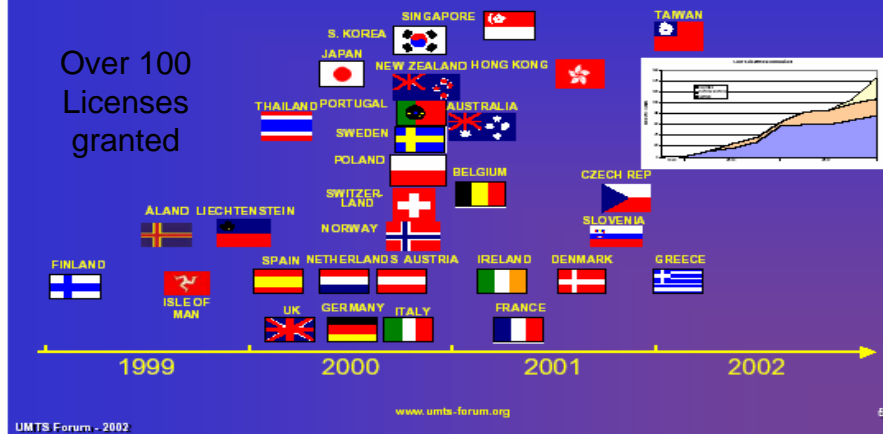
# Current status of 3G spectrum



## 3G Licences (e.g.):

## Where and when

Over 100 Licences granted



UMTS Forum - 2002

www.ums-forum.org

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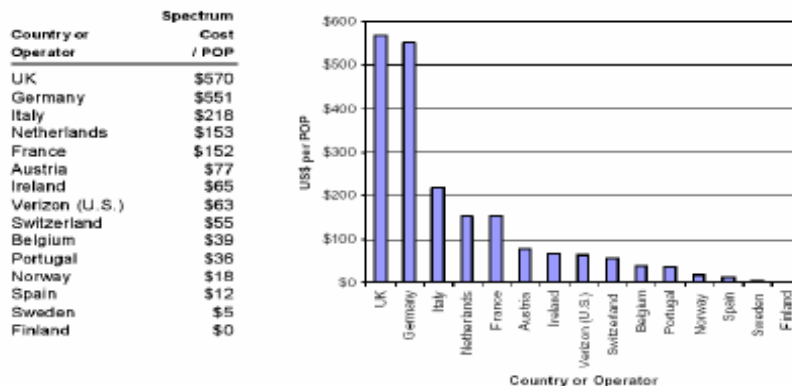
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## 3G Spectrum Cost



Exhibit 1.11

### COST OF 3G FREQUENCY PER POP



Source: Spectrum Strategy Consultants and QUALCOMM

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## UMTS



- ETSI proposed GSM/NA-TDMA /GPRS evolution under name Universal Mobile Telecom. Services (UMTS)
- Most of 3G licenses in Europe **required** operator to deploy a UMTS system covering x% of population by a specific date y
  - Germany: 25% of population by 12/03, 50% by 12/05
  - Norway: 80% of population by 12/04
  - In most countries operators have asked for and received deployment delay due to dot.com bust and equipment delays
    - Estimate 2.5 Billion euros to deploy a 5000 base station UMTS system
- According to UMTS Forum
  - More than 90 million UMTS users as of 10/06 on operating networks in more than 50 countries
  - Most deployments of UMTS in Europe (~40% of market) and Pacific Rim (~38% market)



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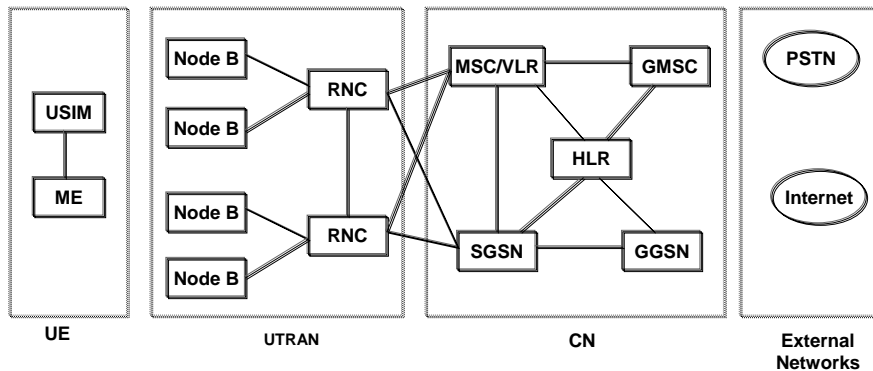


# UMTS



- UMTS is a complete system architecture
  - As in GSM emphasis on standardized interfaces
    - mix and match equipment from various vendors
  - Simple evolution from GPRS – allows one to *reuse/upgrade* some of the GPRS backhaul equipment
  - Backward compatible handsets and signaling to support intermode and intersystem handoffs
    - Intermode; TDD to FDD, FDD to TDD
    - Intersystem: UMTS to GSM or UMTS to GPRS
  - UMTS supports a variety of user data rates and both packet and circuit switched services
  - System composed of three main subsystems

## UMTS System Architecture



- UE (User Equipment) that interfaces with the user
- UTRAN (UMTS Terrestrial Radio Access Network) handles all radio related functionality – WCDMA is radio interface standard here.
- CN (Core Network) is responsible for transport functions such as switching and routing calls and data, tracking users

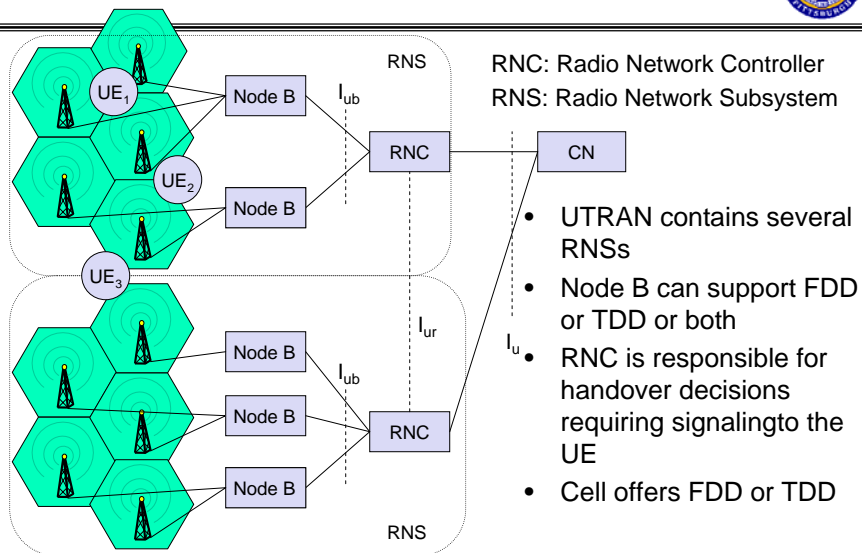
# UMTS System Architecture



- UE
  - ME (Mobile Equipment)
    - is the single or multimode terminal used for radio communication
  - USIM (UMTS Subscriber Identity Module)
    - is a smart card that holds the subscriber identity, subscribed services, authentication and encryption keys
- UTRAN
  - Node B (equivalent to BTS in GSM/GPRS)
    - performs the air interface processing (channel coding, rate adaptation, spreading, synchronization, power control).
    - Can operate a group of antennas/radios
  - RNC (Radio Network Controller) (equivalent to GSM BSC)
    - Responsible for radio resource management and control of the Node Bs.
    - Handoff decisions, congestion control, power control, encryption, admission control, protocol conversion, etc.



# UTRAN architecture



# UMTS System Architecture



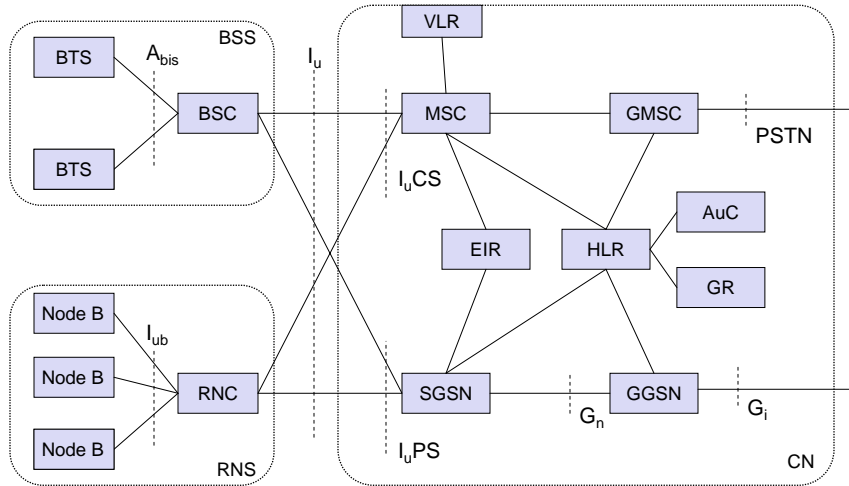
- Core Networks (CN)
  - HLR (*Home Location Register*)
    - database located in the user's home system that stores the master copy of the user's service profile. The HLR also stores the UE location on the level of MSC and SGSN,
  - 3G MSC / VLR
    - Switch and database that serves the UE in its current location for Circuit Switched (CS) services. The MSC function is used to switch the CS transactions, and VLR function holds a copy of the visiting user's service profile, as well as more precise information on the UE's location within the serving system.
  - 3G GMSC (*Gateway MSC*)
    - Switch at the point where UMTS is connected to external CS networks. All incoming and outgoing CS connections go through GMSC.
  - 3G SGSN (*Serving GPRS Support Node*)
    - Similar to that of MSC / VLR but is used for Packet Switched (PS) services. The part of the network that is accessed via the SGSN is often referred to as the PS domain. Upgrade version of serving GPRS support node.
  - 3G GGSN (*Gateway GPRS Support Node*)
    - Functionality is close to that of GMSC but is in the relation to PS services. Upgraded version of gateway GPRS support Node

# Core network

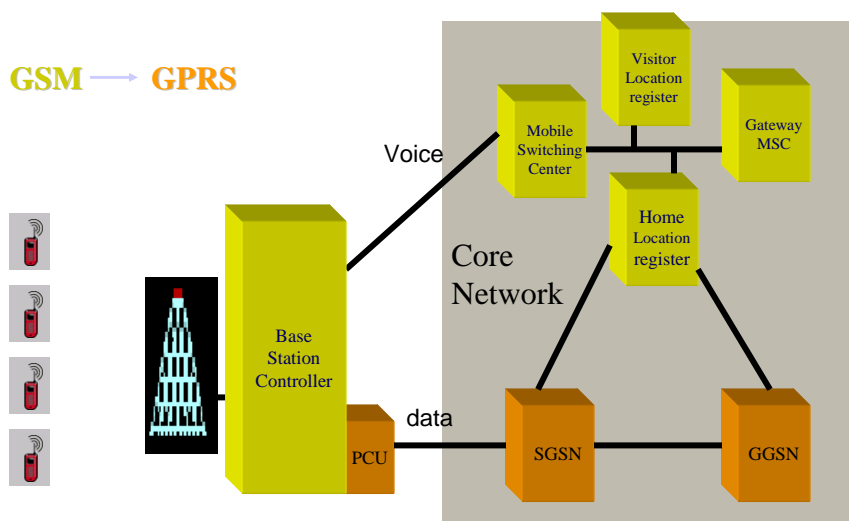


- The Core Network (CN) and the Interface  $I_u$  are separated into two logical domains:
- Circuit Switched Domain (CSD)
  - Circuit switched service including signaling
  - Resource reservation at connection setup
  - 3G versions of GSM components (MSC, GMSC, VLR, HLR)
  - $I_{uCS}$
- Packet Switched Domain (PSD)
  - Handles all packet data services
  - 3G versions of GPRS components (SGSN, GGSN)
  - $I_{uPS}$
- General approach of building on GSM/GPRS infrastructure ,helps to saves \$ and faster deployment

# Core network: architecture



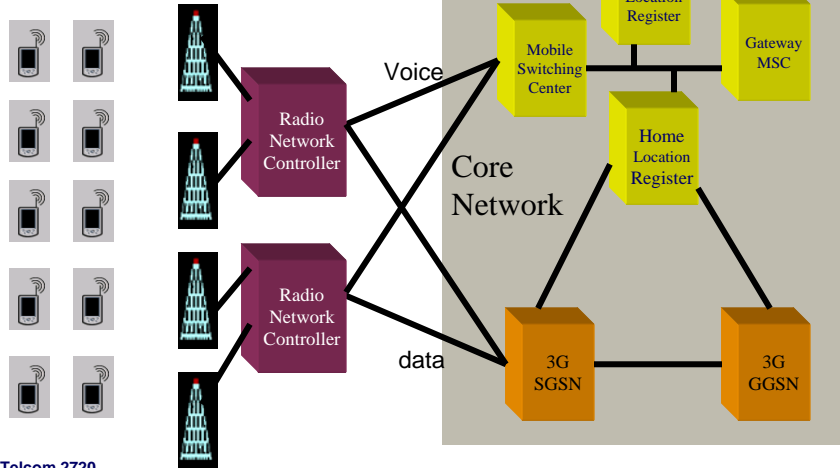
# GSM → GPRS Evolution



## GSM → GPRS → UMTS Evolution



GSM → GPRS → UMTS



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## WCDMA



- Wideband Code Division Multiple Access (WCDMA)
  - The air radio interface standard for UMTS
  - Wideband direct sequence spread spectrum
  - Variable orthogonal spreading for multiple access (OVSF)
- Three types of interface :
  - FDD: separate uplink/downlink frequency bands with constant frequency offset between them
  - TDD: uplink/downlink in same band but time-shares transmissions in each direction
  - Dual mode :supports FDD and TDD
- Wide range of data rates due to CDMA with variable spreading, coding and modes
  - Varying user bit rate is mapped to **variable power** and **spreading**
  - Different services can be mixed on a single carrier for a user

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# WCDMA



- 5-MHz Channel (25 GSM channels)
  - Each service provider can deploy multiple 5MHz carriers at same cell site
  - Each 5 MHz shared by multiple subscribers using CDMA
  - Maximum chip rate = 3.84 Mchips/sec
- Standard advantages of CDMA
  - Soft handoff
  - Frequency reuse cluster size of 1,
  - Better quality in multipath environment
  - RAKE receiver
- QPSK modulation