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# **Evolution of the Cellular Mobile Telephone Service**

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# Introduction

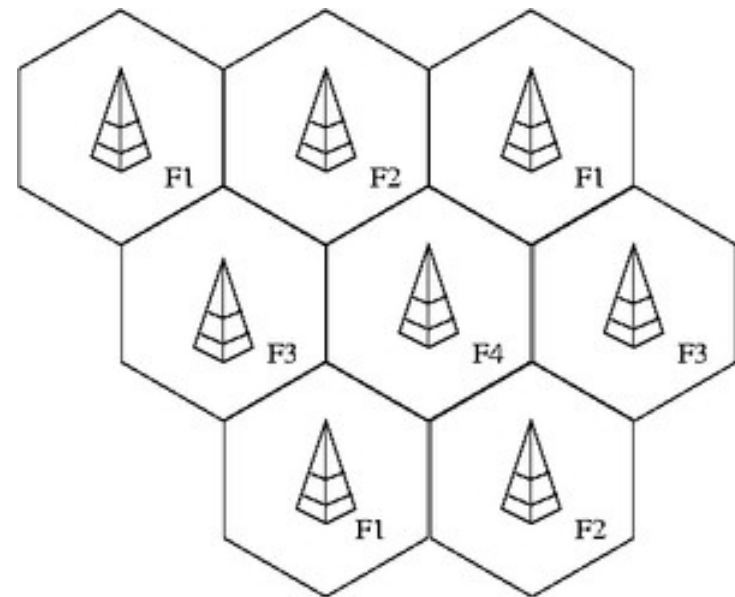
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- ◆ Surprising popularity of **mobile telecommu-  
nications** today
  - ◆ More mobile phone than landline subscribers
  - ◆ **3 Billion GSM subscribers** worldwide
  - ◆ Popularity of data services on mobiles
  - ◆ More value-added applications (SMS, WAP, RBT, MCommerce) available on mobile
- ◆ Need to **push the envelope** and develop new business models, tools and applications
- ◆ **Innovations and technologies** are emerging
  - ◆ We must learn more about it!



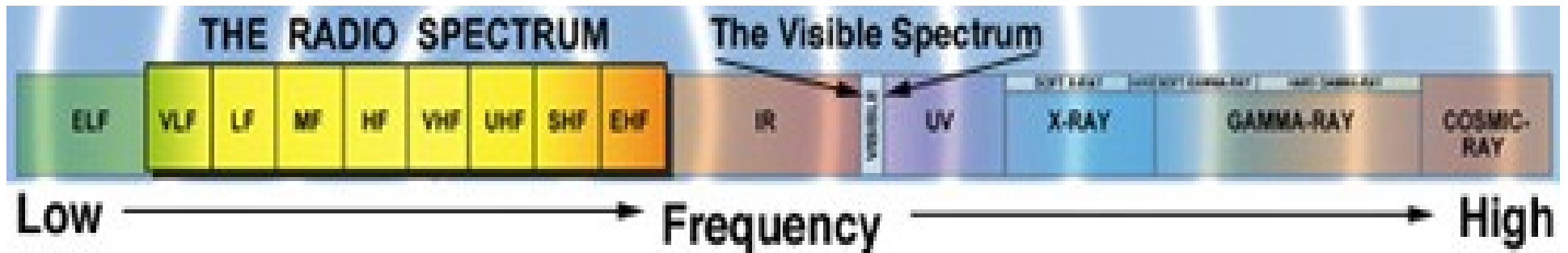
# CMTS

- ◆ **Cellular Mobile Telephone Service** is the legal term used to describe the mobile phone technology
- ◆ Use of cells to **divide coverage areas**
- ◆ Primarily **Wireless technology**
- ◆ Scarce Critical Resource = **Radio Spectrum**





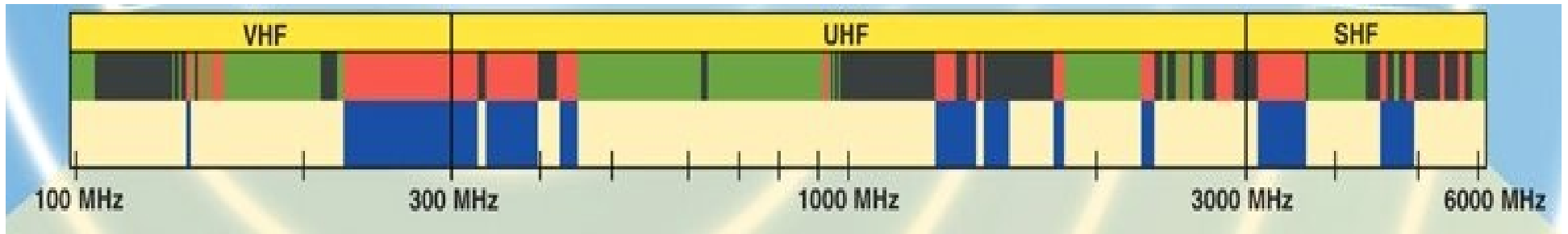
# EM Spectrum



- ◆ Why not use the **entire spectrum**?
  - ◆ Too low it can be heard – **audible range**
  - ◆ Too high it can be seen – **visible range**
  - ◆ Still higher it can cause cancer – **radioactive range**
- ◆ **Limited amount** of usable radio spectrum



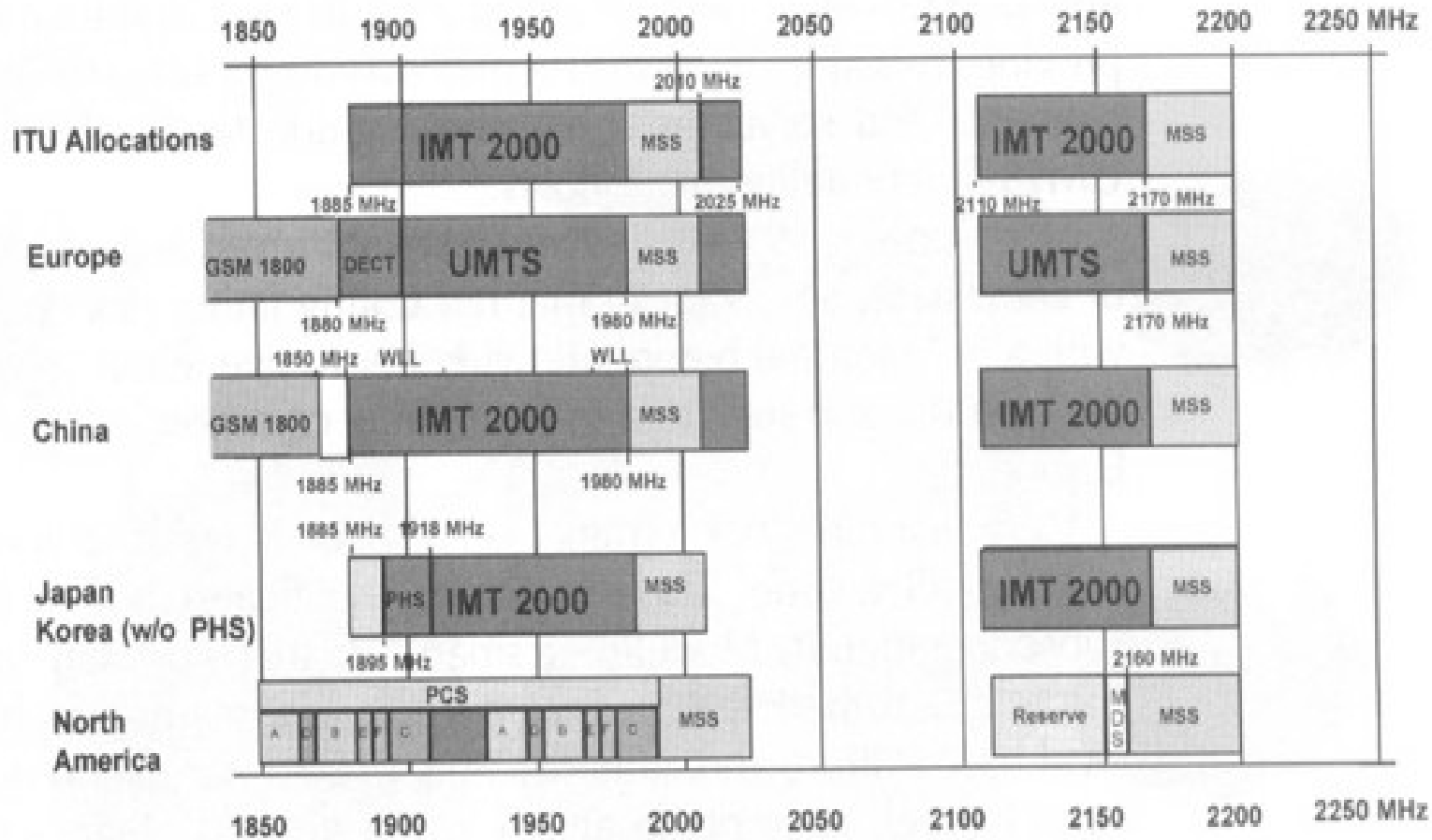
# Usable EM Spectrum



- ◆ **Human** (300 Hz to 3400 Hz)
- ◆ **AM Radio** (300 kHz – 3000 kHz, MF)
- ◆ **FM Radio and TV** (30 MHz – 300 MHz, VHF, UHF)
- ◆ **GSM** (400, 850, 900, 1800 Mhz)
- ◆ **UMTS** (1900MHz)
- ◆ **WiFi** (2.4 Ghz)
- ◆ **Satellite, Point-to-Point Microwave** (All around)



# 3G Spectrum





# Conserve Spectrum?

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- ◆ **Frequency Division Multiplexing (FDM)**
    - ◆ Give each call a particular frequency to use
  - ◆ **Time Division Multiplexing (TDM)**
    - ◆ Uses frequency ranges to divide groups of usage
    - ◆ Give each call time-slots to use
  - ◆ **Code Division Multiplexing (CDM)**
    - ◆ Give each call or transmission a code to use
  - ◆ **Orthogonal Frequency Division Multiplexing (OFDM)**
    - ◆ Give each transmission a frequency and code to use (used in WiMAX and WiFi MIMO)
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# Evolution

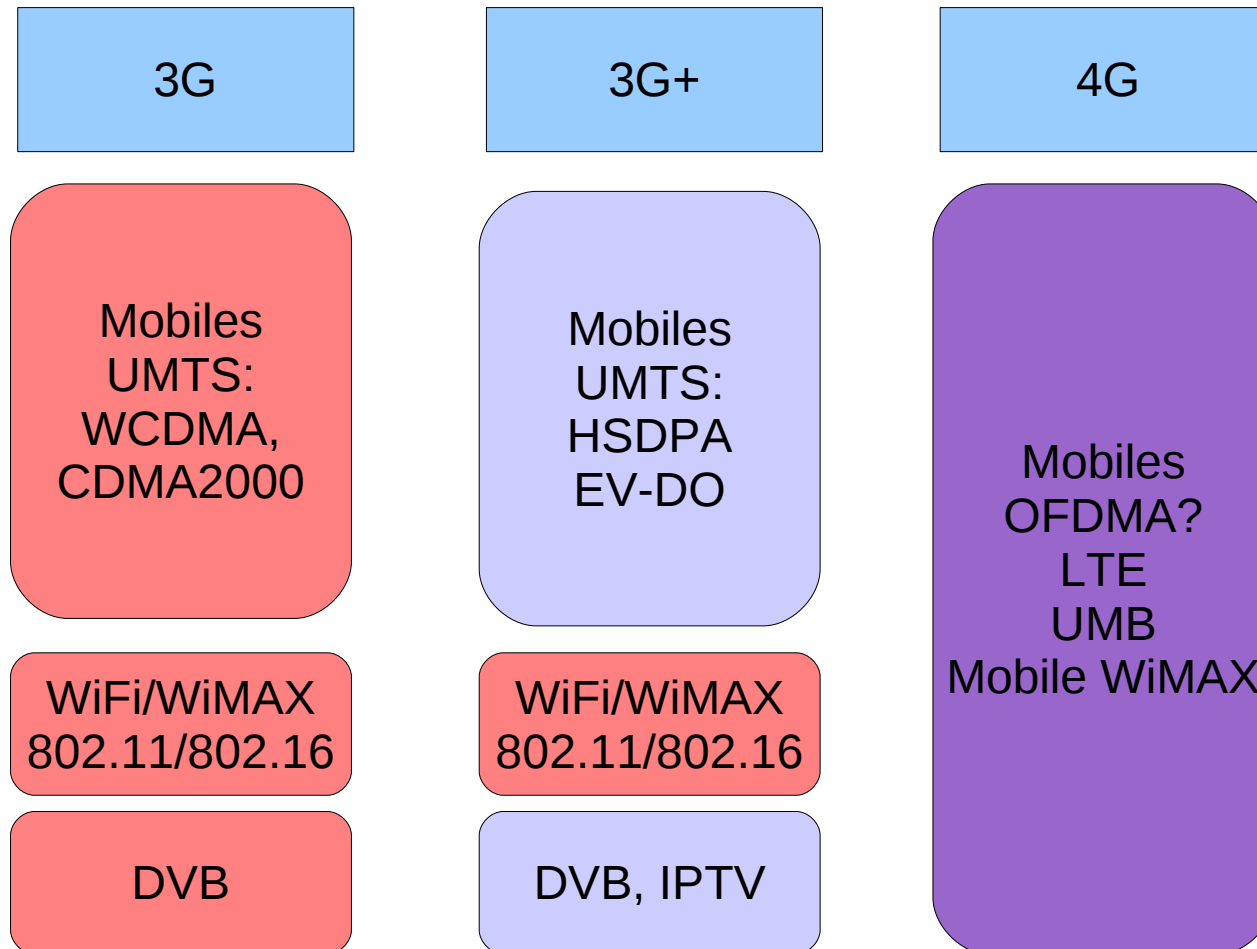
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1G	2G	2.5G
Mobiles TACS, AMPS	Mobiles GSM, IS95 CDMA, IS54 CDMA	Mobiles GRPS, EDGE
Pagers		
Satellite	Satellite	Satellite
	Wireless LAN 802.11a, b	Wireless LAN 802.11 g
Broadcast TV	Broadcast TV	Broadcast TV

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# Evolution





# First Generation

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- ◆ Primarily a **circuit-switched technology**
- ◆ Each service was provided in separate networks (no convergence)
- ◆ Improvement over **Mobile Radios**
  - ◆ Better portability and efficient frequency use
- ◆ Typically, **analog services** and is clone-able
  
- ◆ **1G Systems**
  - ◆ Total Access Communications System (TACS)
  - ◆ Nordic Mobile Telephone (NMT)
  - ◆ Advanced Mobile Phone System (AMPS)



# Second Generation

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- ◆ Still primarily **circuit-switched**, but calls and data are now digital
- ◆ **Integration** of data services into analog system (such as SMS, CSD)
- ◆ First signs of **consolidation**
  
- ◆ **2G Systems**
  - ◆ Global System for Mobile Communications (GSM)
  - ◆ iDEN (trunk radio technology used by Nextel)
  - ◆ IS-136 Digital AMPS (D-AMPS)
  - ◆ IS-95 Code Division Multiple Access (CDMAone)



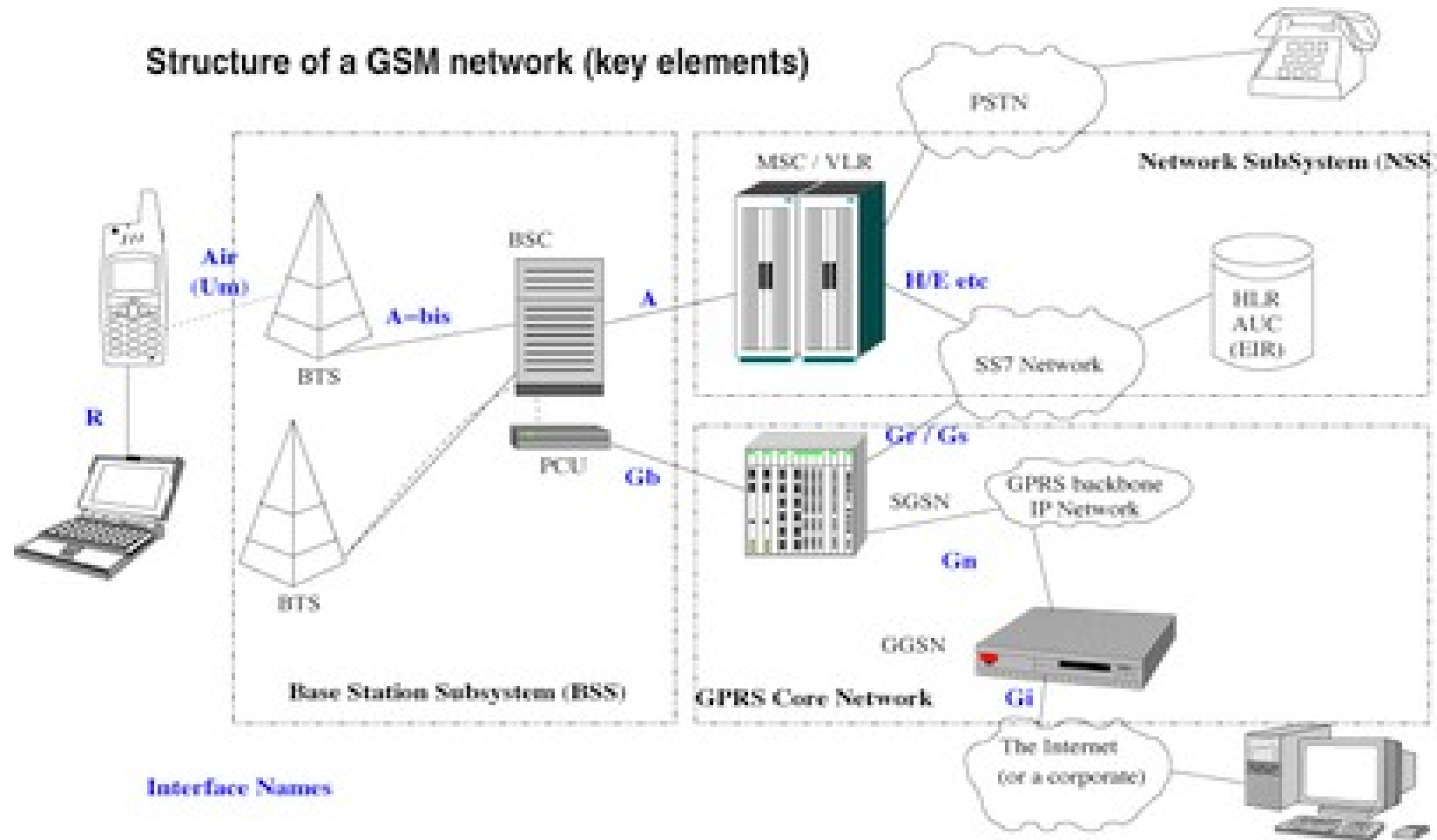
# Second Generation

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- ◆ Emergence of **transitional technologies** to 3G (enable operators to prepare their networks)
- ◆ Created to address need for **greater data rates** and **better latency**
- ◆ Done by **bundling time slots** or codes
  
- ◆ **2.5G Systems**
  - ◆ High-Speed Circuit-Switched Data (HSCSD)
  - ◆ General Radio Packet Service (GPRS)
  - ◆ Enhanced Data Rates for GSM Evolution (EDGE)
  - ◆ CDMA 1x-RTT



# Evolved GSM Architecture





# Third Generation

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- ◆ Universal Mobile Telephone System (**UMTS**)
  - ◆ Provides both **circuit-switch** and **packet-switch** networks like 2G
  - ◆ Greater emphasis on the **packet-switched network**
  
  - ◆ **3G Systems**
    - ◆ Wideband CDMA (**WCDMA**) FDD and TDD mode
      - ◆ GSM evolution uses the standard 1900 Mhz range
    - ◆ **CDMA2000**
      - ◆ CDMA evolution uses PCS frequencies
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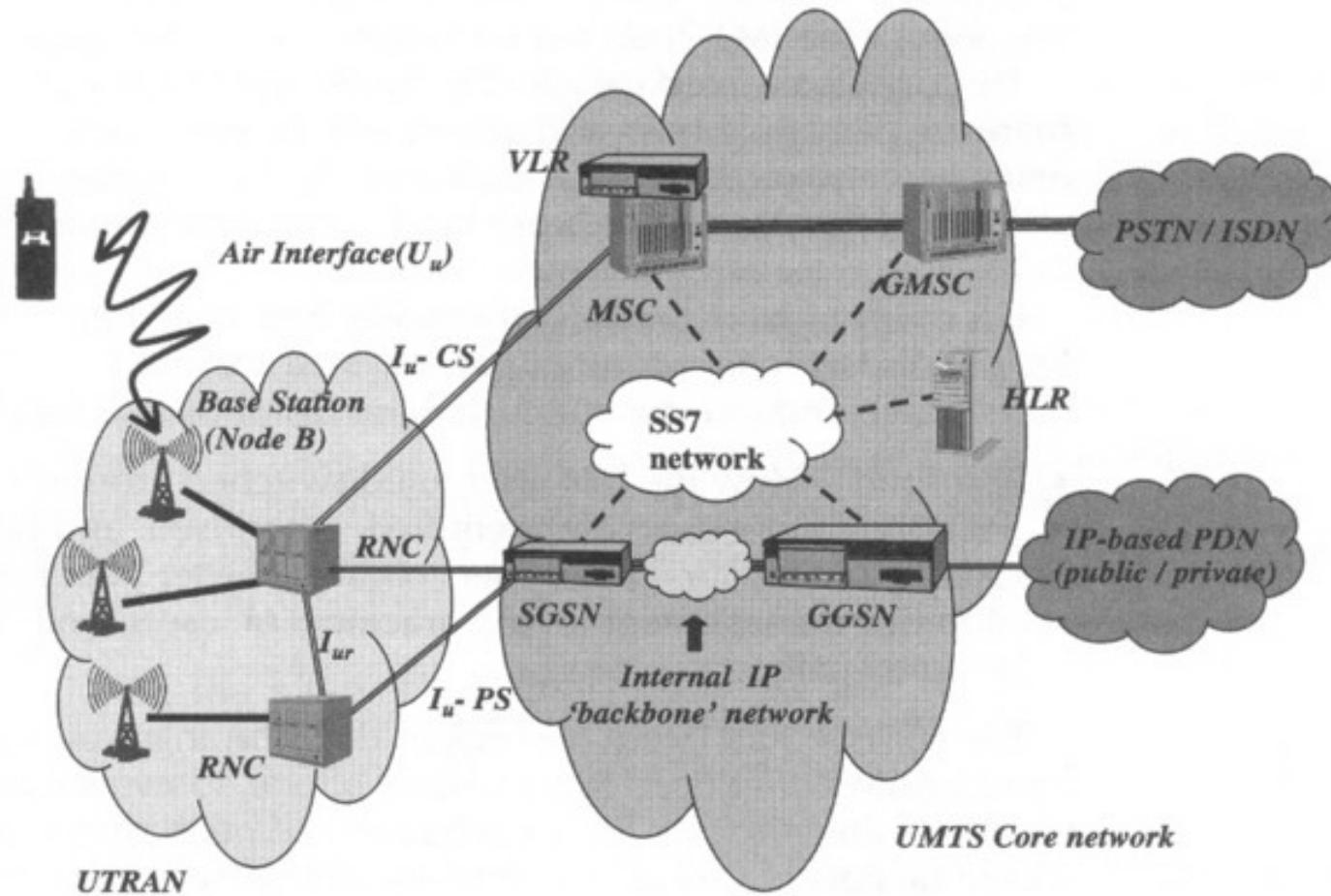
# Third Generation

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- ◆ **Transitional technologies to 3G**
- ◆ Improvement of data rates
- ◆ Greater emphasis on packet-switched network components
- ◆ IP Multimedia Systems (IMS)
  
- ◆ **3.5G Systems**
  - ◆ High-Speed Downlink Packet Access (HSDPA)
  - ◆ High-Speed Uplink Packet Access (HSUPA)
  - ◆ EV-DO Rev A, B, G

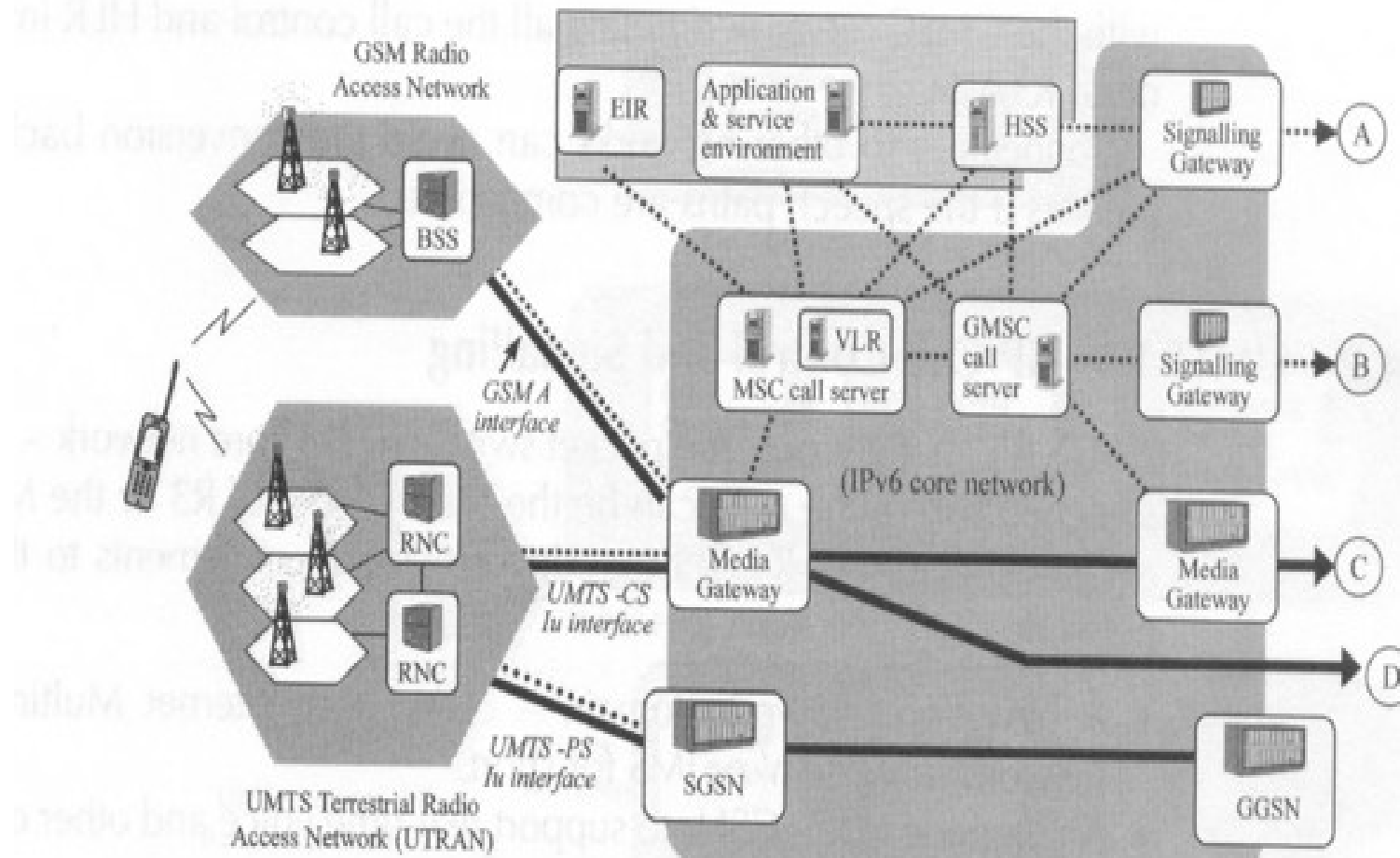


# UMTS R3



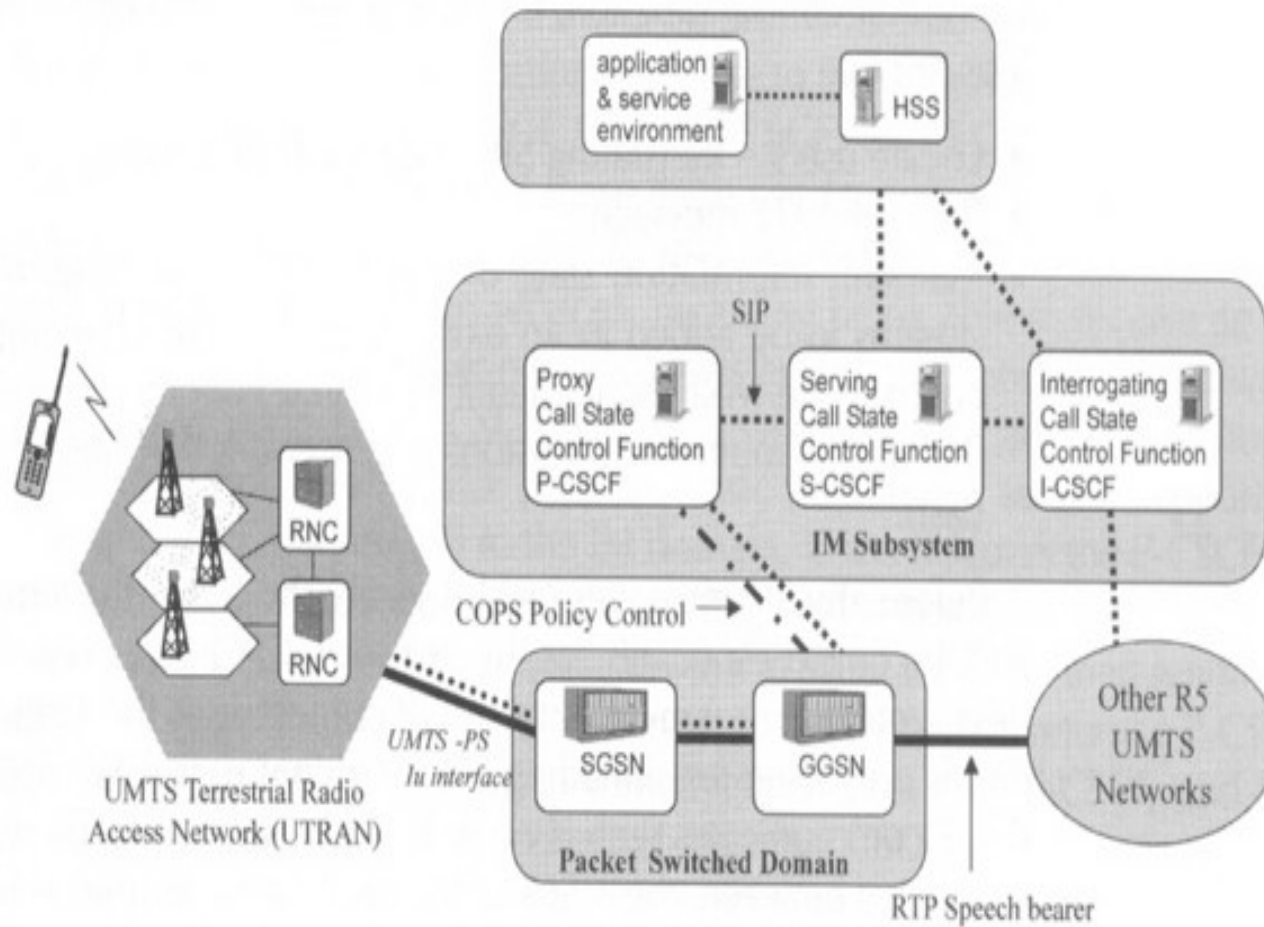


# UMTS R4



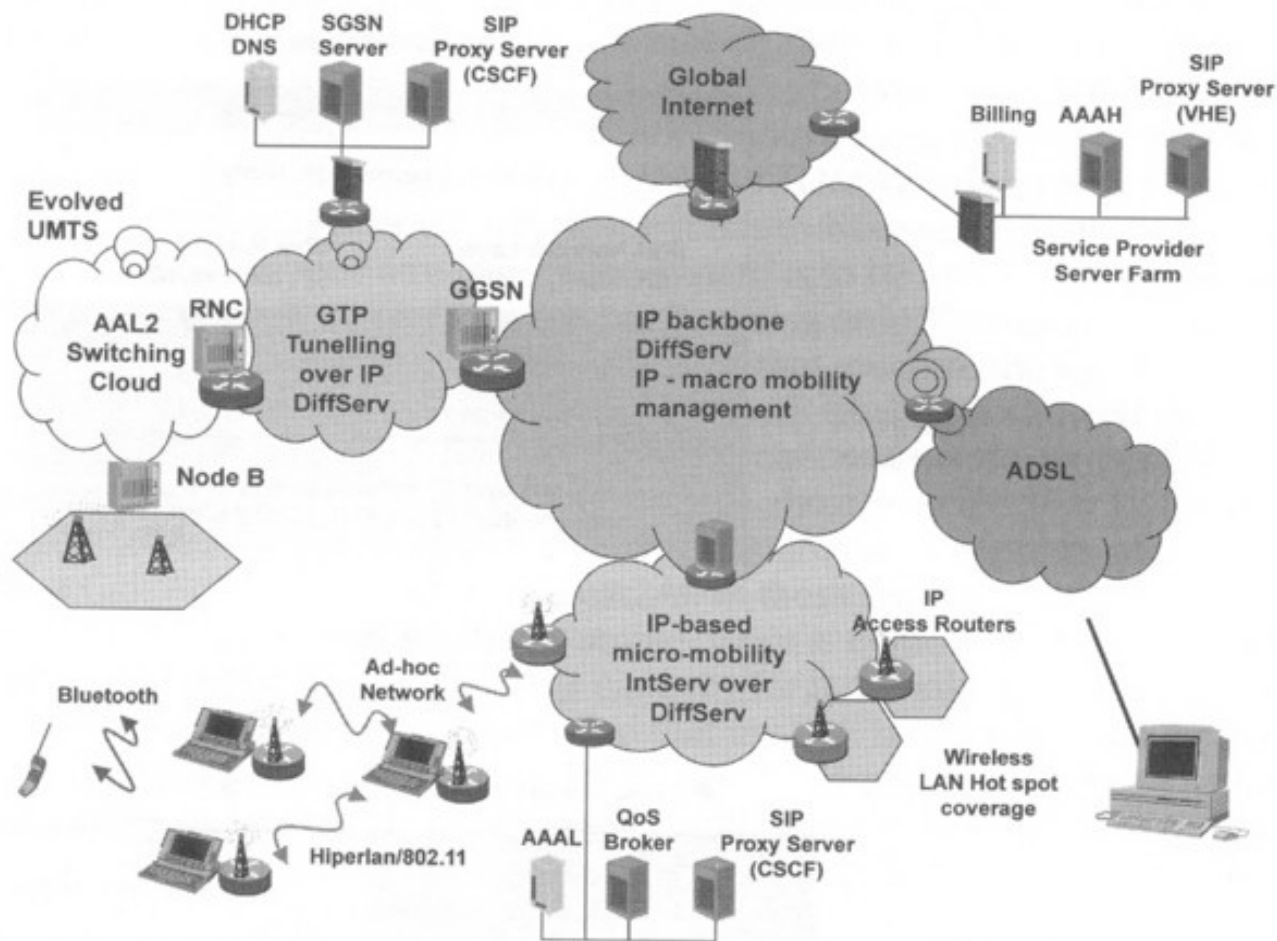


# UMTS R5





# All IP UMTS?





# Fourth Generation

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- ◆ Fully integrated CMTS on a **full packet-switched** core network
  - ◆ Better Integration with IP technology
  - ◆ Remove old vestiges of circuit switch technology
- ◆ **One technology** for the entire world!
  - ◆ Mobile, Satellite, Fixed, Point-to-Point
- ◆ Probably based on **Orthogonal Frequency Division Multiple Access (OFDMA)**
  - ◆ Related Technology used by **LTE, WiMAX, WiFi MIMO** (802.11n), High Speed OFDM Packet Access (**HSOPA**)



# Conclusion

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- ◆ Need to make **better use of spectrum**
  - ◆ FDM -> TDM -> CDM -> OFDM
- ◆ CMTS technology moving towards **packetization** and better IP integration
  - ◆ Easier integration into existing IP systems
  - ◆ Add more services and applications to mobile technology
  - ◆ Integrate better with other communication plays (landline voice, cable and TV)
- ◆ Reduction of the number of **incompatible systems** - A truly global network!



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# Additional Slides



# Patents and IP

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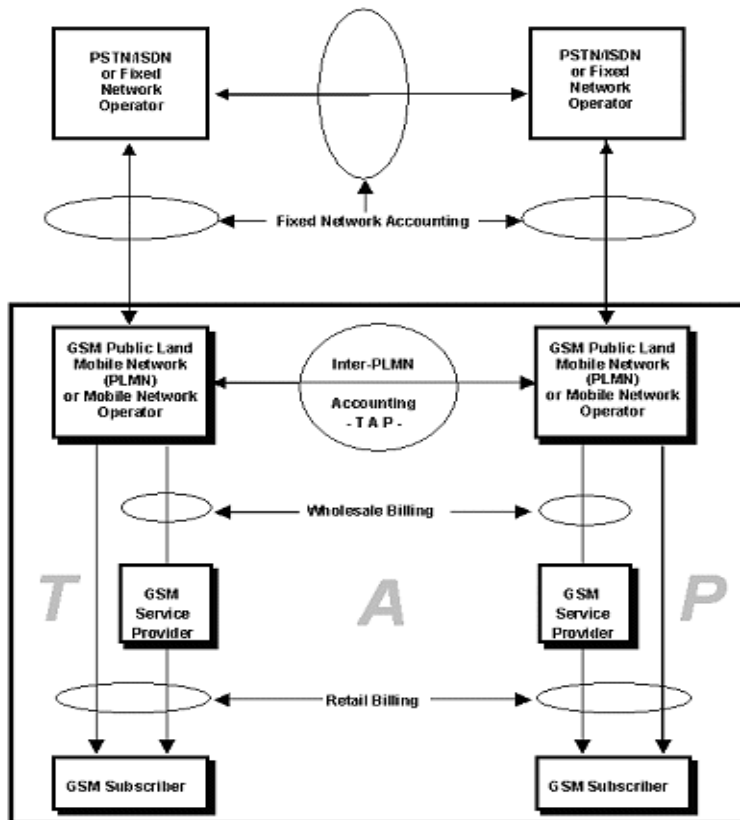
- ◆ **Qualcomm** owns key IP for OFDMA and CDMA
  - ◆ Key technology for CDMAone, WCDMA, CDMA200 and WiMAX physical radio interfaces
  - ◆ Therefore, direction for future mobile technology will take this in mind
- ◆ **GSM** codec belong to a consortium with Philips
  - ◆ Royalty Free for Mobile Phone use
- ◆ **ACELP** coding algorithm is owned by **VoiceAge**
  - ◆ Key codec for the AMR encoding in 3G
- ◆ MPEG 2 Layer 3 is owned by **Fraunhofer Gesellschaft**



# Voice Roaming

**Figure 1.** An Introduction to the Transferred Account Procedure – GSM Billing and Accounting

The figure below illustrates the role of the TAP in the overall GSM billing and accounting system



- ◆ Allow subscriber to continue having **GSM services** in other countries
- ◆ Solved using a **standardize billing exchange** process
- ◆ A similar strategy is used for 3G



# Data Roaming

Roaming with user in Foreign Network connecting back to Home Network

