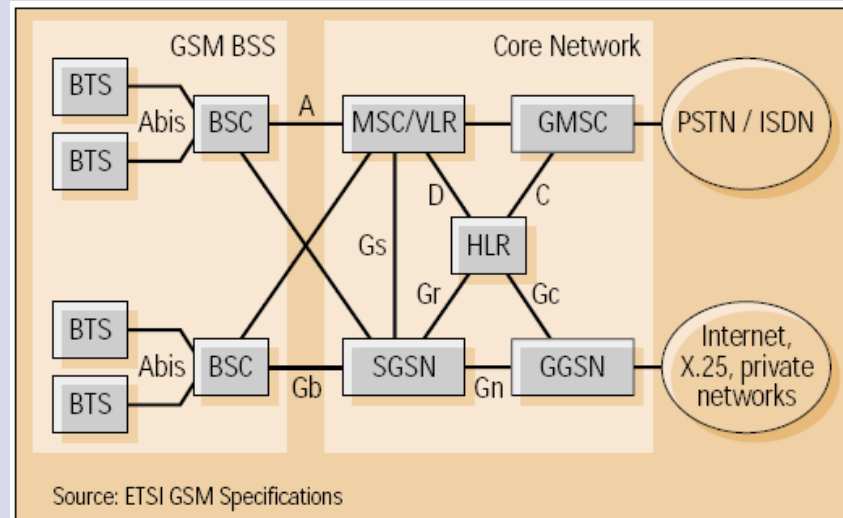


Introduction of GSM, UMTS & WiMax Technology

Network Architecture Comparison

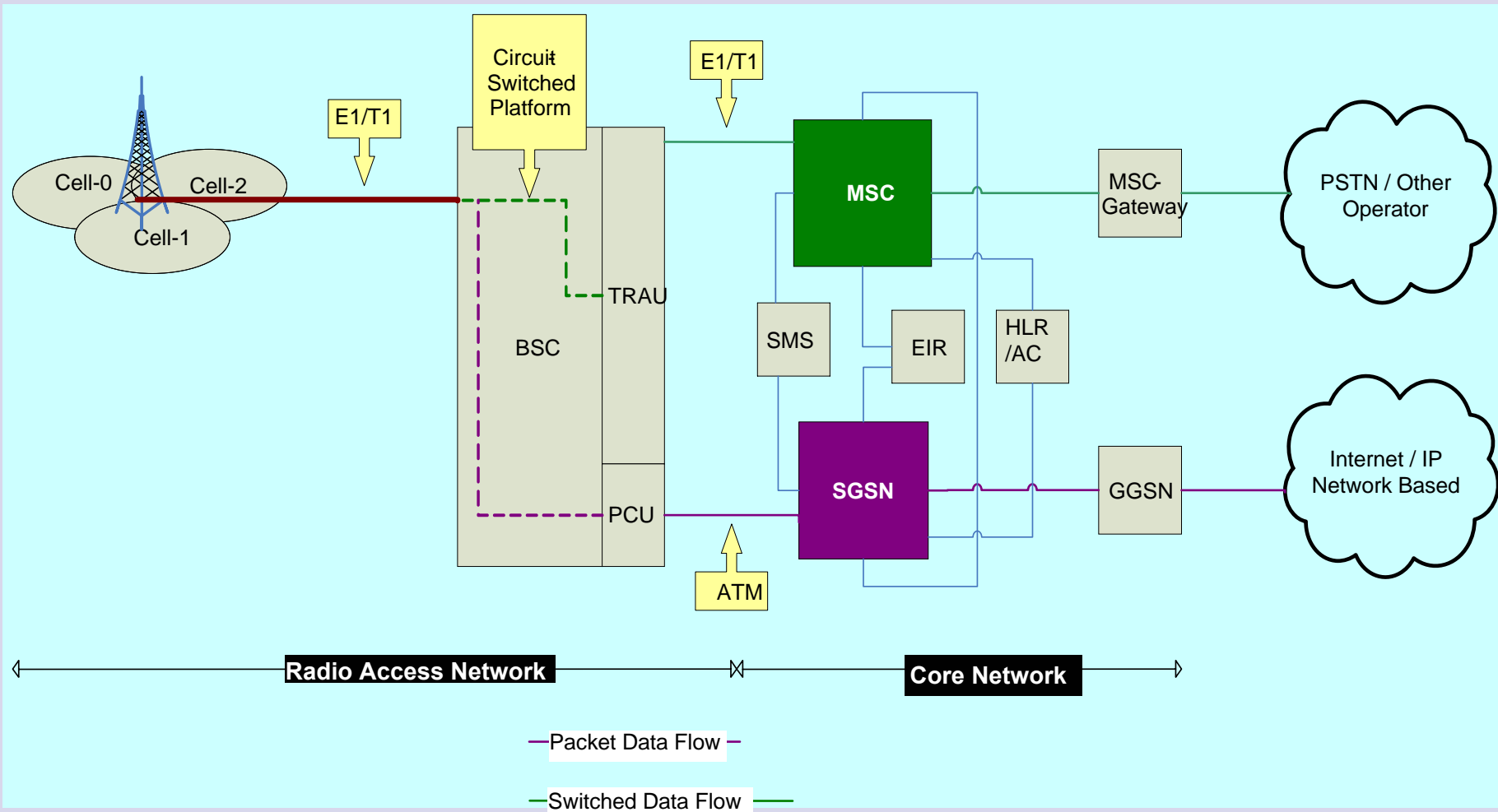
GSM Architecture (1)

- Radio: TDMA Access
- Core: Circuit-Switched Domain (PCM) and Packet-Switched Domain (ATM)
- Services: Voice & Data call
- Limited Bandwidth Data Access (2.5G)



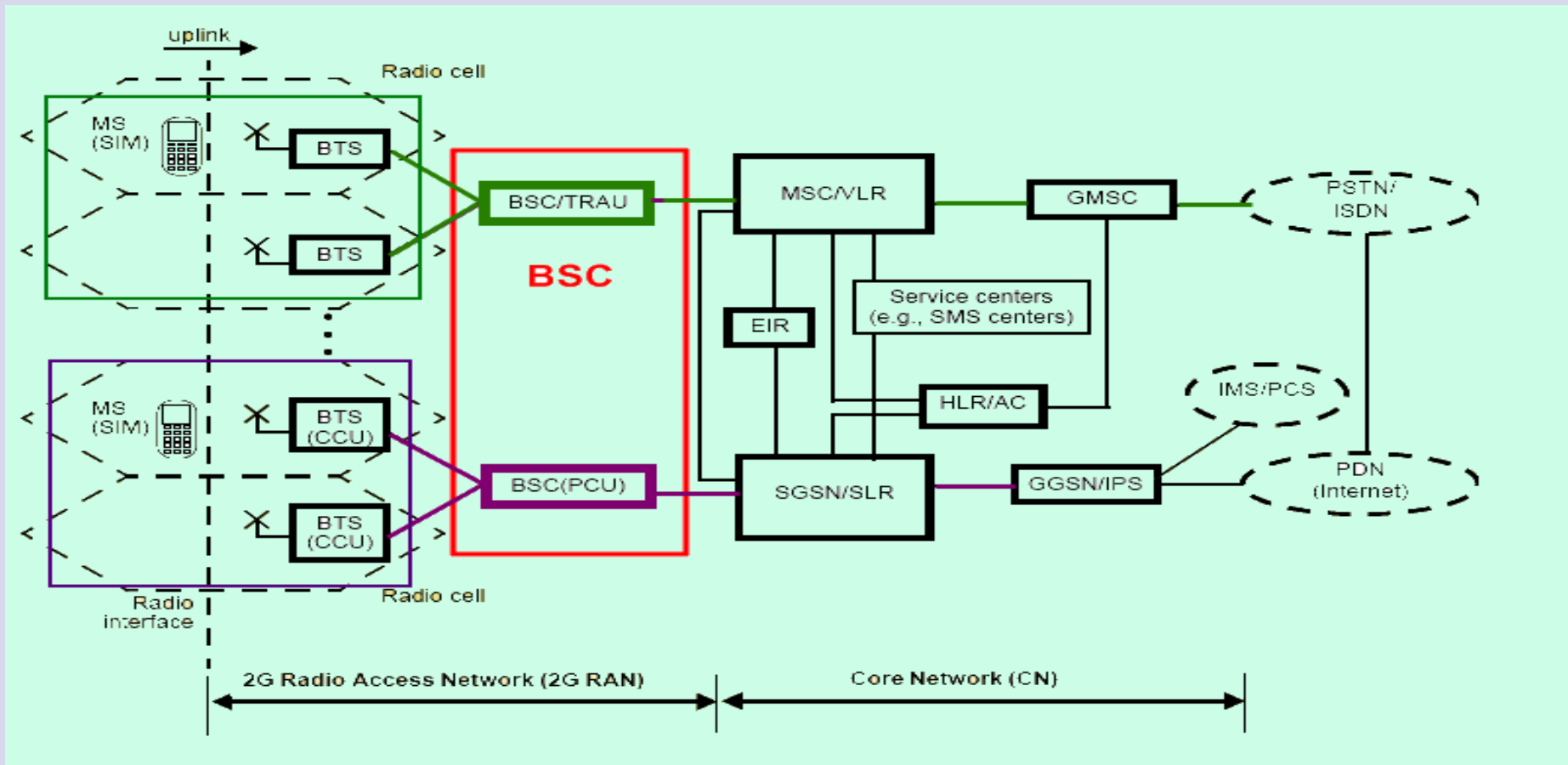
Network Architecture Comparison

GSM Architecture (2)



Network Architecture Comparison

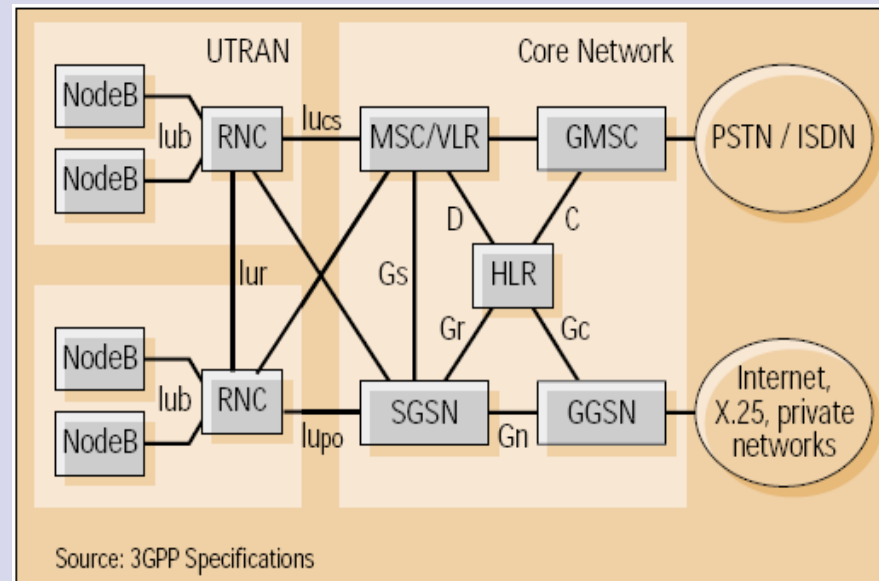
GSM Architecture (3)



Network Architecture Comparison

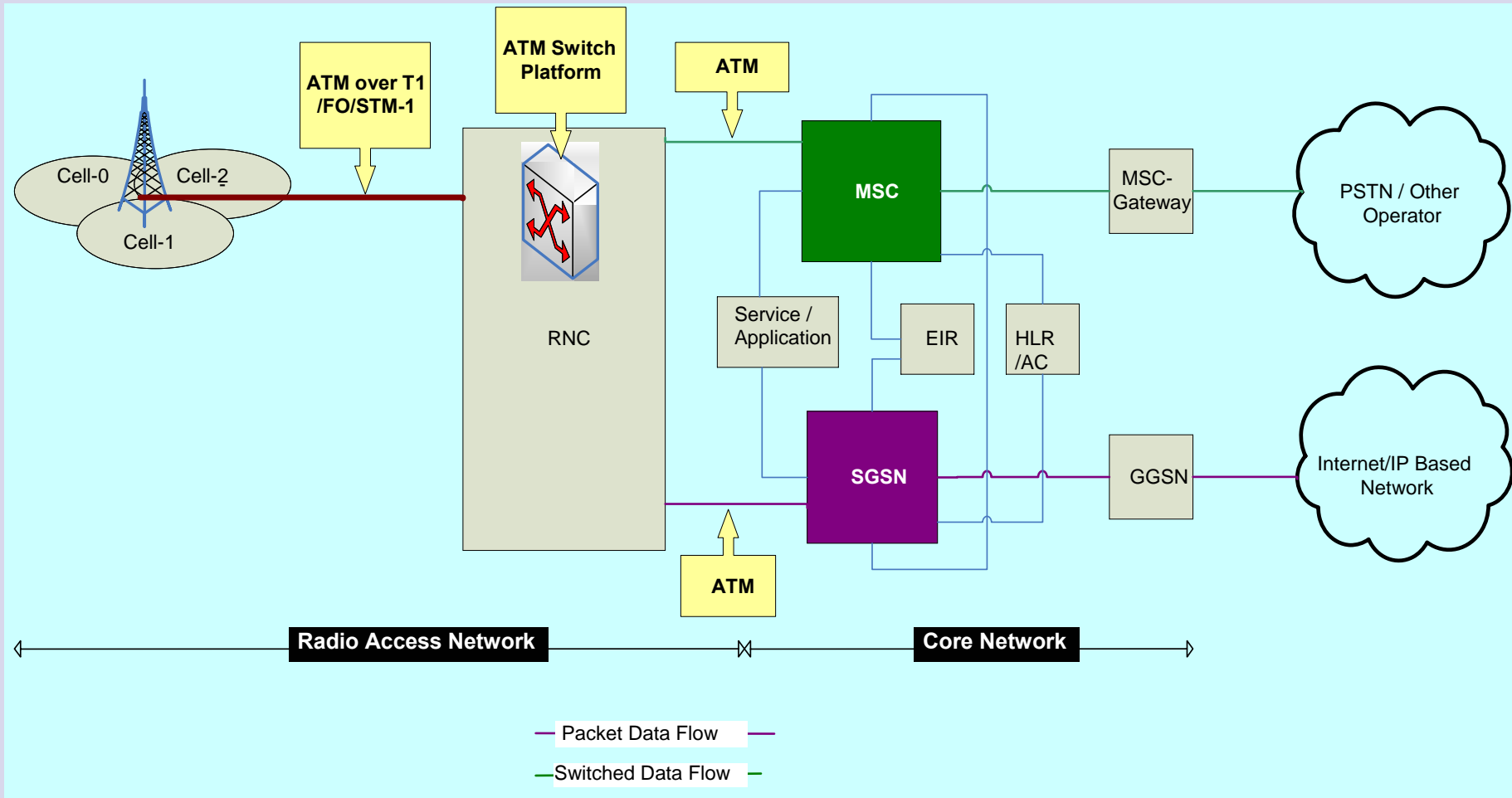
UMTS Architecture (1)

- Radio: WCDMA
- Core: ATM Platform in both Circuit-Switched Domain and Packet-Switched Domain
- Services: Voice Call, Video Call and Data Call
- Broadband Data Access (3.5G)



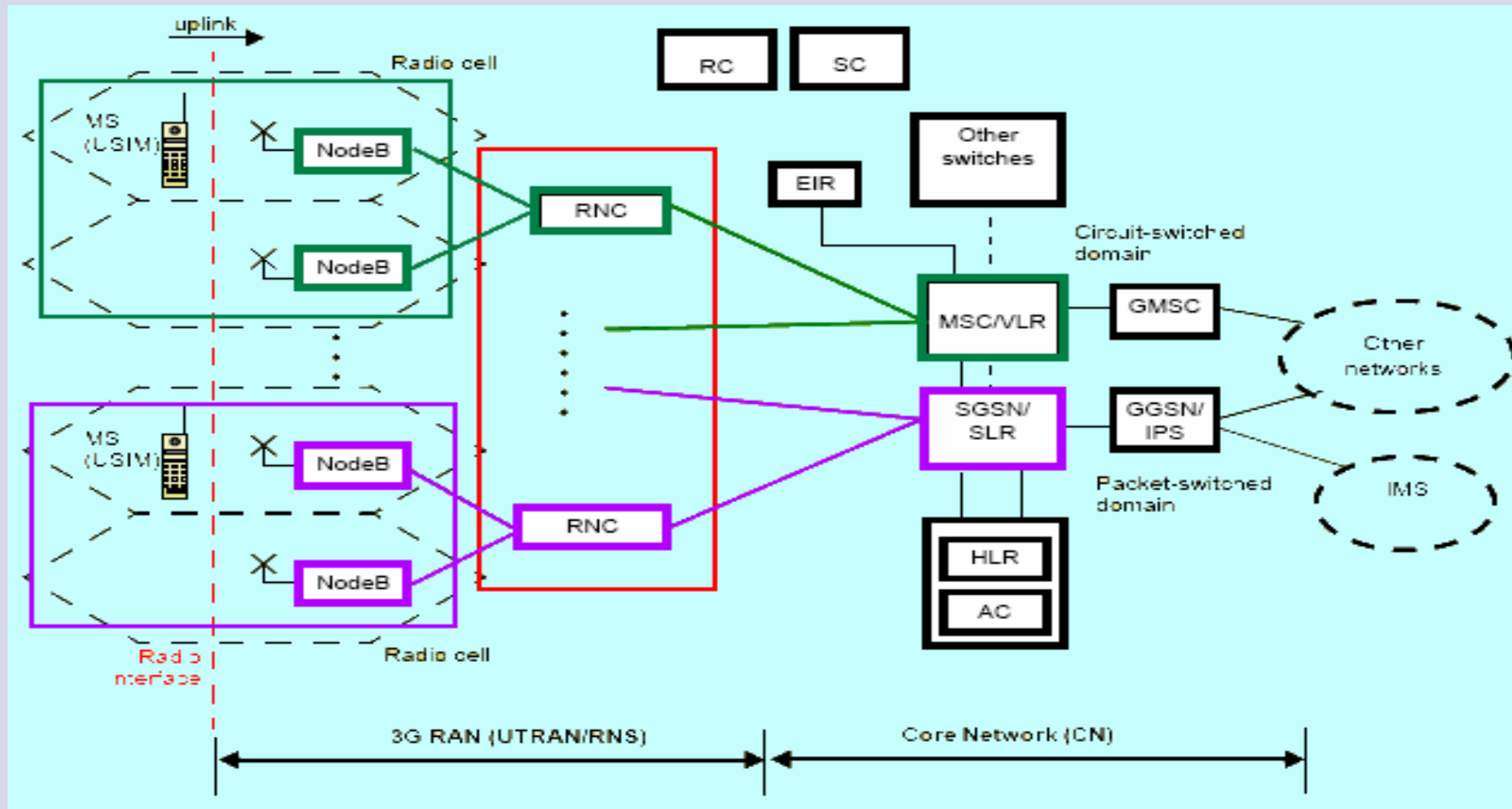
Network Architecture Comparison

UMTS Architecture (2)



Network Architecture Comparison

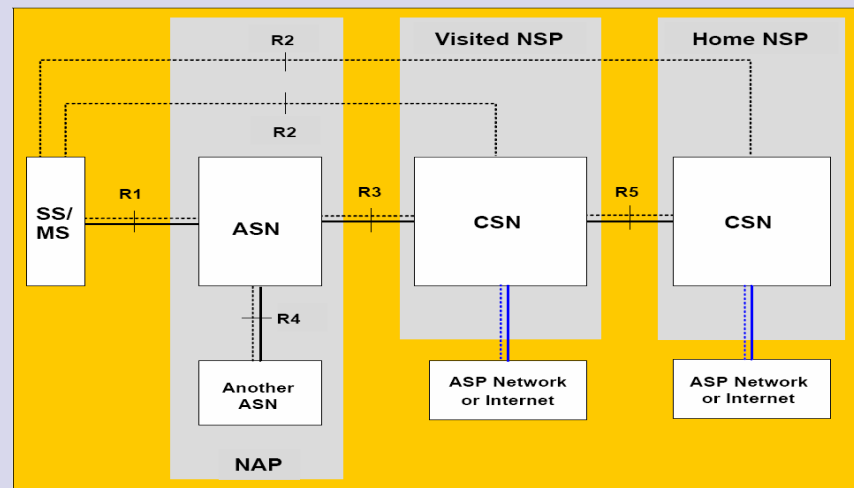
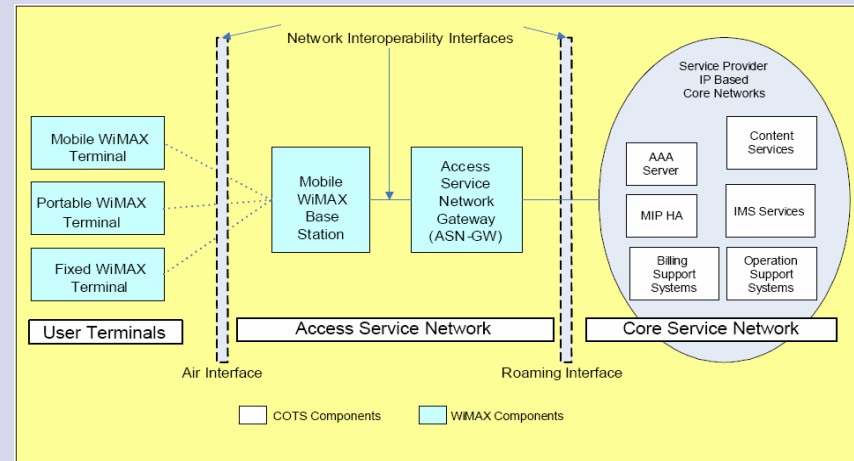
UMTS Architecture (3)



Network Architecture Comparison

WiMAX Architecture (1)

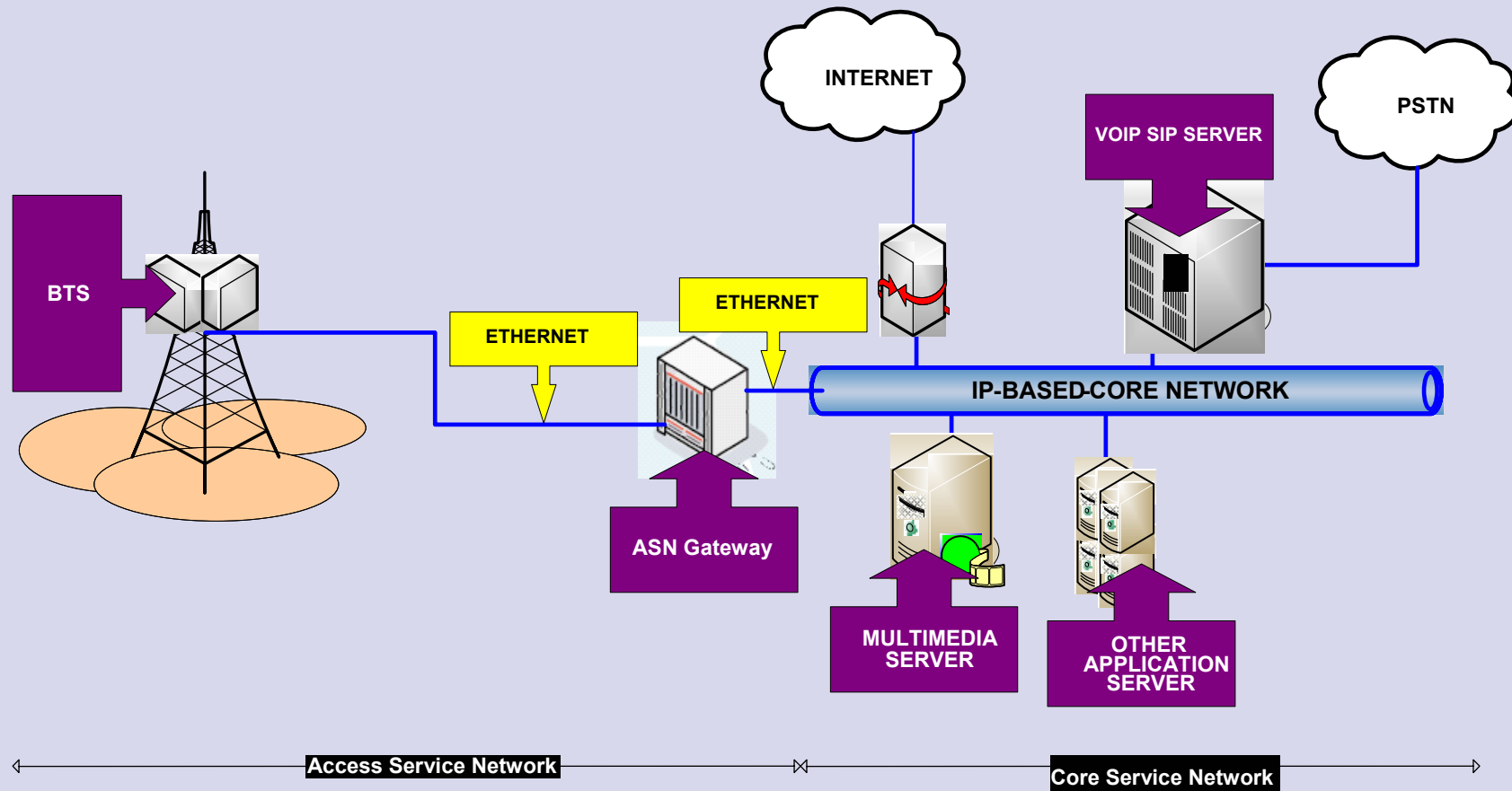
- Radio: OFDM/OFDMA
- Core: All IP Platform with Packet-Switched Domain
- Services: Voice Call, Video Call, Multimedia Streaming & Data Call
- Broadband Data Access



WiMAX Network Reference Model

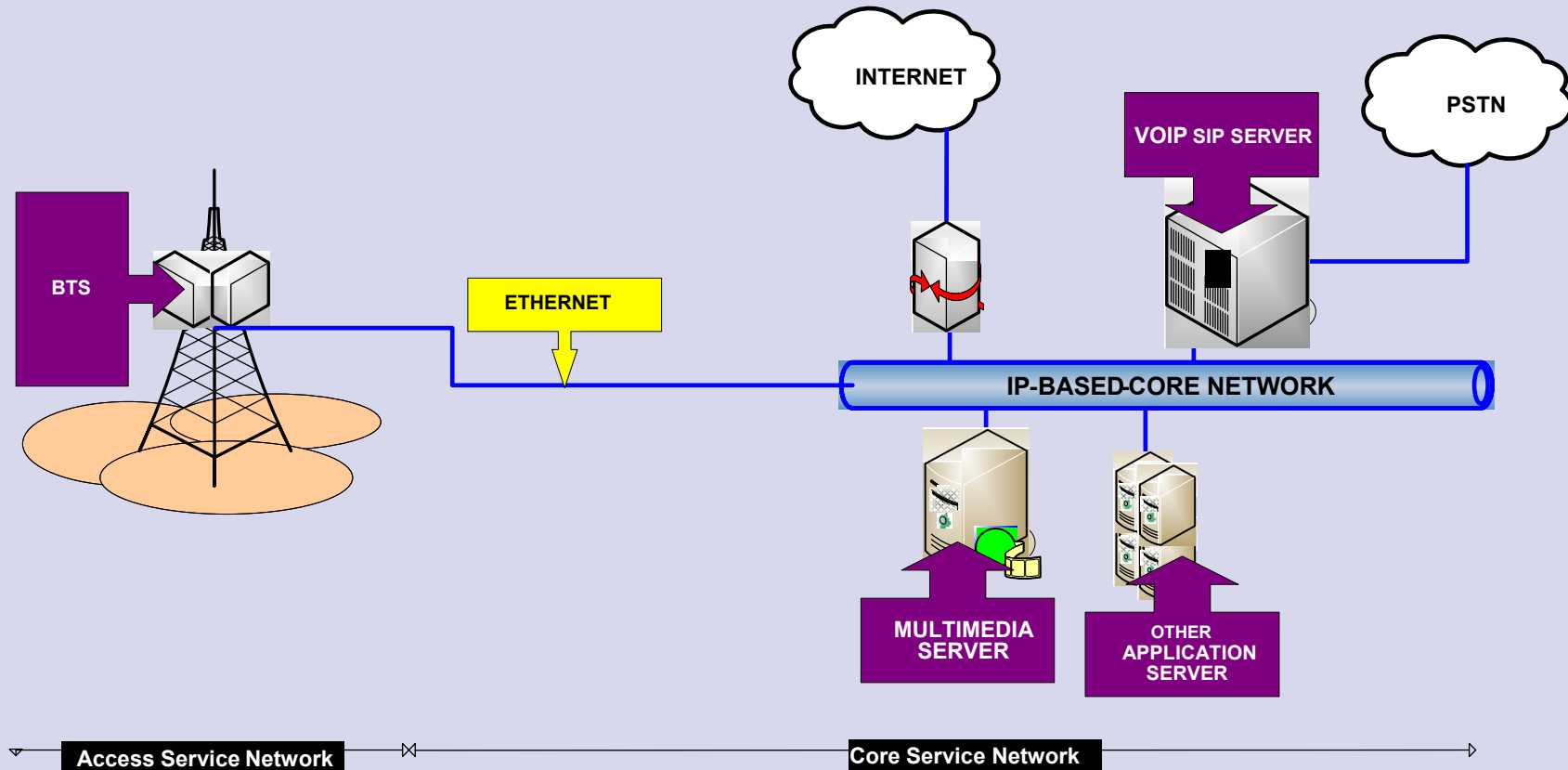
Network Architecture Comparison

WiMAX 16e Architecture



Network Architecture Comparison

WiMAX 16d Architecture

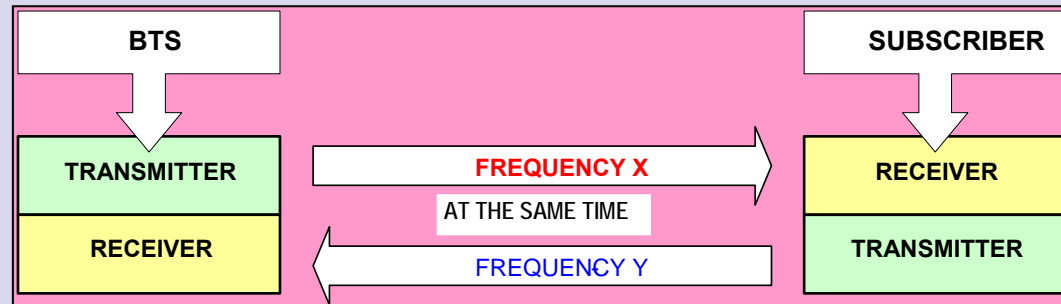


Radio Access Comparison

Duplex Technology

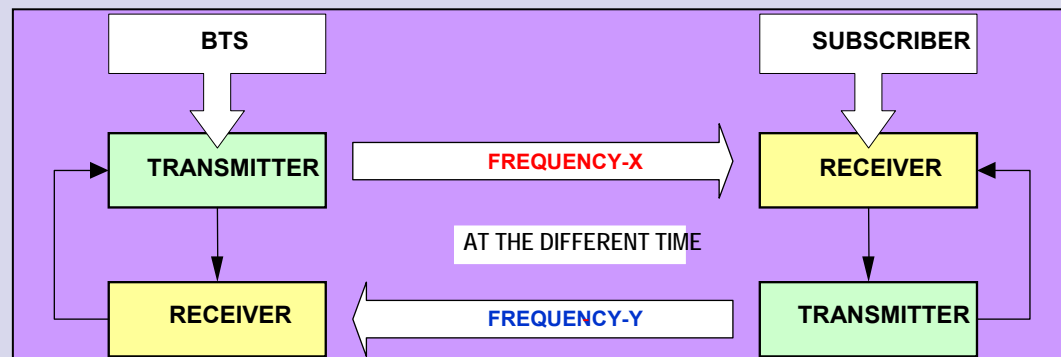
- **FDD**

- Dual Polarization Antenna
(Different UL/DL Freq)
- Better Noise Floor
- Inefficient Spectrum



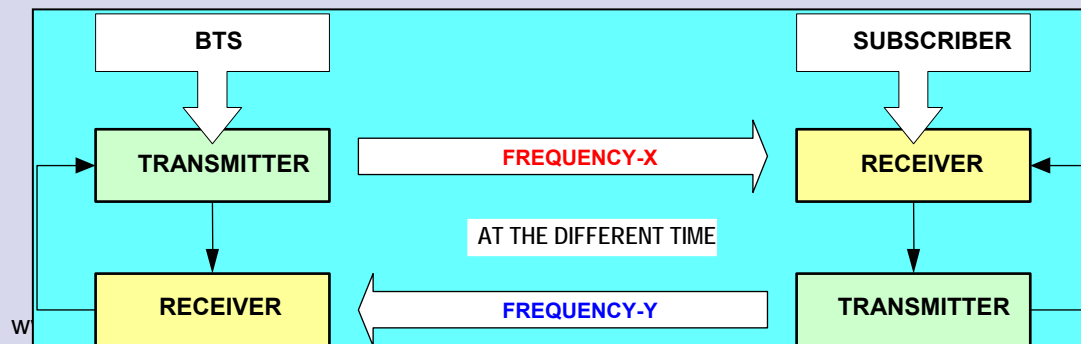
- **TDD**

- Single Polarization Antenna
(The same UL/DL Freq)
- 3dB worse Noise Floor
- efficient Spectrum



- **Half-FDD**

- Single Polarization Antenna.
(Different UL/DL Freq at Different Time)
- 3dB worse Noise Floor
- efficient Spectrum



Radio Access Comparison

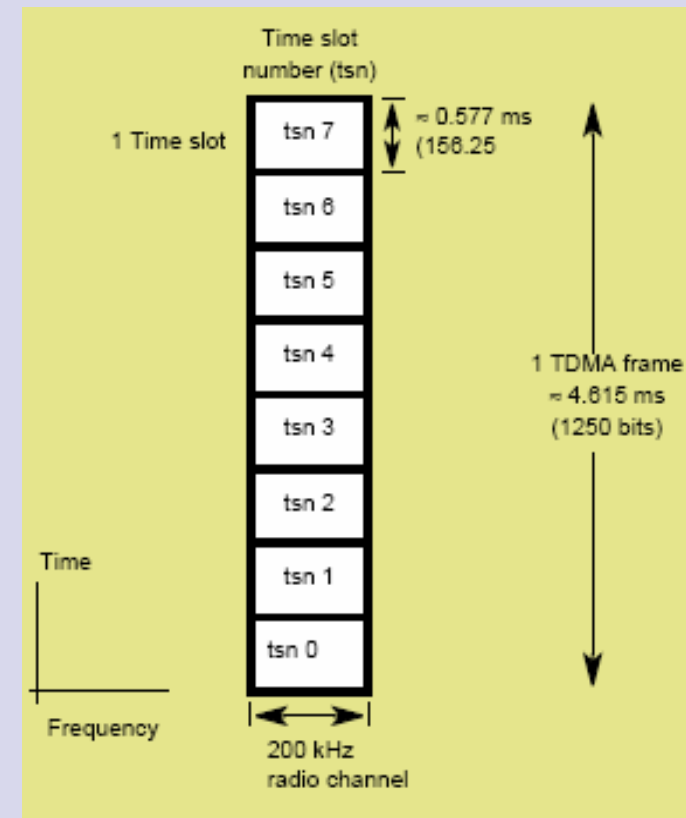
Physical Layer

- TDMA (GSM)
- CDMA (CDMA)
- WCDMA(3G)
- OFDM (WIFI,Pre-WiMAX,WiMAX)

Radio Access Comparison

TDMA (GSM)

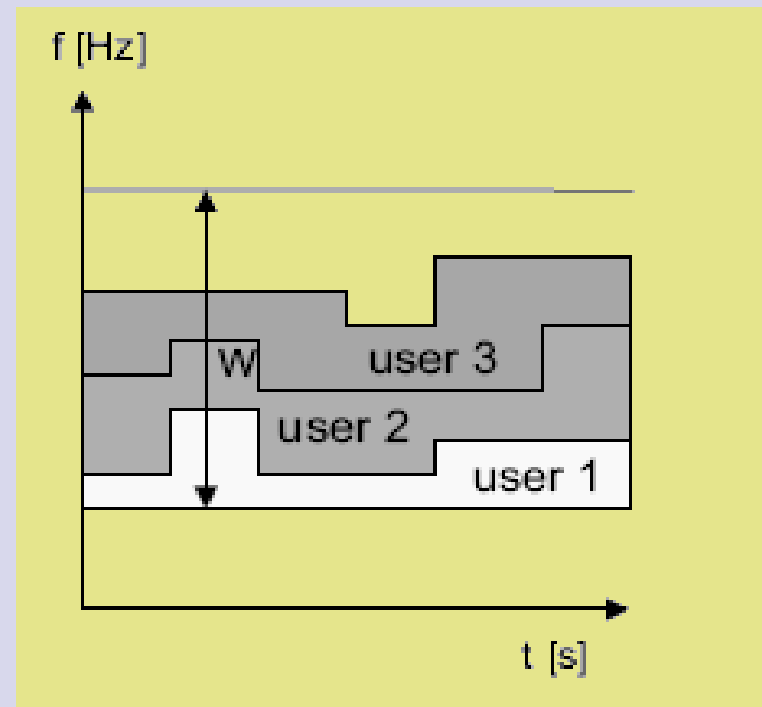
- 200 KHz Radio Channel
- Combine up to 24 Radio Channels per cell
- Modulation: GMSK (Voice & GPRS) and 8-PSK (EDGE)



Radio Access Comparison

WCDMA(3G)

- 5 MHz Radio Channel for W-CDMA
- Single Radio Channel per cell
- Modulation: QPSK(3G) and 16-QAM(3.5G)



Radio Access Comparison

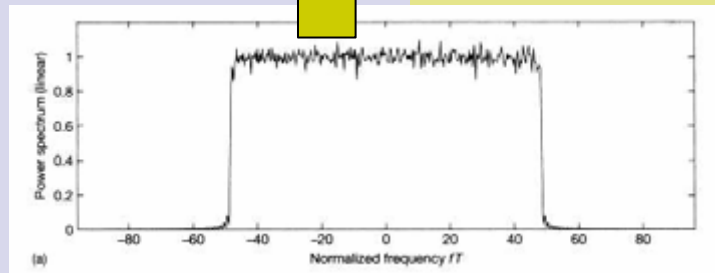
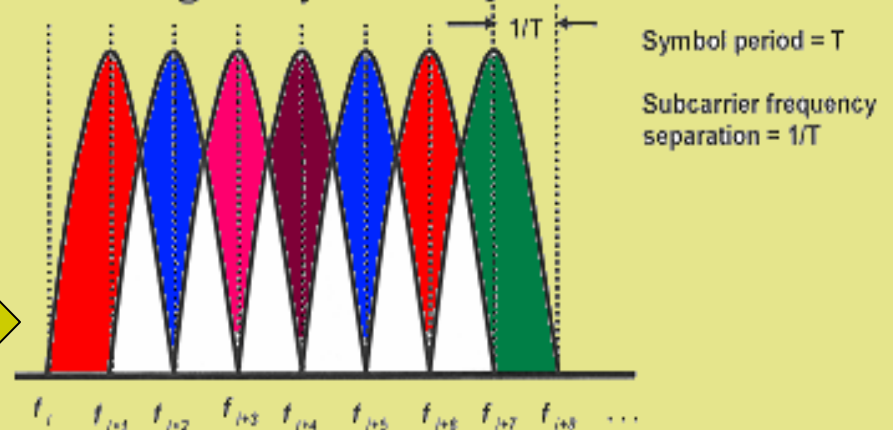
OFDM/OFDMA (WiMAX)

- 1.25, 3.5, 5, 7, 8.75, 10, 14, 20, 25, and 28 MHz Radio Channel
- Single Radio Channel or Combined Radio Channels per cell
- Modulation: BPSK, QPSK, 16QAM, and 64QAM

So, what is OFDM?

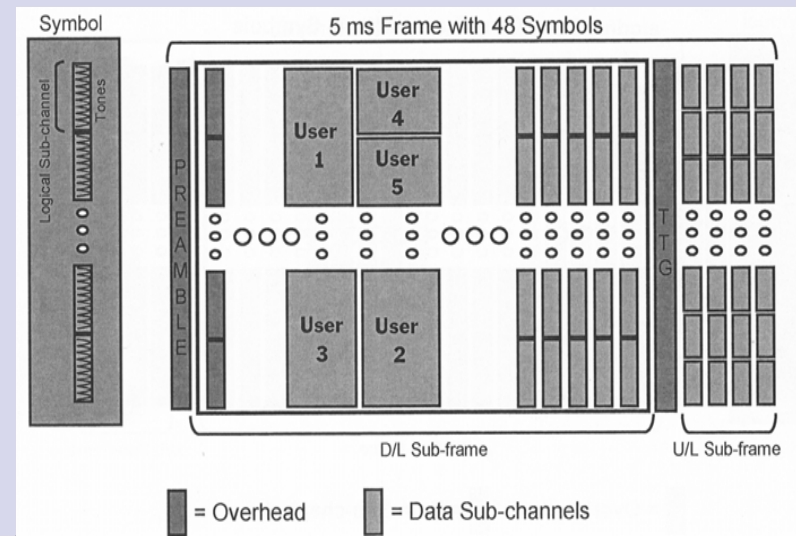
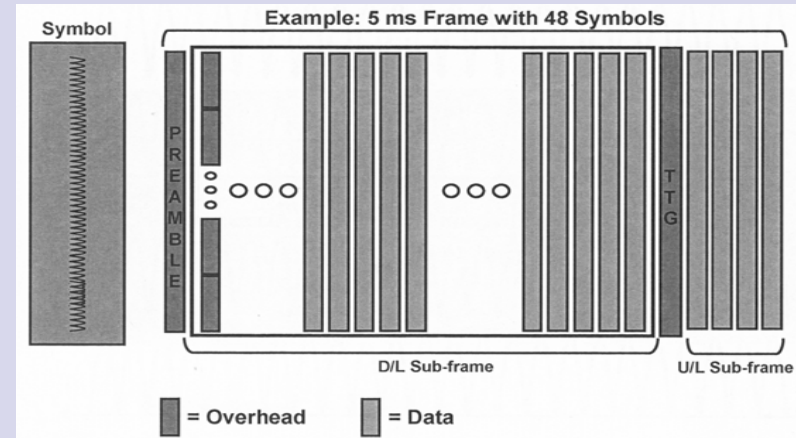
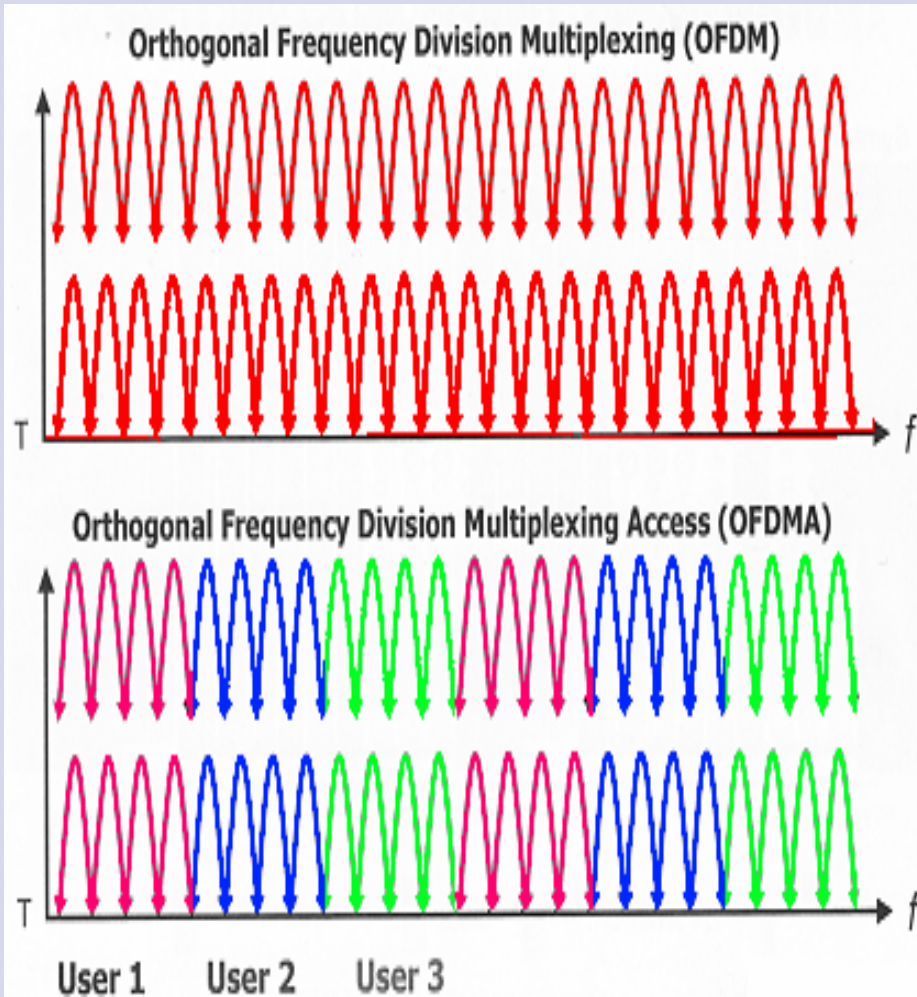
- Orthogonal Frequency Division Multiplexing
- Multiple carriers! A spectrally efficient FDM technique
- Data is distributed across narrow-band tones

Orthogonality is the Key!



Radio Access Comparison

OFDM (16d) vs. OFDMA (16e)



Radio Access Comparison

Bandwidth Per Tone

- Fixed WiMAX

$$BTone = (BW * SampliFreq) / (Tot.of Tones)$$

- Mobile WiMAX

$$BTone = \text{fixed value as } 10.94 \text{ Khz}$$

Parameters	Values			
System Channel Bandwidth (MHz)	1.25	5	10	20
Sampling Frequency (F_p in MHz)	1.4	5.6	11.2	22.4
FFT Size (N_{FFT})	128	512	1024	2048
Number of Sub-Channels	2	8	16	32
Sub-Carrier Frequency Spacing	10.94 kHz			
Useful Symbol Time ($T_b = 1/f$)	91.4 microseconds			
Guard Time ($T_g = T_b/8$)	11.4 microseconds			
OFDMA Symbol Duration ($T_s = T_b + T_g$)	102.9 microseconds			
Number of OFDMA Symbols (5 ms Frame)	48			