

# Multiuser in multicarrier systems for wireless and wireline.

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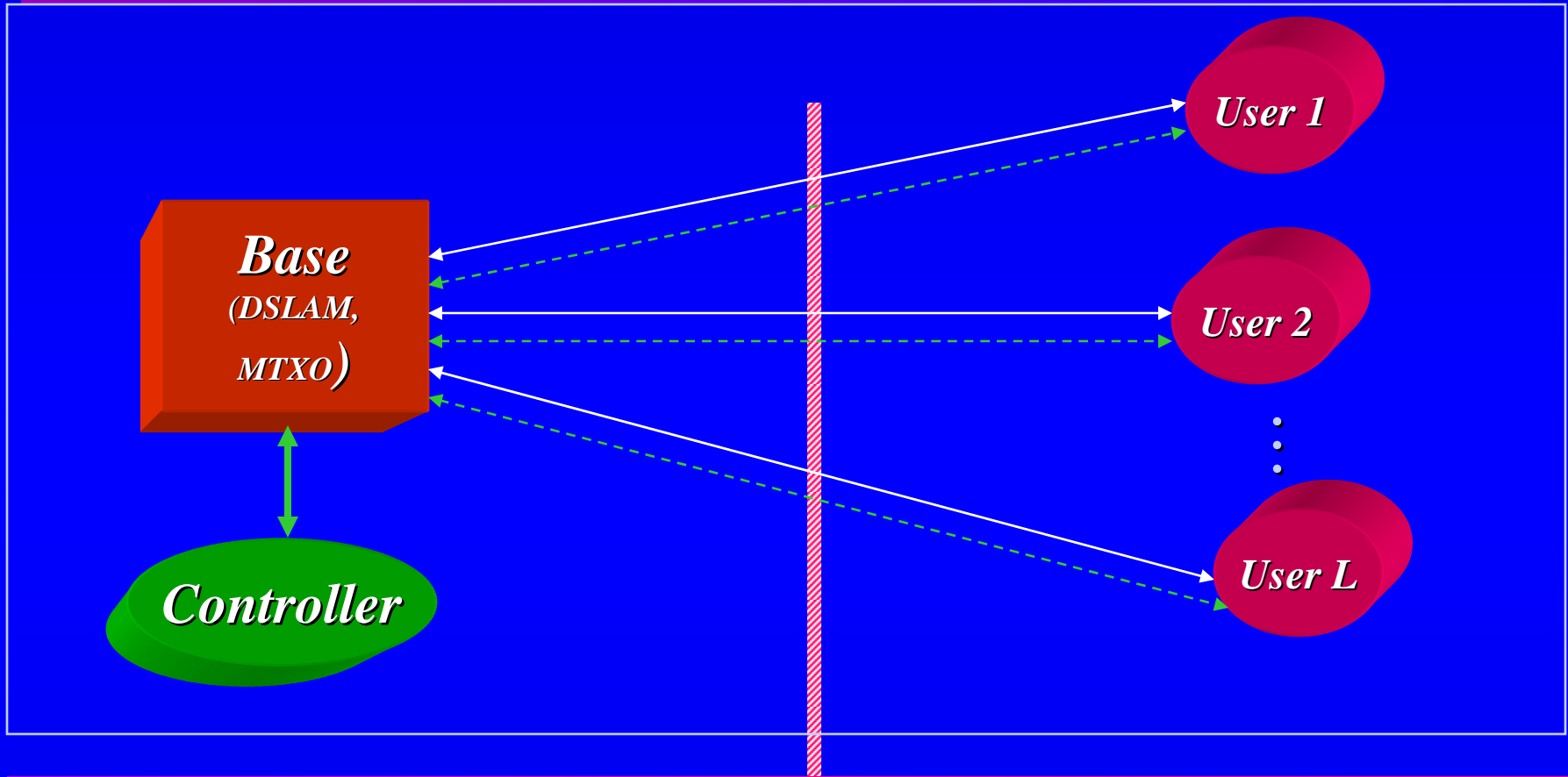


# Tutorial Outline/Schedule

- 9:00-9:20 Multiuser Basics Cioffi
- 9:20-10:30 Danish Photos Bar-Ness
- 11:00-12:30 Academic Songs Bar-Ness
- 12:30-2:00 lunch
- 2:00-3:30 digital siesta Cioffi
- 4:00-5:10 eliminate gas Cioffi
- 5:10-5:30 Summary Bar-Ness



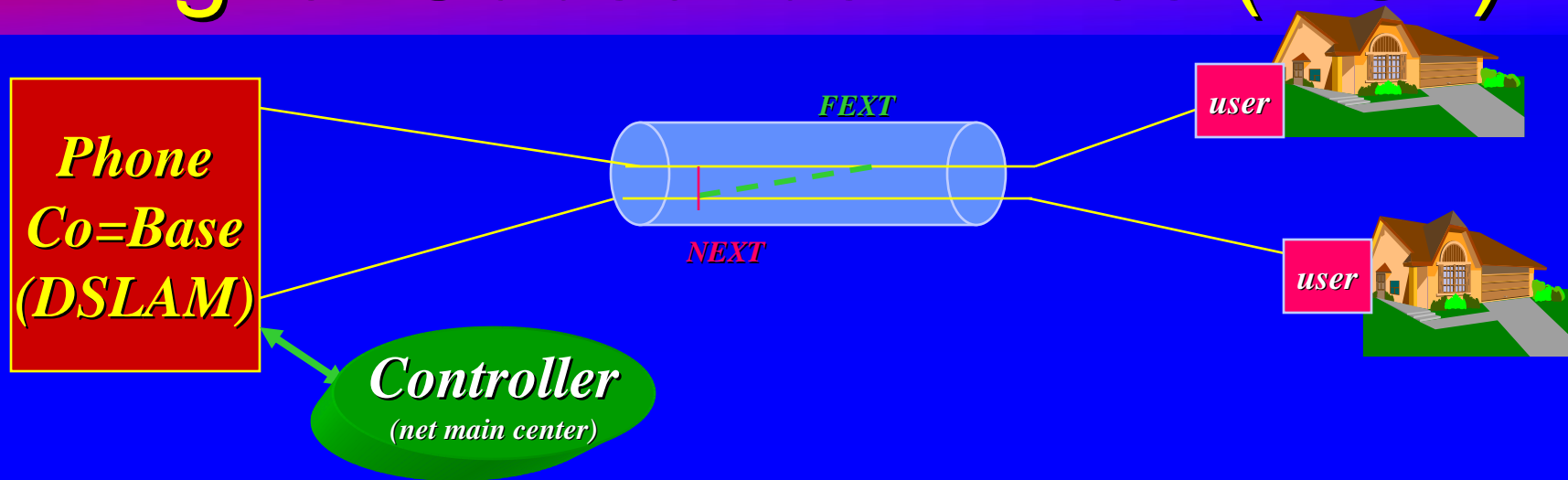
# Multuser Basics



- Goal: Best PHY signals for user sharing of channel
  - ◆ Set spectra/signals, optimization via controller



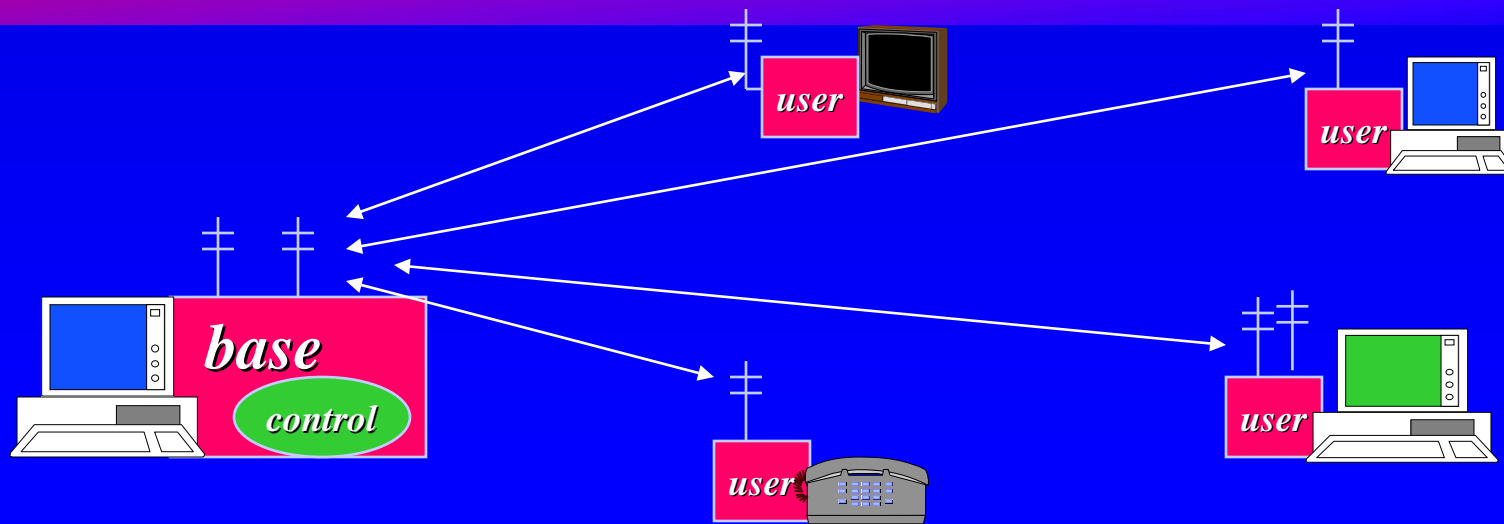
# Digital Subscriber Lines (DSL)



- Twisted-pairs share a “cable”
  - ◆ Radiate despite twisting
  - ◆ Crosstalk is severe – up to 50 wrapped together
- Multiuser situation where base is DSLAM
- Ethernet is another example (4 wires)



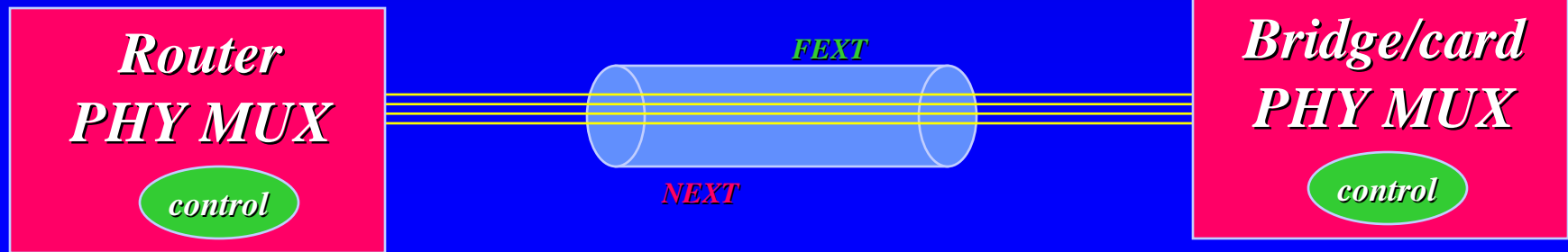
# Wireless LAN



- Wireless fundamentally shared
  - ◆ Crosstalk = co-channel interference
- Base is control unit
- 3G wireless, T/CDMA are other examples



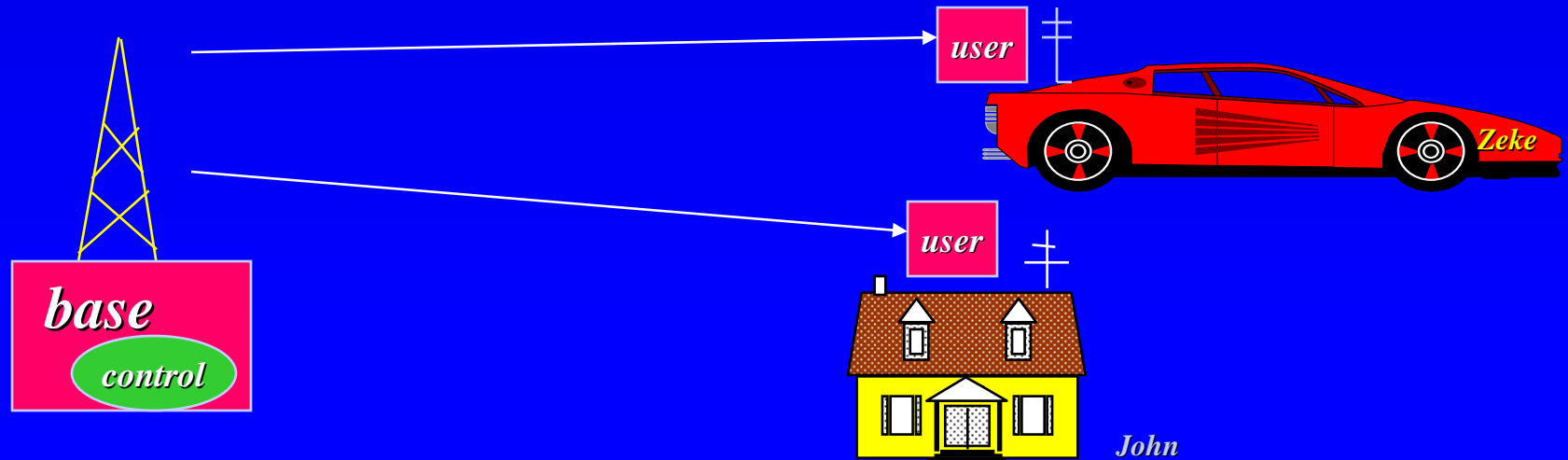
# Ethernet-like (VDSL)



- Up to 4 coordinated tps, cat 3 (EFM), cat 5 (10,100, 1000 BT), cat7 (10GBT)
- Vectored solution



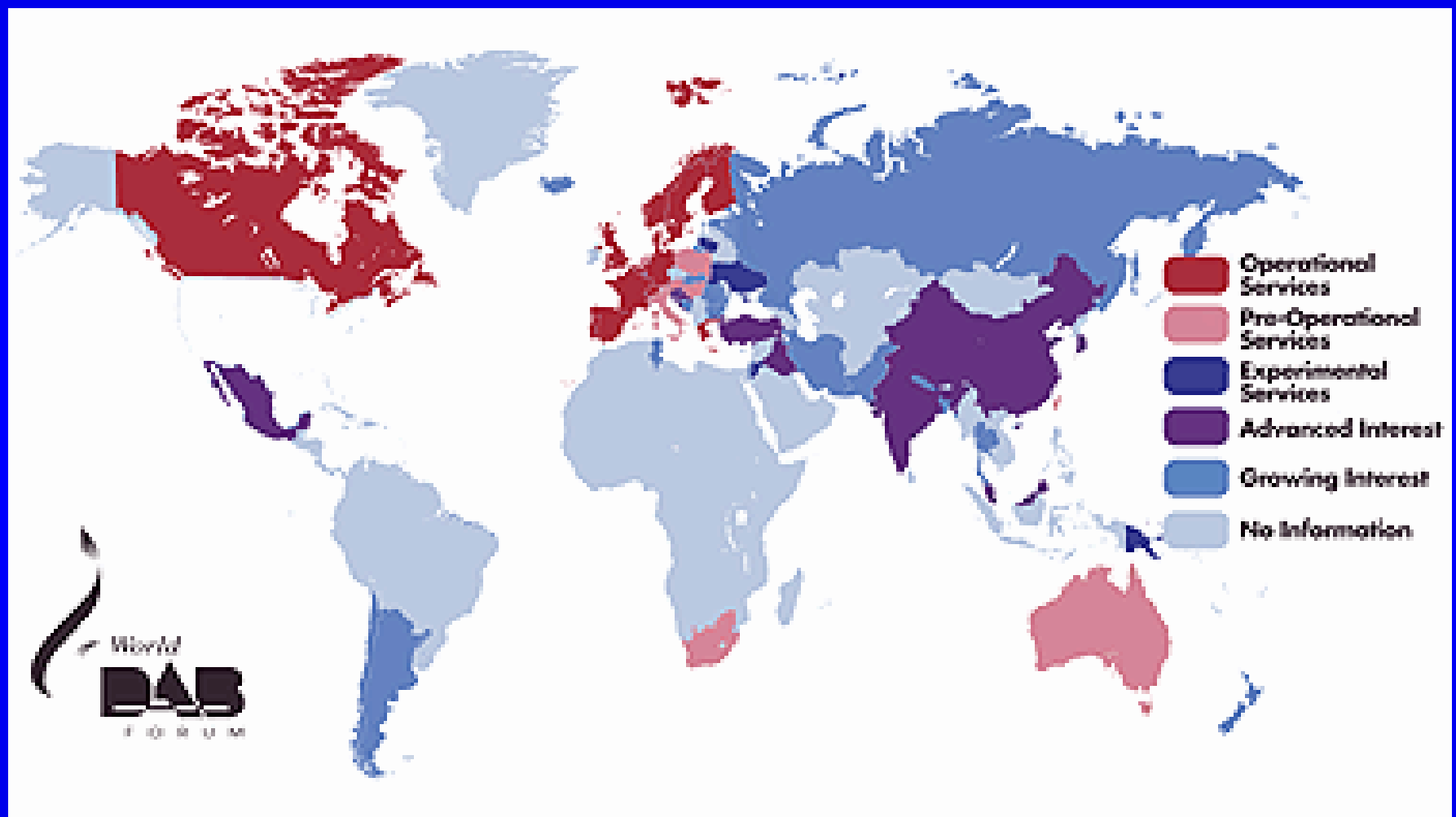
# Digital Audio Broadcasting



- ETSI, 1995.
- Replaces/augments analog FM radio
- “broadcast” problem



# DAB coverage map

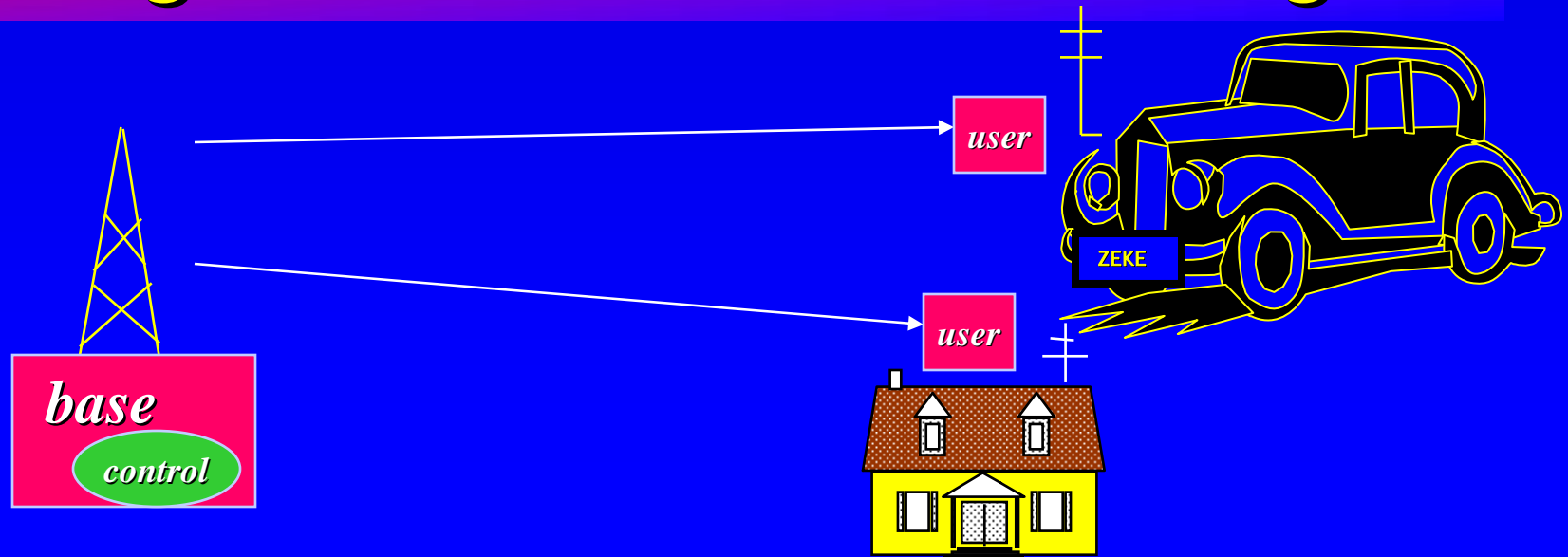


Source:  
[worldDAB.org](http://worldDAB.org)





# Digital Video Broadcasting

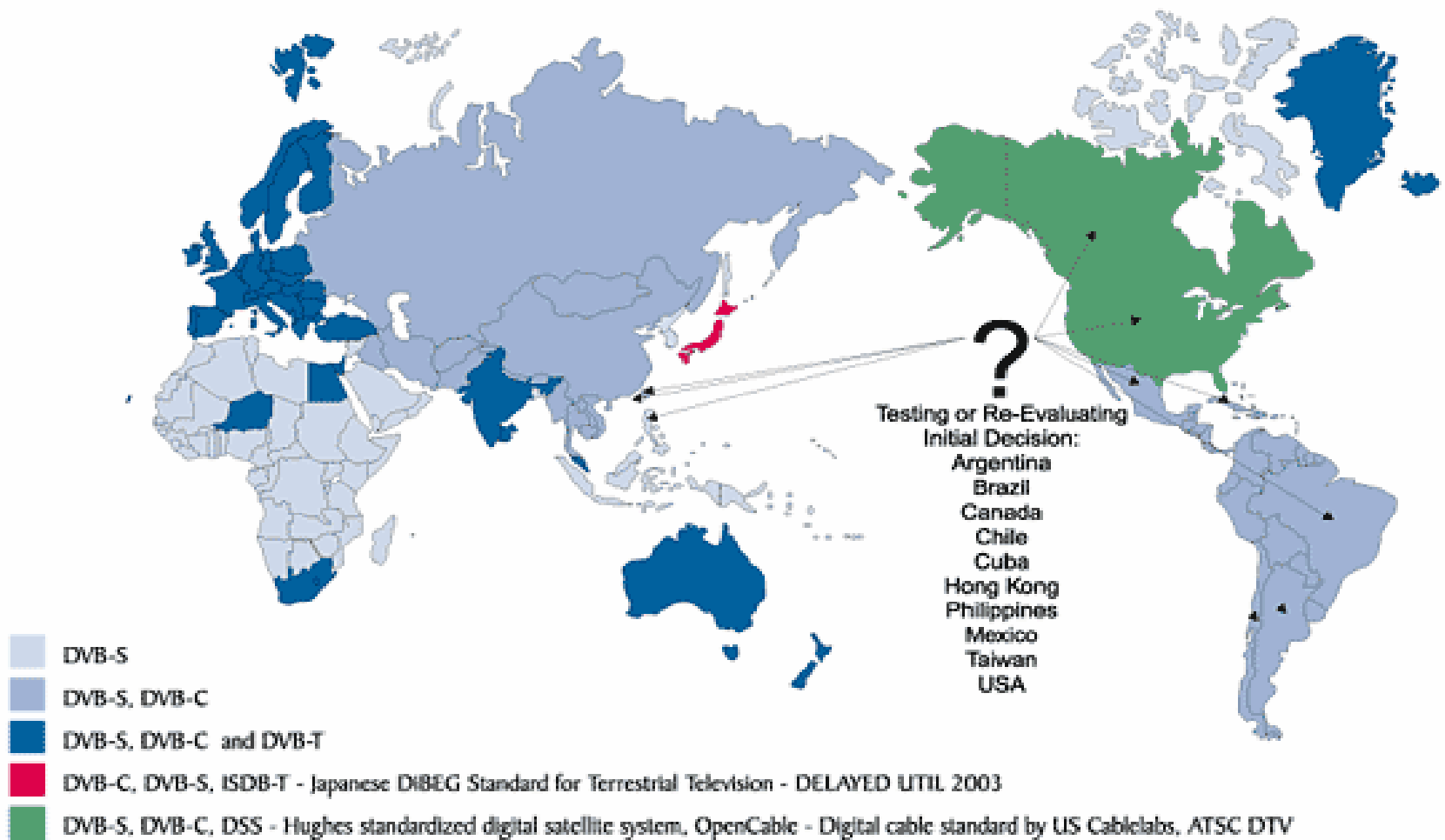


- ETSI, 1997.
- Defines terrestrial, cable and satellite digital television broadcasting.



# DVB adoption

## Digital Standards - Worldwide 2000



Source: DVB.org

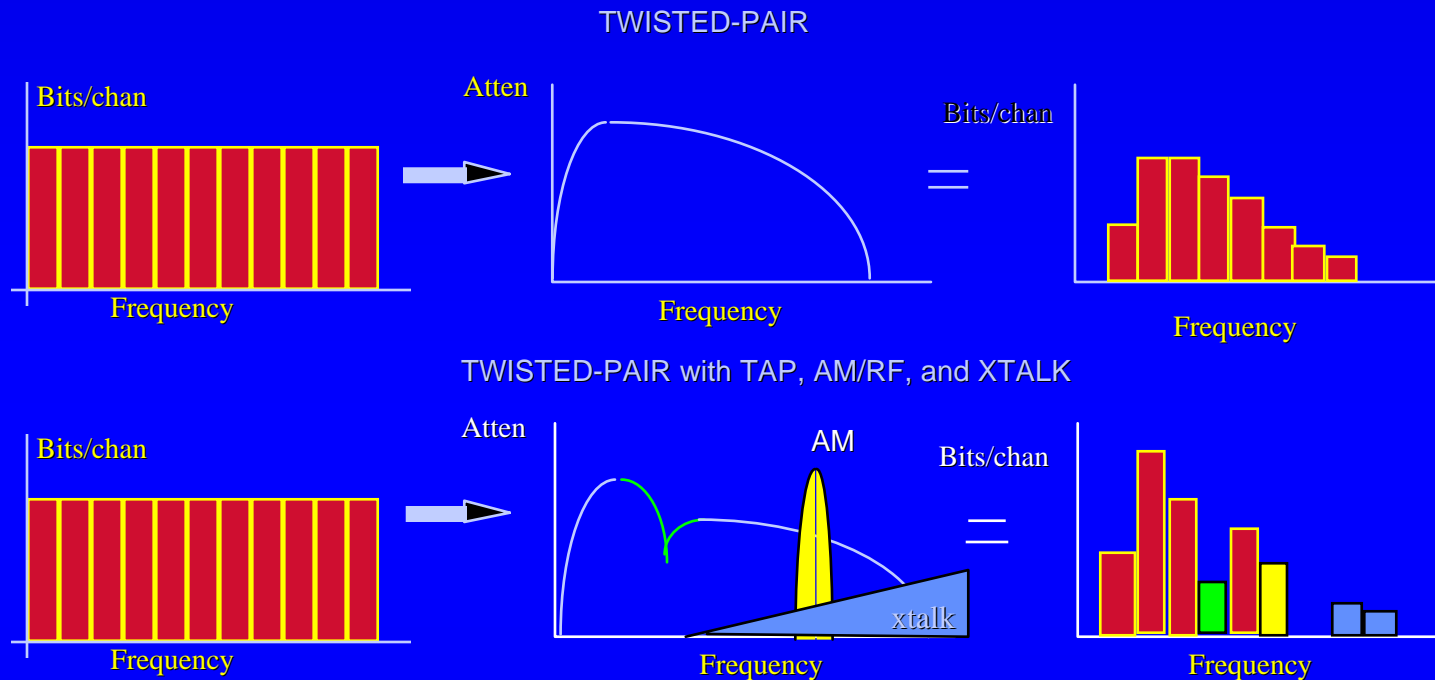


# Brief Mutlicarrier Modulation Review (single user)

- DMT (wired)
- OFDM
- vectoring



# Multitone: DMT Loading Basics (SINGLE USER)



- Optimum – “waterfilling capacity”
  - ◆ Highest data rate, “capacity”, for single user

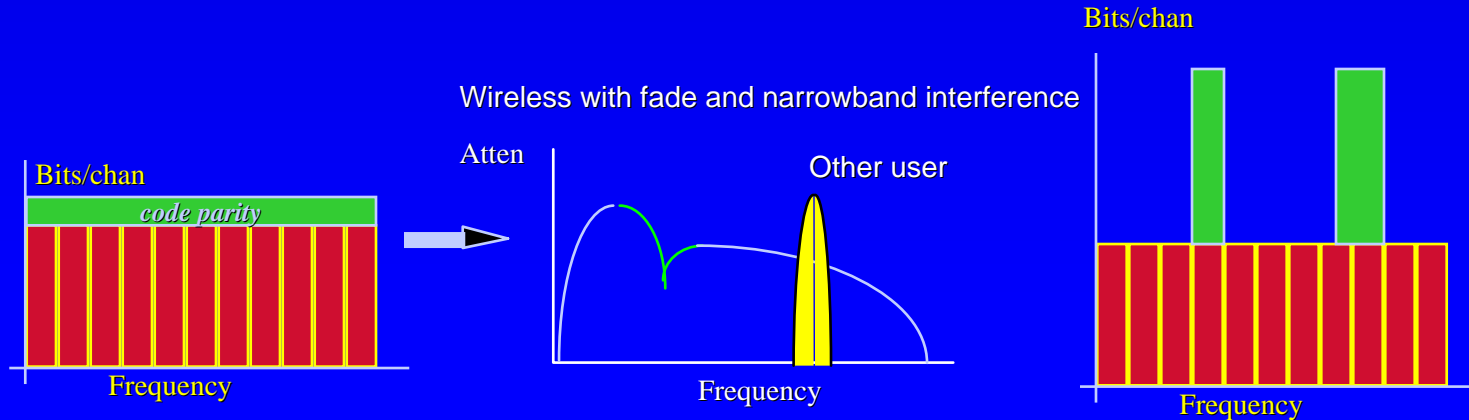


# DMT Uses

- ADSL (10 million lines)
  - ◆ 256 (4 kHz) carriers over 1.104 MHz
  - ◆ Rates to 10 Mbps down /1 Mbps up
- EFM/VDSL
  - ◆ Up to 4096 (4 kHz) carriers over 17.6 MHz
    - ☞ Per line (up to 16384 carriers over 4 lines)
  - ◆ Rates to 100 Mbps symmetric
- Advanced Ethernet (250 Mbps and up)
  - ◆ Many wider carriers



# OFDM – no loading/coding



- Bit optimization per tone not permitted or possible
- Use code instead to offset loss of some of tones
- Suboptimal with respect to DMT, but used in wireless where channel cannot be easily identified at transmitter

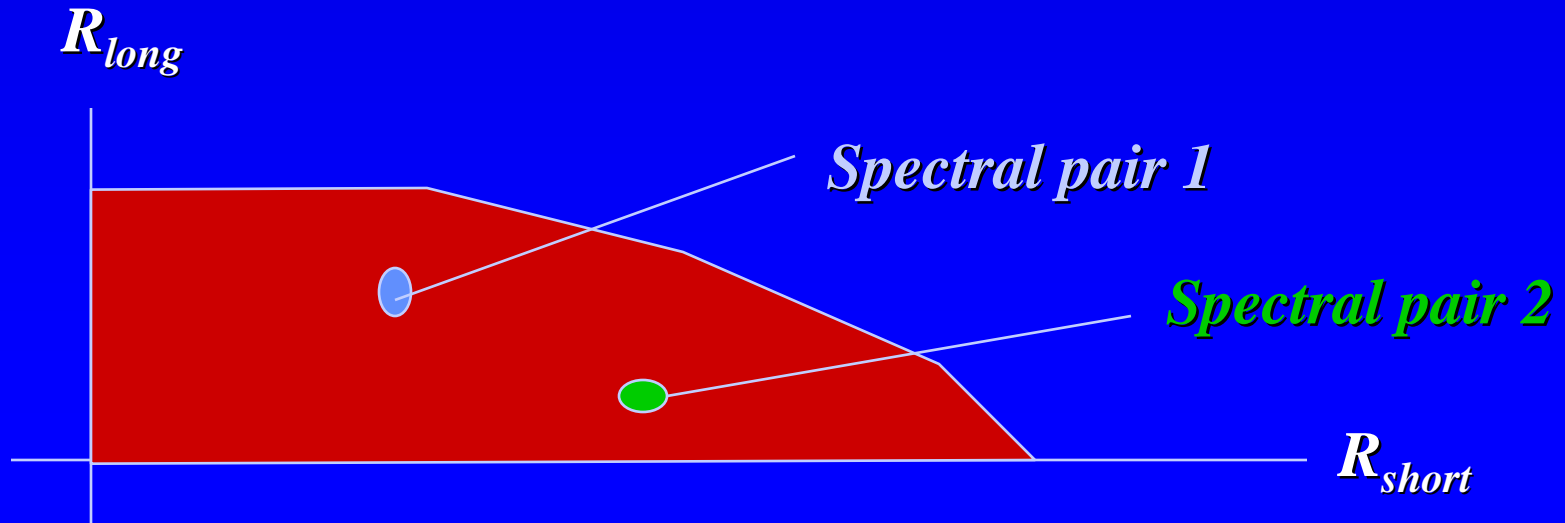


# OFDM Uses (wireless)

- DAB to 2 Mbps
  - ◆ 192-1,536 carriers, 1kHz-8kHz wide each
- Wireless LAN (802.11a)
  - ◆ 48 carriers, 312.5 kHz wide each
  - ◆ To 55 Mbps
- Wireless Broadband/DSL (802.16)
  - ◆ Vectored OFDM – in process
- DVB to 40 Mbps
  - ◆ 1,705/6,817 subcarriers, 1 to 8 kHz wide
- 4G wireless portable seems destined to use OFDM



# Multiuser Rate REGIONS



- Plot of all possible rates of users
- Any point in region is possible, but each with different spectra
  - ◆ Varies for each channel





# The “Down” problem

- Base to Users
  - ◆ “Downstream” in DSL
  - ◆ “Downlink” in wireless
- The “Broadcast Problem” in information theory
  - ◆ Solved recently
- Base coordination level
  - ◆ Spectra: Spectra Balancing
  - ◆ Signals: Vectoring



# The “Up” Problem

- Users to Base
  - ◆ “upstream” in DSL
  - ◆ “uplink” in wireless
- The “multiple access problem” in information theory
  - ◆ Solved about 10 years ago
- Base coordination level
  - ◆ Spectral or none: multiuser detector (MUD)
  - ◆ Signal: vectoring



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- 4:00-5:10 DSL, Ethernet, VDMT Cioffi
- 5:15-5:30 Summary Bar-Ness

