# ATM and ADSL

Lecture 6

- ATM
- VPs / VCs
- Aggregation
- Segmentation
- Coding
- History and modern day

# What was the problem?

- Different information types require different qualities of service from the network
  - stock quotes vs. web
  - video vs. email
- Traditional telephone networks provided:
  - a single quality of service – fixed bandwidth and delay
  - and seemed to be very expensive!
- The Internet supports no quality of service
  - but is flexible and cheap
- The goal was to devise a new network that would support a range of service qualities at a reasonable cost
  - 1980s: voice, video, and data on separate networks
  - Desire for Integrated Services
    - easier to manage
    - innovative new services
  - Potentially to subsume both the telephone network and the Internet

# BISDN is born

- In the early 1990s there was a plan for a “Broadband Integrated Services Digital Network” and it would be based on a techology  known as ATM

Design goals:

- Provide end-to-end quality of service
- High bandwidth (target was 140Mbps to each home!)
- Scalability (reach all homes)
- Manageability
- Cost-effective

# ATM Concepts

1. Fixed-size packets (*cells*)
2. Small-size packets
3. Virtual circuits
4. Statistical multiplexing
5. Integrated services

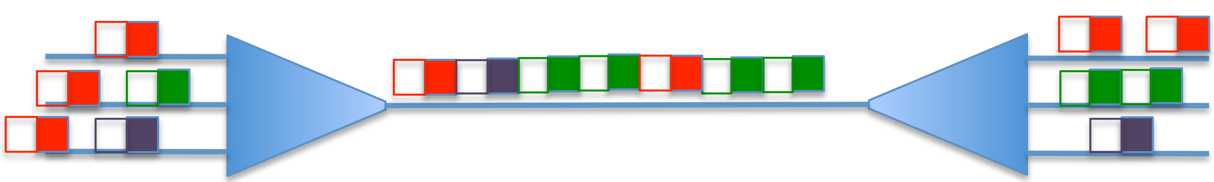
Together

- can carry *multiple* types of traffic
- with end-to-end quality of service

# Reminder…ATM

*"asynchronous transfer mode"*

- the destination of data in the network is based on a label
- all packets are the same size



# Fixed-size packets

- Pros
  - Simpler buffer hardware
    - packet arrival and departure requires us to manage fixed buffer sizes
  - Simpler line scheduling
    - each cell takes a constant chunk of bandwidth to transmit
  - Easier to build large parallel packet switches
- Cons
  - overhead for sending small amounts of data
  - segmentation and reassembly cost
  - last unfilled cell after segmentation wastes bandwidth

# Small packet size

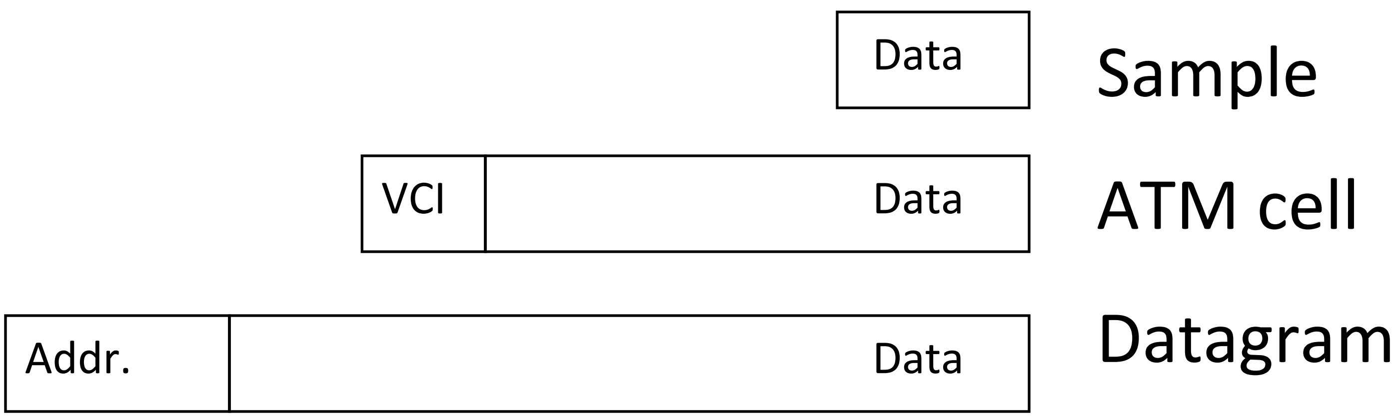
- Pros
  - For voice sampled at 8kHz
    - that is 125 microseconds per byte
    - the smaller the cell, the less time to fill it
      - *packetization delay*
      - in the voice network, we must consider “echo”
  - When multiplexing two flows, small packets allow fine grained scheduling
- Cons
  - The smaller the packet
    - the larger the header overhead
    - less time to process

- Standards body balanced the two to arrive at:
  - 48 bytes + 5 byte header = 53 bytes

  -> maximum efficiency of 90.57%

# Virtual circuits

- Two ways to use packets
  - carry entire destination address in header
  - carry only an identifier



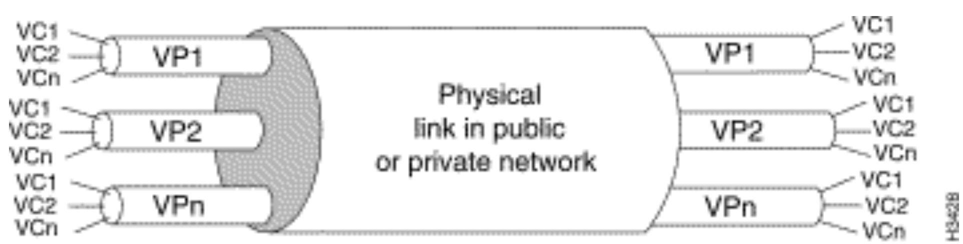
# Features of virtual circuits

- Signaling => separation of *data* and *control*
  - Must establish label mappings in advance
- All packets must follow the same path
  - A failure requires a re-reoute
- Switches store per-VCI state
  - Importantly can store QoS information
- Small Ids can be looked up quickly in hardware
  - harder to do this with IP addresses (esp. v6!)
  - ids can be assigned in sequence
- Setup must precede data transfer
  - delays short messages
- Switched vs. Permanent virtual circuits
  - can pre-establish connections

# ATM - Virtual circuits & paths

| | | | |
|---|---|---|---|
| Byte 1 | GFC | VPI | |
| Byte 2 | VPI | VCI | |
| Byte 3 | VCI | | |
| Byte 4 | VCI | PT | |
| Byte 5 | HEC | | |
| Byte 6 | Payload 1 | | |
| … | … | | |
| Byte 53 | Payload 48 | | |

- Small ids
  - Need as many bits as channels on the link
  - Unrelated to endsystem address space
- We also need to switch ids at intermediate points
- Preallocate a range of VCIs along a path
  - *Virtual Path - VPI*




VP = Virtual path
VC = Virtual channel

# ATM - QoS

- CBR - Constant bit rate:
  - defined by a peak cell rate;
  - service guarantees low delay even at peak.
- VBR - Variable bit rate:
  - defined by average cell rate, with a specified "burstiness";
  - service delivers average rate and may queue traffic within burst spec and throw away anything above that.
- ABR - Available bit rate:
  - a minimum guaranteed rate is specified;
  - service aims to indicate to senders when they might send more.
- UBR - Unspecified bit rate:
  - traffic is allocated to all remaining transmission capacity.

- These simple descriptions turn out to be really hard to put into specifications that make a lot of sense…
  - Ended up with QoS specified by what we could figure how to implement
  - QoS still subject of research 20 years later!

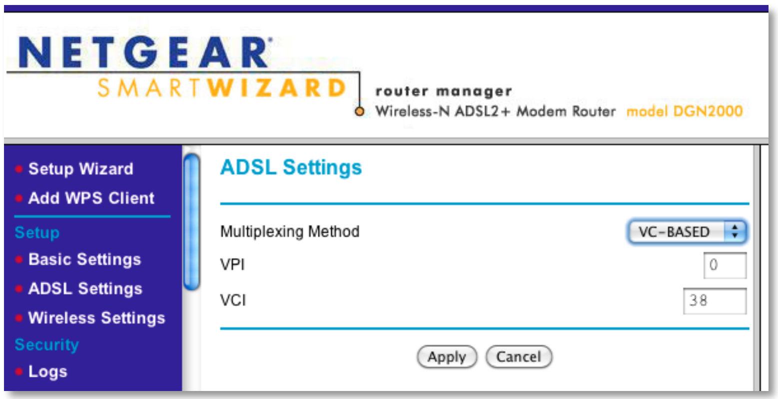
# Challenges in the 80/90s

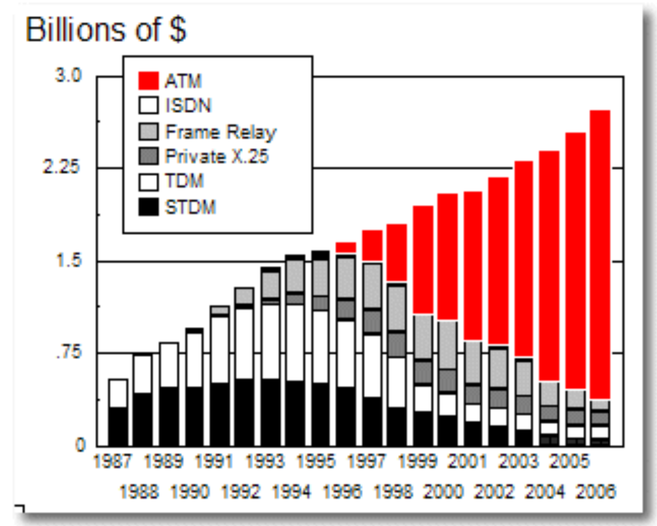
- Quality of service
  - and still a subject of research!
- Scaling
  - little experience
- Competition from other LAN technologies
  - Fast Ethernet
  - FDDI
- Standardization
  - political
  - slow

# Challenges

- IP
  - a vast, fast-growing, non-ATM infrastructure
  - ATM  to IP interoperation is a pain in the neck, because of fundamentally different design philosophies
    - connectionless vs. connection-oriented
    - resource reservation vs. best-effort
    - different ways of expressing QoS requirements
    - routing protocols differ
  - Emerged as IP over ATM…

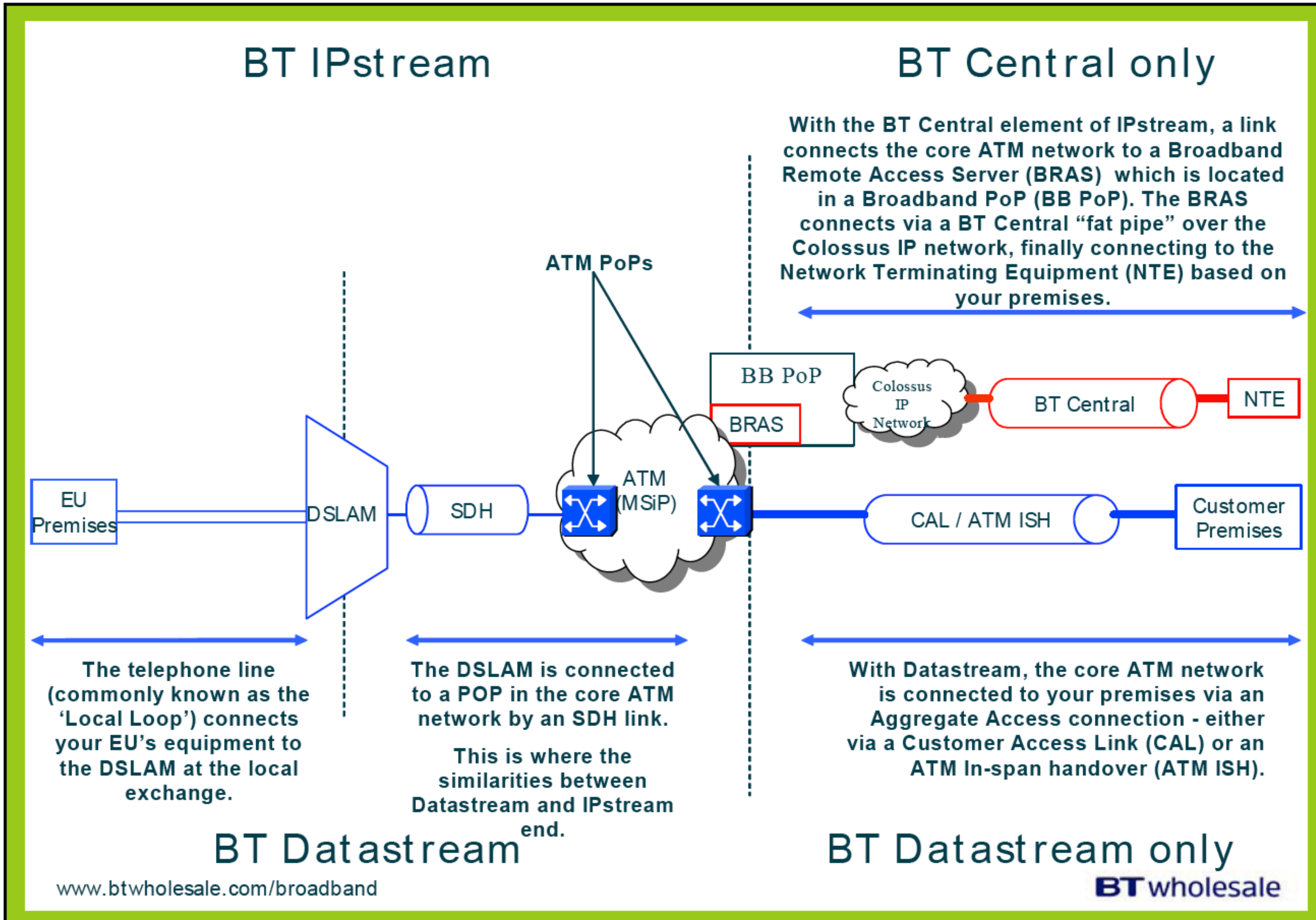
# ATM today



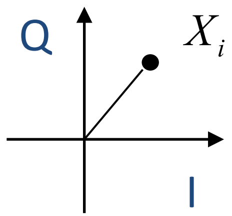



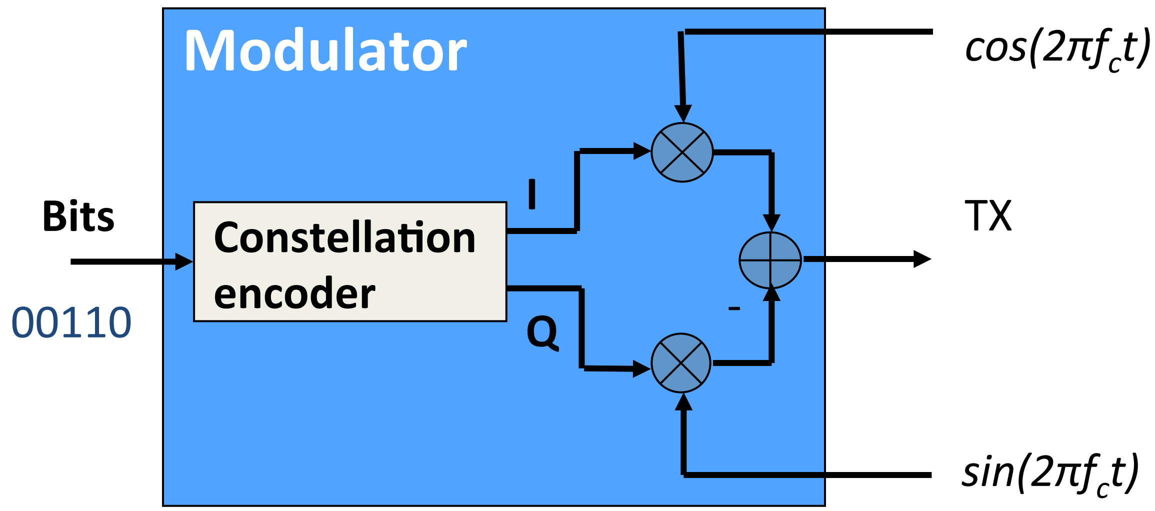

- Widely used in core of mobile networks
- And in combination with some fancy signal processing as basis of ADSL…

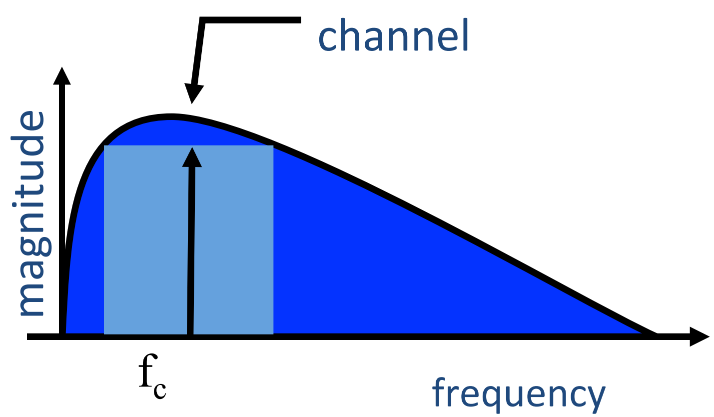
# ADSL as deployed today



# Remember QAM



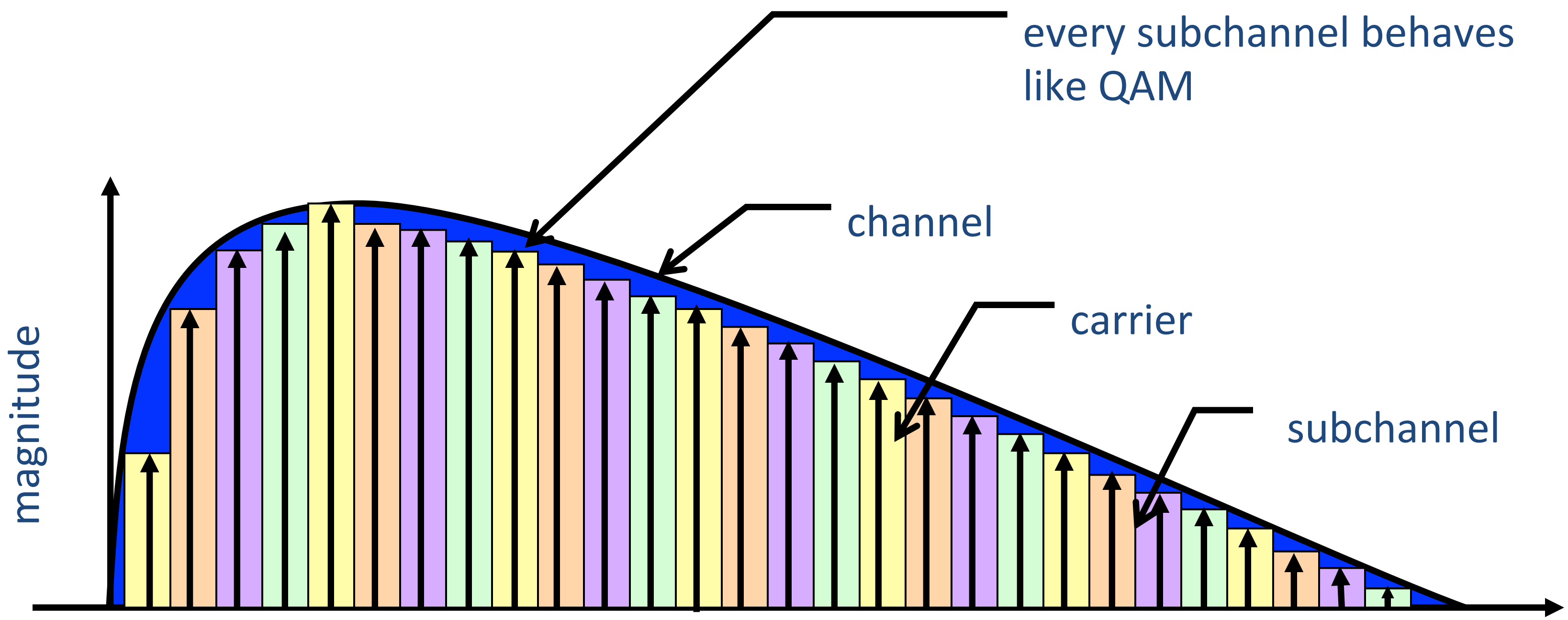




- One carrier - $f_c$
- The symbol rate is the bandwidth of the signal being centered on carrier frequency

# Multicarrier Modulation

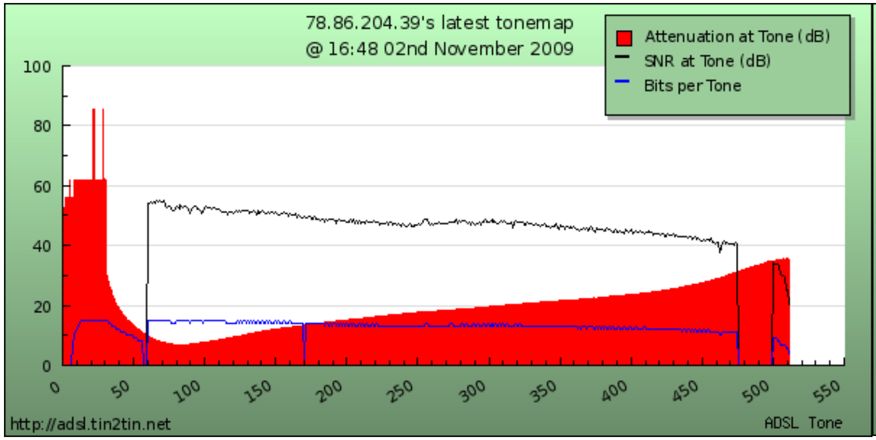
- Divide broadband channel into narrowband subchannels
- Discrete Multitone (DMT) modulation
  - Based on fast Fourier transform (related to Fourier series)
  - Standardized for ADSL
  - Proposed for VDSL

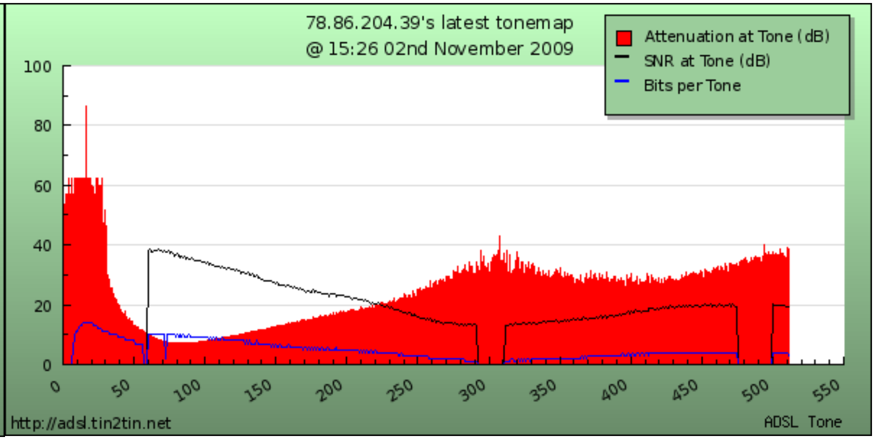



Subchannels are 4.3 kHz wide in ADSL

# Dynamic Issues

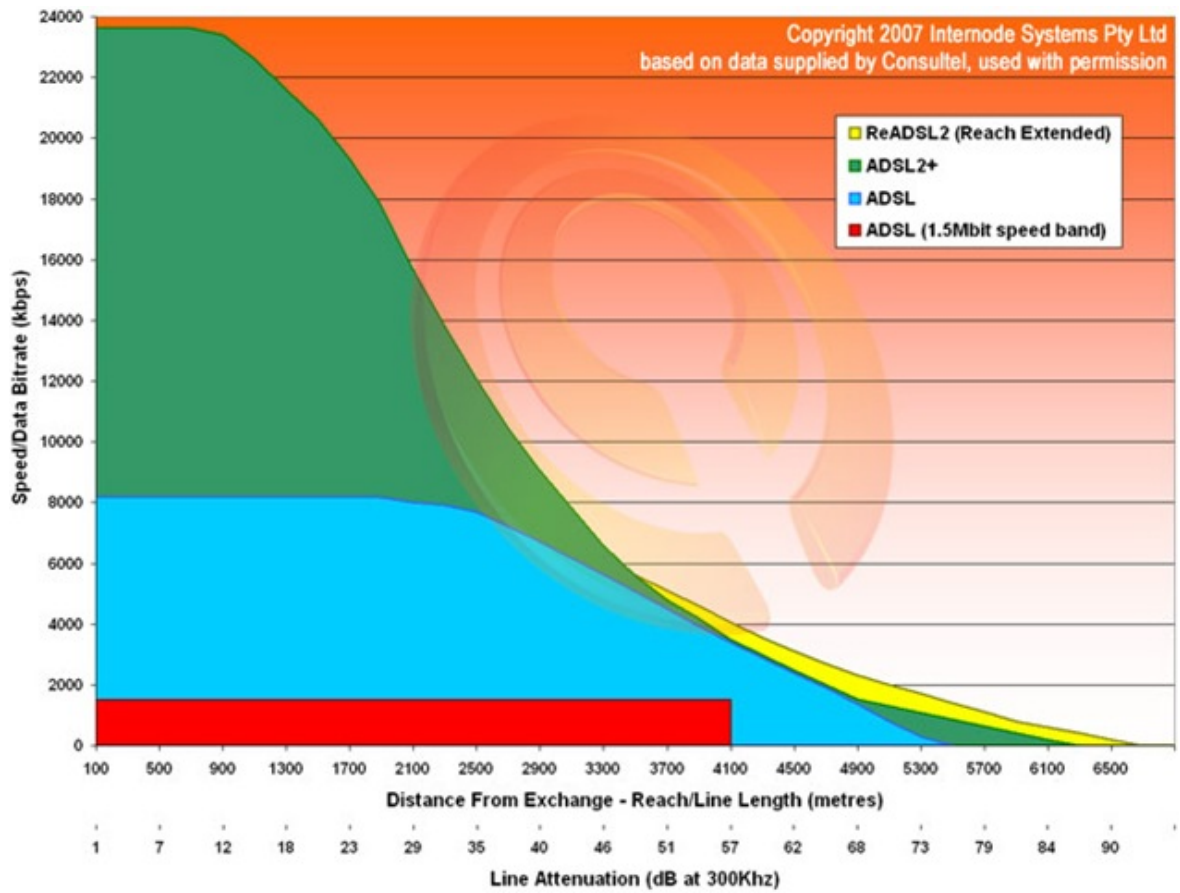
- In real world not usually so clean an envelope
  - Example below is unfiltered phone attachment
- Must adapt to changes in SNR and attenuation in each subcarrier
  - Deal with changing environment, e.g. rain!
  - Others in same wiring loom using ADSL…



# Static issues

- Attenuation with distance eventually kills performance…
- Technology not getting us much beyond 5-6km from DSLAM…



# Communications systems & Electromagnetic Spectrum

- Frequency of communications signals