ATM & ADSL

G54ACC

Lecture 9

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Contents

- Multi-service Networks
- The Solution: ATM
- Challenges

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  - B-ISDN
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An Old Problem

- Different information types require different qualities of service from the network
  - Stock quotes *vs*. web, Video *vs*. email
- Traditional telephone networks provided fixed bandwidth and delay
  - A single quality of service...
  - ...and seemed to be very expensive!
- The Internet supports no quality of service
  - But is flexible and cheap!

The Solution?

- Devise a new network supporting many service qualities at reasonable cost
- 1980s: voice, video, and data carried on separate networks
- Desire for Integrated Services
  - Easier to manage
  - Generate 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 technology 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

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  - Fixed-size packets
  - Small Packets
  - Virtual Circuits
  - Quality-of-Service
- Challenges

ATM Concepts

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

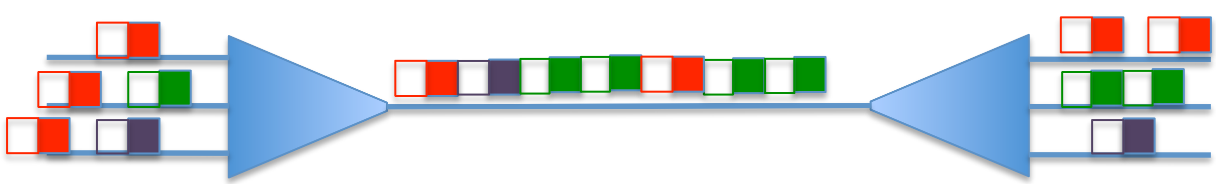
Together

- Carries 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

Fixed-size Packets: Cons

- Overhead for sending small amounts of data
- Segmentation and reassembly cost
- Last unfilled cell after segmentation wastes bandwidth

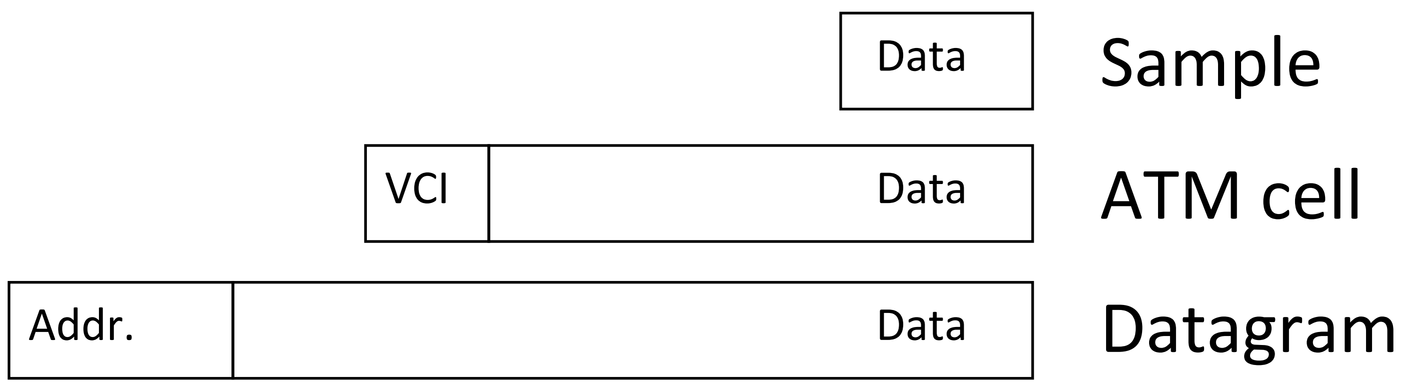
Small Packet Size

- For voice sampled at 8kHz, have 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
- But! 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, or
  - Carry only an identifier



Features of Virtual Circuits (1)

- Signaling gives separation of *data* and *control*
  - Must establish label mappings in advance
- All packets must follow the same path
  - Failure requires a re-route
- Switches store per-VCI state
  - Importantly can store QoS information

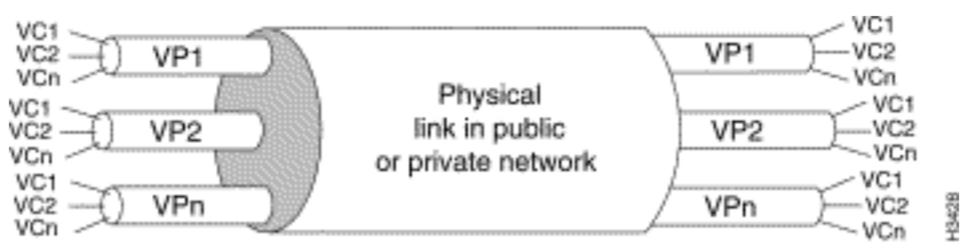
Features of Virtual Circuits (2)

- Small Ids can be looked up quickly in hardware
  - Harder to do with IP addresses (particularly 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

- Small ids
  - Need as many bits as channels on link
  - Unrelated to end-system address space
- Also need to switch ids at intermediate points
- Pre-allocate a range of VCIs along a path
  - *Virtual Path, VPI*

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		



VP = Virtual path
VC = Virtual channel

ATM – Quality of Service, 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, 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

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  - IP
  - Status today
  - ADSL

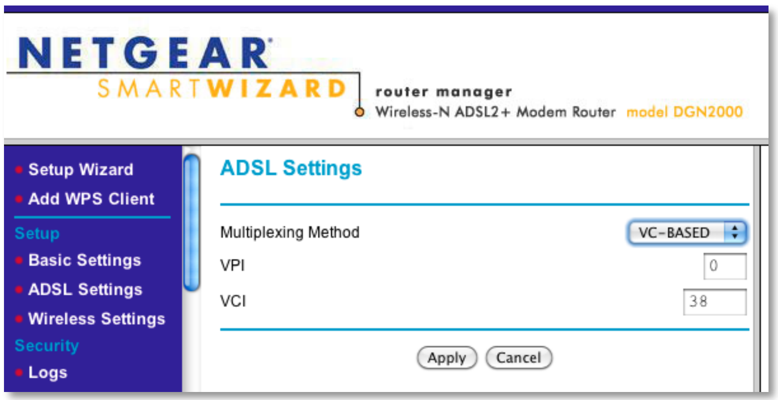
Challenges in the 80s/90s

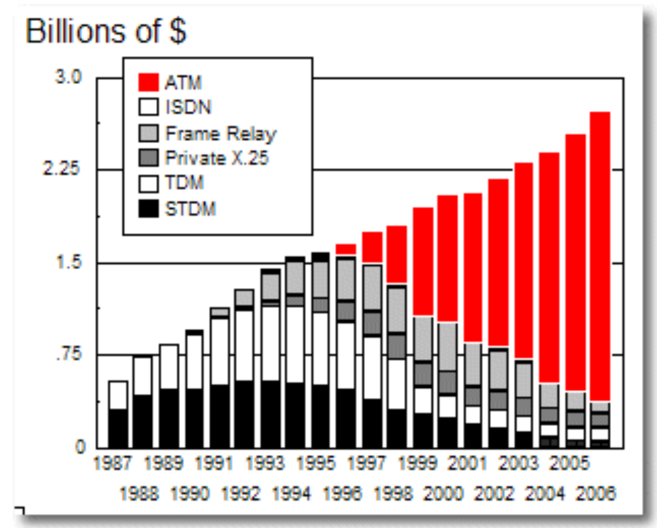
- Quality of service
  - Simple descriptions turn out to be really hard to put into specifications that make a lot of sense
  - Ended up with QoS specified by what we could figure how to implement
- Scaling
  - Little experience
- Competition from other LAN technologies
  - Fast Ethernet, FDDI
- Standardization
  - Political, very slow

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…

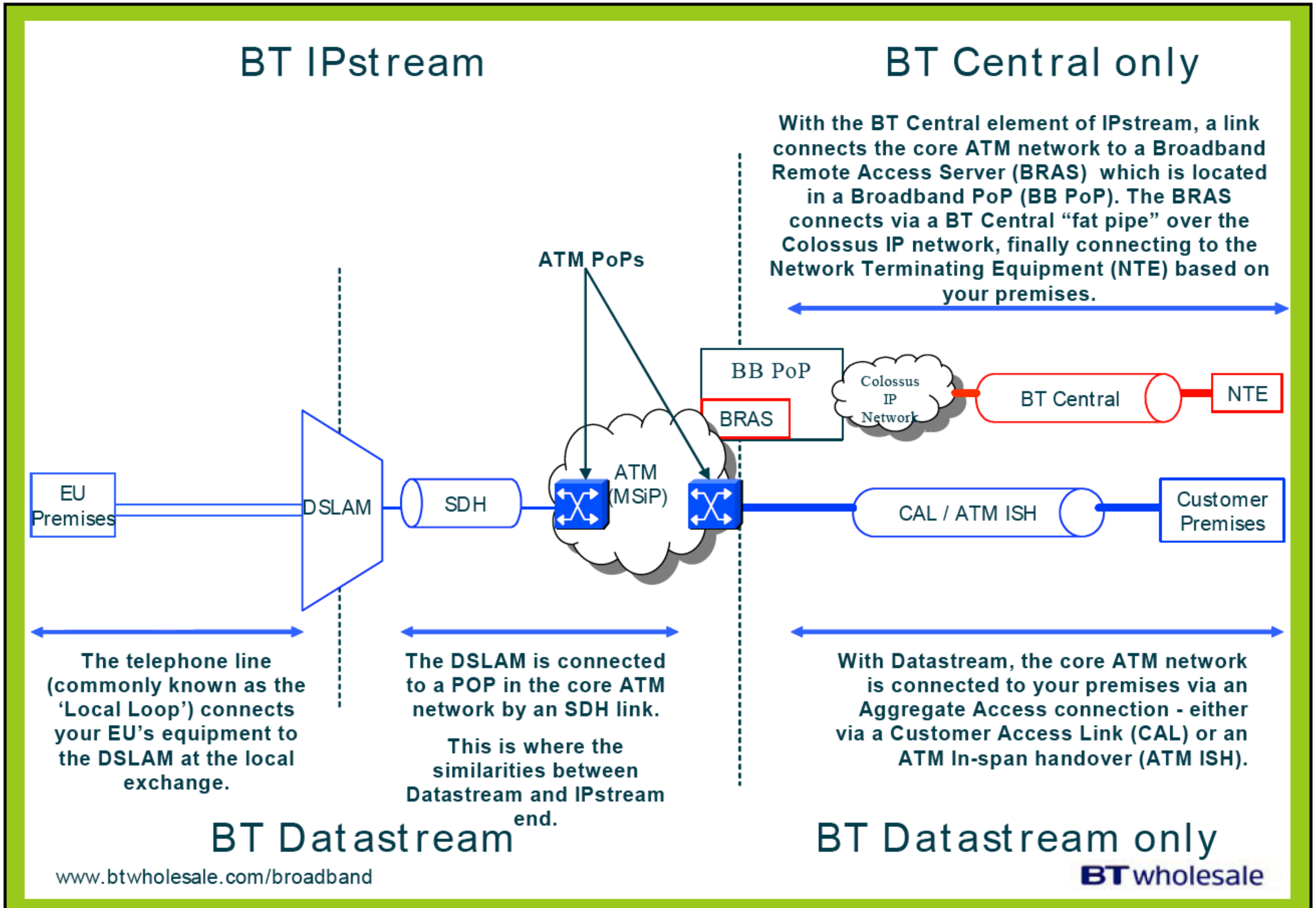
ATM Today



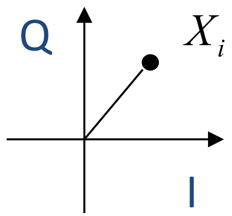


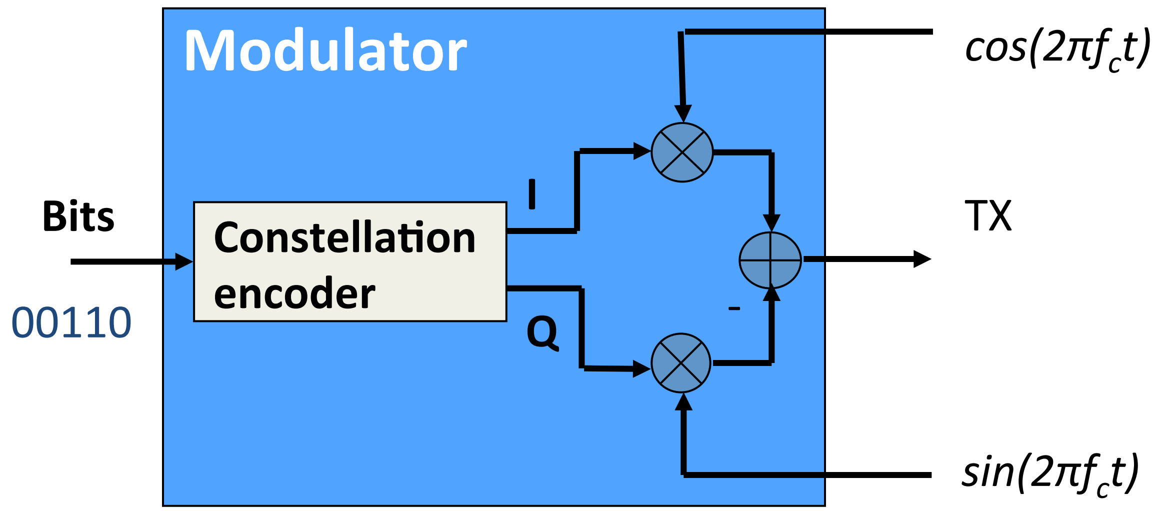
- Widely used in core of mobile networks
- And as basis of ADSL, in combination with some fancy signal processing …

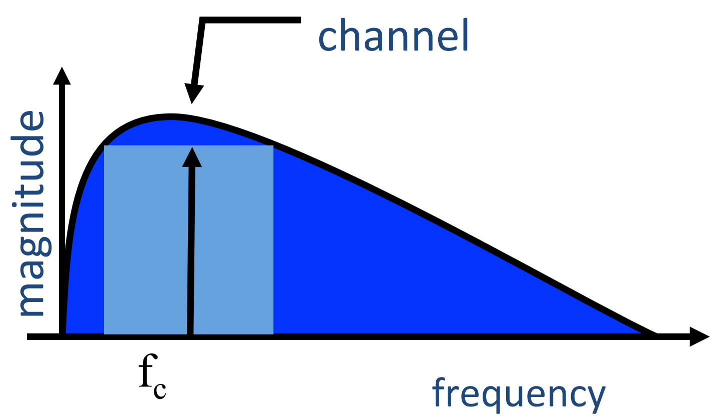
ADSL as Deployed Today



Remember QAM



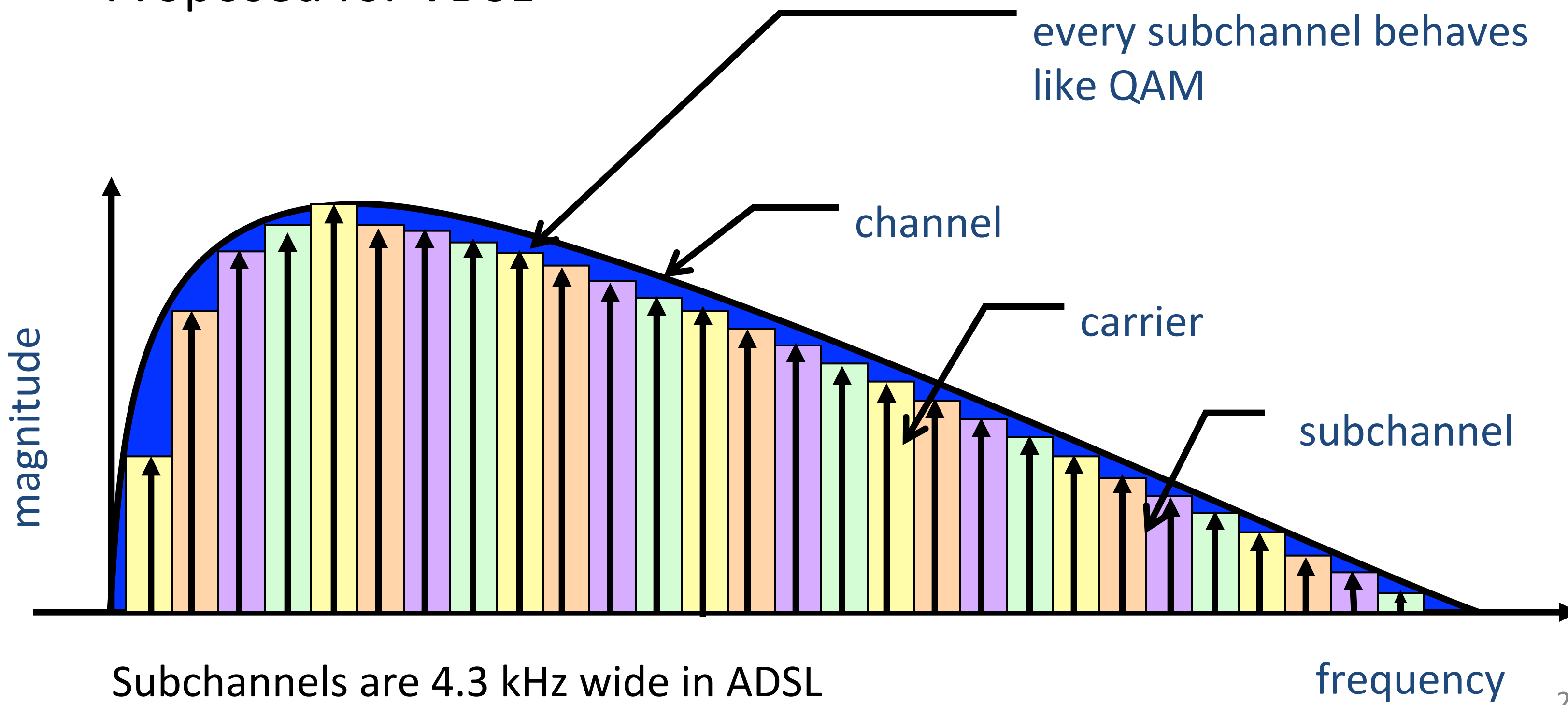




- One carrier, f_c
- The symbol rate is the bandwidth of the signal being centered on carrier frequency

Multicarrier Modulation

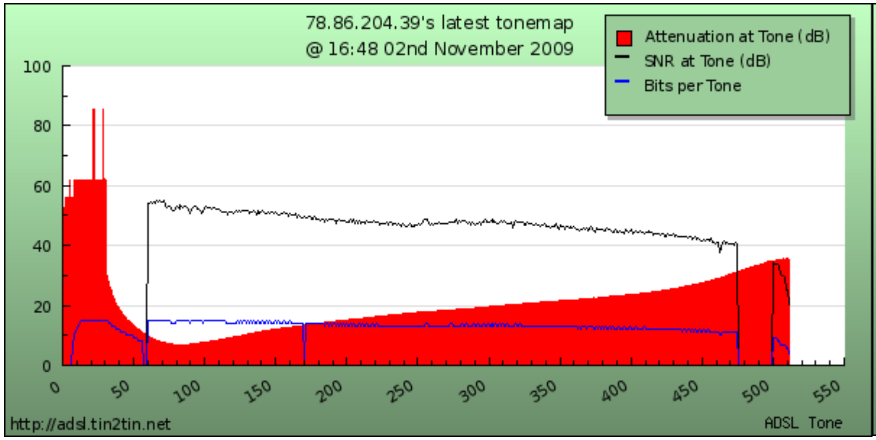
- Divide broadband channel into narrowband sub-channels
- Discrete Multitone (DMT) modulation
  - Based on fast Fourier transform (related to Fourier series)
  - Standardized for ADSL
  - Proposed for VDSL

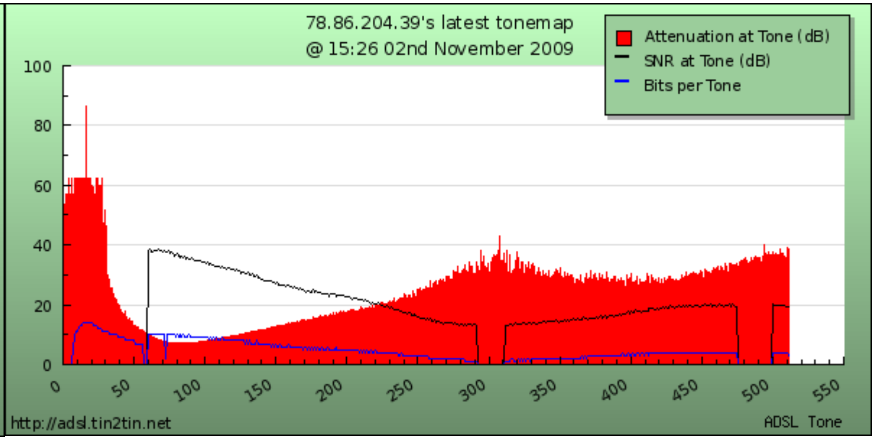


Subchannels are 4.3 kHz wide in ADSL

Dynamic Issues

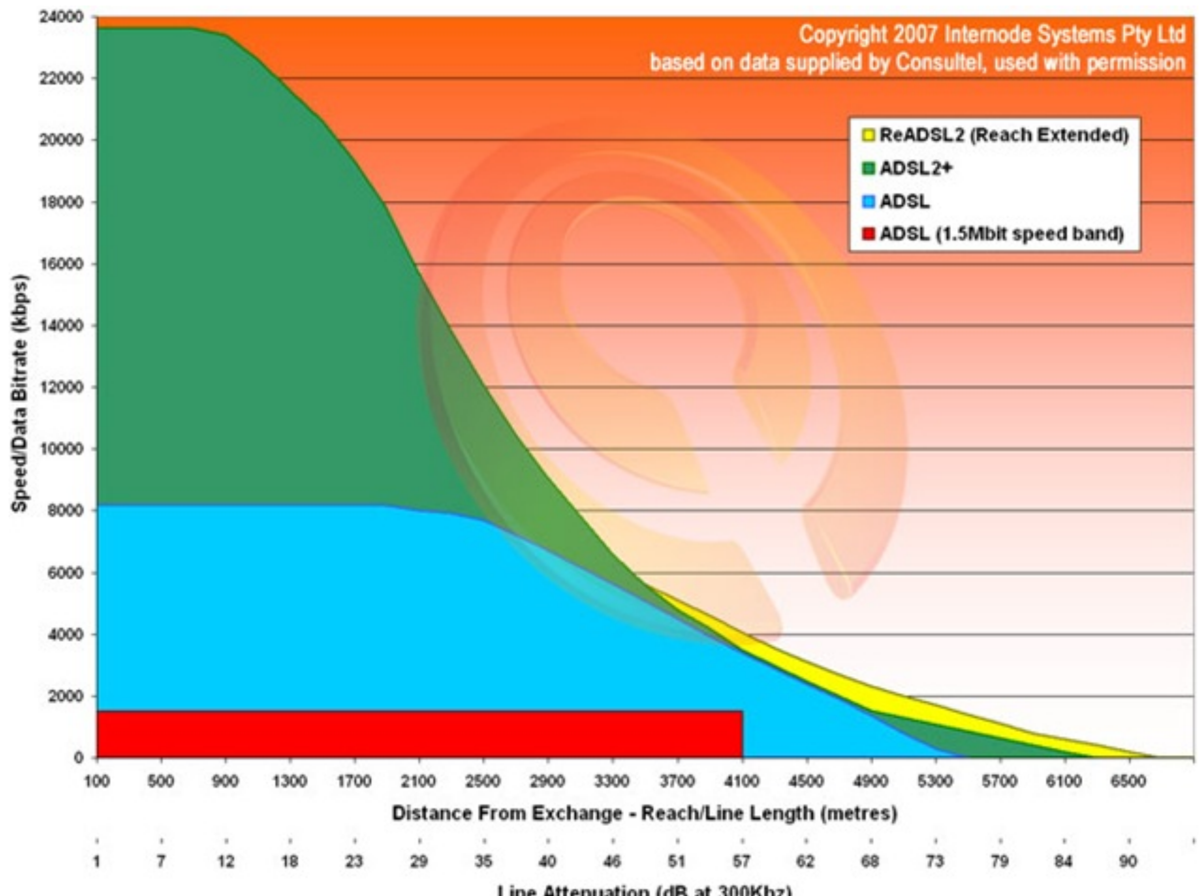
- In real world not usually so clean an envelope
  - Example below is unfiltered phone attachment
- Must adapt to changes in SNR and attenuation in each subcarrier
  - Deal with changing environment, e.g. rain!
  - Others in same wiring loom using ADSL…





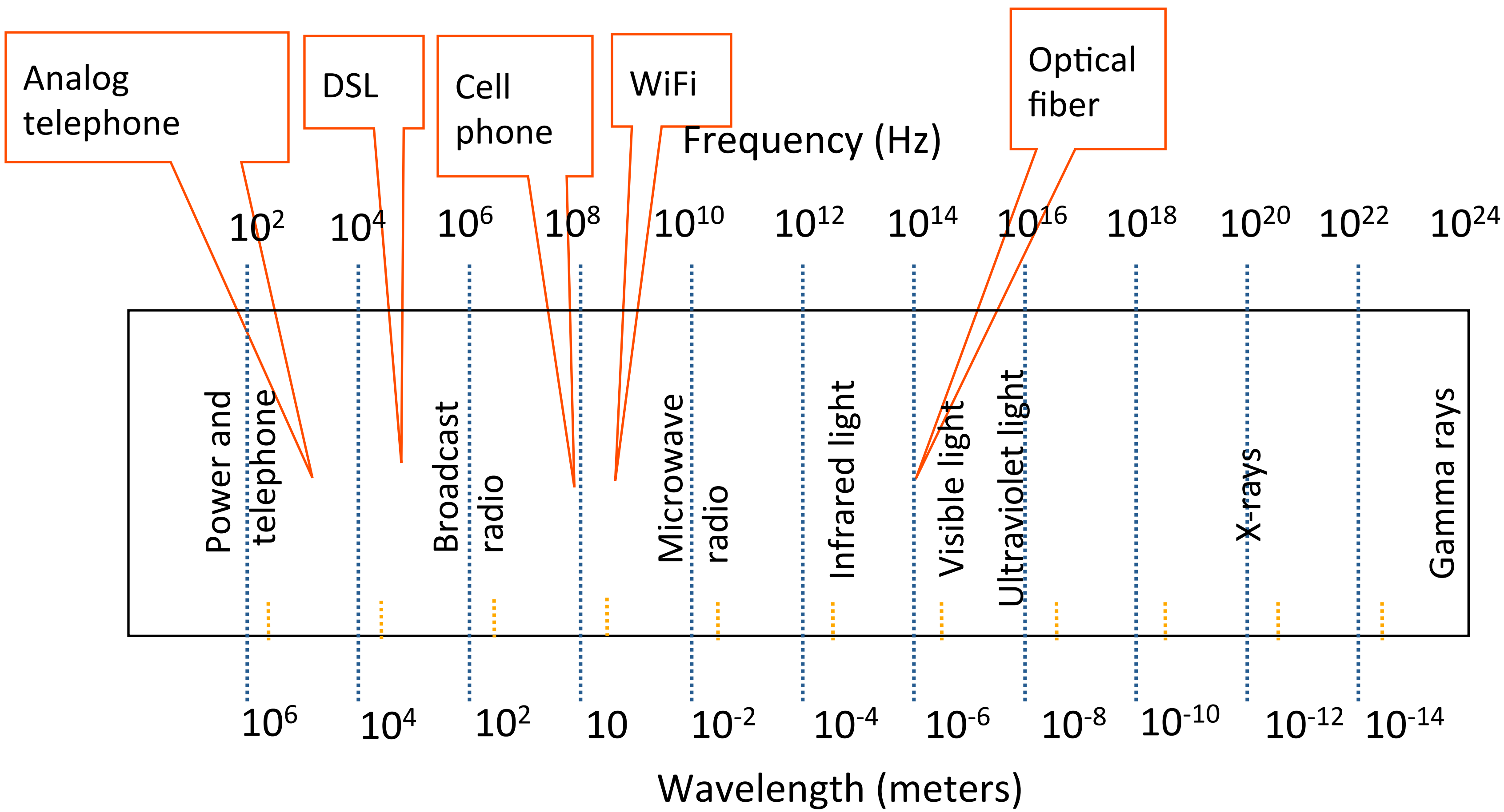
Static Issues

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



Communications systems & Electromagnetic Spectrum

- Frequency of communications signals



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Quiz

1. What is the fundamental problem ATM addresses?
2. How large is an ATM cell in bytes, and why was fixing this in bytes a bad idea?
3. What is the maximum efficiency possible in an ATM network?
4. What simplifications does ATM having a fixed packet size offer over IP? Are they still relevant?
5. How do virtual circuits different from IP routing?
6. What capabilities do virtual circuits permit?
7. What are the four QoS classes offered by ATM, and why?
8. Give four technical differences between ATM and IP networks. What must you do to support IP over ATM?
9. How do ADSL networks provide broadband networking over (very) old copper telephone wiring? What are its limitations?