Network Effects

- One-way delay between sender/receiver
  - Includes encoding, packetization, transmission, propagation, queueing, jitter compensation, decoding
  - Typically, acceptable if < 150msec for domestic calls and < 400msec for international
    - Depends on call's interactivity
  - What can we do to reduce packet delay?

Network effects (cont')

- Packet losses
  - Low-bitrate codecs are very sensitive to packet losses (why?)
  - Should we do retransmissions?
  - Should we do Forward-Error-Correction?
  - Or just, packet loss concealment? How?
- Delay variation or jitter
  - Jitter compensation buffer at receiver
  - How large should this buffer be?
  - Losing vs discarding packets
  - Delay budget calculations
- Insufficient network capacity
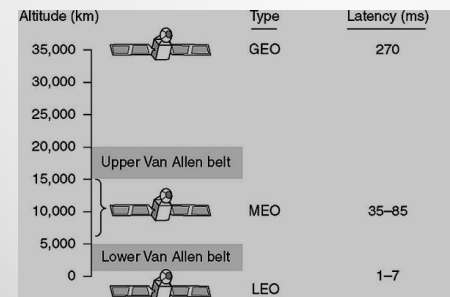 - Rate adaptation (use multiple codecs)

What is propagation delay? (Ethernet Physical Layer)

The propagation speed of a medium refers to the speed that the data travels through that medium.

Propagation delays differ between mediums, which affect the maximum possible length that medium.

Medium	Propagation/ Backbone Networks Transmission Delay	Percentage
Thick Coax	231,000 km/sec	77%
Thin Coax	195,000 km/sec	65%
Twisted Pair	177,000 km/sec	59%
Fiber	198,000 km/sec	66%

Communication Satellites

Altitude (km)		Type	Latency (ms)
35,000		GEO	270
Upper Van Allen belt			
10,000		MEO	35–85
Lower Van Allen belt			
0		LEO	1–7

Communication satellites and some of their properties, including altitude above the earth, round-trip delay time and number of satellites needed for global coverage.

Propagation/Backbone Networks Transmission Delay

Delay example: distance from A to B is 20 000 km in Fiber:

$$\text{Delay} = \frac{20\ 000\ \text{km}}{200\ 000\ \text{km/s}} = 100\ \text{ms}$$

Satellite on the Geostationary orbit:

$$\text{Delay} = \frac{80\ 000\ \text{km}}{300\ 000\ \text{km/s}} = 266\ \text{ms}$$

Application performance requirements:

delay: *time from the data are transmitted to the time the data are received.*

Propagation delay + queueing delay + transmission delay

propagation delay = distance / signal propagation speed

queueing delay: depend on the network load

transmission delay: how fast can you put bits on the wire?

Delay Budget

Delay Source (G.729)	On-net Budget (ms)
Device Sample Capture	0.1
Encoding Delay (Algorithmic Delay + Processing Delay)	17.5
Packetization/ Depacketization Delay	20
Move to Output Queue/Queue Delay	0.5
Access (up) Link Transmission Delay	10
Backbone Network Transmission Delay	Dnw
Access (down) Link Transmission Delay	10
Input Queue to Application	0.5
Jitter Buffer	60
Decoder Processing Delay	2
Device Playout Delay	0.5
Total	121.1 + Dnw

Compression Methods

Compression Method	Bit Rate (kbps)	Processing (MIPS)	Compression Delay(ms)	MOS Score
G711 PCM	64	0.34	0.75	4.1
G726 ADPCM	32	14	1	3.85
G728 LD-CELP	16	18	5	3.61
G729 CS-ACELP	8	20	10	3.92
G729a CS-ACELP	8	10.5	10	3.7
G723.1 ACELP	5.3/6.3	16	30	3.65

Voice Delay Guidelines

One Way Delay (msec)	Description
0–150	Acceptable for Most User Applications
150–400	Acceptable Provided That Administrations Are Aware of the Transmission Time Impact on the Transmission Quality of User Applications
400+	Unacceptable for General Network Planning Purposes; However, It Is Recognized That in Some Exceptional Cases This Limit Will Be Exceeded

ITU's G.114 Recommendation