Internet Problems and Potential

Henning Schulzrinne
Dept. of Computer Science
Columbia University
schulzrinne@cs.columbia.edu

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Overview

- Internet as data mover $\longrightarrow$ telecommunications infrastructure
- Internet telephony
- quality-of-service
- network layer
- transport layer
- applications

Internet as communication medium

- for some, email, web supplanted postal mail, fax, library
- but limited:

means of communications	year	millions/day
US Postal Service	1995	580
AT&T US phone calls	1995	200
ATM transactions	1993	20
UPS daily deliveries	1995	12
AOL email	11/1996	7
Federal Express	1995	2

➠ even for AOL subscribers, less than postal mail
31.8 phone calls, 13.6 emails, 11.2 voice mails, and 8.8 faxes / day.

Service integration

trench/conduit: typical residential, commercial (CATV, phone)

physical: SONET

data link: ATM, ISDN

network: IP ➠ largest speed, media range (300 b/s to 2.4 Gb/s)

Internet telephony: motivation

- compression
- security
- silence suppression
- traffic separation
- user identification
- computer-telephony int.
- shared facilities
- advanced services (simpler than AIN)
- user interface

Internet telephony: cost

Internet telephony: no $20 phone which doesn't need power plug

- build voice-only, single-chip DSP packet phones
- build into network computers
- low-bitrate digital ➠ RS-485 (100 kb/s) or ISDN (144 kb/s) coding

Internet telephony: delay

packetization and coding: G.723.1 = 30 ms + 7.5 ms look-ahead

propagation delay: 5 μs/km

transmission delay: only $10\mu s$ per hop

queueing delay: 16 kb/s voice on OC-12 backbone:

- voice priority ➠ 360 ms max. delay
- WFQ for all voice calls (single class) ➠ 40 ms
- WFQ for each call ➠ 194 ms

- but: 99% percentile more meaningful
- if no 2/4 wire transition ➠ 400 ms delay acceptable
- ATM doesn't help much
- largest delay: operating system, sound card

Internet telephony: interoperation with POTS

either origin, wide-area or callee may be POTS or packet

- end-to-end packet
- tail-end hop off
- front-end hop on

Impact of new Internet services on telephone system

If Internet replaces radio, telephone, . . . :

	minutes/day
long-distance calls, US	14
America Online (AOL)	32
local phone calls, US	38
total phone line usage	52
Internet	57
Television, Sweden	120
television, USA	240

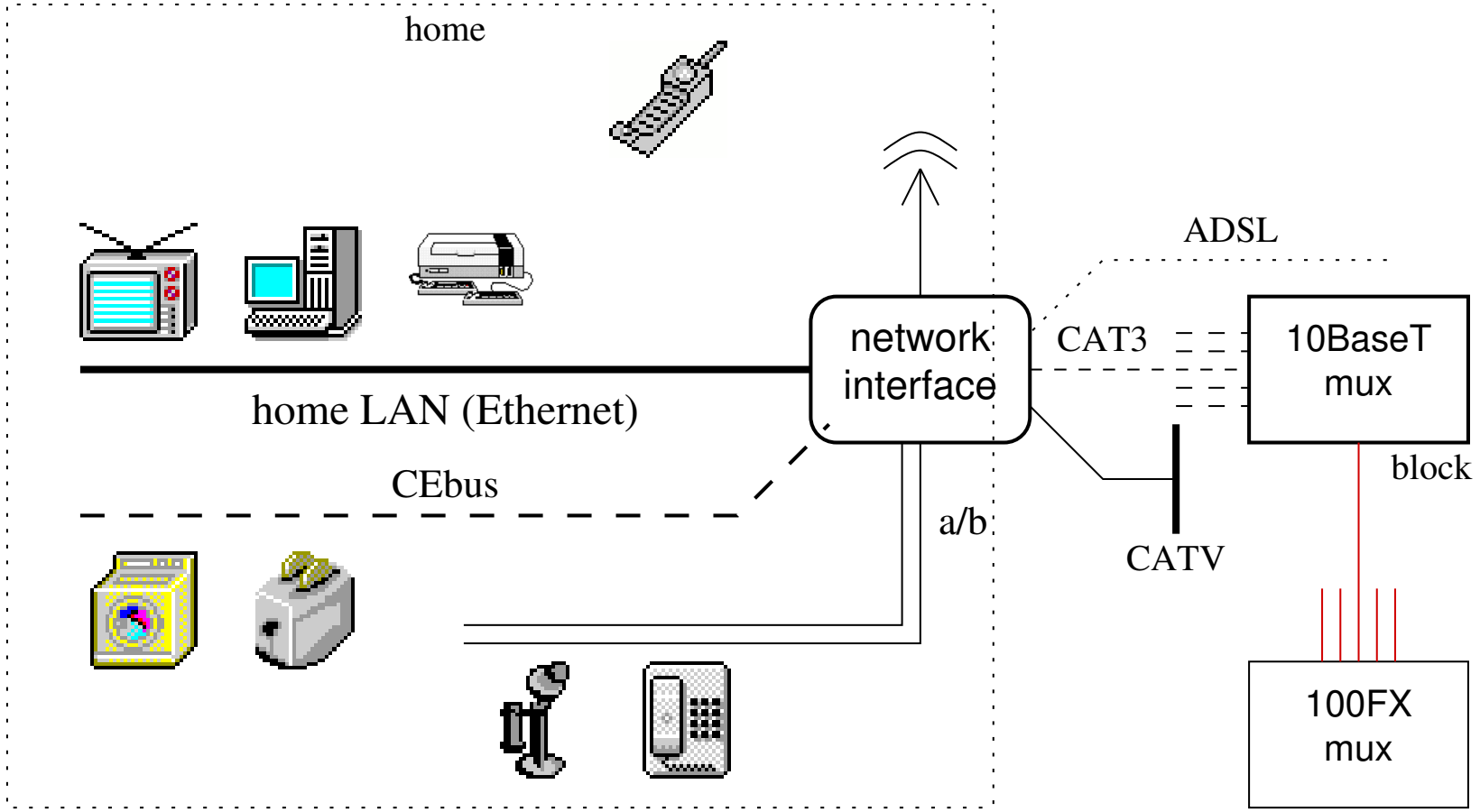
Internet access

phone network not designed for data services:

- low peak bandwidth
- long call-holding times
- no continuous connectivity (➠ Internet telephony)
- modem, business line cost ➠ $19.95/month cannot support radio-type services

➠ build single, “LAN-like” packet network for voice and data

Integrated Access



Switching costs

switching method	ports	capacity (Gb/s)	cents/kb/s	$/interface
10BaseT Ethernet hub	12	0.12	0.6	57
10BaseT Ethernet switch	24	0.24	1.2	121
100BaseTX Ethernet switch	8	0.80	0.5	474
router		2.1	16.0	
local ATM switch	16	2.48	1.0	1581
PBX	256	0.02	218.	140
Lucent 5ESS local (no AIN)	5,000	0.32	469.	300
Lucent 5ESS local (AIN)	20,000	1.28	273.	175
Lucent 4ESS toll (100k lines)	6.40	7.8		

Reliability

- phone switch: 120 seconds/year
- AOL: 88 hours/year for 1996
- ANS: 44 hours/year promised
- Ethernet switch: MTBF $\approx$ 20 years
- router configuration, route flap
- on-line software upgrades
- end-system auto-configuration (already easier than ISDN. . .)

Quality of Service

best effort with traffic engineering: "expected service" ➠ 20 kb/s now

- adaptive applications
- more loss-tolerant than ATM model (1%, not 10^{-12})
- robustness principle

priority: voice, multimedia

- scales in processing load, state
- but no addmission control
- which priority for which service?

class-based scheduling: set aside bandwidth for classes

per-flow reservation: scaling in processing, state

Quality of Service: Per-Flow Reservation

- RSVP: receiver orientation (but: not always needed) ➠ complexity (path divergence)
- Internet virtual private networks
- admit flow, assign to class
- or: integrated with application ($\rightarrow$ router alert)
- "CAC" efficiency not that important

Network Layer — IPv4, IPv6

- datagram is *the* fundamental service model
- scalable from 300 b/s to 2.4 Gb/s
- cut out the middle man (ATM) ➠ IP over Sonet?
- routers can be built *almost* as fast as switches
- $O(1)$ address lookup
- IPv4 ➠ IPv6:
  - dynamic assignment $\leftrightarrow$ ADSL, cable modem, embedded devices
  - intranets with address re-use
  - larger switched networks ➠ address-space efficiency
  - 60 bytes packet header overhead for Internet telephony
  - security, QOS, auto-configuration: can be provided by IPv4

Transport Layer — TCP

- window congestion control doesn't scale to small bandwidths
- packet loss as congestion indicator: wireless, UDP
- packet loss ➠ long pauses
- distance unfairness
- ABR-like service for congestion ➠ separate reliability, congestion control
- TCP-like behavior for other services?
- rely on well-behaved implementations
- reliable multicast: no single protocol?

Application-Specific Protocols

- CORBA (like session, presentation layer) ➠ displace HTTP, etc.?
- stable (and ugly. . .) core: HTTP, telnet, ftp, SMTP + MIME, POP, IMAP
- each: I17N, security, extensions, . . .
- all but telnet: replacable by HTTP
- new protocols: multimedia control (RTSP), telephony signaling (SIP), HTTP extensions (PEP, JEPI, P^3, . . .)

Applications

- addressing: better than `lee1389@provider.com`?
- portable security infrastructure
- caching:
  - basically, only AOL
  - less efficient as more diversity
  - needed for streaming multimedia content

Summary

- integrate at the network layer ➠ media-independent
- cost, functionality advantages of integrating phone, radio
- protocol pieces *almost* there
- fine tuning, but hard to make changes