Re-Engineering the Telephone System

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Overview

- Internet as communication medium
- Internet telephony
- Internet radio and television
- Internet access
- protocol architecture
- reliability

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

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
- silence suppression
- traffic separation
- user identification
- computer-telephony int.
- shared facilities
- advanced services
- user interface

Internet telephony: cost

- Internet telephony: no \$20 phone with no local power
- 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: options and delay bound for 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

Note:

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

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

Internet radio

- niche audiences (shortwave replacement)
- directory services, end-system processing ➠ custom, time-shifted programs
- media-on-demand, near MoD, multicast

Realistic:

- all 12,140 U.S. radio stations ➠ 680 Mb/s
- all 100 major stations in Germany ➠ 5.6 Mb/s
- 45 New York FM stations ➠ 2.5 Mb/s

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

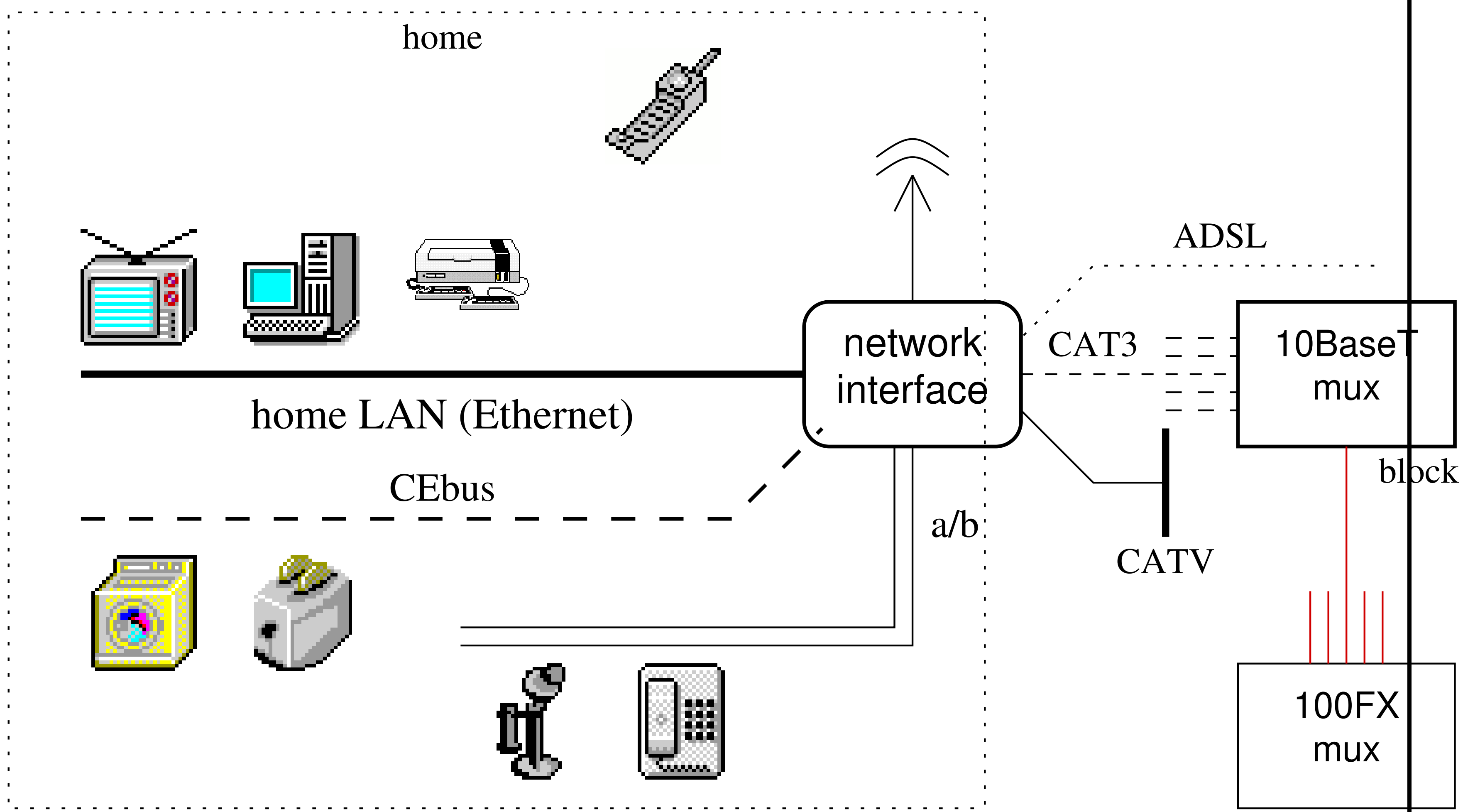
Internet access

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		

Protocol architecture

data delivery: IP(v4,v6) + UDP + RTP

resource guarantees: ➠

- RSVP (+ security, billing)
- IP type-of-service, priority (with rate limiting)
- base guarantees + adaptation

routing: QOS-based routing?

management: SNMPv2

signaling: SIP

media-on-demand control: RTSP, description languages

Telephony signaling

- email address $\longrightarrow$ universal communication identifier: telephony, conferencing, ...
- $+$: location-independent, provider-independent, permanent, mnemonic
- but: entry in low-function devices?
- easy: integration with calendar, LDAP
- protocol: SIP (simple, HTTP-like) or H.323 (ISDN-like)

Reliability

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

Summary

- integrate at the network layer ➠ media-independent
- cost, functionality advantages of integrating phone, radio
- protocol pieces *almost* there
- network reliability?