Internet Telephony for Universities

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Overview

- Internet telephony: motivation and problems
- Campus VoIP architectures
- Session Initiation Protocol (SIP)
- Internet telephony "appliances"
- Programming your telephone (service)
- Mobile services

The phone works — why bother with VoIP?

user perspective	carrier perspective
• variable compression: tin can to broadcast quality	• silence suppression ➠ traffic ↓
• security through encryption	• shared facilities ➠ management, redundancy
• caller, talker identification	• advanced services (simpler than AIN and CTI)
• better user interface	• operational advantages
• internat. calls: TAT transatlantic cable = $0.03/hr	• cheaper switching
• no local access fees (3.4c)	• fax as data
• easy: video, whiteboard, ...	

The new phone companies

- separation bit carriage $\leftrightarrow$ services
- anybody with Internet connection can provide services (ACD, 800, 900, directory, ...)
- distinction "in" vs. "out" of network not useful
- incremental start-up investment not large
- new players:
  - cable companies ➠ no new infrastructure, but mostly one-way
  - electric utilities ➠ need line management anyway
  - Qwest, IXC (resell to ISPs), ...

Internet telephony services

- voice mail $\longrightarrow$ email
- calendar integration
- user-programmable call processing logic
- call first available sales person (ACD)
- call whole department
- web IVR
- return web page with favorite “on hold” music

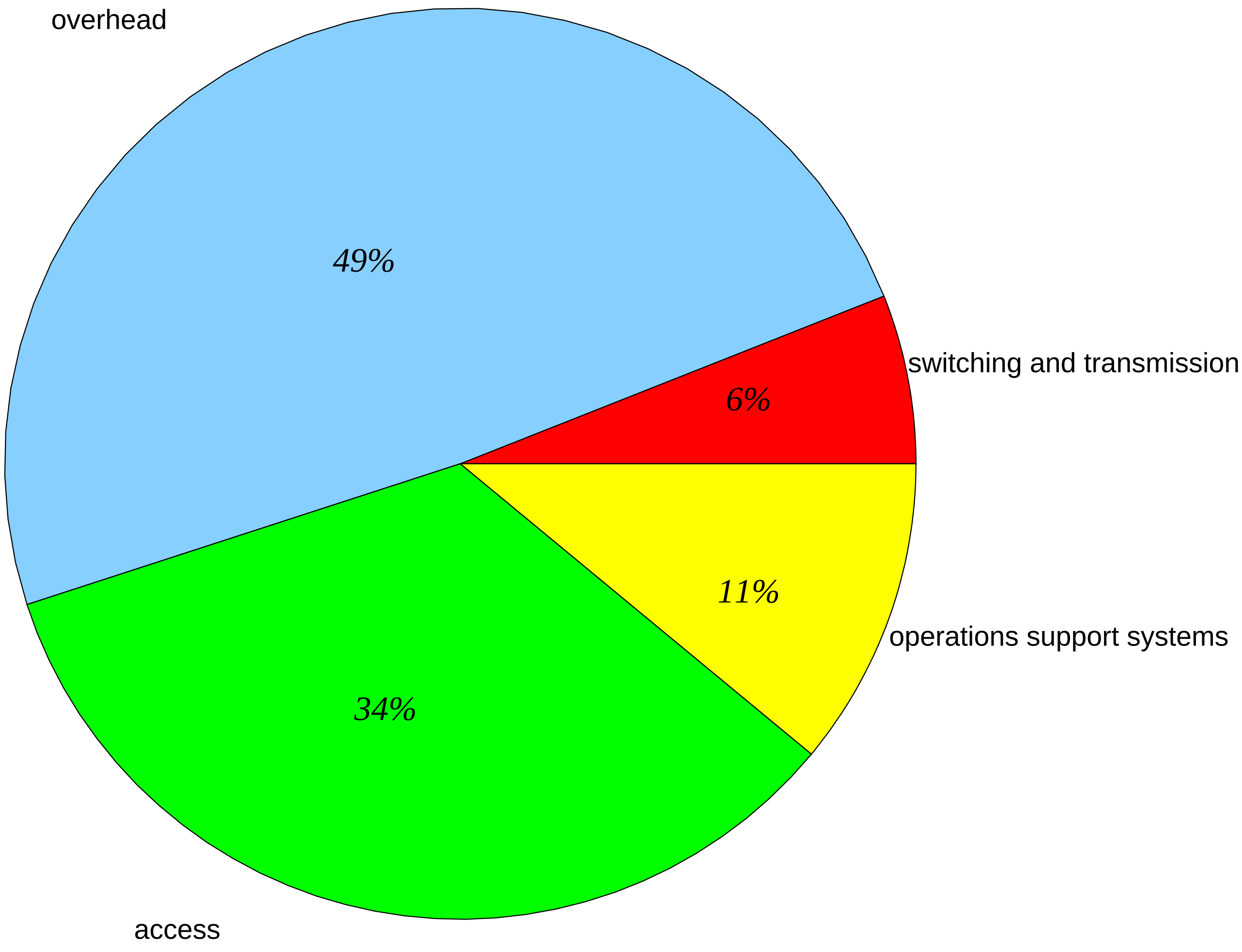
Internet Telephony Services

- camp-on without holding a line
- short message service (“instant messaging”)
- schedule call into the future
- call with expiration date
- add/remove parties to/from call ➠ mesh
- “buddy lists”

Switching Costs

Device	port speed	port cost	cost/64 kb/s
8-port Ethernet hub	10/100 Mb/s	8	0.008
24-port Ethernet switch	10 Mb/s	55	0.35
8-port Ethernet switch	100 Mb/s fiber	474	0.30
8-port Ethernet switch	1 Gb/s	1187	0.08
24×100BaseT + GigE	10/100 Mb/s	141	0.09
100 T1 circuit switch	1.5 Mb/s	25,000	1041
5ESS local (no AIN), 5000 lines	64 kb/s	300	300
5ESS local (AIN), 20,000 lines	64 kb/s	175	175
Small PBX (few hundred lines)	64 kb/s	1,000	1,000
Large PBX ($>$ 5000 lines)	64 kb/s	500	500

Telephone Costs



Transport Costs

network	$/min	$/MB
wholesale telephone	0.01–0.02	
U.S. domestic interstate consumer rates	0.05–0.15	
U.S. domestic intrastate consumer rates	0.05–0.25	
modem		0.25 – 0.50
private line		0.50 – 1.00
frame relay		0.30
MCI frame SVC		0.05
Internet		0.04 – 0.15
Internet modem		0.33
Internet backbone		0.01

1’ voice = 480 kB w/silence suppr., 1 MB without

Phone Usage

"Free" phone calls does not mean unbounded increase:

year	lines (millions)	local calls min/day/line	local calls min/day/person
1980	102.2	39	17.5
1988	127.1	39	20.2
1996	166.3	40	25.1

Why Aren't We Using It Now?

Internet capacity $\ll$ phone traffic:

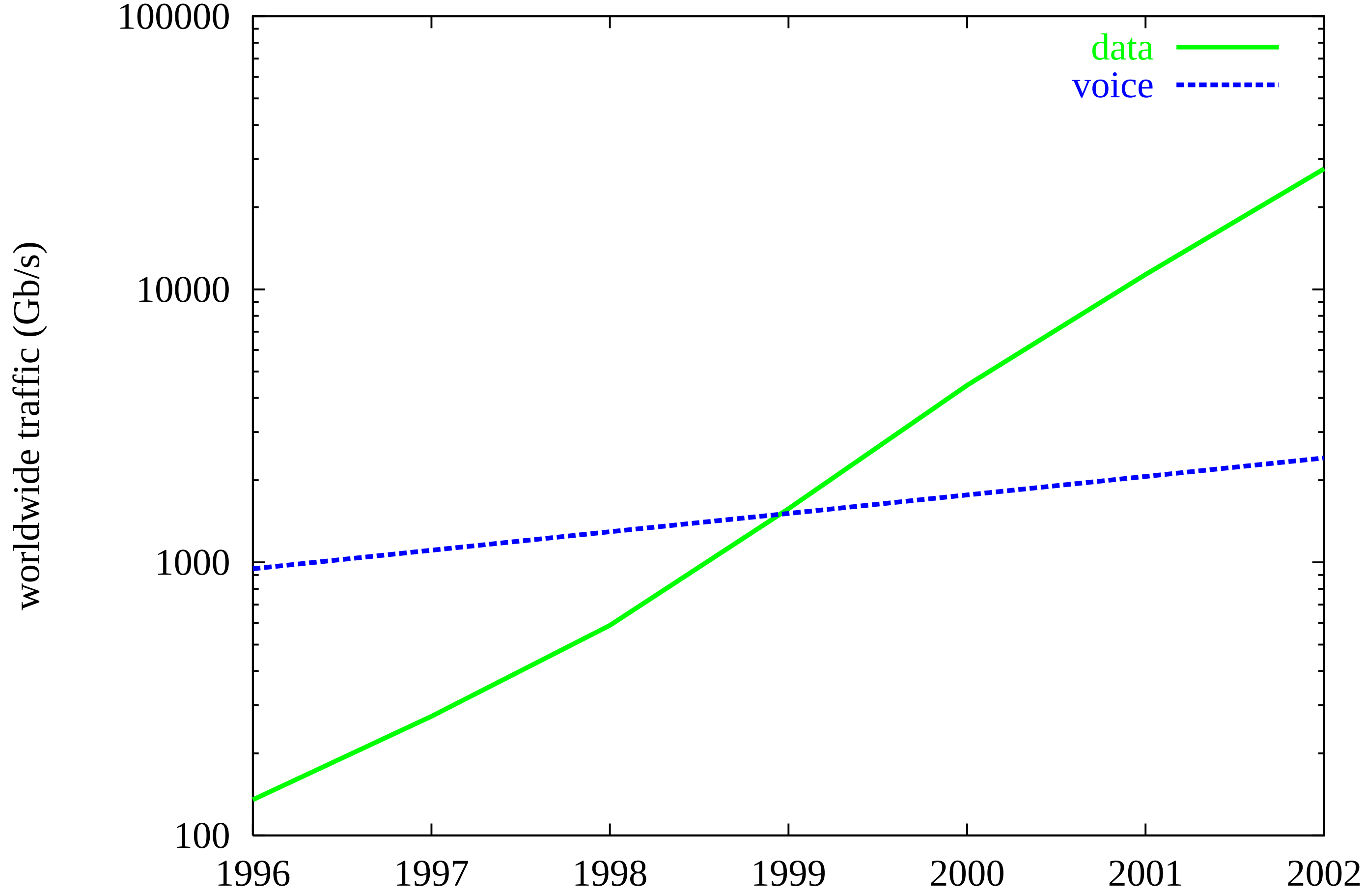
world phone traffic	600	Gb/s	U.S. total	368	Gb/s
international traffic	13	Gb/s	U.S. interstate	55	Gb/s
			AT&T long distance	61	Gb/s
public Internet (late 1997)	75	Gb/s			

- unpredictable sound quality, reliability
- doesn't work well for dial-up users
- no cheap Internet devices
- 640 M phone lines, 122 M in U.S. ➠ gateways
- no billing infrastructure

Projections

- MCI: “80% data, 20% voice”
- “AT&T could lose $350 million in international calls by 2001”
- “By 2002, the Internet could account for 11% of U.S. and international long-distance voice traffic”
- “Up to 10% of the world’s fax market, which generates $45 billion in telecom revenue a year, will move to Internet in 2 or 3 years”
- May 1999: BT builds IP phone network in Spain
- but: cable modems only 250,000 to 275,000 users in US, 10% of Internet users by 2000

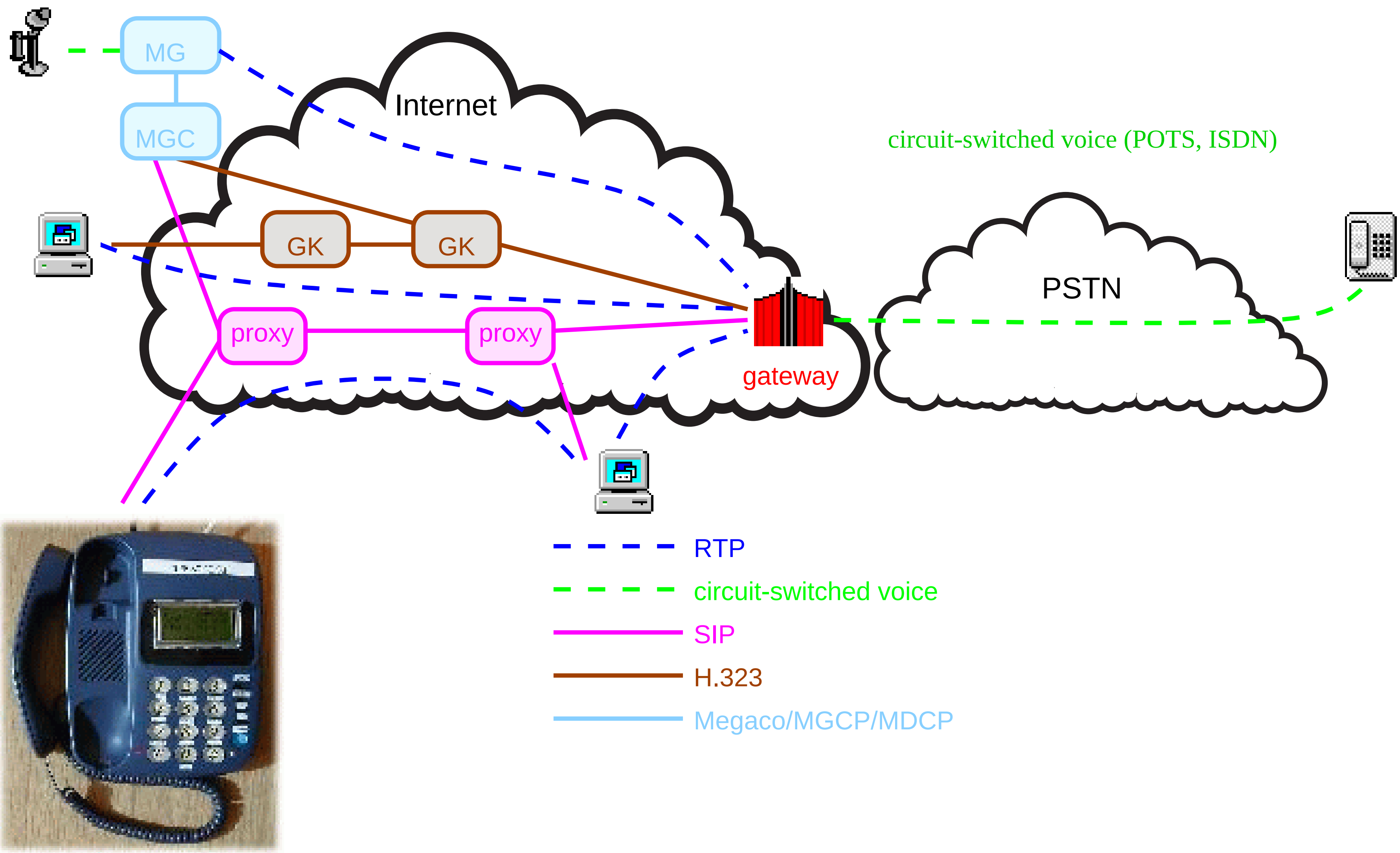
Data vs. Voice Traffic



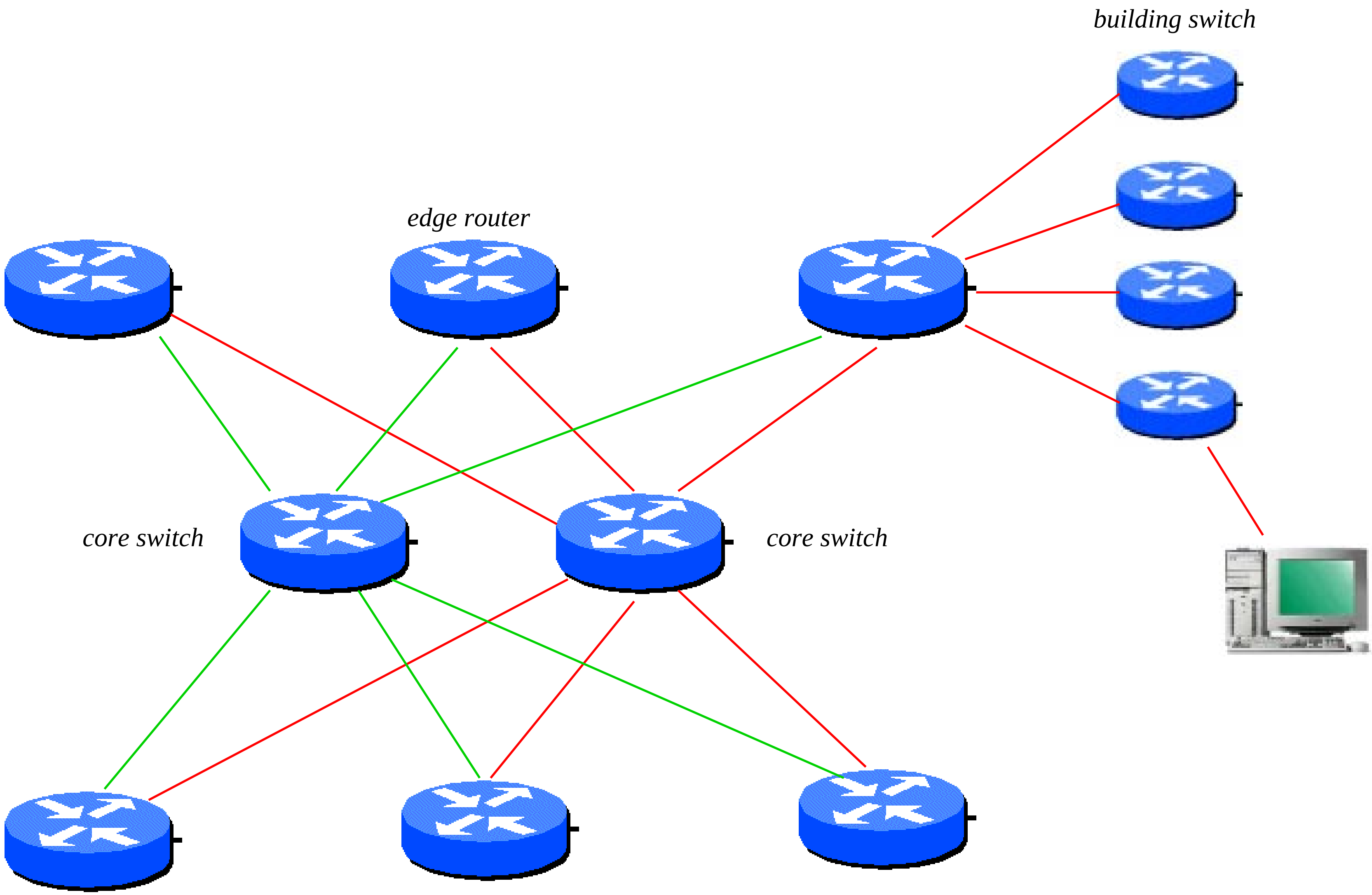
Why on Campus?

- PBX nearing end of useful life, capacity
- dorm rooms, offices already wired with Cat-3/5
- backbone high-speed data capacity (20,000 users at 0.1 Erlang $\rightarrow$ 128 Mb/s, but not all calls are across campus)
- no latency issues
- video, data sharing
- re-use data connections as tie-lines to satellite campuses, dorms, faculty housing, ...

Internet Telephony Architecture



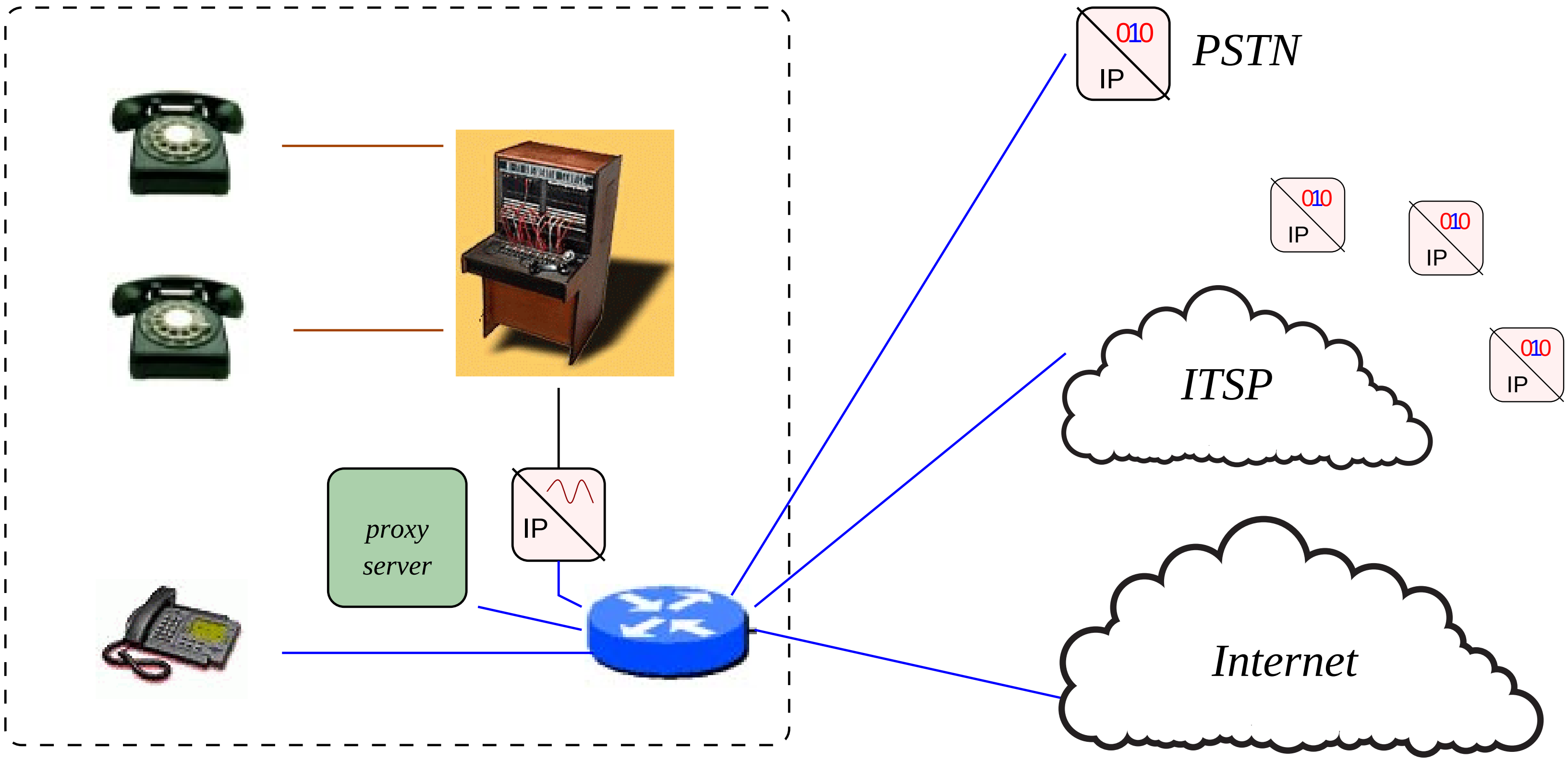
Campus Data Architecture



Architecture Options

- separate wiring vs. same network
- stimulus control vs. intelligent end systems
- IP Centrex vs. external PSTN interface

A Campus VoIP Architecture



Separate Wiring

- re-use CAT3 wiring ⟶ just requires centralized changes
- but: distance limitation of 100–150 m
- power requirements:

Etherphones	3–6 W
Wireless access point	4-11 W
Ethercams	8-11 W
Ethernet hub	30 W?

- powering for end systems and hubs:
  - local battery
  - Ethernet powering

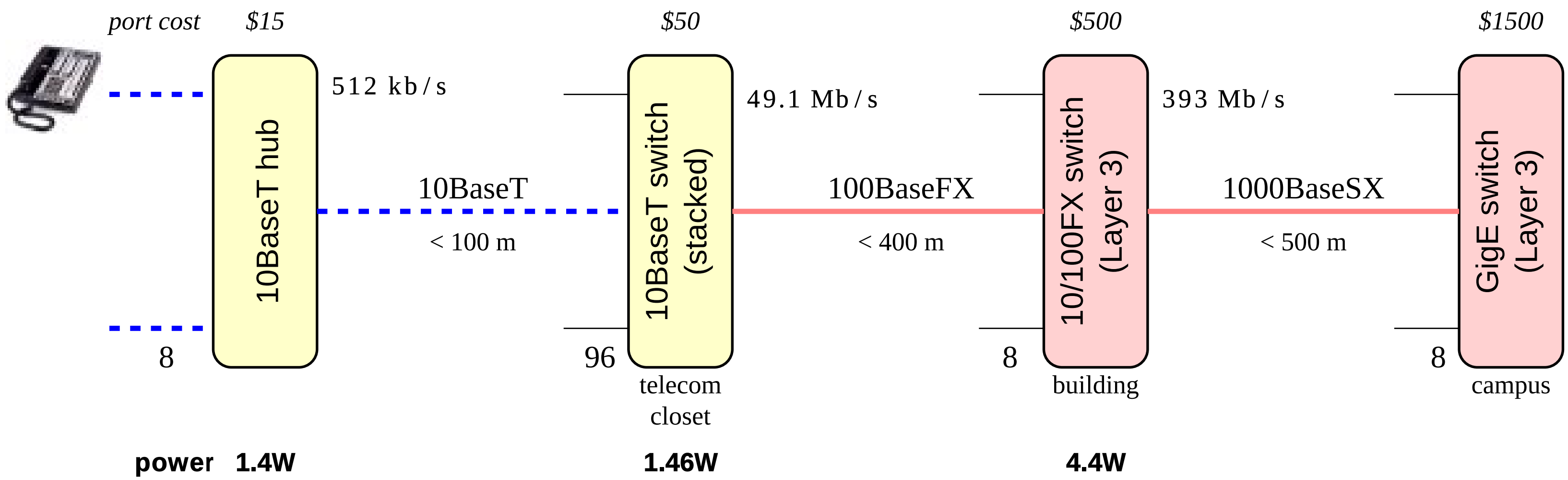
Ethernet Power

Ethernet cable (802.3 working group):

- phantom powered on 3/6, 1/2
- idle wires (4/5 and/or 7/8)
- automatic recognition of powered devices

Do all systems need to be powered?

Architecture for 20,000 Lines



Stimulus Control vs. Intelligent End Systems

	stimulus	end system
protocol	MGCP	SIP, H.323
new services	upgrade MGC	proxy, end system software
user interface	like phone	more state information
scaling	single server	distributed
simple devices	yes	SIP: yes, H.323: ?

Quality of Service

- codecs can be same or better than POTS
- primarily, delay:

  audio encoding/decoding: look-ahead, block (20-50 ms)

  application: non-adaptive playout buffers

  end system: operating system, sound card (buffer)

  propagation: 5 μ/s km

  queueing: depends on congestion

  transmission: line speed; insignificant for $\geq$ T1

Delay

- ITU.T delay target < 150 ms
- average vs. peaks!
- avg. US *round-trip* (UUnet, Oct. 1999): 45.49 ms
- Miami – Seattle (CWI, Nov. 1999): 92.4 ms