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

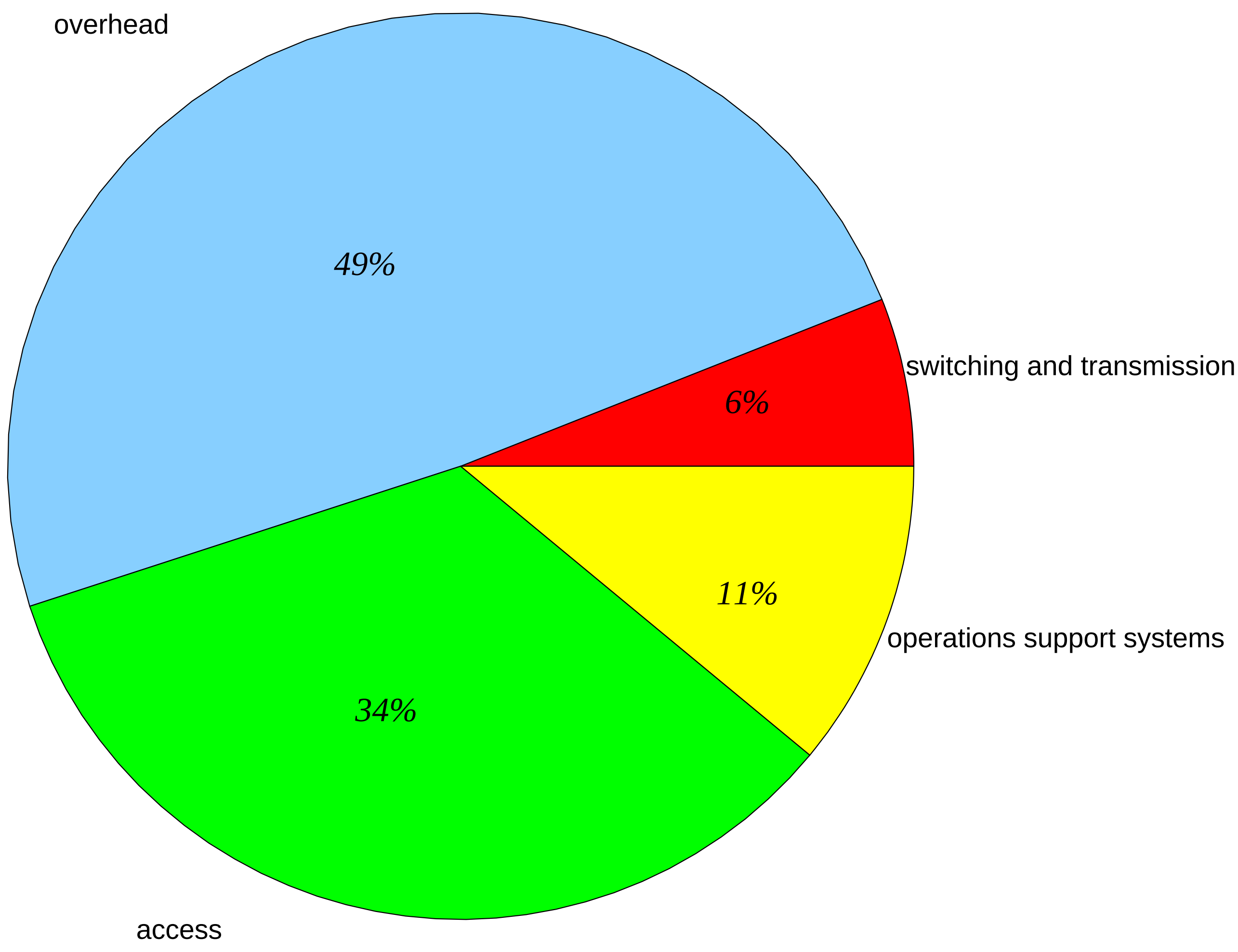
Internet Telephony Services

- 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:

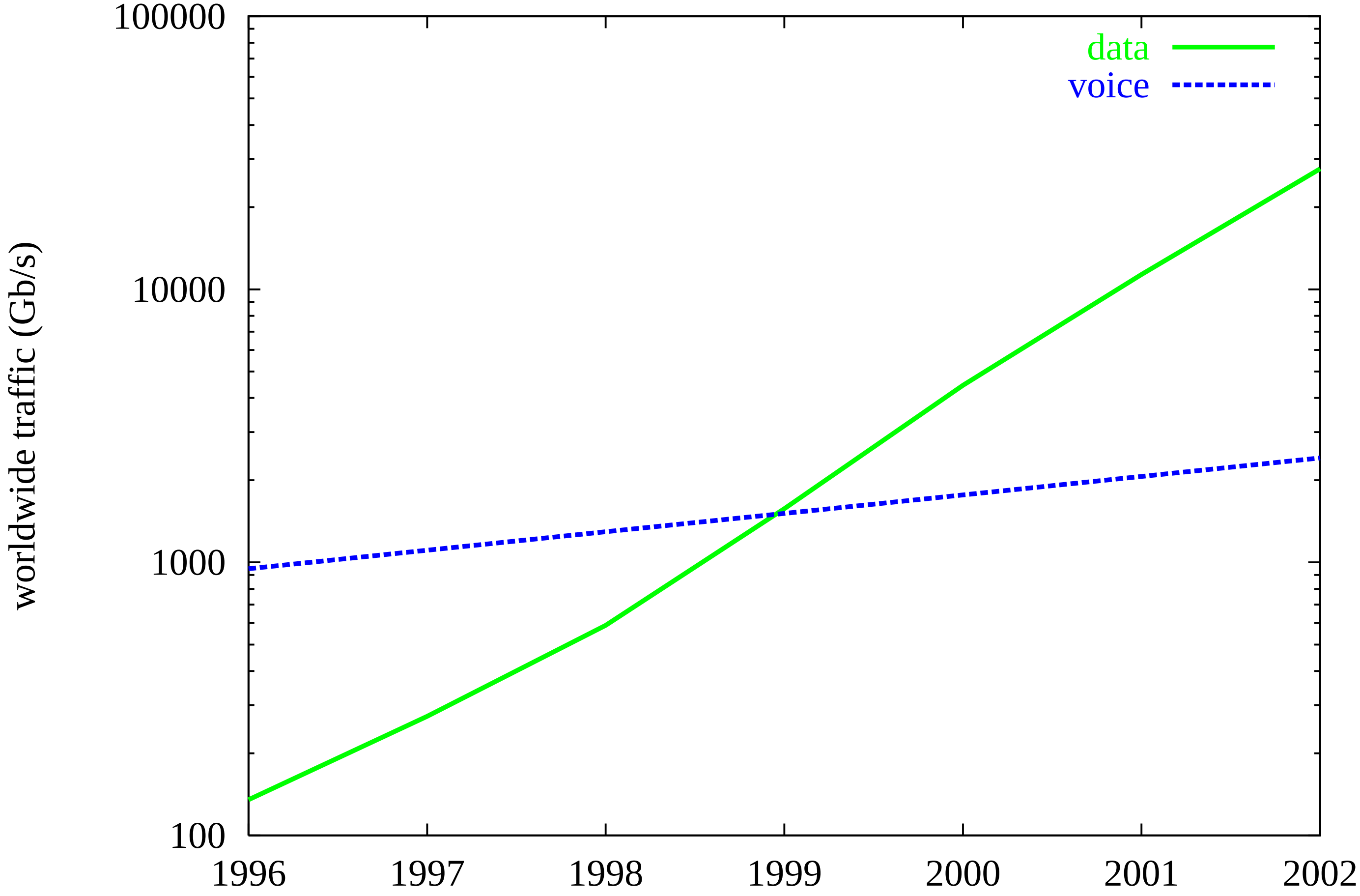
world phone traffic	600	Gb/s	U.S. total	368	Gb/s
international traffic	13	Gb/s	U.S. interstate	55	Gb/s
			AT&T long distance	61	Gb/s
public Internet (late 1997)	75	Gb/s			

- 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

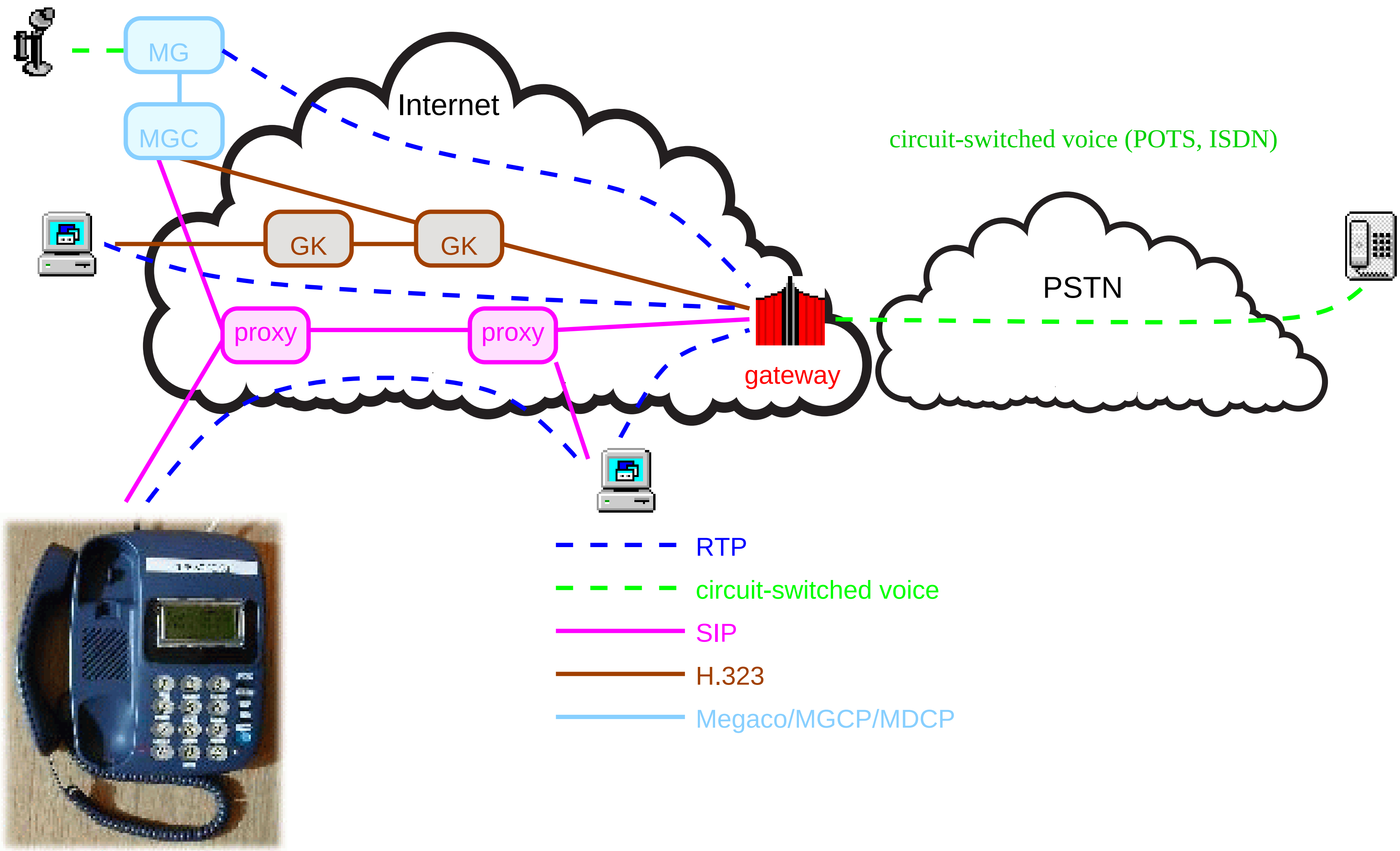
Data vs. Voice Traffic



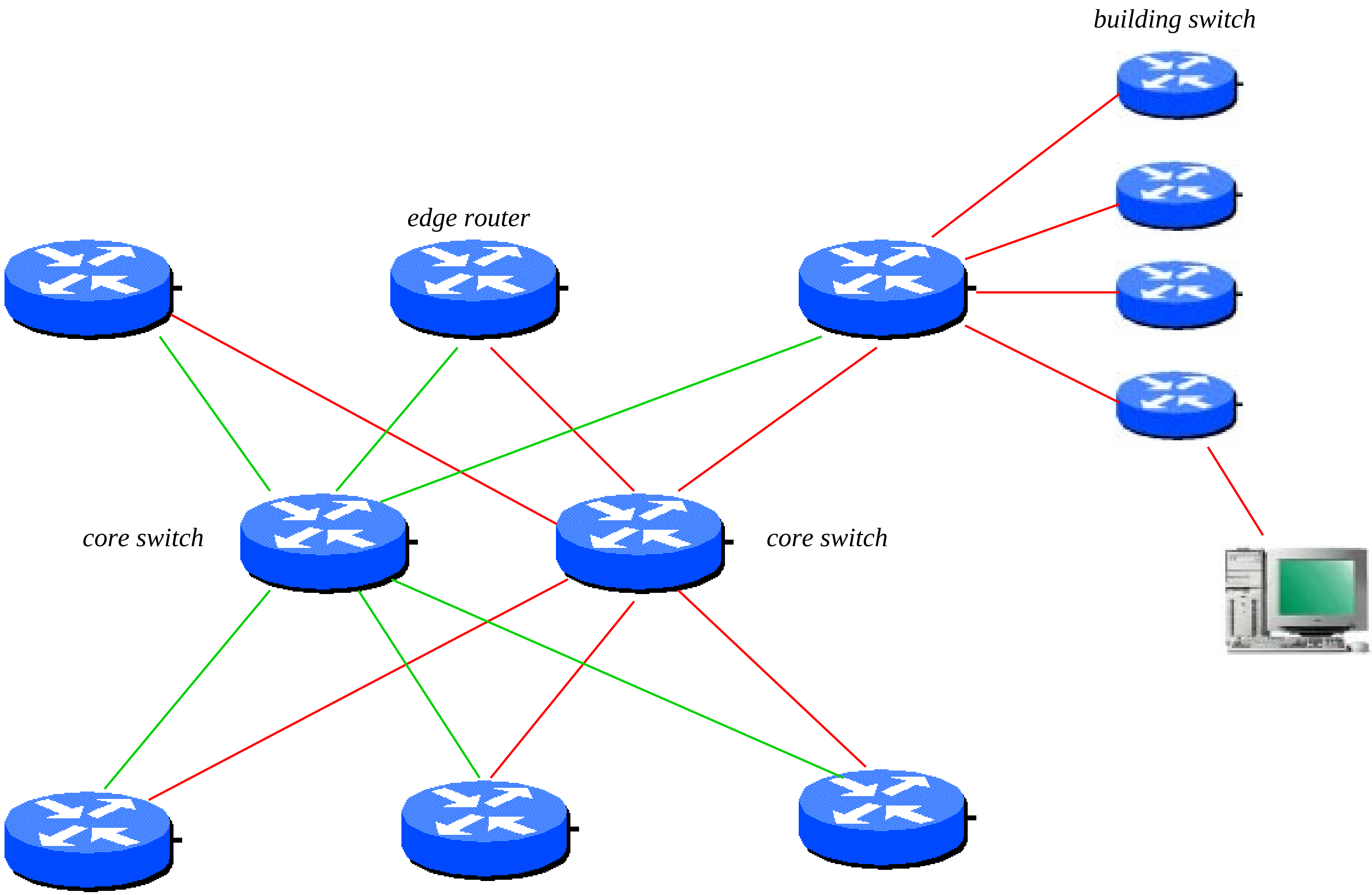
Why on Campus?

- 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



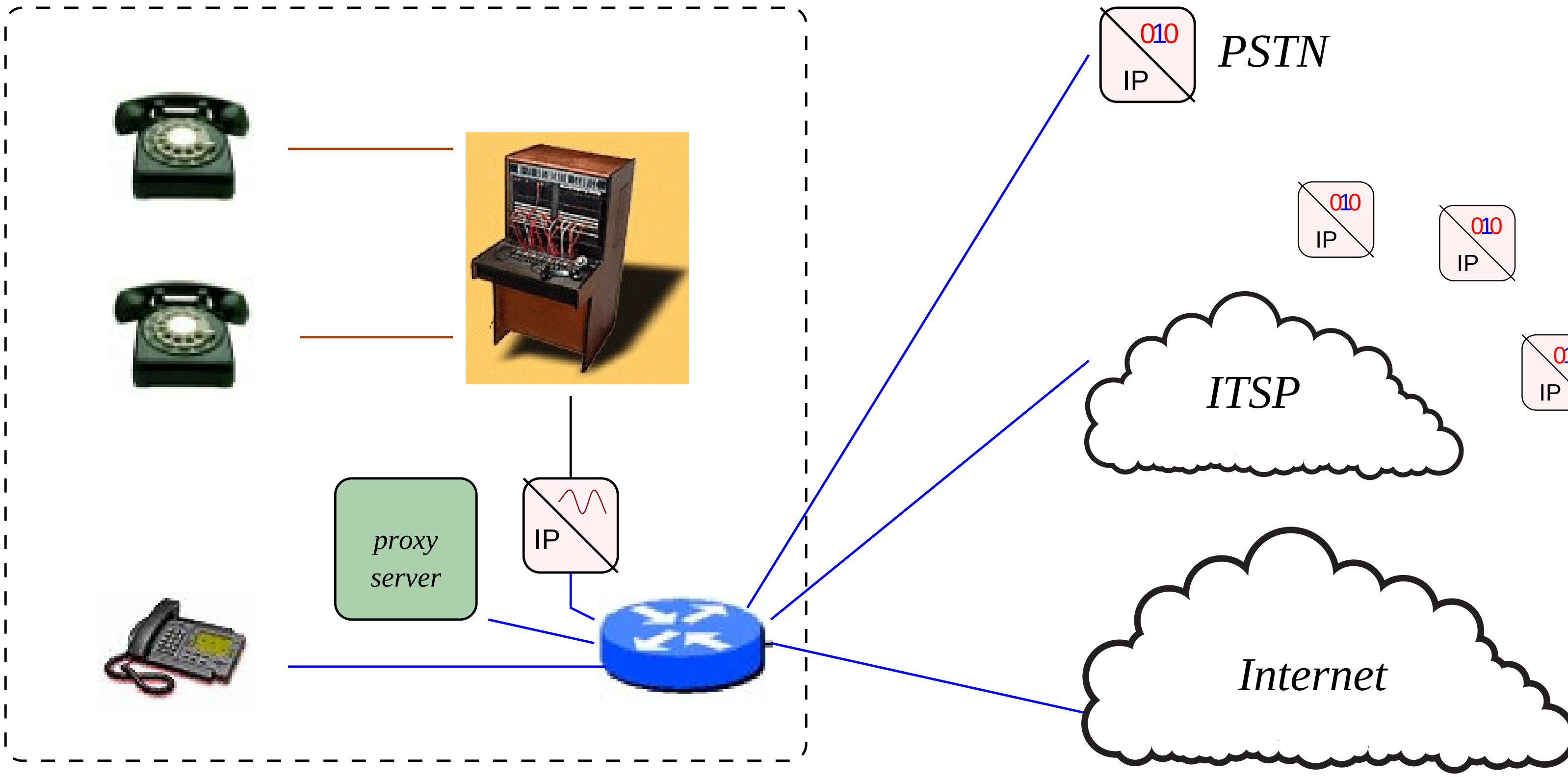
Campus Data Architecture



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 $\longrightarrow$ 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

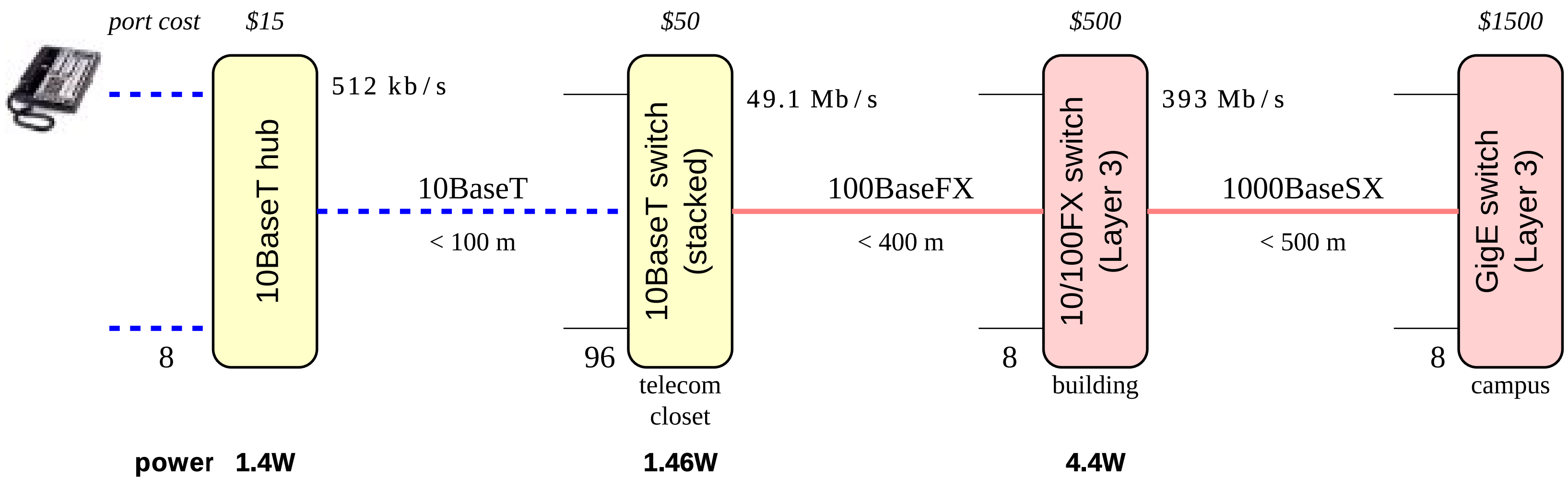
Ethernet Power

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
$>$ 1 service provider	no	yes
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 μs/km

  queueing: depends on congestion

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

Delay

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