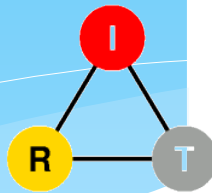# Will the Last Phone User Please Turn Off the Dial Tone?
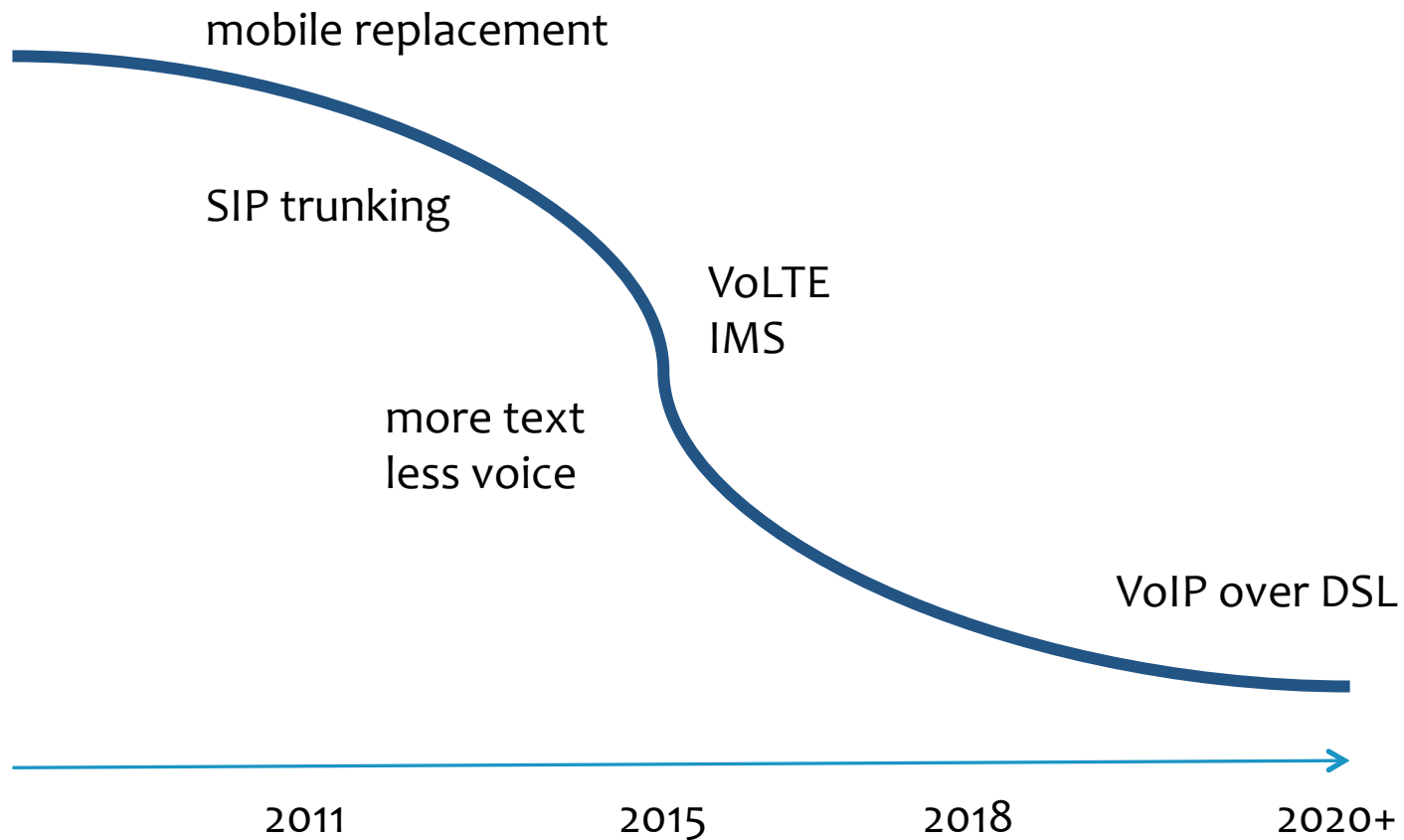
Henning Schulzrinne (Columbia University)
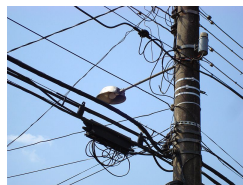
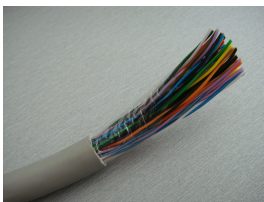# Overview

* The PSTN is dying
  – *1876 ✝ 2018?

* … but real-time communications continues

* Issues:

  – numbering

  – public policy issues

    * 911 & location

* Open Internet as enabler of competitive VoIP

The fall of the PSTN empire

mobile replacement

SIP trunking

VoLTE
IMS

more text
less voice

VoIP over DSL

2011   2015   2018   2020+

Four separate components

Real-time: voice → non-voice

* 1950—2005: real-time ≡ voice

* Now: real-time = web interaction + **text** + voice

* Displacement:
  – teenage 2-hour chat → Facebook, IM
  – coordination & transaction calls → web
    * schedule appointments, travel agency, airline, …
 – business calls → messaging
  – "I'm heading home" → Google Latitude

CS@CU

Time of transition

Old	New
IPv4	IPv6
circuit-switched voice	VoIP + text
separate mobile voice & data	LTE + LTE-VoIP
911, 112	NG911, NG112
digital cable (QAM)	IPTV
analog & digital radio	Pandora, Internet radio, satellite radio
credit cards, keys	NFC
end system, peers	client-server v2 aka cloud

all the energy into transition → little new technology
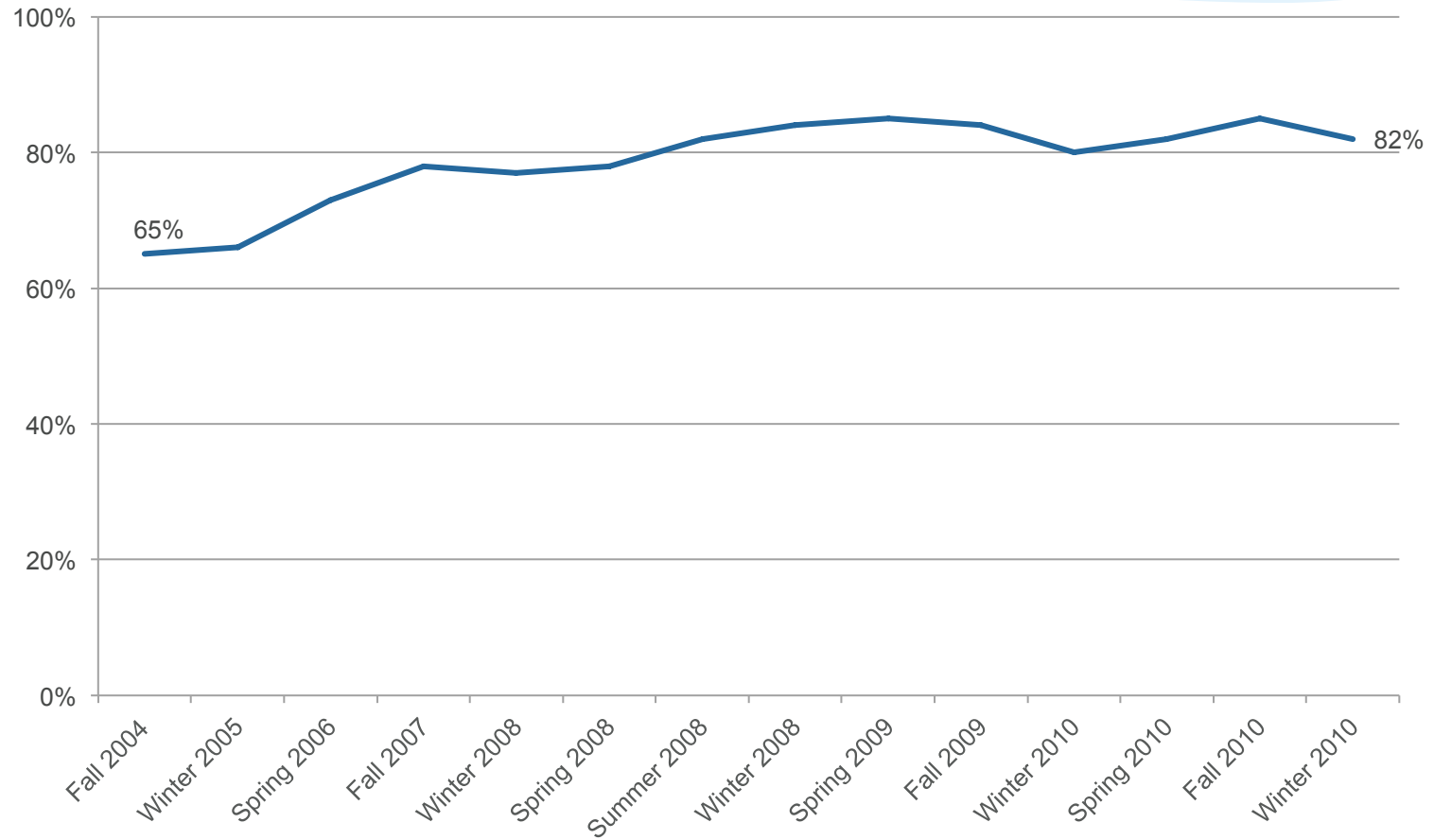
Telecom revenue
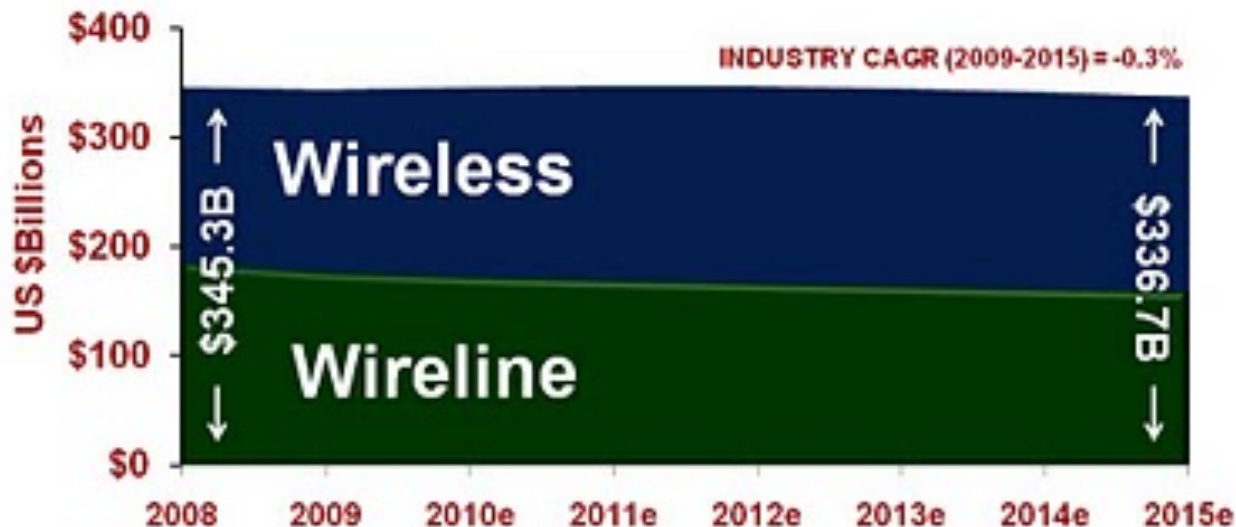
Cell ownership, 2004-2011

Cell ownership vs. other devices
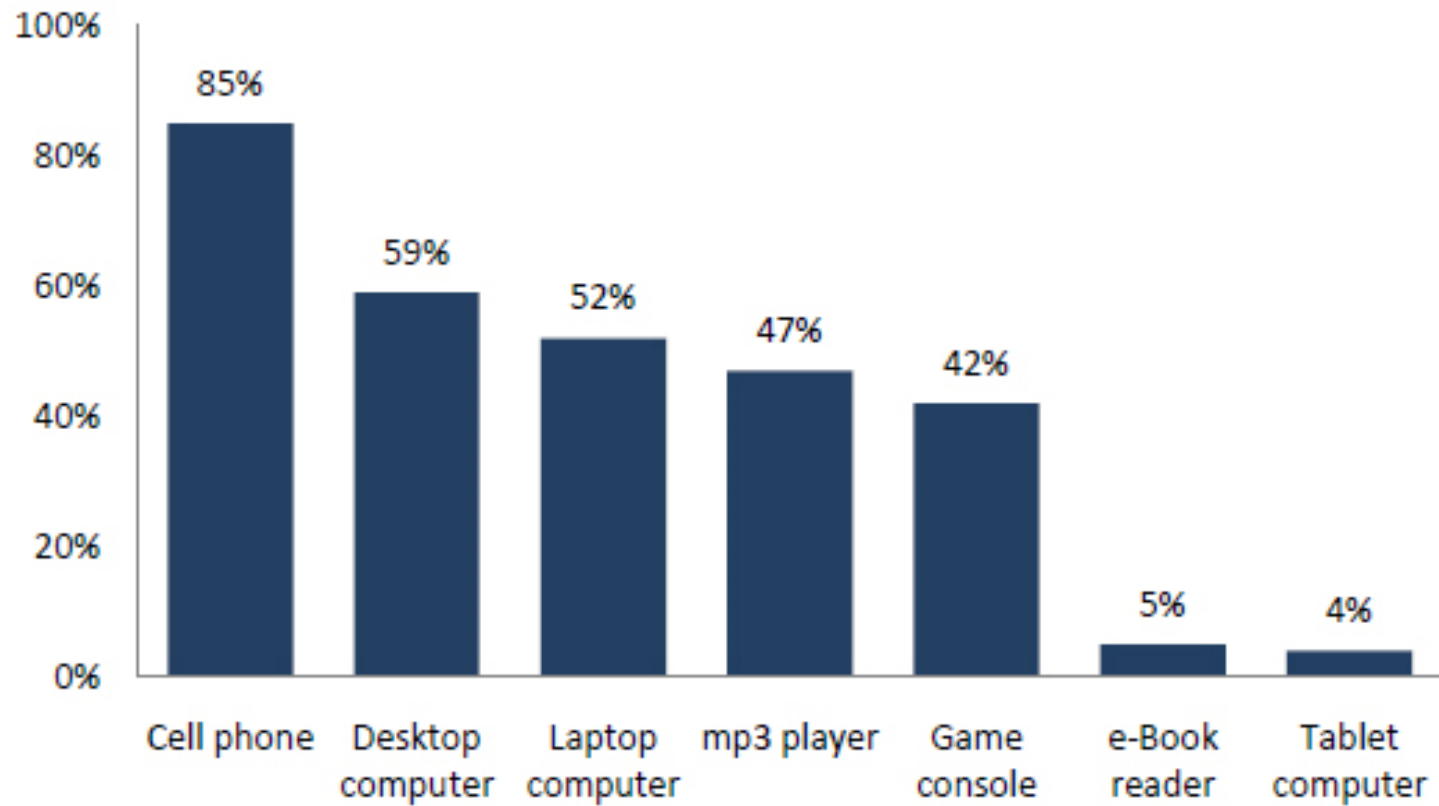
Mobile-only households and demographics (CDC data)

Percentages of adults and children living in households with only wireless telephone service or no telephone service: United States, 2003–2010
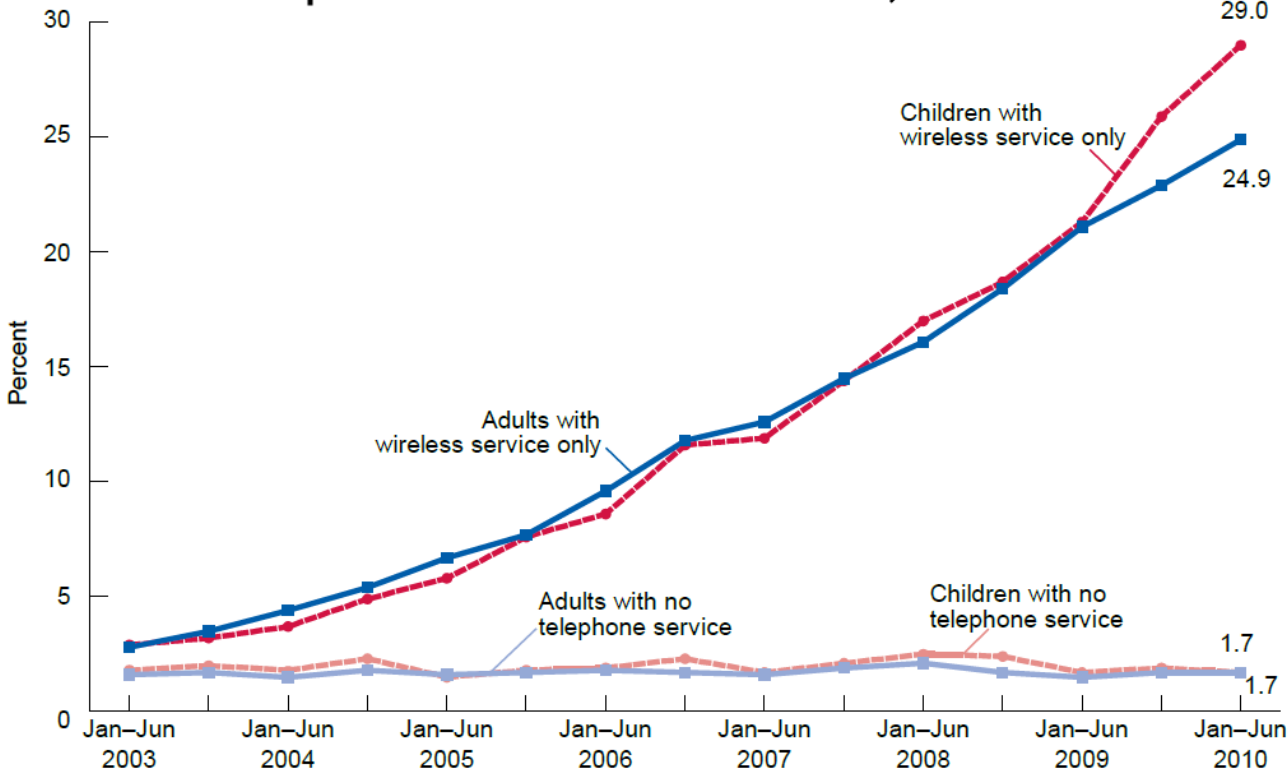
NOTE: Adults are aged 18 years and over; children are under age 18.
DATA SOURCE: CDC/NCHS, National Health Interview Survey.

High Wireless Substitution:

* Young adults (esp. those ages 24-29)
* Renters
* Low income (poverty line or below)
* Latino/Hispanic

Household spending on telecom
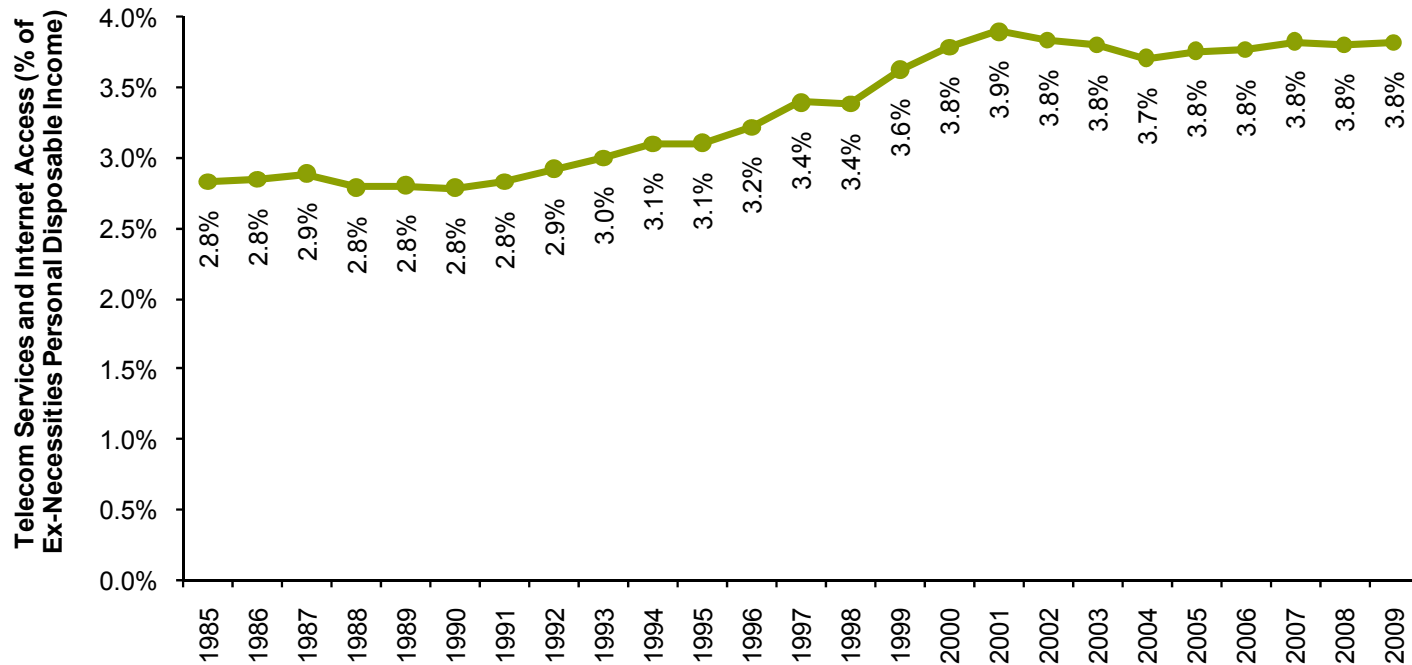
Note: Necessities include food, housing, transportation, energy and healthcare.

→ new services must displace old services

Wireless + Internet replace voice
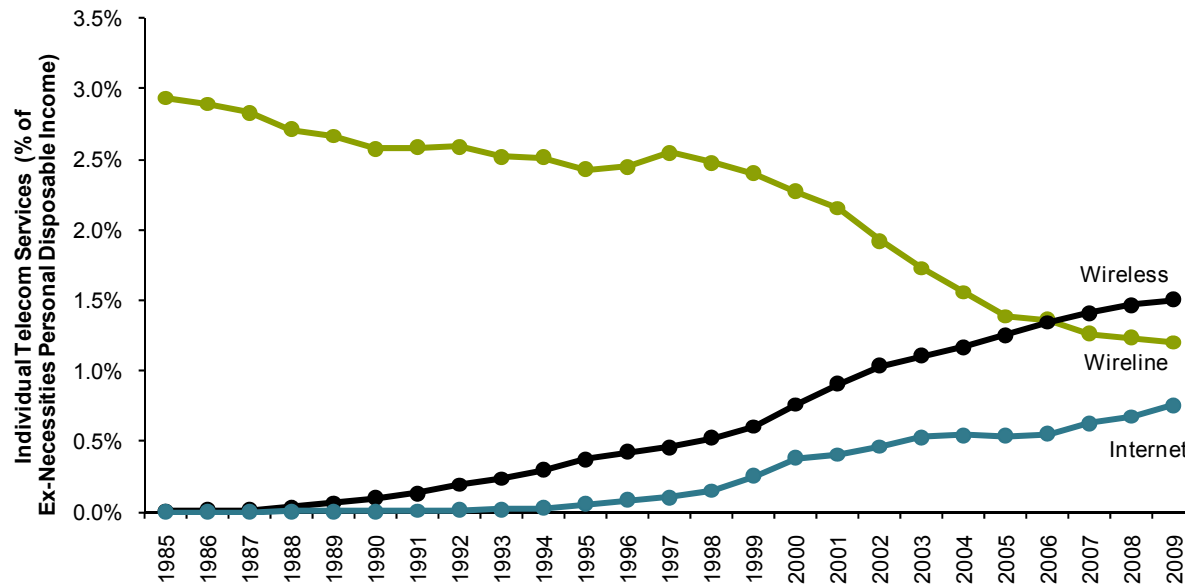
Source: Bureau of Economic Analysis.

Telephone Social Policies

Universal service (Lifeline, high cost, …)	Necessary to function (call doctor, call school, …)
Basic service price regulation	Ensure widespread availability
911	Report emergencies for self and others
Power backup	Ensure emergency communications
Outage reporting	Ensure reliability
Lawful intercept (CALEA)	Phone as tool for criminals
Disability access (ringers, HAC)	Ensure participation in society
CPNI	Phone as private medium

Now: the Internet

Universal service	USF reform? (Connect America Fund)
Price	Unregulated, competition?
911	NG911
Power backup	Cell phones? Responsibility moves to household (UPS)
Outage reporting	FCC Part 4 NPRM multiple access modes
Lawful intercept (CALEA)	Encryption?
Disability access	Twenty-First Century Communications and Video Accessibility Act of 2010?
CPNI	Uncertain privacy rights

It's just a number

Number	Type	Problem
201 555 1212	E.164	same-geographic different dial plans (1/no 1, area code or not) text may or may not work
#250, #77, *677	voice short code	mobile only, but not all no SMS
12345	SMS short code	SMS only country unclear
211, 311, 411, 911	N11 codes	Distinct call routing mechanism Mostly voice-only May not work for VoIP
800, 855, 866, 877, 888	toll free	not toll free for cell phone may not work internationally
900	premium	voice only unpredictable cost

Numbers

* Administered in blocks by NANPA
  - funded by carriers: $5.9M/year
* Separate processes for each number type
  - Regular E.164 numbers by 1k blocks
* Complicated LNP and porting technology
  - often takes several phone calls to provider
  - takes, at best, several hours
  - limited wireline ⇔ wireless porting
  - limited wireline out-of-area porting

Numbers vs. DNS

	Phone #	DNS
Country-specific	mostly	optional
# of devices / name	1 (except Google Voice)	any
# names /device	1 for mobile	any
ownership	carrier, but portability unclear (800#)	property, with trademark restrictions
porting	complex, often manual wireline-to-wireless may not work	about one hour (DNS cache)
delegation	companies (number range)	anybody
identity information	wireline, billing name only	WHOIS data (spotty)

Future numbers

* Should numbers become personal property?
    – separate service & number
    – simplify number portability
* Divorce device & number
    – any-to-any, dynamic mapping
* Separate user identity & number

CS@CU

Cost issues

Monthly expenditure
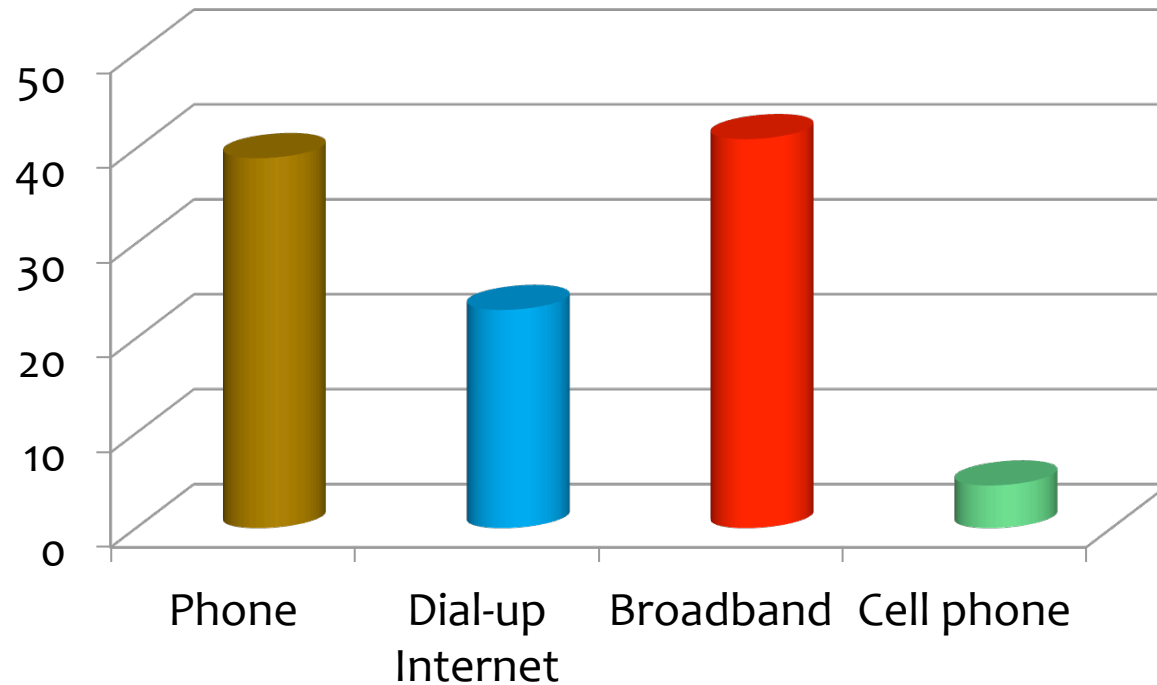
VoIP: $8-$25/month

The curse of fixed costs

* Subscribers decrease → fewer subscribers for same fixed costs
* But: switching equipment is written off

CS@CU

Available access speeds

20 Mb/s

10 Mb/s

5 Mb/s

2 Mb/s

1 Mb/s

marginal VOIP

avg. sustained throughput

10% 60% 90% 97% 100%

of households
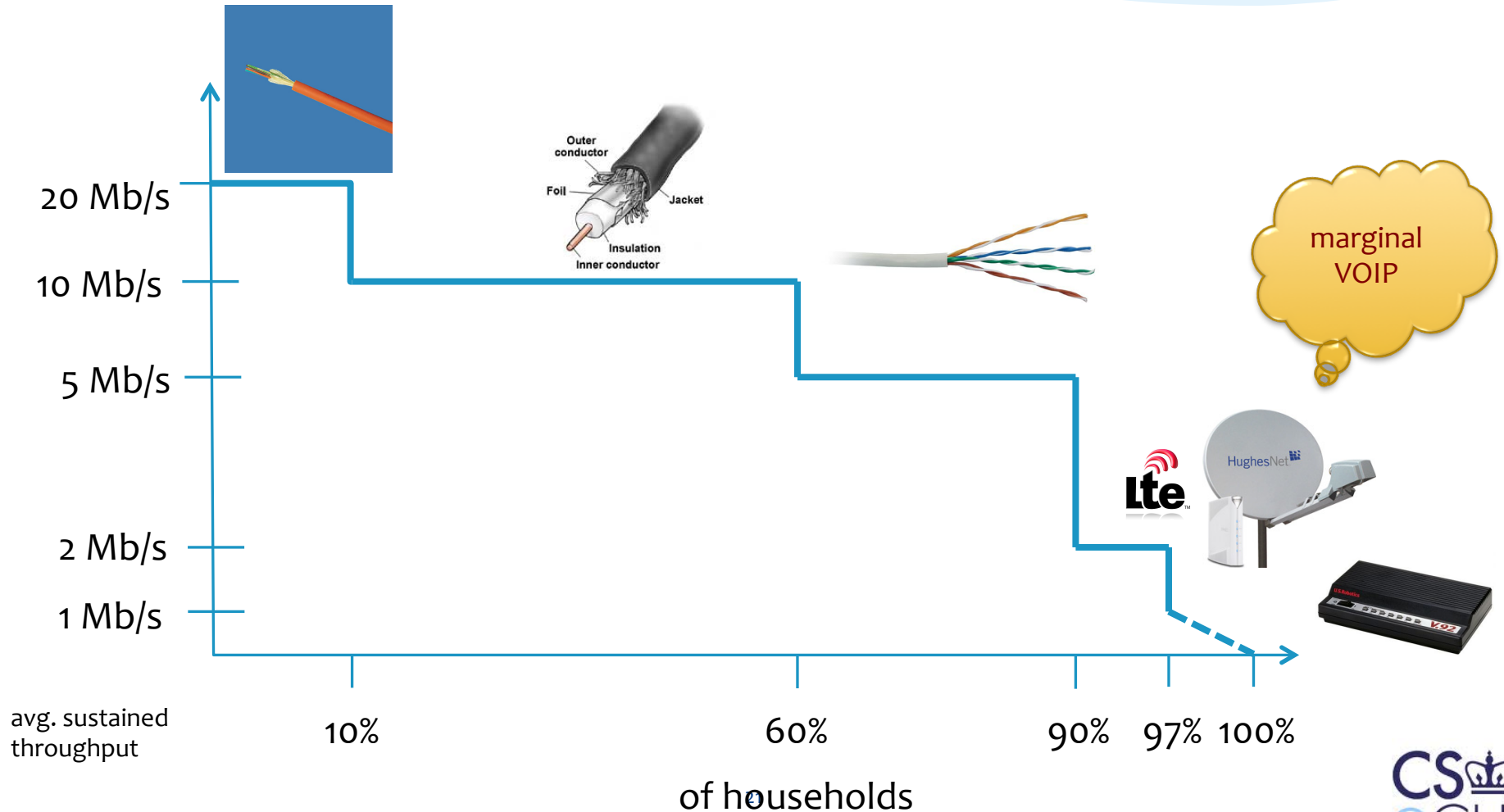
Legacy applications

* "Dry" copper loop
* Alarm systems
  - → transition to cellular (can't cut wire)
* ATMs → wireless, DSL

911

* Transition to NG911 underway
* Main issues:
  - Indoor location for wireless
    * location accuracy of 50/150m not sufficient
    * need apartment-level accuracy, including floor
    * Civic (Apt. 9C, 5 W Glebe), not geo
  - Avoid protracted transition
    * maintain two infrastructures for decade+?
  - National infrastructure →LoST hierarchy

CS
@CU

COLR (Carrier of Last Resort)

* Must offer service in covered area
* No direct equivalent for IP
* → USF
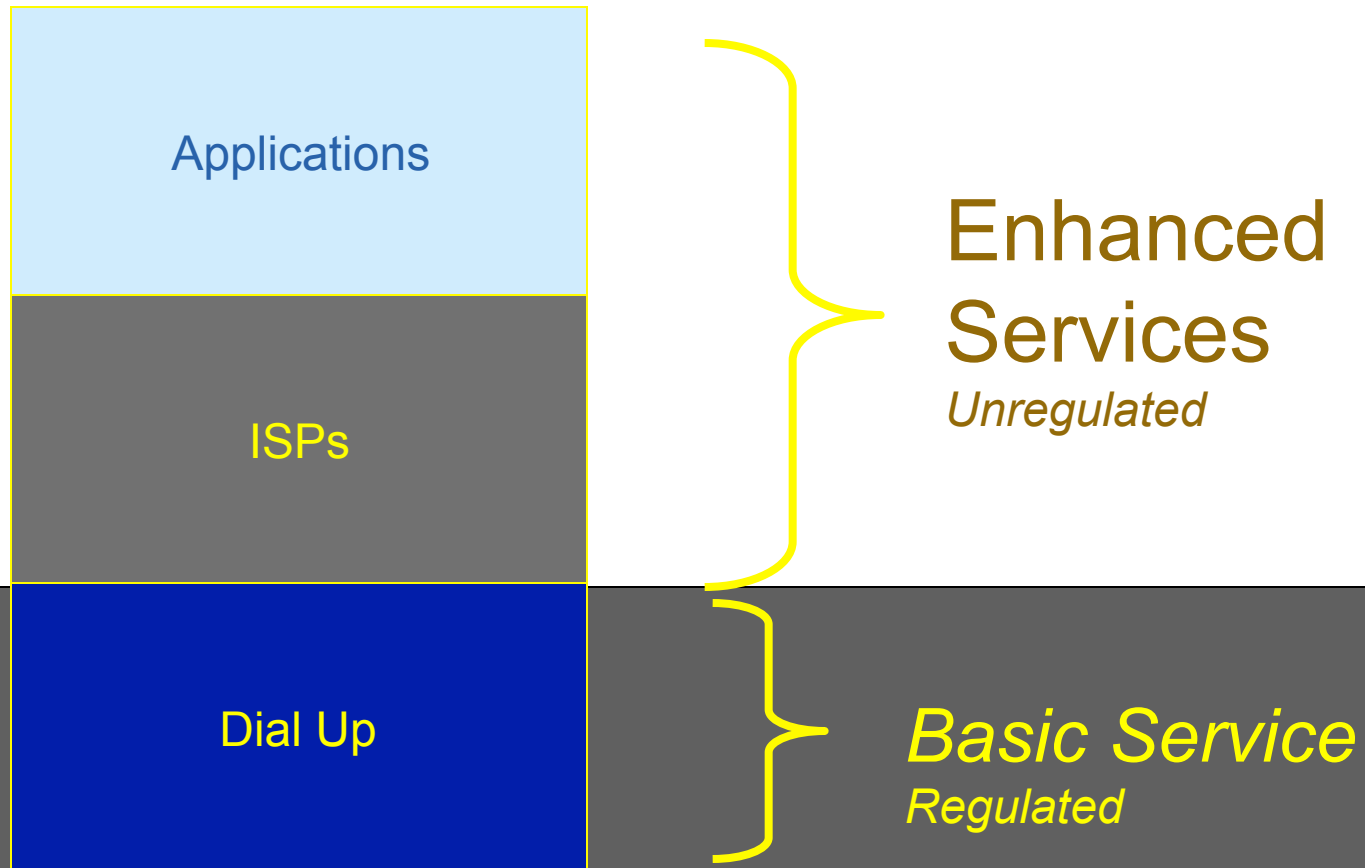
Voice, transport and access
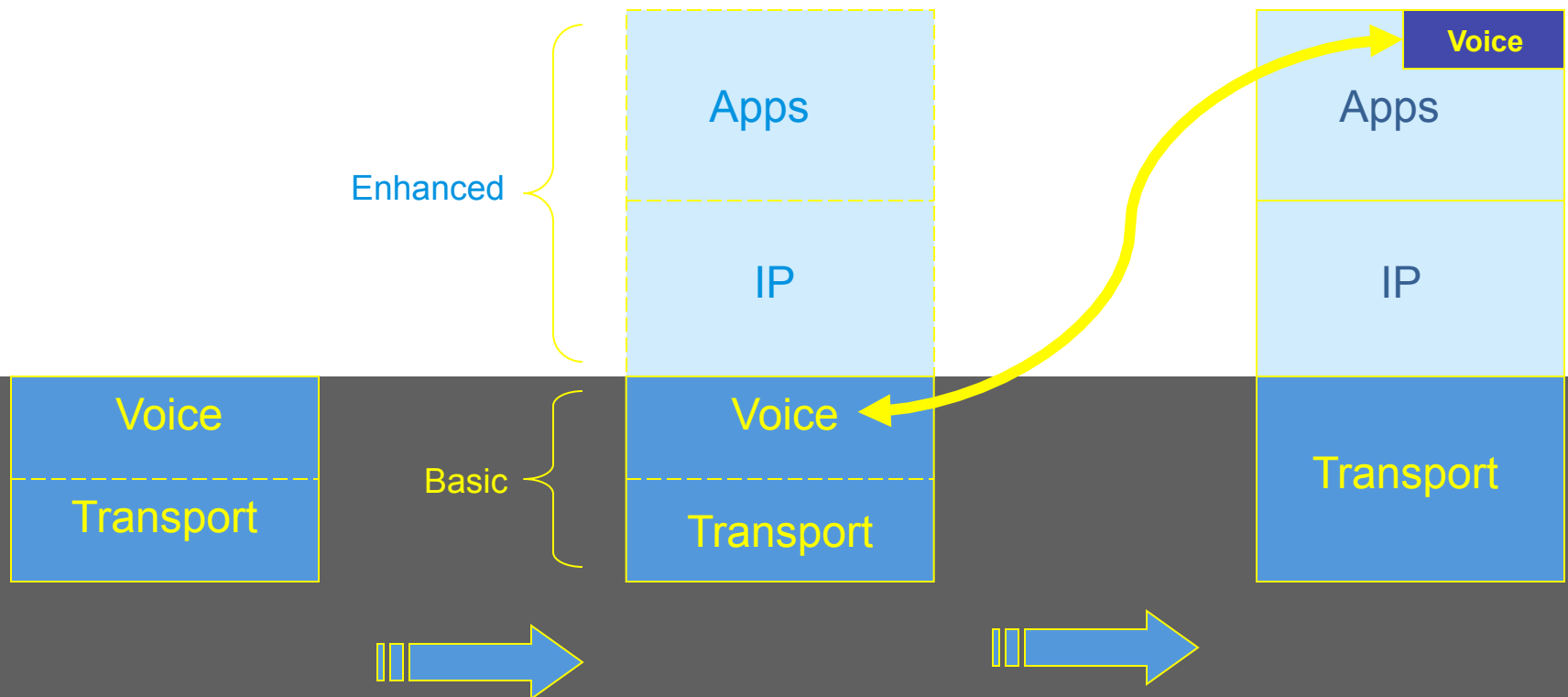
Evolution of competition

Assumption: competition desirable and efficient

1939

Theodore Vail
AT&T

voice

transport

CLEC

OTT
VoIP

ILEC

ILEC

ILEC/CMRS
CATV

1876   1930   1984   1996   2003   2010-

CS@CU
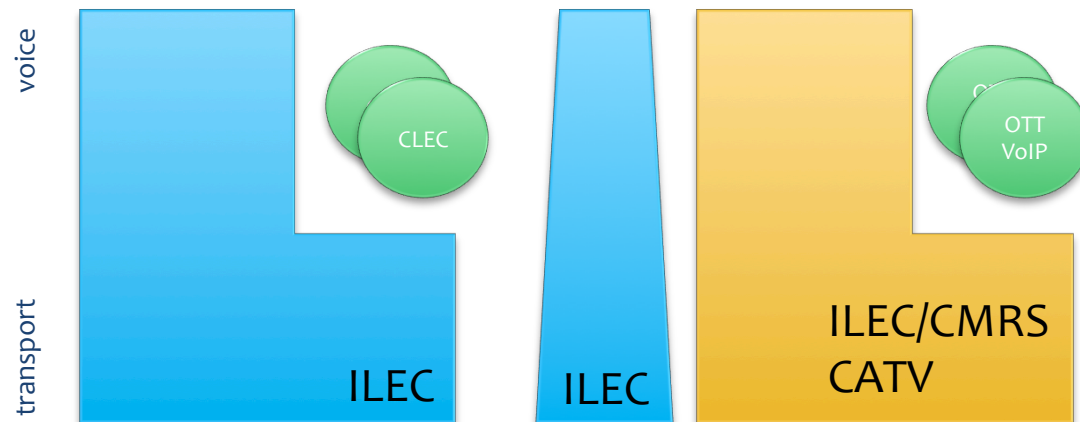
2 Internet futures

Google Chatroulette

content and applications

Level 3

IP

RCN

fiber or copper loop ("Homes with tails")

vs.

content production (*)
content distribution
CDN
broadband access
local infrastructure
regional and national
backbone

AT&T
Comcast/NBC (*)
Verizon

CS@CU

Scenario 1: max. competition

content & application providers

consumers

applications
(Netflix, Pandora, your blog)

web browser
(Firefox, IE, Chrome, …)

OS
(Windows Server, Linux, MacOS)

OS
(Windows, Android, MacOS)

data centers
(Equinix, Amazon, …)

system platform
(Intel, ARM, …)

wide area network
(Qwest, Sprint, VZ, TeliaSonera, NTT, DTAG, Level 3, AT&T)

ISP
(competing)

fiber, radio
(regulated monopoly)

conduit
(public)

Scenario 2: vertically integrated

4 Mb/s   100 Mb/s to consumer

classical
Internet
(web)

Internet

intera
ctive
multi
media
(IMS)

video
(live, VOD)

small operators
Google
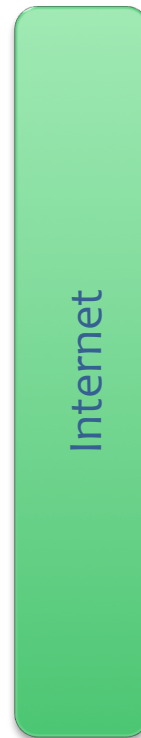
incumbent operator (e.g., AT&T, Verizon)
cable company (sometimes)

CS
@CU

Eyeball ISPs: 2001 vs. 2010

Top U.S. ISPs by Subscriber Q2 2001

- Other 9%
- Cablevision 1%
- Charter 1%
- PeoplePC 1%
- Cox Cable 1%
- Bell South 1%
- Comcast 1%
- Verizon 1%
- AT&T Broadband 2%
- AT&T Worldnet 2%
- Road Runner 2%
- Gateway.net 2%
- Bluelight 4%
- Compuserve 4%
- AtHome 5%
- Prodigy 5%
- Juno 5%
- NetZero 5%
- Earthlink 7%
- AOL 33%
- MSN 9%

August 2001

2010 chart:
- Other 18%
- Mediacom 1%
- Windstream 2%
- Centurylink 3%
- Cablevision 4%
- Qwest 4%
- Charter 4%
- TW 12%
- VZ 15%
- AT&T 17%
- Comcast 20%

CS@CU
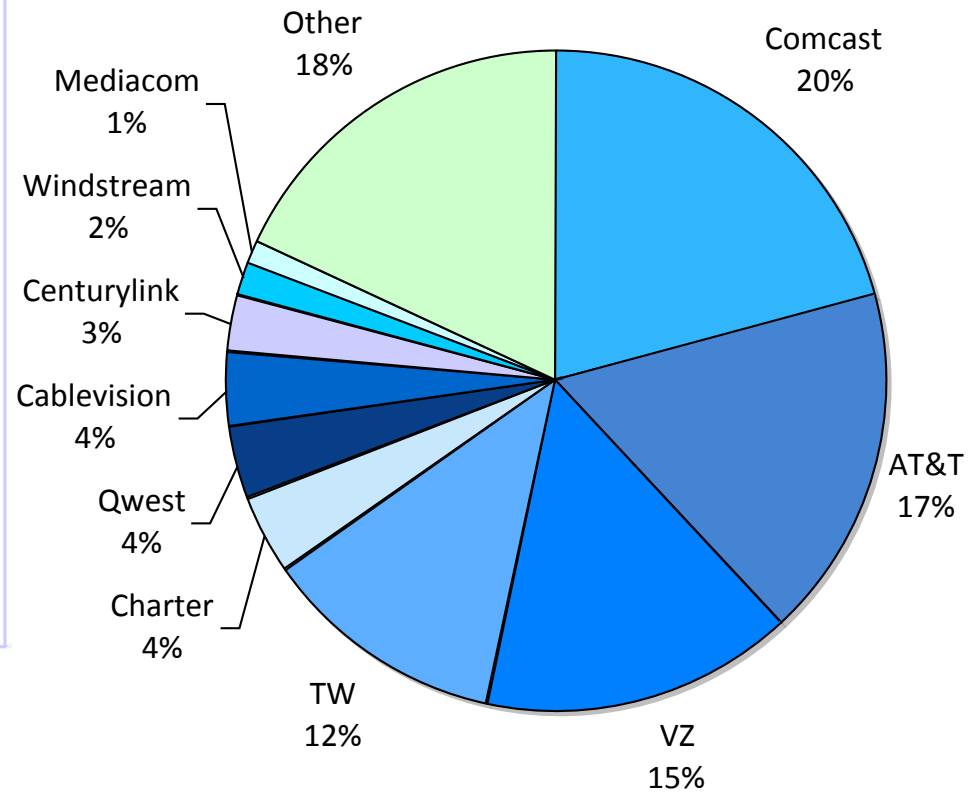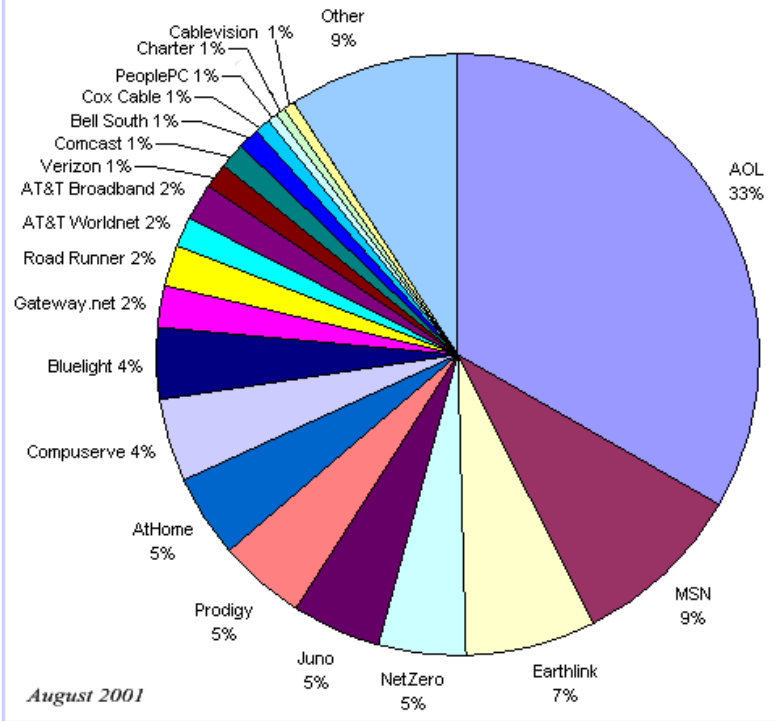
What is network neutrality?

* "The principle advocates no restrictions by Internet service providers and governments on content, sites, platforms, the kinds of equipment that may be attached, and the modes of communication." (Wikipedia)
* 2005 FCC statement:
  - "access the lawful Internet content of their choice.
  - run applications and use services of their choice, subject to the needs of law enforcement.
  - connect their choice of legal devices that do not harm the network.
  - competition among network providers, application and service providers, and content providers."
* *= Any lawful content, any lawful application, any lawful device, any provider*

CS
@CU

Two views

Open Internet advocates
- no prioritization
- flat rates
- all networks

Free market advocates
- no real problem
- allow any business arrangement
- "it's my network"
- use anti-monopoly laws if needed

Why?

* Civic considerations
    - freedom to read (passive)
    - freedom to discuss & create (active)
* Economic opportunity
    - edge economy >> telecom economy
        * Telecom revenue (US): $330B
        * Content, etc. not that large, however
            * Google: $8.44B
        * others that depend on ability to provide services
    - *content, application, service providers*
* Technical motivation
    - avoid network fragmentation
    - reduce work-around complexity

How to be non-neutral

application

**deep packet inspection
block Skype**

transport

**block transport protocol
block UDP & TCP ports
insert TCP RST**

network

**block IP addresses
QoS discrimination**

all affect
VoIP

CS
@CU

Are these neutrality issues?

* Redirect DNS NXDOMAIN to ISP web site
* Content translation
    – e.g., reduce image resolution for cellular data
* Blocking transport protocols other than UDP + TCP
* Prohibit web servers
* Reset DSCP (ToS bits)
* Not allow IPv6
* 3GPP: only make non-BE available to carrier

CS
@CU

Some high-profile cases

* Madison River (2005)
    – DSL provider blocked SIP ports
    – fined $15,000 by FCC
* Comcast (late 2007)
    – insert TCP RST into BitTorrent traffic
    – later overturned on appeal in DC Circuit Court
* RCN (2009): P2P
* Various mobile operators
* Comcast vs. Level 3 (2010, in dispute)
   – Level-3

CS@CU

Network neutrality & freedom of speech

1st amendment: Congress shall make no law abridging the freedom of speech

* Applies only to U.S. government, not private entities
  - Example: soap box in city park vs. mall
  - private vs. public universities
* Freedom to speak + no forced speech
  - demise of "fairness doctrine" (2011 final)

Network transparency

* RFC 1958: "Architectural Principles of the Internet"

  However, in very general terms, the community believes that the goal is connectivity, the tool is the Internet Protocol, and the intelligence is end to end rather than hidden in the network.

* RFC 2275: "Internet Transparency"
  - NATs, firewalls, ALGs, relays, proxies, split DNS

* RFC 3724: "The Rise of the Middle and the Future of End-to-End: Reflections on the Evolution of the Internet Architecture"

* RFC 4924: "Reflections on Internet Transparency"

  A network that does not filter or transform the data that it carries may be said to be "transparent" or "oblivious" to the content of packets. Networks that provide oblivious transport enable the deployment of new services without requiring changes to the core. It is this flexibility that is perhaps both the Internet's most essential characteristic as well as one of the most important contributors to its success.

CS@CU

Network transparency and neutrality

transparent   neutral
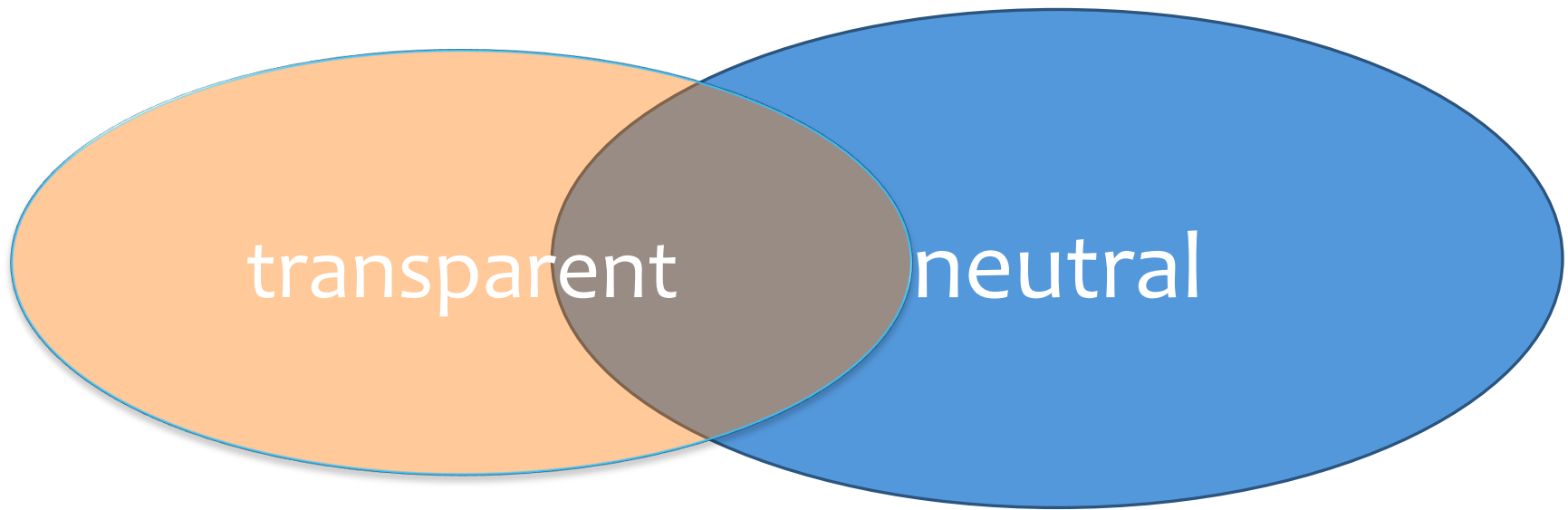
QoS discrimination
pay for priority

block protocol features
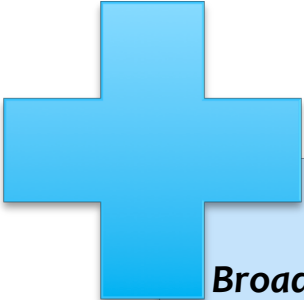
Means, motive and opportunity

* Political motivation
  – suppress undesirable opinion
    * e.g., union web site, abortion SMS
* Economic advantage
  – prevent competition in related services
    * e.g., VoIP or over-the-top VoD
  – leverage pricing power
    * OTT content provider has to offer service to everyone
  – market segmentation
    * consumer vs. business customers
* Non-tariff barriers
  – e.g., special (undocumented) APIs

Open Internet FCC history

* 2004: "four freedoms" (Powell)
* 2005: Internet policy statement (Martin)
* 9/2009: Genachowski speech
  - non-discrimination, transparency
* 12/2009/: NPRM
* 9/2010: PN
* 12/2010: Open Internet rules
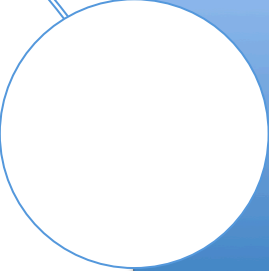* 10,000+ short comments, hundreds of long comments

Who is covered?

Broadband Internet Access Service = A mass-market retail service by wire or radio that provides the capability to transmit data to and receive data from all or substantially all Internet endpoints, including any capabilities that are incidental to and enable the operation of the communications service, but excluding dial-up Internet access service. This term also encompasses any service that the Commission finds to be providing a functional equivalent of the service described in the previous sentence, or that is used to evade the protections set forth in this Part.

excludes

- "edge providers": CDNs, search engines, …
- dial-up
- coffee shops, bookstores, airlines (premise operators)

CS@CU

Principles

Transparency. Fixed and mobile broadband providers must disclose the network management practices, performance characteristics, and terms and conditions of their broadband services;

No blocking. Fixed broadband providers may not block lawful content, applications, services, or non-harmful devices; mobile broadband providers may not block lawful websites, or block applications that compete with their voice or video telephony services

No unreasonable discrimination. Fixed broadband providers may not unreasonably discriminate in transmitting lawful network traffic.

CS@CU

FCC Open Internet order

	Wired	Wireless
Disclosure	yes	yes
Non-blocking	every protocol	"web", "VoIP"
Non-discrimination	reasonable network management	"monitor"

CS
@CU

FCC Open Internet order

* CFR text: 1 page
* Main content: 85 pages
  - with 500 footnotes
* Regulatory Flexibility Analysis
* 5 commissioner statements: 60 pages

Some corner cases

* Parental protection
  – user (paying subscriber…) choice
* KosherNet
* Spam
  – would only affect IP-level blocking
* DOS
  – classified as unwanted traffic

Why You Need It

Koshernet provides the ideal, rabbinically endorsed, internet experience for businesses, schools, parents, teachers, or anyone who wants or needs control over exposure to undesirable content during the internet experience.

CS@CU

47 CFR 8

* **§ 8.1 Purpose.**

  The purpose of this Part is to preserve the Internet as an open platform enabling consumer choice, freedom of expression, end-user control, competition, and the freedom to innovate without permission.

* **§ 8.3 Transparency.**

  A person engaged in the provision of broadband Internet access service shall publicly disclose accurate information regarding the network management practices, performance, and commercial terms of its broadband Internet access services sufficient for consumers to make informed choices regarding use of such services and for content, application, service, and device providers to develop, market, and maintain Internet offerings.

Disclosure (Transparency) – Network Practices

* *Congestion management:* congestion management practices; types of traffic; purposes; practices' effects on end users' experience; criteria used in practices, such as indicators of congestion that trigger a practice, and the typical frequency of congestion; usage limits and the consequences of exceeding them; and references to engineering standards, where appropriate.

* *Application-Specific Behavior*

* *Device Attachment Rules*

* *Security*

CS@CU

Disclosure (Transparency) – Performance

* *Service description*: A general description of the service, including the service technology, expected and actual access speed and latency, and the suitability of the service for real-time applications.

* *Impact of specialized services:* If applicable, what specialized services, if any, are offered to end users, and whether and how any specialized services may affect the last-mile capacity available for, and the performance of, broadband Internet access service.

CS@CU

Disclosure (Transparency) – Commercial Terms

* *Pricing*: For example, monthly prices, usage-based fees, and fees for early termination or additional network services.

* *Privacy Policies*: For example, whether network management practices entail inspection of network traffic, and whether traffic information is stored, provided to third parties, or used by the carrier for non-network management purposes.

* *Redress Options*: Practices for resolving end-user and edge provider complaints and questions.

CS@CU

Conclusion

* Multi-pronged attack on PSTN
  – transition to mobile for consumers
  – cable VoIP
  – less voice, more text
  – Ethernet phones + IP PBX + SIP trunking for business
* Separate PSTN vs. copper infrastructure
* Challenges mostly in retaining PSTN policy goals
  – reliability, affordability, accessibility, ubiquity