Telecom policy: competition, spectrum, access and technology transitions

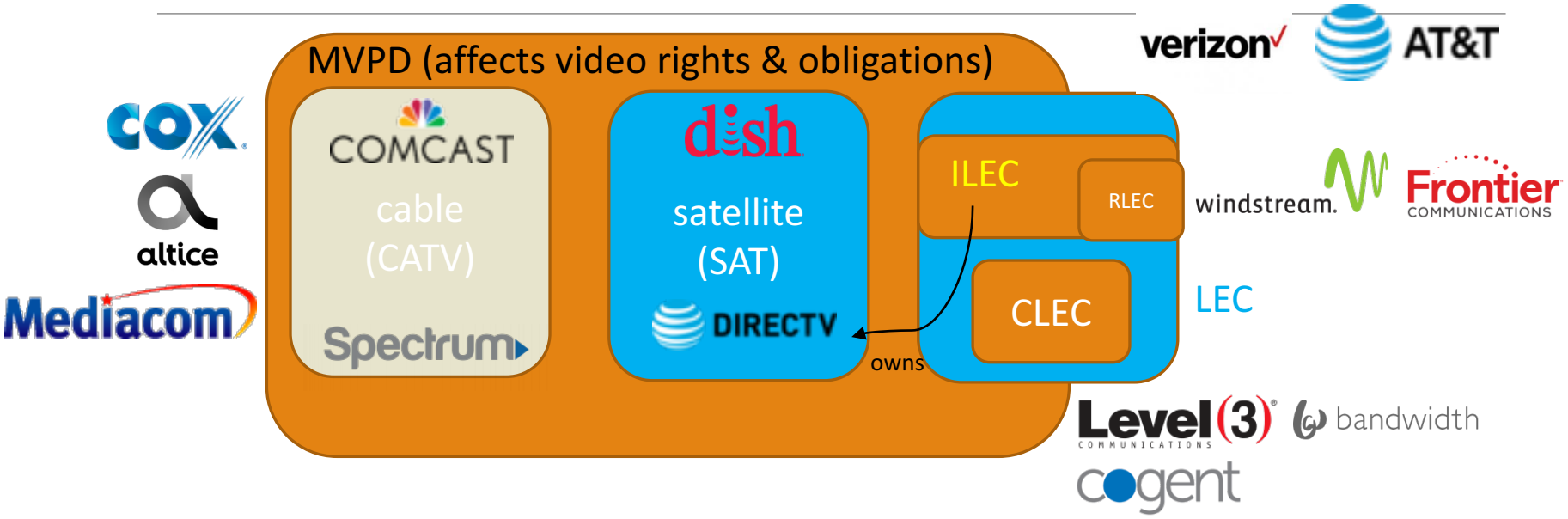
HENNING SCHULZRINNE

Key challenges – (nearly) everywhere

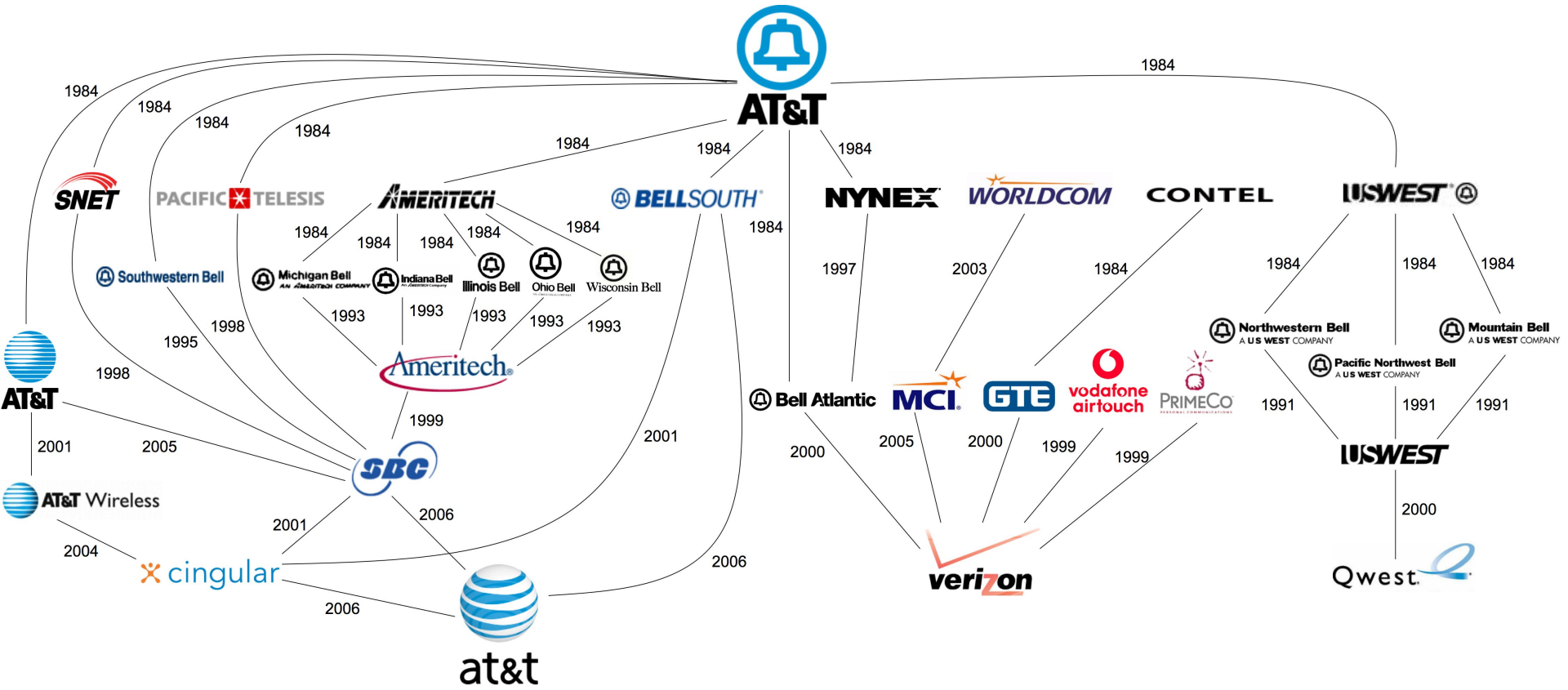
- Costs, competition and investment are poorly understood
- Network neutrality is really about what rules apply to Internet services
- Spectrum is no longer just book-keeping
- Rural broadband is about finding the right levers
- Access for people with disabilities enables functionality for everybody
- Emergency services (112 & 911) are mostly still stuck in pre-Internet

Network economics, competition & investment

The industry is complicated

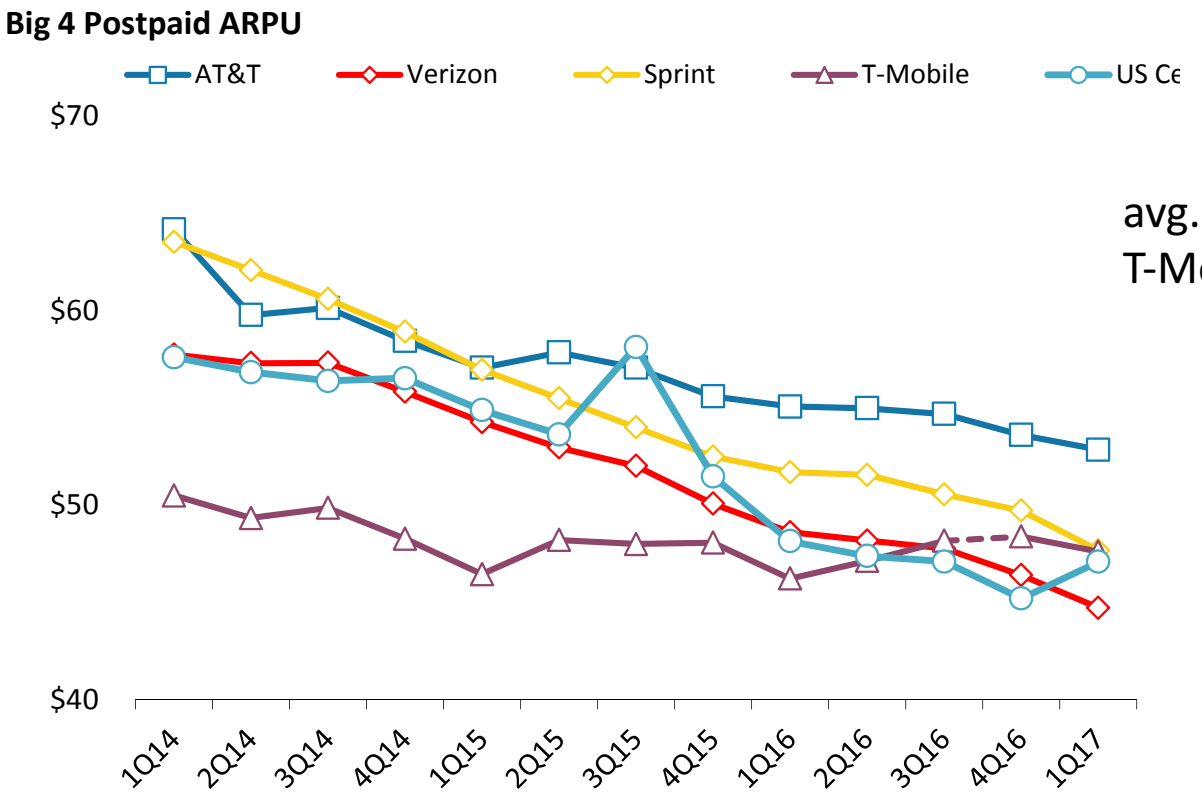


- all entities can serve as a *Broadband Internet Access Service* (BIAS), commonly known as *ISP*
- almost all ”TV” distributors are MVPDs, but not all MVPDs are ISPs (e.g., satellite)
- AT&T, as an ILEC, owns a satellite MVPD (DirecTV)
- Same company can be ILEC in one state & CLEC in another (rare)



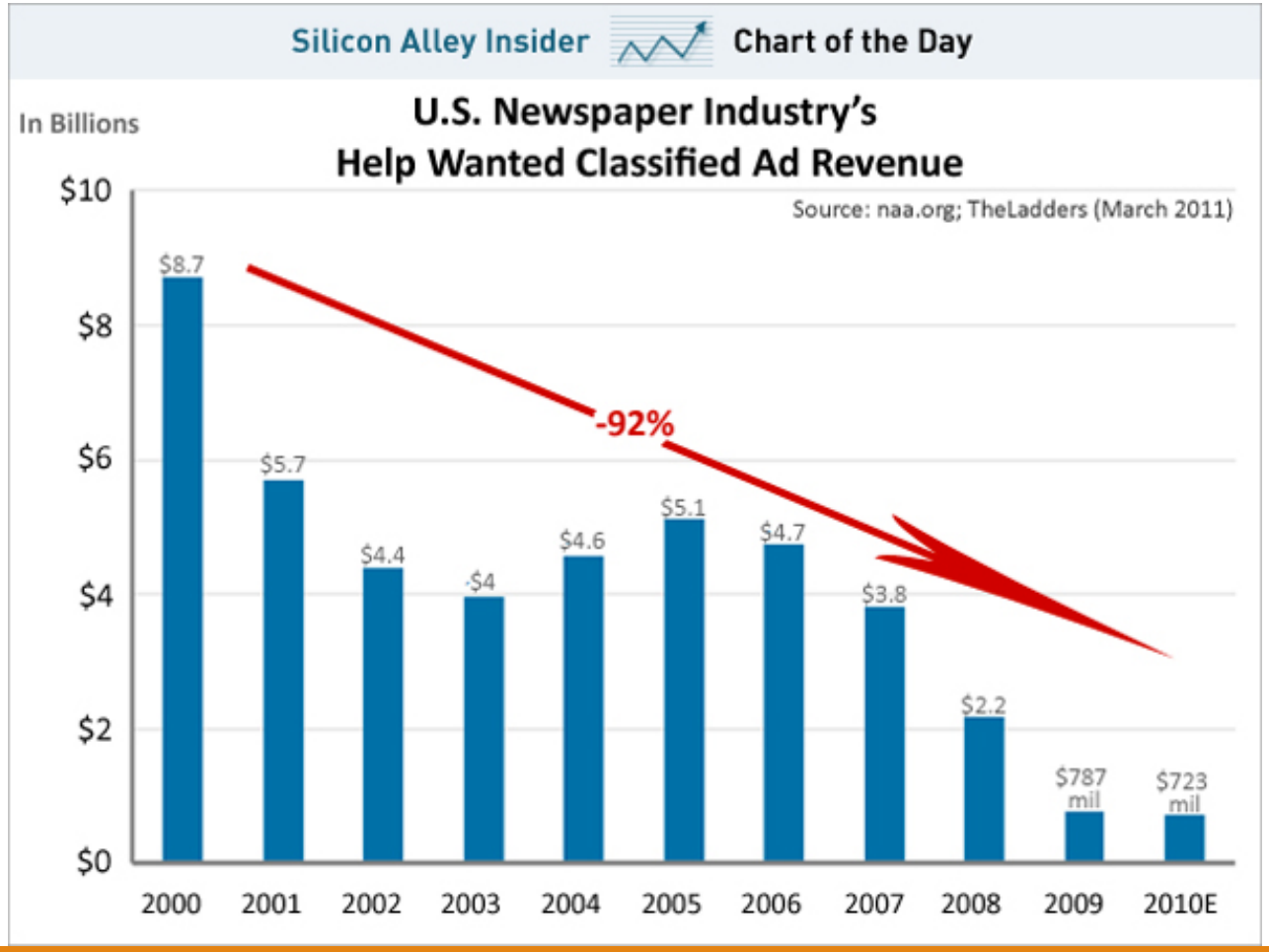
FreePress, 2008

Wireless revenue is falling



avg. about 2.1 GB/month
T-Mobile: 10 GB tethering

Newspaper advertising

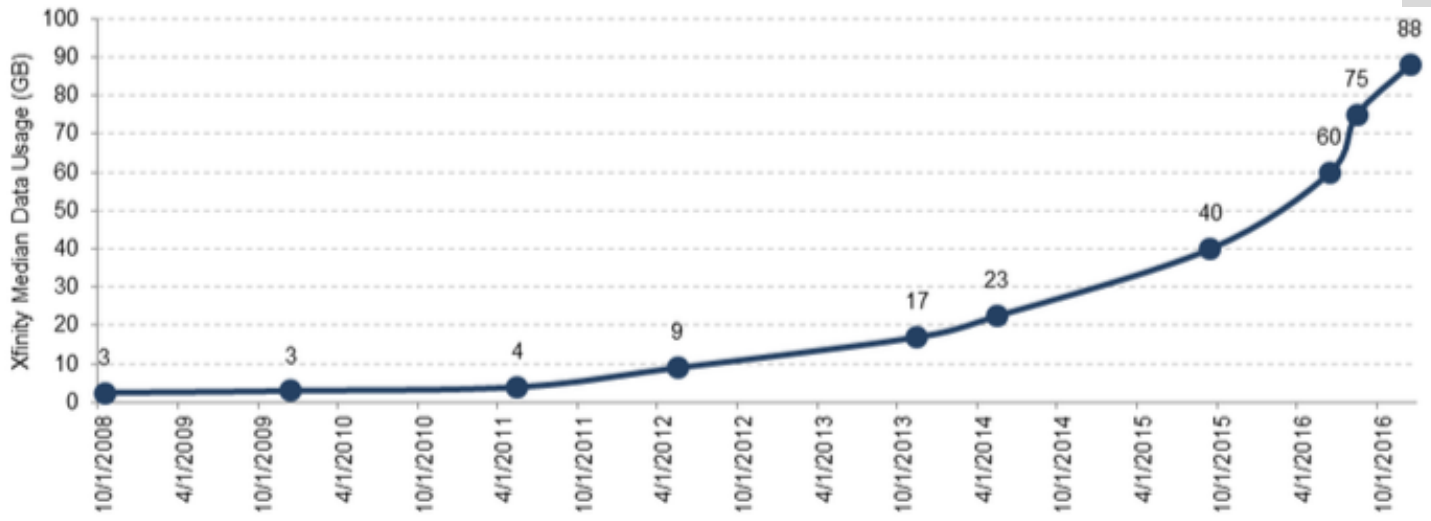


Twenty years ago classifieds provided more than a third of the revenue of *The Washington Post*. Craigslist has destroyed that business for the *Post* and every major paper in the country. (Brookings, 2014)

Problem likely capacity, not speed

Exhibit 13

Comcast: Median Bandwidth Usage per Household per Month, 2008 to 2016



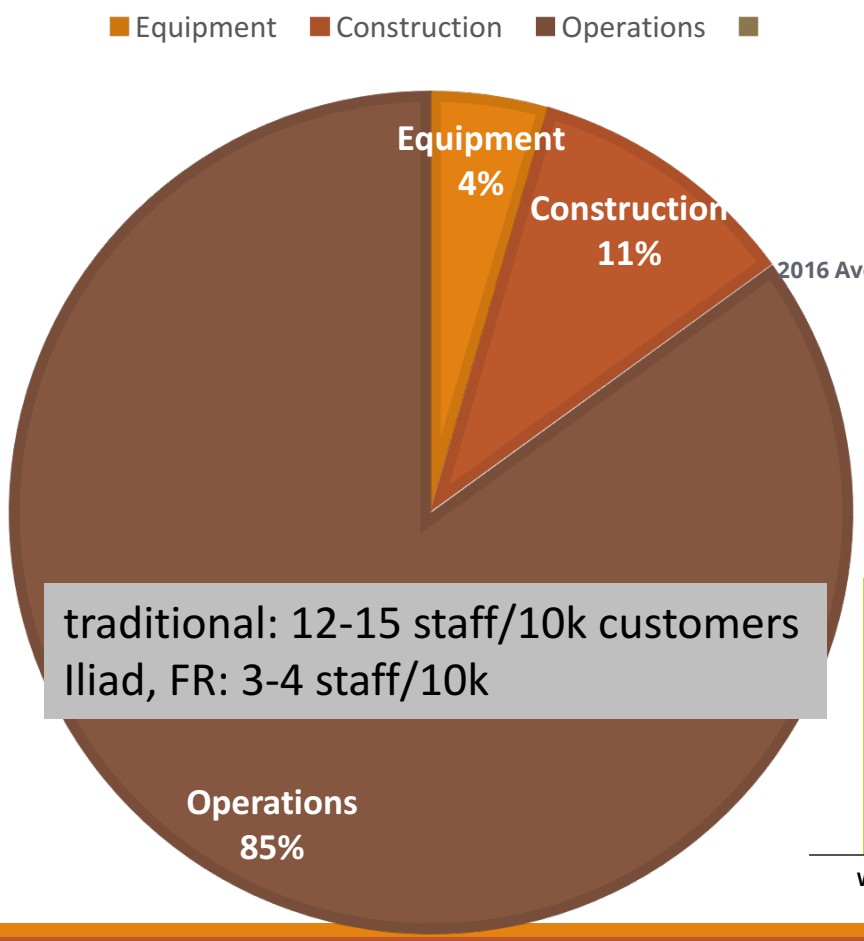
Source: Comcast's website, MoffettNathanson estimates and analysis

June 2017: 100 GB

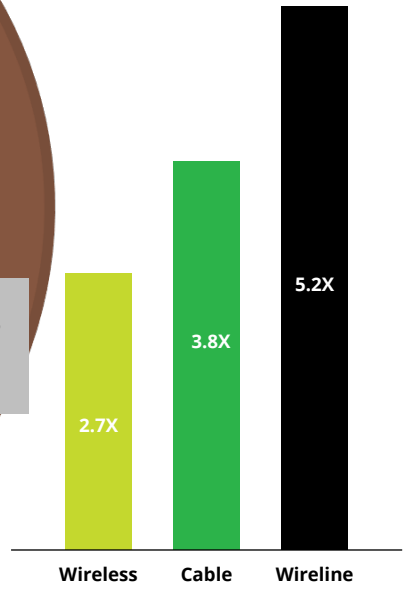
Metrics: not Gb/s or b/s/Hz, but $/GB and $/year

- Consumer market: $/GB delivered
  - little willingness to pay for speed above 10 Mb/s for now
  - unless $/GB → 0, 1 Gb/s just threatens wallet
- NB-IoT: $/device + $/year cost
  - compete with $0 incremental cost BT/Zigbee/WiFi or LPWAN
  - include amortized
  - typically, << $1/month
  - predictable coverage & international reach
  - alternative for one-way: ATSC 3.0 (50+ miles reach, no incremental cost)

Network economics, (over)simplified



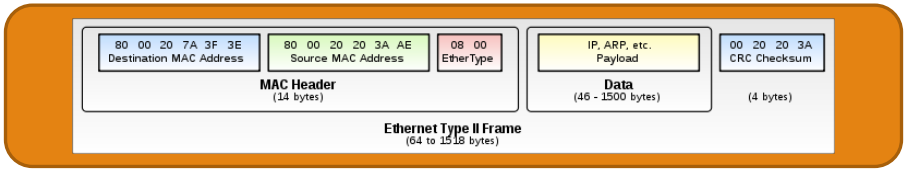
traditional: 12-15 staff/10k customers
Iliad, FR: 3-4 staff/10k



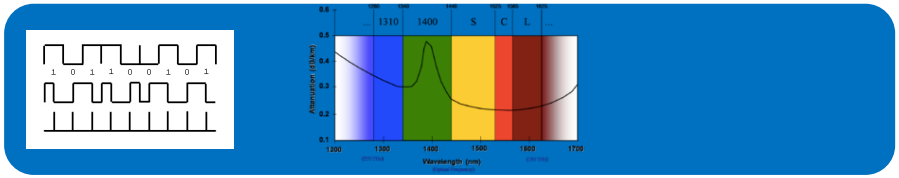
Competition models: vertically integrated

content & applications

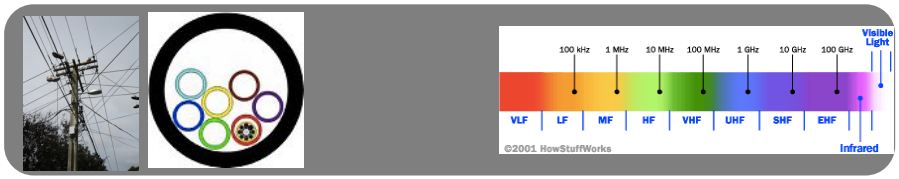
L3…L7



L2 (MAC)



L1 (PHY)

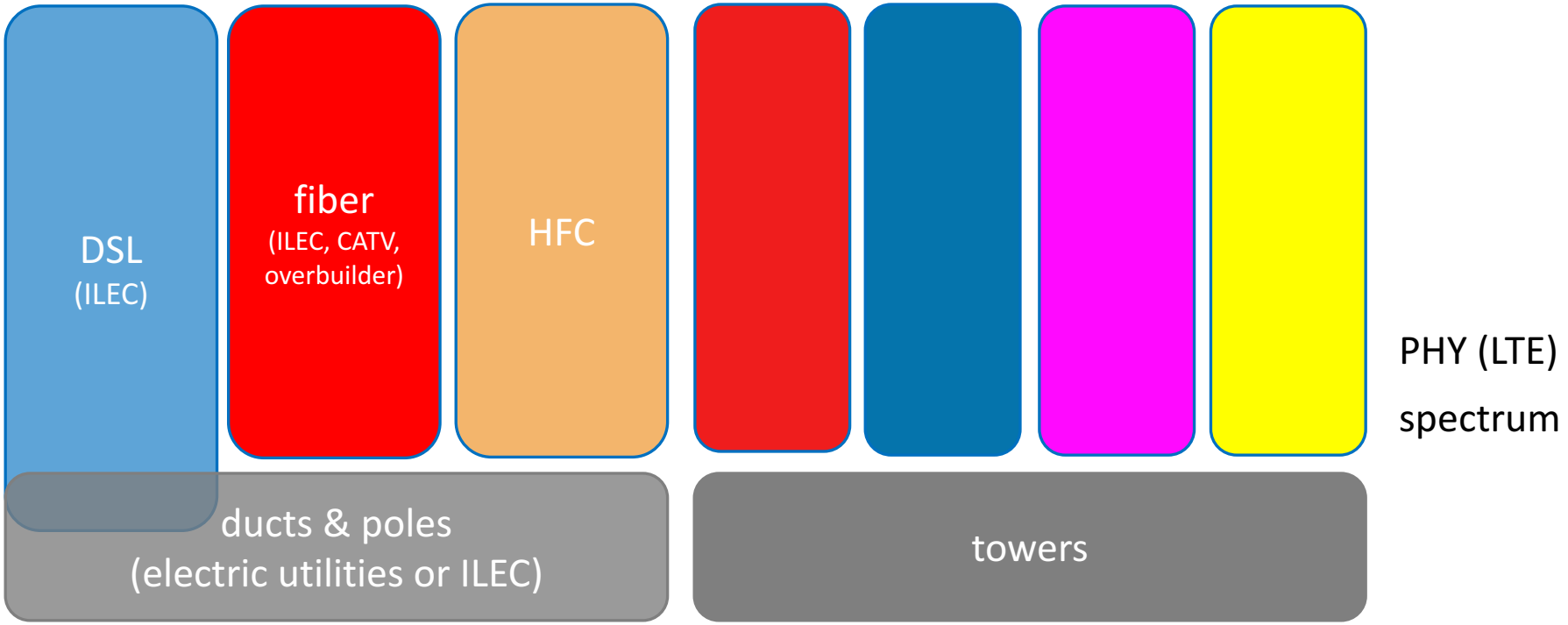


”L0” (infrastructure)

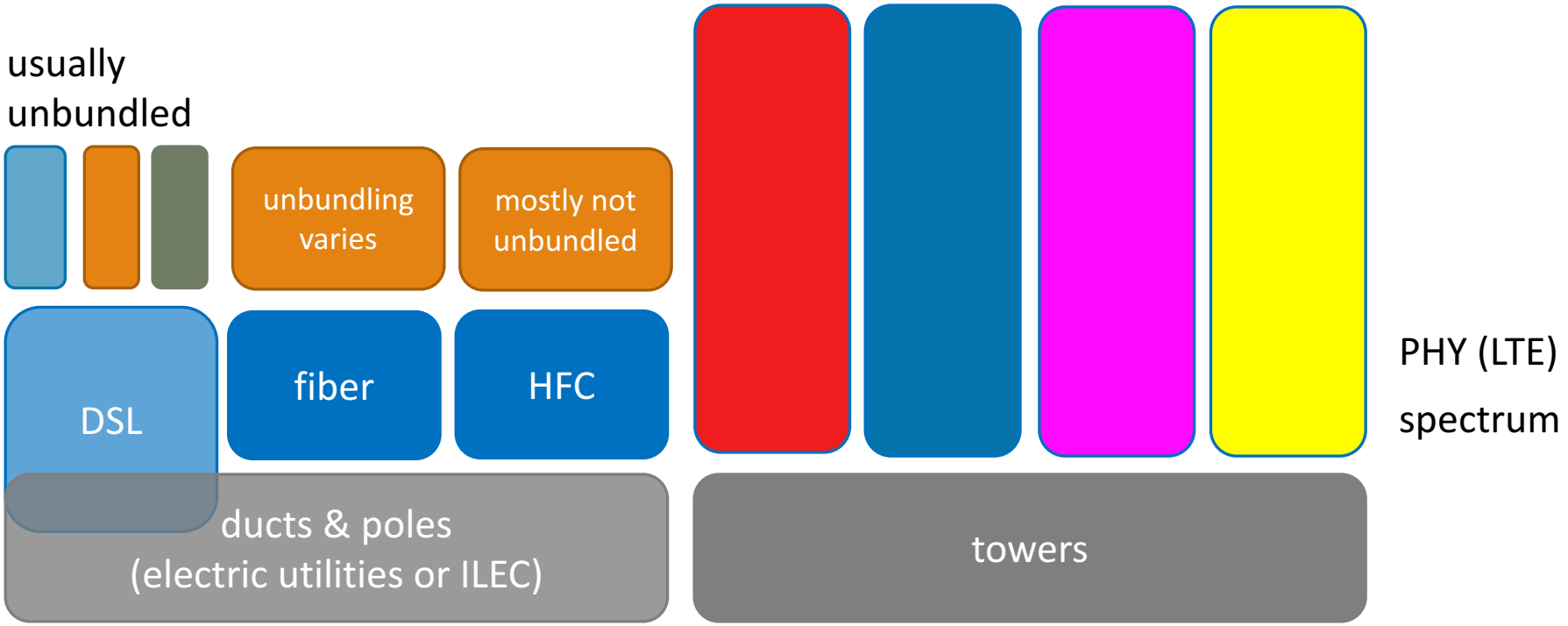
sharing (incumbent + new entrant) vs. neutral third party

Sharing models: US

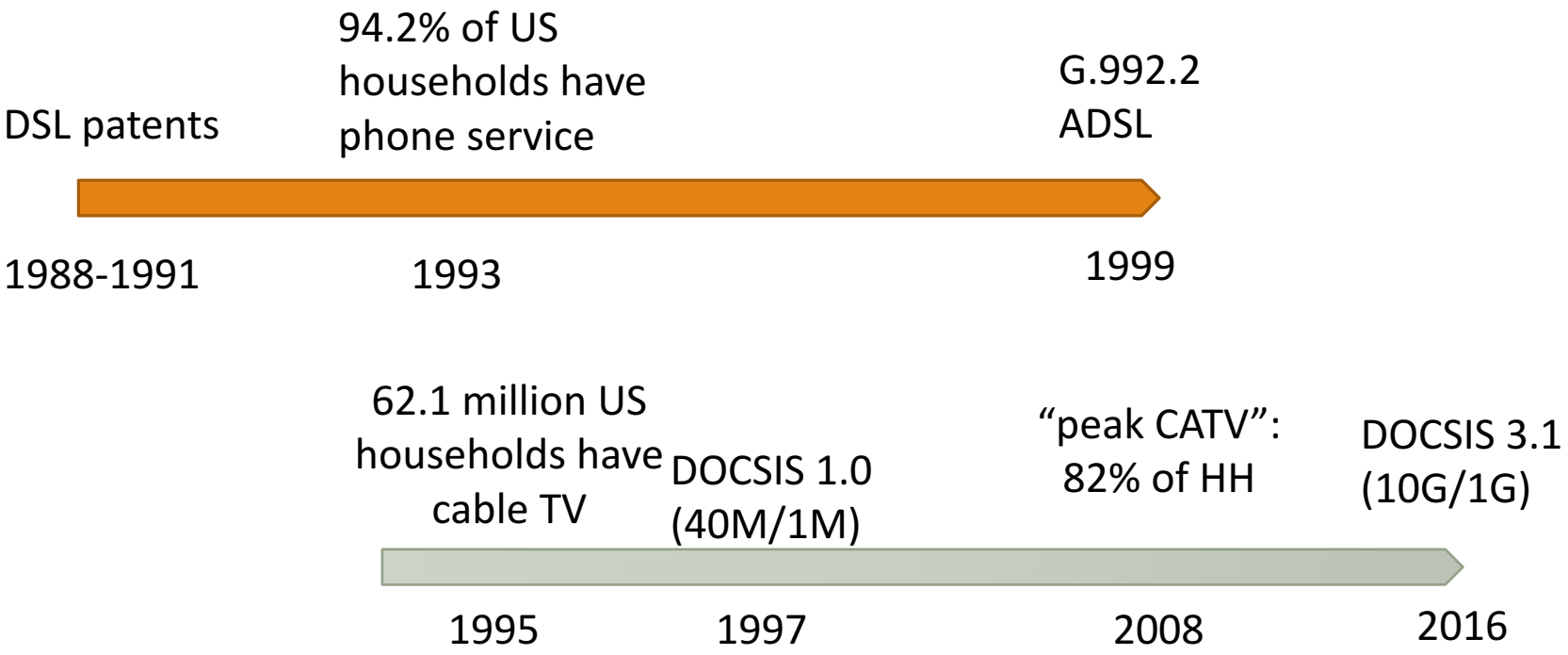
+ WISP & satellite



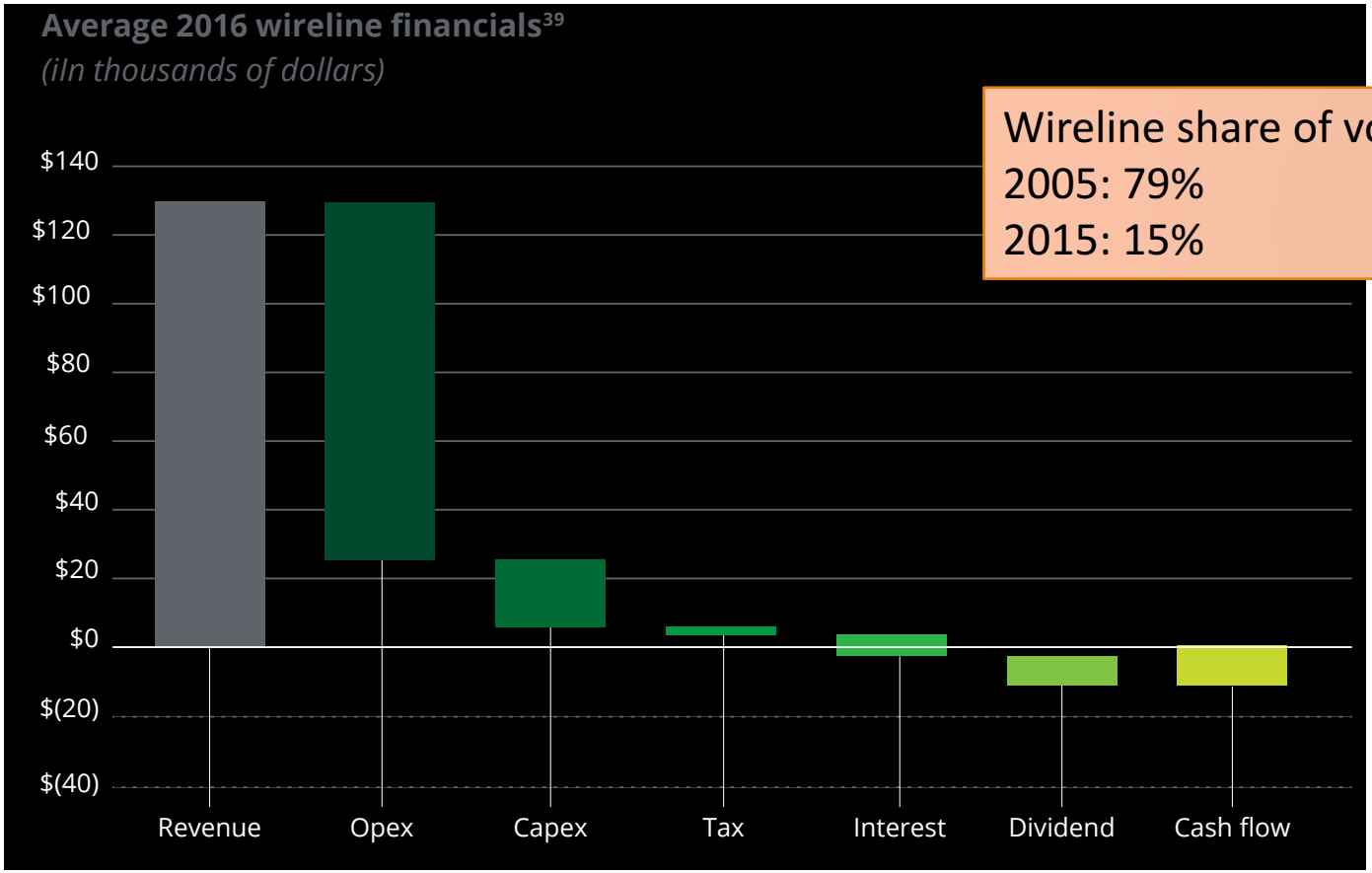
Sharing models: Canada, Europe, Australia



Accidental broadband

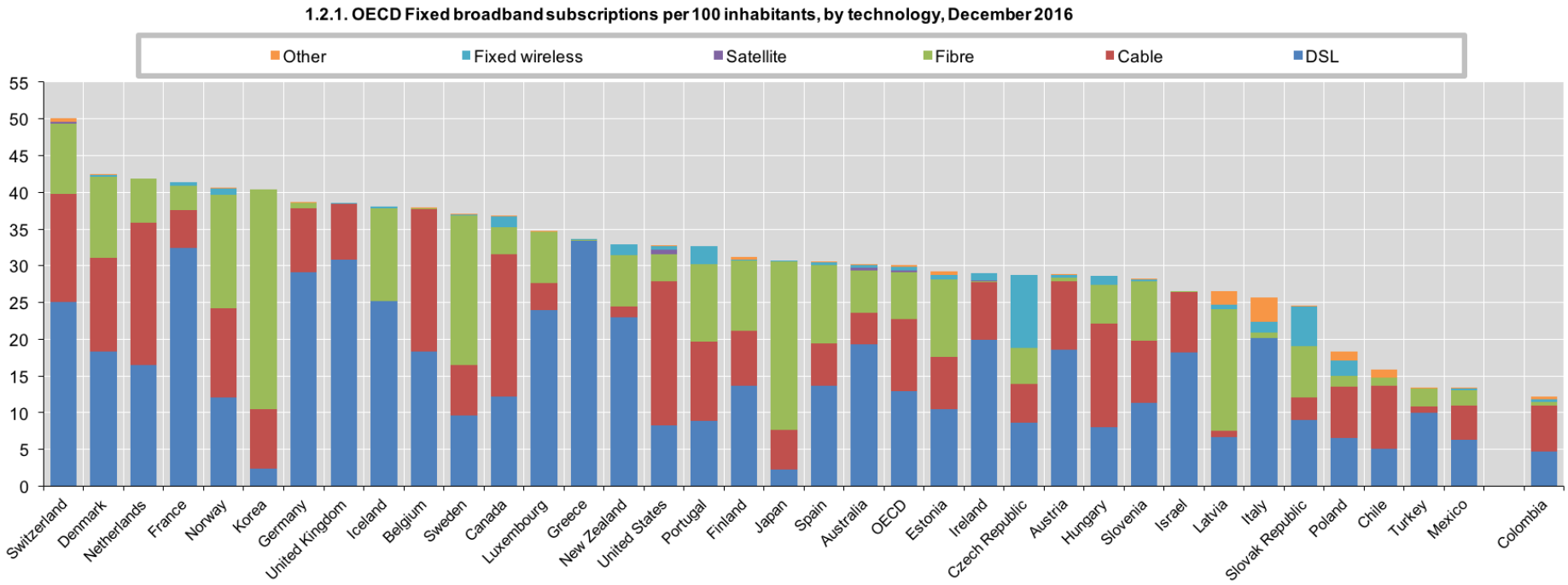


Rural wireline ILECs lack resources



Wireline share of voice revenue:
2005: 79%
2015: 15%

OECD overview

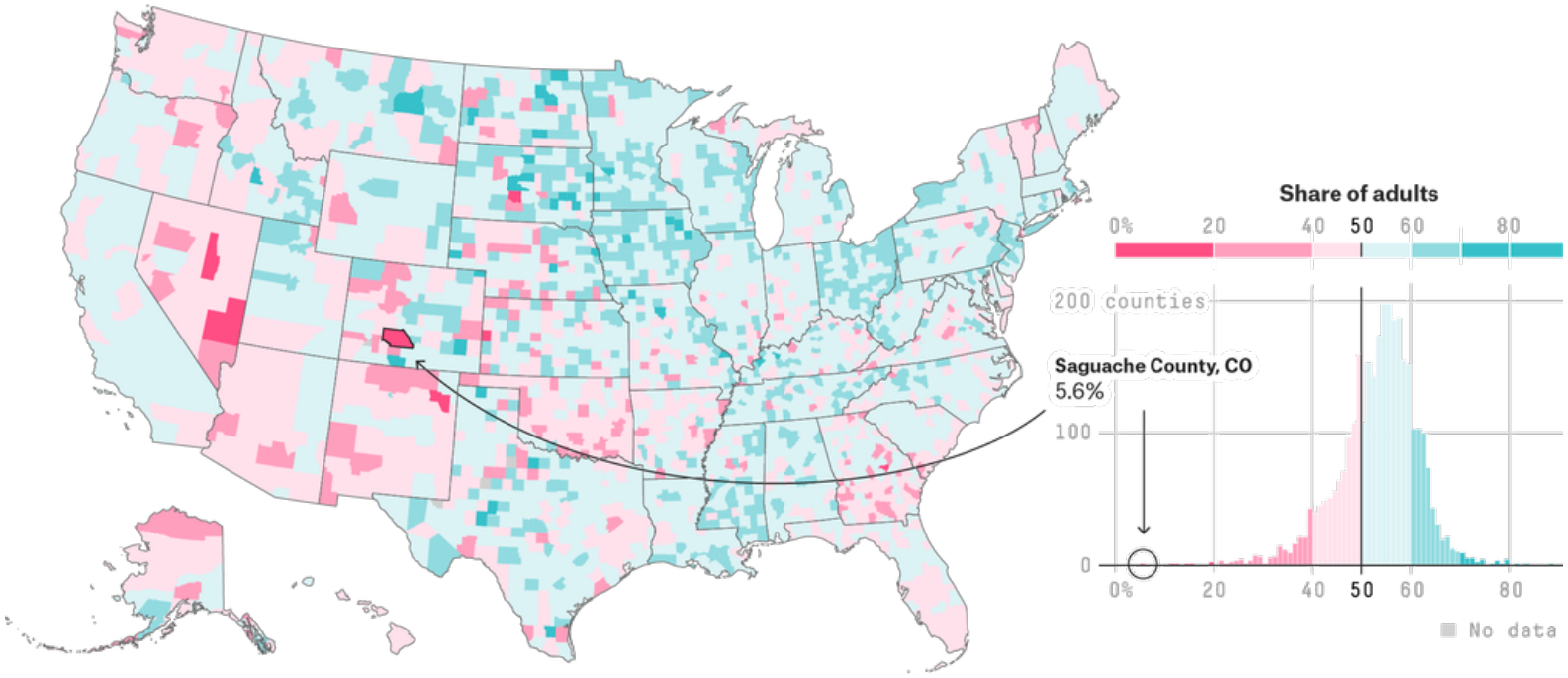


Trade-offs across the world?

- If new deployment, predicted return on investment
  - with unbundling: what is the wholesale price going to be?
  - no magic algorithm --- margin squeeze
- Allow infrastructure owner to provide services?
- Impact on consumer surplus
- US: pole attachment problems
  - if incumbents are pole owners

Rural broadband

Rural broadband US



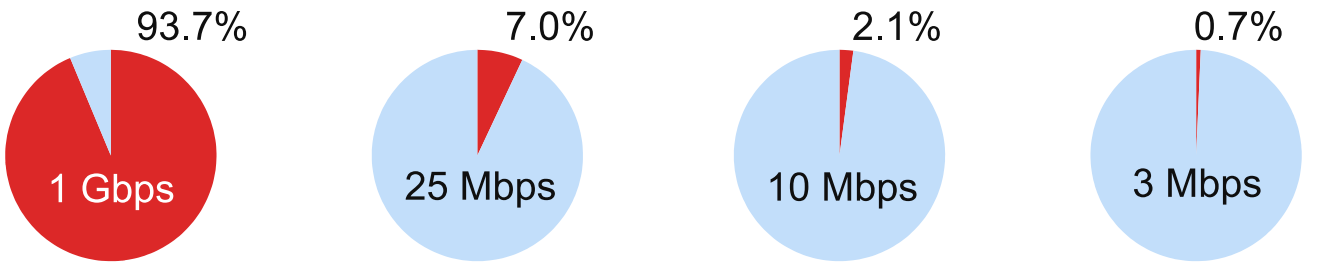
County shares are estimated using data from a 1 percent sample of 240 million voting-age Americans provided by Catalist, an election data firm. Internet connections faster than dial-up include those via DSL, cable, fiber-optic, satellite, etc.

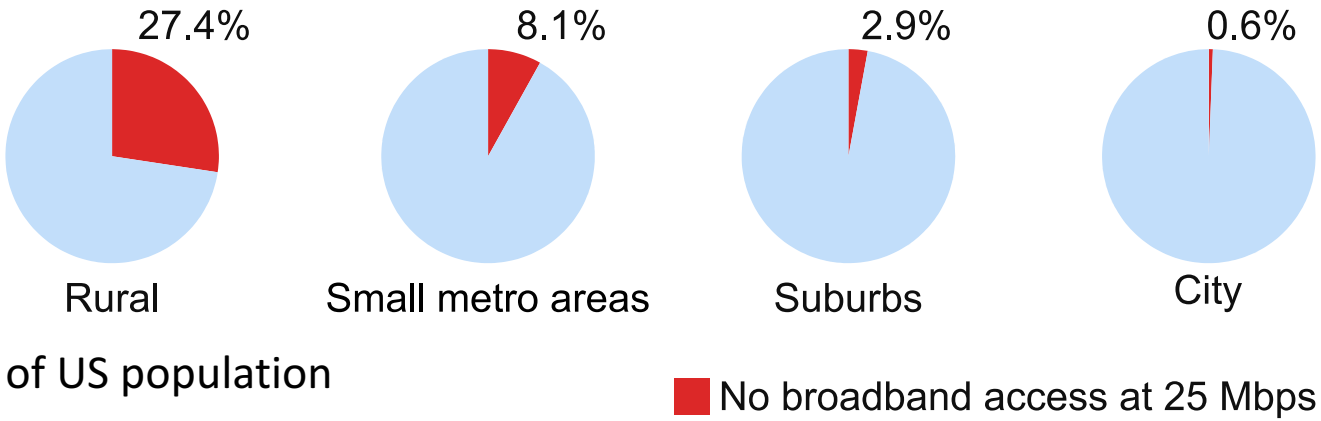
FiveThirtyEight

SOURCE: ARIZONA STATE UNIVERSITY'S CENTER FOR POLICY INFORMATICS

Broadband access by speed & geography

BROOKINGS

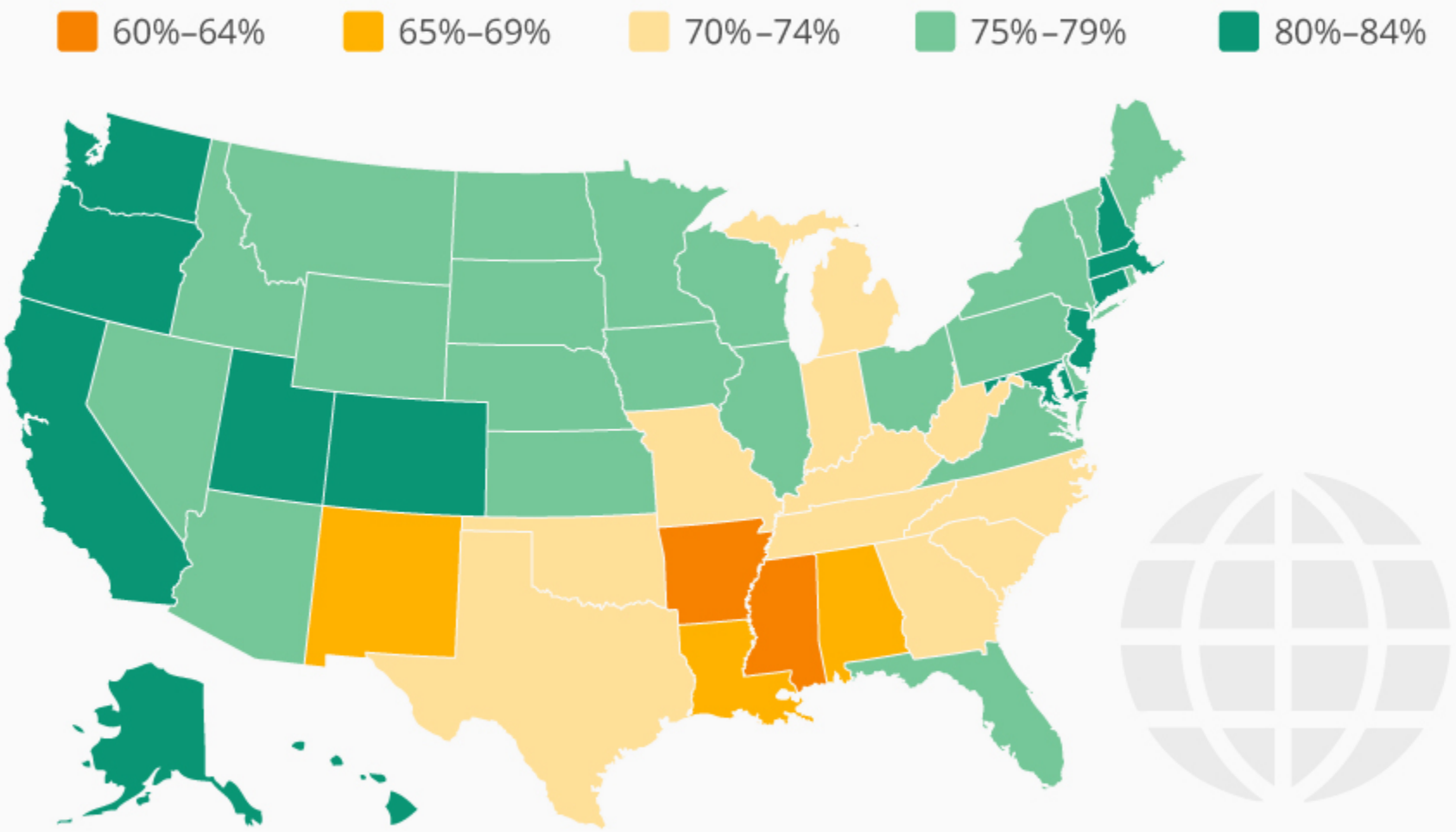




15% of US population

U.S. Home Broadband Penetration by State

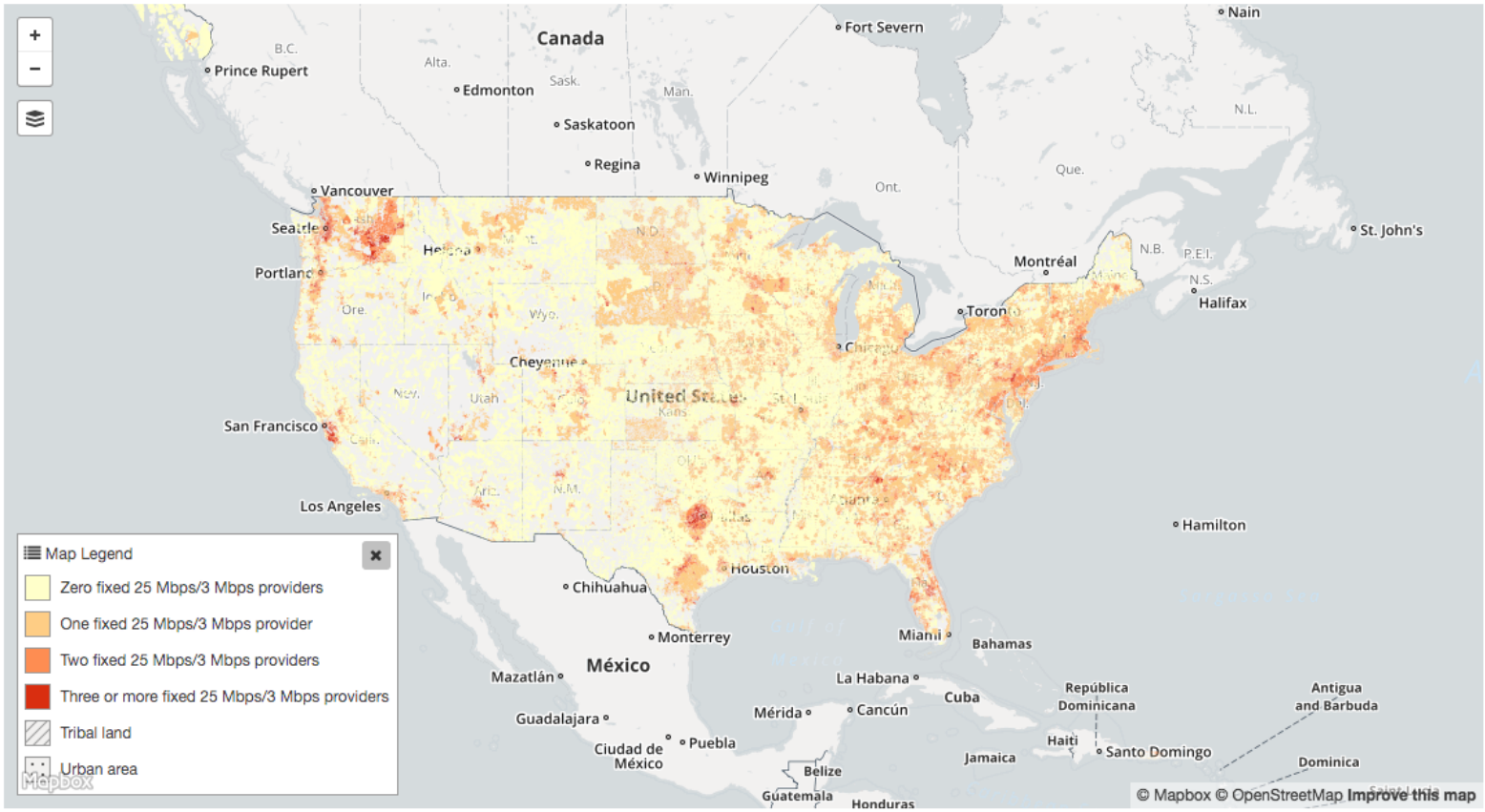
Share of U.S. homes with a broadband internet connection, by state



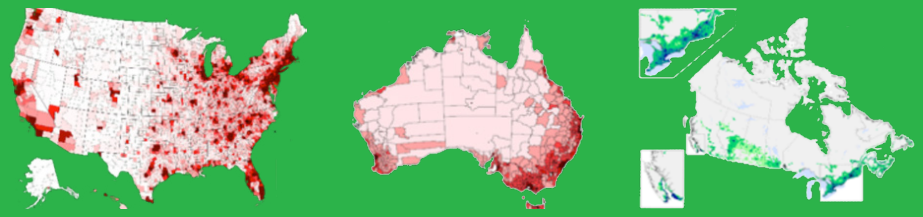
Latest figures as of February 27, 2017

Source: Center for Data Innovation

Number of 25/3 Mb/s providers



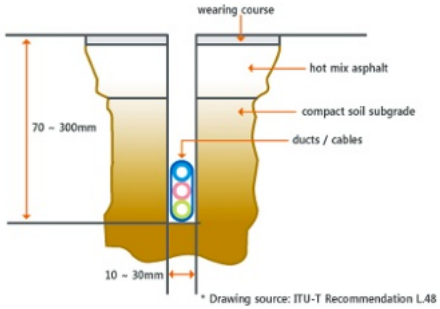
Lower population density, easier broadband

	32.45/km^2	2.91/km^2	3.49/km^2
	United States	**Australia**	**Canada**
			
Percent of population	**Percent of land area**		
60%	8.7%	0.2%	0.5%
80%	20%	0.9%	1.2%
90%	31%	4.2%	3.3%
Land area	**Low density (5–50 people per km^2) challenge**		
Percent of population	37%	18%	14%
Percent of land area	48%	4%	1.4%

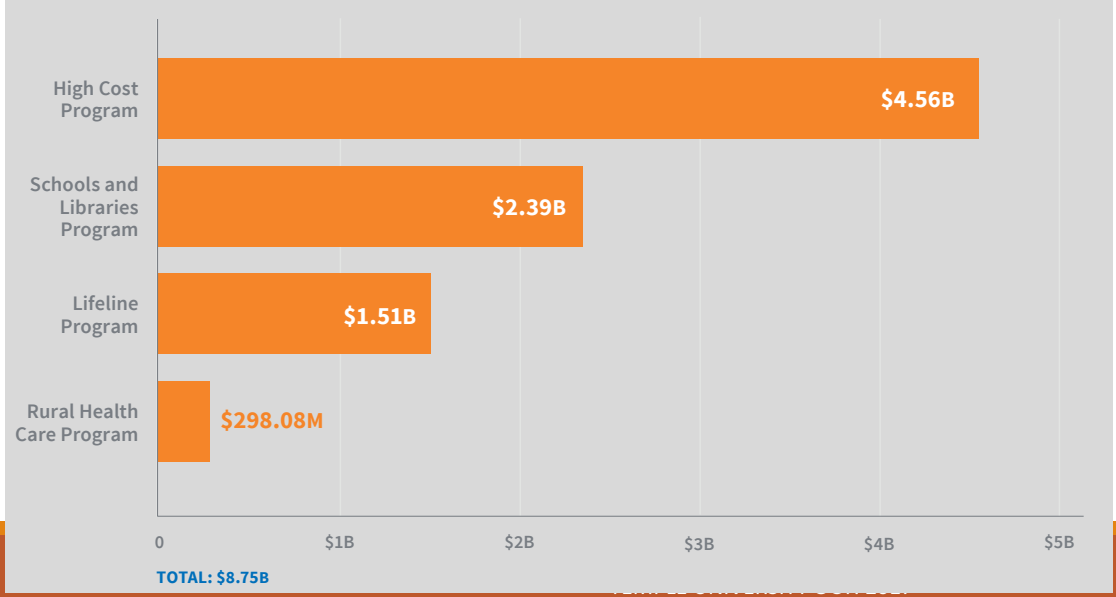
Deloitte, 2017

Policy levers for rural broadband

- Decrease cost of serving
  - "dig once" – bury conduit or fiber during street (or other utility) repair & construction
  - pole attachment: make-ready, rates, shot clocks, …
- Provide funding
  - US: Universal Service Fund



microtrenching



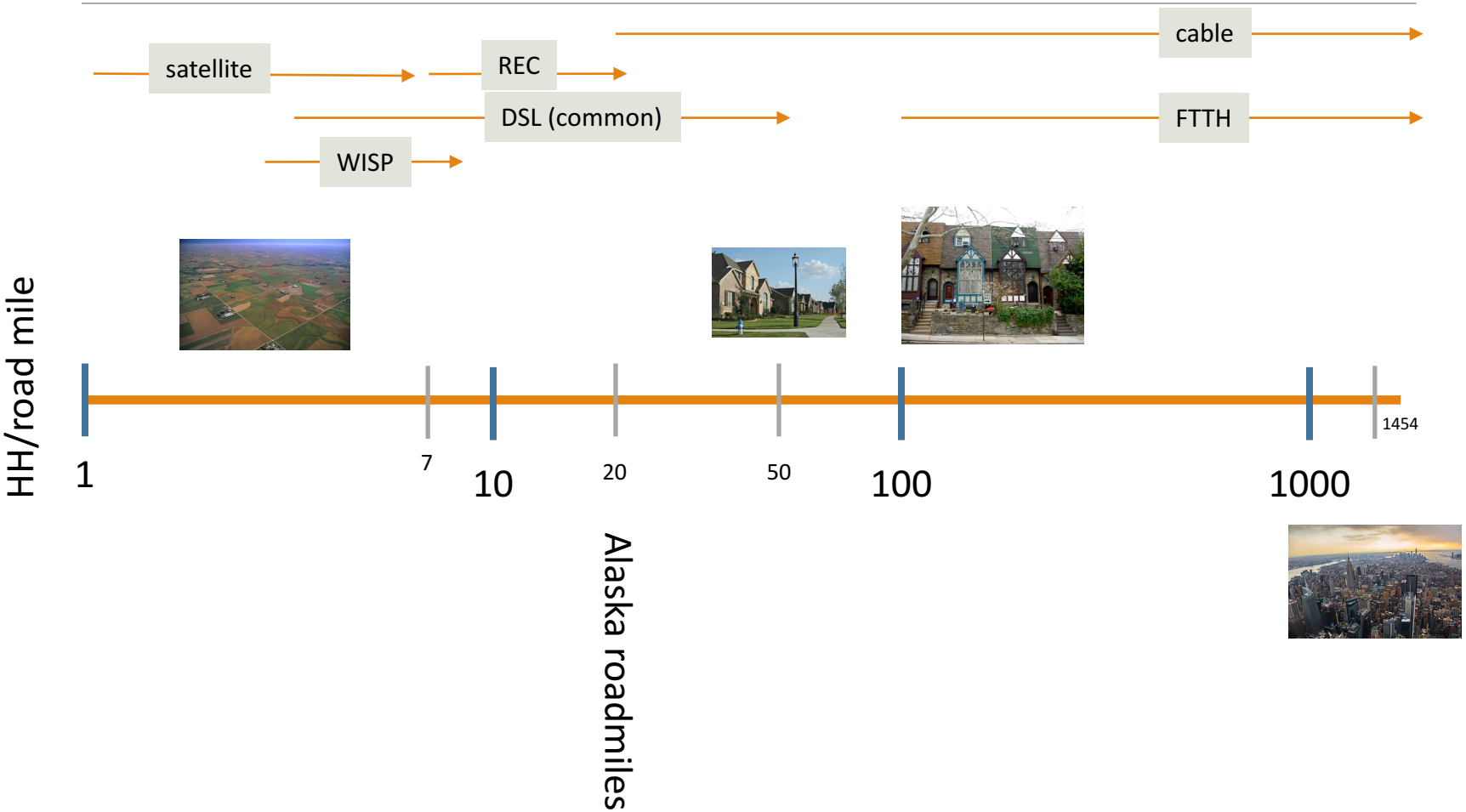
History: rural electrification

- Early 1920s, between 2 and 3% of farms (likely less)
  - 1921: DC had 98.2%, MA 97.8%
- "In 1935, only 10.9% of American farms (744,000) enjoyed central station power, compared with Germany and Japan at 90%, France between 90 and 95%, and New Zealand at 60%."
- "In 1940, just four and a half years after Roosevelt signed Executive Order No. 7037 (followed by 1936 "Rural Electrification Act"), 25% of American farms had been electrified."
- 1950: 90% had been electrified nationally
- Today: 850 distribution coops serving 14 M homes

Rural electrification

- “In 1935, Morris Llewellyn Cooke, a mechanical engineer … appointed by Roosevelt as the REA's first administrator, Cooke applied an engineer's approach to the problem, instituting what was known at the time as "scientific management"—essentially systems engineering. … By 1939 the cost of a mile of rural line had dropped from $2,000 to $600. Almost half of all farms were wired by 1942 and virtually all of them by the 1950s.”
- Cost of aerial **fiber** installation: $14k/mile material, $39k/mile installation (Singer, 2017)
- USDA loans at 2.81% for 30 years

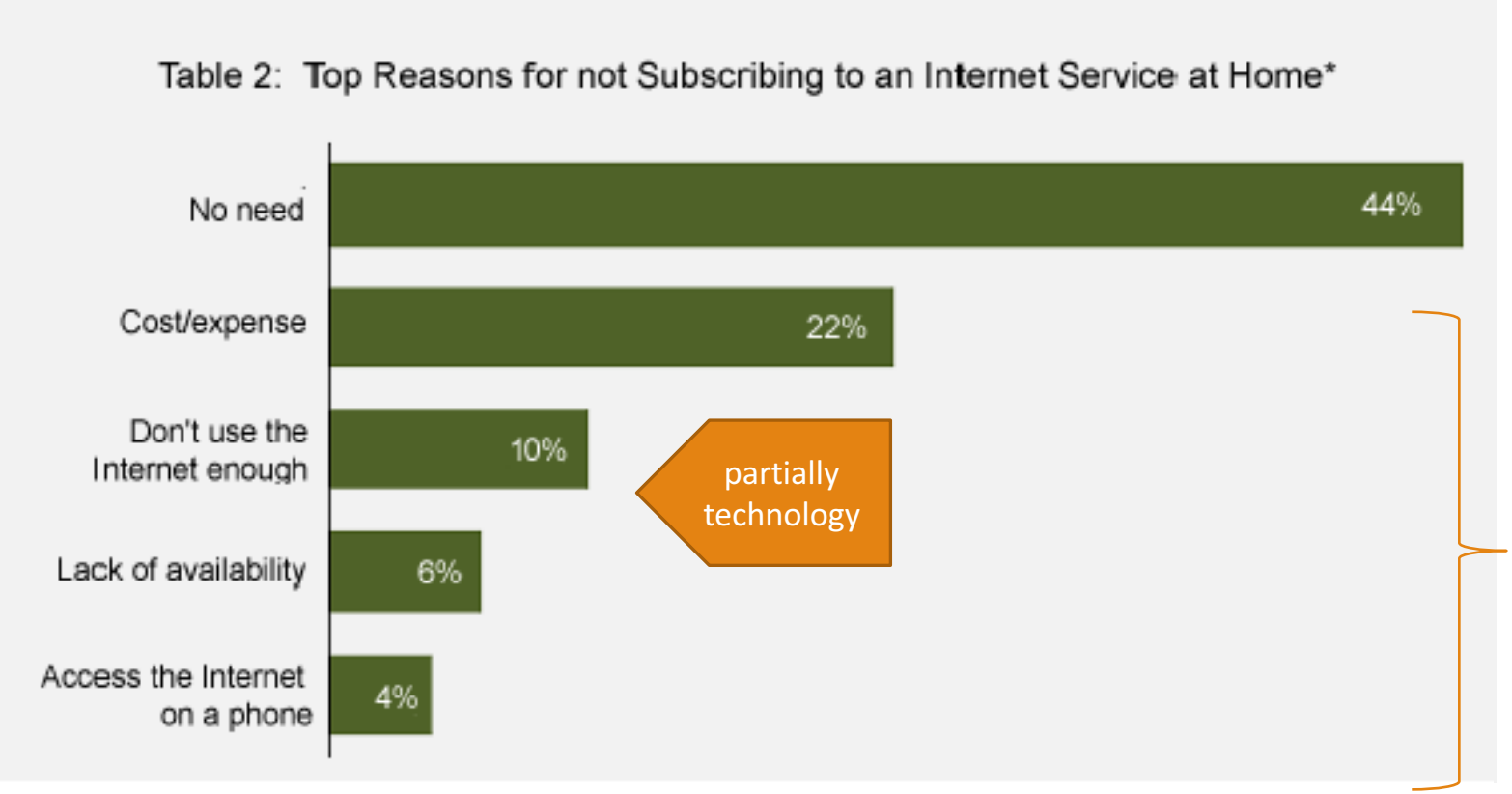
Density determines network choices



Challenges for rural broadband

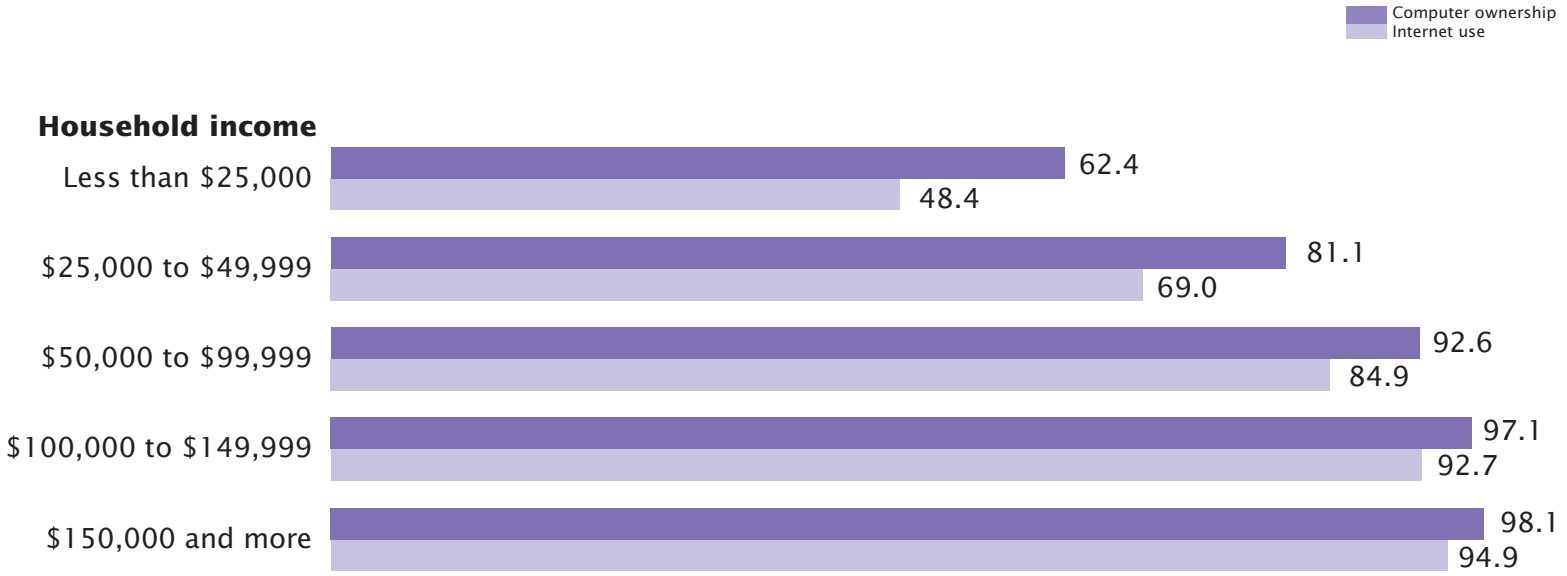
- Who is going to build out?
  - some incumbent local exchange carriers (ILECs) are not interested
  - municipalities may be prohibited by state laws
    - or hurdle is extremely high
  - rural electric cooperatives – serve 14M homes in US (out of ~110M)
    - average, 5.8 electric meters per mile
- Who is going to pay for broadband?
  - pay once or pay forever?
- Are non-landline approaches scalable?
  - TVWS
  - satellite – NGS like OneWeb (600 satellites)
    - currently, about 500k residential satellite subscribers

Reason for non-adoption



** Asked of those who do not currently get an Internet service at home and do not plan to subscribe in the next six months*

Internet usage by income



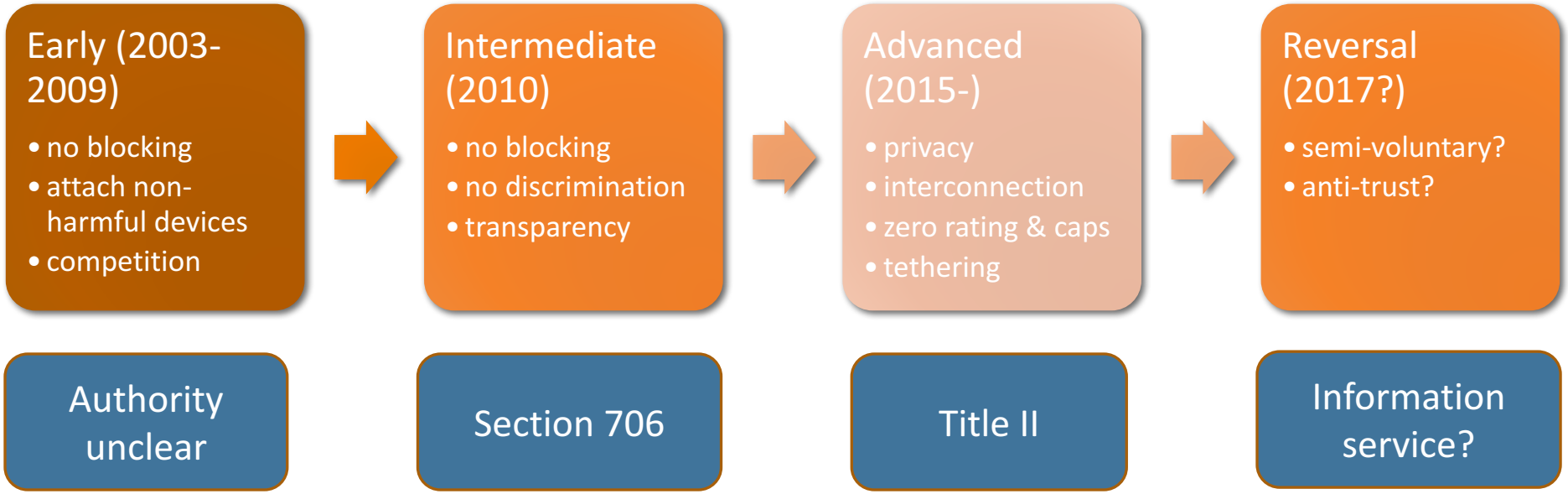
Note: About 4.2 percent of all households reported household Internet use without a paid subscription. These households are not included in this figure.

Computer and Internet Use in the United States: 2013

American Community Survey Reports

Open Internet (Network neutrality)

A simplified evolution



Questions beyond

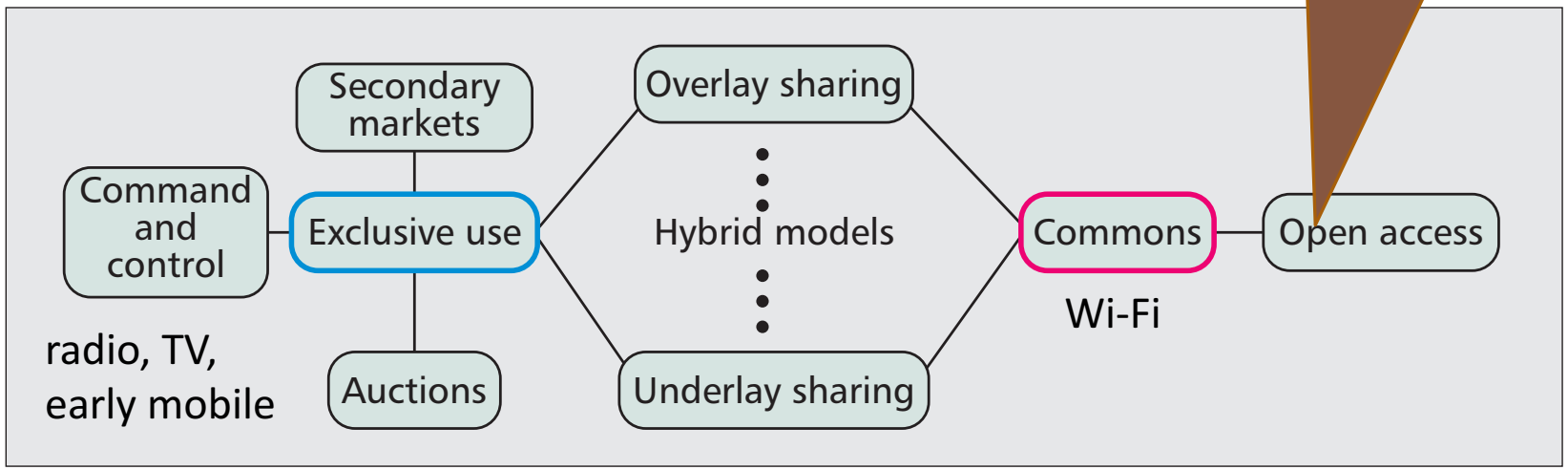
- What are the rights and obligations of
  - broadband Internet access providers?
  - content providers that want to interconnect?
  - handset vendors and application writers?
  - consumers?
  - right-of-way owners (poles and ducts)?
- What are the legal foundations?
- Are there any economic restrictions?
  - Telecom: “just & reasonable”
  - or just anti—trust rules (largely, mergers & acquisition, collusion, …)
- Who sets the rules?
  - FTC – ”unfair or deceptive trade practices”
  - FCC – sector-specific

Spectrum

Spectrum sharing

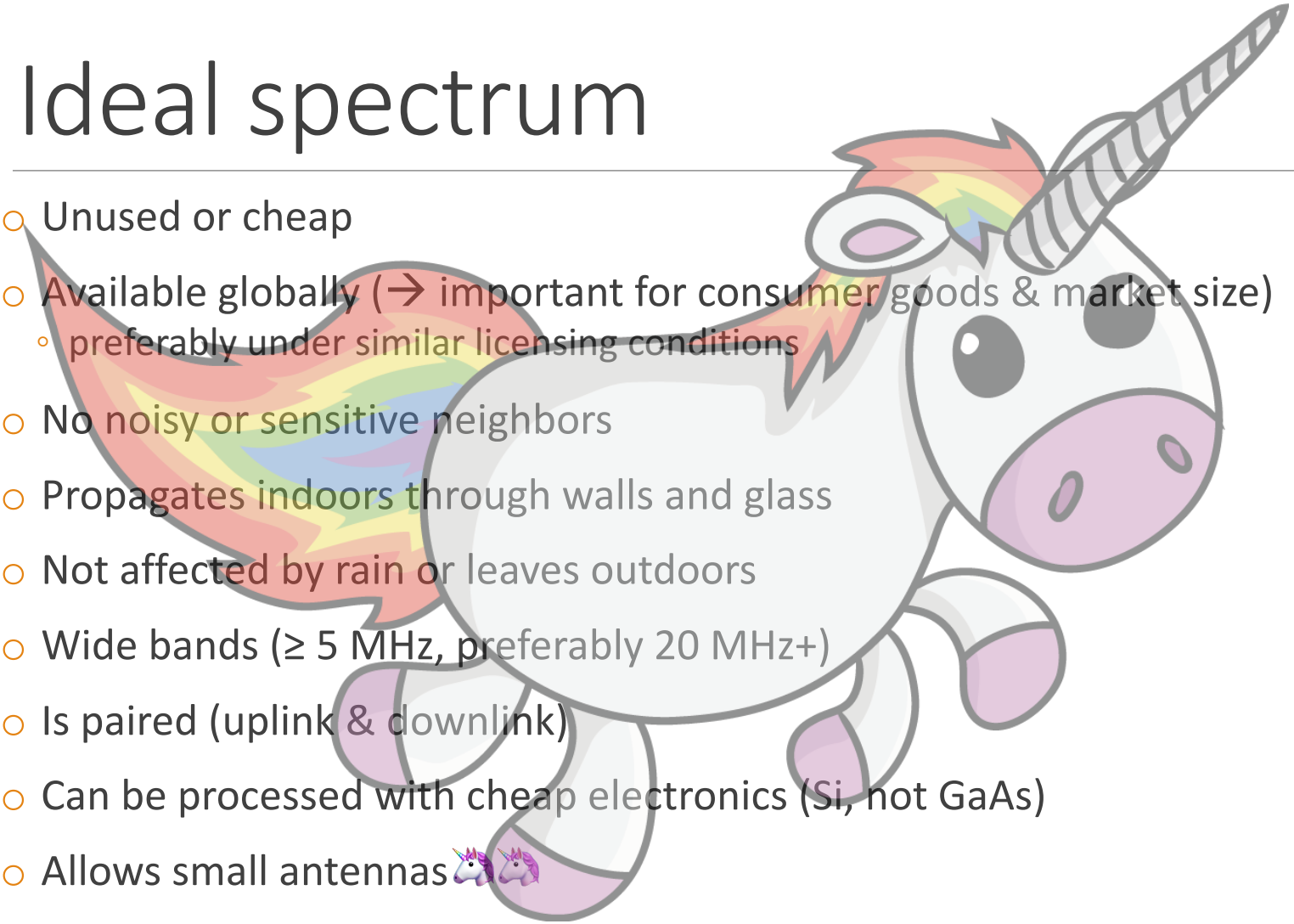
How much politeness & fairness is required?
→ LTE-U & LTE-LAA (license-assisted, listen-before-talk)

through 1990s



US: since 1994

Ideal spectrum



- Unused or cheap
- Available globally (→ important for consumer goods & market size)
  - preferably under similar licensing conditions
- No noisy or sensitive neighbors
- Propagates indoors through walls and glass
- Not affected by rain or leaves outdoors
- Wide bands (≥ 5 MHz, preferably 20 MHz+)
- Is paired (uplink & downlink)
- Can be processed with cheap electronics (Si, not GaAs)
- Allows small antennas 🦄🦄

Spectrum management

UNTIL THE 2000S	"MODERN"
Single purpose	Flexible use
Fixed technology (modulation)	Flexible technology
Exclusive use	Shared, over/underlay
Narrow bands (except TV)	At least 5 MHz, preferably 100
Assume single radio per device	Multiple (> 4) XTR/RCV
Worry mostly about OOB to like	Receiver requirements?
Spectral efficiency secondary	Spectral efficiency matters
Single-country	International coordination

Challenges for spectrum sharing

Unlicensed ~2000

- indoor home
- indoor enterprise
- campus
- --> natural separation
- only power rules (no listen-before-talk (CS) required)

Unlicensed now

- secondary public SSID
  - e.g., CableWiFi
- re-use HFC/FTTH backhaul
- One band, one channel

Unlicensed emerging

- LTE-U, LAA
- what are the "kindergarten" rules?

Spectrum co-existence

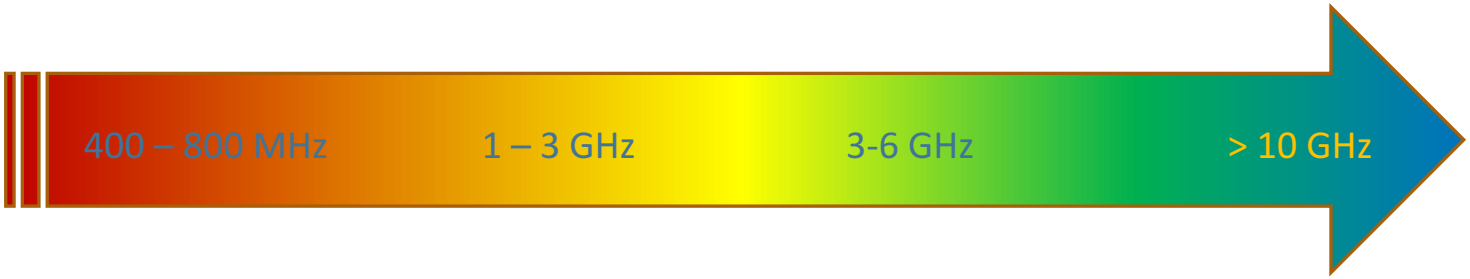
"high tower, high power"
(TV, cellular downlink, radar transmitter)

vs.

- cellular uplink
- radar receiver
- GPS receiver

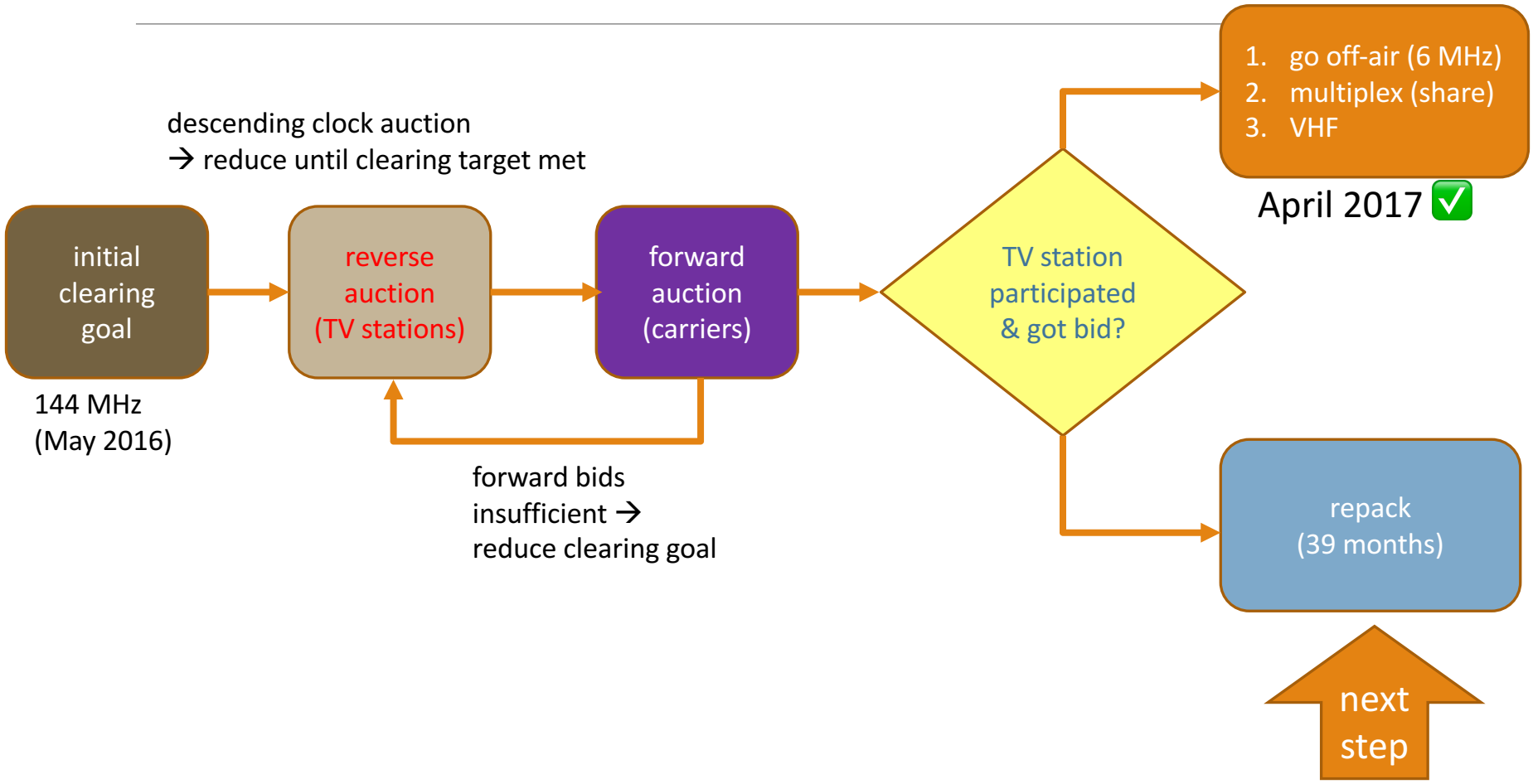
how do I quickly identify sources of interference?

Spectrum roles



base-level coverage (particularly rural)	urban capacity	indoor & capacity	directional capacity
Digital dividend TV incentive auction	AWS-3	3.5 GHz	mmWave R&O

TV incentive auction

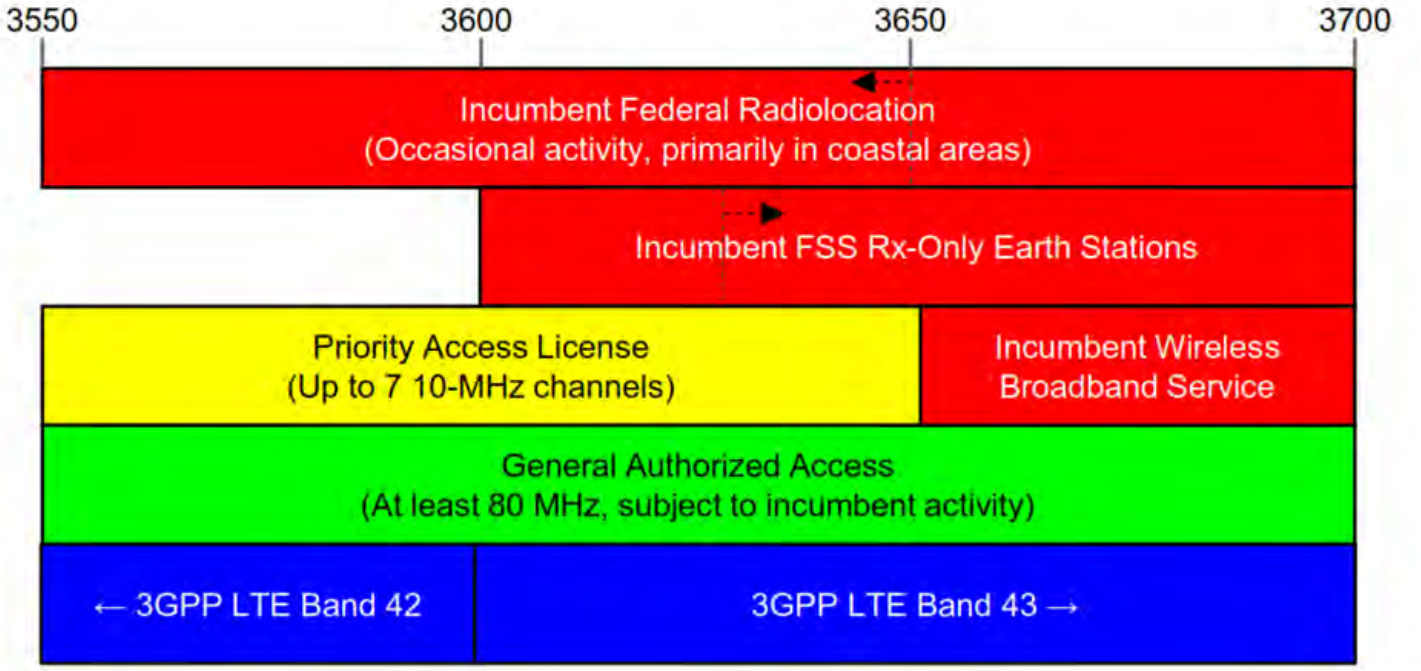


Incentive auction facts

Forward Auction

$19.8 billion	Gross revenues (2nd largest in FCC auction history)
$19.3 billion	Revenues net of requested bidding credits
$7.3 billion	Auction proceeds for federal deficit reduction
70 MHz	Largest amount of licensed low-band spectrum ever made available at auction
14 MHz	Spectrum available for wireless mics and unlicensed use
2,776	License blocks sold (out of total of 2,912 offered)
$1.31	Average price/MHz-pop *sold* in Top 40 PEAs
$.93	Average price/MHz-pop *sold* nationwide

3.5 GHz band



Band 42: TDD, 3.4-3.5 GHz

Band 43: TDD, 3.6-3.65 GHz

Source: Google

FSS: C Band (3.625–4.200)

Universal access

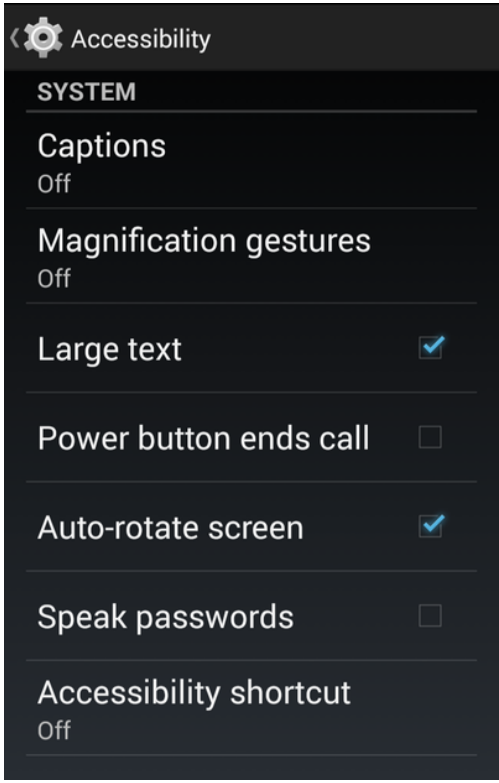
Goal: functional equivalence

- Title IV of Americans with Disabilities Act (ADA):
  - The term "telecommunications relay services" means telephone transmission services that provide the ability for an individual who has a hearing impairment or speech impairment to engage in communication by wire or radio with a hearing individual in a manner that is functionally equivalent to the ability of an individual who does not have a hearing impairment or speech impairment to communicate using voice communication services by wire or radio. Such term includes services that enable two-way communication between an individual who uses a TDD or other nonvoice terminal device and an individual who does not use such a device.

47 USC 225

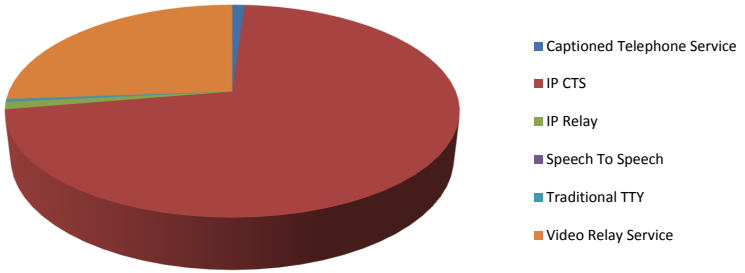
What can be done?

But what about YouTube?
Live events?



Enable access by people with disabilities → provide new capabilities for everyone

Relay services

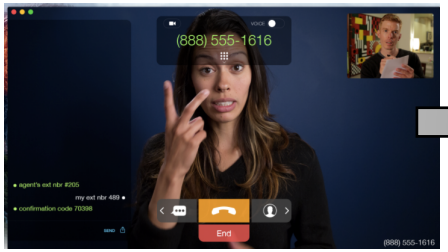


text relay

(legacy, may transition to RTT)

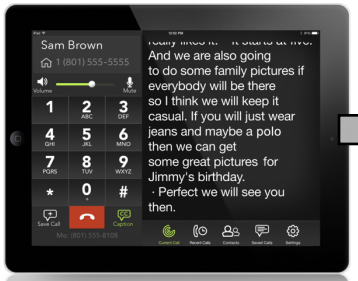
VRS

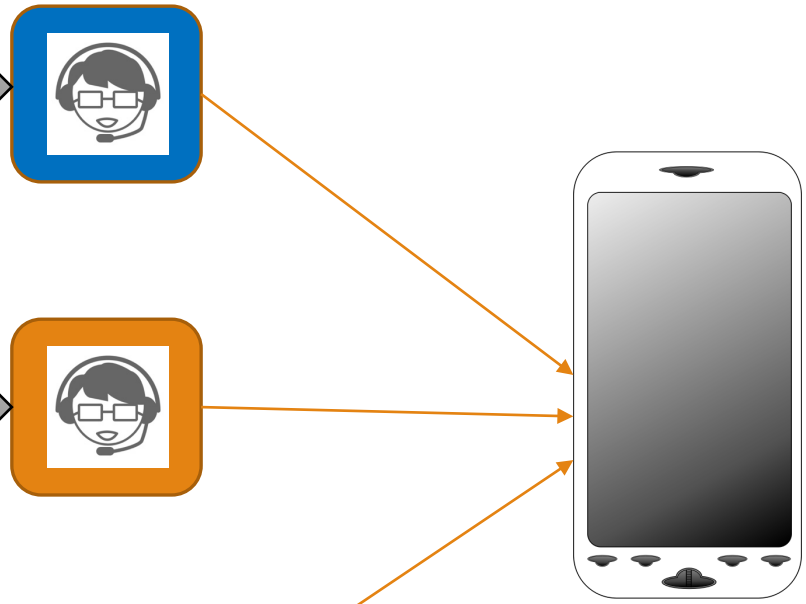
(ASL as first language; mostly culturally Deaf)



IP-CTS

(Non-ASL; mostly late-deafened)





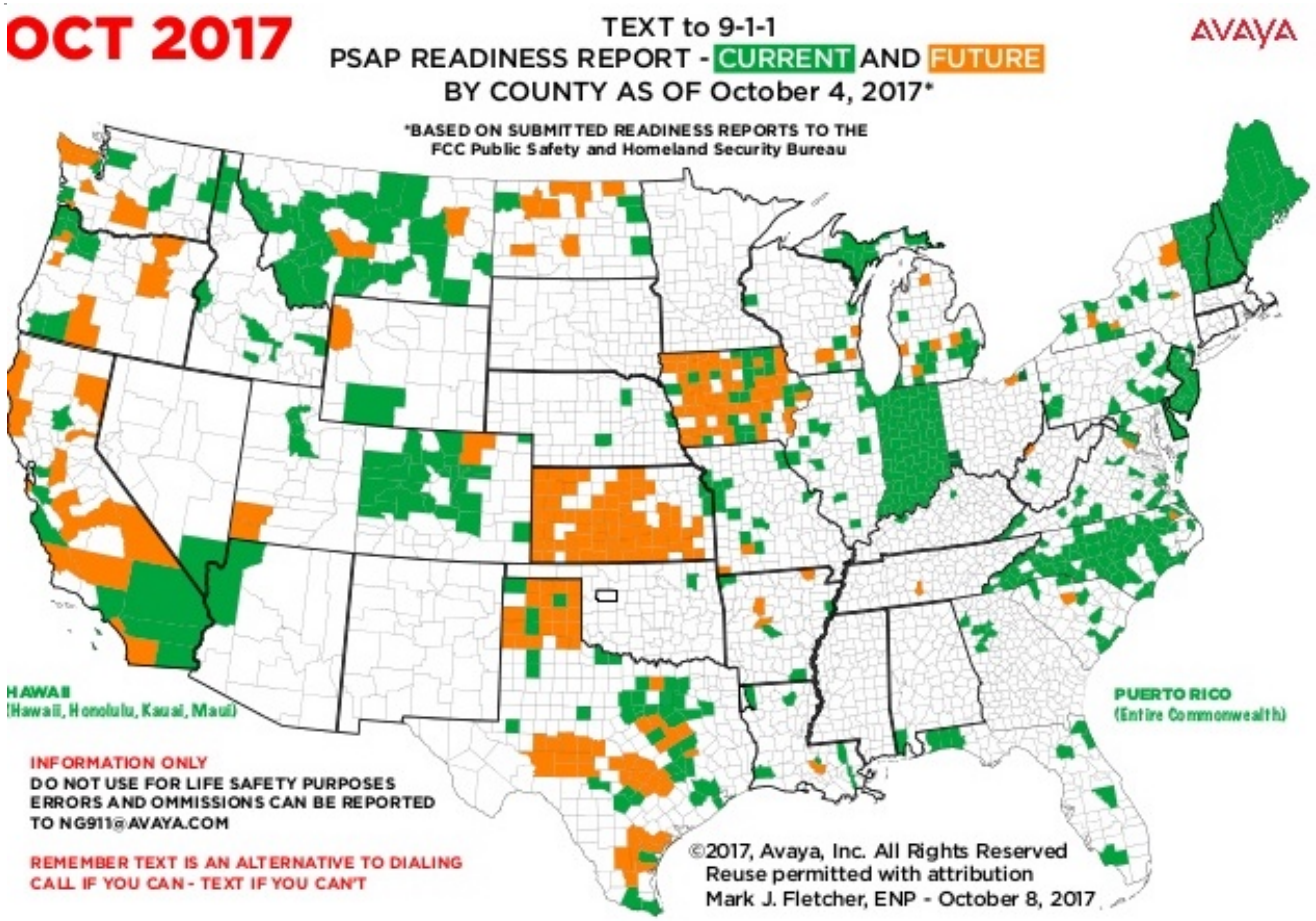
Direct video calling

old model: customer → video interpreter → government agency
new model: customer – (direct video calling) --- government agency

10% of VRS minutes are to small set of destinations, like SSA

Emergency calling

Text-to-911



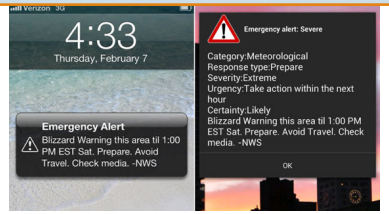
obligation for carriers by June 2015

VoIP emergency communications

phone & SMS-based (local)

WILKES ALERT
EMERGENCY NOTIFICATION SYSTEM

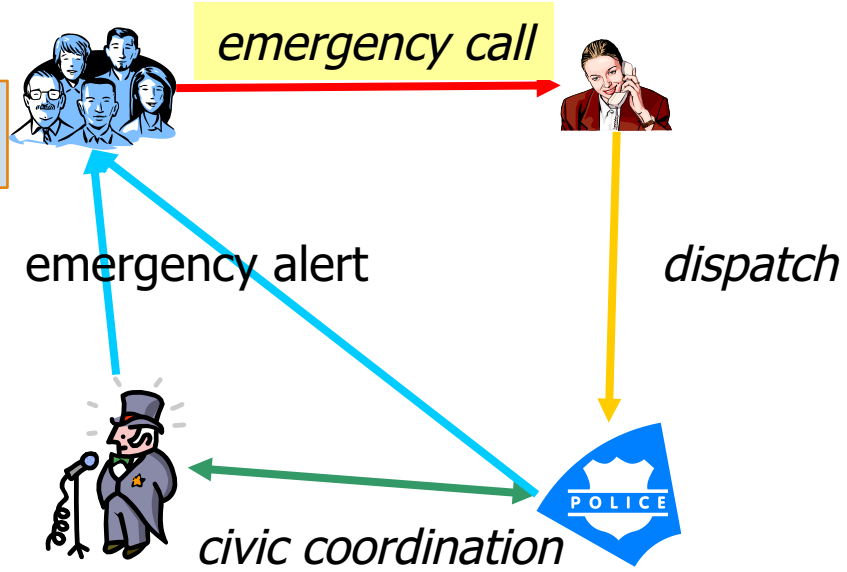
wireless emergency alerts (WEA)



90 characters
(360 in the future?)

AM/FM
TV
cable

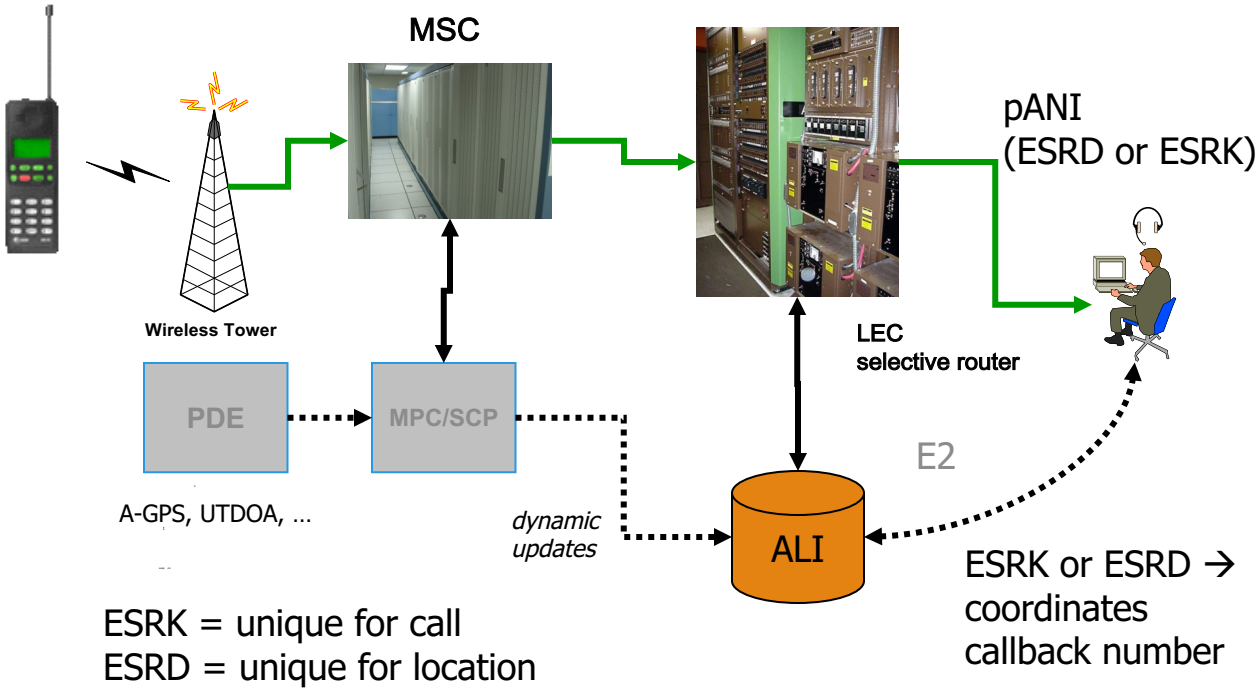
EAS
Emergency Alert System



What distinguishes 911?

- 5,784 PSAPs (in 3,135 U.S. counties)
  - some very large (NYC, LA, Chicago), some tiny
  - technical services by contractors and "system service providers"
- 240 million 9-1-1 calls per year: 70% cellular
- Location delivery
  - 98.6% of population have some Phase II (July 2016) – outdoors!
  - most carriers use hybrid location (GPS + network-based such U-TDOA)
- Funded by variety of add-on 9-1-1 charges on phone bills, not taxes
  - some diverted to other purposes
- Limited regulatory authority for FCC
  - Mostly, iVoIP and cellular providers, not PSAPs
  - some oversight by state public utilities commission or state 911 office

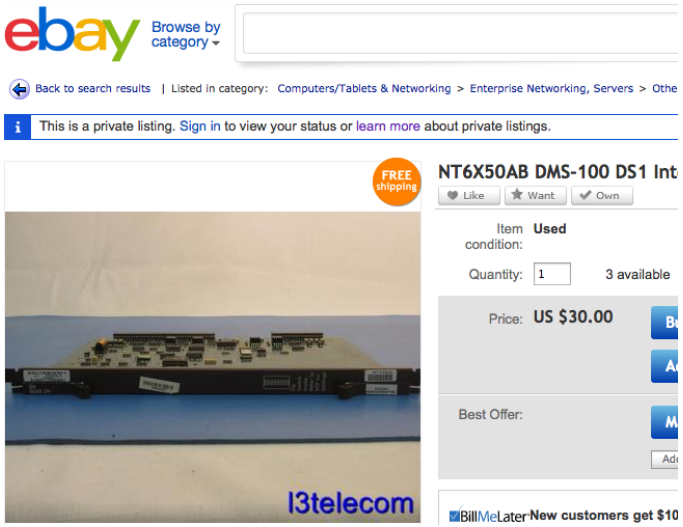
Wireless 911: Phase 2



Switches are ageing

Nortel DMS-100

1979



http://www.phworld.org/switch/ntess.htm

March 8th AT&T Mobility VoLTE 911 Outage

- **March 8, 2017: Significant adverse impact on VoLTE 911 services**
  - Outage appeared to affect AT&T Mobility VoLTE 911 service for approximately 5 hours in the Southeast, Central and portions of the Northeast Region of the US, and eventually, a significant portion of VoLTE 911 calls in the remaining portion of the country.
  - According to AT&T, on a normal day, it would expect its total VoLTE 911 call volume to be approximately 44,000 calls nationwide. During the event, approximately 12,600 unique callers were not able to reach 911 directly.
  - Changes to AT&T's network appeared to cause automated call routing for VoLTE 911 calls to fail.
  - Small subset of calls were answered by a backup call center and routed to first responders. Volume of calls exceeded the call center's capability to manually process them, resulting in a large number of calls being dropped.
  - Some customers received fast busy signals when attempting to call 911. Others report that calls to 911 rang repeatedly without being answered.

Conclusions

- Networks as infrastructure → technology, economics & policy
- Think in decades, not conference cycles
- Network performance is rarely the key problem
  - except maybe at physical layer
- Many of the problems are incentive problems
  - we know how to solve them, but levers are missing
  - or are politically not feasible