Telecom policy: competition, spectrum, access and technology transitions

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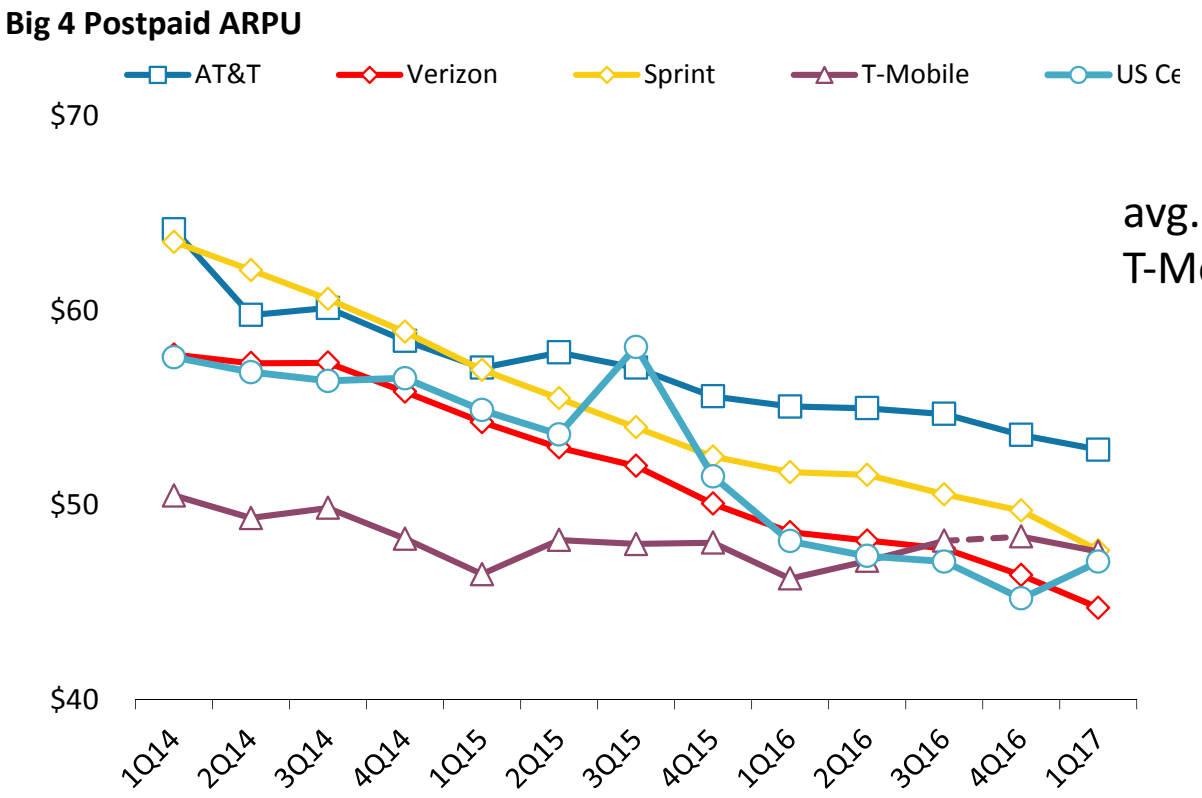
Key challenges – (nearly) everywhere

- Competition and investment are poorly understood
- 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

What's the economic case for 5G?

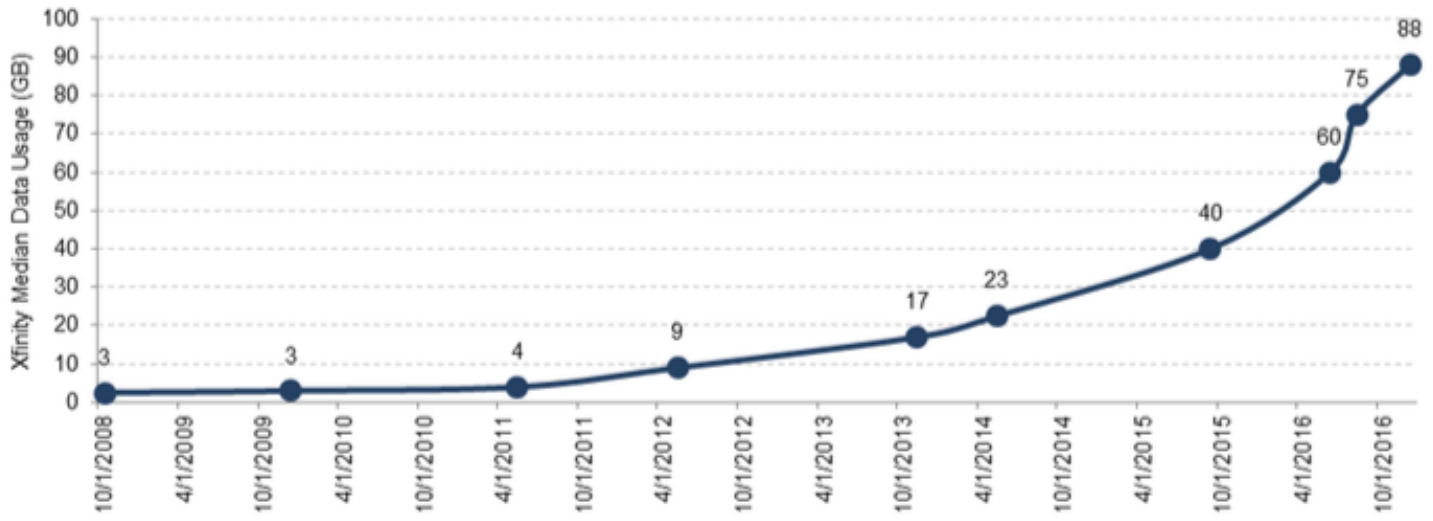


avg. about 2.1 GB/month
T-Mobile: 10 GB tethering

Cord-cutting for broadband?

Exhibit 13

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

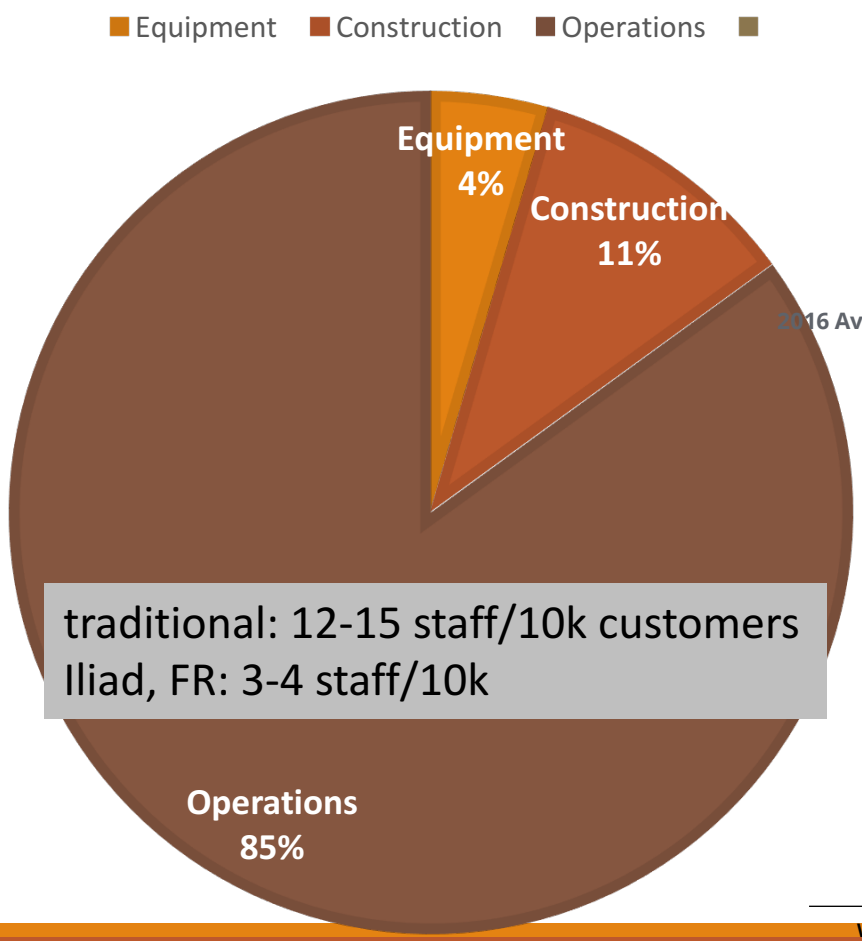


Source: Comcast's website, MoffettNathanson estimates and analysis

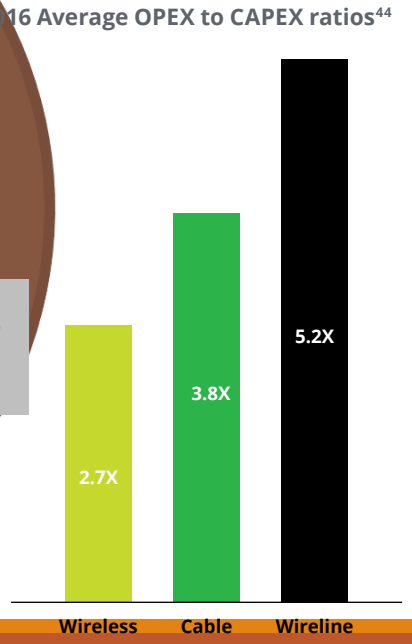
Metrics: not Gb/s or b/s/Hz, but $/GB and $/year

- 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



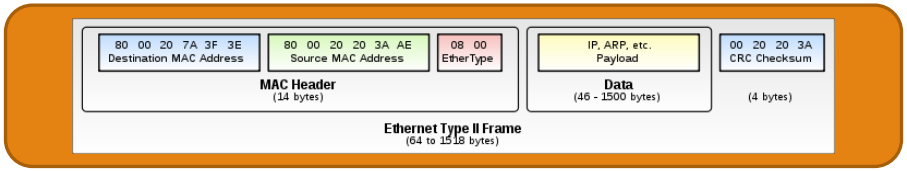
traditional: 12-15 staff/10k customers
Iliad, FR: 3-4 staff/10k



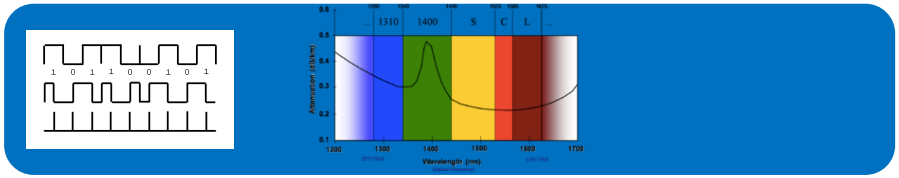
Competition models: vertically integrated

content & applications

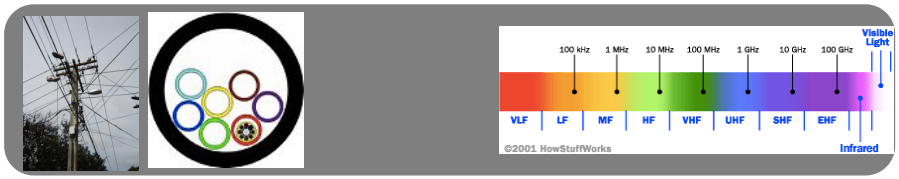
L3…L7



L2 (MAC)



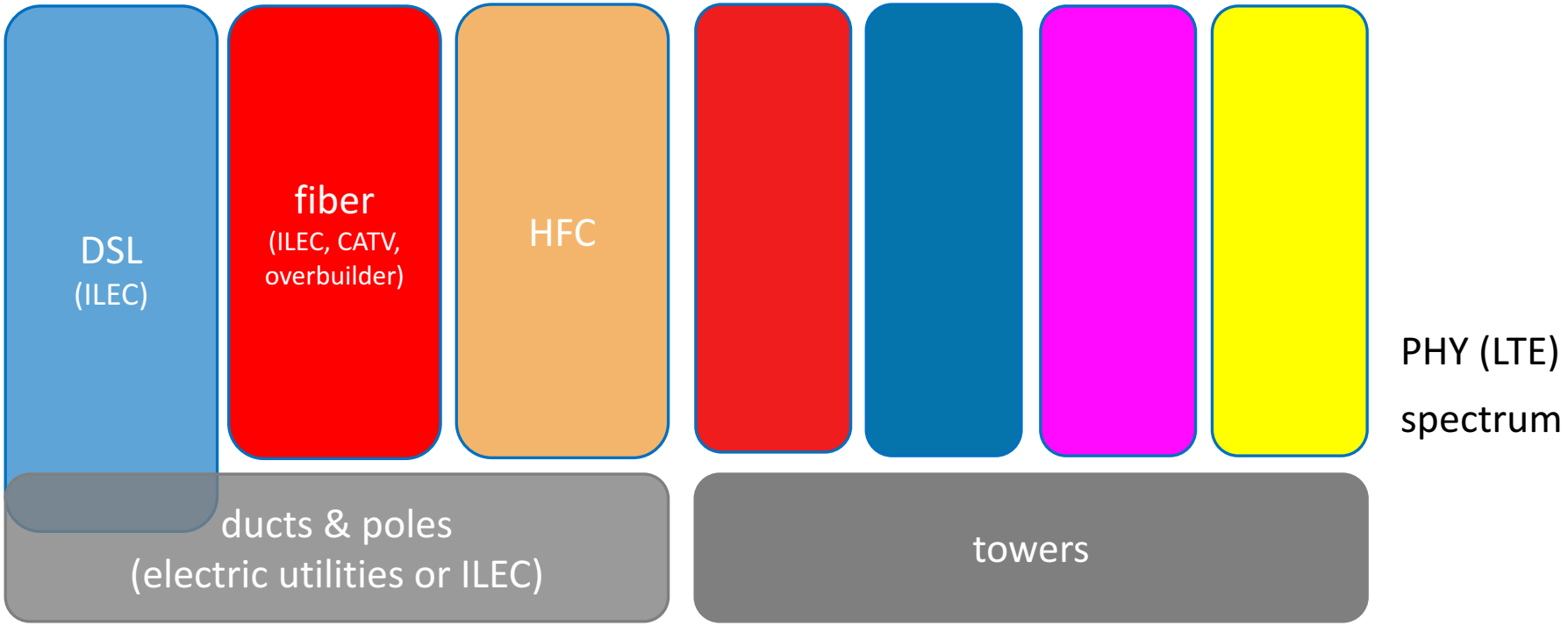
L1 (PHY)



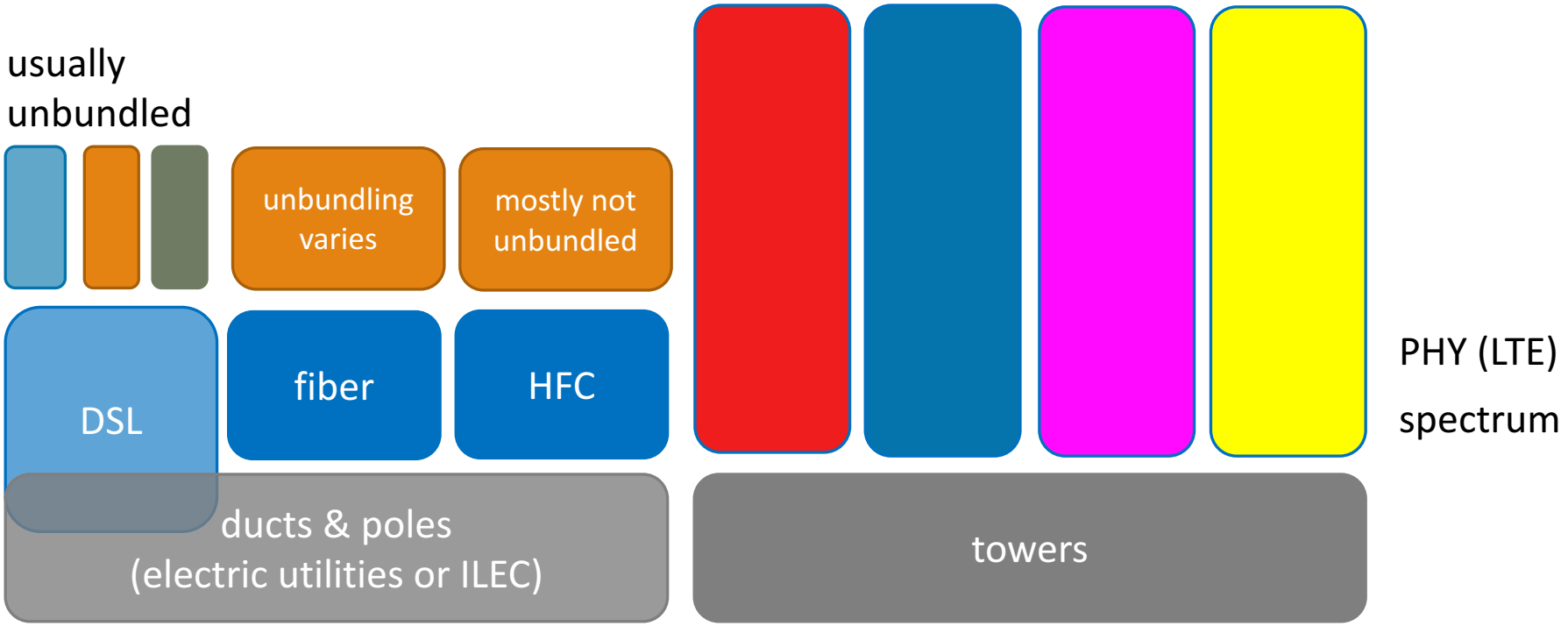
”L0” (infrastructure)

Sharing models: US

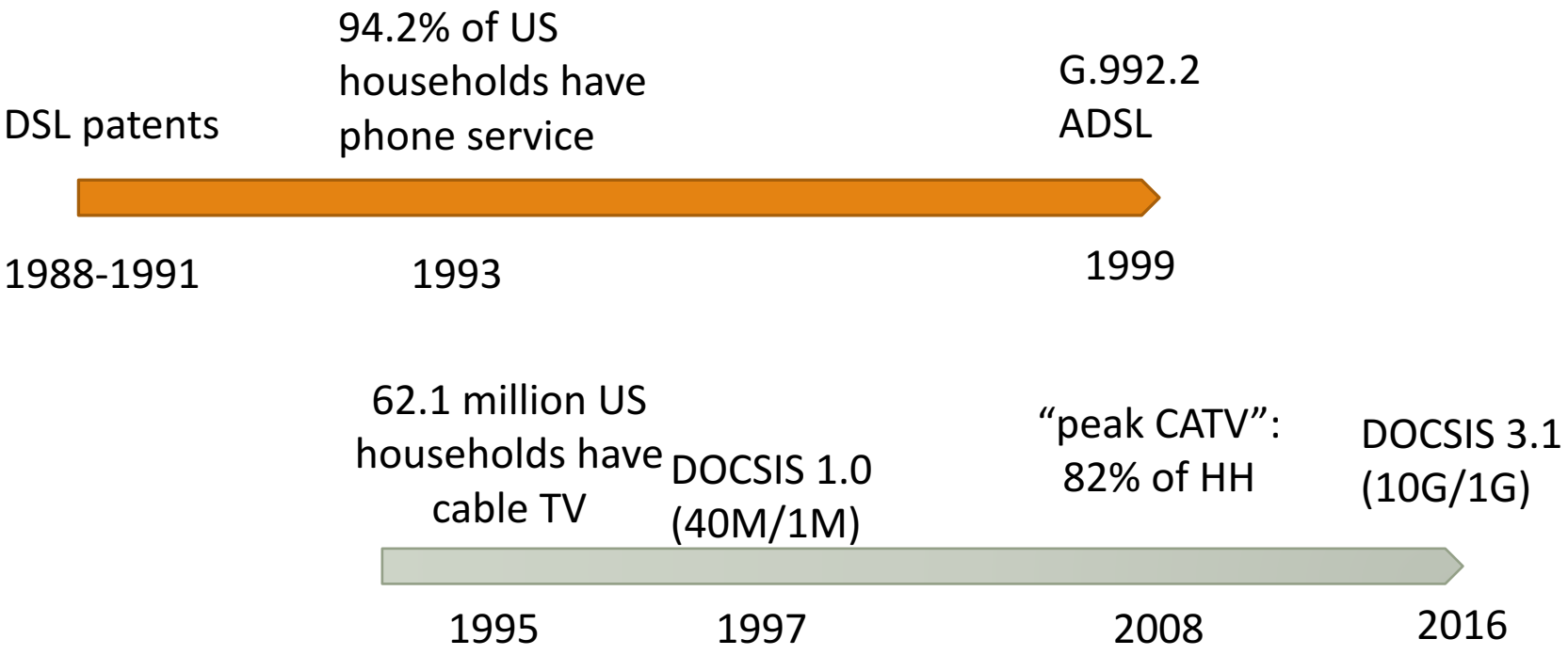
+ WISP & satellite



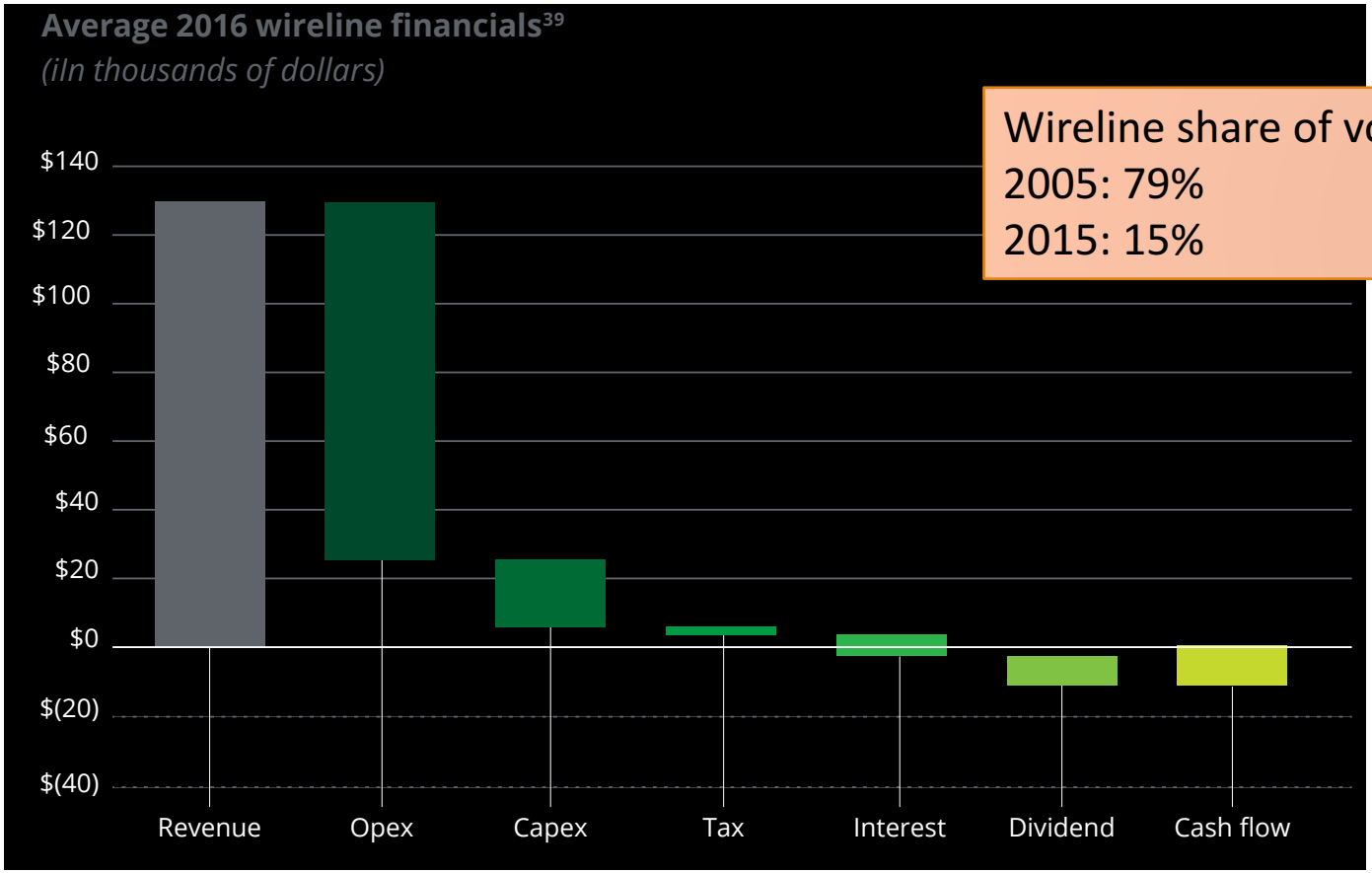
Sharing models: Canada, Europe, Australia



Accidental broadband

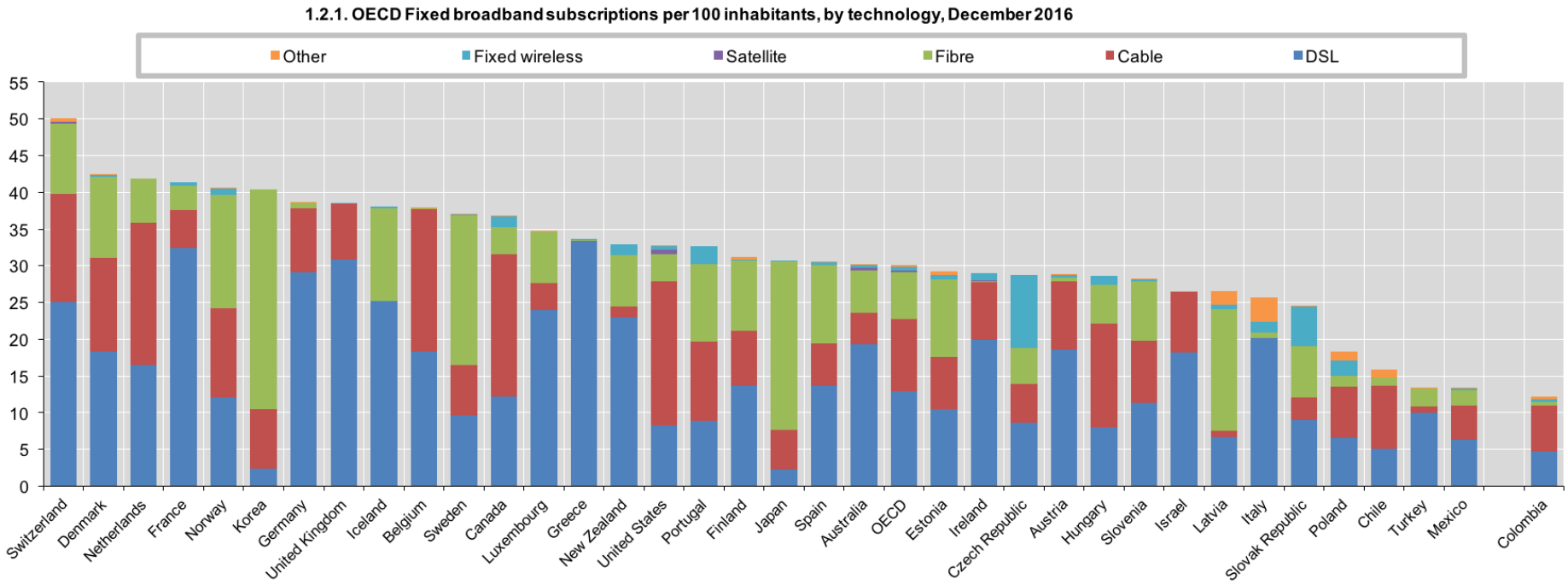


Rural wireline ILECs lack resources



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

OECD overview

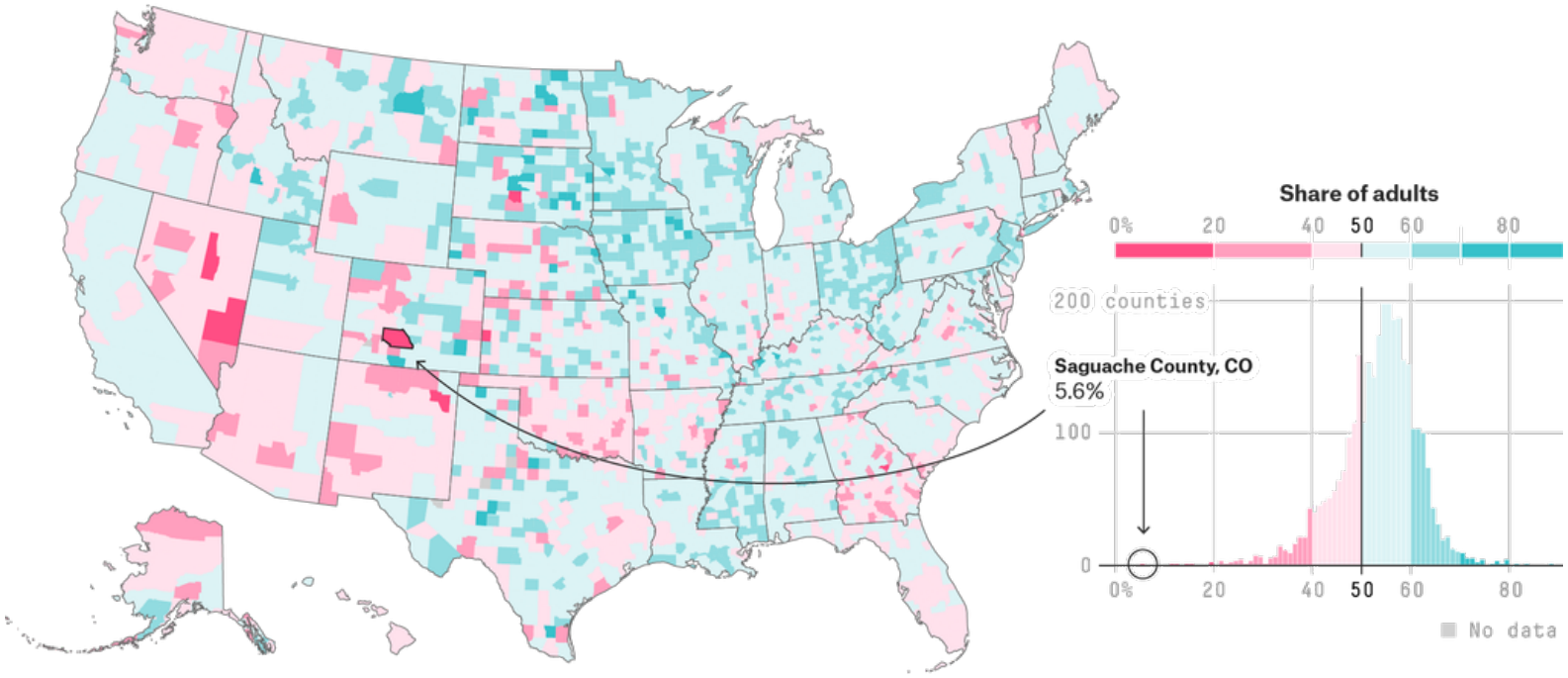


Trade-offs across the world?

- 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

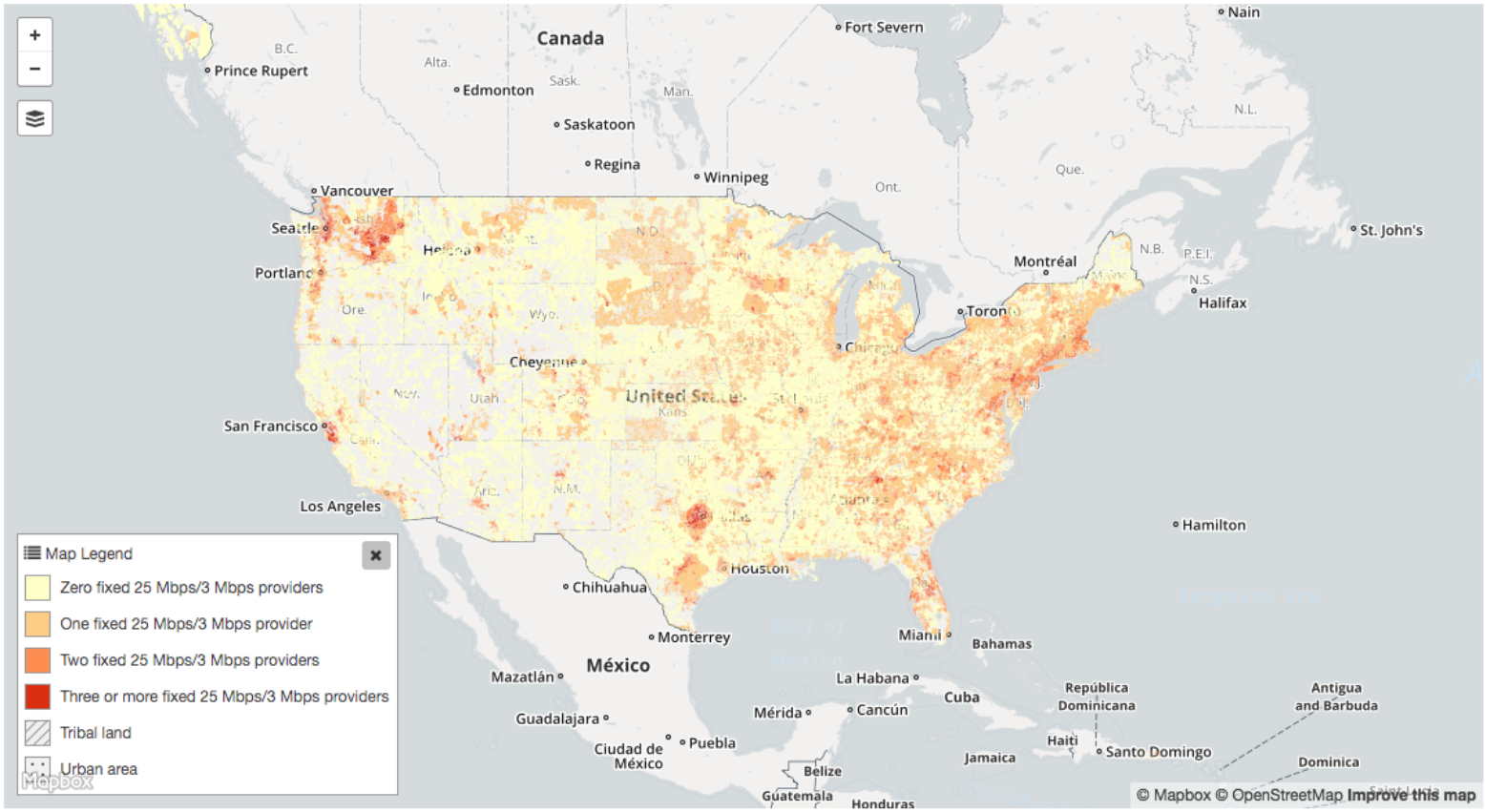


County shares are estimated using data from a 1 percent sample of 240 million voting-age Americans provided by Catalist, an election data firm. Internet connections faster than dial-up include those via DSL, cable, fiber-optic, satellite, etc.

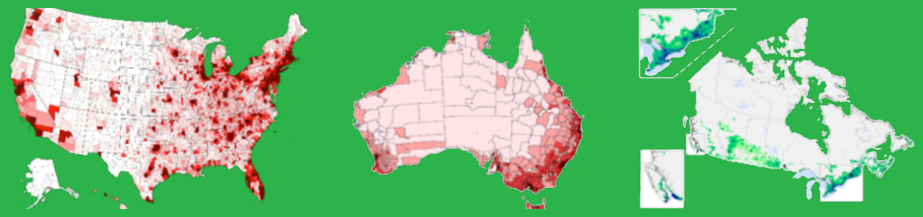
FiveThirtyEight

SOURCE: ARIZONA STATE UNIVERSITY'S CENTER FOR POLICY INFORMATICS

Number of 25/3 Mb/s providers



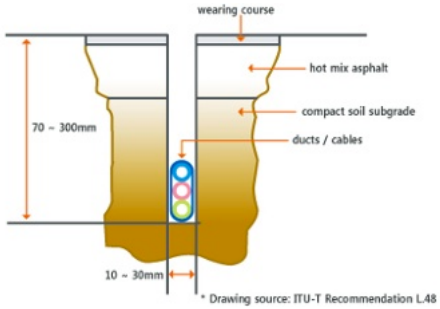
Lower population density, easier broadband

	32.45/km²	2.91/km²	3.49/km²
	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 km²) challenge**		
Percent of population	37%	18%	14%
Percent of land area	48%	4%	1.4%

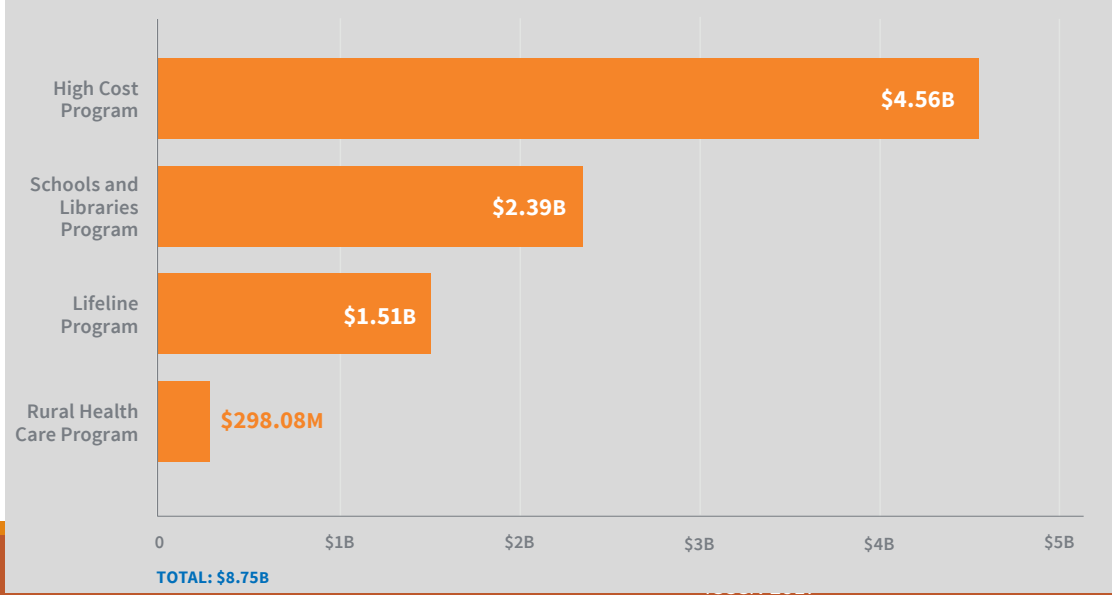
Deloitte, 2017

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

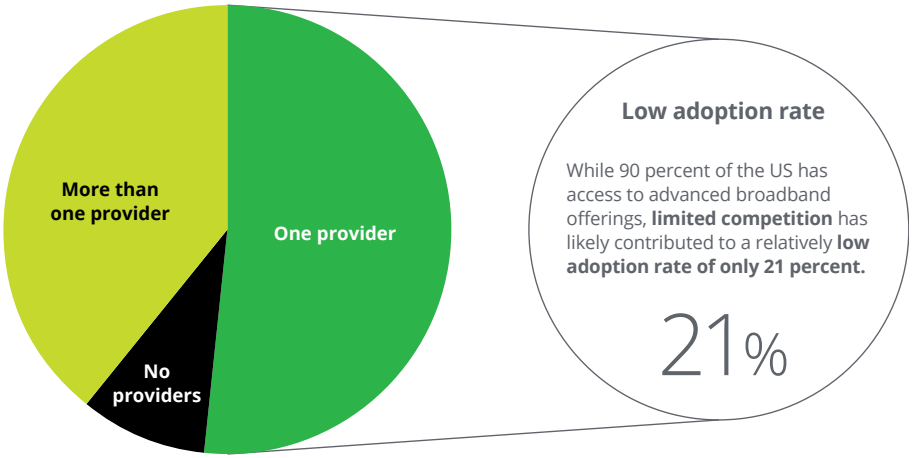


Challenges for rural broadband

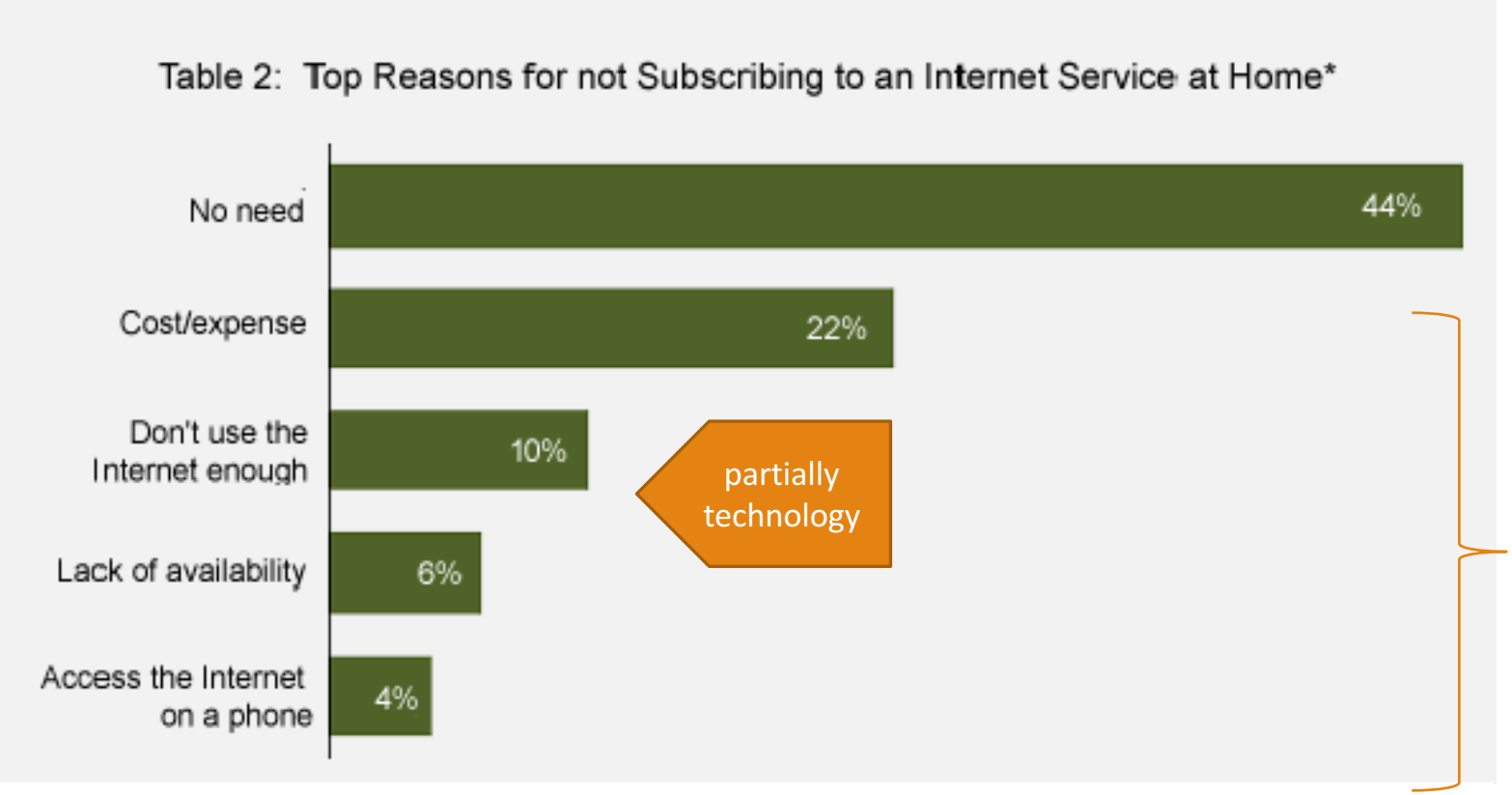
- Who is going to build out?
  - some incumbent local exchange carriers (ILECs) are not interested
  - municipalities may be prohibited by state laws
    - or hurdle is extremely high
  - rural electric cooperatives – serve 14M homes in US (out of ~110M)
    - average, 5.8 electric meters per mile
- 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

Broadband adoption

- Used to be simple binary: “are you on the Internet?”
- Now:
  - low-speed landline Internet
  - mobile Internet
  - high-speed Internet
- What capabilities matter?
  - Facebook and Whatsapp access?
  - ability to fill out job form? → mobile apps
  - content creation → tethering ok?



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*

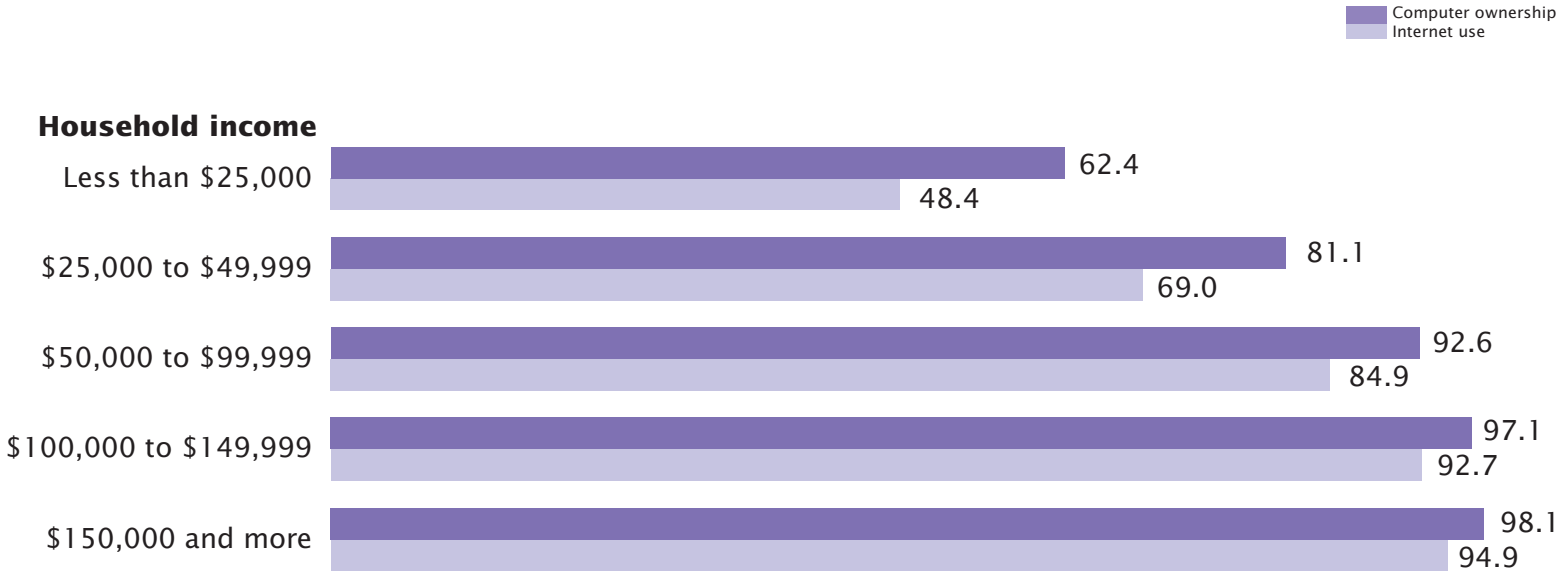
Barriers to Internet adoption

Non-Internet users face four categories of barriers

	Incentives	Low incomes and affordability	User capability	Infrastructure
Barriers directly affecting consumers	Lack of awareness of Internet or relevant use cases Lack of relevant (e.g., local, localized) content and services Lack of cultural or social acceptance	Low income or consumer purchasing power Total cost of ownership for device Cost of data plan Consumer taxes and fees	Lack of digital literacy Lack of language literacy	Lack of mobile Internet coverage or network access Lack of adjacent infrastructure (e.g., grid electricity)
Root causes (e.g., providers, government/ regulatory, industrial)	▪ High content and service provider costs and business model constraints ▪ Low awareness or interest from brands and advertisers ▪ Lack of a trusted logistics and payments system ▪ Low ease of doing business ▪ Limited Internet freedom and information security	▪ Challenging national economic environment ▪ High device manufacturer costs and business model constraints ▪ High network operator costs and business model constraints ▪ High provider taxes and fees ▪ Unfavorable market structure	▪ Under-resourced educational system	▪ Limited access to international bandwidth ▪ Underdeveloped national core network, backhaul, and access infrastructure ▪ Limited spectrum availability ▪ National ICT strategy that doesn't effectively address issue of broadband access ▪ Under-resourced infrastructure development (e.g., FDI limits)

SOURCE: Literature review; expert interviews; McKinsey analysis

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

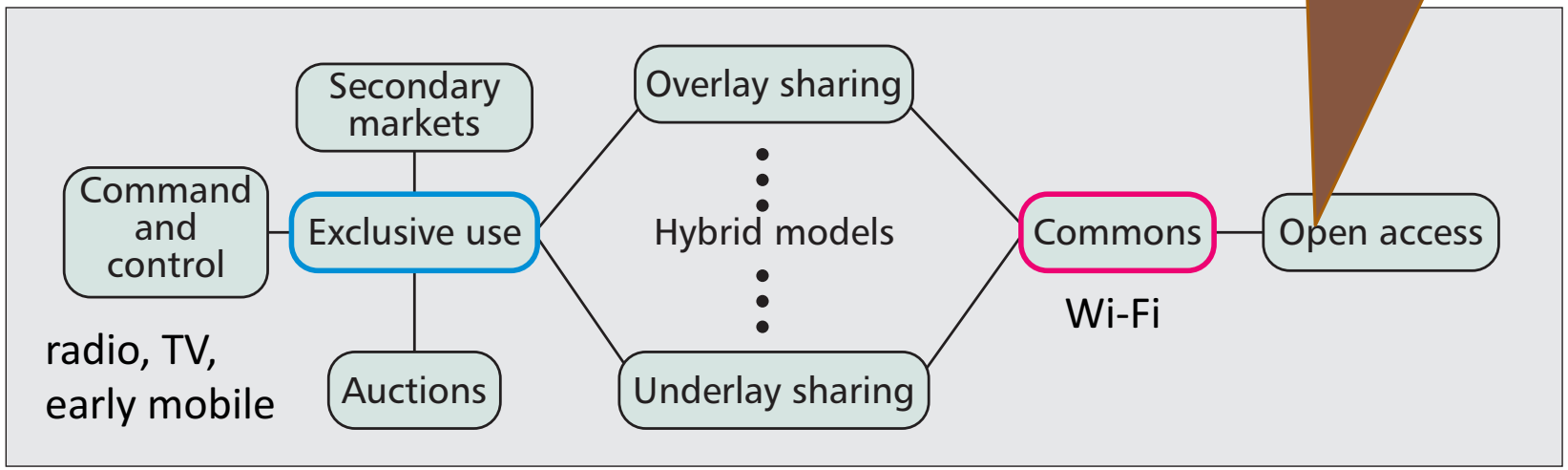
American Community Survey Reports

Spectrum

Spectrum sharing

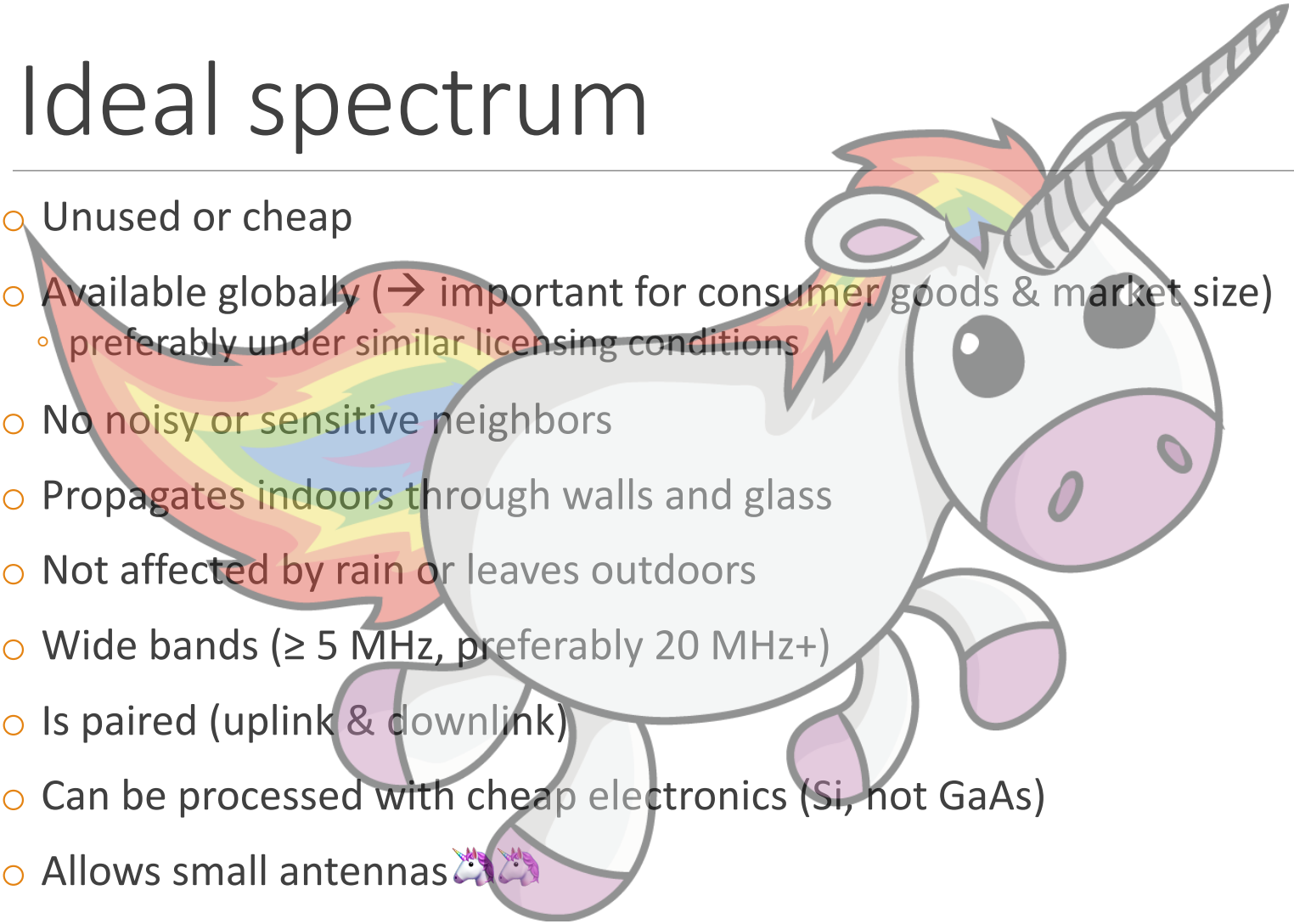
How much politeness & fairness is required?
→ LTE-U & LTE-LAA (license-assisted, listen-before-talk)

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

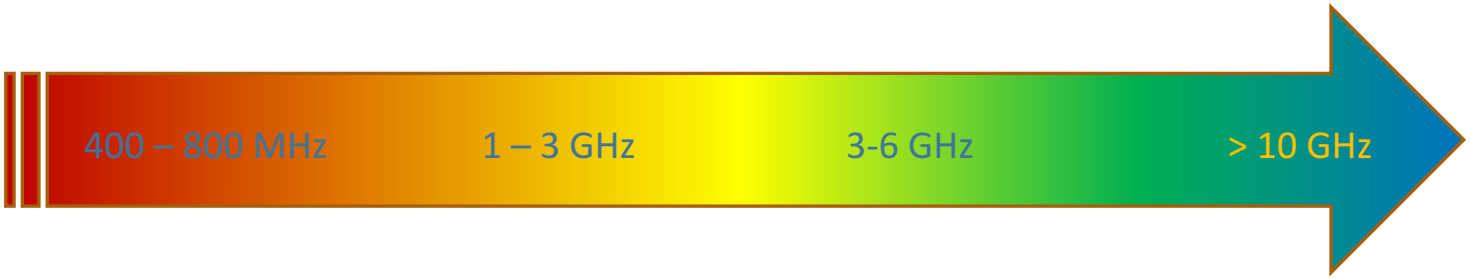
"high tower, high power"
(TV, cellular downlink, radar transmitter)

vs.

- cellular uplink
- radar receiver
- GPS receiver

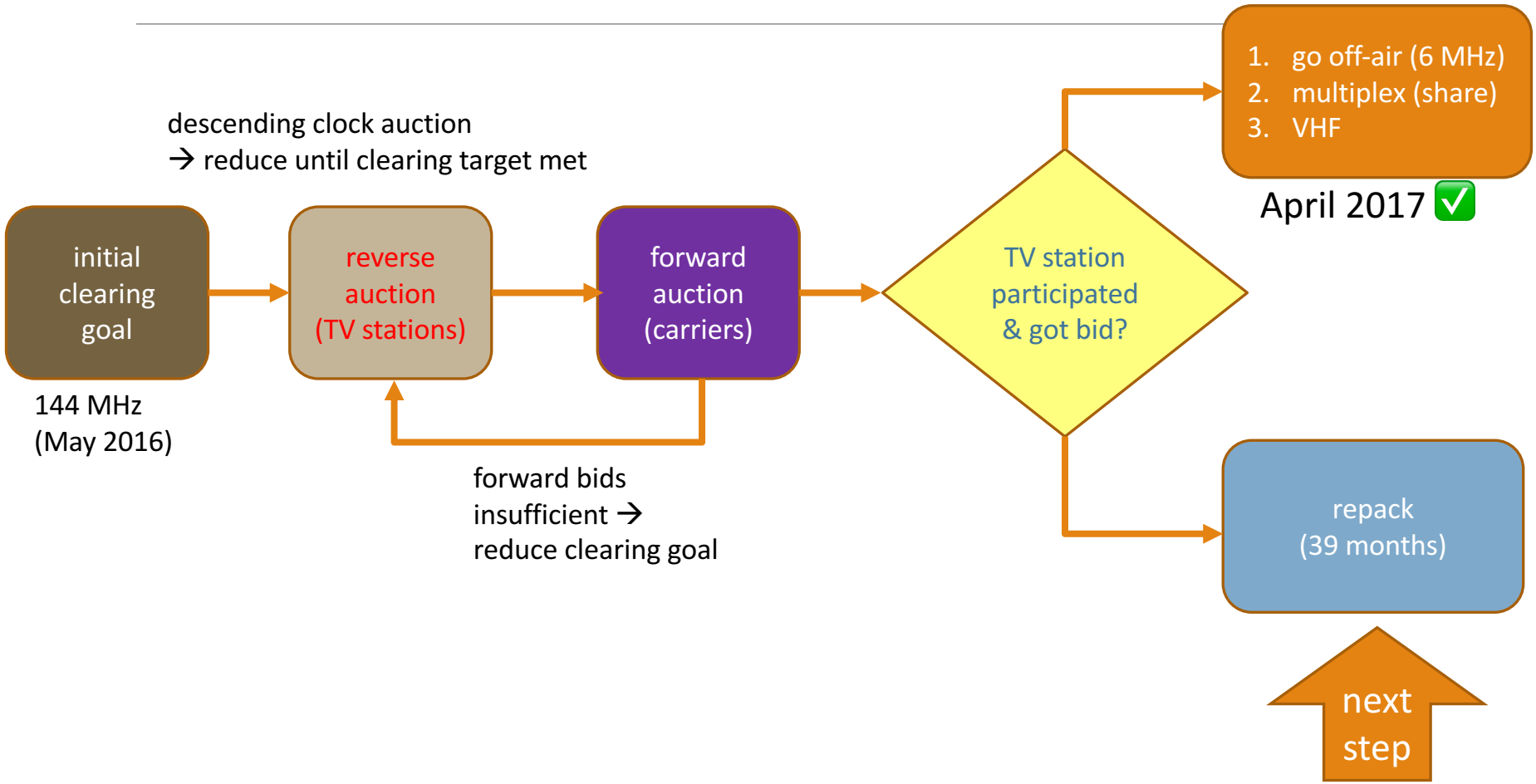
how do I quickly identify sources of interference?

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

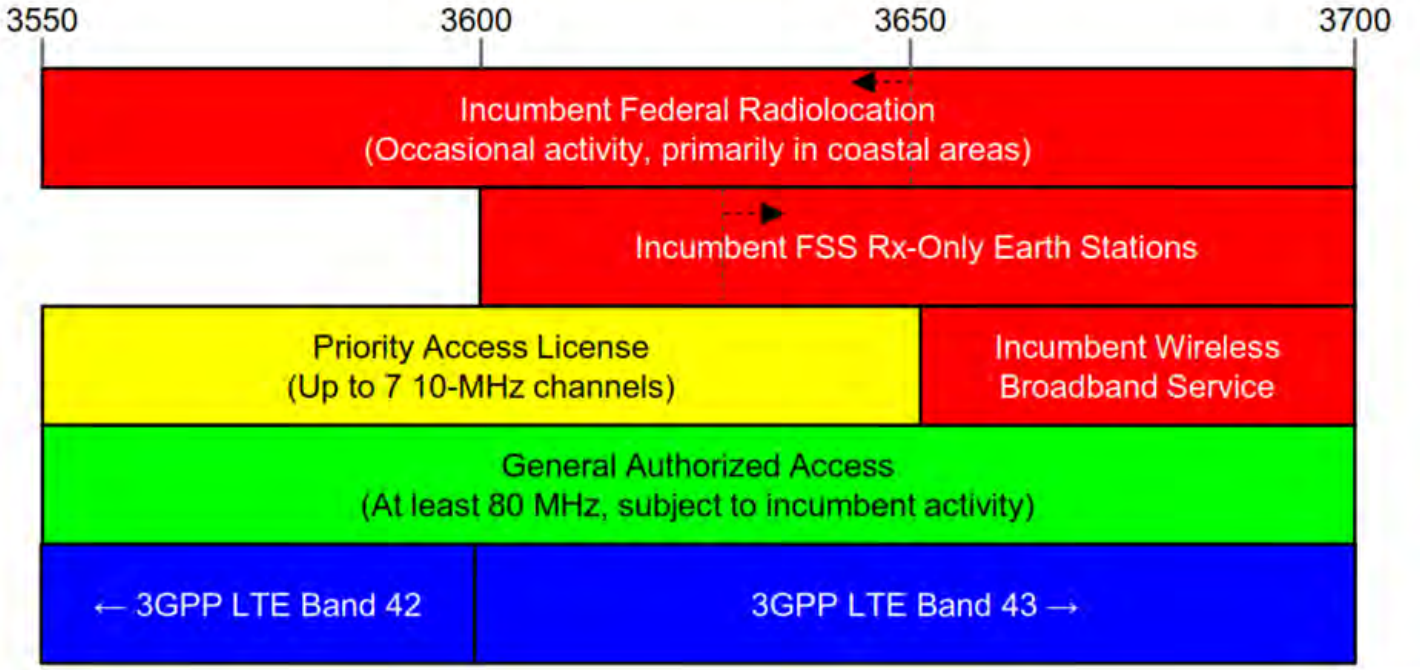


Incentive auction facts

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

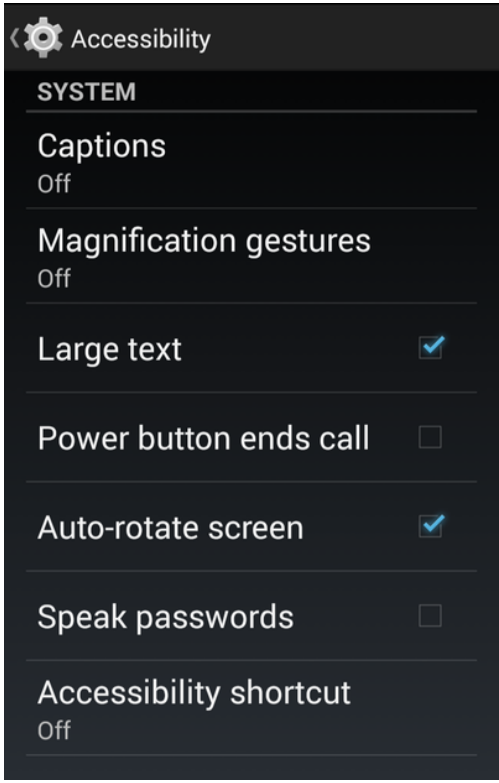
- Title IV of Americans with Disabilities Act (ADA):
  - The term "telecommunications relay services" means telephone transmission services that provide the ability for an individual who has a hearing impairment or speech impairment to engage in communication by wire or radio with a hearing individual 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?

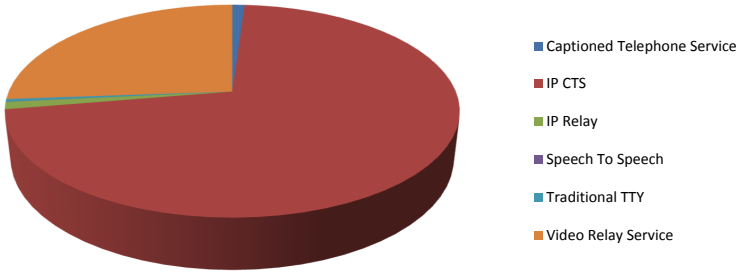
CC

But what about YouTube?
Live events?



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

Relay services

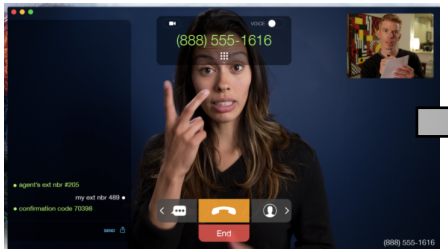


text relay

(legacy, may transition to RTT)

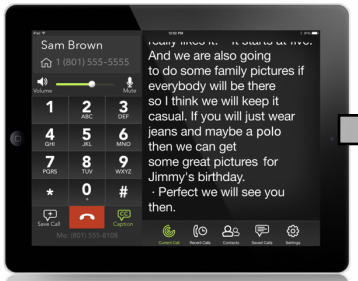
VRS

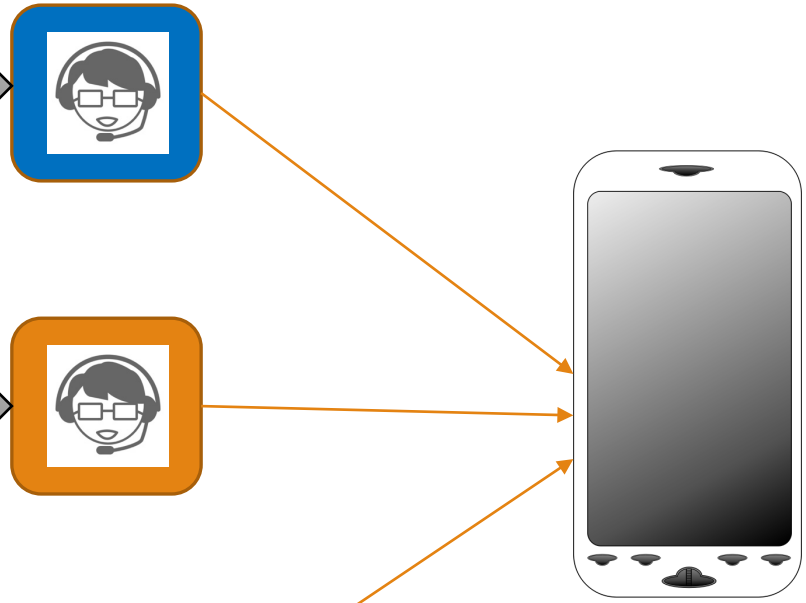
(ASL as first language; mostly culturally Deaf)



IP-CTS

(Non-ASL; mostly late-deafened)



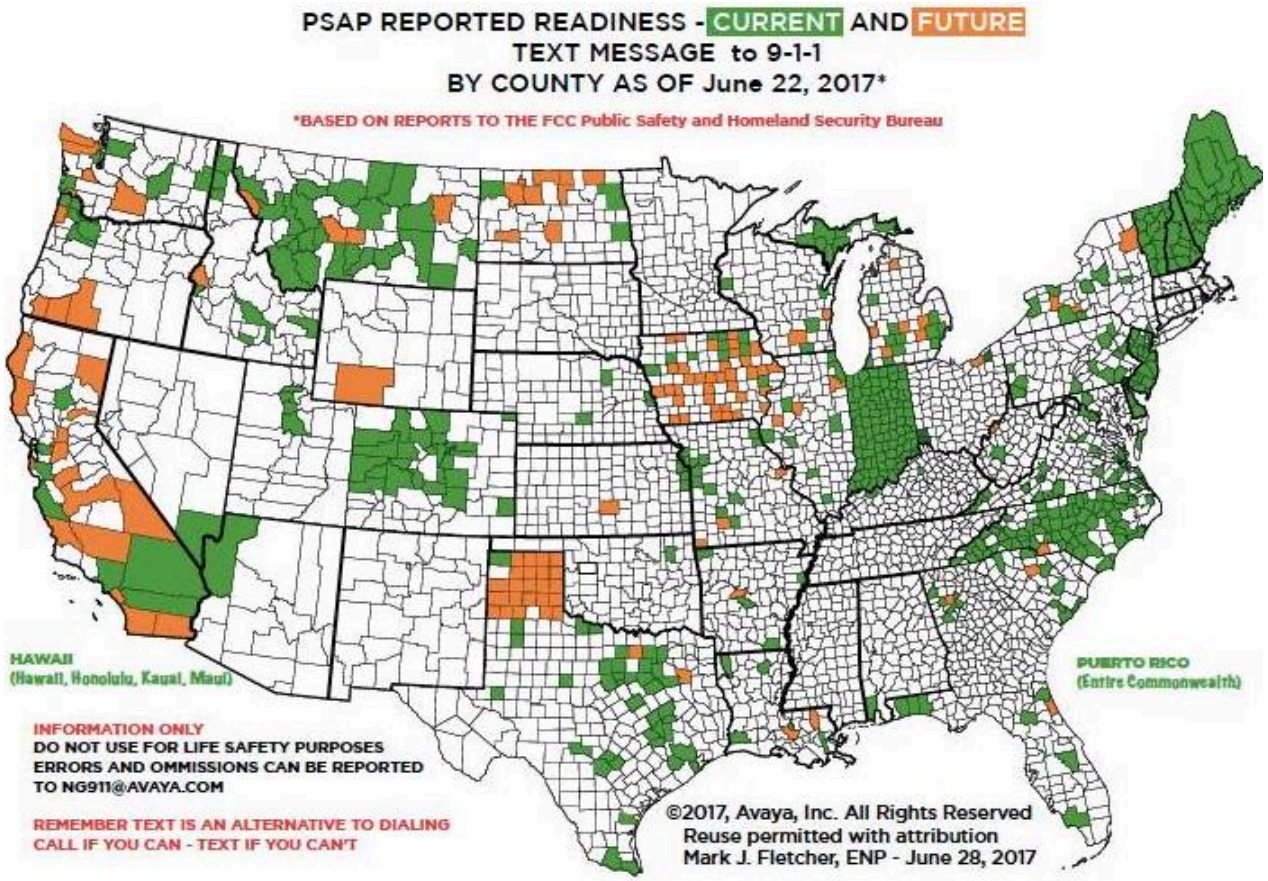


Direct video calling

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

Text-to-911



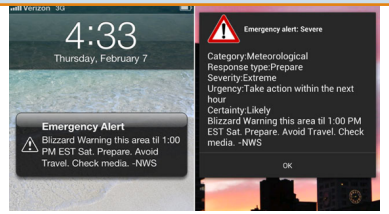
obligation for carriers by June 2015

Emergency calling

VoIP emergency communications

phone & SMS-based (local)

wireless emergency alerts (WEA)



90 characters
(360 in the future?)

AM/FM
TV
cable

emergency call

emergency alert

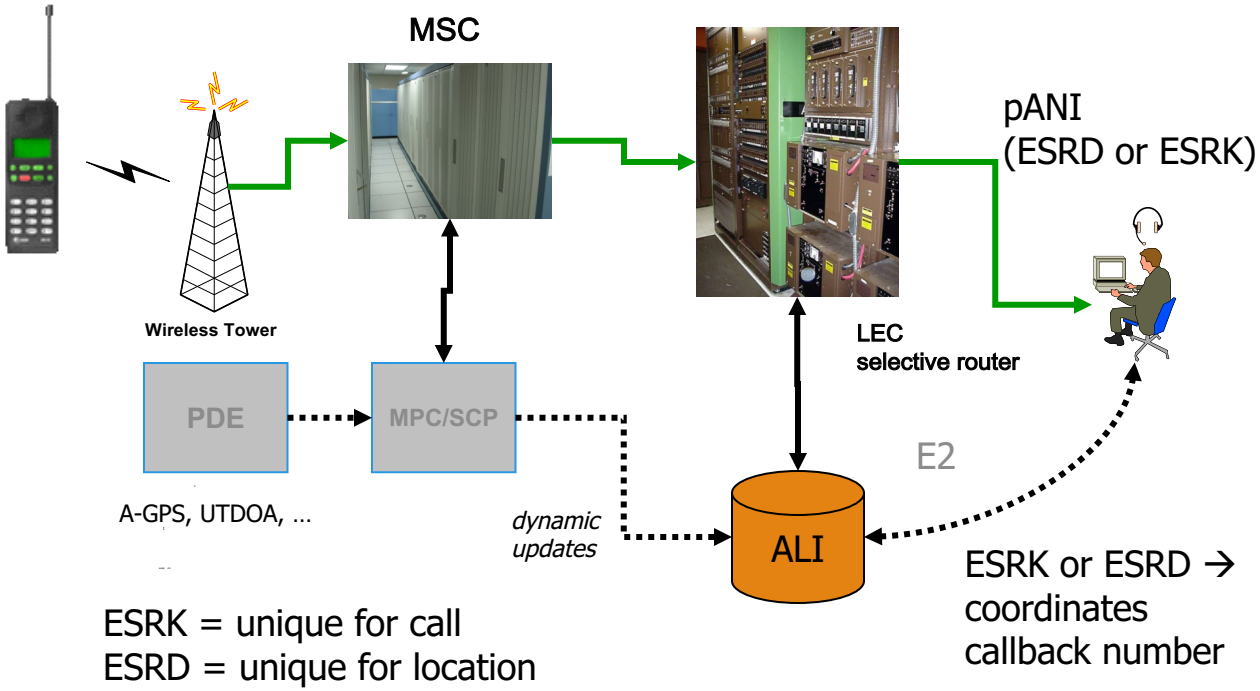
dispatch

civic coordination

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

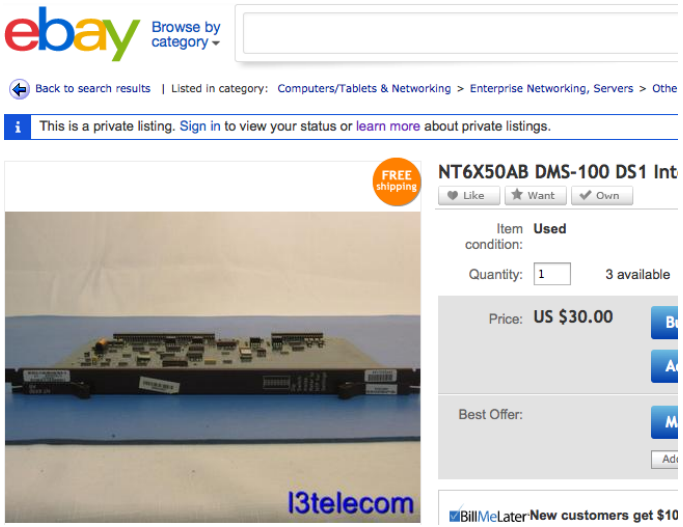


ESRK = unique for call
ESRD = unique for location

Switches are ageing

Nortel DMS-100

1979



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