Why don’t we all have broadband already?

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The views and opinions expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of any agency of the U.S. government.

WTS 2023

Overview

topic today

- Availability, affordability and relevance
- What makes deploying fixed broadband necessary & expensive?
- Technology may help – if it can dig trenches & automate operations
- Affordability may become a larger problem than availability
- Government is likely to play a major role
- Mostly focus on United States, but basic problems similar elsewhere

Digital equity & inclusion – more than access

Digital Inclusion

individuals have access to robust broadband connections, Internet-enabled devices that meet their needs; and the skills to explore, create and succeed in the digital world.

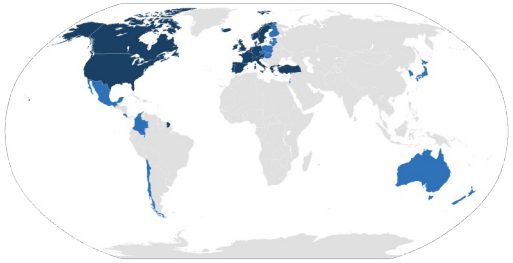
Digital Equity

a condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy, and economy. Digital equity is necessary for civic and cultural participation, employment, lifelong learning, and access to essential services.

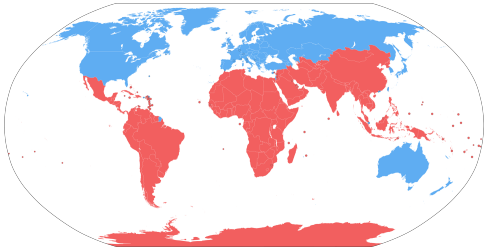
The big questions – only seemingly simple

- Which locations have what broadband (internet)?
- Who uses broadband? Who doesn't and why?
- What speed and other characteristics are important?
- Who should and can provide broadband?
  - Traditional "telephone" companies to rural electric cooperatives to new entrants
- Why are some locations left out?
- What incentives (or mandates) can incentivize (force) providers?
- What makes deployment difficulty?
  - Utility poles! Railroad crossings! Historical artifacts!

OECD/high-income vs. lower-income issues



- wired (or fixed) broadband widely available
- transition from copper to fiber (and FWA)
- least-connected 10%
- affordability for low-income households
- adoption – digital literacy
- applications ("Factory 4.0", telehealth, distance learning)



- wired broadband uncommon: mobile first
- transition from 2G to 4G
- middle mile, transoceanic fiber
- IXPs to avoid tromboning through US
- broad-based affordability
- applications like banking, health, jobs

Benefits of universal access

Telehealth is associated with a **19% reduction in hospital admissions**

And a **25% reduction in admission duration,** leading to a **savings of $1,600 per patient** per year.[15]

2.5%-3% increase in Single-Family Home Values

With **access to** a minimum of **25 Mbps high-speed Internet connection compared to similar urban homes in neighborhoods with 1 Mbps.**[16]

1.1% Increase in Labor Productivity

Using high-speed Internet service could raise earnings-weighted labor productivity by an estimated 1.1%.[17]

At least $1,900 Economic Benefit per Household connected[18]

Potential $140B to the Rural Economy

Greater adoption of digital tools could add $140 billion to the U.S. rural economy.[19]

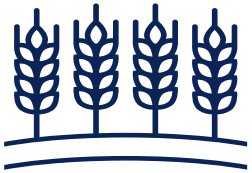
300% Return on Investment

An Indiana study estimated that every **$1 invested in broadband could return $3-$4 in economic activity.**[20]

Benefits of universal access

$18B to $23B Increase with Precision Agriculture

Precision agriculture technologies from ubiquitous high-speed Internet access would bring a **potential gross economic benefit of $18B to $23B**.[21]



Higher GPAs with Internet

On average, students with fast home Internet service report an overall GPA of 3.18, whereas the average GPA for students with no access is 2.81.[22]

A 10-percentage point increase in high-speed Internet subscriptions could lead to a **0.9%-1.5% jump in real per capita GDP** growth in developed economies.[23]

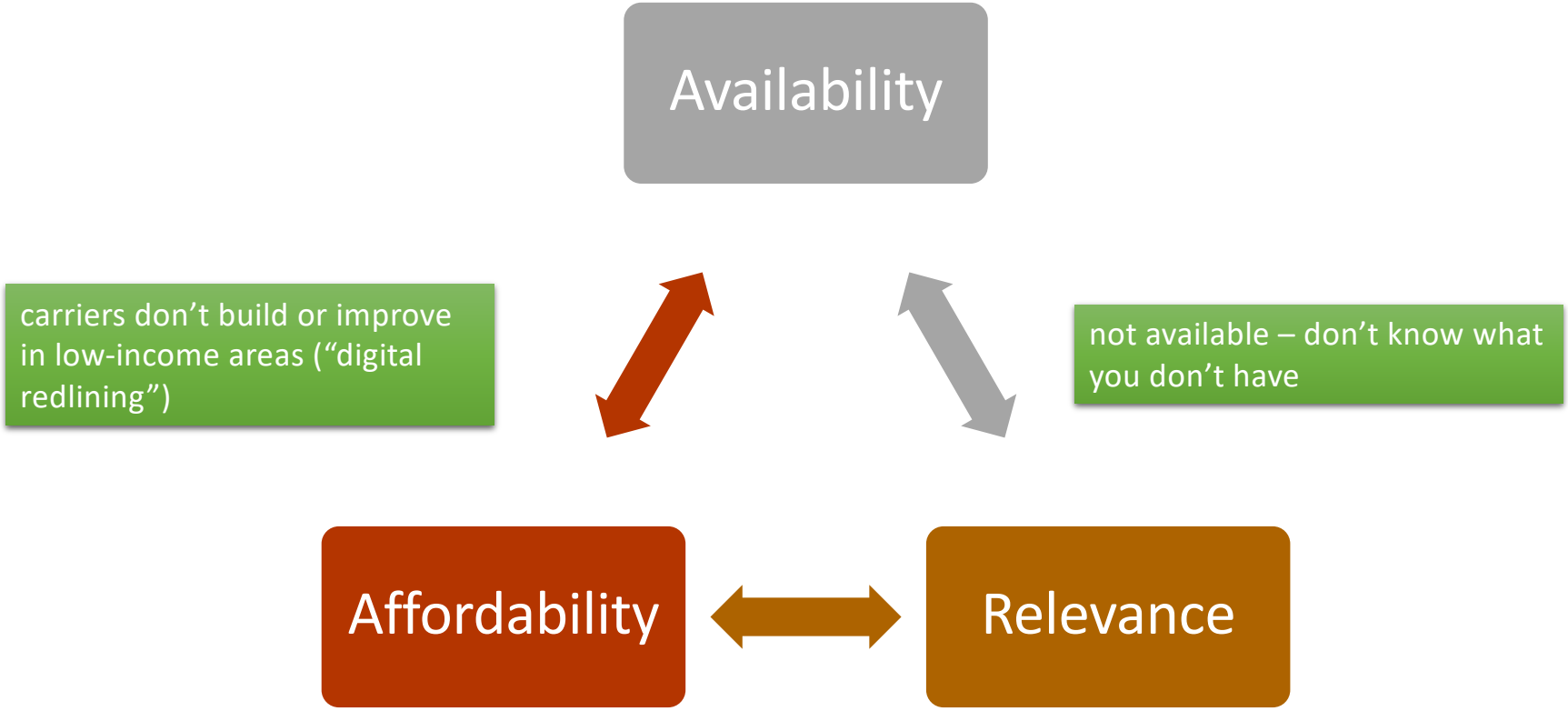
30% Higher Small Business Survival Rate

Internet service allows small businesses to access customers worldwide. Those businesses that can access global markets online have **a 30% higher survival rate than unconnected businesses**.[24]

Note that lack of access to broadband infrastructure is just one of the barriers that small businesses face, and the economic benefits are likely to vary by industry and exposure to competition.[25]

What are the causes for non-adoption?

Availability, affordability and relevance are coupled



Reason for non-adoption

Survey	Primary Reason	Secondary Reason	Tertiary Reason	Fourth Reason	Type of question
Pew Research Center (2019)	Cost – either service is too expensive	Smartphone does everything they need	Other access options outside the home	Cost of computer is too expensive	Closed-ended
	Listed as a reason: (50%)	Listed as a reason: (45%)	Listed as a reason: (43%)	Listed as a reason: (45%)	
	Most important reason (21%)	Most important reason (23%)	Most important reason (11%)	Most important reason (10%)	
Pew Research Center (2015)	Cost – either service is too expensive	Smartphone does everything they need	Other access options outside the home	Cost of computer is too expensive	Closed-ended
	Listed as a reason: (59%)	Listed as a reason: (27%)	Listed as a reason: (46%)	Listed as a reason: (31%)	
	Most important reason (33%)	Most important reason (12%)	Most important reason (10%)	Most important reason (6%)	

https://www.digitalinclusion.org/measuring-the-gap/

What kind of universal broadband do we need or want?

The value of bits

- Technologist: A bit is a bit is a bit
- Economist: Some bits are more valuable than other bits
  - e.g., $/bit(email) ≫ $/bit(video)
  - no-QoS bits dominate in volume

Application	Volume	Cost per unit	Cost / MB	Cost / TB
Cable video	660 GB		$0.06	$60
Voice (13 kb/s GSM)	97.5 kB/minute	10c	$1.02	$1M
Mobile data	5 GB	$40	$0.008	$8,000
MMS (pictures)	< 300 KB, avg. 50 kB	25c	$5.00	$5M
SMS	160 B	10c	$625	$625M

➔ Economic interests not aligned

Three usage intensities

Basic

- SMS or WhatsApp
- maybe low-bandwidth (3G) apps
- electronic payments
- environmental monitoring and single-function devices

500 SMS a month ➔ 50 kB/month

Intermediate

- text and image media
- social media
- email
- maps
- basic gov't forms
- Health portals

1 to 10 GB/month

Full participation

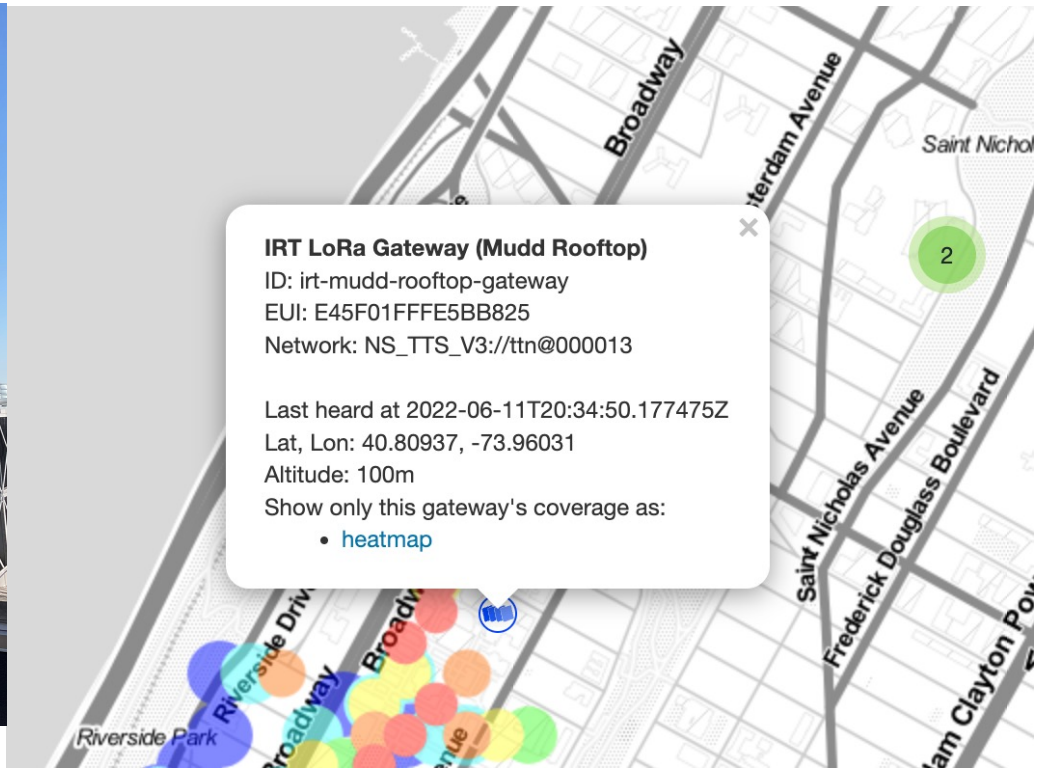
- video entertainment
- video conferencing
- work from home
- distance learning
- telemedicine
- content creation

100+ GB/month

The Things Network

The Things Network

April 2022 (Columbia U.)



Small bandwidth use case

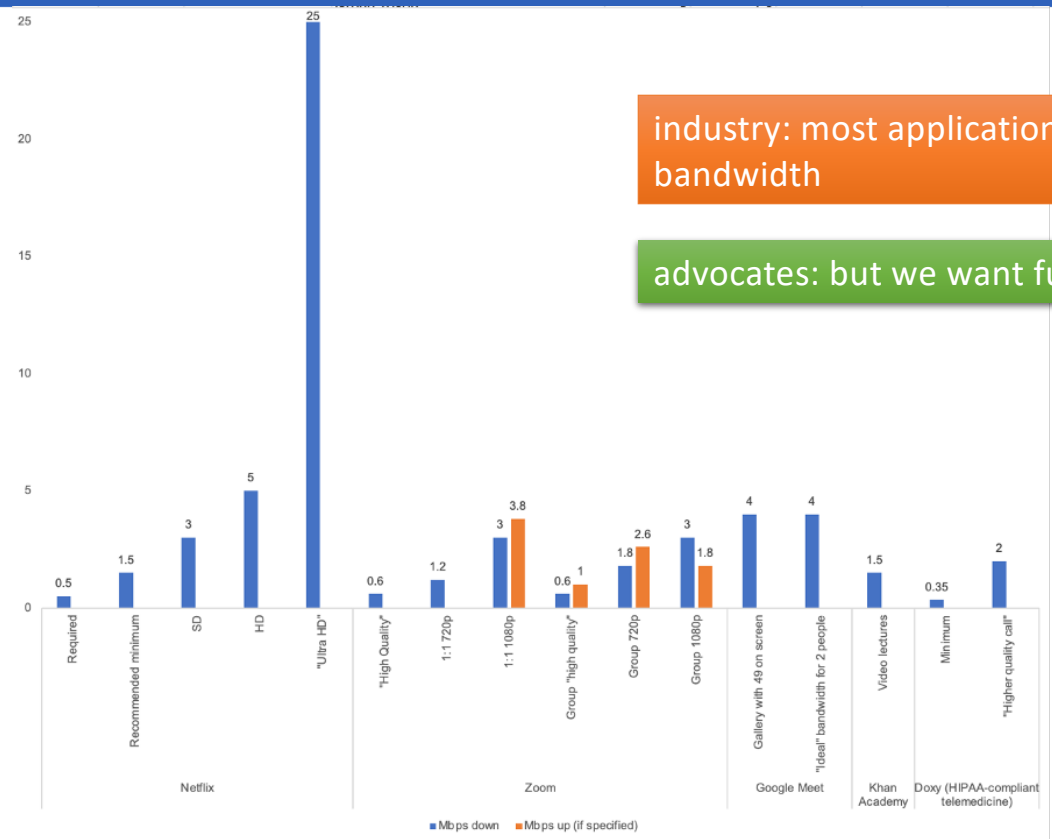
How tiny, cheap smart speakers unlocked the rise of digital payments in India

Vegetable carts, flower shops, mom-and-pop stores: Small speakers that read out digital payment receipts are making fintech companies big money.

rest of world
Reporting Global Tech Stories

The payment soundbox is equipped with a SIM card supporting 2G/4G connectivity to connect with the bank servers. Once, the customer scans the QR and makes the payment, then it is reflected on servers and the signal is processed as a voice alert on the speaker for the payment received.

How much speed do we need?



industry: most applications don't need lots of bandwidth

advocates: but we want future-proof networks!

Technology Policy Institute, 3/21

How much speed do we need?

Date Adopted	Minimum Download	Minimum Upload
1996	200 Kbps	200 Kbps
2010	4 Mbps	1 Mbps
2015	25 Mbps	3 Mbps

2 users or devices at a time

3 users or devices at a time

4 users or devices at a time

Basic Service = 3 to 8 Mbps*

Medium Service = 12 to 25 Mbps

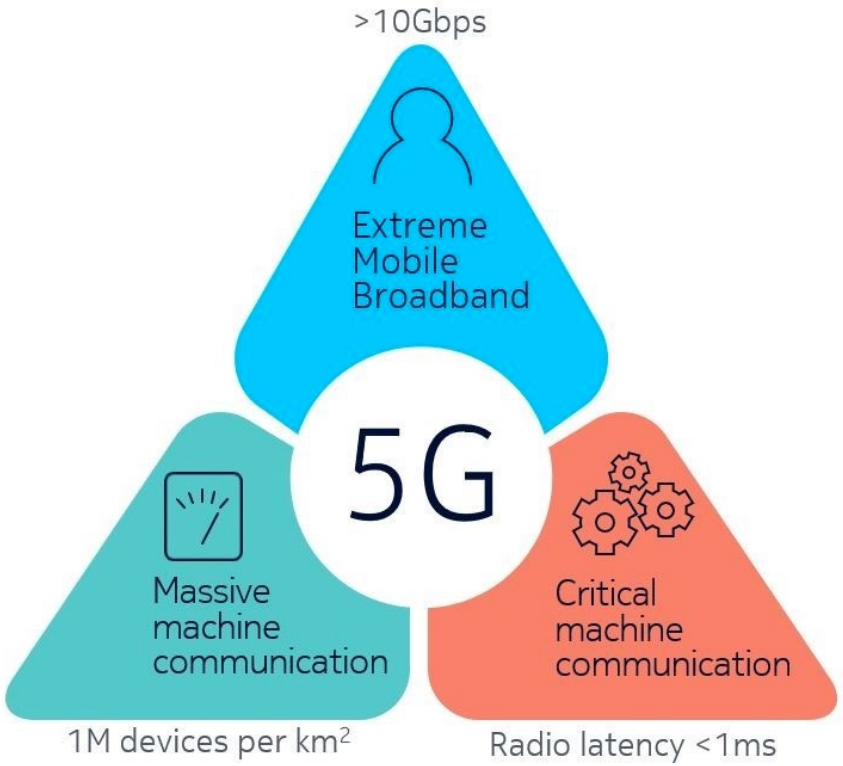
Advanced Service = More than 25 Mbps

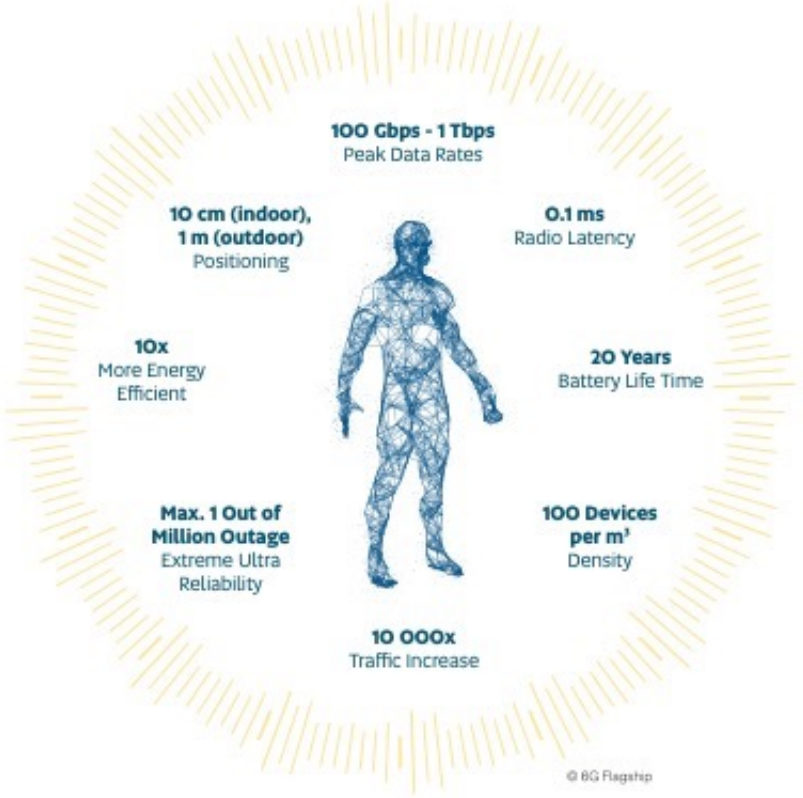
Performance Tier	Speed	Usage Allowance	Weight
Minimum	≥ 25/3 Mbps	≥ 250 GB or U.S. average, whichever is higher	50
Baseline	≥ 50/5 Mbps	≥ 250 GB or U.S. median, whichever is higher	35
Above Baseline	≥ 100/20 Mbps	≥ 2 TB	20
Gigabit	≥ 1 Gbps/500 Mbps	≥ 2 TB	0

Fiber: moot point – buy your ”need” speed or your brag speed
Fixed wireless: 100/20 borderline feasible at scale
Nobody builds new DSL or HFC networks.

BEAD: 100/20 Mb/s for homes, 1 Gb/s for CAIs
100 ms latency

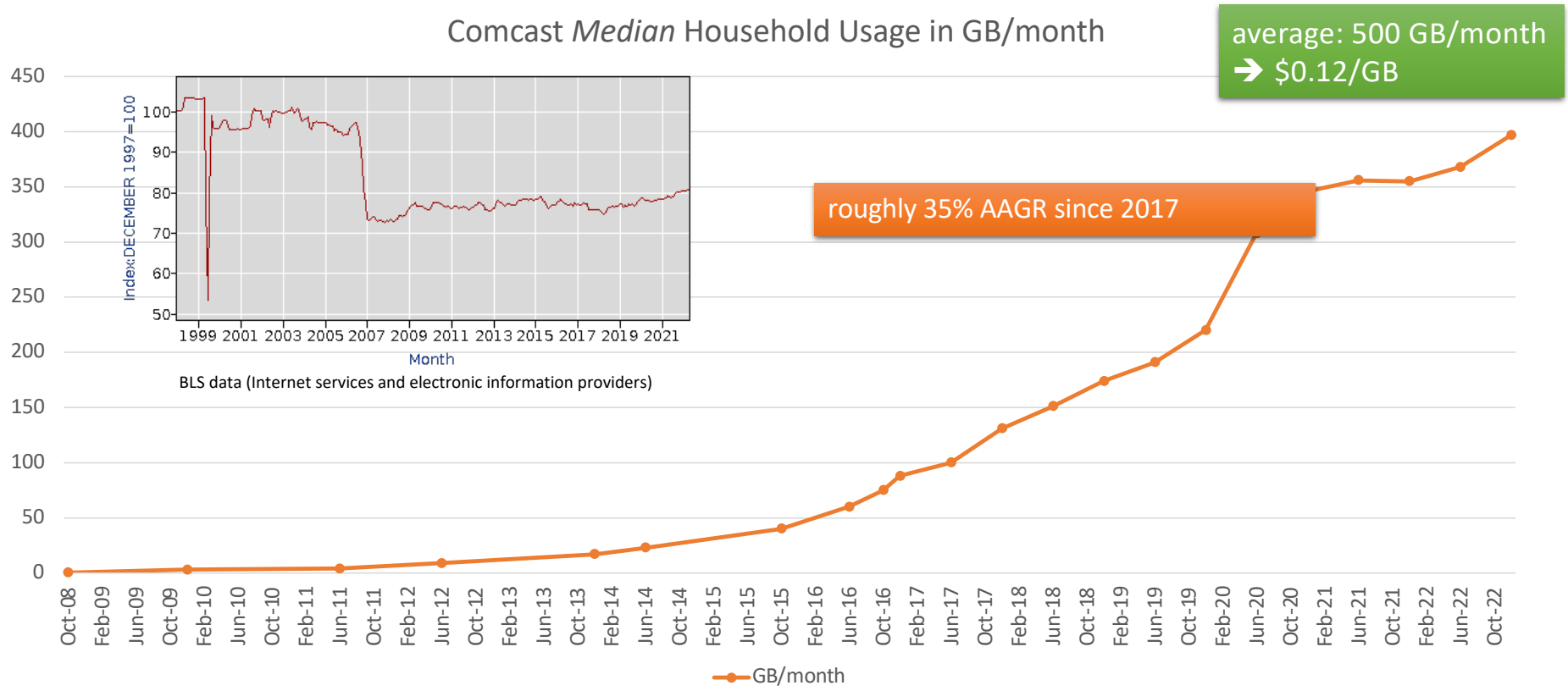
Classical requirements pyramid



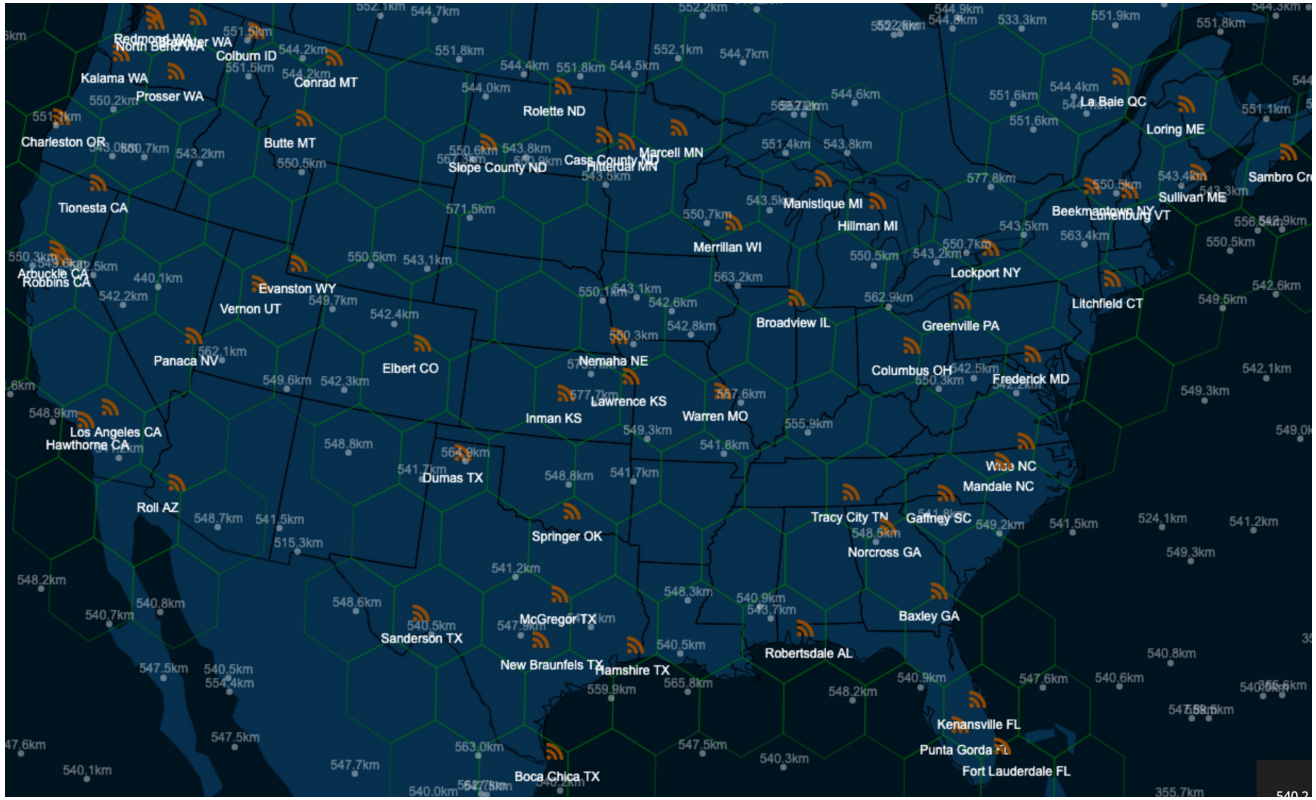


mostly PHY requirements!

The most important metric is missing!



StarLink capacity



https://satellitemap.space/

Ground station

Nemaha NE US

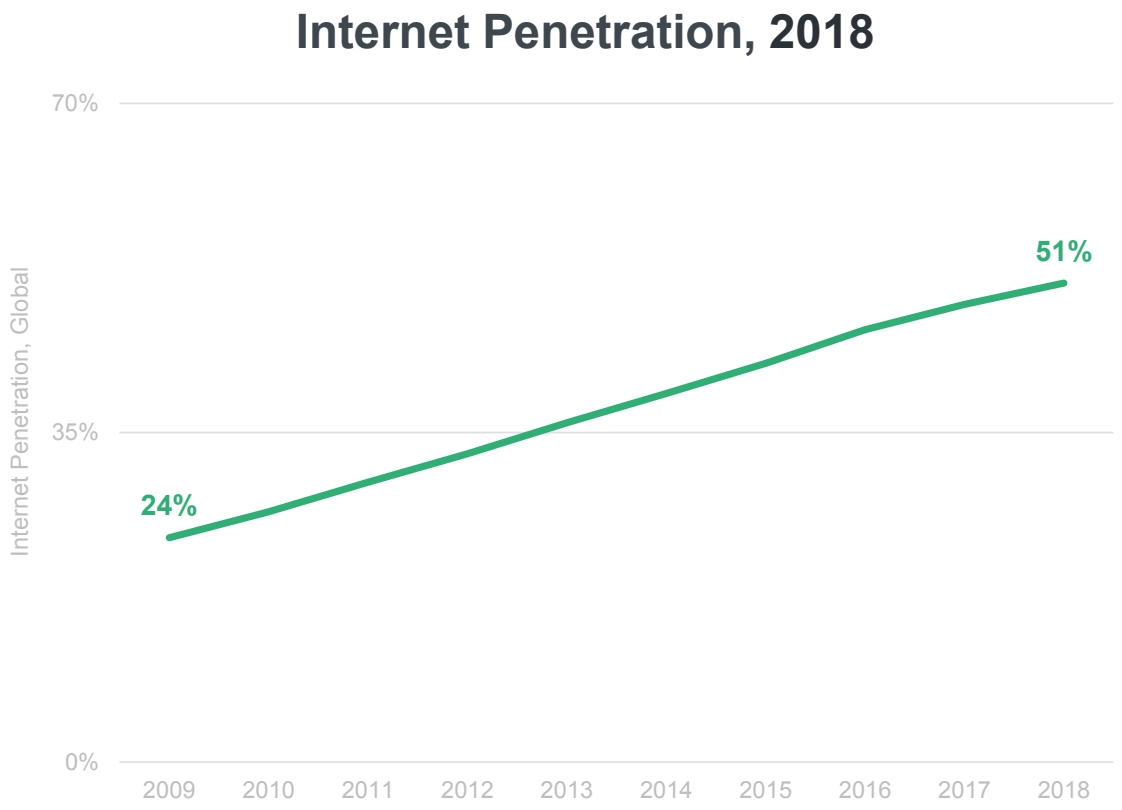
map link (new window)

Antenna count: 8
Antenna diameter: 5 feet
Antenna manufacturer: SpaceX
Uplink: 2.1 GHz total (27.5-29.1, 29.5-30 GHz)
Downlink: 1.3 GHz total (17.8-18.6, 18.8-19.3 GHz)
Date filed: 2020-04-17
https://fcc.report/IBFS/SES-LIC-20200417-00422

satellite lifespan of 5 years
each satellite provides 17-23 Gb/s
3% visible in North America

Who has what broadband?

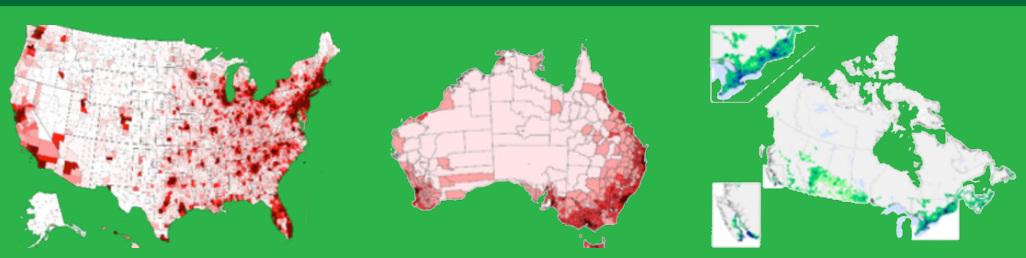
Global Internet users



KLEINER PERKINS
2018
INTERNET TRENDS

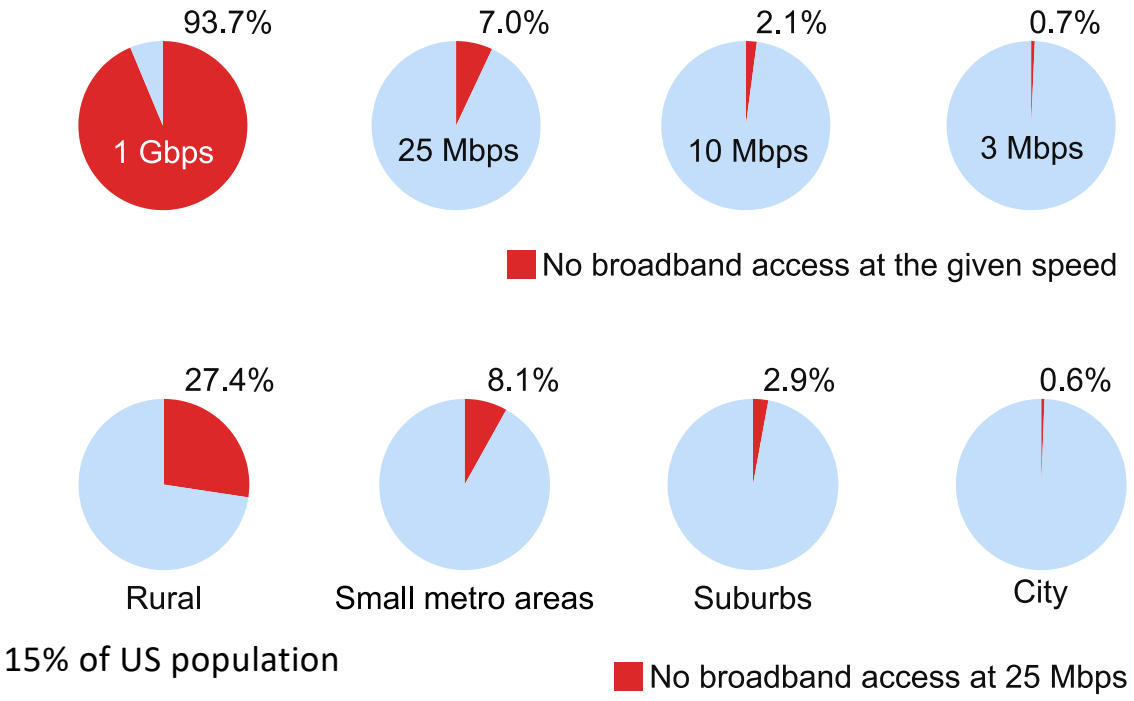
Source: CIA World Factbook, United Nations / International Telecommunications Union, USA Census Bureau. Internet user data is as of mid-year. Internet user data: Pew Research (USA), China Internet Network Information Center (China), Islamic Republic News Agency / InternetWorldStats / KP estimates (Iran), KP estimates based on IAMAI data (India), & APJII (Indonesia). Note: Historical data (particularly in Sub-Saharan Africa) revised by ITU in 2017 to better account for dual-SIM subscriptions (i.e. two Internet subscriptions per single smartphone user).

Lower population density, easier broadband

	32.45/km² United States	2.91/km² Australia	3.49/km² Canada
			
Percent of population	**Percent of land area**		
60%	8.7%	0.2%	0.5%
80%	20%	0.9%	1.2%
90% to be covered requires	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

Broadband access by speed & geography



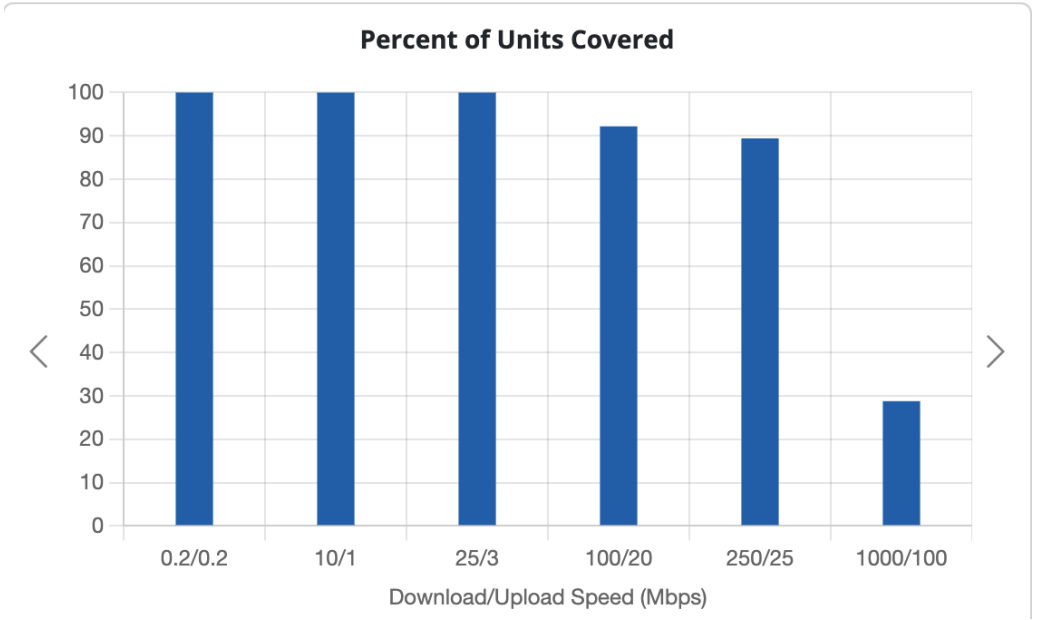
BROOKINGS

Everybody has broadband now

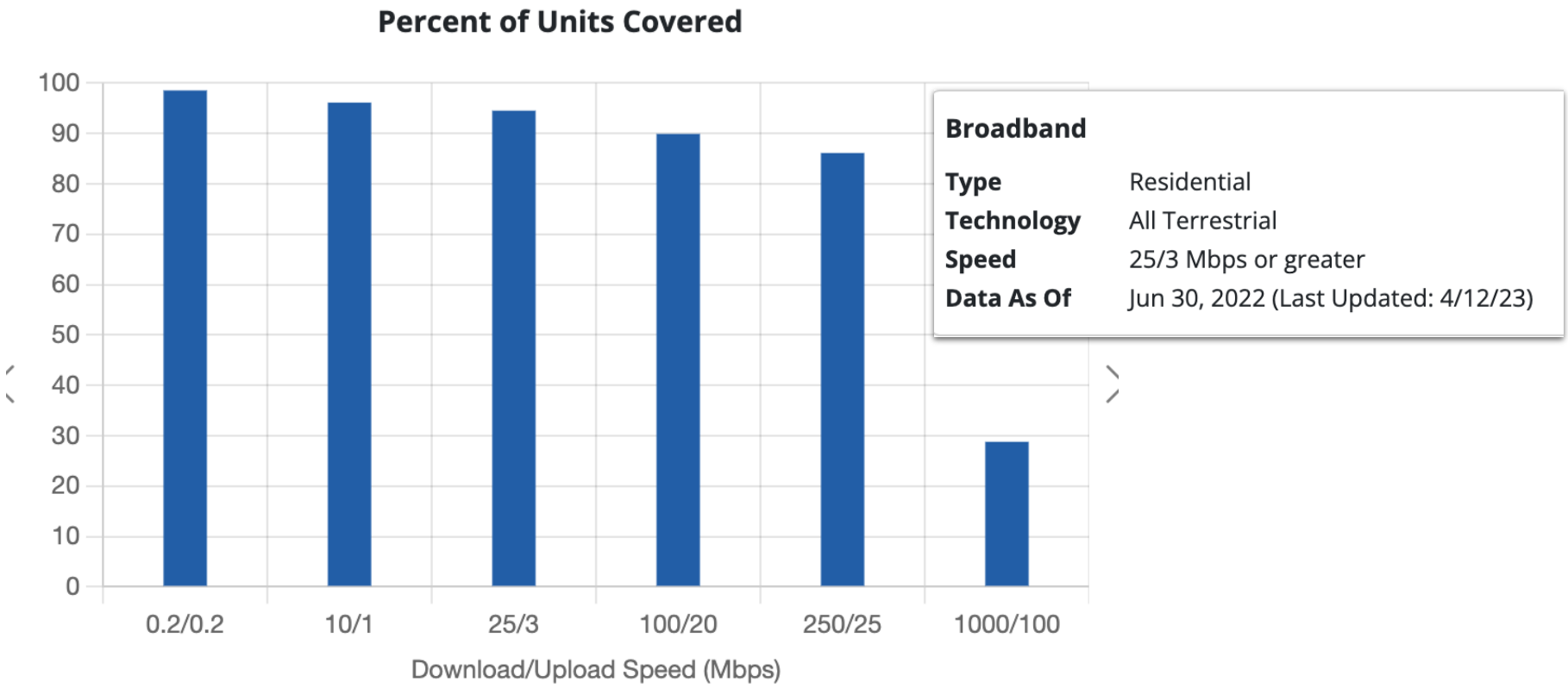
broadbandmap.fcc.gov

Broadband

Type	Residential
Technology	Any Technology
Speed	25/3 Mbps or greater
Data As Of	Jun 30, 2022 (Last Updated: 4/12/23)



Or maybe not


Percent of Units Covered
100
90
80
70
60
50
40
30
20
10
0
0.2/0.2
10/1
25/3
100/20
250/25
1000/100
Download/Upload Speed (Mbps)
Broadband
Type Residential
Technology All Terrestrial
Speed 25/3 Mbps or greater
Data As Of Jun 30, 2022 (Last Updated: 4/12/23)

Licensed fixed wireless complicates things

T-Mobile 5G HOME INTERNET

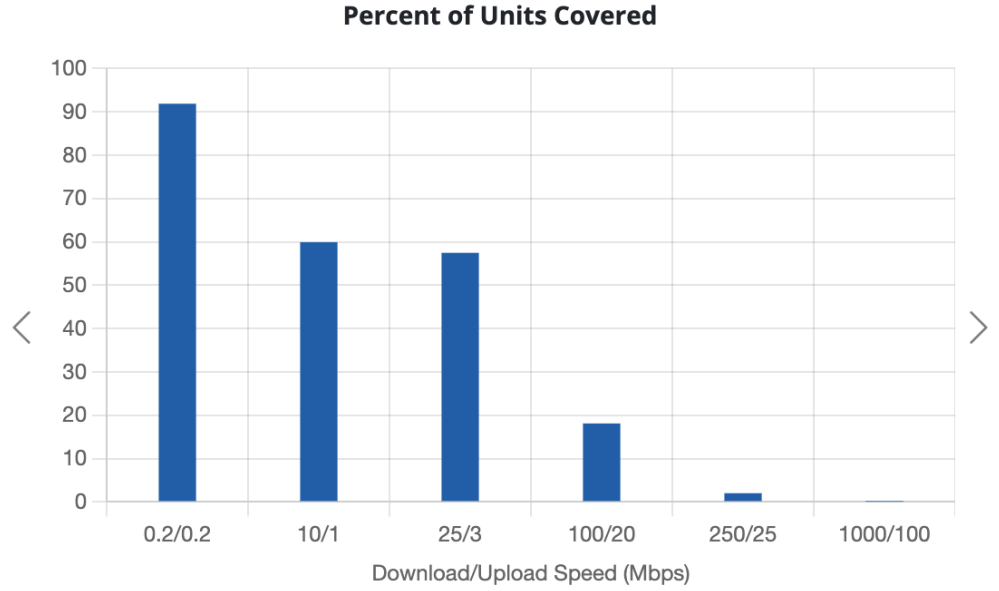
Get Verizon Home Services

uscellular

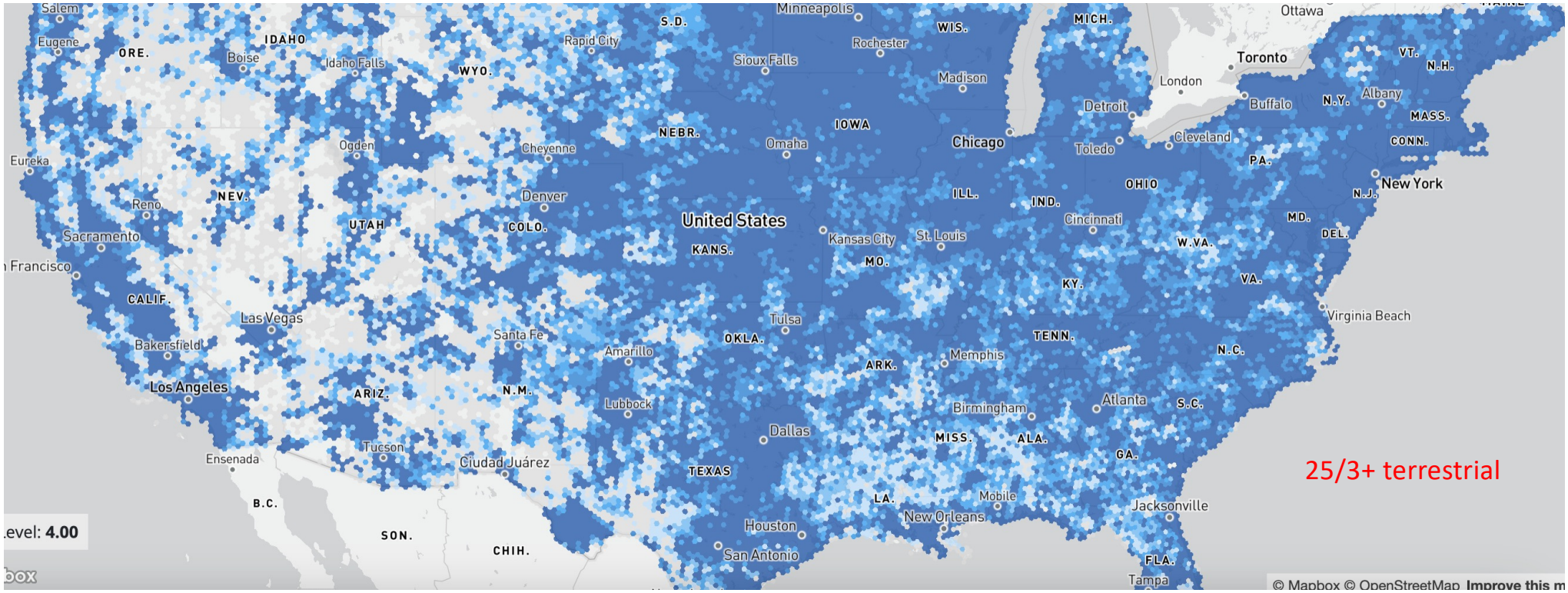
but capacity-based availability

Broadband

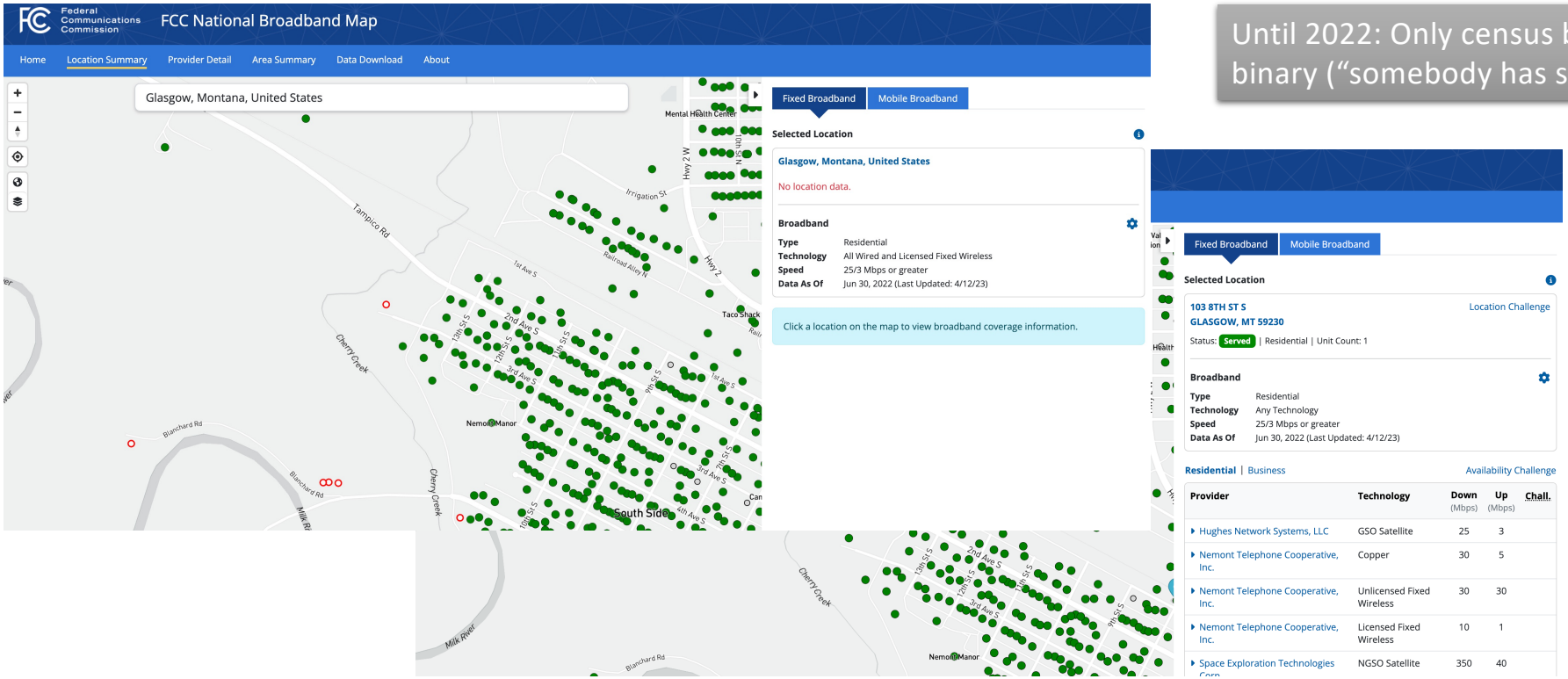
Type	Residential
Technology	Licensed Fixed Wireless
Speed	25/3 Mbps or greater
Data As Of	Jun 30, 2022 (Last Updated: 4/12/23)



Rural broadband US



FCC broadband map

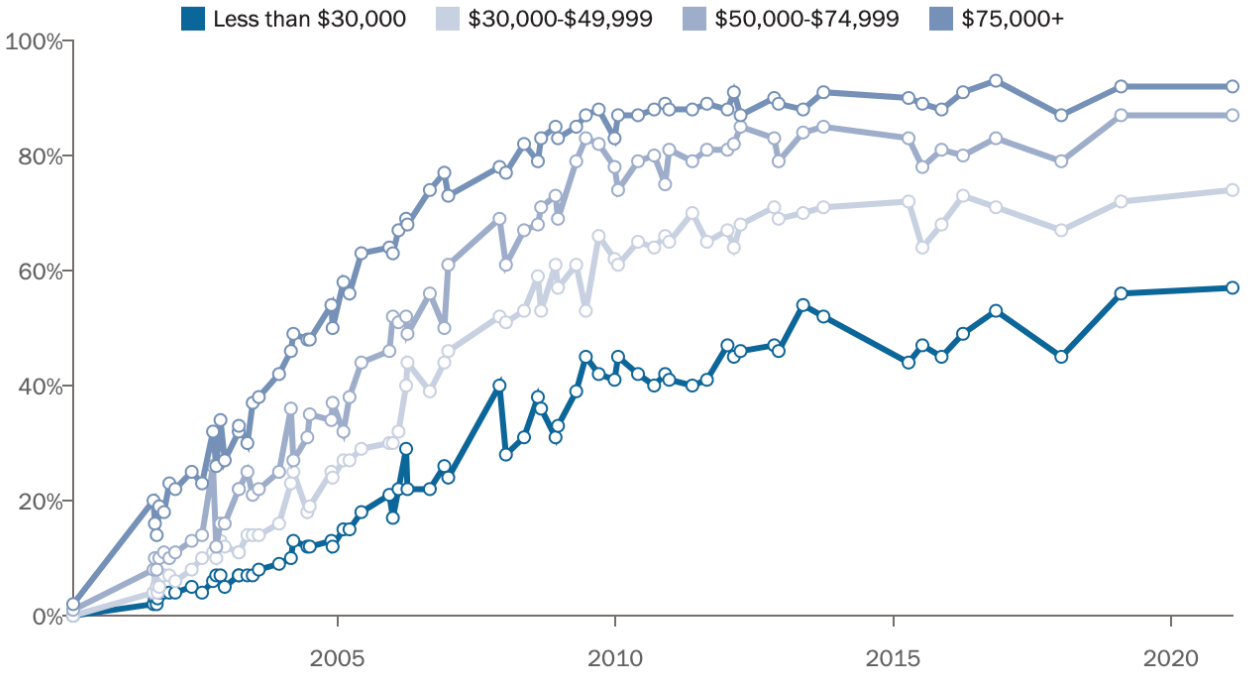


Until 2022: Only census block binary (“somebody has service”)

US: Income plays a major role

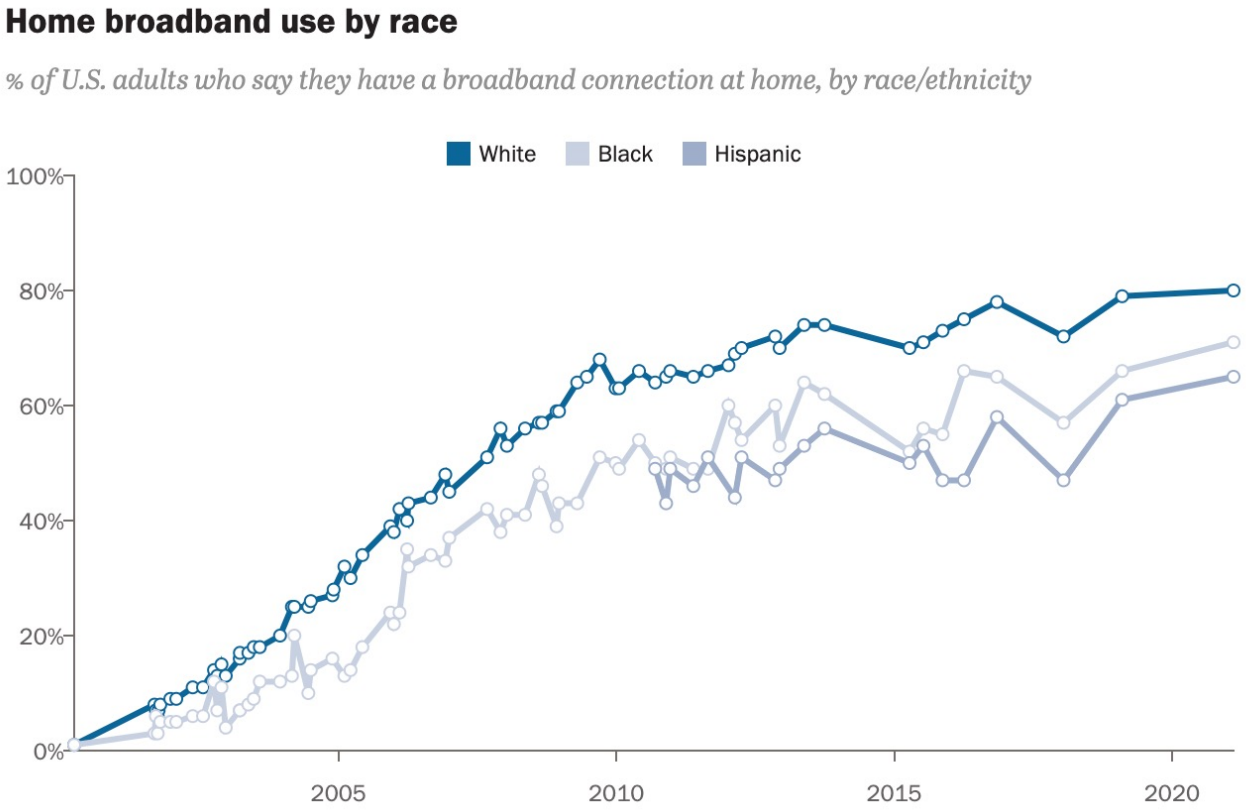
Home broadband use by income

% of U.S. adults who say they have a broadband connection at home, by annual household income



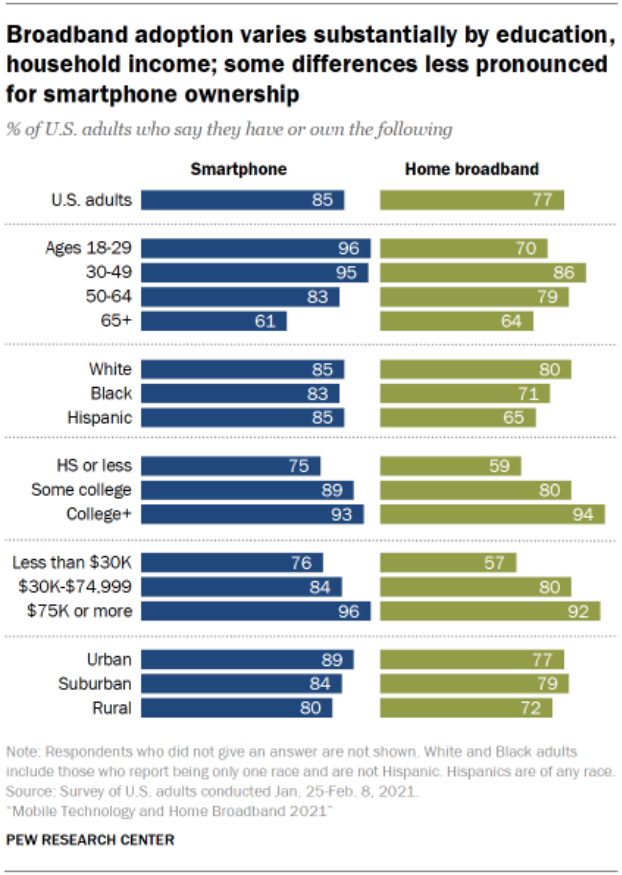
Pew Research

And race, too



Pew Research

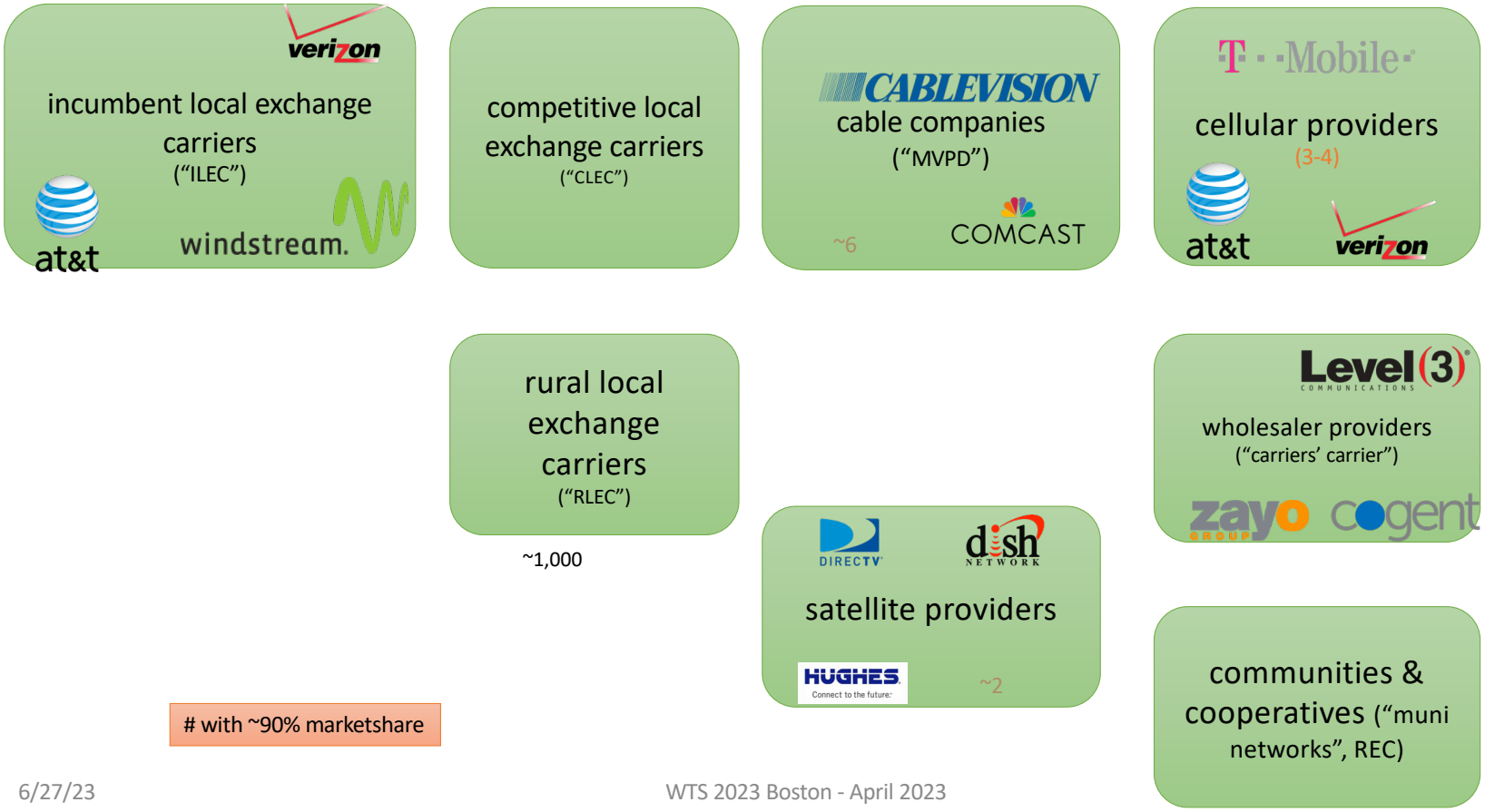
15% of U.S. adults are smartphone-only



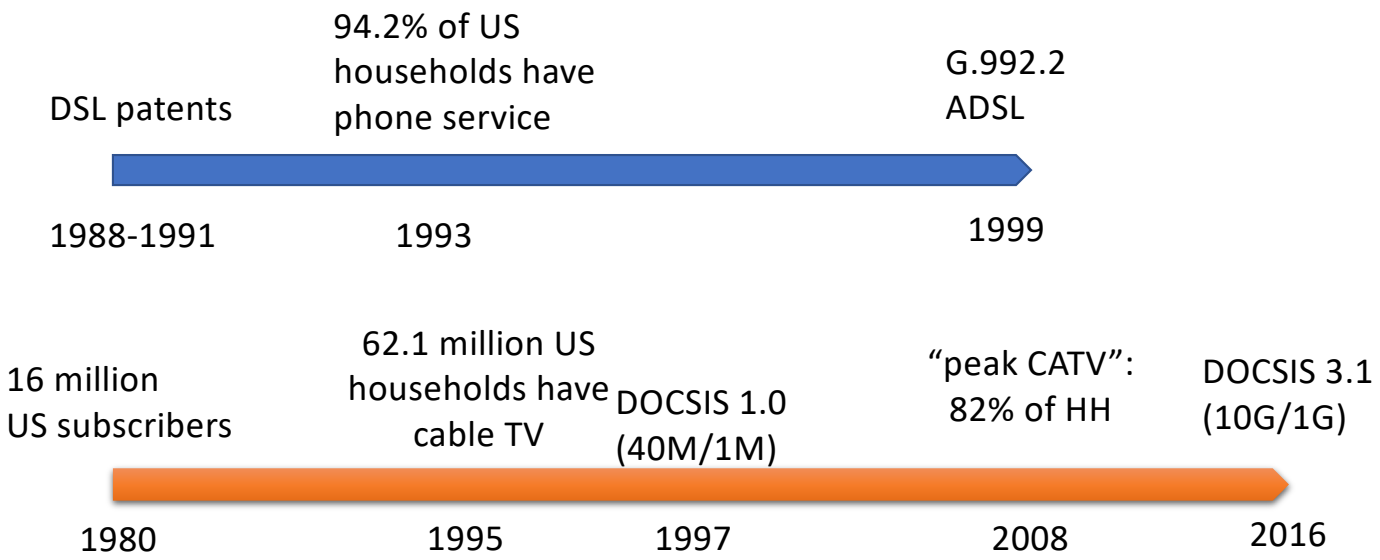
- Smartphones = mostly consumption devices
- + TikTok!
- Hard to do homework on a smartphone
- Hard to do telework

It all depends on your (network) roots

Who runs communication systems and networks?

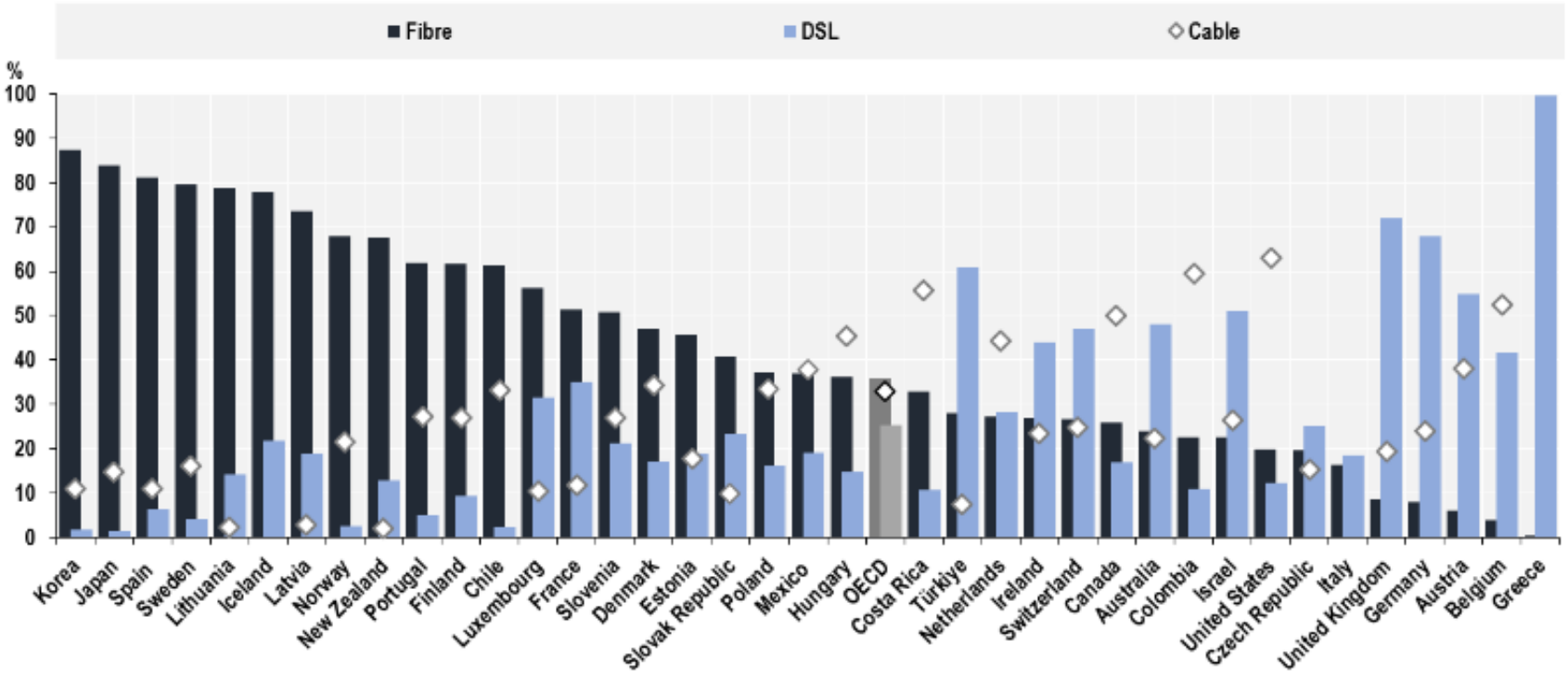


Accidental broadband



➔ DSL and cable infrastructure near-universally or widely available well before use as Internet access

FTTH internationally



June 2022

Improving availability

History: rural electrification

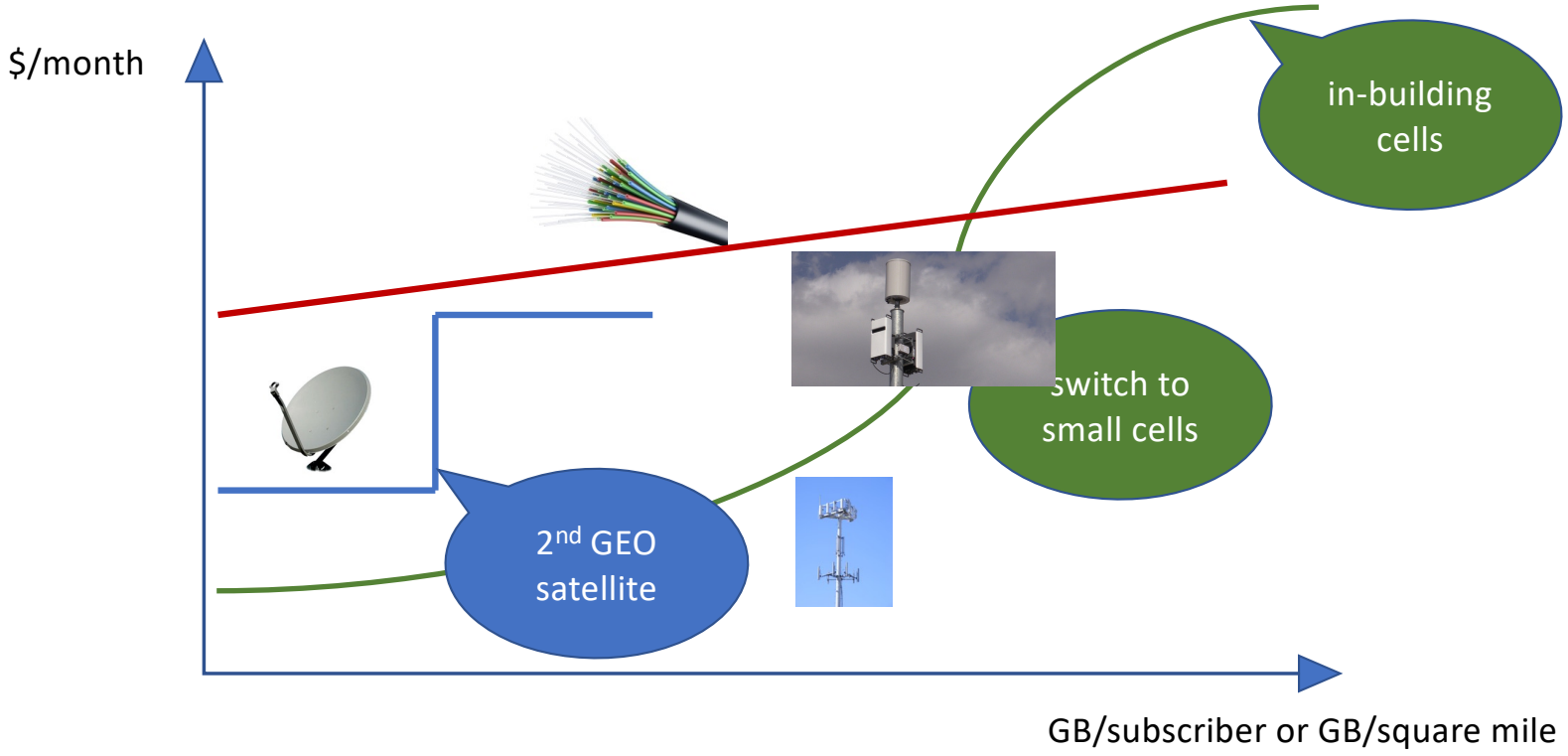
- Early 1920s, between 2 and 3% of farms (likely less)
  - 1921: DC had 98.2%, MA 97.8%
- "In 1935, only 10.9% of American farms (744,000) enjoyed central station power, compared with Germany and Japan at 90%, France between 90 and 95%, and New Zealand at 60%."
- "In 1940, just four and a half years 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

Challenges for rural broadband

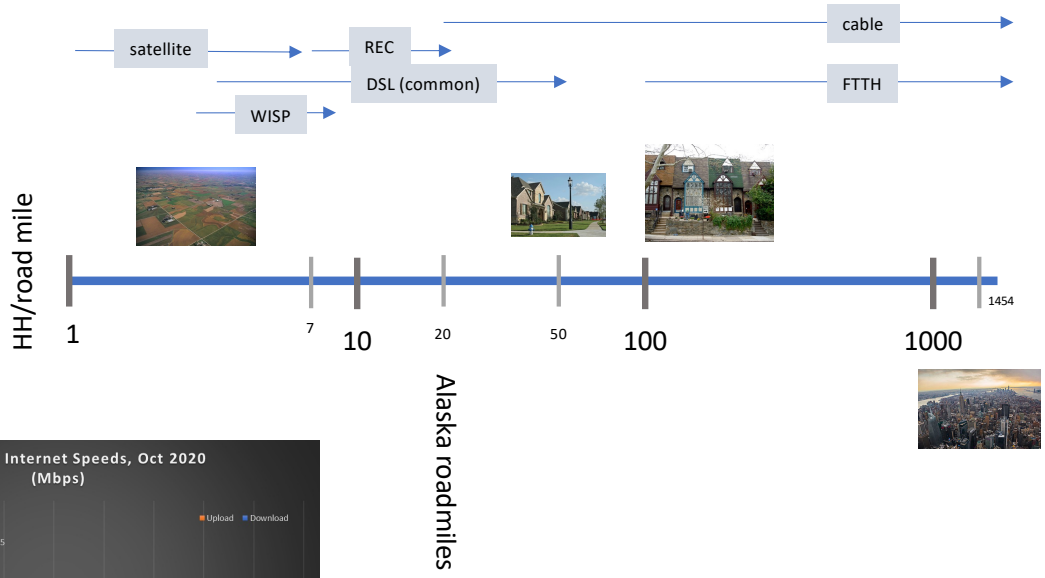
- Who is going to build out?
  - some incumbent local exchange carriers (ILECs) are not interested
  - municipalities may be prohibited by state laws
    - or hurdle is extremely high
  - rural electric cooperatives – serve 14M homes in US (out of ~110M)
    - average, 5.8 electric meters per mile
- Upgrade copper or new infrastructure?
  - fiber closer to the home ("FTTN") OR
  - fiber to the home (FTTH) or fixed wireless (FWA) or LEO
- Who is going to pay for broadband?
  - subsidize once, for *N* years, or forever?
- Are non-landline approaches scalable?
  - TV white spaces, HAPS
  - satellite – NGS like OneWeb (600 satellites) or StarLink
    - currently, about 500k residential satellite subscribers
      - "better than nothing"
      - lacking capacity, high delay, low reliability, expensive
    - LEOs change the picture
      - but same concerns + spectrum + horizon visibility

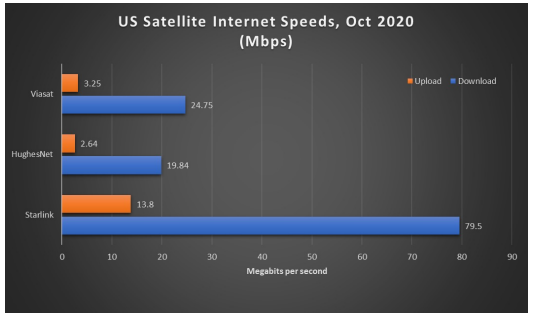
50-150 Mb/s, 40 ms RTT
$120/month
$599 antenna

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



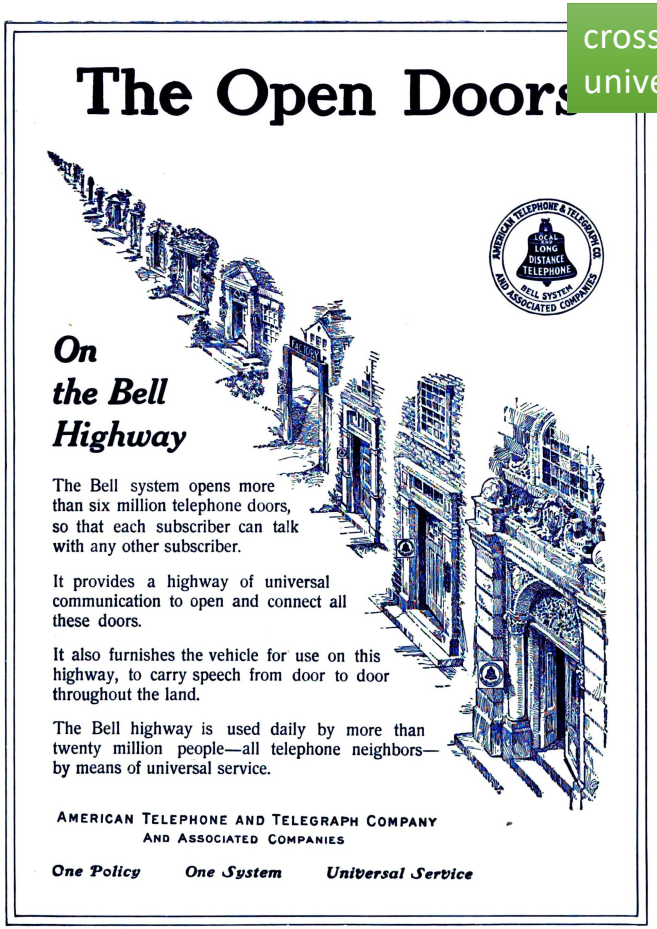
Density determines network choices





How do we pay for this?

Universal Service is more than a century old



The Open Doors

On the Bell Highway

The Bell system opens more than six million telephone doors, so that each subscriber can talk with any other subscriber.

It provides a highway of universal communication to open and connect all these doors.

It also furnishes the vehicle for use on this highway, to carry speech from door to door throughout the land.

The Bell highway is used daily by more than twenty million people—all telephone neighbors—by means of universal service.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
AND ASSOCIATED COMPANIES

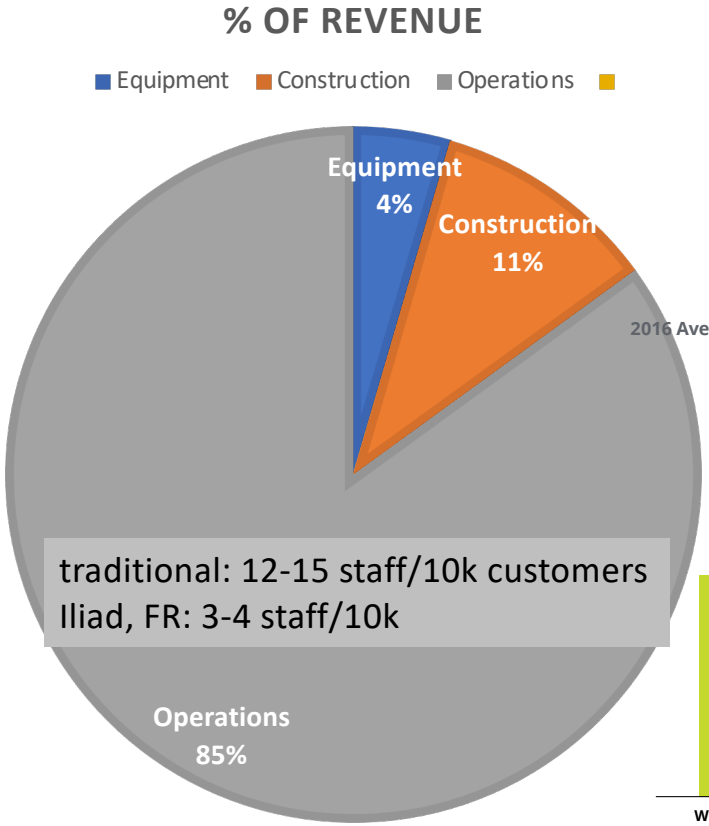
One Policy *One System* *Universal Service*

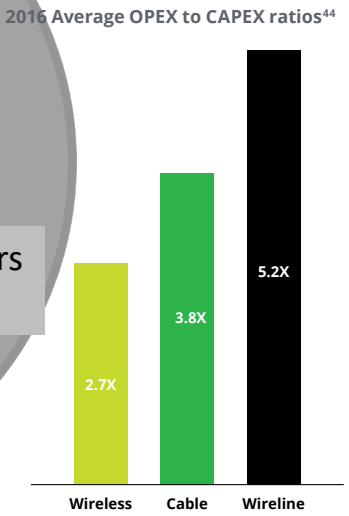
cross-subsidies: long-distance → local (& rural) service
universal service obligation (utility) in service territory

example: *inter-carrier compensation* (ICC)

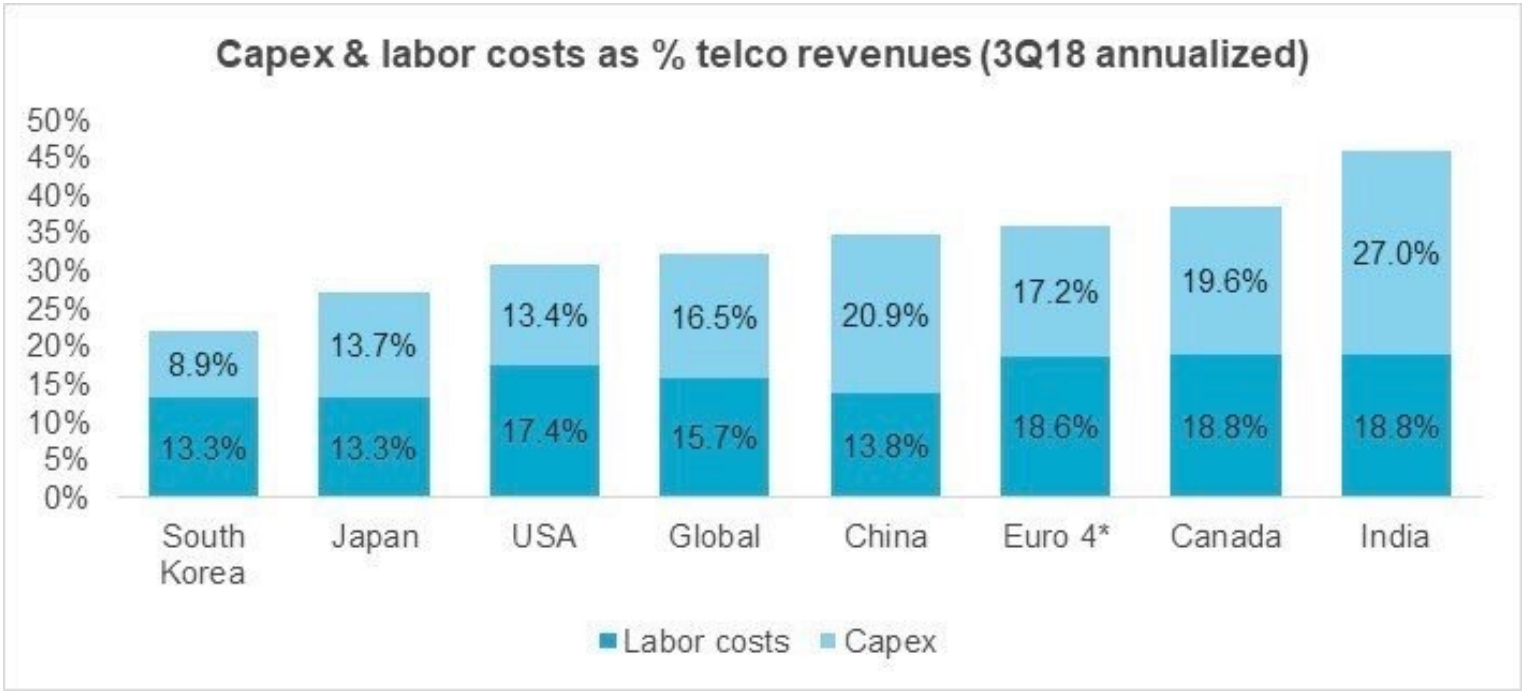
monopoly phone company → 1996 TA
local competition → "cream skimming" →
explicit universal service fund

Network economics, (over)simplified





Labor and capital expenditures



Your (mobile) phone bill at work

Taxes	$2.39
Description	Total (USD)
State Taxes	$1.49
State 911 Tax	$0.90

Fees & surcharges	$2.35
Description	Total (USD)
Federal Universal Service Fund	$2.10
Federal Regulatory Assessment Fee	$0.25

911 fee

USF

funds the FCC

Investment calculation

- $50/month per subscriber → 15% for investment
  - assume 10% for end user investment, rest for backbone, data centers, …
- $5 per month → $60/year → 16.6 years payback for $1,000
- Expected lifetime of fiber: 20 years
- Carriers want ROIC of 10-12%
- cf. Apple iPhone financial model (2.77 years, $300 avg. → $9/month)

	Verizon
ROIC ex-special items and ARILIA, wireless	16.3%
ROIC ex-special items and ARILIA, wireline	-0.3%
ROIC ex-special items and ARILIA, consolidated	11.5%

Trade-offs across the world?

- If new deployment, predicted return on investment
  - may just replace DSL or cable revenue (cannibalization)
  - 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

BEAD and other NTIA programs

Four NTIA broadband programs

Today's focus

BEAD

$42.45B

Broadband Equity, Access & Deployment Program

A program to get all Americans online by funding partnerships between states or territories, communities, and stakeholders to build infrastructure where we need it to and increase adoption of high-speed Internet.

DIGITAL EQUITY

$2.75B

Digital Equity Act

Three programs that provide funding to promote digital inclusion and advance equity for all. They aim to ensure that all communities can access and use affordable, reliable high-speed Internet to meet their needs and improve their lives.

TRIBAL

$2.00B

Tribal Connectivity Technical Amendments

A program to help tribal communities expand high-speed Internet access and adoption on tribal lands.

MIDDLE MILE

$1.00B

Enabling Middle Mile Broadband Infrastructure

A program to expand middle mile infrastructure, to reduce the cost of connecting unserved and underserved areas.

Note: Funding amounts inclusive of all administrative set-asides

BEAD program will provide ~$42.45B for infrastructure planning and implementation

Funding pool
$42.45B

A program to get all Americans online by funding partnerships between states or territories, communities, and stakeholders to build infrastructure where we need it to and increase adoption of high-speed Internet.

PROGRAM HIGHLIGHTS

Entities eligible to apply for this program include:

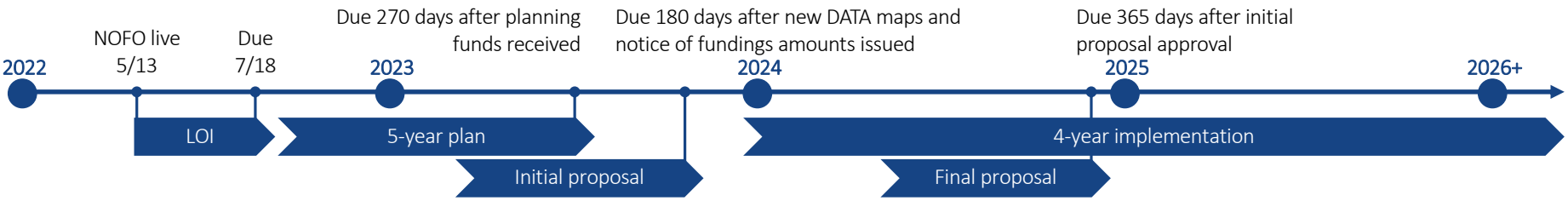
- All 50 States
- The District of Columbia and Puerto Rico
- Other Territories: U.S. Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands

Example eligible uses of funds include:

- Planning for deployment of Internet
- Deploying or upgrading Internet
- Installing Internet in multi-tenant buildings
- Implementing adoption and digital equity programs
- Workforce and job training

ESTIMATED TIMELINE

Timeline approximate unless exact date specified



BEAD will prioritize Complete coverage of unserved locations and underserved locations (where funding permits), then CAIs

First, Eligible Entities must serve all unserved locations (incl. serving multi-tenant buildings)

- **Unserved locations** without reliable Internet and with download speeds <25 Mbps, upload speeds <3 Mbps, and latency < 100ms [**Reliable = fiber, cable, DSL or licensed fixed wireless**]

Second, Eligible Entities must serve all underserved locations

- **Underserved locations** without reliable Internet and with download speeds <100 Mbps, upload speeds <20 Mbps, and latency <100 ms

Next, NTIA strongly urges Eligible Entities serve Eligible Community Anchor Institutions

- **Eligible Community Anchor Institutions** are entities (e.g., school, library, hospital) that facilitate greater use of high-speed Internet service by vulnerable populations and have download speed <1 Gbps
- **Other eligible uses** include affordability programs, cybersecurity training, workforce development., etc.
- If an Eligible Entity wants to use funds for other eligible uses instead of eligible Community Anchor Institutions, then it must provide a strong rationale

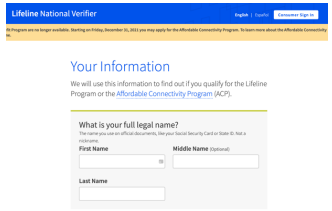
BEAD broadband deployment

- > 100 Mb/s download, 20 Mb/s upload, < 100 ms latency
- “Program prioritizes projects designed to provide fiber connectivity directly to the end user”
- If cost above extremely high-cost threshold, can choose other reliable technology or “most robust, affordable, and scalable technologies achievable under the circumstances particular to that location.”

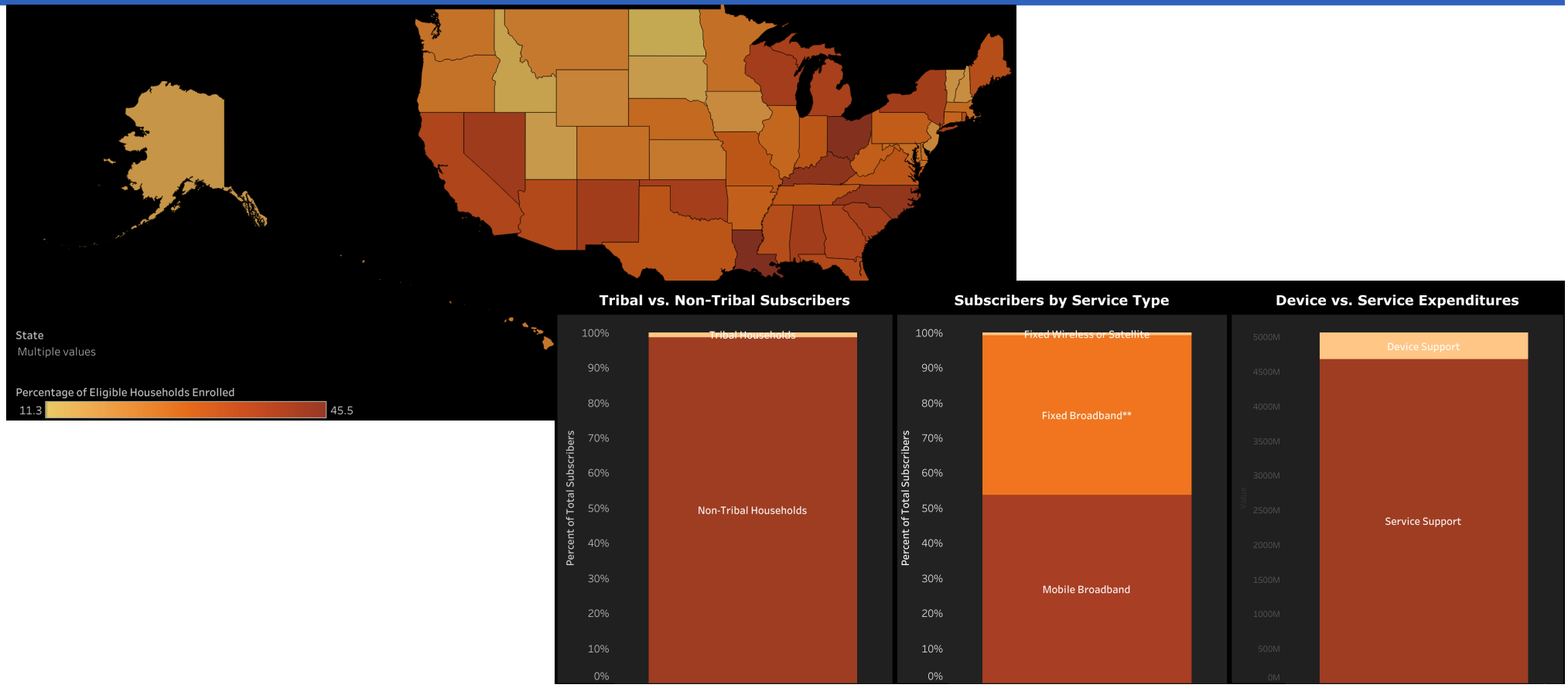
Affordability

IIJA Affordable Connectivity Program

- $30/month subsidy
  - + $100 subsidy for laptop, tablet, desktop computer
- eligibility:
  - income must be at or below 200% of the Federal Poverty Guidelines
    - e.g., $25.6k for single person, $53k for family of 4
    - cf. median family household income: $86k
  - receive benefits from Medicaid, Supplemental Nutrition Assistance Program, Supplemental Security Income, Federal Public Housing Assistance, or Veterans and Survivors Pension Benefit
  - student on free and reduced-price lunch program or the school breakfast program (including the Community Eligibility Provision)
  - has received a Federal Pell Grant in the current award year
- National Lifeline Verifier
- about 33% participation



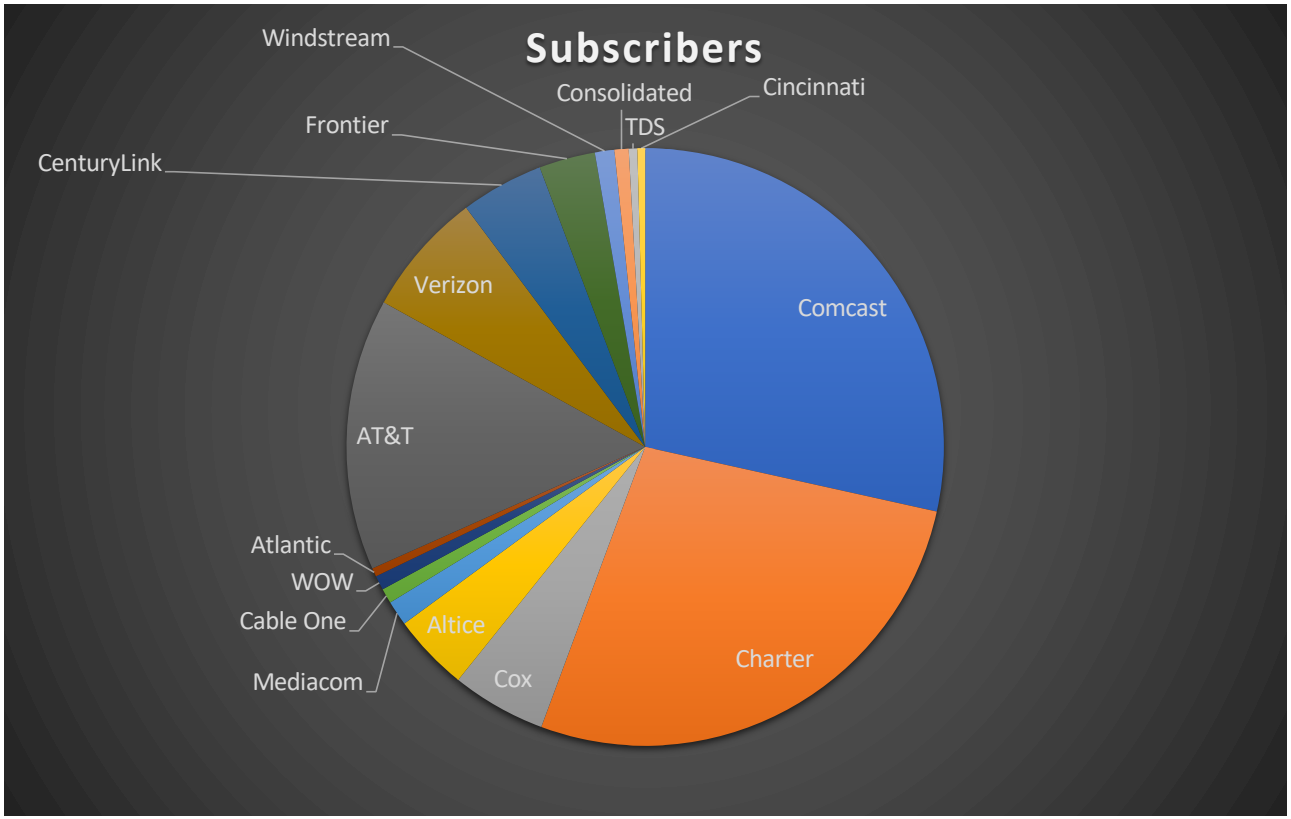
ACP enrollment by state and service



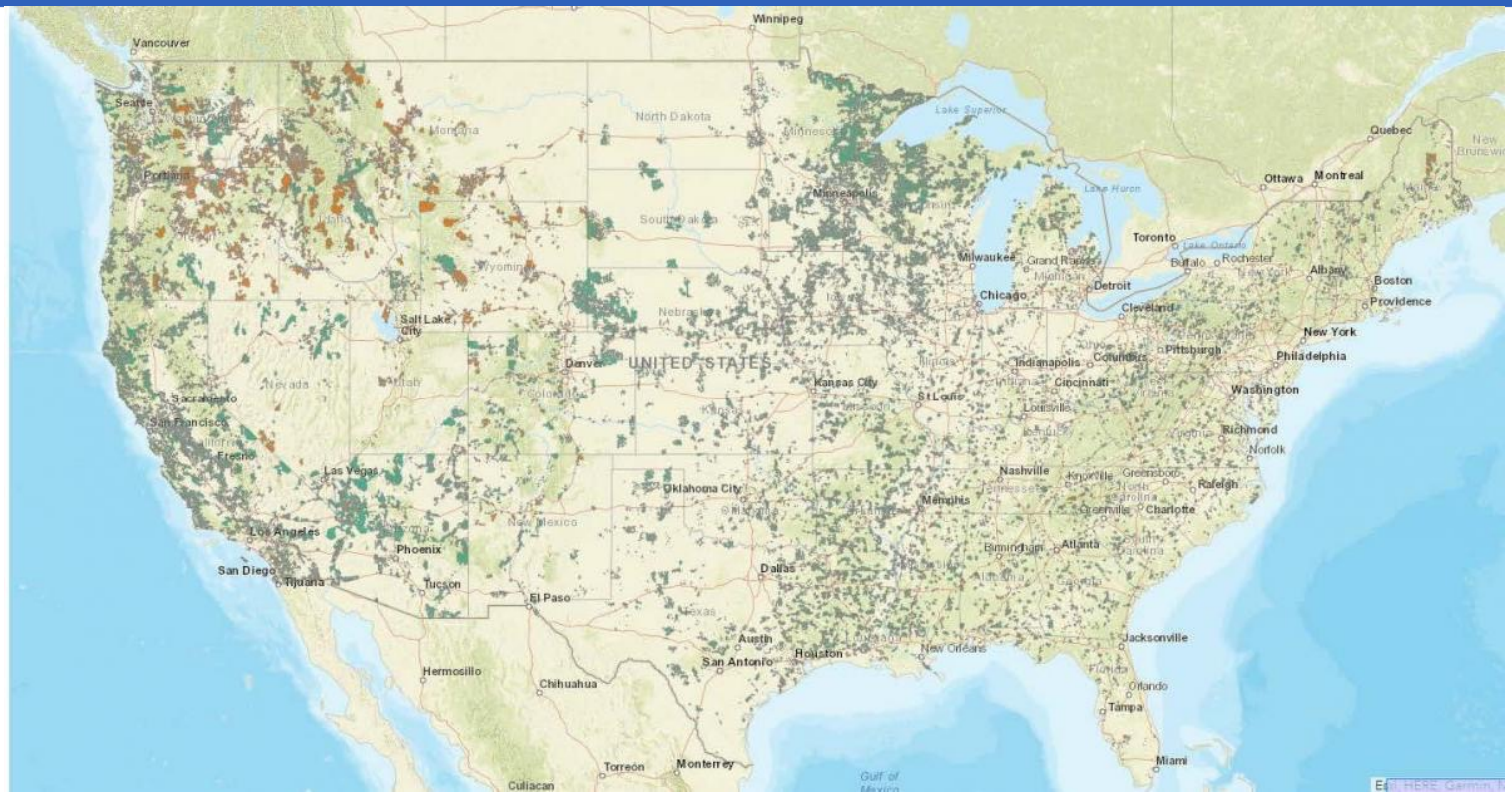
Conclusion

- Availability, affordability & relevance
- Except for large cable companies, challenging economics for (new) ISPs
- Introducing competitive fiber speeds is difficult everywhere
- Who should subsidize high-cost and low-income areas? Taxes or fees?
- Emphasis on automation (+ staff cuts) and simplified service structure
  - not new services, protocols, speeds
- Research directions:
  - fully autonomous, self-configuring networks – reduce OpEx!

But a few large carriers dominate



RDOF (2020) outcome

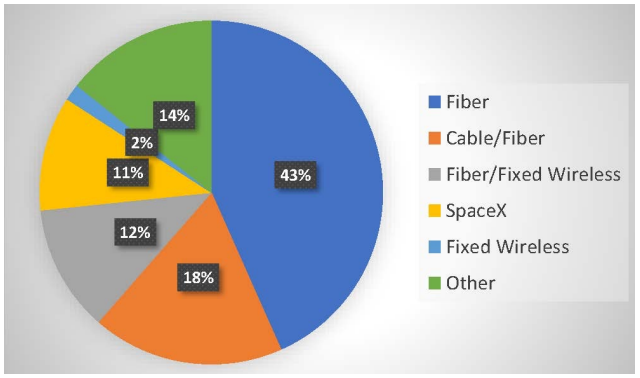


https://www.ctcnet.us/analytics/rdof-winners/

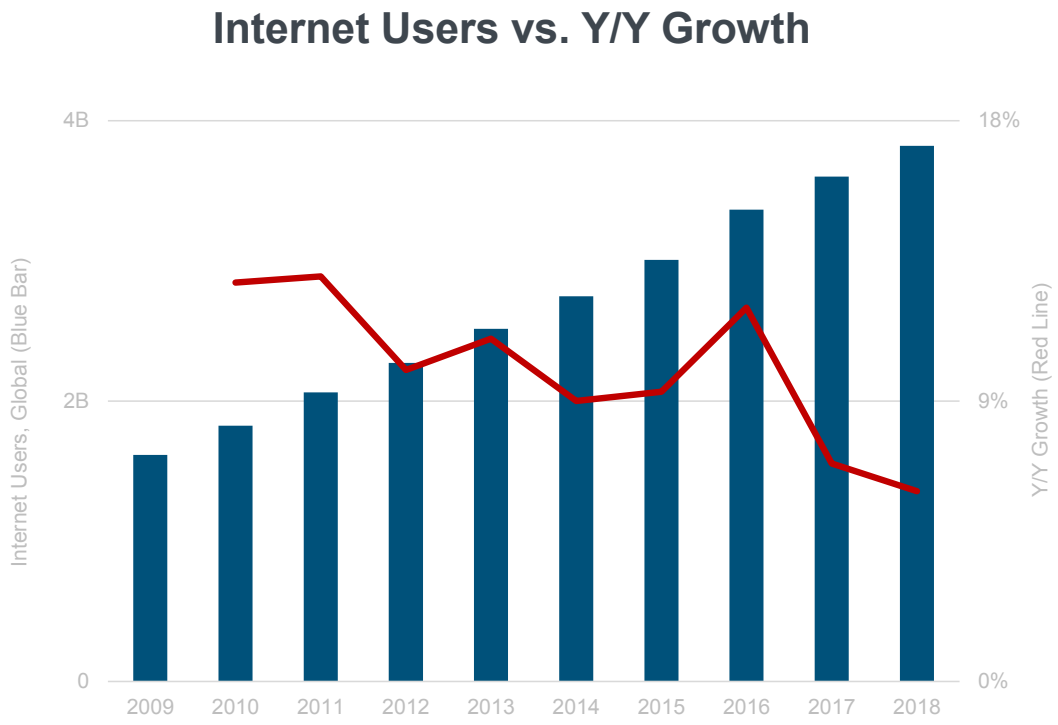
Rural Digital Opportunity Fund (RDOF) - 2020

- Old (pre-1996) model: incumbent is obligated to provide “universal service”
  - even if economically inefficient
  - “carrier of last resort” (COLR)
- Transition model: large incumbent telephone companies get money
  - based on cost estimates → often upgrade DSL from really slow to slow
- New model: reverse auction → lowest subsidy wins support
  - non-traditional providers, new entrants, satellite, …

Performance Tier	Speeds Required	Bandwidth Allowance	Weight
Minimum	≥ 25/3 Mbps	≥ 250 GB or U.S. average, whichever is higher	50
Baseline	≥ 50/5 Mbps	≥ 250 GB or U.S. median, whichever is higher	35
Above baseline	≥ 100/20 Mbps	≥ 2 TB	20
Gigabit	≥ 1 Gbps/500 Mbps	≥ 2 TB	0
Latency	**Requirement**		**Weight**
Low Latency	≤ 100 ms		0
High Latency	≤ 750 ms & MOS of ≥4		40

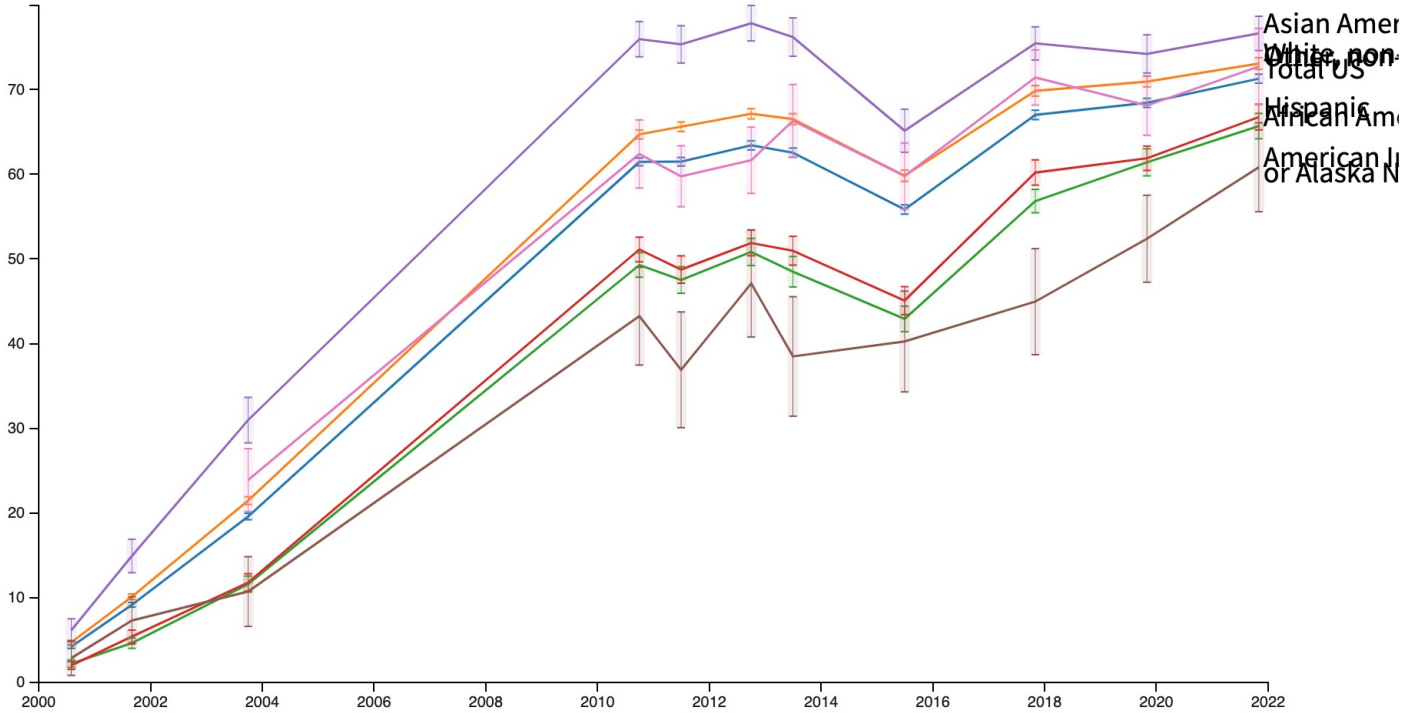


Global internet growth – 2009–2018



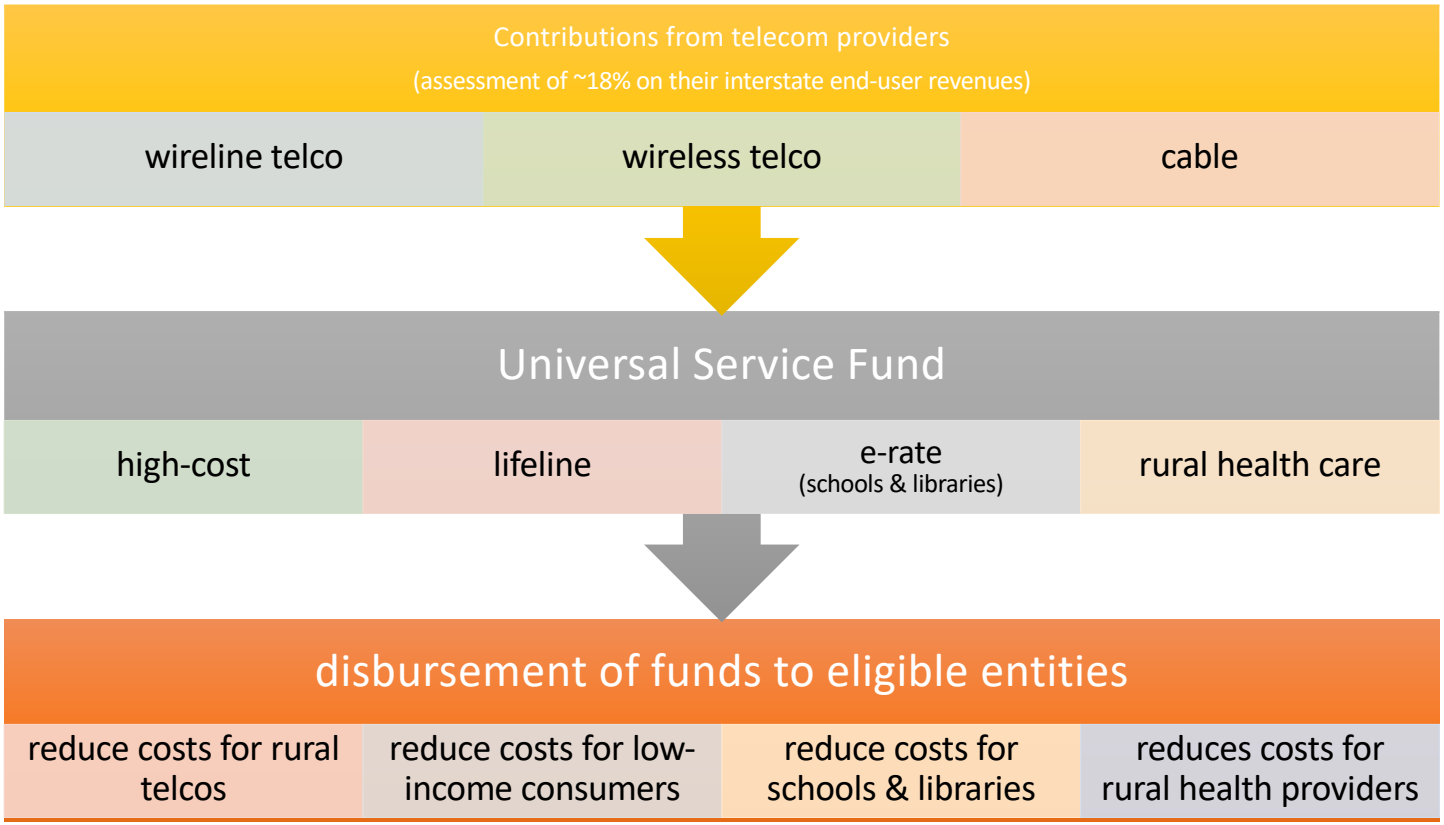
Internet user data is as of mid-year. Source: United Nations / International Telecommunications Union, USA Census Bureau. Pew Research (USA), China Internet Network Information Center (China), Islamic Republic News Agency / InternetWorldStats / Bond estimates (Iran), Bond estimates based on IAMAI data (India), & APJII (Indonesia).

By race, too



NTIA

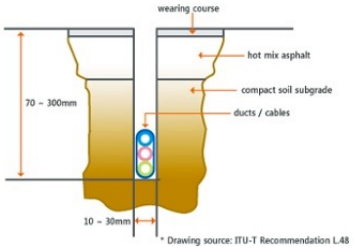
Universal Service Fund (USF)



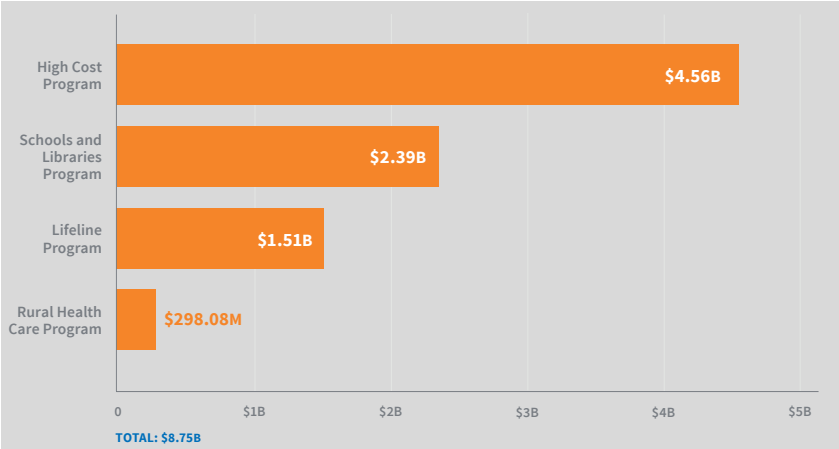
Allison Baker, 2017

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, …
    - some rates regulated by FCC, but contentious
- Provide funding
  - US: Universal Service Fund (FCC), BEAD (NTIA), US Department of Agriculture, US Treasury Capital Project funds, states, …



microtrenching



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

$10,958 in 2017

Public-private partnerships

	ASSET LEASED	CITY/COUNTY ROLE	CASE STUDIES
LAYER 0	Conduit	Conduit Maintenance	West Des Moines Lincoln
LAYER 1	Dark Fiber	Fiber Maintenance	Westminster Springfield Huntsville Holly Springs Urbana-Champaign
LAYER 2	Lit circuits over fiber	Fiber Maintenance & Optical Network Operations	Utopia Ammon

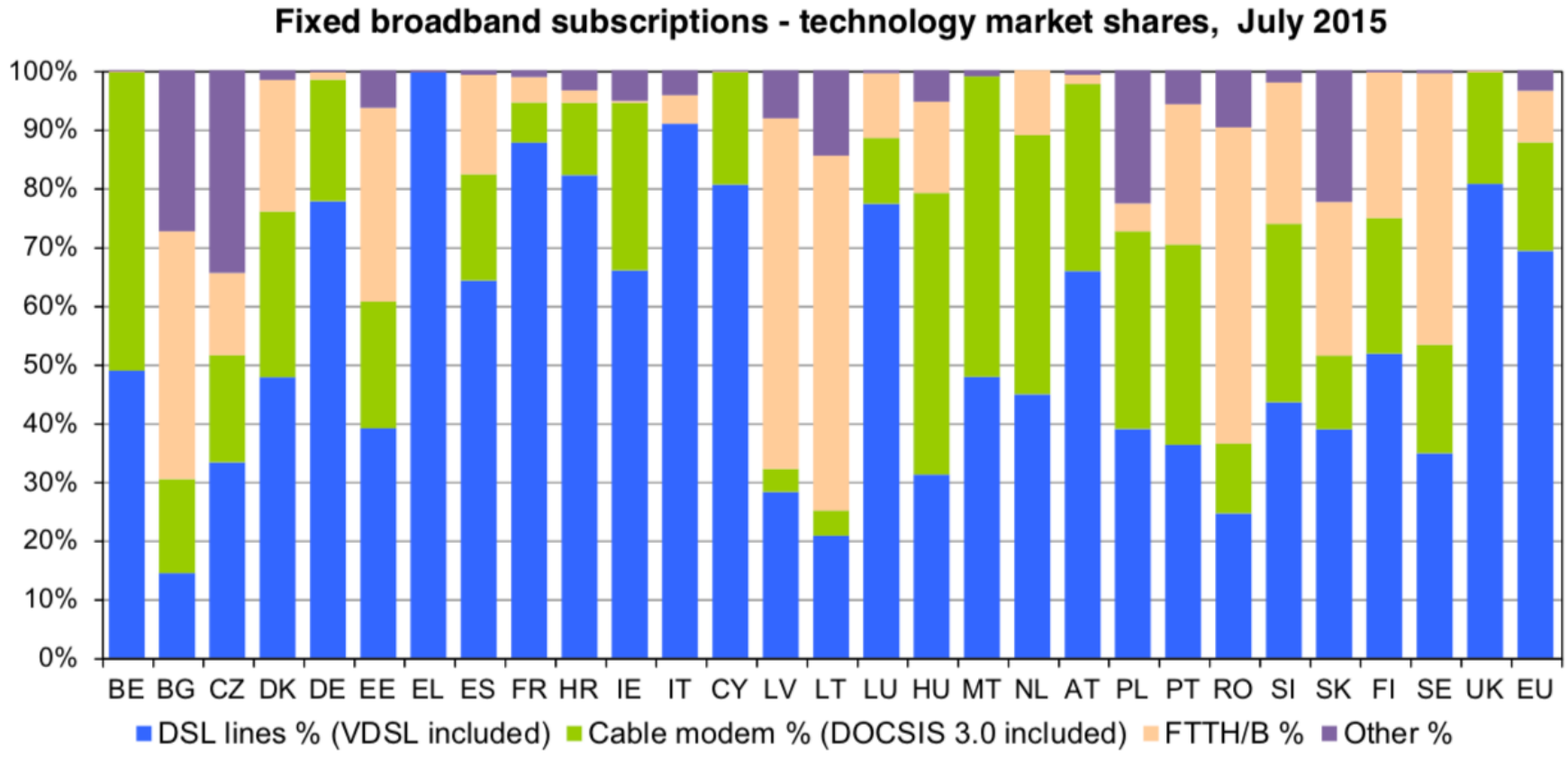
open access or
single provider

Benton Institute, Oct. 2020

More fiber observations

- Fiber middle-mile cost: $50-70k/mile
- Fiber cost: 144 strands = $10k/mile, 48 strands = $4.7k/mile
- Common characteristics:
  - avoid active elements in network → power, maintenance → PON
  - recently: avoid anything except fiber (including splitters)
    - cf. wireless last mile approach
  - fiber home run, even if PON (Google Fiber, Stockholm)
- Fiber cost higher for buried, but cheaper if conduit or aerial
- Recent FTTH:
  - avoid indoor installation (cf. Verizon FiOS)
  - one box in home (ONT + 802.11ac), not ONT + MoCa STB

Technology path dependence



COVID-19 changed thinking

Pre-COVID-19

- Biggest problem: no broadband in small parts of rural America
- Low income households have Lifeline for basic connectivity
- Need to solve mapping problem first to understand scope of unavailability
- 10-year programs (USF CAF II, RDOF)
- Can always go to the local library or school
- 25/3 is plenty fast

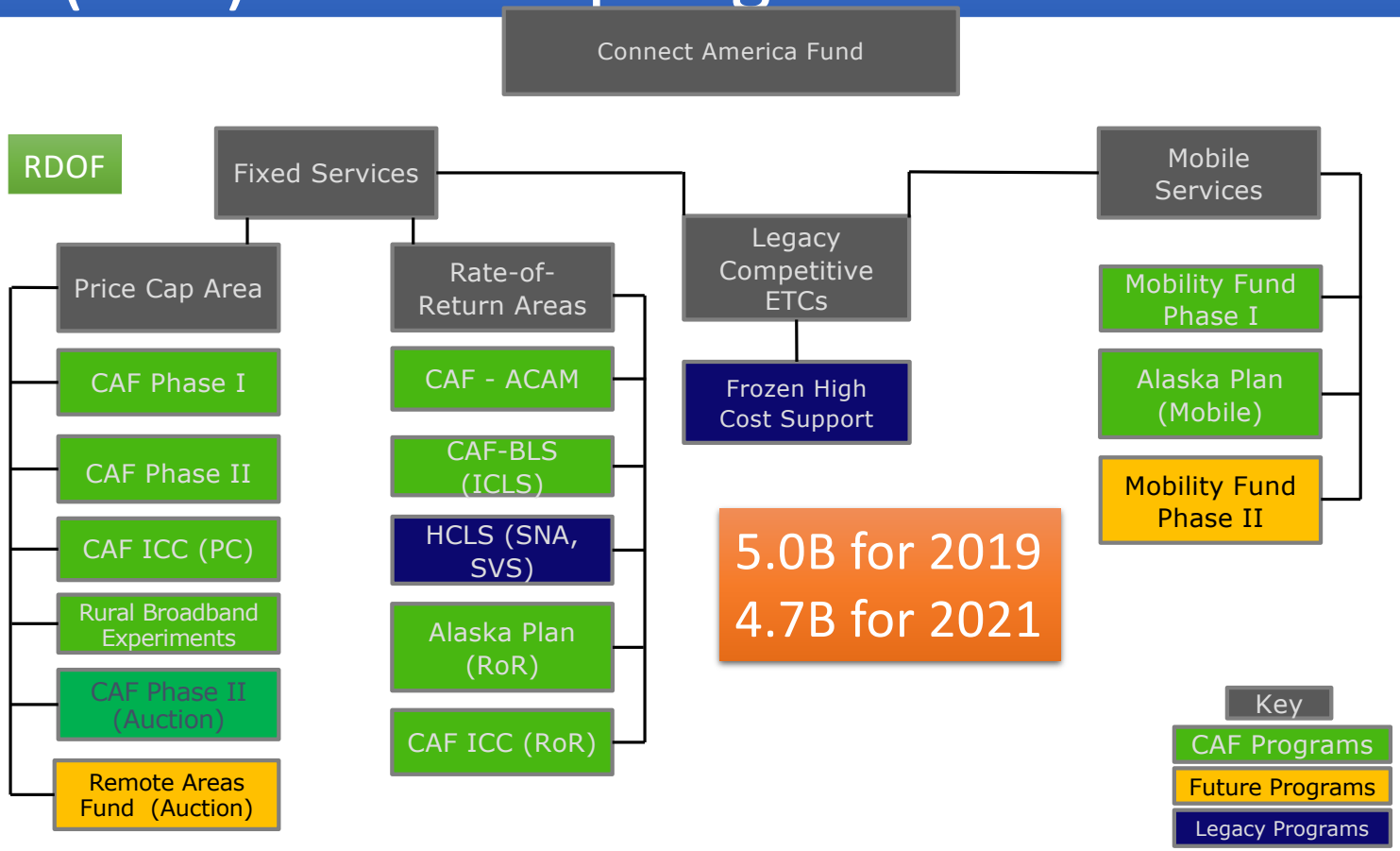
With COVID-19

- Biggest problem: lots of people can't afford broadband
  - and quality of supposedly-covered areas is low
  - no 25/3 broadband in urban areas
    - only 1.5%, but that's 3.9 M people
    - vs. 11.1 M rural
    - "digital redlining"
  - or cannot afford devices
- Students cannot wait 10 years
- Local library (and school) is closed
- Multiple video conferences bust 3 Mb/s upstream

Long-running arguments

- Who should fund universal service?
  - Old model: interstate communication – now, 27%
  - New model (Congressional bills): general revenue
  - Other models: connection-based, number-based, include BIAS revenue, …
- Balance between rural (build-out, provider subsidy) and urban (consumer subsidy)?
  - cf. farm bills -- agricultural subsidies vs. SNAP
- Build for today's perceived minimum need or tomorrow?
  - subsidies paid over seven to ten years
  - AT&T 2014: 4 Mbps "Given the pace at which the industry is investing in advanced capabilities, there is no present need to redefine "advanced" capabilities"
- Minimum usable speed or closer to "urban" (cable) speeds?

We've tried this for a while: Connect America Fund (CAF) and off-spring



Lifeline

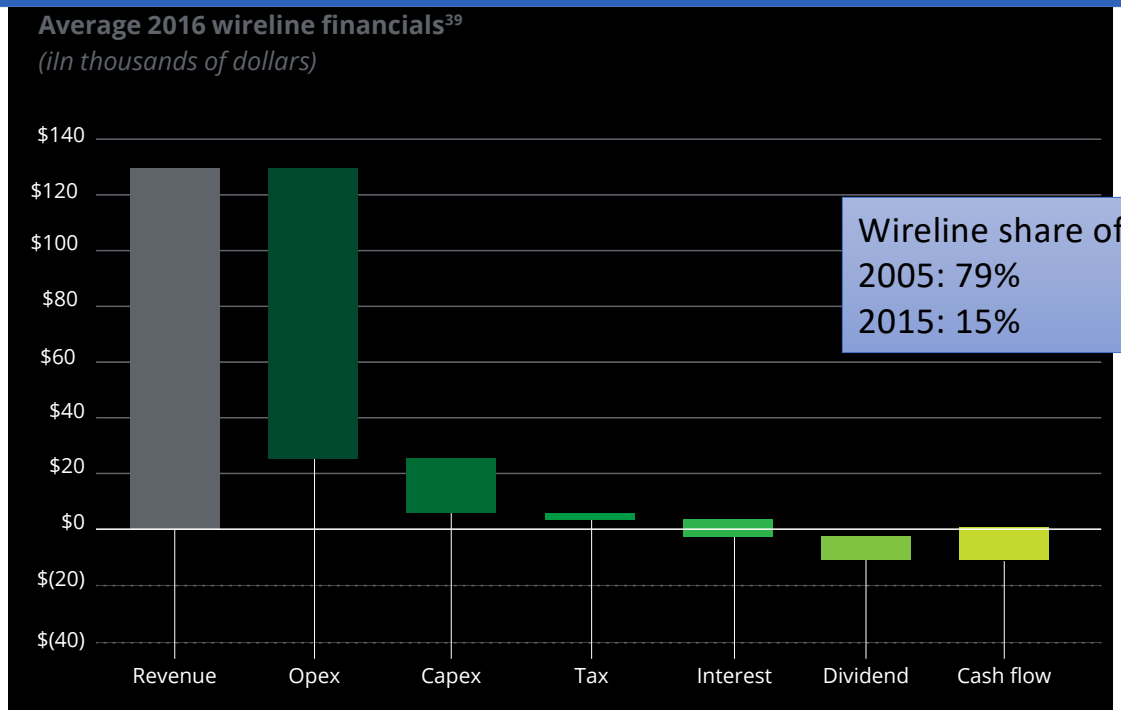
- Established in 1985 by the FCC and mandated by Congress in the Telecommunications Act of 1996
  - used to be mostly local phone, now mostly mobile
- Federal program that lowers the monthly cost of phone and internet for qualified low income consumers
  - Program qualification based on income or participation in a qualifying assistance program (e.g., SNAP, Medicaid, SSI, Public Housing Assistance)
  - Basic support amount is $9.25 per month and up to $34.25 for consumers living on Tribal lands
    - e.g., 1,000 minutes of voice, 4.5 GB of data
- Concerns about fraud
  - unused phones
  - multiple phones in one household
  - phones to ineligible consumers

But Lifeline has reached (mostly) the end of its line

State	July 2020 Subscriber Count	2018 Lifeline Eligible Households Based on ACS Data	Estimated 2020 Lifeline Participation Rate
Alabama	84,707	586,269	14%
Alaska	21,218	63,554	33%
Arizona	171,625	724,439	24%
Arkansas	79,667	390,538	20%
California	1,612,738	3,772,226	43%
Colorado	62,177	490,133	13%
Connecticut	73,640	357,860	21%
Delaware	14,001	99,002	14%
District of Columbia	18,876	87,184	22%
Florida	396,392	2,294,462	17%
Georgia	272,302	1,056,298	26%
Hawaii	7,579	104,985	7%

- one per household – who gets the phone?
- too little data even if tethering enabled
  - 3 hours of Zoom per month
- not all children can get access

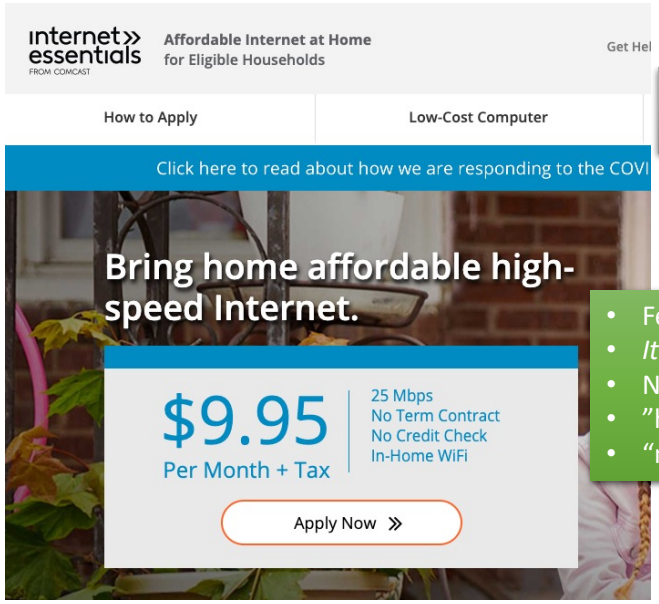
Rural wireline ILECs lack resources



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

ARPU(fiber) = ARPU(DSL) + ϵ
cost(fiber) >> cost(DSL)

Provider-based: Comcast Internet Essentials



Some school districts give out bulk vouchers

- Fear of bills
- *It's free – must be a scam*
- Not available in 58% of households
- "have not subscribed within 90 days"
- "no overdue bill within 12 months"

see also NDIA NATIONAL DIGITAL INCLUSION ALLIANCE