Framing for Session 1: Understanding Properties of Internet Access: Deployment, Adoption, Performance, Pricing

Ellen Zegura, Georgia Tech
Monisha Ghosh, U of Chicago
NSF WOMBIR Workshop 2
15 April 2021

Access 101

Last “mile” between user device and Internet

Rich and varied technologies, often spectrum constrained

Fixed broadband - access via fixed-location technology (fiber, cable, Ethernet)

Mobile broadband - access via a mobile-location technology (cellular, satellite)

“Broadband” - contested and evolving

- minimum or median? advertised or measured? fixed != mobile?
- FCC: 25/3 Mbps fixed; 5/1 Mbps (minimum) or 10/3 (median) mobile

Deployment = provider has *made access available*

Adopted = consumers have *purchased from deployed options* (affordability)

Who collects access data?

Users - to monitor their own performance, to hold providers accountable, to contribute to crowd-sourced data collection efforts

Providers - to understand their networks, for FCC compliance (Form 477)

Government/FCC - to monitor progress on requirement to “encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans” (1996 Telecommunications Act); FCC aggregates provider data and independently collects volunteer panel user data

Location services companies - to improve their service

Researchers - typically in targeted areas as hyper-local ground truth

What is collected?

Basic: Upload/download speed at a location (NB: privacy concerns)

Basic+: latency to a nearest server or collection of servers, jitter

Application performance: Web page transfer time, video QoE metrics to a nearest server or collection (avg rate, rate changes, rebuffering)

Ilities: Pricing, affordability, reliability

For mobile: signal strength, provider, radio type, location (NB: privacy concerns)

Next set of slides

What do we know from *provider data* (via reports to the FCC)?

What do we know from *crowdsourced (user) data*?

- Ookla
- OpenCellID
- FCC Measuring Broadband America
- (Not included: M-lab or any proprietary sources)

Myths and Resources

What do we know from provider data (via FCC)

In US, FCC requires providers to report on *deployment data* (availability) at the census block level and *subscriber data* (adoption) at the census tract level

Measurement methodology issues (including serious accuracy concerns)

Available via the Broadband Deployment Report

Most recent (#14) in January 2021 (See Resources)

Look at two examples from BDR 2021 but please take with a grain of salt

Note: US focus here

Example: *Deployment* data **Fig. 1** (Tribal omitted on 4G LTE)

Deployment (Millions) of Fixed Terrestrial 25/3 Mbps Services

	2015		2016		2017		2018		2019	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
United States	287.853	89.9%	296.320	91.9%	304.473	93.5%	309.000	94.4%	313.749	95.6%
Rural Areas	38.271	61.5%	42.628	67.7%	46.982	73.7%	50.146	77.7%	53.834	82.7%
Urban Areas	249.582	96.7%	253.692	97.7%	257.491	98.3%	258.854	98.5%	259.915	98.8%
Tribal Lands	2.290	57.8%	2.520	63.1%	2.734	68.1%	2.922	72.3%	3.203	79.1%
Pop. Evaluated	320.289	100.0%	322.518	100.0%	325.716	100.0%	327.167	100.0%	328.210	100.0%

Fig. 2b

Deployment (Millions) of Mobile 4G LTE with a Median Speed of 10/3 Mbps[147]

Area	2015		2016		2017		2018		2019	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
United States	247.649	82.2%	265.270	86.4%	275.091	86.8%	298.401	93.8%	310.923	97.4%
Rural Areas	33.260	68.4%	35.112	68.1%	36.585	64.3%	45.904	79.7%	53.156	90.8%
Urban Areas	214.389	84.8%	230.158	90.1%	238.506	91.8%	252.497	96.9%	257.767	98.8%
Pop. Evaluated	301.457	92.6%	307.067	95.2%	316.793	97.3%	318.269	97.3%	319.341	97.3%

Example: *Adoption* data for fixed terrestrial

25/3 Mbps					
United States	48.1%	53.5%	60.2%	65.1%	69.4%
Non-Urban Core Areas	43.2%	48.9%	55.1%	59.9%	64.5%
Urban Core Areas	51.5%	56.9%	64.0%	69.2%	73.3%
Tribal Lands	31.7%	33.4%	37.9%	44.0%	46.5%
Non-Urban Core Areas	28.5%	30.3%	34.5%	38.7%	40.6%
Urban Core Areas	37.1%	39.4%	45.1%	56.1%	61.8%

What do we know from crowd-sourced (user) data?

Active: packets sent specifically to measure performance

Passive: performance inferred from existing traffic

Background: tests run without user initiation, either periodic or triggered by other activity

User-initiated: user decides to run test

Public: measurement data publicly available

Public aggregate: measurement data made available in aggregates

Private controlled: measurement data made available selectively via data use agreements

Example: Public Speedtest data by Ookla

Active testing, user-initiated, ioS and Android

Fixed and mobile (cellular) broadband

Data shared: Download speed, upload speed, latency, #measurements, #unique devices

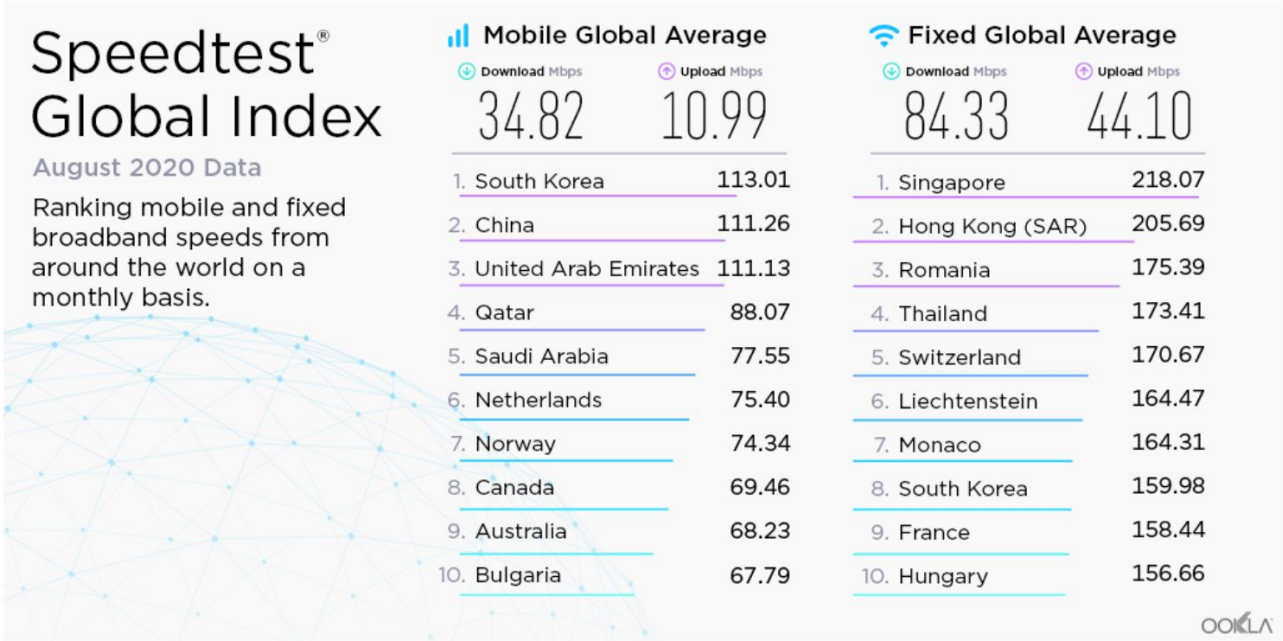
Averaged in z=16 tiles (600 m^2); 3 month time window

Filtered for measurements containing GPS-quality location accuracy

Data available publicly on AWS (see Resources)

Ookla Global Index

Highlights from the Speedtest Global Index



Example: Cell Tower Locations by OpenCellID

Active testing, user initiated, Android and Windows Mobile, multiple apps

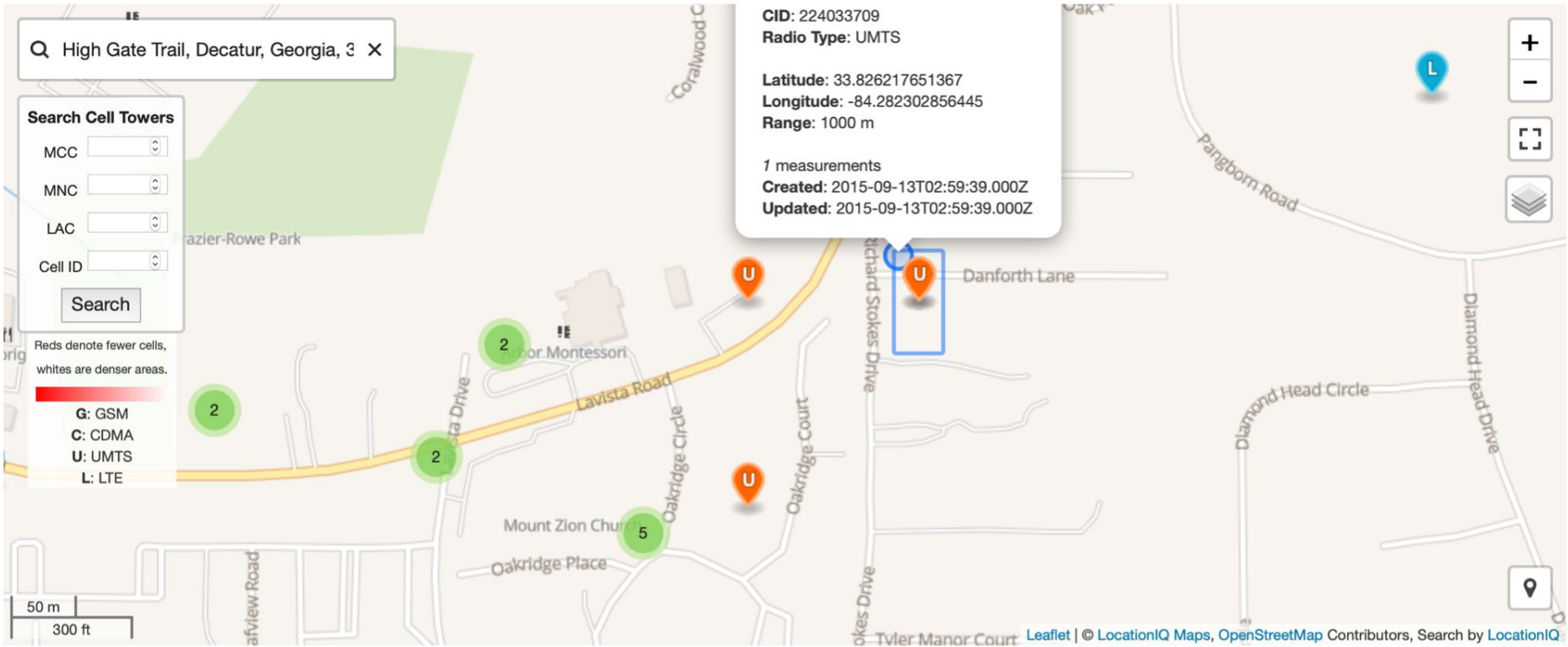
Data collected: Radio type, cell ID, location; Optionally: signal strength, date and time, speed, direction, GPS quality

Location measurements for given radio/cellID averaged

Data shared by country and radio type from OpenCellID (see Resources)

Data shared via API access key as cell location lookup, cell IDs in an area, #cells in an area

OpenCellID interactive map



Example: US FCC Measuring Broadband America (Fixed)

Active testing, randomized schedule, from measurement kit, Android developed by SamKnows (FCC contractor for MBA program)

Volunteers sent custom software on COTS router

Download speed, upload speed, web, UDP latency and loss, video, DNS,...

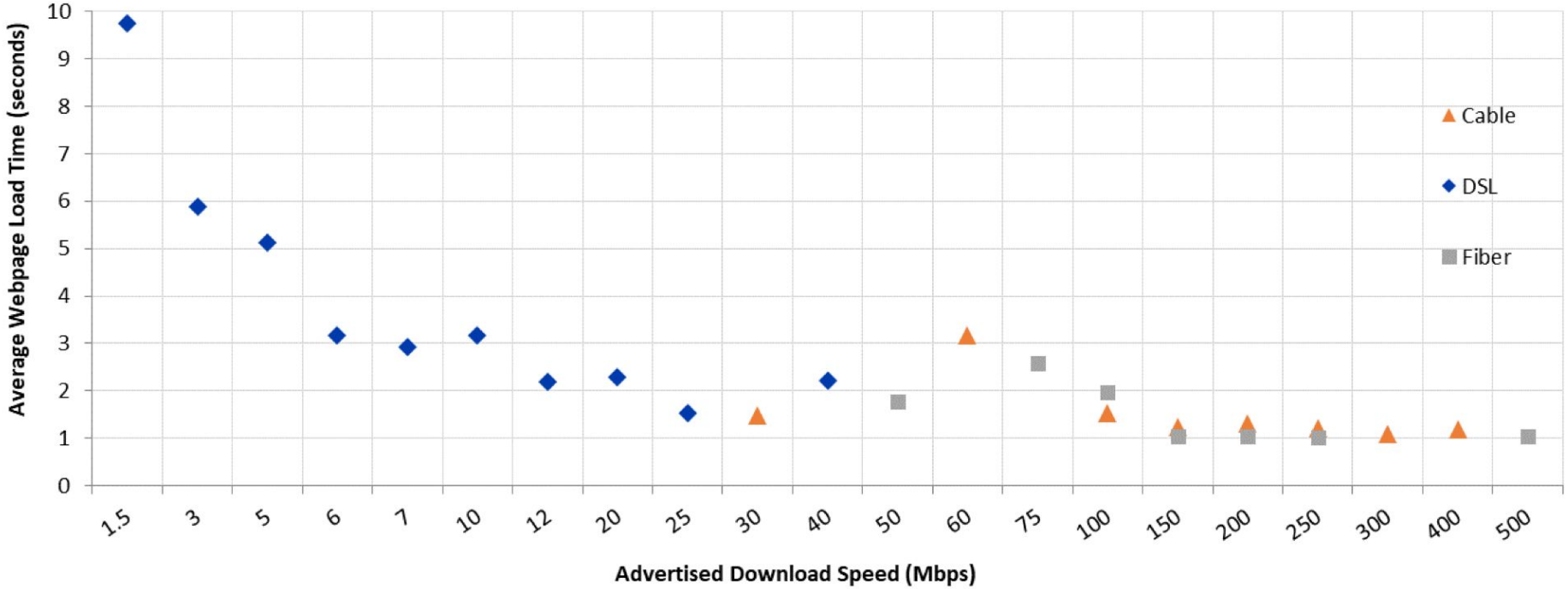
2931 participants in the 10th report (Sept 2019), 10 ISPs

Monthly data at granularity of a participant with census block/track/county location (whichever has >1000 people)

Data available publicly at FCC website (see Resources)

MBA Fixed Broadband Report (10th)

Chart 9: Average webpage download time, by advertised download speed.



Myths

We have all the data we need

Broadband access problems are a rural issue only

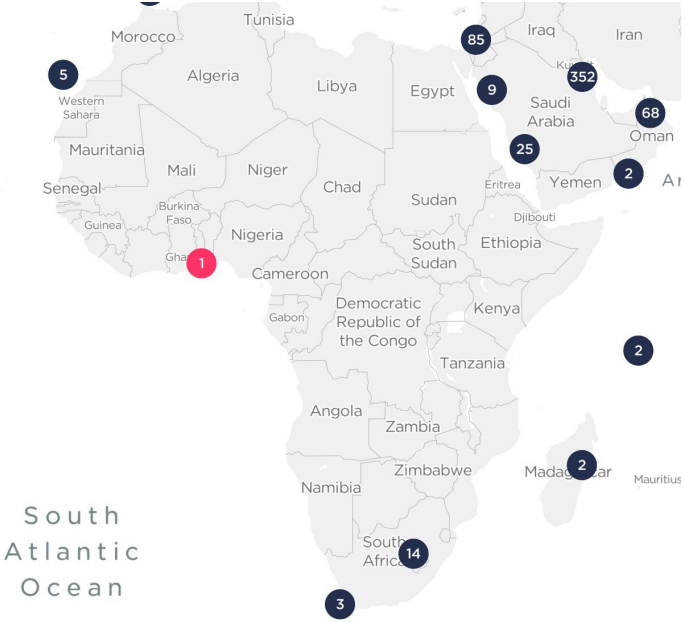
Cellular providers know their coverage accurately

Cellular and fixed wireless performance are easy to predict from propagation models

The FCC (or some other TLA agency or company) knows it or will solve it

Speedtest is the answer

5G will solve the problem (see figure, from Ookla)



Resources

Measurement methodology comparison from Ookla/Speedtest perspective: https://www.speedtest.net/about/knowledge/test-methods

Ookla public data set: https://registry.opendata.aws/speedtest-global-performance/

OpenCellID data set: http://opencellid.org/downloads/

Interactive map of OpenCellID data: https://opencellid.org/#action=statistics.cells&sortByRadio=4&dateFrom=&dateTo=&mcc=&mnc=&zoom=17&lat=33.790391&lon=-84.30627

FCC Fixed Source Code https://github.com/SamKnows/skandroid-fcc

FCC Mobile Github Repository https://github.com/FCC/mobile-mba-androidapp

Resources

https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-broadband-america-program-fixed

Most recent FCC Broadband Deployment Report (Jan 19, 2021): https://docs.fcc.gov/public/attachments/FCC-21-18A1.pdf

CNET article:

https://www.cnet.com/features/millions-of-americans-cant-get-broadband-because-of-a-faulty-fcc-map-theres-a-fix/

Example: FCC: Measuring Broadband America (Mobile)

Active testing, automated though can disable and run manually, Android and iOS

Uses FCC Speedtest app

Upload and download speed, latency, packet loss, jitter, wireless perf, handset model and OS

Space granularity is Cellular Market Area (CMA)

Time granularity is between a day and a quarter

[Editorial comment: much less useful than fixed data]