

Covid and the Digital Divide



The Digital Divide

- Many people have excellent Internet access—but others don't
- The differences are often due to race, income, and location—rural areas were less likely to have broadband access
- This has always been a serious issue—but the pandemic has shown how critical it is

Why are there Differences?

- Laying fiber or cable is expensive
- Even cellular connectivity requires fiber “backhaul”
- (A cell tower has an effective service radius of about 1.5 km—less in densely populated areas like Manhattan)
- Crucial number for profitability: subscribers per km of fiber
- The termination equipment, e.g., cable modems, can also be expensive, though that cost is generally borne by the subscriber

Population Densities

- Rural
- Suburban
- Urban
- Manhattan. . .
- Suburban is usually the sweet spot—reasonable population density (and often income); fewer bureaucratic hassles than in larger cities

Costs of Running Cable

- Cheapest: attach new cable to existing poles
- ☞ Often resisted by incumbent providers
- Installing new poles
- ☞ Often resisted by neighborhoods
- Existing underground conduits
- Burying cable without conduits
- Even when there are existing poles, there is often some need to bury some of the cable run

Optimization, ISP Style

- Go for low cost, high subscriber rate
- Rural areas have too few households per km of cable—take rate *can't* be high
- (Some broadband technologies have cable length limits)
- Poor urban areas: lots of bureaucracy; too few people can afford the service
- Result: little availability in poor or rural areas

Cable Modems

- Modern cable TV plants are actually hybrid fiber-coax
- The fiber is expensive but provides essentially unlimited bandwidth, but the coax has limited bandwidth
- Conversion between fiber and coax is done at a “fiber node”
- Increasing the bandwidth to a neighborhood requires more fiber nodes, i.e., more cost
- Again: what is the expected take rate?

- Rural areas may not have cable TV service
- Even if they do, upgrading the cable plant to handle bidirectional traffic can be expensive
- The usual solution is to use DSL (digital subscriber line)
- But—for electrical reasons, DSL doesn't work on phones too far from a central office, and is speed-limited by line length
- This is solvable, but at a cost
- What is the subscriber rate per km of phone line?

Satellite Links

- Satellite links seem attractive for rural areas: no cables to run
- However: ground stations can be expensive
- Also: TCP bandwidth is **inversely proportional to packet round trip time**, which for satellites is limited by the speed of light:

$$BW = \frac{MSS}{RTT} \frac{C}{\sqrt{p}}$$

where RTT is the packet round trip time. (MSS , C , and p aren't relevant here).

- If the relay satellite is in geosynchronous orbit (about 36,000 km up), minimum round trip is $4 \times 36000/300000 \approx .5$ seconds
- By comparison: NYC to Stanford RTT is about .075 seconds
- Starlink will change that—some day...

Asymmetric Bandwidth

- For some access technologies, e.g., DSL, there is a tradeoff between upstream and downstream bandwidth available on a given cable
- For others, it's much simpler (and hence cheaper) to provide asymmetric bandwidth
- ISPs have long prioritized downstream bandwidth: streaming movies, downloading large web pages, etc.
- That's not always the best tradeoff for telecommuters

What About Race?

- Due to historical racism, Black communities are often lower income, hence less likely to pay for an expensive service
- That in turn lowers the likely take rate, which in turn lowers provider incentive to run new cable
- Result: less availability in Black neighborhoods

- Some older folks are on (low) fixed incomes and can't afford good connectivity (or computers!)
- For others, it's unfamiliarity with computers, and unwillingness or inability to learn
- In either case, too few older folks are online

The Net Result

- For economic reasons, poorer and rural neighborhoods often have poor Internet service
- As a consequence, Black neighborhoods often also have poor service
- And then came Covid. . .

- Jobs moved online
- Healthcare moved online
- Education moved online
- It all happened very suddenly

Working Via the Internet

- Many jobs moved online immediately, with little productivity hit
- Other jobs can't be done as well that way
- Still others can't be done remotely at all
- Often, it was the higher-paying jobs that could move online more easily

- Programming is one of the easiest jobs to move remote
- 👉 Much work time is spent staring at a screen anyway. . .
- But—there are still meetings, interactions with colleagues, and more
- Conferencing systems, e.g., Zoom, can (often) replace formal meetings, but that works better with video, i.e., with higher bandwidth available
- Replacing informal meetings is harder, though there are tools like Slack that try to fill that void
- There are no good ways to replace serendipitous meetings

Managing Remote Workers

- Many companies express concern about managing remote workers
- How many hours are they working?
- Are they working when at their desks?
- Is there a better way to measure, and hence manage, productivity?

Work Environments

- Some people—especially better-paid people—have dedicated home offices
- Others have to share space, and work from their bedrooms, kitchens, etc.
- These are often not-great work environments, with plenty of noise and distractions
- (Zoom-bombing cats have become a cliché. And then there was the attorney who accidentally appeared in online court with a [cat-head filter](#)...)

At the Other End of the Scale...

- Jobs that require hands-on physical access are very hard to move online
- Examples: construction, factory work
- Horrendous infection rates at meat-packing plants early on in the pandemic
- In principle, some of that could have been made remote-compatible, but only with a lot of advance planning and investment in robots
- But that sort of investment may cost jobs—unclear if it's a net win for labor

- Many experimental science jobs can't be done fully online
- Someone has to fill the test tubes, dissect the mice, etc.
- A lot—but not all—of medicine is hands-on, especially for very sick patients

- For many jobs, customers expect to be served by a person
- Most ordinary banking transactions can be handled by ATMs—but not all, and not everyone is comfortable using them.

“In private, many senior bank executives tasked with raising attendance among their direct reports expressed irritation. They said it was unfair for highly paid employees to keep working from home while others — like bank tellers or building workers — dutifully come in every day.”

New York Times

The Great Resignation

- Many Americans have been quitting their jobs lately
- Often, this has been workers in low-paid, high-stress jobs, involving contact with the public and with unsupportive management
- Even increased wages—supply and demand!—hasn't lured back that many people
- One consequence: more robots

- Many businesses have started buying robots where there were none before
- Examples: bartending robots, carrying food from restaurant tables to tables, frying food
- Is this shift permanent? If so, has the number of jobs permanently decreased?
- Note that these jobs are often low-paid but entry level

Covid Vaccination Access

- Online access has been critical for access to Covid vaccinations
- Early on, it was vital for finding sites, making reservations, etc.
- Even today, it's useful for making appointments for booster shots
- Some web sites (e.g., the NYC site) were not just user-unfriendly, they were downright user-hostile
- Internet access is still useful for buying N95 masks, Covid rapid tests, finding PCR testing sites, etc.
- What of the elderly, who are much less likely to be online but are the most in need of protection?
- (There have been volunteer efforts to help such people)

- Many doctors and hospitals started offering telemedicine: video calls between doctors and patients
- Eliminate the need to visit in person, travel, etc.
- Again, what of those without good online access?
- (Other issues: insurance payments to physicians for such calls, state licensing requirements, etc.)

From: Lee C. Bollinger <officeofthepresident@columbia.edu>
Subject: Update on COVID-19
Date: March 12, 2020 at 10:44 AM
To: president@lists.columbia.edu

Dear fellow members of the Columbia community:

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In light of the spread of the virus, especially in the New York metropolitan region, we now need to take further steps. Specifically, in order to reduce the density of our residential environment, while respecting the interests and needs of students who have reason to continue to remain in residence on campus, we are instituting three critical decisions: (1) The University will remain open and functioning; (2) All classes for the remainder of the semester will be conducted online; and (3) We encourage any students who are able to move out of undergraduate residence halls for the rest of the semester to do so, and we are ready to help in that process. The Office of University Life and your school will follow up with more information.

Remote Education: Synchronous versus Asynchronous

- Synchronous

-  Students are online while the instructor is teaching

- Asynchronous

-  Instructors record lectures; students watch/listen at their leisure

Synchronous Remote Instruction

- Requires enough bandwidth for bidirectional communication, often by video
- More bandwidth demands with multiple students (or teachers!) in the house
- Theoretically better, in that it allows for more interaction
- But—many people don't have enough bandwidth
- (Also social factors: many people don't like to have their cameras on)
- AR/VR might make for better pedagogical experience, but would require even more bandwidth

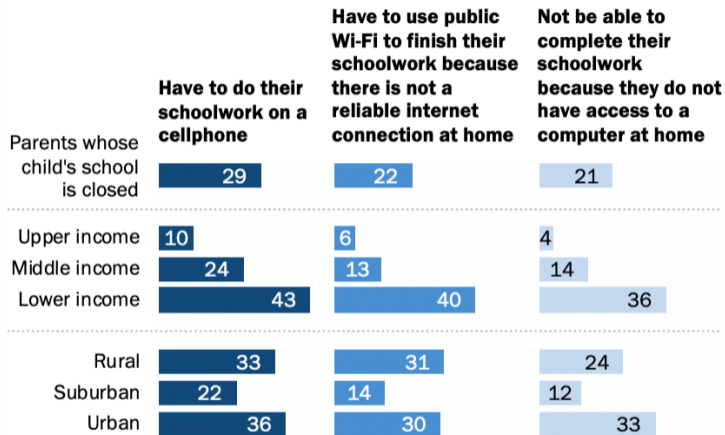
Asynchronous Remote Instruction

- Can work with lower bandwidth—downloads can happen at off-peak, slower than real-time, etc.
- Also useful for people who aren't available (work, timezones, childcare responsibilities) during class
- But: much less interaction with the instructor

Who Has the Bandwidth?

- The FCC estimates that for four simultaneous sessions, you need 250/25 Mbps (download/upload speeds)
- 👉 During Covid, this was easily needed for many families with children doing remote schooling
- Per FCC figures, poverty and low population density correlate with poorer Internet access
- Also note: availability of high-speed service is not the same as subscription to it

Poverty as an Issue



Taken from a [Pew Research report](#).

Parking Lot WiFi

- Many libraries and schools advertised their “parking lot” WiFi
- Other people went to stores (Starbucks, Taco Bell, etc.) that offered free WiFi
- But there was sometimes **pushback**: “In a community where there are high rates of community violence, we’re asking kids to be sitting ducks with pieces of technology that people could steal from them”

- Access to suitable devices is also an issue
- Richer areas were more likely to be able to provide laptops and/or tablets to poor students
- But—students with school-provided devices were more likely to be subject to surveillance

Remote Proctoring

- Many schools and instructors—including at Columbia—have adopted remote proctoring systems for exams
- Arguably, necessary—the rate of cheating is quite high
- But—it's privacy-invasive, can fail to recognize darker-skinned faces, demands good bandwidth (and sometimes a private, quiet room), and more
- At least one proctoring company has acquired a reputation of suing its critics

- Teaching online is different—but few people do it well
- (For me, seminars work well; lectures, not as much)
- Hybrid classes, with some students physically present and some remote, pose special challenges
- Other [pedagogical issues](#)?

So What Do We Do?

- Infrastructure
- Employment
- Medicine
- Education

Infrastructure—What Doesn't Work

- The basic economics of deploying Internet service won't change
- There can be some changes at the margins—enforcing the rules on access to existing poles—but it's still fundamentally an expensive business
- Low Earth orbit atellites can't solve this in the general case—you can't add capacity locally
- Fixed wireless can't solve it: you still need fiber for backhaul

Infrastructure—What Does Work

- Laying cable is, arguably, a natural monopoly
- The government could subsidize this part, similar to the Rural Electrification Administration during the Depression
- Providing Internet service over that cable is not a natural monopoly
- 👉 Cable providers could be compelled to lease access
- Take rate is an economic issue; it could be subsidized even more than it already is

- Many employers already provide devices to employees
- School systems should—even without a pandemic, the Internet is valuable for research and other homework
- But—students are entitled to more privacy!

- There likely can't be any one rule—jobs are too different
- What works for a software engineer doesn't work for a plumber
- There might be some ability to tweak the tax code to better account for work-at-home spaces

- As noted, all students need devices and connectivity
- Teachers need training in how to teach online
- We probably need more research—and more and better tools—about online instruction

- We have to prevent the economics of poverty from getting in the way
- The digital divide is real; Covid has struck at that fault line
- The goal has to be to minimize the divide

Questions?



(Mallard duck and ducklings, Central Park, June 23, 2020)