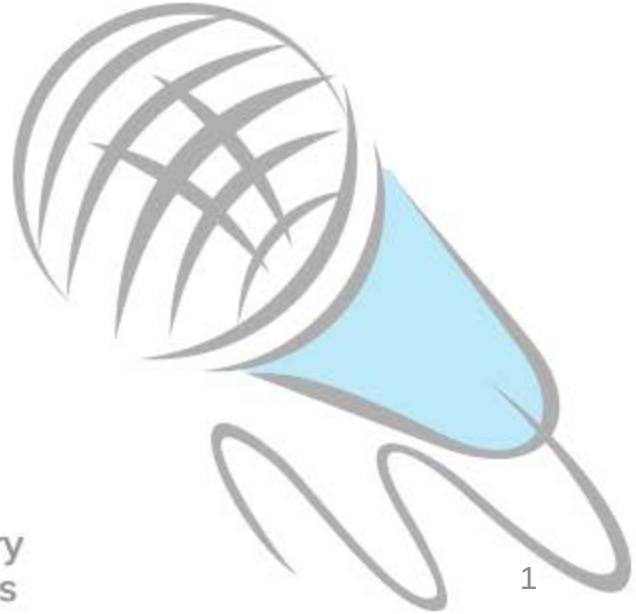
Hearing #10 on Competition and Consumer Protection in the 21st Century

Federal Trade Commission

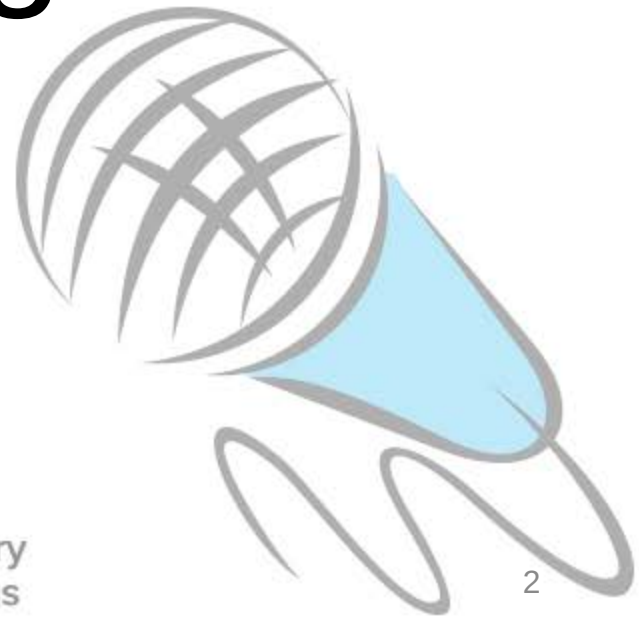
Constitution Center

March 20, 2019



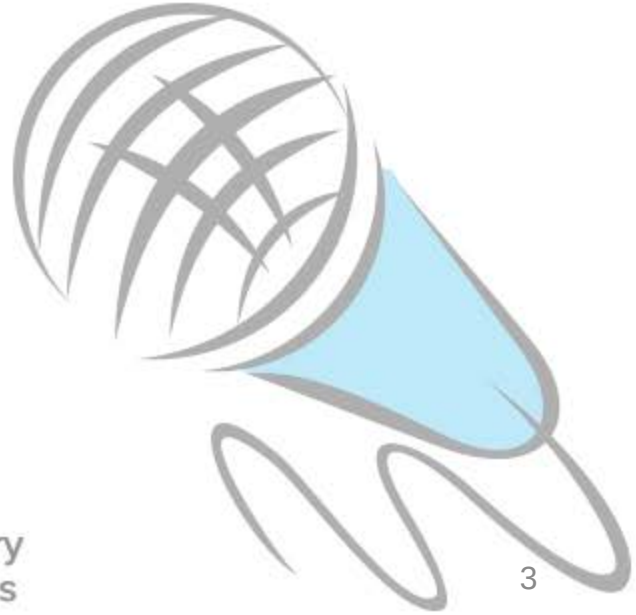
Welcome

We Will Be Starting Shortly



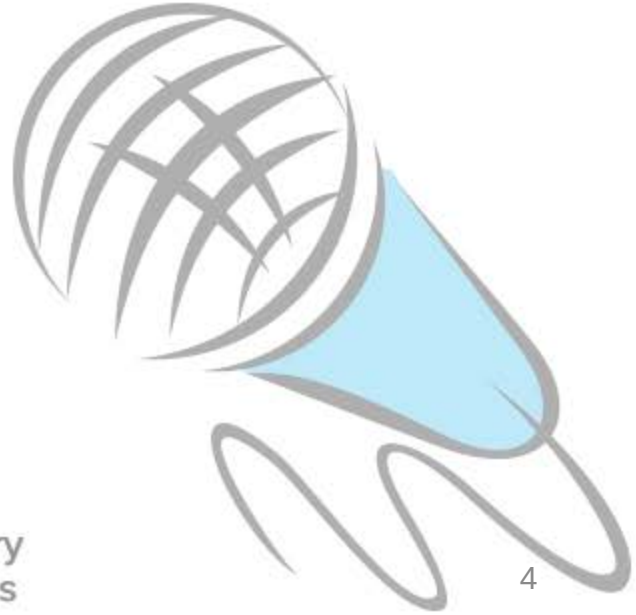
Welcome

Ruth Yodaiken
Federal Trade Commission
Office of Policy Planning



Introductory Remarks

Alden Abbott
Federal Trade Commission
Office of General Counsel



Technological Developments in Broadband Networking

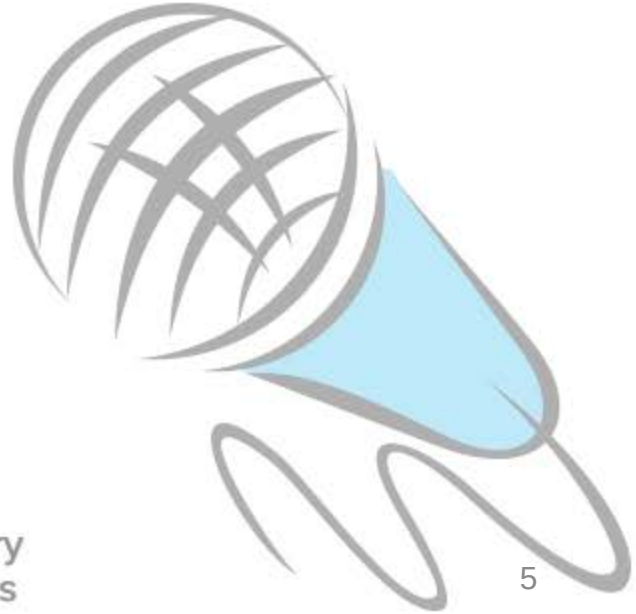
Evolution of Broadband Networking: 2008 to 2018

kc claffy

University of California, San Diego

Center for Applied Internet

Data Analysis



Outline

- Technology primer: traffic, topology, transit
- Evolution: platforms, interconnection, complexity
- Implications: competition, potential harms
- Technology attempts to measure/mitigate potential harms
- What's different this decade?

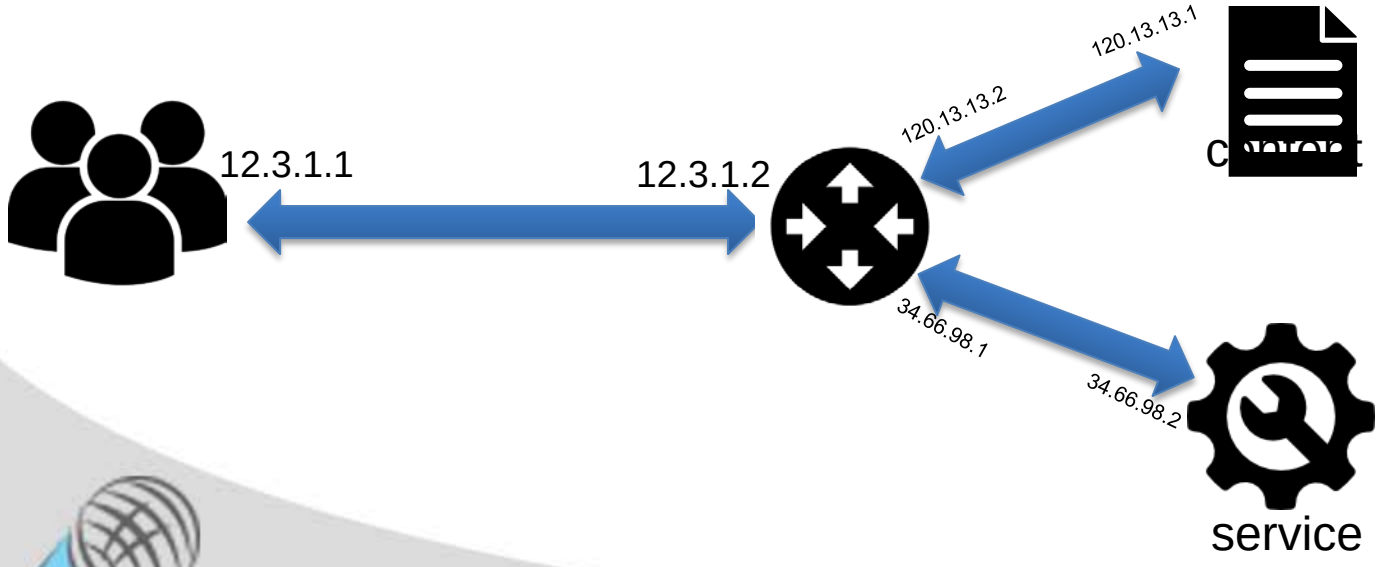
Aim to address this question

- Which (recent and expected) technological developments, or lack thereof, are important for understanding the competitiveness of the industry or impacts on the public interest?

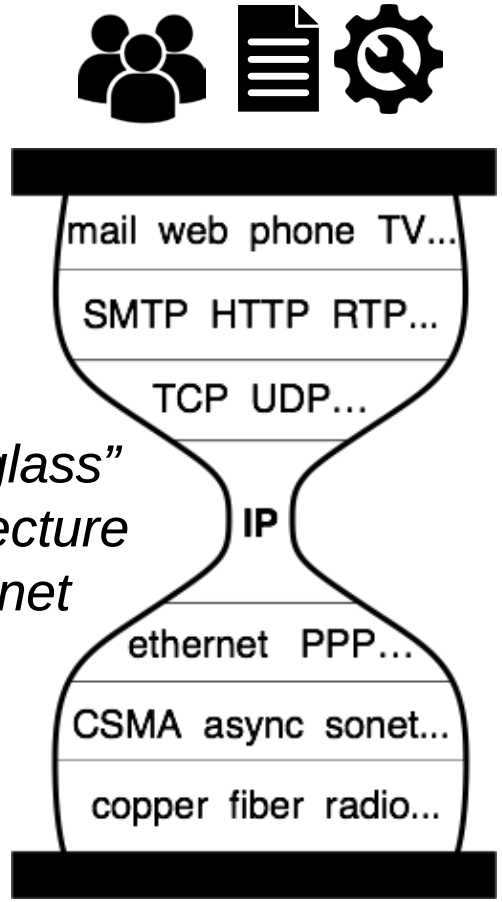
Global public IP platform

Traffic routed across global Internet platform, i.e., devices reachable via an IP address.

Anyone (two) can interconnect!

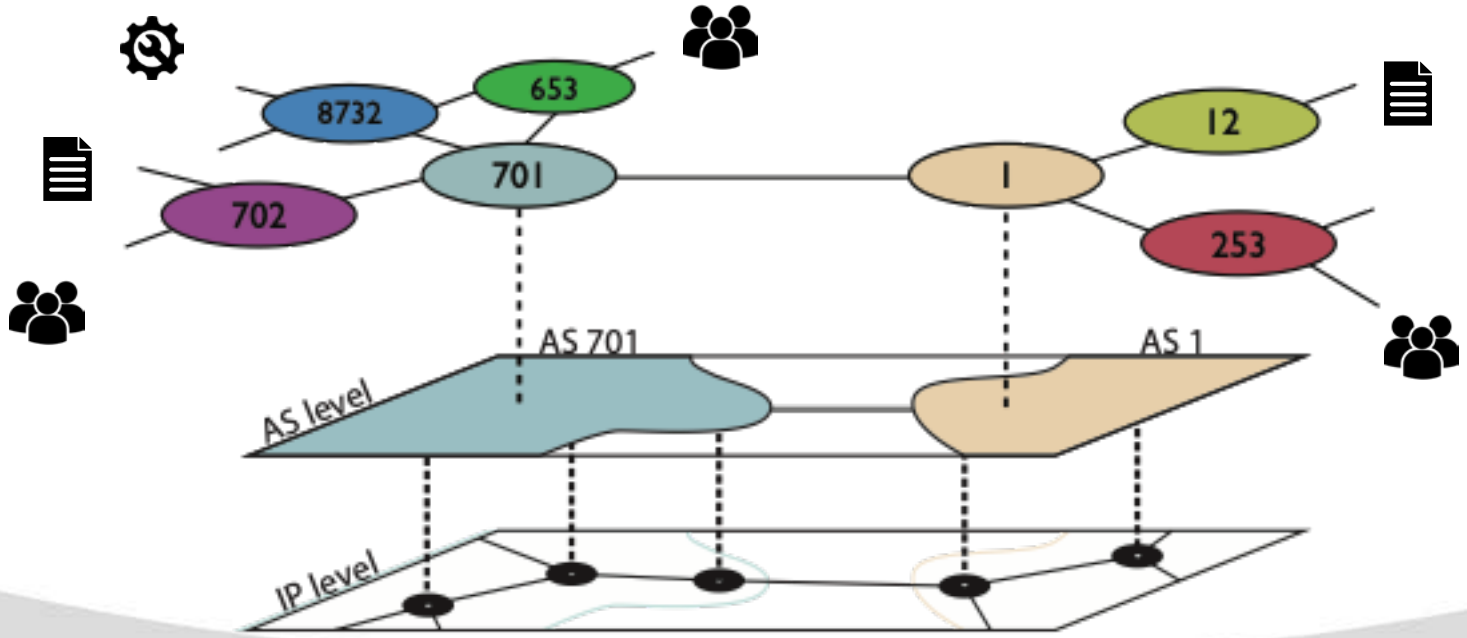


Layered "hourglass" protocol architecture of TCP/IP Internet



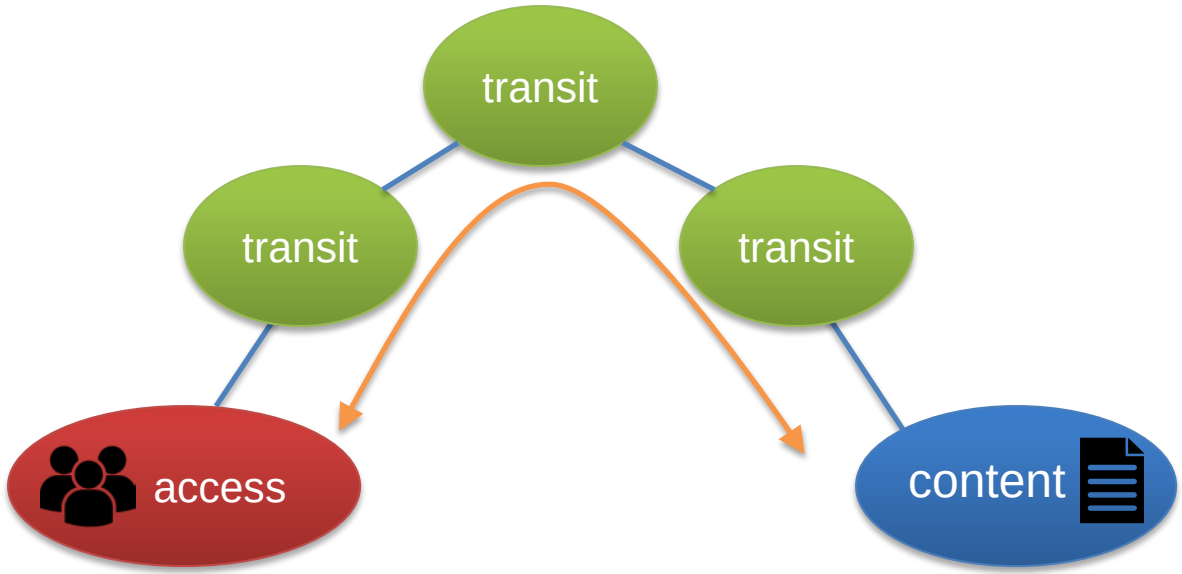
Internet interconnection

- IP addresses grouped (on routers and) into networks
- Organized by Autonomous Systems (ASes)
- 70K+ ASes independently interconnect to form global Internet



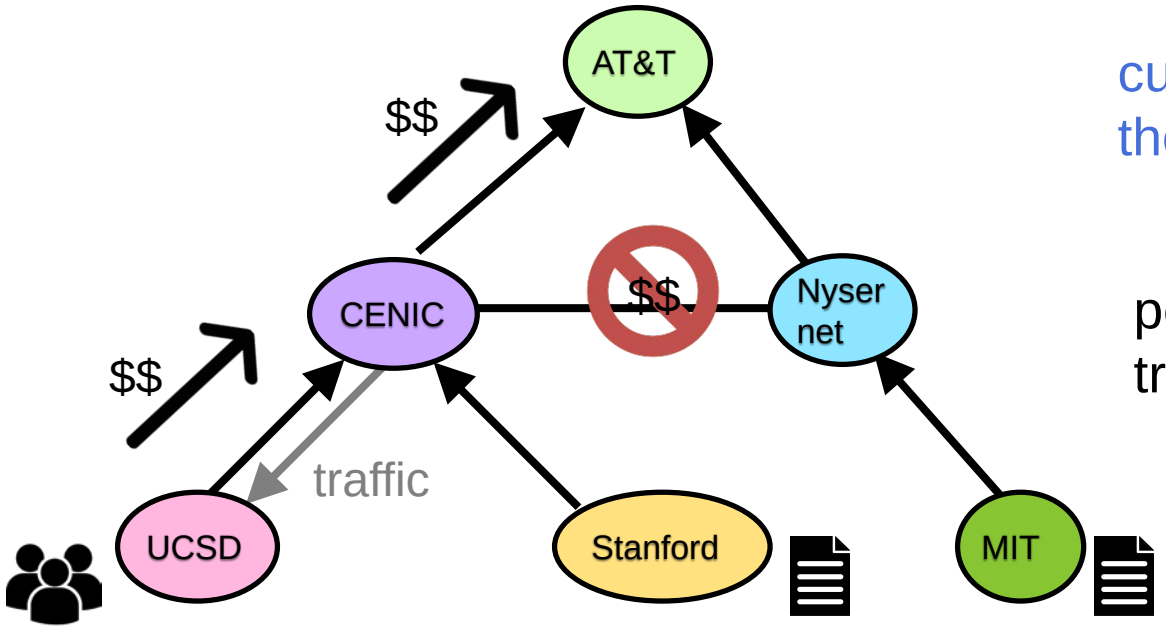
Internet transport (simplified)

Traffic flows through **transit providers** between **access** and **content** providers



Early (90s) AS interconnection hierarchy

One can conceptualize interconnection structure based on (inferred) money flows.



customer —$$ →— **provider**

customer pays provider to transit their traffic

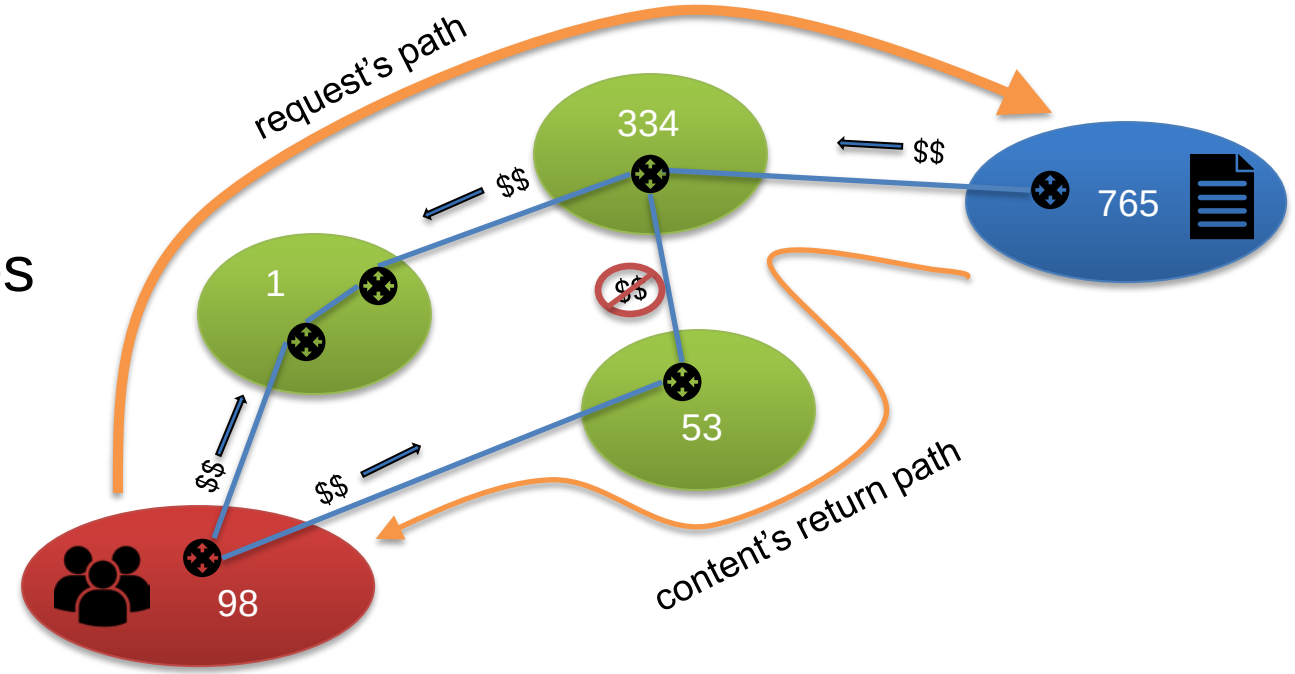
peer — $$ — **peer**

peers do not pay to accept each other's traffic (assumed symmetric traffic flow)

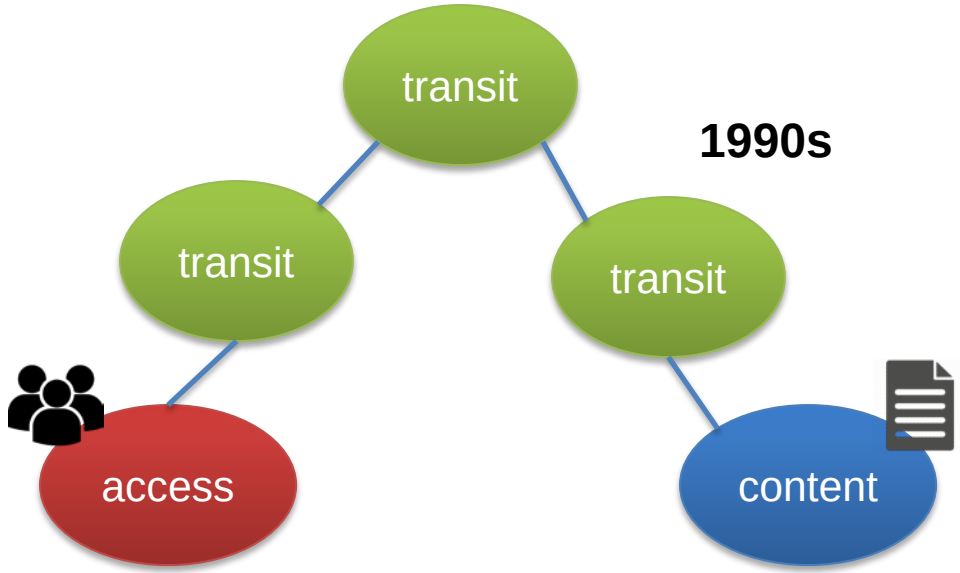
IX(P): neutral facility for traffic exchange (was "point")

Internet routing (simplified)

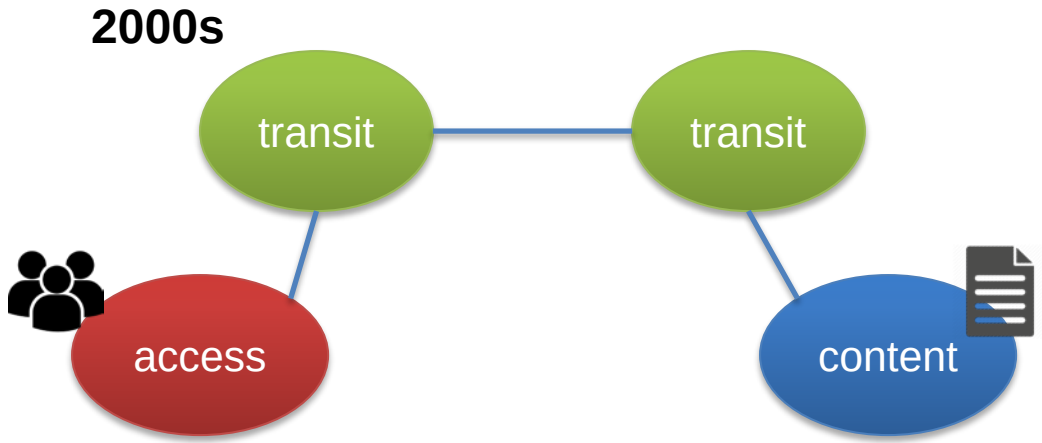
- Each router **locally optimizes** choice of next hop along path
- Applies network operator's routing policy to known topology; computes & propagates best paths
- Network operators balance: cost, performance, path length
- Often results in asymmetric routes
- Many edge networks (blue) only have *default route,* to transit provider



2010s: Content moves closer to consumer

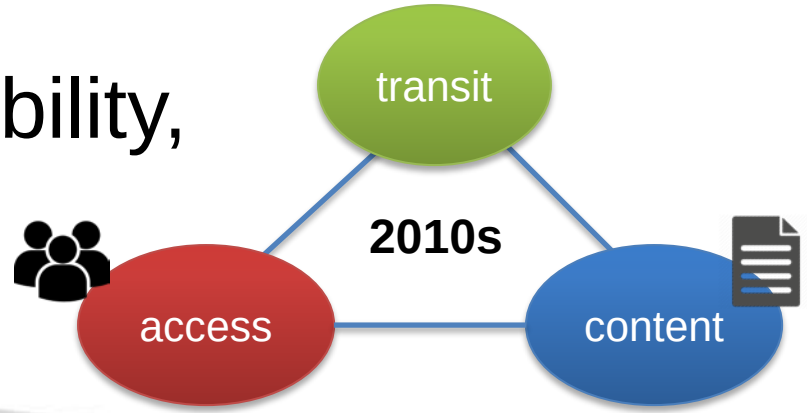


1990s



2000s

Optimizes performance, reliability, availability cost

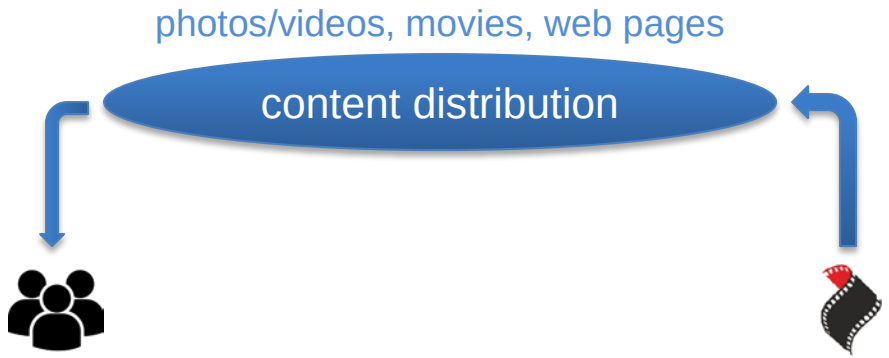


2010s

In face of relentless growth in demand (mostly video)

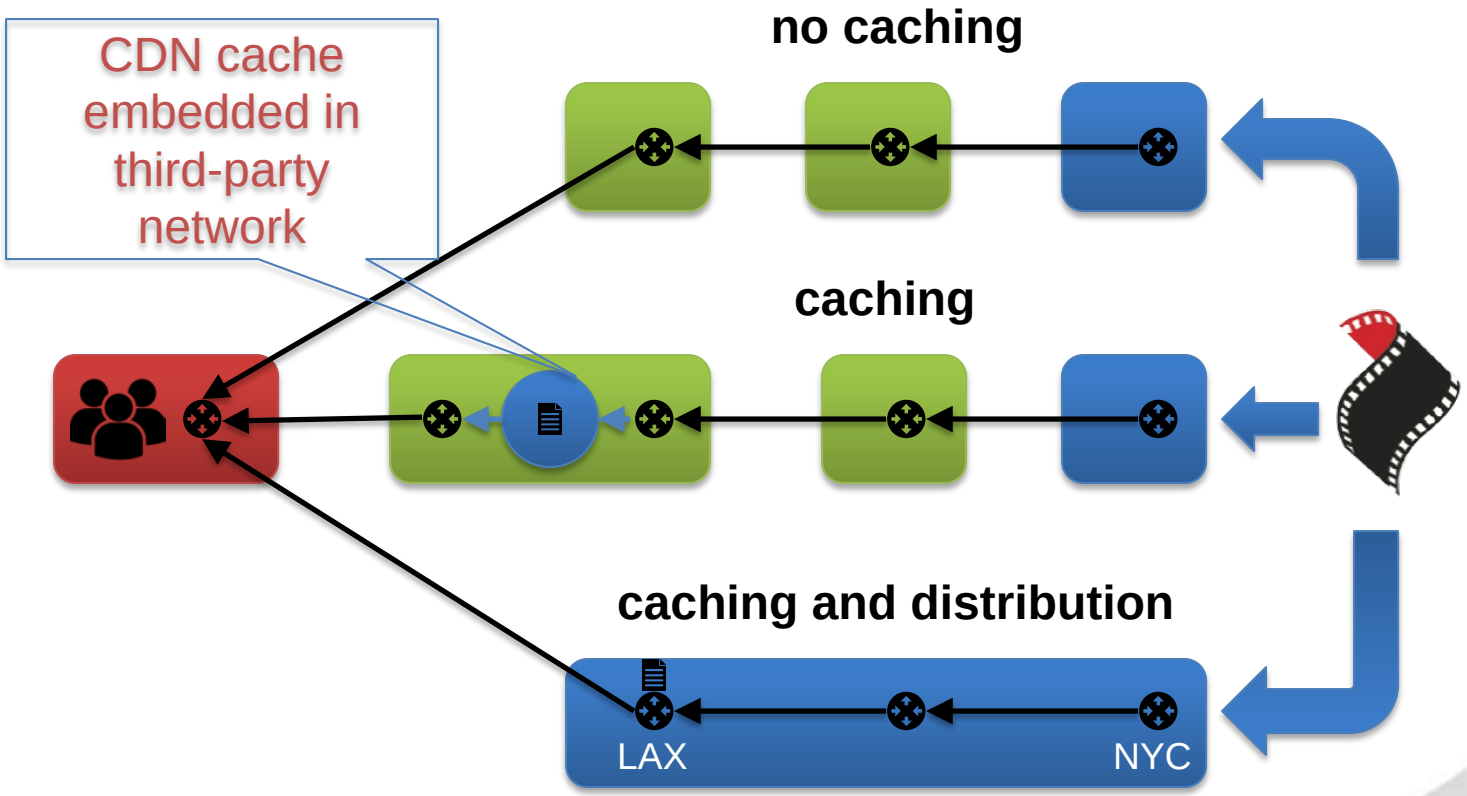
Consolidation in content distribution

- While there continue to be small local content providers (UCSD), most traffic now handled by a few giant content providers (Google) or content distribution networks (Akamai)
- CDN business: transiting traffic from point where it enters CDN platform to an exit near consumer. At low cost.
- Key driver: Internet eating TV, gaming

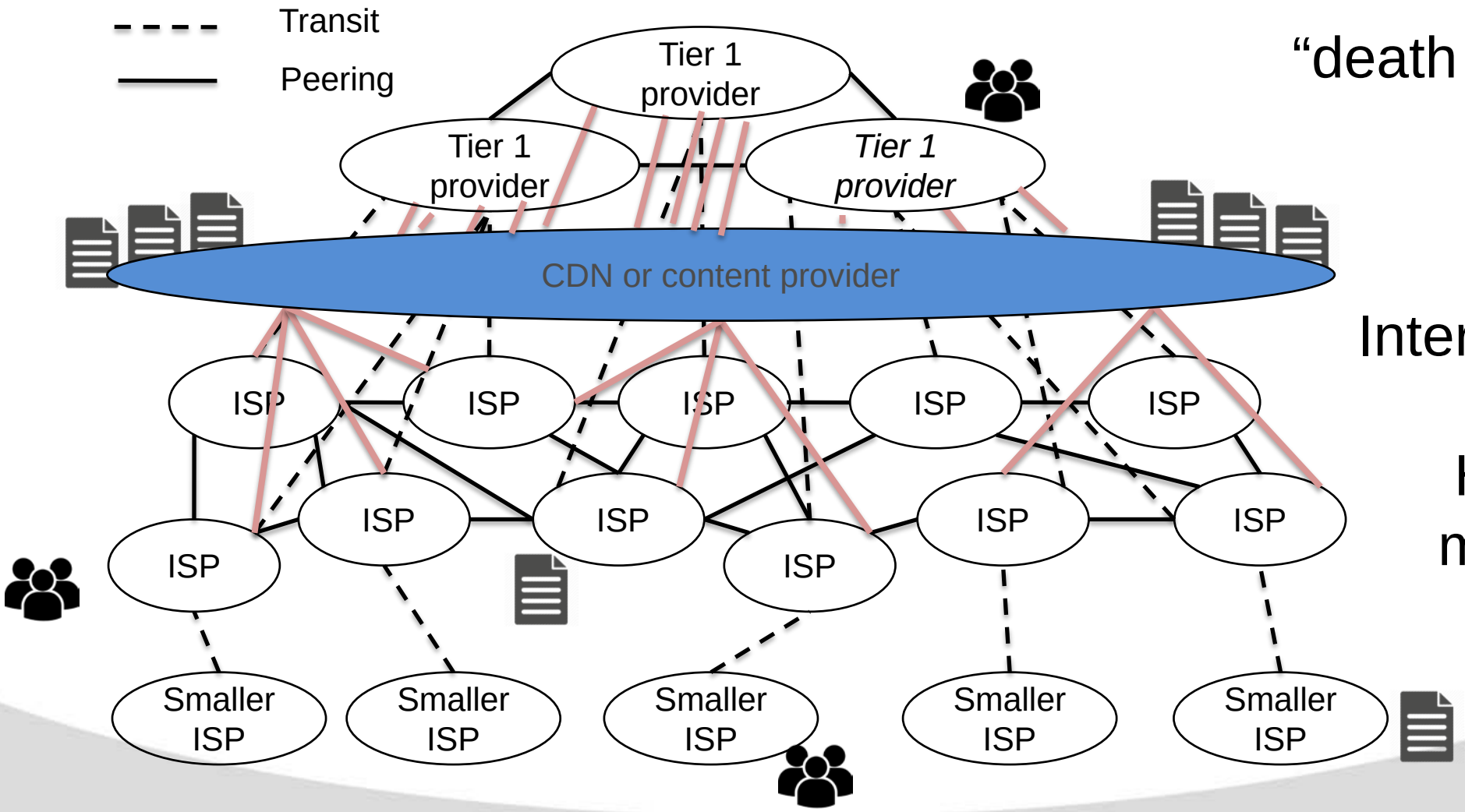


Content distribution strategies

Large companies may combine all three strategies.



Does not reduce complexity..

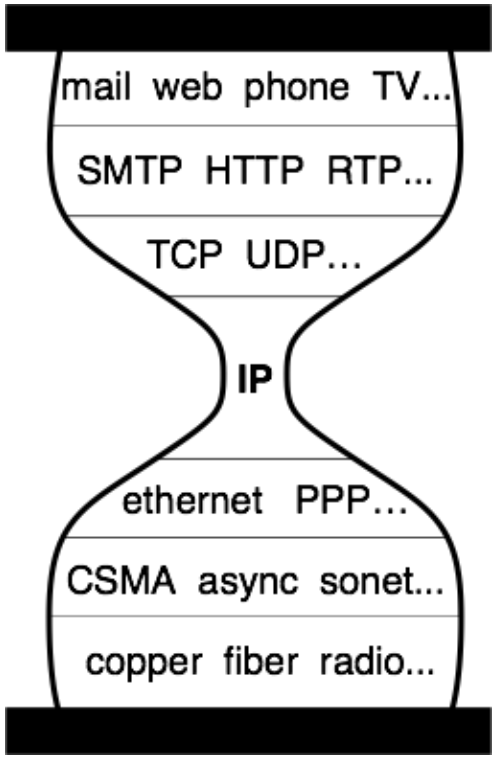


"death of transit"?

Dense Interconnection

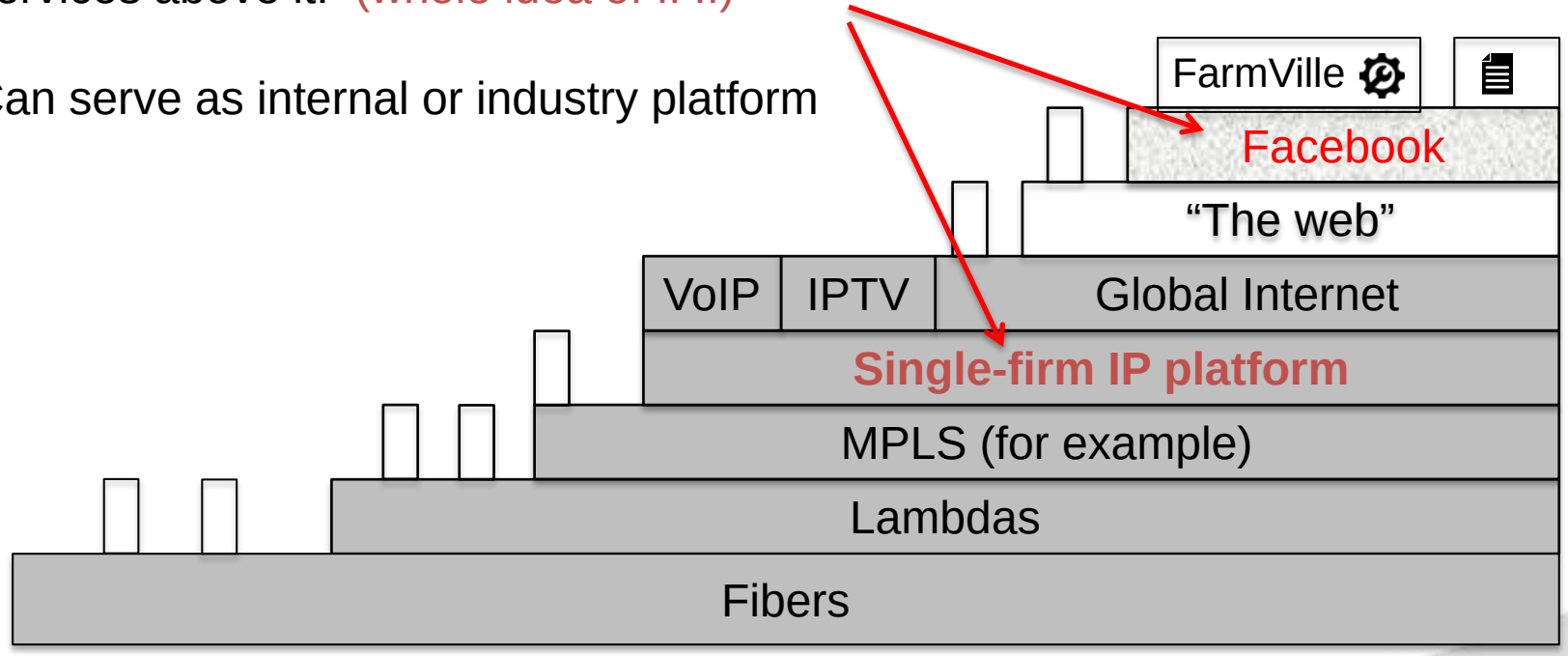
Hard to measure

Internet platform layers



Allows the integration of multiple technologies below the platform and support of multiple services above it. (whole idea of IP..)

Can serve as internal or industry platform

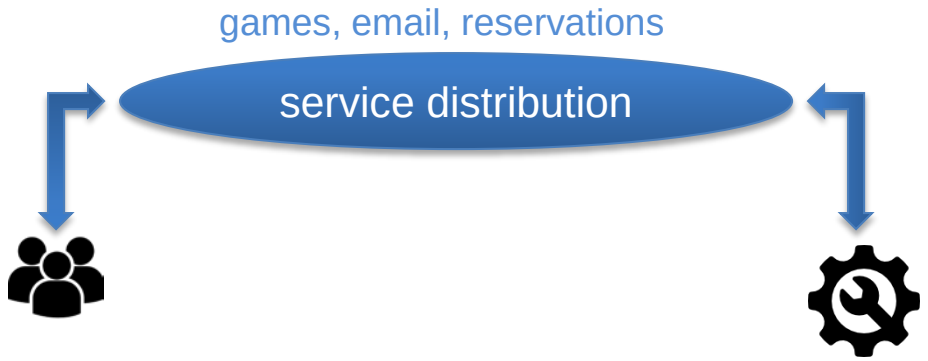


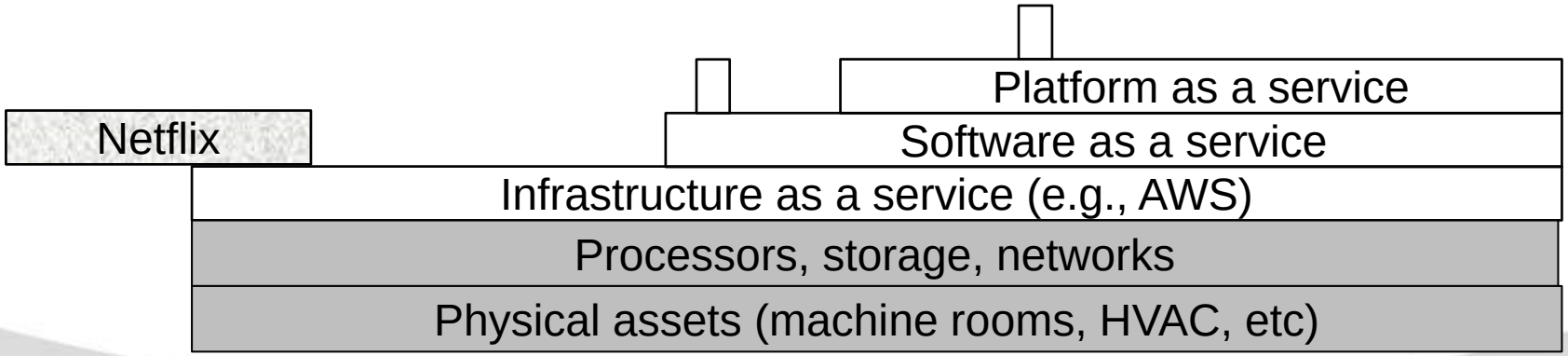
Dueling definitions

- **Online platform**: An online marketplace that places one party in touch with another, such as buyers and sellers. E.g., eBay, Craigslist, Amaz Mktplce, Airbnb, app store
  - Emphasis—multisided
- **Online platform**: a group of technologies that are used as a base upon which other apps or technologies are developed. E.g., IP, IoS, Android, AWS
  - Emphasis—programmable, service component, generality

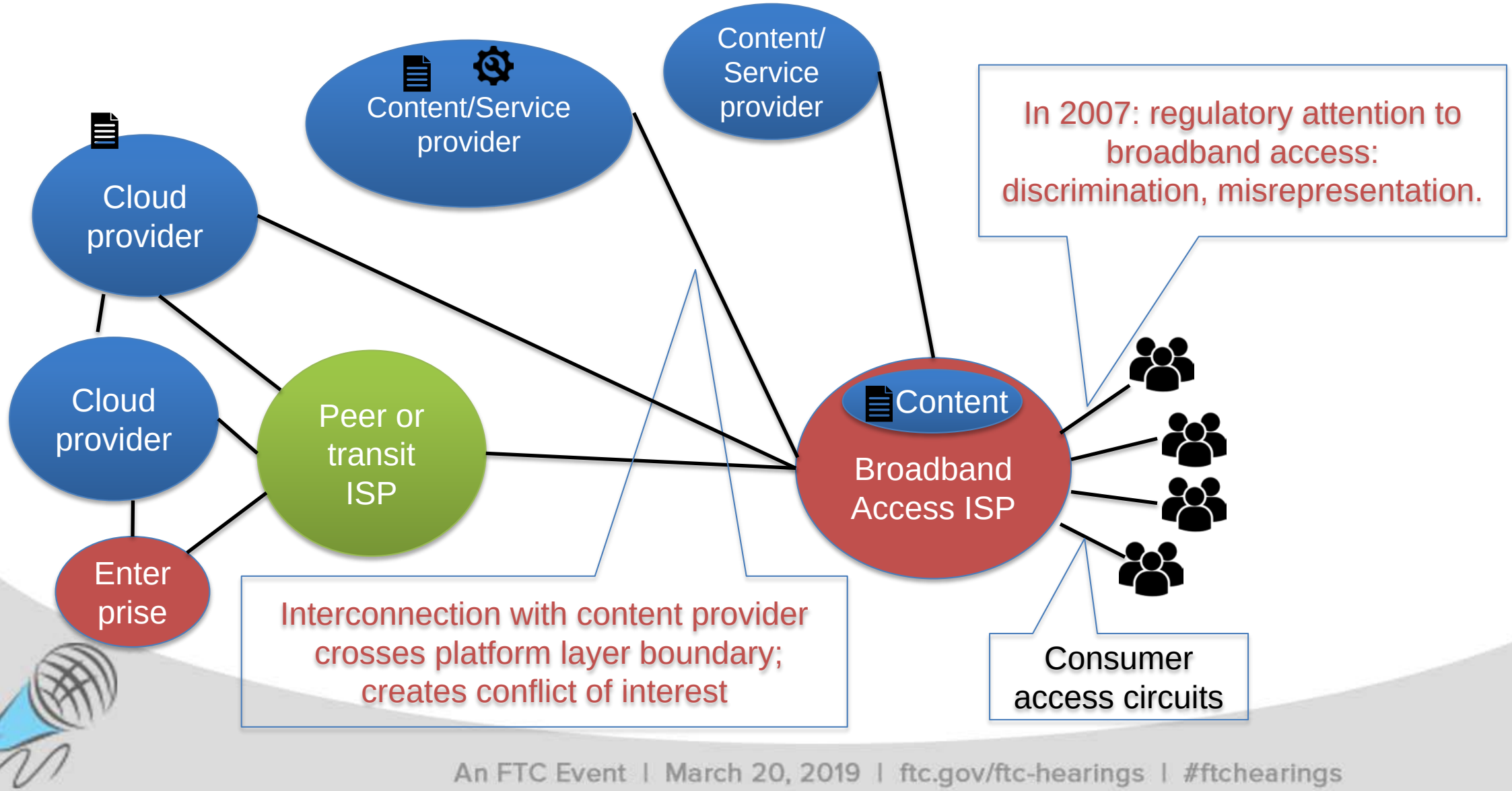
Growing: Cloud Service Platforms

- Externalizing internal industry platform
- New platform layer through which to distribute content and services
- Provide service replication and distribution
- Many web applications/services now first built upon “Internet giants’” cloud service platforms





Interconnection *across* platform layers



Implications of cross-platform-layer interconnection dynamics for competition

Smaller ISPs have less opportunity to interconnect with BigContent

→ Must access content providers via exchange points (85%)
→ Less likely to vertically integrate themselves
→ Cannot leverage transit and content cost savings
  → Particularly hard in rural areas, with 10-40X buildout cost
→ Cannot give customers a better experience in accessing content

Like with video programming…

American Cable Association (smaller ISPs) survey:
https://www.ftc.gov/system/files/documents/public_comments/2018/08/ftc-2018-0049-d-1623-155196.pdf

Potential Interconnection Harms

- Carrier and third-party services on top of single-firm IP platform can compete with third-party services running over “common” Internet.
- Interconnection points enable exercise of market power
  - Technical discrimination of traffic across the link.
    - Selective dropping or rate limiting
  - Inadequate capacity leading to impaired QoE
  - Discriminatory pricing or business terms (more likely?..)

These are not new concerns

"*Principally, … concern about the following issues:*

- ***blockage, degradation, and discrimination of content/apps***
- *vertical integration*
- *effects on innovation at edges*
- *lack of "last-mile" access competition*
- *legal and regulatory uncertainty*
- *diminution of political and other expression on the Internet"*

Broadband Connectivity Competition Policy, FTC Staff Report, 2007, p.5.
https://www.ftc.gov/sites/default/files/documents/reports/broadband-connectivity-competition-policy/v070000report.pd

See also: http://www.cybertelecom.org/notes/cc_history.htm

Technology Approach Tried in 2015

- Measure the key characteristics of interconnection links.
  - Or mandate the reporting of those parameters
  - FCC used this approach in ATT/DirecTV merger
  - Outsourced to “Independent Measurement Expert”
- That approach begs many questions:
  - Is measuring individual links actually the right approach?
  - How does one measure the key characteristics of a link?
  - How well does that map to consumer harm?
  - Note: no agreed methods to measure QoE!

These are “Complex Empirical Questions”

“The balance between competing incentives on the part of *broadband providers* to engage in, and the potential benefits and harms from, discrimination and differentiation in the *broadband* area raise complex empirical questions and may call for substantial additional study of the market generally, of local markets, or of particular transactions. Again, further evidence of particular conduct would be useful for assessing both the likelihood and severity of any potential harm from such conduct.”

FTC’s “Broadband Connectivity Compeition Policy”,2007
https://www.ftc.gov/sites/default/files/documents/reports/broadband-connectivity-competition-policy

Technology to detect harmful discrimination

- Not clear what FCC learned from AT&T reporting exercise
- Several other approaches to interconnection measurement
  - Each provides a part of a very complex picture
  - Need objective perspective to integrate and cross-validate
- No silver measurement bullet
- Limited ability for academics to sustain this kind of work
  - And yet much of it is research

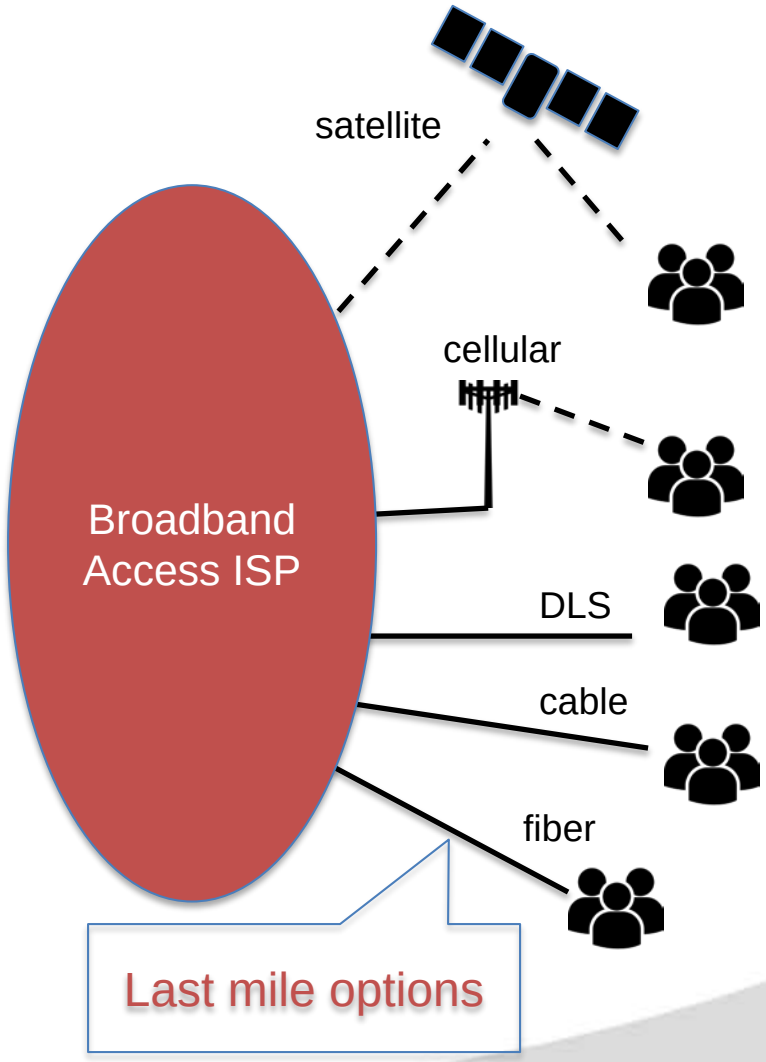
[Feb 27 11:31:03 2019] Shutting down Netalyzr

"After nearly a decade of providing this service we have decided to shut down Netalyzr in the first week of March 2019…. We simply no longer have the resources to advance Netalyzr or to provide reasonable support for your many questions about connectivity problems.

What FCC is measuring: access bandwidth

(4K video= 15-25 Mbps/sec)

	Downstream bandwidth
Satellite	12-25Mbps
DSL	3-45Mbps
Cable	100-200Mbps
Fiber	100-100Mbps (sym, stable)



Limitations:
Rural regions not well sampled (see recent Microsoft data)
Does not measure interconnection performance
Does not capture many things consumers care about
performance to top 10 sites, privacy, data caps
Does not measure mobile (mobile data released 2019, no analysis/report)

FCC MBA program, "*8th Measuring Broadband America Fixed Broadband Report*" (2017 data, 10K homes)

Since 2007, same concerns have expanded

- To multiple platform layers
  - Gathering & analyzing evidence difficult. Validating harder.
  - Complex sector. And complexity increasing.
  - More at stake ➡ more at risk

Concerns from 2007 FTC broadband report

blockage, degradation, and discrimination of content/apps
vertical integration
effects on innovation at edges
lack of "last-mile" access competition
legal and regulatory uncertainty
diminution of political and other expression on the Internet

Why so complex?

- Market, technology, legal, political, cultural, social forces interact in co-evolving adaptive systems
- Topology & traffic shifts not primarily driven by technology
- But if we do not understand the role, capabilities, and limitations of technology to *create* and *solve* problems, attempted interventions are likely to fail

Evidence-based policy needs to understand:

- Internet operates as set of layered, multi-sided, platforms, interconnecting **across** layers, e.g., content to transit
- Platform structure and dynamics, including market sides and incentives
- How to achieve relevant transparency and public accountability related to specific potential harms
- How to find/fund sources of objective, unbiased expertise

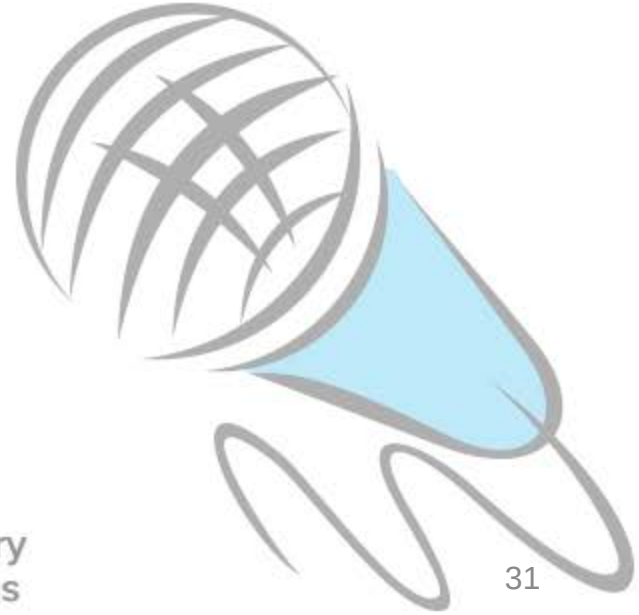
Technological Developments in Broadband Markets

Internet Interconnection and Interdomain Routing: The Changing Landscape

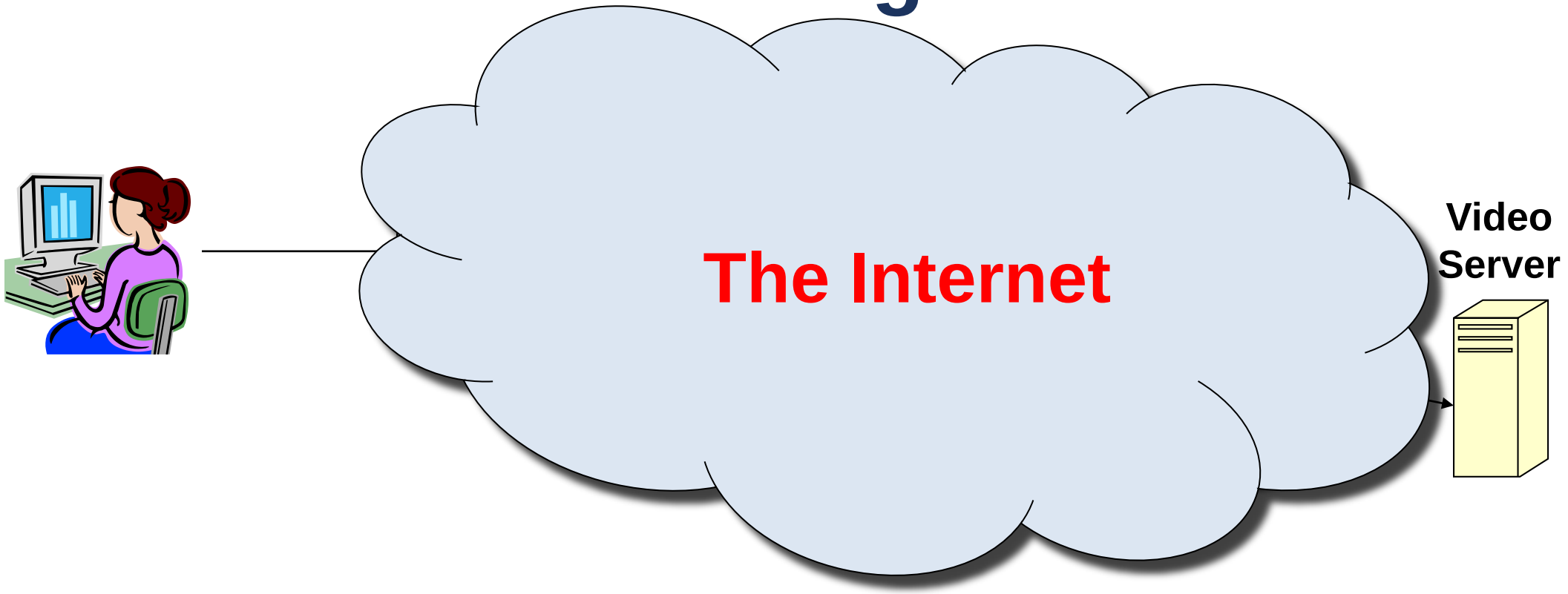
Nick Feamster

Princeton University

Department of Computer Science



Internet Routing in a Nutshell



- **Large-scale:** Thousands of autonomous networks
- **Self-interest:** Independent economic and performance objectives
- But, must cooperate for global connectivity

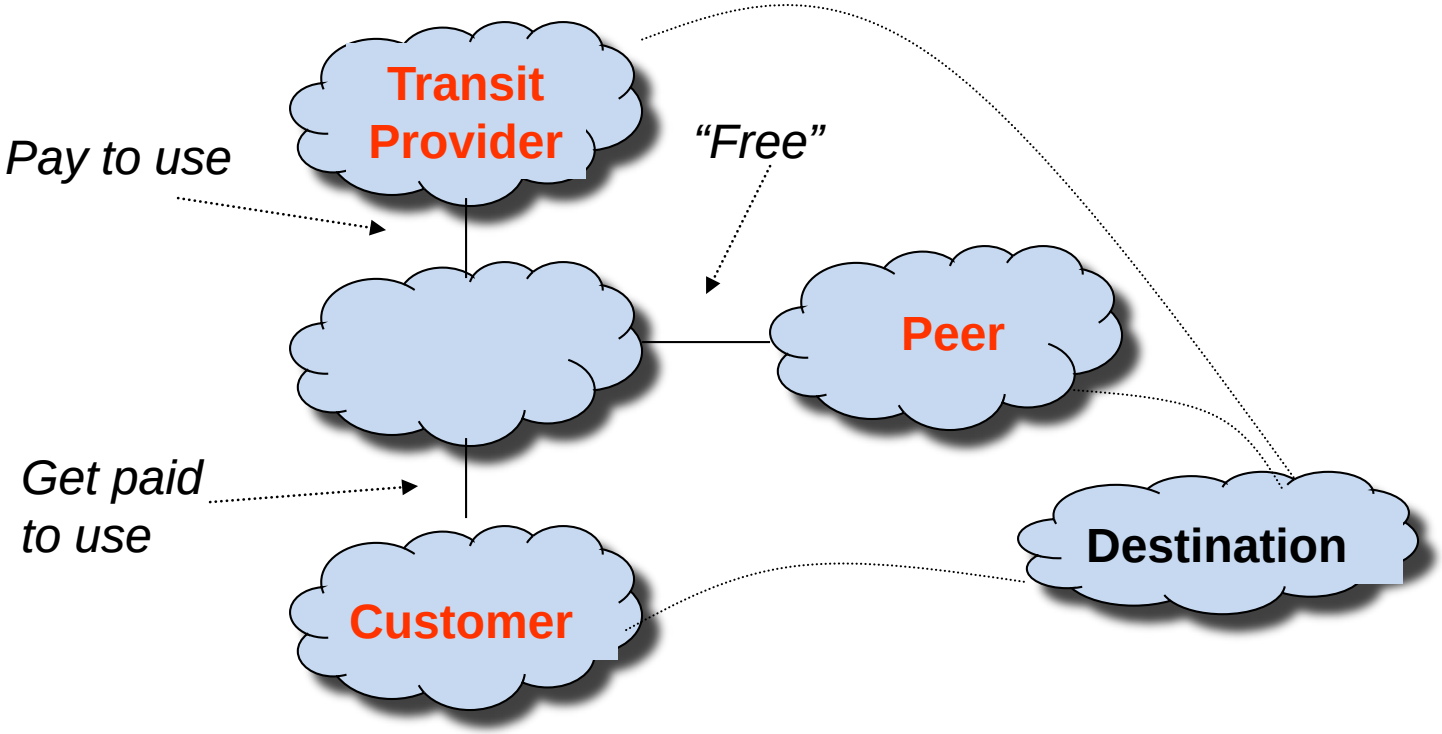
See http://nms.lcs.mit.edu/~feamster/papers/dissertation.pdf (Chapter 2.1-2.3) for optional coverage of the topic.

Architecture: Loose Coordination

- **There is no central authority that manages Internet interconnection.**

- The Internet ecosystem arises from many **bilateral** and **multilateral** decisions of interconnecting networks.

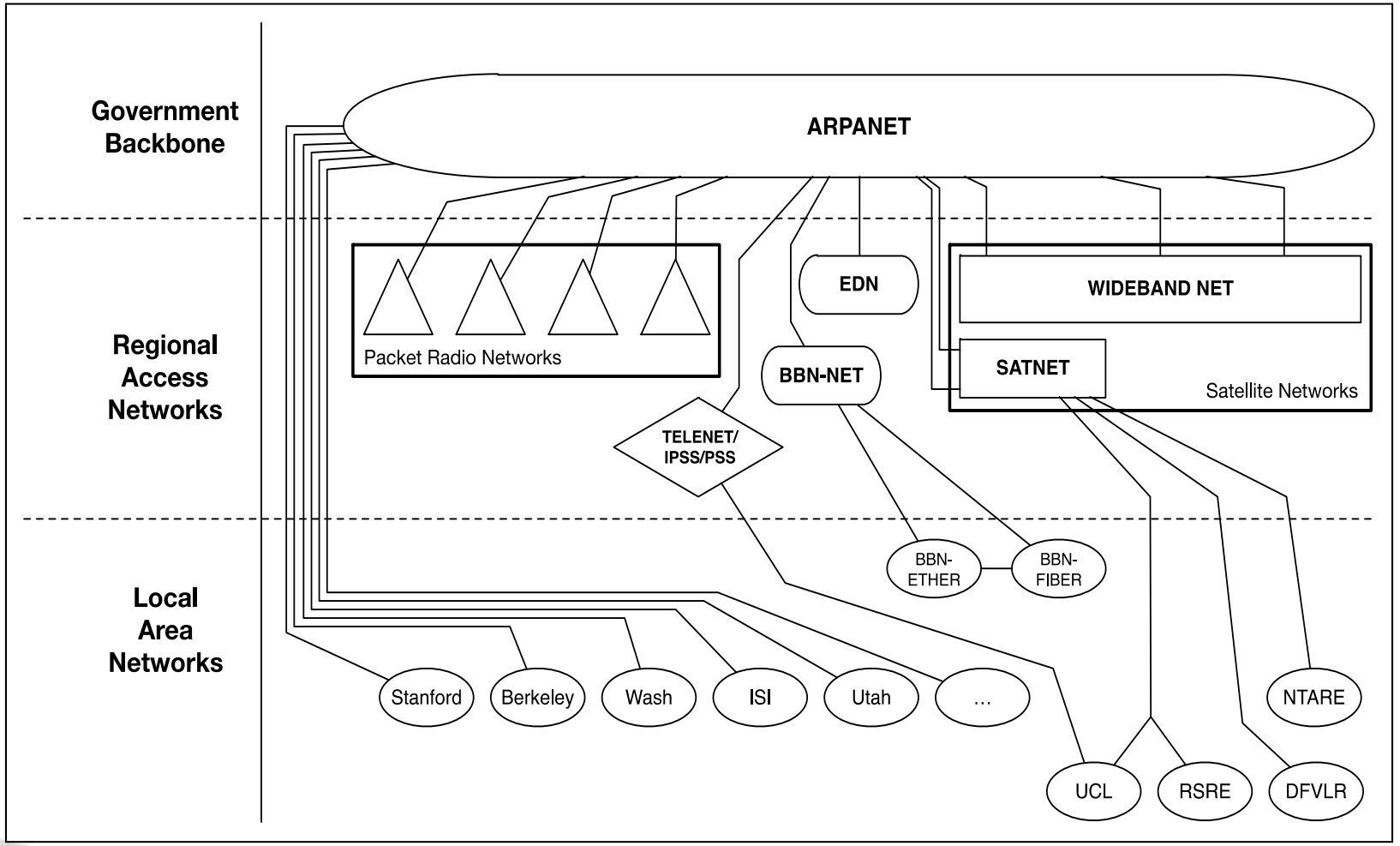
Internet Economics in a Nutshell



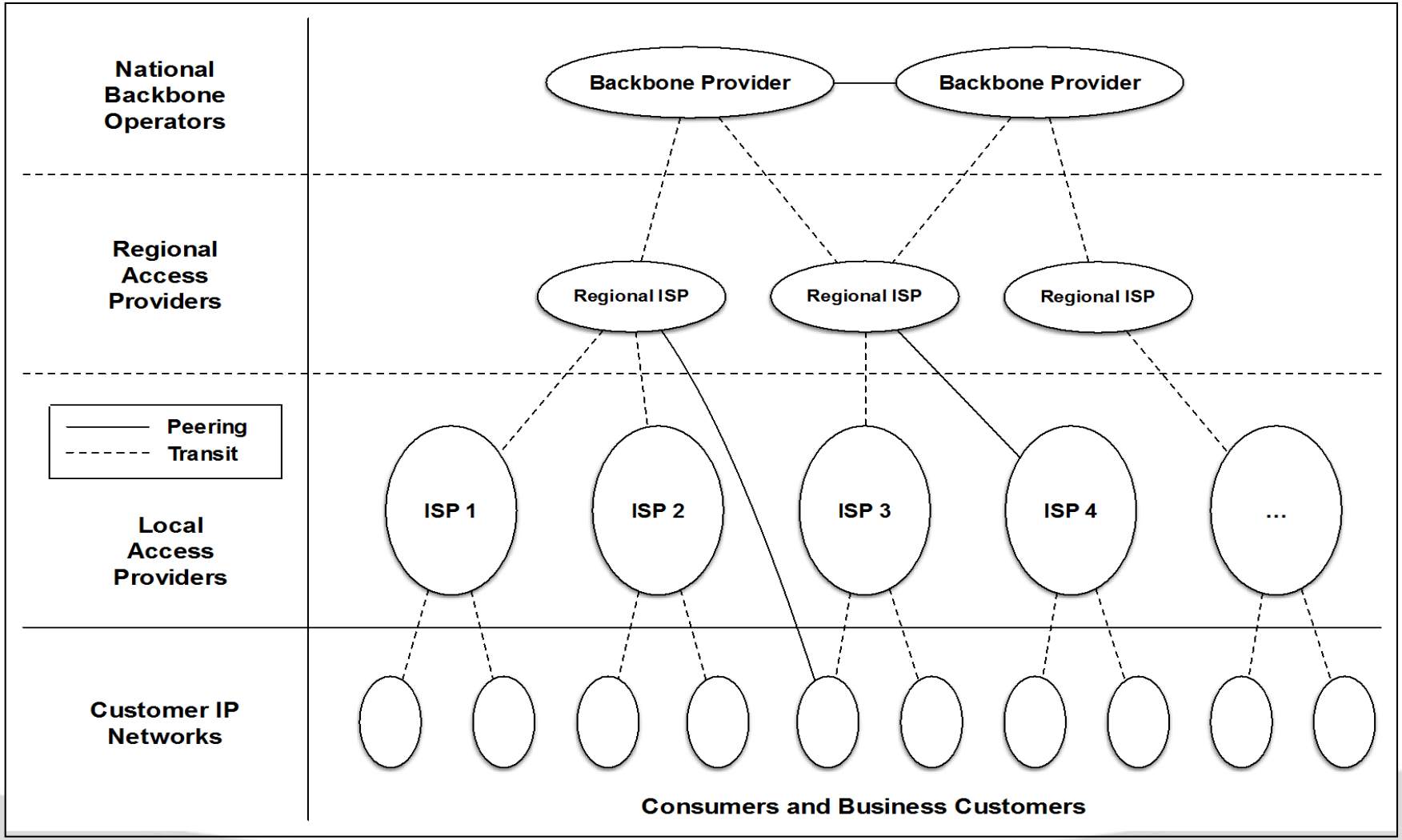
- **Transit:** One network pays for reachability to some set of destinations. (e.g., the rest of the Internet)
- **Peering:** Networks change traffic with one another
- Peering can be "settlement free" or "paid"

A Brief History of the Internet

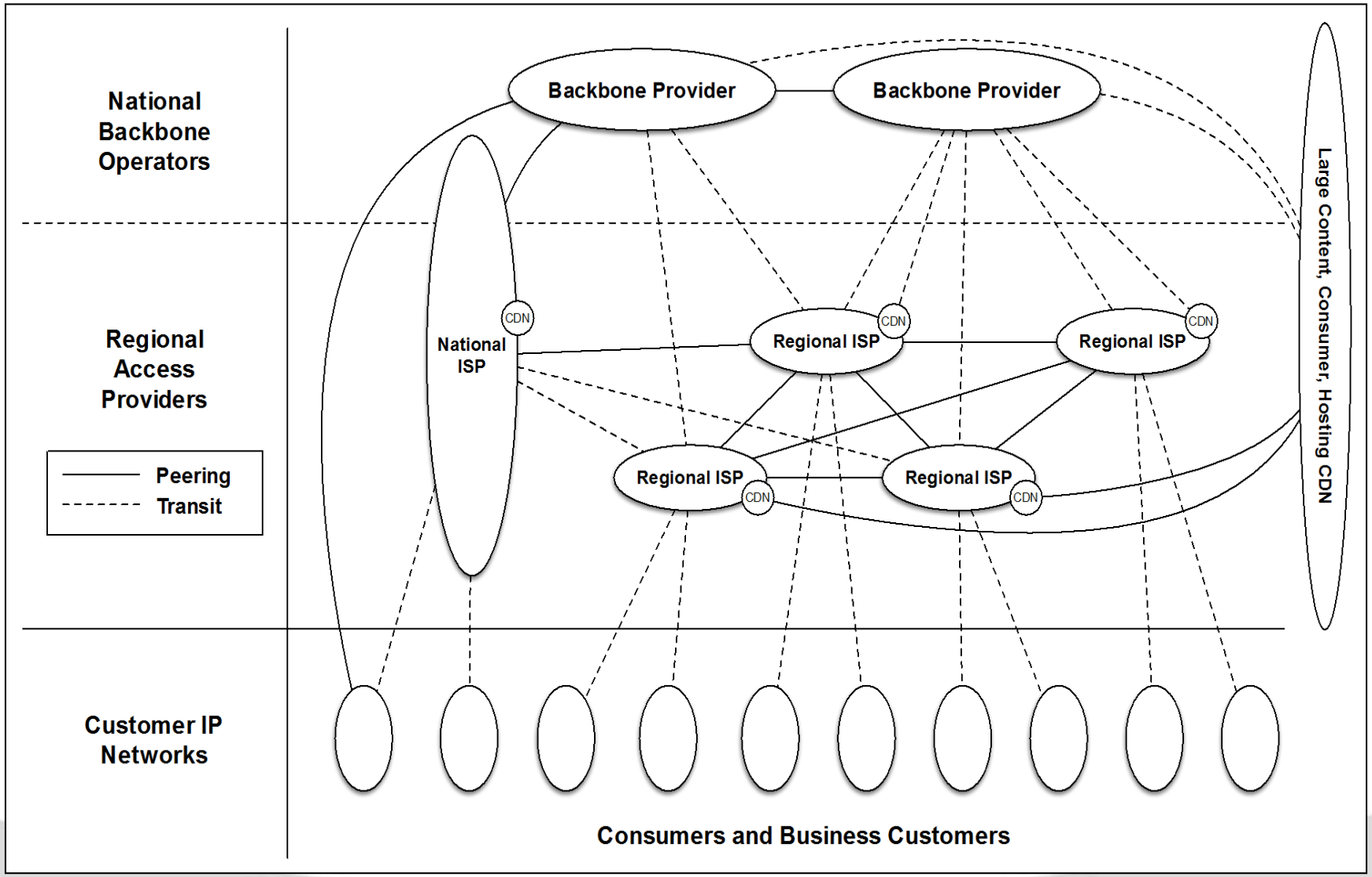
The Pre-Commercial Internet (pre-1995)



Internet Topology 1995-2005: Commercial Hierarchy



Today's Internet: "Flat", Bilateral



Market (and Performance) Trends

- Pre-2013: **Transit and Direct Interconnect**
  - Network performance determined by network path

- 2013 – Present: **Distributed Cloud Services**
  - Performance determined by proximity of content to the user
  - “The network is the computer.”

Two Significant Ongoing Developments

- **Traffic volumes are growing.**
  - Video traffic dominates
  - Video resolution is increasing.

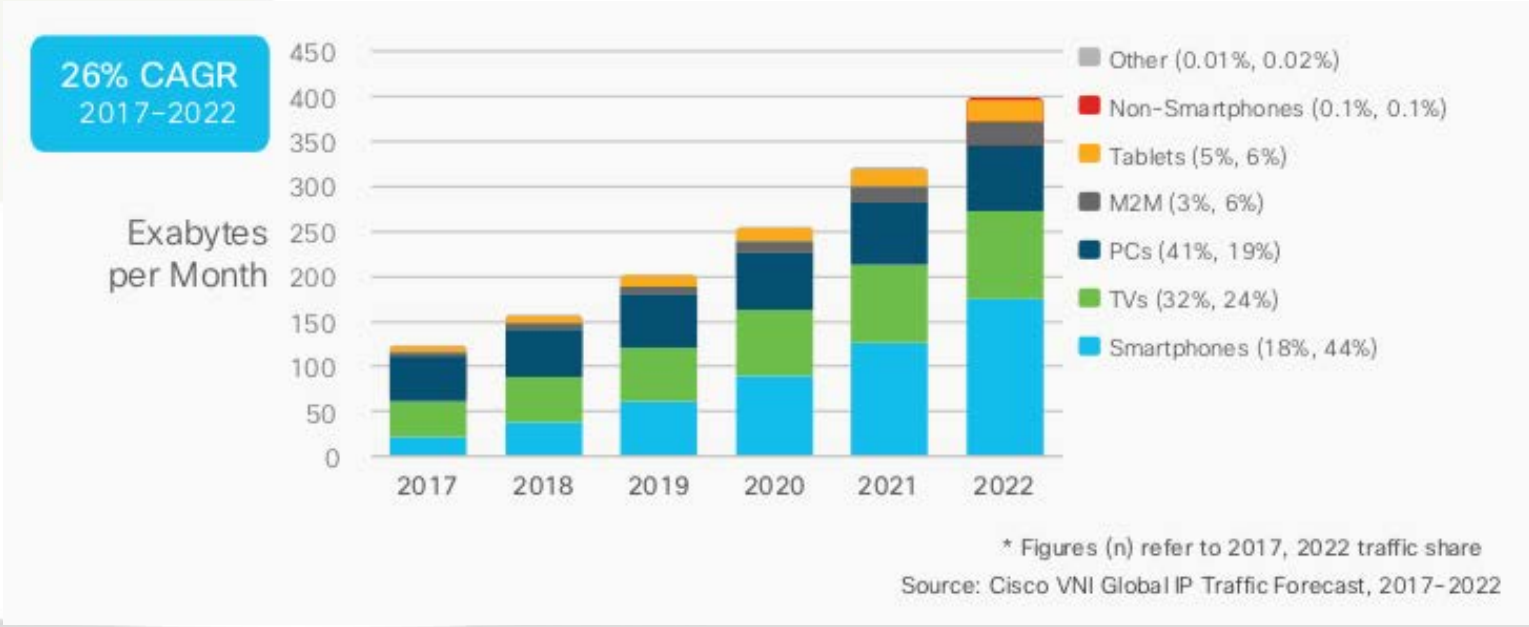
- **Methods of delivering traffic are evolving.**
  - Internet traffic is increasingly being delivered via CDNs.
  - The “old Internet” was hierarchical. Now, mostly bilateral.
  - Distinction between CDNs and cloud services is smaller.

Traffic Volumes are Growing

Traffic is Growing, Driven by Video

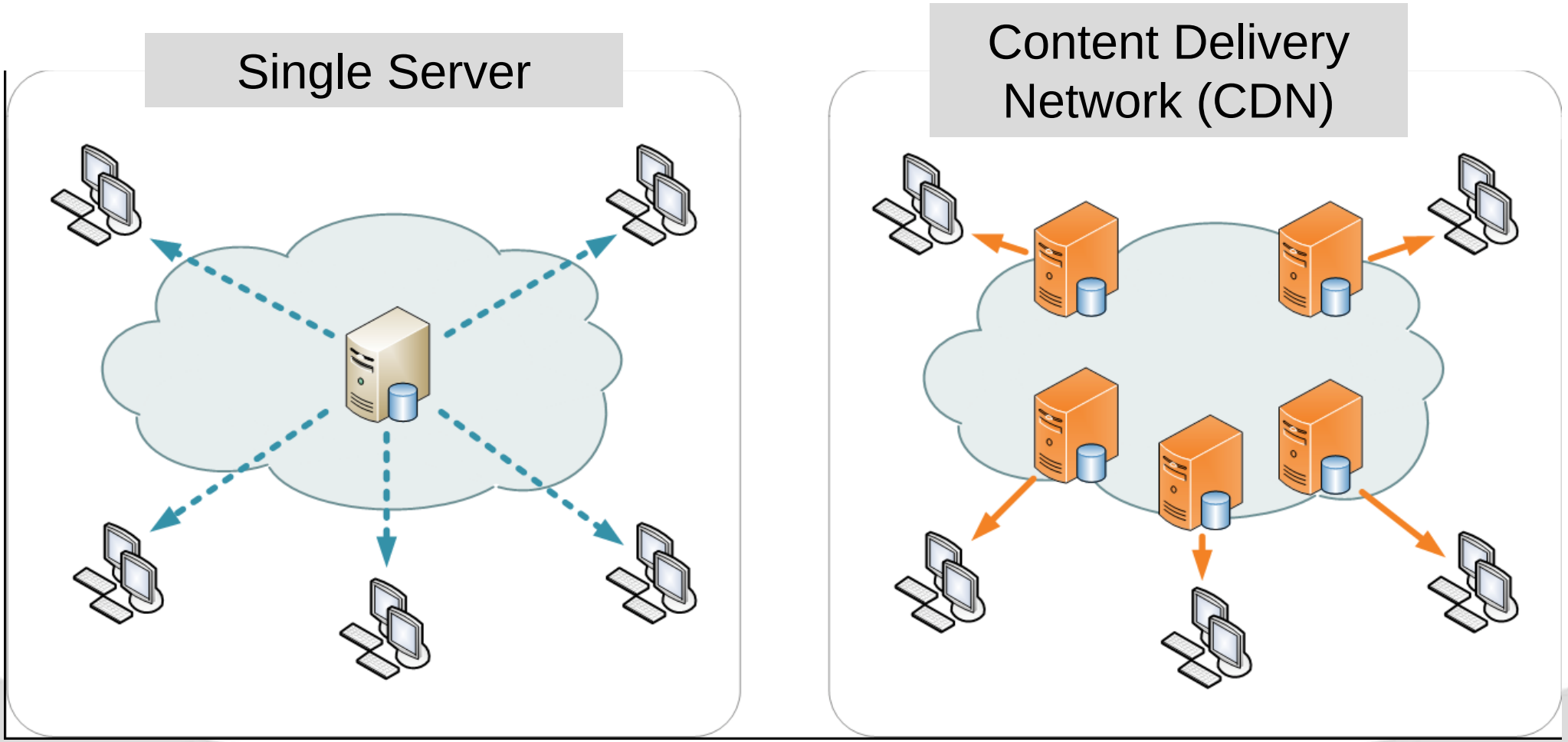
Year	Global internet traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GB per second
2007	2,000 GB per second
2017	46,600 GB per second
2022	150,700 GB per second

Source: Cisco VNI, 2018.

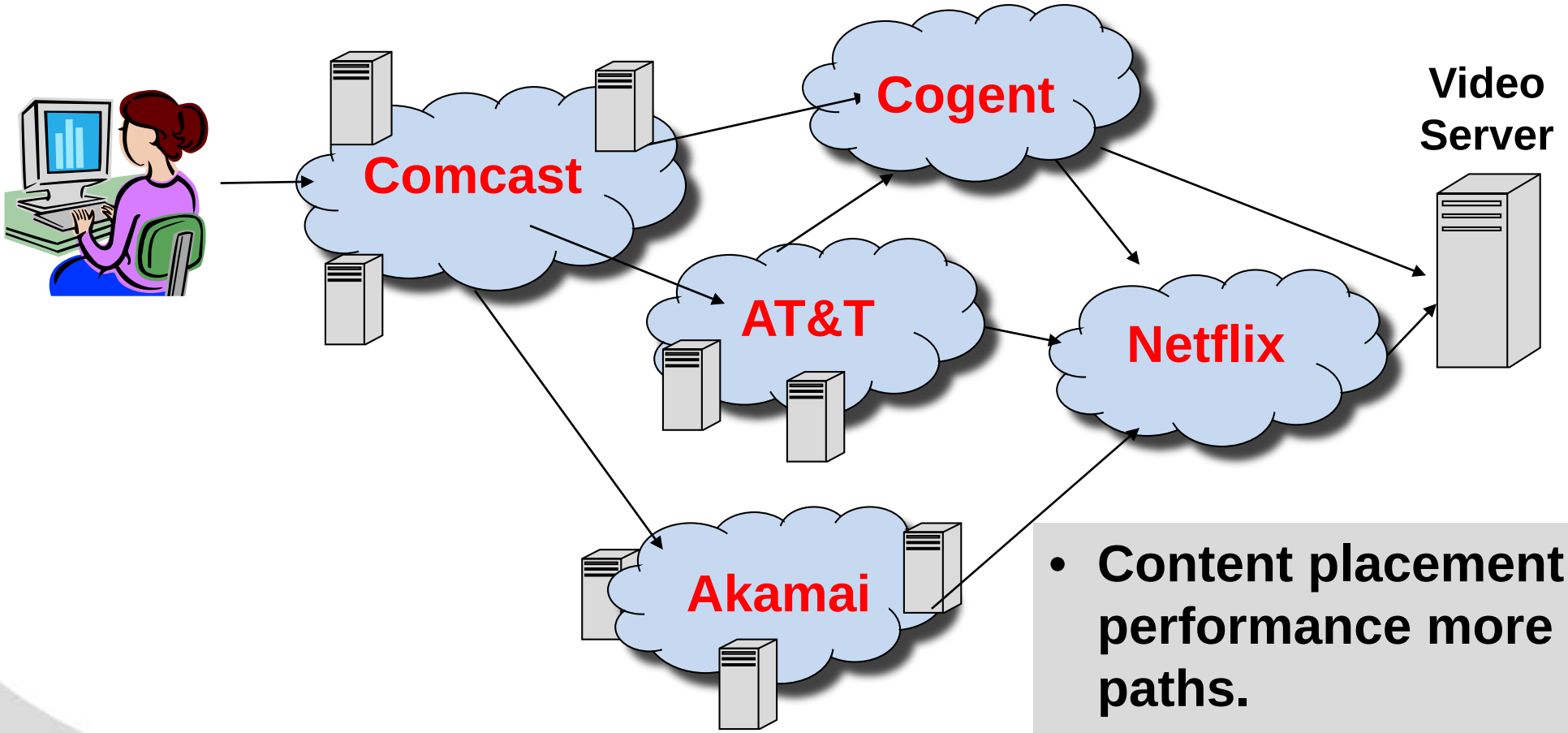


Methods of Delivering Traffic are Evolving

Content Delivery Networks

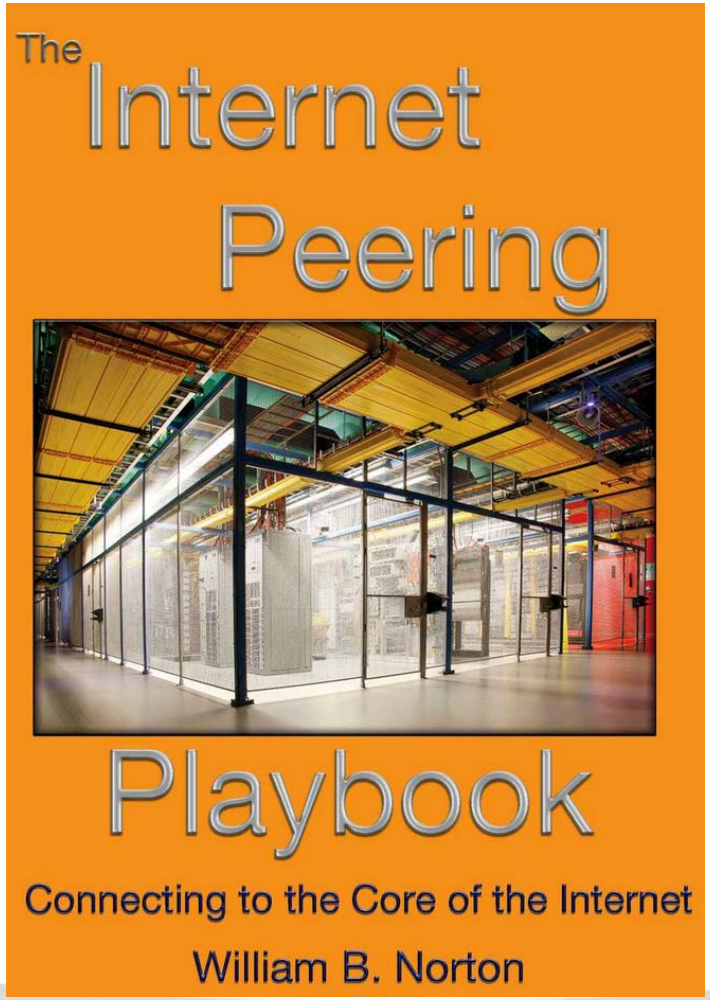


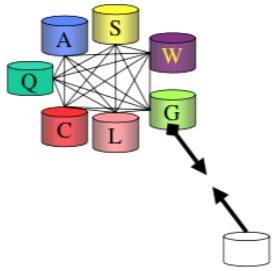
The Rise of Content Delivery



- **Content placement affects performance more than network paths.**
- Content delivery affects traffic volumes, traffic balance on interconnects.

The “Peering Playbook” (Hint: Everybody Wants to Win)





Chicken

Exodus didn't think Genuity would risk disrupting its customers access to Exodus customers. The end result was de-peering and operational disruptions on both sides. Peering resumed only after both sides reached an agreement to spread the traffic load across more interconnection points across the U.S. to reduce the distance the Exodus traffic was carried on Genuity's infrastructure[37].

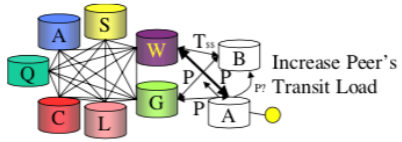
The Chicken tactic is employed to abruptly change the peering relationship, and as the case above demonstrates, can have operational impact if neither side succumbs to the change and de-peers. It is worth pointing out that the aggressor of the Chicken Tactic rarely increases revenue from this tactic; the disruption is usually so significant and the destruction of relationship so severe that the "loser[38]" does not choose the aggressor as a supplier of transit services.

9. Traffic Manipulation: Increase Peer Transit Load

"Startled beasts indicate that a sudden attack is coming.[39]"

The most devious of all the tactics presented is the Traffic Manipulation Tactic. One ISP targets a peer and forces its traffic over the potential peers' *transit* services, to maximize the target ISP's cost of accessing its traffic. To illustrate, consider the figure below, where ISP A wants to peer with ISP B. ISP A forces its traffic to ISP B to go through ISP W, which is ISP B's *Transit* Provider, even though a lower cost path[40] exists.

After some time elapsed, ISP A opens a dialog with ISP B, who reviews the traffic analysis data and is surprised that ISP A has not appeared on the radar screen as a potential peer. Seeing the great transit expense that is paid for access to this traffic, the peering decision is easy for ISP B; ISP A is clearly a large traffic peer that is expensive to access over a transit link. Peering is established with the target.



Traffic manipulation stops[41] about a month after peering is established. Since only a very small percentage of ISPs do the traffic analysis[42] necessary to detect this maneuver, this tactic often goes undetected.

The Traffic Manipulation Tactic is most effectively deployed by network savvy Content Providers. Since web traffic is asymmetric, the producer of the responses (the content player) has the greater ability to force a larger amount of traffic along one path or another.

A few notes from the Peering Coordinators. First, this tactic requires a large amount of spare capacity to handle the manipulated traffic to go along either path[43]. Second, if the tactic is detected, the Peering Coordinator Community is small enough that everyone in the community hears about it. At the same time, Traffic Manipulation is used by some ISPs as a way to manage Traffic Volume Ratio requirements for peering with the Tier 1 ISPs.

37 Conversations with the parties involved in the conflict.

38 It was also interesting to hear the heated debates over the definition of "loser" in this scenerio.

39 http://www.online-literature.com/suntzu/artofwar/15/ Lesson #22. The rising of birds in their flight is the sign of an ambuscade. [Chang Yu's explanation is doubtless right: "When birds that are flying along in a straight line suddenly shoot upwards, it means that soldiers are in ambush at the spot beneath."] Startled beasts indicate that a sudden attack is coming. Our analogy here is that the traffic influx may be the traffic manipulation tactic.

40 Lower cost in the financial sense, not necessarily the routing sense.

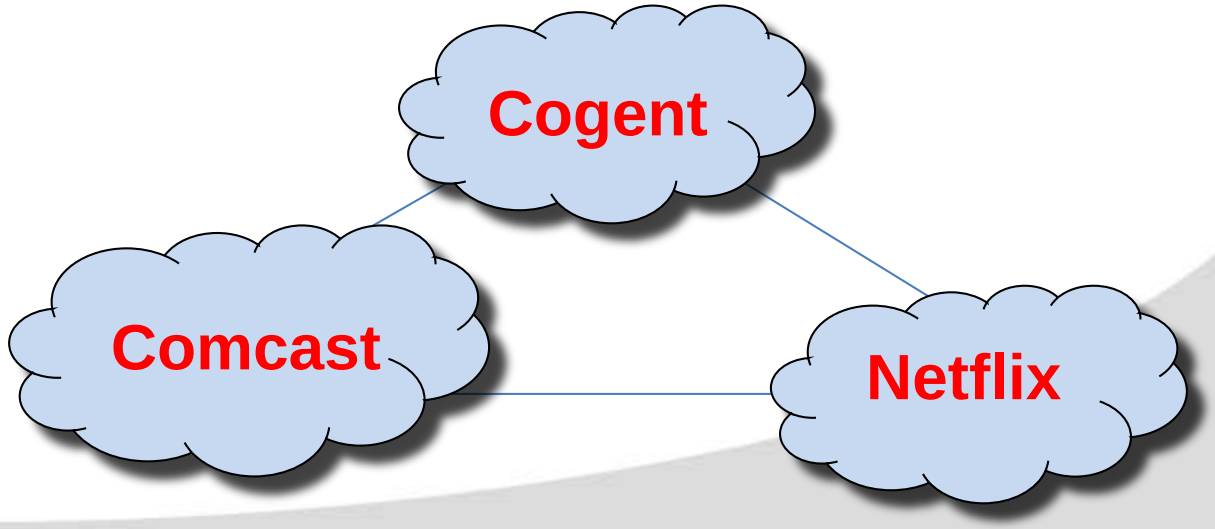
41 Anonymous. Multiple Content Companies have admitted to this maneuver.

42 "Internet Service Providers and Peering" research showed that fewer than 5% of ISPs have the resources for traffic analysis.

43 Anonymous.

"Traffic Manipulation": Increase Transit Load

- "The most devious of all tactics…"
- One network targets a another by sending traffic over that network's transit links, to drive up costs.
- The targeted network decides to peer.



Two Key Observations

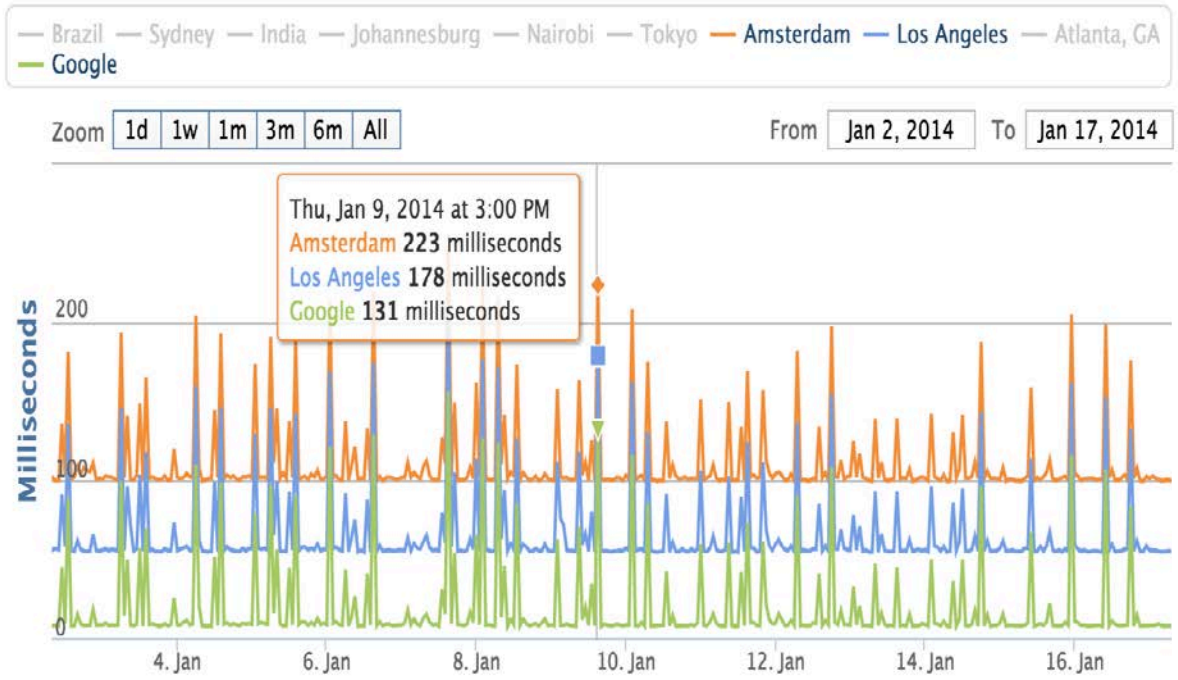
- Traffic patterns (e.g., utilization) can be measured.
  - There are better and worse ways to do so.
  - Nothing is perfect yet, but computer scientists are working on it.

- At the core of this is business.
  - There is a lot of money at stake.
  - Interconnection costs money.
  - It’s much better if “the other guy” pays.

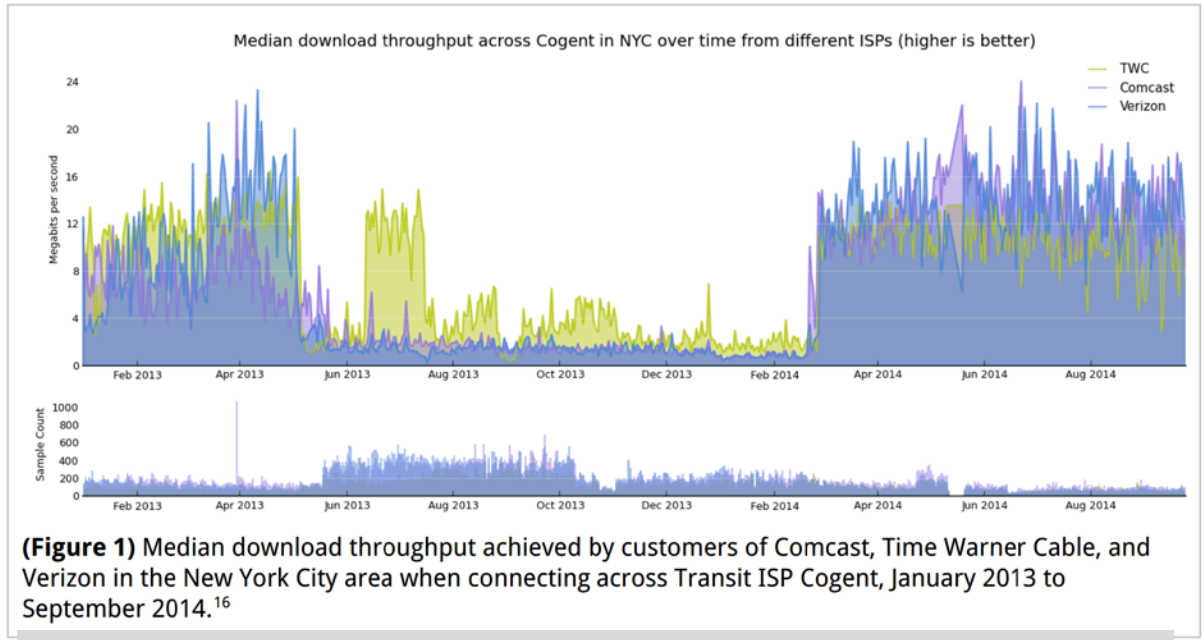
Looking Back:
Retrospective on Interconnection

2013: The Internet Wasn't Ready for This

High Latencies Across the Internet



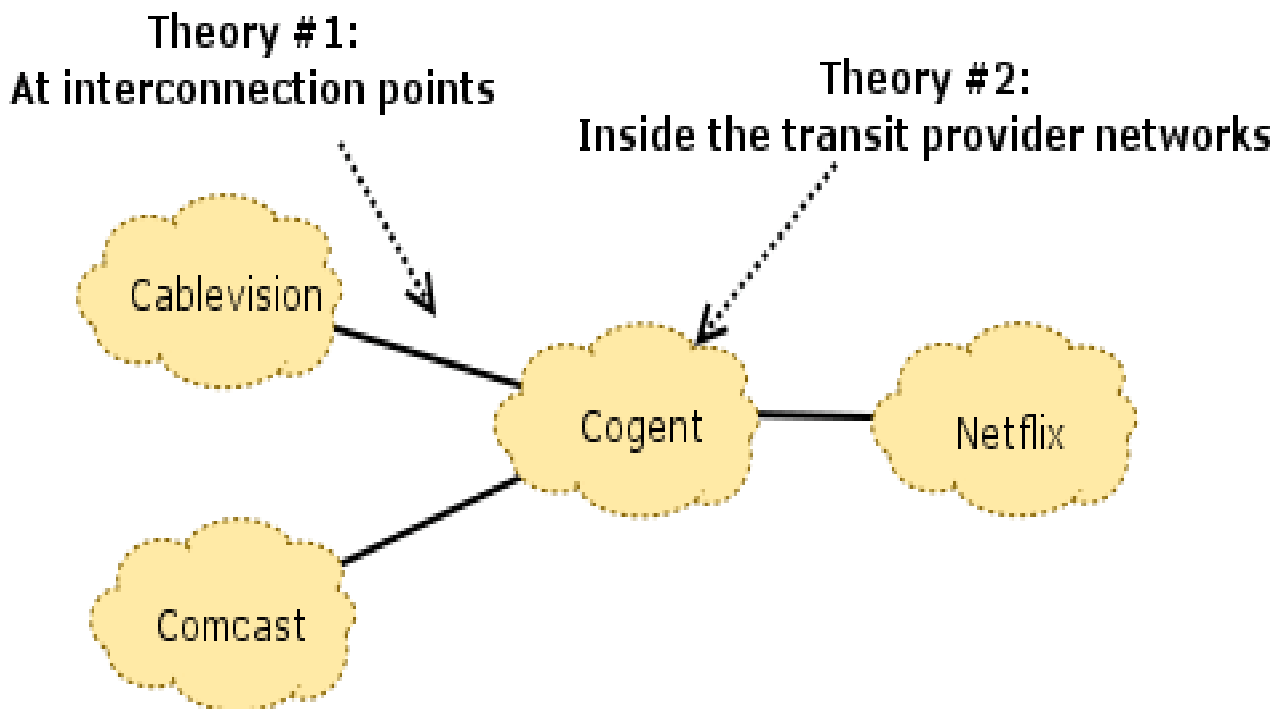
…and Low Throughput



(Figure 1) Median download throughput achieved by customers of Comcast, Time Warner Cable, and Verizon in the New York City area when connecting across Transit ISP Cogent, January 2013 to September 2014.[16]

ISP Interconnection and Its Impact on Consumer Internet Performance. Measurement Lab Report. October 2014.

Who's to blame?
(Corollary: Who should pay?)

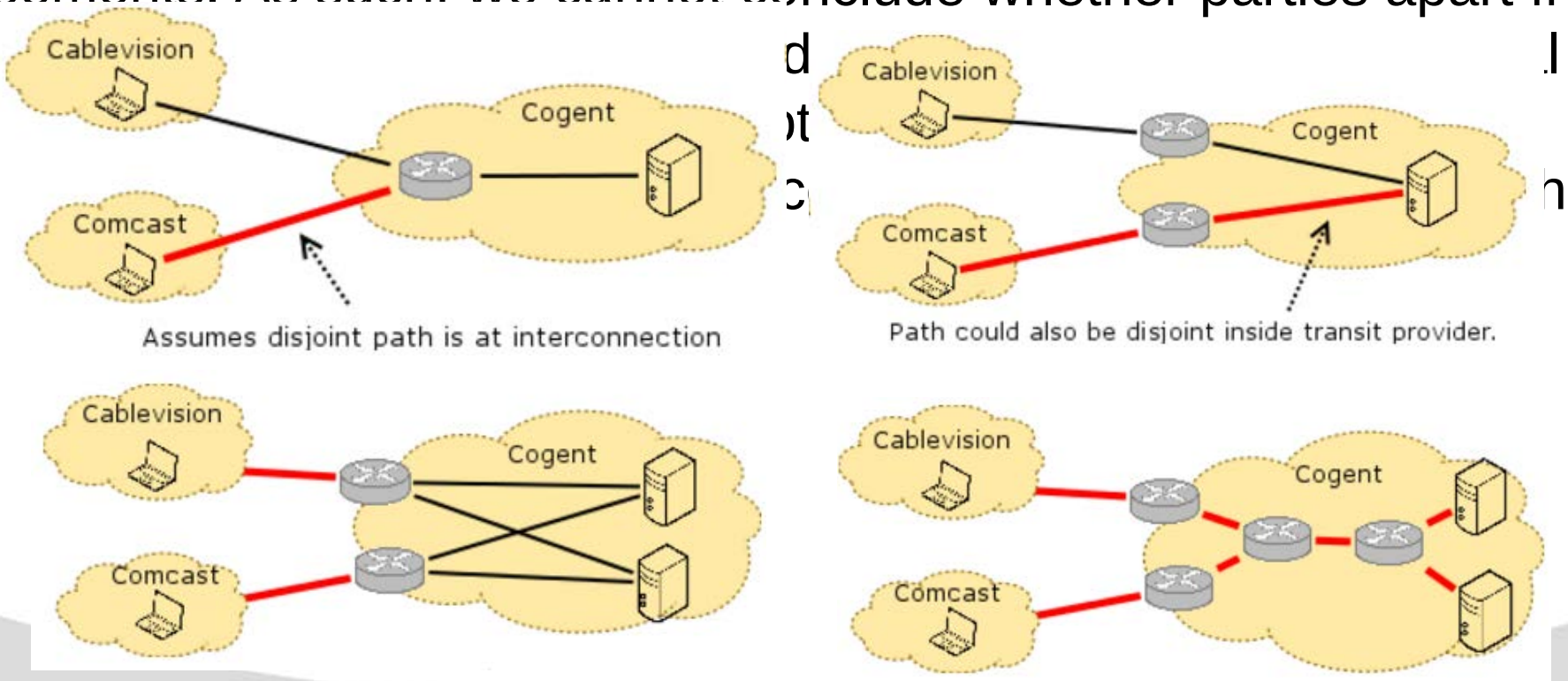


- Access ISP?
- Transit provider?
- Both?

Be Careful What You Read… Consider the Source

"It is important to note that while we can infer that performance degradation is interconnection-related, we do not have the contractual details and histori nection agreements. As such, we can parties apart from the d l que t imp n me

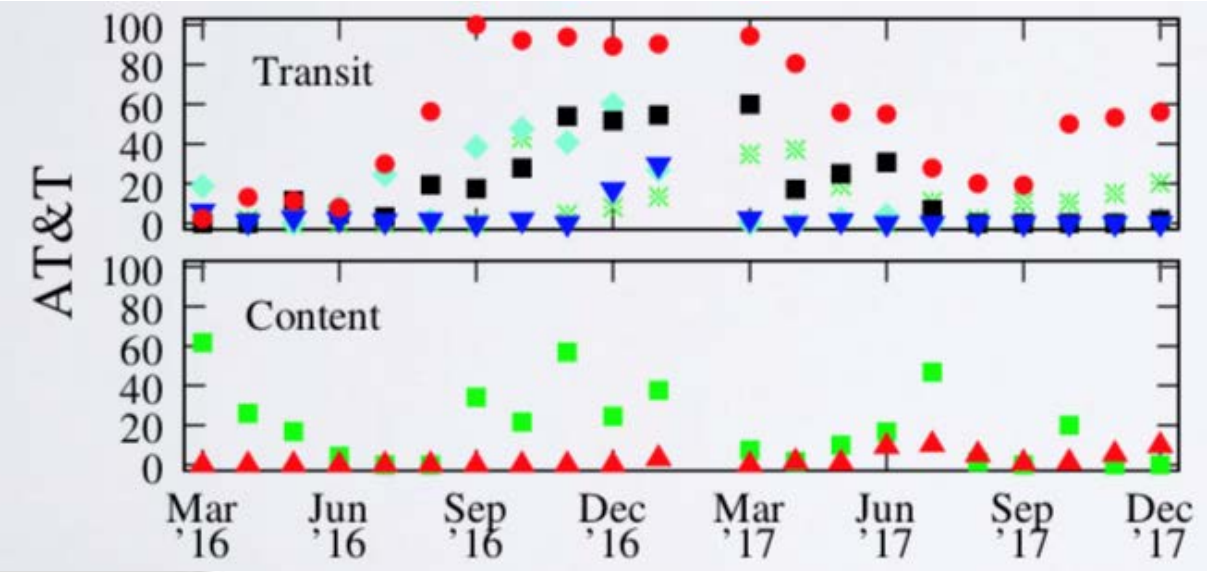
Not really…



Other Ways to Look at Interconnects

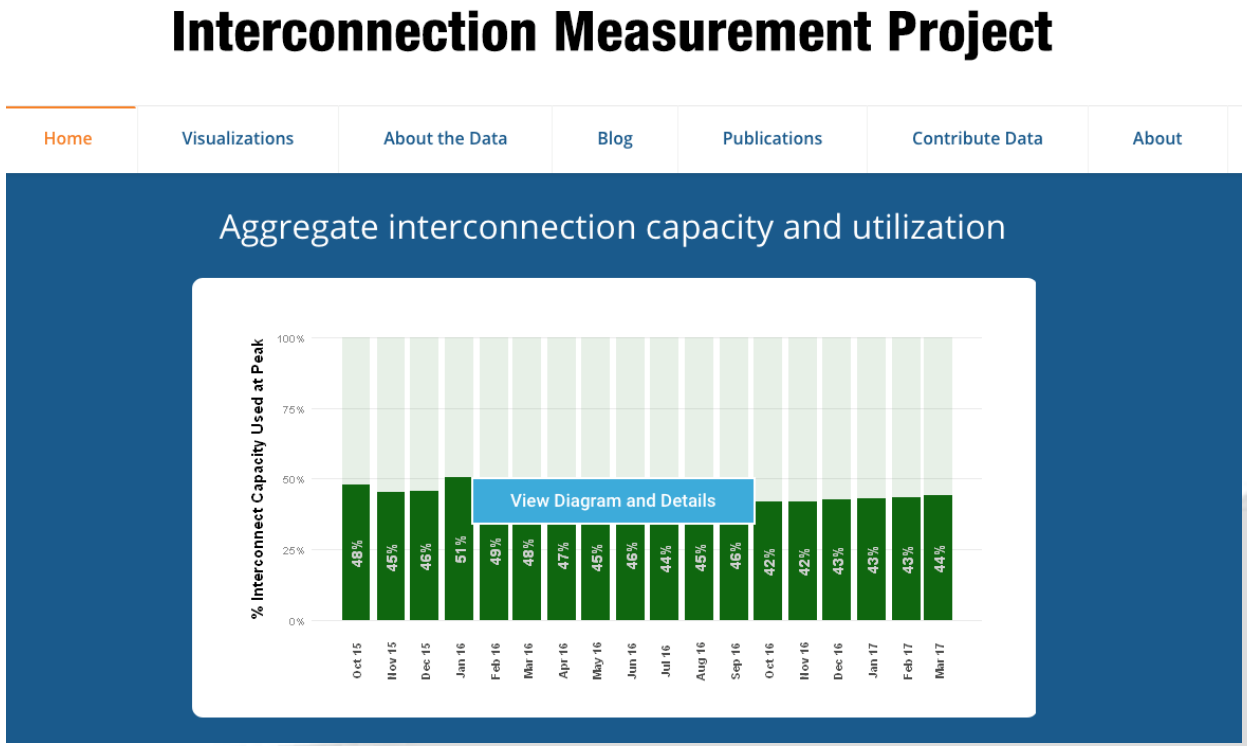
Actively measure the interconnects

- Pros: No special access, public data
- Cons: Cannot measure direct parameters (capacity, utilization)



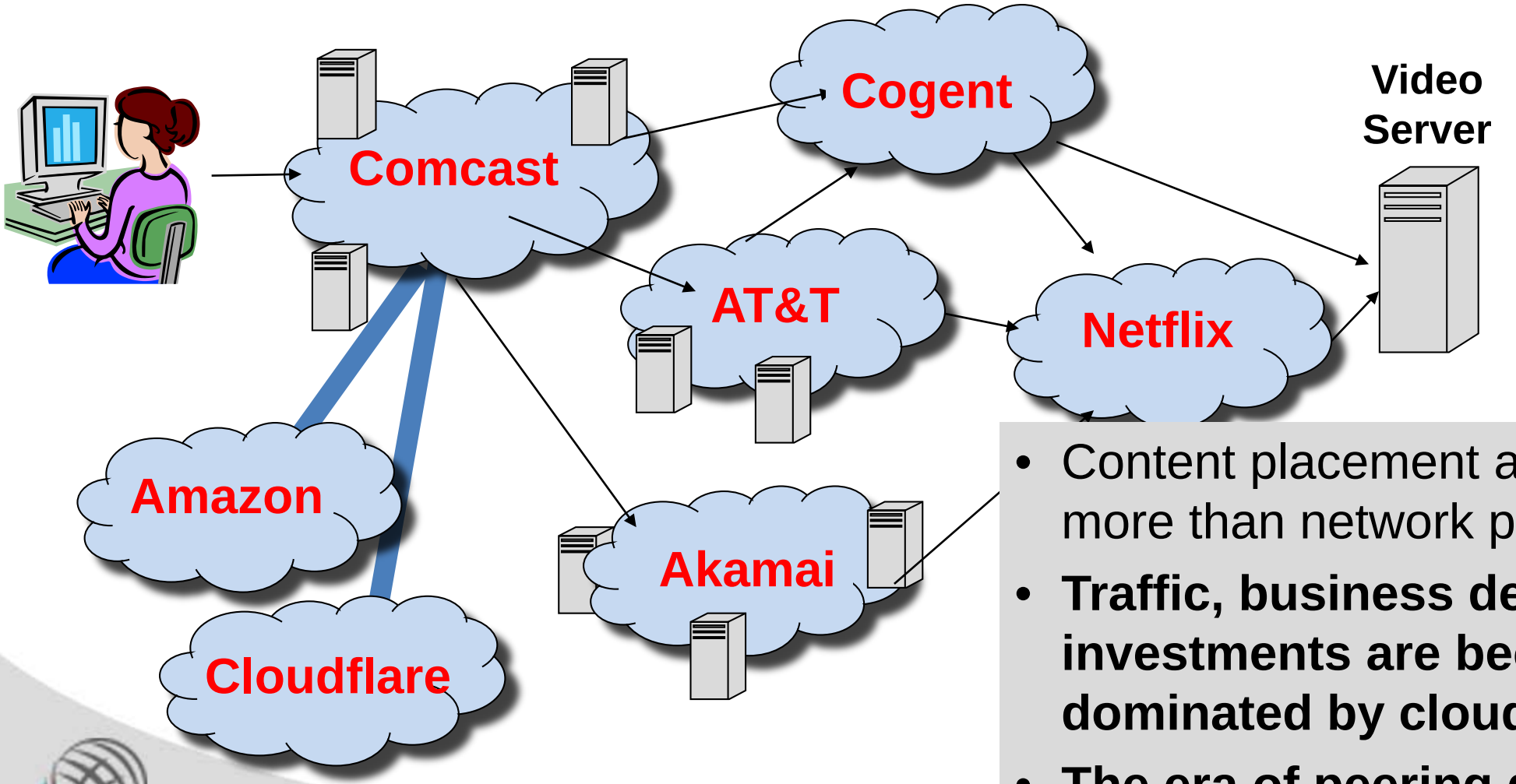
Directly report on interconnect utilization

- Pros: Direct data
- Cons: Special access, privacy concerns



Looking Ahead

The Death of Transit and Peering Disputes



- Content placement affects performance more than network paths.
- **Traffic, business decisions, and investments are becoming dominated by cloud services.**
- **The era of peering disputes is over.**

Market Consolidation Continually Shifts

- Access ISPs
- Transit ISPs
- CDN / Cloud services
- Private networks
- App stores
- Operating systems
- Software APIs

Control can consolidate in any one of these parts of the ecosystem.

Important to take a holistic view towards consumer protection. Five years ago, it was the interconnect.

Now, it is the CDN / distributed cloud.

Summary

- **Traffic volumes are growing.**
  - Video traffic dominates.
  - Video resolution is increasing.

Nick Feamster
Princeton University
feamster@cs.princeton.edu
https://www.cs.princeton.edu/~feamster/

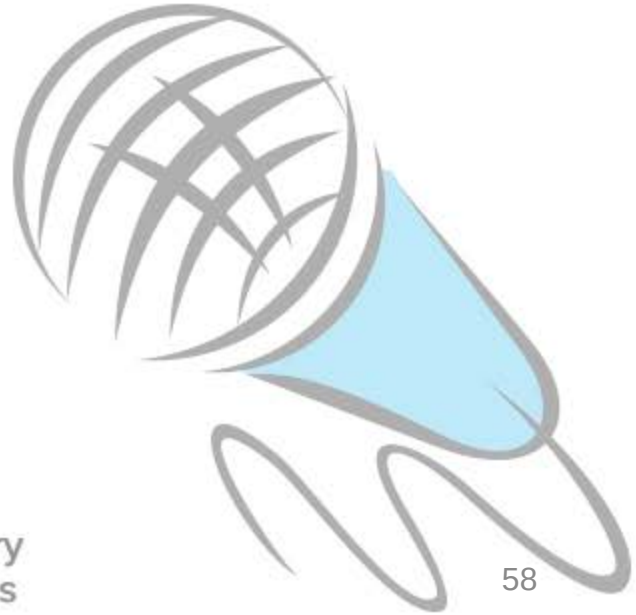
- **Methods of delivering traffic are evolving.**
  - Internet traffic is increasingly being delivered via CDNs.
  - The “old Internet” was hierarchical.
  - Now, mostly bilateral, and driven by CDNs/distributed cloud.

- These developments are playing out in a dynamic economic, political landscape.
  - Measuring the access link “speed” is only part of the picture.
  - Even measuring the interconnect is only part of the picture.

- Technologists can help bridge the gap between **what we can measure** and **what consumers care about** (ultimately, a good Internet experience).

Break

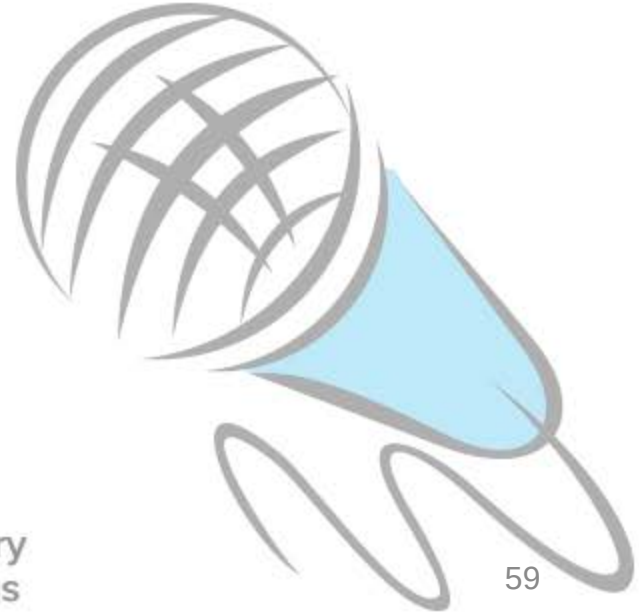
10:15-10:30 am



Speed Advertising Claims, Substantiation, and Section 5

Session moderated by:

Kristin Williams
Federal Trade Commission
Bureau of Consumer Protection



The Federal Trade Commission Act

- Section 5 of the FTC Act, 15 U.S.C. § 45, prohibits unfair or deceptive acts or practices in or affecting commerce.

Deceptive Practices

- Representation or omission (failure to disclose)
- Likely to mislead consumers acting reasonably under the circumstances
- Material

Unfair Practices

- Substantial injury
- Not reasonably avoidable
- Not outweighed by benefits to consumers or competition

Advertising Law Basic Principles

- Advertising must be truthful and not misleading.
- Companies are responsible for all claims – express and implied – that reasonable consumers take from ad.
- Objective claims must be substantiated before they are made.

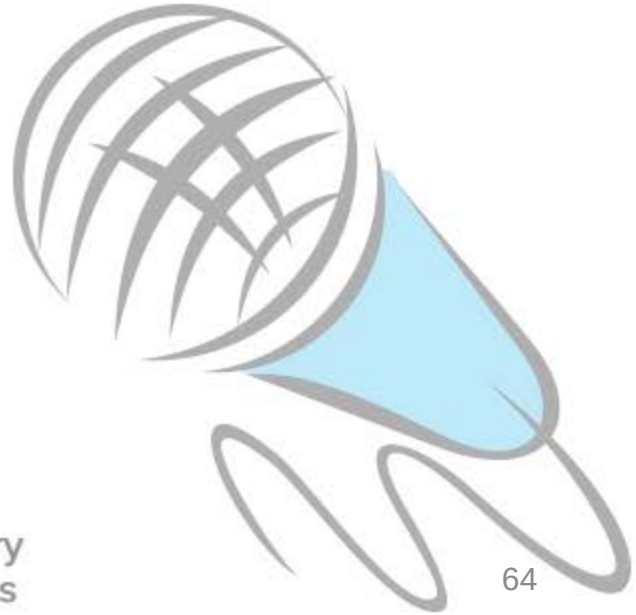
Speed Advertising Claims, Substantiation, and Section 5

Measuring Access Speed

David Clark

MIT Computer Science and

Artificial Intelligence Laboratory



Measures of quality

- Speed
  - More is better, up to a point.
- Latency
  - Less is better, down to a point.
- Loss
  - An idle link should not have packet loss.
- Usage
  - Video generates a lot of traffic

Focusing on Wireline Access

- Cellular service has different measures of quality.
  - Speed is normally not part of marketing.
  - Emphasize reliability, coverage.
- Another conversation

Summary

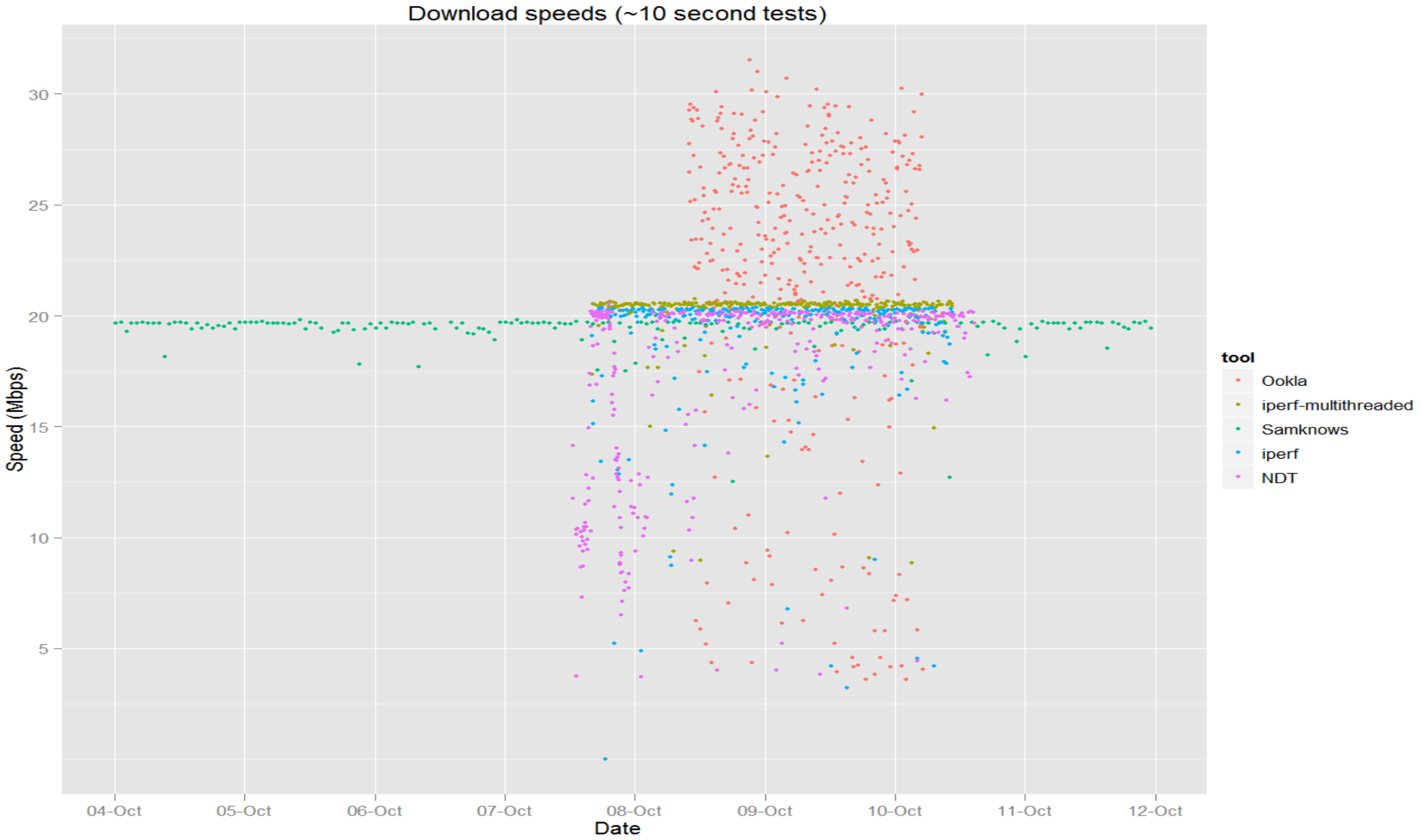
- Different measurement tools can give very different answers.
  - Different design, different objective, bugs.
- As speeds get higher, measurement becomes more difficult.
- Speed may not continue to be the flagship measure of quality.

Some Measurements From 2010

1. FCC/Samknows (on-net, 10 second test)
2. Ookla/Speedtest
3. Measurement Lab/NDT
4. Iperf
5. Iperf-multithreaded

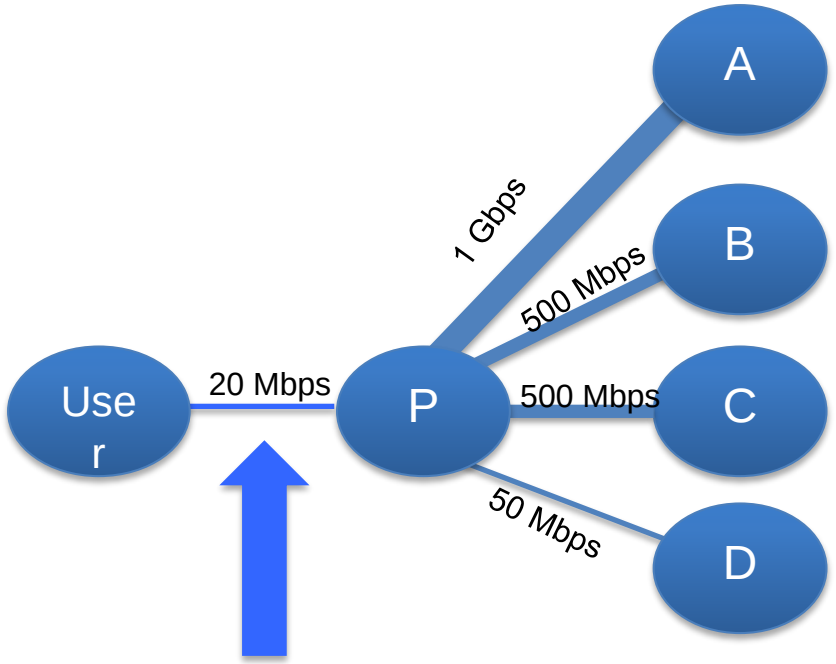
All tests from residence with Samknows unit.

Tests 2-5 to same server at MIT.


Download speeds (~10 second tests)
Speed (Mbps)
30
25
20
15
10
5
04-Oct
05-Oct
06-Oct
07-Oct
08-Oct
09-Oct
10-Oct
11-Oct
12-Oct
Date
tool
Ookla
iperf-multithreaded
Samknows
iperf
NDT

Measuring a “Slow” Link

- Many different test methodologies will arrive at similar estimates of performance when the broadband access link is the bottleneck
- Increasingly not the case today
  - Gigabit broadband
  - Home WIFI problems



Focus of tests

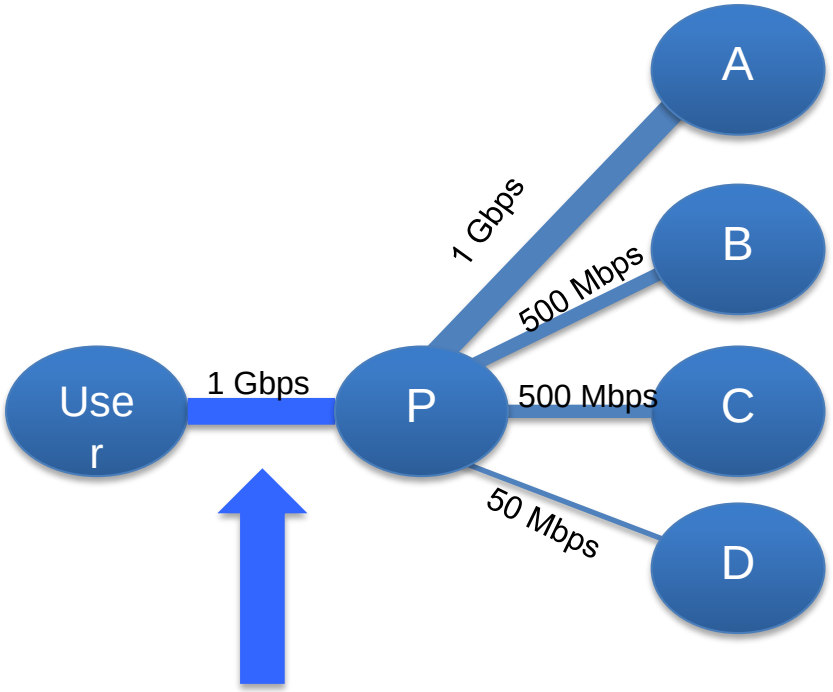
How To Measure a “Fast” link

Consider two polar cases:

1) **Gigabit everywhere**
2) **Gigabit locally** – Gigabit islands

Intermediate cases to highlight options:

3) **Gigabit in aggregate**
4) **Gigabit to select destinations**



No longer the expected bottleneck

Test Methodologies Differ

Only commonality across all these different popular tests is that they report speed test results in the same units (Mbps).

MLAB

Sam Knows™

FAST

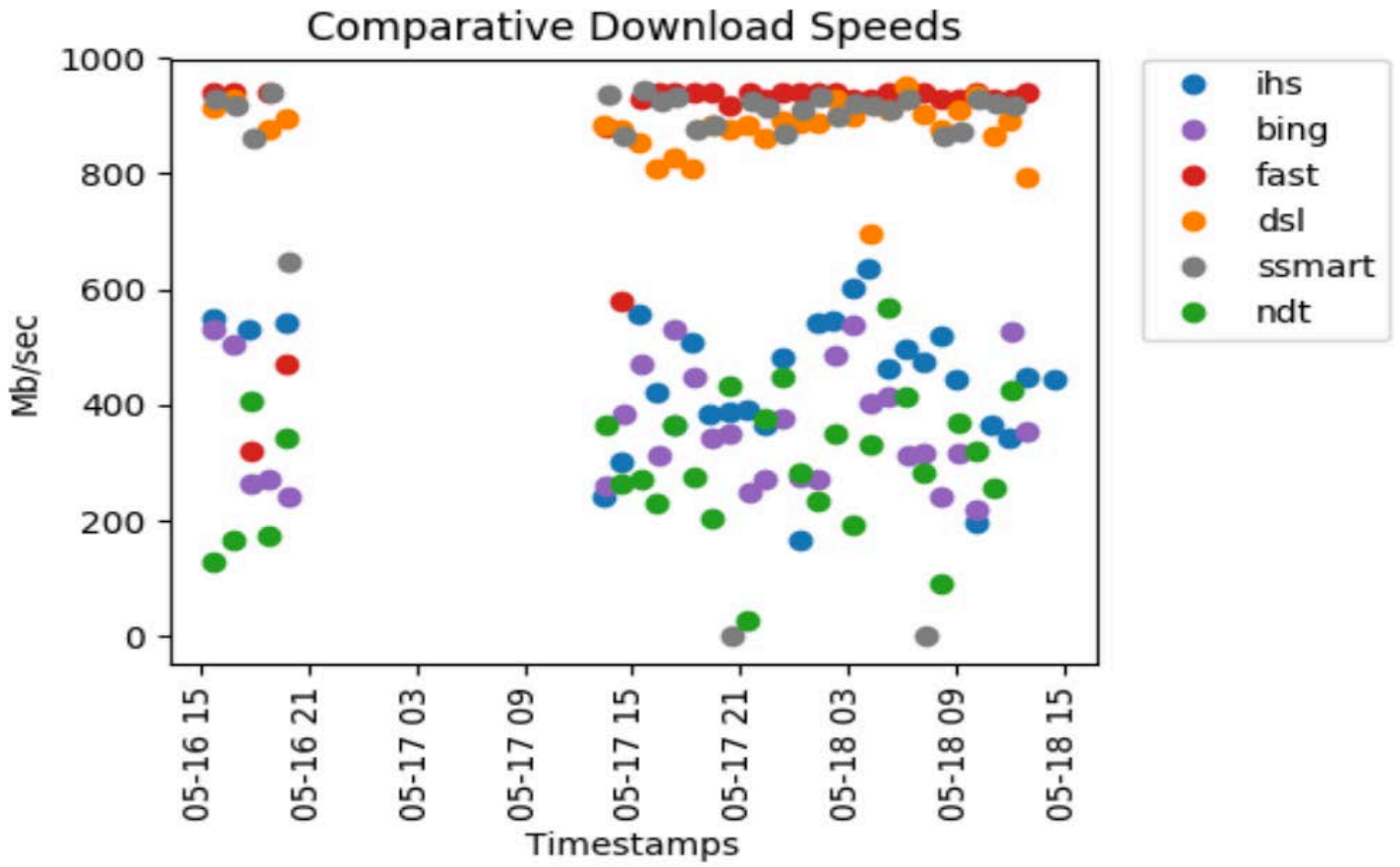
Internet Health Test

DSLReports

SPEEDTEST™

Comparison of measurement tools

- A single gigabit connection.



Test	Flows	Destinations	Deployment	Server selection	Reported speed	IPv6	Implied performance expectation	Clear performance target
NDT	Single	Single	S/W, crowdsource	Nearby and server load	Total bytes/ Total time	No	Single off-net destination	No
IHT	Sequential	Multiple	S/W, (NDT) crowdsource	Nearby and server load	Average of all tests	No	Single off-net destination	No
Fast	Parallel	Multiple	S/W, crowdsource	Regular Netflix server selection algorithm	Average after ramp up	Yes	Aggregate performance to single content provider	No
DSL Reports	Parallel	Multiple	S/W, crowdsource		Total bytes / Total time	No	Aggregate performance to multiple cloud providers	No
Measuring Broadband America	Parallel	Single	H/W, known sites	On-net / quality off-net	Average after ramp up	Yes	Single on-net destination	Contracted service tier
Xfinity	Parallel	Single	S/W, crowdsource	On-net / off-net		Yes	Single on or off net destination	No
Ookla	Parallel	Single	S/W, crowdsource	Nearby	Average after ramp up	No	Single on or off net destination	No

Comparing Drawbacks

- Hardware based measurement:
  - Limited deployment
- Web/App based measurement:
  - Selection bias.
    - Frustrated people more likely to run test.
  - No knowledge of provisioned speed.
  - Host/home network impairments can limit utility.

Questions for Consideration

- Are gigabit speeds important today?
  - How do these speeds relate to the user experience?
- How should market and regulatory expectations evolve as broadband access speeds increase toward gigabit speeds?
  - Will speed continue to be the flagship metric of service quality?
- What changes are occurring or need to occur in the major measurement platforms to improve the measurement of gigabit broadband?
- What should the research agenda be to address the technical and policy challenges of gigabit broadband?

Further Reading

- Bauer, S., D. Clark, W. Lehr. *Understanding broadband speed measurements* https://groups.csail.mit.edu/ana/Publications/Understanding_broadband_speed_measurements_bauer_clark_lehr_TPRC_2010.pdf
- Bauer, Steven and Lehr, William and Mou, Merry, *Improving the Measurement and Analysis of Gigabit Broadband Networks* (March 31, 2016). Available at SSRN: https://ssrn.com/abstract=2757050
- Bauer, Steven and Lehr, William and Hung, Shirley, *Gigabit Broadband, Interconnection, Propositions and the Challenge of Managing Expectations* (September 1, 2015). TPRC 43: The 43rd Research Conference on Communication, Information and Internet Policy Paper. Available at SSRN: https://ssrn.com/abstract=2586805

Speed Advertising Claims, Substantiation, and Section 5

Measuring Internet Access “Speed”: Five Lessons

Nick Feamster

Princeton University

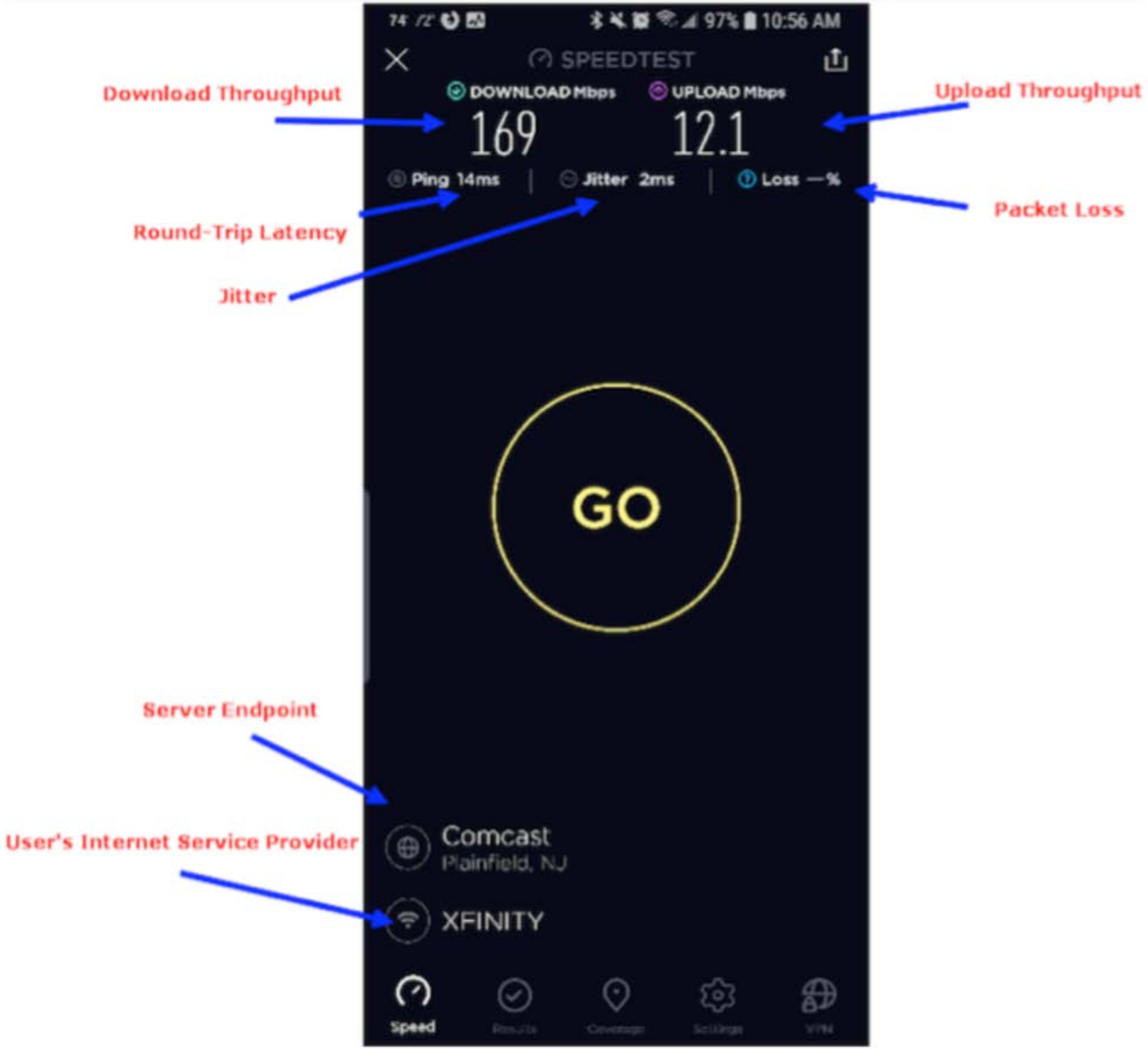
Department of Computer Science

Summary: Five Lessons

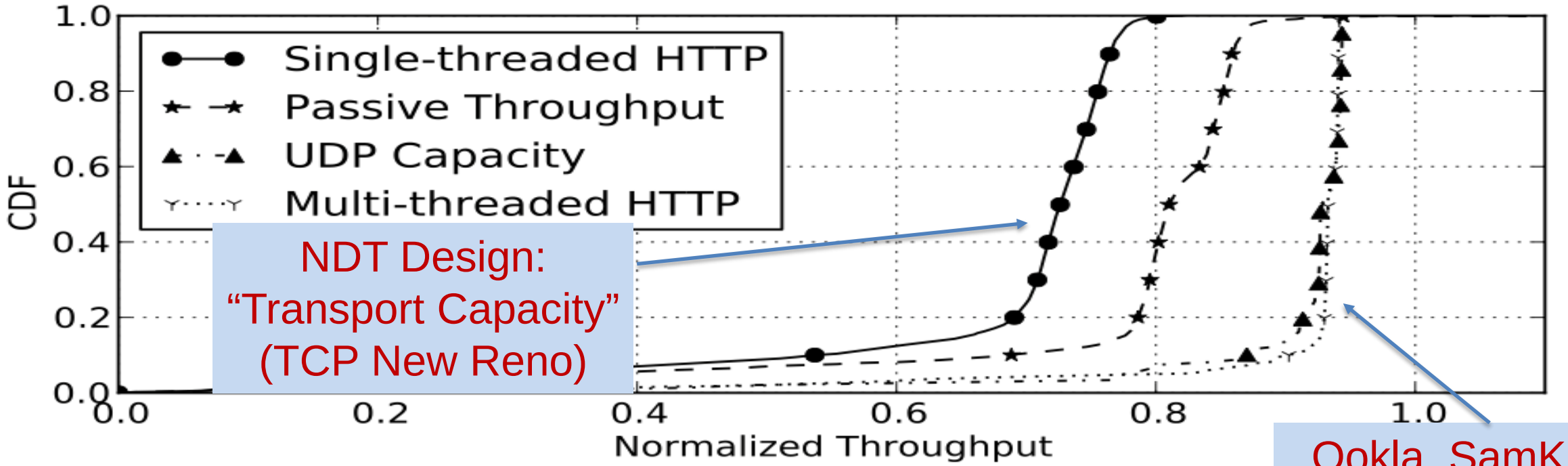
- “Speed” has many facets.
- Different techniques measure different aspects of speed.
- Many factors can limit a client-based speed test.
- Faster “speed” doesn’t mean better performance.
- As speeds get faster, speed testing gets harder.

“Speed” Has Many Facets

- Throughput (up, down)
- Latency
- Jitter
- Packet Loss



Different Techniques Measure Different Aspects of Speed



NDT Design:
"Transport Capacity"
(TCP New Reno)

Ookla, SamKnows Design:
"Link Capacity"

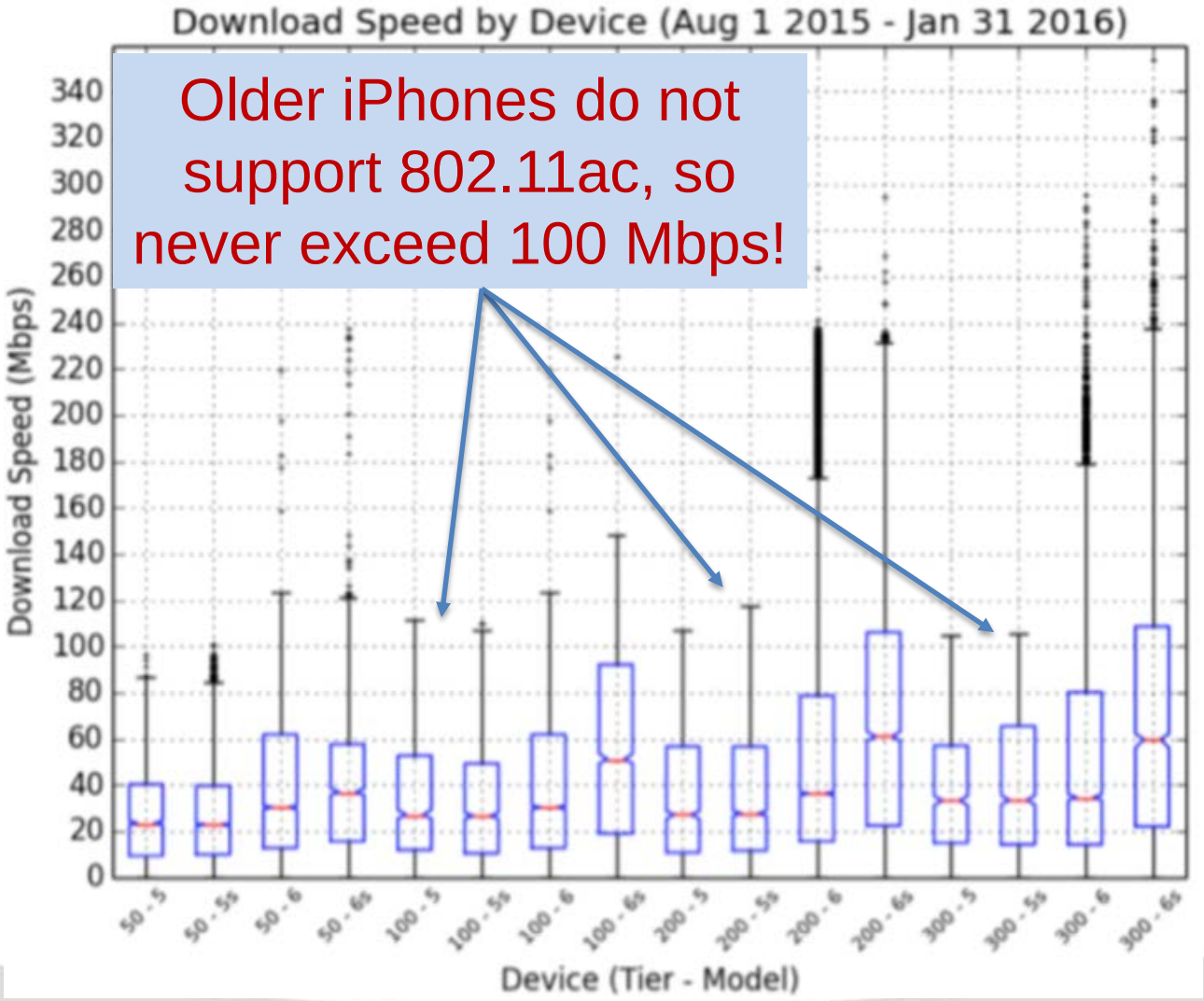
Sundaresan, S., Burnett, S., Feamster, N., & De Donato, W. (2014, June). BISmark: A Testbed for Deploying Measurements and Applications in Broadband Access Networks. In *USENIX Annual Technical Conference* (pp. 383-394).

Sundaresan, S., De Donato, W., Feamster, N., Teixeira, R., Crawford, S., & Pescapè, A. (2011, August). Broadband internet performance: a view from the gateway. In *ACM SIGCOMM* (Vol. 41, No. 4, pp. 134-145). ACM.

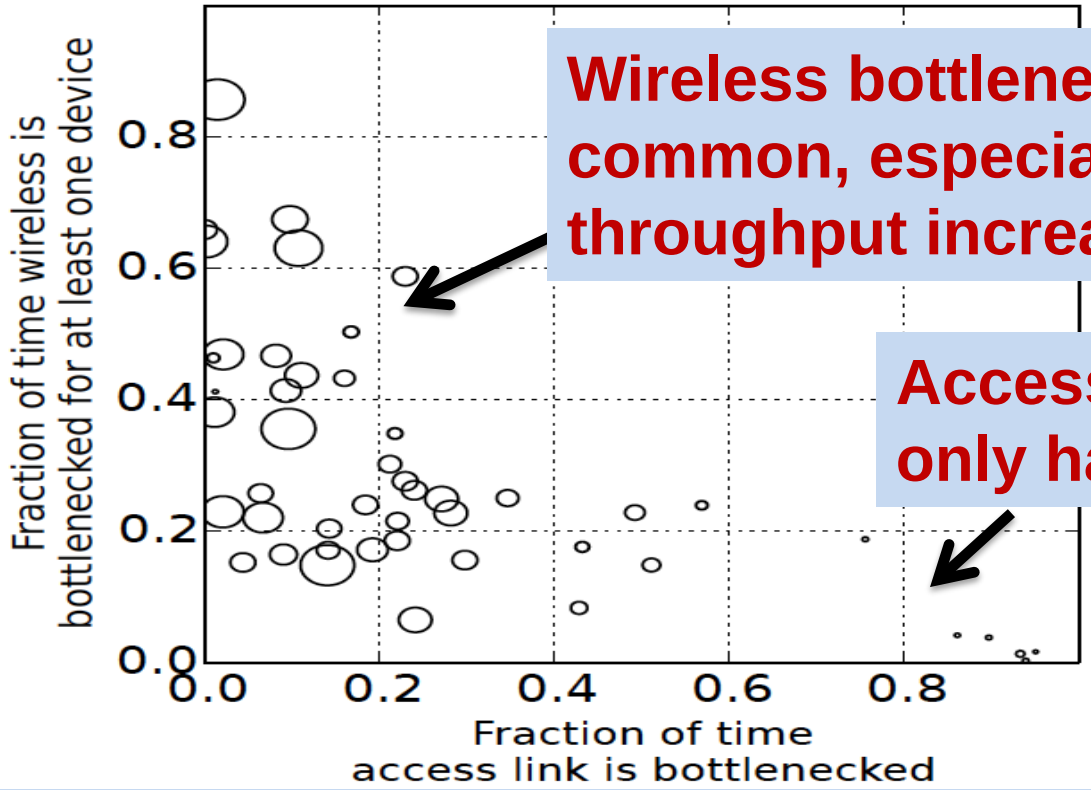
Many Factors Limit a Client-Based Speed Test

- Client device (hardware, software)
- Home network
- Network path
- Measurement server infrastructure
- Test parameters (length, # connections)

The Device Can be the Bottleneck



The Home Network Can Be the Bottleneck



Wireless bottlenecks are common, especially as throughput increases

Access link bottlenecks are rare, only happens at low throughput

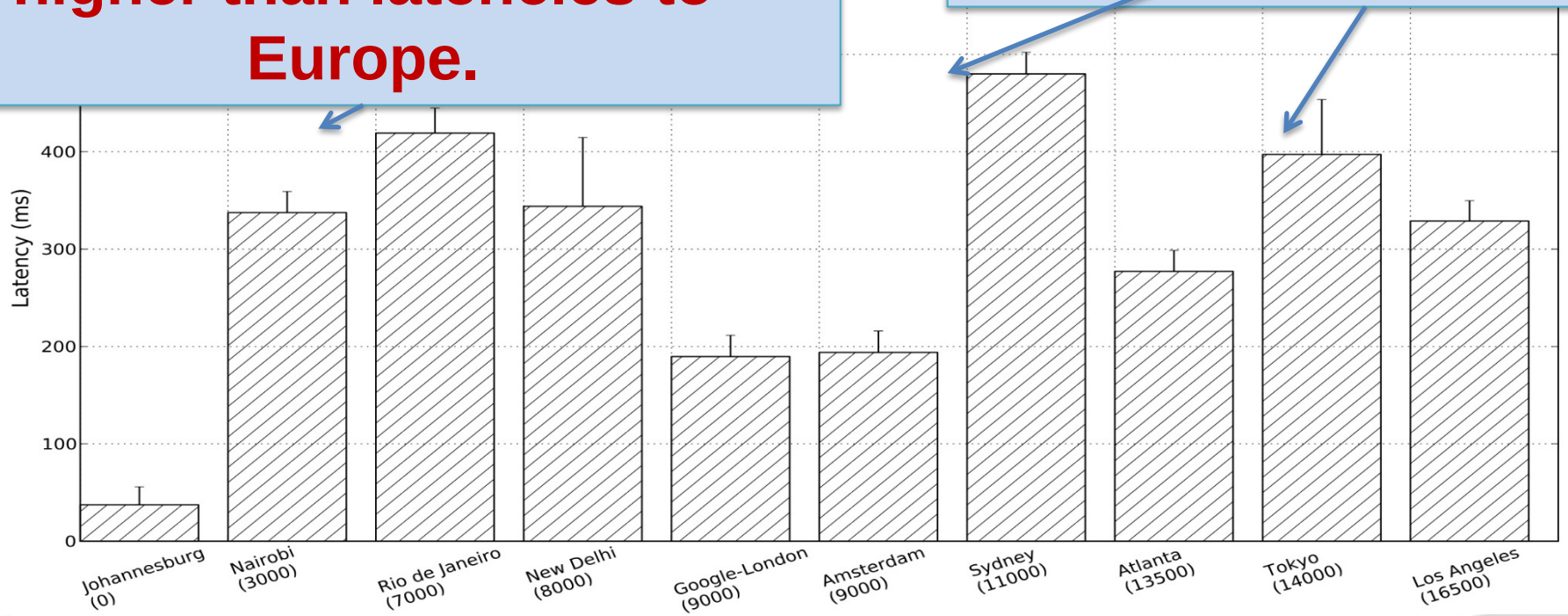
Homes with throughput greater than 35 Mbits/s almost never see access link bottleneck. (2015)

Sundaresan, S., Feamster, N., & Teixeira, R. (2016, March). Home network or access link? locating last-mile downstream throughput bottlenecks. In *International Conference on Passive and Active Network Measurement* (pp. 111-123).

The Network Path can be the Bottleneck

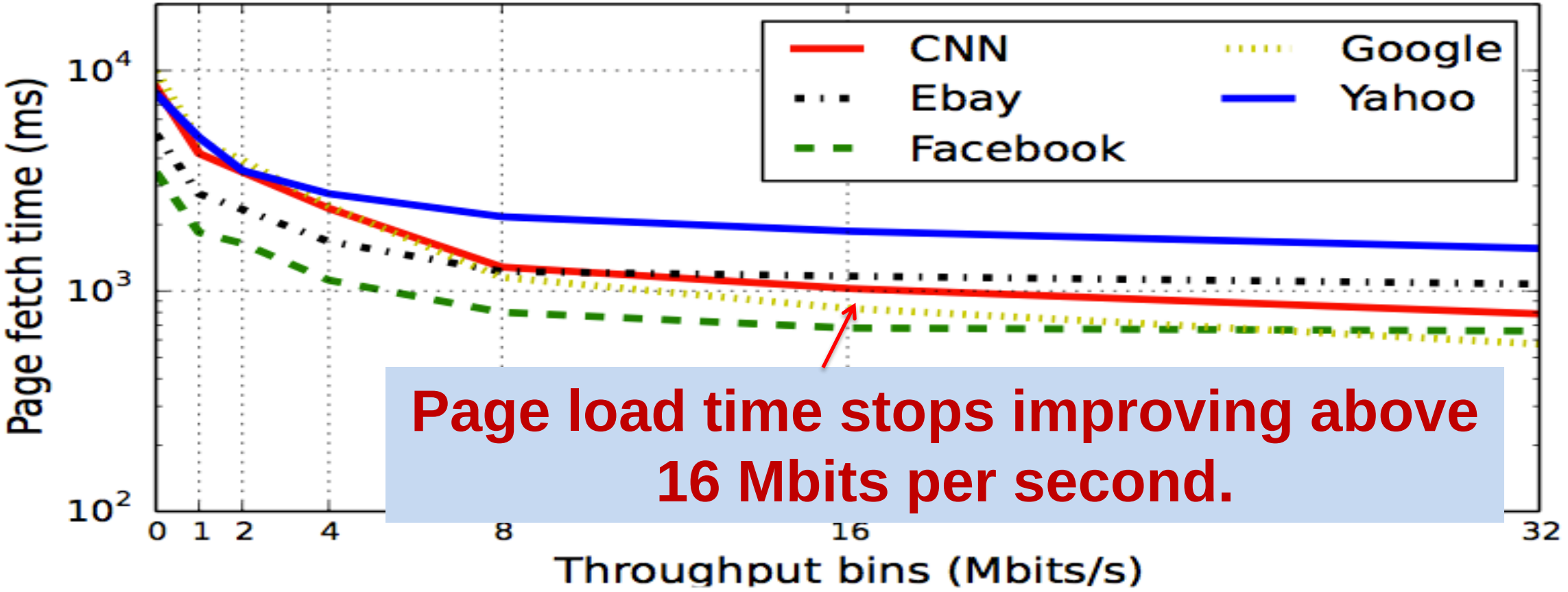
Latencies from South Africa to Kenya, Brazil, India are 2x higher than latencies to Europe.

Connectivity to Australia, Japan also shows higher latency.



Gupta, A., Calder, M., Feamster, N., Chetty, M., Calandro, E., & Katz-Bassett, E. (2014, March). Peering at the Internet's frontier: A first look at isp interconnectivity in Africa. In *International Conference on Passive and Active Network Measurement* (pp. 204-213).

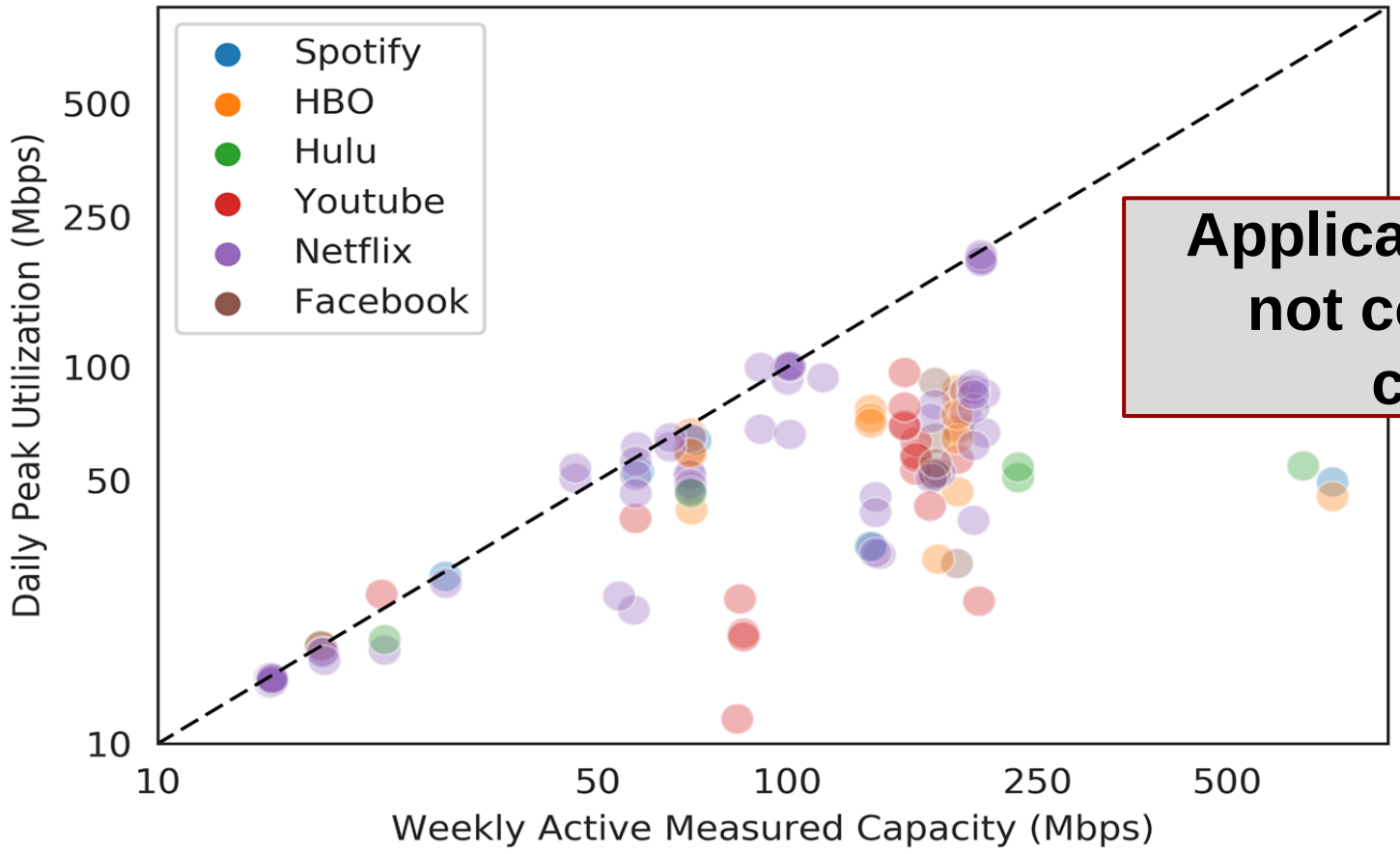
Faster Speed Doesn't Mean Better Performance



Page load time stops improving above 16 Mbits per second.

Sundaresan, S., Feamster, N., Teixeira, R., & Magharei, N. (2013, October). Measuring and mitigating Web performance bottlenecks in broadband access networks. In *ACM SIGCOMM Internet measurement conference* (pp. 213-226). ACM. **Community contribution award.**

Application Performance Doesn't Always Need "Top Speed"



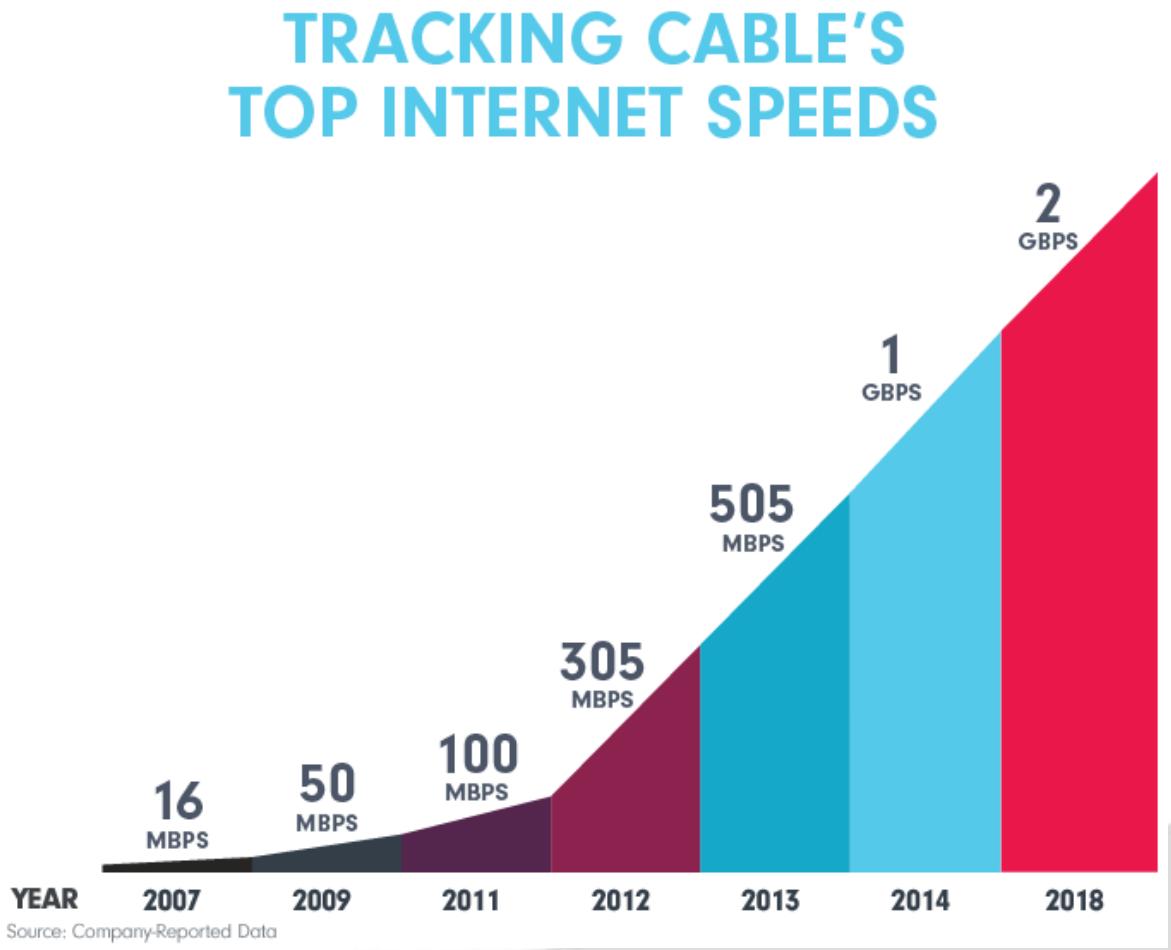
Applications often do not consume link capacity.

User Experience Depends on Application Performance

- **Startup delay:**
  How long does the video take to start playing?
- **Video resolution:**
  What is the resolution of the video?
- **Bitrate changes:**
  Does the video bitrate change during playback?
- **Rebuffering events:**
  Does the video re-buffer during playback?

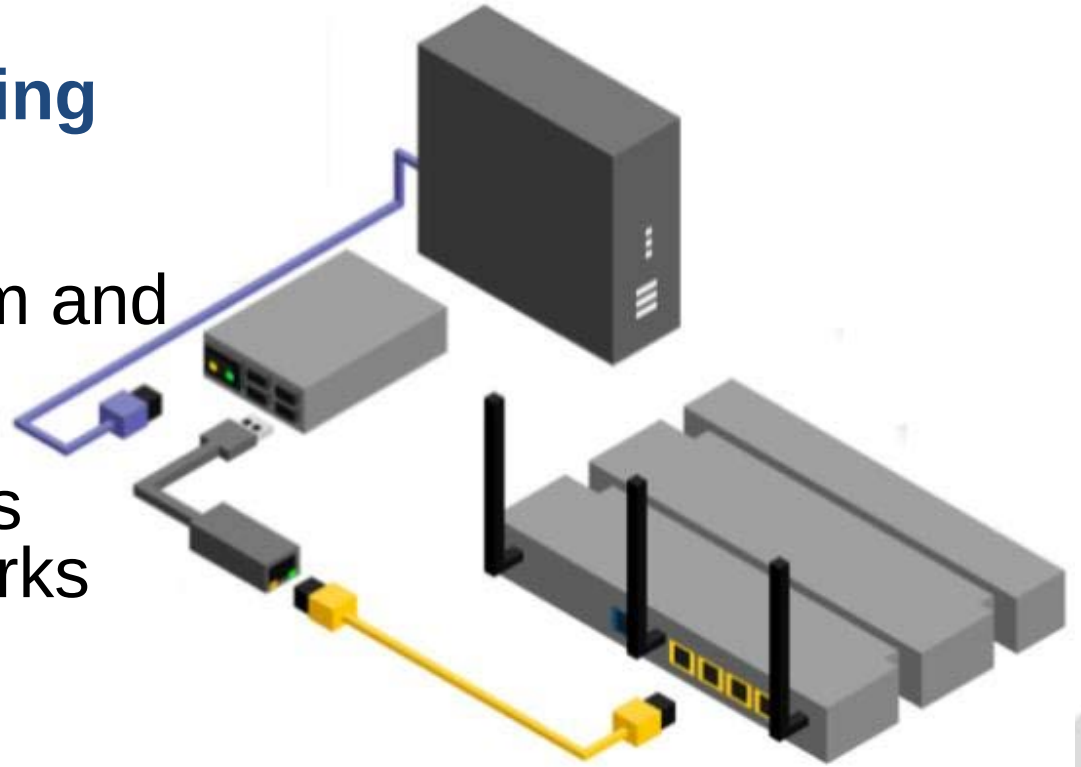
As Speeds Get Faster, Speed Testing Gets Harder

- Measuring access links is getting harder.
- Conventional tests take more data.
- Bottlenecks are moving elsewhere.
- Apps don’t saturate the access network capacity.



The Gigabit Era: The Future is Passive

- Estimate application performance using mostly
passive measurements **without breaking encryption**
- Device is in-line, between cable modem and user's wireless router, or off-path
- Implemented in Go for low-cost devices (Raspberry Pi, Odroid) on home networks
- Pilot home network deployment:
~60 in US, ~10 in Paris



Summary

- “Speed” has many facets.
- Different techniques measure different aspects of speed.
- Many factors can limit a client-based speed test.
- Faster “speed” doesn’t mean better performance.
- As speeds get faster, speed testing gets harder.
- The future of testing is passive application monitoring.

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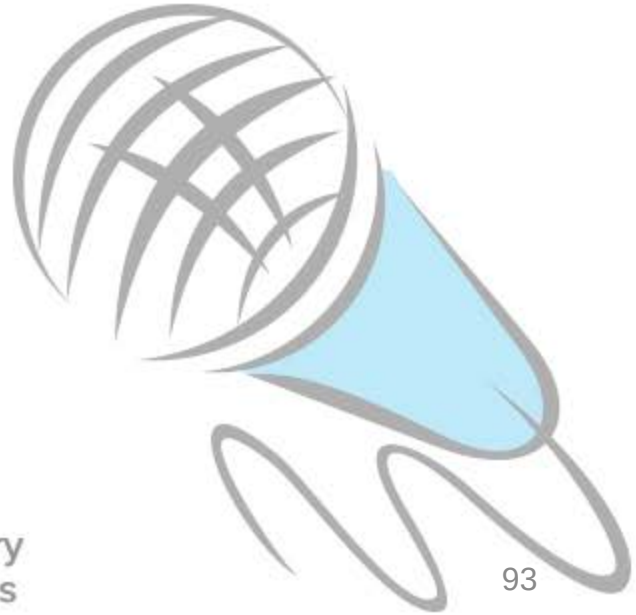
Speed Advertising Claims, Substantiation, and Section 5

NAD Cases

Laura Brett

National Advertising Division

Advertising Self-Regulatory Council



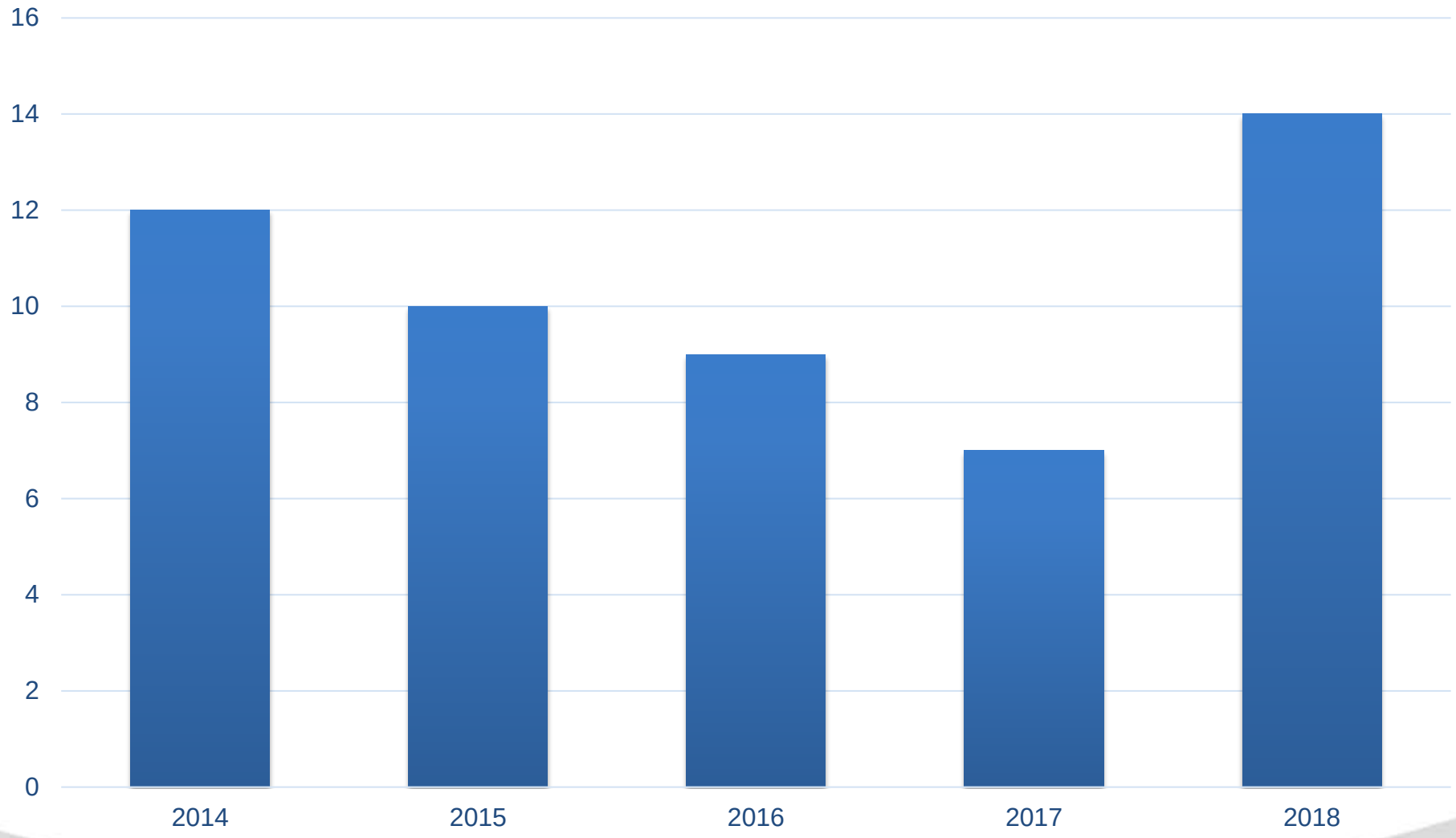
Telecommunications Challenges

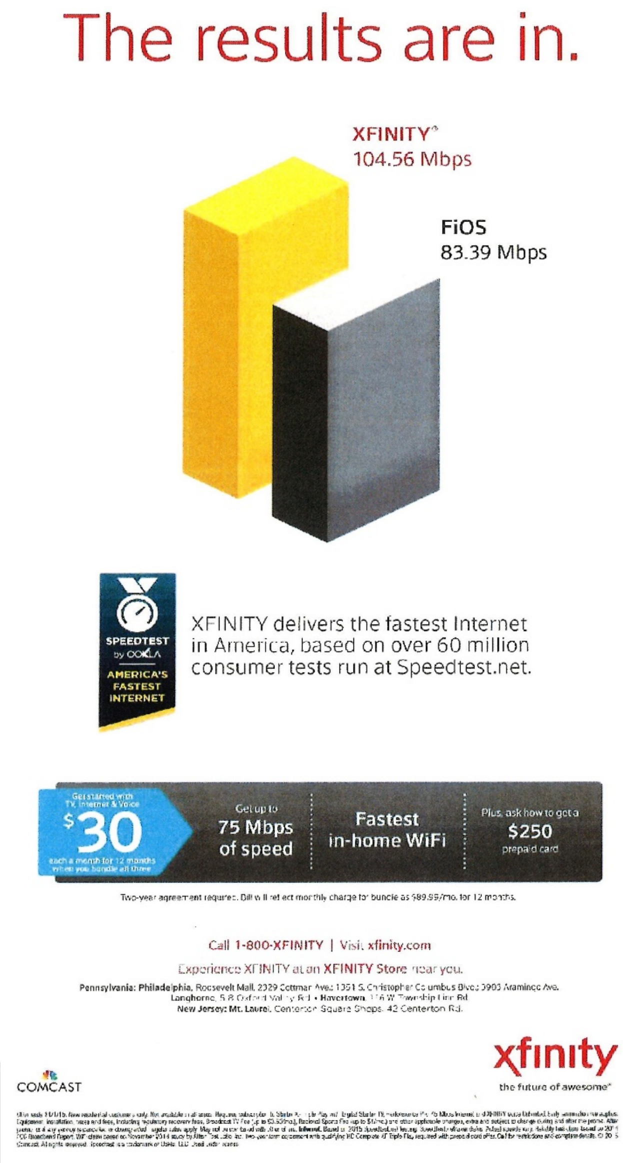
Companies that Participated in Self-Regulation:

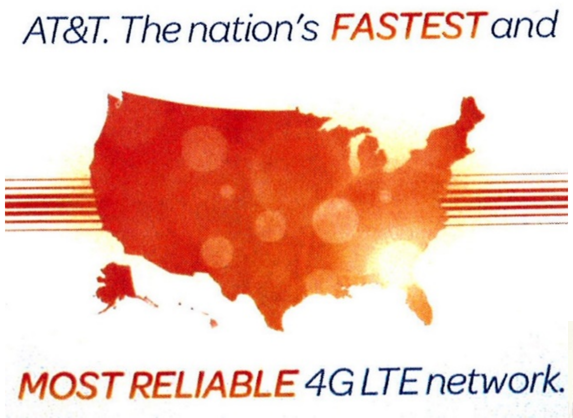
AT&T, Verizon, T-Mobile, Sprint, Comcast, Charter, DIRECTV, DISH and Frontier.

34 Cases involving express or implied speed claims

NAD Telecom Cases by Year



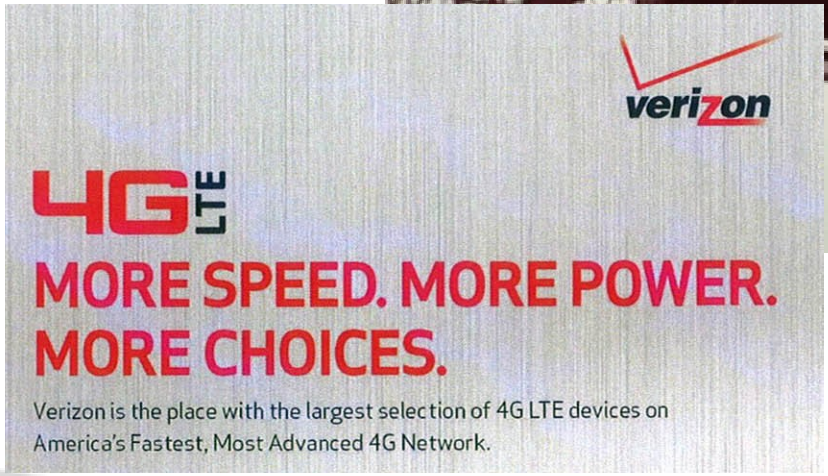

The results are in.
XFINITY
104.56 Mbps
FiOS
83.39 Mbps
SPEEDTEST by OOKLA
AMERICA'S FASTEST INTERNET
XFINITY delivers the fastest Internet in America, based on over 60 million consumer tests run at Speedtest.net.
$30
Get up to 75 Mbps of speed
Fastest in-home WiFi
Plus, ask how to get a $250 prepaid card
Call 1-800-XFINITY | Visit xfinity.com
Experience XFINITY at an XFINITY Store near you.
xfinity
the future of awesome
COMCAST


AT&T. The nation's FASTEST and
MOST RELIABLE 4G LTE network.


SWITCH TO T-MOBILE
FASTER


AMERICA'S
FASTEST
4G LTE
NETWORK


INTERNET SPEEDS
20x FASTER.
Introducing AT&T Fiber.
AT&T Fiber
CLEARCHANNEL


verizon
4G LTE
MORE SPEED. MORE POWER.
MORE CHOICES.
Verizon is the place with the largest selection of 4G LTE devices on America's Fastest, Most Advanced 4G Network.

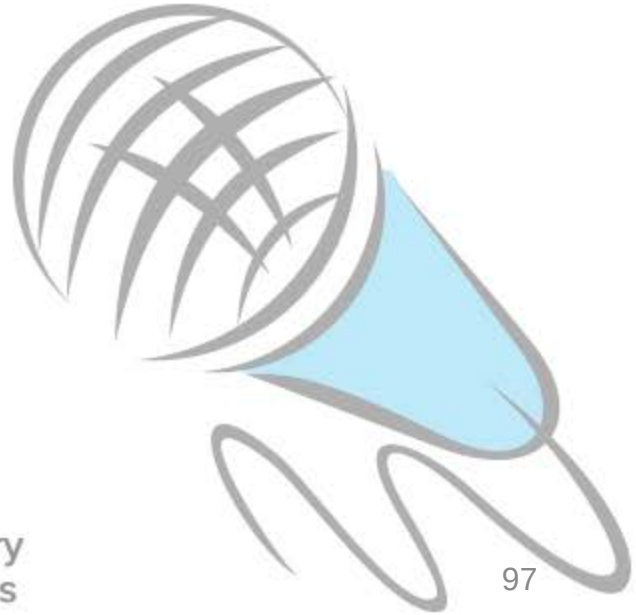
Speed Advertising Claims, Substantiation, and Section 5

First Principles of Advertising: Implications for Speed Claims

Debra J. Ringold

Willamette University

Atkinson Graduate School of Management



"…Advertising Seeks to Persuade and Everyone Knows It" (Calfee 1997)

- Consumers are skeptical of claims designed to differentiate, generic claims, and advertising as an activity
- Consumers make distinctions between search, experience, and credence attribute claims
- Consumers use advertising claims to form working hypotheses they test in a variety of ways

Advertising Communicates Information and Shapes Markets

- Most effective when communicating “new” information of “value” to consumers
- Small numbers of information sensitive consumers can affect price, quality, etc. and market structure

Power Has Shifted to the Consumer

- Advertisers speak in the context of the Internet
- Consumers overcome traditional market asymmetries
- Consumers band together against producers
- Consumers shape the value chain, often in record time

“Do You Have the Internet Speed You Need?” (FTC 2019)

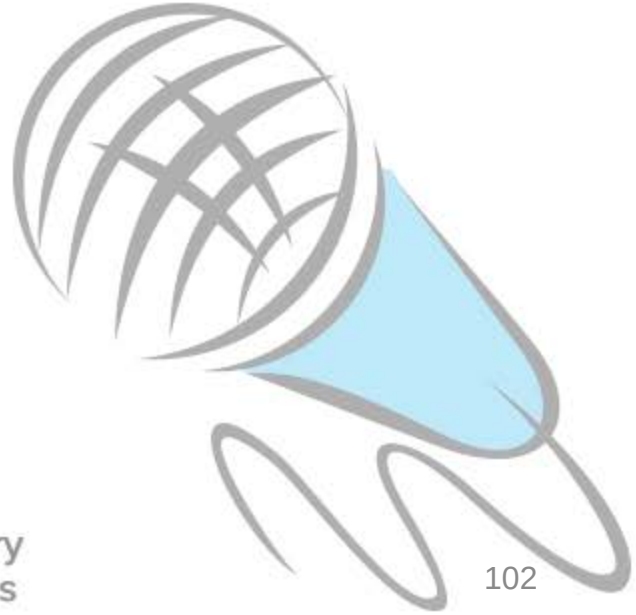
- Most/many consumers don’t trust/like their ISP
- 95% know what kind of Internet service they have
- Internet speed calculators, expert advice abounds
- Free on-line services evaluate Internet speed

Speed Advertising Claims, Substantiation, and Section 5

Joshua Stager

Open Technology Institute

New America

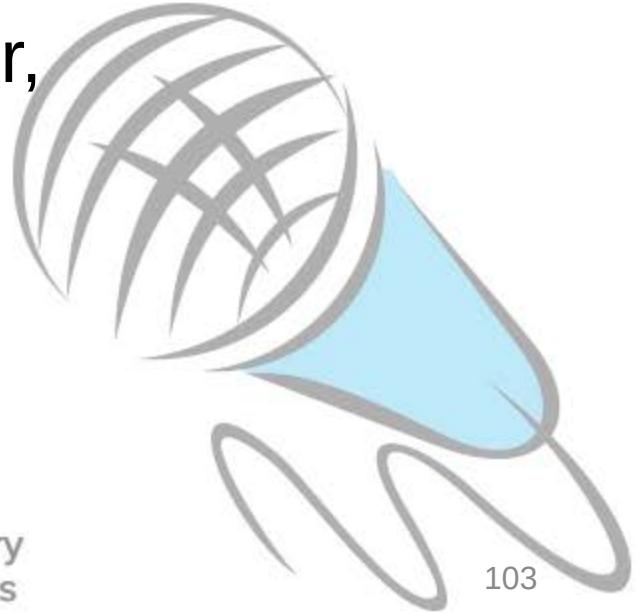


Speed Advertising Claims, Substantiation, and Section 5

Panel Discussion:

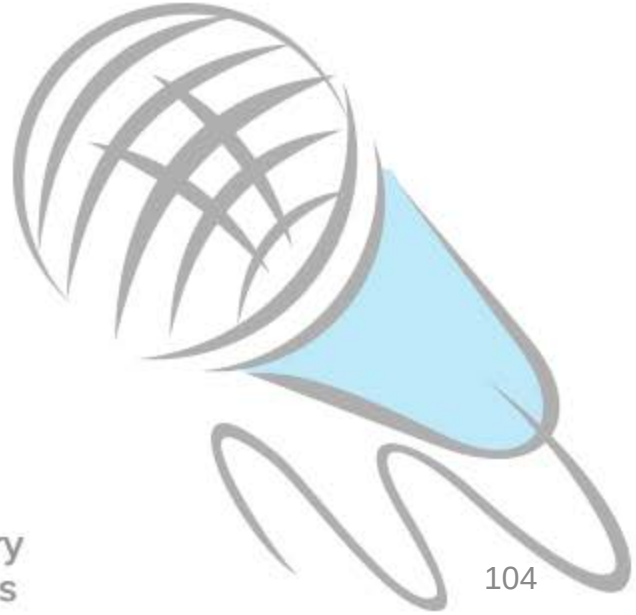
Laura Brett, David Clark, Nick Feamster,
Debra J. Ringold, Joshua Stager

Moderator: Kristin Williams



Break

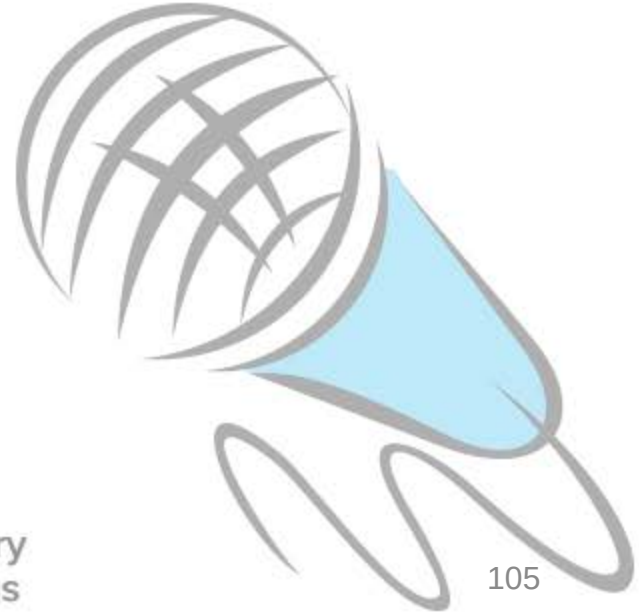
12:00-1:00 pm



Evolving Markets and Technological Developments: Market Structure

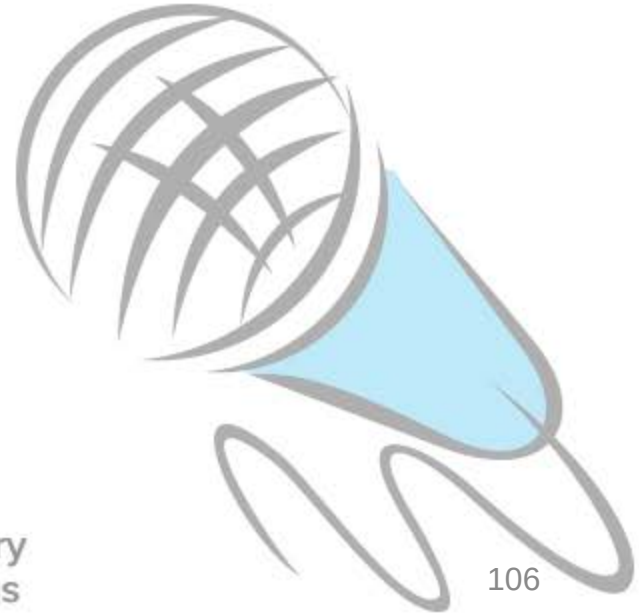
Session moderated by:

Ruth Yodaiken
Federal Trade Commission
Office of Policy Planning



Evolving Markets and Technological Developments: Market Structure

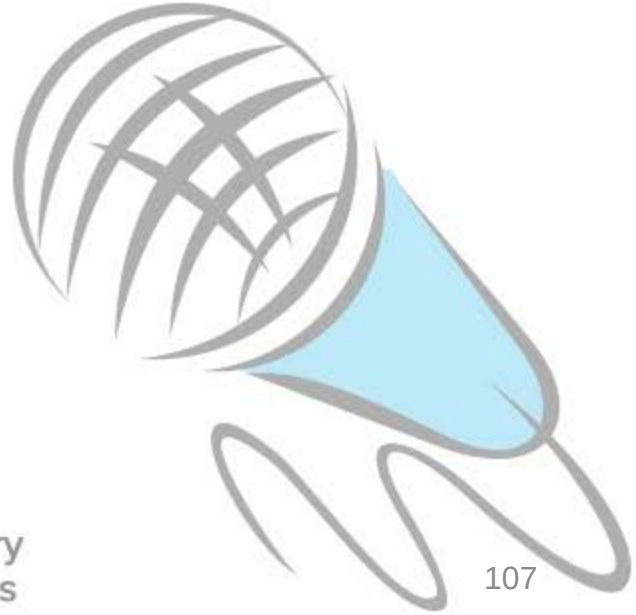
Matthew A. Brill
Latham & Watkins LLP



Evolving Markets and Technological Developments: Market Structure

Smaller Cable Operator Views on Broadband Markets, Technologies and Competition

Thomas A. Whitaker
Shentel



Overview: Broadband Markets Served by Smaller Cable Operators

- In rural broadband markets served by smaller cable operators,* despite higher costs to serve, competition exists and supply is growing
  - Network and service investment by smaller operators has been substantial and will continue to grow
    - Today most housing units served by smaller operators can receive DOCSIS 3.0 service (at least 100 Mbps), and performance is certain to increase[1]
  - Prices (as measured per Mbps) have declined rapidly[2]
  - New providers, including fixed and 4G wireless, satellite and electric coops, are constantly seeking to enter the broadband market in rural areas
- While smaller operators in rural markets have built to many unserved locations, consumers in more remote areas may be unserved; over the past 5 years, federal and state programs have reduced the number of unserved homes substantially, and these programs continue to work[3]

* Smaller cable operators initially provided traditional Pay TV service and moved into providing broadband service 25 years ago; today, as video margins have eroded, their predominant offering is broadband

Identifying Smaller Cable Operators That Provide Broadband Service

- Smaller cable operators serve about 8M broadband subscribers and pass about 17M housing units[4]
  - Shentel has ~75,000 broadband subscribers in VA, WV, and PA rural areas
- Most smaller cable operators, like Shentel, provide broadband service in rural markets
  - In general, smaller cable operators in rural markets for broadband service face more challenging economics because they lack network and operational scale, locations are less dense, and consumers are less well-off
- Other smaller operators “overbuild” incumbents in more urban markets
  - Overbuilders, like RCN and WOW!, further ensure robust competition but face challenging economics because they enter markets where incumbent providers already provide service, need to expend large amounts of capital upfront to build a network, and need to achieve scale rapidly to be viable

Smaller Cable Operators Face Competition in Downstream Broadband Markets

- Smaller cable operators' competitors in rural areas* in downstream markets --
  - **Incumbent telephone providers**
    - Virtually all smaller cable operators compete with an incumbent telco
    - For Shentel, the incumbent CenturyLink is a strong competitor because it provides 25 Mbps service at a low price point to loyal customers
  - **Other wireline entrants, like electric coops**
    - Electric coops have existing infrastructure (*e.g.*, poles) and operations
    - In Virginia, CVEC is overbuilding Nelson County Cablevision with an all-fiber network[5]
  - **Fixed wireless providers**
    - Fixed wireless providers have a low entry cost and tend to serve "value" customers with sufficient broadband speeds at prices 10-20% below wireline providers
  - **Satellite providers**
    - Satellite providers have capacity limits but a low entry cost and target "value" customers
  - **4G Mobile providers**
    - Many "value" customers can afford only one provider and often want mobile capability

*Overbuilders in more urban markets face competition from incumbent cable and telco providers, as well as mobile providers

Smaller Cable Operators Face Competition in Downstream Broadband Markets

- The existence of competition in downstream rural and "overbuild" markets served by smaller cable operators is indicated by –
  - **Increasing Supply (Investment)**
    - Smaller operators have invested over $12B in the past decade to upgrade their networks to DOCSIS 3.0/3.1 and continue to invest more than $1B annually[6]
    - Shentel has invested more than $125M over the past 5 years and will invest another $25M this year
  - **Declining Prices (on a per Mbps basis)**
    - Broadband prices for smaller operators have declined substantially on a per Mbps basis[7]
    - Shentel just reduced prices from $3/Mbps to $.50/Mbps; it offers 50 Mbps--$50/month, 150 Mbps--$80/month, and 300 Mbps--$110/month[8]
  - **Good Customer Service**
    - Smaller cable operators are recognized for their customer service[9]
    - Shentel was the independent operator of the year in 2017[10]

Smaller Cable Operators Have No Leverage in Upstream Broadband Markets

- Because smaller cable operators in rural markets* have fewer subscribers (traffic and “eyeballs”) and networks with no, or at most limited, regional reach --
  - Most smaller operators seeking to interconnect and exchange traffic with peering providers, edge providers, and CDNs need to use and pay a transit provider to carry traffic to and from an internet exchange points (IEP)
  - Shentel is somewhat unique in that its networks are relatively proximate to major IEPs and it has sufficient traffic to justify building to IEPs, but even then, it must pay for peering

*Overbuilders in more urban markets generally carry traffic to IEPs but must pay for peering

Concluding Thoughts about Broadband Markets Served by Smaller Cable Operators

- By virtually any measure, broadband service in markets served by smaller cable operators is a “good news” story
- Government can further increase supply by –
  - Removing barriers to network deployment, including by ensuring providers have timely access at reasonable cost to poles/conduit/ducts and to public and private rights-of-way
  - Awarding subsidies efficiently in “unserved markets” for the deployment of robust broadband networks
- Government also should ensure consumers have reasonable access to clear, accurate, and sufficient information about broadband service rates, terms, and conditions to select a provider and service tier

End Notes

[1] *See Communications Market Report et al*., GN Docket No. 18-231 *et al*., Report, FCC 18-181 at Fig. G-4 (Dec. 26, 2018)

[2] *See* Comments of the Fiber Broadband Association, FCC WC Docket No. 17-108 at 7-15 (July 17, 2017)

[3] Locations being served from FCC Connect America Fund Phase I – 638k; Phase II – 4.331M. Additional locations served from RUS Broadband Loan and Community Connect Grant programs and state programs such as the New York State Broadband program

[4] *Connecting Hometown America*, American Cable Association Paper, (2014) available at www.americancable.org

[5] "Central Virginia Electric Cooperative Announces First Stop in Appomattox for Fiber Network Installation," (June 22, 2018) available at https://www.mycvec.com/news/detail/central-virginia-electric-cooperative-announces-first-stop-in-appomattox-for-fiber-network-installation

[6] Derived from ACA member public announcements, discussions with ACA members, and SEC filings

[7] *See* note 2 above

[8] *The FCC's 2019 Urban Rate Benchmark: 50/5 Mbps for ~$100/month; 100/10 Mbps for ~$106/month; 250/25 Mbps for ~$129/month

[9] *See* "Readers' Choice Awards 2018: Internet Service Providers, PC Magazine (May 23, 2018)

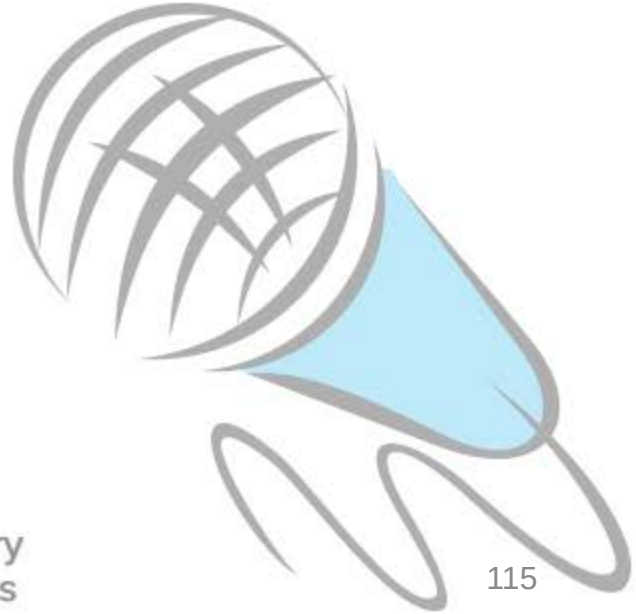
[10] Shentel, Cablefax's Independent Operator of the Year (June 8, 2017) available at http://www.cablefax.com/eventsawardswebinars/cablefaxs-top-ops-luncheon

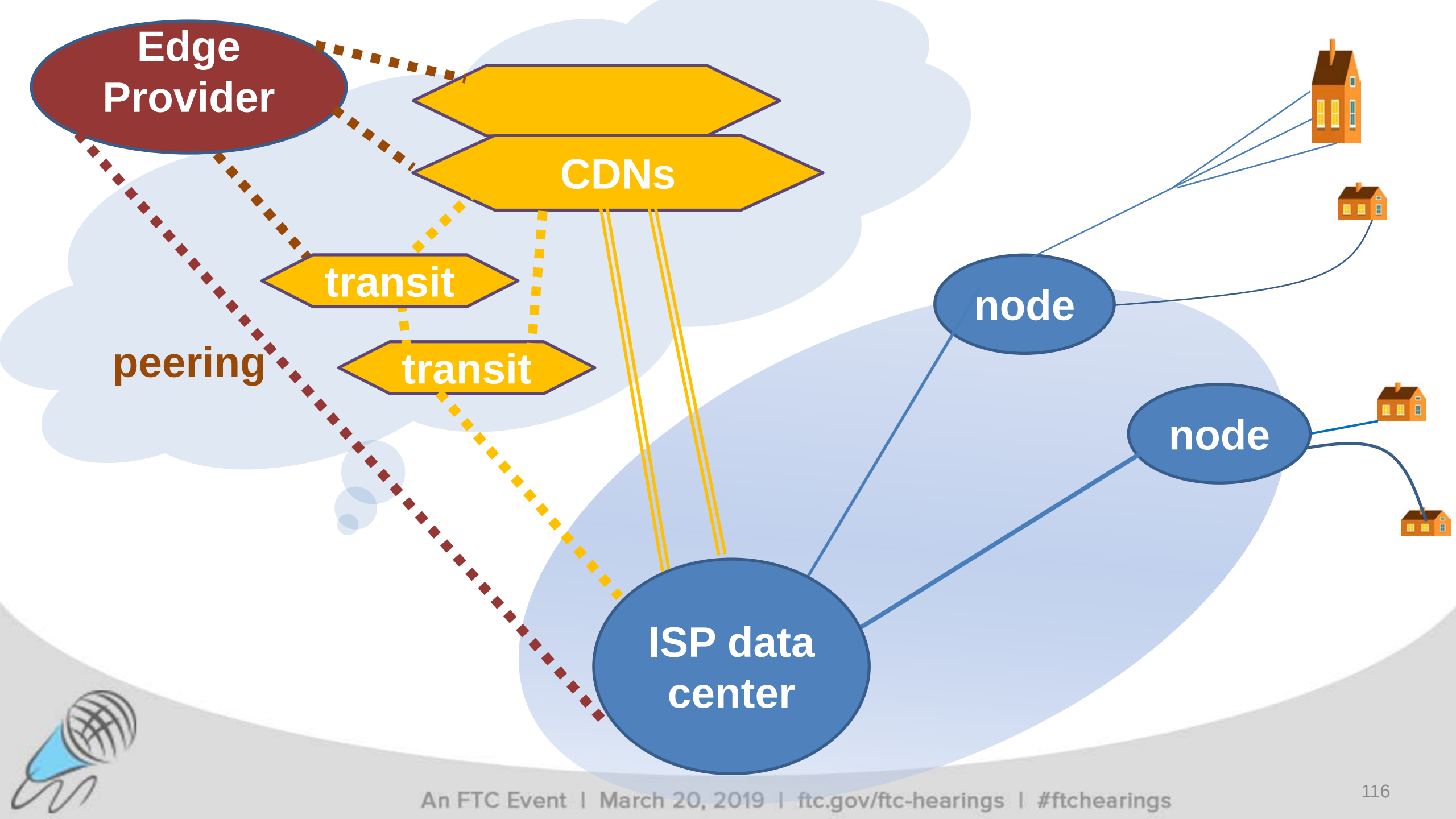
Evolving Markets and Technological Developments: Market Structure

Panel Discussion:

Matthew A. Brill, Thomas A. Whitaker,
Tithi Chattopadhyay, John Bergmayer,
kc claffy

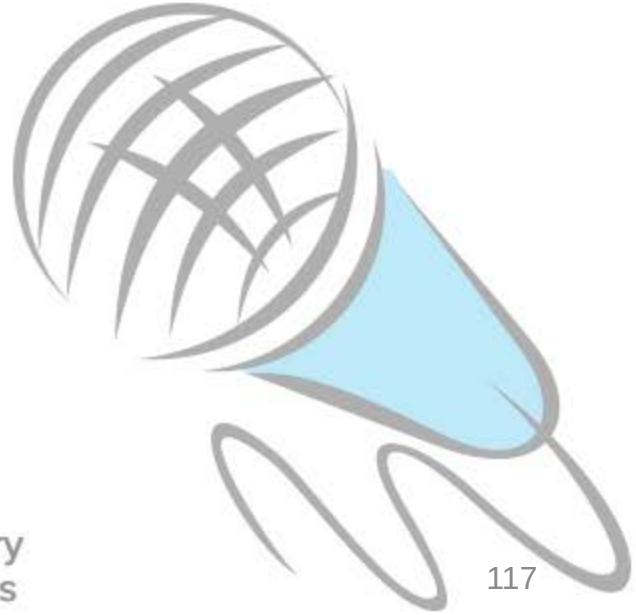
Moderator: Ruth Yodaiken




Edge Provider
CDNs
transit
transit
peering
node
node
ISP data center

Evolving Markets and Technological Developments: Market Structure

Tithi Chattopadhyay
Princeton University
Center for
Information Technology Policy



Overview

Market Structure

- The Network – Stakeholders and their relationships
- Investments in Broadband – Factors impacting investments
- Outcomes – How does one assess competition in this market?

What is going on in State Governments?

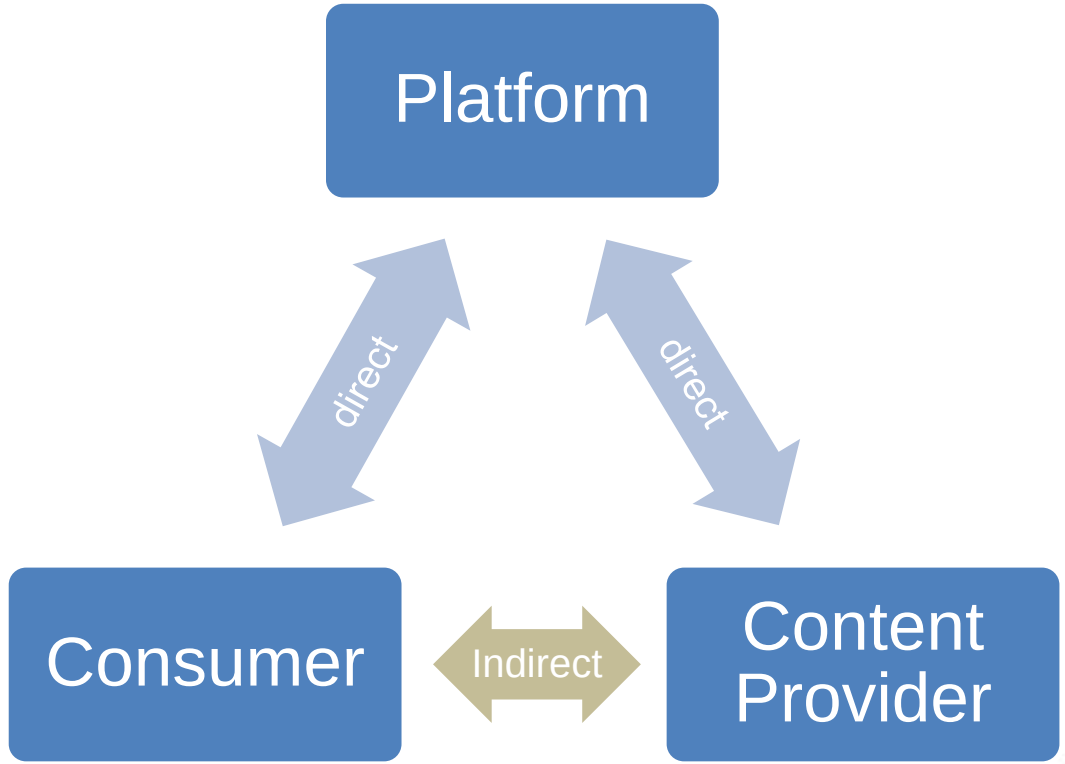
Market Structure: The Network

- Different stakeholders
  - Broadband providers – access & backbone
  - Edge providers
  - Consumers – residential, business and CAIs
- Other considerations for broadband stakeholders
  - Different technologies
  - Rural and urban markets

Market Structure: The Network

Economic relationships in the network

- Factors that determine prices in two-sided markets
  - Relative size of the other group
  - Price sensitivity of user groups
  - Type of fee levied



Market Structure: Investments

Factors impacting investments in this market

- Price discrimination – quality, quantity and market segments
- Product differentiation
- Other investment challenges – density of subscribers, regulatory hurdles, competitive hurdles

Market Structure: Outcomes

- Competition in this market
  - Horizontal relationships
  - Vertical relationships
- What does this mean to a consumer?
  - Switching costs
  - Understanding commercial terms & performance
    - What's changing?
  - Application specific information
    - Disclosing leveraging practices

What is going on in State Governments?

- Section 706 - Pertained to encouraging and incentivizing deployment of broadband technology
- After the 2017 FCC ruling – Four different strategies employed
  - Do nothing
  - Sue the FCC
  - Enhancing requirements for state contracts and grants
  - Direct state level laws
- Transparency and data collection
  - Passive testing and deployments
- Rural deployments

Evolving Markets and Technological Developments: Market Structure

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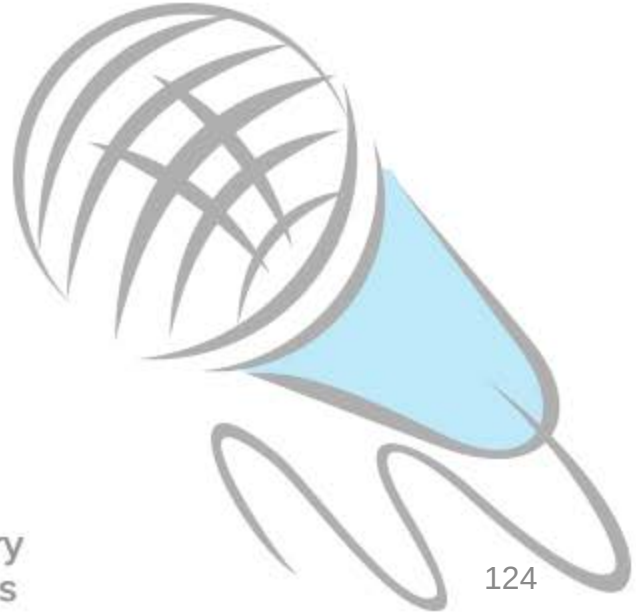
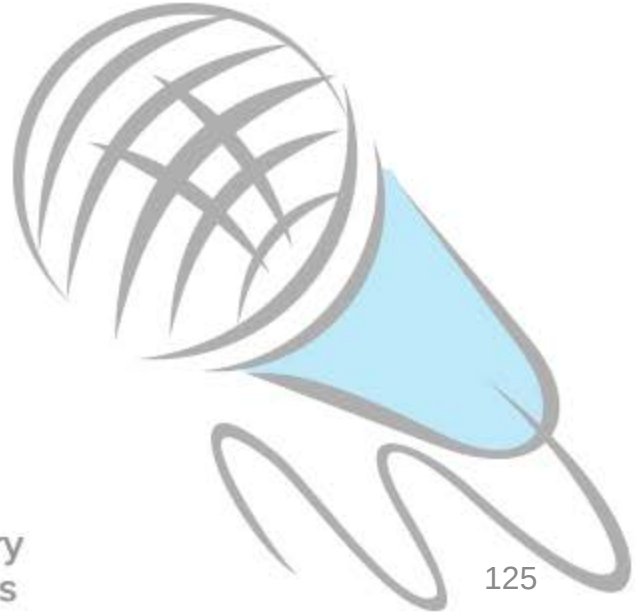
Tithi Chattopadhyay, John Bergmayer,
kc claffy

Moderator: Ruth Yodaiken



Evolving Markets and Technological Developments: Market Structure

John Bergmayer
Public Knowledge



Evolving Markets and Technological Developments: Market Structure

Panel Discussion:

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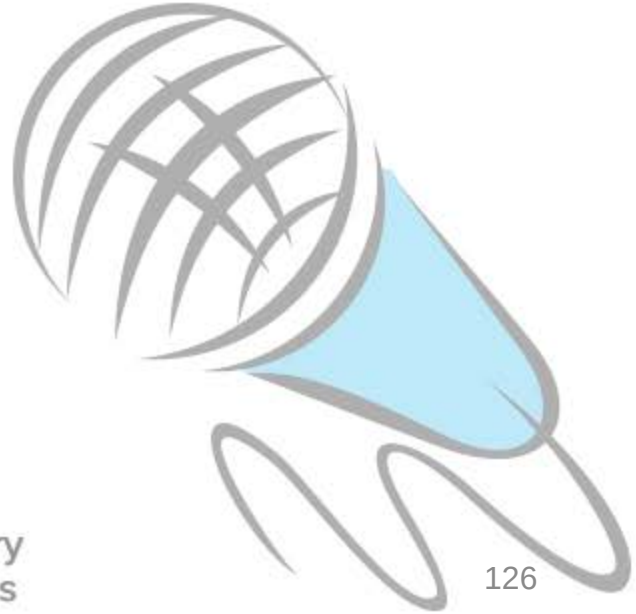
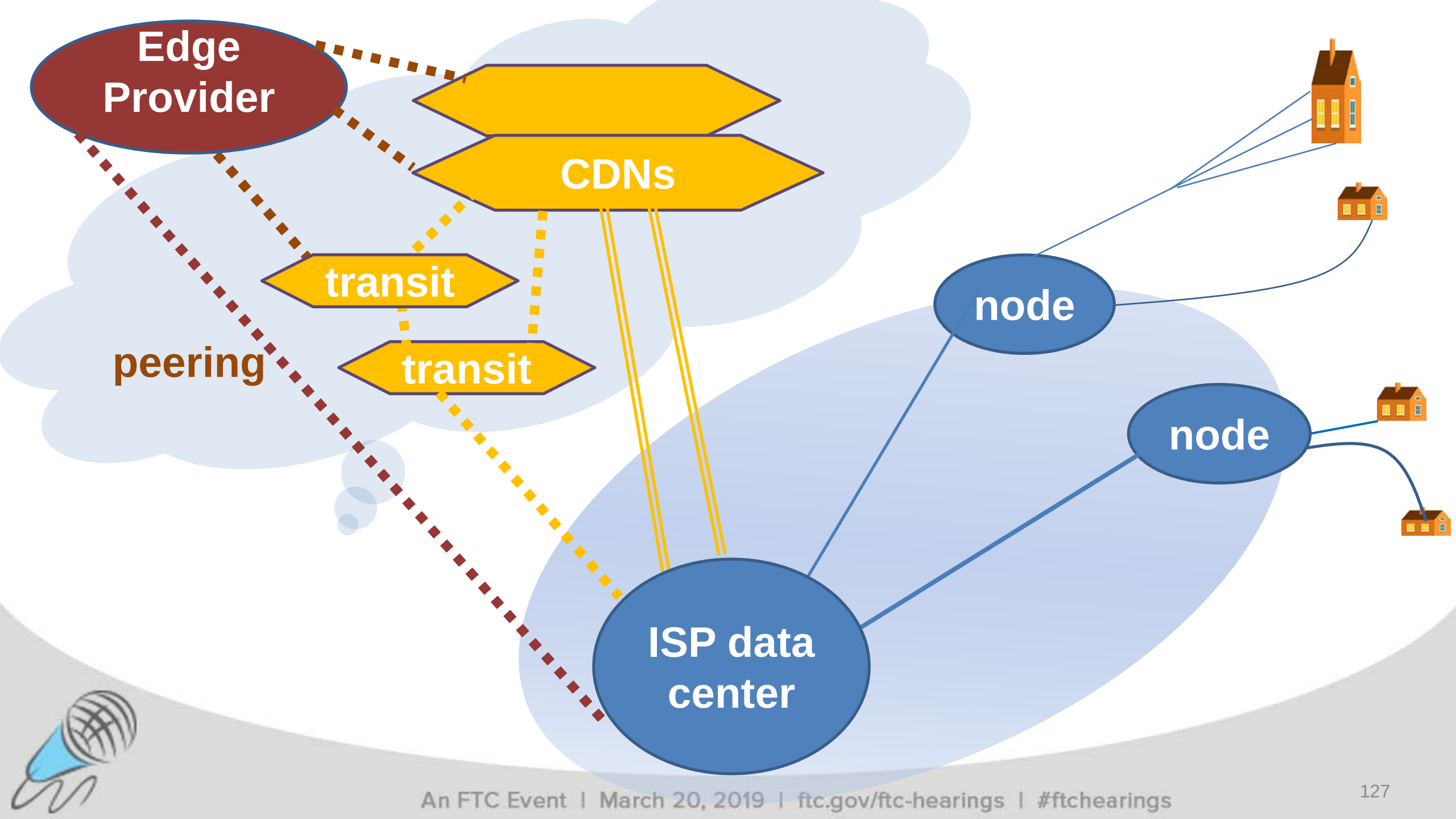
Tithi Chattopadhyay, John Bergmayer,
kc claffy

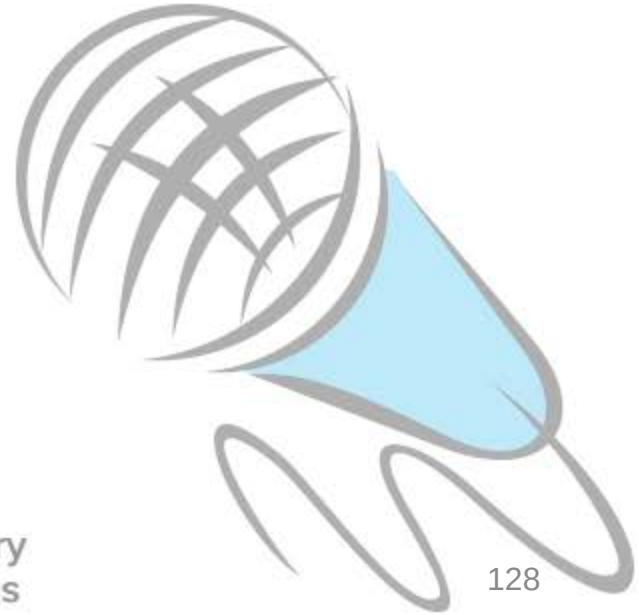
Moderator: Ruth Yodaiken




Edge Provider
CDNs
transit
transit
peering
node
node
ISP data center

Break

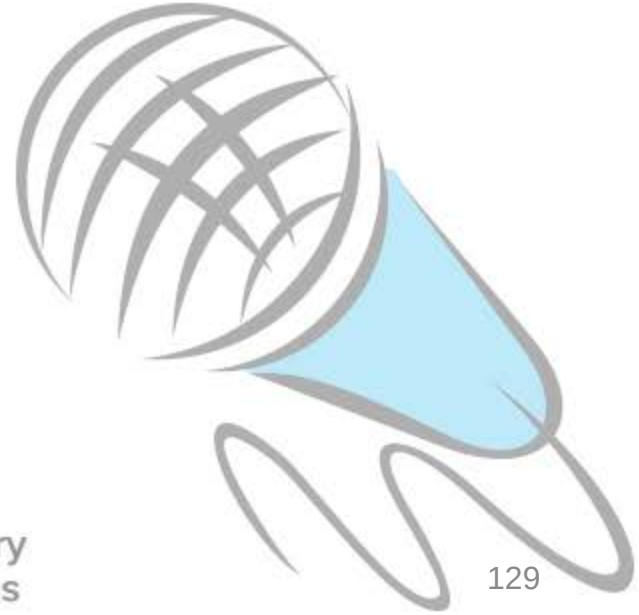
2:15-2:30 pm



Evolving Markets and Technological Developments: Policy Applications

Session moderated by:

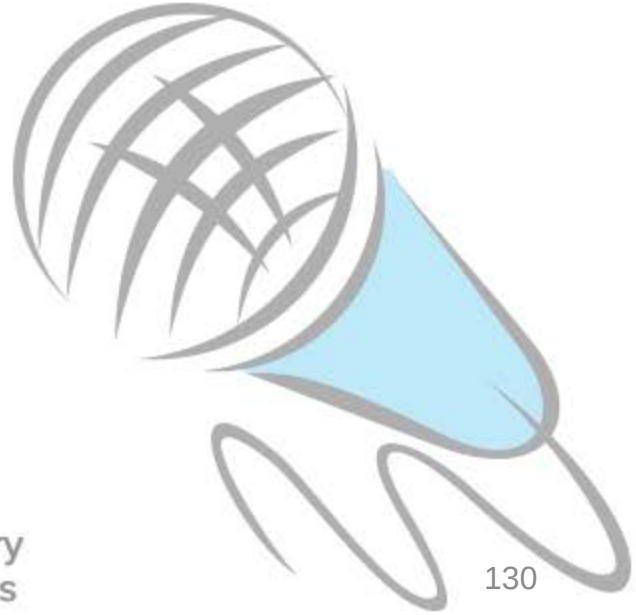
Suzanne Munck
Federal Trade Commission
Office of Policy Planning



Evolving Markets and Technological Developments: Policy Applications

Christopher S. Yoo

University of Pennsylvania

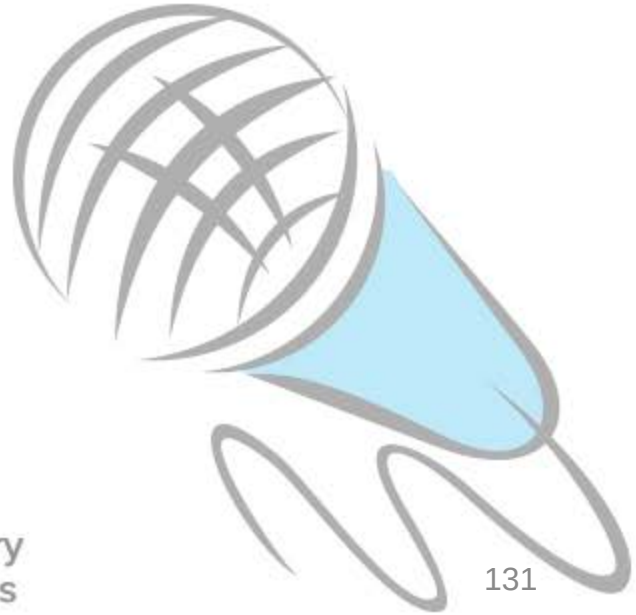


Evolving Markets and Technological Developments: Policy Applications

Gigi Sohn

Georgetown Law Institute for

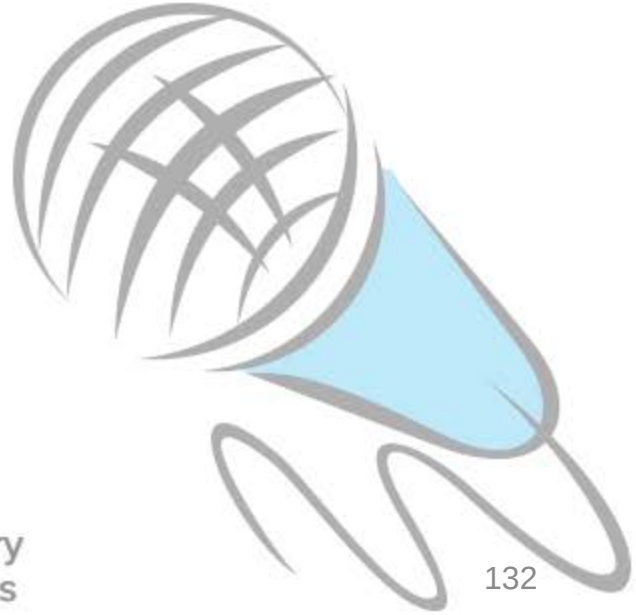
Technology Law & Policy



Evolving Markets and Technological Developments: Policy Applications

Berin Szoka

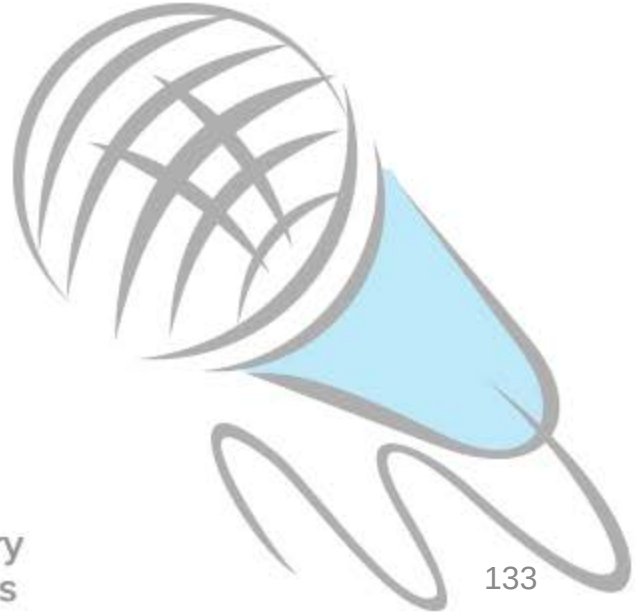
TechFreedom



Evolving Markets and Technological Developments: Policy Applications

Mitch Stoltz

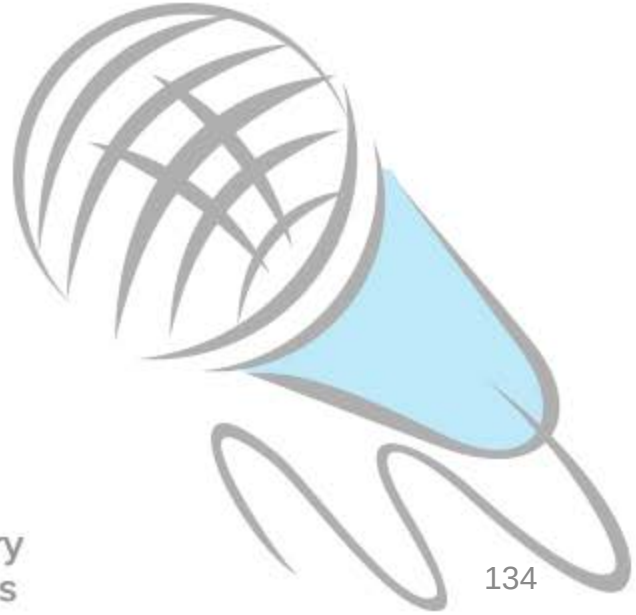
Electronic Frontier Foundation



Evolving Markets and Technological Developments: Policy Applications

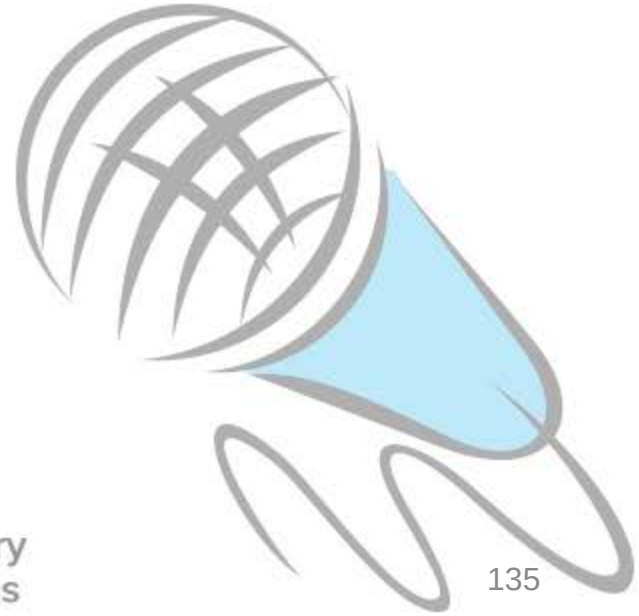
Tom Struble

R Street Institute



Evolving Markets and Technological Developments: Policy Applications

Tejas N. Narechania
University of California, Berkeley
School of Law

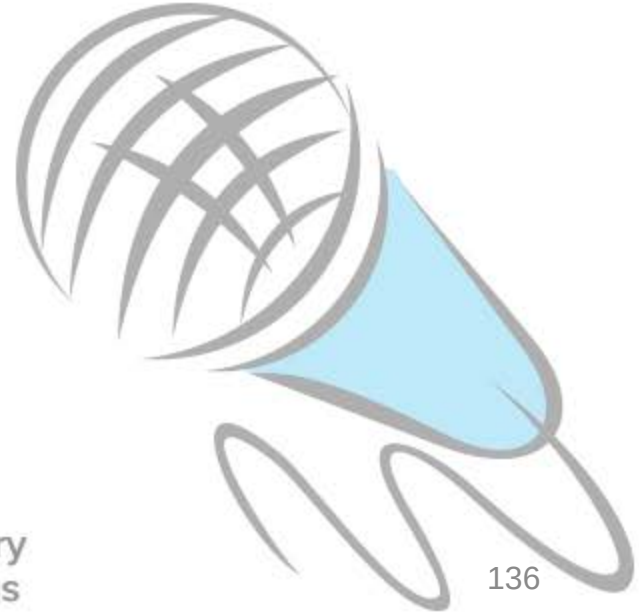


Evolving Markets and Technological Developments: Policy Applications

Panel Discussion:

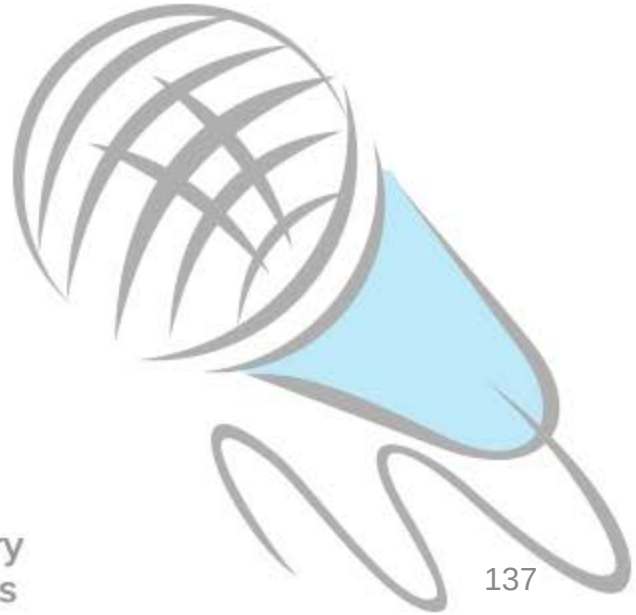
Christopher S. Yoo, Gigi Sohn,
Berin Szoka, Mitch Stoltz,
Tom Struble, Tejas N. Narechania

Moderator: Suzanne Munck



Break

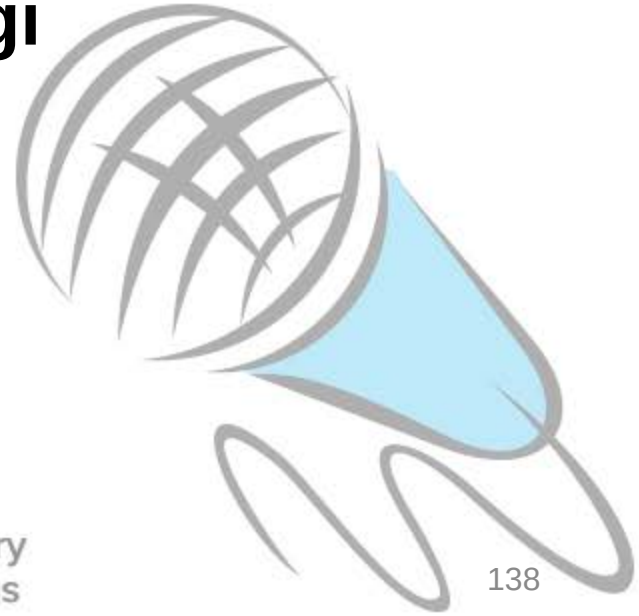
4:00-4:15 pm



Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

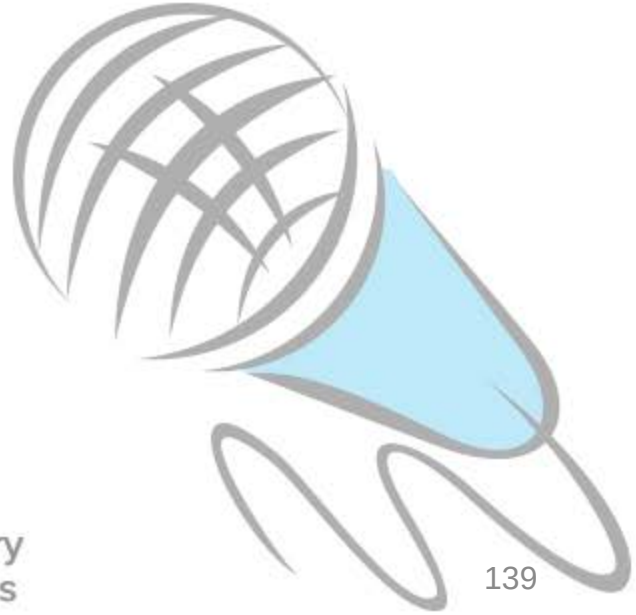
Session moderated by:

Suzanne Munck & Katherine Ambrogi
Federal Trade Commission
Office of Policy Planning



Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

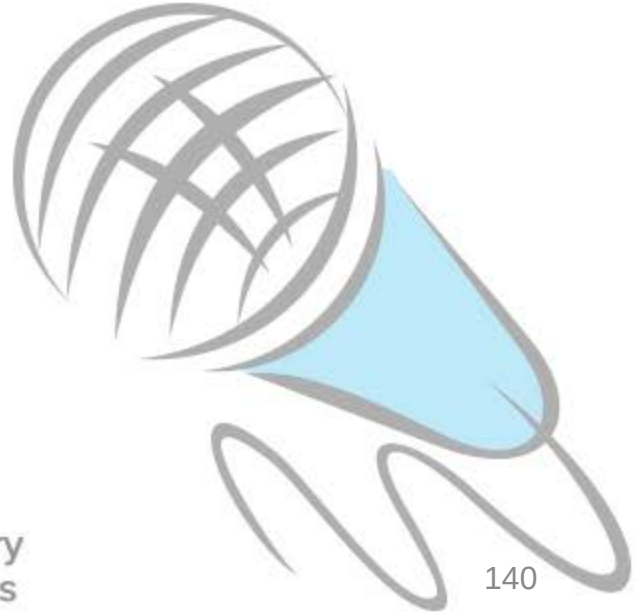
Howard Shelanski
Georgetown University Law Center
Davis Polk & Wardwell LLP



Hearings on Competition and Consumer Protection in the 21st Century
An FTC Event | March 20, 2019 | ftc.gov/ftc-hearings | #ftchearings

Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

Michelle P. Connolly
Duke University
Department of Economics



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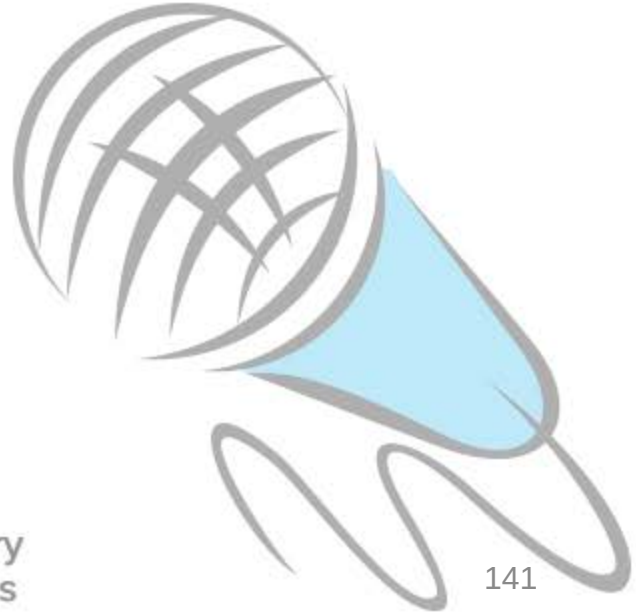
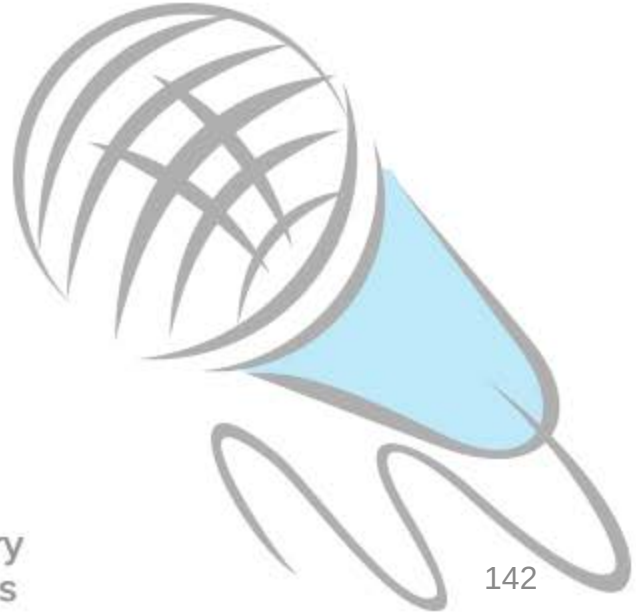
Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

William Blumenthal
Sidley Austin LLP



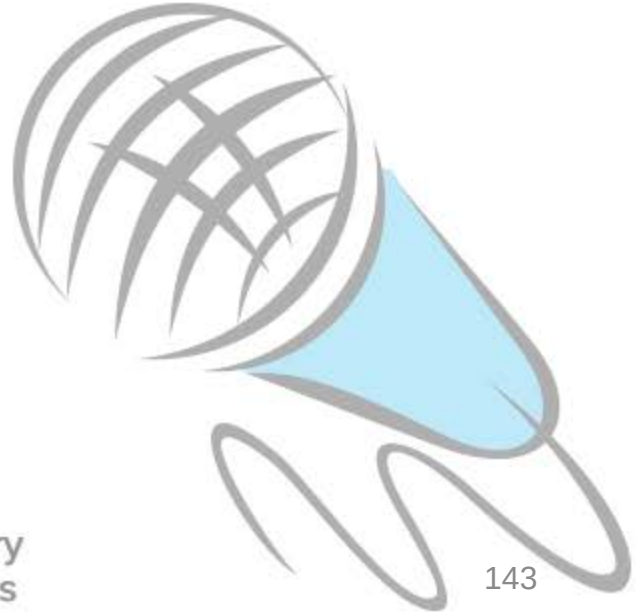
Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

Jonathan B. Sallet
Benton Foundation



Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

Michael L. Katz
University of California, Berkeley
Haas School of Business



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Identifying Efficiencies and Remedying Competitive Harms in Broadband Markets

Panel Discussion/Hypotheticals:

Howard Shelanski, Michelle P. Connolly,
William Blumenthal, Jonathan B. Sallet,
Michael L. Katz

Moderators: Suzanne Munck & Katherine Ambrogi

Hypothetical 1

An ISP supports a videoconferencing application for two years, until it discontinues support of the application. As a result, the ISP's customers no longer can access the videoconferencing program.

The ISP says that it discontinued service because the program uses too much data.

The press reports that the ISP is developing a competing videoconferencing service, although that service is not yet available to consumers.

Hypothetical 1

An ISP supports a videoconferencing application for two years, until it discontinues support of the application. As a result, the ISP's customers no longer can access the videoconferencing program.

The ISP says that it discontinued service because the program uses too much data.

The press reports that the ISP is developing a competing videoconferencing service, although that service is not yet available to consumers.

- ***What if*: The ISP has supported multiple videoconferencing applications for two years, including its own service. Now that its own service is more established, it discontinues support of previously supported competing services.**

Hypothetical 2

An ISP has 60% share in the relevant market. It does not provide a voice over internet protocol (VoIP) service, but several VoIP providers offer over the top service available via the ISP. The ISP enters into a contract with a VoIP provider who pays a fee to the ISP in exchange for preferred network management. A public interest group files a complaint with the FTC that customers of the OTT VoIP Services are experiencing service disruptions.

Hypothetical 2

An ISP has 60% share in the relevant market. It does not provide a voice over internet protocol (VoIP) service, but several VoIP providers offer over the top service available via the ISP. The ISP enters into a contract with a VoIP provider who pays a fee to the ISP in exchange for preferred network management. A public interest group files a complaint with the FTC that customers of the OTT VoIP Services are experiencing service disruptions.

- ***What if*: The ISP prevents customers from using the OTT VoIP services.**

Hypothetical 3

An ISP and a content delivery network (CDN) each have 60% share of their relevant markets. The ISP and CDN enter into a merger agreement. There is no direct overlap between the services offered by the merging parties. The ISP plans to integrate the CDN service into its network, and only offer the CDN content to its customers.

Hypothetical 3

An ISP and a content delivery network (CDN) each have 60% share of their relevant markets. The ISP and CDN enter into a merger agreement. There is no direct overlap between the services offered by the merging parties. The ISP plans to integrate the CDN service into its network, and only offer the CDN content to its customers.

- ***What if*: the ISP offers the CDN to its customers as part of their fee-for-service, but creates a pay-wall for customers who access the CDN content via other ISP services?**

Hypothetical 4

Two IP platforms operate their own private IP networks. The platforms also serve content to the public internet. The platforms create a joint venture by which they create a private platform for customers through which they offer prioritized network management for paying clients.

Thank You

Hearing #11: March 25-26

The FTC's Role in a Changing World

Federal Trade Commission, Headquarters

Hearing #12: March 25

Roundtable with

State Attorneys General

Federal Trade Commission, Constitution Center