Network Neutrality is About Money, not Packets
(Price discrimination, not packet discrimination)

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A simplified evolution of network neutrality

Early (2003-2009)
• no blocking
• attach non-harmful devices
• competition

Intermediate (2010)
• no blocking
• no discrimination
• transparency

Advanced (2015-)
• privacy
• interconnection
• zero rating & caps
• tethering

Reversal (2017?)
• semi-voluntary?
• anti-trust?

Authority unclear
Section 706
Title II
Information service?
How to be non-neutral

- **Application**
  - Deep packet inspection
  - Block Skype
  - User tracking

- **Transport**
  - Block transport protocol
  - Block ports
  - Insert RST

- **Network**
  - Block IP addresses
  - QoS discrimination
  - Zero-rating

Not all practices are necessarily violations
Some high-profile cases

- VPN blocking (Comcast, roughly 2001) - unconfirmed
- WiFi blocking (AT&T AUP, 2002)
- Madison River (2005)
  - DSL provider blocked SIP ports
  - fined $15,000 by FCC
  - based on Section 201 “just and reasonable”
- Comcast (late 2007)
  - insert TCP RST into BitTorrent traffic
  - later overturned on appeal in DC Circuit Court
- RCN (2009): P2P

- FaceTime on AT&T
- Comcast vs. Level 3 (2010, in dispute)
  - interconnection
- Comcast, Verizon, AT&T, … vs. Netflix
termination (2013-2014)
- Zero-rating (AT&T, T-Mo, VZ, Comcast)
2015 Open Internet rules

• Applied to both fixed and mobile wireless networks
• Transparency → Measuring Broadband America reports
• No blocking
• No unreasonable discrimination ("reasonable network management” exception)
  • historically, not contentious
• Interconnection as "area of observation"
• General conduct rule
It used to be simple (ca. 1990)
Vertical integration happened
Residential telecom is highly concentrated

Top Broadband Internet Providers in the U.S.

<table>
<thead>
<tr>
<th>Cable Companies</th>
<th>Subscribers at end of 4Q 2017</th>
<th>Net Adds in 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comcast</td>
<td>25,869,000</td>
<td>1,168,000</td>
</tr>
<tr>
<td>Charter</td>
<td>23,903,000</td>
<td>1,310,000</td>
</tr>
<tr>
<td>Altice</td>
<td>4,046,200</td>
<td>83,700</td>
</tr>
<tr>
<td>Mediacom</td>
<td>1,209,000</td>
<td>47,000</td>
</tr>
<tr>
<td>WOW (WideOpenWest)</td>
<td>732,700</td>
<td>13,800</td>
</tr>
<tr>
<td>Cable ONE*</td>
<td>524,935</td>
<td>11,027</td>
</tr>
<tr>
<td>Other Major Private Company**</td>
<td>4,880,000</td>
<td>90,000</td>
</tr>
<tr>
<td><strong>Total Top Cable</strong></td>
<td>61,164,835</td>
<td>2,723,527</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telephone Companies</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AT&amp;T</td>
<td>15,719,000</td>
<td>114,000</td>
</tr>
<tr>
<td>Verizon</td>
<td>6,959,000</td>
<td>(79,000)</td>
</tr>
<tr>
<td>CenturyLink</td>
<td>5,662,000</td>
<td>(283,000)</td>
</tr>
<tr>
<td>Frontier</td>
<td>3,938,000</td>
<td>(333,000)</td>
</tr>
<tr>
<td>Windstream</td>
<td>1,006,600</td>
<td>(44,500)</td>
</tr>
<tr>
<td>Cincinnati Bell</td>
<td>308,700</td>
<td>5,500</td>
</tr>
<tr>
<td>FairPoint^</td>
<td>301,000</td>
<td>(5,624)</td>
</tr>
<tr>
<td><strong>Total Top Phone</strong></td>
<td>33,894,300</td>
<td>(625,624)</td>
</tr>
<tr>
<td><strong>Total Top Broadband</strong></td>
<td>95,059,135</td>
<td>2,097,903</td>
</tr>
</tbody>
</table>
Economic incentives for carriers

• Reducing competition for vertically-integrated services
  • make competitor less attractive (quality, price)
    • e.g., only offer higher speed tiers for MVPD subscribers
  • volume discrimination (zero-rating for own content or service)
    • → Madison River VoIP, Comcast RST, Netflix interconnection

• Two-sided market
  • termination monopoly → no “fair” price
    • cost for incremental quality or traffic can’t be determined objectively
    • very little of the fixed network cost depends on volume
  • overlaps with first concern
  • third-party paid services
    • → Netflix interconnection, ”intercarrier compensation”

• Leveraging customer information
QoS

• Well-known: no end-to-end (inter-provider) QoS
• But local QoS $\rightarrow$ “specialized services”
  • VoIP, MVPD video
• Problem: for any reasonable service, most of the time, high-QoS $\equiv$ basic-QoS
  • $\rightarrow$ users will only upgrade rarely (see Paris Metro pricing)
• No good charging mechanism:
  • carrier-provided application: advantages provider
  • negotiated individually: scaling problems for small providers or small ISPs
  • paid by third party automatically: end-to-end signaling?
    • block chain!
  • subscriber paid by bucket: plausible
  • zero cost: e.g., “get 2 Mb/s at low latency, up to 1 GB/month” $\rightarrow$ consumer choice
Principle 1: User choice

• User choice as metric for reasonable carrier behavior
  • in addition to network protection against attack or abuse
• Encapsulate no blocking, no discrimination
• Allows QoS differentiation
  • users can designate traffic
  • requires UNI signaling mechanism \(\rightarrow\) SDN simplifies
  • probably API rather than (say) RSVP
    • easy except for differential charging
Principle 2: Virtual Structural Separation

- Structural separation theoretically avoids vertical integration concerns
  - traditionally, separate layer 3 and layer ½
  - here, layer 3 vs. applications

- But price setting is unsolved problem
  - easier for QoS than base rate (smaller $!)
    - margin squeeze problem
  - use non-vertically-integrated provider as benchmark?
Principle 3: Transparency

• Not just performance, but price
  • see 2015 OI order
  • ISPs are only large consumer expenditure that’s non-transparent
    • and health care – but there is no Packet Insurance
    • “taxes, fees, and surcharges not included”
    • Try predicting second-year charge for residential ISP

• Price discrimination by obfuscation
NN challenge: customer differentiation

• Inconvenient for both sides of NN debate: business vs. residential users
  • with fiber, speed, quality, facilities likely similar
• Download speed increases reaching diminishing returns
• Volume limitations are unpopular
  • but may be sufficient to separate home ”edge computing” from residential use
• Prediction: three tiers
  • Variable-speed mobile for price-sensitive (small) households
  • Near-flat fiber access with below-server cap
  • Business volume metered (similar to cloud services)
Conclusion

• NN is an economics (charging) problem, not a QoS or network management problem
  • Price discrimination, not packet discrimination
• Made much more difficult by vertical integration and lack of competition
  • Including difficulty of using multiple services at once
• Reach same conclusion as for voice telephony: flat rate, with $0 ICC