Technology and the Benefits and Risks of Network Neutrality Requirements

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Net Neutrality and Discrimination

- Advocates say networks have ability and incentive to limit customer choices through discrimination.
- Opponents say network neutrality legislation could interfere with useful activities
- Both are right.

- This talk will address
  - How emerging technology can discriminate
  - How discrimination can benefit users
  - How discrimination can harm users, *if* network has sufficient market power
  - Why we should seek a *balanced* policy
  - How the issue has been mis-framed under vague principles

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What is Net Neutrality?

- Definitions have *not* converged.

- According to principles endorsed by the FCC, consumers should

    1. have access to legal content of their choice
    2. be able to run applications of their choice
    3. be permitted to attach devices of their choice
    4. receive meaningful information on their service plans
        - or the right to choose among competing providers

- Access to content/application/device could depend on
    - availability,
    - availability at acceptable quality of service, and/or
    - availability at a reasonable price.

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Internet is based on Packet Switching

Divide content into discrete pieces.

Place data pieces into packets, with control information.

Send each packet separately.

HEADER	DATA	TRAILER

CONTROL INFO SUCH AS SOURCE, DESTINATION, ETC.

CONTROL INFO SUCH AS CRC

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Early Internet Technology

- Best effort delivery of packets
  - packets lost, delayed, delivered out of order
- Most resources allocated first-come-first-served
  - Priority was possible, but not used
- Little intelligence within the network to defend against threats

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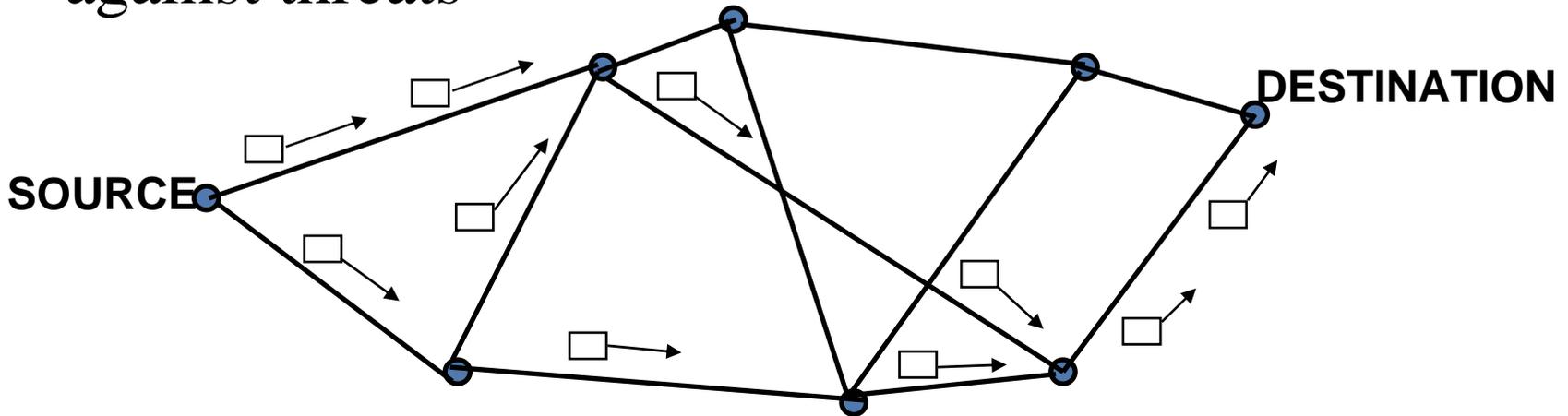
Technology of Discrimination

- Two orthogonal aspects of discrimination
  - Must determine which packets/users/streams to favor
  - Must provide benefits to favored group

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Determining which streams to favor

- Traditional: Use fields in header, one packet at a time
  - e.g. IP addresses, port numbers, MAC addresses
  - Reveals identity of sender and recipient, sometimes device manufacturer
  - Information about application is unreliable
- Now possible: Flow classification
  - Maintain state for all streams underway
  - Considers packet size, interpacket gap, stream duration
- Now possible: Deep packet inspection
  - Maintain state, combine info from many packets
  - Can access application-layer information
- Can cross-index with information not in traffic
  - use identity of user to look up billing info, credit info, etc.
- With all of the above, network has detailed info on each stream
  - It knows subscriber, application, content, content/service provider, attached device, billing info, and more

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Helping favored streams/hurting others

- Block streams

- Put favored traffic in better "channel"
  - May or may not meet typical definition of "discrimination"

- Let traffic control algorithms adjust data rates, end-to-end delays, packet loss rates, blocking rates (QoS)
  - Scheduling: which packet is transmitted next?
  - Dropping: which packet is dropped during overflow?
  - Admission control: which stream can begin transmission?
  - Routing: which path should a packet take?

- Add fee based on type of traffic observed
  - e.g. application, content, subscriber, content/service provider.

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Benefits of Blocking

- Identify and block security threats
  - e.g. malware, denial of service attacks, fake control packets
  - Cannot always identify threat. There will be false positives and false negatives
- Block traffic from non-conforming devices
  - e.g. to insure that devices obey protocols

Discrimination to Improve Fairness

- With high-speed always-on connections, traffic from a few users can dominate network, so others could starve
- After a user's limit is reached,
  - block traffic, or
  - assign low priority to user's traffic, or
  - charge user extra

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Discrimination for Diverse Services ("A bit is a bit" and other fallacies)

- Different services impose different burden on a network
  - High or low data rate.
  - Steady or highly bursty.
  - Different quality of service (QoS) requirements
  - May or may not adapt when there is congestion.
- With discriminatory traffic control algorithms
  - Carry more traffic and still meet diverse QoS requirements
  - Might reduce infrastructure cost per user.
- With discriminatory pricing
  - Can provide incentive to accept lower-priority service.
  - Can provide incentive to shift usage to less congested period
  - Can align price per packet with "cost" per packet.
    - Cost is opportunity cost

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Monopoly Rents in the Broadband Market

- Network operator has *extensive* information
  - From inspecting all traffic, billing info, more
- Extract consumer surplus by using this info to set prices as close as possible to what user is willing to pay.
  - Shifts benefit of Internet access from users to carrier
  - For both consumers and content/service providers
- Intentionally degrade QoS so those willing to pay for better service will do so.

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Monopoly Rents in Upstream Market

- Many "upstream" markets depend on Internet
  - e-commerce, communications (videoconferencing, VOIP), info distribution (video streaming, MP3s), advertising, consumer devices

- As with broadband market
  - Network can exploit extensive information
  - Deliberately degrade QOS to further segment market
  - To extract consumer surplus, set price near willingness to pay *in each market*
  - Shifts benefit of each market from users to carrier

- Separate markets
  - VOIP from downloading digital products
  - Downloading PDFs from downloading MP3s
  - Downloading one song from another

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Monopoly Rents in Upstream Market

- Examples
  - On e-commerce sites, charge 1 cent for book sale, 2 cents for CD sale
  - Charge 20 cents for popular iTune download, 10 cents for less popular
    - Network knows which are popular.
  - Charge 10 cents per minute of (unaffiliated) VOIP traffic
- Observations
  - Can protect legacy services (telephony, video broadcasting)
    - One vendor calls this "revenue bypass"
  - Can extract monopoly rents from competitive markets
    - i.e. Consumer pays monopoly prices, some to carrier
  - Can do so without entering market or affiliating with provider

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Content Filtering and Discourse

- Will networks limit access to content because it is harmful to the company?
- Politics
  - Advocacy for issues that the company opposes
  - Candidates who the company opposes
- Commerce
  - Rivals competing with the company
  - Consumers complaining about the company
  - Labor unions opposing the company
- There are accusations that some of this is happening already, and denials

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A Balanced Policy

- Can we find a policy that limits how network operators can discriminate in a manner that
  - prevents them from fully exploiting market power in ways that seriously harm users, and
  - does not prevent them from using discrimination in ways that greatly benefit users?
- Impact on upstream markets is probably most important
  - More total consumer surplus in upstream markets.
  - Harder to prevent harmful discrimination in broadband market
- With discrimination intended to extract consumer surplus in upstream markets, prices are likely to be inconsistent with costs.
  - where costs are opportunity costs of carrying traffic
  - This observation may help define an effective balanced policy.

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Conclusions on Discrimination

- Discrimination can benefit users
  - improve security, improve quality, decrease infrastructure cost, allocate resources to those who value them the most.
  - Imposing net neutrality could do harm.
- Discrimination can harm users if network operator has sufficient market power.
  - Network has access to extensive information
  - Using this info, network can discriminate to extract consumer surplus in broadband market and each upstream market,
    - even if the upstream market is competitive
    - even if the network is not affiliated with any upstream provider
  - Not imposing net neutrality could do harm

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Conclusions on Net Neutrality

- Debate should focus on specifics of a balanced policy
  - Deter most harmful forms of discrimination
  - Allow most beneficial forms of discrimination
  - It may not be possible to preserve *all* beneficial discrimination and eliminate *all* harmful discrimination

- Debate has been mis-framed. It should not be about
  - The inherent evils of discrimination
  - Unfair affiliate relationships, vertical integration
  - The rights of networks to differentiation
  - The freedoms of end users
  - Other diversions

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For more information, see

"The Benefits and Risks of Mandating Network Neutrality, and the Quest for a Balanced Policy"
www.ece.cmu.edu/~peha/policy.html

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