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What is the Network Neutrality Debate About?

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U.S. Debate Highly Politicized

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Framing the Debate

- **"The Future of the Internet is at Stake"**
- **"Keep the Internet Free of Regulation"**
- **"Protect Internet Freedom"**
- **"Hands off the Internet"**
- **"Now what they would like to do is use my pipes free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it. So there's going to have to be some mechanism for these people who use these pipes to pay for the portion they're using. Why should they be allowed to use my pipes?"** ***CEO of AT&T***

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Outline

- What is neutrality/non-neutrality
- Types of Discrimination
- Economics of Discrimination
- User responses to discrimination
- Current U.S. legislation

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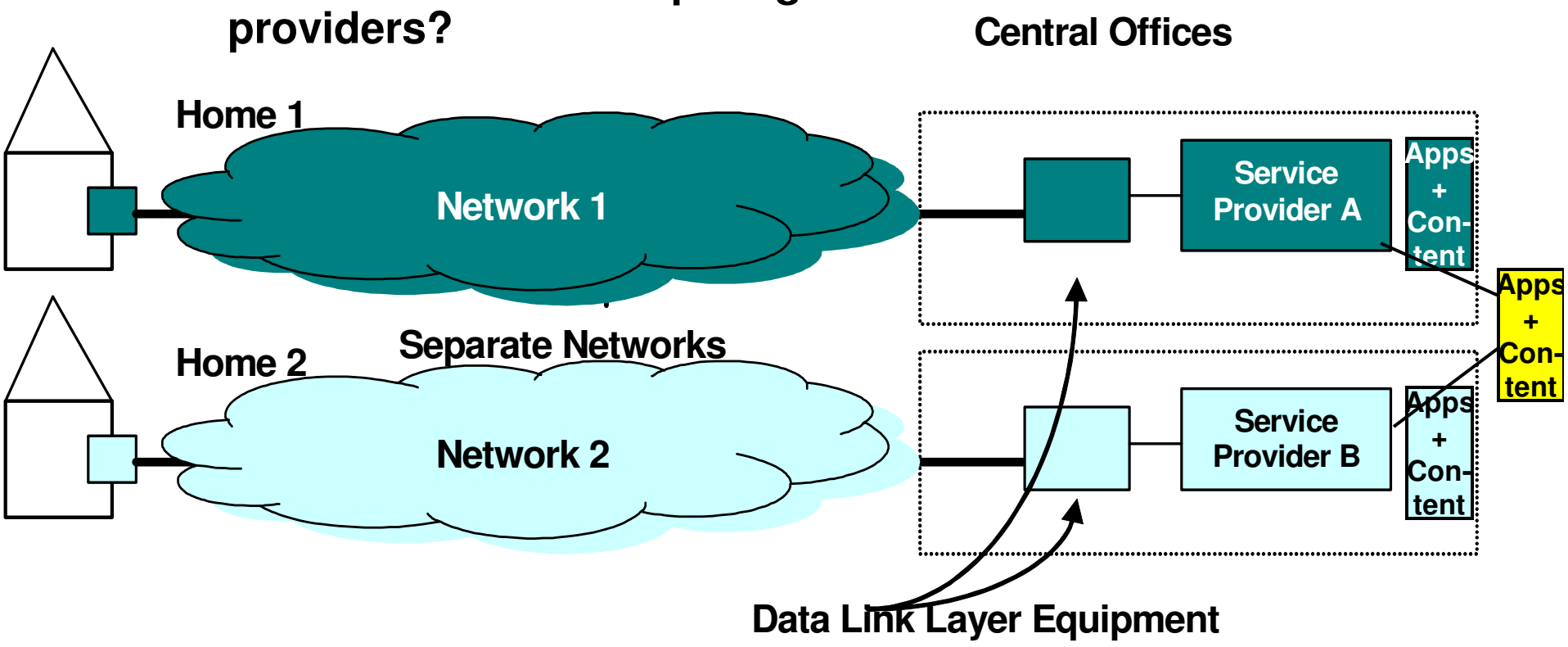
What is Net Neutrality?

- Will vertically integrated ISPs allow unfettered access to unaffiliated or competing content and services providers?



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Examples of Net Neutrality Concerns

- **Internet Access Providers might**
  - **Block access to applications or services which compete with similar services offered by affiliates**
  - **Provide multicasting or superior QoS only to affiliates and not to non-affiliates**
  - **Engage in exclusive dealing for access to QoS capabilities**
  - **Deliberately degrade performance for some applications to provide relatively better performance for others**
  - **Block access to content with which IAP disagrees politically**
  - **Degrade "best effort" service to incent consumers to purchase more costly "QoS-enhanced" service**
  - **Force non-affiliates to interconnect at economically disadvantageous locations compared to affiliates**

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Perspectives on Net Neutrality

- A network management issue?
- An economic issue?
- An innovation issue?
- A Free Speech issue?
- A truth-in-advertising issue?
- A governance issue?

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Net Neutrality: A Network Management Frame

- How should ISPs deal with the rapid growth of Internet Traffic
  - Adjust prices within the current flat-rate, best effort model
  - Rationing of capacity for particular applications
  - New pricing models based on usage
  - New pricing models based on quality of service
- Concerns about how these new business models affect competition and innovation
- How should ISPs deal with security?
  - Spam, “Phishing,” Distributed Denial of Service attacks

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Net Neutrality: An Economic Framing

- Potential for abuse of market power
  - In the U.S., Internet Access Providers have Significant Market Power
  - Fears that IAPs will use this SMP in anti-competitive ways in the market for interconnection, services and applications
- IAP has terminating monopoly
  - Once consumer has picked an IAP, the IAP has a monopoly on access to that consumer
    - Can extract monopoly rents from those trying to reach consumer
- Introducing product quality variation provides scope for welfare enhancing price discrimination to support capital investment

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Net Neutrality: An Innovation Frame

- Current operation of the Internet has allowed many new ventures to emerge offering diverse applications and services
  - *e.g.* Skype, Napster, Youtube, MySpace
- New business models being discussed by IAPs may make launching new services more costly and more difficult resulting in less innovation

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Static vs Dynamic Efficiency

- Static efficiency sets prices to maximize welfare in short term
- Dynamic efficiency considers impact of prices on entry and innovation.
  - Allocating more cost to content providers may reduce content/application diversity and entry
  - Content diversity has externality benefits not appropriable by network operators
    - ➔Therefore they are likely to undervalue it
- "Money for network investment" vs "Preserving the freedom to innovate new services and applications"

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Net Neutrality: A Political Framing

- **Free speech concerns**
  - **Fears that IAPs will discriminate or block access to content based on political considerations**
  - **More than 30 countries in the world block access to some types of web content**

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Net Neutrality: A Truth-In-Advertising Frame

- Operators advertise “speeds up to X Mbps”
  - Advertised speeds rarely available
- Operators rate limit certain applications without notice to consumers or providing alternatives for those who value those applications
- Operators terminate customers for “overuse” without defining what that means or providing means for customers to monitor their usage

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Net Neutrality: A Governance Frame

- If there are legitimate concerns to be protected by government action, what should that action be?
  - How to write a rule which prohibits or discourages "bad" behavior while minimizing interference with "good" or innovative behavior?
- Statute versus regulatory proceeding
- *Ex ante* vs *ex post* regulation

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Why Has This Issue Emerged in U.S.?

- U.S. wireline broadband market is effectively a duopoly
  - Dominated by incumbent LEC and cable operator
- Unlike Europe, U.S. has abandoned effective enforcement of LLU, line sharing, and bitstream access
- Lack of competition means little protection against potential discrimination by access providers

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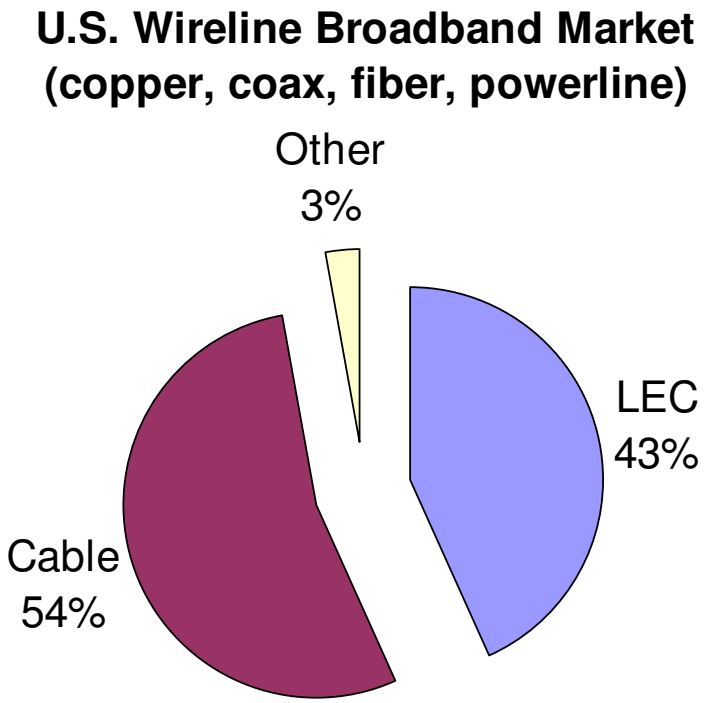
Duopolistic U.S. Wireline Broadband Market



Source: U.S. FCC, "High-Speed Services for Internet Access: Status as of June 30, 2006," FCC January, 2007

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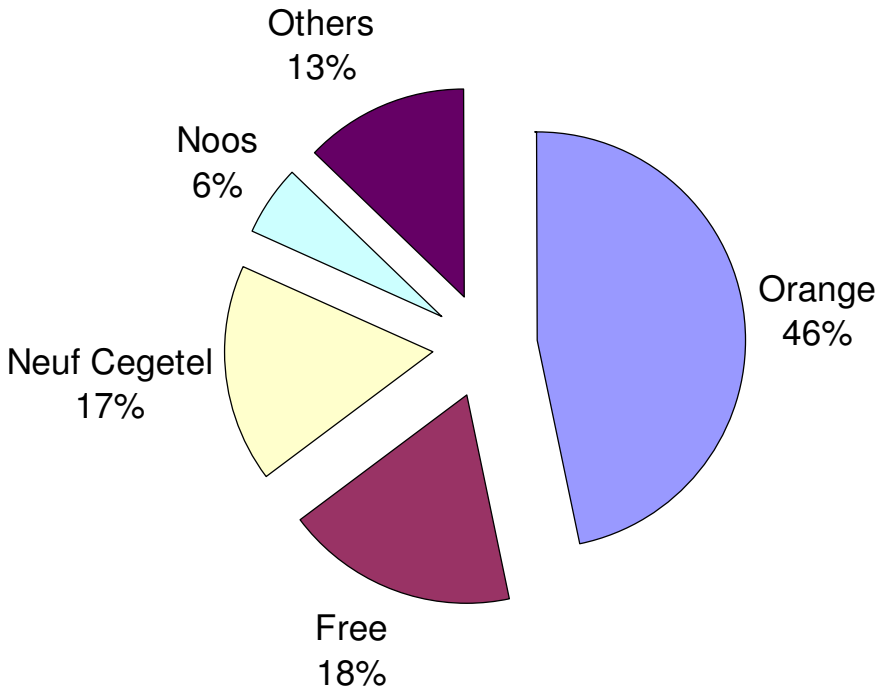
Compare to the French Broadband Market

France Broadband Market Shares
As of 12/31/2006



Source: http://www.zdnet.fr/actualites/internet/0,39020774,39367842,00.htm and ARCEP data

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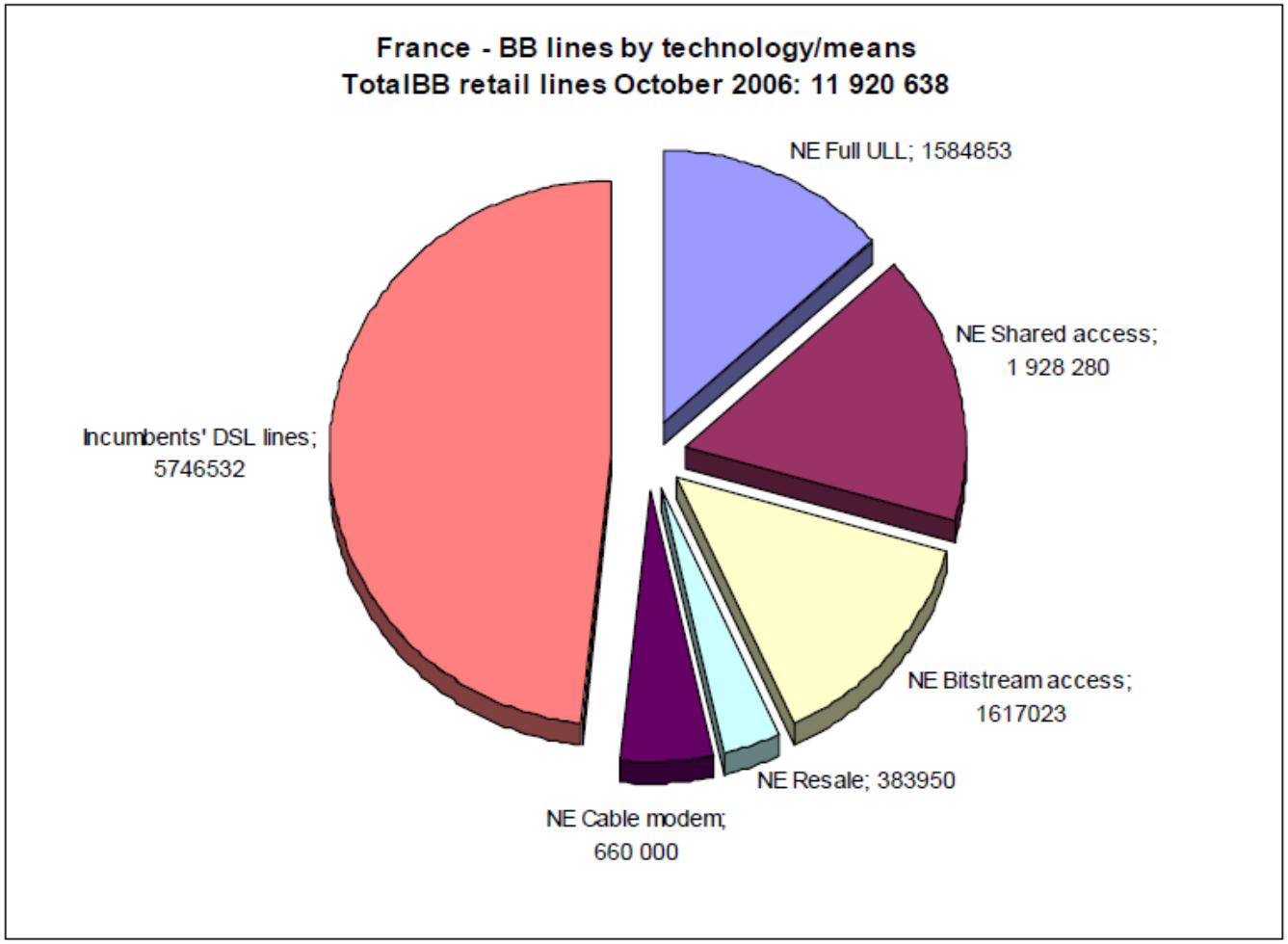
France BB Market by Technology



Source: European Commission, *12th Report on the Implementation of the Telecommunications Regulatory Package - 2006*

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What is Net Neutrality?

- **FCC Policy Principles (adopted August 2005)**
  - ***"To encourage broadband deployment and preserve and promote the open and interconnected nature of the public Internet:***
    - **consumers are entitled to access the lawful Internet content of their choice.**
    - **consumers are entitled to run applications and use services of their choice, subject to the needs of law enforcement.**
    - **consumers are entitled to connect their choice of legal devices that do not harm the network.**
    - **consumers are entitled to competition among network providers, application and service providers, and content providers."**
  - **Policy statement contains no enforcement provisions**

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Examples of Non-Neutrality

- **Madison River Telephone**
  - **Madison's ISP service blocked use of its network for Vonage Voice over IP**
- **Verizon.net terms of service**
  - **"3. AUTHORIZED USER, USE, AND RESPONSIBILITIES.**
  - **...**
  - **3.6 If you subscribe to Broadband Service:**
  - **...E. You may not use the Broadband Service to host any type of server personal or commercial in nature."**
- **Comcast terms of service**
  - **May not use internet service for streaming video**
- **Cable companies make DOCSIS QoS capabilities available to their own VoIP offering but not to competitive offerings**

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Examples of Non-Neutrality

- In Norway, NextGenTel limited bandwidth for free content from Norwegian Broadcasting Corporation (NRK) that competed with NGT's pay offerings
- In Korea, multiple ISPs block HanaTV Internet video on demand service
- Numerous operators degrade performance of P2P protocols
  - e.g. Rogers Cable (CA), nildrem (UK) Canal Digital (NO)
  - Discriminates against Joost and AOLTV which use P2P protocols
- Verizon and Cingular prohibit VoIP over their 3G wireless data service and limit equipment choices

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Types of Discrimination

- **Blocking**
  - **Block based on content, application or end-point identity**
- **Degradation**
  - **Limit the bandwidth or performance of particular applications or particular customers**
- **Prioritization**
  - **Ensure superior performance for selected applications or providers**
    - **Those without priority inevitably see degradation**
- **Interconnection**
  - **Allow some content providers to interconnect close to end user (better performance, lower cost) while forcing others to interconnect at a distance (lower performance, higher cost)**

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Sometimes Discrimination is Good

- Discrimination *may* be welfare enhancing
  - Where marginal costs are below average costs, price discrimination can enable more users to subscribe
  - Prioritization can optimize aggregate consumer welfare at a fixed level of capacity.
    - May reduce need for costly capacity upgrades
- Treating network as a two-sided market and optimally allocating costs between consumers and content/service providers can improve total welfare
- How does one distinguish between "reasonable" and "unreasonable" discrimination?

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What is "Reasonable Discrimination"?

- **Access Speed**
  - **ISPs charge users based on port speed or peak traffic rate ("burstable service")**
  - **Access tiering: e.g.**
    - **$14.99/mo for 768 kbps**
    - **$19.99/mo for 1.5 Mbps**
    - **$24.99/mo for 3 Mbps**
    - **$34.99/mo for 6 Mbps**
  - **Note that these prices are unrelated to the bit rates available over the access link from the customer to the central office/headend**
    - **The same DSL equipment is used to provide 768kbps or 6 Mbps service. Rate is limited by traffic metering software in the DSLAM or CMTS**
  - **Rate independent of the nature of the traffic**
  - **In principle, all traffic is treated the same ("best effort")**

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What is "Reasonable Discrimination"?

- Volume
  - Most U.S. ISPs do not charge by volume
    - Simplifies accounting
    - Low volume users end up subsidizing high volume users
  - Volume-based charging
    - Used in Canada, Portugal, by many US wireless ISPs.
  - Neutral with respect to client or application
  - Heavy users provide more money to invest in infrastructure to serve them
  - But, actual costs to network operator are based on peak traffic, not volume
    - Unfair to off-peak users
    - Note: diurnal variations for Internet traffic much less than for voice

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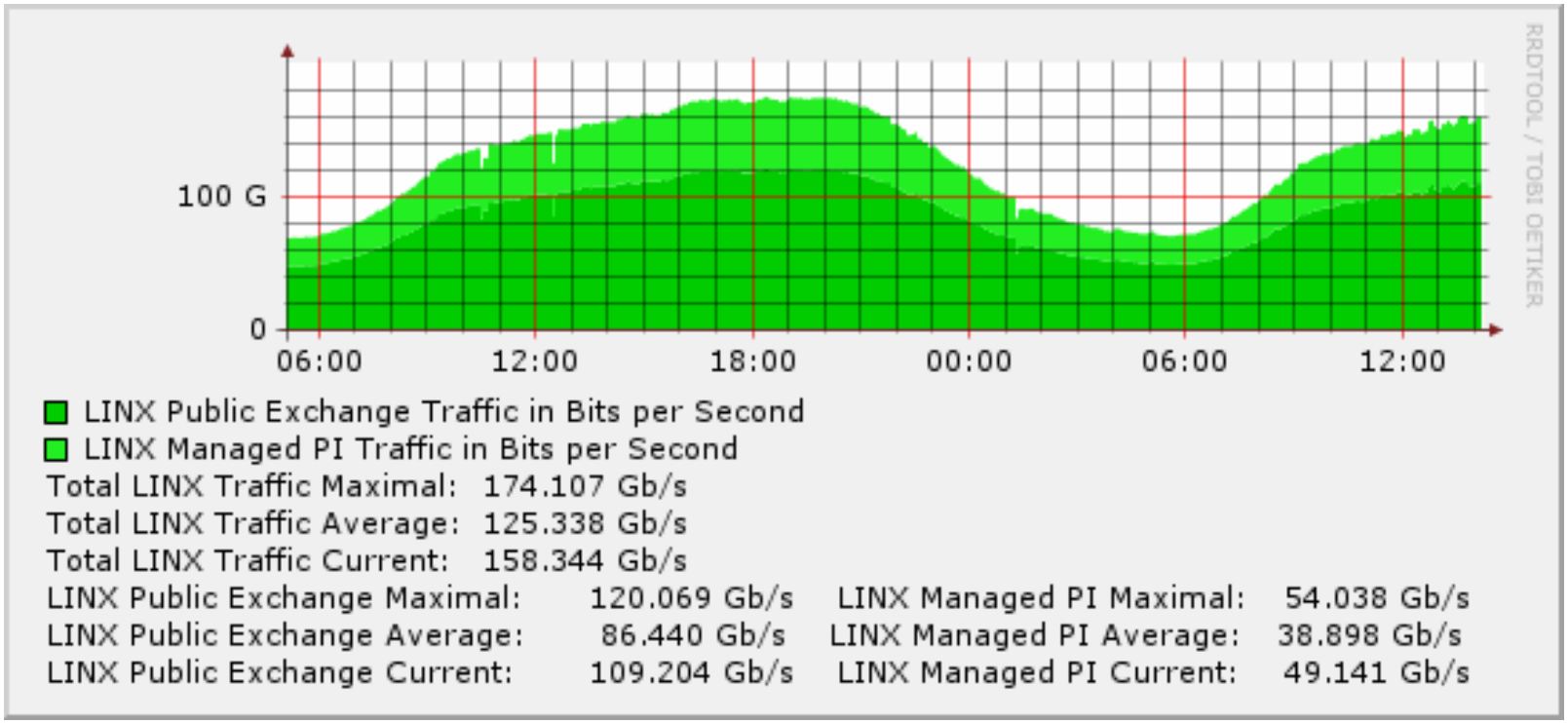
Daily Traffic Through LINX



- **Ratio of peak to average ≈ 1.4**

Source: http://www.linx.net/www_public/our_network/traffic_stats, visited November 15, 2006

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Treating Content and Users Differently

- **Quality enhancing versus quality reducing discrimination**
  - **Providing "enhanced" service to selective users/applications vs**
  - **Providing "reduced" service to unfavored users or applications**
  - **Relative to the default of best effort**

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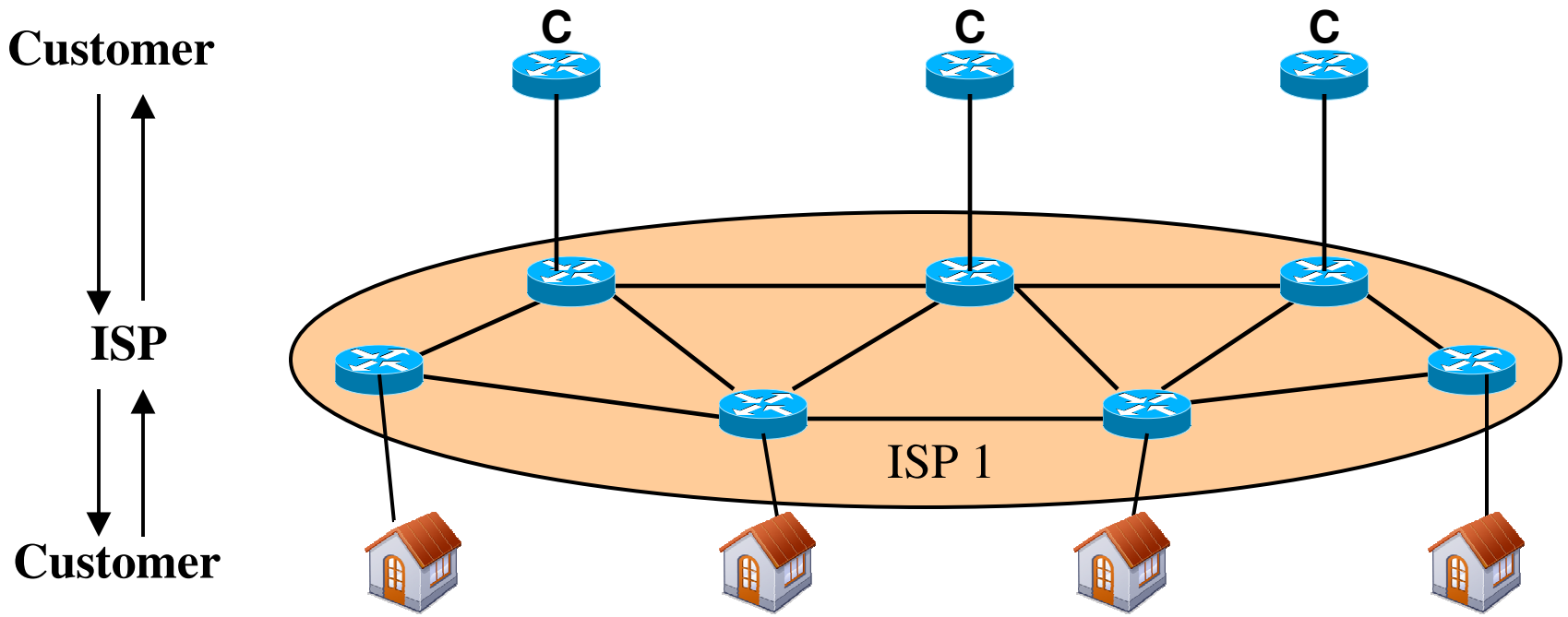
Treating Content Differently

- Exemptions for speed or volume limits
- Example
  - Customer A purchases 768 kbps access tier from Bellsouth
  - Movielink video pays Bellsouth a surcharge that allows Movielink's video to be streamed to user A at rates in excess of 768 kbps.
  - Hypothetical implementation:
    - 768 access tier normally implemented by traffic metering at DSLAM
    - Movielink video would be marked on entrance to Bellsouth network with TOS code.
    - DSLAM would allow TOS marked packets to go through even if access tier rate would be exceeded
- Would Bellsouth surcharge it's own video delivery?
  - If not, this provides Bellsouth video a cost advantage over Movielink video

Net Neutrality and QoS

- QoS means treating some packets differently from others
  - Lower delay
  - Lower loss probability
- If QoS is unpriced, what stops a user from marking all traffic high priority?
- If QoS is priced,
  - Who pays?
    - Recipient or sender or both?
  - Who may purchase?
    - Available to all at a posted price
    - Available to all at prices dependent on user or content
    - Available to some by exclusive contracting
- Does charging for QoS constitute “unreasonable” discrimination?

How Do ISPs Get Paid?



- **Customer pays ISP for access and backbone transport**

Adapted from David C. Clark

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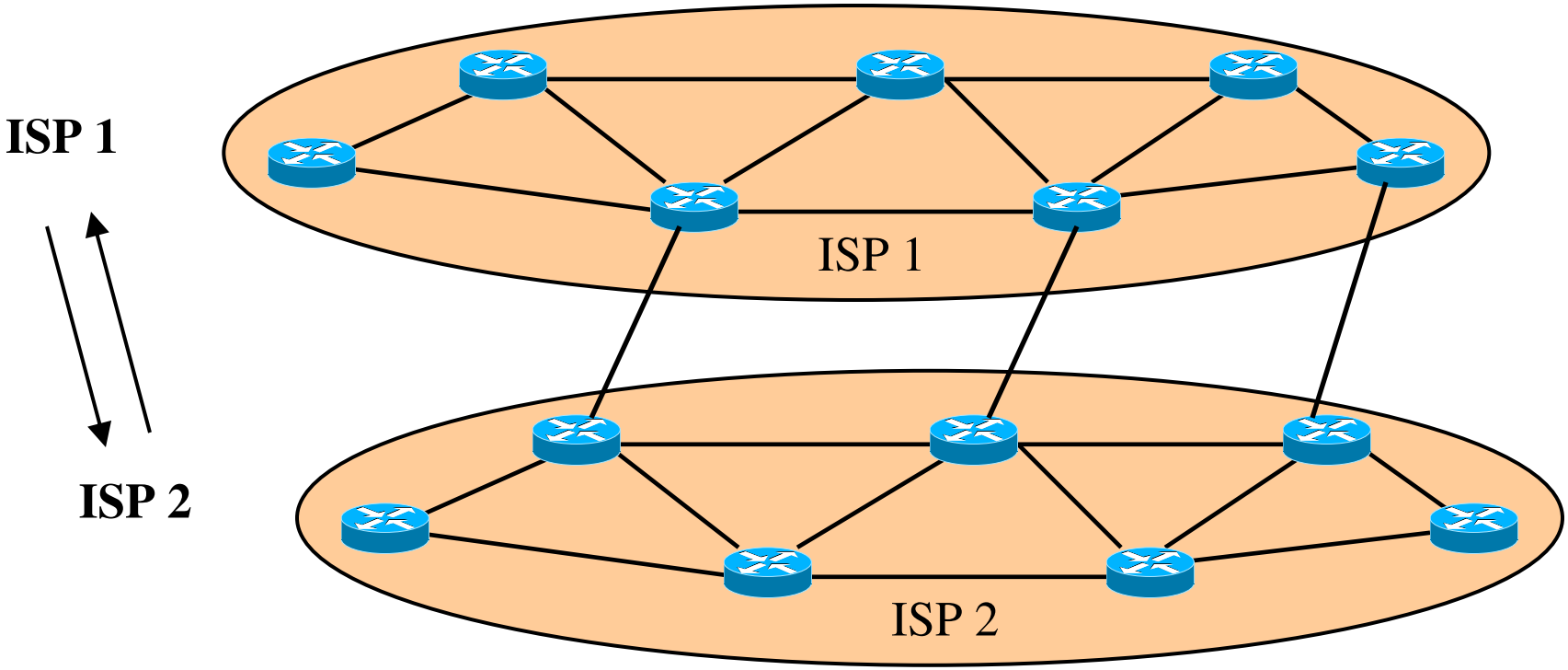
ISP Peering



- ISPs exchange traffic without payments when symmetric traffic flow

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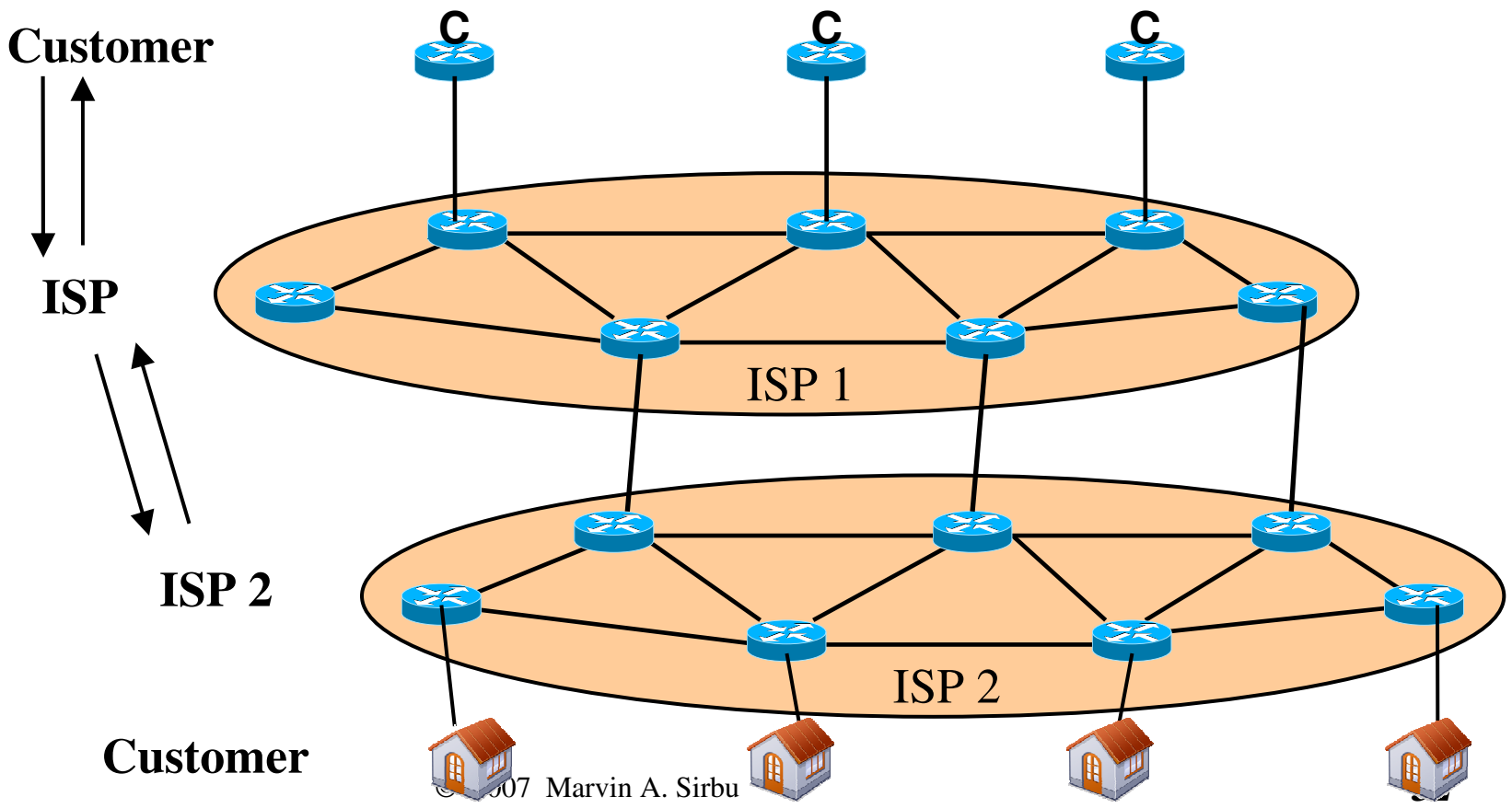
Content Provider Served by Competing Backbone Provider

- If backbones peer without settlement, ISP2 receives nothing from Content Providers
  - Peering without payment presupposes symmetric traffic



Impact of QoS

- Suppose Broadband Access Provider implements QoS but does not support Inter-Domain QoS (i.e. *between* ISPs)
- Content provider who wants QoS is obliged to connect directly to Access ISP
  - Threat to competitive backbone ISPs

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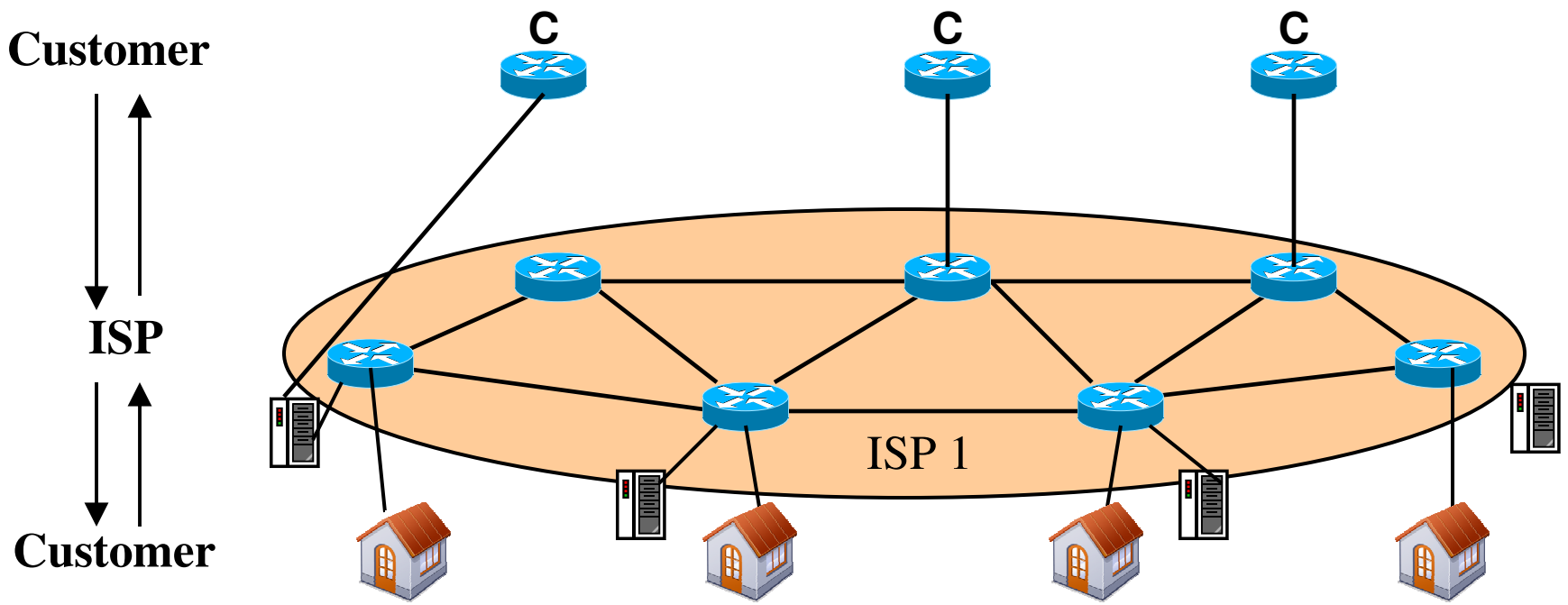
Impact of Third Party Content Delivery Networks



- Content delivery networks cache content close to customer
  - Reduces traffic on ISP1 backbone
- Will ISPs allow CDNs to optimally interconnect so competing content can have as good performance as affiliated content?

Discrimination and QoS Pricing

- Price for QoS could be based on the opportunity cost of devoting network capacity to QoS enhanced services instead of best effort services.
  - Price set to reflect resource costs for providing QoS
- In the absence of competition, QoS could also provide a mechanism for price discrimination
  - Set prices to extract additional consumer surplus from those who value QoS

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"Versioning" and Price Discrimination

- Well known result in microeconomics
- Typically some customers are willing to pay more for "quality" than other customers
- Can extract more money from consumers by having multiple goods at different quality levels
- Producer profit is maximized by *reducing* the quality of the lowest alternative, to incent more consumers to pay for a higher quality offering
  - E.g. deliberately reduce the quality of a "best effort" service to get more customers to pay for "priority" service
- Versioning may or may not be welfare enhancing
  - Access speed tiering is a form of versioning

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Terminating Access Monopoly

- Unless the customer is multihomed, the broadband ISP has a *monopoly* on reaching the customer
- The ISP has the means and incentive to extract monopoly rents from parties sending traffic to the customer
- Similar to the problem of CLECs charging exorbitant terminating access charges
- Competition among access providers does not solve the problem
  - *Cf* CLECs

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Characteristics Used for Discrimination

- Link layer protocol
- IP address (source/destination)
- Upper layer protocol field
- Type of Service (TOS) field
- Packet length
- Interpacket spacing
- Transport layer well known port (source/destination)
- Application header and content determined from *deep packet inspection*

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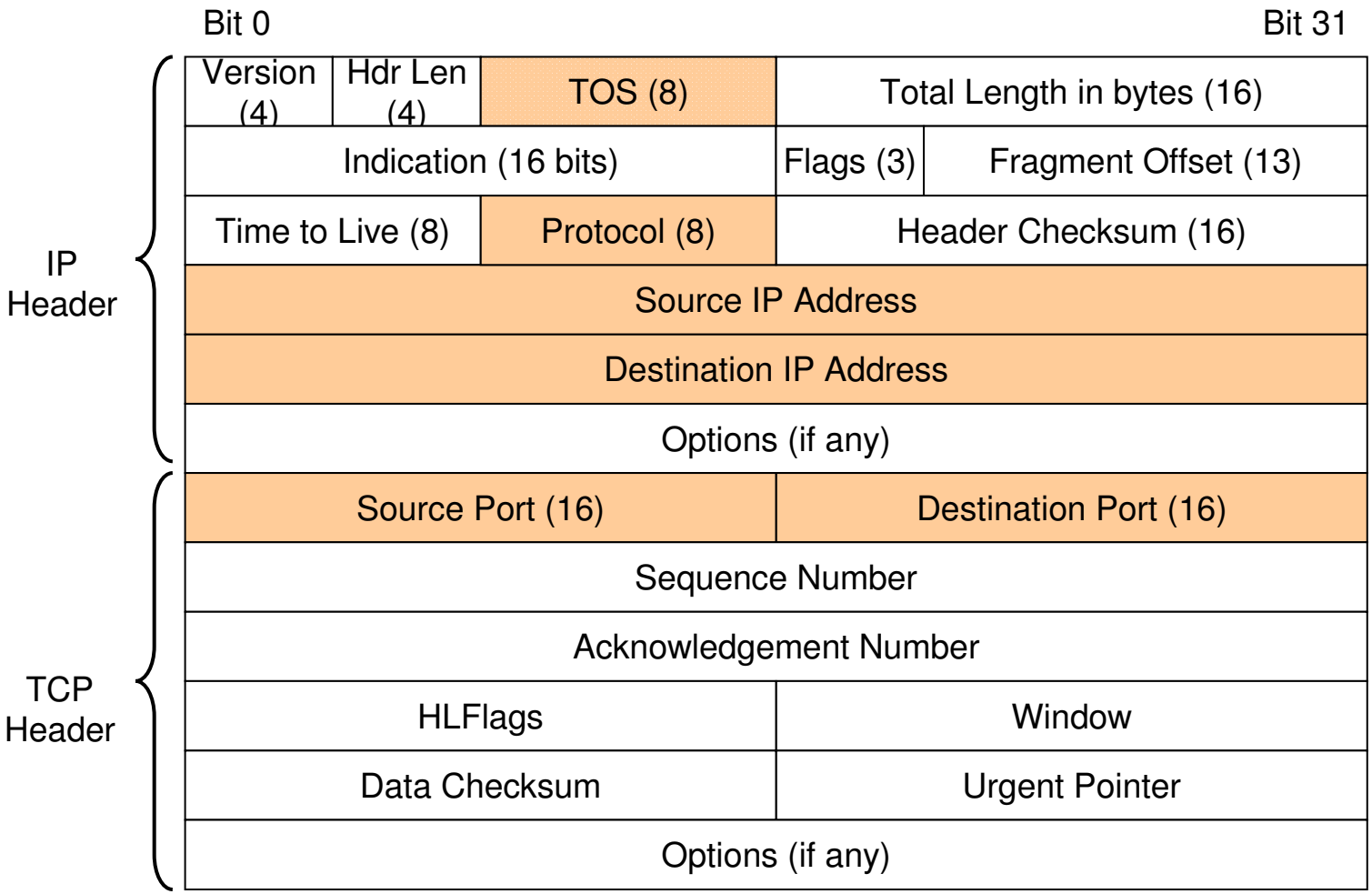
Packet Headers Showing Fields Used for Discrimination



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Deep Packet Inspection

News Release

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FOR IMMEDIATE RELEASE

Ellacoya Networks Bolsters Deep Packet Inspection Capabilities

New product release boasts industry-leading detection of encrypted applications; activates mirror port for further analysis of encrypted data

Merrimack, New Hampshire and Broadband World Forum, Paris – October 11, 2006 – Ellacoya Networks, Inc., a leading provider of carrier-grade Deep Packet Inspection (DPI) solutions for broadband IP networks, today announced it has enhanced the DPI capabilities of the Ellacoya IP Service Control System with its new 6.4 Software Release. The new release adds application detection and classification functionality for encrypted applications, including bandwidth intensive encrypted peer-to-peer (P2P) such as BitTorrent and Skype (primarily in North America/Europe) and

Source: http://www.ellacoya.com/news/pdf/2006/EllacoyaBBWF_Europe.pdf, visited November 15, 2006

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User Responses to Discrimination

- Disguise the characteristics used for discrimination
  - Effective only against *performance reducing* discrimination
    - E.g. rate limiting of P2P or blocking
  - By, for example, *e*ncryption of packet beyond the IP header to prevent:
    - Discrimination based on TCP port numbers
    - Discrimination based on deep packet inspection
  - By using a VPN
    - to hide content provider IP address
    - To foil analysis based on per flow inter-packet spacing

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User Responses to Discrimination

- Living with discrimination
  - Use of CPE buffering to compensate for network induced jitter or rate limiting
    - Trickle charge a digital video recorder vs watching in real time
  - Enhanced compression to compensate for rate limiting
- Bypass discrimination
  - Create alternative bit paths
    - Community wireless networks
    - Municipal networks
  - Enhance competition by reducing switching costs
    - Multihoming

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Policymaker's Dilemma

- Some forms of charging for volume or QoS are welfare enhancing as they lead to more efficient use of capacity investments
- Some forms of pricing are little more than versioning to extract monopoly rents and are welfare decreasing
- How can one write a policy which permits one and prohibits the other without engaging in detailed price regulation?
- Should policy be:
  - *ex ante* – general rules written in advance; or
  - *post hoc*—regulator deals with complaints of discriminatory behavior only after they arise

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Policy Options

- Forbid blocking
- Forbid degradation
- Forbid QoS
  - Is capacity expansion cheaper than QoS?
    - Internet 2 says yes
- Forbid charging for QoS
  - Carriers may prioritize video traffic as designated by customer/content provider but without charge
    - What keeps BitTorrent from marking all traffic as “video”
- Require ISP to provide same services to unaffiliated content providers as it provides to affiliates
  - What about a price squeeze?

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Definitional Problems

- Can an ISP discriminate against
  - Spam?
  - Denial of Service Attack traffic?

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Summary

- Access providers with market power have ability and incentive to discriminate with respect to content and applications
- Some forms of discrimination are welfare enhancing; others are not
- Net neutrality refers to attempts to limit by rule "unreasonable" discrimination by ISPs
- Some advocates willing to sacrifice putative potential benefits of QoS rather than risk its misuse
- Debate over *ex ante* or *post hoc* approach to policy