Interconnection in the Internet: the policy challenge

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Background

• Erosion of old models
  – Revenue neutral peering no longer obvious efficient outcome.
  – Who pays may vary even without recourse to market power argument.

• Dispute between Comcast and L3 attracted attention.
  – CDNs raise specific issues.
  – See our TPRC papers, etc., for more background.

• Policy implications
  – Points up problems with NN antidiscrimination rules.
  – No new regulation now, but that may not remain true.
    • Concern is valid
  – Better data and/or disclosure requirements may help.
Traditional peering

• When two similar ISPs (e.g. tier 1 ISPs) propose to peer:
  – Probably both have similar internal cost structures.
  – Incremental cost is negative for both of them
    • Both save money (cost of transit).
  – No new traffic is associated with the agreement.
  – Complexity of negotiation leads to setting transfer payment $W$ to 0.
    • Economist would say this is often an efficient outcome.
If they are not similar?

• A more common situation today.
  – Negotiation between ISPs of different size.
  – Negotiation between ISPs with different internal cost structures.
  – Negotiation between ISPs with different classes of customers.
    • Obvious current case: ISP1 is broadband access network; ISP2 is CDN.
Different sizes?

- Paper by Odlyzko and Tilly: “A refutation of Metcalf’s law…”
  - Metcalf’s law: all users value each other equally → value of net goes up as $N^2$.
  - Consequence: if two networks connect (e.g. peer), the gain in value to each is independent of relative size. (e.g. revenue neutral peering is valid).
  - Their view: users do not value each other equally.
  - Consequence: small network get more value from peering, and thus should pay.
Simple picture

Money flows in from the edges.
• So there must be a point where the flows meet.

Assertion: Payment from ISP2 does not signal market power.
Some terminology

Before

ISP2

Cost $C_2$

ISP1

Cost $C_1$

After

ISP2

Cost $C_2 + I_2$

ISP1

Cost $C_1 + I_1$

Several cases:

• $I_1 < 0; I_2 < 0$ (Traditional peering—both sides save money.)
• $I_1 > 0; I_2 < 0$ (Many CDNs) [POINT OF CONTENTION]
• $I_1 < 0; I_2 > 0$ (CDN for rural ISP)
• $I_1 > 0; I_2 > 0$ (No interconnection will occur unless some other party pays)
Cost-based argument

Negotiation to set transfer payment $W$ is bounded by cost savings. (But actual values for I are hard to determine and not public...)
Refining the questions we should ask

• Assuming that we cannot use actual cost models as an input to any analysis...

• What factors might determine the outcome of bargaining?

• Are there bounds on the outcome that might signal market power and the need for intervention?
  – Could we just use rents (e.g. high profits) as a signal of market power?
Content vs. conduit—the role of “value”.

- With commercial content, there is a payment from consumer to the producer/programmer: the content payment.
  - This is separate from the delivery (conduit) fee.
  - (Content fees take all sorts of forms. Heavily studied by economists.)
- In other circumstances (e.g. telephony) there is no content fee.
  - We just talk to each other—peer production of content.
- If the context of negotiation is access to commercial content, then discussions of value can signal two different things:
  - Attempts to tap into “content payment”.
  - Negotiation over allocation/recovery of the incremental costs.
- Telephone example.
  - “800” numbers.
  - No payment for content but variation in who pays based on perceived value.
History: tapping the content value

• Railroads used to have value-based pricing.
  – Sustained by regulation.
• Trucking undercut high-value pricing with “bytes is bytes” (a ton is a ton) pricing.
  – Contributed to collapse of railroads.
• Lessons:
  – Bad game plan.
  – Presumption: value pricing implies either regulatory intervention or market power.
    • Or that distortion from a cost basis is minimal.
Discussing balance of value is acceptable

- When is it safe(r) to discuss value pricing?
  - One answer: *two-sided markets*
  - Remember the analysis by Odlyzko
- Term in economics:
  - Provider with two customer classes, *which depend on each other.*
- Classic example: singles club.
  - Charge men and women different prices: “ladies’ night”.
- Lots of economic theory on rationale to set prices for classes.
  - The railroad situation was *not* a two-sided market.
    - The different customers were not dependent.
- Important point: relative value is being used as a basis to allocate *cost recovery.*
  - Singles clubs are highly competitive.
Consider the ISP

• Is an ISP a provider in a two-sided market?
  – Are there mutually dependent customer classes?
    • CDN and customer?

• Proposition:
  – Value-driven negotiation over cost recovery is just fine.
  – Extraction of payments associated with the value of content is suspect.
  – So how can we tell the difference?
Specific case: CDNs

• Are CDNs a “class” of customer?
  – Lots of different content payment models.
    • Netflix: consumer pays Netflix pays CDN (pays ISP?).
    • ESPN3: consumer pays ISP pays ESPN (pays MLBAM) pays CDN (pays ISP?).
    • Ad-based: Advertiser pays programmer pays CDN (pays ISP?).
      – Only significant case with additional infusion of money.
  – But all the content seems to be “commercial”.
• To my knowledge, CDNs do not/cannot demand a “value-based component” in their pricing.
  – Highly competitive and commodity.
  – Would seem to suggest that all CDN traffic could validly be put into one “value class” in two-sided analysis.
CDNs

Payment from CDN does not automatically signal market power.

Provider payments. Claim: cannot demand payment related to content value

Customer payments.

Hypothesis: $I_{\text{CDN}} < 0$ (costs go down); $I_{\text{ISP}} > 0$ (costs go up).
Bounding the bargaining—one example

In this configuration, what caps the price that ISP can charge CDN?
Topological limits

- In the previous picture, why would CDN ever agree to pay ISP more than the cost of transit to CDN if it reaches ISP by its peering partner?
  - Better performance
    - Yes, but probably not sufficient to justify a big distortion.
  - ISP blocks CDN traffic coming from “Another ISP” peer.
    - That would be pretty blatant discrimination.
  - ISP de-peers “Another ISP”, or demands paid peering.
    - Back where we started.
    - But with a tougher job of value discrimination.
Finding the bright line

- Payment from CDN to ISP could be:
  - Extraction of a rent based on the value of the content.
  - Resolution of the “two-sided market” value-based cost allocation.
- Where is the line?
  - A candidate rule: the line is not at “zero payment”, but at a point that is a function of customary transit costs.
    - Perhaps some discount (due to routing restrictions).
    - Perhaps some premium (for enhanced service)?
  - Even though specific agreements and incremental costs are NDA stuff, could a “customary function” emerge?
    - Customary function might be easier to explicate to regulator than cost models for incremental costs $I_1$ and $I_2$.
- But nature of negotiation still undefined.
  - Who pays whom how much?
Balance of flows

• One traditional basis for agreeing to revenue-neutral peering has been balance of flows.
  – A long tradition.
  – But actually no obvious basis in cost.
    • Circuits cost the same no matter which way the traffic flows. (Asymmetry leads to under-utilized capacity.)
  – Seems to be based on assumption that balance of flows signals “similarity of character”.
  – Seems to be based on rough rule that value follows the packets.
    • But this could be totally backwards.
• When ISPs are clearly not similar, no clear reason why balance of flows is a good rule of thumb.
  – Level 3 has challenged this idea.
New idea: patterns of usage

• Netflix as example:
• Consider two extremes.
  – All users consume Netflix content equally.
  – Only one user consumes Netflix content.
• If the ISP-CDN connection is revenue neutral:
  – In the former case, users have equal total usage, so the Netflix-specific usage is balanced out.
  – In the latter case, the usage-related costs of this user are being spread across all the users.
  – But not all users have equal usage, as we know.
Distribution of monthly usage.
Cross-user subsidy

• If all users pay the same for unequal usage, this is cross-user subsidy.
  – This is *not* a two-sided situation—the users are not mutually dependent.

• Why is this subsidy sustainable?
  – The amount is small and not worth thinking about. (Let’s see if this is true.)
  – All participants in the market prefer it.
  – ISPs are not subject to competition.
  – Regulators demand it.
Some real numbers?

• (Based on some data we have from ISPs about user behavior. Report with data out “any day now”.)

• With flat rate pricing, everyone pays the price for the average usage.
  – How to measure usage?
  – What price to assign?
Measuring usage

• Current approach is to measure total monthly usage.
  – An approximation—cost primarily relates to busy-period load.
  – Preliminary data suggests that distribution of monthly usage and busy-period usage are proportional. So a good approximation.
• But an interesting point. Move from P2P to streaming may have moved the heavy users to the peak period.
Some numbers from our data

• For latest month, mean usage: 16.1GB/m.
• Median usage is 4.25GB/m.
• So for median user, usage-related cost is about 3.8x with flat-rate pricing
• The “really big users” are getting a “really big subsidy”, but there are not many of them.
  – The neutral point is the 73%ile user.
Now estimate usage costs.

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How to recover costs of heavy users

• Ignore the issue and charge flat rate.
• Usage caps and tiers.
  – The users pay directly.
  – (Nobody seems to like actual per-byte pricing.)
• The “other side” pays—the provider or the CDN.
  – The bargaining over cost recovery I have been referring to.
An enhanced negotiation

• When two ISPs negotiate:
  – Specifically an access ISP and a CDN
• First try the “balance of flows” rule and see if both sides are satisfied.
• If not, consider the degree of uniformity of destinations from the CDN across the ISP
  – If uniform, ISP *might* agree that it is satisfactory to have the users pay cost directly.
    • If all the money comes from the users, what difference does it make?
  – If highly non-uniform, ISP *might* ask payment so that these customers are not being subsidized by all the other users.
    • Alternative is to go to usage tiers and bill users directly.
Using caps to get the CDN to pay

• Example: Australia
  – Low monthly caps.
  – Providers and CDNs pay for “premium service” so that their bytes do not count against the cap.
    • Called “un-metering”.
Usage caps change the negotiation

• What price should an access ISP charge a CDN to “un-meter” content?
  – It is not capped by customary transit.
  – CDN does not have the flexibility to change routes.
  – So seems to increase greatly the power of the access ISPs.
  – Which implies that usage caps and price tiers may attract regulatory “attention”.

Review: assumptions and ideas

• CDN market is competitive
  – CDNs do not partake of the content payment.
    • (Except perhaps as collection agent.)
• Interconnection can result in significant incremental costs, positive or negative.
  – May be many reasons.
• Transit costs may provide a customary basis to cap reasonable outcomes of negotiation.
Some summary thoughts about policy

• Rational discussion of interconnection cannot be separated from discussion of the carriage of commercial content.

• In the context of commercial content, consider:
  – 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. (Early FCC principle.)

• Retail pricing policy (e.g. whether to have low usage caps) will end up being tangled with bulk interconnection negotiation.