Interconnection in the Internet: the policy challenge

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Outline

-- Motivation

-- Content/ISP interconnection

-- Usage-based pricing
Motivation: changing world of Internet interconnection

Then

-- ISPs similar except for size
-- “best effort” data
-- Two types of interconnect:
  * Peering: revenue neutral traffic exchange between ‘equals’
  * Transit: Buying ISP pays $/Mbps to Selling ISP for delivery of traffic to rest of Internet
-- Hierarchical... Tier 1 at top
-- Internet an unregulated overlay on PSTN

Now

-- ISPs heterogenous
  * Access ‘eyeball’ ISPs
  * CDNs
  * etc.
-- Multimedia traffic
  * Best effort data
  * VoIP
  * Streaming video/audio
-- Interconnection complexity
  * Peering, transit, and...
  * Paid-peering, partial transit, etc.....
-- Internet is the new PSTN!
Q: Is it time to regulate Internet interconnection?

-- FCC Network Neutrality Order (Dec2010)

-- Comcast/Level 3 spat

Q: Is it reasonable that a CDN should pay an access ISP to deliver content traffic?

Q: Is the emergence of paid-peering a problem in need of a regulatory solution?

Q: How large are the content usage costs anyway?

Q: Will these costs make end-user usage-based pricing necessary?
Traffic Flows from Content Delivery (CD) to Access Network (A)

\[ C_A? \] $0.01/GB (Netflix, 2011) (w/o access)
\[ $0.08/GB (Geist, 2011) \]
\[ $0.10/GB (Clark, 2008) \]

$0.20-$0.30/GB w/access (?)
>$1/GB overage fees

Assume $0.20/GB
-- avg usage 20GB/month,
so avg sub usage $4/month

90min HD movie at 5Mbps,
$0.65

Usage-related costs are substantial, even if not overwhelming
$ Flows in the Internet....

Figure 2: CDN to ISP A Money Flows

Payment P:
P=0: traditional revenue neutral peering
P(CD->A): CD covers (some of) cost $C_A$
P(A->CD): A covers some of the cost $C_{CDN}$
If $P(CD\rightarrow A)$ too large, CD sends traffic via $T$

In that case, CD pays $t$ for transit (and so does A!): $P<t$

High-volume transit $\sim $ $1$/Mbps $\Rightarrow$ $0.0062$/GB vs. $C_A \sim $ $.10-$.30$/GB

Comcast rumored to be getting $2-4$/Mbps for paid peering (Norton, 2011)
‘Single-hop’ access also constrains

Figure 4: Configuration of connections for single-hop access.
Paid peering opens up new routing solutions

Point is that in today’s Internet CDNs have many options for delivering Traffic into A’s network... and matrix of those options works to limit Payments that A might extract from the CDN...
Who has the bargaining power?

Access ISPs because of terminating (or originating) monopoly power?
   -- maybe....

CDNs because they can control routing of content and thus impact the Access ISPs costs
   -- 40% of peak traffic is streaming content
   -- A few CDNs control significant volumes of traffic
   -- Not just “hot potato v. cold potato routing” but much finer-grained control in time and by link....

BUT bargaining costs money – delays, failures, ..... 

Adopting norms can save money....

(In split the $ game, players often opt for 50/50 split...)
Changing Norms for Interconnection

Study of existing peering policies identified 25 criteria, 10 of which common

“Balance of flows” was common for revenue-neutral peering
  -- why? Because reasonable proxy for value of interconnect.
    If traffic balanced, net payment = 0 regardless of what $/GB is
    If cost small, then net payment = 0 regardless of what GB are
  -- (Typically, not strict.... 2:1 or so fine... but not 10:1)
  -- and “balance of flows” still provides hook to limit ‘abuses’ like one-hop transit

With paid peering, what might the emergent norms be???
  -- paid-peering to recover the higher costs associated with asymmetric usage is ok as long as not too high.... So less than transit...

  -- some proxy for costs?? Route-miles internal to ISP as a proxy for hot v. cold potato routing, or industry averages for outside plant costs, etc.
Why not recover usage costs from subscribers?

-- An obvious (and necessary) solution if negotiated bargain with CD fails to result in significant contribution to recover $C_A$ but what is the pricing model?

-- Flat rate pricing: ensure that $/month subscriber fee sufficient to recover $C_A$ but then all subscribers share burden of payment

-- Usage pricing tiers: pay more if higher GB per month
  - Better than $/GB usage pricing since evidence users want predictable payment. Overage fees are not to collect revenue but to induce correct tier selection.
  - Changes interconnection negotiation game....e.g., Australia where content providers can pay to have their content excluded from quota
  - Consumer-facing usage fees provides hook for access ISPs to gain interconnection bargaining power.
  - Demonstrates complex dynamics and centrality of interconnection to broadband policy
Usage fees and Interconnection

How large are the costs of usage?
-- Our estimates suggest they are significant but not huge

How big is the subsidy for heavy users?
-- <$1/month to flat rate BB service? Who cares....
   Occasional heavy use option attractive. Metering expensive.

-- $10/month or $100/month? Usage-based pricing or caps needed

-- Exactly how heavy are heavy users? A: they can be very heavy....
   (but is that traffic during the peak...)

-- Ballpark estimate? Median user 5GB v. Mean user 20GB/month,
   @ $0.20/GB, median user contributing $3/month to subsidize heavy
Summing up

Q: Is it reasonable that a CDN should pay an access ISP to deliver content traffic? *Yes. Payment does not imply market power.*

Q: Is the emergence of paid-peering a problem in need of a regulatory solution? *No (at least today). Paid peering may be seen as reasonable response to changing market.*

Q: How large are the content usage costs anyway? *Significant but still modest (but better information would help...)*

Q: Will these costs make end-user usage-based pricing necessary? *Not necessarily, but it would be reasonable if it did occur.*

Q: Recommendation for policy? *Watch but avoid strong intervention. Better transparency and public data on traffic, norms, terms, & conditions would be good*