# 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**

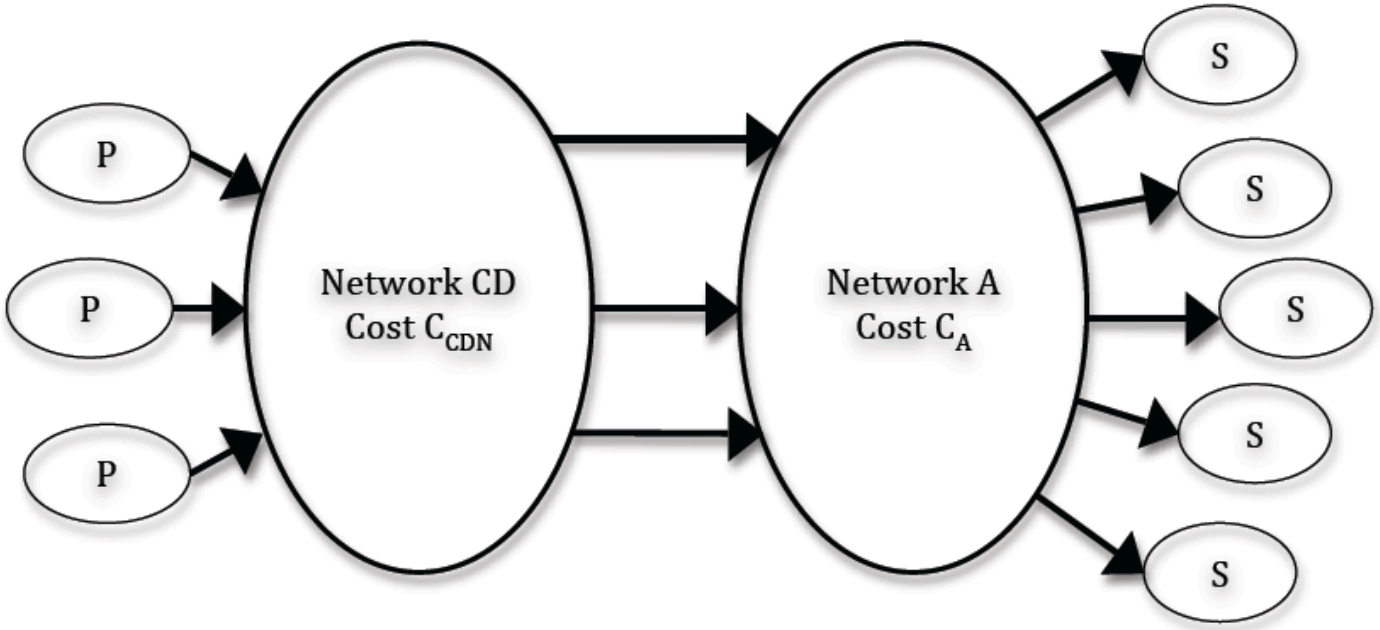
**Q: Is it reasonable that a CDN should pay an access ISP to deliver content traffic?**

**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)

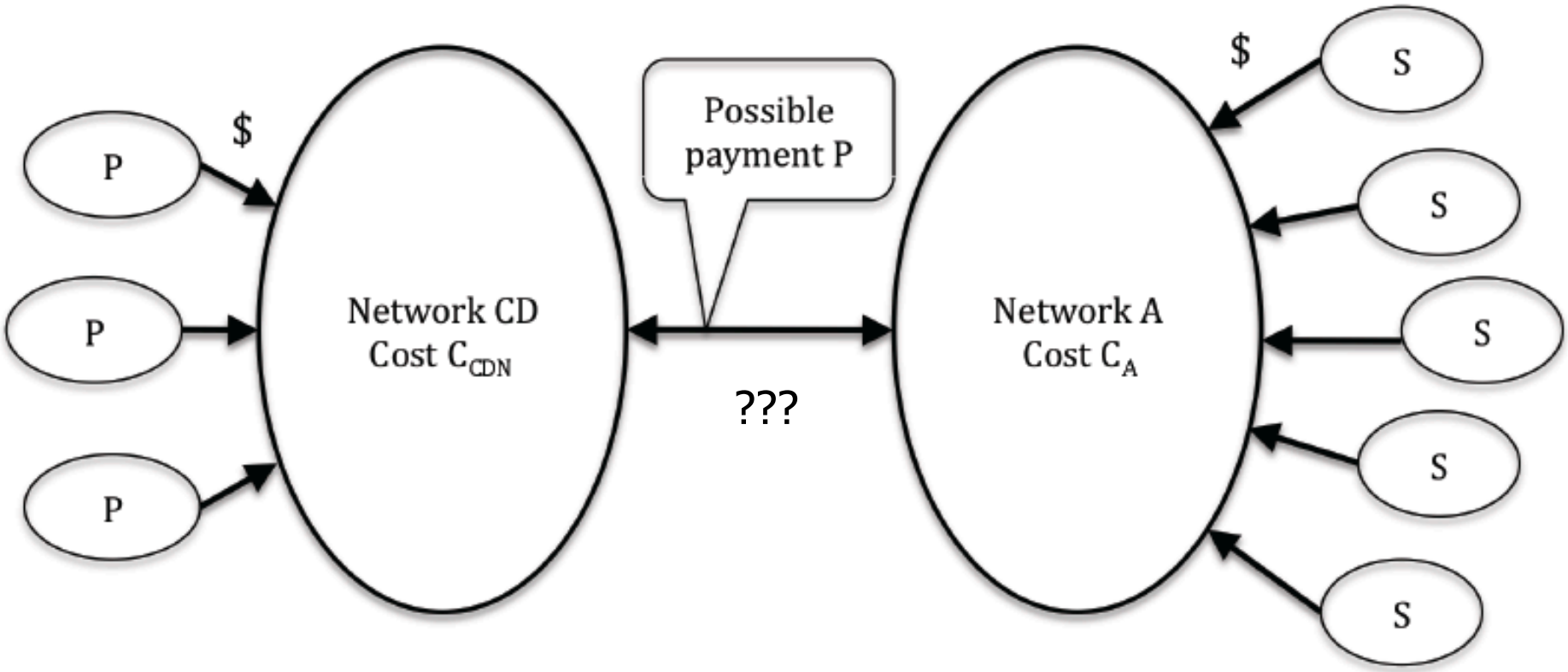
$0.20-$0.30/GB w/access (?)
>$1/GB overage fees

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*

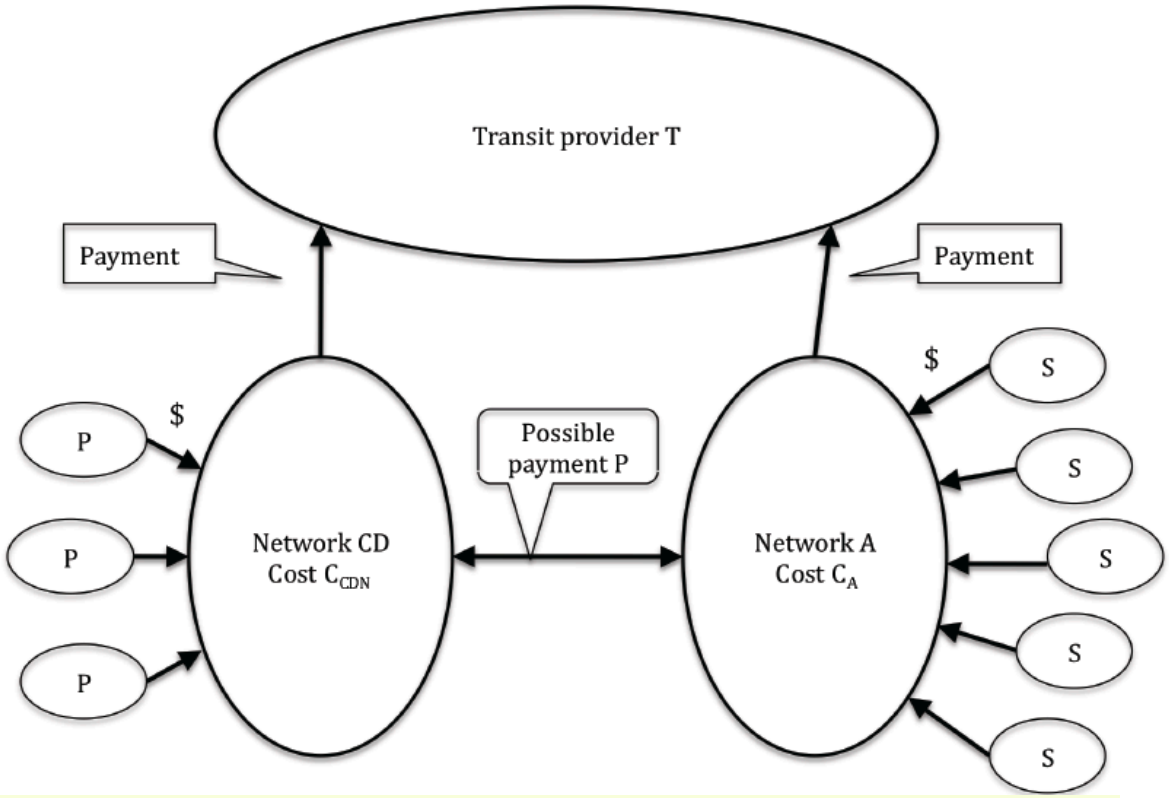
# $ Flows in the Internet….




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 $C_{CDN}$

**Figure 2: CDN to ISP A Money Flows**

# Transit option constrains payments




If P(CD->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 ~ $1/Mbps => $0.0062/GB vs. $C_A$ ~ $.10-$.30/GB

Comcast rumored to be getting $2-$4/Mbps for paid peering (Norton, 2011)

# ‘Single-hop’ access also constrains

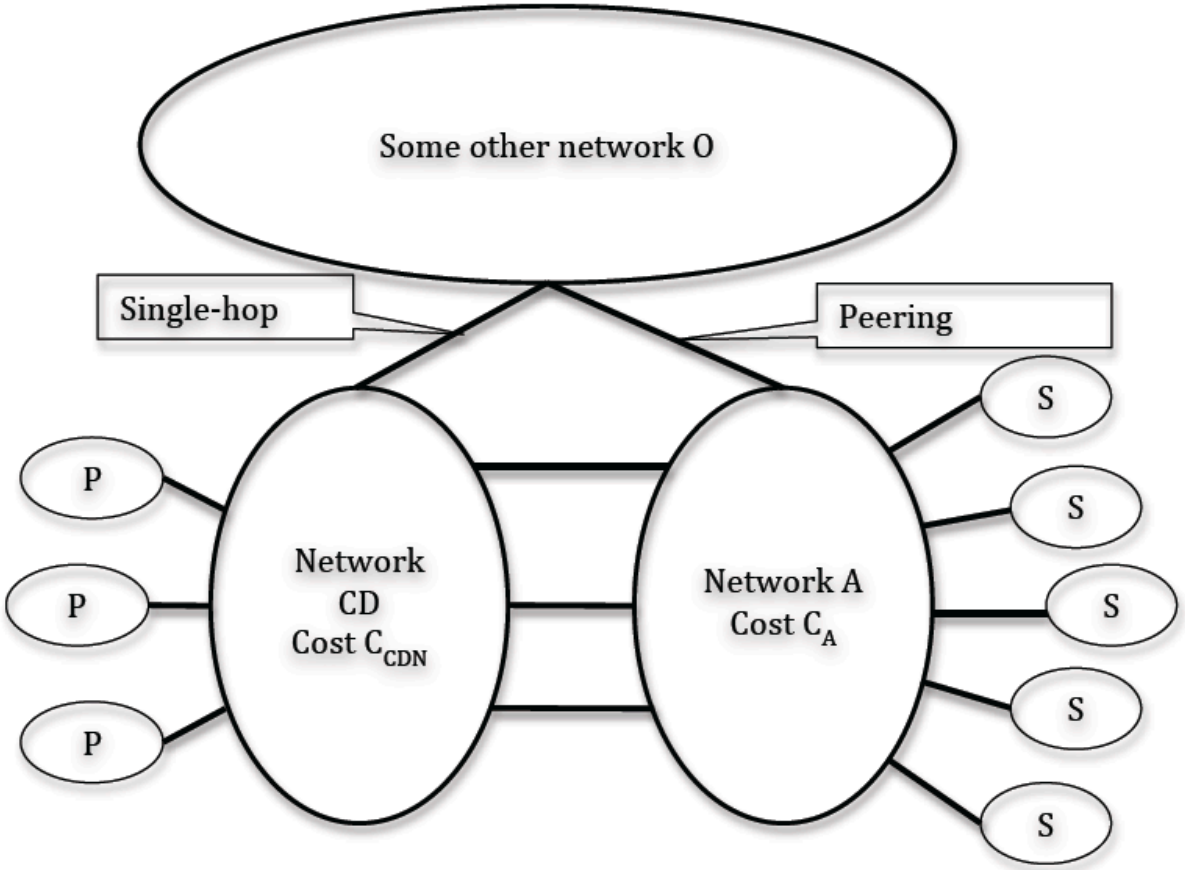



Figure 4: Configuration of connections for single-hop access.

# Paid peering opens up new routing solutions

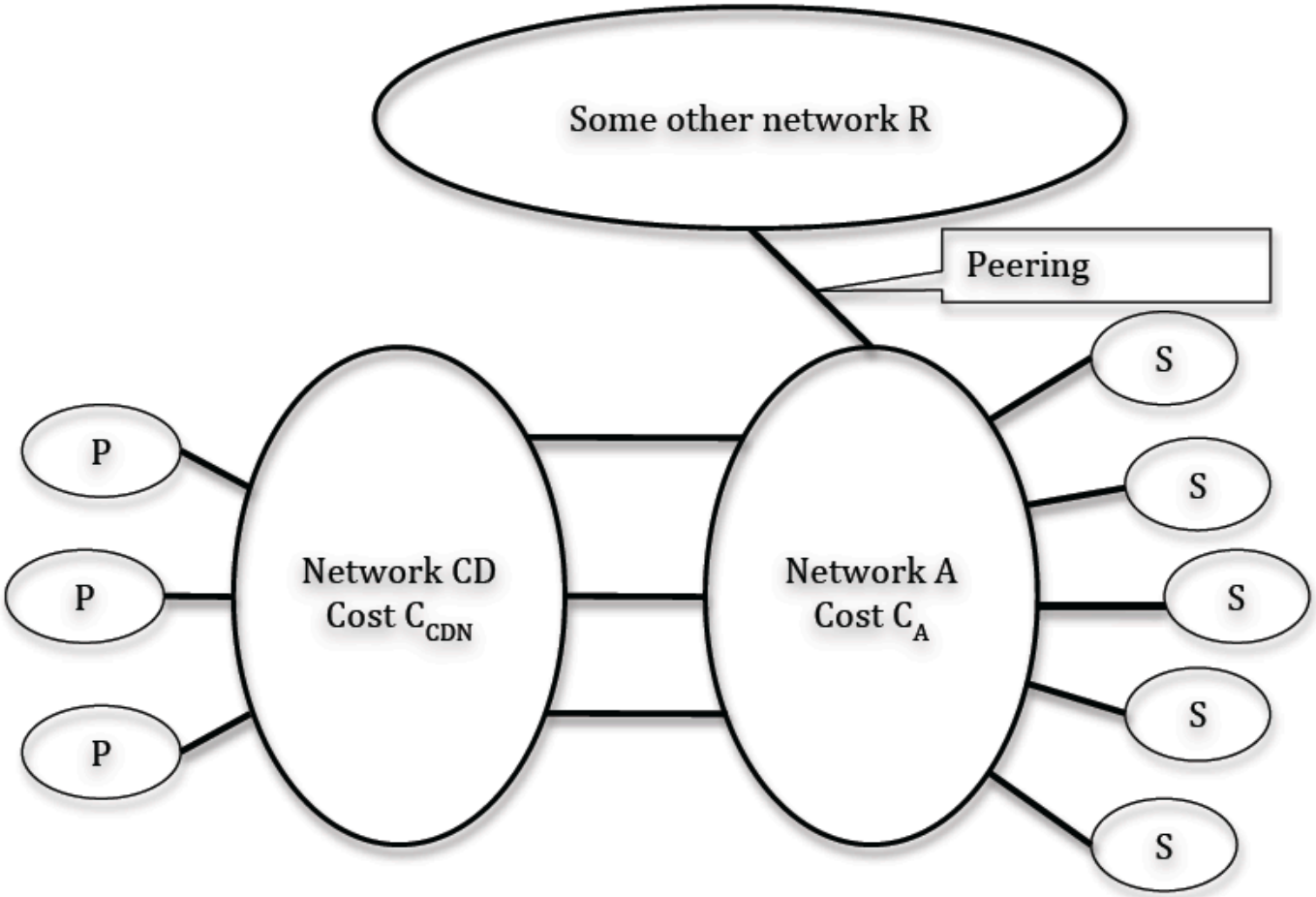



Figure 5: Network CD negotiates to gain access to S via the peering arrangement between S and A.

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**