My Promise to you

• You will understand (roughly) how the Internet is interconnected

• Specifically, you will understand and apply the following terms:

• 1) Internet Transit

• 2) Internet Peering

• 3) Internet Peering Ecosystem, Tier 1 ISPs, Tier 2 ISPs; their position and motivations, and the role of Internet Exchange Points
Building Blocks

• **Part I** - Definitions of Transit and Peering

• **Part II** - Application of definitions: The Internet Peering Ecosystem

• **Part III** - The Theoretical Framework behind Internet Exchange Points

This is a Discussion Talk

Quizzes scattered throughout
Who am i?

- William B. Norton (Bill Norton)
- Internet Operations Researcher: Authored Industry White Papers...
Video Internet: The Next Wave of Massive Disruption to the U.S. Peering Ecosystem (v1.5)

William B. Norton <wnb@equinix.com>

Abstract

In previous research we documented three significant disruptions to the U.S. Peering Ecosystem as the Cable Companies, Large Scale Network Savvy Content Companies, and Tier 2 ISPs started peering openly. By peering content directly with eyeballs, they effectively bypassed the Tier 1 ISPs resulting in improved performance, greater control over the end-user experience, and overall lower operating costs.

This paper predicts a new wave of disruption that potentially dwarfs this previous redirection of Internet traffic. Short video clip web sites, full length motion pictures, and television shows are now available via streaming to on-line devices and via downloading to iPods. More sites are coming on-line as high quality movies from independent producers are being distributed via peer-to-peer methods. We observe these flash crowd effects and the larger movie file sizes as the crest of the first wave of significant incremental load on the Internet.

The majority of this paper details four models for Internet Video Distribution (Transit, Content Delivery Networks, Transit/Peer/DIY CDN, Peer2Peer) across three load models. The cost models include network and server equipment along with pricing models for various distribution methods. Over one hundred walkthroughs of this paper have led to stepwise refinements of the models and insights into why one would prefer or not prefer one model over the other.

The summary of the paper is a comparison of these video distribution techniques in terms of $/per video units from the Video Service Provider perspective. We highlight cascading obstacles preventing large scale delivery of video traffic using commodity transit in a single location. The CDN solution and the multi-site Transit with Peering solution bypass some of these obstacles, while the peer-2-peer solution, while controversial, yields (by far) the lowest cost solution from the video service provider perspective.

Previous Wave of Evolution of the U.S. Peering Ecosystem

The U.S. Internet Peering Ecosystem went through three significant disruptions in or about 2001:

1. Cable Companies Peer. The North American cable companies’ Internet transit provider (or “licences”) went bankrupt in 2001, forcing the cable companies to build out and manage their own multi-gigabit-per-second Internet infrastructure with only 30 days notice. With peer-2-peer traffic representing 40% to 60% of their transit bill, they quickly recognized the benefits of peering that traffic directly with each other.

2. The Large Scale Network Savvy Content Providers entered into the Peering Ecosystem as their traffic volume grew into the tens of gigabits-per-second. By engaging in peering directly with the Tier 2 ISPs, both groups were able to improve performance and lower their transit expenses while enhancing and increasing control over the end-user experience. The majority of this paper details four models for Internet Video Distribution (Transit, Content Delivery Networks, Transit/Peer/DIY CDN, Peer2Peer) across three load models. The cost models include network and server equipment along with pricing models for various distribution methods. Over one hundred walkthroughs of this paper have led to stepwise refinements of the models and insights into why one would prefer or not prefer one model over the other.

3. MSOs peer with Content. Since then, the cable companies peer directly with each other and with the large scale content companies. Several of these content companies have

![Figure 1 – 2001 U.S. Internet Peering Ecosystem](image)

The term “Peering” is the reciprocal (and usually free) exchange of access to each others customers.
Part I: Definitions of Transit and Peering
Def: The Internet is a network of networks.
Def: ISP sells access to the Internet, so...
An ISP must itself get attached to an ISP already attached to the Internet.
Def: ‘Transit’ is service whereby one ISP sells access to the Internet.
“A port in the wall that says ‘Internet this way’”
Billing Internet Transit: 95th Percentile

1 month of 5 min Samples = \( v_n - v_{n-1} \)

Highest Monthly Sample

\[ \text{134 Mbps} \] 95th Percentile measure

Lowest Monthly Sample

\[ \text{1 Mbps} \]

\{ 36 hrs/month to burst for free \}

Challenge: How can you GAME this system?
Free Transit!!
35hrs burst to 26 ISPs

Upstream ISP A  B  C  Z

Enter minimum commits...
Minimum Commits: Tiered Transit Pricing

Business Knobs:
- ISP(s) selection
- Minimum Commits
- Negotiated Price

So, Transit is Easy, Cheap
Why do we need this Peering thing?
100Gbps*$4/Mbps=$400K/mo

Source: 2008 NANOG
Discussions: $4/Mbps!
Def: ‘Peering’ is a reciprocal exchange of access to each others customers.

Motivations to peer
1) Cost Savings
2) Performance Benefits
3) Additional revenue
   3a) ABOV
   3b) AMZN

All traffic except red traffic goes this way

Upstream ISP(s)

All traffic except blue traffic goes this way
Two key points about peering

1) Peering is **not** Transitive
2) Peering is **not a perfect substitute** for Transit
Part II - The Internet
Peering Ecosystem

From 30,000 feet - applying the definitions

Armed with these definitions..
Def: Global Internet Peering Ecosystem consists of a set of interconnected internet regions (countries).
Def: A Tier 1 ISP is an ISP that has access to the ENTIRE Internet Region Routing Table Solely via Peering Relationships.

(Doesn’t buy transit from anyone to reach any destination in the Internet Region.)

Motivation: Is NOT motivated to Peer in region to reduce transit fees, Is NOT motivated to peer with anybody else.

Behavior: “Restrictive” Peering Policy
Ecosystem Member: Tier 2 ISP

**Def:** A Tier 2 ISP is an ISP that has to purchase Transit to access some part of the Internet Region.

**Motivation:** Is motivated to Peer in region to reduce transit fees.

**Behavior:** “Open” Peering or “Selective” Peering Policy Active in Peering Forums
Content Providers

Def: A Content Provider focuses on content development and does not sell access to the Internet.

Motivation: SLAs w/well known ISP

Behavior: “No Peering” Policy
Quiz

1) Definition of Transit: _______________________

2) Definition of Peering: _______________________

3) Definition of an “Open” Peering Policy: _______________________

4) Definition of a “Selective” Peering Policy: _______________________

5) Definition of a “Restrictive” Peering Policy: _______________________

Tier 1 ISP X

Tier 2 ISP A

Tier 1 ISP Y

Tier 2 ISP B

Content Provider C
Apply Defs: Peering Dynamics & Motivations

Tier 1 ISP X

Tier 1 ISP Y

Tier 2 ISP A

Content Provider

No, I already hear your routes for FREE!

QuickTime™ and a decompressor are needed to see this picture.

No, like $.

No, like $,
& I Like customer B

Synch Point:
You have all the defs needed to predict behavior in the Peering Ecosystem.
You should be able to answer the question at hand.
Evolution of the U.S. Peering Ecosystem
Illustrative of dynamics
Applies definitions
1) Volume of traffic is huge
2) Cable Cos Open Peering
3) “Kazaa Effect” amplifies peering benefits
1) Volume of traffic is huge
2) Content is Open Peering
3) Improves End-User Experience
4) Leading Players are paving the way

...need to move out of Bankrupt colo anyway…
1) Volume of traffic pulled away from T1s is huge
2) Reduces perceived need for T1s (for local delivery anyway)
3) T1s still needed for distance

→ Content Literally right on the Cable Company Network
Internet Exchange Points
A Theoretical Framework
IX Network Externality

IX Value

Value derived from IX participation

IX Critical Mass (Value=Cost)

Cost of IX Participation

The Startup Hump

Discussion Here

f(#participants, uniqueRoutes)
Asked IX Operators

- **How did you get to critical mass?**
- Europe: ISP consortium starts it
- Commercial Company targets key ISPs
- Drop price of Participation
- Equity
- Evangelize, host content (BW sales as lure in)
- Find new large volume target peering customers (Video)
Models of IXes

- IX separate from colo (Europe)
- IX owns colo (US)
- LINX/AMS-IX/DE-CIX model
- US Equinix/PAIX/NOTA model
Neutrality

• ISP-neutrality
• Carrier-Neutrality
• Carrier and Colo neutrality
• Why is this important - Turkish Internet example
## Peering Math

<table>
<thead>
<tr>
<th></th>
<th>Colo</th>
<th>IX Port</th>
<th>Total Peering Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colo</td>
<td>$1,500 per mo</td>
<td>$3,500 per mo</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

### Gbps | Transit $/Mbps | Peering
---|----------------|-------
1  | $5.00          | $5.00 |
2  | $4.50          | $2.50 |
3  | $4.50          | $1.67 |
4  | $4.50          | $1.25 |
5  | $4.30          | $1.00 |
6  | $4.30          | $0.83 |
7  | $4.30          | $0.71 |
8  | $4.00          | $0.63 |
Peering v Transit

Chart 2
Peering vs. Transit

General Observations

Peering v Transit is always a question
+Performance
+Marketing Benefits
+Control
PeeringDB

- How do I contact an ISP for Peering?
- PeeringDB - http://www.peeringdb.com
- Face-to-face
- E-mail
- Phone Calls
- Internet Relay Chat
- Introductions
- IX Operator staff
Sign into Peering DB

- Browse the pages
Common Peering Prerequisites

- 24/7 NOC
- Multiple geographically diverse locations
- Consistent announcements
- Single AS
- Traffic volume minimums
- Not be a customer
Conclusion

- This was an overview (Peering 101)
- concepts and common lexicon
- NANOG is an opportunity to have face-to-face discussions with potential peers
- White Papers on the net:
  - Google ‘william b. norton’