The Law, Politics, and Economics of Interconnection

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Outline

• Defining Our Terms
  – Internet Service Provider
  – Peering vs. Transit
  – Internet Exchange Point
• The Economics of Peering
• The Politics of Peering
• IXP Peering: Developing Country Examples
  – Mongolia, Kenya, Bangladesh
• IXP Obstacles
  – Legal/Regulatory Considerations
• Business Considerations in Peering
  – Choosing Peers, Cost/Benefit Analysis, Choosing Peers
  – Complications
• Peering Simulation Game

• *Intro to IXP Agreements*
• *Roundtable Q&A with Peering/IXP experts*
<table>
<thead>
<tr>
<th>Internet</th>
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</table>
| • Definition: A network of independent networks.  
  – Common interconnection standards  
  – Open interfaces  
  – Common naming & addressing systems  |
<p>| • To users, it appears to be one single network, where every end user can access every connected device and user.  |
| • Basic goal of Internet: Connectivity.  |</p>
<table>
<thead>
<tr>
<th>Internet Service Providers</th>
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<tbody>
<tr>
<td>• Definition: An ISP sells to businesses, organizations, and end-users connectivity to the global public Internet.</td>
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<tr>
<td>• To sell connectivity to the global public Internet, each ISP needs to buy connectivity to the global public Internet</td>
</tr>
<tr>
<td>- ISPs are both clients and providers</td>
</tr>
<tr>
<td>- ISPs buy connectivity from upstream ISPs (wholesale), and sell it to customers (retail or wholesale)</td>
</tr>
</tbody>
</table>
ISPs live in strange world…

• A parallel universe:
  – Fierce competitors who must cooperate
    • In a sense, the service an ISP offers is the cooperation of other ISPs to route and deliver its customers’ traffic
  – Providers to some; clients of others
    • ISPs’ customers can become resellers, then competitors, then upstream providers
    • Internet service is essentially a commodity: Retail ISP can easily become a wholesaler; wholesale provider can easily add retail operations
Transit vs. Peering

- **Transit** = business relationship where one ISP provides (usually sells) connectivity to all destinations on the global Internet.
  - Bilateral business & technical arrangement.
  - *Transit provider* carries traffic to 3d parties or from 3d parties to customer (end point).
  - Most transit agreements: transit provider will carry traffic to/from its other customers AND to/from every destination on the Internet.
    - I.e., transit provider gives clients access to all network routes in its routing table.
  - Defined price for access to entire Internet.
    - Usually on a volume basis, measured in Mbps
  - From customer perspective: Simple relationship
    - Customer pays; transit provider gives access to entire Internet
    - Generally includes Service Level Agreement (SLA), installation & Network Operations Center (NOC) support
Transit vs. Peering

• *Peering* = business relationship where 2 ISPs each give reciprocal access to their own customers
  – Bilateral business & technical arrangement
  – 2 providers agree to accept traffic from one another and from one another’s customers (and their customers’ customers)
  – No obligation to carry traffic to 3rd parties
  – No cash payments involved (more like barter); no settlement
  – No Service Level Agreement (SLA)
  – *Not the same as “peer” in BGP!*
Only Transit, No Peering

Upstream Transit Provider

My ISP

Transit

Her ISP

Transit

Your ISP

Transit
Peering

Upstream Transit Provider

Transit

My ISP

Her ISP

Peering

Peering

Your ISP

Transit
Peering

Upstream Transit Provider

My ISP

Transit

Her ISP

Transit

Your ISP

Routing Table
(From Peering Only)

Routing Table
(From Peering Only)

Routing Table
(From Peering Only)
Peering is not pass-through

- Peering partners announce to each other only routes for their own customers
- Previous graphic: My ISP cannot send packets to Your ISP via Her ISP, even though My ISP and Your ISP are both peers of Her ISP
- If you peer with another ISP, it does not mean that that ISP can “dump” all its traffic onto your network (only traffic to your customers)
Phony IXPs

- Dominant transit provider provides local exchange points in one or two major cities
- Commercial transit provider uses “IXP” as a marketing term, but offers only a router with BGP-4 peering, enabling local transit and/or transit to the global Internet
- Not a “true” IXP, because not neutral and/or not offering peering (only transit)
Transit & Peering Choices

- ISP must either
  - Exchange traffic directly with other ISPs (peering), or
  - Pay a larger ISP to do it (transit)
- Because an ISP cannot peer with every other ISP in the world (10,000+), most ISPs try to do both:
  - Exchange as much traffic as possible with peers, AND
  - Pay for the portion that can’t be exchanged via peers
- ISP goal: Minimize transit to minimize costs
The Politics of Transit

- The larger ISPs that sell transit to developing countries are nearly always US-, European-, or Japanese-owned.
- In most developing countries, domestic ISPs do not peer with each other.
- Any country whose ISPs do not peer with each other relies exclusively on transit, and is:
  (a) Needlessly exporting capital, and
  (b) Effectively subsidizing Internet in the developed world.
- Developing country payments for transit are not small.
Developing Country w/ no Peering

- Each ISP has its own international connection to the global Internet
  - Satellite or fiber
- Even domestic traffic has to flow over international links before being routed back to another local ISP
- This is needlessly expensive, and limits services (high latency)
- Without domestic peering, it’s actually better to host online content and services offshore
The Content Angle

- Without significant domestic traffic interchange, there’s little incentive to host domestic Internet content
- Result: Few domestic content sources for developing world Internet users
  - And continued reliance on US-generated content, with US-generated advertising, from US companies pushing US products
IXP = Internet Exchange Point

- A physical network infrastructure (layer 2), operated by a single entity to facilitate the exchange of Internet traffic between 3 or more ISPs.
- True IXP is NEUTRAL
- Typically, the IXP operator owns and operates the switching platforms used to interconnect the various users/subscribers.
  - Shared switch fabric, where users arrange peering via bilateral agreements and then establish BGP-4 sessions between routers to exchange routes and traffic
- Advantages: Lower Costs and Better Quality of Service
- Not technically complicated; challenge is in human dynamics
Cost Advantages

- International links entail both upstream and downstream packet traffic (and costs)
  - In telephony world, costs of calls are regulated
    - International settlement rules: shared 50/50-ish between telcos
  - In Internet, no regulation
    - Costs depend on privately negotiated peering vs. transit agreements.

- Developing country ISPs must sign transit, not peering, agreements with backbone providers (or their customers), and must pay 100% of both outbound and inbound packet traffic.
  - In that sense, backbone providers treat all smaller ISPs equally (whether developing country or not)

- Domestic peering = less transit = lower costs
Service advantages

• Most developing country ISPs use satellite circuits for international connections to upstream ISPs
  – Few fiber optic connections available
• Satellite connections introduce latency
  – International exchange of domestic traffic via satellite requires at least 2 satellite hops
• Even with fiber, more hops means more opportunities for delay
Note:

- Drawing a circuit to your local IXP does not guarantee peering.
- Not all ISPs at an IXP will peer with all other ISPs.
- Once at the IXP, each ISP must still negotiate bilateral peering with each other ISP with which it wishes to peer.

- But if peering is your goal, IXP is cost-effective: Single connection to the IXP allows easy connectivity to numerous providers.
The Case of Mongolia

- January 2001: ISPs meet in Ulaanbaatar
  - Consensus: We need domestic IXP
  - All ISPs connecting via satellite, with over a half second latency for every packet in each direction
- April 2001: Mongolia Internet Exchange launches with 3 members
- March 2002: 6th member joins MIX
  - Latency for domestic traffic drops from 650 to less than 10 milliseconds
- Government role: none
The Case of Kenya

- No IXP on African continent outside South Africa
- KIXP organized by TESPOK, launched in November 2000
- December 2000: CCK orders KIXP closed on complaint from Telkom Kenya
Kenya: Background

- Telkom Kenya has statutory monopoly over fixed network infrastructure (local, national, international, leased lines)
- ISP services open to competition, but ISPs rely on Telkom Kenya for underlying infrastructure
- Until KIXP, all Internet traffic in Kenya exchanged internationally
  - Before IXP, roughly 30% of upstream traffic was actually to a domestic destination [TESPOK]
  - Compare: In South Africa, with several IXPs, roughly 70% of traffic is domestic-bound
KIXP

- Reduced latency from average of 1200-2000 milliseconds (via satellite) to 60-80 milliseconds
- Reduced costs:
  - 64 kbit/s circuit:
    US $200 (domestic) vs. $3375 (int’l)
  - 512 kbit/s circuit:
    US $650 (domestic) vs. $9546 (int’l)

[Source: TESPOK]
Kenya: Endgame

- Kenyan ISPs argued that KIXP is closed user group, which would be legal under Kenyan Telecommunications Act
  - Also: Local exchange of domestic traffic does not contravene Telkom Kenya’s international monopoly, as all international traffic would continue to flow over its international links
- TESPOK initially pursues lawsuit, but reaches settlement with CCK based on formal licensing
  - In fact, 2 different IXP applications are submitted, gazetted, and granted by CCK
- October 2001: CCK grants license, with request that ISPs partner with Telkom Kenya
- February 2002: No decision from telco, so ISPs go forward and re-launch KIXP
The Case of Bangladesh

- No IXP
- Why not? BTTB (Bangladesh Telegraph and Telephone Board) says: “No funding available from government.”
  - Even though IXP would save BTTB money, lower costs for users, improve levels of service
- As government-sanctioned monopoly, BTTB needs regulator approval (and budgeting) for new services
- Traceroute from one Bangladeshi ISP to another shows traffic travelling via Hong Kong, the U.S., and Canada, with 2 satellite hops
- Most Bangladeshi sites hosted in the U.S.
• For developing countries, domestic exchange of Internet traffic has clear advantages in Cost & Quality of Service
• IXPs enable neutral, cost-effective domestic peering
  – Plus, secondary benefits for the local Internet community: IXP can be efficient location for services like caching & content delivery, DNS, ccTLD, web hosting
• So what are the obstacles?
  – Or: Why isn’t everyone leaping onto the IXP bandwagon?
### IXP Obstacle 1: Resistance by Monopoly Telecom

- Monopoly telecom likes monopoly rents
- Sole provider of international leased lines
- Thinks of other ISPs as direct competitors, rather than as potential customers
  - Wants to delay effective competition for wholesale or retail ISP services
- Politically powerful
IXP Obstacle 2: Resistance by Government/Regulator

- Law states: “You will connect to the Internet through the monopoly telecom!”
- Sometimes driven by monopoly telecom:
  - Dependence on telecom revenue for national budget
  - Telecom influential with regulatory authority
- Regulator lacks understanding of Internet
- Use of statutory or other licensing requirements for telecommunications facilities
- Possibly: actual corruption
IXP Obstacle 3: Resistance by competing ISPs

- Lack of trust
- Fear of making life cheaper for (or even subsidizing) competitors
- Fear that “interconnection” means stealing of customers
- Fear that IXPs are too complicated
  - “American/European IXPs have sophisticated switches, powerful routers, large expenses, huge complexity”
  - Equipment vendors sometimes promote this feeling by pushing big, complex equipment
Legal/Regulatory Considerations

• Subsidize formation of IXP?
  – May be needed to catalyze facility
  – But: Artificial subsidies may discourage formation of additional, competing IXP facilities with different price structures, different features, different exchange policies

• Neutral management of IXP is key
  – By agreed neutral (university or academic institute), or ISP association

• Government should promote IXPs in general, rather than specially subsidize a particular (government-run) IXP
  – Good rule of thumb: Government should withdraw from involvement within 18 months

• Tax incentives or exemptions?
  – Generally not needed, if IXP is incorporated as cooperatively-owned or self-owned non-profit entity

• Protection from take-over by for-profit entity?
Beware: The Chokehold Maneuver

• Problem: If there is a dominant ISP in the market, it may participate in the IXP, but severely under-provision its link to the IXP
  ➔ The Thin Pipe Stratagem

• Result: Competitors’ customers encounter slow connections to dominant’s customers
  – Understandably, they fault the competitor ISP for the poor connection, not the incumbent (“I don’t care who’s to blame; I just want a fast connection”)
  – Strong incentive to switch to dominant ISP

• Cause for regulation?
  – If so, how?
  – Compare: Mandatory Multi-Lateral Peering Agreements (MMLPA)
    • My 2 cents: Bad idea
    • Creates disincentive to large ISPs to interconnect
    • Removes incentive to keep technical operation in top condition

• Mandatory interconnection makes more sense in the case of legally granted monopolies.
What can Governments do?

- IXPs rise with cooperation; fall without it
- Governments should ensure legal/regulatory environment supports cooperation and investment
  - ISPs are a suspicious bunch in fierce competition
  - Will be highly sensitive to the danger that its IXP investment actually benefits competitors
- Neutral management of IXP is key
  - Government should ensure that its laws and licensing regime (if any) allow ISPs to create a neutral, co-operative, commonly-owned and -managed, non-profit entity that is protected from acquisition by dominant ISP or telecom operator
  - Agreed neutrals: ISP association (usually), or fully independent neutral like a university or institute.
Regulatory Considerations

• Subsidize formation of IXP?
  – May be needed to catalyze facility
  – But: Artificial subsidies may discourage formation of additional, competing IXP facilities with different price structures, different features, different exchange policies

• Government should promote IXPs in general, rather than specially subsidize a particular (government-run) IXP.

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• Protection from take-over by for-profit entity?
Legal “Backbone” Monopolies

- Dominant ISPs have strong incentives to harm the public interest
  - Raise prices above competitive levels (no competition)
  - Stop cooperating with smaller ISPs
    - Refuse to interconnect (or refuse to peer)
    - Execute a price squeeze (make retail price = wholesale price)
    - Degrade the quality of interconnection (all together or one-by-one)

- So: Governments should not protect “backbone” monopolies
  - No reason for it (Internet is not fixed-wire telephony)
  - At least: mandate interconnection by legal monopolies.
  - Indeed: WorldCom / MCI merger
So: Now you’ve got an IXP

- Let’s look at some of the business considerations in deciding whether or not to peer.
- Bottom line: only peer if benefits > costs.
- First, identify a likely peer
  - Usually based on quantities of traffic
  - An ISP might analyze its inbound and outbound traffic flows to identify most common AS destinations/sources, and determine which peering connections would most reduce costly transit.
  - Analysis may require lots of work, so an ISP might use an alternative: Intuition.
Negotiation of Peering Agreement

• So, first, you have done the cost/benefit analysis, and you think it would probably be beneficial to peer.
• Second, find relevant contact at target ISP.
• Often, discussions of peering arrangements are done under Non-Disclosure Agreements (NDAs)
## How & where to peer?

1. Direct circuit interconnection?
2. IXP-based interconnection via shared fabric?

- **Factors:**
  - Speed of deployment
  - Difficulty (initial and ongoing)
  - Cost (initial and ongoing)

- **Most often, joining a neutral IXP will make faster, easier, and cheaper to establish peering relationships than attempting direct circuit connections with each peer.**
  - And: IXP may also allow private peering at the exchange point via fiber or copper cross-connects
Note: Collective Action Problem

• Before an IXP exists, ISPs have to make individual cost/benefit analyses whether to contribute to the launch of the IXP
• Unless enough collectively decide to create the IXP, there will be no IXP
• Factors:
  – Will it be neutral & not advantage competitors?
  – Costs: upfront costs, future operating costs, fees
  – How to share costs equitably?
  – Will IXP be managed professionally & competently?
  – Will IXP attract more potential peers in the future?
  – How are technical and financial decisions made?
Peering Cost/Benefit Analysis

• Some premises:
  – Transit is expensive
  – Volume of Internet traffic is growing fast
    • Customers like ever-new Internet services that consume ever-more bandwidth (video, multimedia, MP3s, etc.)

• How to compare transit vs. peering?
  – On a common basis: Mbps
  – Transit cost is easily calculated: look at your upstream provider’s bill
    • Tiered pricing structures are common, though volume savings are often small
## Sample Estimate of Peering Costs

### Fixed costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport into IXP</td>
<td>500/month</td>
</tr>
<tr>
<td>ISPA fees:</td>
<td>500/month</td>
</tr>
<tr>
<td>(Rack space + switch port on public peering fabric)</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>1000/month</strong></td>
</tr>
</tbody>
</table>

### Peering Bandwidth (Mbps)

- Depends on how much is exchanged via IXP
### Sample Peering Cost per Mbps

<table>
<thead>
<tr>
<th>Mpbs Exchanged</th>
<th>Peering cost per Mbps</th>
</tr>
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<tbody>
<tr>
<td>0.5</td>
<td>2000</td>
</tr>
<tr>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>333</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
</tr>
<tr>
<td>5</td>
<td>200</td>
</tr>
<tr>
<td>6</td>
<td>167</td>
</tr>
<tr>
<td>8</td>
<td>125</td>
</tr>
</tbody>
</table>
Compare Transit with Peering

(Assumes transit cost starting at 400/Mbps)
Less Quantifiable Motives for Peering

- Competitive advantage from lower latency
- More control over routing; more flexibility
- Redundancy
  - If peering sessions fail, ISP still has transit
  - If transit fails, at least peering connections are maintained; if transit goes bankrupt, IXP presence can allow for fast & easy change of providers
  - Multiple peers improve network reliability & decrease effect of any single failed connection.
- Peering relationships with other ISPs allow for better sense of competitive environment
- Marketing, especially to content providers and customers of ISP’s hosting services
Complications

• Traffic asymmetry
  – One peer ISP’s customers host lost of web content; the other peer ISP’s customers are mainly dial-up users. (But WWW traffic is inherently asymmetric – who benefits more?)
  – In some cases, ISPs will peer without settlement up to a certain ratio (ex: 4:1 traffic out to traffic in), and then on a Mbps usage basis beyond that (“paid peering model”).

• Investment asymmetry
  – ISPs don’t want to subsidize their competitors.

• Desire to sell transit
  – ISPs may hope to make competitors transit customers rather than peers.

• Peering takes commitment of ISP resources
  – Equipment, circuits, staff time, etc.
  – Legal work: negotiations & contracts

• Peering demands more ISP cluefulness than transit
  – Peers may not have sufficient engineering competence at all times, requiring careful staff attention & increased processing power for filters.
  – No Service Level Agreements (SLAs) among peers.

• BGP is complicated
Business → Technical

- Interconnection is inextricably both a business and technical matter
  - (If, of course, laws & regulations allow it)
- Business decisions to peer must be documented in legal agreements, and implemented at the technical level in the form of policies, rules, safeguards.
Bottom Line: Trust & Perception

- Every ISP needs to make its own (subjective) analysis of peering costs vs. benefits.
- Each ISP in a peering relationship must perceive that the benefits and burdens are shared more or less equally.
- Developing country ISPs need to develop trust relationships based on rational self-interest (cost-benefit)
  - Don’t think in terms of zero-sum-game (it’s not)
  - Don’t just think of yourself as an end-point consumer of international bandwidth; you may be building a future (national/regional) backbone
Peering Simulation Game

- ISPs occupy adjacent squares; no blocking
- Revenue: Each square occupied = $2000 transit revenue/turn
- Cost: Upstream transit fees = $1000/turn for each square occupied by other ISPs
  - (Transit fees proportional to size of Internet)
- Peering negotiation after each turn
  - If 2 ISPs build into exchange and reach peering agreement, transit costs to peer’s squares eliminated
  - Cost of peering: 2 lost turns + $2000/turn
  - Cost divided according to negotiated agreement
Intro to IXP Agreements

- Equinix
- JINX/CINX
The Feedback Loop:

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<mclaughlin@pobox.com>
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Bill Woodcock (Packet Clearing House)
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- Paper: Introduction to Exchange Point Economics
- Paper: Differentiating Transit Exchanges from Peering Exchanges
- Paper: Policy Guide for Developing Nations Wishing to Encourage the Formation of a Domestic Internet Industry
  (Papers available at <http://www.pch.net/documents/papers>