The Law, Politics, and Economics of Interconnection

Andrew McLaughlin

Berkman Center, Harvard Law School

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Internet

- Definition: A network of independent networks.
  - Common interconnection standards
  - Open interfaces
  - Common naming & addressing systems
- 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.

Internet Service Providers

- Definition: An ISP sells to businesses, organizations, and end-users connectivity to the global public Internet.
- To sell connectivity to the global public Internet, each ISP needs to buy connectivity to the global public Internet
  - ISPs are both clients and providers
  - ISPs buy connectivity from upstream ISPs (wholesale), and sell it to customers (retail or wholesale)

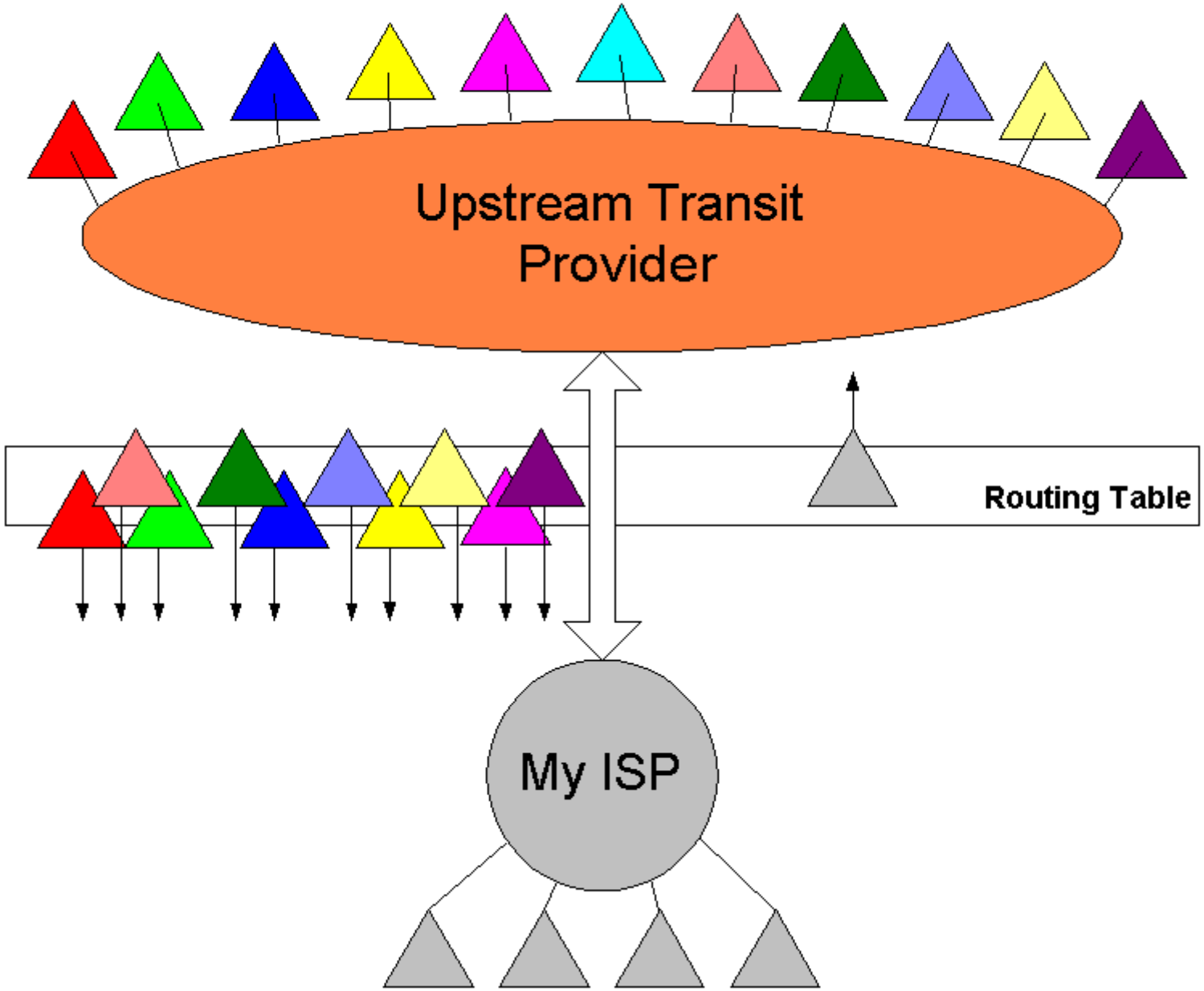
ISPs live in strange world…

- 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

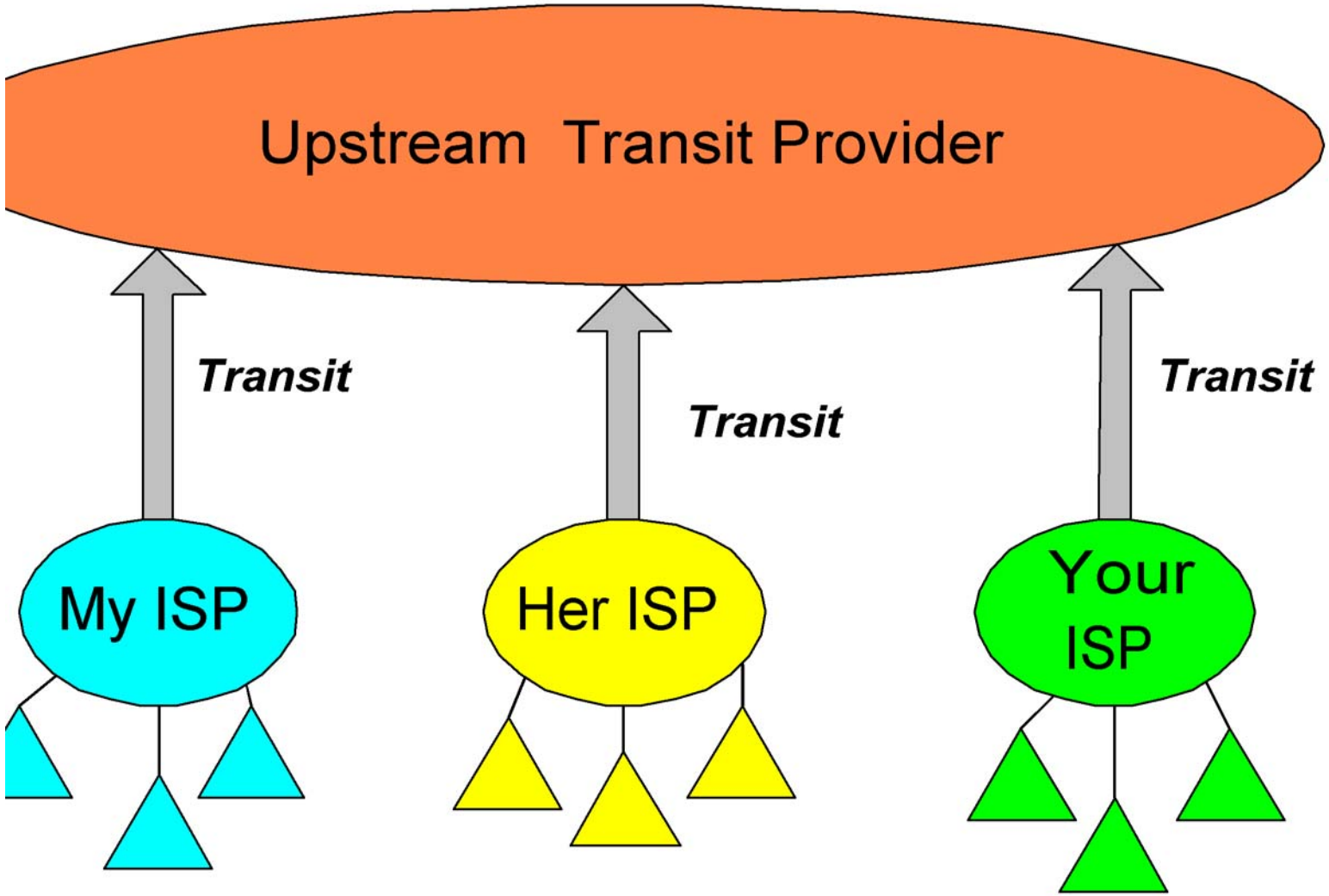
Transit Relationship



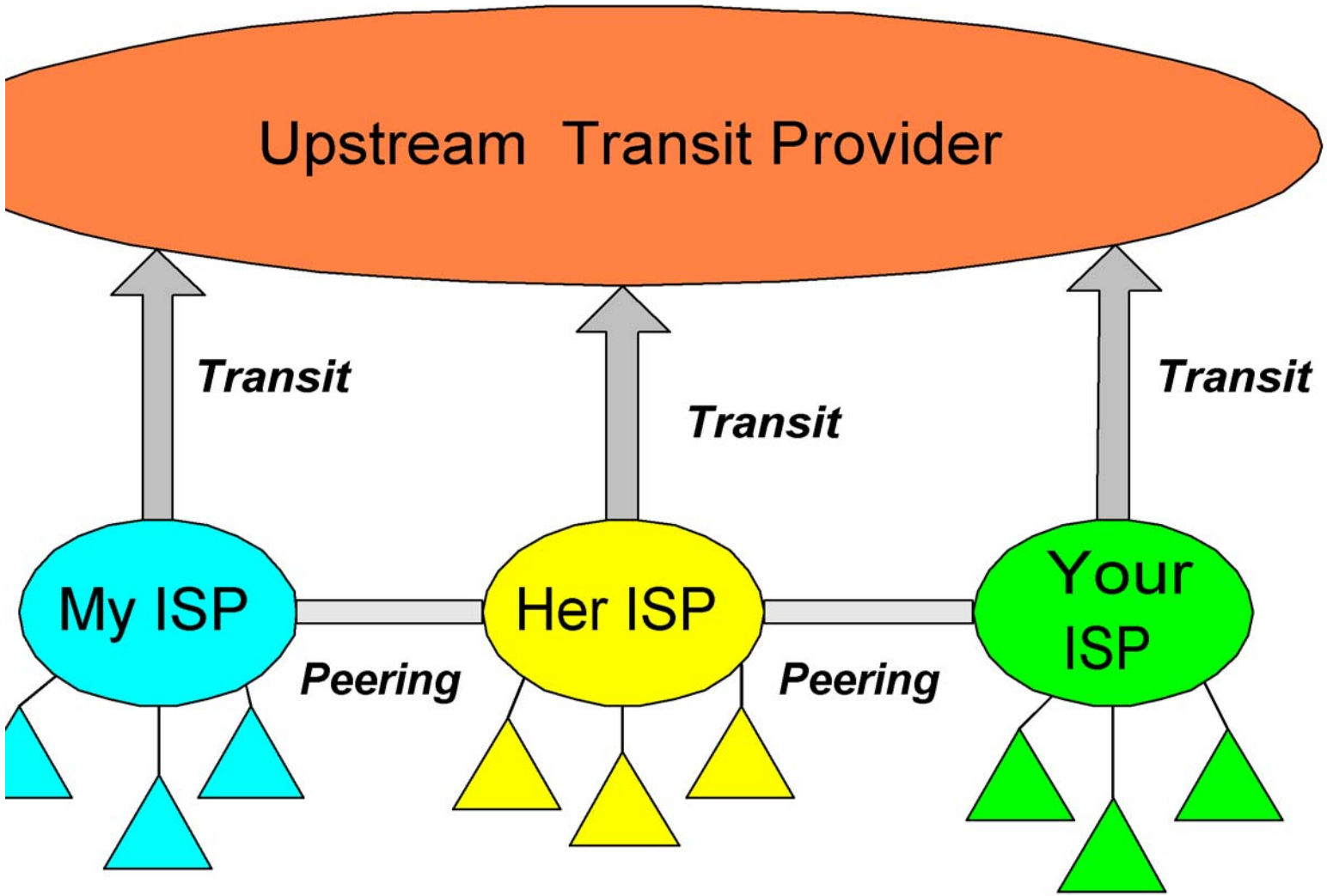
Transit vs. Peering

- *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 3d parties
  - No cash payments involved (more like barter); no settlement
  - No Service Level Agreement (SLA)
  - *Not the same as "peer" in BGP!*

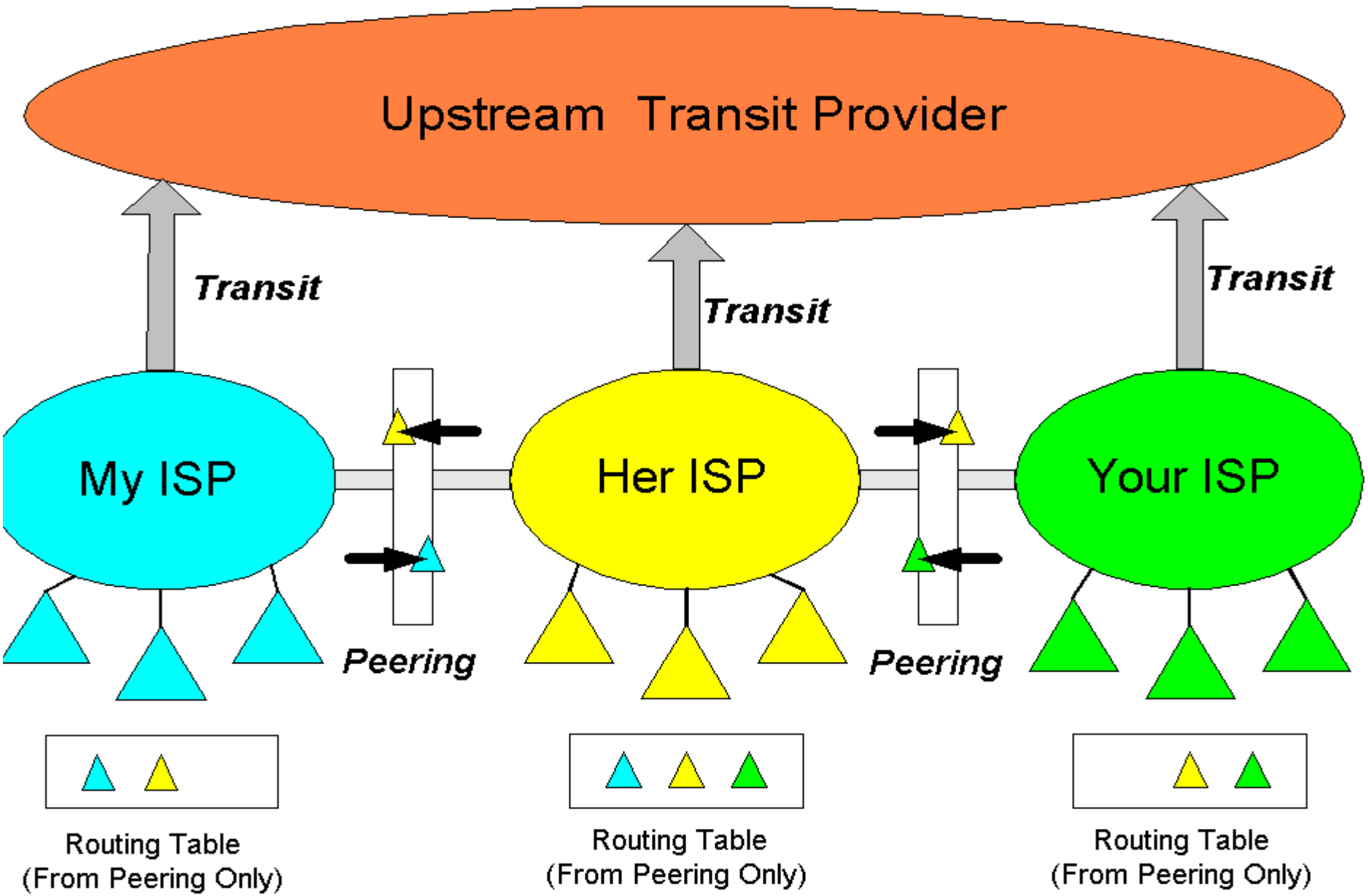
Only Transit, No Peering



Peering


Upstream Transit Provider
Transit
Transit
Transit
My ISP
Her ISP
Your ISP
Peering
Peering

Peering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My ISP
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Peering
Peering
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 bi-lateral 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 trafic 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.

So…

- 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?
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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

Transport into IXP:	500/month
ISPA fees: (Rack space + switch port on public peering fabric)	500/month
Total:	1000/month

Peering Bandwidth (Mbps)

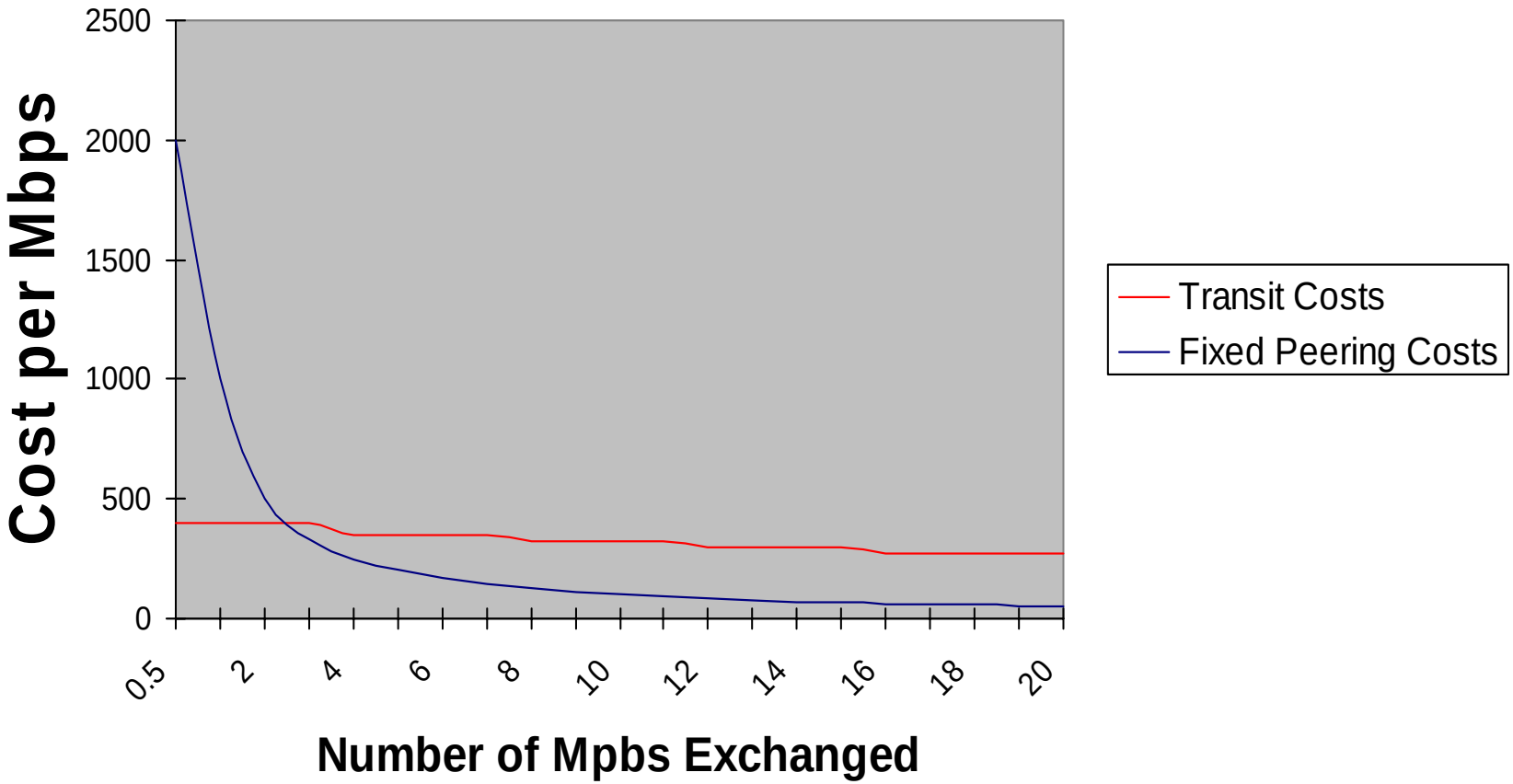
- Depends on how much is exchanged via IXP

Sample Peering Cost per Mbps

Mpbs Exchanged	Peering cost per Mbps
0.5	2000
1	1000
2	500
3	333
4	250
5	200
6	167
8	125

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

Equinix MoU

- JINX/CINX

The Feedback Loop:

Andrew McLaughlin

<mclaughlin@pobox.com>

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