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Introduction to Exchange Point Economics

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- Exchanges must be inexpensive, not reliable.
- There should be multiple exchange point *operators*, but only one *switch fabric* per geographic region.
- Open peering promotes growth; closed peering causes stagnation.

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Inexpensive, not Reliable

- All but about a dozen ISPs purchase transit.
- Thus all peering is simply an economic optimization versus transit. It exists simply to reduce the average per-bit cost. Shorter paths are a collateral benefit.

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Inexpensive, not Reliable (2)

- The effectiveness of peering can be directly measured as a function of its reduction of per-bit cost versus transit.
- Thus making peering inexpensive is more beneficial to its effectiveness than making it reliable.

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Inexpensive, not Reliable (3)

Example:

Transit may cost $0.50/gigabit.

Reliable (99.999%, 26 sec/mon downtime) peering may cost $0.40/gigabit.

Unreliable (99.9%, 45 min/mon downtime) peering may cost $0.005/gigabit.

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Inexpensive, not Reliable (4)

- Transit cost: $500/megabit/second/month at 40% utilization = $0.50/gigabit.
- Reliable exchange cost: $10,000/month for 100 megabits/second at 15% utilization = $0.40/gigabit.
- Unreliable exchange cost: $500/month for 100 megabits/second at 50% utilization = $0.005/gigabit.

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Inexpensive, not Reliable (5)

- Example ISP ships 10 terabits/month (approximately 40 megabits/second average)
- If exclusively by transit, $5,000/month.
- If 50.001% by transit and 49.999% by reliable exchange, $12,500.05/month.
- If 50.1% by transit and 49.9% by unreliable exchange, $3,005/month.
- Reliable exchange saves $4.95 of transit, but costs $9,500 extra each month.

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Switch Fabric Fragmentation

- Every region needs exactly one switch fabric, where a region is defined as any area bounded by a step-function in the cost of backhaul.
- Additional switch fabrics damage connectivity, increase costs, and decrease value.
- Multiple exchange point operators increase price/performance options and increase value, as long as one fabric spans them all.

Switch Fabric Fragmentation (2)

Example:

Fifty peers, with 100 routes each, peer at a single exchange (“A”) in a region. They pay $500/month each to participate in the exchange.

Each pays $0.102/month/route for peering.

($500/month divided by 4,900 routes.)

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Switch Fabric Fragmentation (3)

A second, unconnected exchange (“B”) is started in the same region, offering service at $400/month.

Fifteen providers leave exchange A to join exchange B instead.

Ten providers join B as well as A.

Twenty-five providers remain just at A.

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Switch Fabric Fragmentation (4)

		Cost	Routes	Cost/Route
A only	25	$500	3400	$0.147
B only	15	$400	2400	$0.167
Both	10	$900	4900	$0.184
Average		$550	3400	$0.161

When a second unconnected exchange is added, costs double, or reachability is halved.

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Switch Fabric Fragmentation (5)

		Cost	Routes	Cost/Route
A only	11	$500	3200	$0.156
B only	9	$400	3000	$0.133
C only	8	$600	2900	$0.207
A & B	7	$900	4100	$0.220
B & C	6	$1000	3800	$0.263
A & C	5	$1100	4000	$0.275
A, B & C	4	$1500	4900	$0.306
Average		$706	3530	$0.206

When a third unconnected exchange is added, the effects become correspondingly worse.

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Open Peering is the Only Effective Way to Create Value

- Any one ISP's customers make up an insignificantly small portion of the Internet.
- The amount your customers are paying to reach your other customers is insignificant, relative to the amount they're paying to reach everyone else's customers.

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Peering Creates Value (2)

The value which you as an ISP have to sell to your customers is the sum of the bandwidth at each of the exits of your network, weighted by the number of routes available through each.

Peering Creates Value (3)

There are three ways to increase the value which you have to sell to customers:

- Buy it (purchase transit)
- Sell it (sell transit) or
- Peer

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Peering Creates Value (4)

- Purchasing transit is expensive. Although it is generally necessary and desirable to purchase some transit, economic optimization requires that it be used as little as possible.
- A network cannot survive by reselling transit alone, as that would be an unnecessary middleman position.

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Peering Creates Value (5)

- Selling transit is necessary and desirable, as that increases the number and size of your customer base, the group of people who pay you money.
- However, you cannot sell as fast as the Internet grows overall, so the portion of the Internet which consists of your customers will decline over time.
- Thus selling transit is too slow a means of increasing value. It also constitutes a chicken-and-egg problem: if you depend upon sales for growth of value, and depend upon growth of value to fulfill new sales, you cannot gain momentum.

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Peering Creates Value (6)

Adding peering bandwidth both costs less and can be achieved more quickly than adding either purchased or sold transit bandwidth, since it's both geographically aggregated and temporally flexible.

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Peering Creates Value (7)

- Switching from an open peering policy to a closed peering policy will necessarily retard the growth-rate of your network, both in absolute terms, and relative to your competitors who are growing through the addition of new peering bandwidth.
- No network has ever been profitable while pursuing a closed-peering strategy.

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Collateral Lesson: Peering and Sale of Transit are Complementary, not Mutually Exclusive

There exist a set of related fallacious beliefs which cause innumerate people in this industry to lose money:

that it is not advantageous to peer with one's customers,

that refusing to peer with another ISP can do them disproportionately more harm than it does one's self,

and most ridiculously, that if you refuse someone peering, they might become your customer instead.

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Collateral Lesson 1: Peering with Customers is Good

- Any peering increases the amount of bandwidth you have available to sell to your customers.
- If you peer with a customer, it increases the amount of bandwidth which you can sell to other customers.

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Collateral Lesson 1: Peering with Customers is Good (2)

- Peering with a customer means offering them free routes *to* your other customers within the same region.
- If 0.1% of your traffic is between your own customers, and you peer with 10% of your customers, 0.001% of your traffic is between a pair of customers which are both also peers.

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Collateral Lesson 1: Peering with Customers is Good (3)

- Thus by peering with 10% of your customers, you increase the bandwidth you have to sell to customers 0.1% of the time. In exchange, you either sacrifice payment for 0.001% of your traffic or need to create a new billing method for it. These numbers are both insignificant.
- What's important is that it allows you to have a uniform peering policy without having to special-case an exception class.

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Collateral Lesson 2: Refusing Peering Hurts You Both

- When an ISP refuses to peer with another ISP, both are hurt.
- ISPs which refuse to peer are generally failing to peer with a set of other ISPs which *collectively* advertise more routes than the ISP which is failing to peer.

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Collateral Lesson 3: If You Refuse Someone Peering, You Create a Customer for your Competitor

- If ISP “A” refuses to peer with ISP “B,” two possibilities exist:

  B will buy transit from one of A’s competitors to reach A, or

  B will peer with one of A’s transit providers to reach A.

- At best, A loses the possibility of selling B transit, and creates a customer for one of their own competitors.
- At worst, A loses the possibility of selling B transit, and has to pay to receive traffic which B can send for free in any volume.

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Summary

- Only an inexpensive exchange can succeed.
- Only one switch fabric should exist in a region.
- Connections should be offered by multiple exchange point operators with different facilities at different price points.
- ISPs which wish to grow and be profitable must peer with everyone they can.

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www.pch.net/documents/papers/intro-economics