Internet Exchange Points
Benefits & Requirements

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ISP Lifecycle: Simple Aggregator

Single Transit Provider ——— IXPs

ISP Network

Customers
ISP Lifecycle: Redundancy and LCR

Redundant Transit Providers ——— IXPs

ISP Network

Customers
ISP Lifecycle: Local Peer

Redundant Transit Providers — IXPs

ISP Network

Single IXP

Customers
ISP Lifecycle: Network Service Provider

Redundant Transit Providers —— IXPs

NSP Network

Multiple IXPs

Customers
Hot Potato Routing
Hot Potato Routing

Red Customer sends to Green Customer via Red NSP
Hot Potato Routing

Red NSP delivers at *nearest* IXP
Hot Potato Routing

Green NSP backhauls from distant IXP
Hot Potato Routing

Green ISP delivers to Green Customer
Hot Potato Routing

Green Customer replies via Green NSP

Redundant Transit Providers

Red NSP Network

Red Customer

IXP

Green NSP Network

Green Customer

Redundant Transit Providers
Hot Potato Routing

Green NSP delivers at nearest IXP
Hot Potato Routing

Red NSP backhauls from distant IXP
Redundant Transit Providers

Hot Potato Routing

Red NSP delivers to Red Customer

Red NSP Network

IXP

Green NSP Network

IXP

Red Customer

Green Customer
Hot Potato Routing

**Red Network** is responsible for its own costs
Hot Potato Routing

**Green Network** is responsible for its own costs

Redundant Transit Providers

Red Customer

Red NSP Network

IXP

Green NSP Network

IXP

Green Customer
Hot Potato Routing

Symmetry: Fair sharing of costs

The old circuit-switched networks have dubbed our financial model “bill and keep”
Tools for thinking about Internet Exchanges in economic terms

What are we, as ISPs, selling?
The right to modulate bits.
That right is a perishable commodity.
Where do we get the potentially-modulatable bits?
The right to modulate bits

Any Internet connection is a serial stream of time-slices.

Each time-slice can be modulated with a binary one or zero, one bit.

Each customer purchases potentially-modulatable bits at some rate, for example, 2mbps, which is 5.27 trillion bits per monthly billing cycle.
That’s a perishable commodity

The quality (as opposed to quantity-per-time) characteristics of an Internet connection are loss, latency, jitter, and out-of-order delivery.

Loss increases as a function of the number and reliability of components in the path, and the amount of contention for capacity.

Latency increases as a function of distance, and degree of utilization of transmission buffers by competing traffic sources.

Jitter is the degree of variability in loss and latency, which negatively affects the efficacy and efficiency of the encoding schemes which mitigate their effects. Jitter increases relative to the ratio of traffic burstiness to number of sources.

Out-of-order delivery is the portion of packets which arrive later than other, subsequently-transmitted packets. It increases as a function of the difference in queueing delay on parallel paths.

All of these properties become worse with time and distance, which is a reasonable definition of a perishable commodity.
So where do we get the bits?

The value of the Internet is communication. The value is produced at the point at which communication occurs between two ISPs, and it is transported to the customers who utilize it.

Thus, all the bits we sell come from an Internet exchange, whether nearby, or far away.
An analogy

Let’s look at another perishable commodity with more readily observed economic properties... **Bananas.**
Value decreases with time & distance

The value of a banana decreases, the further it gets from the farm which produced it.

The shelf-life which the consumer can expect decreases, and eventually it becomes overripe, then rotten.
Cost increases with time & distance

The cost of a banana increases, the further it gets from the farm which produced it.

Salaries and hourly labor, warehouse leasing, diesel fuel, truck amortization, loss and spoilage, insurance, and other factors contribute additively.
In a competitive environment, retail price is limited by competition, so time and distance influence the price more than the number of middlemen.
The problem is the same:

ISPs form a delivery chain, bringing perishable bits to the consumers who purchase them.
So how do we improve things?
Bring the customer nearer an IX...

**High cost**
Low value

**Low cost**
High value

...or bring an IX nearer the customer.
So how do we recognize a successful exchange?

The purpose of an IX is to lower participating ISPs’ average per bit delivery costs (APBDC).

A cheap IX is probably a successful one. An expensive IX is always a failure. Reliability is just hand-waving by salespeople.
Determining Need

Sufficient end-user base?
No existing facility to build upon?
Sufficient degree of locally-destined traffic?
Geographic Location

User population
Fiber facilities or rights-of-way
Founding participants
Density

Centralized in one room
Campus of adjacent buildings
MAN
Frame or ATM cloud
Building Management

Telco hotel
University computing or telecommunications facility
City emergency services facility
In-Building Facilities

Pathways
Power
Cooling
Access and security
Services

Switch fabric
Crossconnects
Route-server
Remote hands
NTP
Web caching
Business Structure

- Incorporated or unincorporated?
- Staffed or volunteer?
- Non-profit or for-profit?
- Cooperative or external ownership?
- Cost-recovery (predictive or actuals), ad-hoc, or market pricing?
Policies

BLP, MLPA or MMPLA?
Mandatory looking-glass?
Routing and switch-port information public or members-only?
Secrecy in the event of security problems, failures, or mistakes
Extensible switch fabric?
Thanks, and Questions?

Copies of this presentation can be found in Keynote, PDF, QuickTime and PowerPoint formats at:

http://www.pch.net/resources/tutorials/ix-construction

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