Interconnection, Peering and Financial Settlements in the Internet

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Interconnection

- an overview of how ISPs interact to form today’s Internet
The Sum of Many Parts

- The Internet is the sum of more than 30,000 component service providers (ISPs)
- Each ISP has its own network with services, tariffs, customers, policies.

- many policies
- many services
- one Internet?
The Well-Ordered Internet

• This view is based on a conventional distribution infrastructure

• Every relationship is bilateral
  – a provider sells services to a consumer

• Tiering of the ISP sector
  – Tier 1 - global backbone transit networks
  – Tier 2 - national wholesale transit networks
  – Tier 3 - local retail access ISPs

• Assumption that every relationship is part of a provider / client hierarchy
The Well-Ordered Internet

• The resultant structure is a hierarchy of relationships
The competitive ISP industry tends to equilibrate on the lowest local cost structures
There are no objective criteria to identify who is the provider and who is the customer
Debt is better than profit as a means of leverage of ISP value
- there are fewer ways of establishing true value
underlying carriage tariffs shape Internet-based ‘locality’
Within each local tier cell ISPs tend to SKA peer - or not
- bluff is a critical component of the peering game
Strict tiering blurs because of the confusion over value identification
- is content of equal value to transit?
The Internet - as we know it
The Problem - as we see it

- how to interconnect many thousands of component networks while:
  - minimizing local cost everywhere by:
    - localizing transit traffic
    - matching diverse import, export and transit policies
    - avoiding super dense traffic black holes
    - maintaining stability and quality
      - both technical and financial
    - staying within the bounds of available technologies
  - and also adding thousands more component networks
The Role of the Exchange

• An examination of the rationale for public Internet exchanges
The N-squared problem

- $N^2$ circuits, $N^2$ peerings
- questionable scaling properties
The Exchange Router

- Too simple
- Router-based exchanges impose transit policy

Exchange Router selects preferred path to destination A
The Exchange Switch
Bilateral peering allows each ISP to select preferred path to destination A

- An L2 switch does not implement routing policy
- Routing policy is then the outcome of bilateral agreements
The Distributed Exchange

- Use of L2 virtual circuits to support bilateral peering eliminates the need for co-location
Adding Value to the Exchange

- exchanges represent a very efficient centralized service launch point
The Role of Private Peering

• Not all interconnection happens at public exchanges
• Exchanges can represent very dense traffic aggregation points
• Exchanges do not readily permit continuity of QoS mechanisms
• Exchanges are vulnerable to third party forcing
• Private peering allows private financial arrangements
What is being exchanged?

- **IP Routes**
  - A sends B routing advertisements

- **IP Packets**
  - B sends A IP packets destined to A’s advertised network’s
Routing Policy

- At an exchange you may exchange routes with any other network that is also present at the exchange.
- Whom you choose to exchange routing information with is a matter of local policy determination:
  - local purchase of transit
  - honoring remote transit obligations
  - local peering
Routing Policy

- Which routes you choose to advertise is a matter of policy.

- Network A PEERS with Network B:
  - A advertises A’s CUSTOMERS to B
  - A does NOT advertise its value-added customer SERVICES to B
  - A does NOT advertise its peer-learned routes to B
  - A does NOT advertise its upstream provider’s routes to B
Routing Policy

Client Services  Client Routes  Peer ISPs

Upstream ISPs
Peering and Financial Settlements

• An overview of the financial basis of interconnection within the Internet
Follow the Money

In a uniformly structured retail market the money flow is easy to identify:

- John initiates the transaction
- John pays his local provider A for the entire end-to-end transaction charge for the end-to-end service
- A pays B to terminate the transaction
- B terminates the transaction at Mary without charging Mary
Interprovider - Who pays who?

- The inter-provider financial relationship will vary for each individual transaction.
- The net outcome is balanced through financial settlement.

Financial Settlement

A pays B  $0 settlement point  B pays A
Interprovider - Who pays who?

• BUT, this assumes:
  - each transaction has a measurable value
  - each transaction is individually accountable
  - each transaction is funded by the end clients in a consistent fashion
    • initiator direction pays or
    • responder direction pays
Enter the Internet . . .

- In the Internet there is no readily identifiable uniform bi-directional transaction
  - The currency of interaction must shift to the lowest common denominator
  - Each individual IP packet is an individual ‘transaction’

- In a chaotic retail market each part of a multi-provider supported transaction has an individual monetary flow
  - The ‘value’ can be in either direction at each interconnection

- Per-Service charging is difficult
  - The service is within the IP payload
  - Per-packet transmission is the currency of IP money
Cost Apportionment

- Financial Settlements are intended to undertake a role of fair cost apportionment
  - How are costs incurred by Internet Providers?
  - How does each provider apportion local costs?
Distributed packet costs

Per-packet transit costs

$1

$3

$2

$1

$1
BUT

- IP packets
  - have a vanishingly small value
  - have no readily identifiable transaction context
  - may not be delivered
  - have no tracking field in the header to accumulate ‘value’
  - are usually not individually accounted within a retail tariff structure
The Internet model

- There is no known objective financial settlement model which is financially robust and technically feasible in the Internet.
- The most stable outcome is a bilateral agreement creating a provider/customer relationship, or SKA peer relationship.

A is a customer of B
SKA
B is a customer of A
How are costs apportioned?

- At the consumer level, IP transmission costs are administratively apportioned bilaterally between sender and receiver.

John funds partial path
Mary funds partial path

SKA handover

John to customer
 provider

Mary to customer
 provider

customer
 provider

customer
 provider
Fixed Relationships

• There are no known IP financial settlements models that are technically and financially fair and robust
• Every peering tends to a statically determined relationship of provider/ customer or SKA peer
• The resultant business strategy
  – only SKA peer with ‘larger’ ISPs
Every customer wants to be a peer
Every peer wants to be a provider

Bigger is better
- ISPs that aggregate through mergers and takeovers can obtain access to a more advantaged position with respect to their peer ISPs
Today’s Environment

- Natural tendency to aggregate within the ISP industry
  - Economies of scale of operation
  - Access to more advantageous SKA peering agreements

- Risk factors
  - Reduction of competitive pressure
  - Collective action on industry peering arrangements
  - Collective action on retail pricing
Imminent Death of the Net Predicted - MP3 at 11:00

- Aggregation of the IP global transit market to a very small number of operators
- Ability to execute global price setting through control of the underlying transmission resource
- Recovery of operating margins through elimination of competitive pressure for commodity pricing
- Is the communications industry attempting to rebuild the colonial structures of global provider and local franchise operator?
The Bottom Line

• A stable open competitive market for ISP services is based on the public availability of pricing at all levels.

• Continued operation of a strongly competitive IP supply market may require an active role for regulatory intervention at the level of inter-provider interaction.

• Intense aggregation is always an alternative to industry regulation.
Further Reading


- Varian, H., "The Information Economy - The Economics of the Internet, Information Goods, Intellectual Property and Related Issues". [http://www.sims.berkeley.edu/resources/infoecon/](http://www.sims.berkeley.edu/resources/infoecon/) This is a collection of references to other online resources, and is a useful starting point for further reading on this topic.
Further Reading

- ISP Survival Guide - Geoff Huston - John Wiley & Sons