Interconnection, Peering and Financial Settlements in the Internet

Geoff Huston

Telstra

. . . 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.

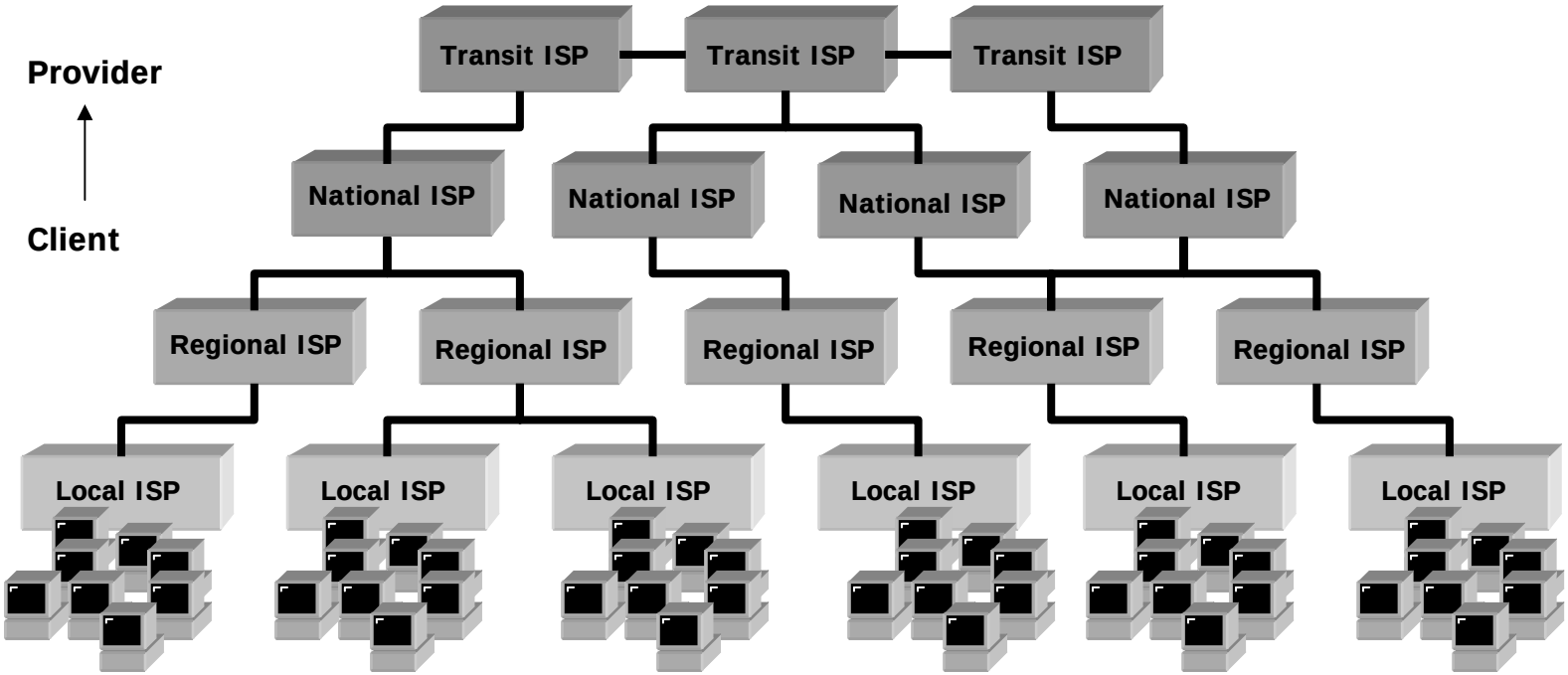
- many policies
- many services
- one Internet?

. . . 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

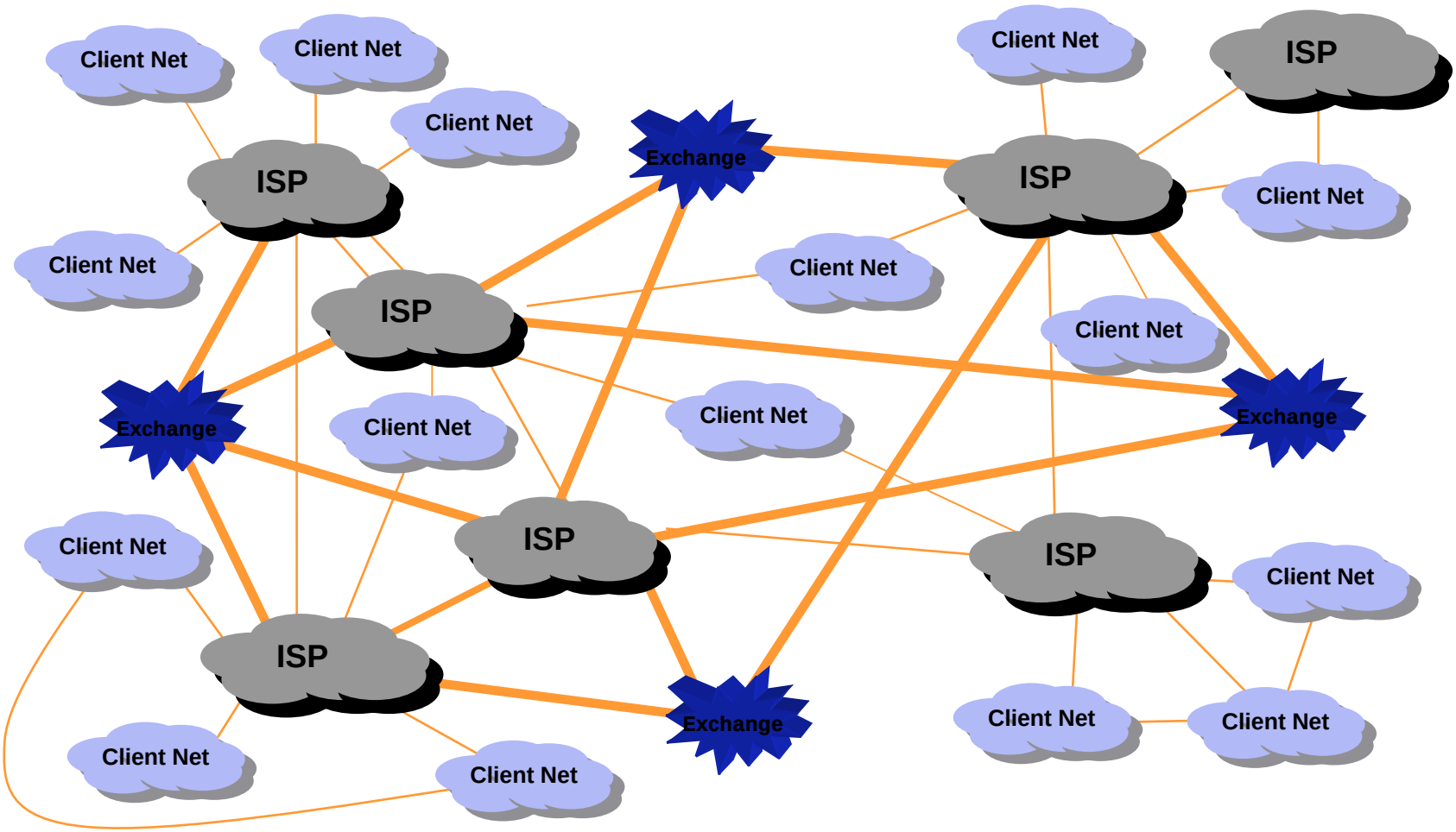
- The resultant structure is a hierarchy of relationships



. . . The Internet - as we know it

- 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

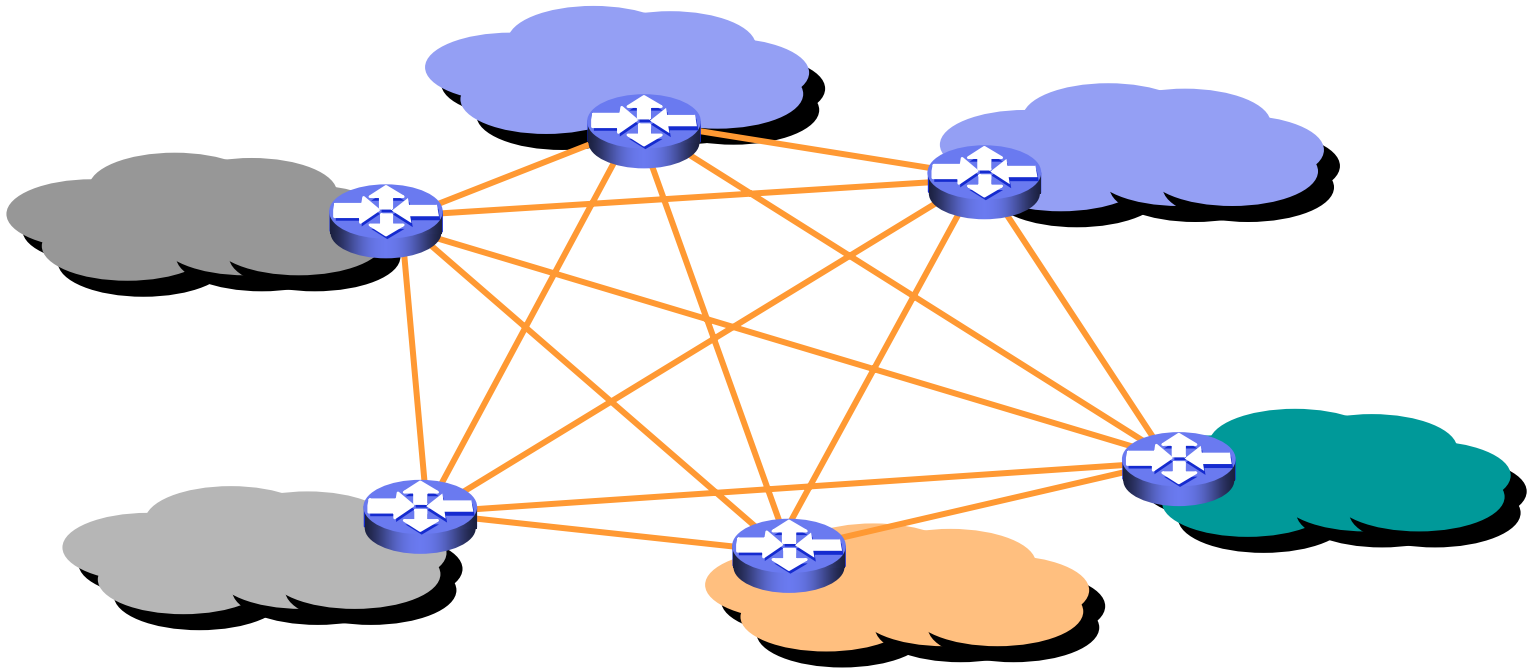
- how to interconnect many thousands of component networks while:
  - minimizing local cost everywhere by:
    - localizing transit traffic
    - matching diverse import, export and transit policies
    - avoiding super dense traffic black holes
    - maintaining stability and quality
      - both technical 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

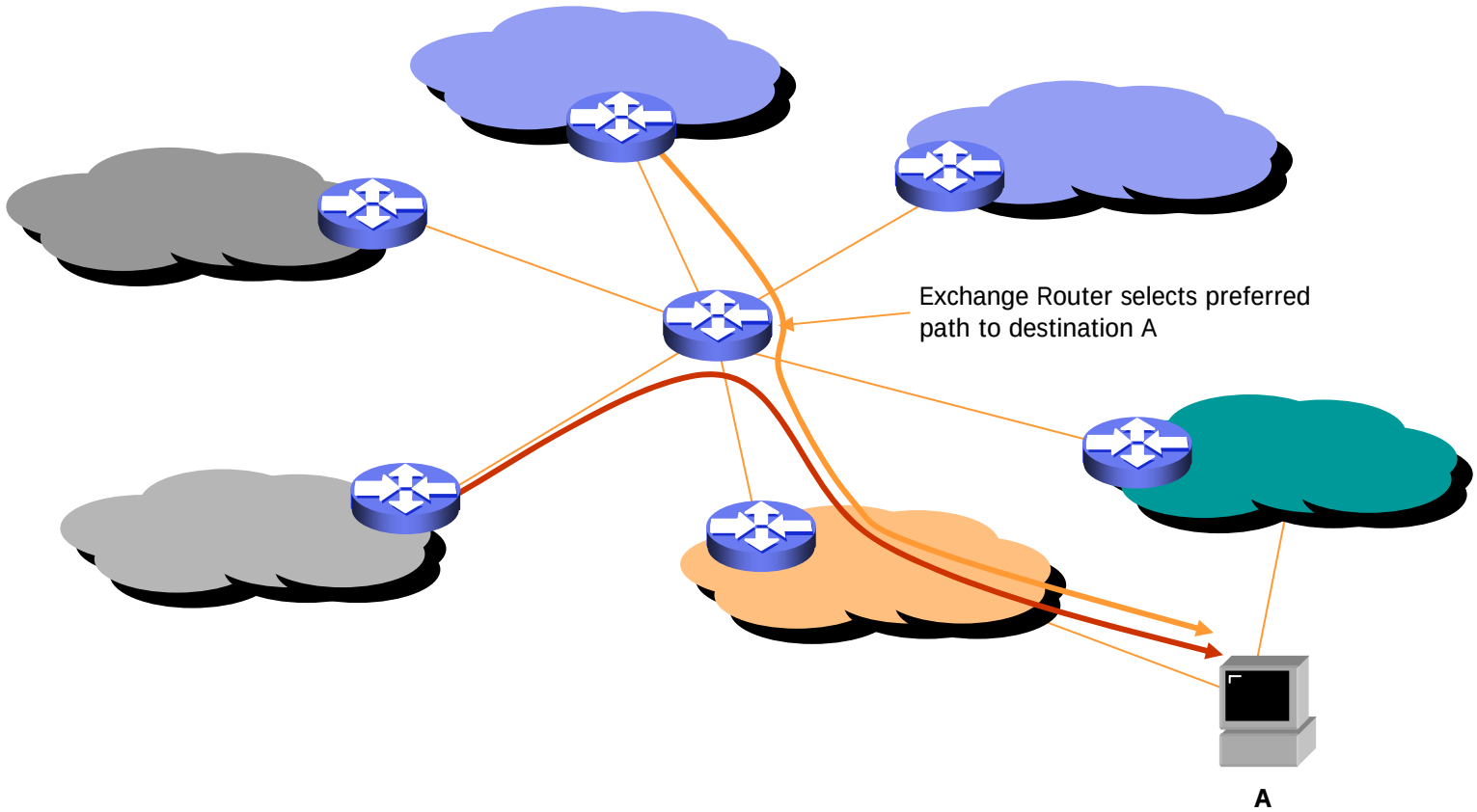
. . . The N-squared problem

- N^2 circuits, N^2 peerings
- questionable scaling properties

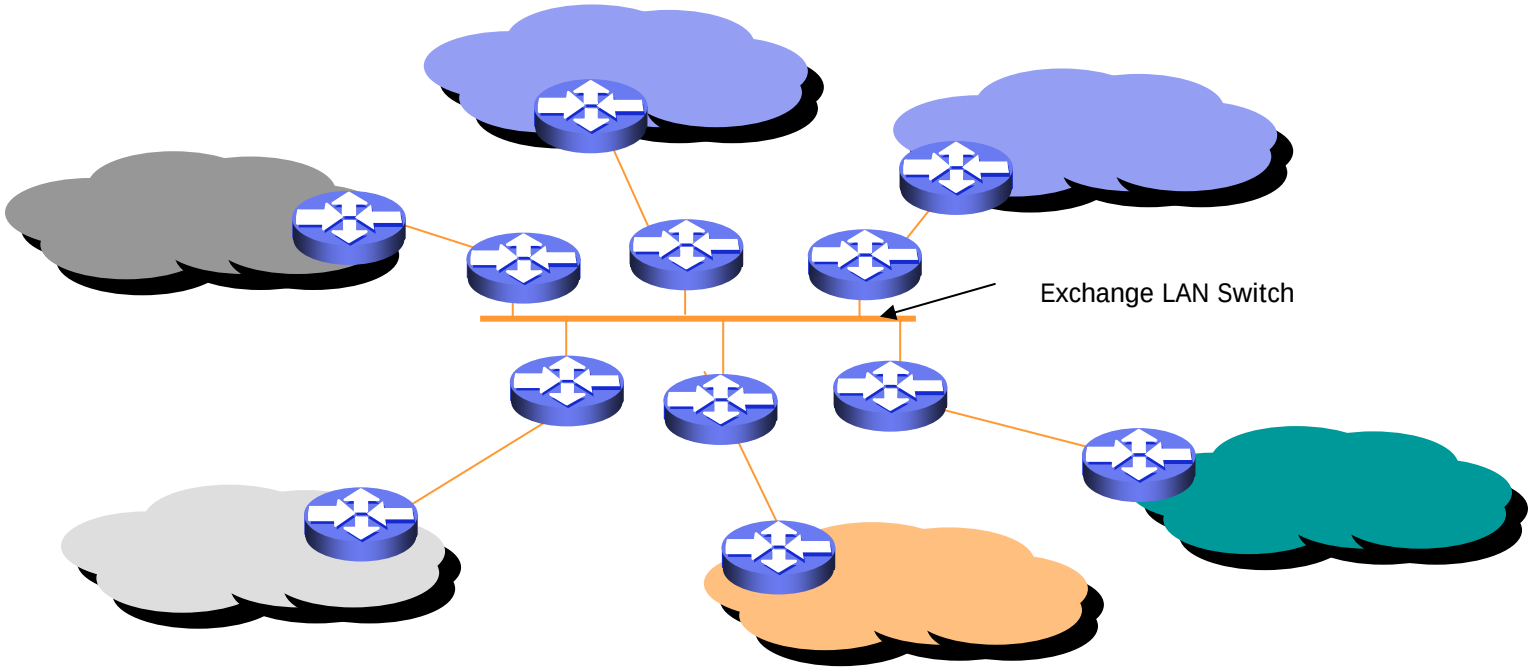


. . . The Exchange Router

- Too simple
- Router-based exchanges impose transit policy

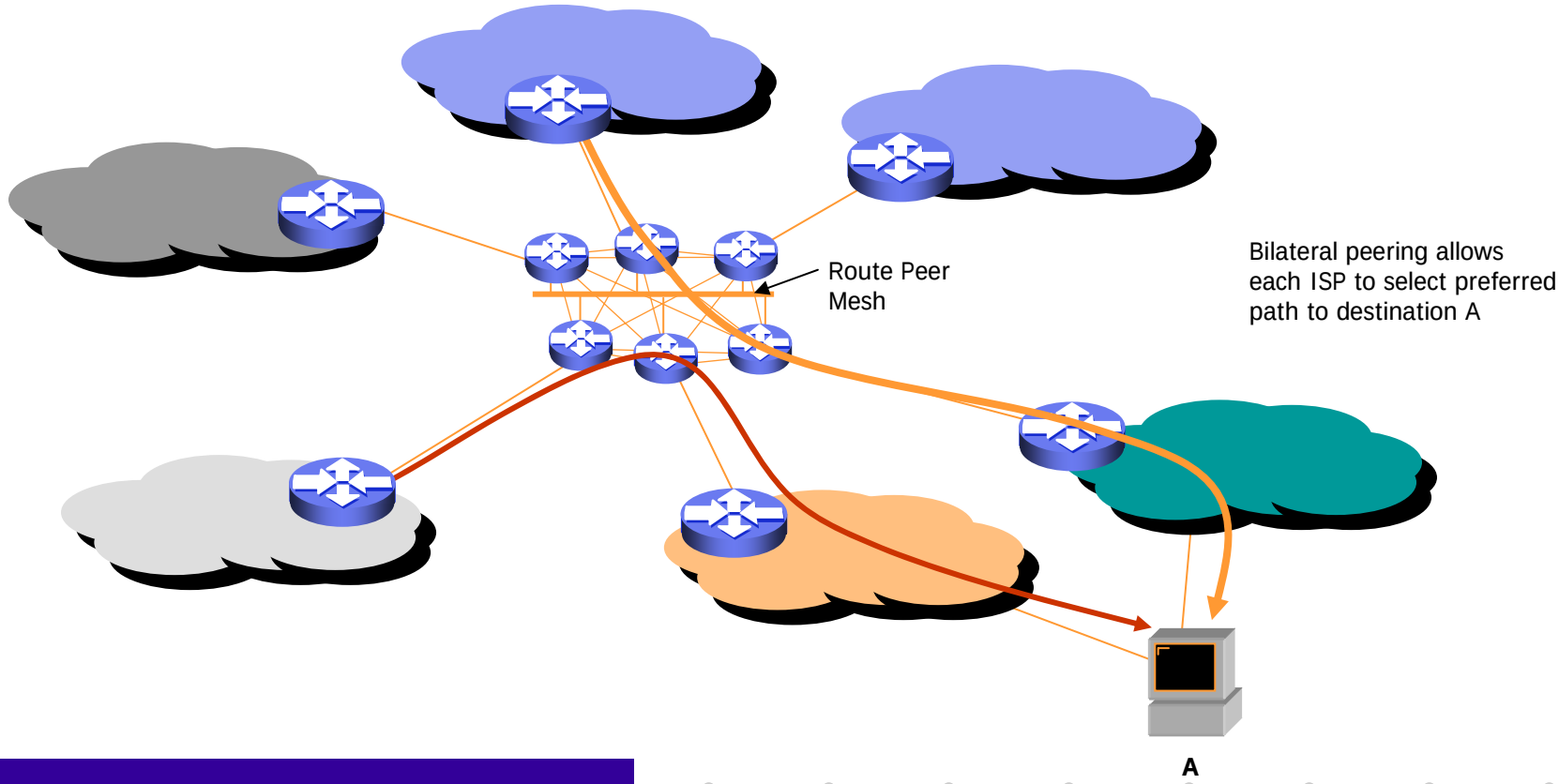


. . . The Exchange Switch



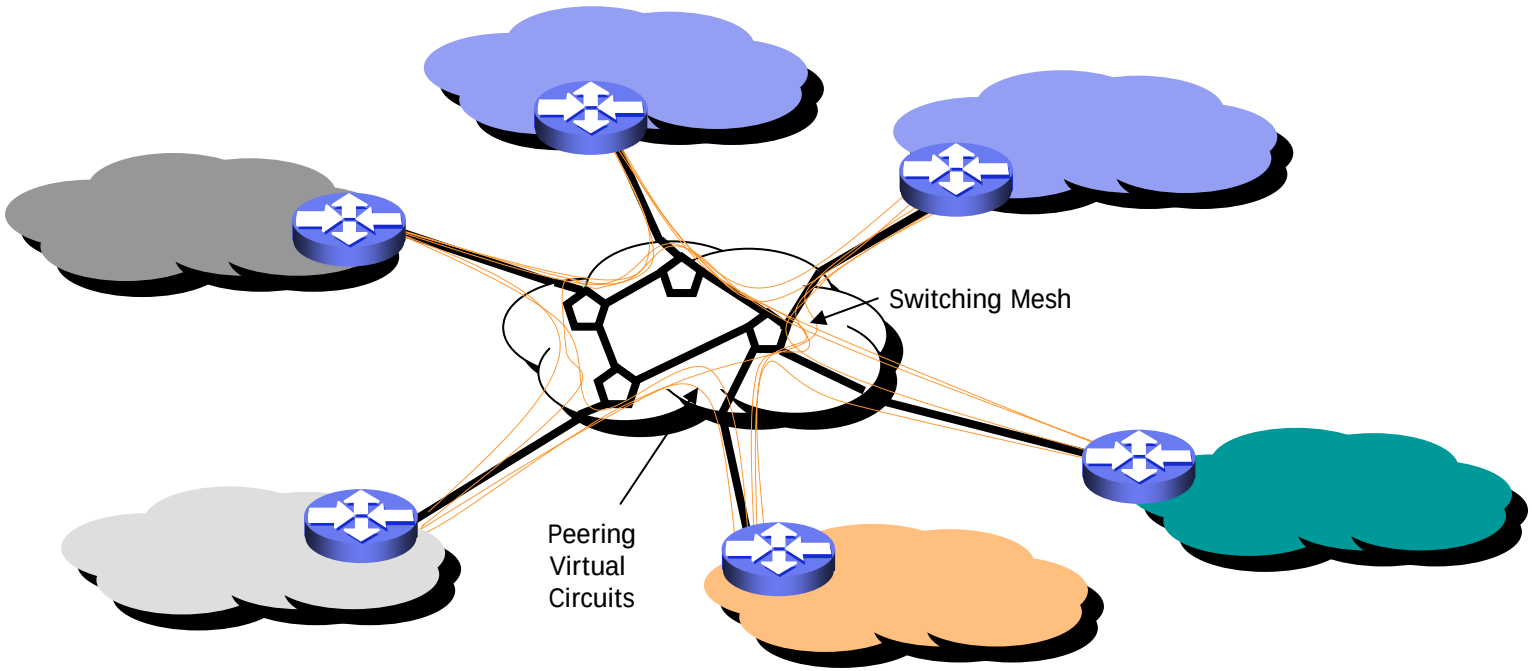
. . . The Exchange L2 Switch

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



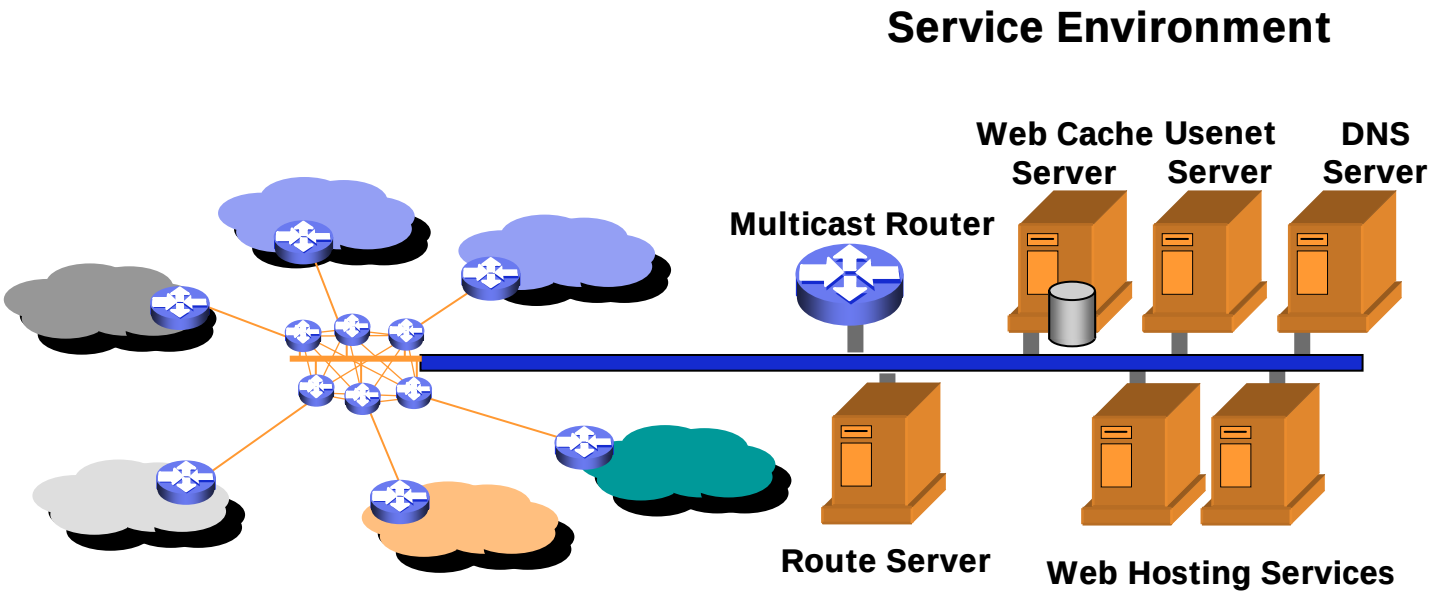
. . . The Distributed Exchange

- 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

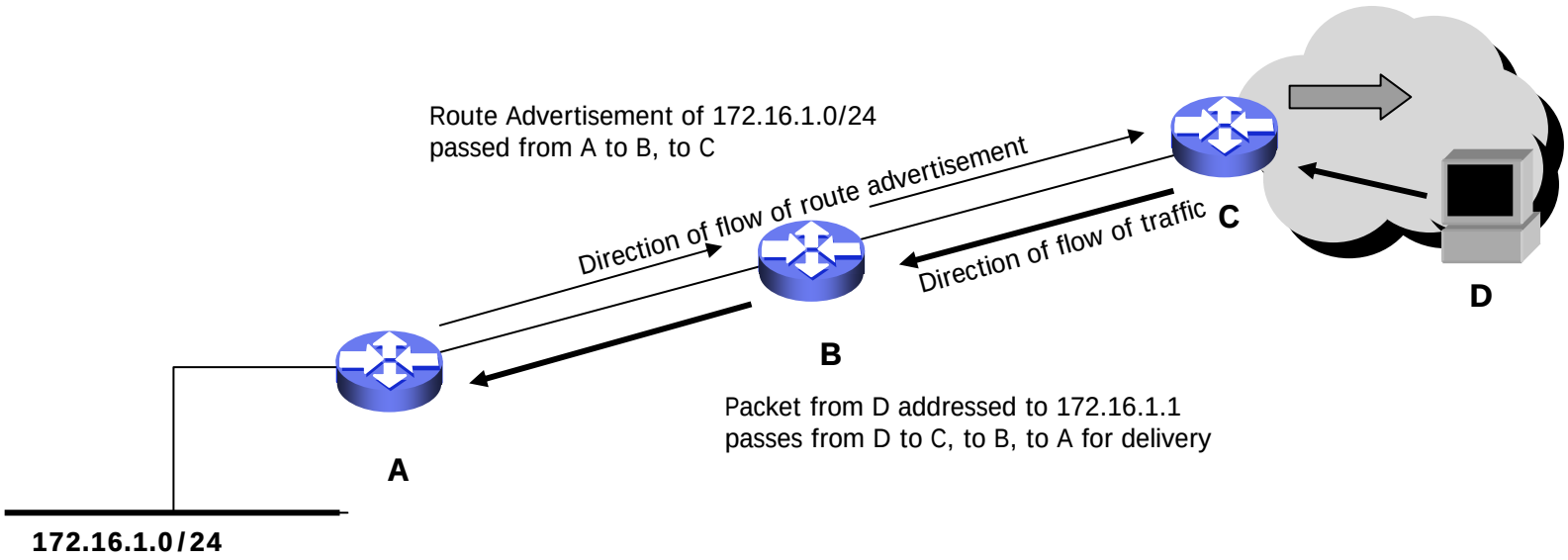


. . . The Role of Private Peering

- 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



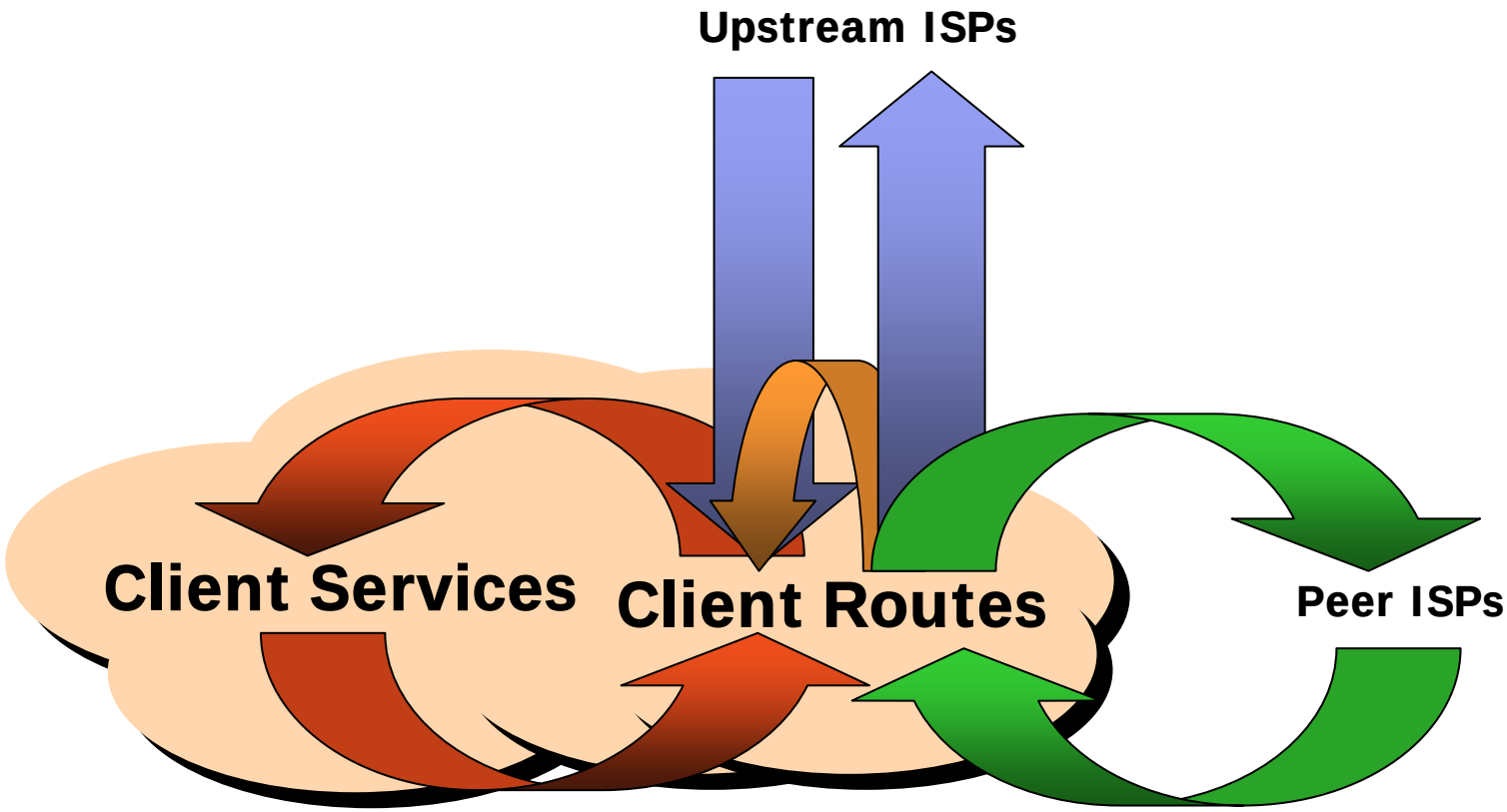
. . . Routing Policy

- 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

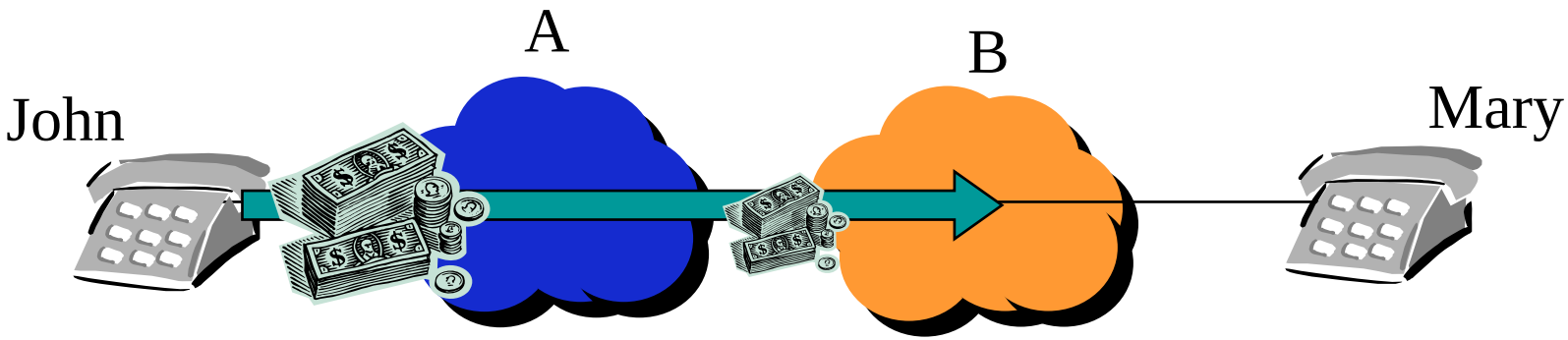


Peering and Financial Settlements

- An overview of the financial basis of interconnection within the Internet

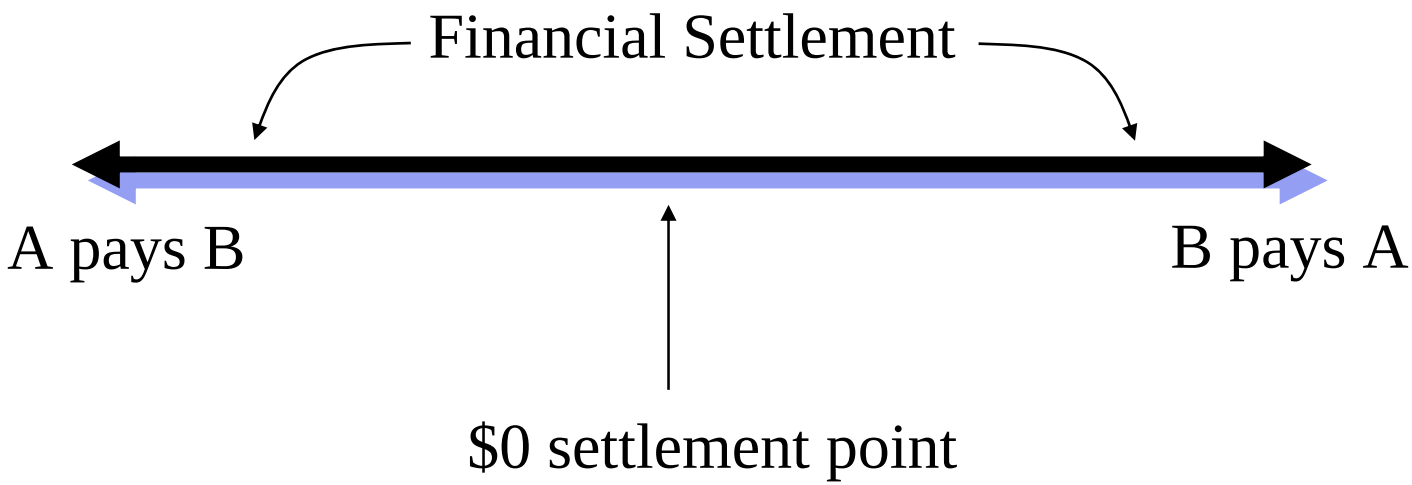
. . . Follow the Money

- 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



. . . 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

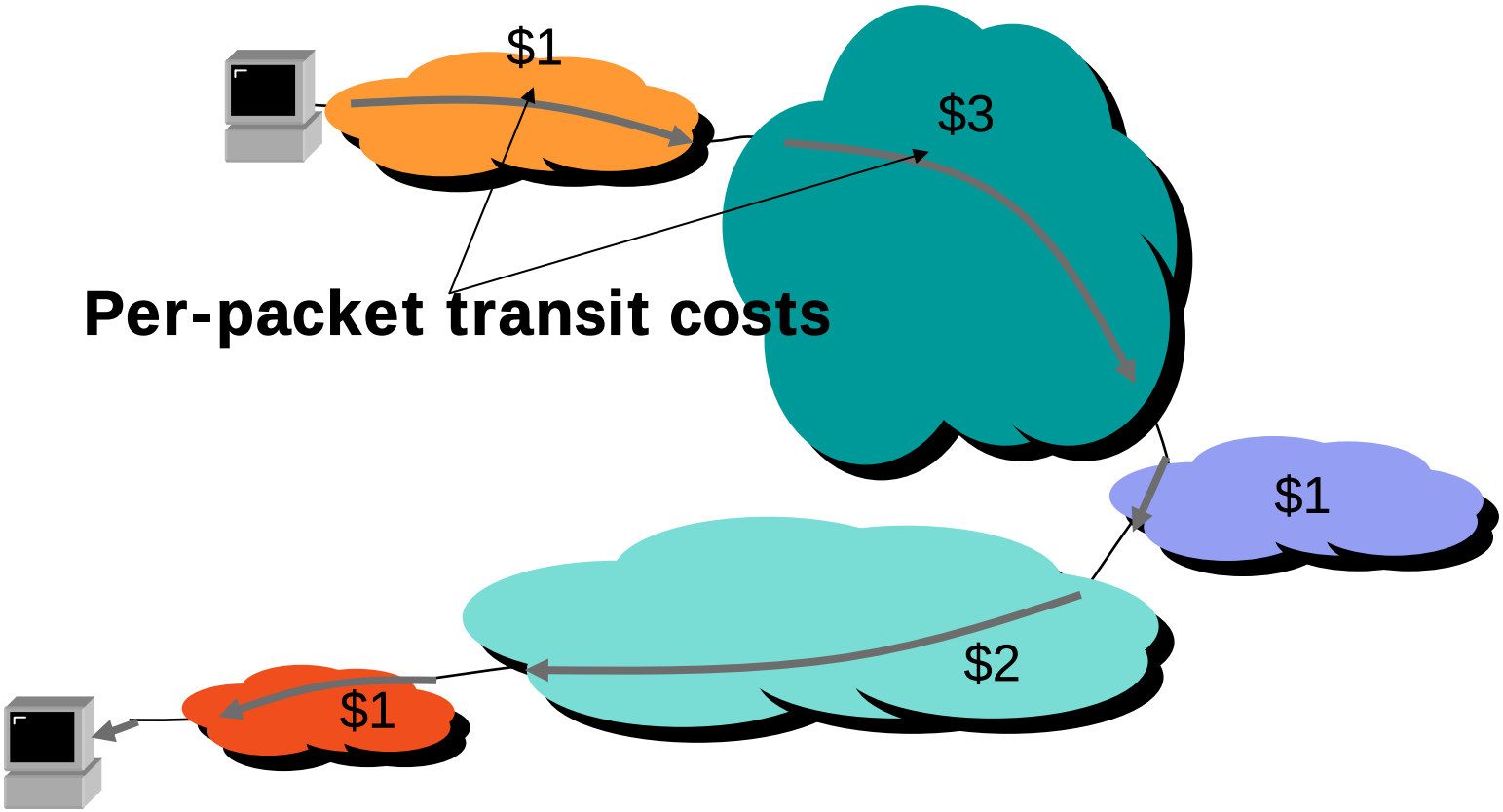
. . . Enter the Internet . . .

- 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

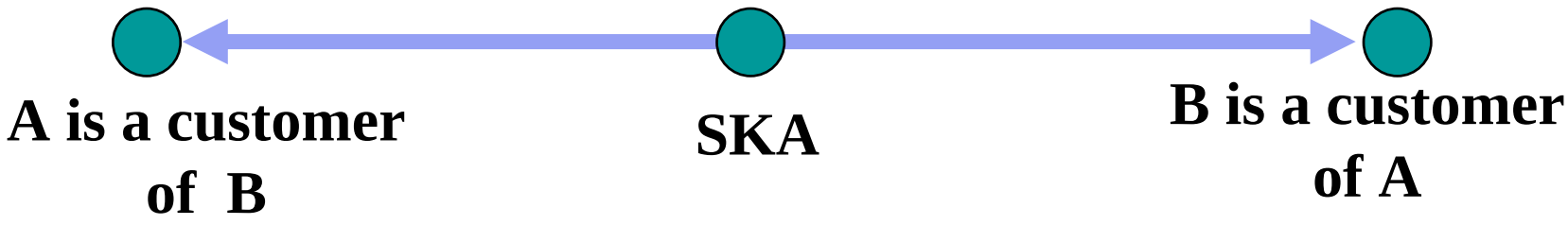


. . . BUT

- 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

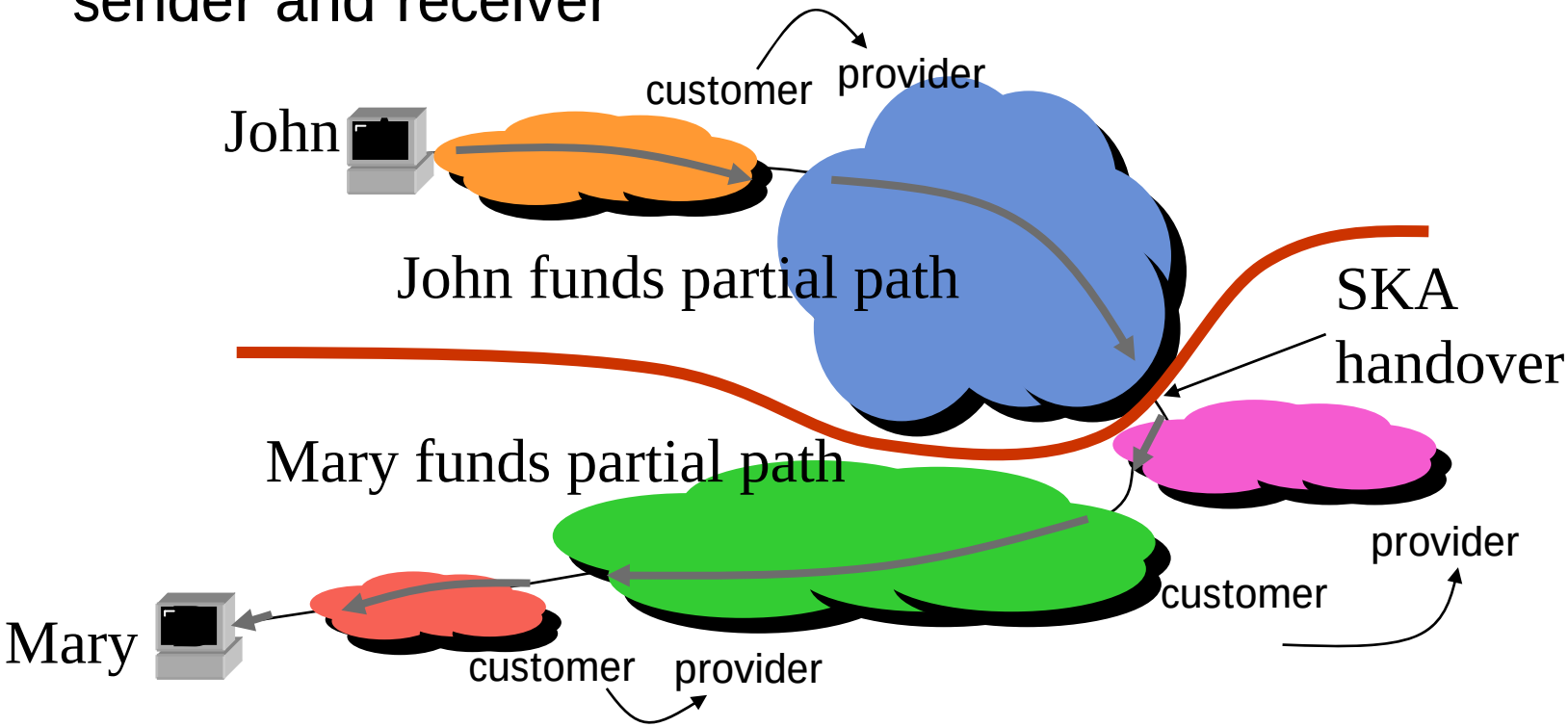
. . . The Internet model

- 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



. . . How are costs apportioned?

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



. . . 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

. . . The Aggregation of 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 II: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

- Frieden, R., "Without Public Peer: The potential Regulatory and Universal Service Consequences of Internet Balkanization", Virginia Journal of Law and Technology, ISSN 1522-1687, Volume 3, Article 8, September 1998. **http://vjolt.student.virginia.edu/graphics/vol3/vol3_art8.html** A good briefing paper from an economic perspective on interconnection issues, with particular attention to the domestic situation in the United States.

- Cukier, K., "Peering and Fearing: ISP Interconnection and Regulatory Issues", presented paper at the Harvard Information Infrastructure Project Conference on the Impact of the Internet on Communication Policy, December 3-5 1997. Conference program is at http://ksgwww.harvard.edu/iip/iicompol/agenda.html The Cukier paper is at **http://ksgwww.harvard.edu/iip/iicompol/Papers/Cukier.html**

- Shapiro, C., Varian, H., "**Information Rules: A Strategic Guide to the Information Economy**", ISBN 087584863X, Harvard Business School Press, November 1998. A broader look at the Internet from an economic perspective, looking at both content and service provider economics.

- Varian, H., "The Information Economy - The Economics of the Internet, Information Goods, Intellectual Property and Related Issues". **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

- INET’99 Conference Paper: Interconnection, Peering and Financial Settlements - Geoff Huston
- ISP Survival Guide - Geoff Huston - John Wiley & Sons