Seminar Internet Economics

Economy Driven Peering Settlements

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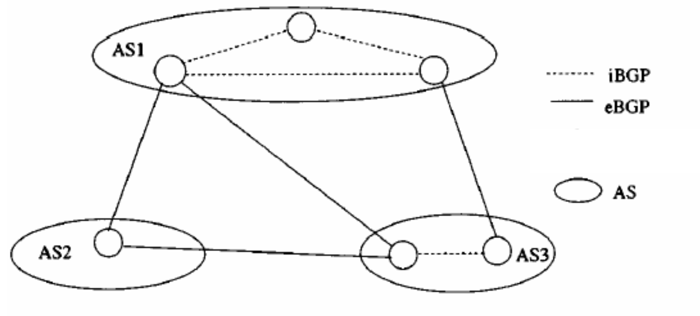
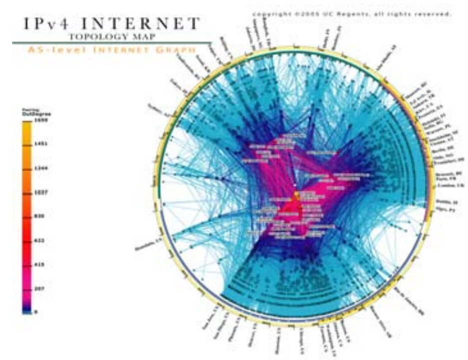
1 Peering Basics and Motivation

Internet Structure: Set of Autonomous Systems

- **Autonomous Systems (AS)**
  - Interior Routing: iBGP
    - Traffic between customers of same ISP
  - Exterior Routing: eBGP
    - Traffic with external ISPs



- **Hierarchical ISP Relationships**
  - ISP buys upstream Traffic to access entire Internet
  - No Cost for AS-internal Traffic
- **Very dynamic Relationships**
  - No stable Structure
  - No clear Definition of Tier 1 ISP



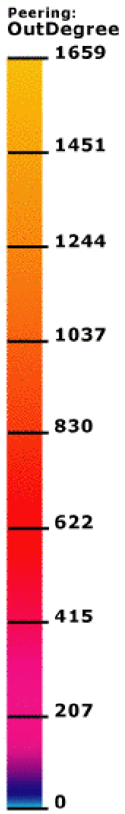
IPv4 Topology Map by Caida.org

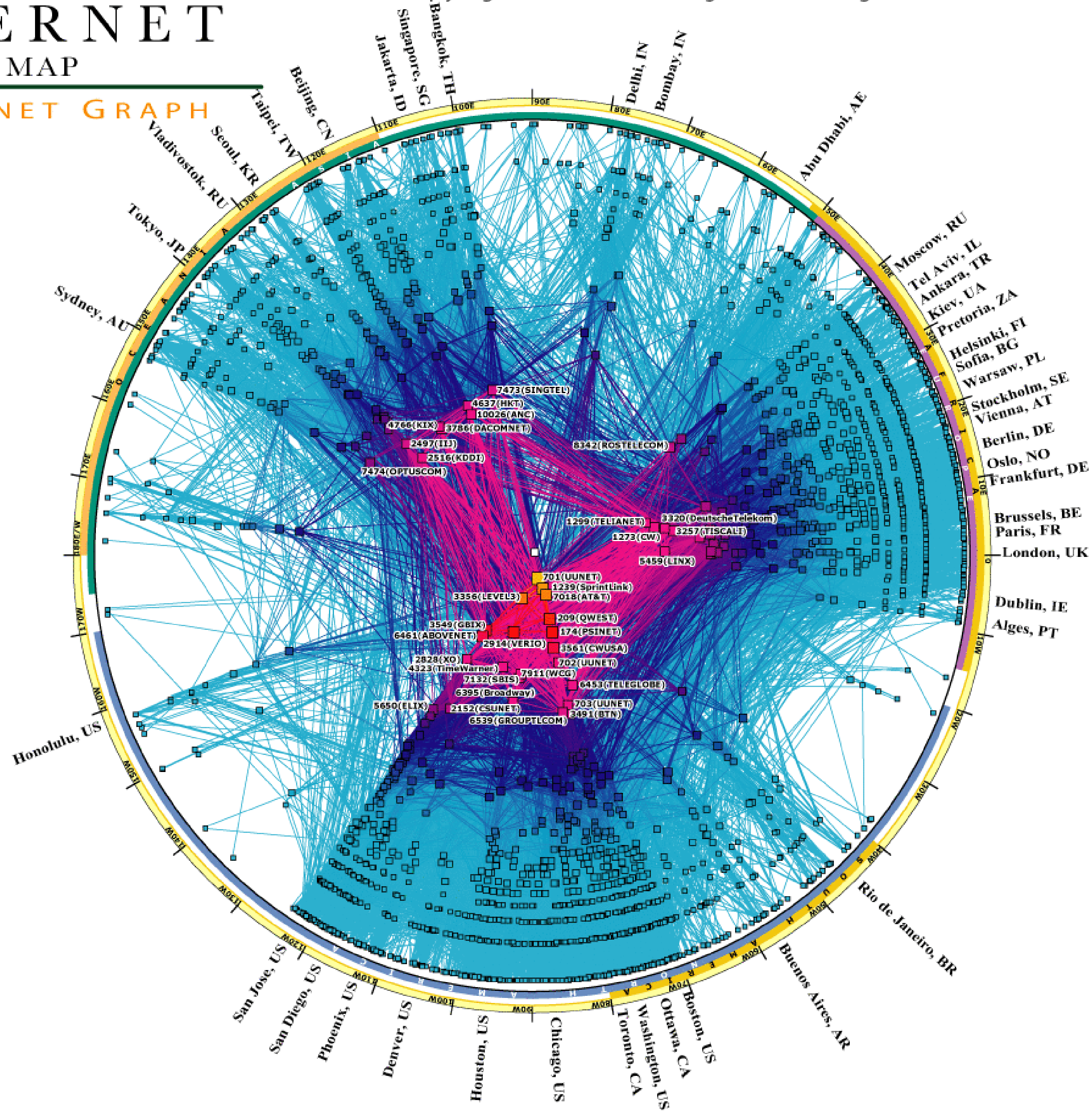
Sources: www.caida.org / Lixin Gao, Stable Internet Routing Without Global Coordination

IPv4 INTERNET

TOPOLOGY MAP

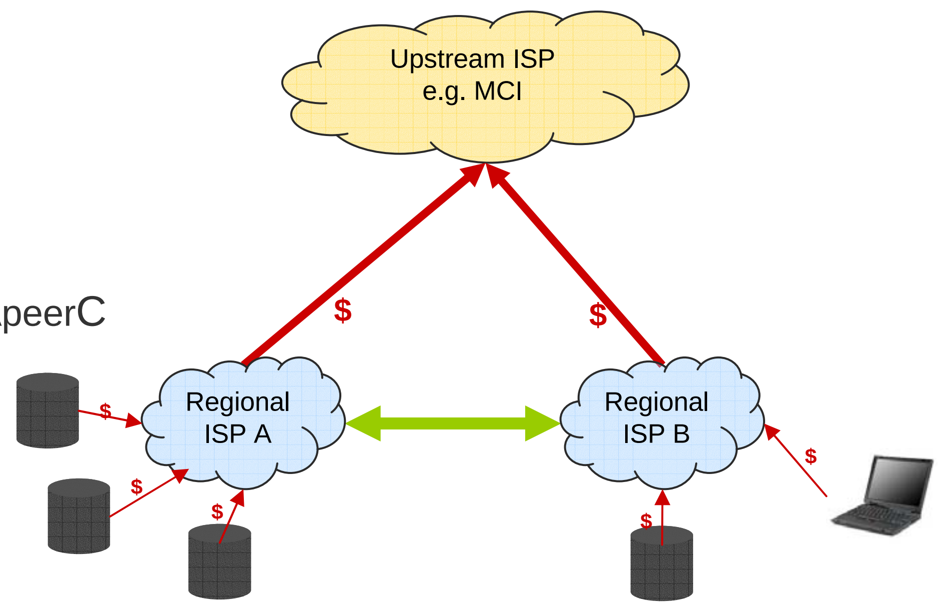
AS-level INTERNET GRAPH





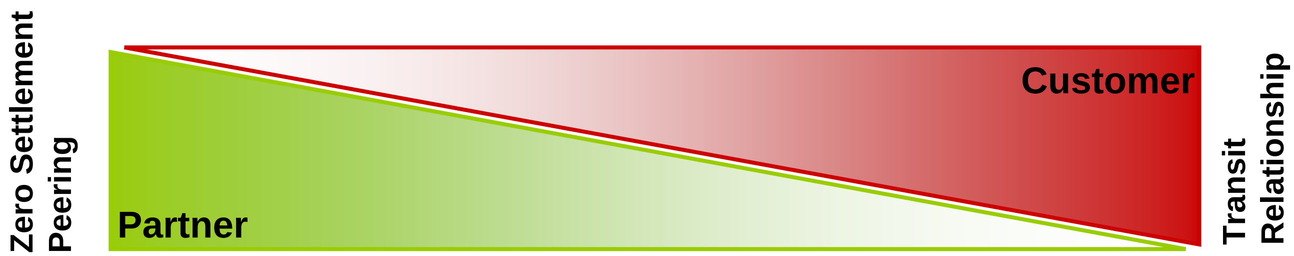
Possible Inter-AS-Relationships

- **Transit: One ISP provides (usually sells) Access to all Destinations in its Routing Table**
  - Customer-Provider Relationship
  - Provider = Upstream Carrier
- **Peering: Both ISPs reciprocally provide Access to each others Customers**
  - Mutual open Network Access
  - Interconnection Agreement
  - Optional: Backup for Transit Server
  - Non-Transitive Relationship:
    ApeerB and BpeerC does not imply ApeerC



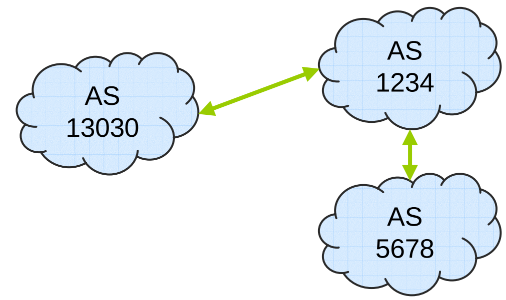
Variations of Cost Allocation

- **Zero-Settlement Peering without Restrictions**
  - Unlimited, uncharged Traffic in both Directions
  - Infrastructure Cost shared by both Parties
- **Zero-Settlement with Limited Traffic Volume**
  - Monitoring / Balancing Resource Consumption
  - Relative or Absolute Traffic Allowance
- **Flat Rate for Weaker Peer**
  - Instead of Volume-based Transit Charges

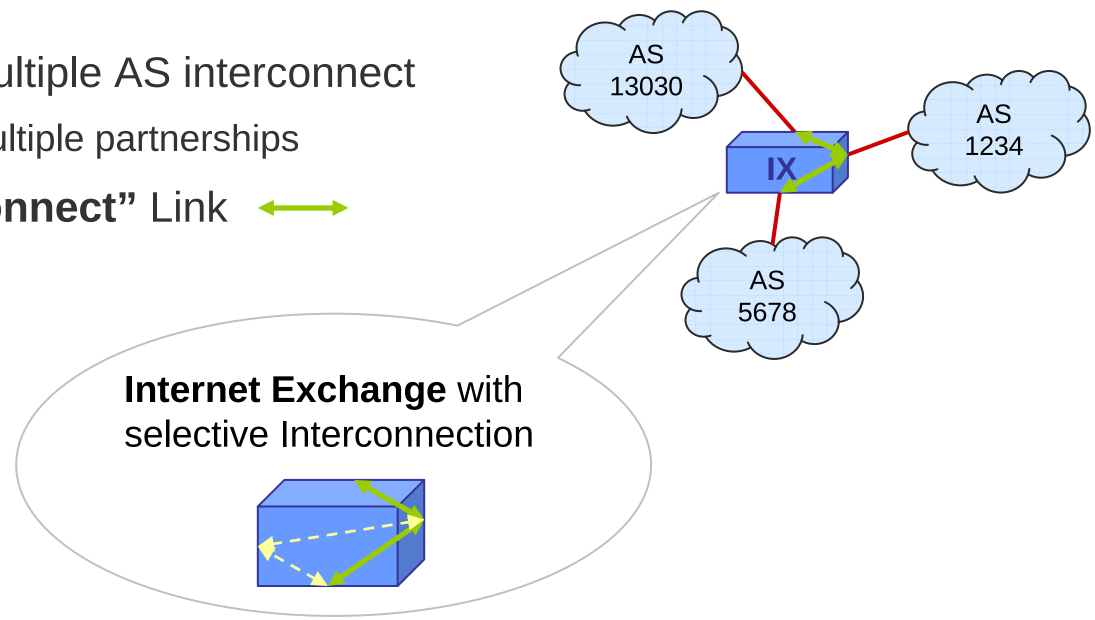


Ways to Interconnect on the Implementation Level

- **Direct Circuit Interconnection**
  - Point-to-Point between two specific AS
  - Very specific investment



- **Exchange-Based Interconnection**
  - Internet Exchanges (IXs)
  - Shared Switches where multiple AS interconnect
    - Shared Investment for multiple partnerships
  - Connection via **“Cross-Connect”** Link



Peering Policies Define Prerequisites for Interconnection

- **Technical Aspects**
  - Point of Presence (POP) at specific Internet Exchange
  - Protocol Version (e.g. BGP-4)
  - Membership of RIPE NCC → Existence of AS Number
- **Business Aspects**
  - Customer Base (Content Servers / End-Customers)
  - Allowed Peering Relations
- **Legal Aspects**
  - Non Disclosure Agreements
  - Security Standards and Legal Bindingness
- **Definition: “Open Peering Policy”**
  - Willing to peer without Limitations → Zero-Settlement Peering
  - No restrictions in the Selection of Partners → With Anyone

BGP = Broader Gateway Protocol

Internet Traffic Costs – Peering vs. Transit

- **Peering Costs**
  - Infrastructure
    - Additional Switches
    - Physical Connection to Peer / Internet Exchange
  - Setup Costs
    - Evaluation of Potential Peering Partners and Negotiations
    - Technical Setup
  - Maintenance Costs
    - Network Specialists (BGP Skills)
    - Monitoring / Controlling
- **Transit Costs**
  - Infrastructure
  - Transit Charged by Upstream ISP

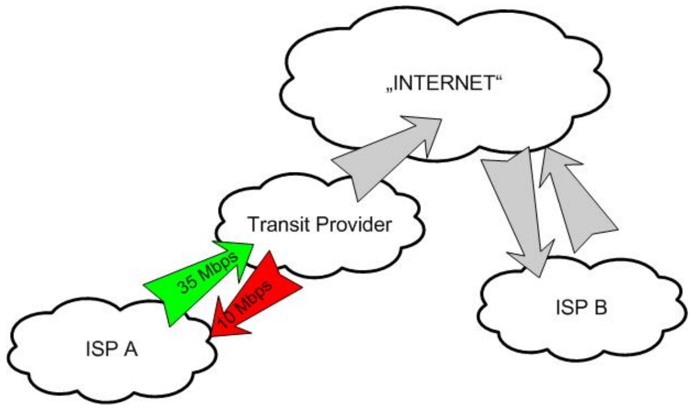
Peering:
A Business Case

2

To Peer or not to Peer (1 / 6)

- **Analysing Traffic Flow**
  - End Destination of outgoing Traffic?
  - Potential peers are mostly neighbours, but do not need to
- **Potential Peering Partner ISP B**
  - 35 Mbps to ISP B
  - (10 Mbps from ISP B)
- **For Simplicity**
  - Assumption: Transporting Traffic to Peering Point generates same Costs as to Transit Partner

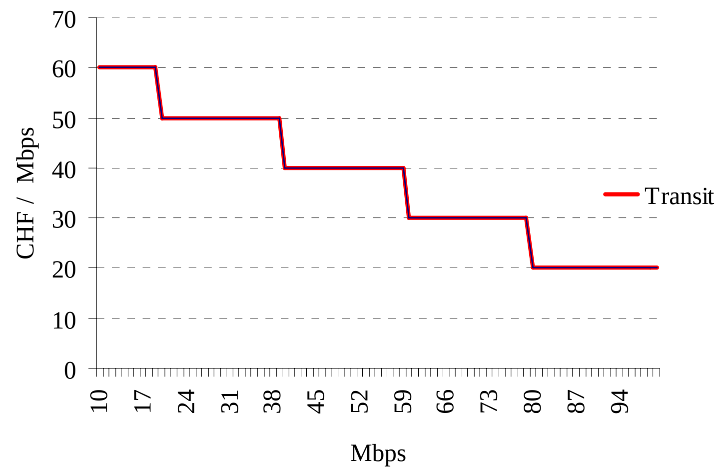
Destination ISP	AS #	Mbps
ISP B	8404	35.00
COLT Internet	8220	15.61
Sunrise #1	6730	13.24
IBS	8271	8.45
…	…	…



To Peer or not to Peer (2 / 6)

- **Accounting in Transit / Customer Relationship**
  - Past: Traffic Volume = 95th Percentile
  - Today mostly Capacity only
  - Avg. Mbps / Month
  - Lower Prices for higher Volume (indirect Economies of Scale)

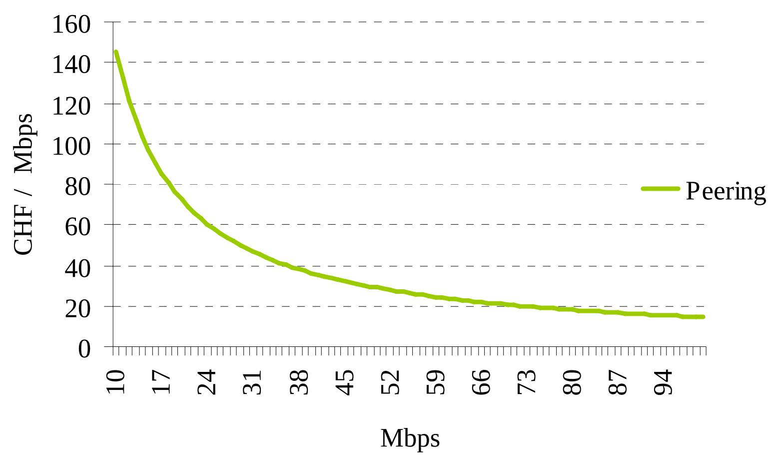
Mbps / month	CHF / month
0 – 20	60
20 – 40	50
40 – 60	40
60 – 80	30
80 -	20



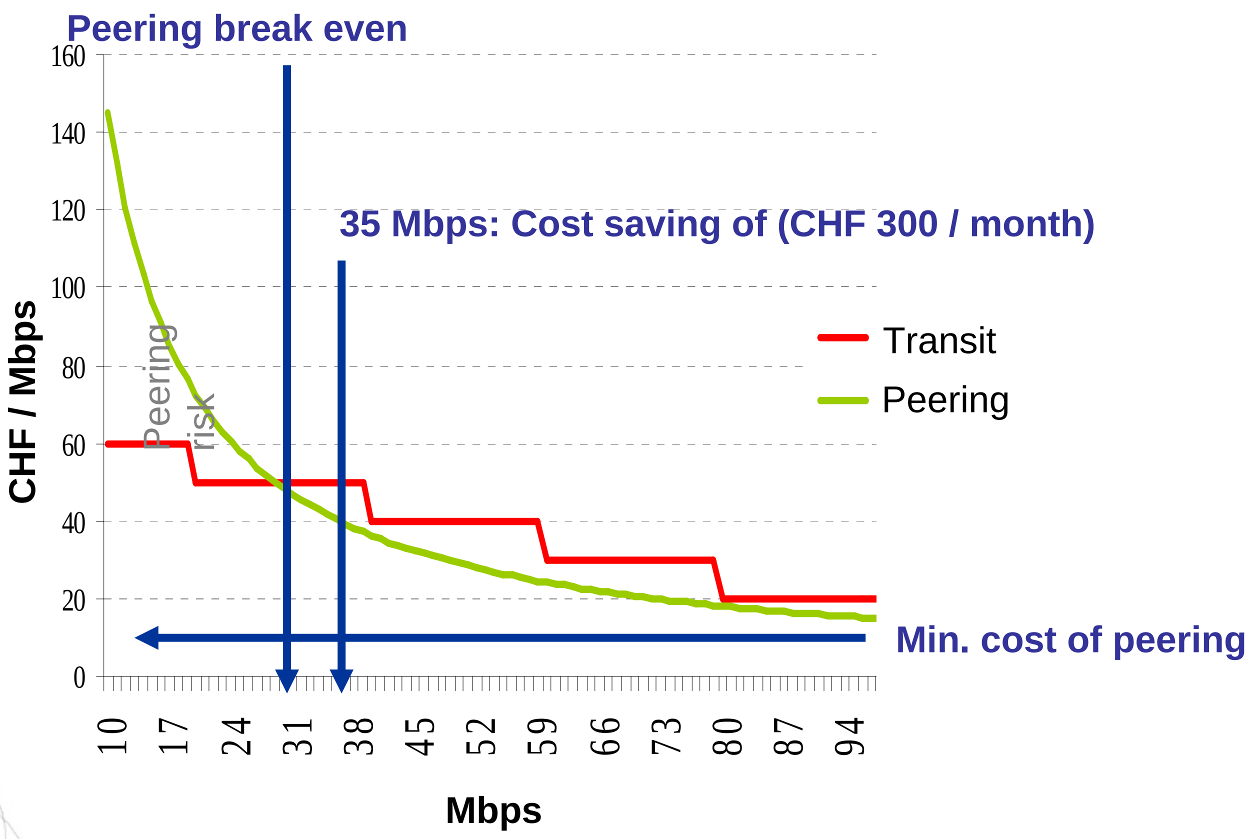
To Peer or not to Peer (3 / 6)

- **Important to realise:**
  - Even Zero-sum peering is not free
  - Fixed Infrastructure Costs instead of variable Transit Costs
- **Prices charged by IX**
  - Prices of TIX Zürich (December `05)
  - 10/100 Base TX due to Traffic < 100 Mbps
- **Distributing fixed Costs**
  - Total CHF 1450
  - Direct Economies of Scale

Position	CHF / month
10/100 Base TX Port	500
1000Base LX Port	2000
Half rack	950



To Peer or not to Peer (4 / 6)



To Peer or not to Peer (5 / 6)

- **In our Example (35 Mbps / Month):**
  - Transit Costs CHF 50 / Mbps > Total of CHF 1750
  - Peering Costs CHF 41.42 / Mbps > Total of CHF 1450
  - Peering!
  - Minor Difference due to high Infrastructure Prices at TIX
- **Problem: Peering not profitable for ISP B**
  - Only Transit Costs of CHF 60 * 10 > Total CHF 600
  - Compared to CHF 1450 for Peering > Total CHF 1450
  - Transit!

To Peer or not to Peer (6 / 6)

- **No Peering Agreement?**
  - Revenue Loss of ISP B cannot be covered by additional Payments from ISP A
- **Reusability / Traffic Volume**
  - Peering Infrastructure can be used for other Peering Agreements
  - Only Upload Traffic to be paid → Otherwise both would pay a Minimum of 45 * CHF 40 = CHF 1800 for Transit
- **Solution:**
  - ISP A and ISP B agreed on significantly cheaper Private Peering
- **But there are many more Factors to consider…**

3 Further Decision Factors for Peering

Why else to Peer ... or not to Peer

- **Lower Transit Cost**
  - As discussed
  - Only one Factor among others
- **Improved Quality of Service (QoS)**
  - Redundancy → Higher Reliability
  - Lower Latency for Local Traffic
  - Fewer Package Losses
- **Control Over Traffic Flows**
- **Technical Competences**
  - BGP Protocol Specialists for Routing Setup
  - Problem Support: No SLA as with Transit Providers

SLA = Service Level Agreements / Qos = Quality of Service

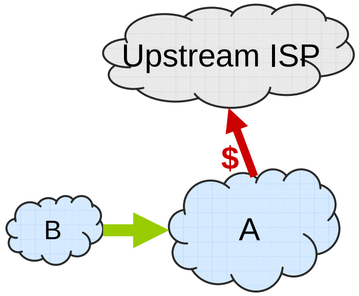
How and With Whom to Peer ... or not to Peer

- **Strategic Decisions**
  - Enlarge Network to increase Attractiveness
  - Avoid Peering with Possible Customers
  - Improve Corporate Image by Peering publicly
  - Information Asymmetries among Market Participants
  - The Art of Peering
    - End Run Tactic
    - Traffic Manipulation: Increase Peer Transit Load
    - Wide Scale Open Peering Policy
    - Bluff
    - Aggressive Traffic Build-up
    - Friendship-based Peering
- **Political Moves**
  - Refusing to Peer with Competing ISPs
  - Unfair Peering Policies to maintain Market Power
  - Interpersonal Differences

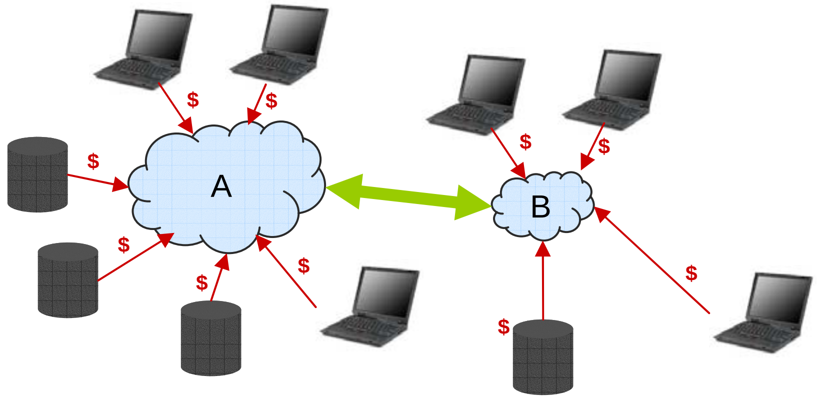
Source: E. Norton, Equinix

Reasons not to Peer with smaller ISP's

- **Scenario: Large ISP A – Smaller ISP B**
- **Backbone Freeriding**
  - B uses A's Upstream Capacity to avoid Transit Cost
  - Avoidable by proper BGP Configuration



- **Business Stealing**
  - Assumption: A and B address the same Customer Base
  - By Peering, A gives up its competitive Advantage of lower Latency for local Access
    - e.g. to Webserver on ISP A
    - Reduction of Network Externalities



Peering in Switzerland

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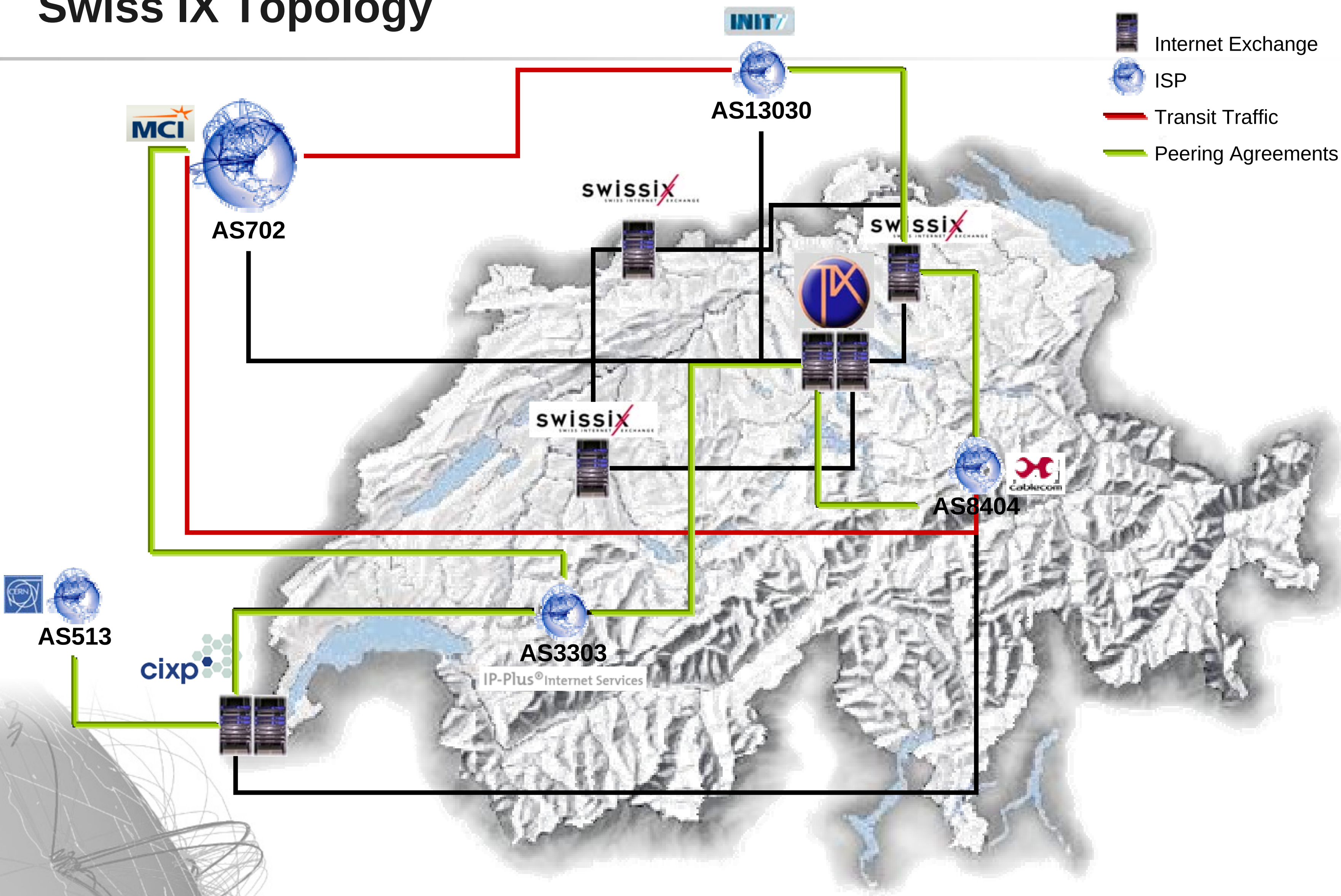
Current Situation – Present Internet Exchanges in Switzerland

- **CIXP operated by CERN**
  - Distributed neutral Internet Exchange Point
  - 2 Datacenters in Geneva
  - 29 ISP’s connected
  - Since 1989
- **TIX operated by IXEurope**
  - 2 Datacenters in Zurich
  - 57 ISP‘s connected
  - Since 1998
- **SwissIX**
  - Non Profit Organisation, Free of Charges (full Sponsorship)
  - Distributed Peering Platform
  - 5 Datacenters in Zurich, Bern, Basel and Glattbrugg
  - 57 ISP‘s connected
  - Since 2001

Current Situation – Present ISP Players

- **Swisscom IP Plus**
  - 10 Peering Agreements at TIX (2000Mbps)
  - 7 Peering Agreements at CIXP (1000Mbps)
  - Large Content Provider Customer Base
  - Large Content Supplier Base
- **Cablecom**
  - Large Content Supplier Customer Base
- **Init7**
  - Open Peering Policy
  - Large Content Provider Customer Base
  - ~ 600 Peering Agreements on several Sites
- **CERN**
  - European Organization for Nuclear Research

Swiss IX Topology



5 Further Settlement Models

Settlement Models Today (1 / 2)

- **Today: Transit or Peering Relationship?**
- **Problems of Customer / Transit Agreements:**
  - Often unnecessary Routing over Upstream Layers
  - Lower QoS due to higher Latency, Burst Rate, etc.
- **Problems of Peering Agreements:**
  - Backbone Freeriding
  - Business Stealing Effect
  - „Unfair“ Cost Distribution
  - Closed Peering Policies

Settlement Models Today (2 / 2)

- **Deadweight Loss from „No-Peering“ – Decisions**
  - Lower QoS
  - Higher Costs for Consumer
  - Economical nonsense to route traffic over U.S.
- **Settlement Models in the Telephony Market**
  - Differences:
    - End-to-End Connection, no dynamic Routing
    - Hard QoS Constraints
    - Sender pays
  - Similarities:
    - Bilateral Agreements
- **New Settlement Models for the Internet?**
  - Comparison to the Post Market in the 17th / 18th Century

Settlement Models - Dimensions

- **Service Categories / Architecture:**
  - Best-effort, Packet based (no QoS)
  - DiffServ, connectionless also (some QoS)
  - IntServ, connection-oriented (QoS)
- **Charging Unit**
  - Per Contract , per Packet, per Flow, per Reservation, …?
- **Pricing Strategies**
  - Cost Sharing, different Classes, SLA's, Auctions
- **Resulting Dimensions**
  - Economical Efficiency, technological Efficiency, social Welfare

Examples of Settlement Models (Best Effort)

- **Smart Market**
  - Sender based Auction
  - „Bid“ Field in Header to indicate Willingness to pay
  - Congestion Situation: Packet is sent when:
    „Bid“-Field > Market-clearing Price = Bid of lowest-Priority admitted Packet
  - Vickrey Auction: Optimal to bid true Values
- **Paris-Metro Pricing**
  - Equal Service but different Prices (!)
  - Self-regulating Market

Examples of Settlement Models (Best Effort)

- **Smart Market**
  - + „Fair Value“ for Packet Price
  - + Takes the Social Cost of delivering Packet into Account
  - - Very high Accounting overhead
  - - Packet Loss Problem not considered
- **Paris-Metro Pricing**
  - + Self-regulating
  - - Problem when Service Providers underprice each other →Loss of Advantage
- **No real QoS-Levels:**
  - In both Cases still a best Effort Service
  - VoIP, Video-Streams, important Data Flows?

Examples of Settlement Models (DiffServ)

- **DiffServ Bandwith Brokers as Mini-Markets**
  - ISP Border Routers as Brokers
  - SLA Definition for Transmission
  - Explicit SLA between two ISP
    Implicit SLA between A and B

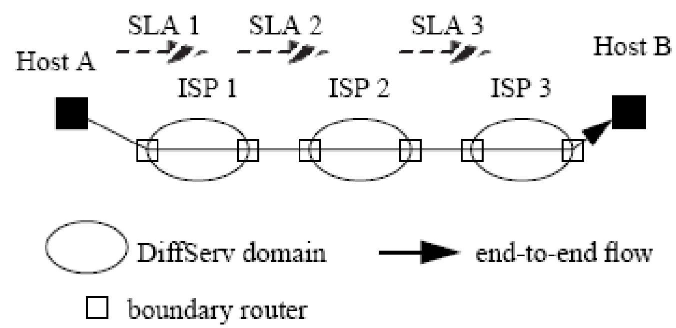


Figure 1: DiffServ network model

Examples of Settlement Models (DiffServ)

- **DiffServ Bandwith Brokers as Mini-Markets**
  - SLA for QoS
  - Border Routers serve as Brokers for AS / ISP
  - Before Data is sent, SLA has to be defined and priced
  - Many SLA over the whole End-to-End Connection
  - Overbuying of Traffic vs. Accounting Overhead
  - Price Announcements occasionally

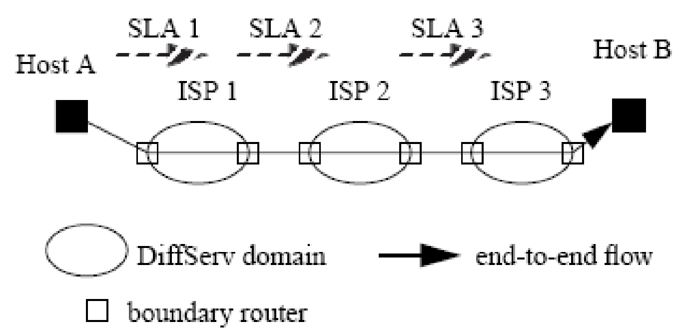


Figure 1: DiffServ network model

Examples of Settlement Models (DiffServ)

- **DiffServ Bandwith Brokers as Mini-Markets**
  - \+ QoS Guarantees
  - \+ Economic Efficiency
  - \- Signalling Overhead
  - \- No real Pricing Schemes yet
  - \- No Price Transparency for Customers

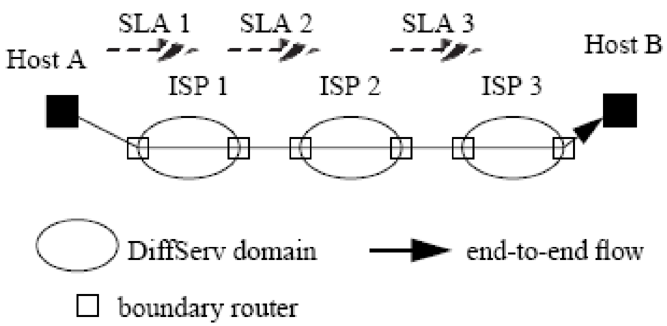


Figure 1: DiffServ network model

Examples of Settlement Models (IntServ)

- **Per-flow Reservation using RSVP**
  - „Hard“ QoS Guarantees between Sender and Receiver
  - Explicit Reservation
  - Prices added to RESV Message
  - Auctioning of QoS Levels and Prices
  - Possible also with edge Pricing

Examples of Settlement Models (IntServ)

- **Per-flow Reservation using RSVP**
  - \+ Hard QoS Guarantees
  - \- Large Accounting and Communication Overhead
  - \- Price Transparency

6 Conclusions

Conclusions

- **High Impact on today‘s Internet Structure**
  - Internet as technical Backbone of the Economy
  - Peering has flattened the Internet‘s Hierarchy
  - More Interconnections: QoS, Redundancy
- **Strategic Decisions lead to Deadweight Losses**
  - Thinking outside the Box „Peer / Transit“
  - Need for more flexible Settlement Models
- **Increasing Technological Requirements for the Internet**
  - VoIP, Video Telephony, VOD, IPTV, globally distributed Offices
  - Need for high Quality of Service guarantees
- **There‘s no commercial Peering Market**
  - Savings, but no Revenues

Invitation

- **We would like to invite you to visit one of SwissIX's Datacenters**

- **February 2nd, 2006**
  - 13:30 after the IE Seminar
  - Guided Tour: app. 1 Hour
  - Location: interxion in Glattbrugg
- **Please sign up here or via eMail to sinja@access.unizh.ch**
  - Deadline for eMail Sign up: 23rd December, 2005
  - Maximum 15 Participants (first come first serve)

7

Discussion

Topics

- **Internet‘s Transition and Retail Market admit high Economies of Scale**
  - Aggregation of Providers → Higher Market Concentration
  - Centralisation vs. today‘s decentralised Structure?
  - Decreased social Welfare?
- **Governmental Regulations vs. Market Dynamics?**
  - High Quality Internet as „Service publique“?
  - Mandatory open Peering Policy for ISP‘s?
- **Quality Issues**
  - Importance of Service Level Agreements?
  - Price Differentiation?

Peering Settlement Game

- **Settings**
  - 4 competing ISP‘s with Venture Funding of $25‘000 each
  - Squares representing a Territory of Customers
  - 4 Internet Exchanges where Peering can be settled
  - 2 Transit Providers connected to the Internet
- **The Game:**
  - ISP rolls the die (representing the regional Marketing Campaign Success) → Number of Squares to expand by
  - If accessing an IX: Peering Negotiations with collocated ISPs at the IX can be started
    - Peering Cost to be split: $2‘000 recurring Fees and Loss of 2 Turns to implement Peering Installation
    - No Transit Traffic among Peering Partners for the respective Customers
- **Cost Rules for ISPs (recurring every Round):**
  - Provider Revenue: $2‘000 per occupied Square
  - Transit Costs: $1‘000 per Square occupied by Competition
  - Specific Peering Costs
- **Player‘s Objective**
  - Profit Maximisation