Master Course
Computer Networks
IN2097

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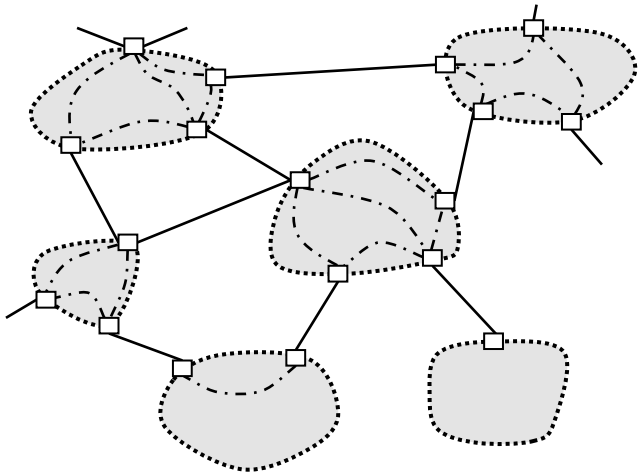
The Internet

Counting

- Worldwide
  - > 700.000.000 Hosts
  - > 37.000 Autonomous Systems
  - > 3.000.000.000 Assigned IP Addresses
  - > 2.180.000.000 Reachable IP Addresses
- Europe
  - > 126.600.000 Hosts
  - > 19.000 Autonomous Systems
  - > 420.000.000 Reachable IP Addresses
  - > 500.000.000 Assigned IP Addresses
- Germany
  - > 13.300.000 Hosts
  - > 1.200 Autonomous Systems
  - > 70.700.000 Assigned IP Addresses (5.500 prefixes)
  - > 62.700.000 Reachable IP Addresses



Snapshot 2011

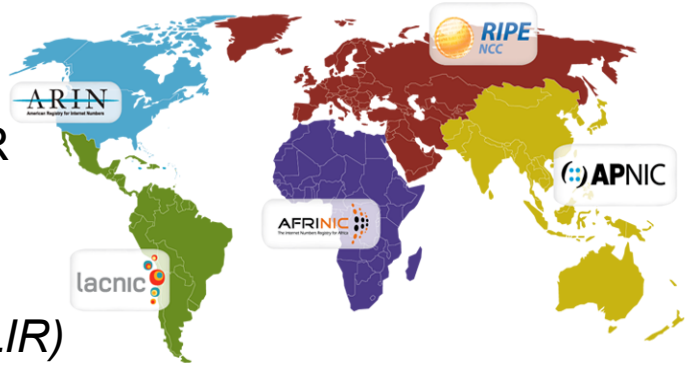
Associations for Internet Names and Numbers

- **ICANN**
  - *„Internet Corporation for Assigned Names and Numbers“*
  - Private endowment (non-profit)
  - Administration of DNS Top Level Domains
  - Close collaboration with IETF and other related Intenet bodies (e.g., ISOC)

- **IANA**
  - *„Internet Assigned Numbers Authority“* (non-profit)
  - Operations via ICANN
  - Assignment of Internet numbers and Internet names
  - Administration of DNS root name servers
  - Administration of reverse DNS infrastructure (.arpa)
  - Assignment of protocol names and protocol numbers

- **NRO**
  - *„Number Resource Organization“*(non-profit)
  - Association of the 5 *„Regional Internet Registrars“ (RIR)*
  - Represents interest of RIRs towards ICANN/IANA

- **Regional Registrars** (non-profit)
  - ARIN, RIPE, APNIC, LACNIC, AfriNIC
  - *RIPE: „Réseaux IP Européens“* European RIR
  - Assigns IP addresses and AS numbers
  - Delegation of reverse DNS
  - Operation of Registrar database
  - Administration of *„Local Internet Registries“ (LIR)*



RIPE Database

- RIPE: registration and administration of Internet resources
  - AS information
  - Prefix information
  - Routing information
  - administrative work
- Online Whois service, and offline data bases
  - provides non-personal meta data
  - example:

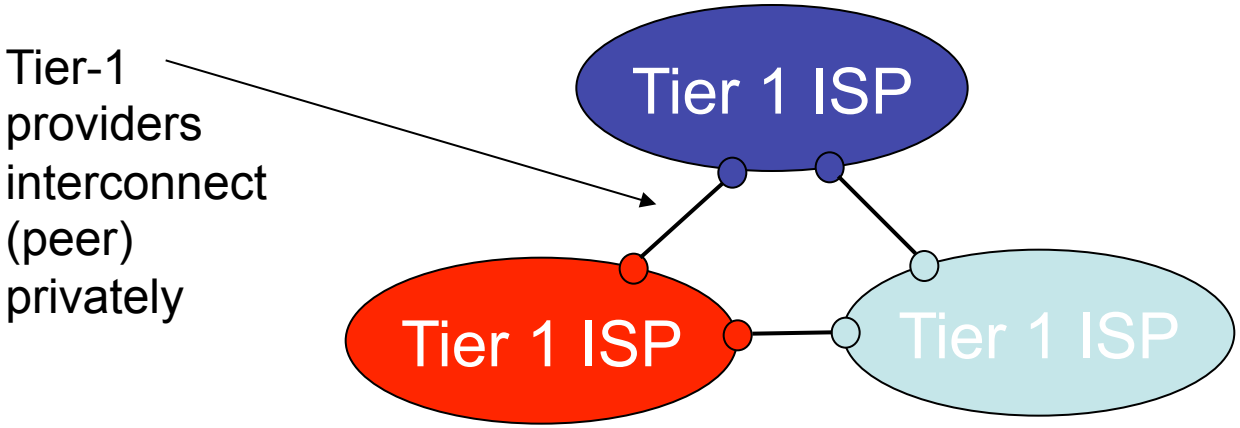
```
% Information related to 'AS56357'

aut-num:    AS56357
as-name:    TUM-I8-AS
descr:      Technische Universitaet Muenchen
descr:      Chair for Network Architectures and Services
import:     from AS680 accept ANY
import:     from AS33926 accept ANY
import:     from AS48918 accept ANY
export:     to AS680 announce AS56357
export:     to AS33926 announce AS56357
export:     to AS48918 announce AS56357
```

Internet Ecosystem

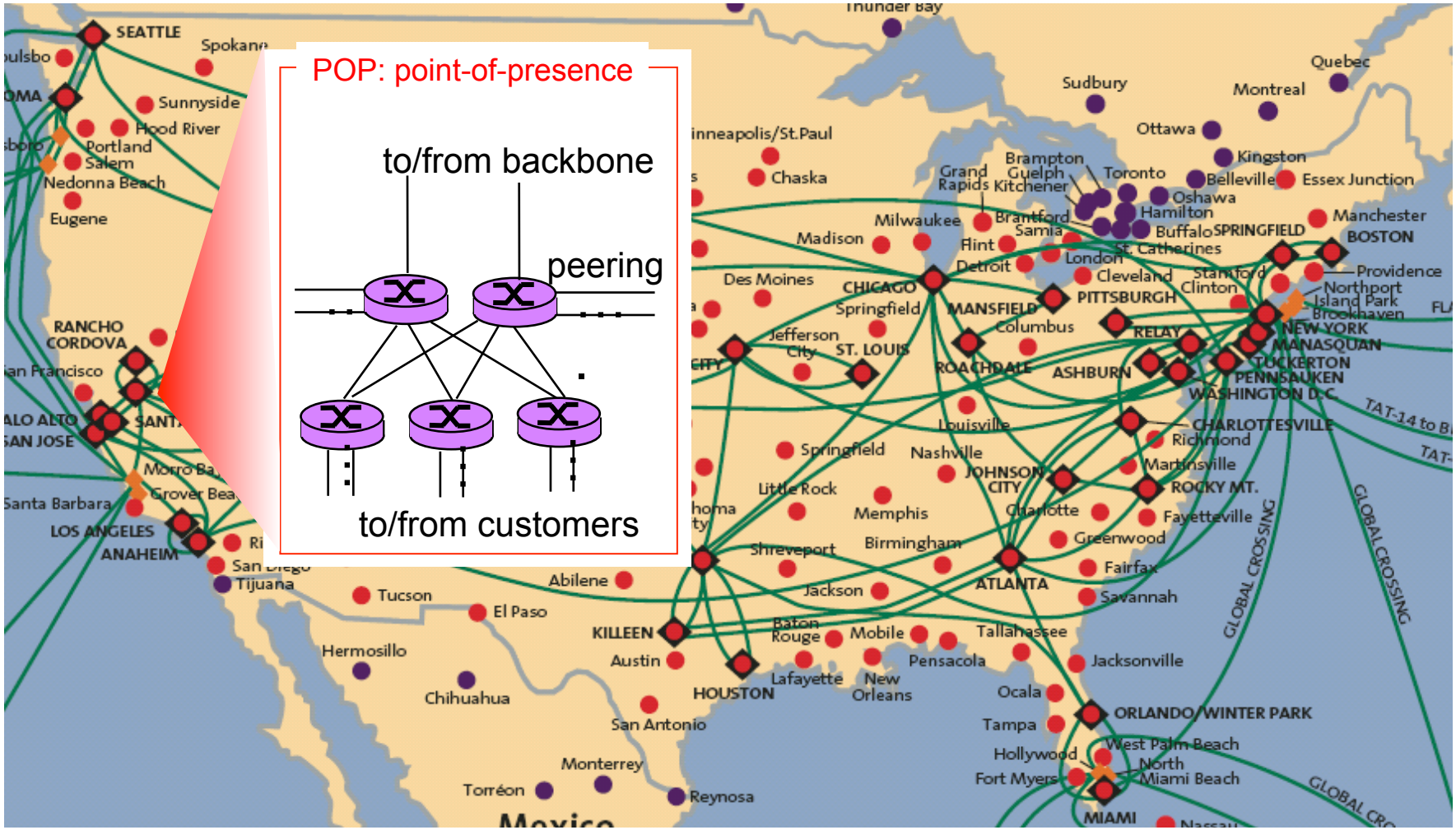
- >30,000 autonomous networks
- Networks with different
  - different roles and business type
    - stub networks
    - transit networks
    - content providers
  - Influenced by traffic patterns, application popularity, economics, regulation, ….
- Peering
  - bilateral contracts
  - Customer-provider, settlement-free peering, or in between
- Internet Exchange Points

Internet structure: network of networks

- roughly hierarchical
- at center: “tier-1” ISPs (AT&T, Global Crossing, Level 3, NTT, Qwest, Sprint, Tata, Verizon (UUNET), Savvis, TeliaSonera), national/international coverage
  - treat each other as equals
  - can reach every other network on the Internet without purchasing IP transit or paying settlements



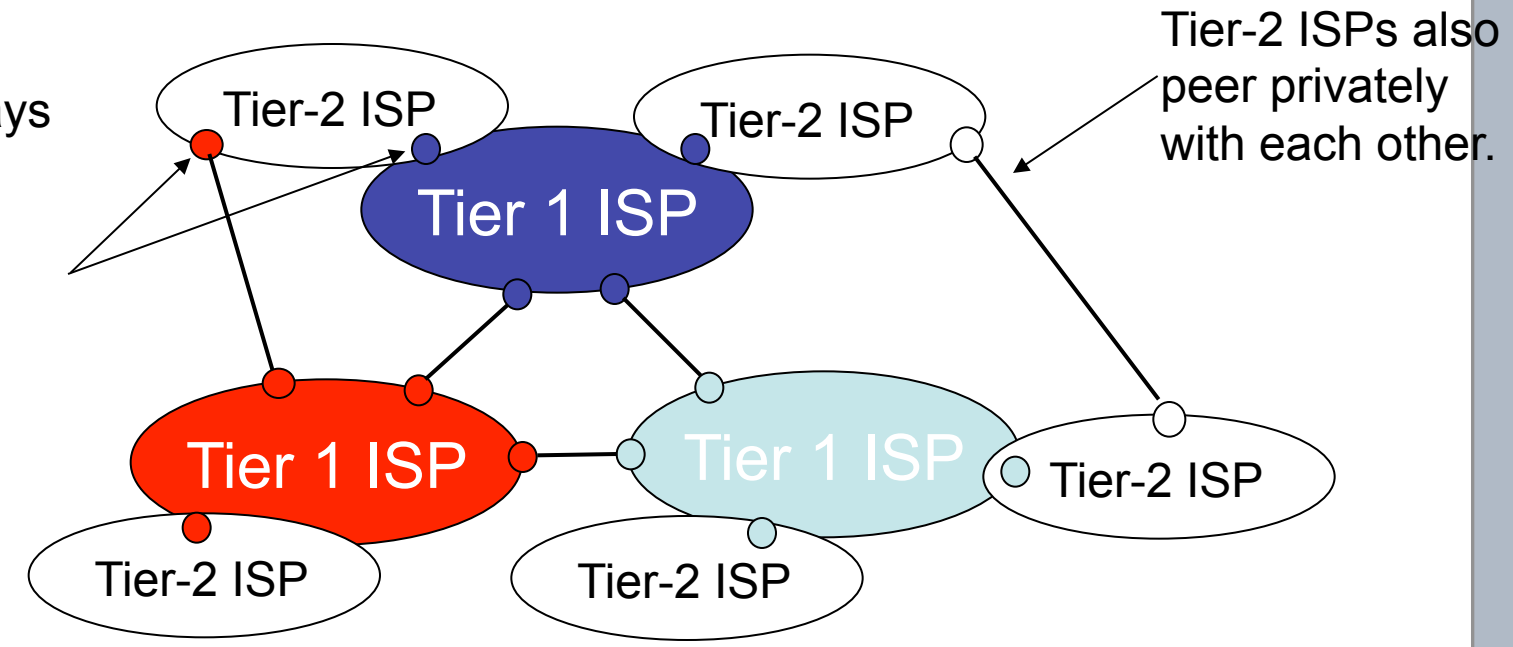
Tier-1 ISP: e.g., Sprint



Internet structure: network of networks

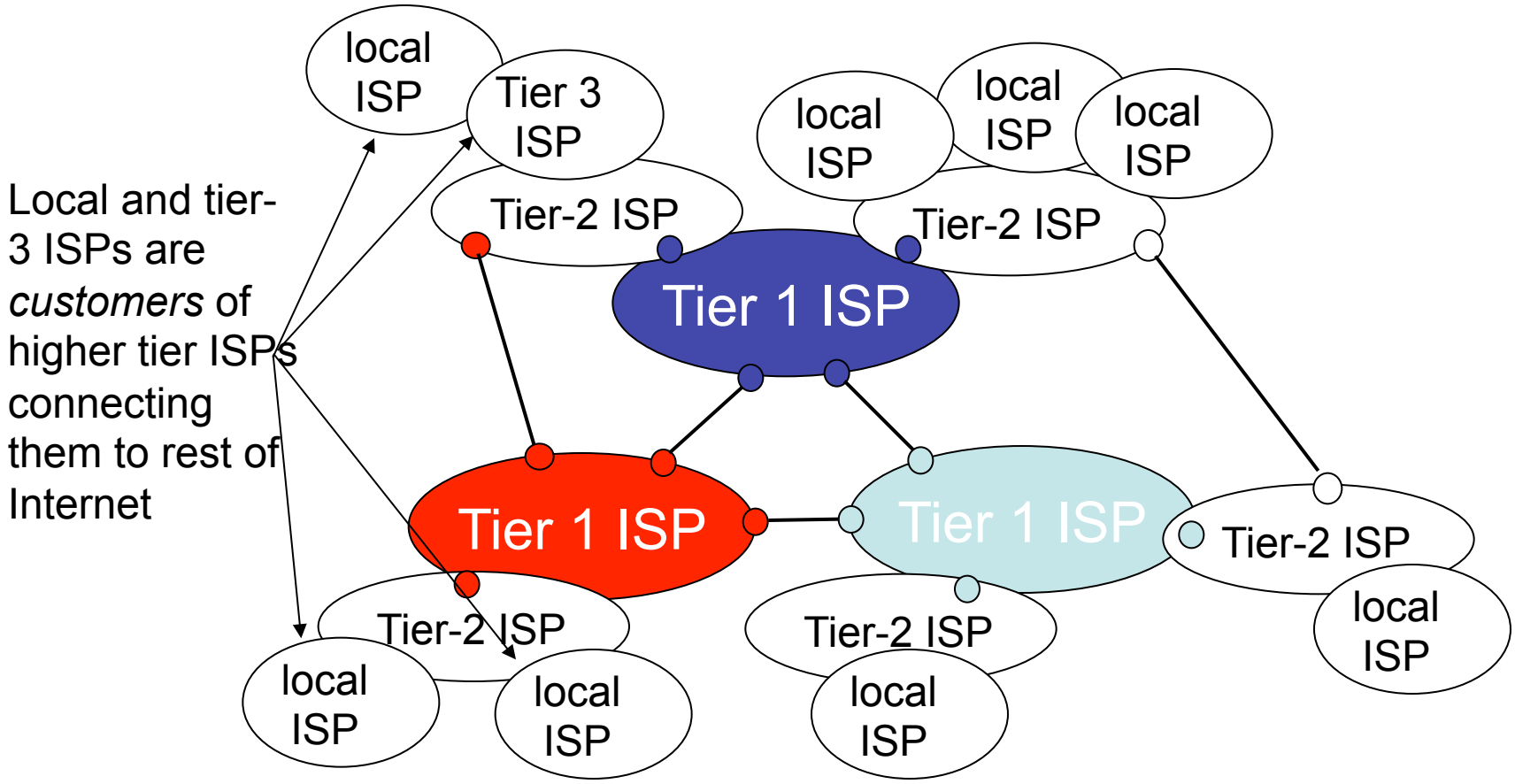
- "Tier-2" ISPs: smaller (often regional) ISPs
  - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

- Tier-2 ISP pays tier-1 ISP for connectivity to rest of Internet
- tier-2 ISP is *customer* of tier-1 provider



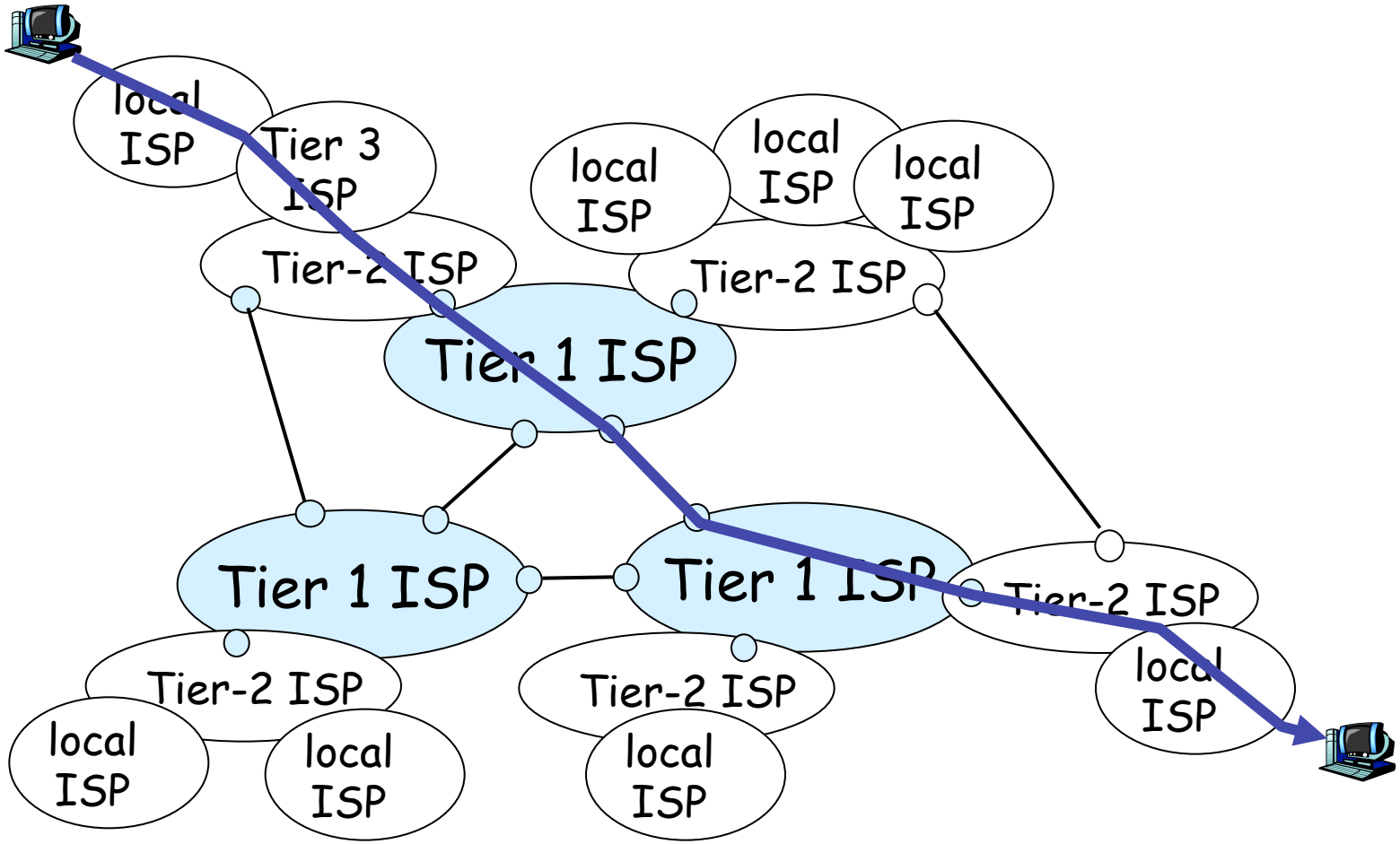
Internet structure: network of networks

- "Tier-3" ISPs and local ISPs
  - last hop ("access") network (closest to end systems)

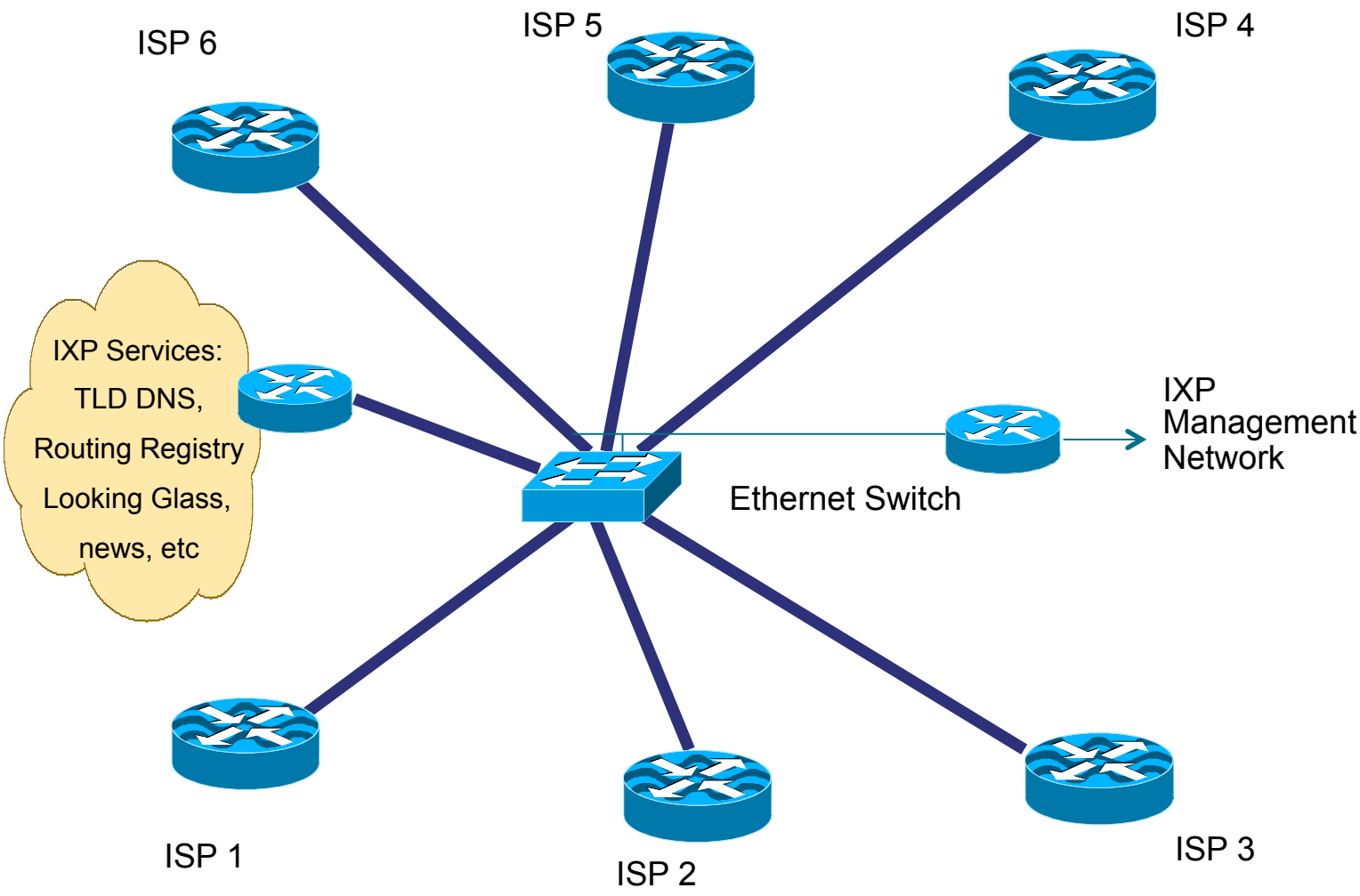


Internet structure: network of networks

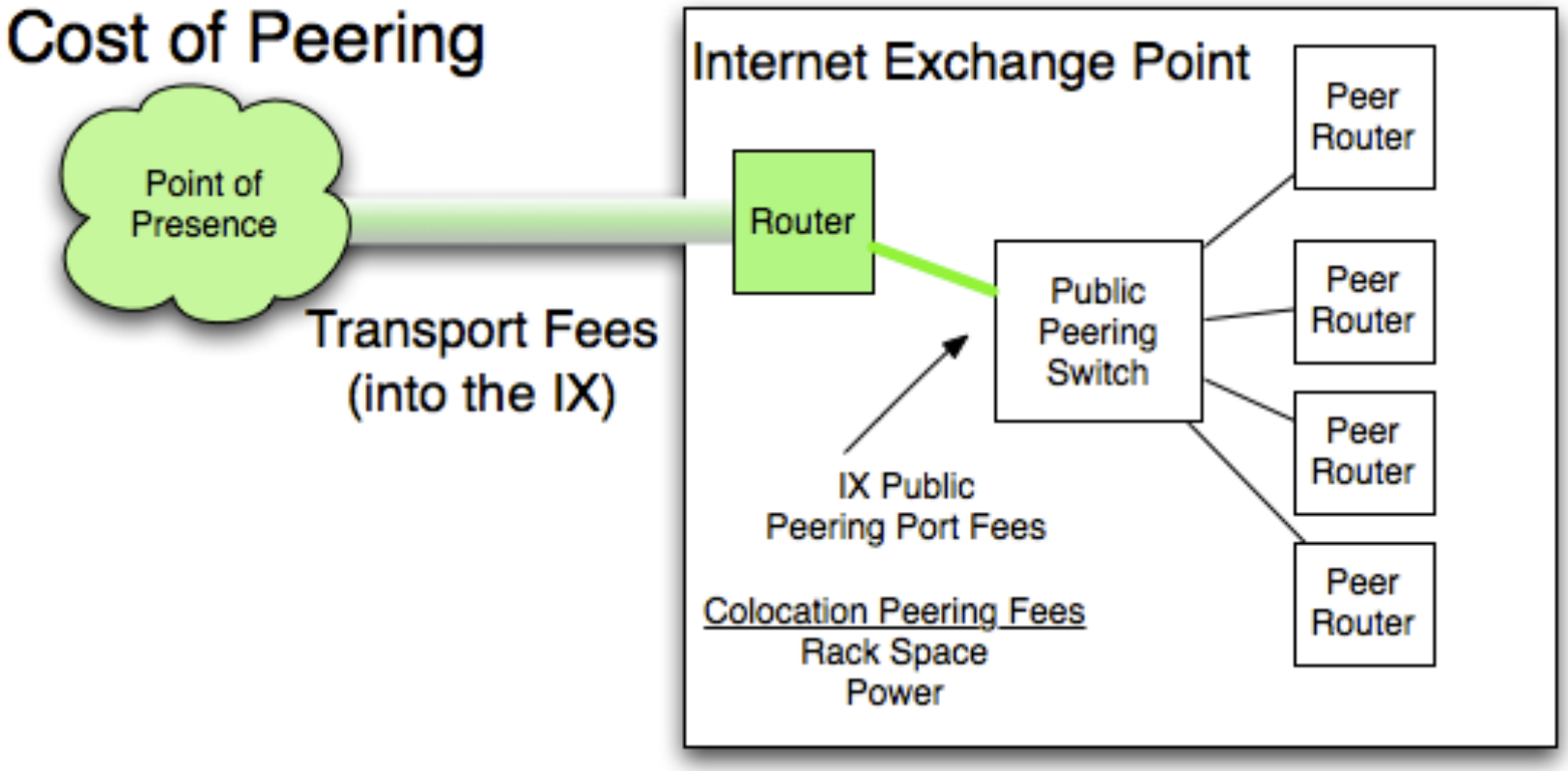
- a packet passes through many networks!



Internet Exchange Point

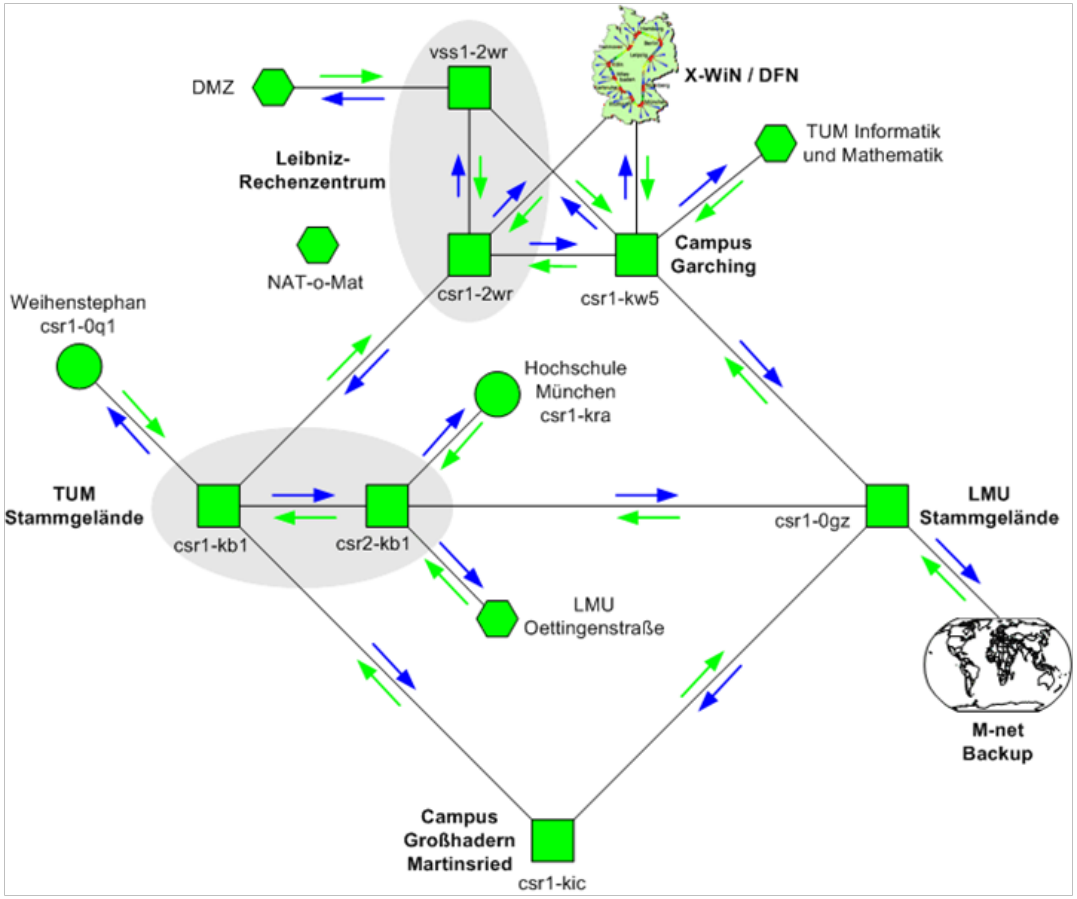


Cost of Peering at Internet Exchange Point



source: William B. Norton, „Internet Peering“, http://drpeering.net/

- Munich Scientific Network
- Universities, university clinics, student halls
- 2.000+ LANs (IPv4)
  400+ LANs (IPv6)
- 1.200+ switches
- 80.000+ hosts
  120.000+ users
- Traffic
  200 TB/Month
  upstream
  300 TB/Month
  downstream

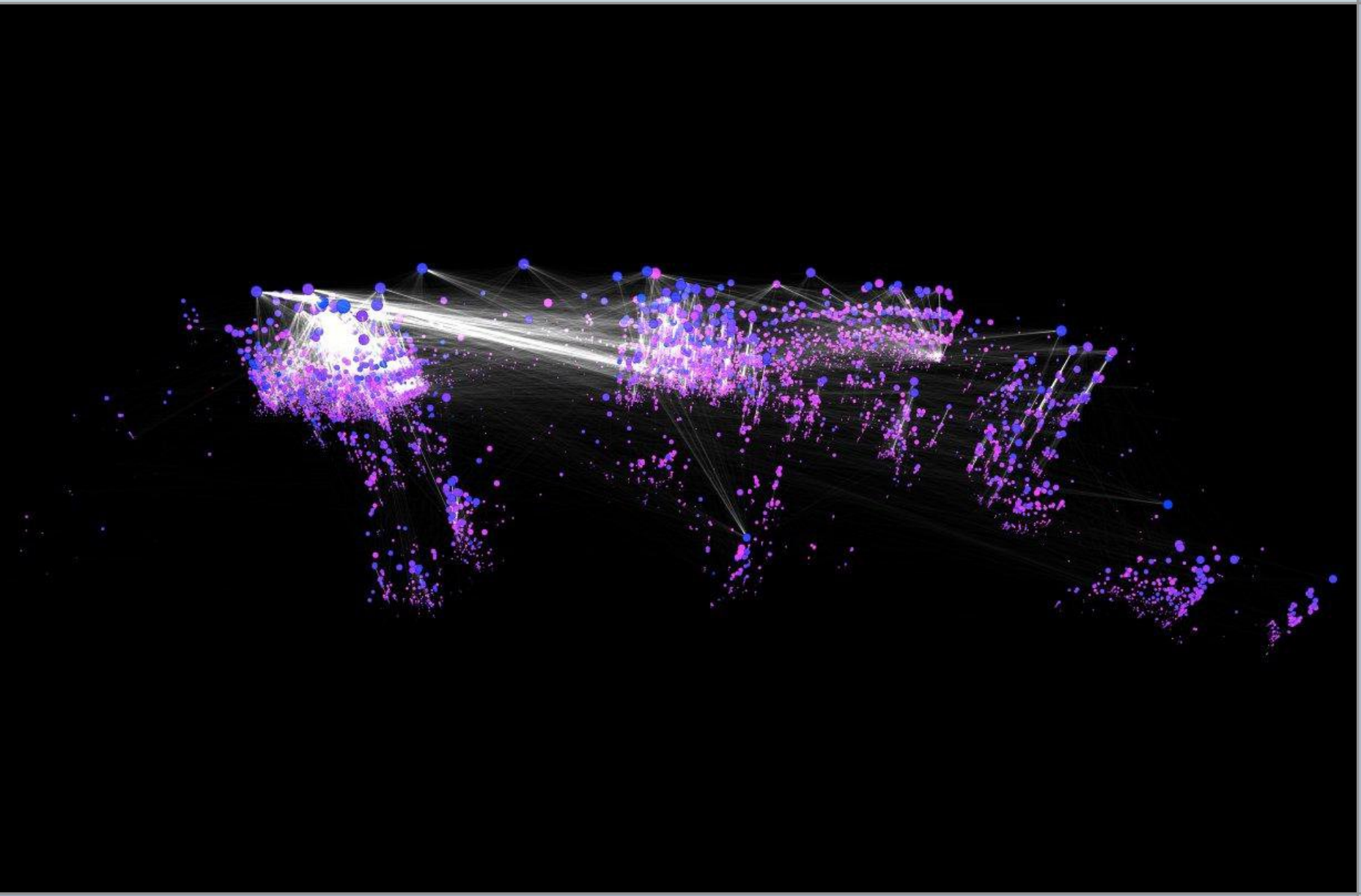


Internet Structure

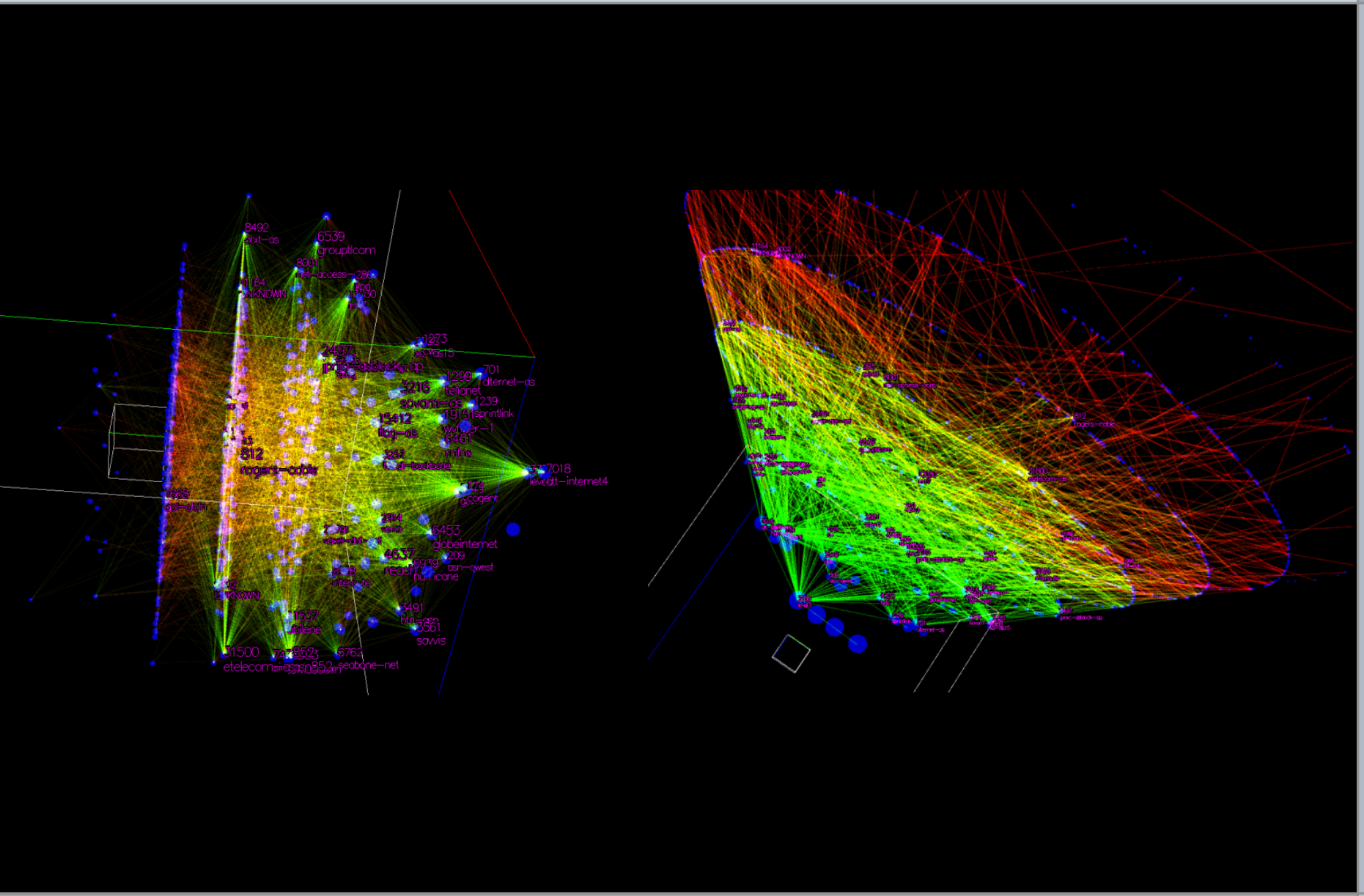
Visualisation of paths and AS structures

- Layouting
- Clustering
- Edge-Bundling

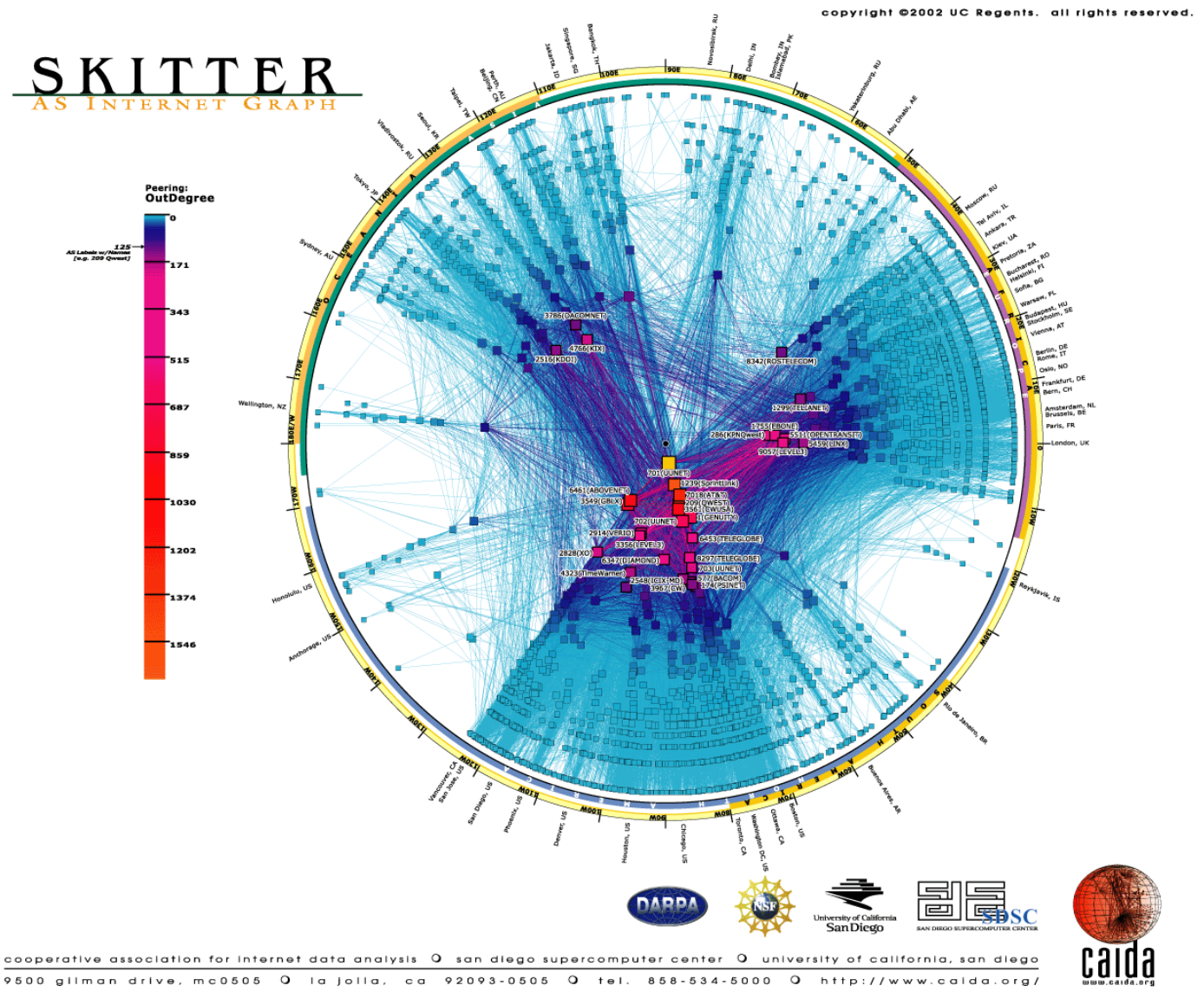
Internet AS Structure



Internet AS Structure



ISP Peering Relations



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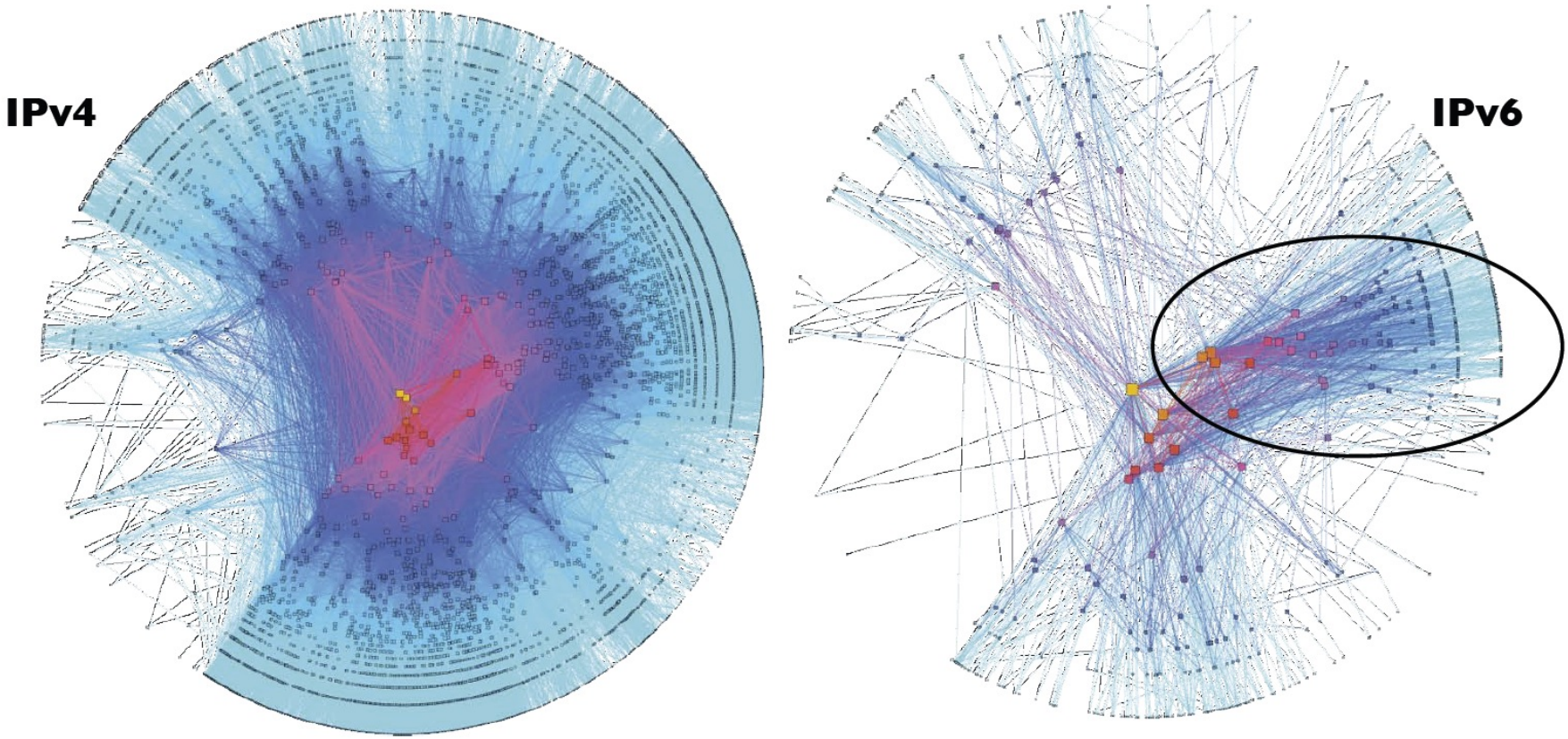
IPv4 vs. IPv6 Graphs



source: caida.org