

Structure of the Internet

→ A view

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Content

- **Aim and outcomes of this lecture**
- **Structure of the Internet**
- **Connectivity of the Internet**
- **Data flow through the Internet**
- **Summary**

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Structure of the Internet

→ Aims and outcomes of this lecture

Aims

- To introduce the idea of the Internet
- To explore the structure of the Internet
- To analyze the connectivity and the data traffic of the Internet
- To analyze the challenges we have with the Internet
- To assess the need of an Internet Early Warning System

At the end of this lecture you will be able to:

- Understand what the Internet from the communication point for view is.
- Know something of the structure of the Internet.
- Understand how the processes between provide works.
- Understand the motivation of the changes in the connectivity and the data traffic of the Internet.

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Internet (1/3)

→ Networks

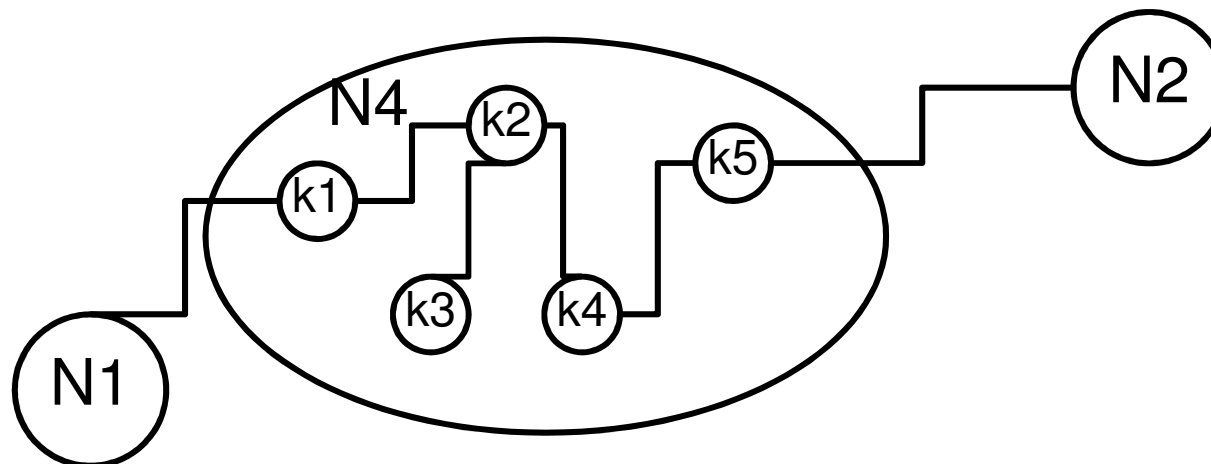
- A **network (N)** is an interconnected group of nodes (K), such as computers, hubs, switches, routers, and so on.

$$N = \langle K, L \rangle$$

- $K :=$ Number of nodes (k)

$$K = \{k_1, k_2, \dots, k_n\}$$

- $L :=$ Connection (links) between nodes (k)



Internet (2/3)

→ Autonomous Systems (AS)

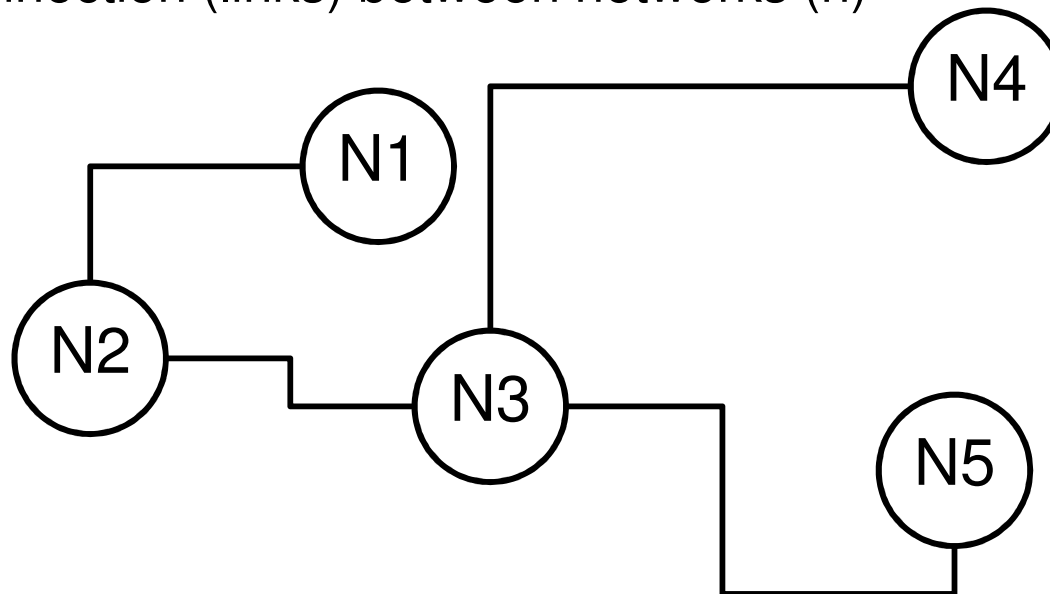
- „An **Autonomous Systems (AS)** is a connected group of one or more IP prefixes run by one or more network (N) operators, which has a **SINGLE** and **CLEARLY DEFINED** routing policy.“ [1]

$$AS = \langle N, L \rangle$$

- N := Number of networks (n)

$$N = \{n_1, n_2, \dots, n_m\}$$

- L := Connection (links) between networks (n)



Internet (3/3)

→ Interconnected networks

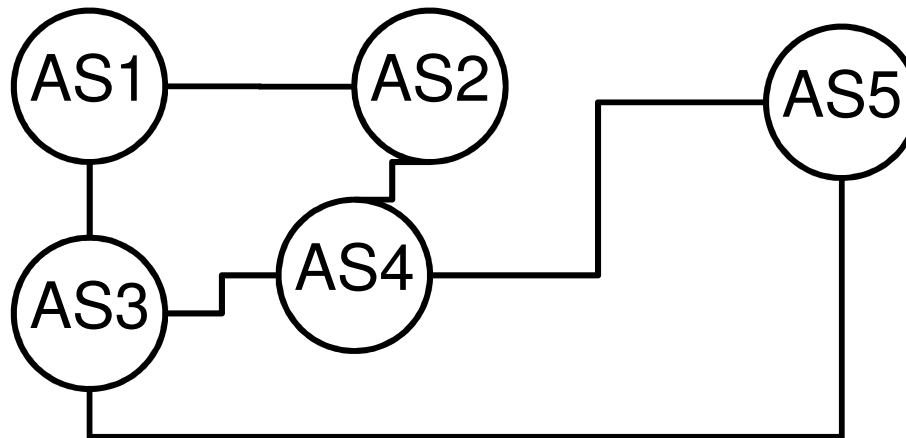
- The **Internet (I)** consists of independent networks, the Autonomous Systems (AS) which are connected.

$$I = \langle AS, L \rangle$$

- AS := Number of Autonomous Systems (AS)

$$AS = \{as_1, as_2, \dots, as_N\}$$

- L := Connection (links) between Autonomous System (AS)



Structure of the Internet

→Autonomous Player

■ **Autonomous Systems (AS)**

- The global Internet consists of thousands of independent networks, the Autonomous Systems (AS)
- Currently there are about 31.000 different ASs advertised in the global Routing table
- The AS operators have different policies for the size and expansion of their network
- An AS needs a strategy to connect with other ASs using upstreams, private or public peerings
- There are more than 66.000 logical connections between ASs at the moment

■ **Different types of Autonomous Systems**

- Large Companies, e.g. business consumer (41 %)
- Internet Service Providers, e.g. IP-carrier (35 %)
- Universities (11 %)
- Internet Exchange Points, e.g. public data exchange nodes (2 %)
- ...

Structure of the Internet

→ Connection with other ASs

- **Upstream**
 - For upstream the **smaller AS** have to **pay** to the **bigger AS**
- **Private peering**
 - Private peering is a **connection between AS of the same level**
 - Normally there is **no payment** for the exchanged data
- **Public peering**
 - Public peering is a data exchange nodes (e.g. Switches), where a lot of AS make a **central peering**.

Networks / AS

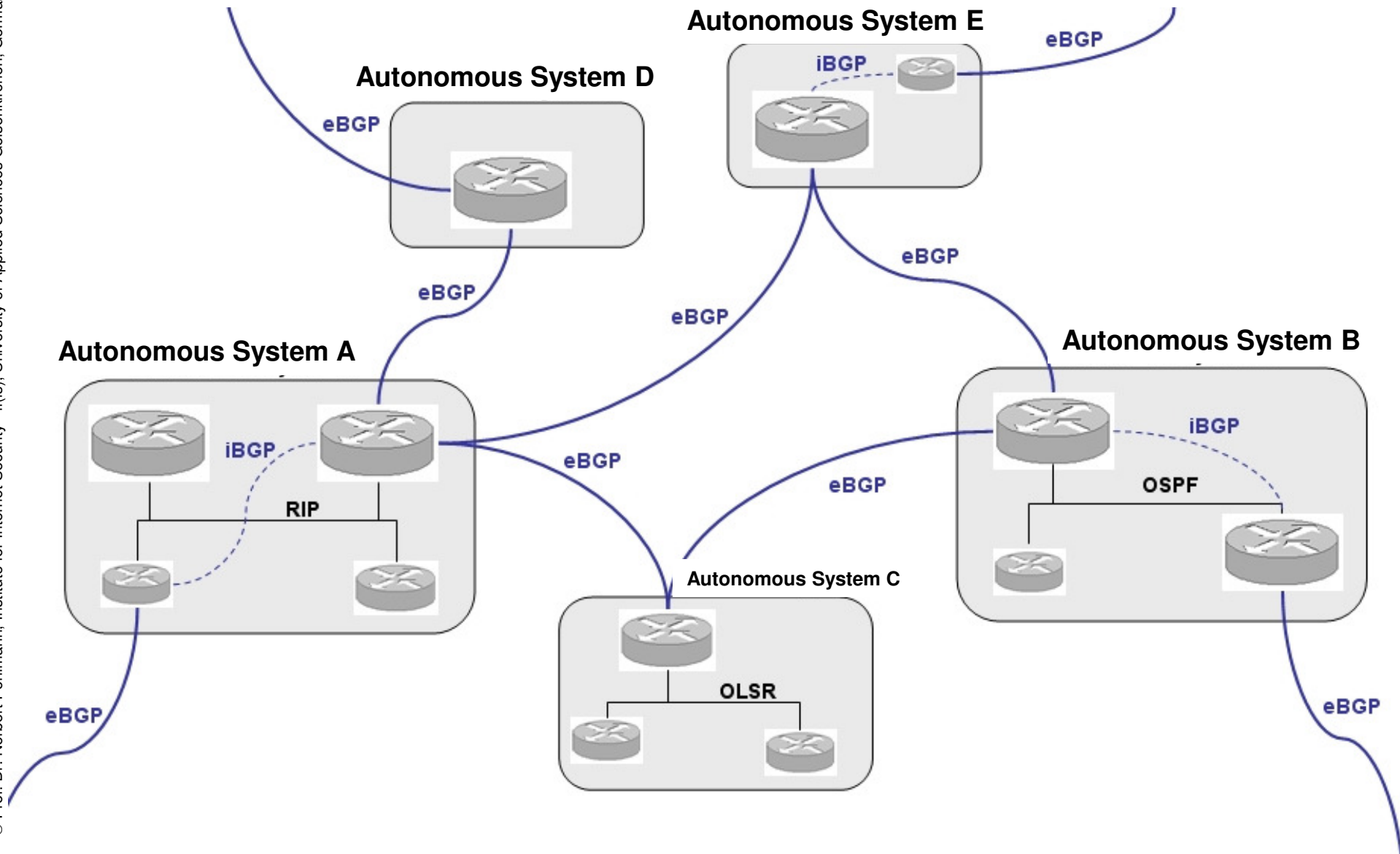
→ Overview



- **Autonomous System (AS):**
 - Network(s) having one integrated management.
 - One AS can be set up by a number of networks, which are connected by routers.
- **Interior Gateway (IG):**
 - Interner Router of an Autonomous Systems (AS)
- **Exterior Gateway (EG):**
 - Router at the boarder from one AS to another (border router)

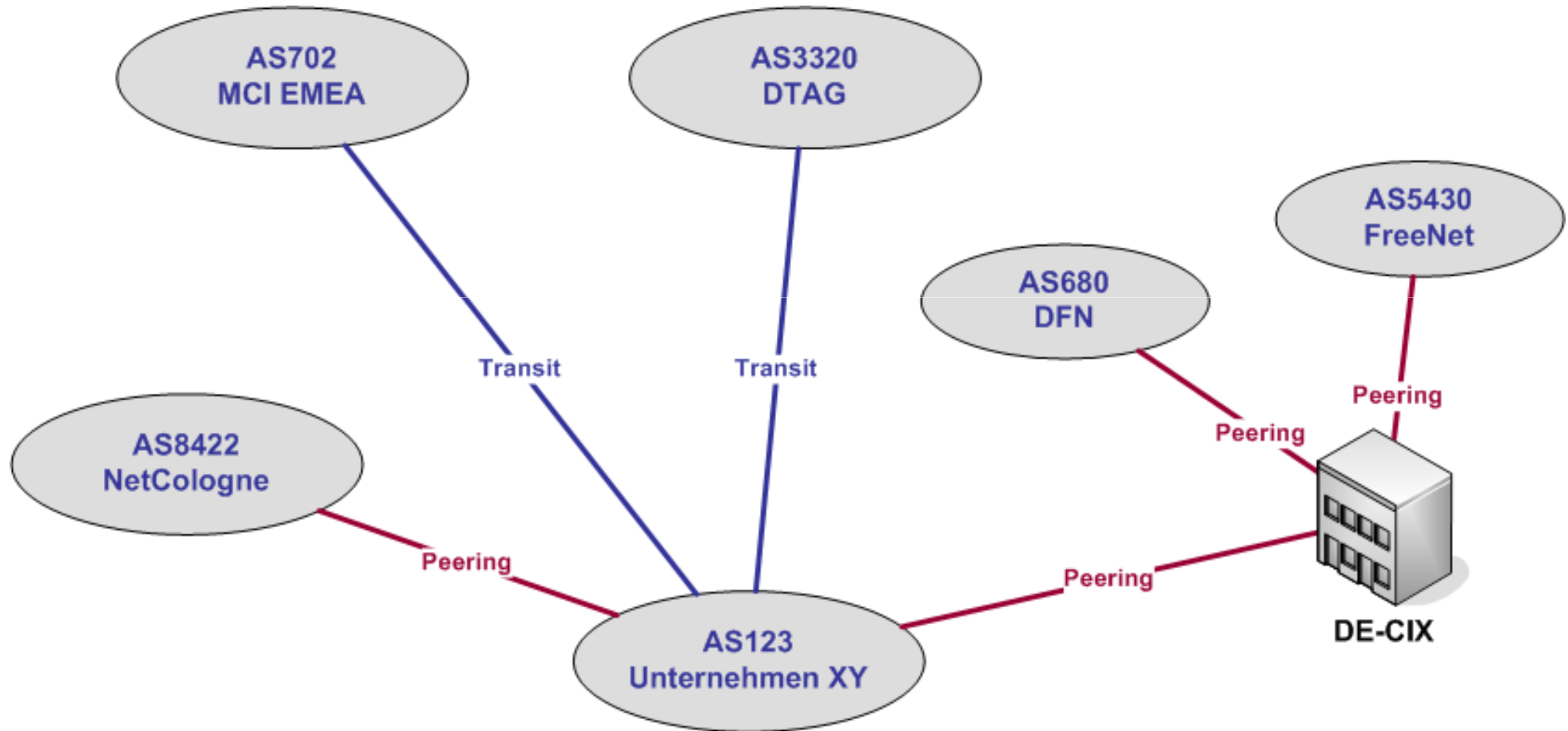
Autonomous Systems

→ Overview



Autonomous Systems

→ Strategy of the Provider



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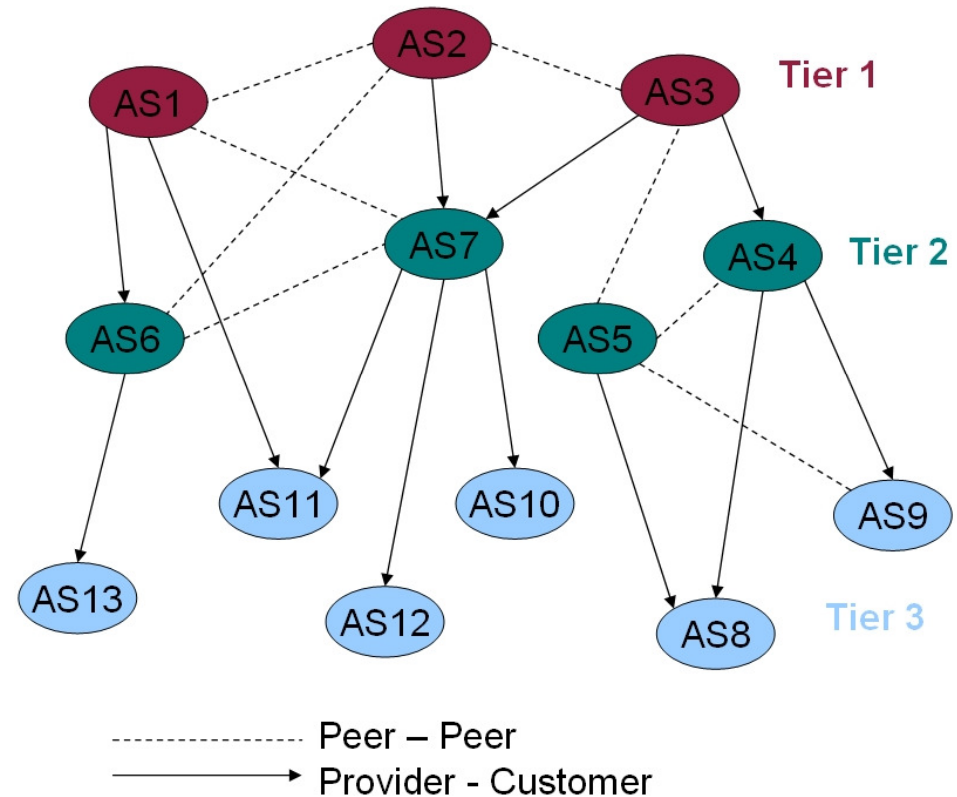
Structure of the Internet

→Connectivity of the Internet

■ Ongoing analysis on the Route Views Snapshot

- ≤ 2 = 63 % (~17.000)
- ≤ 10 = 94 %
- > 10 = 6 %
- > 100 = 0,4 %
- > 300 = 0,1 % (~27)

- Economical necessities affect the carrier's proceeding
- This yields to a destabilization of the internet infrastructure

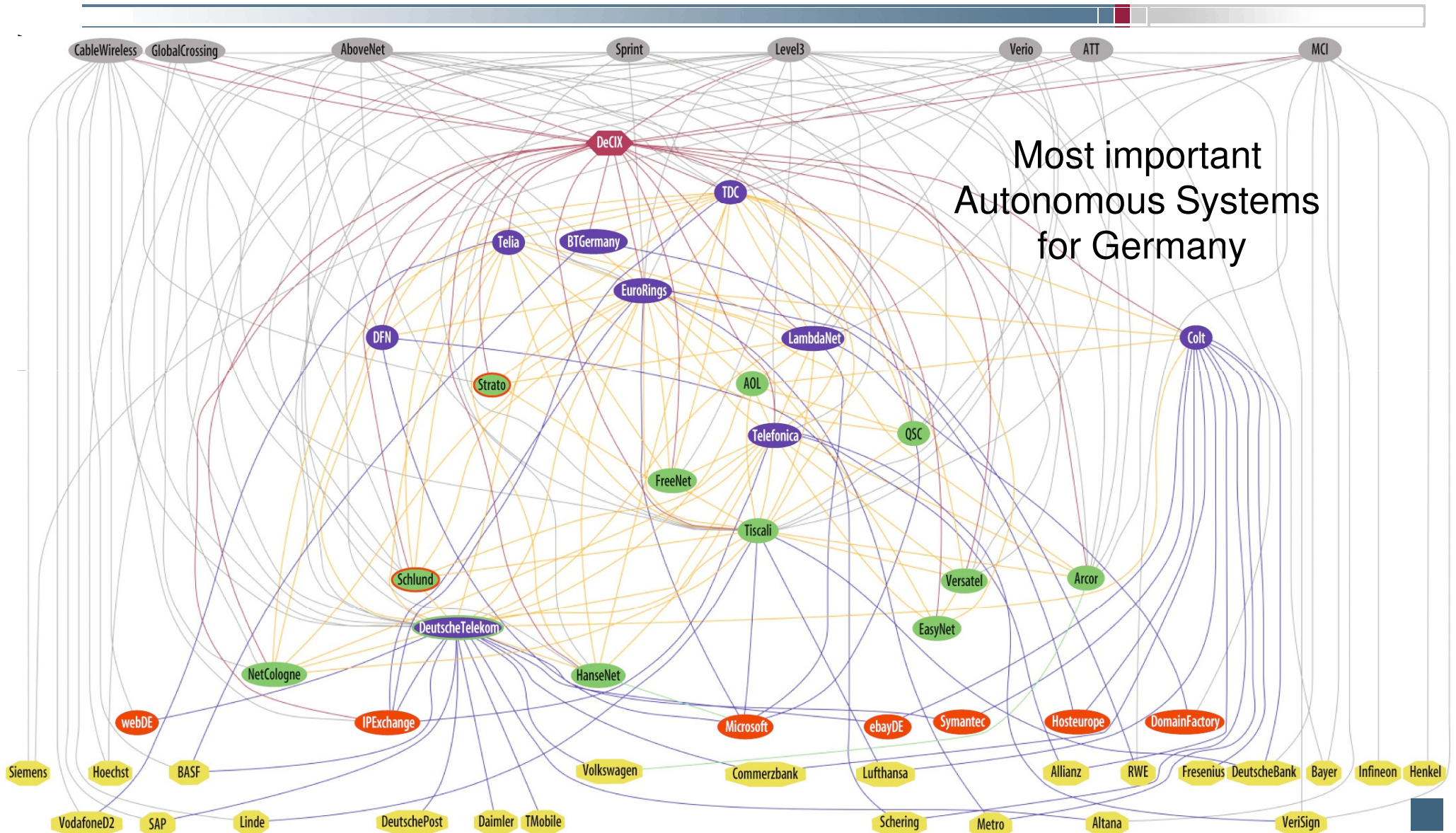


■ What is imported in this field?

- We need an entity which keeps an eye on the level of connection and the reliability of all ASs in the Internet

Structure of the Internet

→ Analysis of „Internet Germany“

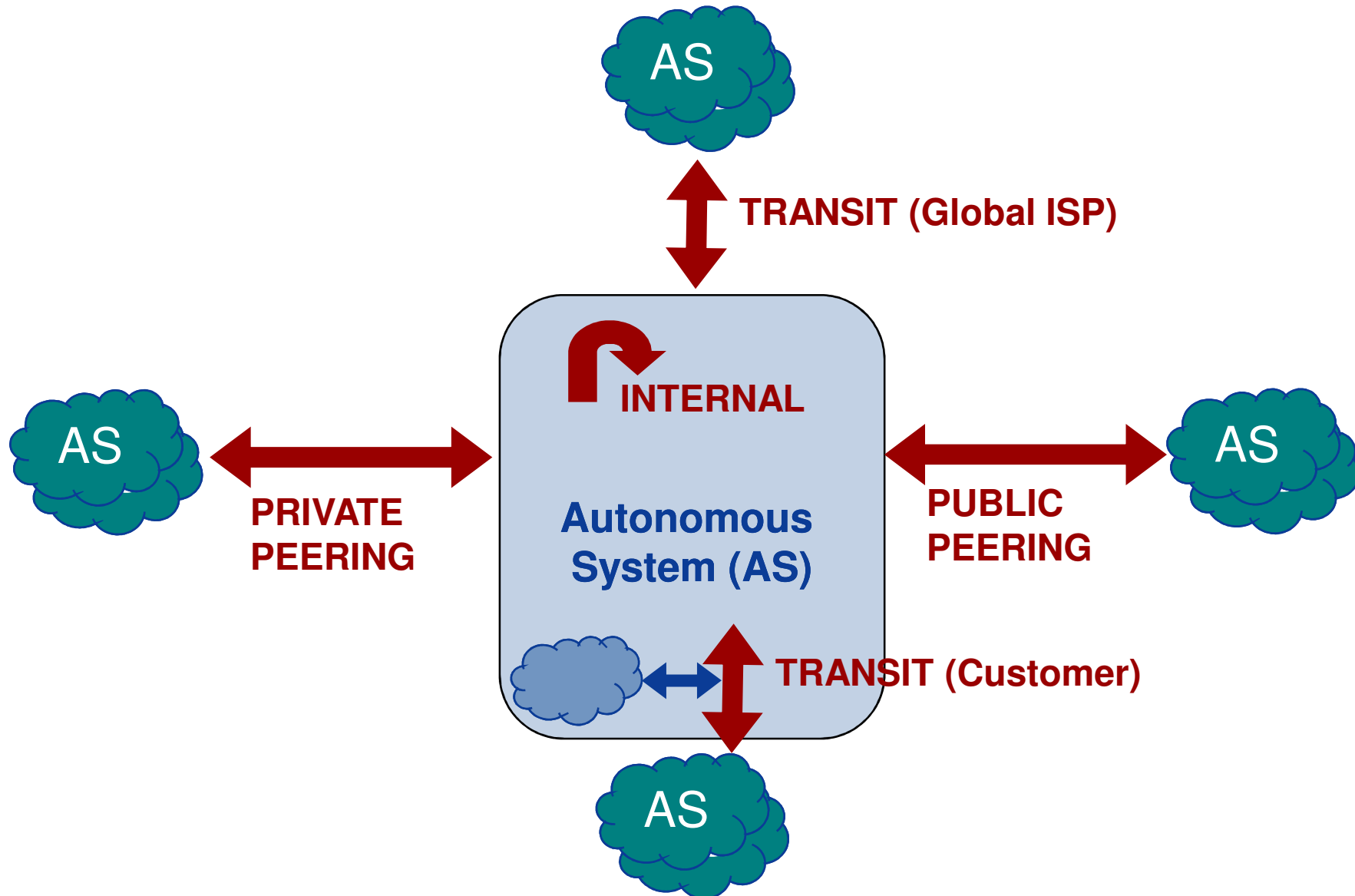


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Data volume

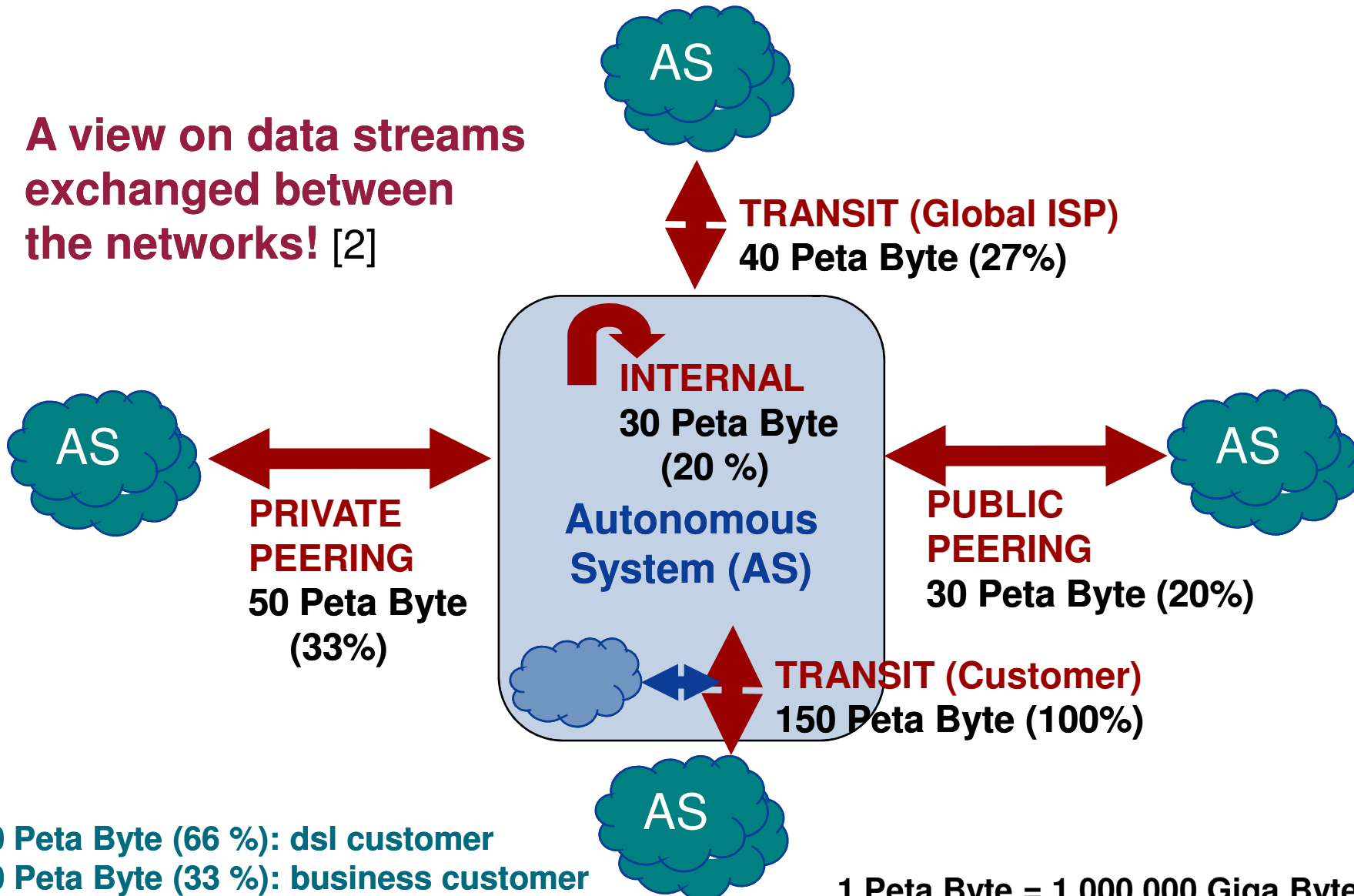
→ Model for Internet Germany



Data volume / month in Germany

→ Estimation (2007)

A view on data streams exchanged between the networks! [2]



100 Peta Byte (66 %): dsl customer
50 Peta Byte (33 %): business customer

1 Peta Byte = 1.000.000 Giga Byte

Trend

→ Everything over IP (all-IP)

- **Triple-Play;** Internet, IPTV and VoIP using one single line
 - Decouple from the telephone line
 - IPTV has highest requirements of the available data rates (Downstream)
 - SDTV: from 2 - 6 Mbit/s (depending on used compression; for each TV channel)
 - HDTV: from 6 - 16 Mbit/s (depending on used compression; for each TV channel)
 - (VoIP: maximal 100 kbit/s, depending on used compression; for each parallel call)
 - Till 2015 an increase of the IPTV users to more than 7 million is expected in Germany (population about 82 million)
 - **QoS can only be guaranteed within one AS !!!**

■ **Traffic 2011:**

- **40% Internet**
- **60% AS-Traffic**

Traffic 2006:

- 80 % Internet
- 20 % AS-Traffic

Global data traffic

→ Cisco survey

- Annually growth from 2006 till 2011: [3]
 - 58% growth by private users
 - 21% growth by businesses
- Just the video content on **YouTube** is responsible for about **10 percent of the data traffic**; still increasing!
- Important for the borders to other AS, due to the fact that the content is most of the time in another country (another AS).

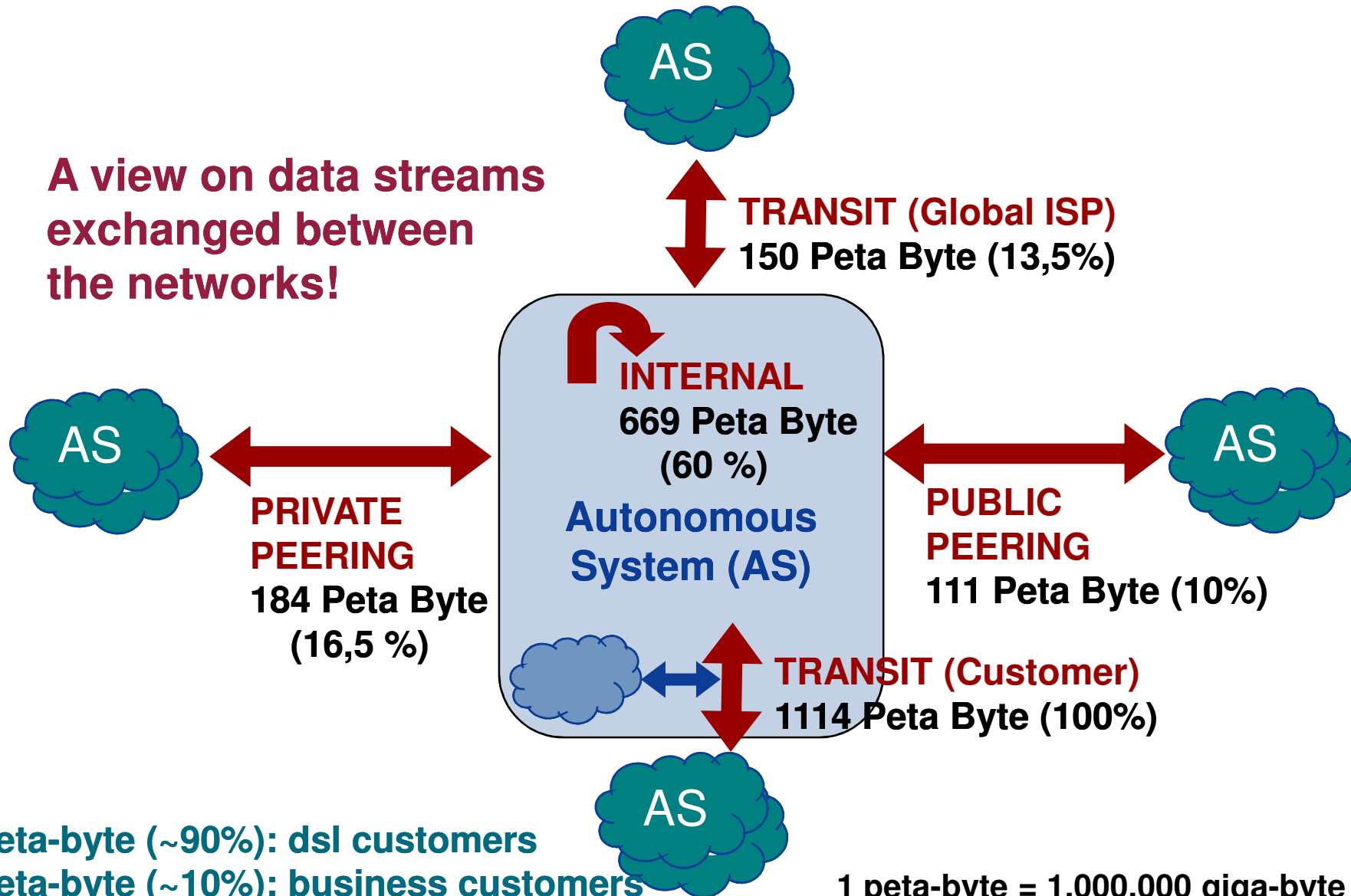
■ year	2006	2007	2008	2009	2010	2011
■ privat	100 (66%)	158	250	395	623	984 (88%)
■ business	50 (33%)	60	73	89	107	130 (12%)
■ sum	150	218	323	484	730	1114

(peta-byte per month!)

Data volume / month in Germany

→ Estimation (2010)

A view on data streams exchanged between the networks!



984 peta-byte (~90%): dsl customers
130 peta-byte (~10%): business customers

1 peta-byte = 1.000.000 giga-byte

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Structure of the Internet

→ Summary

- Structure of the Internet is self regulated.
- Only few organisations really knows what happens in the Internet.
- The connectivity will have less strategic meaning for some provider in the future, due to new strategies and services (e.g. IPTV).
- **A open question is:**
Do we need another internet for business customers in the future?
- What we need is an entity which keeps an eye on the level of connection, the data traffic and the reliability of all ASs in the Internet.

Structure of the Internet

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Thank you for your attention!
Questions?

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Structure of the Internet

→ Literature

- [1] [http://en.wikipedia.org/wiki/Autonomous_system_\(Internet\)](http://en.wikipedia.org/wiki/Autonomous_system_(Internet))
- [2] N. Pohlmann: “Wie verlässlich ist das Internet?“
<http://www.internet-sicherheit.de/fileadmin/docs/publikationen/IP-Sicherheit-Verlaesslichkeit-12-02-08.pdf>
- [3] M. Gröne: „Datenraten im Internet“
<http://www.internet-sicherheit.de/fileadmin/docs/publikationen/Studienarbeit-Groene-Datenraten-im-Internet.pdf>

Links:

AiconViewer: <http://www.internet-sicherheit.de/aiconviewer/>