



# The German Internet Infrastructure: Exposure and Monitoring

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# Agenda

- 🕒 Motivation & Objectives
- 🕒 How to Identify the German Internet Infrastructure?
  - From IP-Blocks to ASes
  - Classifying the ASes Relevant in Germany
  - Snapshots of the Minimal Spanning Routing Graphs
- 🕒 An Exposition: Pictures from the German Internet
- 🕒 Some Analytics: What do the Graphs Tell?
- 🕒 Outlook: Reactive Monitoring
- 🕒 Summary



# Motivation

- o The Internet approaches a role of critical infrastructure within most countries
  - More and more communication, administration, business and entertainment processes are IP-dependent
- o Operational risks and protective potentials unknown from a national perspective
  - Require identification of players and interplay
- o The Internet faces political controversies and legal actions (country-wise)
  - Good to know about the national impact onto the (international) Internet community



# Objectives

- o Automated detection and visualization of the 'German Internet'
- o Questions towards a nation-centric understanding of the Internet:
  - Does a national classification make sense?
  - To which degree is IP-Routing nationally confined?
  - How to protect the national Backbone against international attacks and route-hijacking?
  - How about structural dependencies and robustness of the national Internet?
  - How much intra-country transport is dependent on international transit and by which country?





# How to Identify the German Internet Infrastructure?

Find all “members” from Germany:

- o Identify IP-blocks belonging to German Orgs.

  - Use `org / admin-c` records from RIPE-DB

- o Derive corresponding prefix and AS

  - Use / check with different data sources: RIPE-DB, TEAM-Cymru, Route Monitors

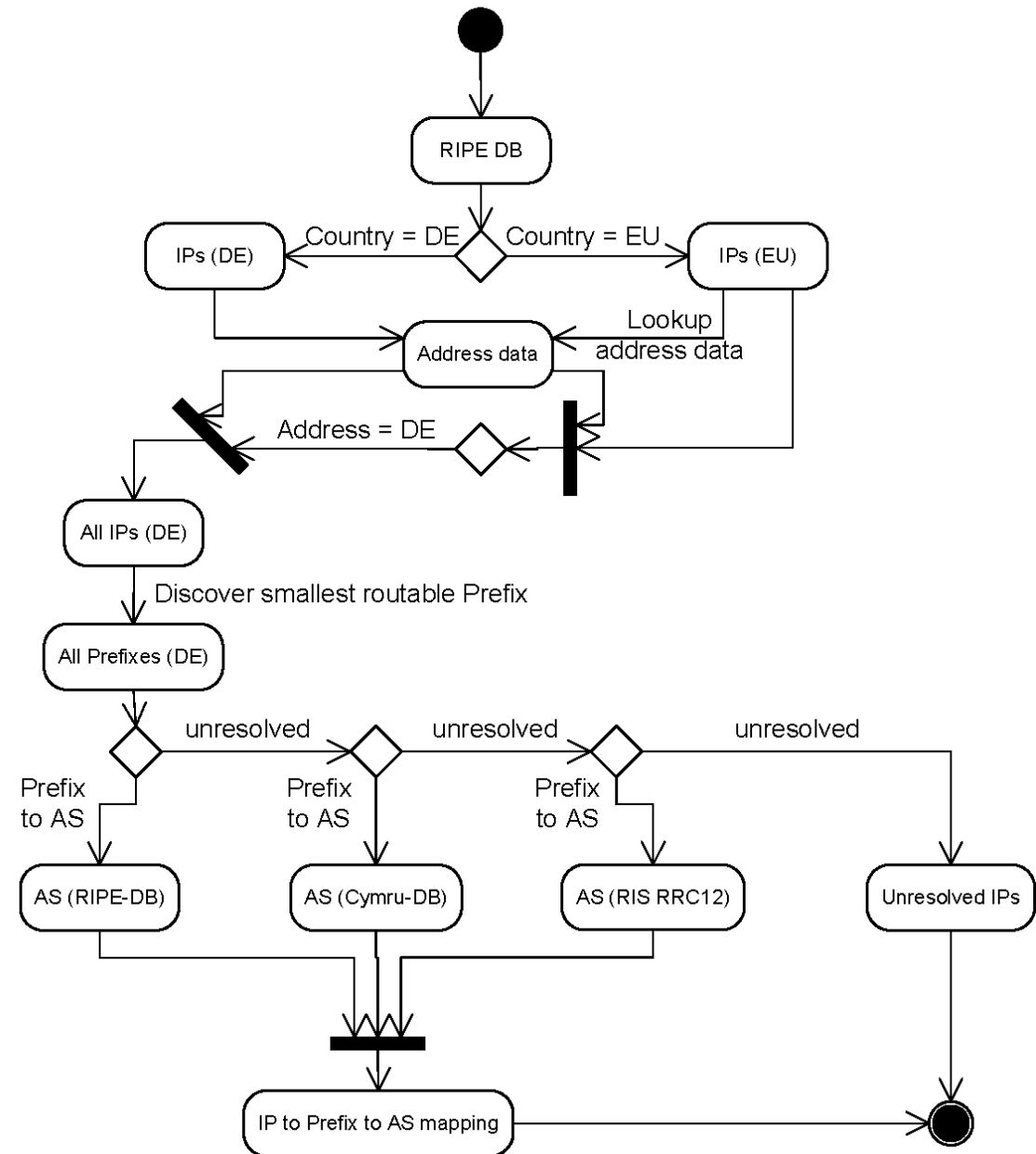
- o Problem: Incomplete/noisy databases, outdated entries, ...



# Tool Chain

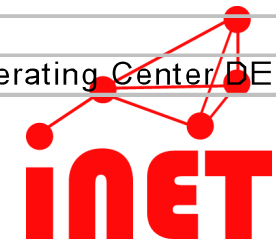
Fully automated process detects

- o 245.524 IP Blocks
- o 6278 Prefixes in
- o 1472 ASes
- o Error: 5286 IP-blocks ( $\approx 2\%$ ) unresolved



# Result: List of ASes Serving German IP-Members

#ASN	ASNAME	ORG	ADMIN
71	HP-INTERNET-AS Hewlett-Packard Company	-NA- -NA-	Vincent Giles Hewlett Packard Europe, 5,
174	COGENT Cogent/PSI	-NA- -NA-	Cogent Communications Hostmaster Coge
209	ASN-QWEST - Qwest Communications Company, LLC		-NA-
250	SACREDCHAO-AS AS250.net Foundation Proje	-NA- -NA-	Michael Horn -----, AS250
286	KPN KPN Internet Backbone	-NA- -NA-	KPN Internet KPN, P.O. Box 30000, 2500
288	European Space Agency	-NA- -NA-	European Space Agency ESA European S
553	BELWUE Landeshochschulnetz Baden-Wuertter	-NA- -NA-	Peter Merdian Landeshochschulnetz Bade
680	DFN-IP service X-WiN	-NA- -NA-	Christian Grimm DFN-Verein Geschaefsss
702	AS702 Verizon Business EMEA - Commercial IP	-NA- -NA-	WorldCom EMEA RICE Application World
705	UUNET - MCI Communications Services, Inc. d/b/a Verizon Business		-NA-
1103	SURFNET-NL SURFnet, The Netherlands	-NA- -NA-	SURFnet Network Services Radboudkwart
1239	SPRINTLINK - Sprint		-NA-
1257	TELE2	-NA- -NA-	Lars Michael Jogback Tele2 AB, Box 62, S
1273	CW Cable and Wireless plc	-NA- -NA-	Cable and Wireless IP GSOC Europe Cab
1299	TELIA NET TeliaNet Global Network	-NA- -NA-	TeliaNet Routing Registry TeliaSonera Sw
1661	ANS-ATLANTA - ANS Communications		-NA-
1668	AOL-ATDN - AOL Transit Data Network		-NA-
1754	DESY-HAMBURG	-NA- -NA-	Network Operating Center/DESY DESY, N



# Classification of ASes

- o Differentiate per Tier: NecLab
- o Differentiate per Tier & Size: UCLA
- o Classify according to organizational sector
  - Approach: Keyword spotting

## Taxonomie kritischer Akteure im Internet

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Behörden, Verwaltung und Justiz	I&K: Software- und Systeme
Energie	Industrie (Produzierendes Gewerbe)
Finanz-, Geld- und Versicherungswesen	Medizinwesen (Krankenkassen, Krankenhäuser, med. Versorgung)
Gefahrstoffe	Presse, Medien, Verlage
Handel	Transport und Verkehr
I&K: Internet Peering Points	Versorgung
I&K: ISPs (ohne Endkunden-Zugang), Internet Infrastruktur	Wissenschaft, Forschung & Kultur
I&K: Access Provider	Sonstiges

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# Result: Classified AS-List

- 10282;ORANGE-BUSINESS-SERVICES-CEEUR;-NA-;Orange Business Services - Internet team -NA-;tier2;smallISP;ISPs (ohne Endkunden-Access), Internet Infrastruktur
- 12422;EVONIK-AS;-NA-;Marcus Johannes Eickhoff Evonik Service GmbH, S-IS-GNS-SCM, Weissfrauenstrasse 9, 60287 Frankfurt, Germany;tier3;stub;Industrie (Produzierendes Gewerbe)
- 12510;SAP\_AG\_WDF;-NA-;Internet Services SAP AG SAP AG, Internet Services, Matthias Braun, Dietmar-Hopp-Allee 16, D-69190 Walldorf, Germany;tier2;stub;Industrie (Produzierendes Gewerbe)
- 12544;ADVANCEBANK;-NA-;-NA-;NA;NA;Finanzdienstleister (Banken, Versicherungen, ...)
- 12654;RIPE-NCC-RIS-AS;RIPE NCC RIPE Network Coordination Centre, P.O. Box 10096, 1001 EB Amsterdam, The Netherlands;-NA-;tier2;stub;ISPs (ohne Endkunden-Access), Internet Infrastruktur
- 12680;Gruner-und-Jahr-AS1;-NA-;Gerhard Annussek Gruner+Jahr AG & Co, Am Baumwall 11, D-20459 Hamburg, Germany;tier3;stub;Presse, Medien, Verlage



# Snapshots of the Minimal Spanning AS-Routing Graphs

- o Construct graph from pair-wise interconnecting AS-Paths
- o Extract paths from AS-Monitoring-Project (shortest path from policy-based selection)
  - Currently: NECLab path-matrix
  - Future work: UCLA link base, requires calculation of path-matrix
- o Determines inter-connecting ASes from outside Germany

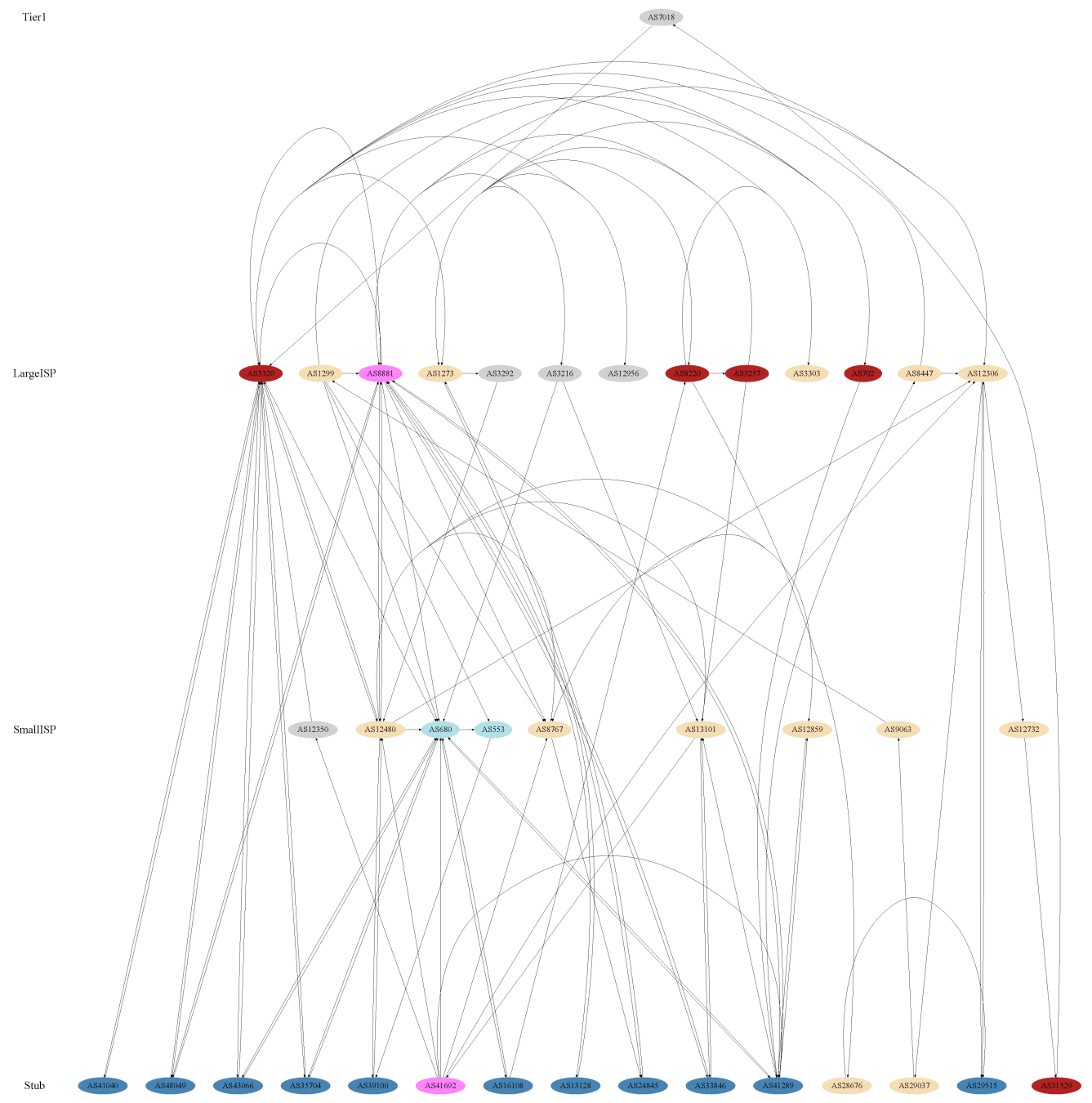


# Pictures from the German Internet

- o Visualization using GraphViz
- o Automated production of different views
  - Routing hierarchies
  - Structural minimization
  - Communication flows
- o Targets at sectors and German players



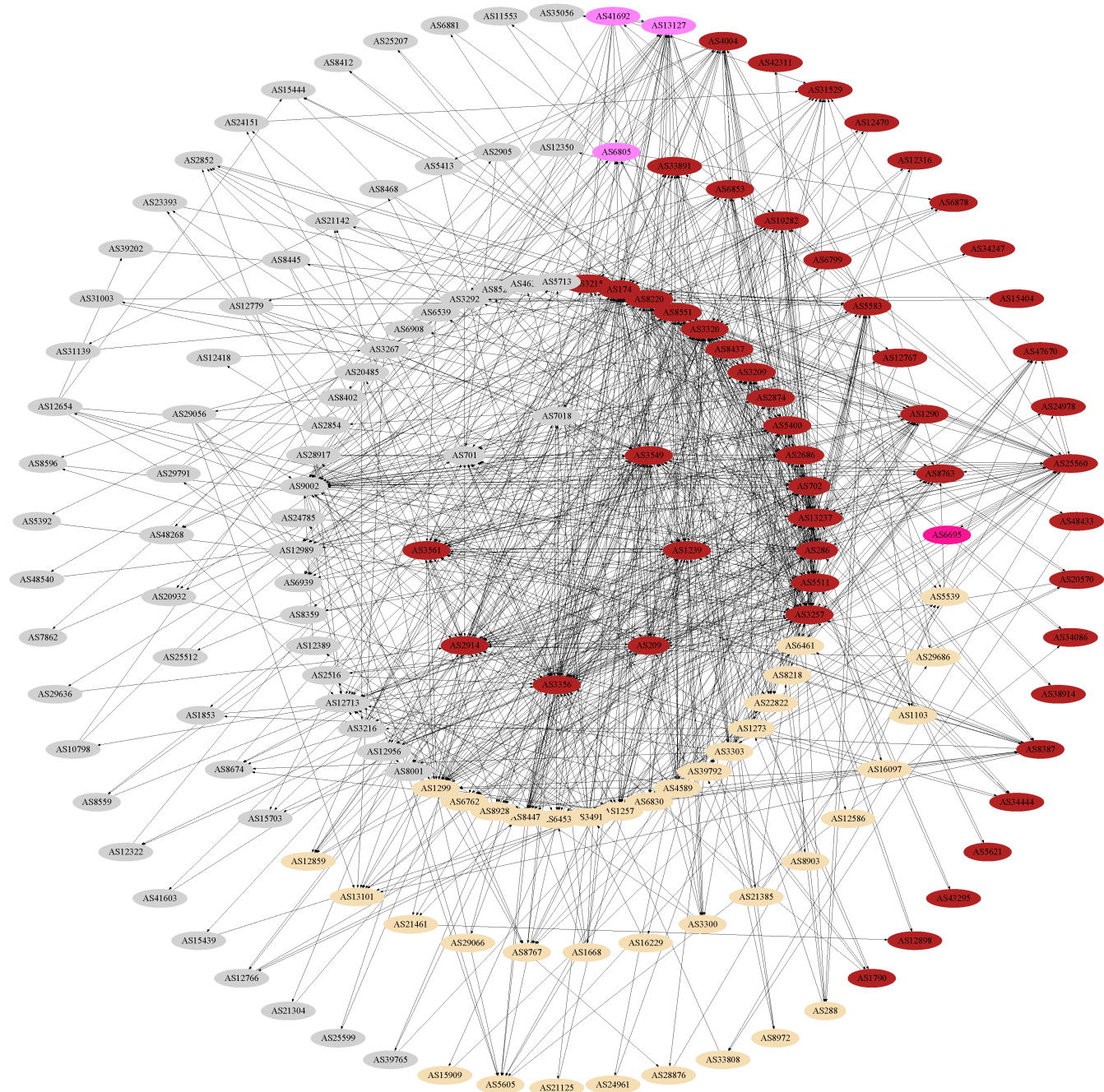
# Routing Hierarchy



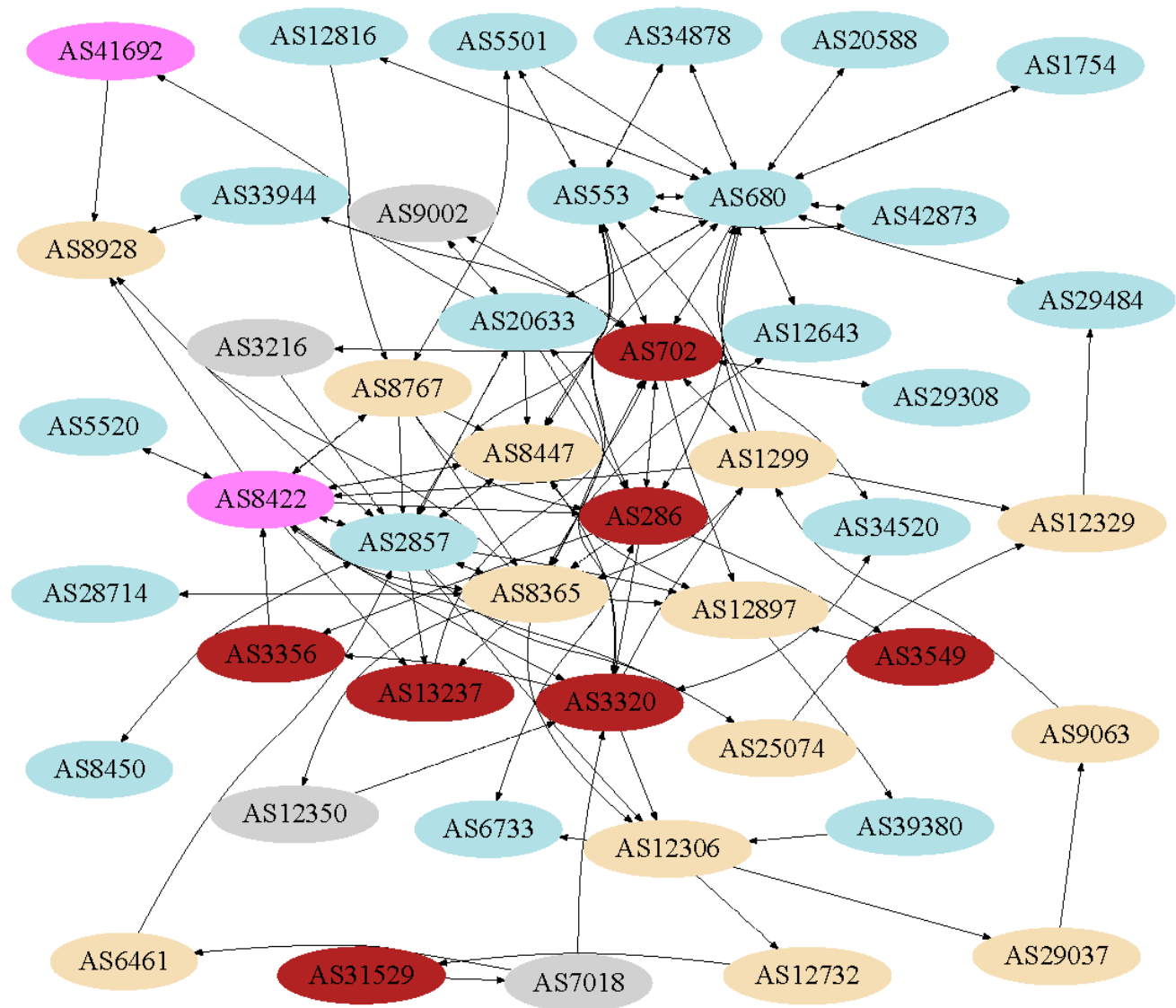
Behörden, Verwaltung und Justiz



# Hierarchical Ring Model for Large ISPs

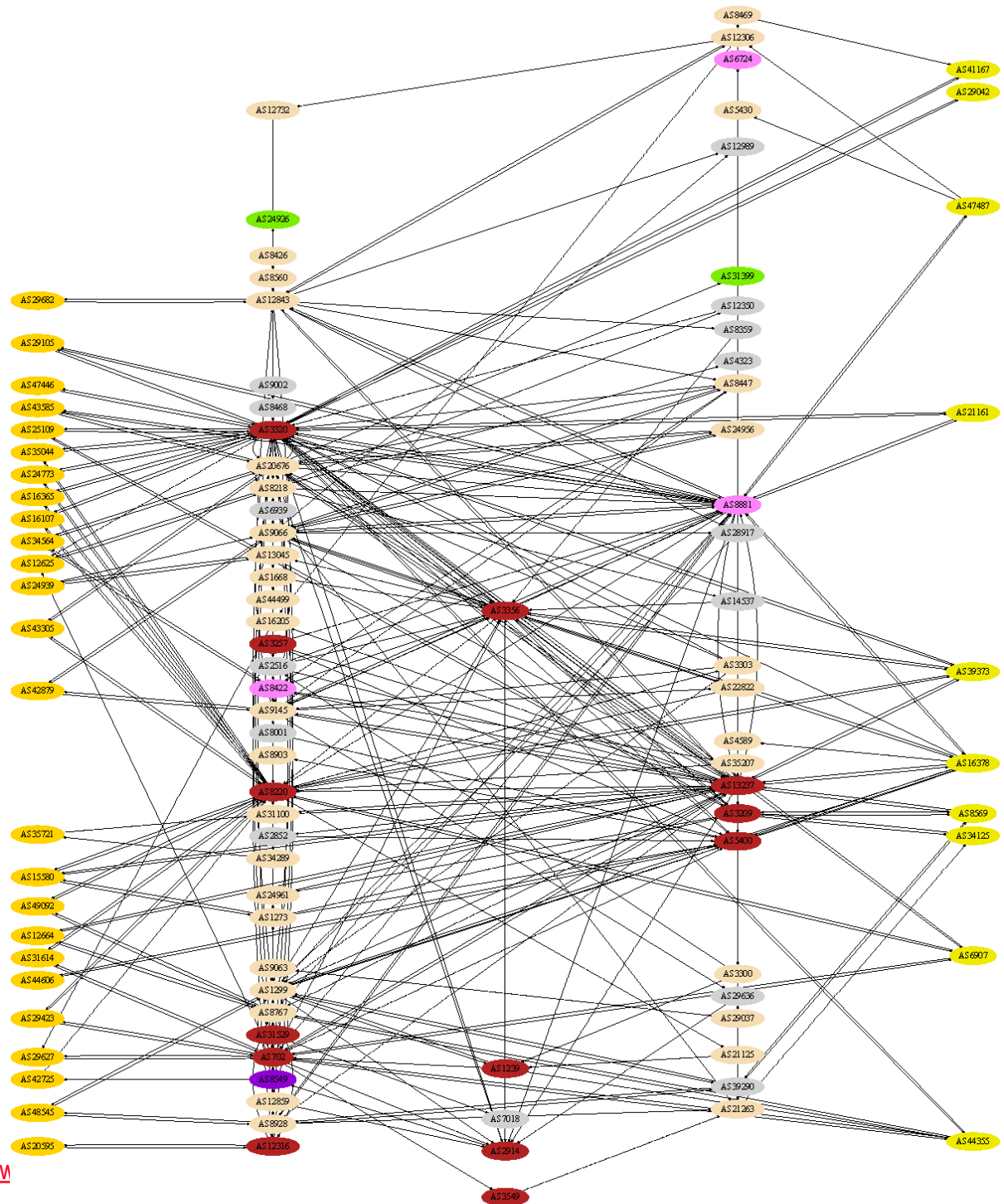


# Kamada -Kawai Spring Model

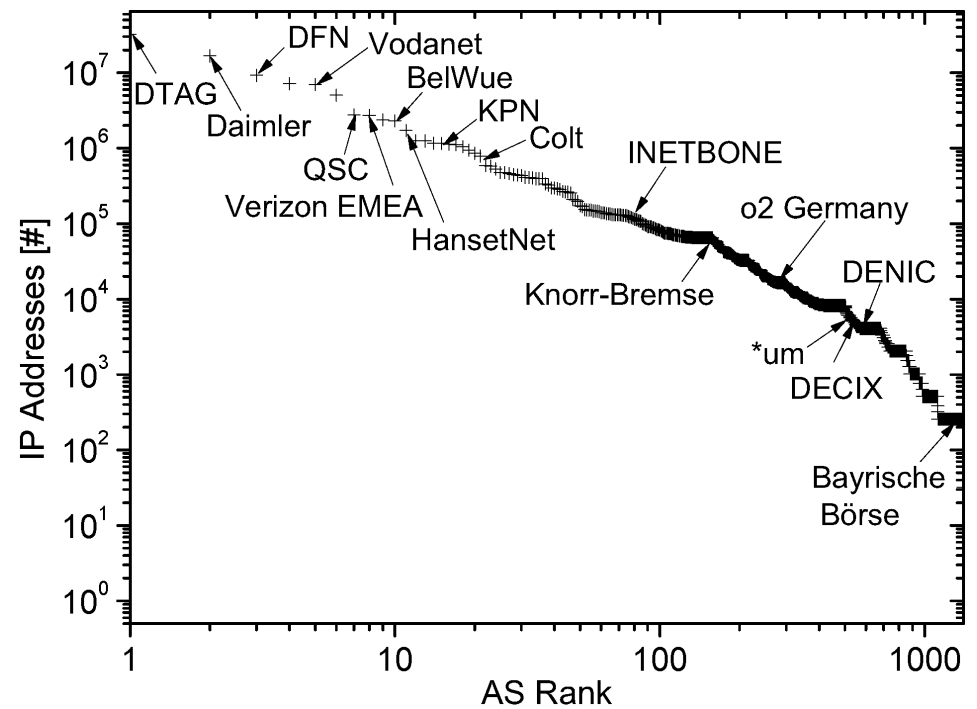
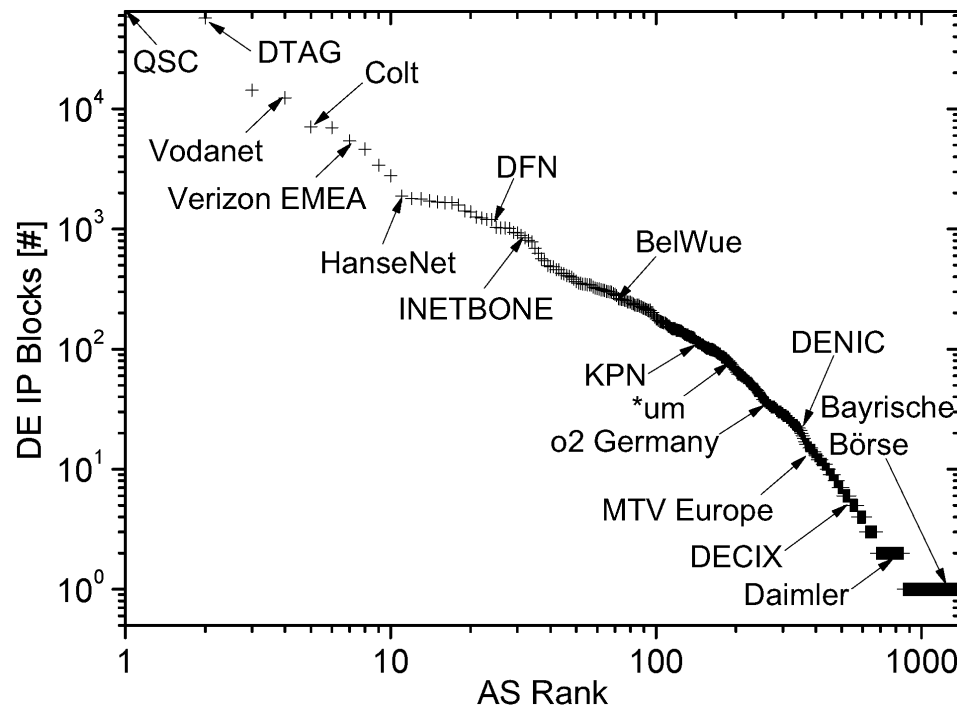


Sonstiges: Wissenschaft, Forschung & Kultur (F&E)

# Information Flows: Finance - Traders



# Analysis: AS Ranking







# Betweenness Ranking

- o Top Five Betweenness-holders fairly stable
- o DTAG top 5 (88 %), top (63 %)
- o Top Betweenness' enhanced within business sectors

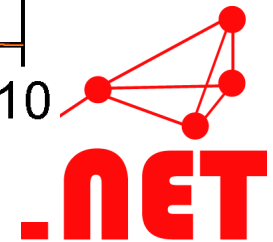
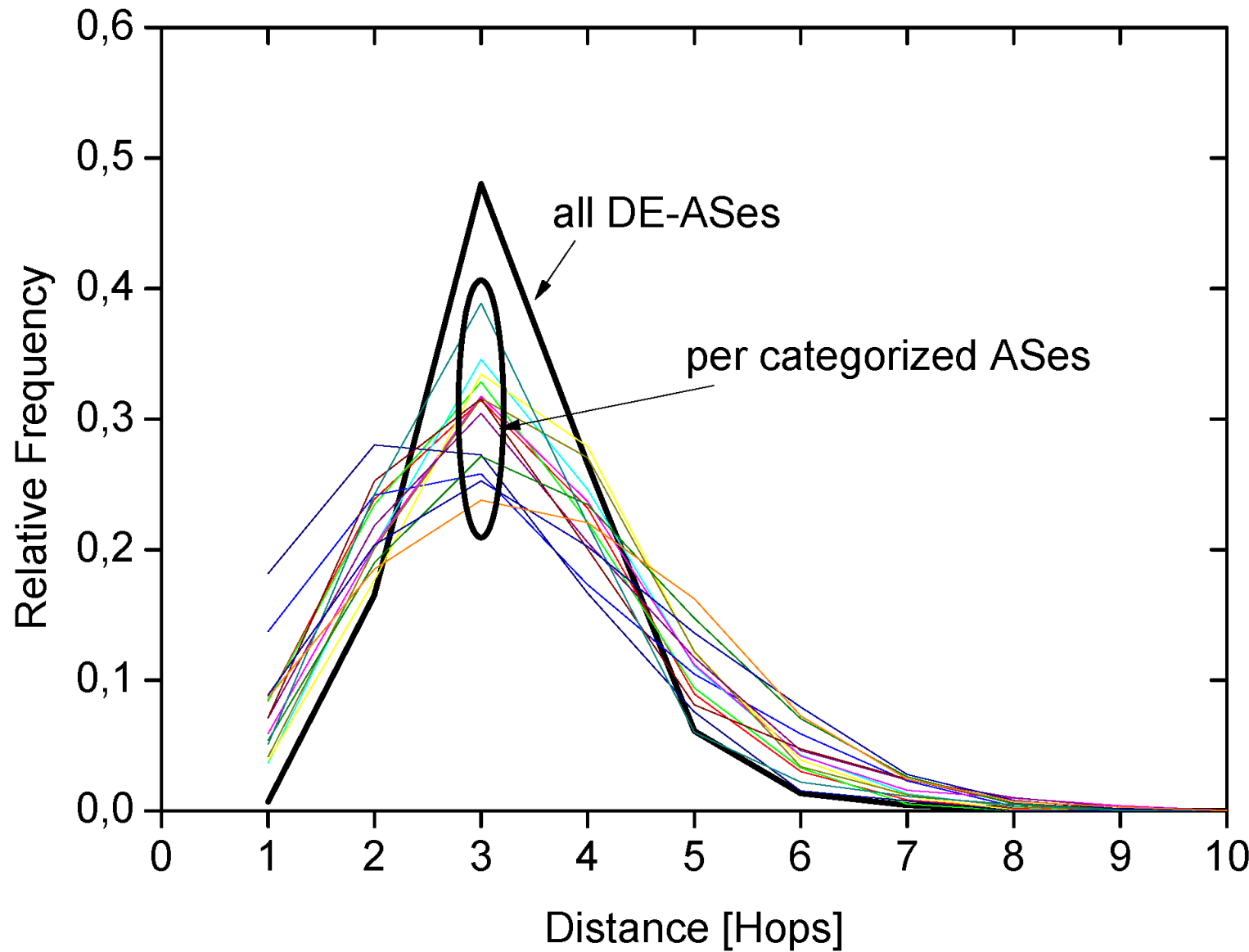
All DE		Large ISPs		Research	
Ranked AS	Betweenness	Ranked AS	Betweenness	Ranked AS	Betweenness
1. DTAG	0.166	1. DTAG	0.216	1. DFN	0.271
2. Versatel	0.100	2. Cogent	0.115	2. JGU Mainz	0.197
3. Lambdanet	0.089	3. Lambdanet	0.104	3. Plusline	0.193
4. Level 3	0.077	4. Tinet	0.102	4. Verizon	0.171

**Tabelle 2** Relative Betweenness der führenden ASen verschiedener Teilnehmergruppen

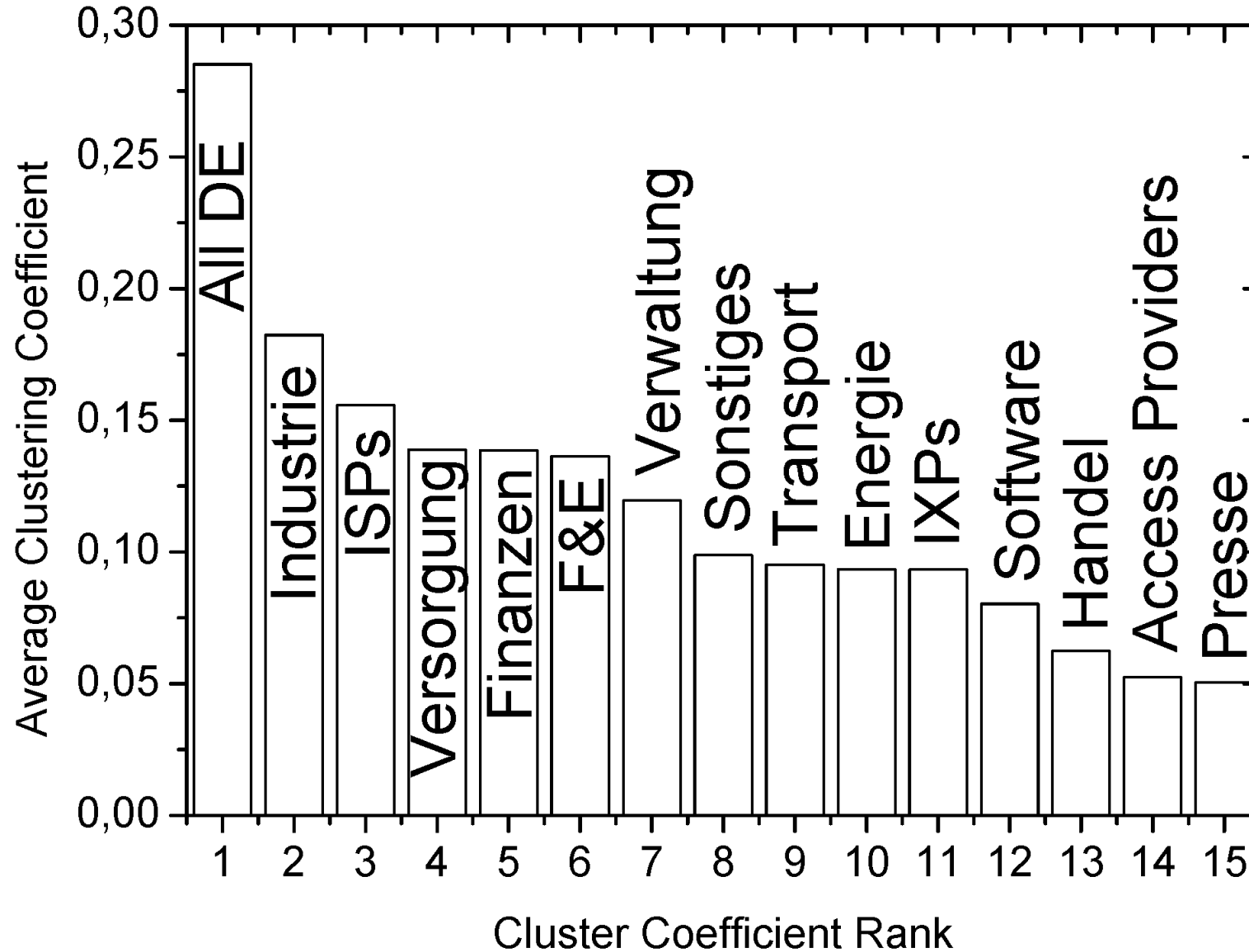




# Distances



# Cluster Coefficient





# Outlook: Reactive Monitoring

Monitor, analyze & understand the evolution of the nation-state routing system

o Continuous snapshots possible with tool-chain

- Limited to one Update per 24 h

o Fine-granular approach: Listen to BGP updates as incremental changes to daily snapshot

- Need not reflect actual routing states

o Reality-check: Actively measure (trace) relevant routes

- Needs monitors, preferably at IXPs.



# Summary

- o Routing Atlas of an unusual perspective on the Internet backbone
  - Reflects focus of public/political/market sectors
  - Fine-grained view on regional sectors
- o Good starting point for continuous monitoring
  - To enhance reliability and safety of nation-state routing
- o Work may facilitate a better understanding of 'national Internet infrastructures' and advance the maturity and long-term vision in debates and decision processes.

