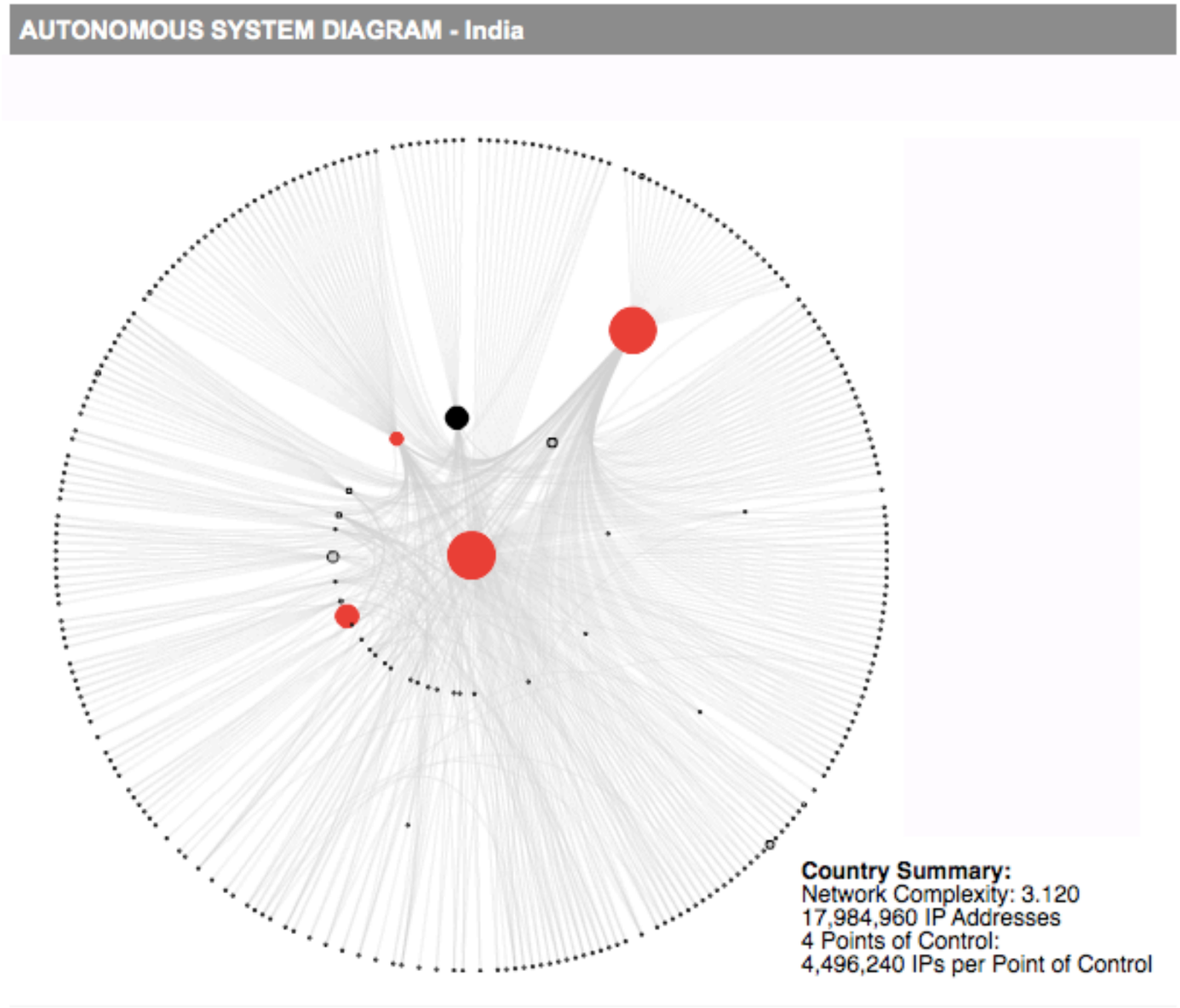
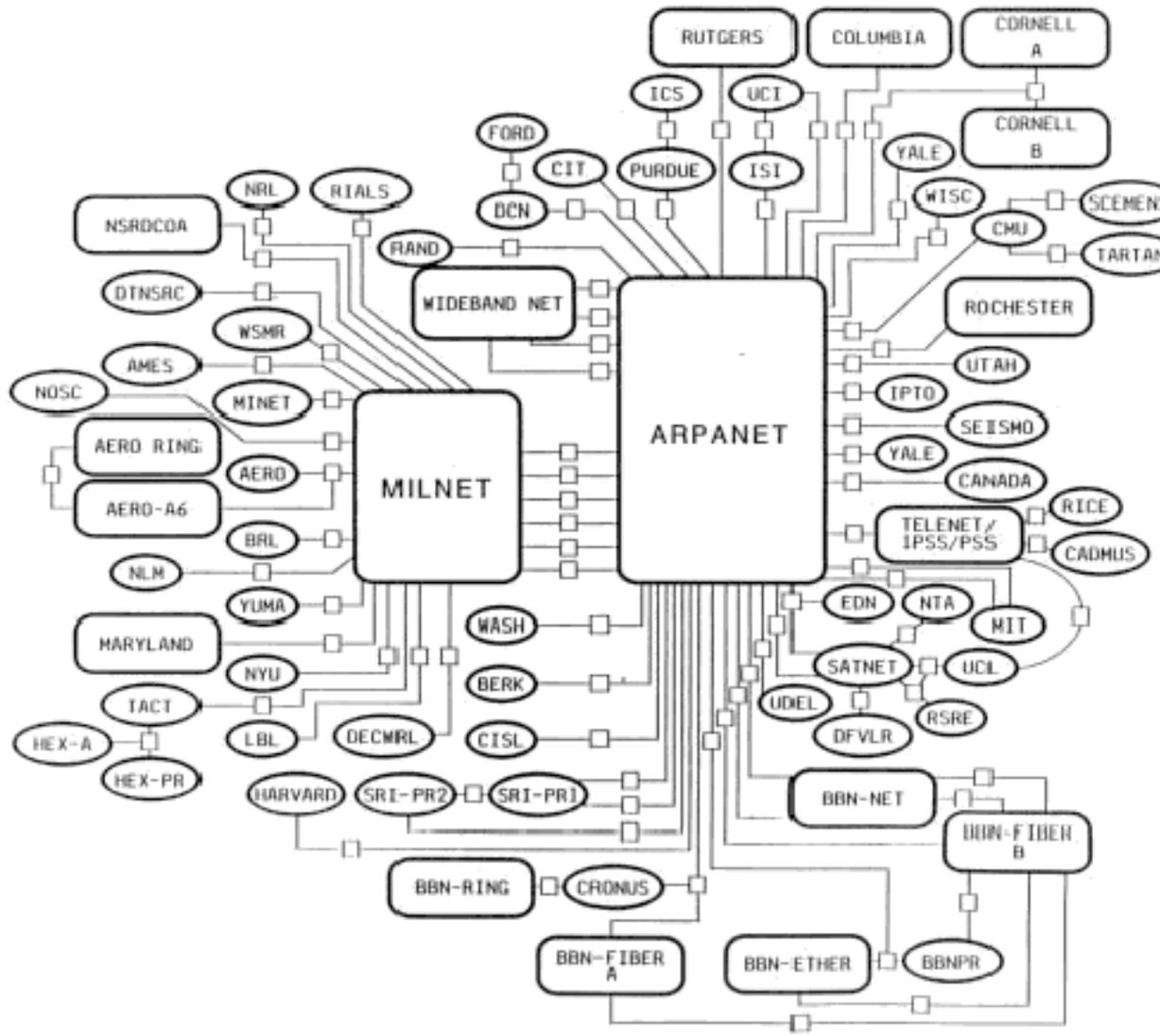
Mapping Local Internet Control

Hal Roberts, David LaRochelle, Rob Faris, John Palfrey
Berkman Center for Internet & Society at Harvard University

http://cyber.law.harvard.edu/netmaps

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YALE
WISC
SCEMENS
CMU
TARTAN
NRL
RIALS
NSRDCOA
BCN
RAND
WIDEBAND NET
ROCHESTER
DTNSRC
WSMR
AMES
UTAH
NOSC
MINET
IPTO
SEISMO
AERO RING
AERO
MILNET
ARPANET
YALE
CANADA
AERO-A6
RICE
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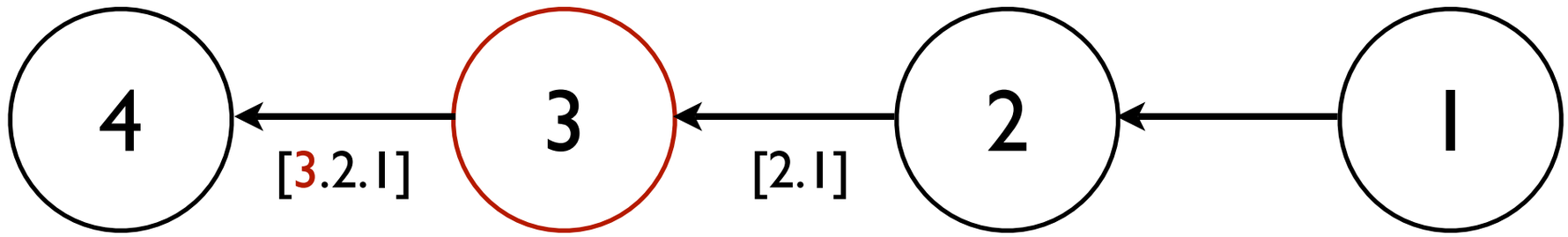
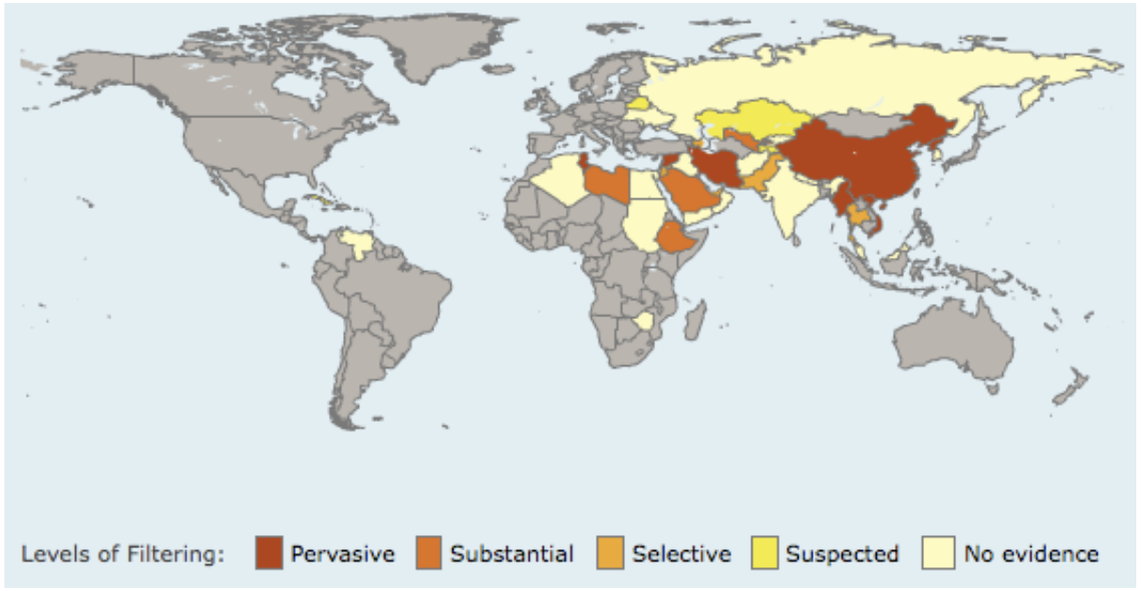
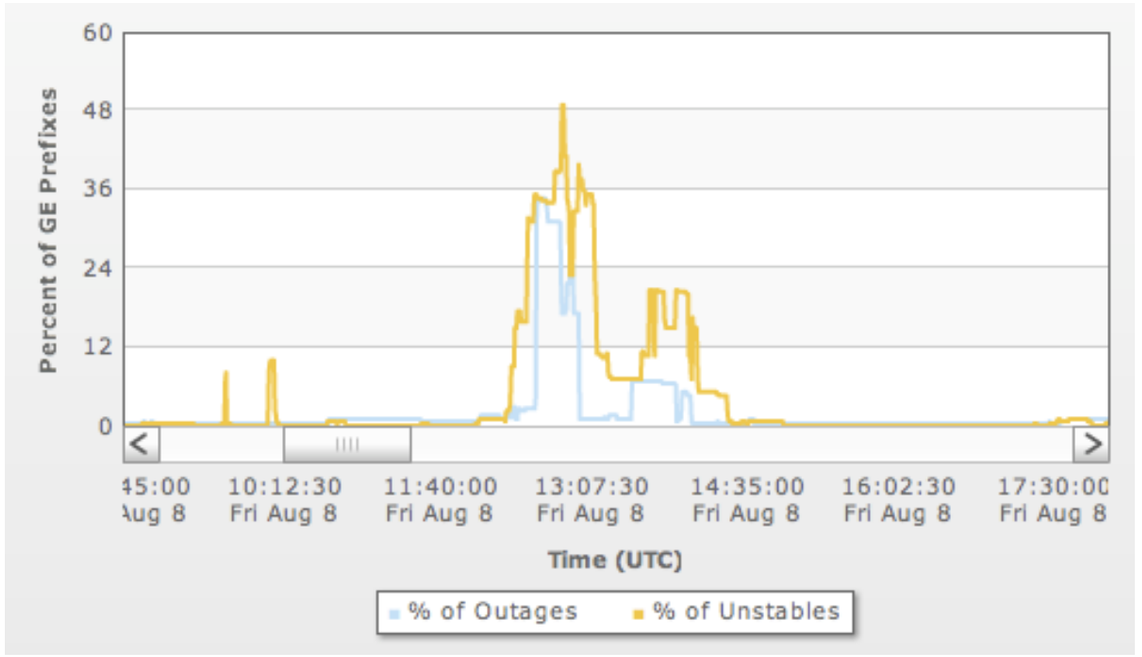
NLM
EDN
NTA
YUMA
MIT
WASH
MARYLAND
SATNET
UCL
NYU
BERK
UDEL
IACT
RSRE
DFVLR
HEX-A
LBL
DECWRL
CISL
HEX-PR
HARVARD
SRI-PR2
SRI-PR1
BBN-NET
BBN-FIBER B
BBN-RING
CRONUS
BBN-FIBER A
BBN-ETHER
BBNPR

BGP AS Paths:
Maps of Control





How can China block falundafa.org? 3.2.1



How can Russia block Georgia? 3.2.1

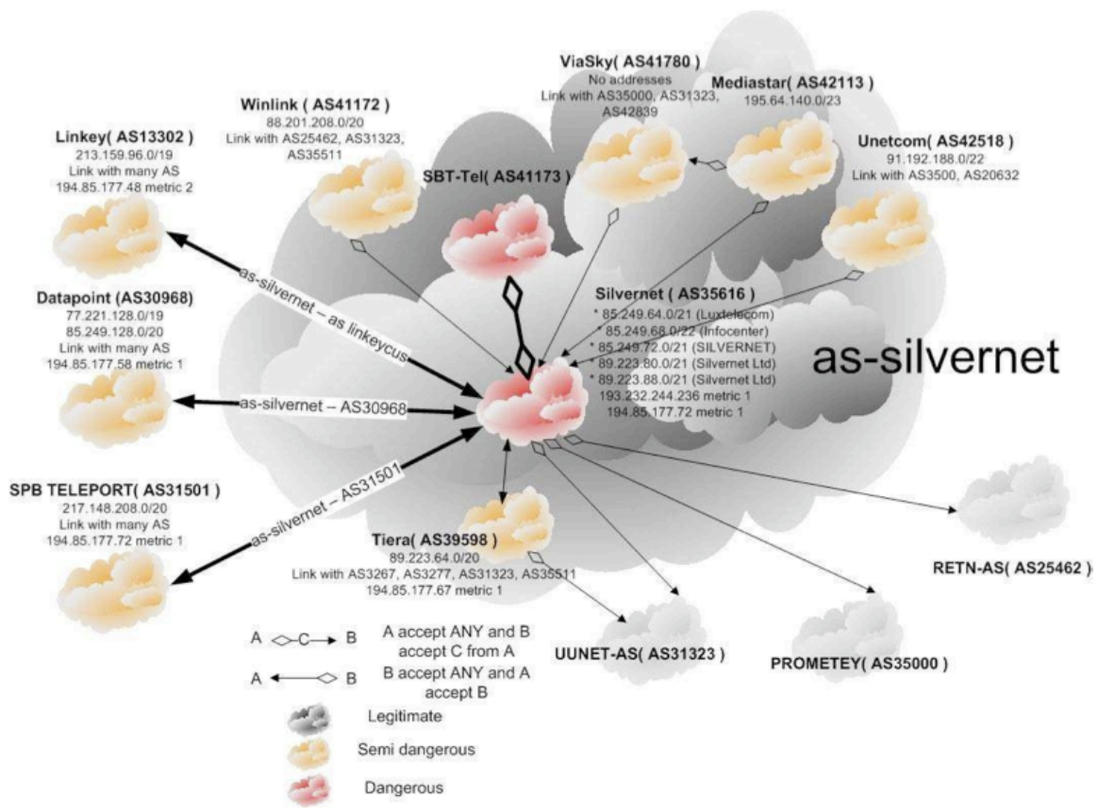
Study Group 3 LGX/Splitter Wiring, San Francisco
Issue 1, 12/10/02

Mathew F. Casamassima, (732) 420-2033, mcasamassima@att.com

Cabinet Naming:

Equipment	Name
Splitter Cabinet	SPC
LGX Cabinet	LXC
Meta Data Cabinet	MDC
Network Management Cabinet	NMC
Data Filter Cabinet	DFC
Juniper M40E Router Cabinet	JC
Sun V880 Cabinet	S8C
Sun 3800 Cabinet	S3C
Sun Storedge Cabinet	SSC
ADC Chassis For LGX	lxp
ADC Chassis For Splitter	spp
ADC Splitter Module	spl
ADC Bulkhead Module (LGX)	bk
Juniper M160	jp
Juniper M40e	j4
Narus STA 6400	nr
Sun Fire V880/Narus Logic Server	s8
Sun Fire 3800	s3
Sun StorEdge T3	st
Sun StorEdge FC switch	sf
Cisco Catalyst 2924M-XL	cz
BayTech DS9	b9
BayTech RPC22	bv
Brocade SilkWorm 2800 Switch	bz
Lucent LGX	LLGX

How can the NSA surveil the Internet? 3.2.1

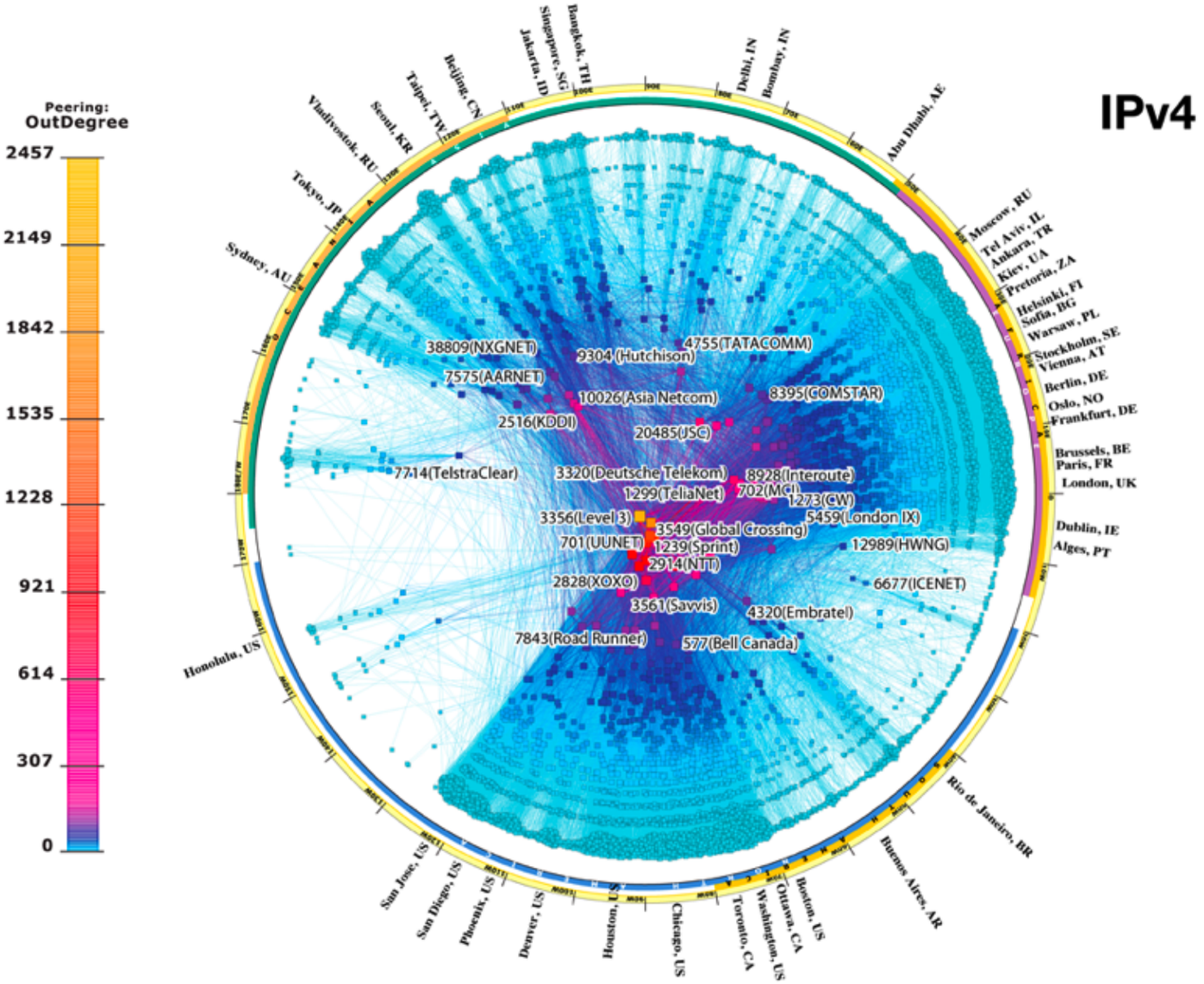


How can ISPs cut out malware ISPSs? 3.2.1

CAIDA

IPv4
INTERNET TOPOLOGY MAP
JANUARY 2009

AS-level INTERNET GRAPH



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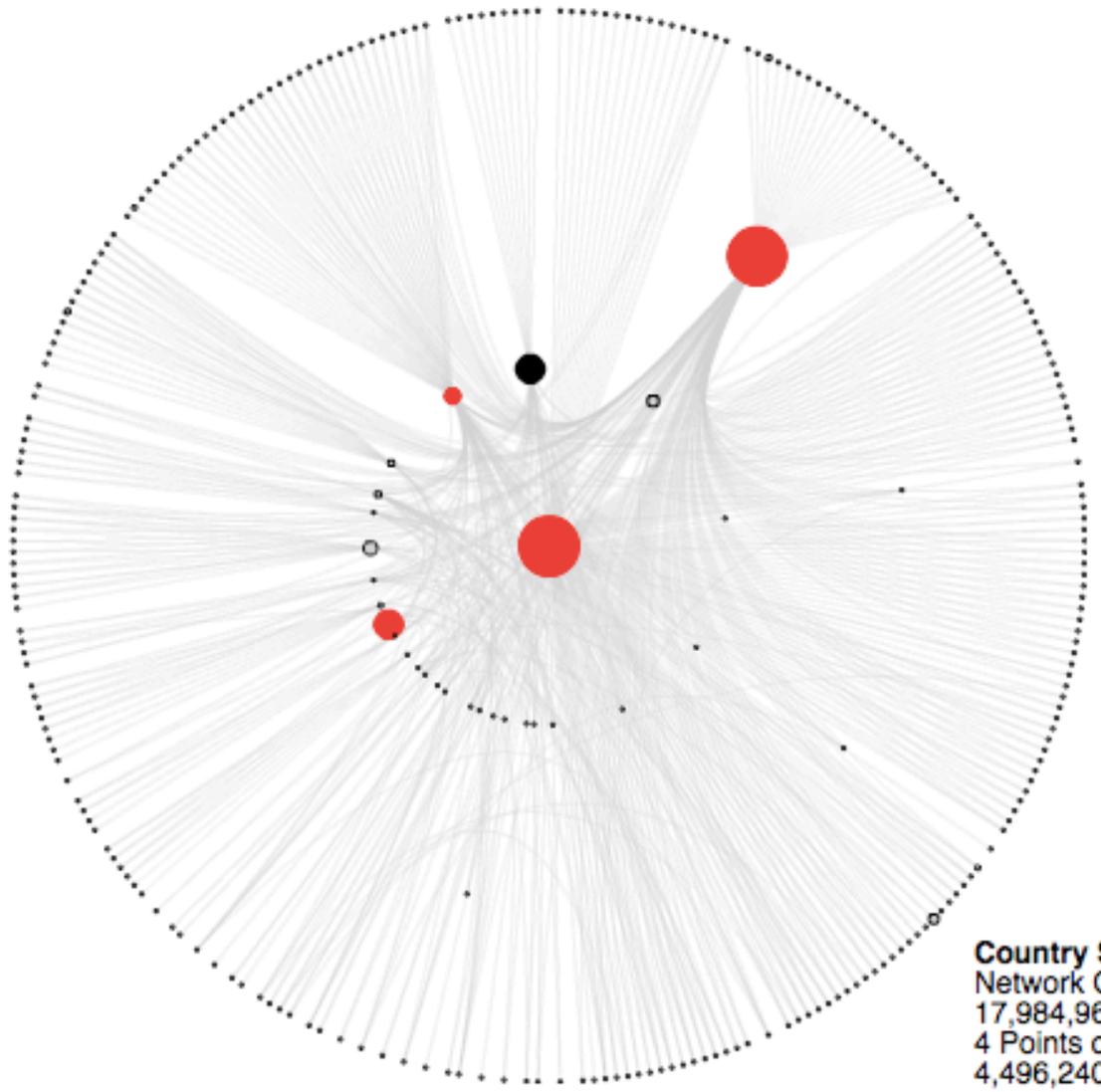
Mapping Method

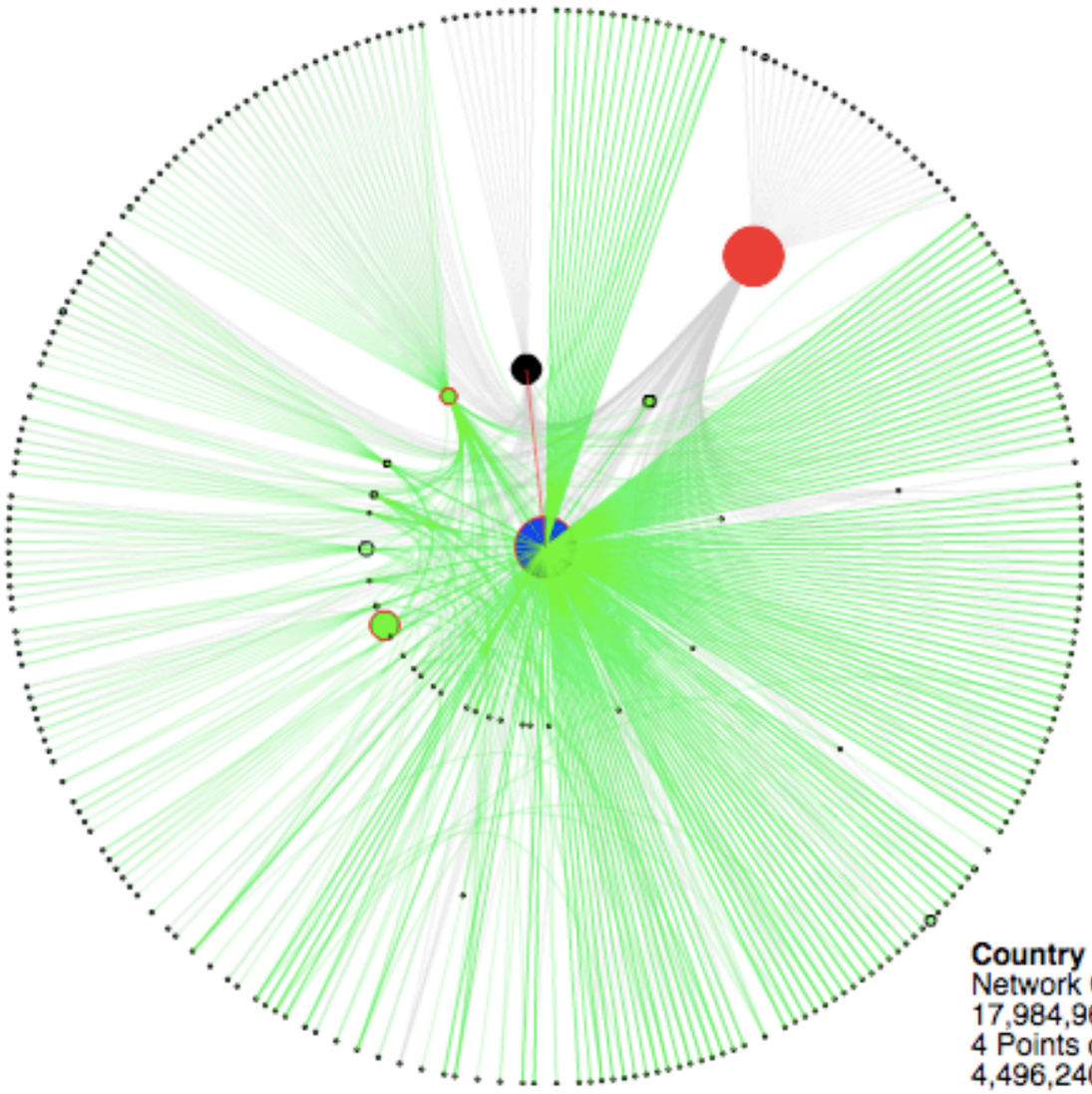
* get all ASs from AS Relationships
* look up country of each AS
* merge all foreign ASs into 'Rest of World' AS
* generate a network graph for each country's ASs

AUTONOMOUS SYSTEM DIAGRAM - India



Country Summary:
Network Complexity: 3.120
17,984,960 IP Addresses
4 Points of Control:
4,496,240 IPs per Point of Control

AUTONOMOUS SYSTEM DIAGRAM - India



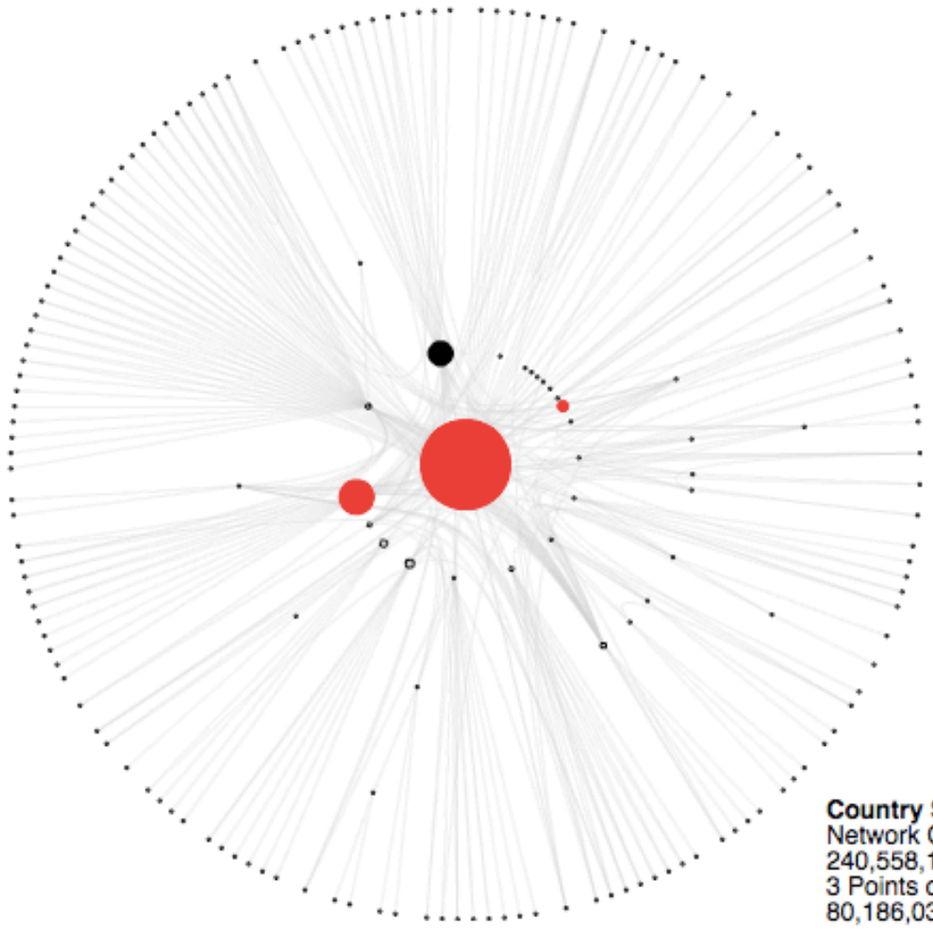
Country Summary:
Network Complexity: 3.120
17,984,960 IP Addresses
4 Points of Control:
4,496,240 IPs per Point of Control

Points of Control Method

* look up number of IPs for each AS
* traverse up tree of ASs for each country
* add the number of IPs of each AS to its providers.
* for multiple parents, divide by number of parents
  (caveats below!)

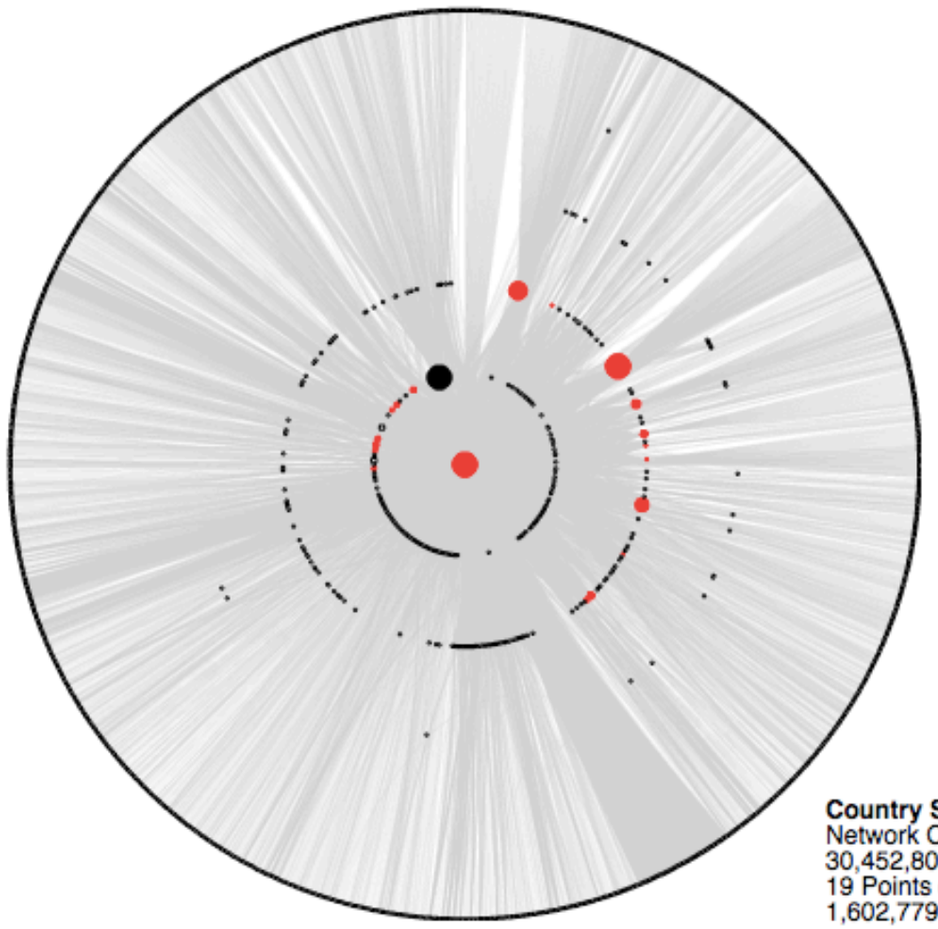
* add AS with most connected ips to points of control set
* add next AS with most connected ips excluding ASs
  in points of control set or their consumers
* continue until 90% of total ips of the country are included

AUTONOMOUS SYSTEM DIAGRAM - China



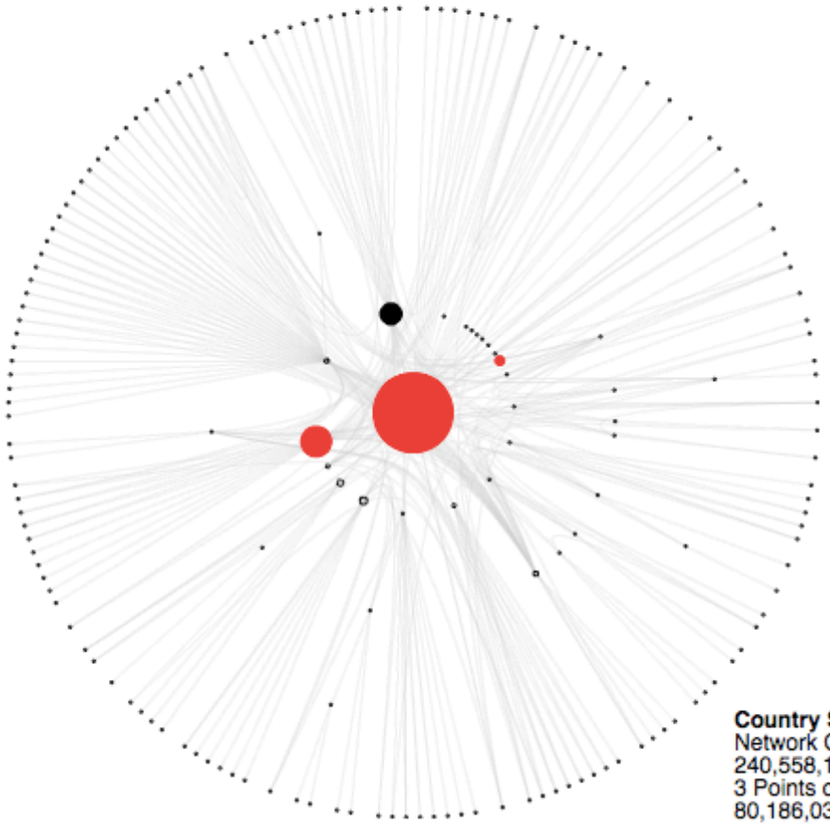
Country Summary:
Network Complexity: 0.113
240,558,105 IP Addresses
3 Points of Control:
80,186,035 IPs per Point of Control

AUTONOMOUS SYSTEM DIAGRAM - Russian Federation



Country Summary:
Network Complexity: 19.388
30,452,809 IP Addresses
19 Points of Control:
1,602,779 IPs per Point of Control

AUTONOMOUS SYSTEM DIAGRAM - China



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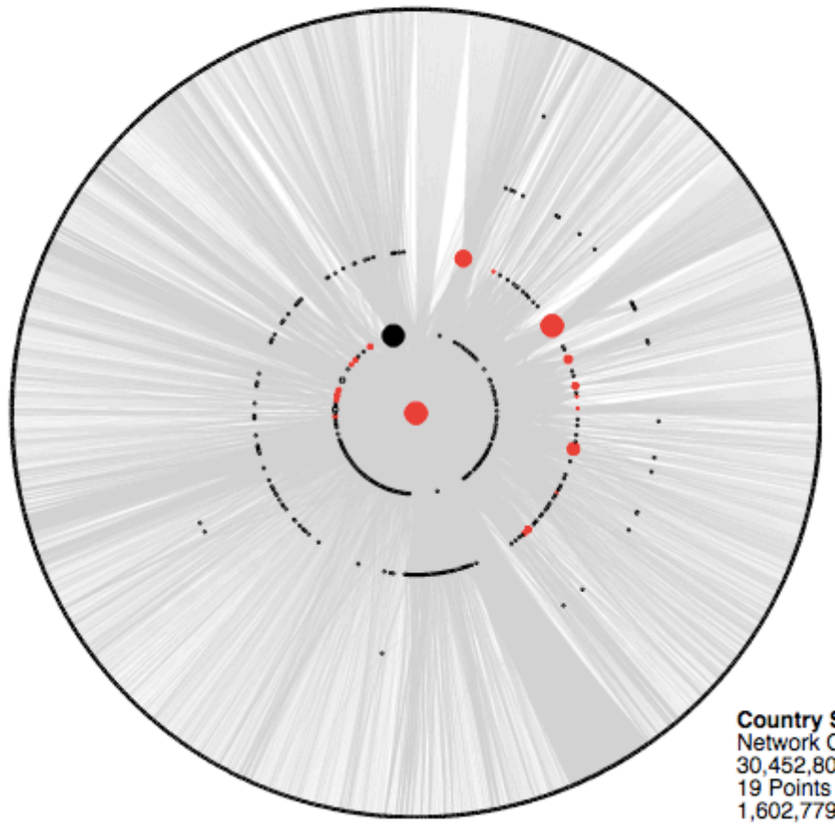
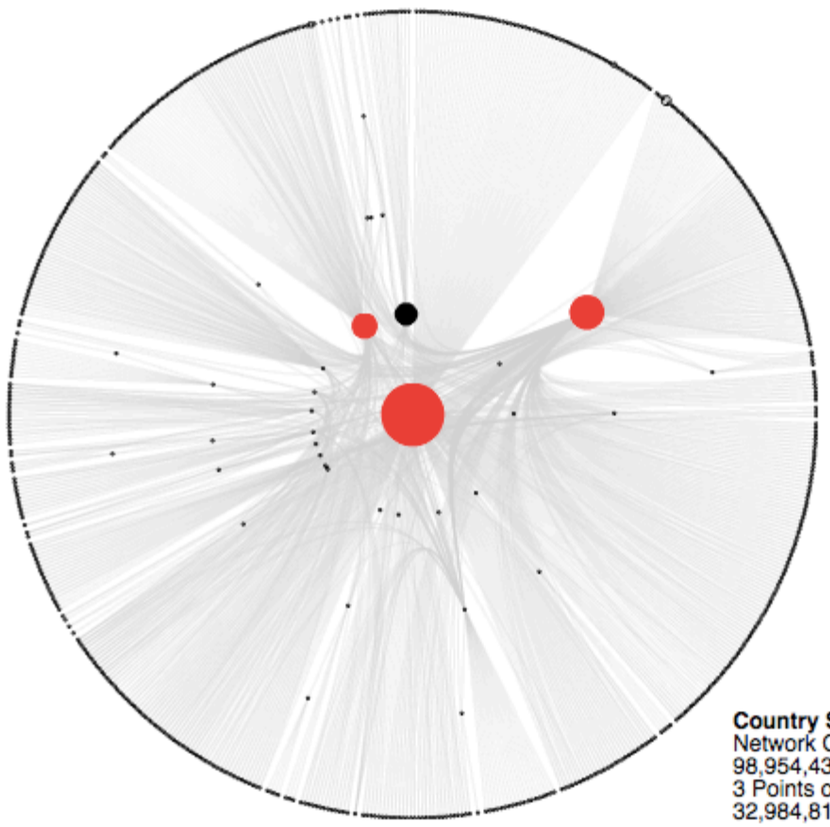


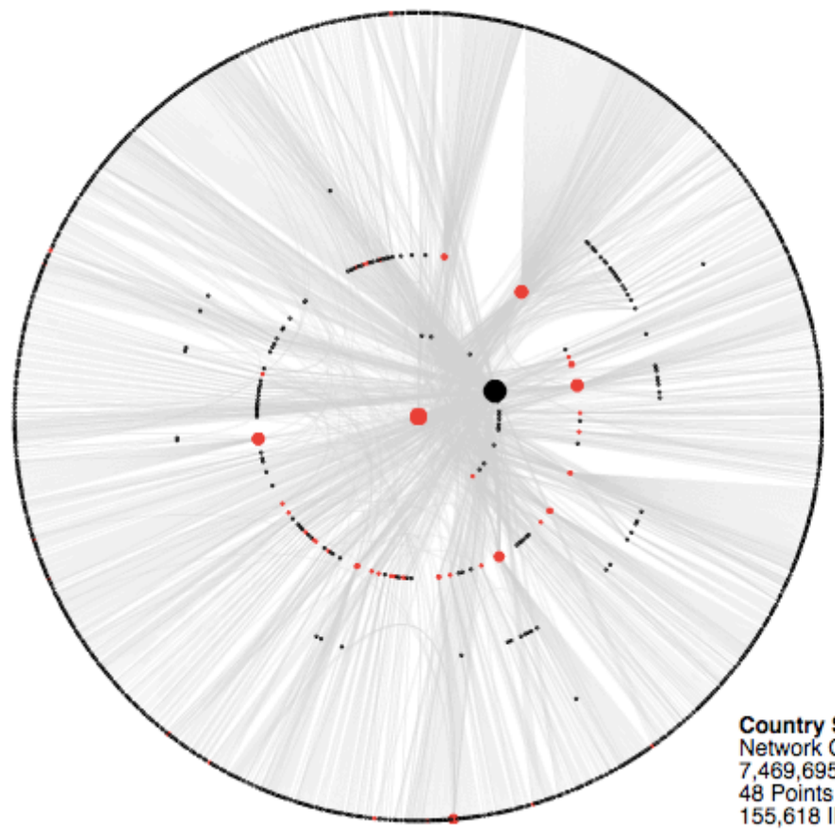
Country Summary:
Network Complexity: 19.388
30,452,809 IP Addresses
19 Points of Control:
1,602,779 IPs per Point of Control

AUTONOMOUS SYSTEM DIAGRAM - Korea, Republic of



Country Summary:
Network Complexity: 1.047
98,954,432 IP Addresses
3 Points of Control:
32,984,810 IPs per Point of Control

AUTONOMOUS SYSTEM DIAGRAM - Ukraine



Country Summary:
Network Complexity: 25.452
7,469,695 IP Addresses
48 Points of Control:
155,618 IPs per Point of Control

Rank	Country	Total IPs	Total Autonomous Systems	Points of Control	IPs Per Point of Control	Complexity
1 of 15	China	240,558,105	177	3	80,186,035	0.11
2 of 15	Korea, Republic of	98,954,432	637	3	32,984,810	1.05
3 of 15	Japan	161,064,743	495	8	20,133,092	0.55
4 of 15	Taiwan, Province of China	31,769,916	106	5	6,353,983	0.75
5 of 15	Turkey	11,632,896	226	2	5,816,448	2.72
6 of 15	Australia	38,026,901	642	7	5,432,414	3.20
7 of 15	Italy	36,268,672	454	7	5,181,238	2.08
8 of 15	France	31,974,177	434	7	4,567,739	2.09
9 of 15	India	17,984,960	291	4	4,496,240	3.12
10 of 15	Brazil	35,690,176	483	8	4,461,272	2.95
11 of 15	Mexico	17,515,592	158	4	4,378,898	1.12
12 of 15	United Kingdom	56,644,753	1177	13	4,357,288	4.34
13 of 15	Germany	80,719,913	932	19	4,248,416	1.68
14 of 15	Iran, Islamic Republic of	4,073,728	96	1	4,073,728	3.82
15 of 15	Canada	44,085,103	705	14	3,148,935	3.35

Complexity Method

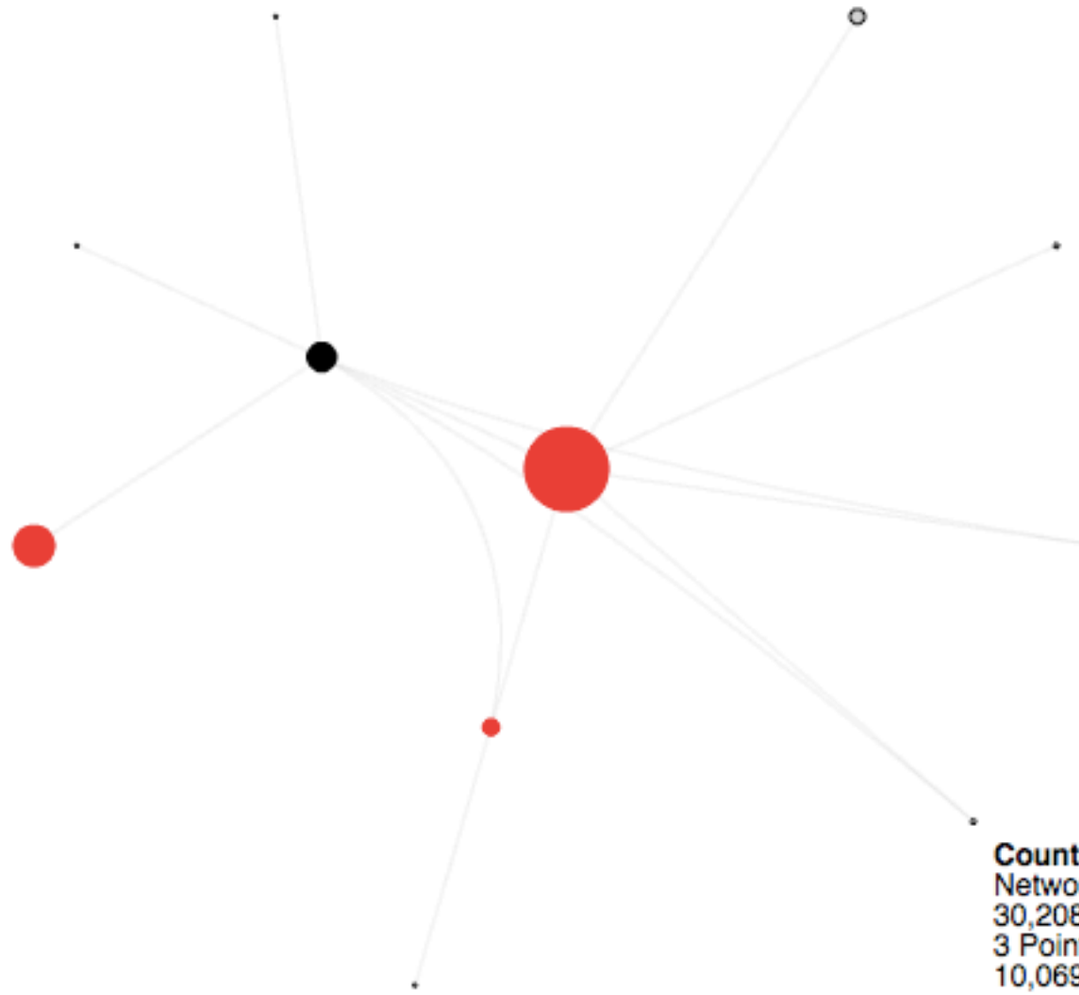
* C = AS * ∑(CI(a) / I)) / I
  * C = Complexity
  * AS = total number of ASs for country
  * ∑ = sum for each AS in country
  * CI(a) = connected IPs for AS
  * I = total IPs in country

* A network is more complex if it:
  * has more ASs per IP address,
  * has more connections per AS, and
  * has more of its IP addresses at edges of network

Rank	Country	Total IPs	Total Autonomous Systems	Points of Control	IPs Per Point of Control	Complexity
1 of 15	China	240,558,105	177	3	80,186,035	0.11
2 of 15	Libyan Arab Jamahiriya	294,912	1	1	294,912	0.34
3 of 15	Costa Rica	1,458,688	5	2	729,344	0.35
4 of 15	Morocco	1,085,952	4	2	542,976	0.37
5 of 15	Dominica	183,040	1	1	183,040	0.55
6 of 15	Japan	161,064,743	495	8	20,133,092	0.55
7 of 15	United Arab Emirates	2,521,344	8	2	1,260,672	0.57
8 of 15	Peru	2,206,464	13	3	735,488	0.61
9 of 15	Gabon	151,552	1	1	151,552	0.66
10 of 15	Viet Nam	9,435,904	56	4	2,358,976	0.75
11 of 15	Taiwan, Province of China	31,769,916	106	5	6,353,983	0.75
12 of 15	Algeria	1,448,960	11	2	724,480	0.77
13 of 15	Venezuela, Bolivarian Republic of	4,135,168	30	4	1,033,792	0.79
14 of 15	South Africa	13,807,378	75	6	2,301,229	0.83
15 of 15	Syrian Arab Republic	665,600	3	1	665,600	0.85

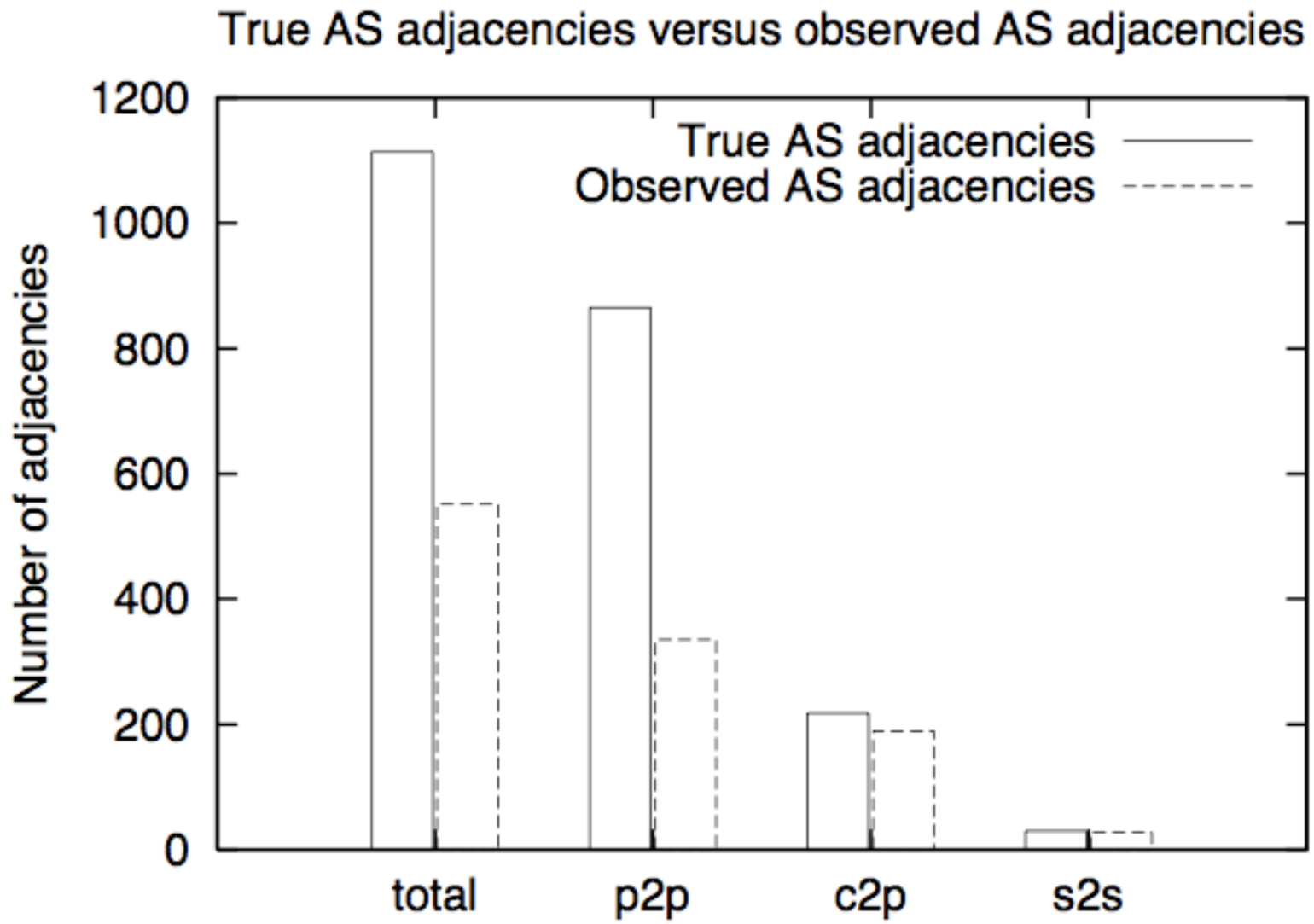
Rank	Country	Total IPs	Total Autonomous Systems	Points of Control	IPs Per Point of Control	Complexity
1 of 15	Angola	30,208	10	3	10,069	41.66
2 of 15	Isle of Man	43,904	13	5	8,780	31.77
3 of 15	Uganda	48,896	9	4	12,224	30.36
4 of 15	Mozambique	41,472	10	4	10,368	30.07
5 of 15	Mongolia	171,776	24	2	85,888	25.90
6 of 15	Ukraine	7,469,695	1122	48	155,618	25.45
7 of 15	Uzbekistan	166,144	24	6	27,690	23.14
8 of 15	Tanzania, United Republic of	125,440	19	6	20,906	22.15
9 of 15	Bulgaria	3,049,856	342	32	95,308	20.48
10 of 15	Russian Federation	30,452,809	2346	19	1,602,779	19.39
11 of 15	Latvia	1,369,728	145	6	228,288	19.20
12 of 15	Tajikistan	42,240	7	3	14,080	19.18
13 of 15	Barbados	26,624	5	3	8,874	18.96
14 of 15	Bangladesh	681,600	72	2	340,800	18.80
15 of 15	Cambodia	208,384	28	7	29,769	18.26

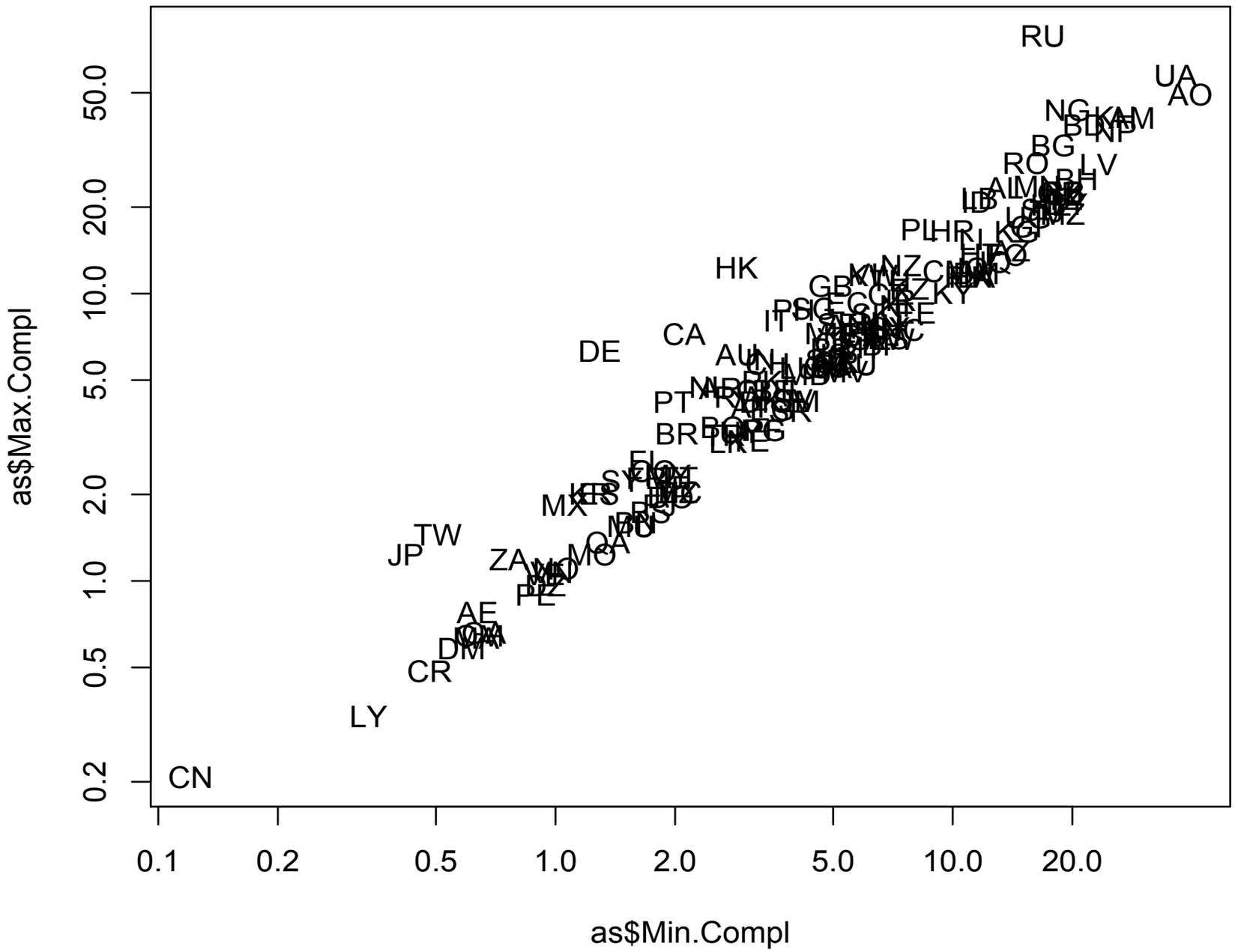
AUTONOMOUS SYSTEM DIAGRAM - Angola



Country Summary:
Network Complexity: 41.660
30,208 IP Addresses
3 Points of Control:
10,069 IPs per Point of Control

Quantum Internet Topology

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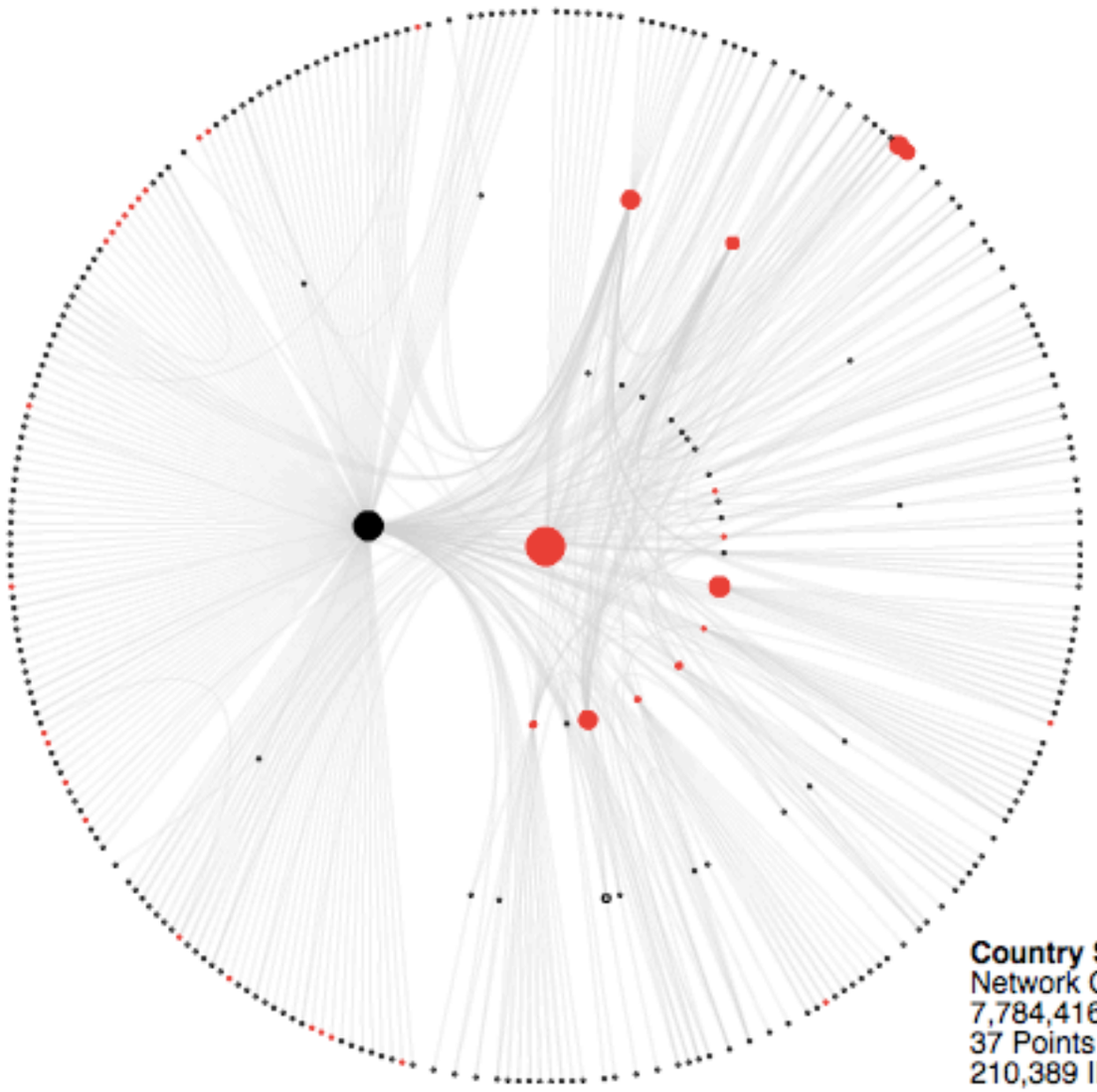
AUTONOMOUS SYSTEM DIAGRAM - Sweden



Country Summary:
Network Complexity: 6.619
7,784,416 IP Addresses
37 Points of Control:
210,389 IPs per Point of Control

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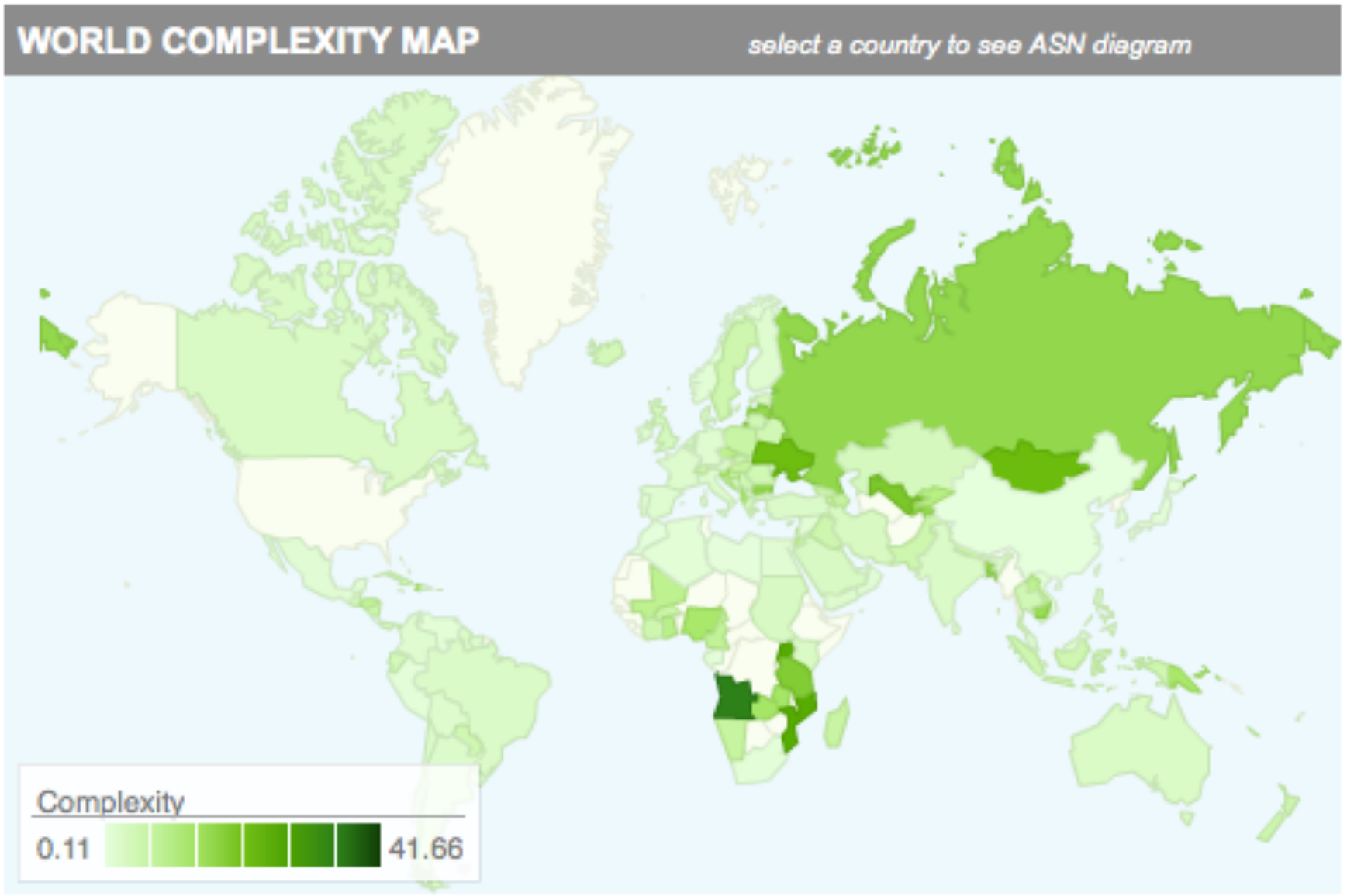
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