IPv4 INTERNET
TOPOLOGY MAP
AS INTERNET GRAPH

Peering: OutDegree

| 2135 |
| 1868 |
| 1601 |
| 1334 |
| 1067 |
| 800 |
| 533 |
| 266 |
| 0 |

Labels within the graph (selected ASes):

7473(Singapore Tel.)
9304 (Hutchison)   4637(Reach)
4766 (Korea Tel)
703 (UUNET)   3786 (DACOM)   20485(USC)
2516(KDDI)   10026(Asia Netcom)   15412(Flag)
7714(TelstraClear)
3320(Deutsche Telekom)   8928(Interoute)
1299(TeliaNet)   702(MCI)
786(JANET)   127/3(CW)
5459(London IX)
3356(Level 3)
701 (UUNET)   174 (Cogent)   3257(Tiscali)
7018(AT&T)   1239(Sprint)
3549(Global Crossing)   5511(France Tel)
209(Qwest)
2914(NTT)   6453(Teleglobe)
6461(Abovenet)
7132(SBC)   3491 (Beyond)
4323(Time Warner)
2828 (XO)   3561(Savvis)

INTERNET TOPOLOGY MAPPING ANALYSIS

This visualization represents a macroscopic snapshot of the Internet for two weeks: 2 July 2007 - 9 July 2007. The graph reflects 201 IP addresses and 2,000,796 IP links (immediately adjacent addresses in a traceroute-like path) of topology data gathered from 16 monitors probing approximately one million destinations spread across 62,159 (26.7% of the total) globally routable network prefixes.

We aggregate this view of the network into a topology of Autonomous Systems (ASes) each of which approximately maps to an Internet Service Provider (ISP). We map each IP address to the AS responsible for routing it, i.e., the origin (end-of-path) AS for the best match IP prefix of this address in Border Gateway Protocol (BGP) routing tables. We use the largest publicly available set of core BGP routing tables collected by the University of Oregon's RouteViews project. The abstracted graph consists of 12,979 Autonomous System (AS) nodes and 35,589 peering sessions. Using the prefixes from the BGP table and Digital Envoy™'s Netacuity™, we mapped each AS to the geographic center of its announced address space. For 7 ASes, we could not determine a geographical location. The resulting graph contains 12,423 ASes and 38,429 peering sessions.

The position of each AS node is plotted in polar coordinates, pos(radius, angle) (pos(r,q)), where:

$$\text{radius} = 1 - \log\left(\frac{\text{outdegree(AS)} + 1}{\text{maximum.outdegree} + 1}\right)$$

$$\theta = \left(\begin{array}{c}\text{longitude of the AS headquarters}\\\text{in whois records}\end{array}\right)$$

The outdegree of an AS node is the number of "next hop" ASes that were observed accepting traffic from this AS. The link color reflects outdegree, from lowest (blue) to highest (yellow). Some ISPs toward the center have been manually labeled.

Graphing dimensions of peering richness and geographic information reveals the highly "core-centric" nature of certain ASes based in North America. While ISPs in Europe and Asia have many peering relationships with ISPs in the U.S. there are fewer links directly between ISPs in Asia and Europe. Both technical (cabling and router placement and management) as well as policy (e.g. business cost models and geopolitical considerations) factors contribute to peering arrangements represented in this graph.

Between 2006 and 2007, the AS with the largest number of links, Level 3, appears to have risen to 40% more links than its closest rival, UUnet. During the same period, we see a trend of increased connectivity between the European and Asian ASes.

note:
Nodes can be placed on the outer rim even though they have many links, because their outdegree is zero.
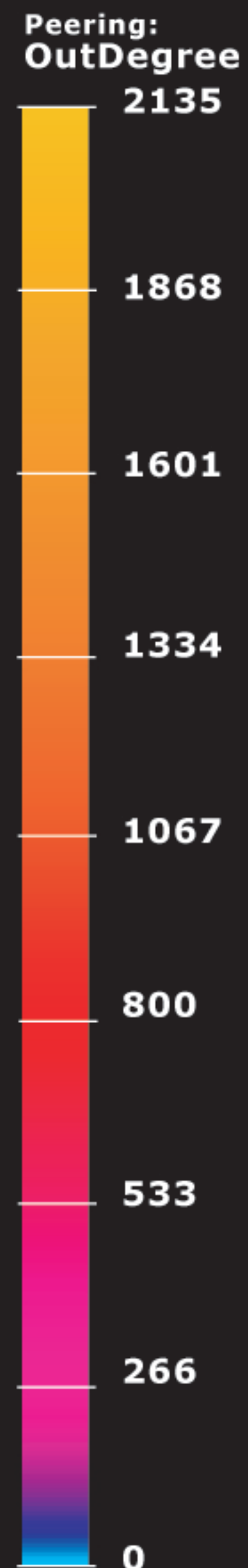
TOPOLOGY MAPPING ANALYSIS TEAM

Bradley Huffaker
Andre Broido
Marina Fomenkov
Young Hyun
Dan Andersen
Ken Keys
David Moore
kc claffy

SKITTER DEVELOPERS

Ryan Koga
Anukool Lakhina
Daniel McRobb

TOPOLOGY ANALYSIS MONITOR HOSTS

APAN	Univ. of Oregon - ANTC
CANET	Univ. of Waikato
MFN	Univ. of Illinois, UC
RSSAC	Vrije Univ., Amsterdam
WIDE	

ARTWORK DESIGN

Oliver Jakubiec
Lisa Hecht