

# Network Traffic Evolution

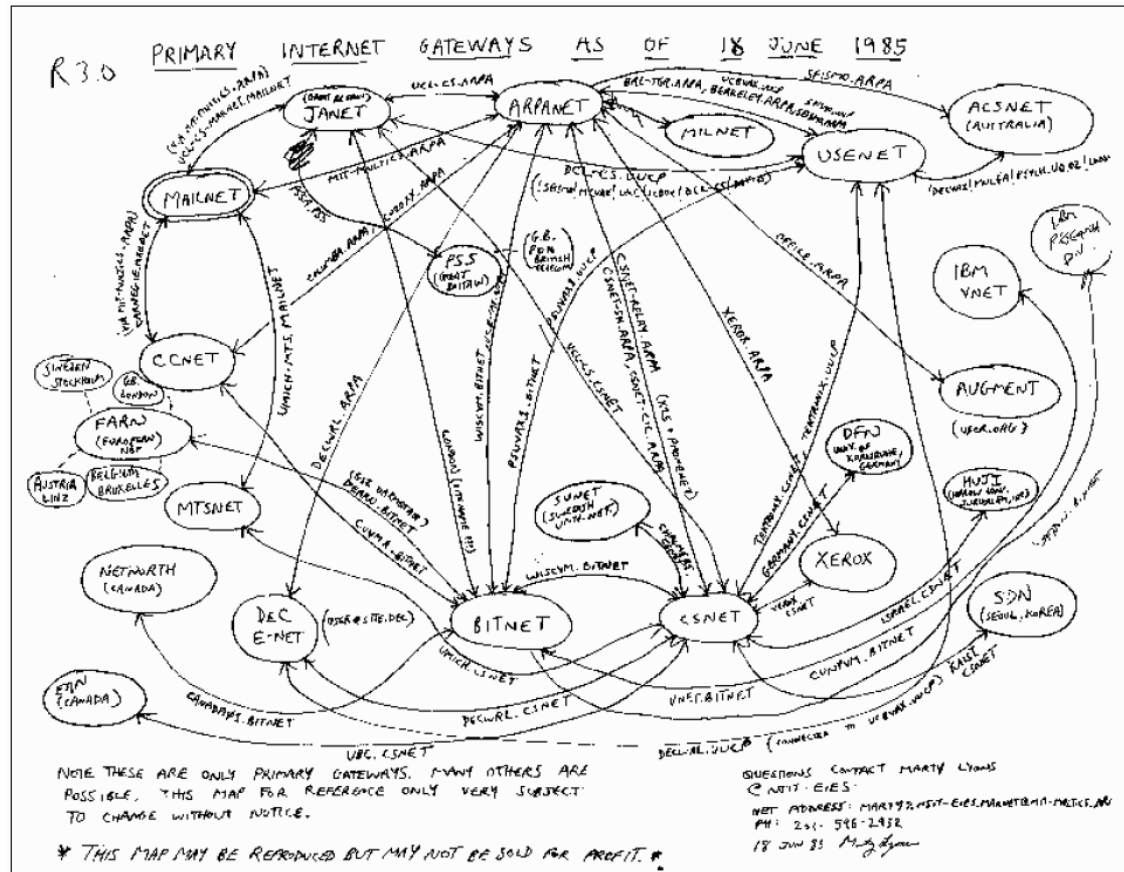
Prof. Anja Feldmann, Ph.D.

# The Internet

- *As with any new facility, there will be a period of very light usage until the community of users experiments with the network and begins to depend upon it. One of our goals must be to stimulate the immediate and easy use by a wide class of users.*
- Steve Crocker; Host Software; [RFC 1](#); 7 April 1969.

# The Internet in the early days

- Applications such as telnet, FTP, Usenet newsgroups, IRC, MUDs and mailing lists to empower a community to share information
- Marshall McLuhan foresees the global village



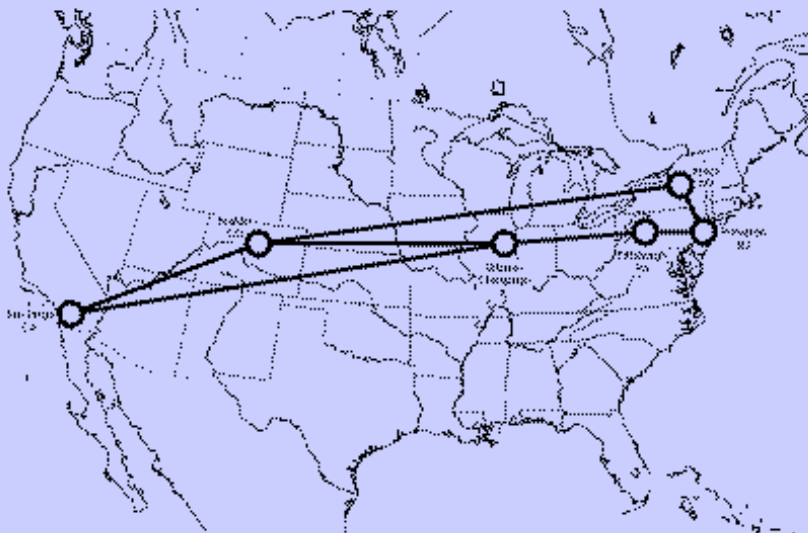
# Internet history: ARPANET

- ❑ 10:30 PM on October 29'th, 1969 the first packets between 2 ARPANET nodes
- ❑ Mar. 1970, first ARPANET node on the US east coast.
- ❑ Sep. 1971 remote access via Terminal Interface Processor (TIP)
- ❑ Dec. 1972. 24 sites on the ARPANET
- ❑ Dec. 1973. 37 sites on the ARPANET, including satellite link from California to Hawaii.
- ❑ 1973, University College of London, England and Royal Radar Establishment, Norway connected to the ARPANET.
- ❑ Jun. 1974 62 computers connected to the ARPANET.
- ❑ Mar. 1977 111 computers on the ARPANET.
- ❑ 1983 an unclassified military only network, MILNET, split off from the ARPANET.
- ❑ 1985. ARPANET gateways to external networks across North America, Europe, and in Australia, and the Internet was global in scope.
- ❑ 1990. The ARPANET was retired in 1990. NSFNET took over for most universities.

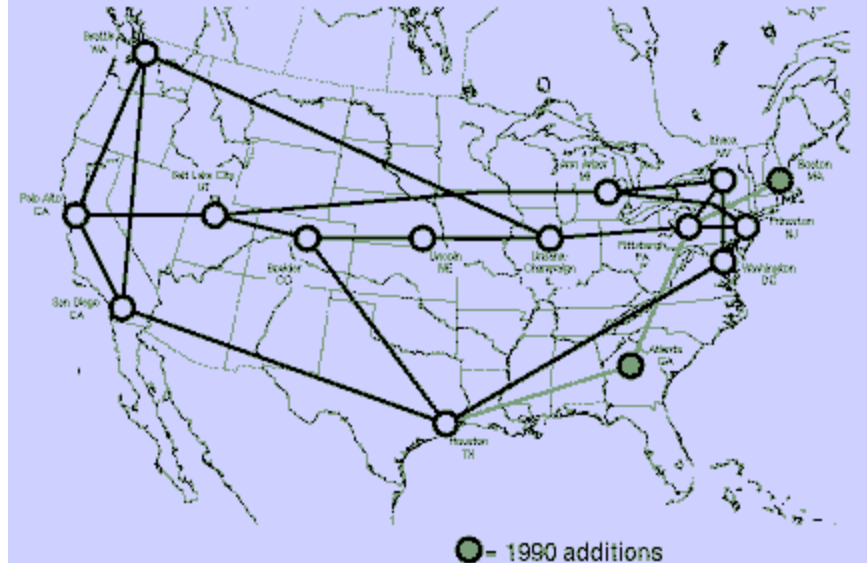
# Internet history: NSFNET 1987-1995

- ❑ As part of the NSFNET contract, Krol authored the [Hitchhiker's Guide to the Internet](#) to provide a help manual for NSFNET users, providing one of the first comprehensive surveys of the Internet.

NSFNET Backbone network  
Fuzzball nodes, 56 kbps  
July 1986 - July 1988



NSFNET Backbone network  
IBM NSS nodes, 1.544 kbps (T1) topology  
July 1989 - November 1992

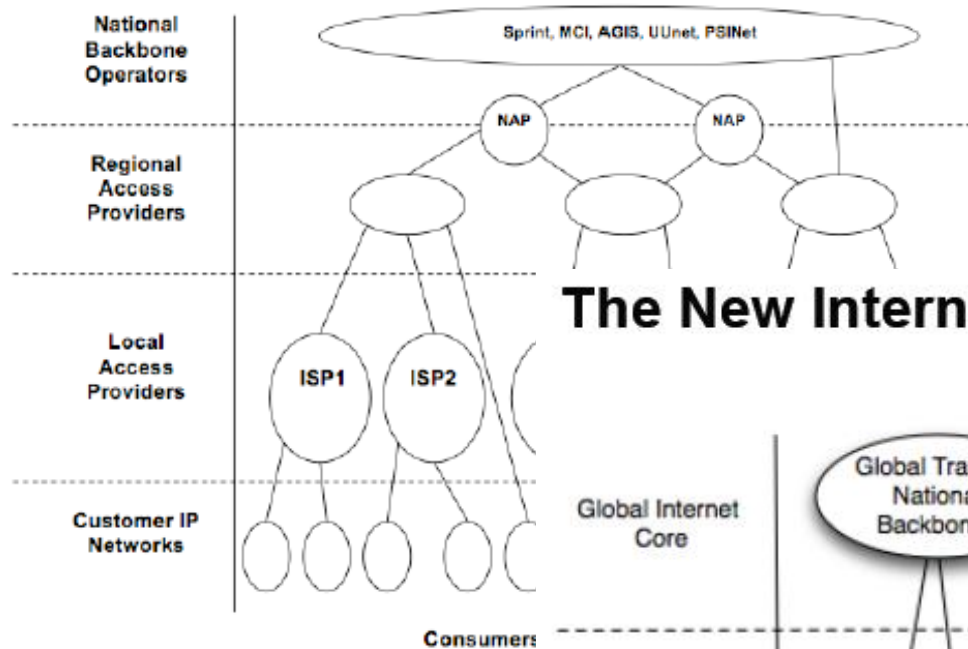


# Internet history: NSFNET stats

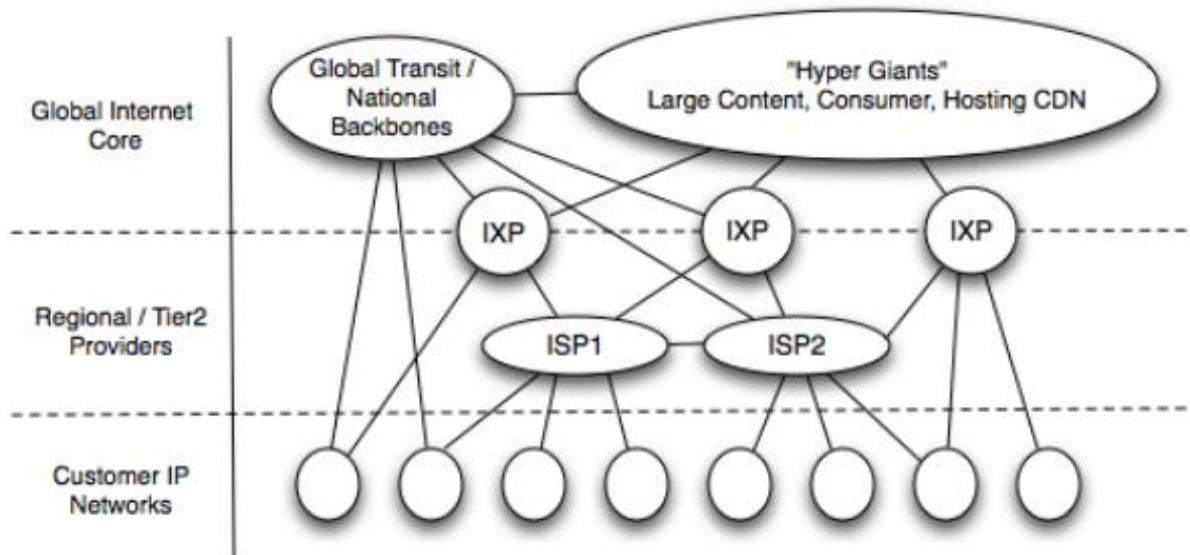
- ❑ By January, 1992, the NSFNET traffic exceeded 12 billion packets (1 trillion bytes) of traffic a month. By November the traffic had doubled, and NSFNET was connected to more than 7,500 networks, one third of which were outside the United States.
- ❑ In December, 1992, the NSFNET backbone was completely converted to a T3 or 44.736 Mbps capacity, capable of transmitting 4 and a half million characters a second.
- ❑ In 1994, the traffic on NSFNET broke the 10 trillion bytes a month level.

# Today's Internet

## Textbook Internet (1995 – 2007)



## The New Internet



# Questions to be answered

- ❑ What creates the structure of the Internet
- ❑ How does an ISP topology look like?
- ❑ How is reachability guaranteed?
- ❑ Which route does my traffic take?
  - Is it the “best” route?
  - Which of multiple servers should one choose?
  - How does traffic flow?
  - What is the traffic matrix
  - Who is providing the content?
    - Are CDNs dominating?
    - Is Google dominating?



# Network Dynamics: User population

## □ Number of Internet hosts

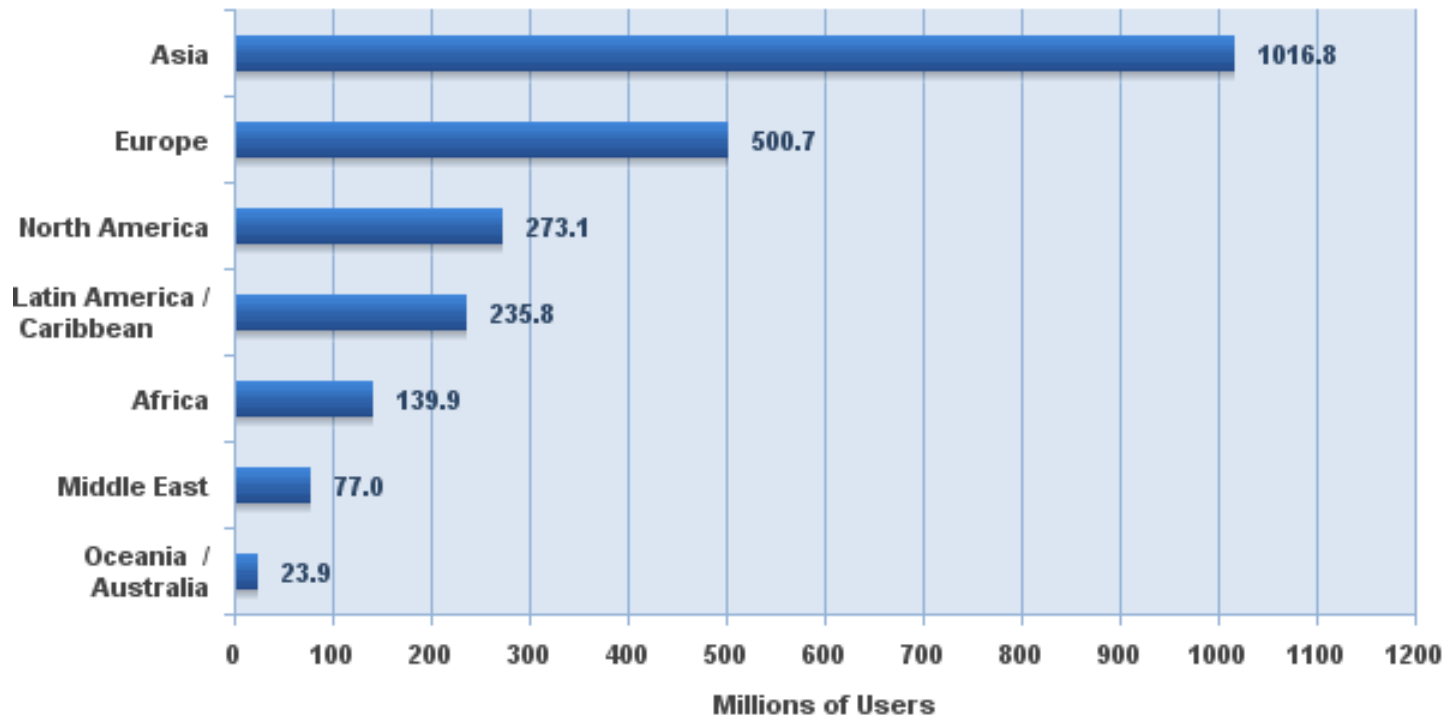
- Early 1989: 80,000
- Early 1992: 727,000
- Oct. 1993: 2,056,000
- Late 1996: 10,000,000
- ....

## □ Internet traffic volume (Merit; Inc.)

- March 1991:  $1.3 \times 10^{12}$  bytes/month
- March 1994;  $1.1 \times 10^{13}$  bytes/month
- ...

# Internet users

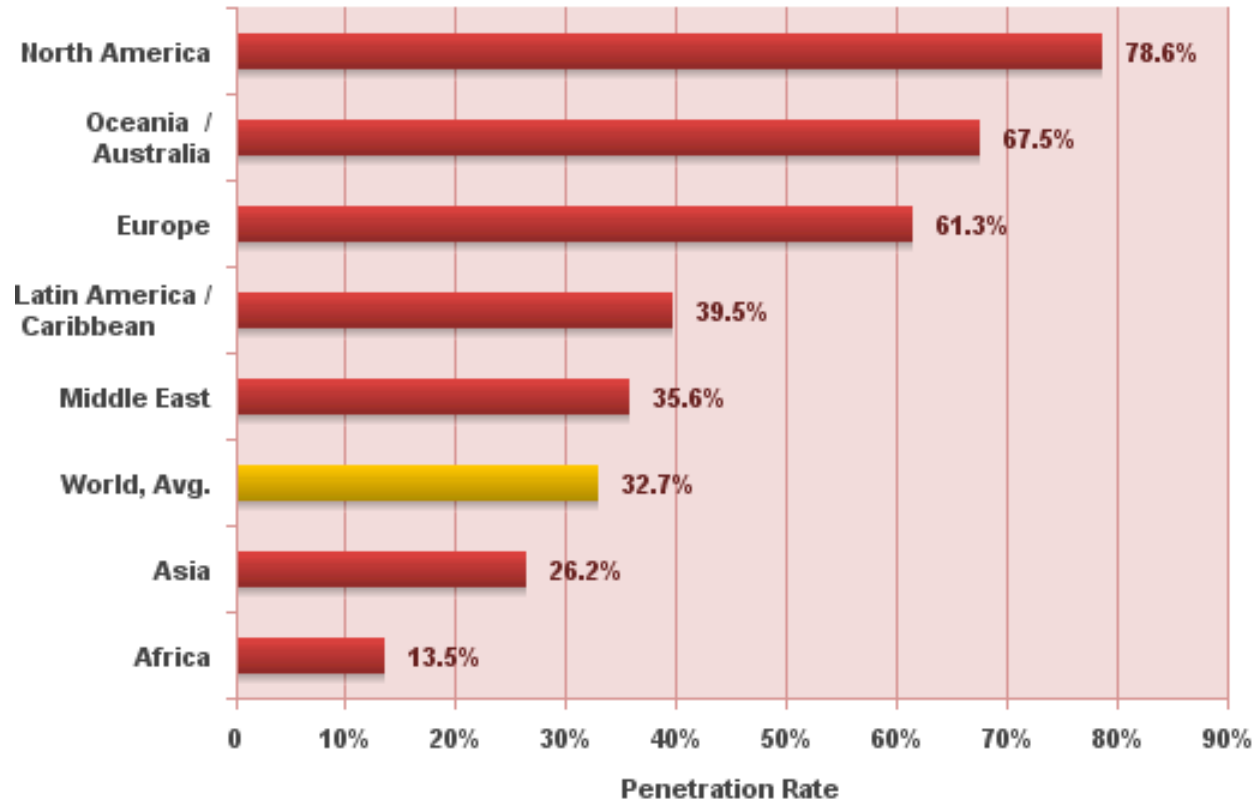
## Internet Users in the World by Geographic Regions - 2011



Source: Internet World Stats - [www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)  
Estimated Internet users are 2,267,233,742 on December 31, 2011  
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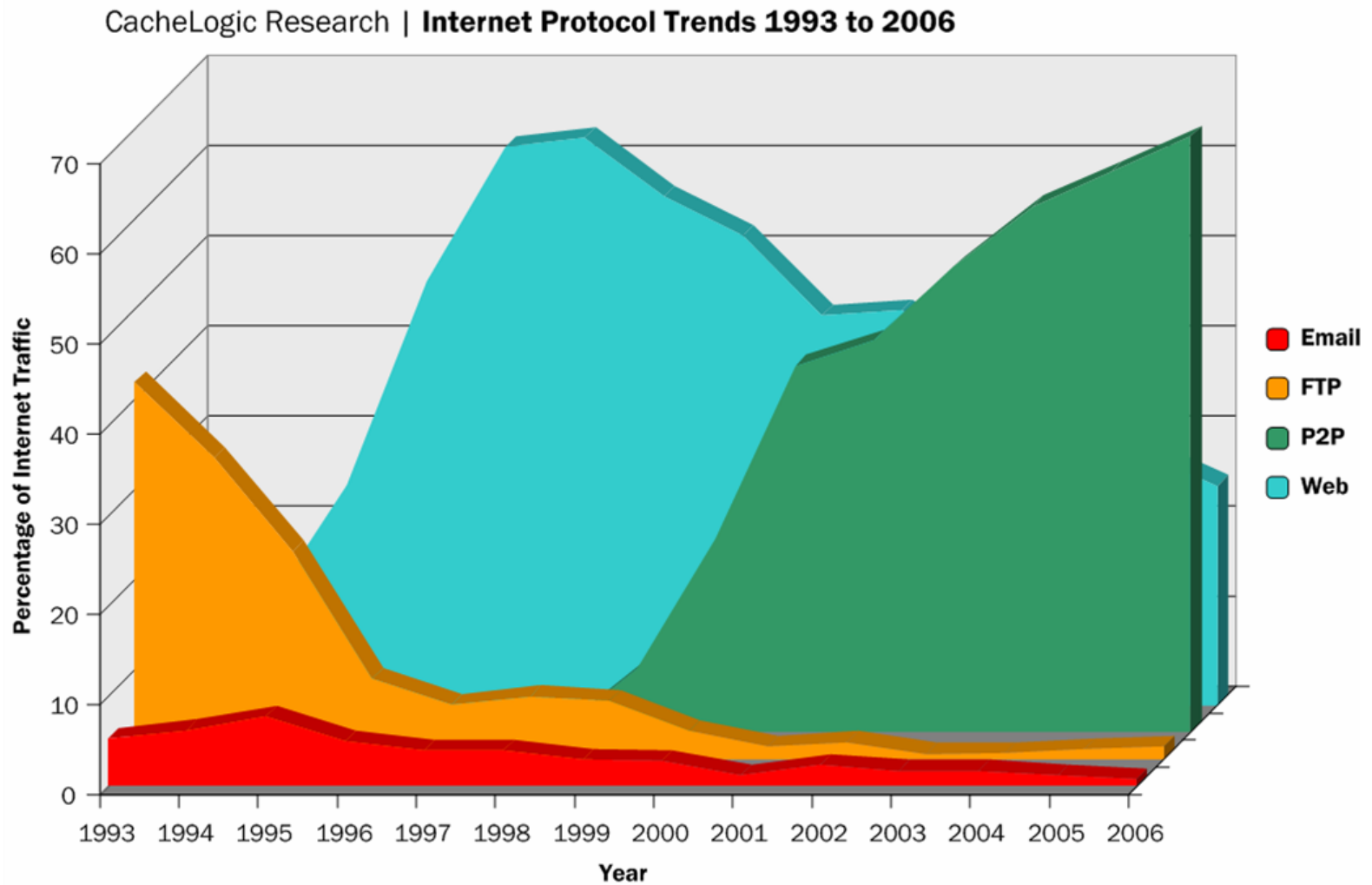
# Internet penetration rates

## World Internet Penetration Rates by Geographic Regions - 2011



Source: Internet World Stats - [www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)  
Penetration Rates are based on a world population of 6,930,055,154 and 2,267,233,742 estimated Internet users on December 31, 2011.  
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# Application mix?



# Netdynamics – „Killer application“

## □ WWW and the Internet

- 1993: ... Hardly any WWW traffic on the Internet
- 1994: ... About 10% of total Internet traffic is WWW
- 95/96: ... Up to 60-70% of overall Internet traffic is WWW
- ....??????...

# Incoming AT&T traffic by port

(18 hours of traffic to AT&T dial clients on July 22, 1997)

Name	port	% bytes	% packets	bytes per packet
world-wide-web	80	56.75	44.79	819
netnews	119	24.65	12.90	1235
pop-3 mail	110	1.88	3.17	384
cuseeme	7648	0.95	1.85	333
secure web	443	0.74	0.79	603
internet chat	6667	0.27	0.74	239
file transfer	20	0.65	0.64	659
domain name	53	0.19	0.58	210
. . .				

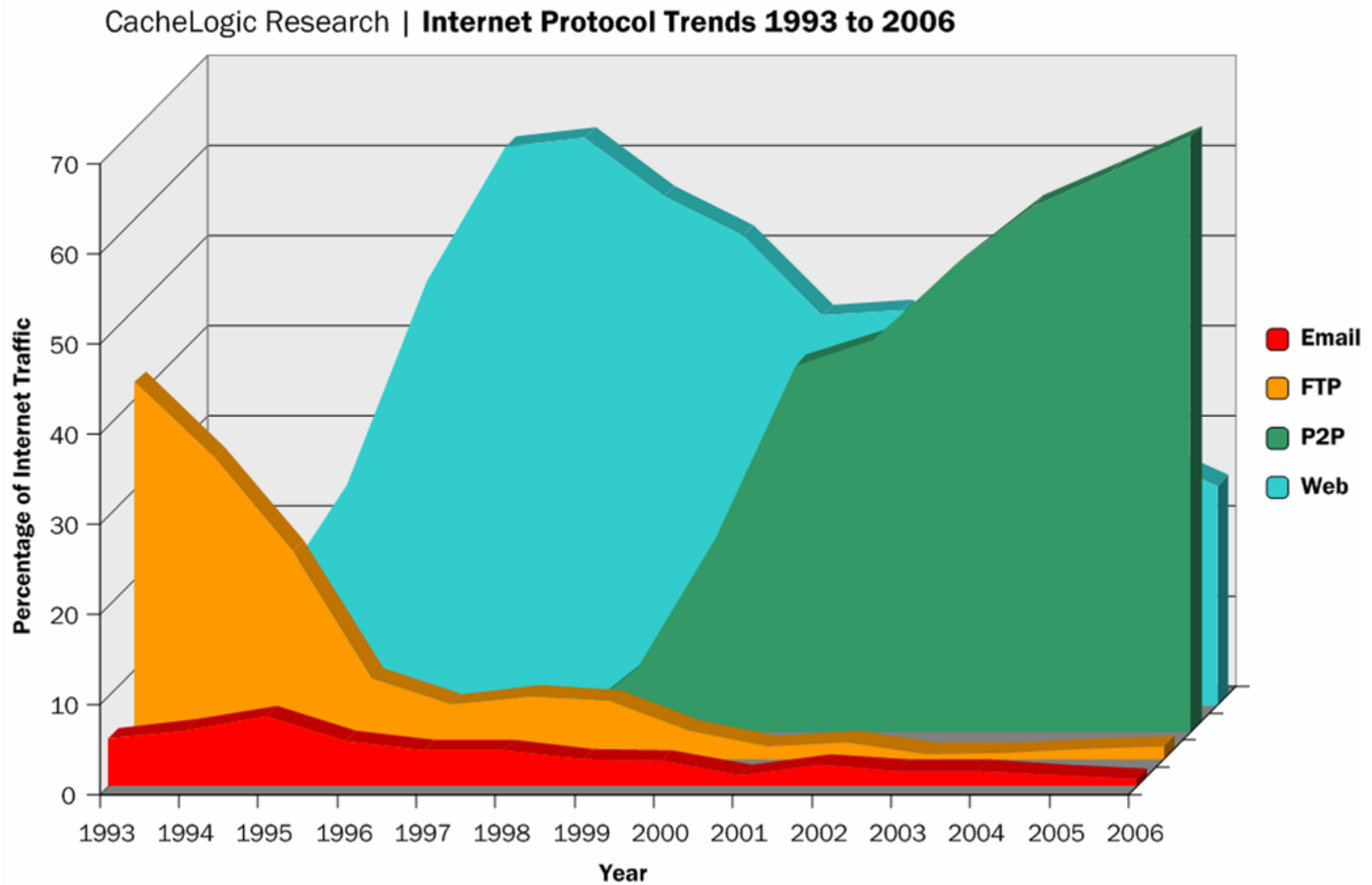
World Wide Web traffic dominates traffic mix

# MWN traffic by port

(24 hours of traffic to/from MWN clients in 2006)

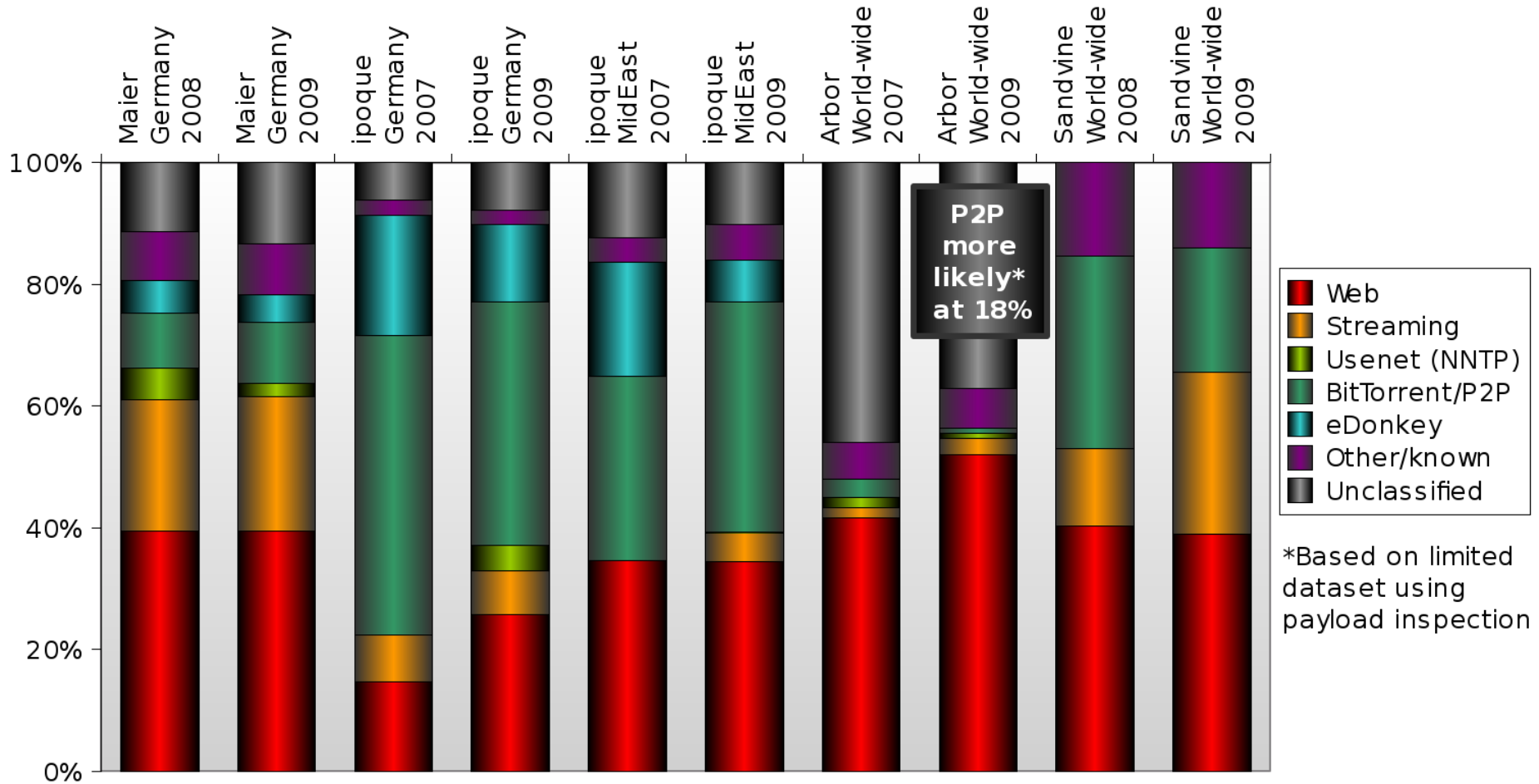
Port		% Conns	% Success	% Payload
Web	<b>80</b>	<b>70.82%</b>	<b>68.13%</b>	<b>72.59%</b>
	445	3.53%	0.01%	0.00%
Web	443	2.34%	2.08%	1.29%
SSH	22	2.12%	1.75%	1.71%
Mail	25	1.85%	1.05%	1.71%
	1042	1.66%	0.00%	0.00%
	1433	1.06%	0.00%	0.00%
	135	1.04%	0.00%	0.00%
< 1024		83.68%	73.73%	79.05%
<b>&gt; 1024</b>		<b>16.32%</b>	<b>4.08%</b>	<b>20.95%</b>

# Application mix?





# Application mix – today?

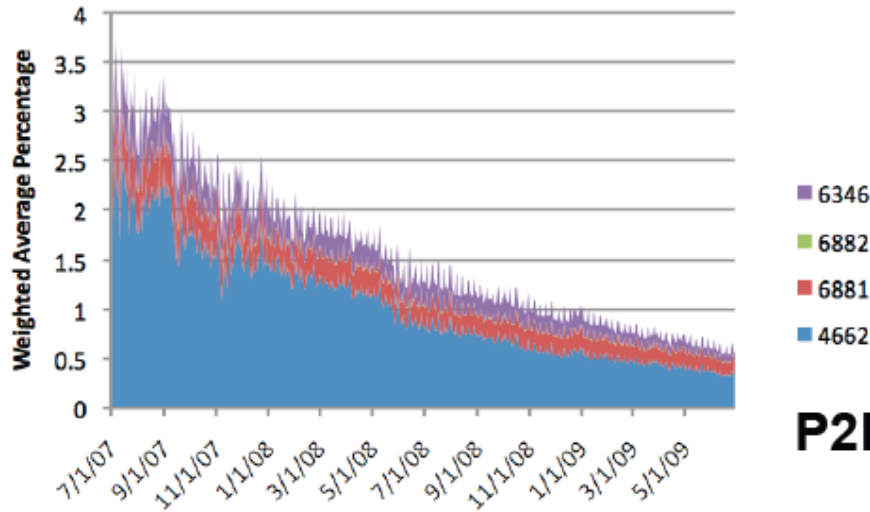


# Questions to be answered

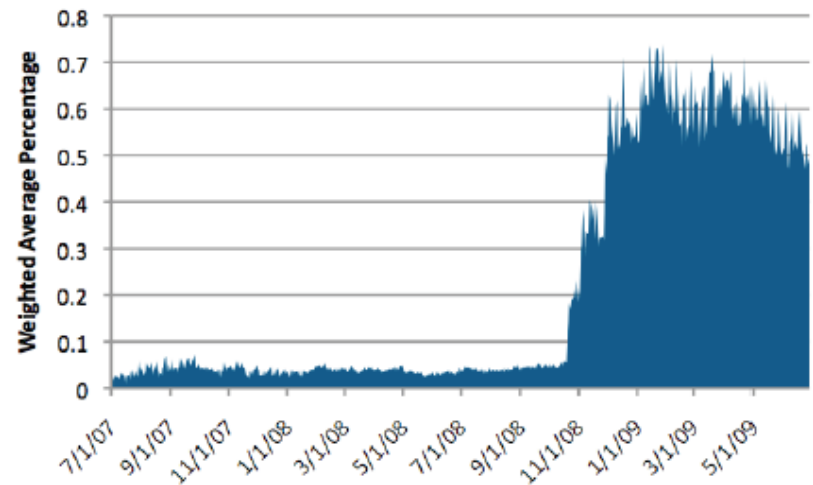
- ❑ Why do the results vary by study?
- ❑ What does it mean to be representative?
- ❑ How can one determine the application mix?
- ❑ What about user privacy?

# P2P vs. Direct Download Providers

## Global P2P Trends



## P2P Replaced by Direct Download



# Questions to be answered

- ❑ Why do the results vary by study?
- ❑ What does it mean to be representative?
- ❑ How can one determine the application mix?
- ❑ What about user privacy?
- ❑ What about individual applications?
  - P2P
  - Gaming
  - Online Social Networks
  - ...