The Future of the Internet

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John S. Quarterman, jsq@mids.org, President

With input from Peter H. Salus, peter@mids.org, Editorial Director

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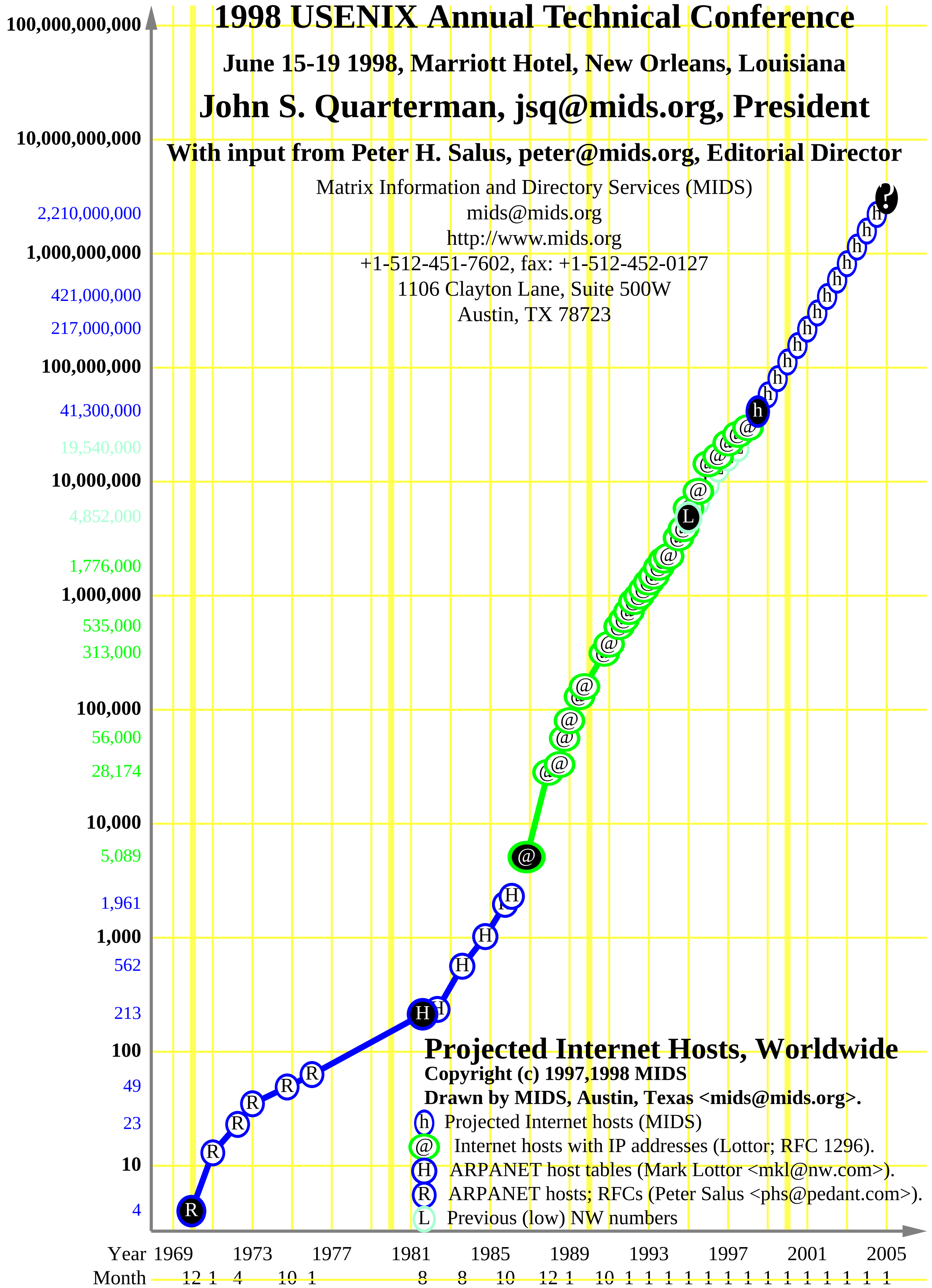
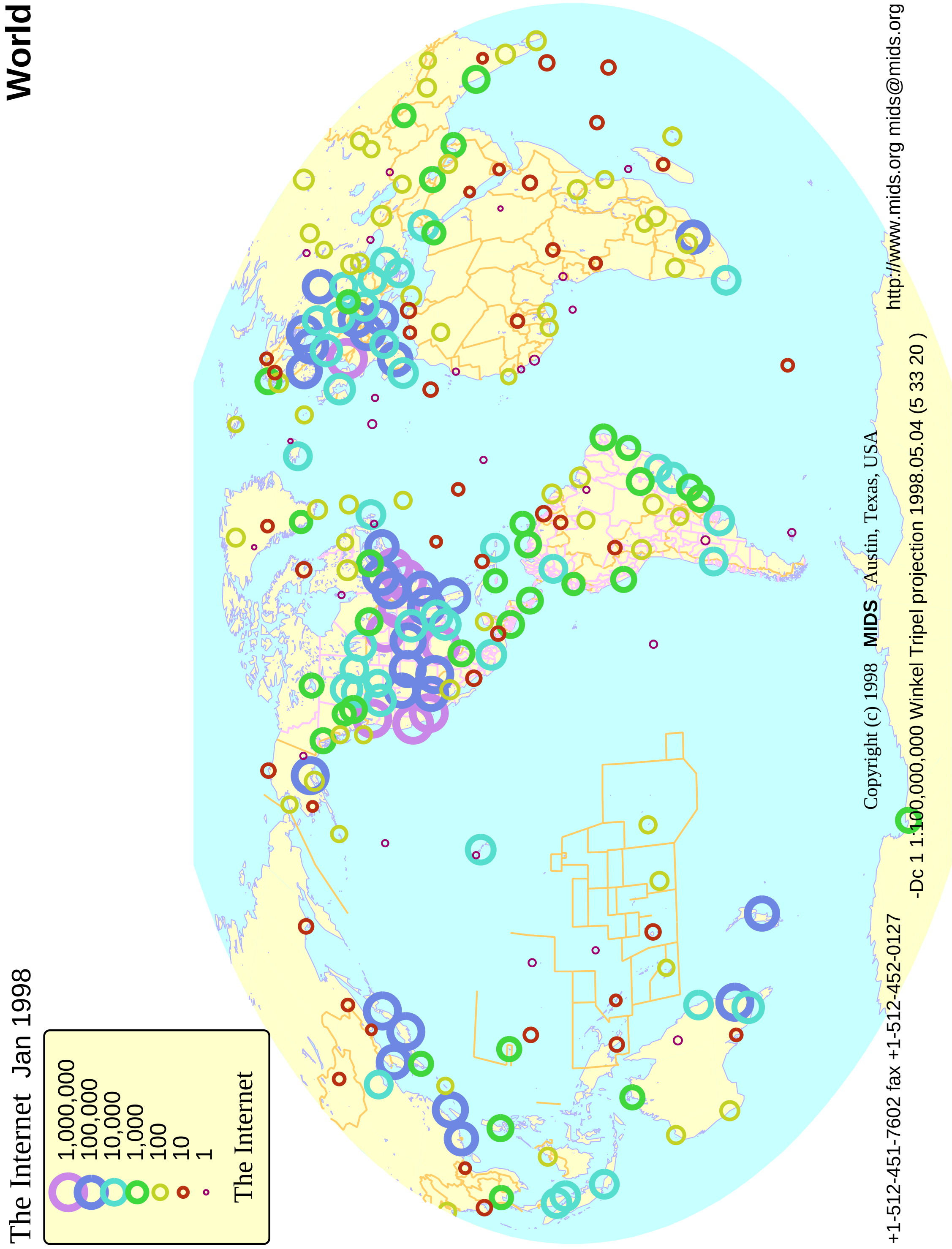
Austin, TX 78723



Contents

(graphics in italics)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Copyright (c) 1998 MIDS Austin, Texas, USA
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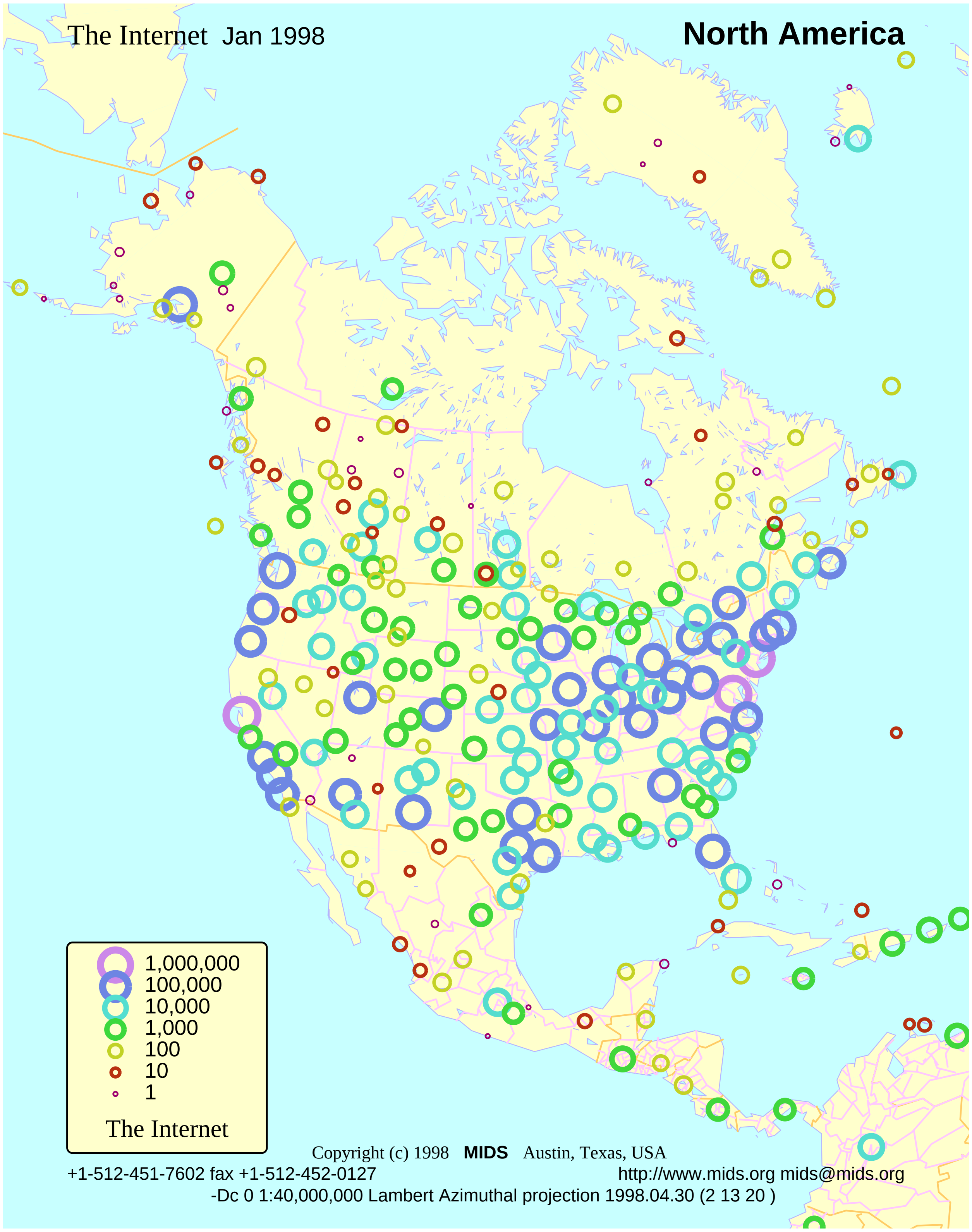
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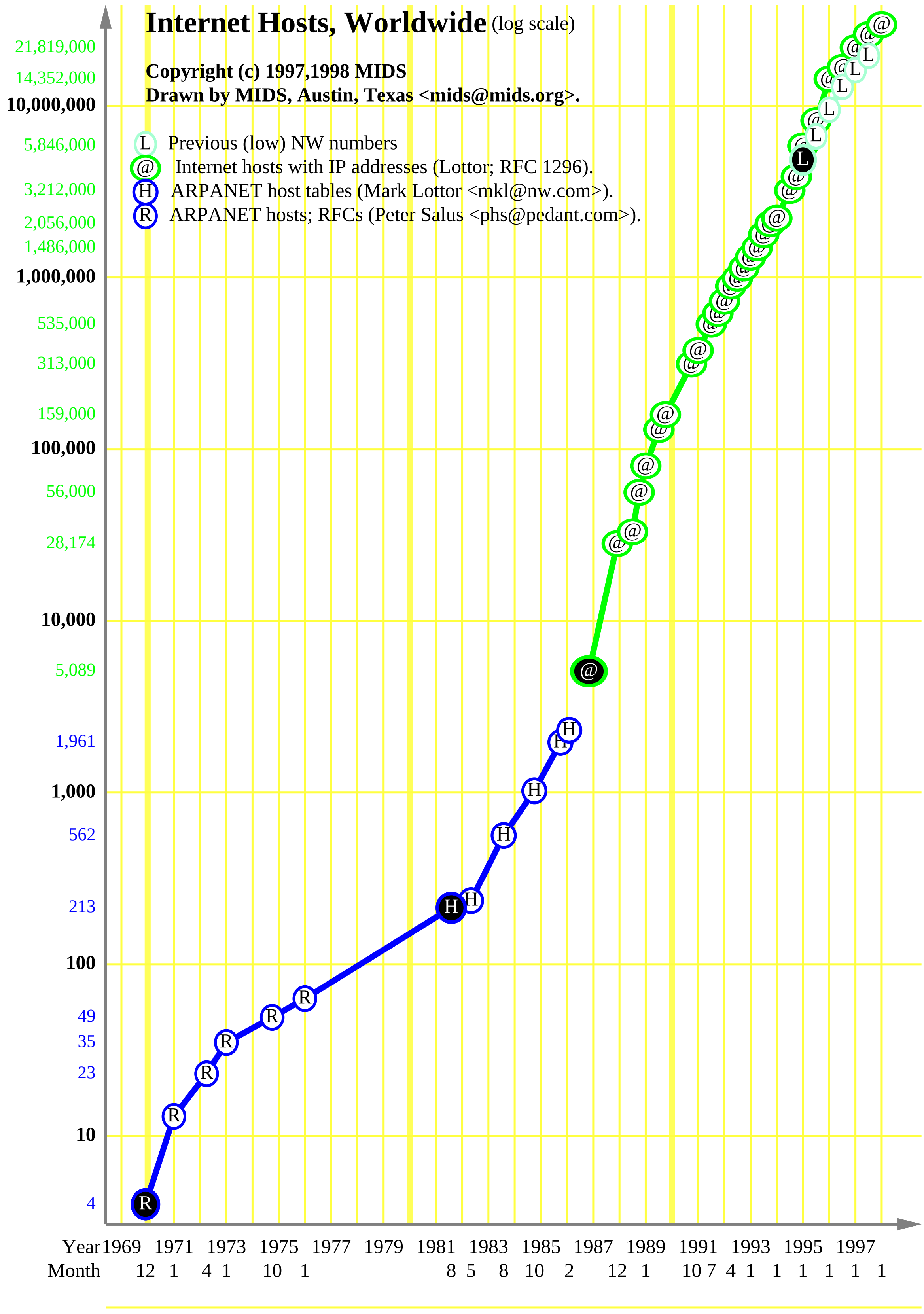
Internet Hosts, Worldwide (log scale)
Copyright (c) 1997,1998 MIDS
Drawn by MIDS, Austin, Texas <mids@mids.org>.
L Previous (low) NW numbers
@ Internet hosts with IP addresses (Lottor; RFC 1296).
H ARPANET host tables (Mark Lottor <mkl@nw.com>).
R ARPANET hosts; RFCs (Peter Salus <phs@pedant.com>).
21,819,000
14,352,000
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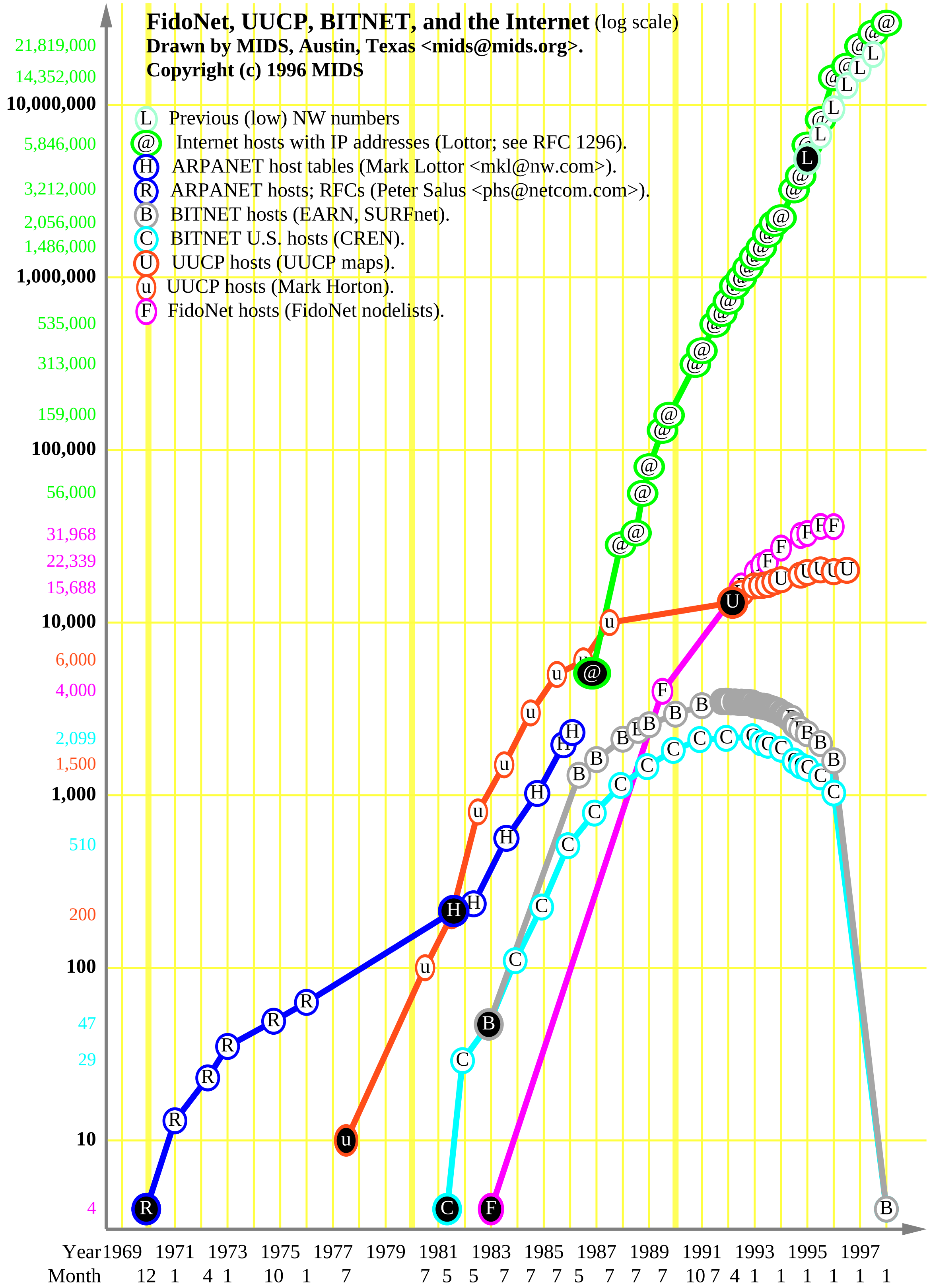
FidoNet, UUCP, BITNET, and the Internet (log scale)
Drawn by MIDS, Austin, Texas <mids@mids.org>.
Copyright (c) 1996 MIDS
L Previous (low) NW numbers
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H ARPANET host tables (Mark Lottor <mkl@nw.com>).
R ARPANET hosts; RFCs (Peter Salus <phs@netcom.com>).
B BITNET hosts (EARN, SURFnet).
C BITNET U.S. hosts (CREN).
U UUCP hosts (UUCP maps).
u UUCP hosts (Mark Horton).
F FidoNet hosts (FidoNet nodelists).
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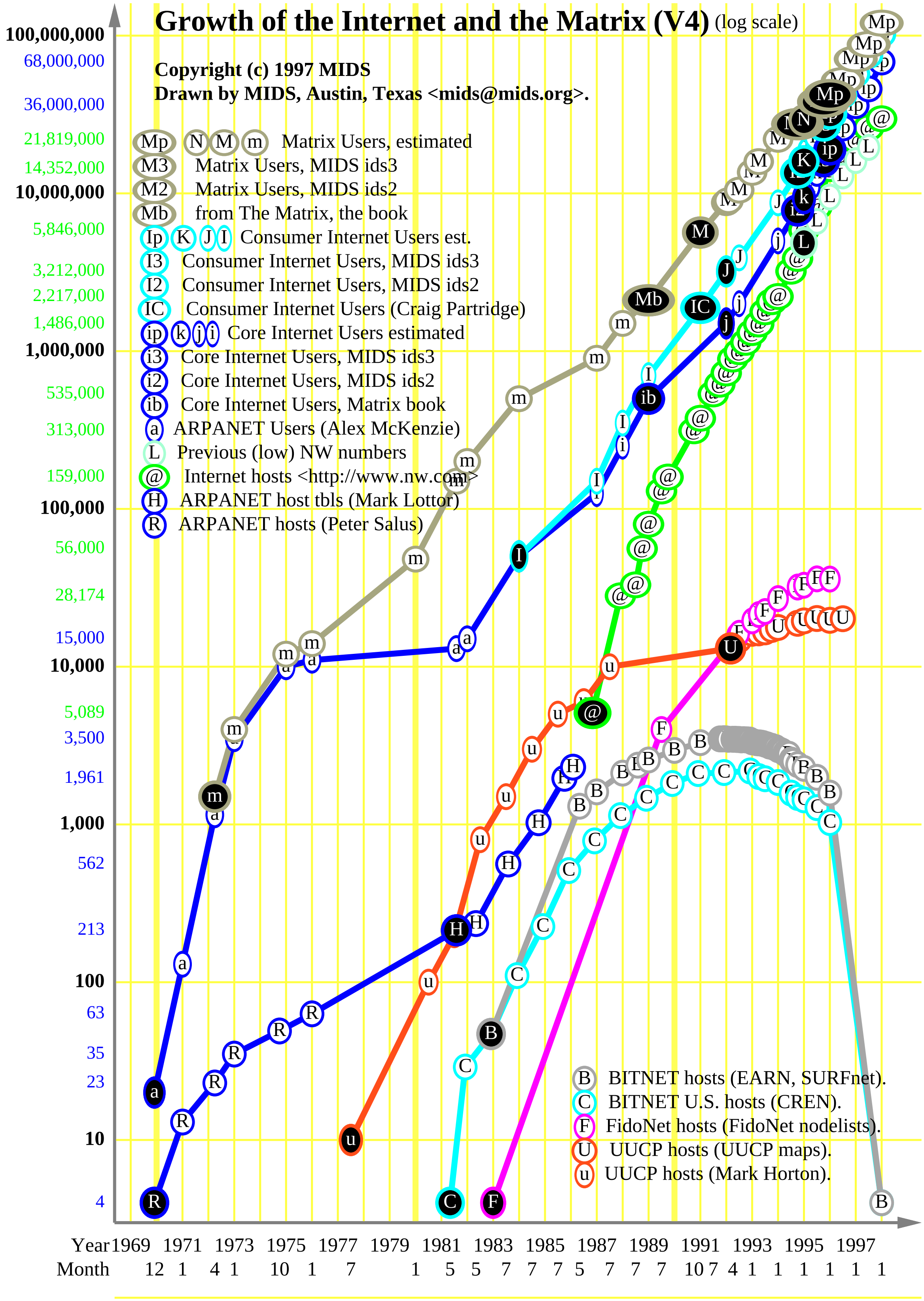
Internet Growth History

- The Internet now covers much of the world.
- Its historical growth has been very rapid.
- It has outlived and absorbed other networks.


Growth of the Internet and the Matrix (V4) (log scale)
Copyright (c) 1997 MIDS
Drawn by MIDS, Austin, Texas <mids@mids.org>.
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M2 Matrix Users, MIDS ids2
Mb from The Matrix, the book
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I2 Consumer Internet Users, MIDS ids2
IC Consumer Internet Users (Craig Partridge)
ip k j i Core Internet Users estimated
i3 Core Internet Users, MIDS ids3
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ib Core Internet Users, Matrix book
a ARPANET Users (Alex McKenzie)
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H ARPANET host tbls (Mark Lottor)
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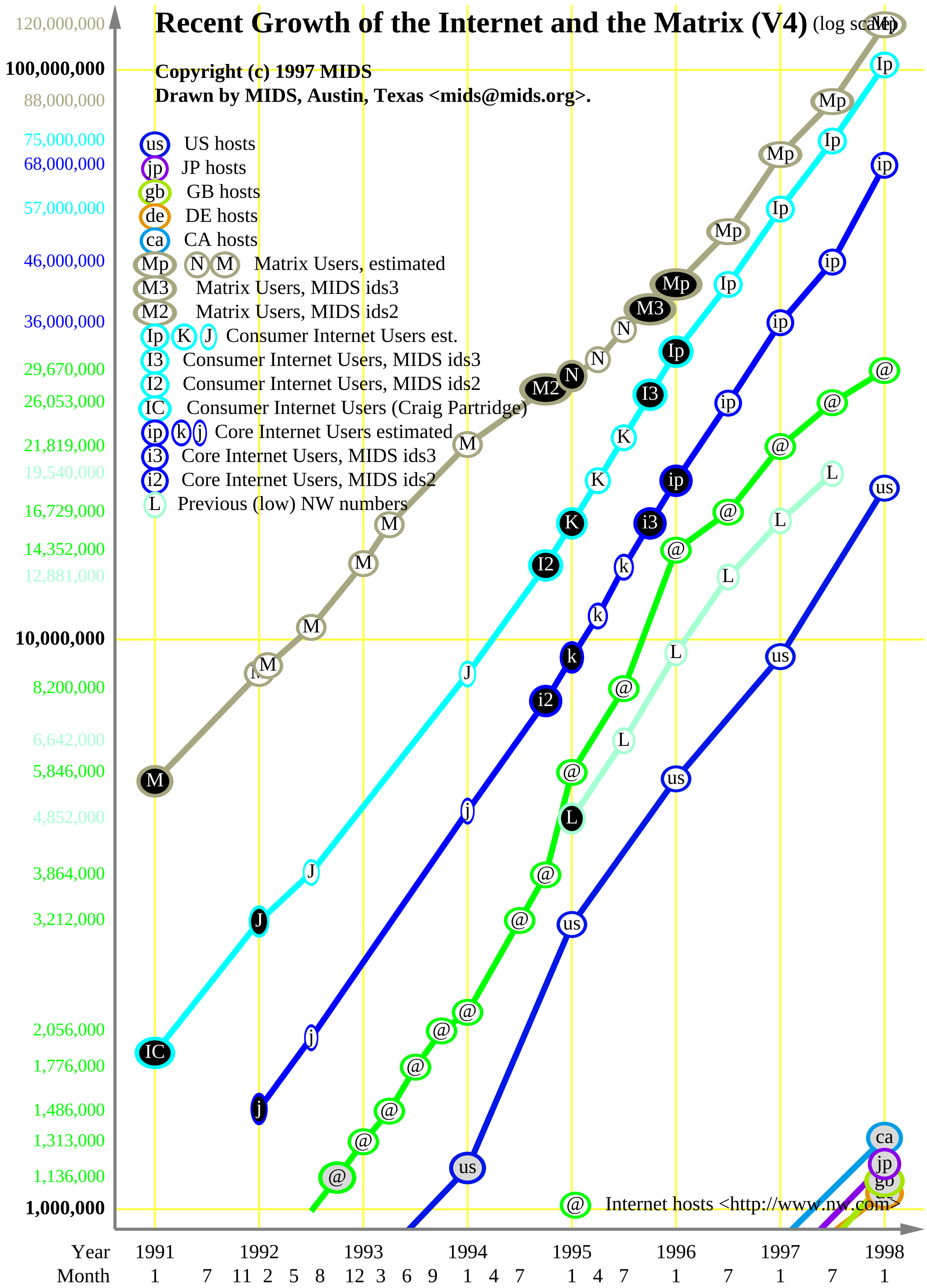
Recent Growth of the Internet and the Matrix (V4) (log scale)
Copyright (c) 1997 MIDS
Drawn by MIDS, Austin, Texas <mids@mids.org>.
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de DE hosts
ca CA hosts
Mp N M Matrix Users, estimated
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M2 Matrix Users, MIDS ids2
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I3 Consumer Internet Users, MIDS ids3
I2 Consumer Internet Users, MIDS ids2
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@ Internet hosts <http://www.nw.com>
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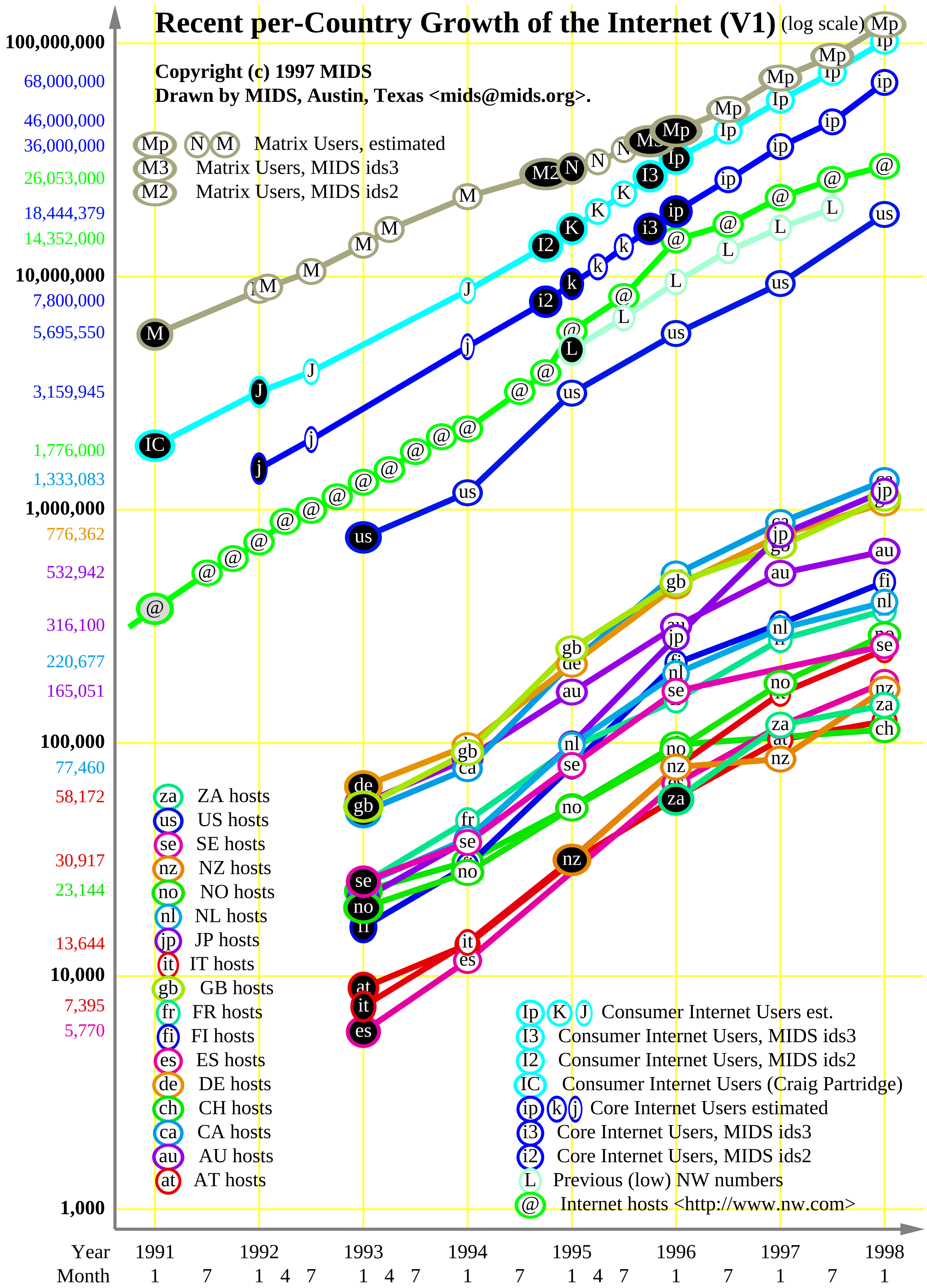

Recent per-Country Growth of the Internet (V1) (log scale)
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M2 Matrix Users, MIDS ids2
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us US hosts
se SE hosts
nz NZ hosts
no NO hosts
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jp JP hosts
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fi FI hosts
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L Previous (low) NW numbers
@ Internet hosts <http://www.nw.com>
Year 1991 1992 1993 1994 1995 1996 1997 1998
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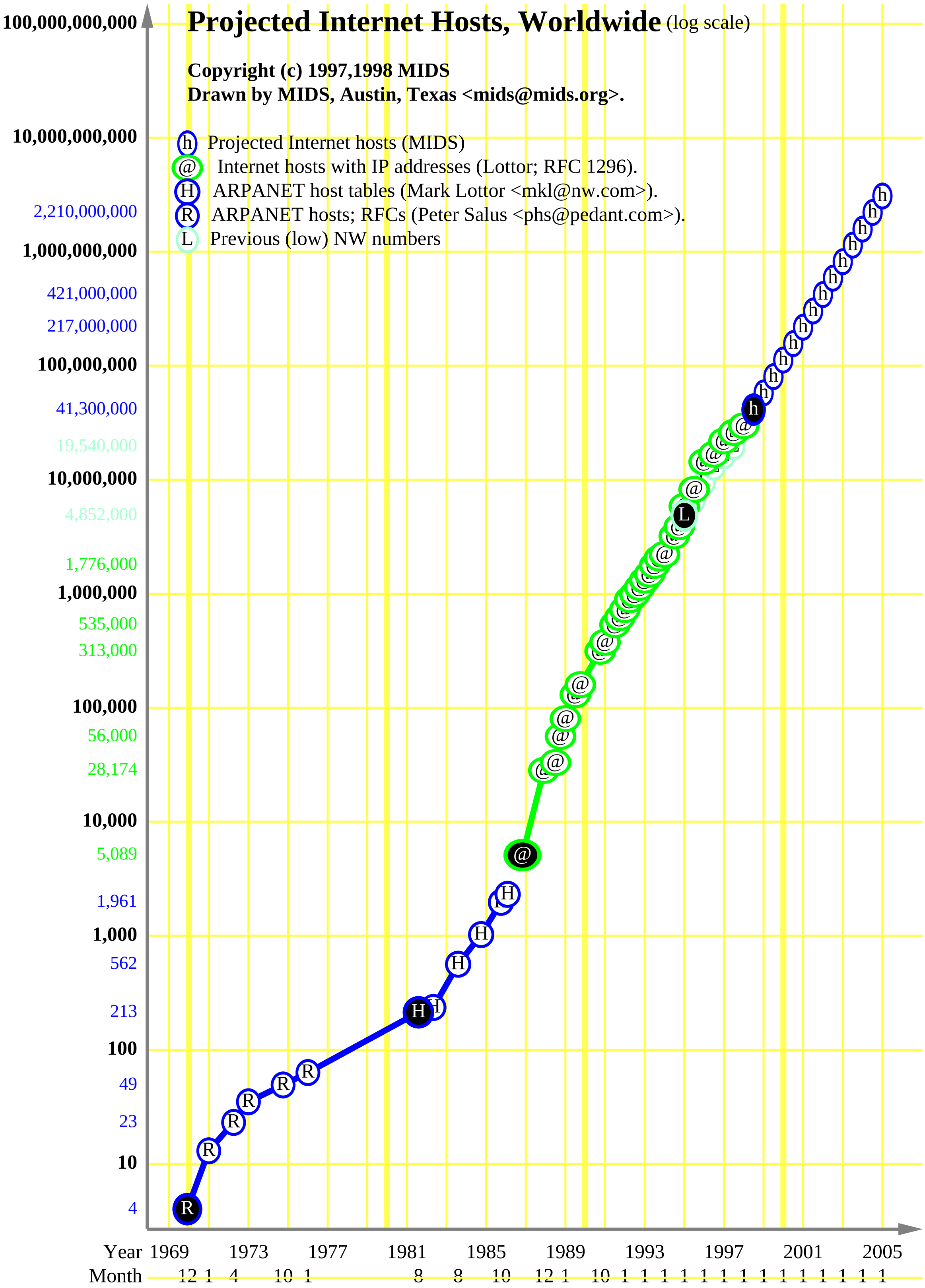
What now?

- In December 1995, Bob Metcalfe predicted the Internet would fail catastrophically in 1996.
- He changed his prediction after seeing historical latency data from the MIDS Internet Weather Report <URL:http://www.mids.org/weather/>.
- I’ve been hearing ‘‘imminent death of the net’’ since about 1977, before the Internet, in ARPANET days.
- Twice (in 1993 and 1997)
- I’ve heard predictions from Network Wizards data that Internet growth has slowed.
- Neither appears to have been correct.
- But the Internet growth curve must bend some time.
- Has Internet growth started slowing?
- If not, when will it?


Projected Internet Hosts, Worldwide (log scale)
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100,000,000,000
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2,210,000,000
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4,852,000
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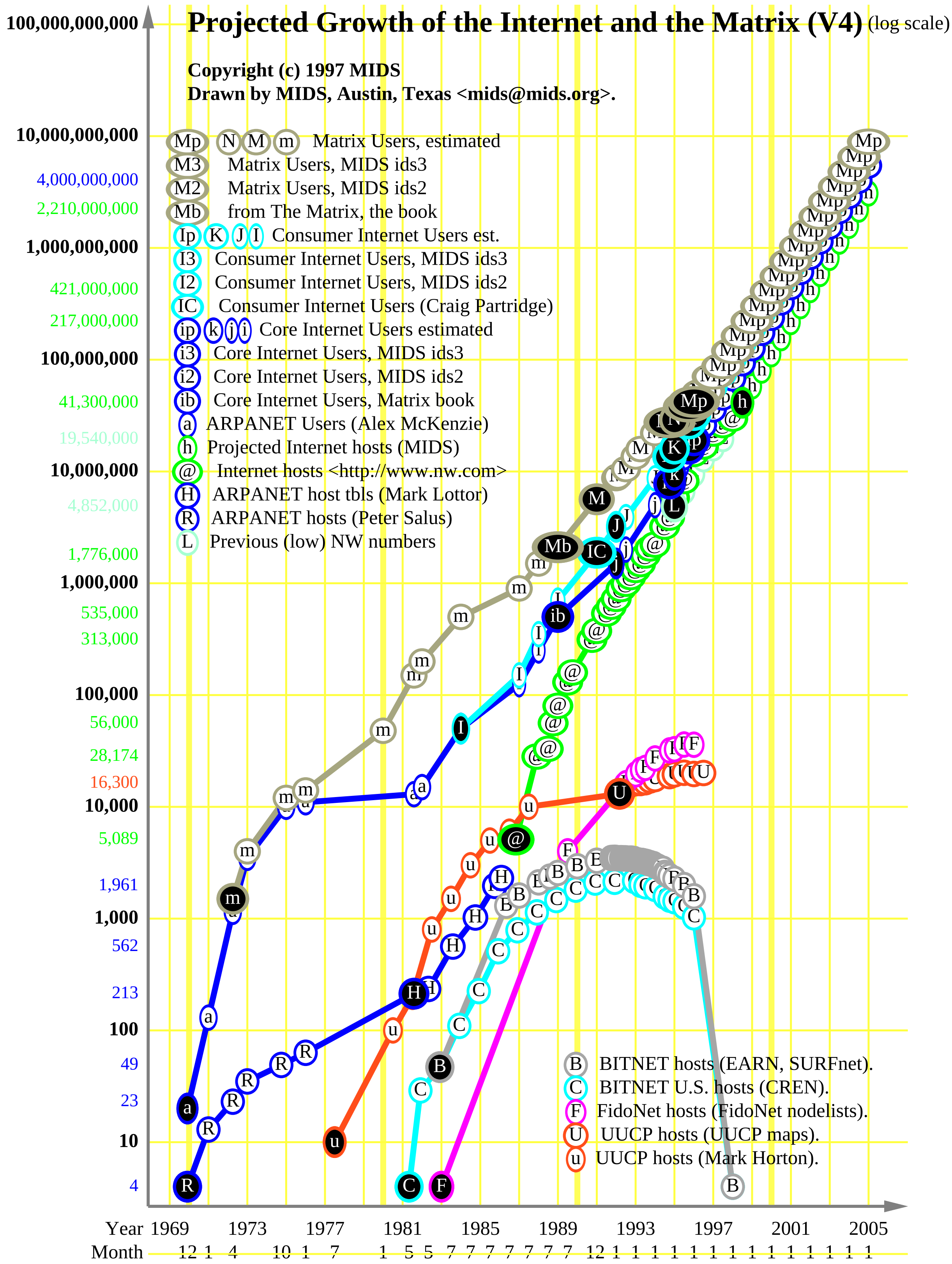
Year 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005
Month 12 1 4 10 1 8 8 10 12 1 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1

Prediction Fault: core dump

The history of predictive speculation is rife with bizarre faults.

- Alexander Graham Bell thought the telephone was purely a business tool and had no personal applications.
- Tom Watson Sr. predicted a tiny business market for computers and no home market.
- HP thought there was no market for personal computers and turned away the future founders of Apple.
- Steve Jobs thought home applications for Macintoshes would consist of balancing checkbooks, keeping telephone numbers, writing letters, and looking up recipes.
- Neither Jobs nor Bill Gates predicted the mutual effects of the Internet and the PC.
- Even some ARPANET pioneers thought a decade ago that fax was going to bury electronic mail.
- Alex McKenzie wrote to Haberman in 1971 that the ARPANET might eventually have 2,000 users.
- The original ARPANET address space was 8 bits.
- It was expanded to 16 bits.
- Then to 32 bits.
- And now again with IPv6.
- Not even Vint Cerf predicted the current size or social effect of the Internet.
- Who would have expected every movie advertisement to include a web URL?

So take any technological predictions with a grain of salt.



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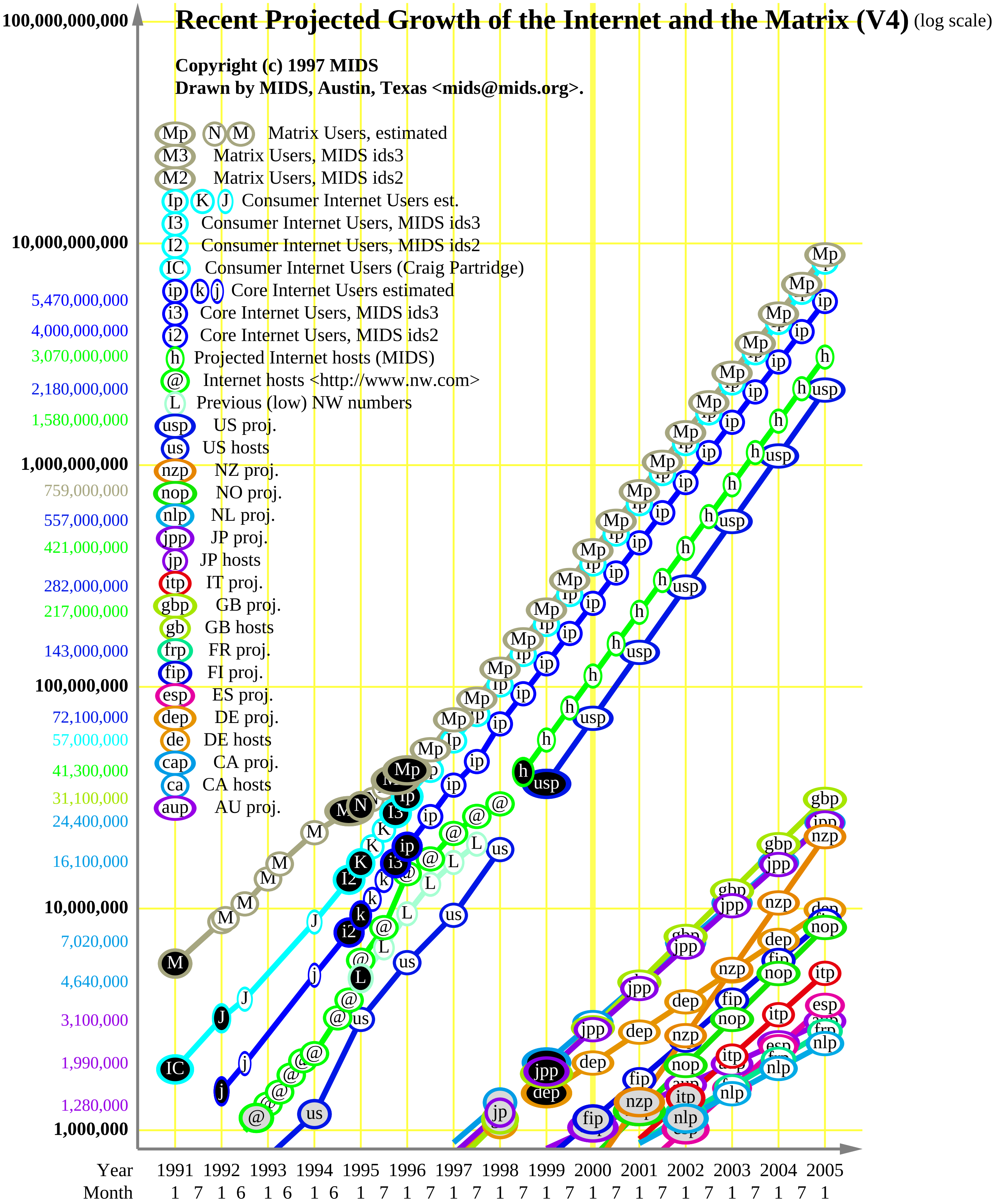

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ip k j Core Internet Users estimated
i3 Core Internet Users, MIDS ids3
i2 Core Internet Users, MIDS ids2
h Projected Internet hosts (MIDS)
@ Internet hosts <http://www.nw.com>
L Previous (low) NW numbers
usp US proj.
us US hosts
nzp NZ proj.
nop NO proj.
nlp NL proj.
jpp JP proj.
jp JP hosts
itp IT proj.
gbp GB proj.
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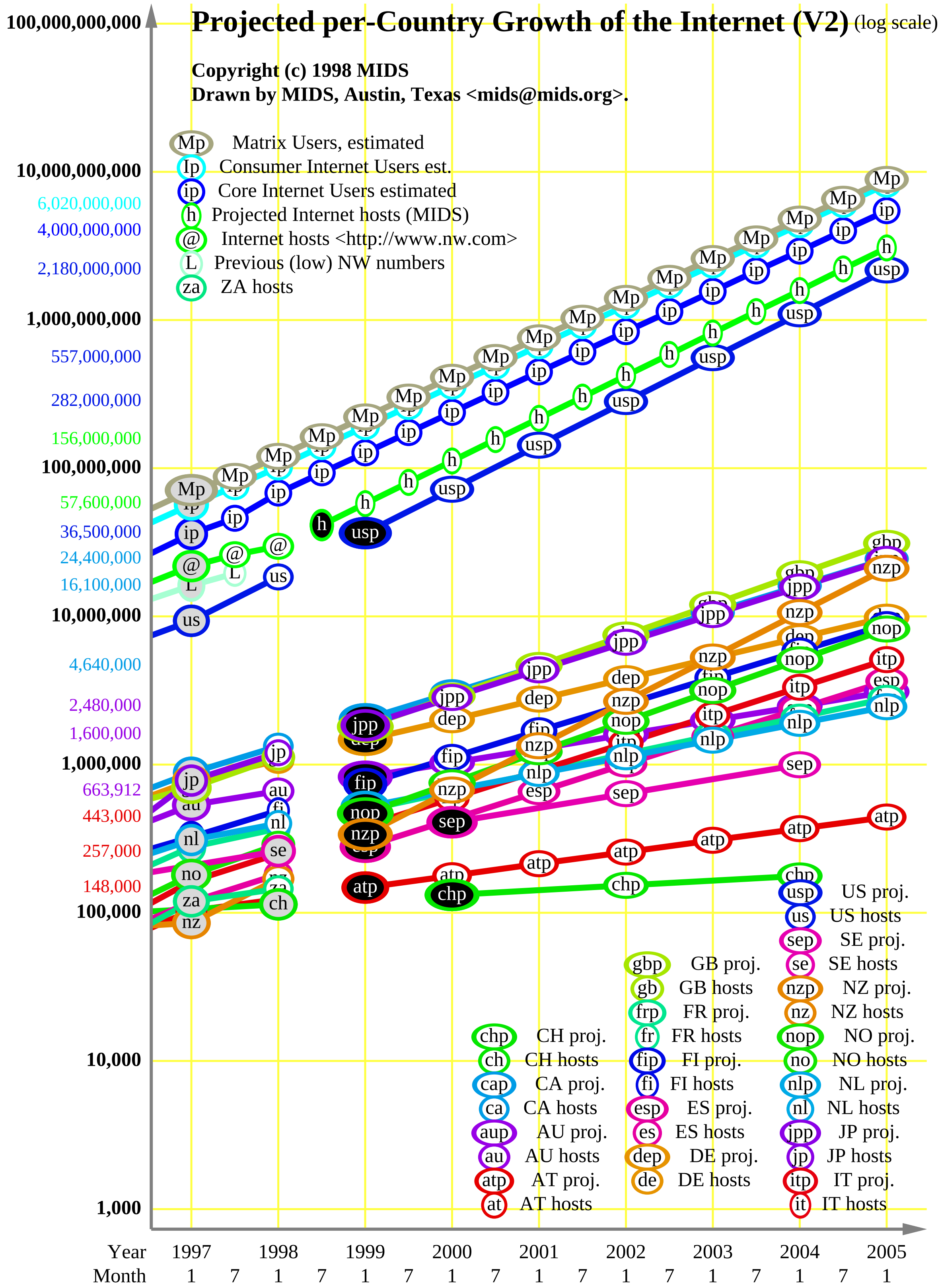
Internet Predictions

The Internet has its own bizarre prediction problems.

- Only one size measure covers the entire history of the Internet:
- Mark Lottor's Network Wizards <URL:http://www.nw.com/> Internet Domain Surveys.
- Jan 1998 NW survey has different data collection method, because of DNS zone transfer problems.
- NW published corrected estimates for the previous six NW surveys (3 years back).
- Over-corrected? No way to be sure.
- If corrections are right, Internet growth knee may be imminent.
- But Jan 1998 datapoint and most recent uncorrected NW data fit historical curve.
- If uncorrected data is mostly right, Internet growth continues unabated.


Projected per-Country Growth of the Internet (V2) (log scale)
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Ip Consumer Internet Users est.
ip Core Internet Users estimated
h Projected Internet hosts (MIDS)
@ Internet hosts <http://www.nw.com>
L Previous (low) NW numbers
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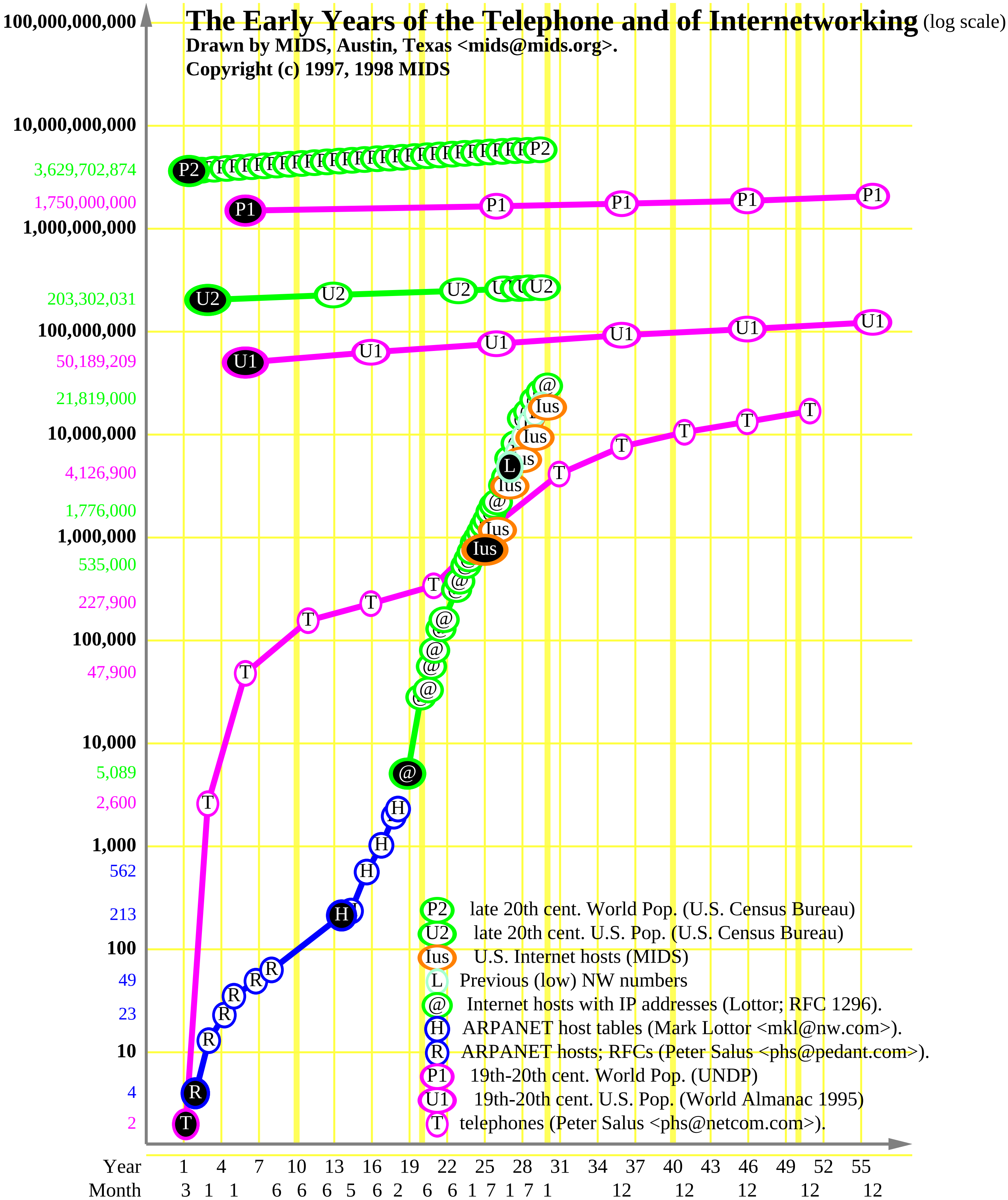
The Early Years of the Telephone and of Internetworking (log scale)
Drawn by MIDS, Austin, Texas <mids@mids.org>.
Copyright (c) 1997, 1998 MIDS
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P2 late 20th cent. World Pop. (U.S. Census Bureau)
U2 late 20th cent. U.S. Pop. (U.S. Census Bureau)
Ius U.S. Internet hosts (MIDS)
L Previous (low) NW numbers
@ Internet hosts with IP addresses (Lottor; RFC 1296).
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R ARPANET hosts; RFCs (Peter Salus <phs@pedant.com>).
P1 19th-20th cent. World Pop. (UNDP)
U1 19th-20th cent. U.S. Pop. (World Almanac 1995)
T telephones (Peter Salus <phs@netcom.com>).
Year 1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55
Month 3 1 1 6 6 6 5 6 2 6 6 1 7 1 7 1 12 12 12 12 12

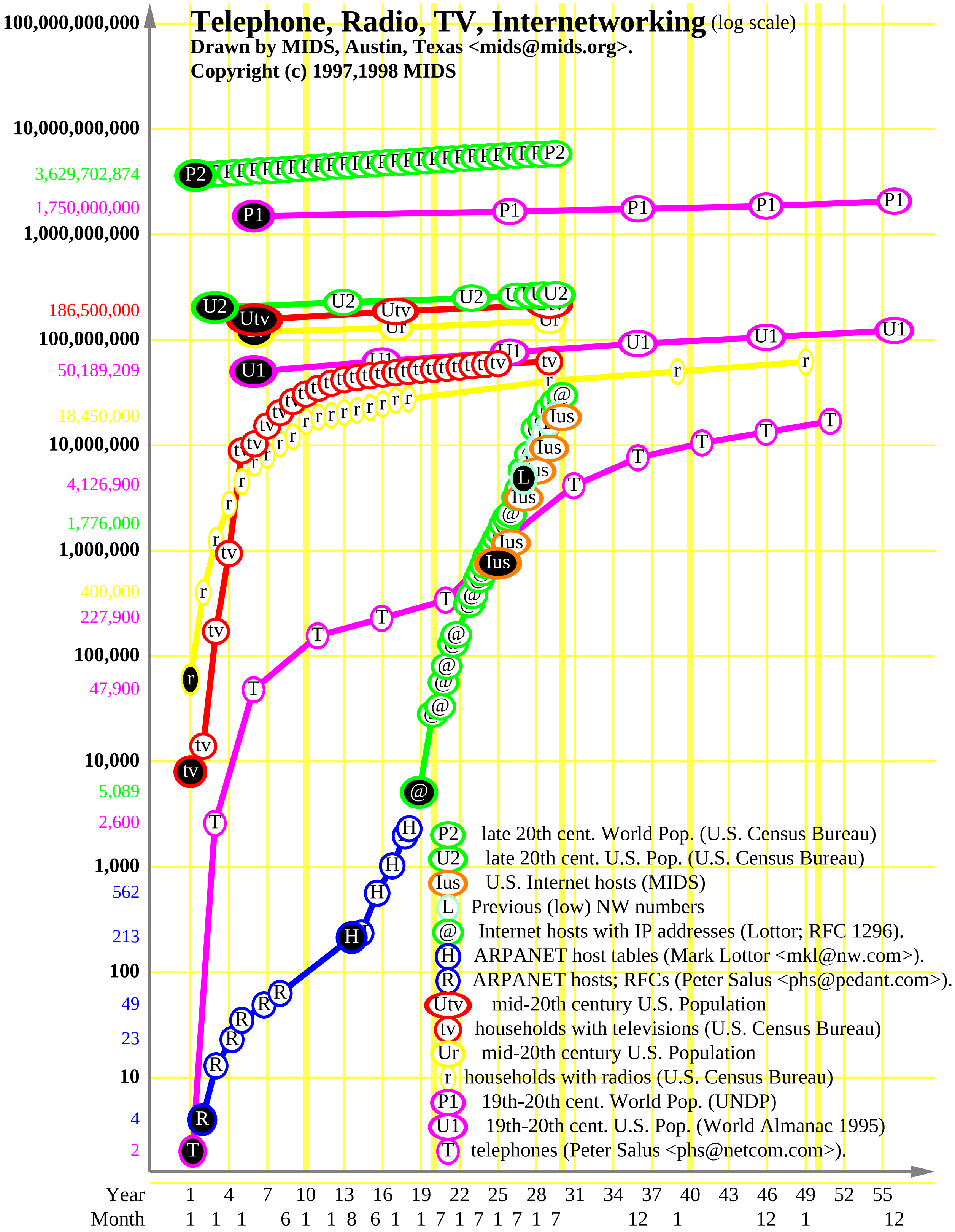
Will the U.S. continue to contain more than half of the Internet?

No.

- The U.S. had a head start, which it can't maintain forever.
- Internet hosts per country are strongly related to population and economy.
- For those reasions, the U.S. will for the indefinite future be a major and leading Internet country.
- But Japan, German, U.K., and others are rapidly catching up.
- The Internet in the U.S. will saturate before it does in those countries.

This is similar to what has happened with other utilities and technologies, such as

- Automobile
- Telephone
- Radio
- Television


Telephone, Radio, TV, Internetworking (log scale)
Drawn by MIDS, Austin, Texas <mids@mids.org>.
Copyright (c) 1997,1998 MIDS
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P2 late 20th cent. World Pop. (U.S. Census Bureau)
U2 late 20th cent. U.S. Pop. (U.S. Census Bureau)
Ius U.S. Internet hosts (MIDS)
L Previous (low) NW numbers
@ Internet hosts with IP addresses (Lottor; RFC 1296).
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Utv mid-20th century U.S. Population
tv households with televisions (U.S. Census Bureau)
Ur mid-20th century U.S. Population
r households with radios (U.S. Census Bureau)
P1 19th-20th cent. World Pop. (UNDP)
U1 19th-20th cent. U.S. Pop. (World Almanac 1995)
T telephones (Peter Salus <phs@netcom.com>).

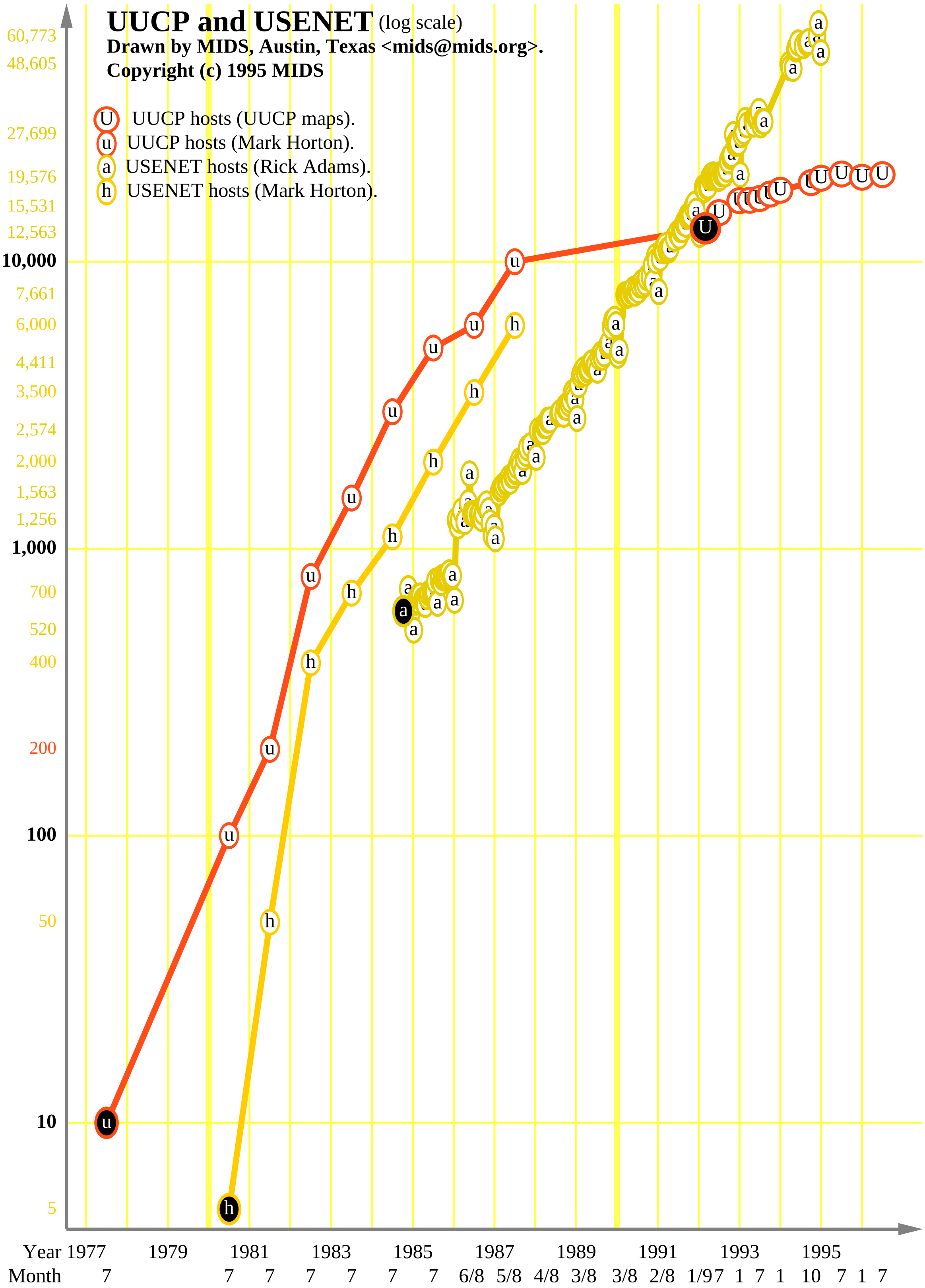
Internet Analogies

The Internet is not like telephone, radio, or TV.

- The Internet has sustained very rapid growth for a longer period than any of those technologies.
- Internet hosts are not subject to total population limits.
- The Internet can spread faster because it is not tied to a single physical technology.

Consider USENET news.

- Originally a service on top of UUCP.
- Spread over FidoNet and elsewhere.
- Especially over the Internet.
- USENET is now mostly transported by the Internet.
- This network service outlived its underlying technology.
- Electronic mail is another example.
- TCP/IP is designed to carry services over multiple physical technologies.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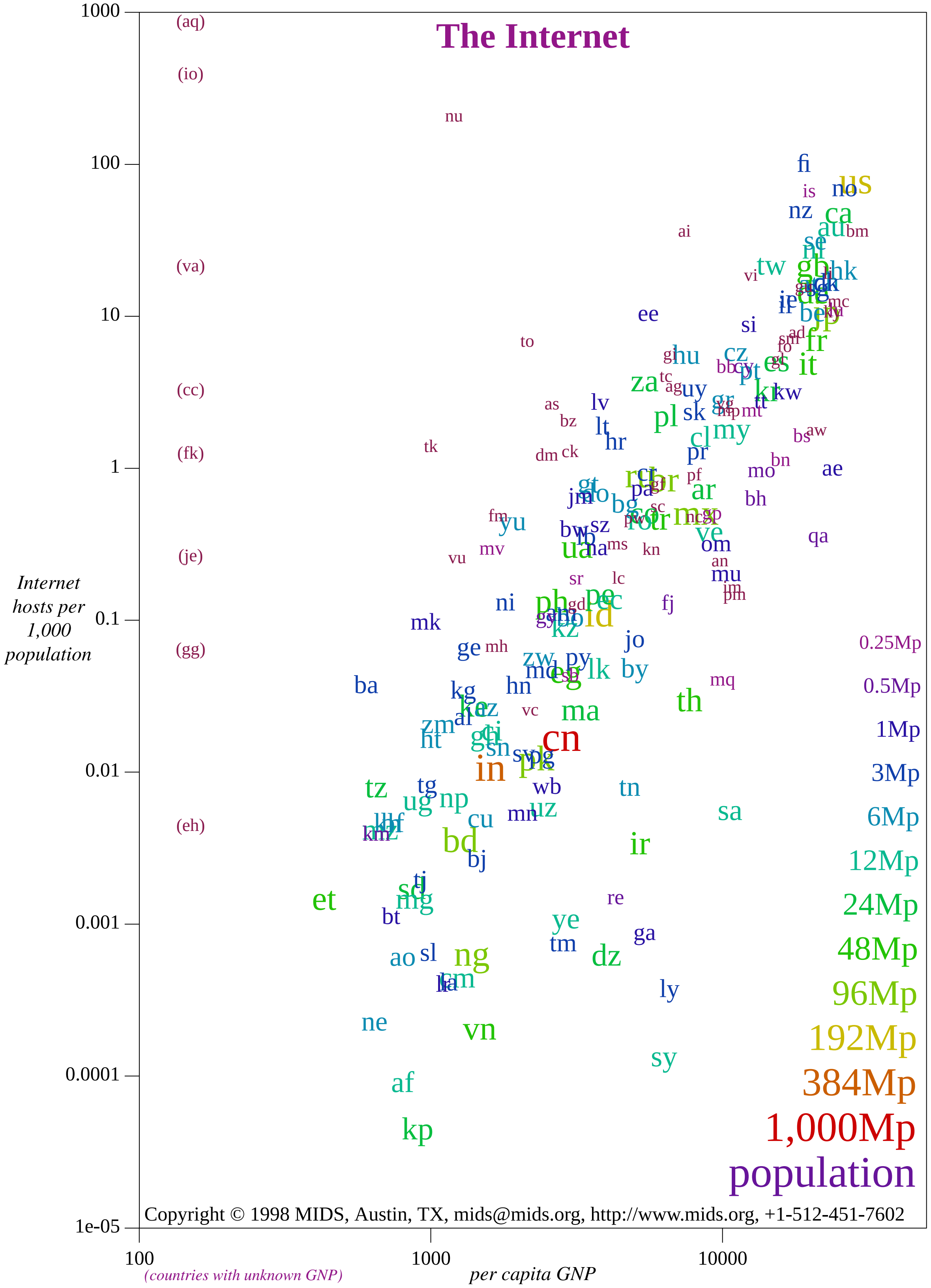
10
5
Year 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995
Month 7 7 7 7 7 7 7 6/8 5/8 4/8 3/8 3/8 2/8 1/97 1 7 1 10 7 1 7

U.S. Internet Predictions

The U.S. is still unlike other countries on the Internet.

- The U.S. still has more than half (62.8%) of all Internet hosts, as of January 1998,
- with domains (and often hosts) localized to the city level by MIDS,
- not just by top level domain, as in raw NW data.
- By recent previous NW data (localized by MIDS),
- U.S. host growth had started to slow,
- while Japan was rising like a rocket.
- Now Japan has slowed,
- as Japan approaches its natural place in hosts per capita in relation to per capita income (see scatterplot)
- Meanwhile, the U.S. growth decline was apparently an artifact of the NW measurement problem.


The Internet
Internet hosts per 1,000 population
1000
100
10
1
0.1
0.01
0.001
0.0001
1e-05
100
1000
10000
per capita GNP
(countries with unknown GNP)
(aq)
(io)
(va)
(cc)
(fk)
(je)
(gg)
(eh)
0.25Mp
0.5Mp
1Mp
3Mp
6Mp
12Mp
24Mp
48Mp
96Mp
192Mp
384Mp
1,000Mp
population
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January 1998

Hosts and Domains Per Country

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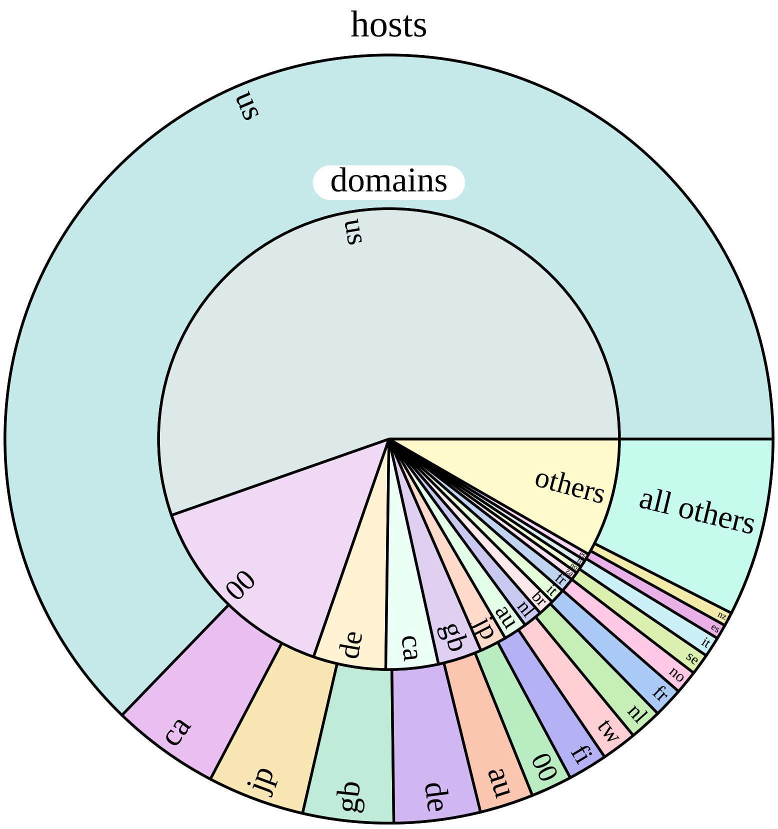


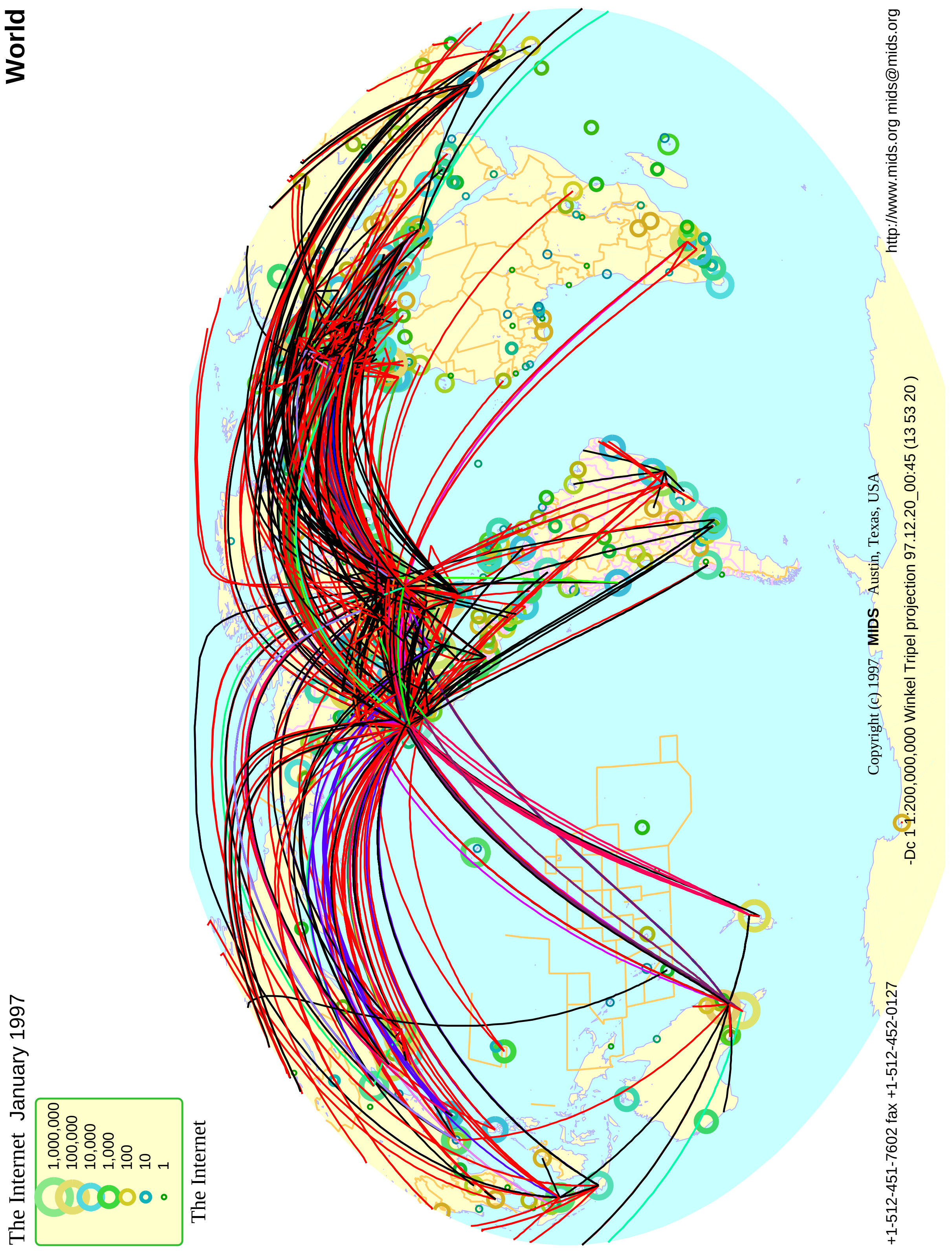
Will one company make all the software?

No.

- Even Microsoft doesn’t do that now.
- A router is not a server is not an end-user host.
- Look at Linux.

History shows that no monopoly ever lasts.

- Consider U.S. automobile manufacturers circa 1972.
- Who would have thought that GM, Chrysler, and Ford could be overtaken by Japanese car makers?
- U.S. Steel.
- Eventually anti-trust actions may grow teeth.


World
The Internet January 1997
1,000,000
100,000
10,000
1,000
100
10
1
The Internet
http://www.mids.org mids@mids.org
Copyright (c) 1997 MIDS Austin, Texas, USA
-Dc 1 1:200,000,000 Winkel Tripel projection 97.12.20_00:45 (13 53 20)
+1-512-451-7602 fax +1-512-452-0127

Will one company be the only global ISP?

No.

- Not even Worldcom can pull that off.
- T-1 vs. E-1.
- Regional politics.

Once again: history shows that no monopoly ever lasts.

- National monopoly PTTs used to be the norm.
- Nations won’t tolerate those anymore.
- Yet national differences are still barriers to entry for global telecoms.
- Shifts in Internet technology.
- Fiber optics, the web, wireless, cable, satellite.
- The Internet is too big, grows too fast, and changes too rapidly.