Computer Networks

History

Grading Policy:

- 20% Homework and Projects
- 35% Midterm
- 45% Final

References

- Main textbook:
  - James F. Kurose and Keith W. Ross, “Computer Networking; A Top-Down Approach,” 7th Edition, 2017.

- Additional textbooks and References:
  - Larry L. Peterson and Bruce S. Davie, “Computer Networks: A Systems Approach,” 5th Edition, March 25, 2011.
  - Andrew Tanenbaum, “Computer Networks,” 4th Edition, Prentice Hall.
  - W. Stallings, “Data and Computer Communications,” Prentice Hall.

Early communication over long distance

- Between human beings
- Letter and messenger
  - Information carried by physical objects
  - Speed limited by transportation means: horse, bird, train, car
  - Bandwidth? Distance? Security?
- Fire
  - Early optical communication
  - Speed of light
  - Bandwidth? Distance? Security?

Communication using electricity

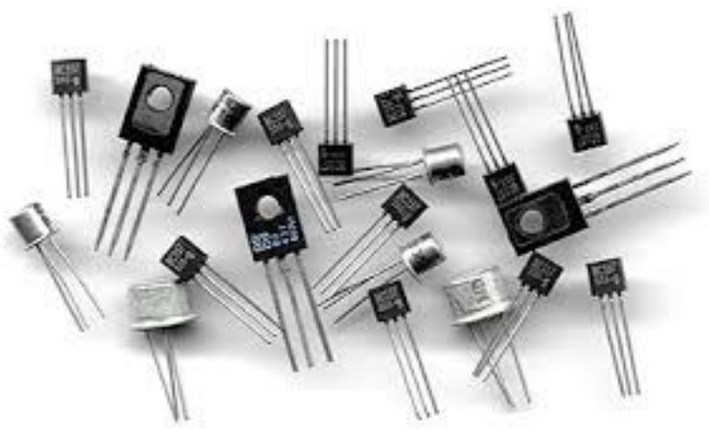
- 1827 (1206) Ohm's Law
- 1837 (1216) "Workable" telegraph invented by Samuel Morse
- 1838 (1217) demonstration over 16 kilometers at 10 w.p.m.
- 1851 (1230) Western Union founded
- 1861 (1240) Maxwell published an early form of his equations
- 1868 (1247) Transatlantic cable laid
- 1876 (1255) Alexander Bell invented the telephone
- 1885 (1264) AT&T formed
- 1892 (1271) First automated commercial telephone switch

Age of Telephones

- 1903 (1282) 3 million phones in the U.S.
- 1904 (1283) Invention of vacuum tube
- 1915 (1294) First transcontinental telephone line
- 1948 (1327) Transistor invented by Bell scientists.
  Famous paper of Shannon (birth of information theory): “A Mathematical Theory of Communication”
- 1963 (1342) Digital transmission introduced
- 1965 (1344) 1ESS central office switch introduced
- 1969 (1348) Arpanet was born
- 1985 (1364) Last telegraph circuit closed down
- 1999 (1378) Last 4ESS install in ATT network

Vacuum tubes vs. transistors vs. modern CPUs

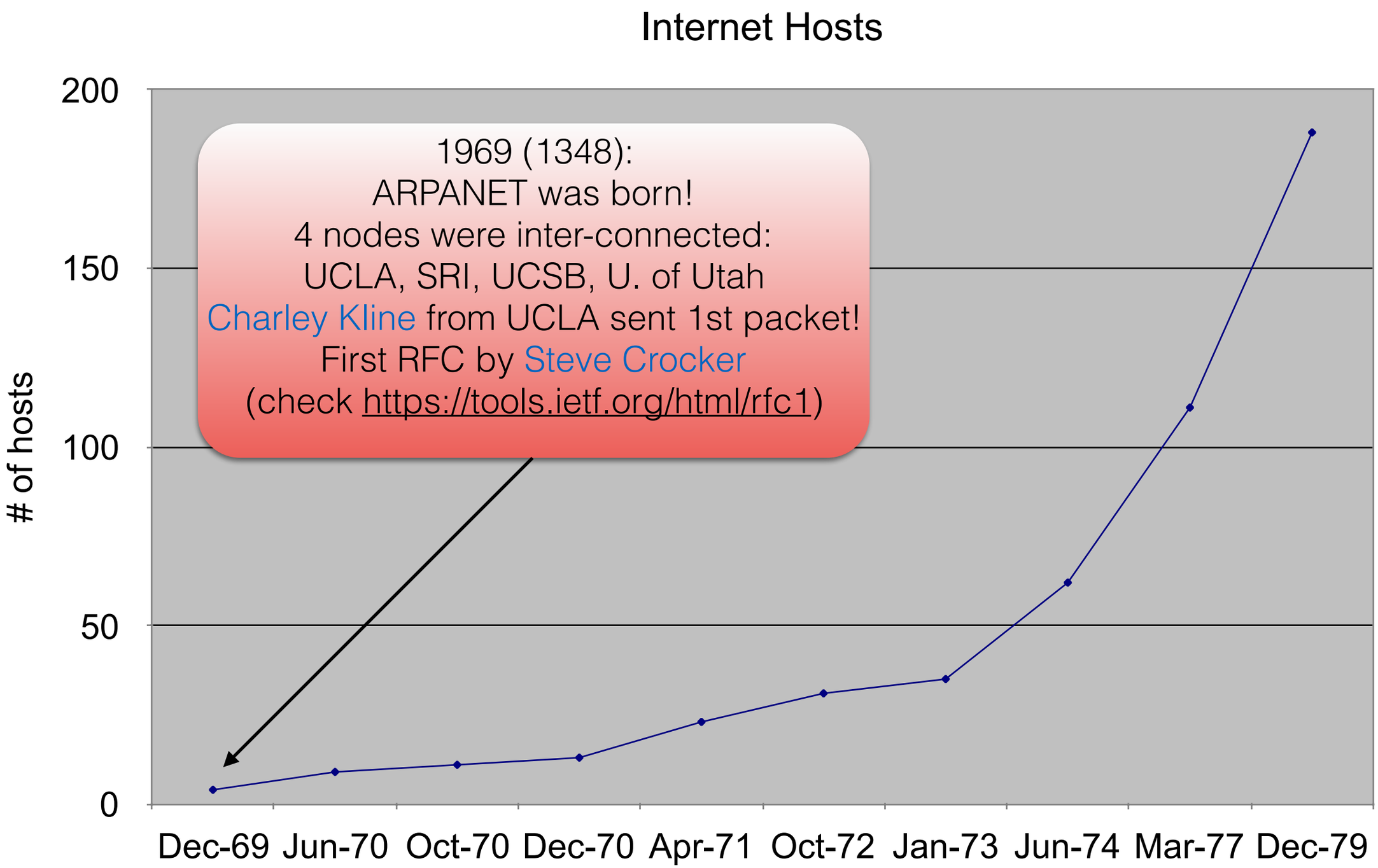
1904 ⟶ 2019



Intel Xeon Platinum 9282

# of cores: 56
Clock: 2.6-3.8 GHz
Lithography: 14nm
# of transistors: ~8 billion
Power Consumption: 400W

A Fast-Forwarded History of Internet!



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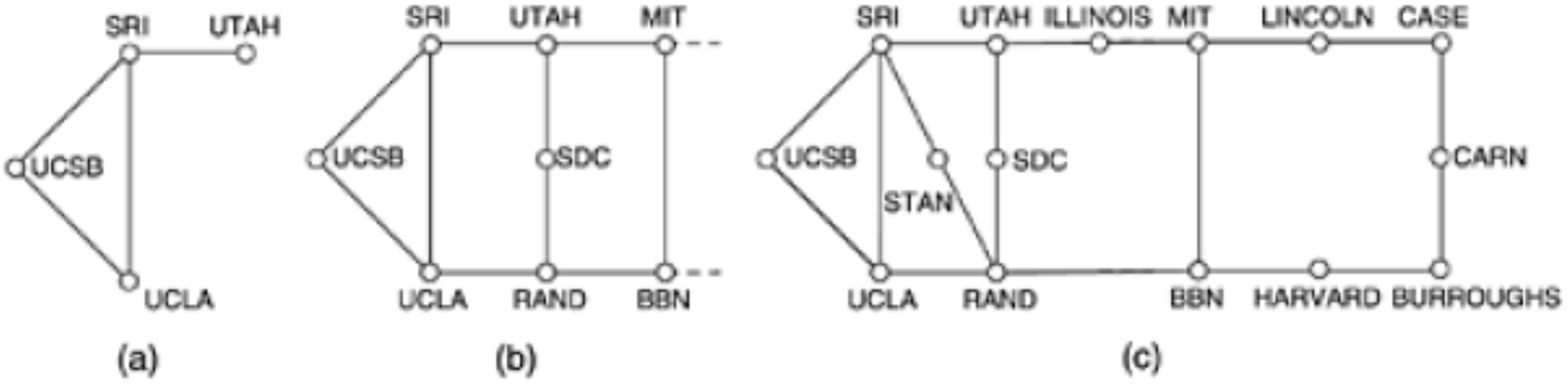

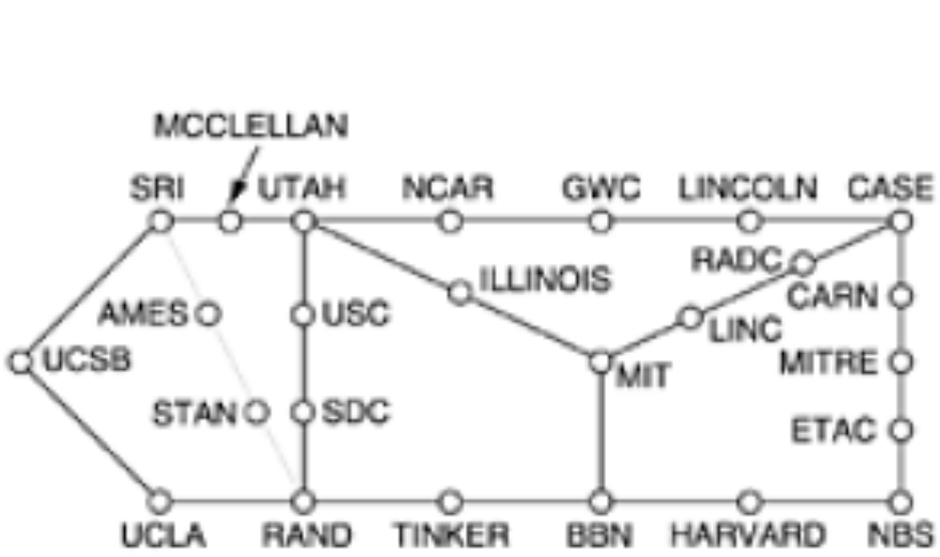

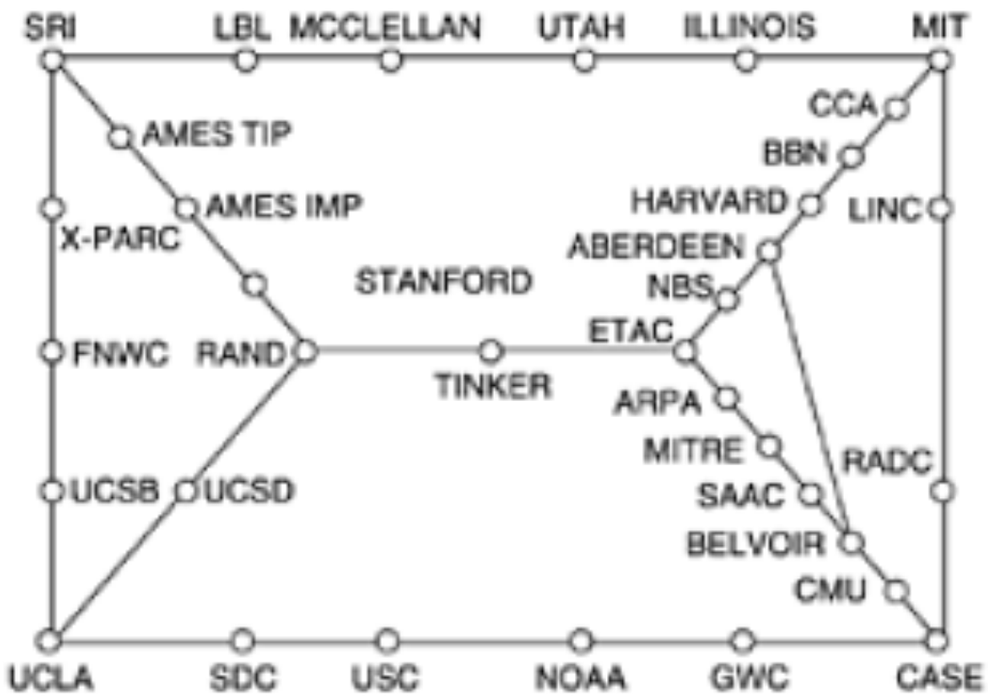

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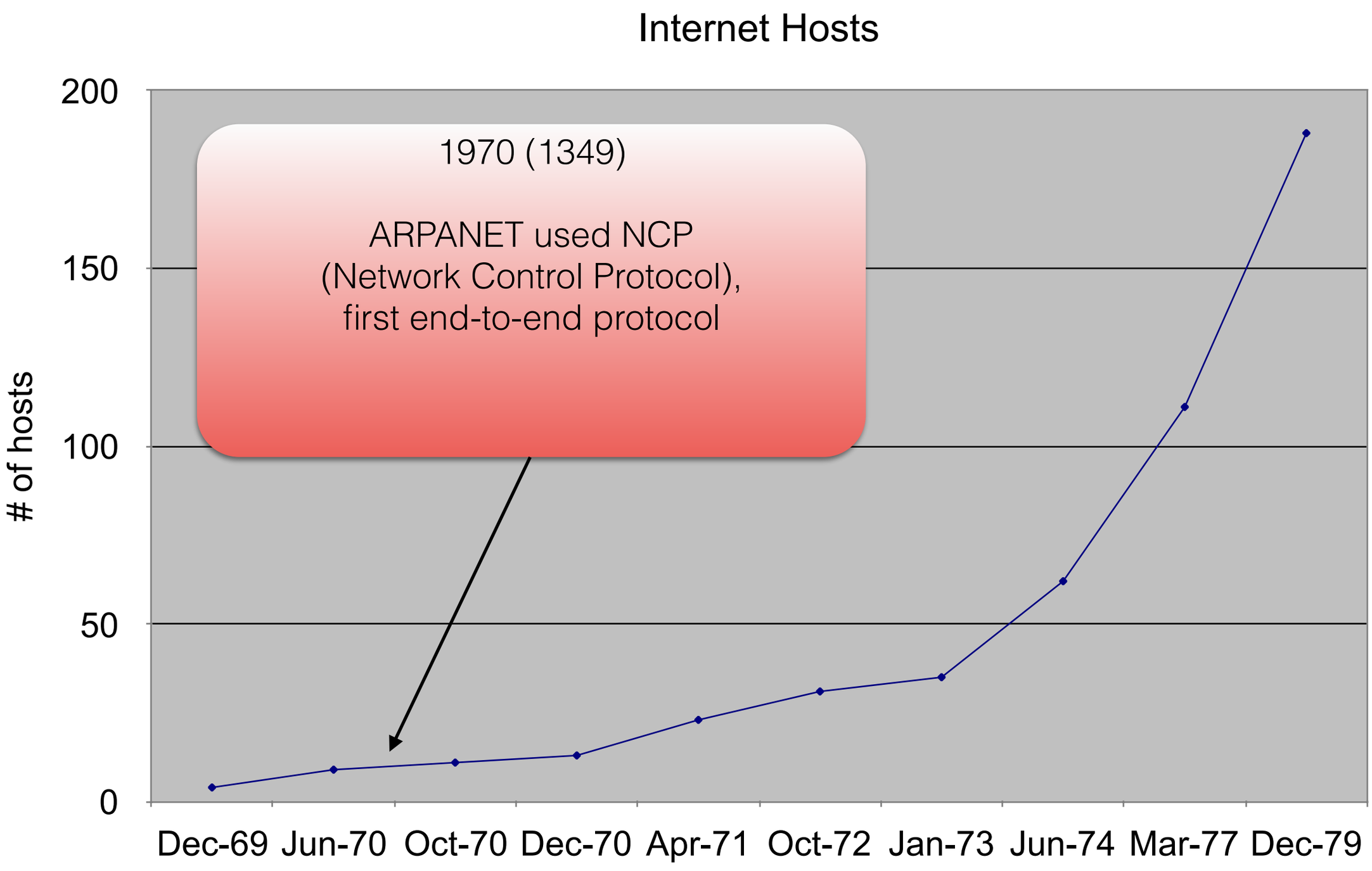

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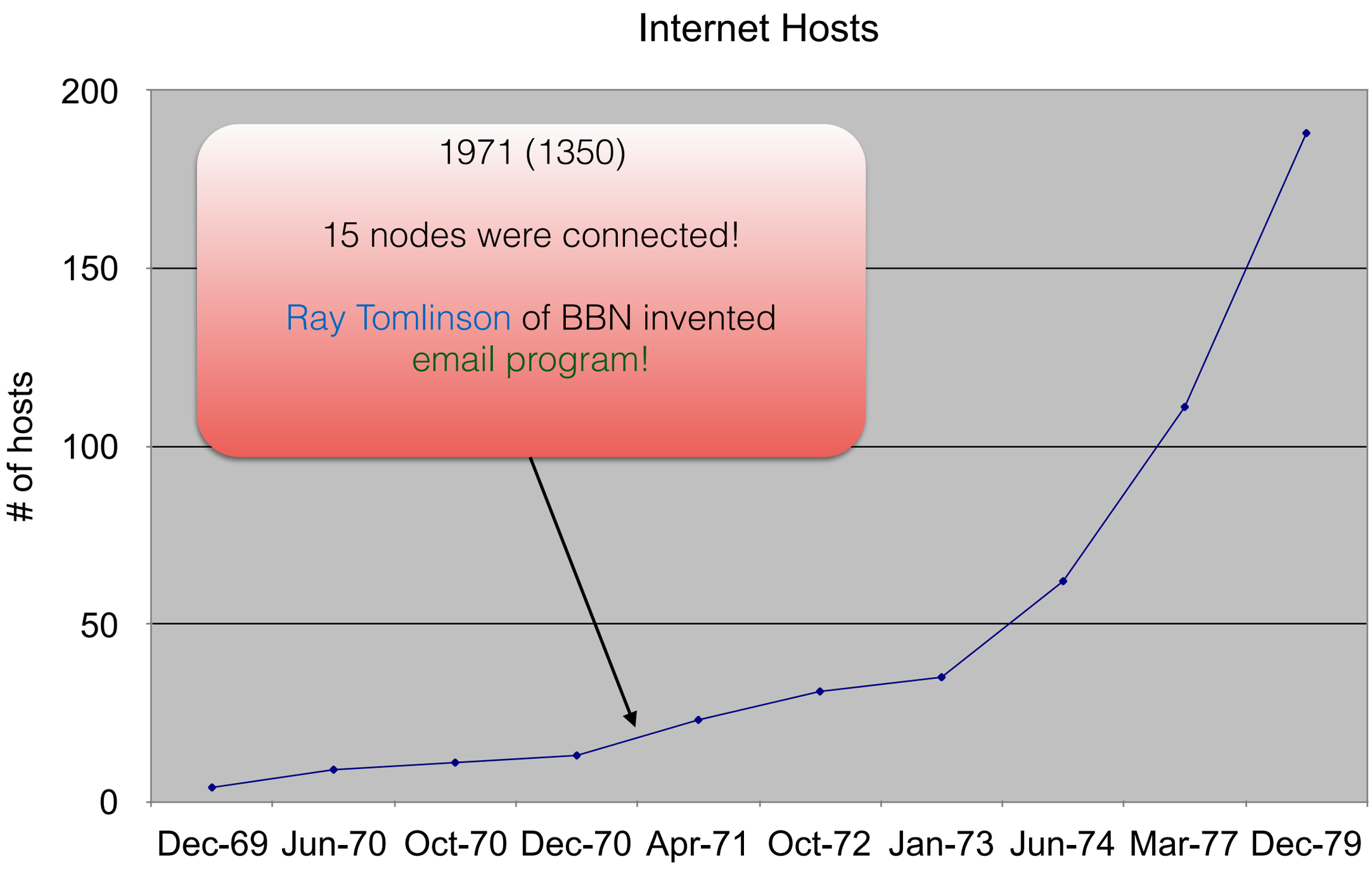

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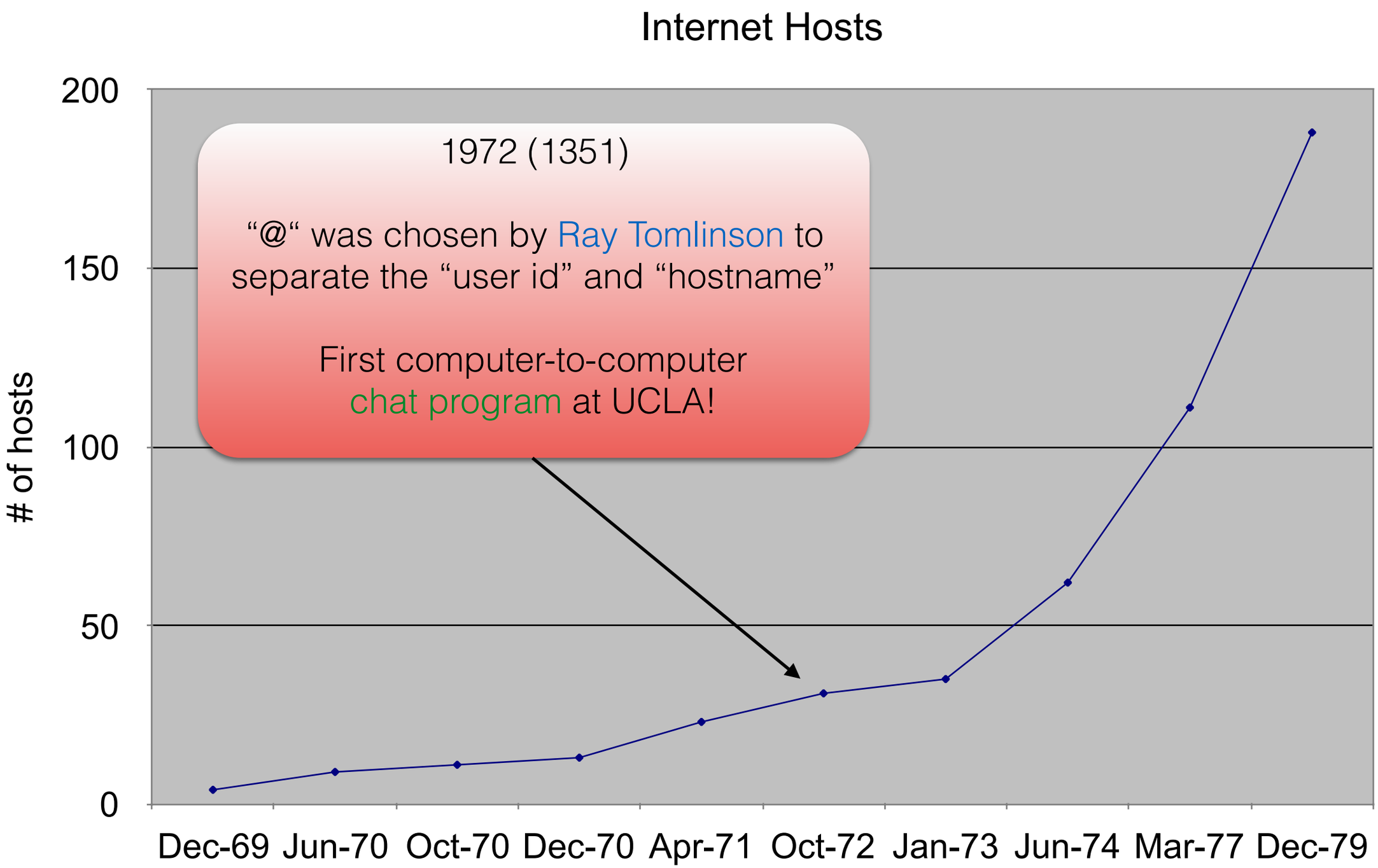

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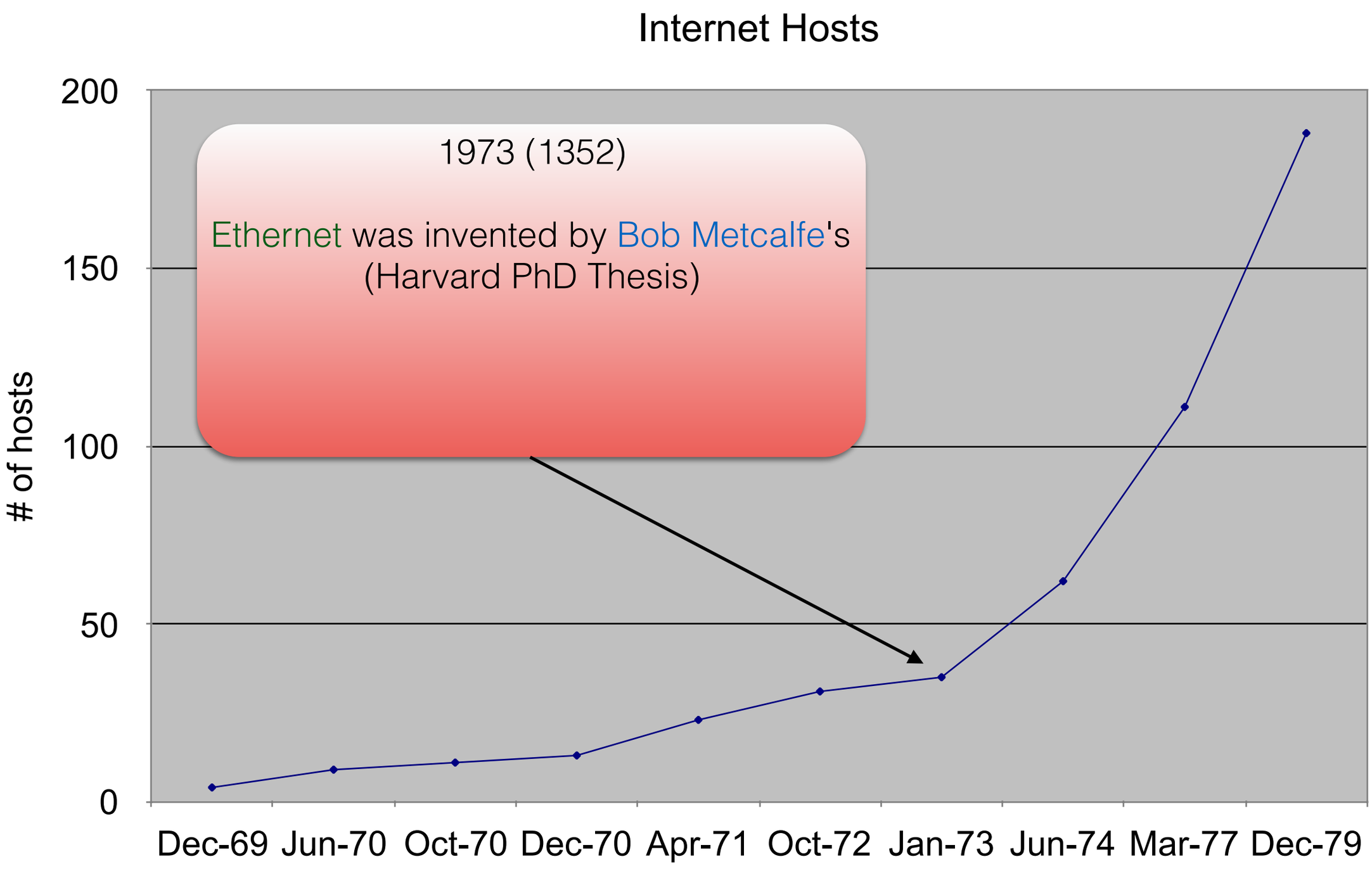

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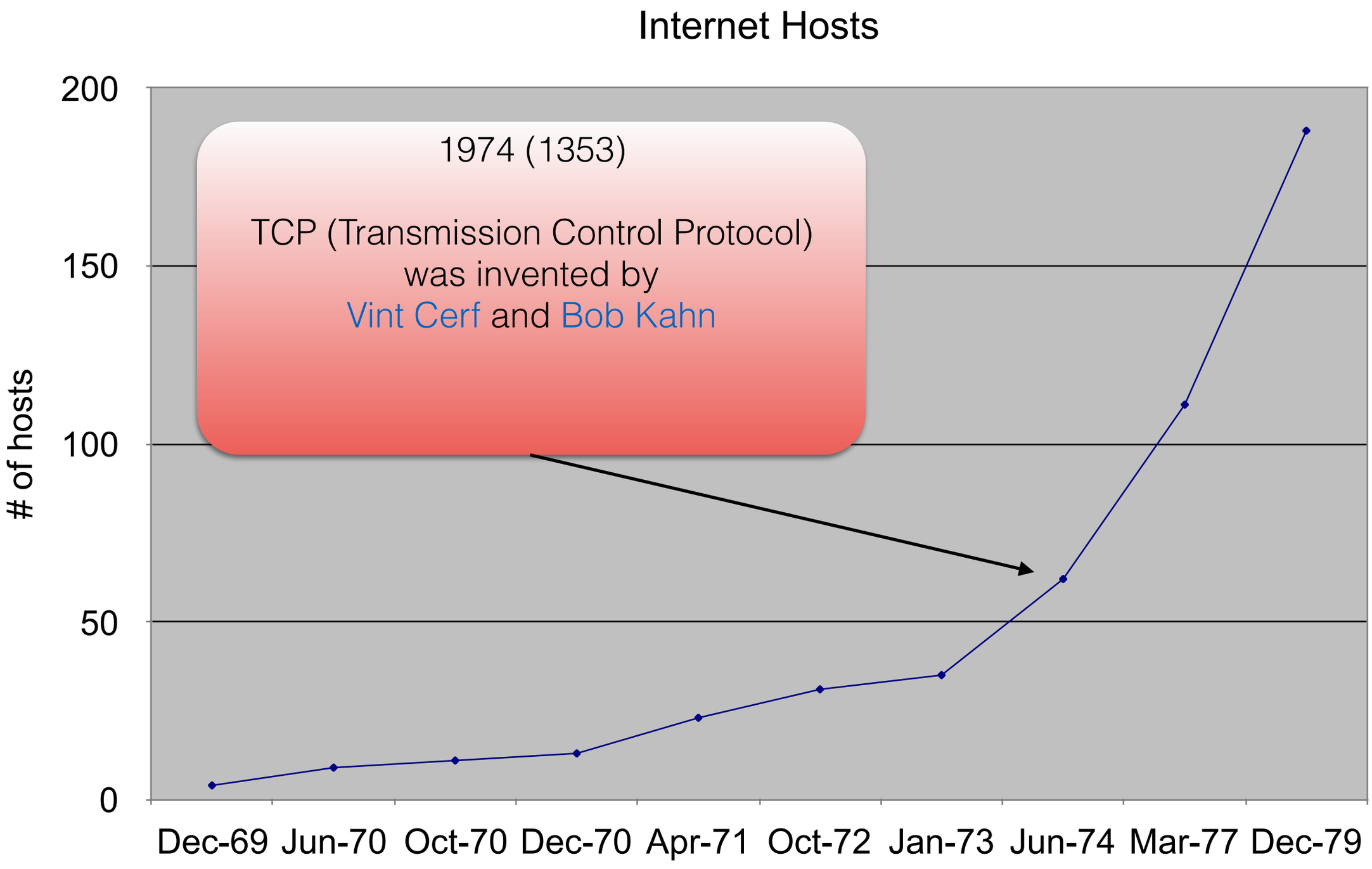

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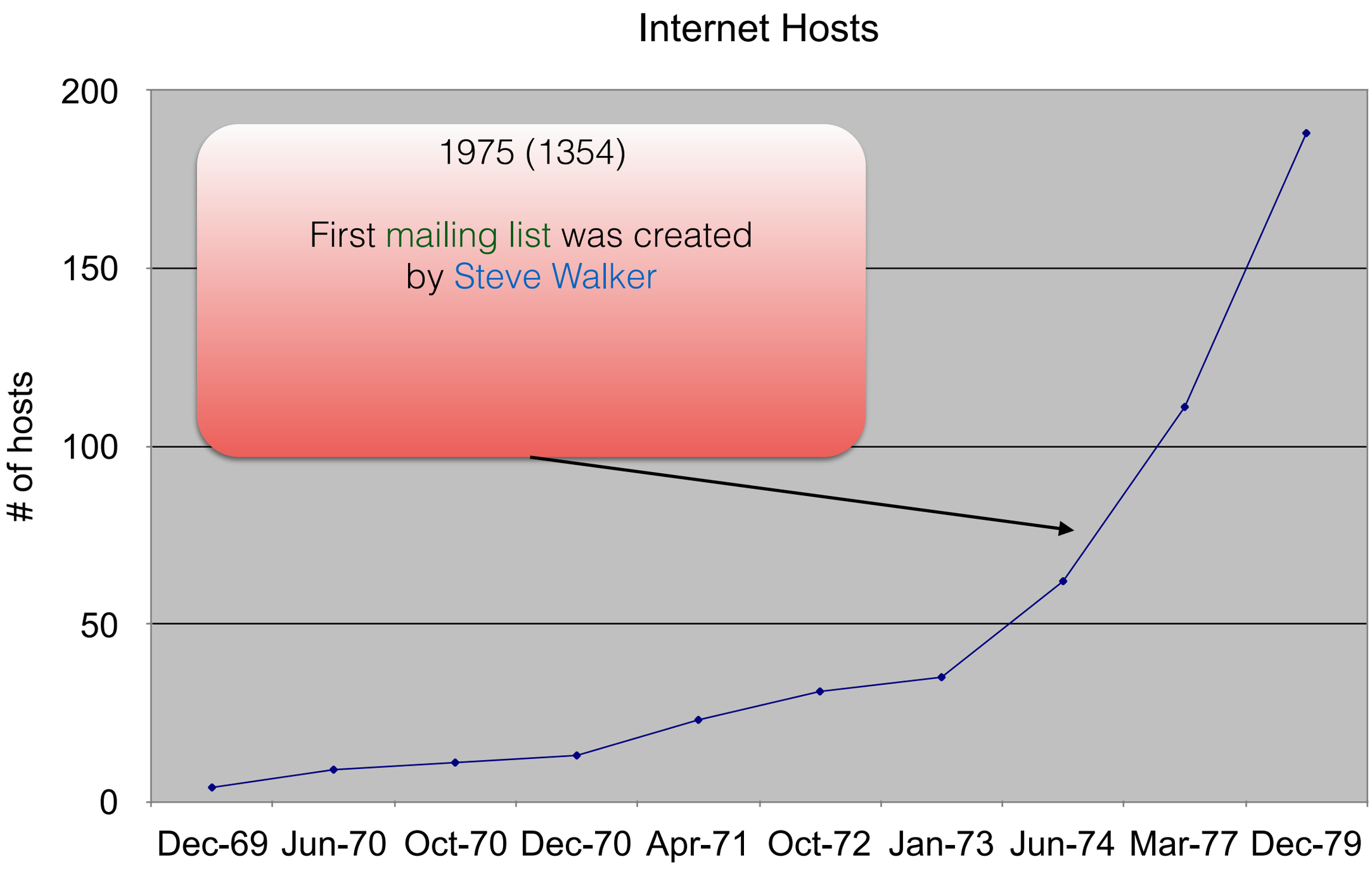

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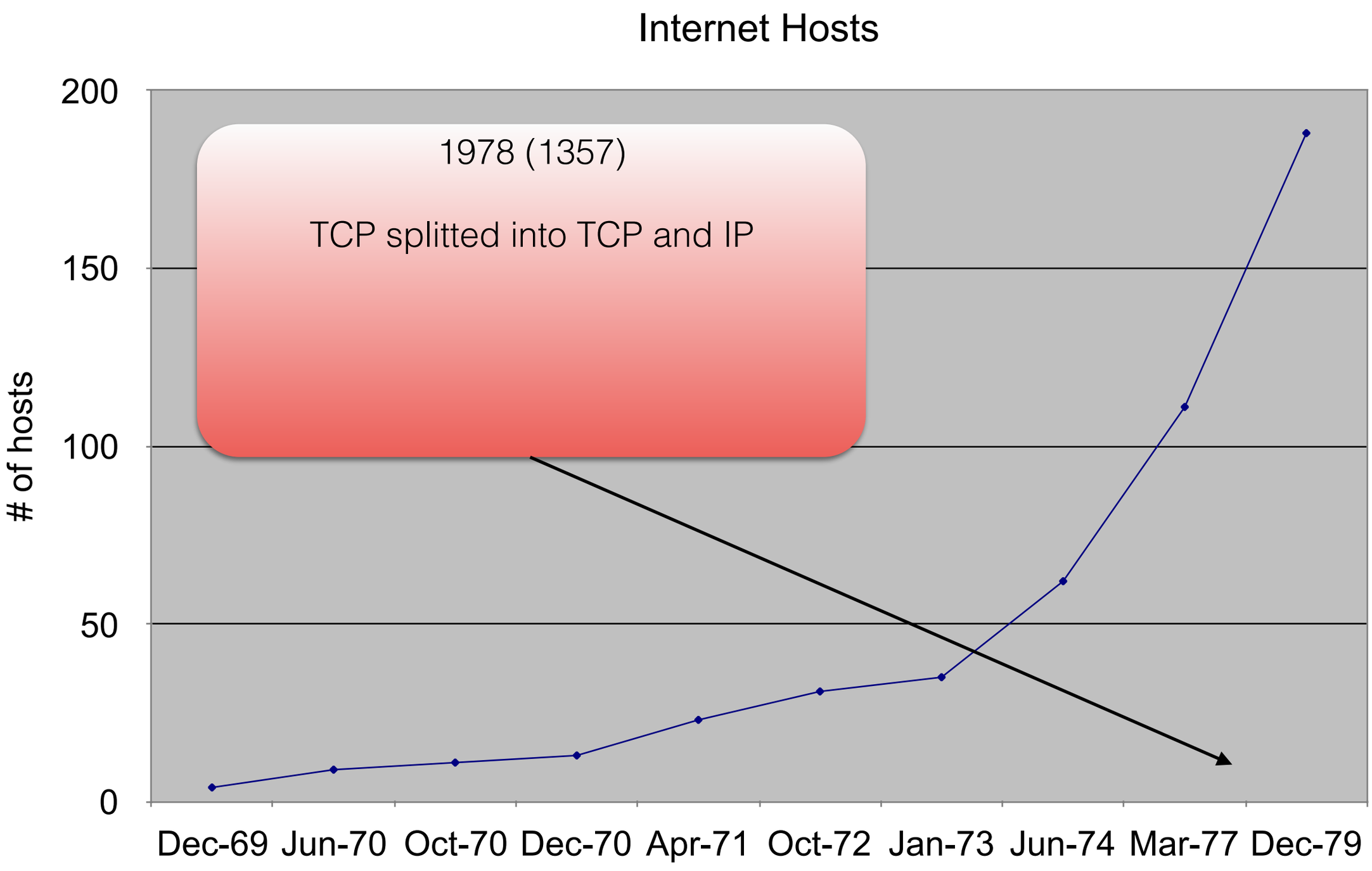

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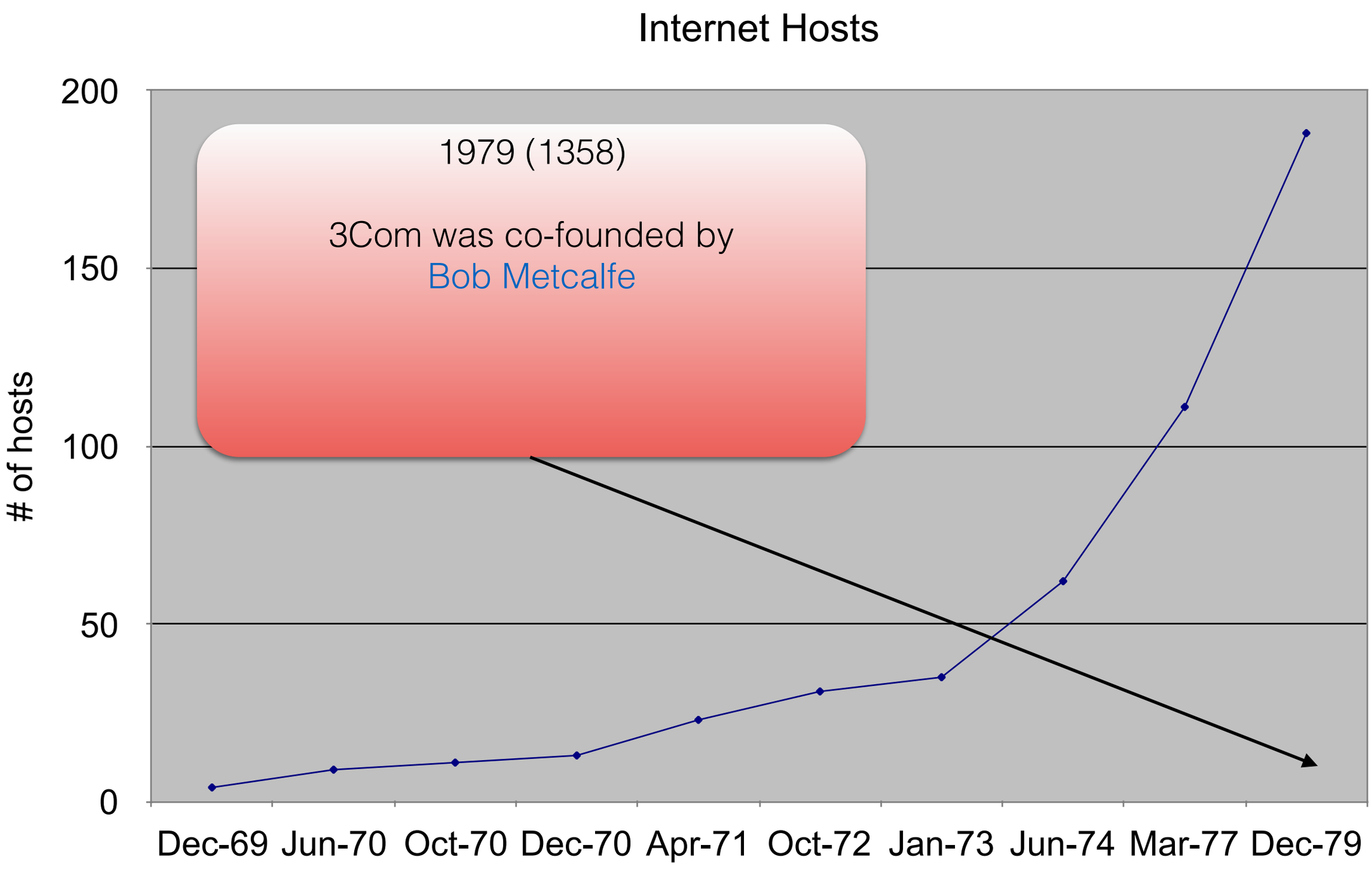

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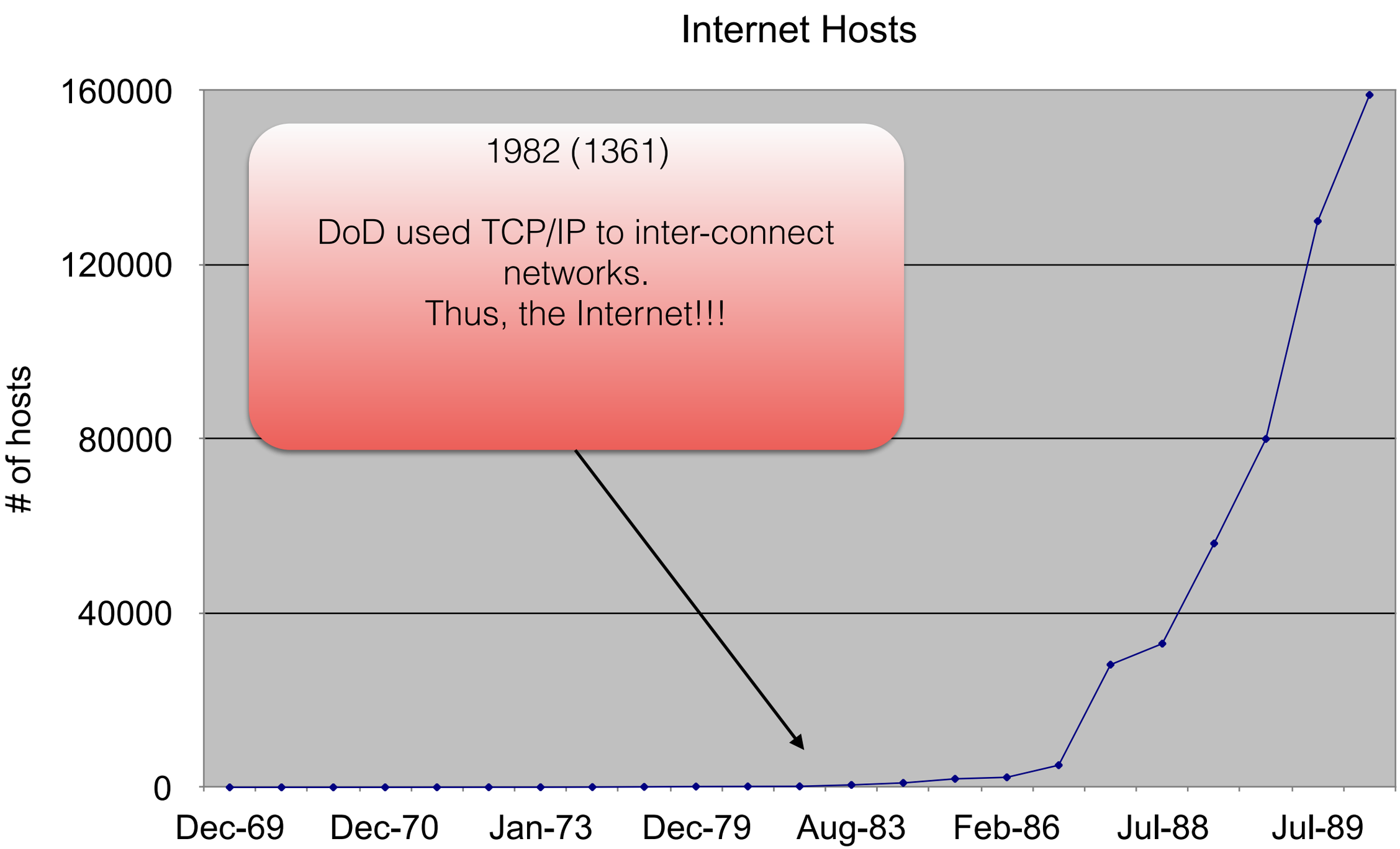

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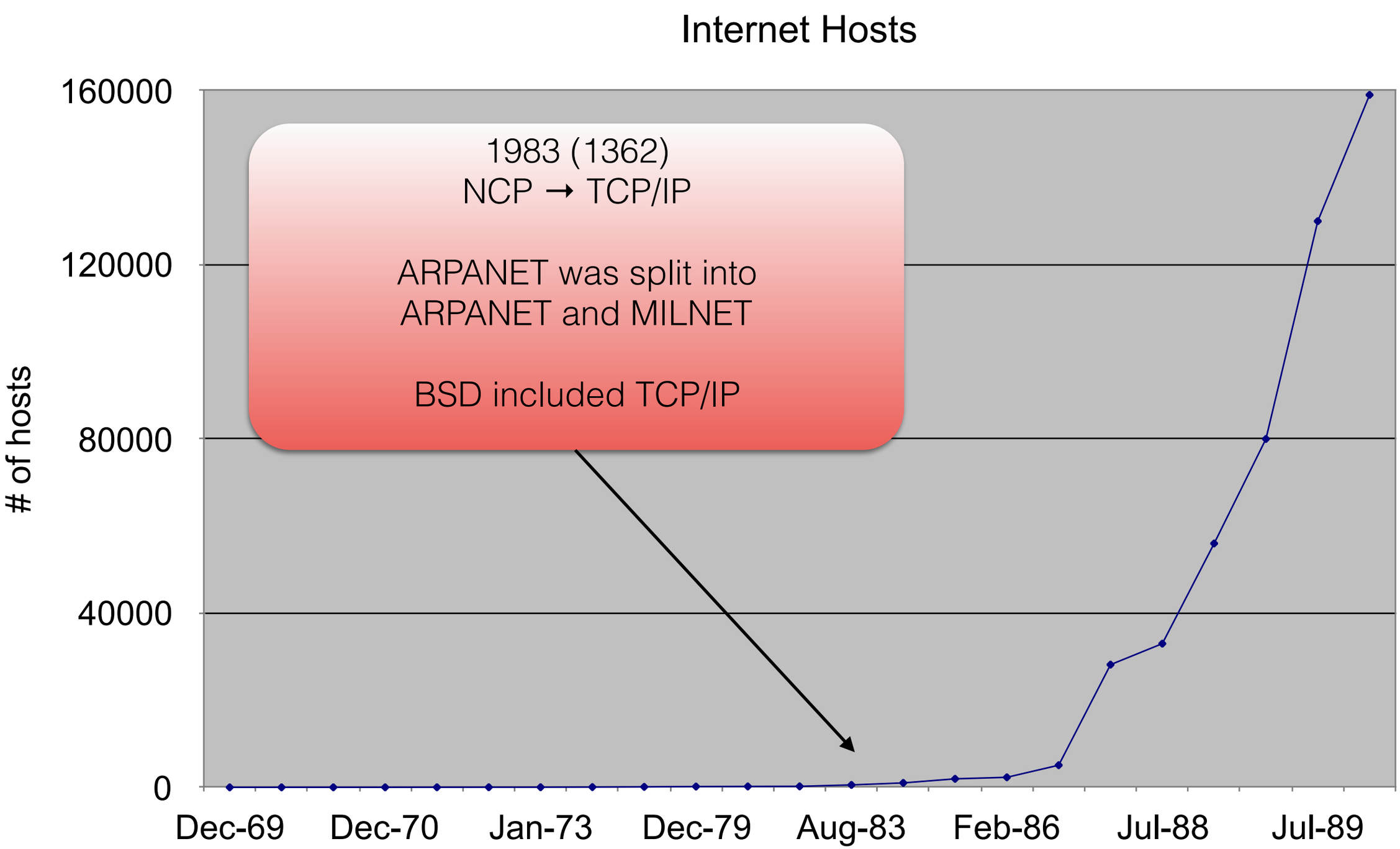

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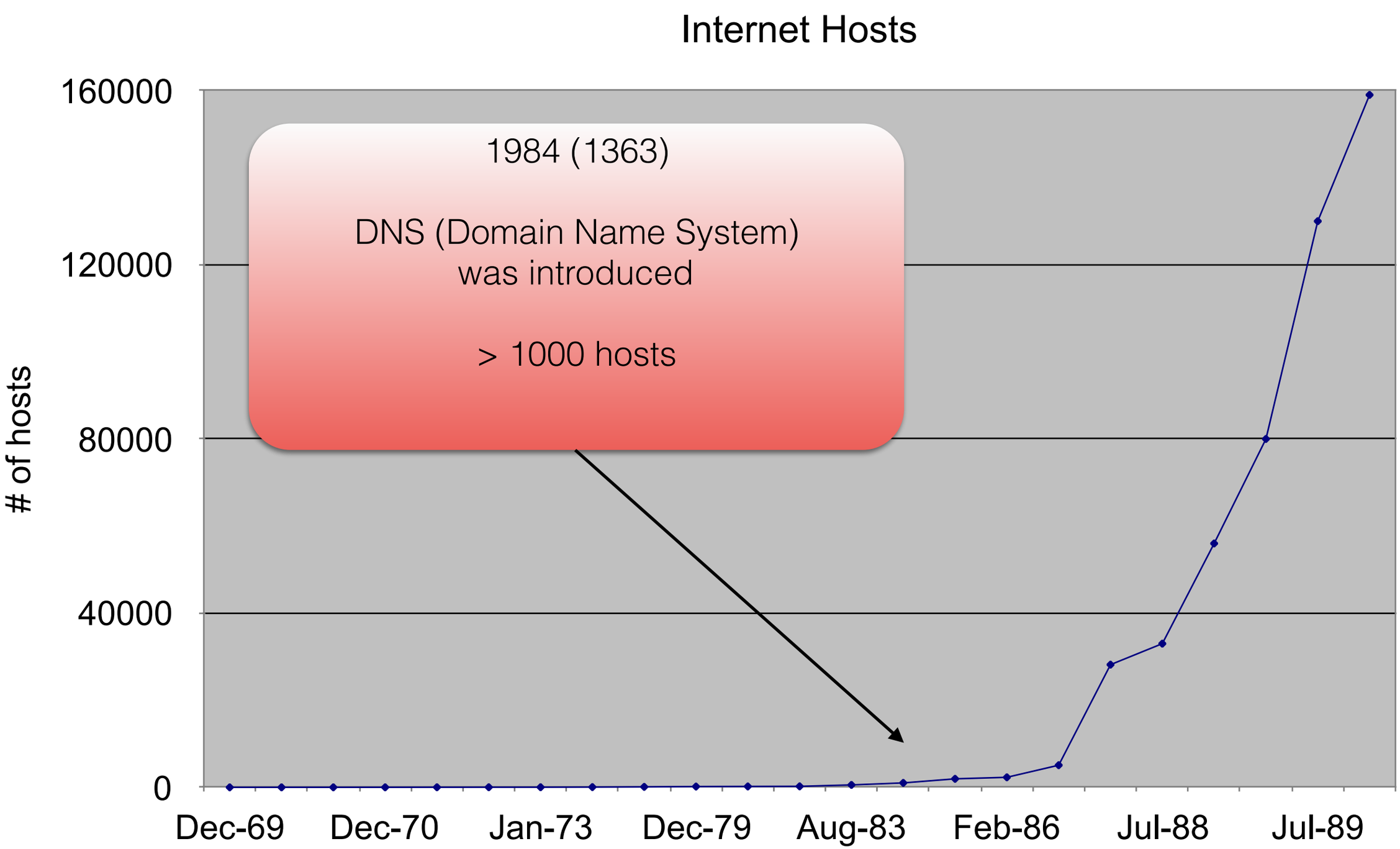

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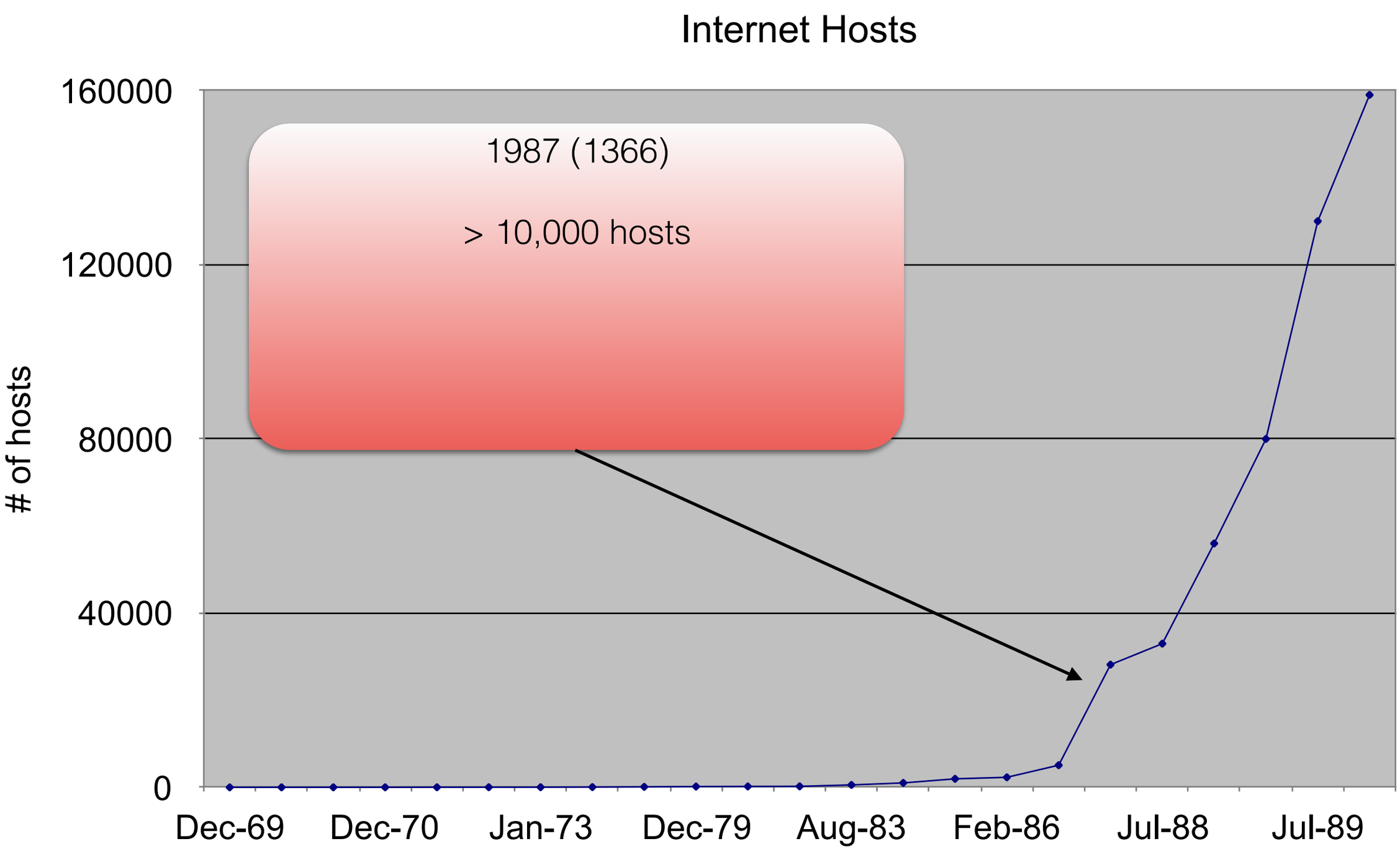

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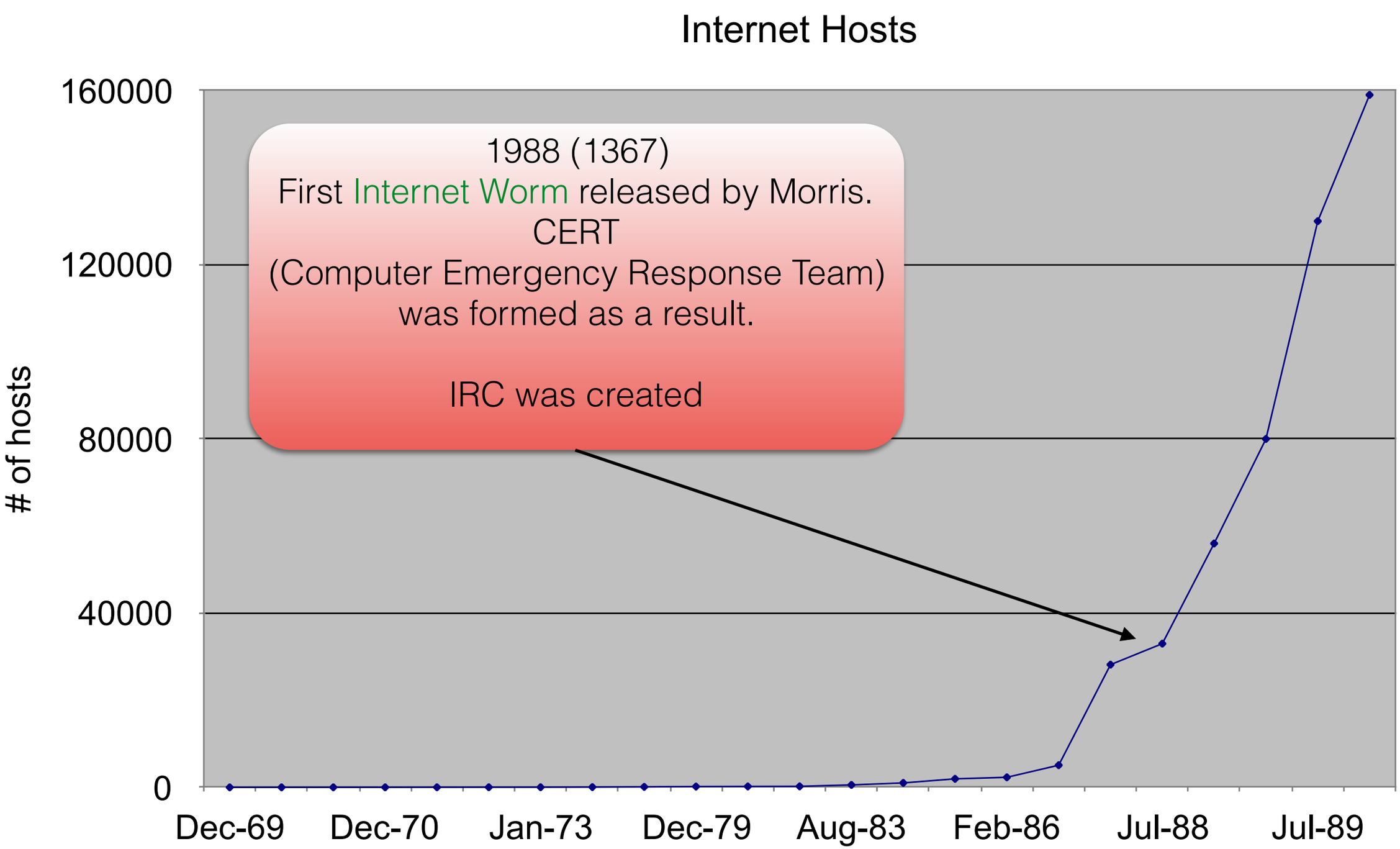

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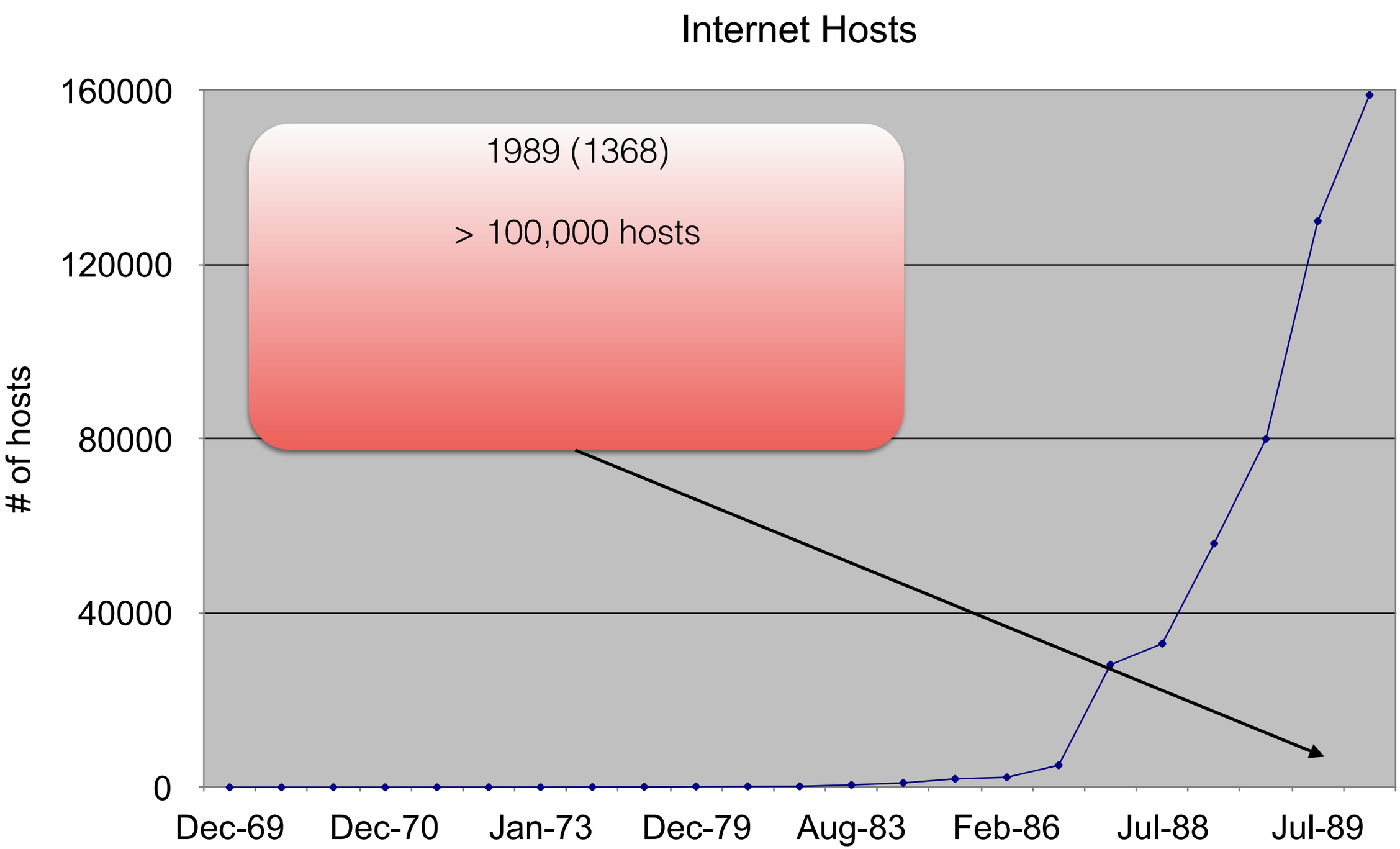

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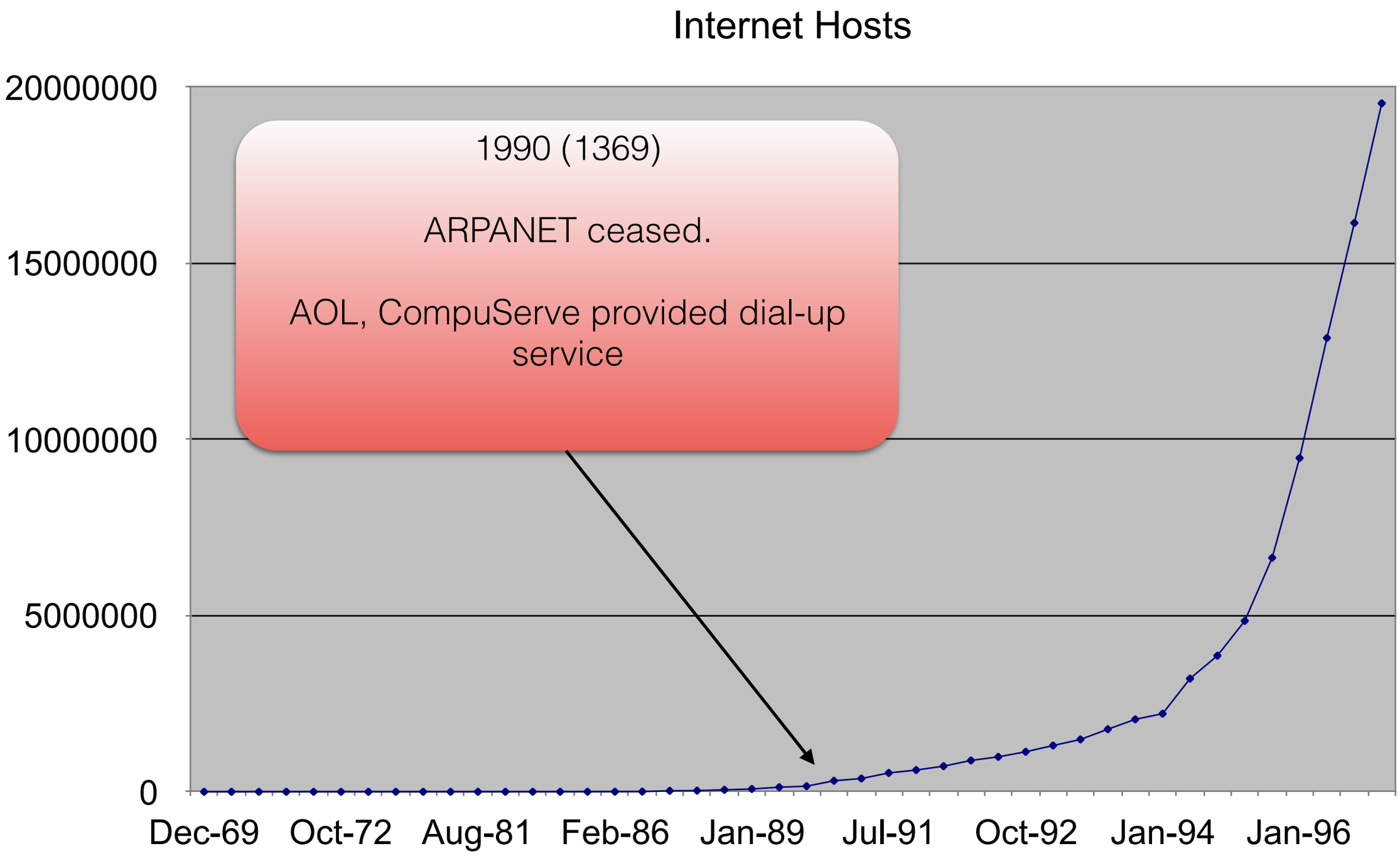

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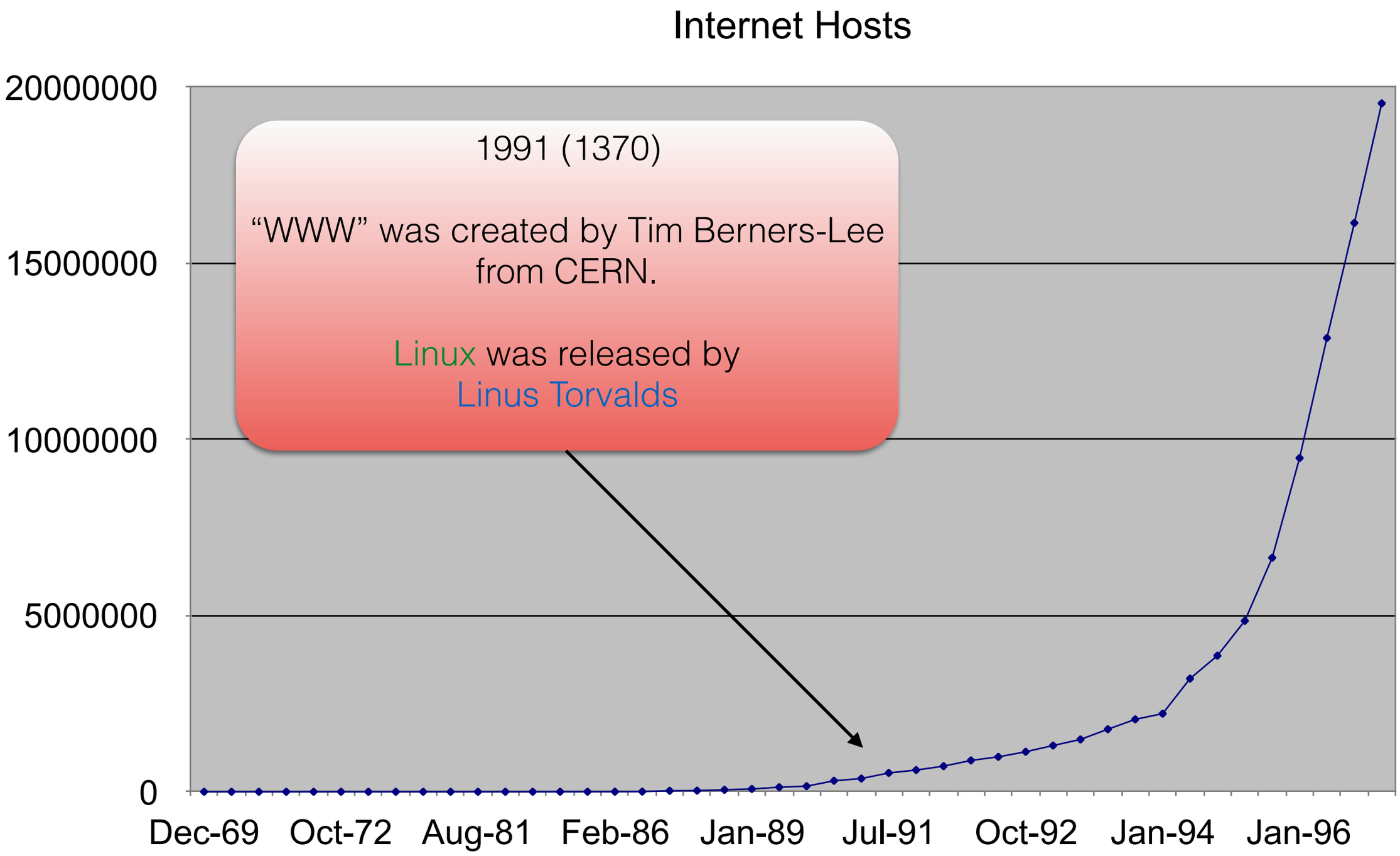

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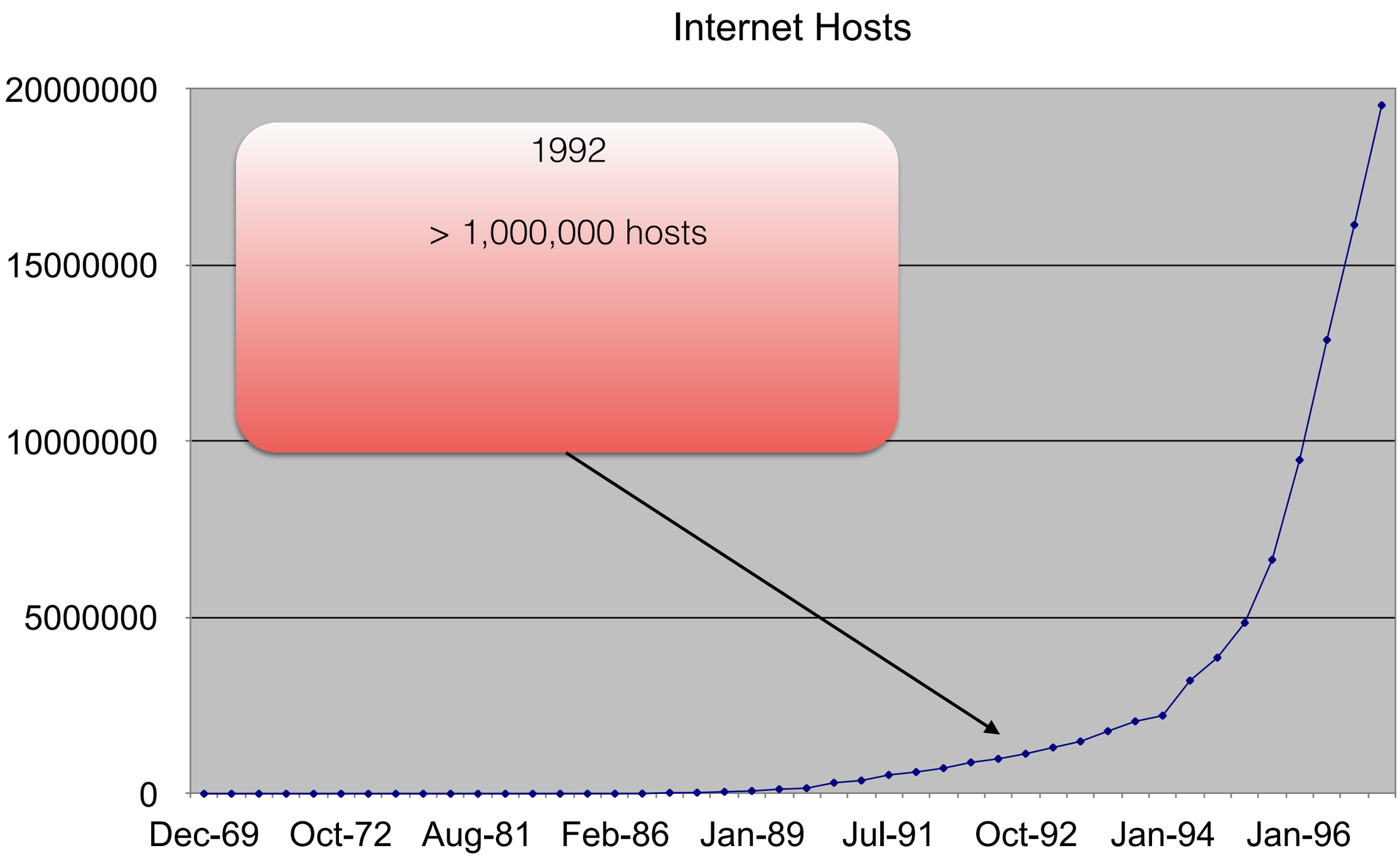

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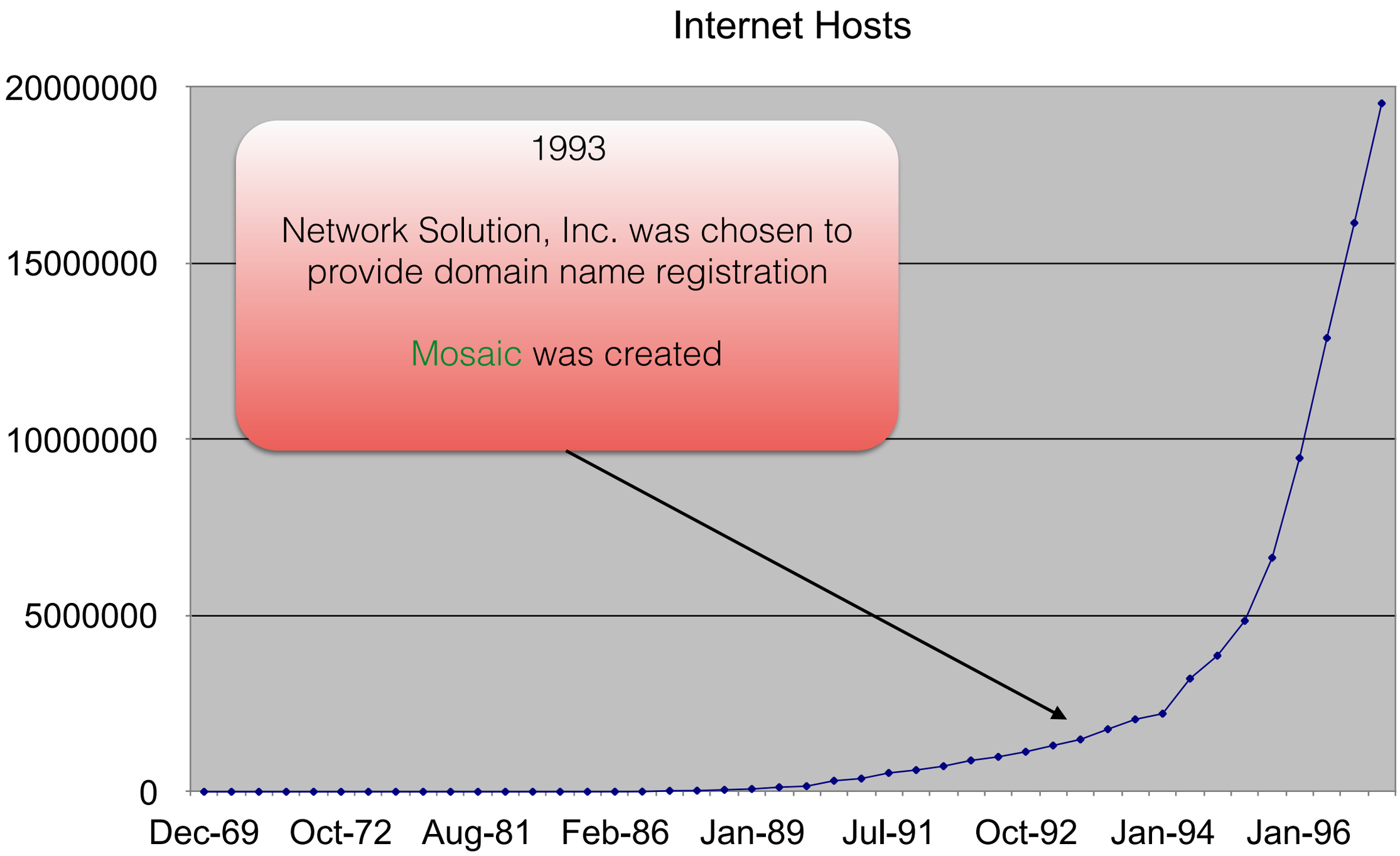

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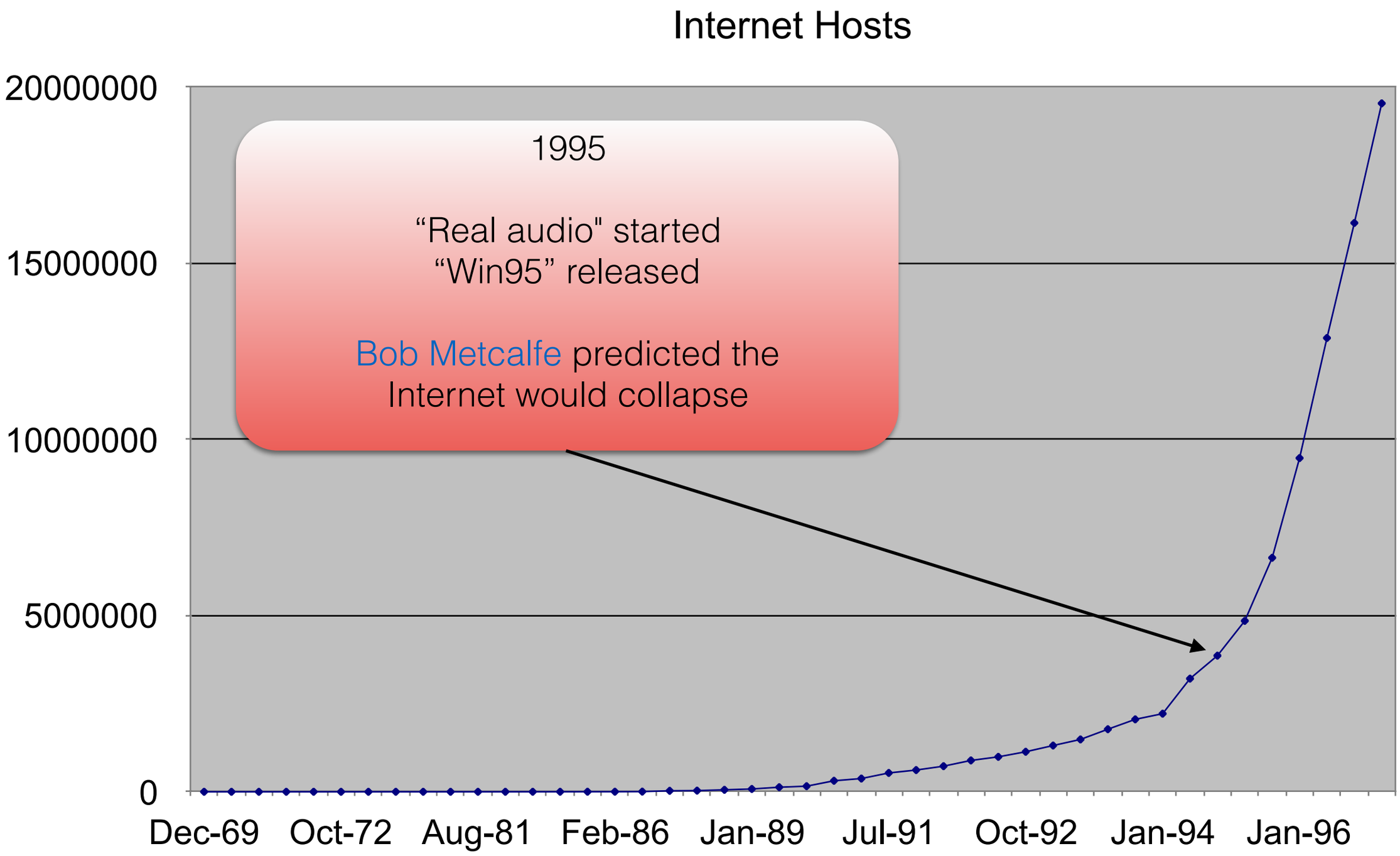

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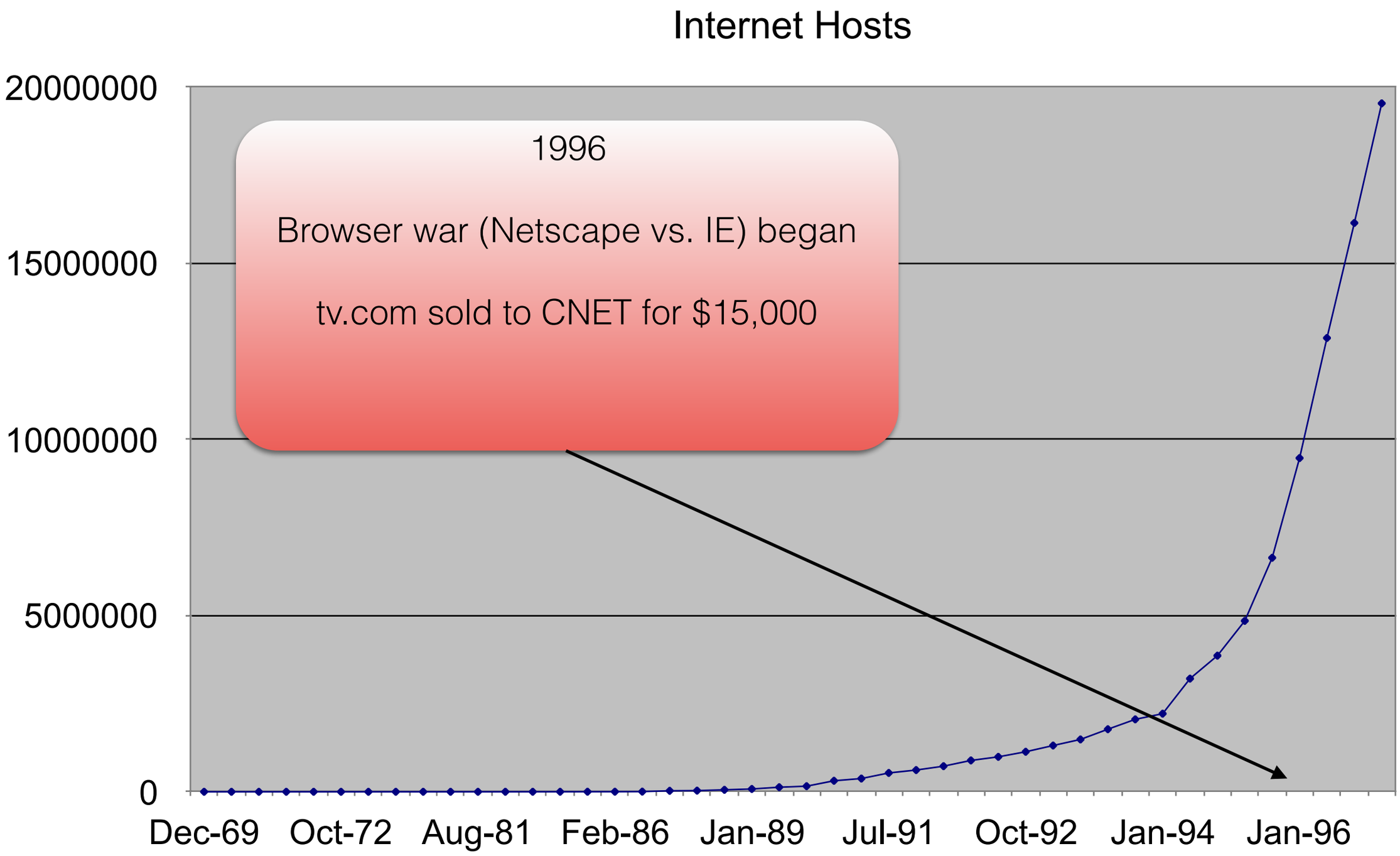


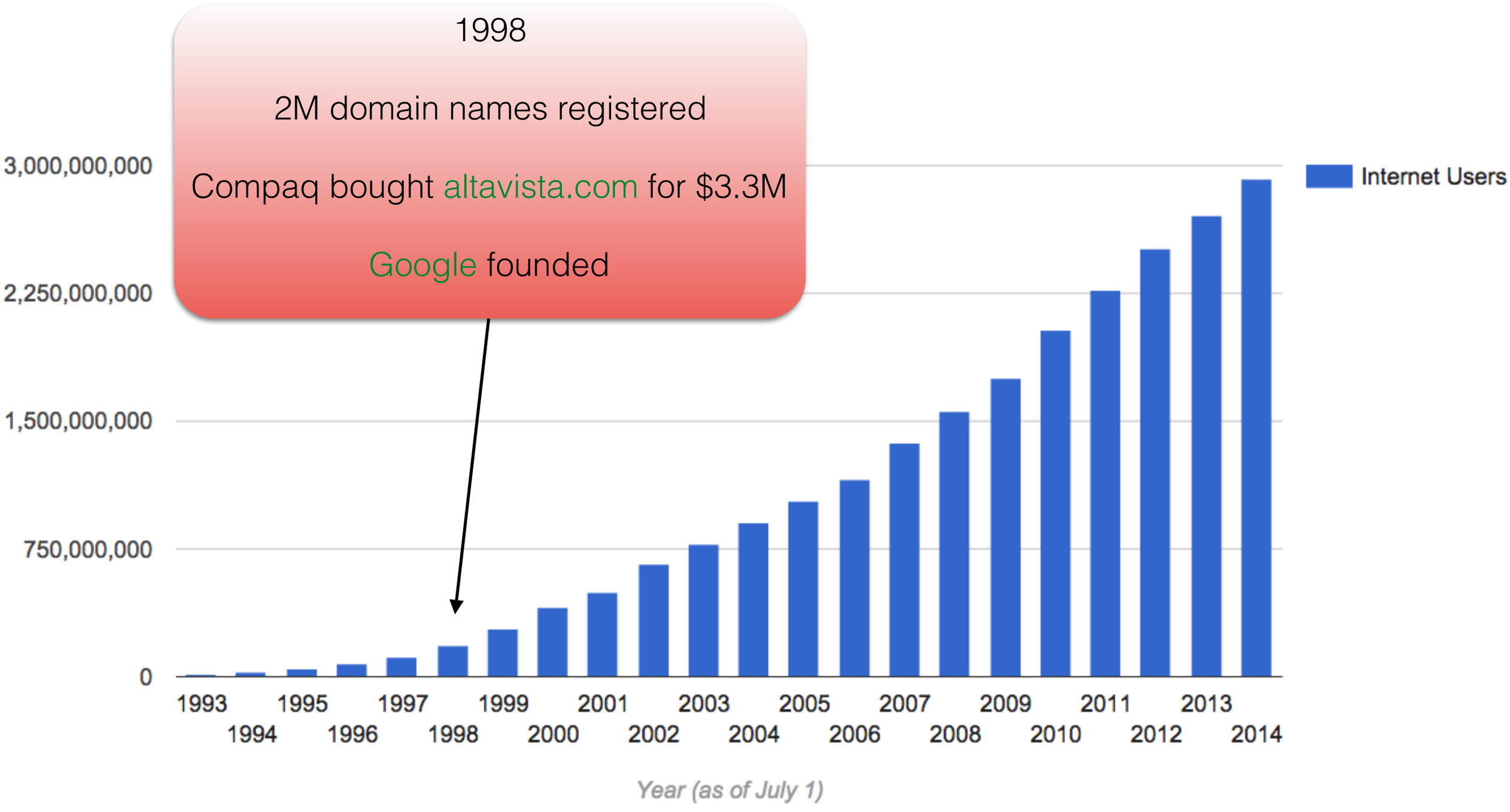
A Fast-Forwarded History of Internet!

1998

2M domain names registered

Compaq bought altavista.com for $3.3M

Google founded



Source: http://www.internetlivestats.com/internet-users/

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1999

First online banking.

business.com sold for $7.5B.

Napster released

Source: http://www.internetlivestats.com/internet-users/

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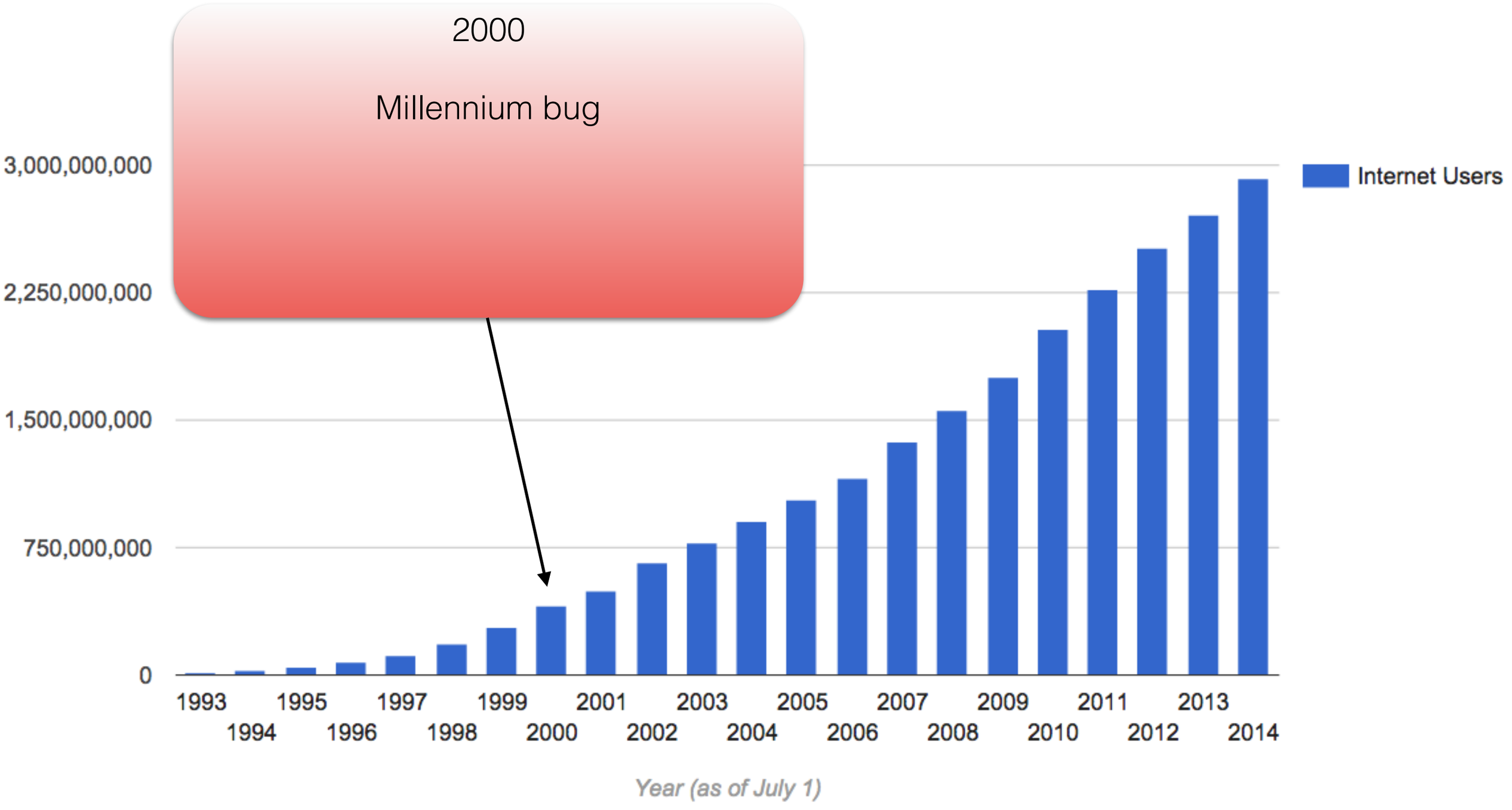

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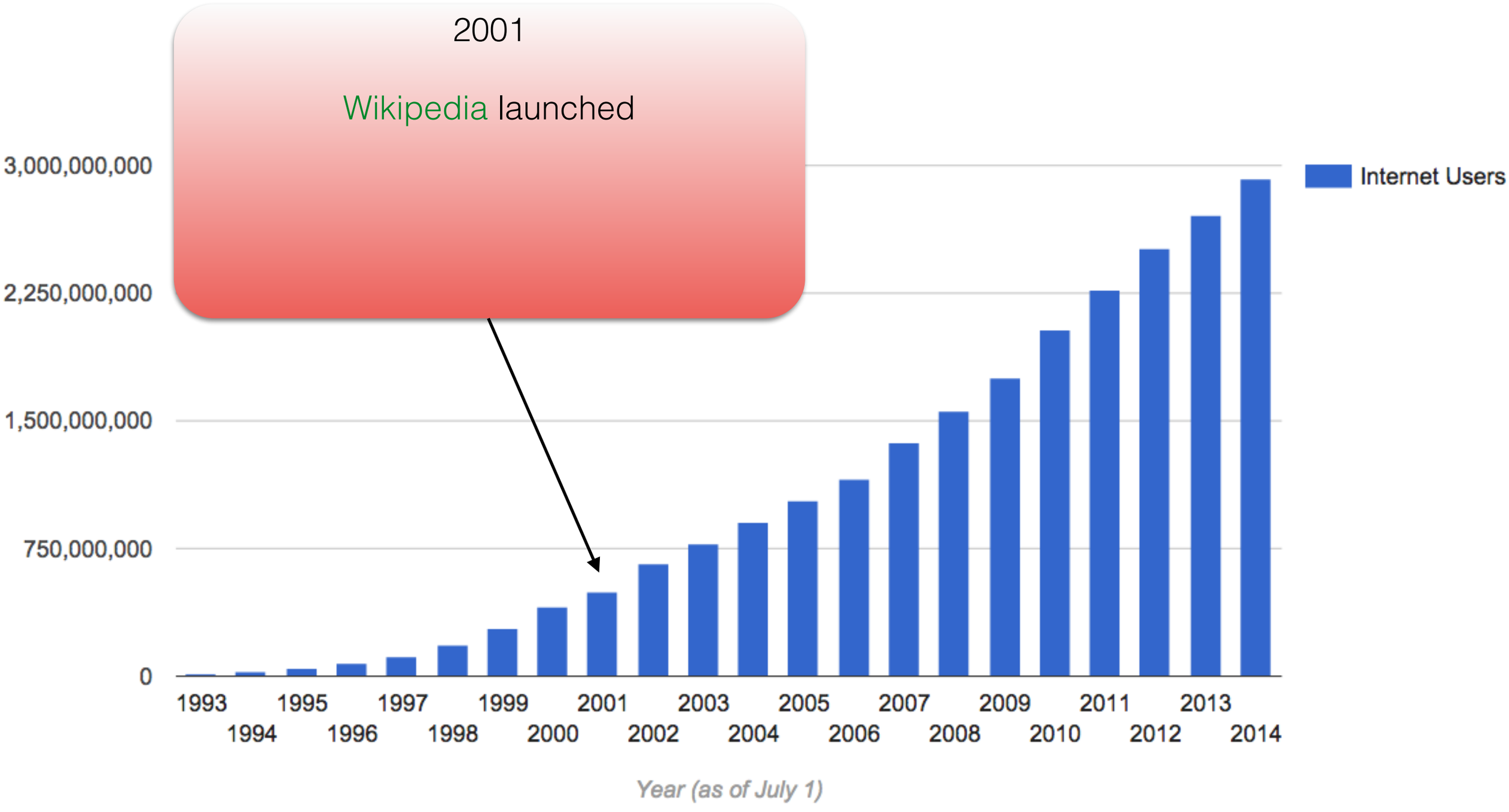

Source: http://www.internetlivestats.com/internet-users/

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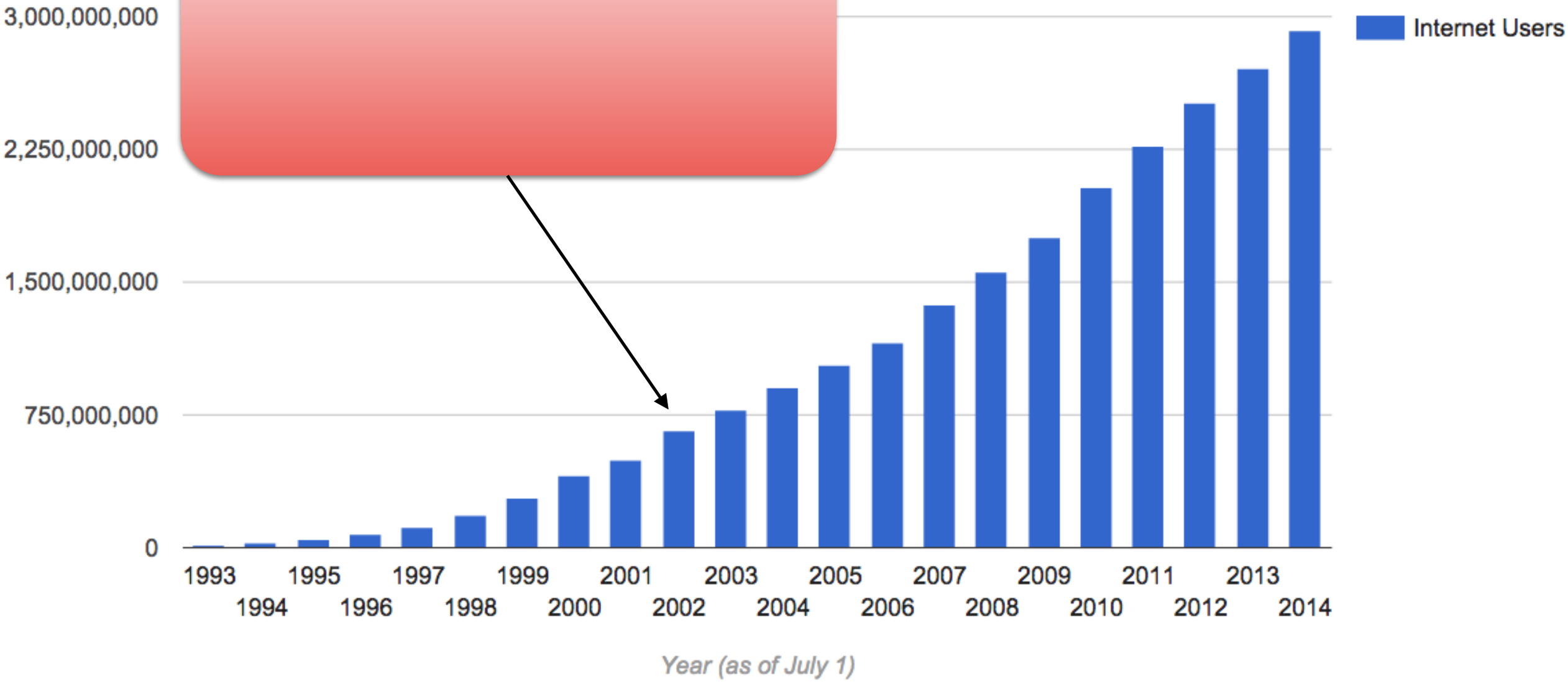
2002

Myspace launched



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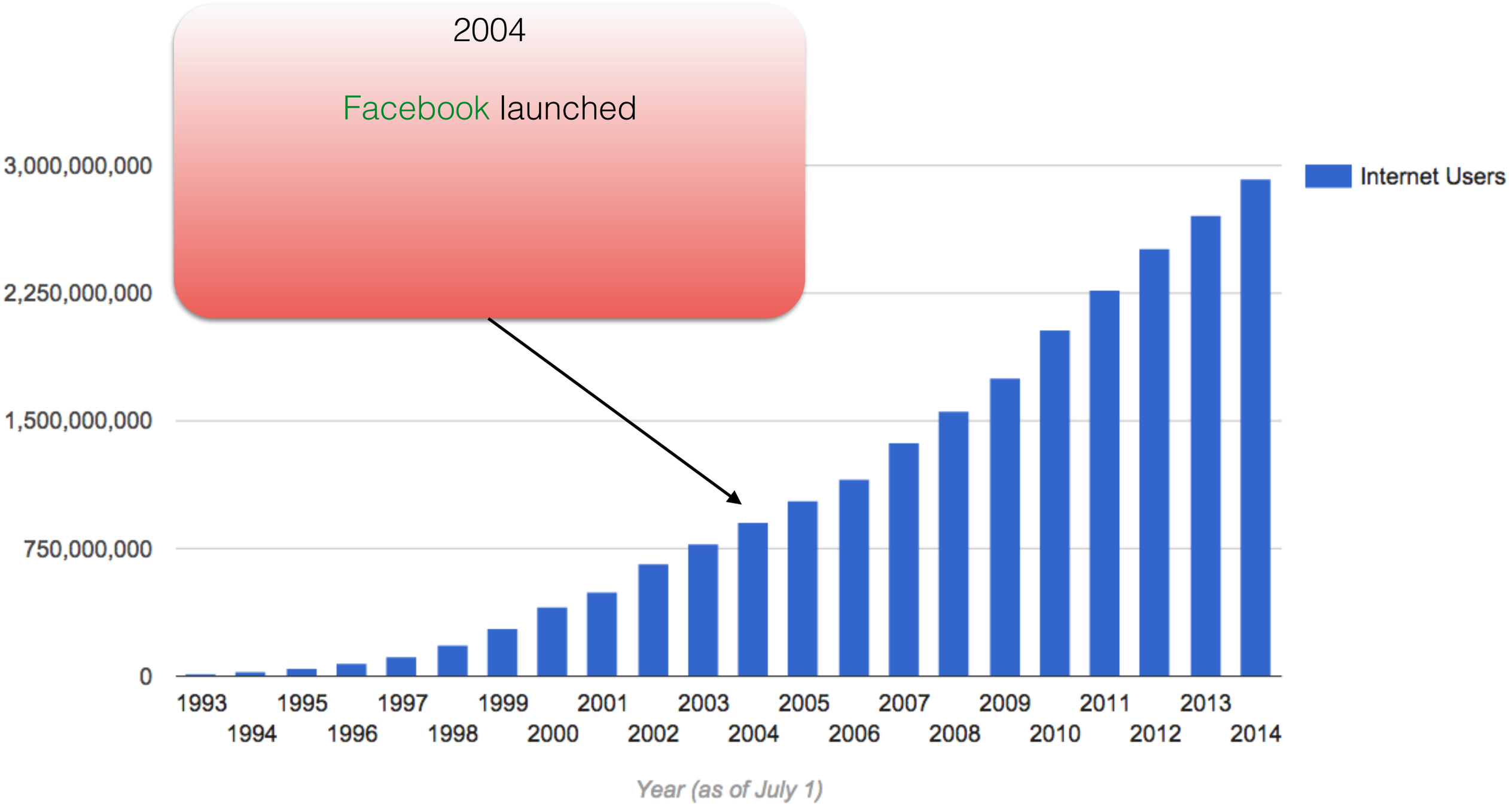


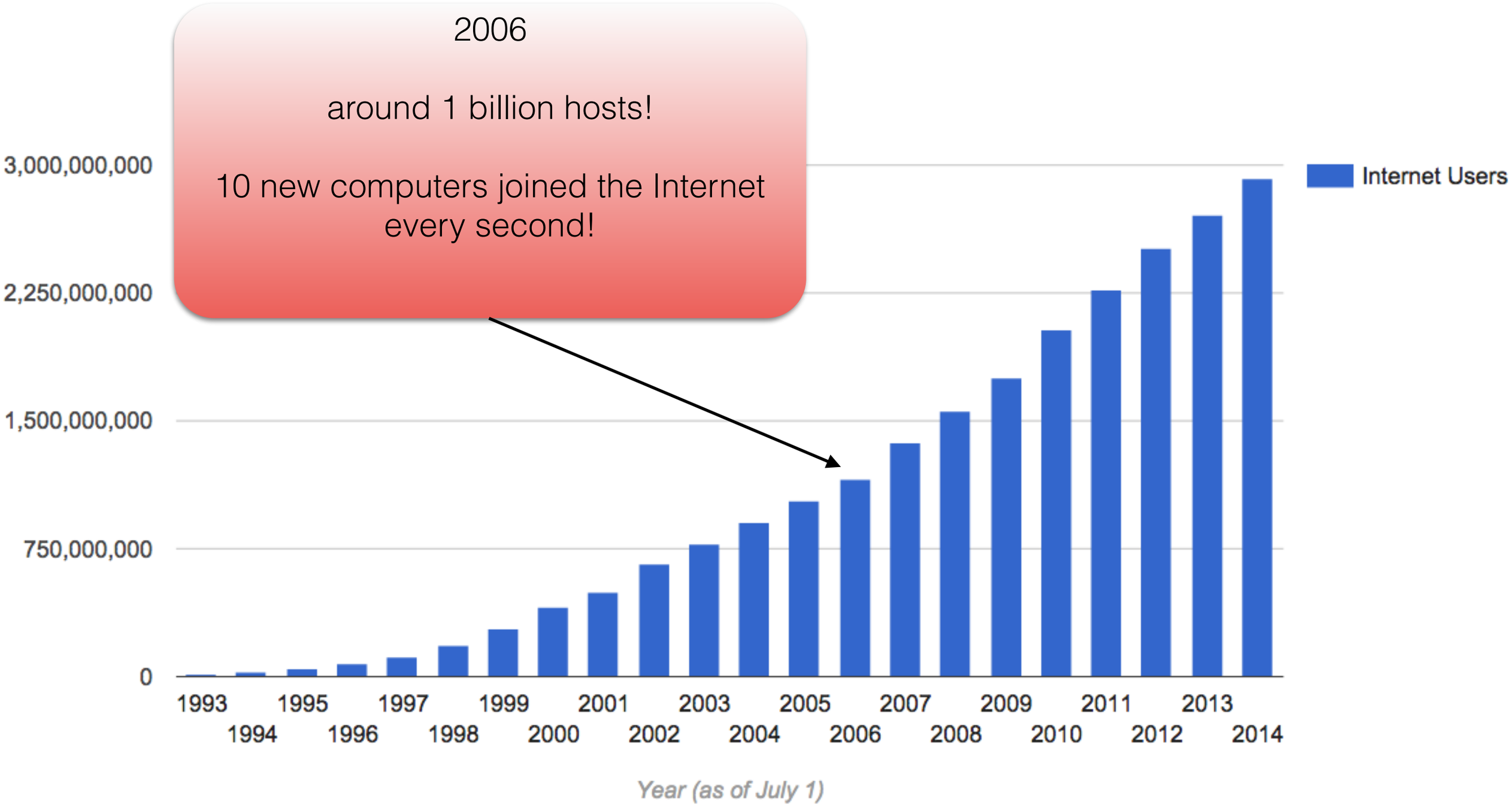
Source: http://www.internetlivestats.com/internet-users/

A Fast-Forwarded History of Internet!

2006

around 1 billion hosts!

10 new computers joined the Internet every second!



Source: http://www.internetlivestats.com/internet-users/

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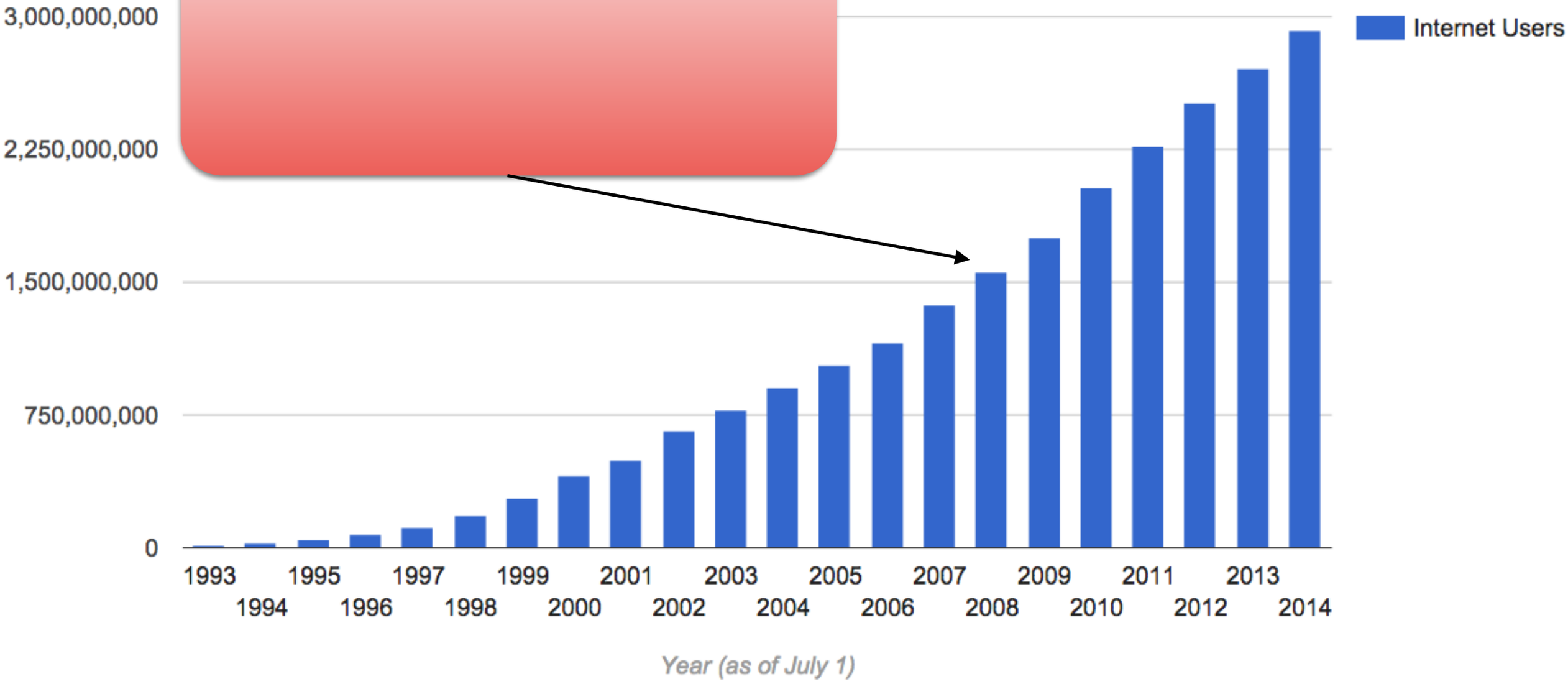
2008

Google valued at 138 billion dollars!!!

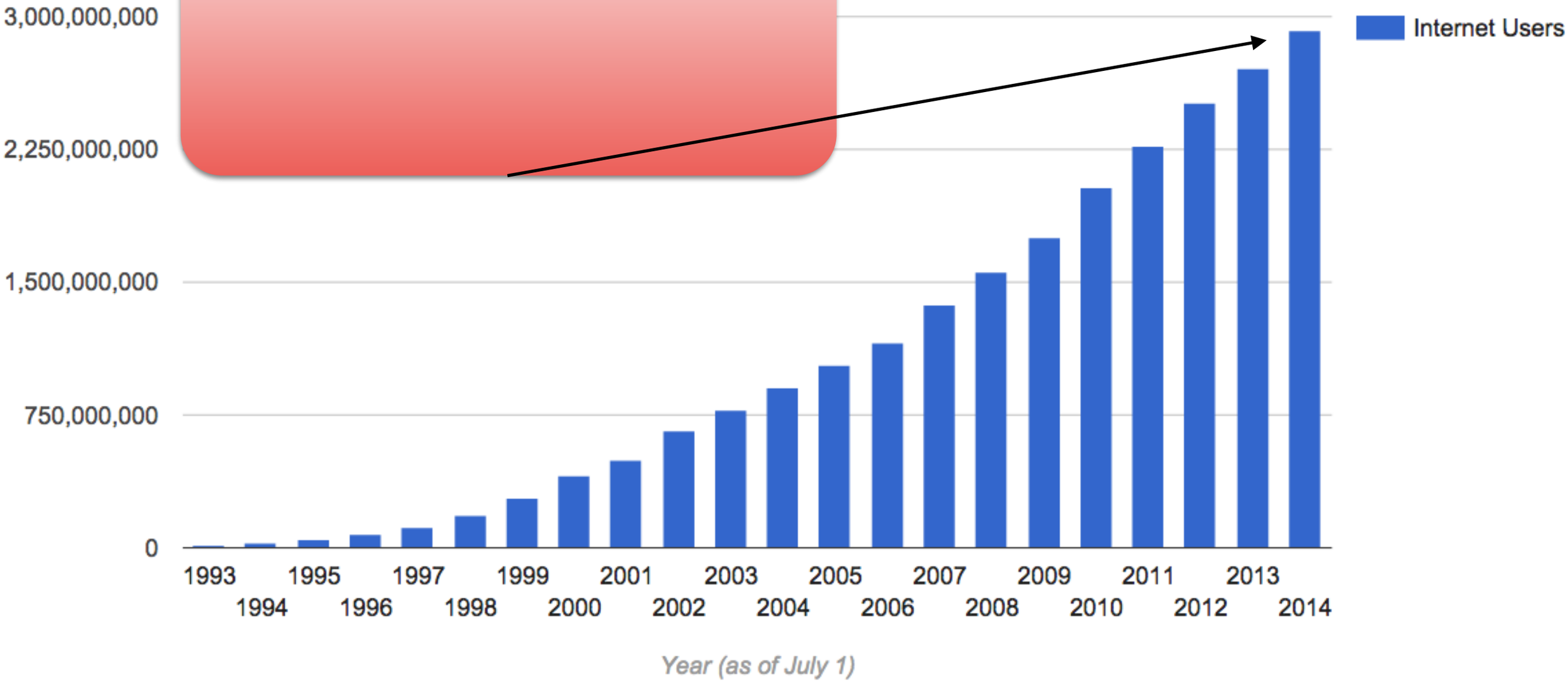


Source: http://www.internetlivestats.com/internet-users/

A Fast-Forwarded History of Internet!

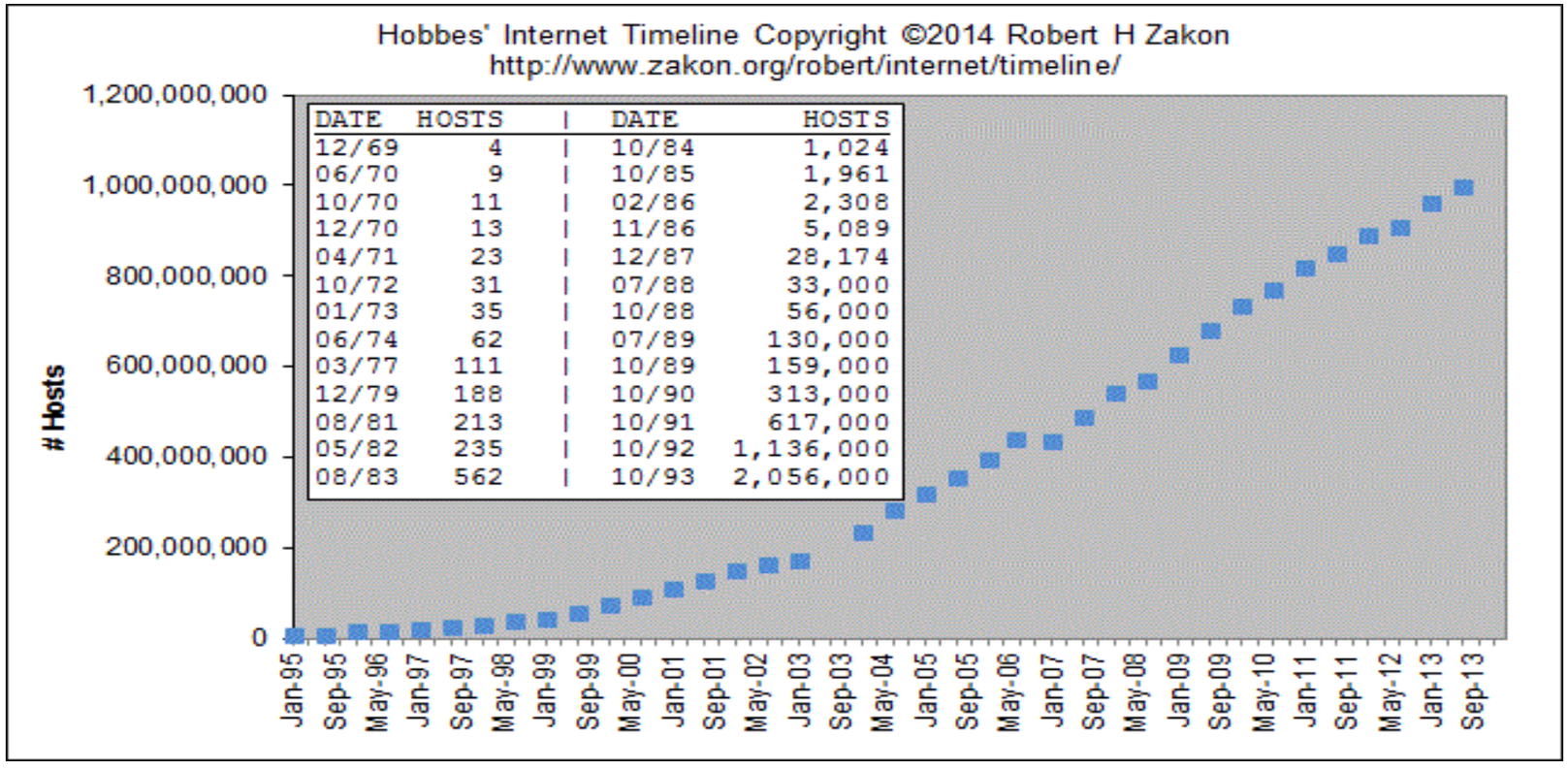
2014

Facebook worth 200 billion dollars!!!

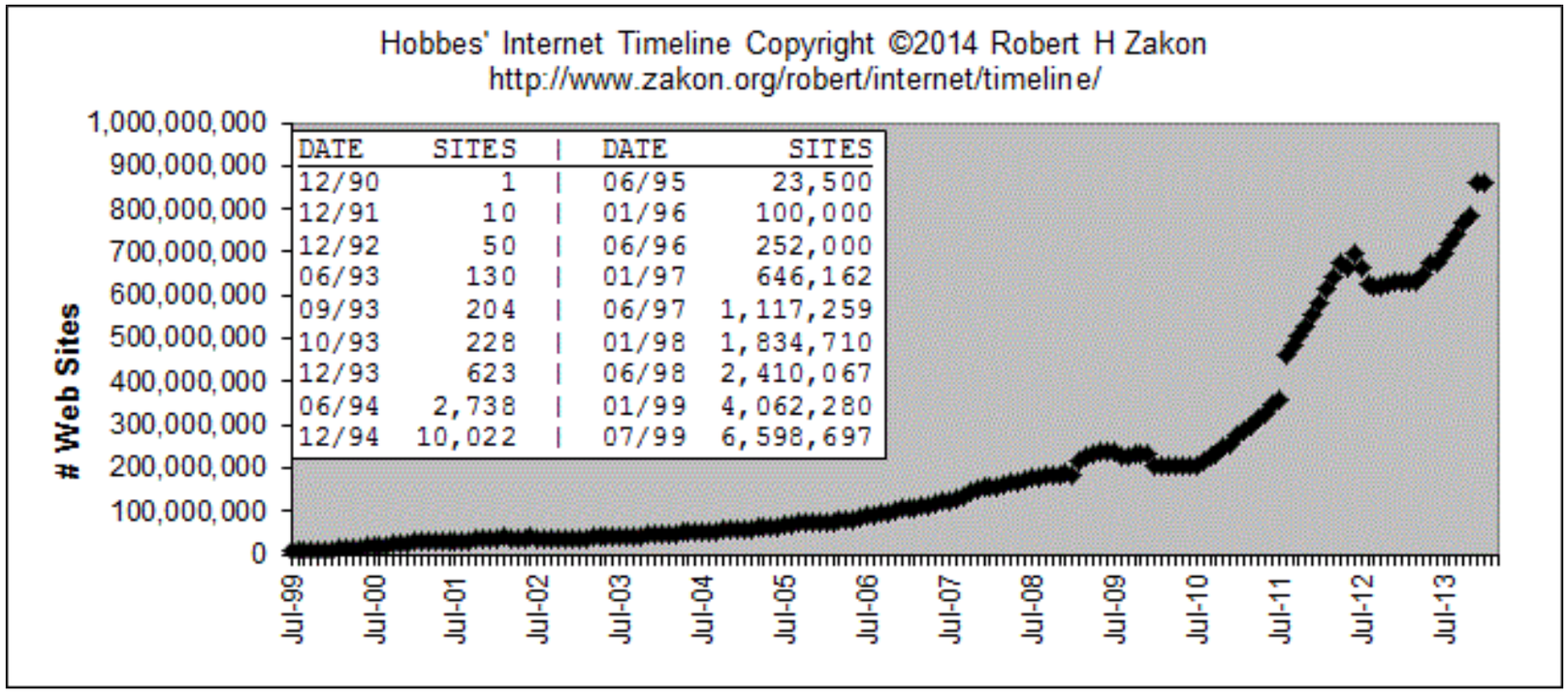


Source: http://www.internetlivestats.com/internet-users/

Internet Growth



DATE	HOSTS	DATE	HOSTS
12/69	4	10/84	1,024
06/70	9	10/85	1,961
10/70	11	02/86	2,308
12/70	13	11/86	5,089
04/71	23	12/87	28,174
10/72	31	07/88	33,000
01/73	35	10/88	56,000
06/74	62	07/89	130,000
03/77	111	10/89	159,000
12/79	188	10/90	313,000
08/81	213	10/91	617,000
05/82	235	10/92	1,136,000
08/83	562	10/93	2,056,000



DATE	SITES	DATE	SITES
12/90	1	06/95	23,500
12/91	10	01/96	100,000
12/92	50	06/96	252,000
06/93	130	01/97	646,162
09/93	204	06/97	1,117,259
10/93	228	01/98	1,834,710
12/93	623	06/98	2,410,067
06/94	2,738	01/99	4,062,280
12/94	10,022	07/99	6,598,697

List of Countries by Internet Usage (2014)

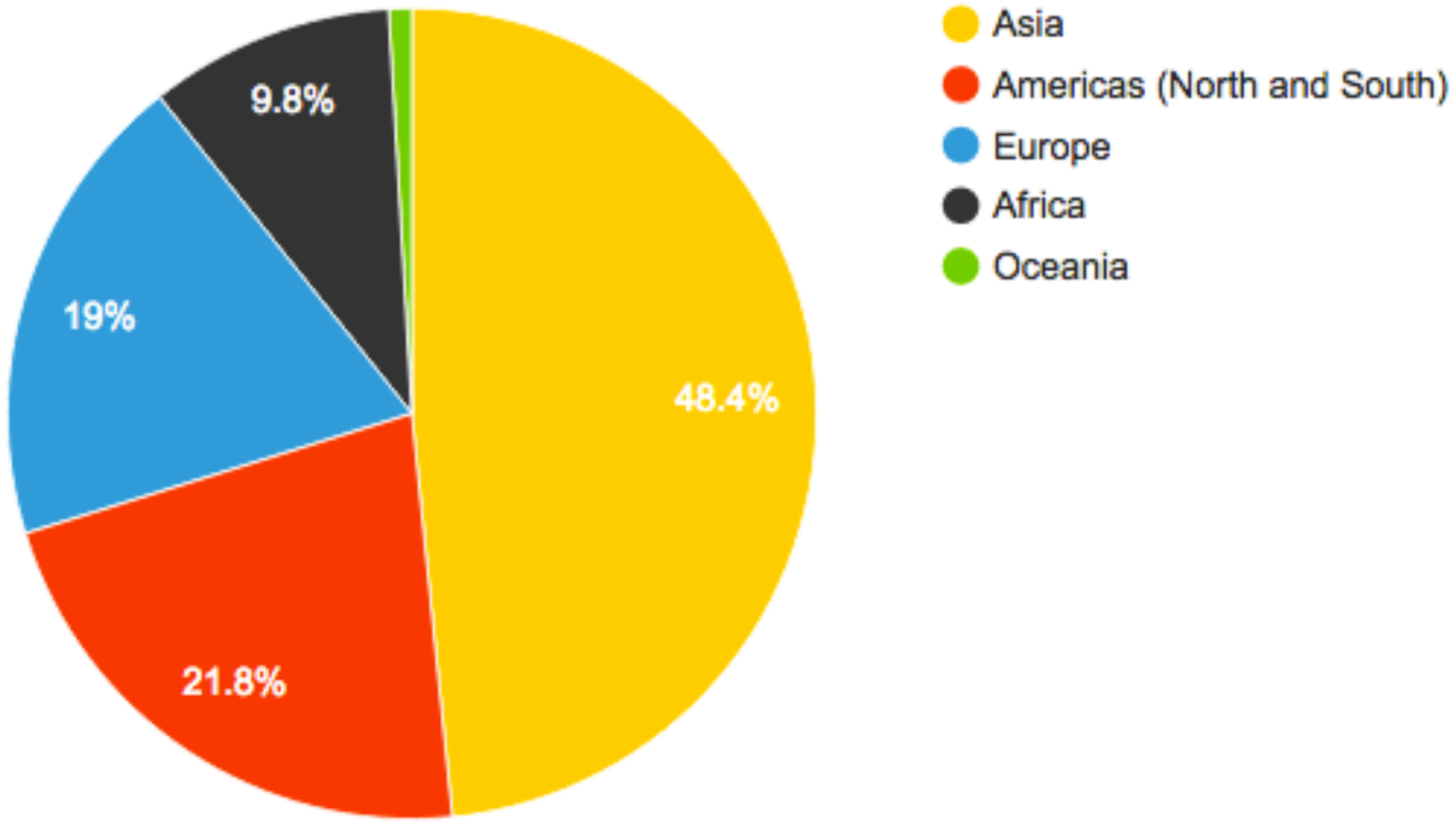
Rank	Country	Internet Users	1 Year Growth %	1 Year User Growth	Total Country Population	1 Yr Population Change (%)	Penetration (% of Pop. with Internet)	Country's share of World Population	Country's share of World Internet Users
1	China	641,601,070	4%	24,021,070	1,393,783,836	0.59%	46.03%	19.24%	21.97%
2	United States	279,834,232	7%	17,754,869	322,583,006	0.79%	86.75%	4.45%	9.58%
3	India	243,198,922	14%	29,859,598	1,267,401,849	1.22%	19.19%	17.50%	8.33%
4	Japan	109,252,912	8%	7,668,535	126,999,808	-0.11%	86.03%	1.75%	3.74%
5	Brazil	107,822,831	7%	6,884,333	202,033,670	0.83%	53.37%	2.79%	3.69%
6	Russia	84,437,793	10%	7,494,536	142,467,651	-0.26%	59.27%	1.97%	2.89%
7	Germany	71,727,551	2%	1,525,829	82,652,256	-0.09%	86.78%	1.14%	2.46%
8	Nigeria	67,101,452	16%	9,365,590	178,516,904	2.82%	37.59%	2.46%	2.30%
9	United Kingdom	57,075,826	3%	1,574,653	63,489,234	0.56%	89.90%	0.88%	1.95%
10	France	55,429,382	3%	1,521,369	64,641,279	0.54%	85.75%	0.89%	1.90%
11	Mexico	50,923,060	7%	3,423,153	123,799,215	1.20%	41.13%	1.71%	1.74%
12	South Korea	45,314,248	8%	3,440,213	49,512,026	0.51%	91.52%	0.68%	1.55%
13	Indonesia	42,258,824	9%	3,468,057	252,812,245	1.18%	16.72%	3.49%	1.45%
14	Egypt	40,311,562	10%	3,748,271	83,386,739	1.62%	48.34%	1.15%	1.38%
15	Viet Nam	39,772,424	9%	3,180,007	92,547,959	0.95%	42.97%	1.28%	1.36%
16	Philippines	39,470,845	10%	3,435,654	100,096,496	1.73%	39.43%	1.38%	1.35%
17	Italy	36,593,969	2%	857,489	61,070,224	0.13%	59.92%	0.84%	1.25%
18	Turkey	35,358,888	3%	1,195,610	75,837,020	1.21%	46.62%	1.05%	1.21%
19	Spain	35,010,273	3%	876,986	47,066,402	0.30%	74.38%	0.65%	1.20%
20	Canada	33,000,381	7%	2,150,061	35,524,732	0.98%	92.89%	0.49%	1.13%
21	Poland	25,666,238	2%	571,136	38,220,543	0.01%	67.15%	0.53%	0.88%
22	Colombia	25,660,725	7%	1,739,108	48,929,706	1.26%	52.44%	0.68%	0.88%
23	Argentina	24,973,660	7%	1,600,722	41,803,125	0.86%	59.74%	0.58%	0.86%
24	South Africa	24,909,854	14%	3,022,362	53,139,528	0.69%	46.88%	0.73%	0.85%
25	Iran	22,200,708	9%	1,850,445	78,470,222	1.32%	28.29%	1.08%	0.76%

List of Countries by Internet Usage (2019)

TOP 20 COUNTRIES WITH HIGHEST NUMBER OF INTERNET USERS - JUNE 30, 2019						
#	Country or Region	Population, 2019 Est.	Population 2000 Est.	Internet Users 30 June 2019	Internet Users 31 Dec 2000	Internet Growth 2000 - 2019
1	China	1,420,062,022	1,283,198,970	829,000,000	22,500,000	3,584 %
2	India	1,368,737,513	1,053,050,912	560,000,000	5,000,000	11,100 %
3	United States	329,093,110	281,982,778	292,892,868	95,354,000	207 %
4	Brazil	212,392,717	175,287,587	149,057,635	5,000,000	2,881 %
5	Indonesia	269,536,482	211,540,429	143,260,000	2,000,000	7,063 %
6	Japan	126,854,745	127,533,934	118,626,672	47,080,000	152 %
7	Nigeria	200,962,417	122,352,009	119,506,430	200,000	59,653 %
8	Russia	143,895,551	146,396,514	109,552,842	3,100,000	3,434 %
9	Bangladesh	168,065,920	131,581,243	94,445,000	100,000	94,345 %
10	Mexico	132,328,035	101,719,673	88,000,000	2,712,400	3,144 %
11	Germany	82,438,639	81,487,757	79,127,551	24,000,000	229 %
12	Turkey	82,961,805	63,240,121	69,107,183	2,000,000	3,355 %
13	Philippines	108,106,310	77,991,569	67,000,000	2,000,000	3,250 %
14	Vietnam	97,429,061	80,285,562	64,000,000	200,000	31,900 %
15	United Kingdom	66,959,016	58,950,848	63,356,621	15,400,000	311 %
16	Iran	82,503,583	66,131,854	62,702,731	250,000	24,981 %
17	France	65,480,710	59,608,201	60,421,689	8,500,000	610 %
18	Thailand	69,306,160	62,958,021	57,000,000	2,300,000	2,378 %
19	Italy	59,216,525	57,293,721	54,798,299	13,200,000	315 %
20	Egypt	101,168,745	69,905,988	49,231,493	450,000	10,840 %
TOP 20 Countries		5,187,499,066	4,312,497,691	3,131,087,014	251,346,400	1,145 %
Rest of the World		2,528,724,143	1,832,509,298	1,291,407,608	109,639,092	1,077 %
Total World		7,716,223,209	6,145,006,989	4,422,494,622	360,985,492	1,125 %

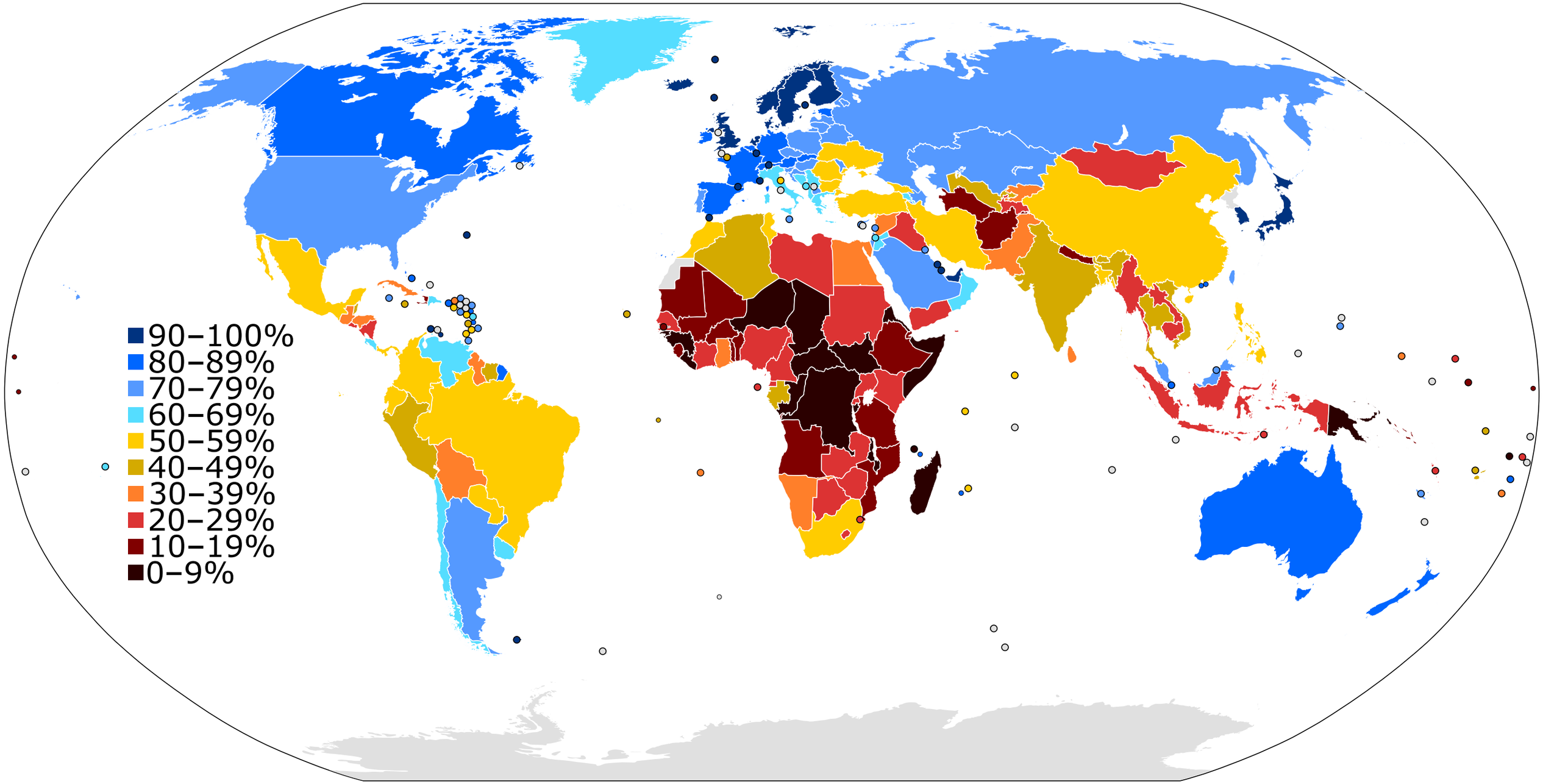
Internet Users by Region

- As of July 1, 2013:

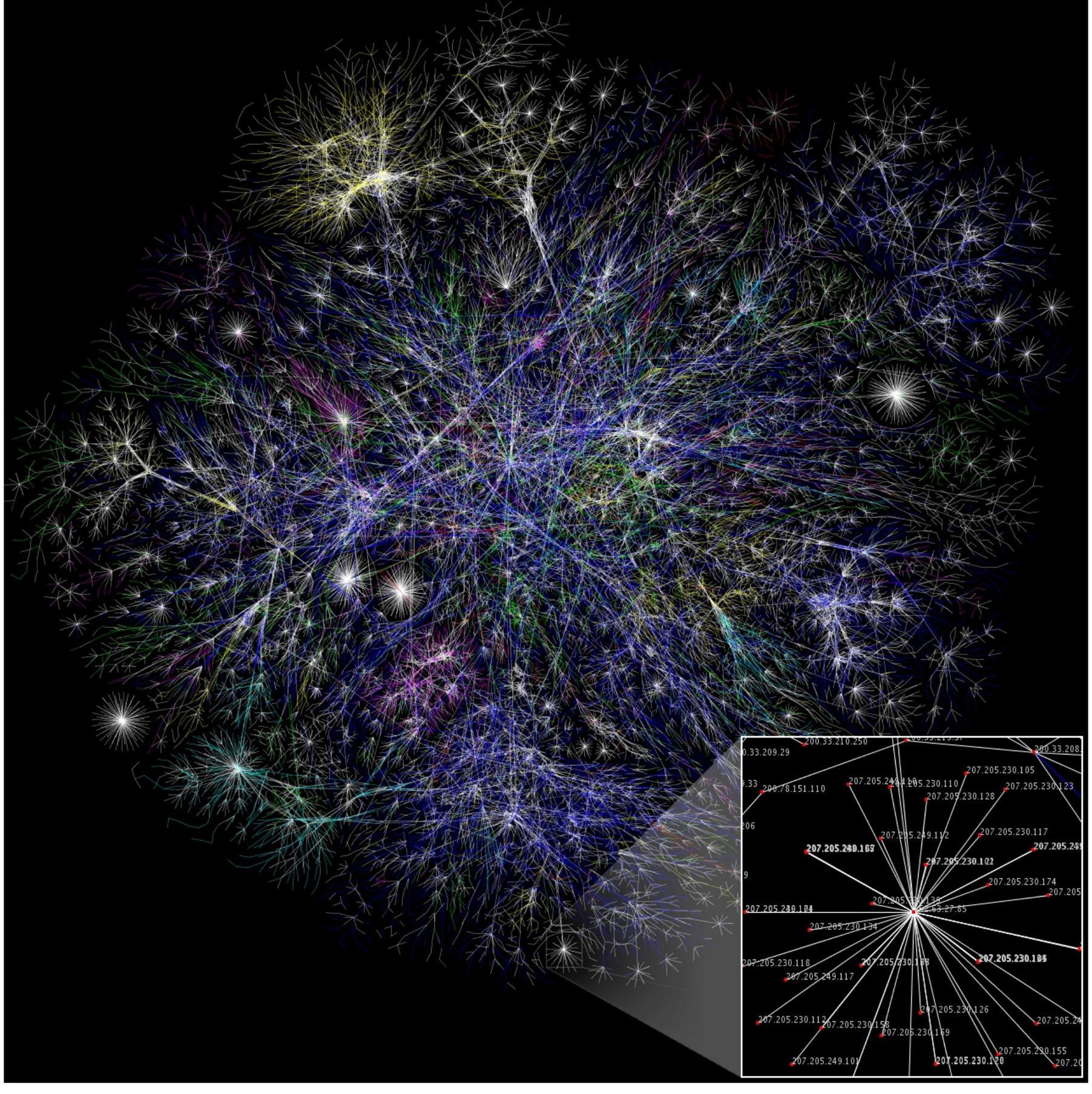


Source: http://www.internetlivestats.com/internet-users/

Global Internet Usage (2015)



Source: Wikipedia

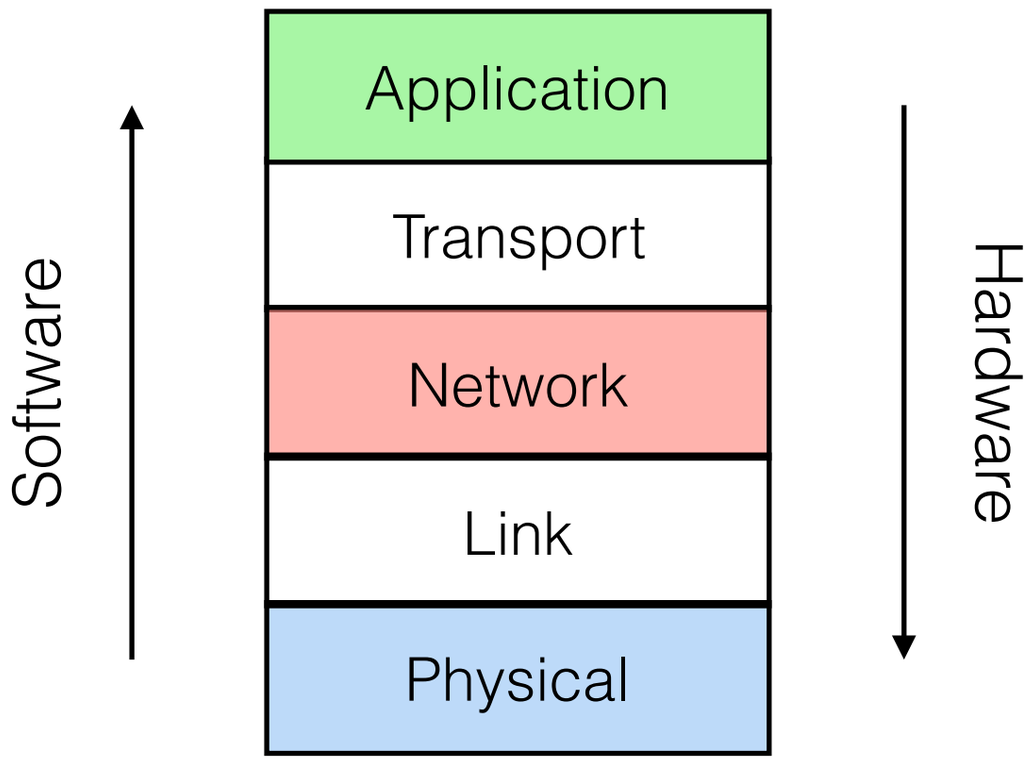


A partial map of the Internet, rendered based on ping delay and colored based on Top Level Domains
Source: http://en.wikipedia.org/wiki/File:Internet_map_1024.jpg

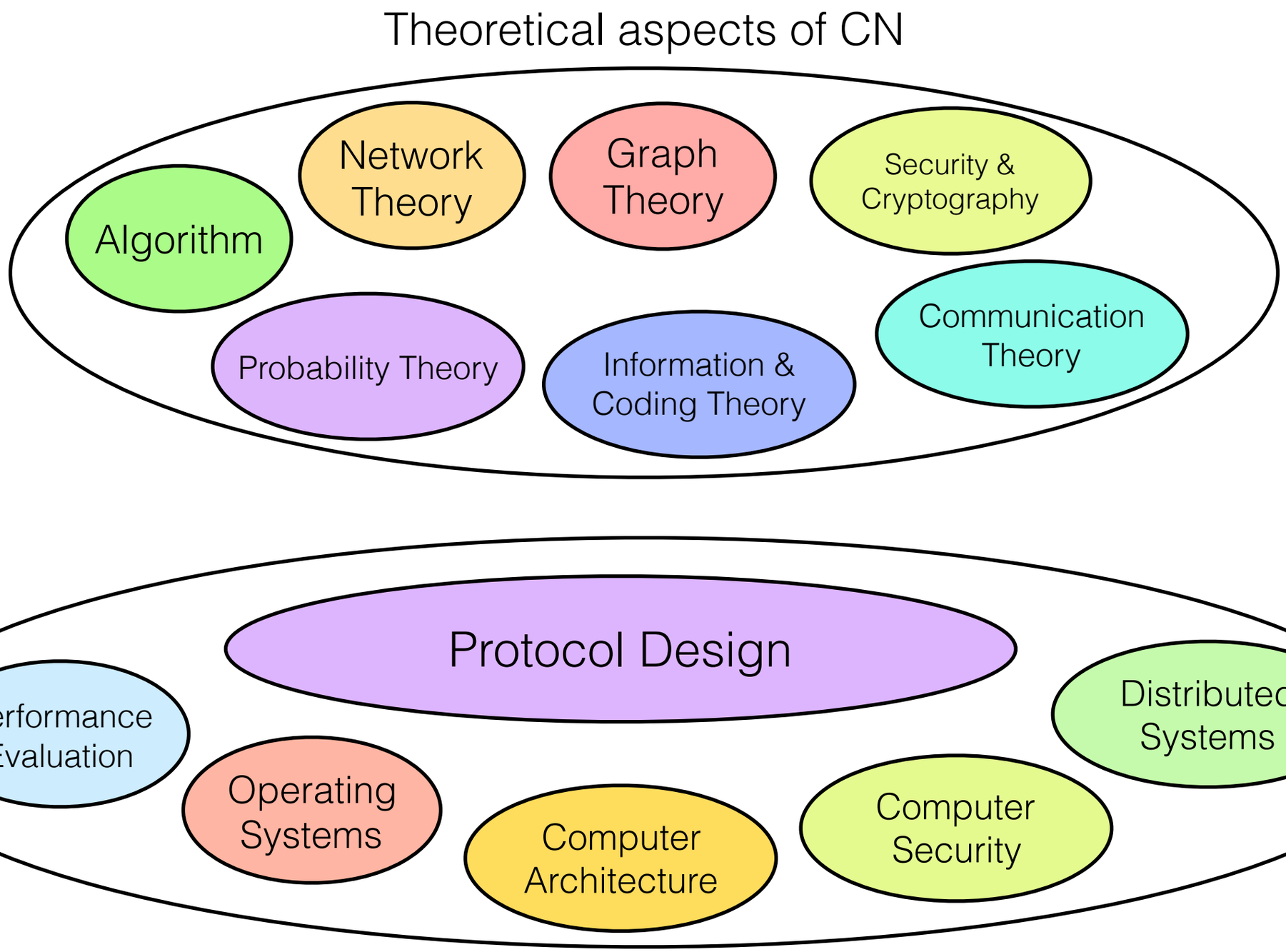
How To Deal With Such A Mess?! :D

- Computer networks (in particular the Internet) have become very complex and non-homogeneous!
  - Many different hardwares, many different applications, various type of connectivities, lots of standards…
- In this course, we aim to understand the basic and fundamental ideas behind the design and development of computer networks
- In particular, we would like to answer the following questions:
  (1) How does it work despite of such a complexity and non-homogeneity?
  (2) How can we design such a large system?
  (3) How it should be maintained?

Modular Design is our Friend!



Computer networks areas of study



Some Abbreviations

- ARPANET: The Advanced Research Projects Agency Network was an early packet switching network and the first network to implement the protocol suite TCP/IP. Both technologies became the technical foundation of the Internet. ARPANET was initially funded by the Advanced Research Projects Agency (ARPA) of the United States Department of Defence. [en.wikipedia.org/wiki/ARPANET]

- RFC: A Request for Comments (RFC) is a type of publication from the Internet Engineering Task Force (IETF) and the Internet Society, the principal technical development and standards-setting bodies for the Internet. [en.wikipedia.org/wiki/Request_for_Comments]

Some Abbreviations

- IETF: The Internet Engineering Task Force (IETF) develops and promotes voluntary Internet standards, in particular the standards that comprise the Internet protocol suite (TCP/IP). It is an open standards organisation, with no formal membership or membership requirements. All participants and managers are volunteers, though their work is usually funded by their employers or sponsors.

  The IETF started out as an activity supported by the U.S. federal government, but since 1993 it has operated as a standards development function under the auspices of the Internet Society, an international membership-based non-profit organisation.

Some Abbreviations

- BSD: Berkeley Software Distribution (BSD) is a Unix operating system derivative developed and distributed by the Computer Systems Research Group (CSRG) of the University of California, Berkeley, from 1977 to 1995. Today the term “BSD” is often used non-specifically to refer to any of the BSD descendants which together form a branch of the family of Unix-like operating systems. Operating systems derived from the original BSD code remain actively developed and widely used. [en.wikipedia.org/wiki/Berkeley_Software_Distribution]

Some Abbreviations

- IRC: Internet Relay Chat (IRC) is an application layer protocol that facilitates communication in the form of text. The chat process works on a client/server networking model. IRC clients are computer programs that a user can install on their system. These clients communicate with chat servers to transfer messages to other clients. IRC is mainly designed for group communication in discussion forums, called channels, but also allows one-on-one communication via private messages as well as chat and data transfer, including file sharing.
[en.wikipedia.org/wiki/Internet_Relay_Chat]

Acknowledgment

- History of the Internet, WeeSan Lee weesan@cs.ucr.edu, www.cs.ucr.edu/~weesan/cs6/01_history_of_the_internet.ppt
- Hui Zhang, 15-441 Networking, School of computer science,CMU, Fall 2007