

CE 443 - Computer Networks

Mehdi Kharrazi
Department of Computer Engineering
Sharif University of Technology



Acknowledgments: Some of the slides are fully or partially obtained from other sources. Reference is noted on the bottom of each slide, when the content is fully obtained from another source. Otherwise a full list of references is provided on the last slide.



What happens when you click on a URL?

- When you click on a URL, 17 messages are exchanged on the internet
 - 6 message to translate the server name to IP address
 - 3 messages to setup a TCP connection
 - 4 messages for your browser to send the HTTP “get” request, and server response (assuming the page it self fits in one message)
 - 4 messages to tear down the connection

History



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 Electrons

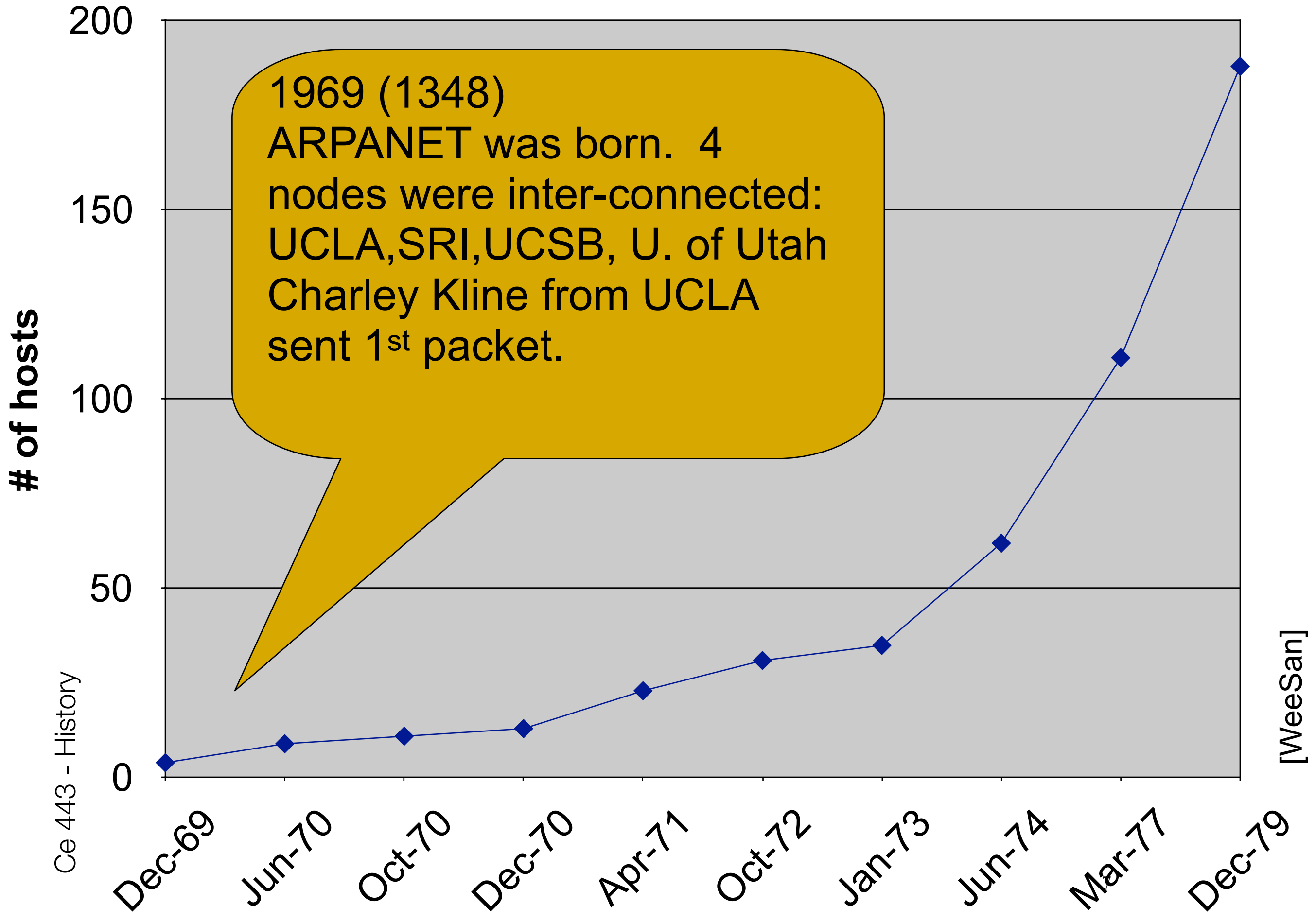
- 1827 (1206) Ohm's Law
- 1837 (1216) "Workable" telegraph invented by Samuel Morse
- 1838 (1217) demonstration over 16 kilometers at 10 w.p.m.
- 1851 (1230) Western Union founded
- 1868 (1247) Transatlantic cable laid
- **1876 (1255) Alexander Bell invented the telephone**
- 1885 (1264) AT&T formed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



Age of Telephones

- 1903 (1282) 3 million phones in the U.S.
- 1915 (1294) First transcontinental telephone line
- 1948 (1327) Transistor invented by Bell scientists
- 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

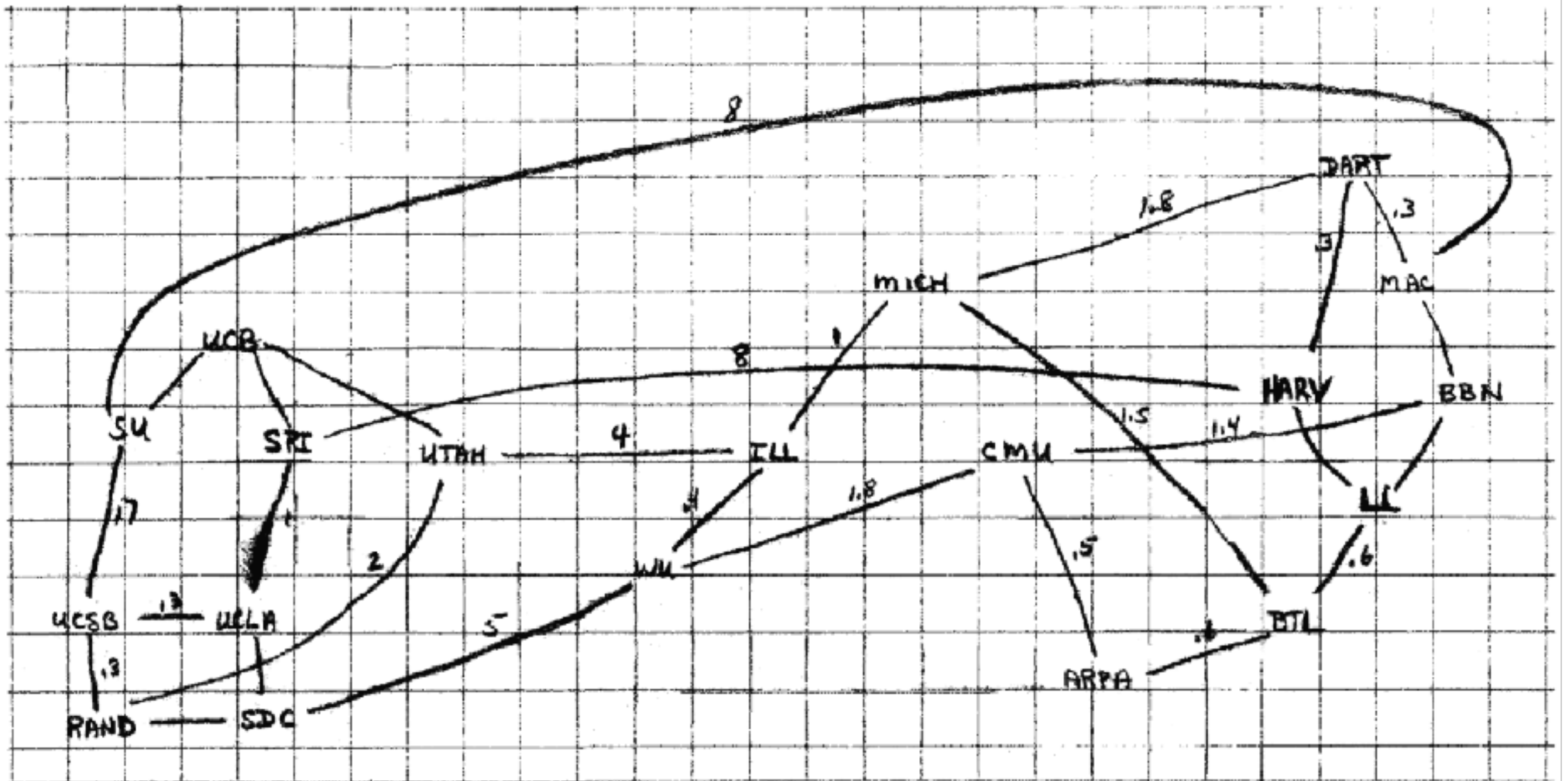
Internet Hosts



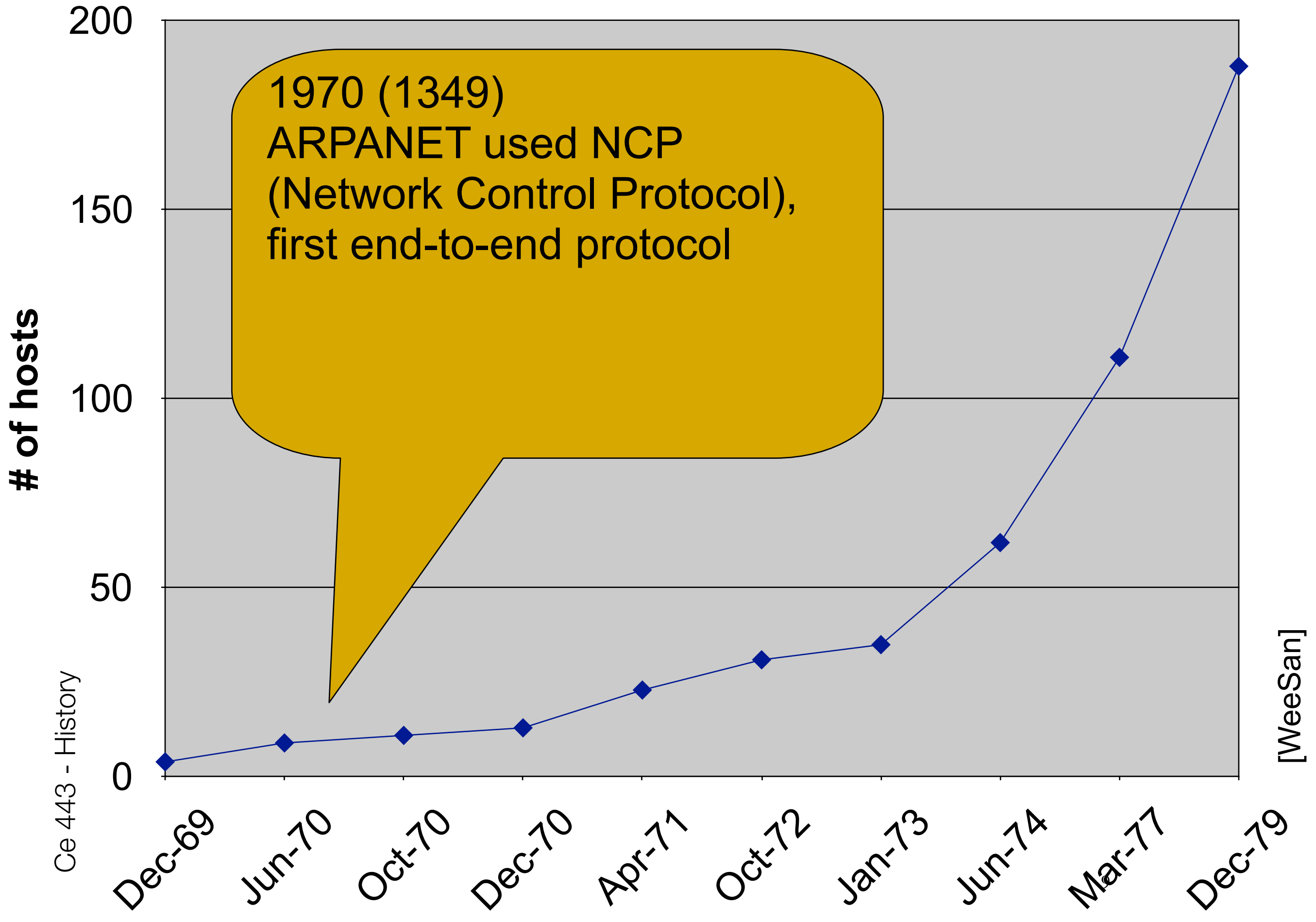


ARPAnet plan

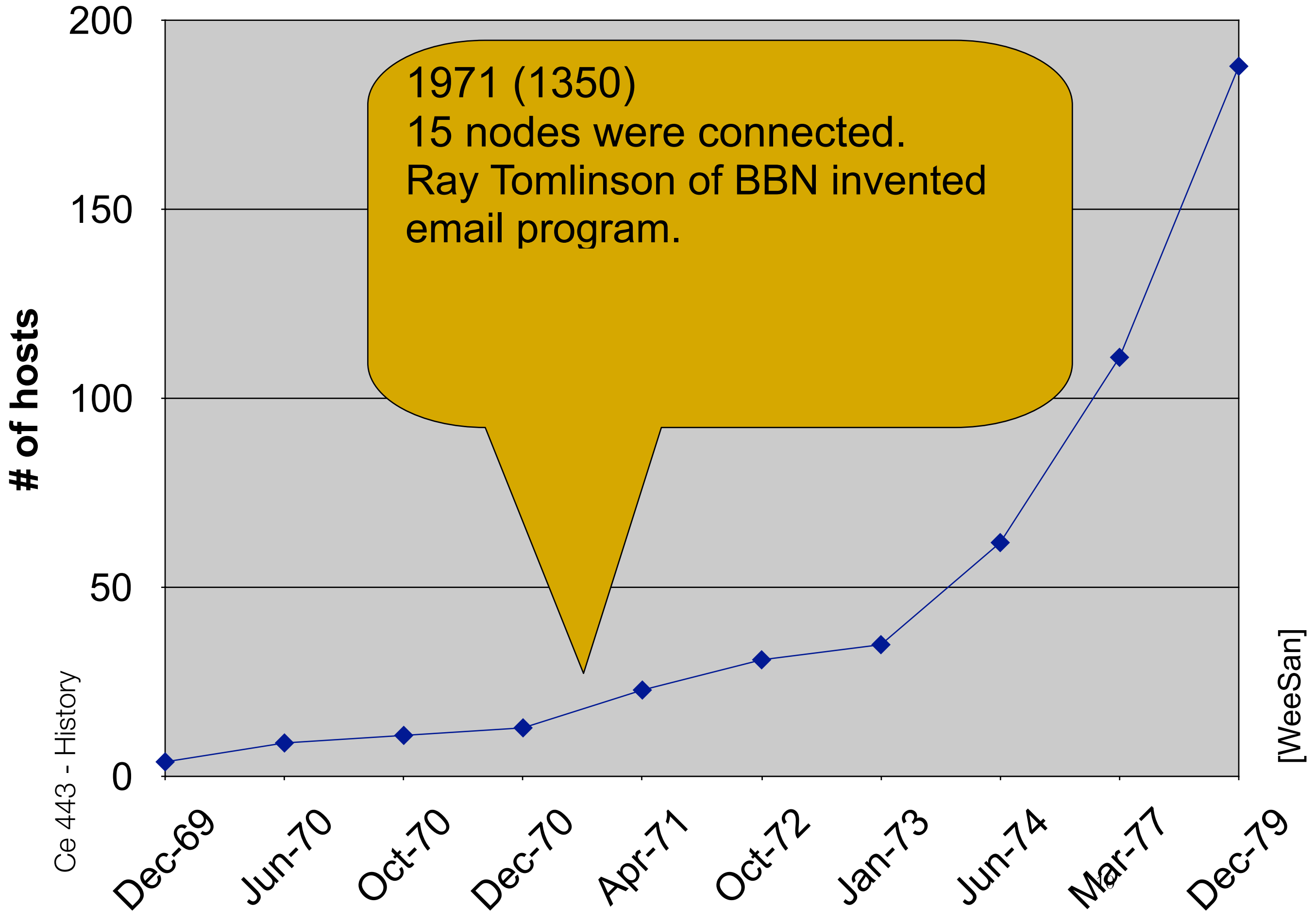
- Rough sketch by Larry Roberts, late 1960s.



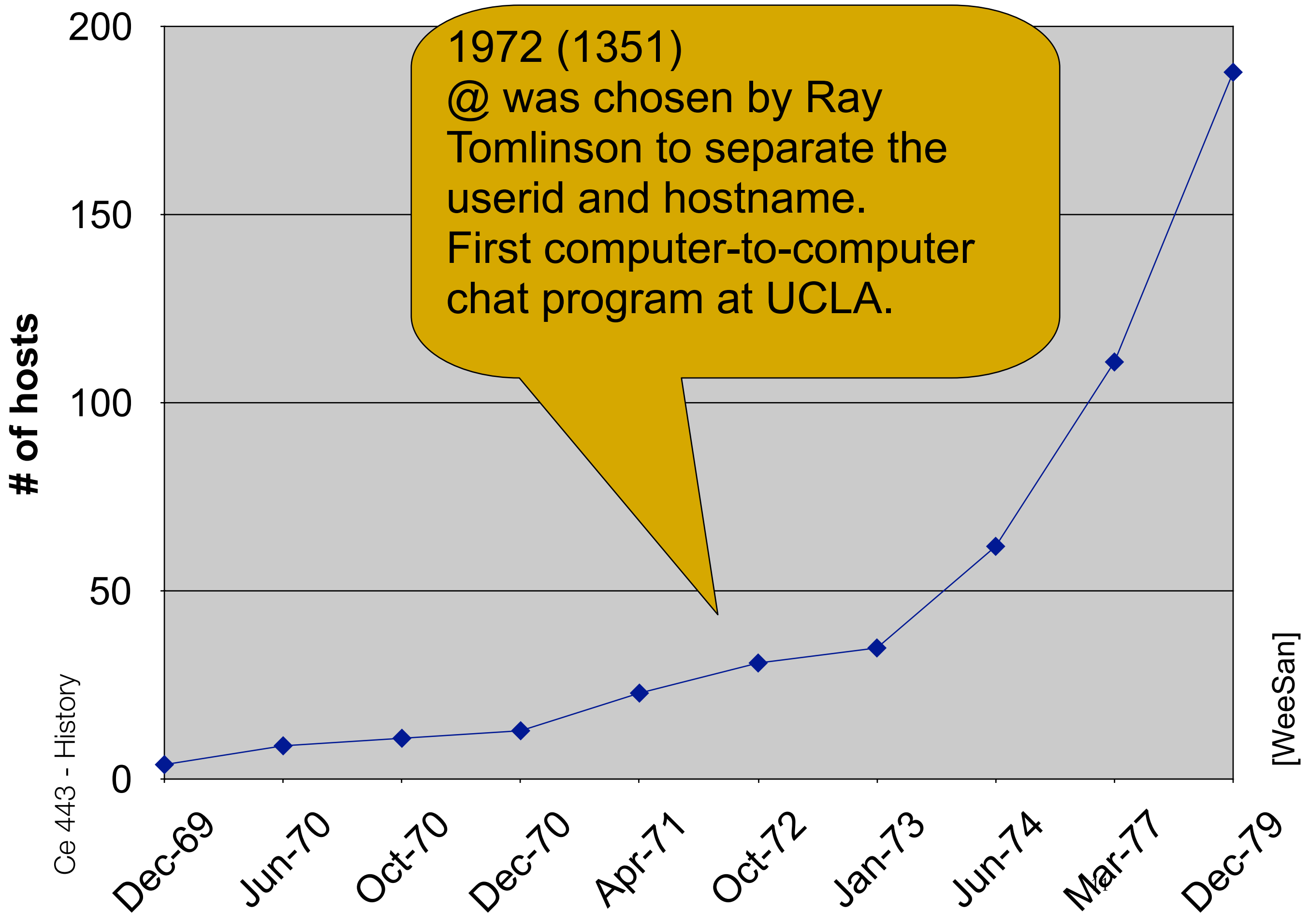
Internet Hosts



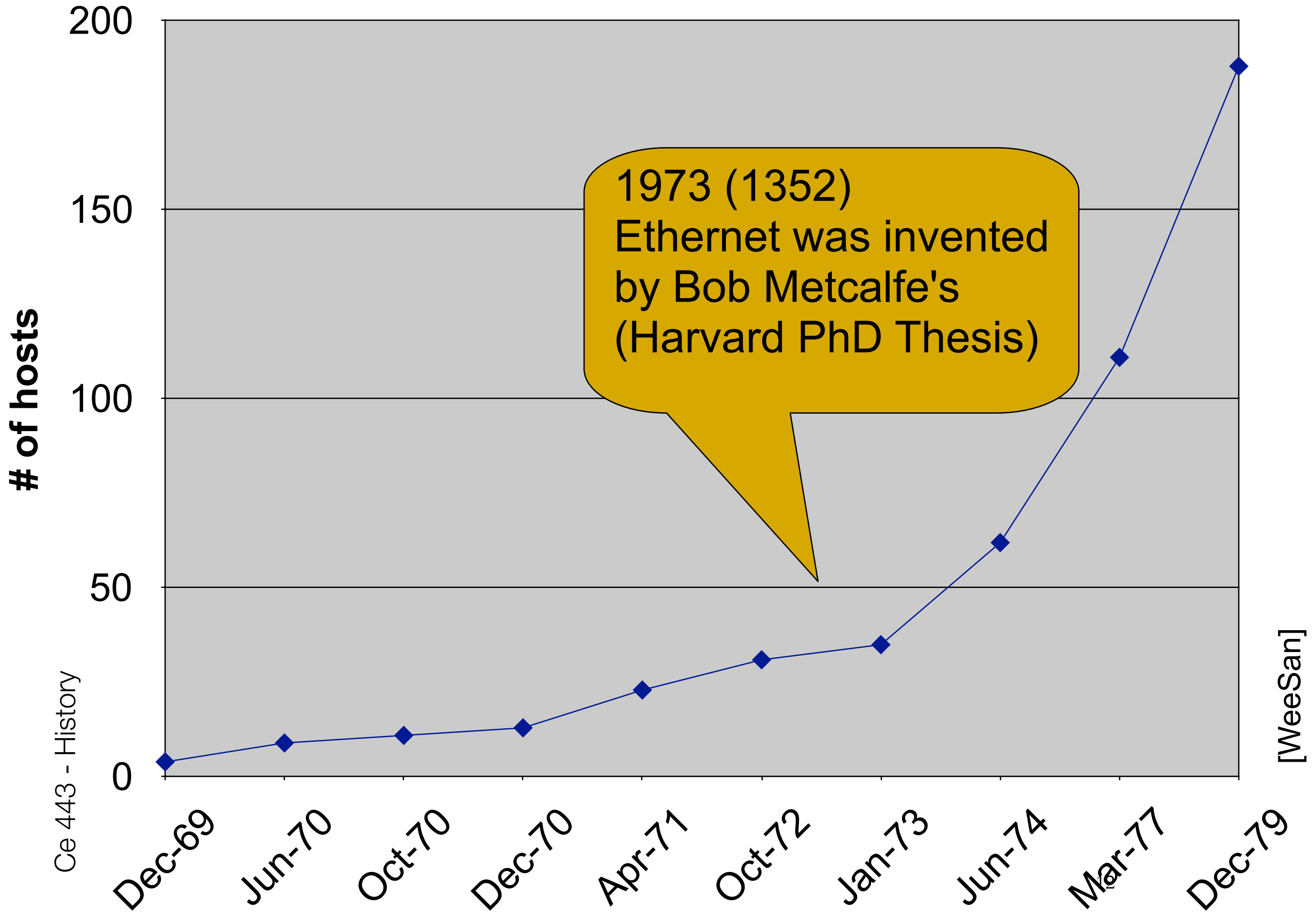
Internet Hosts



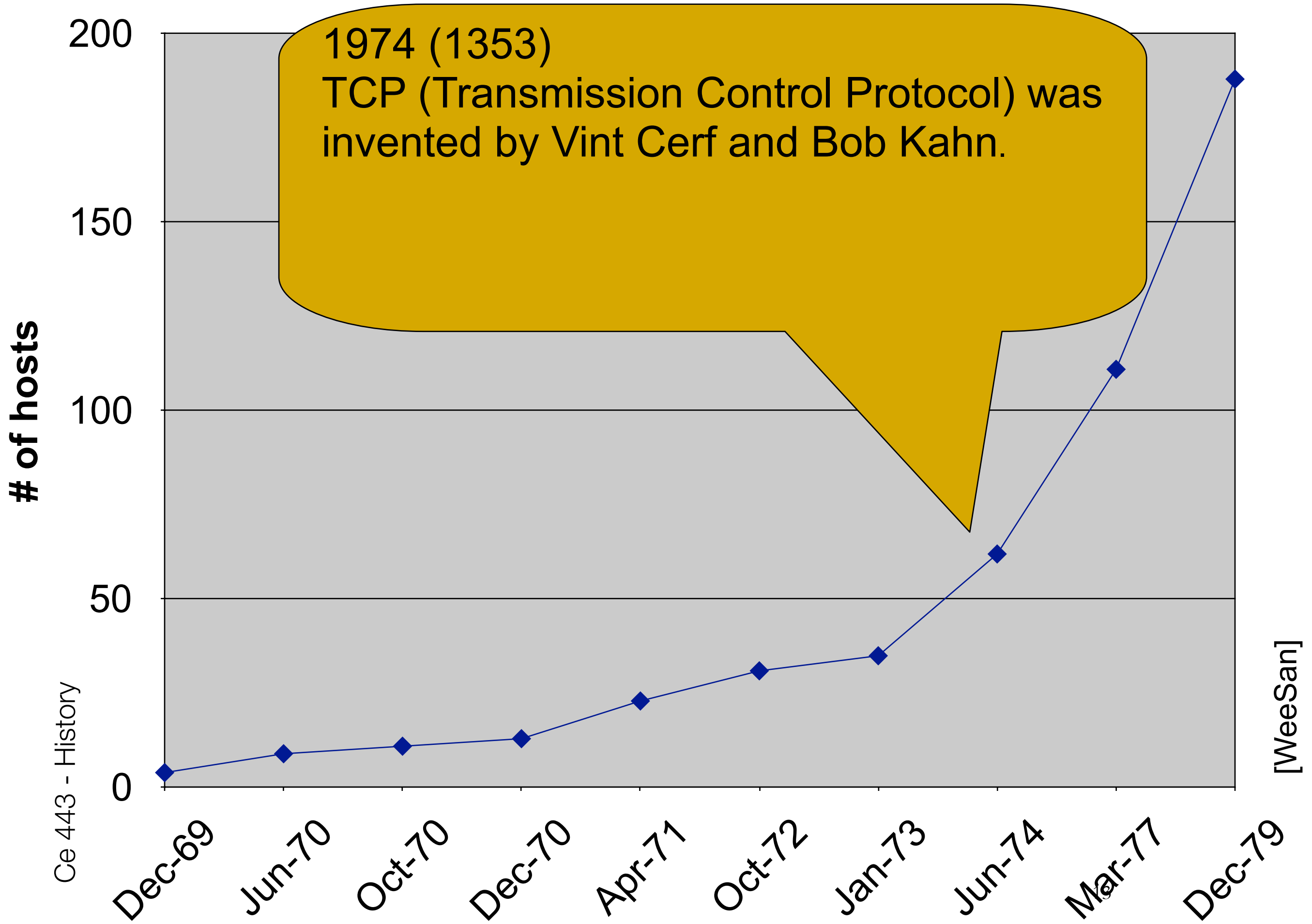
Internet Hosts



Internet Hosts



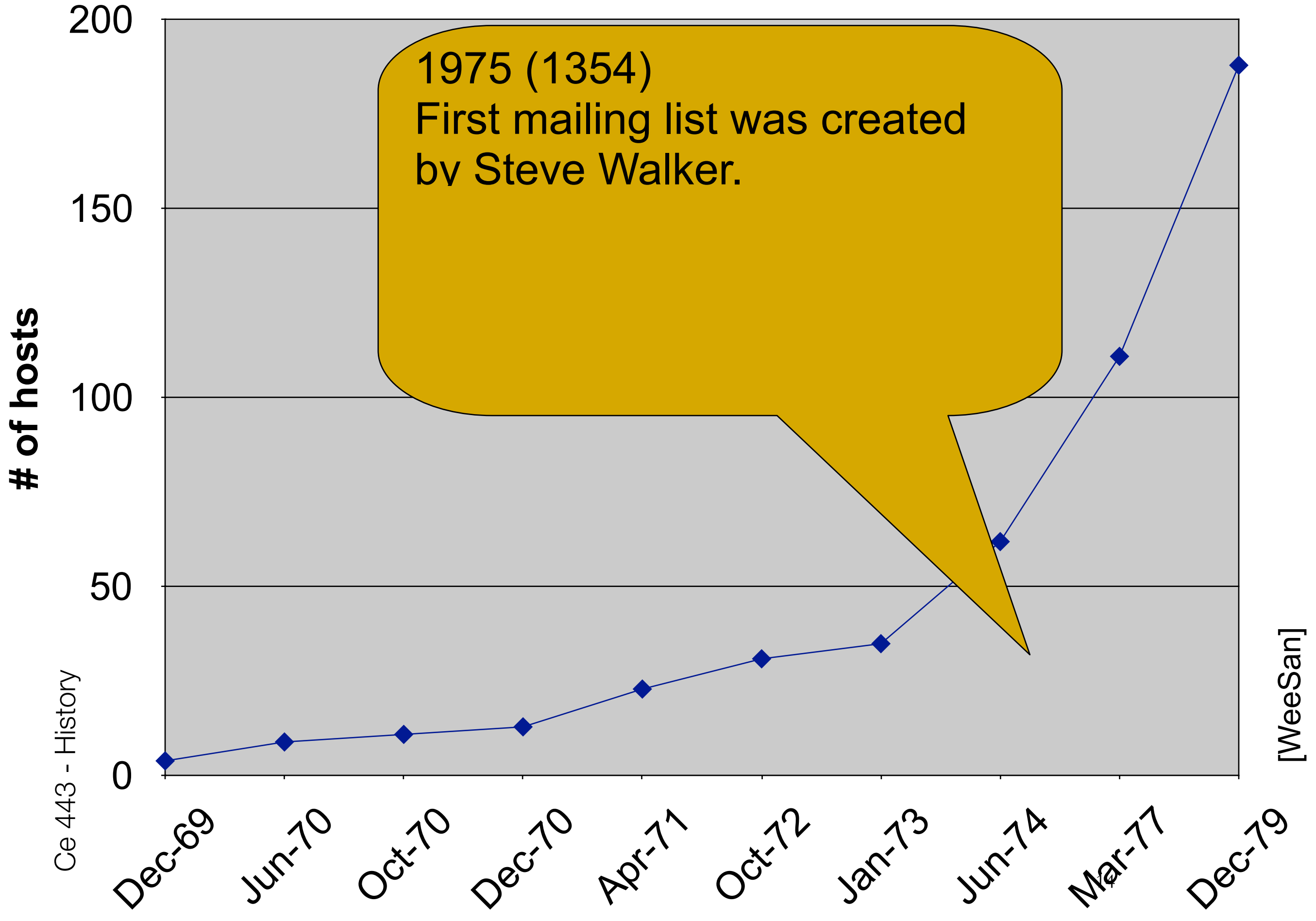
Internet Hosts



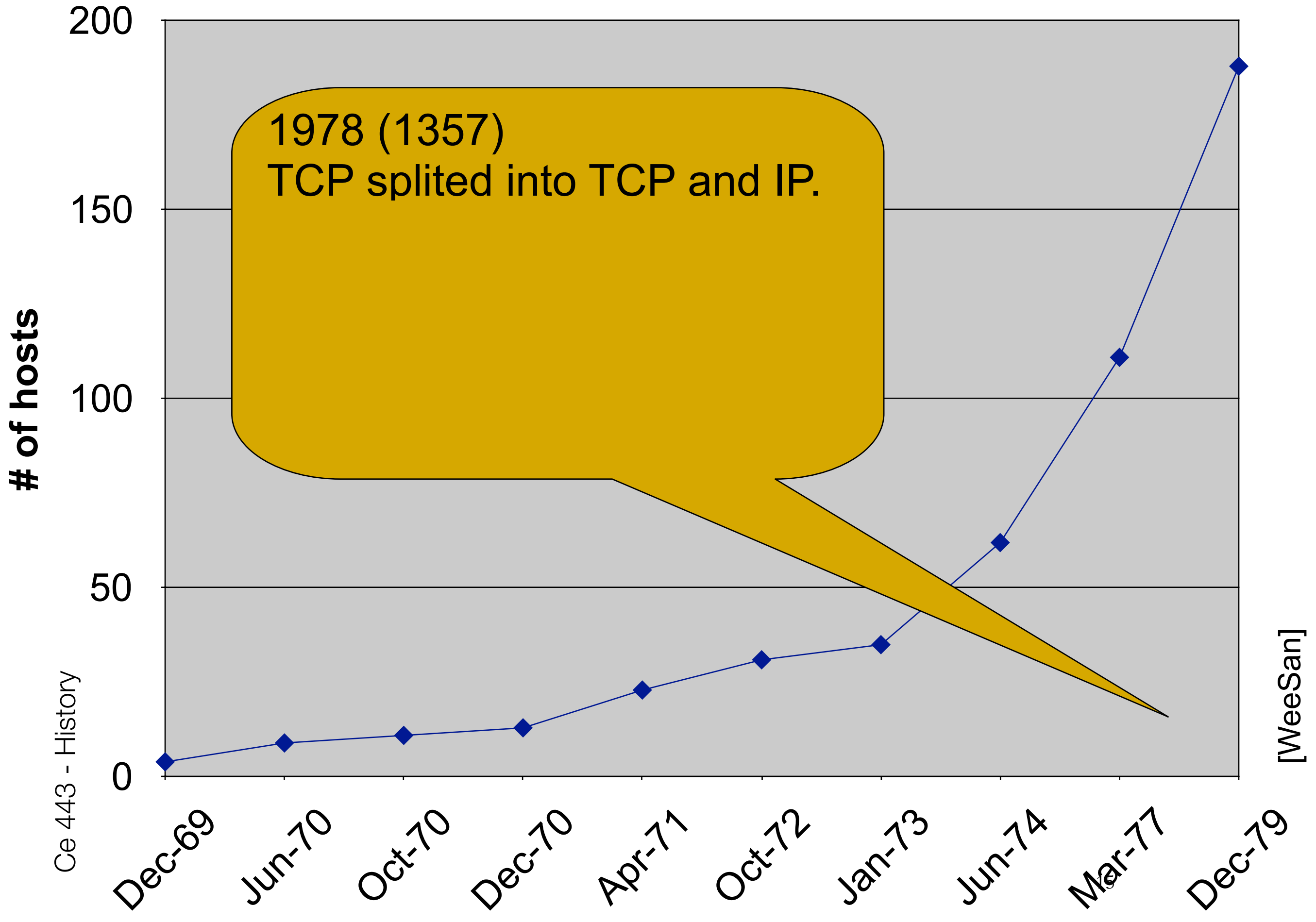
Ce 443 - History

[WeeSan]

Internet Hosts



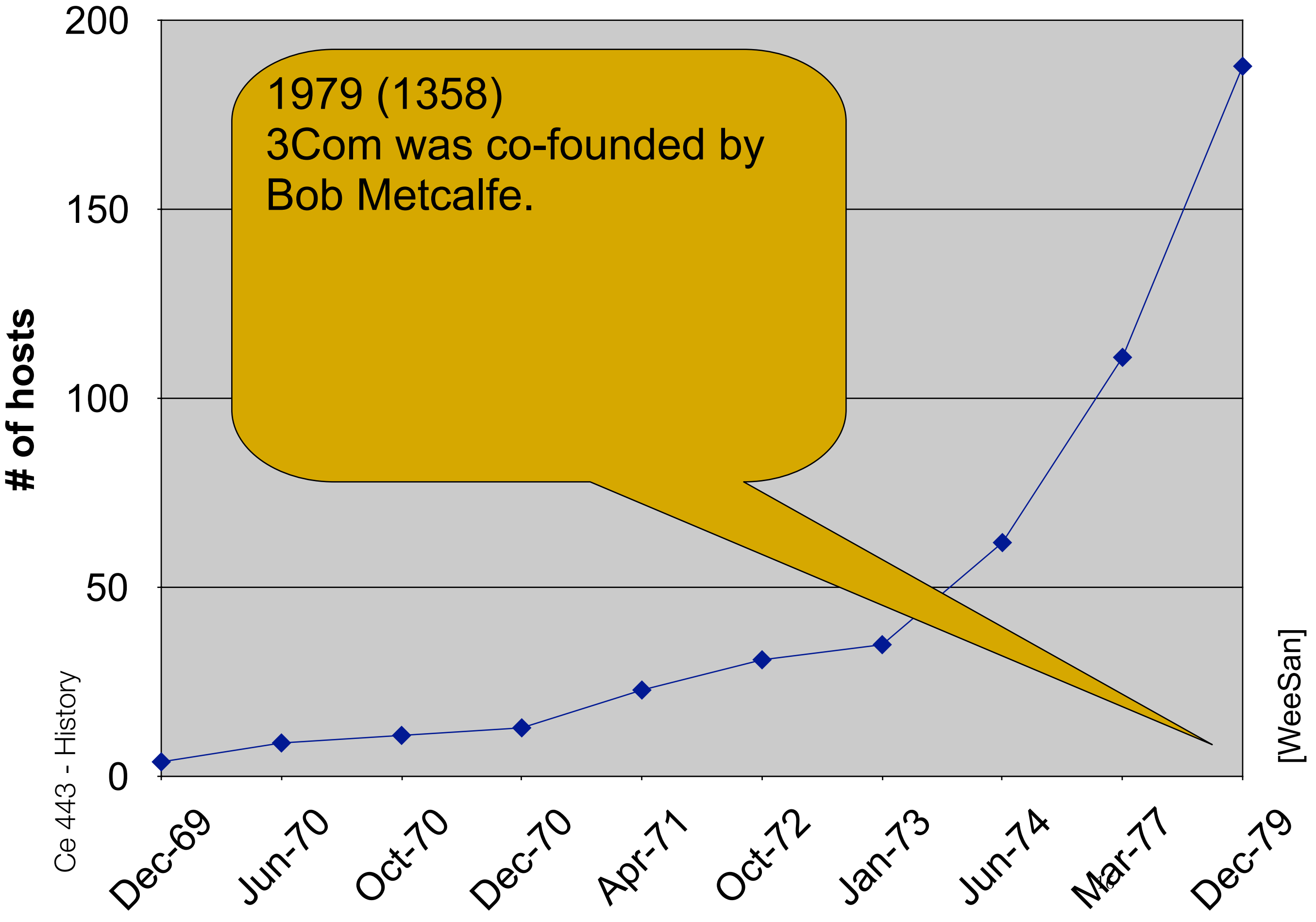
Internet Hosts



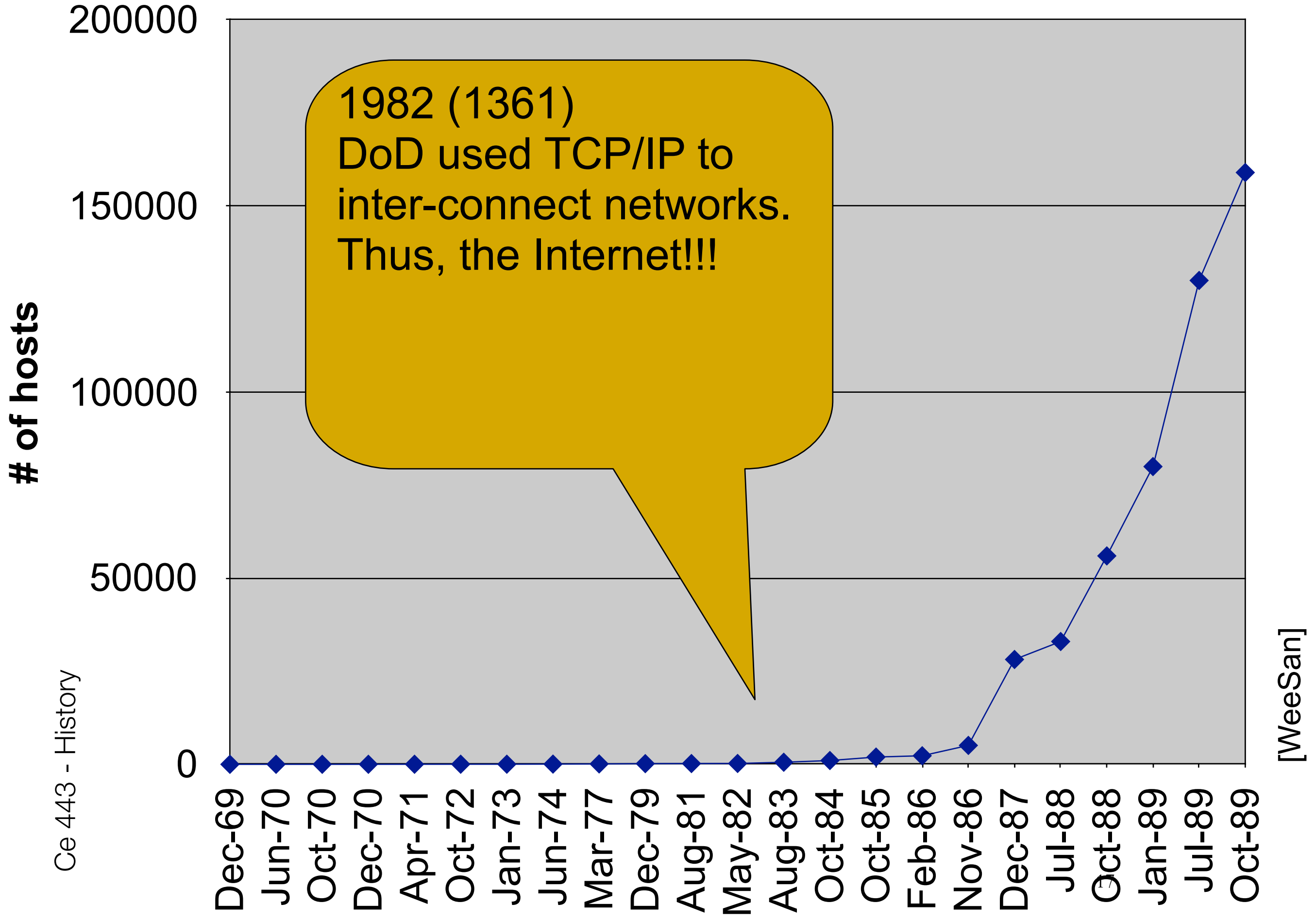
Ce 443 - History

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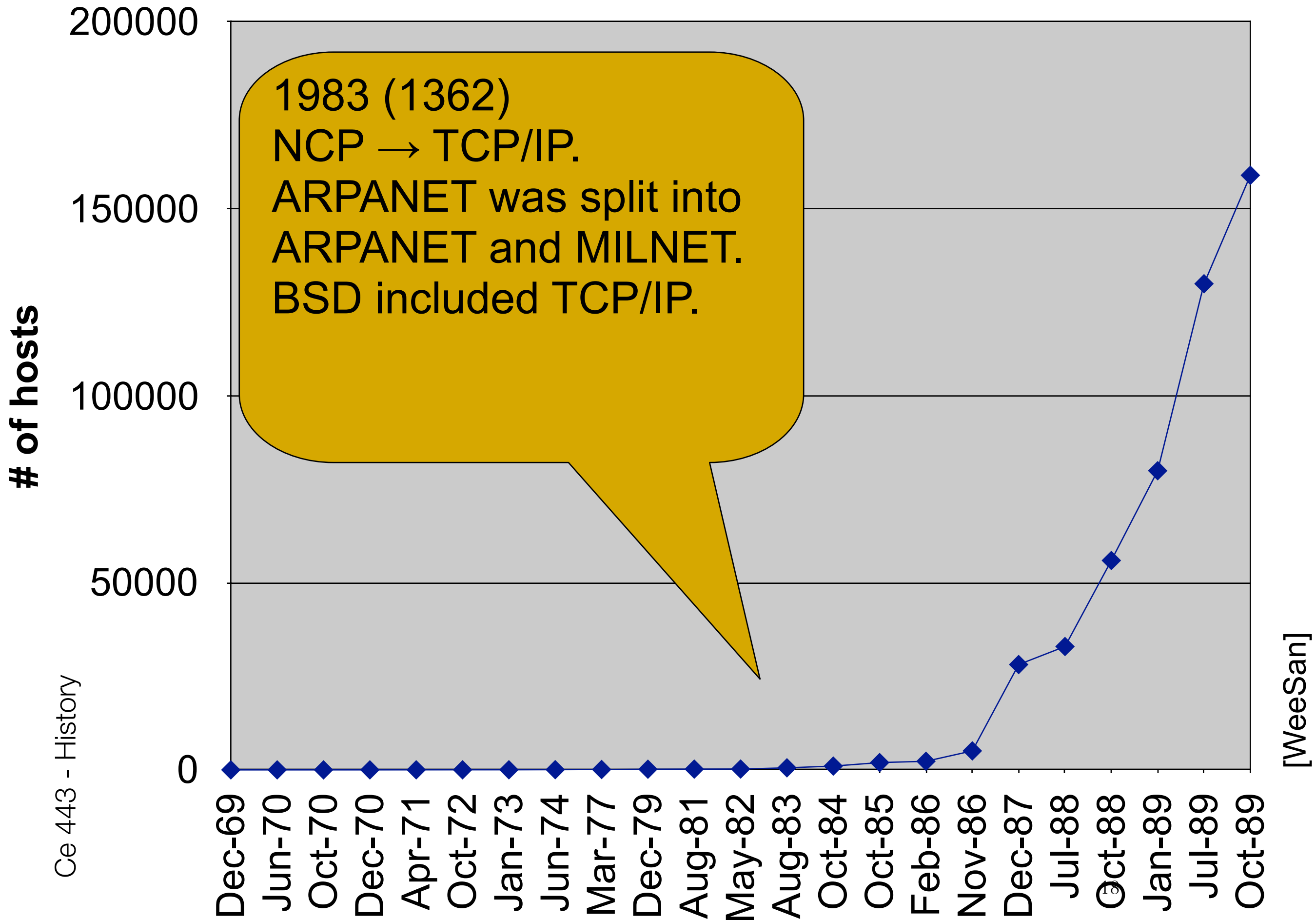
Internet Hosts



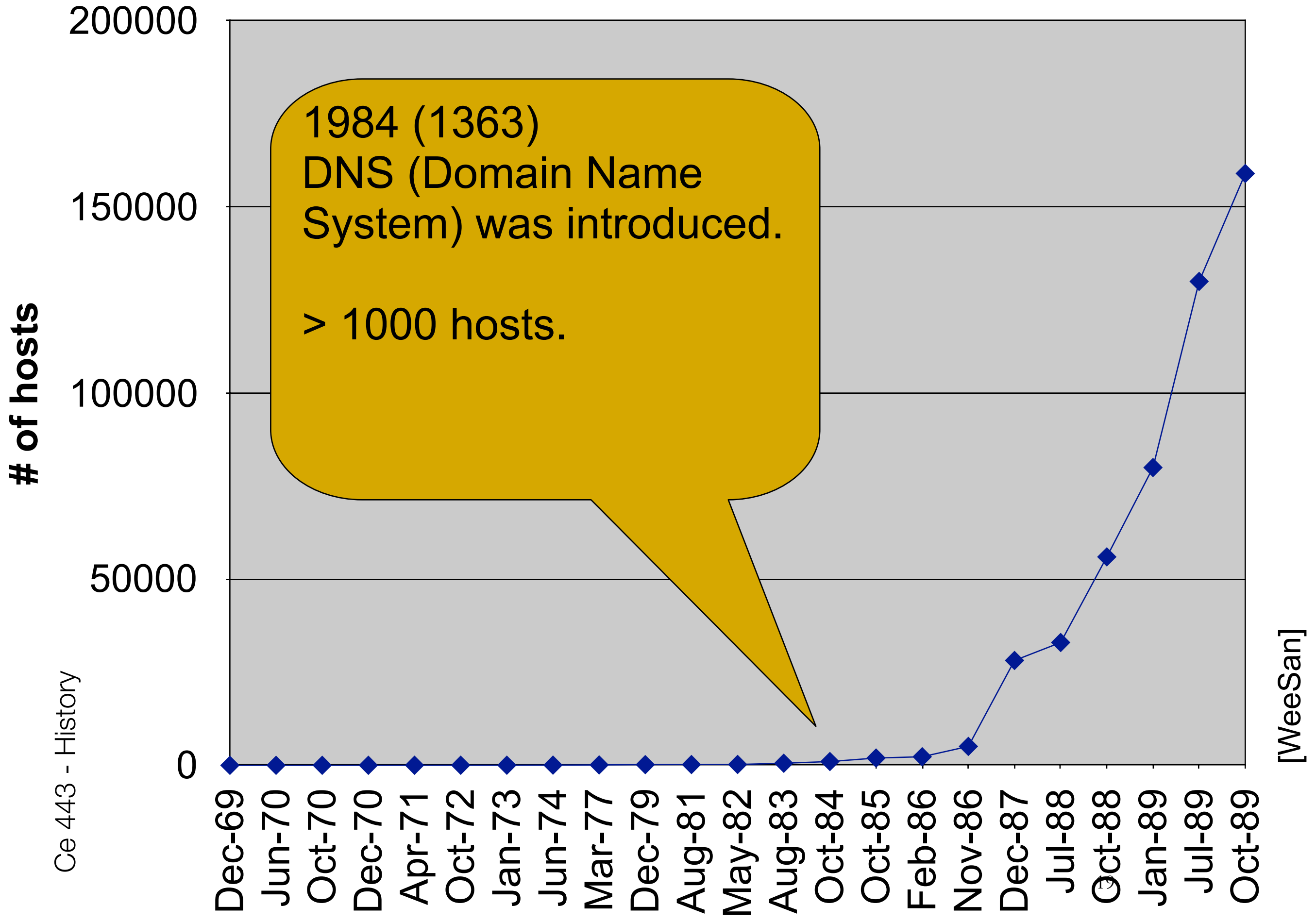
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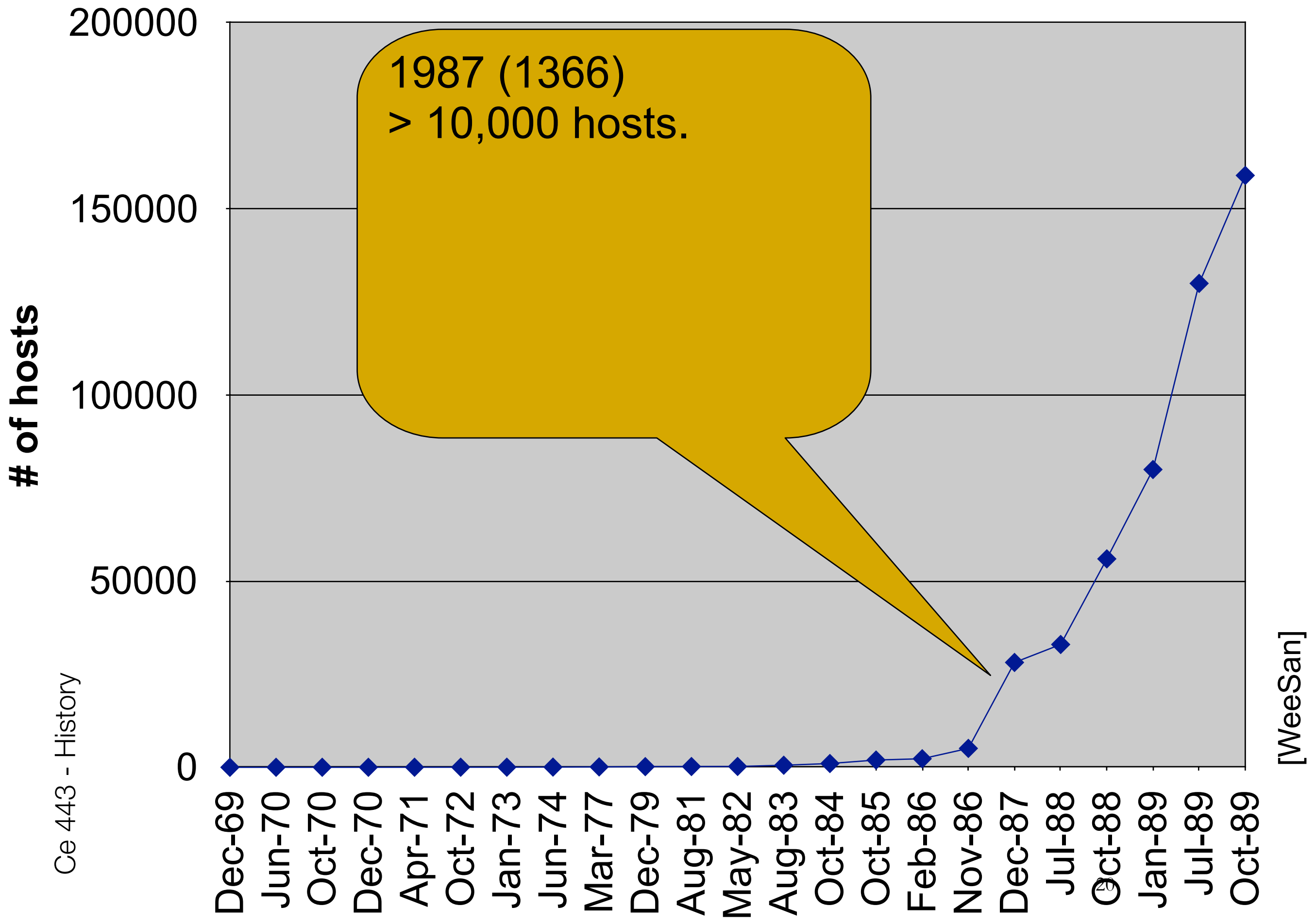
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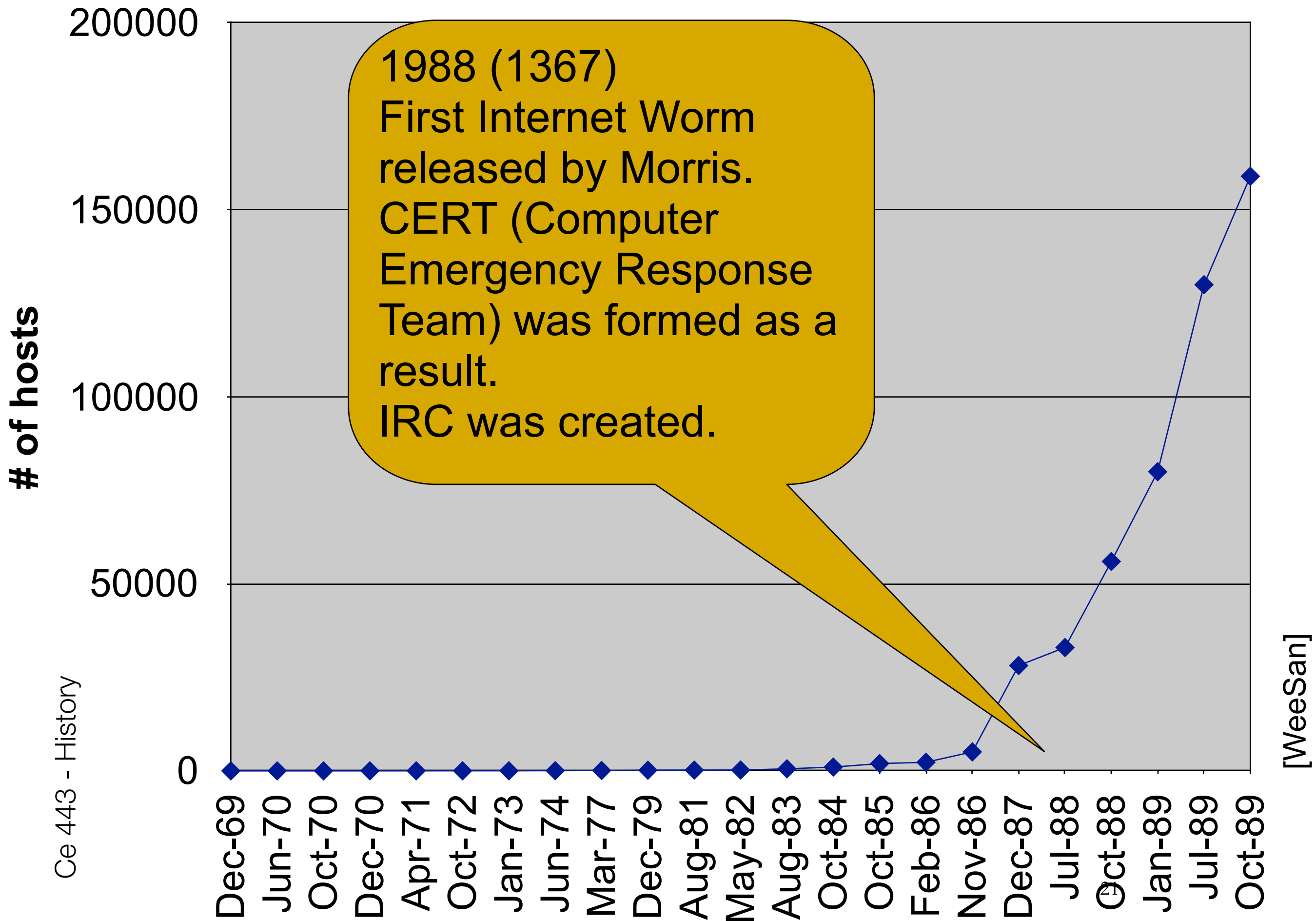
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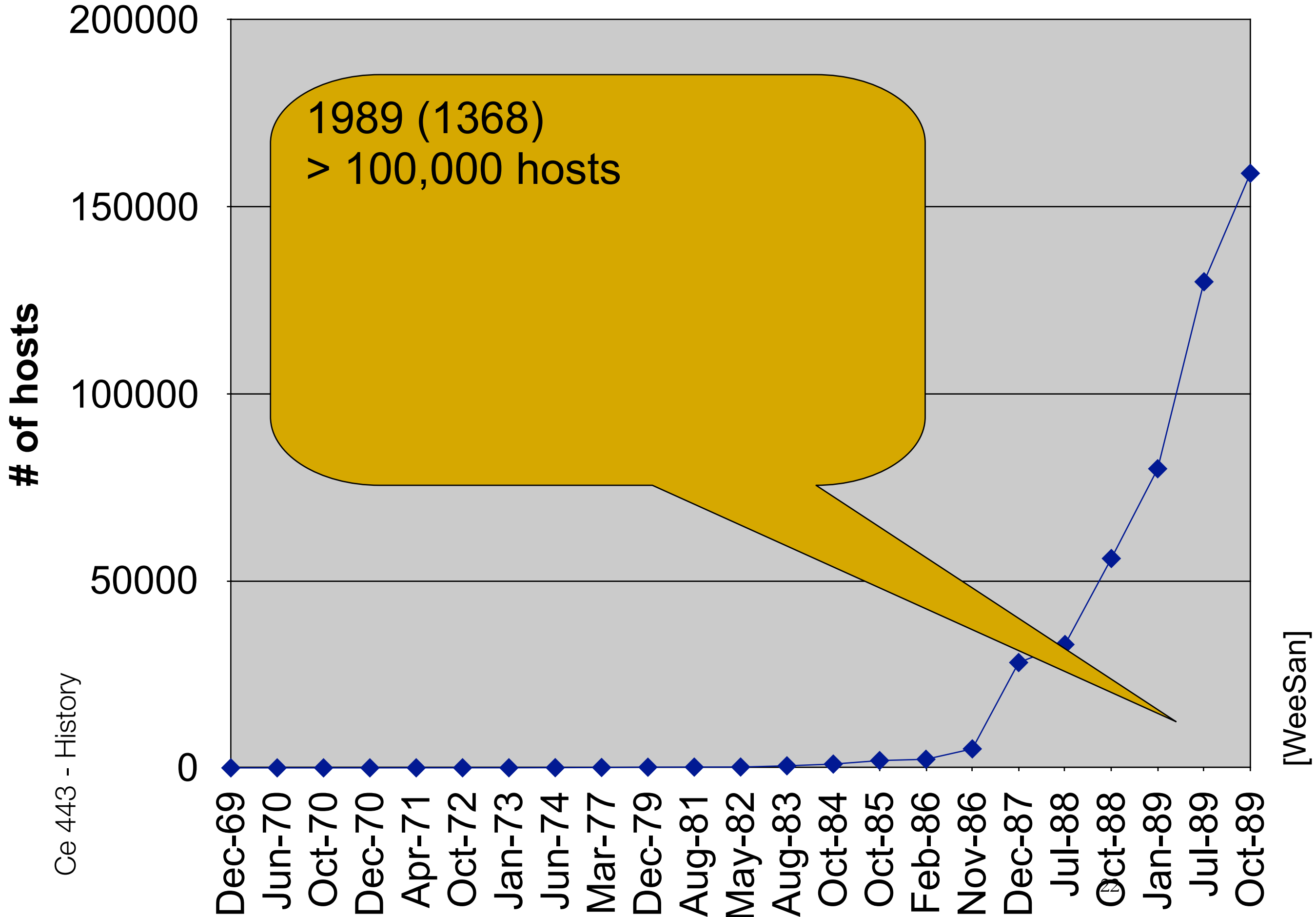
Internet Hosts



Internet Hosts



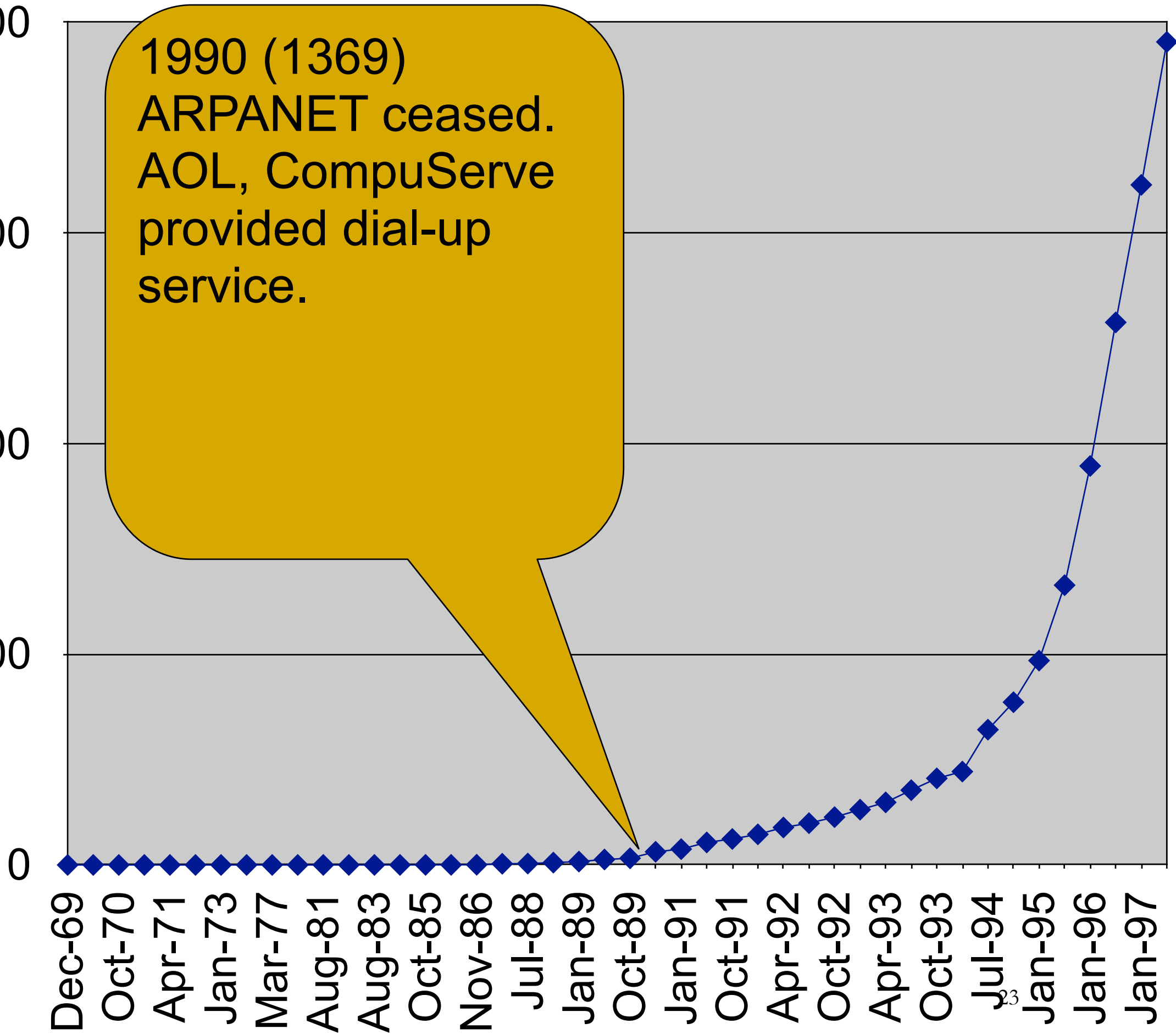
Internet Hosts



Internet Hosts

of hosts

20000000
15000000
10000000
5000000
0



Internet Hosts

of hosts

20000000

15000000

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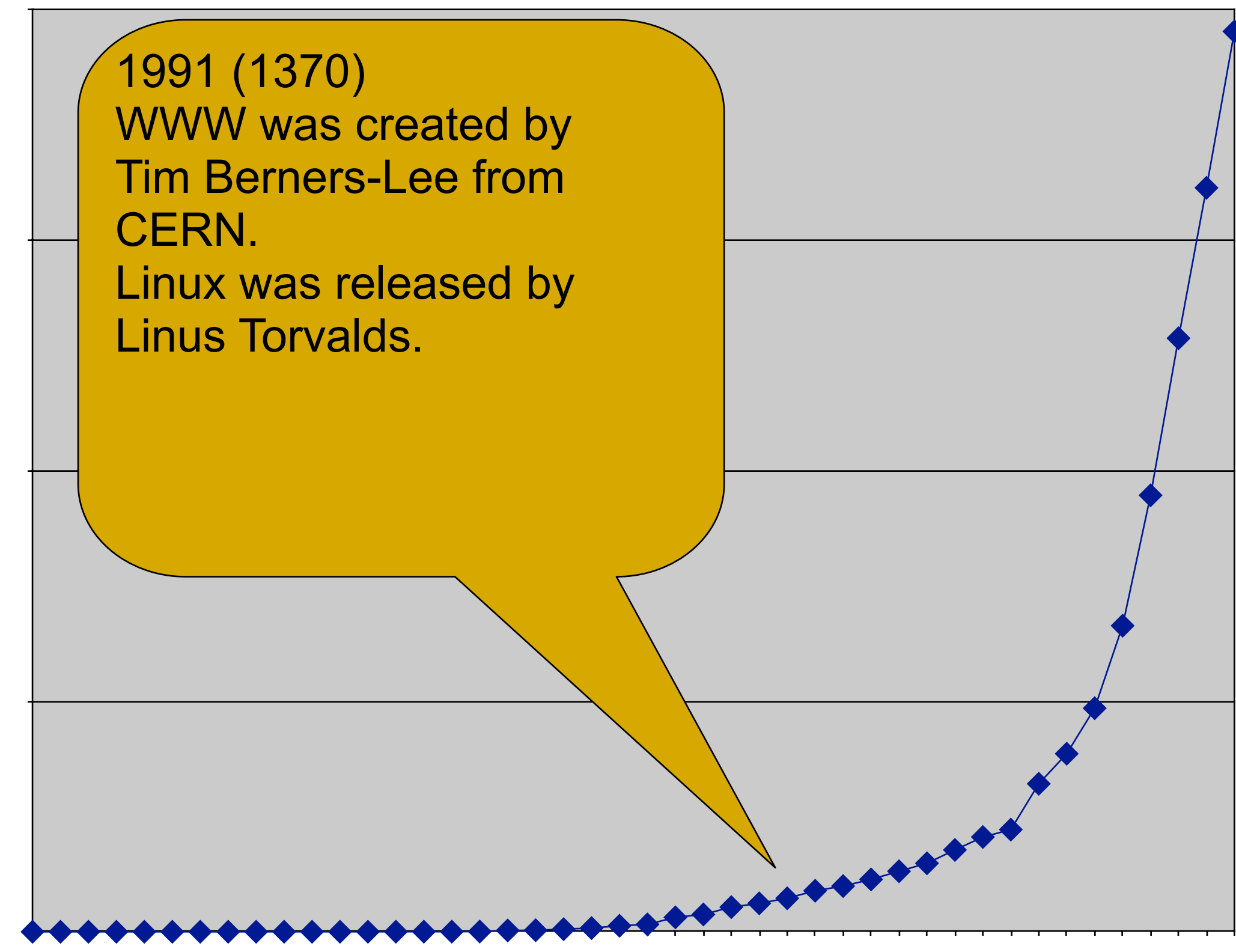
0

Dec-69
Oct-70
Apr-71
Jan-73
Mar-77
Aug-81
Aug-83
Oct-85
Nov-86
Jul-88
Jan-89
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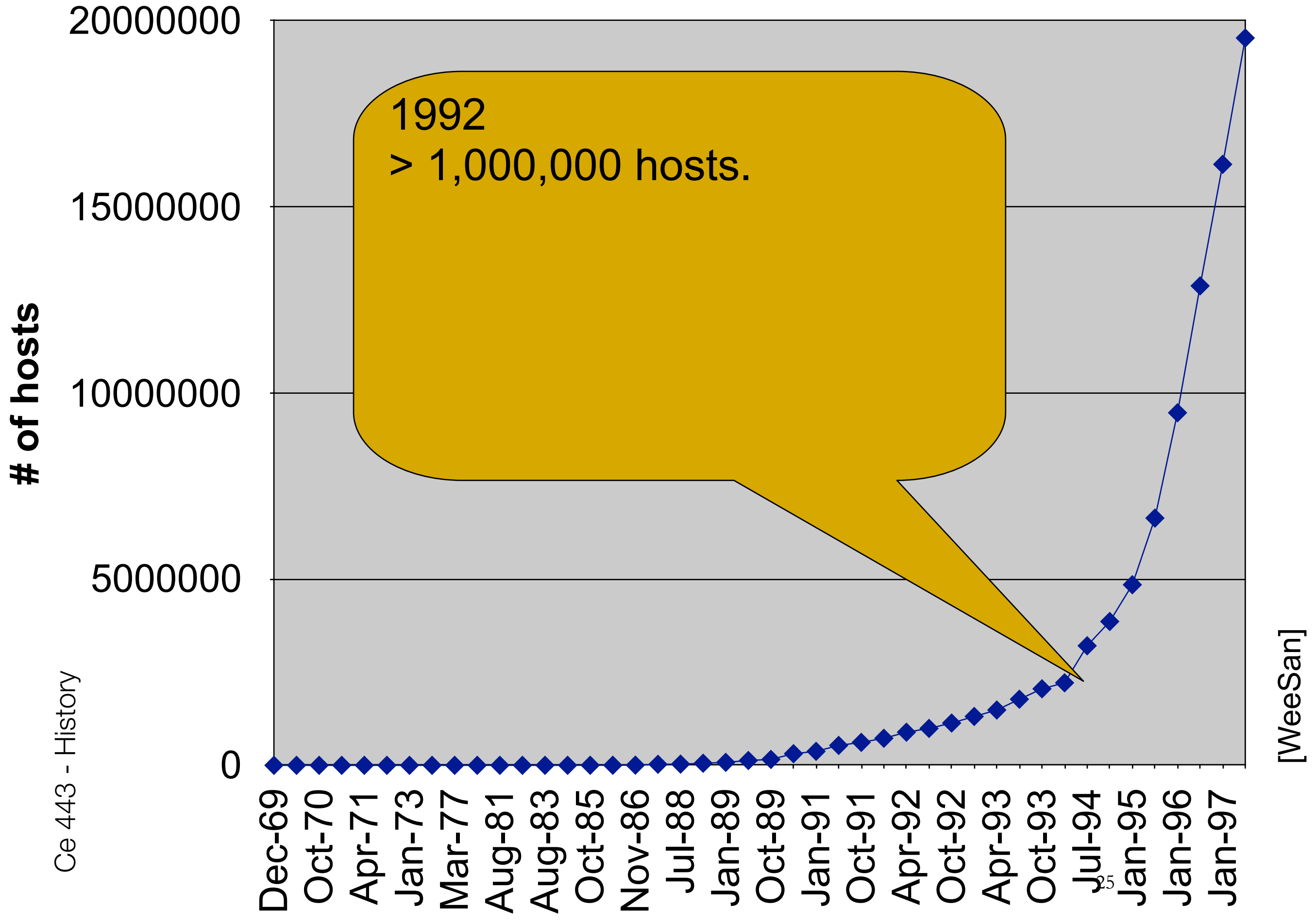
1991 (1370)
WWW was created by
Tim Berners-Lee from
CERN.
Linux was released by
Linus Torvalds.

Ce 443 - History

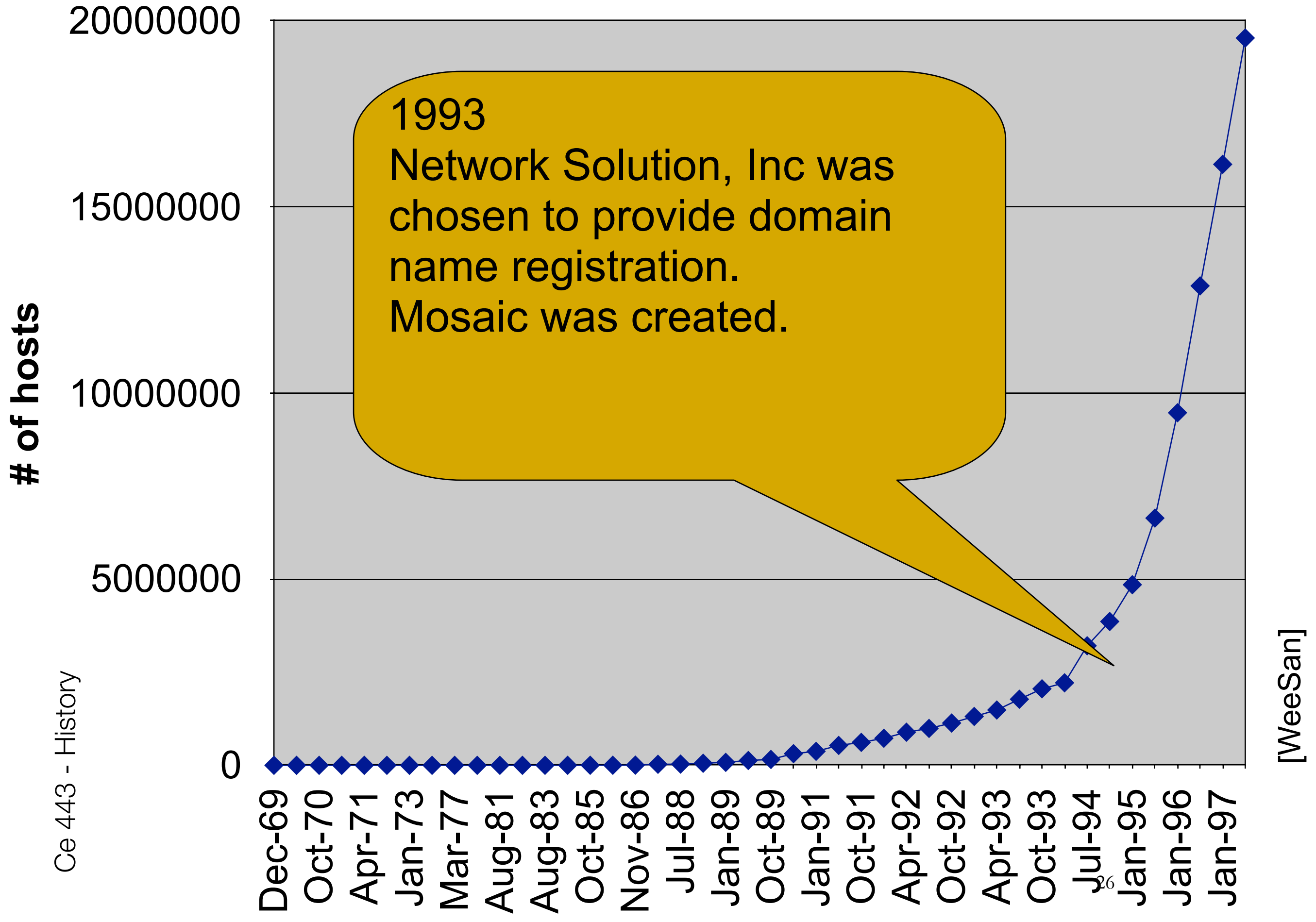
[WeeSan]



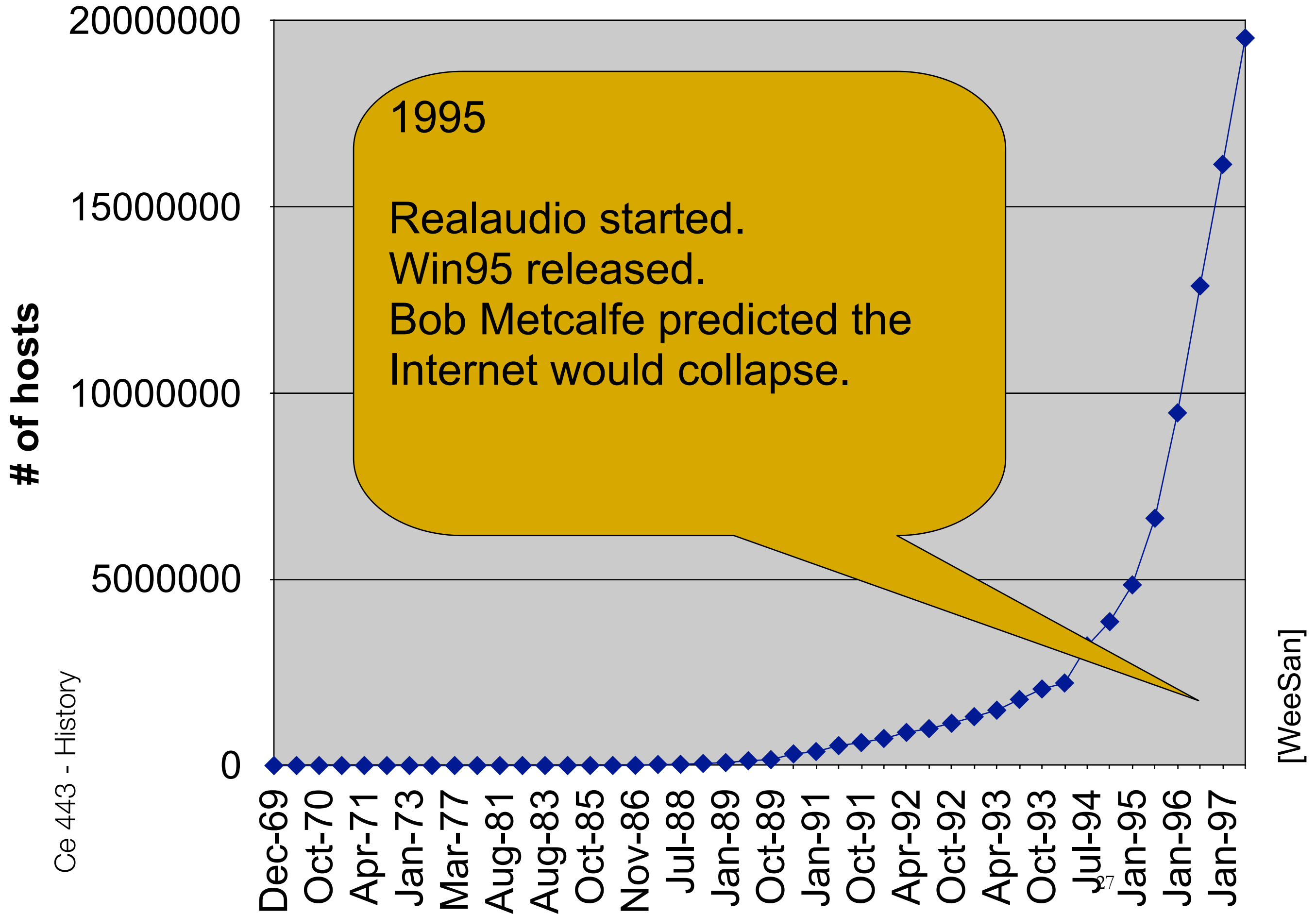
Internet Hosts



Internet Hosts



Internet Hosts



Internet Hosts

of hosts

20000000

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Dec-69
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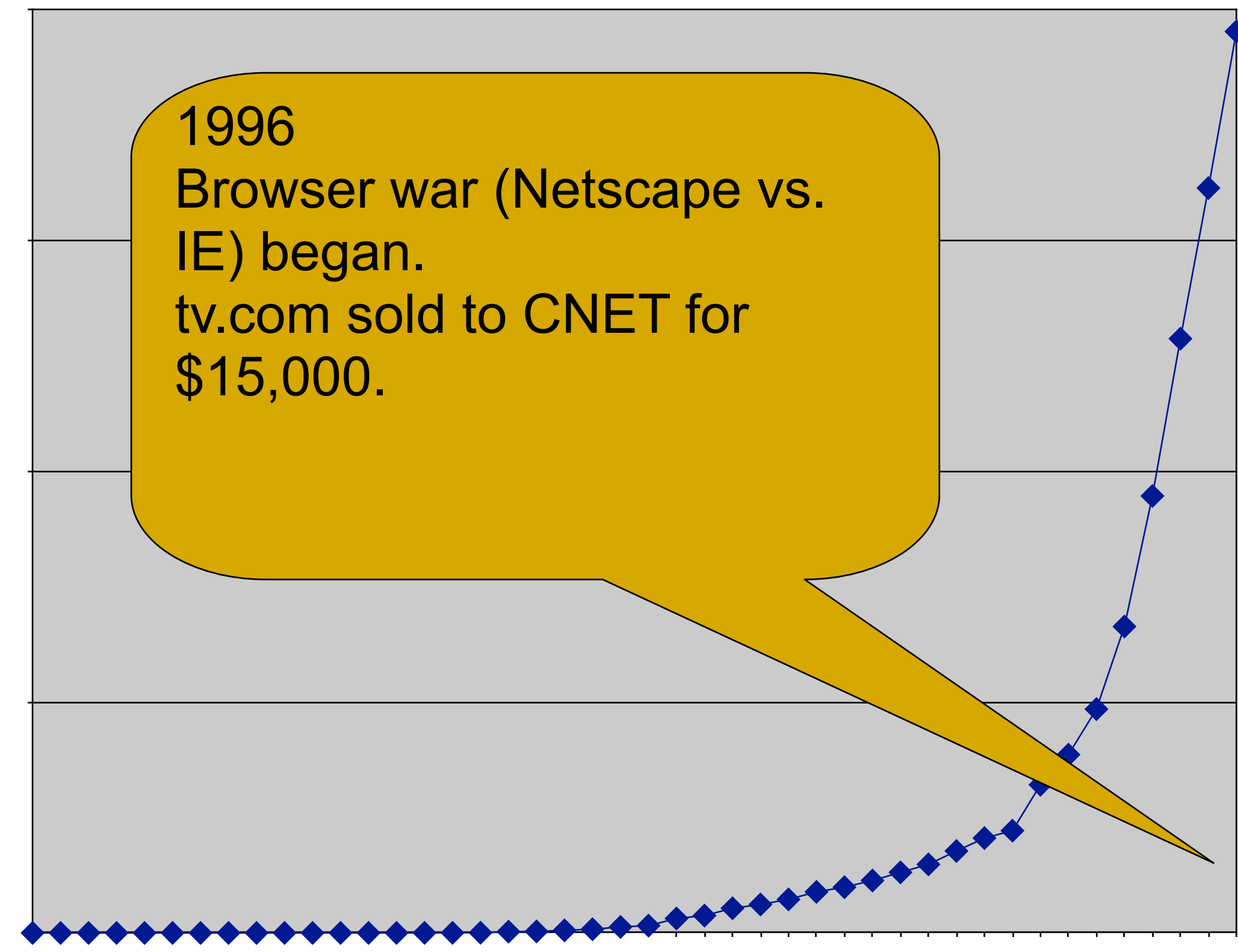
1996

Browser war (Netscape vs. IE) began.

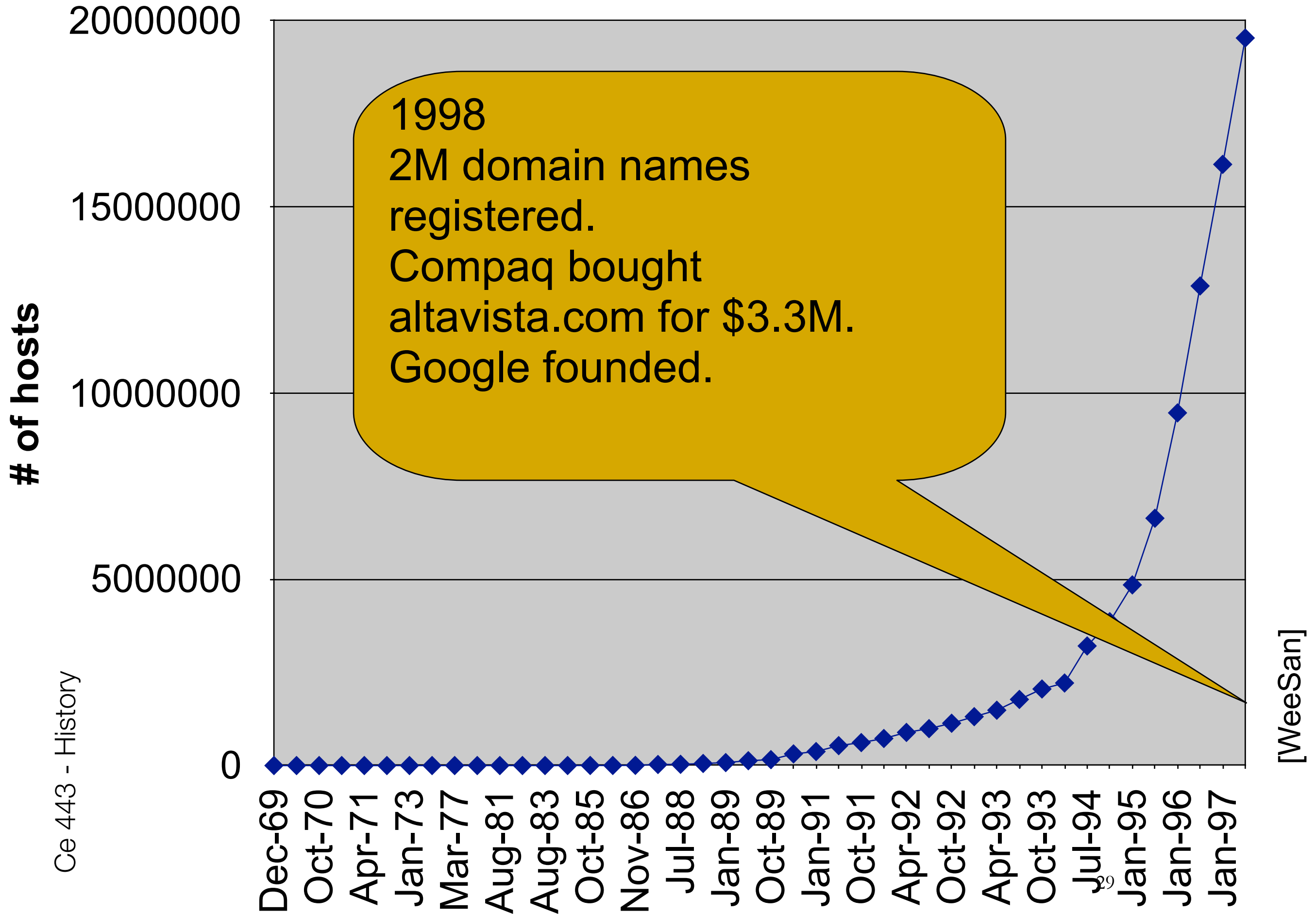
tv.com sold to CNET for \$15,000.

Ce 443 - History

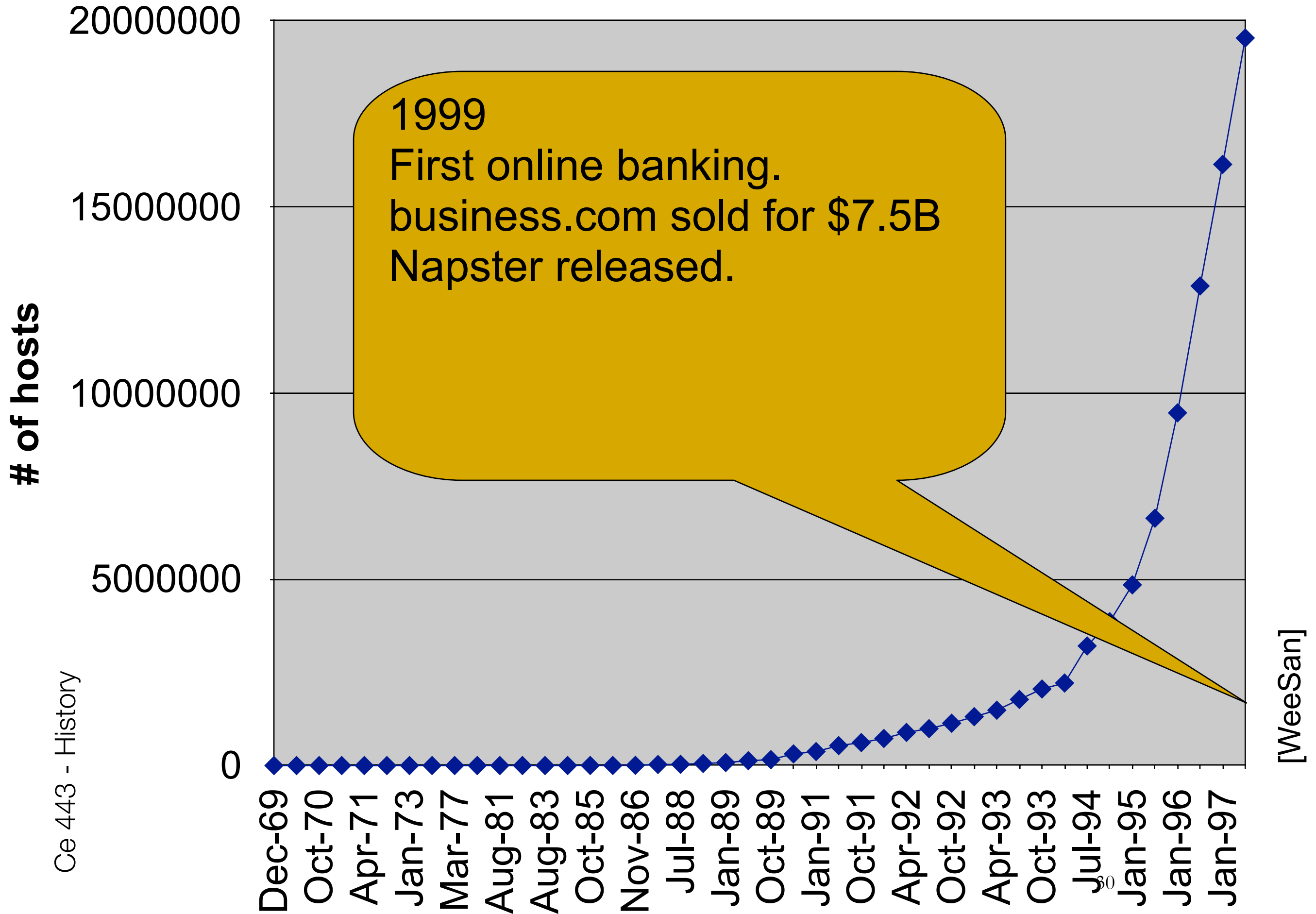
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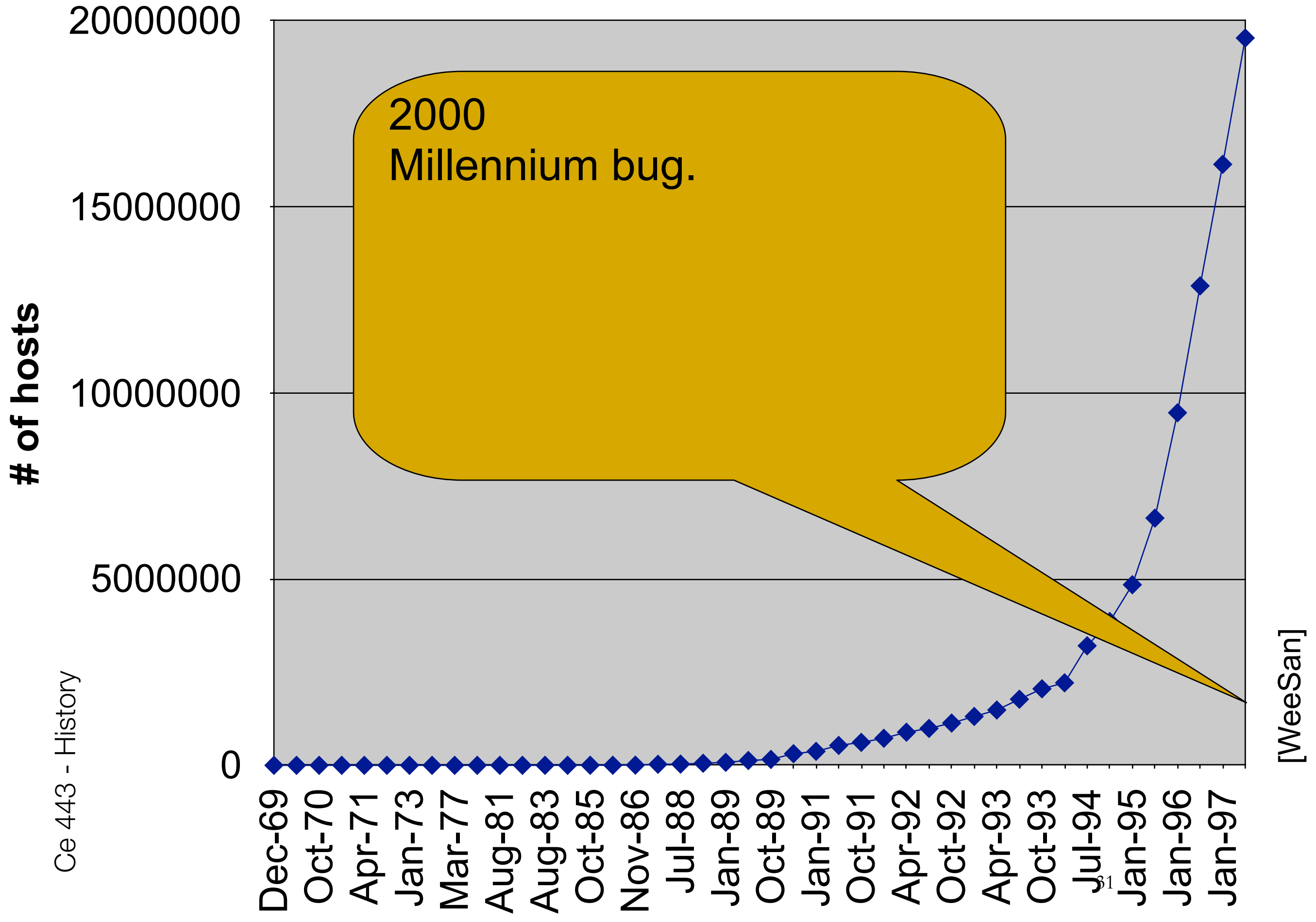
Internet Hosts



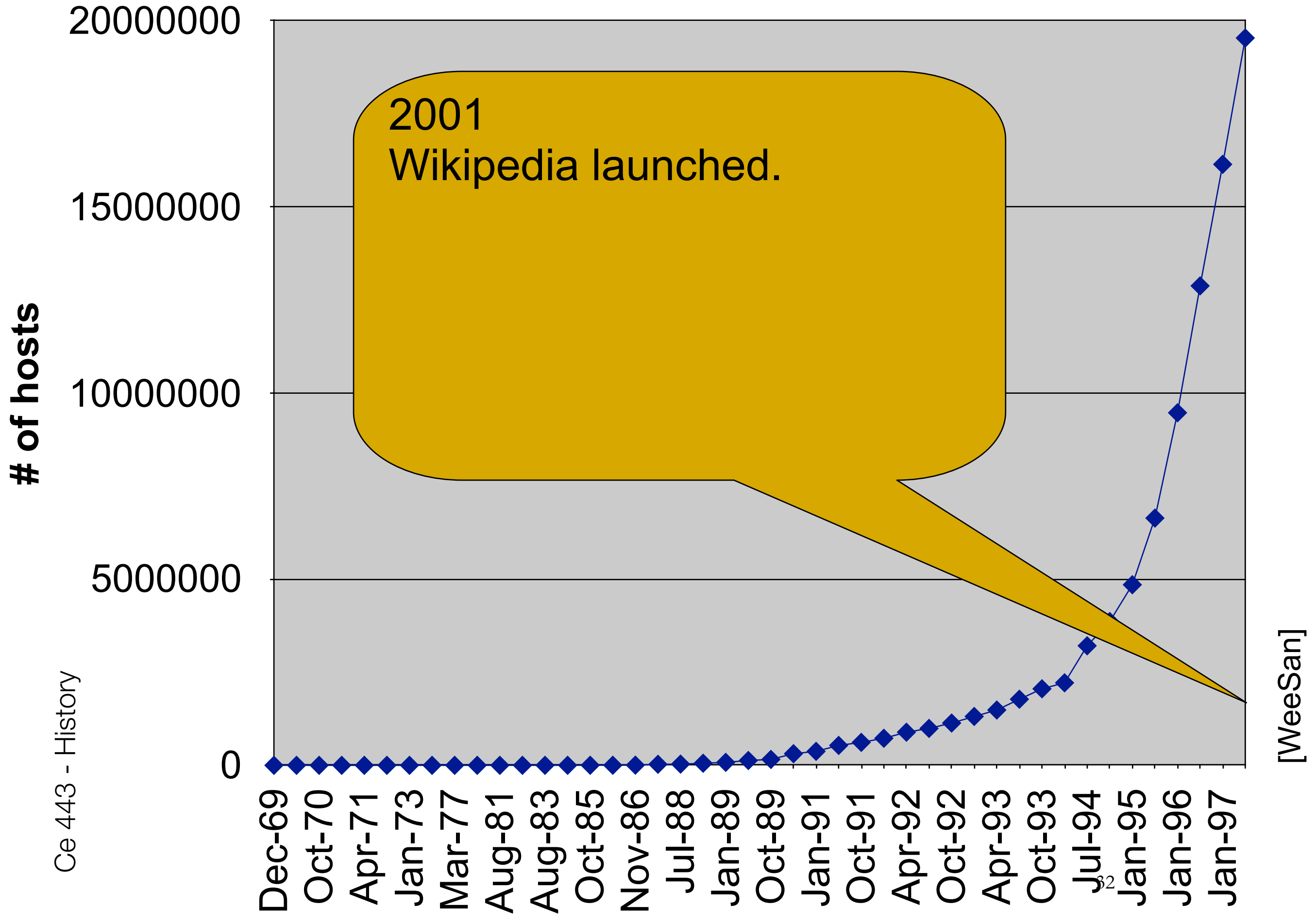
Internet Hosts



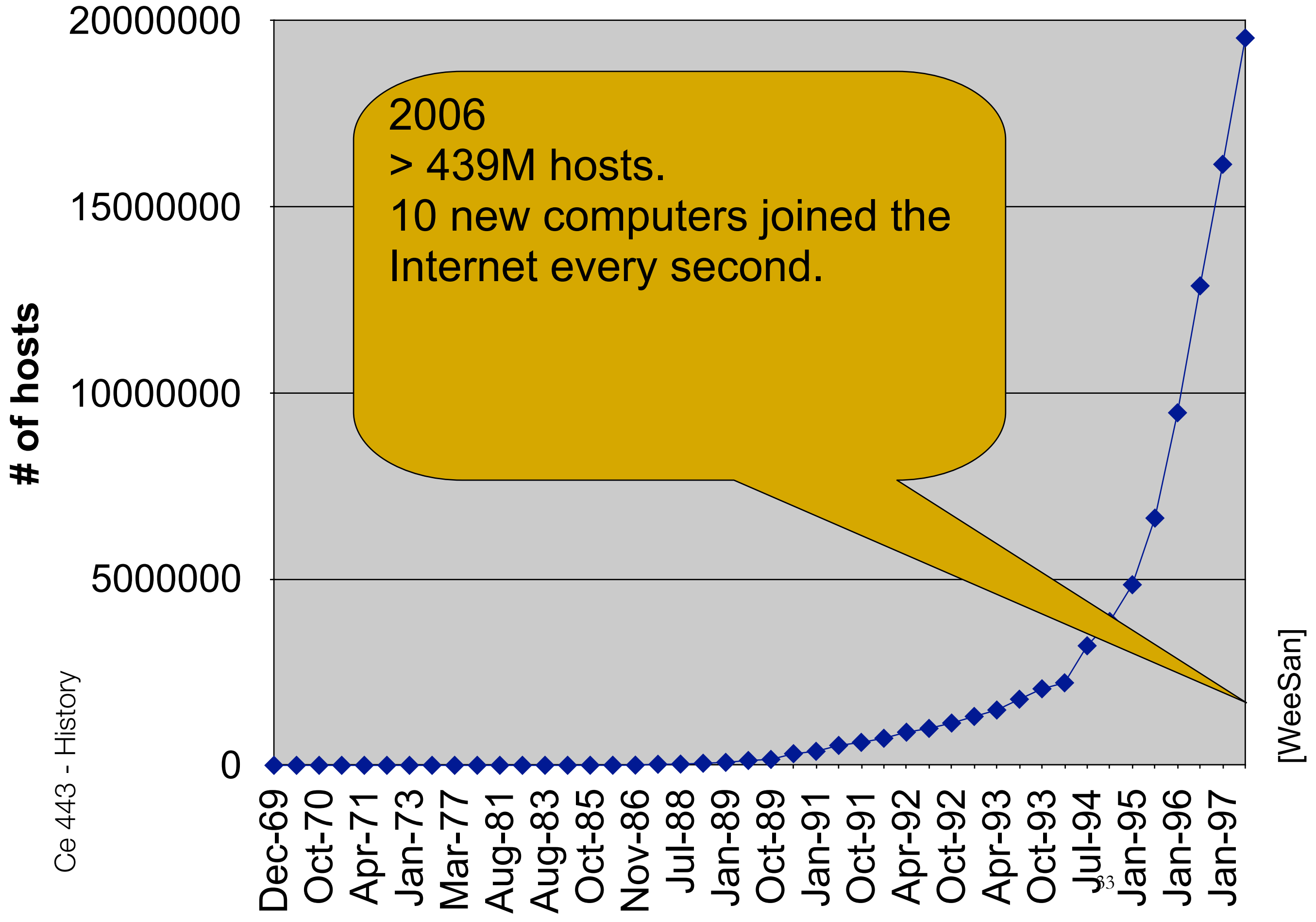
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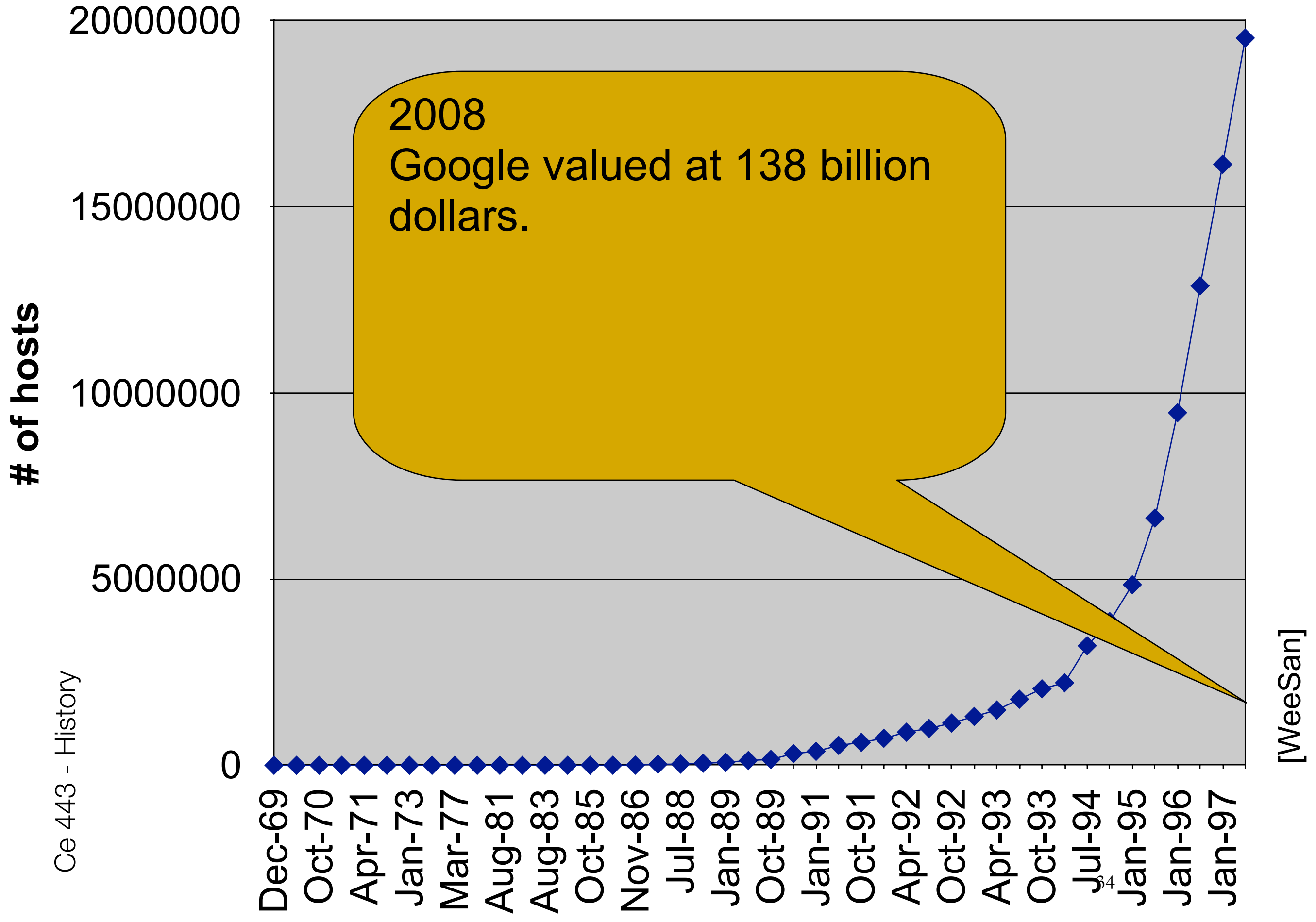
Internet Hosts

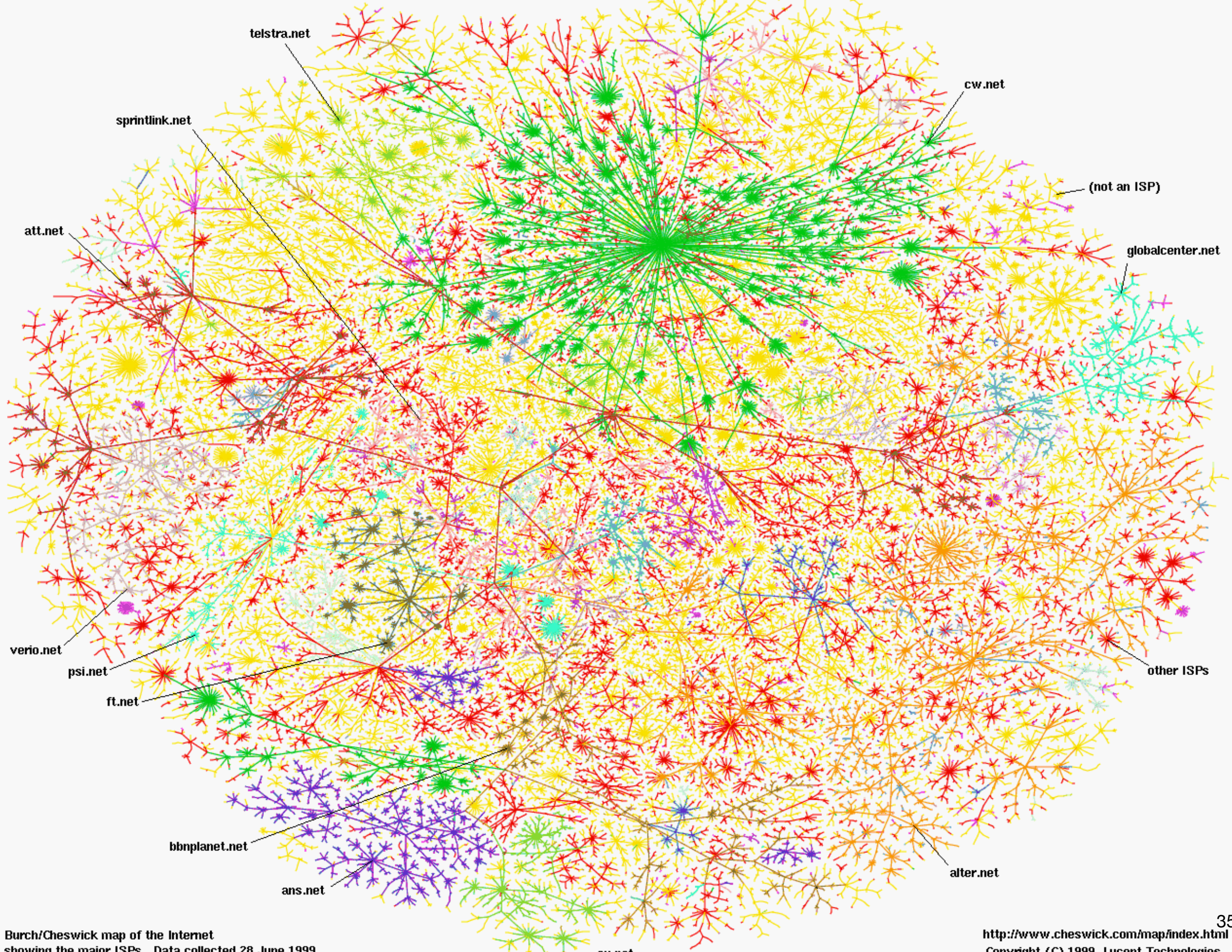


Internet Hosts

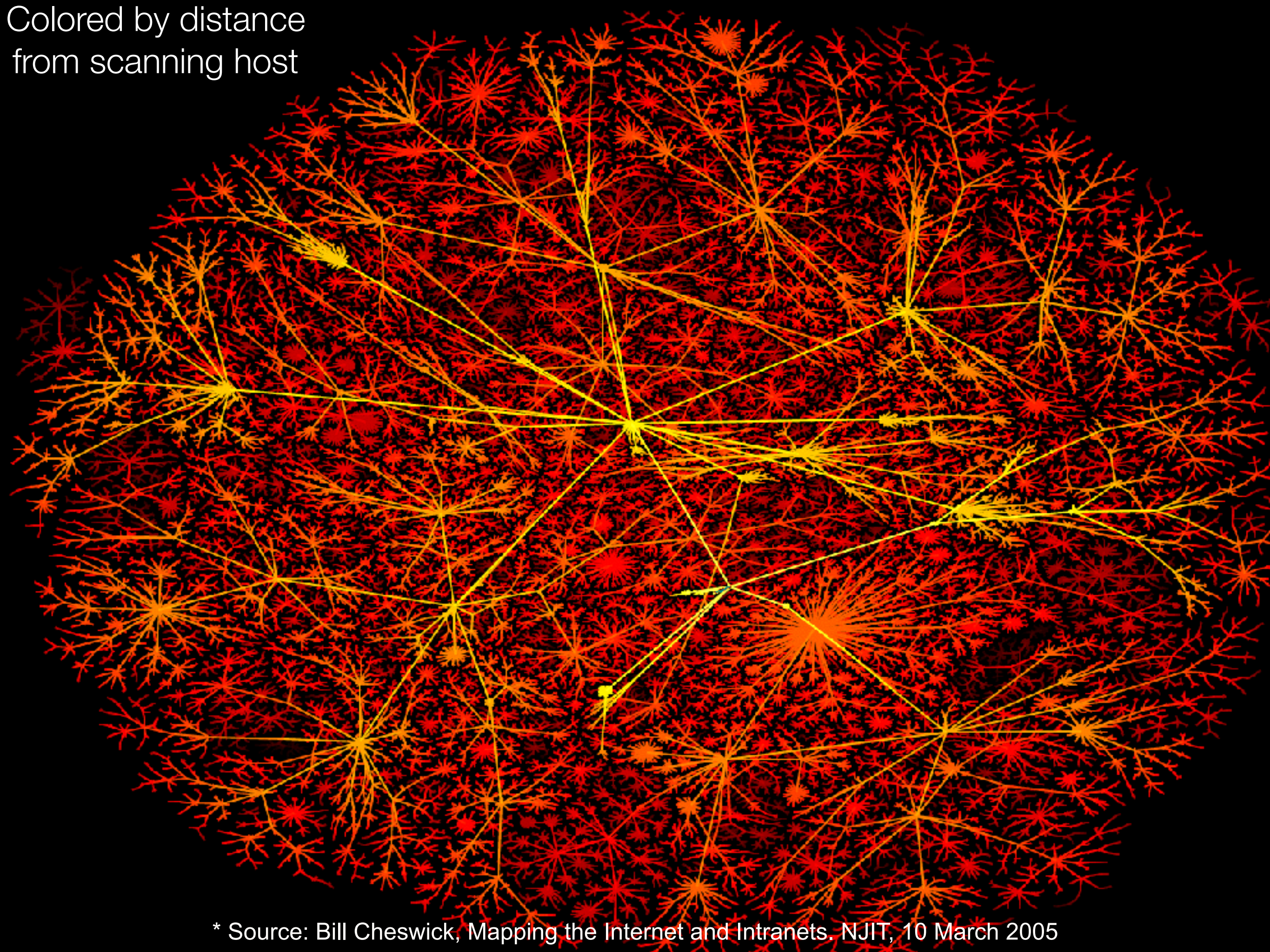


Internet Hosts





Colored by distance
from scanning host



* Source: Bill Cheswick, Mapping the Internet and Intranets, NJIT, 10 March 2005



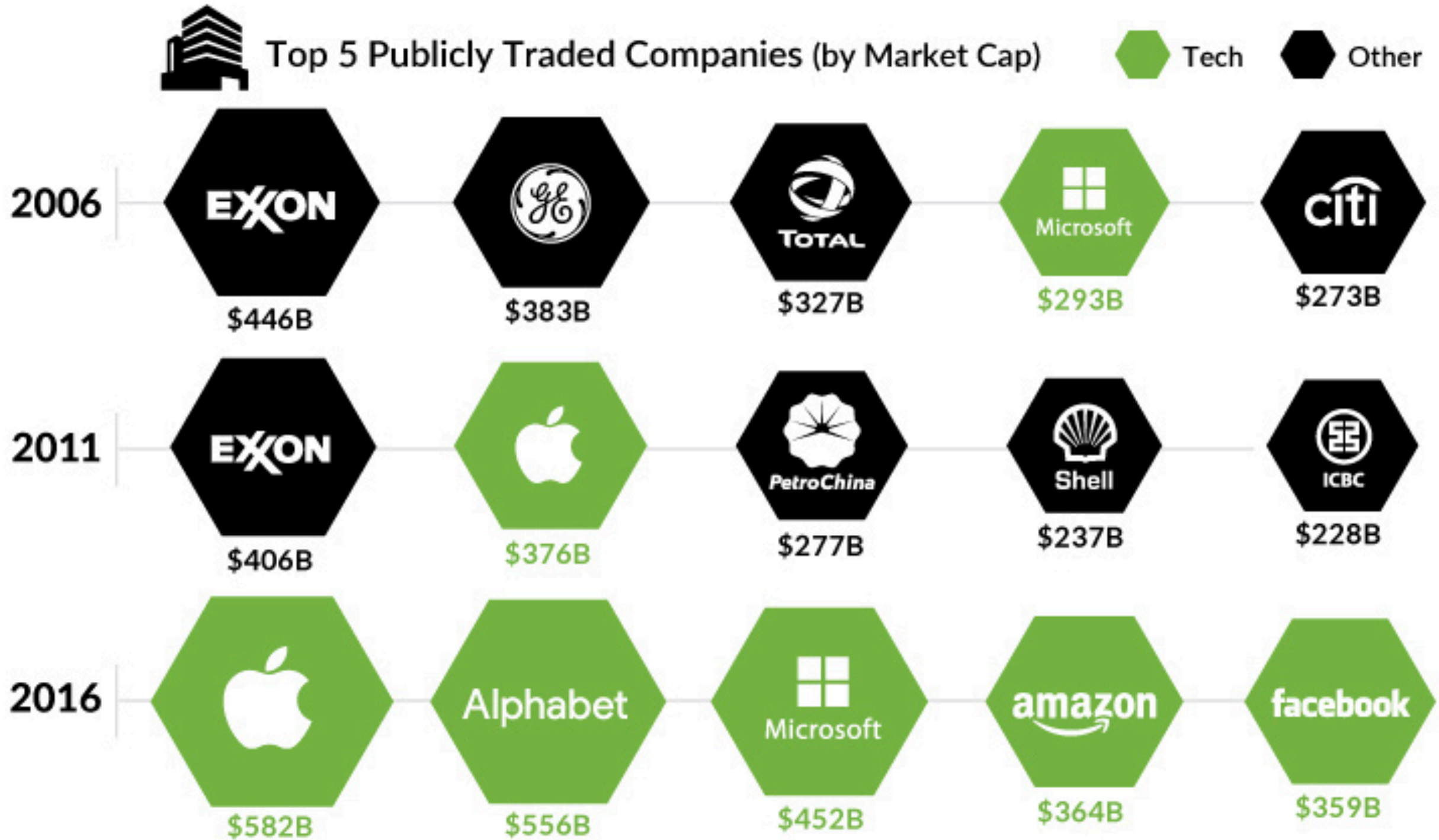
New Applications

- Email, remote terminal access (telnet) and file transfer (ftp) were the original ARPAnet applications.
- Audio/video (1992...)
 - Telephony, conferencing, streaming media.
- World Wide Web (1993...)
 - browsing a mesh of hyperlinks.
 - Altavista search engine (Dec 1995)
- Peer-to-peer (2000...)
 - File sharing
- Social Network
- Video on Demand
 - Netflix

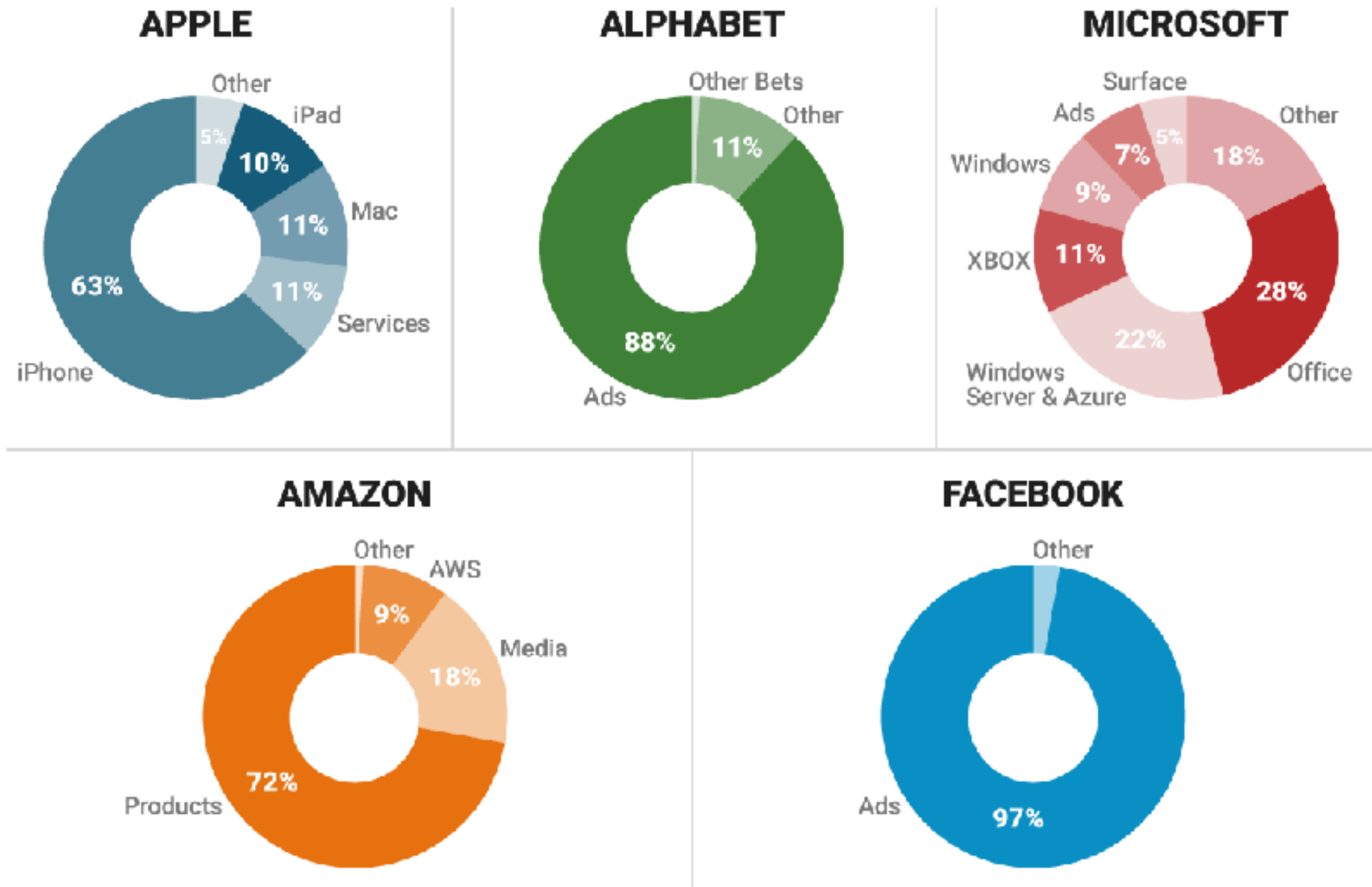




Times have changed



Revenue Streams of The Big 5 Tech Companies



SOURCE: Company annual reports. Figures FY2016

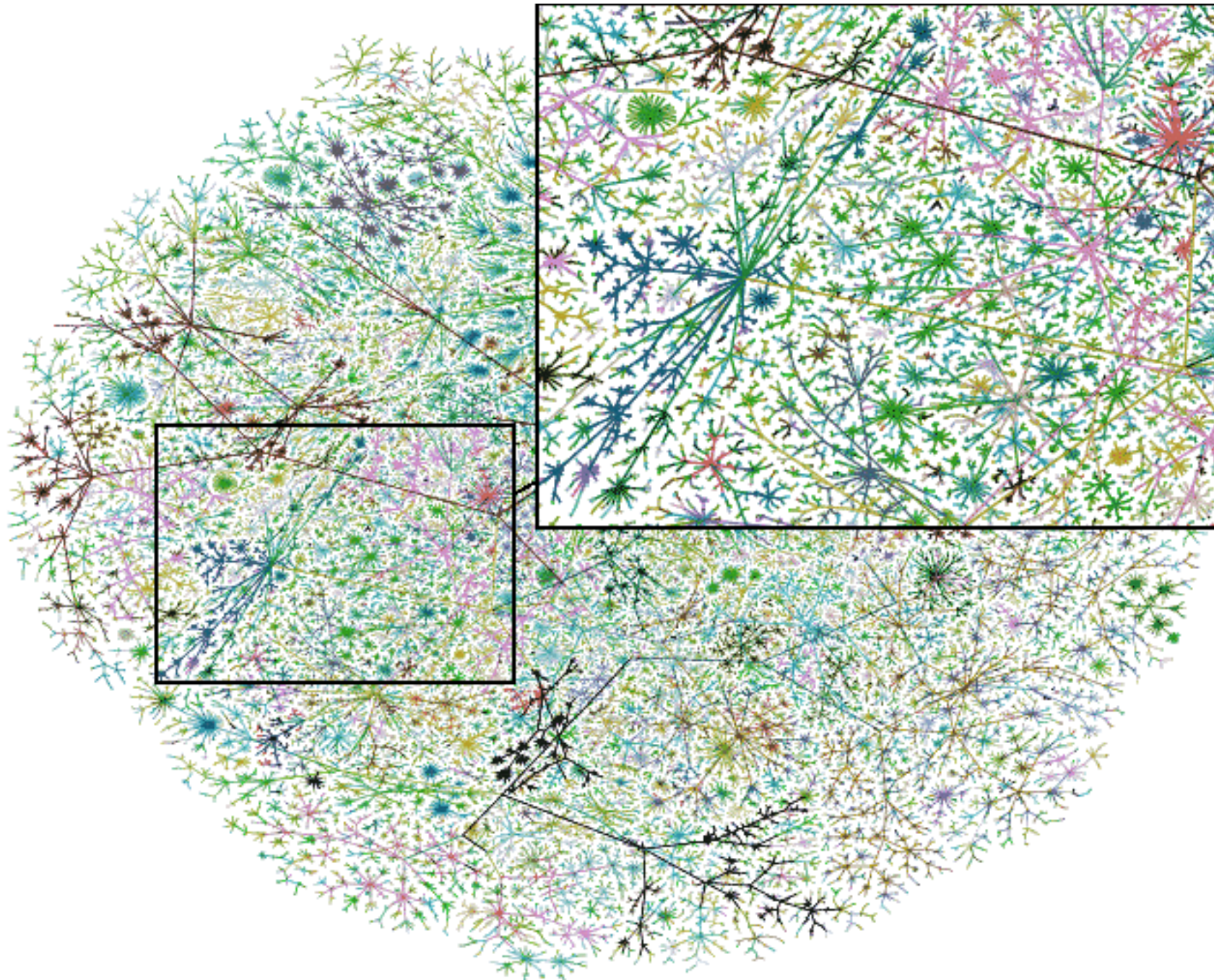


Problem 1: Congestion

- Congestion Control matches offered load to available capacity.
 - TCP congestion control has done this since 1988
- Problem: insufficient dynamic range:
 - Slow and flaky wireless links.
 - Very high speed intercontinental paths.
- Some possible solutions do exist, but:
 - Change is hard, all solutions must interact well.
 - How to decide what is “good enough”?
 - How to get consensus on which solution to deploy?

Problem 2: Routing

(Internet map, 1999)



Problem 2: Routing

(which path to take through the net)



- BGP4 is the only inter-domain routing protocol currently in use world-wide.
 - Lack of security.
 - Ease of misconfiguration.
 - Policy through local filtering.
 - Poorly understood interaction between local policies.
 - Poor convergence.
 - Lack of appropriate information hiding.
 - Non-determinism.
 - Poor overload behaviour.



Problem 3: Security

- We're reasonably good at encryption and authentication.
 - Not so good at actually turning these mechanisms on.
- We're rather bad at key management.
 - Hierarchical PKIs rather unsuccessful.
 - Keys are a single point of failure.
 - Key revocation.
- We're really bad at deploying secure software in secure configurations.
 - No good way to manage epidemics.
 - Flash worm: infect all vulnerable servers on the Internet in 30 seconds.

Problem 4: Availability/ Denial of Service



- The Internet does a great job of transmitting packets to a destination.
 - Even if the destination doesn't want those packets.
 - Overload servers or network links to prevent the victim doing useful work.
- Distributed Denial of Service becoming commonplace.
 - Automated scanning results in armies of compromised zombie hosts being available for coordinated attacks.

Details on the Course



Administrivia

- Website:
 - sharif.edu/~kharrazi/courses/40443-962/
 - You are expected to check the website regularly
- Textbook:
 - Computer Networks: A Systems Approach (Fourth Edition), by Larry L. Peterson, Bruce S. Davie, March 2007.
- Prerequisites: 40-181 Probability and Statistics
- Corequisites: 40-424 Operating Systems
- You must also take, 40-416 with 40-443



Administrivia

- TAs
 - Solmaz Salimi
 - Seyed Ali Tabaei Aghdaei
 - Narges Rezaie
 - Nima Karimipour
- Grading
 - 50% homework
 - 20% midterm
 - 30% final



Policies

- There will be a zero tolerance policy for cheating/copying. The first time you are caught, you will receive a zero for the task at hand. If you are caught for a second time, you will fail the course. Providing your assignment to someone else is considered cheating on your behalf.
- If you turn in your assignments one day late you will lose 25% of the grade, two days will cost you 50% and three days 75% of the grade. No submissions will be accepted after the third day. Penalties may be calculated continuously and per hour of delay.



Policies (con't)

- Each of you has a 3 day extension you could use over the PAs as you wish. The minimum you could use at each instance is a 1 day extension. So you can not extend PA1 by 12 hours and then PA2 by 60 hours. You could use the 3 days with one PA, or 1 day for each PA, or 2 days for PA1 and 1 day for PA2, or 1 day for PA1 and 2 days for PA2, or ... (I hope you get the idea!)
- The 3 day extension will be applied to PA0 and what ever remains would be carried over to PA1 and so on.
- There is a good probability that things go south (i.e. you get sick, network fails, your computer crashes, there is a bug in the PA, server fails, etc.) as the deadline approaches. So keep that in mind and plan for Murphy's law in advance, don't leave things for the last minute.



Acknowledgments/References

- [WeeSan] History of the Internet, WeeSan Lee weesan@cs.ucr.edu, www.cs.ucr.edu/~weesan/cs6/01_history_of_the_internet.ppt
- [Zhang07] Hui Zhang, 15-441 Networking, Fall 2007, School of computer science, CMU.
- [Peterson07] Computer Networks: A Systems Approach (Fourth Edition), by Larry L. Peterson, Bruce S. Davie, March 2007.
- [Feamster15] Computer Networks, COS 461, Princeton University Spring 2015.