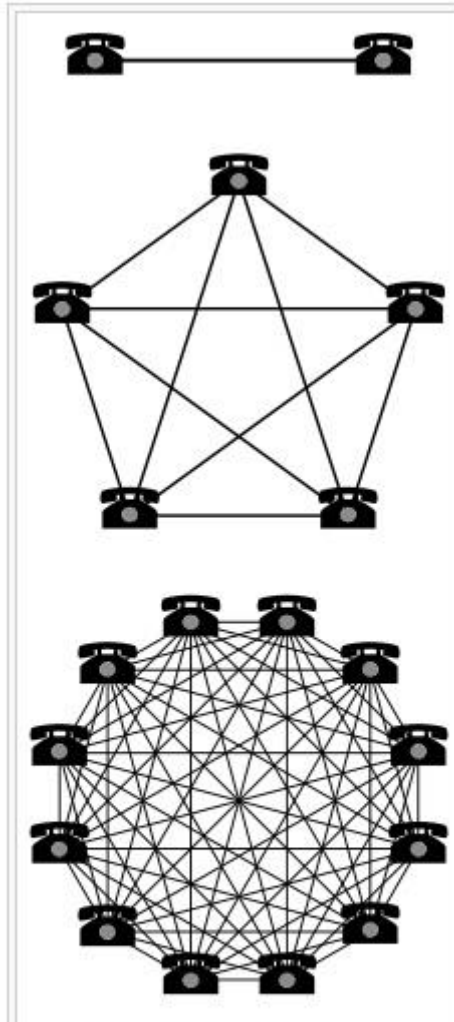# Computing, Communication, and Cognition

Three Laws that define the internet society: Moore's, Gilder's, and Metcalfe's

Dr. Jack M. Wilson

Distinguished Professor of Higher Education, Emerging Technologies, and Innovation

Two telephones can make only one connection, five can make 10 connections, and twelve can make 66 connections.

Moore's Law

- In 1965 Gordon Moore, co-founder of Fairchild Semiconductor and Intel wrote that the number of components on a computer chip were doubling every year.
  - Moore's Law: https://en.wikipedia.org/wiki/Moore's_law
- In 1975 he revised that to a two year doubling period, but as we look back at the data we can see that it was closer to 18 months. The exact number is not as important as the fact that the power of the computer chip was DOUBLING in a comparatively short time. This meant that:
  - Things that are hard to do today are easy tomorrow.
  - The cost of equivalent computing power is halving on a similar time scale. The cost is going down.
  - Designer need to plan ahead for implementations or risk being obsolete when introduced to the market!
    - Do not design for today.
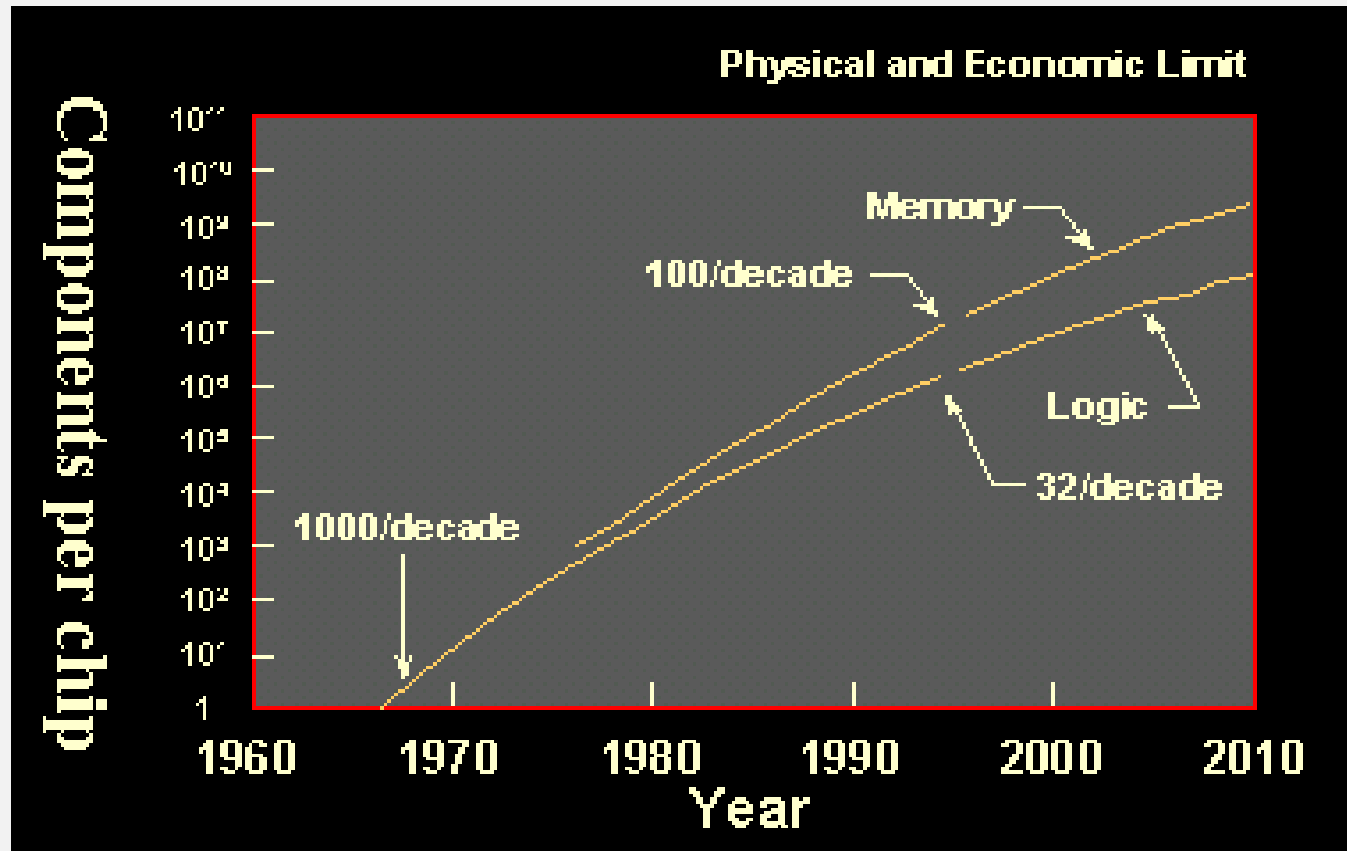   - Design for the deployment date.

Moore's Law

- Moore's Law is an expression of basic physics on silicon wafers on which computer chips are constructed.

- It means the number of components double on each chip

- It means that the device size gets smaller on each chip allowing more to be put in the same space.
  - This required advances in the physics of electronics on silicon.

- still held after 30+ years.

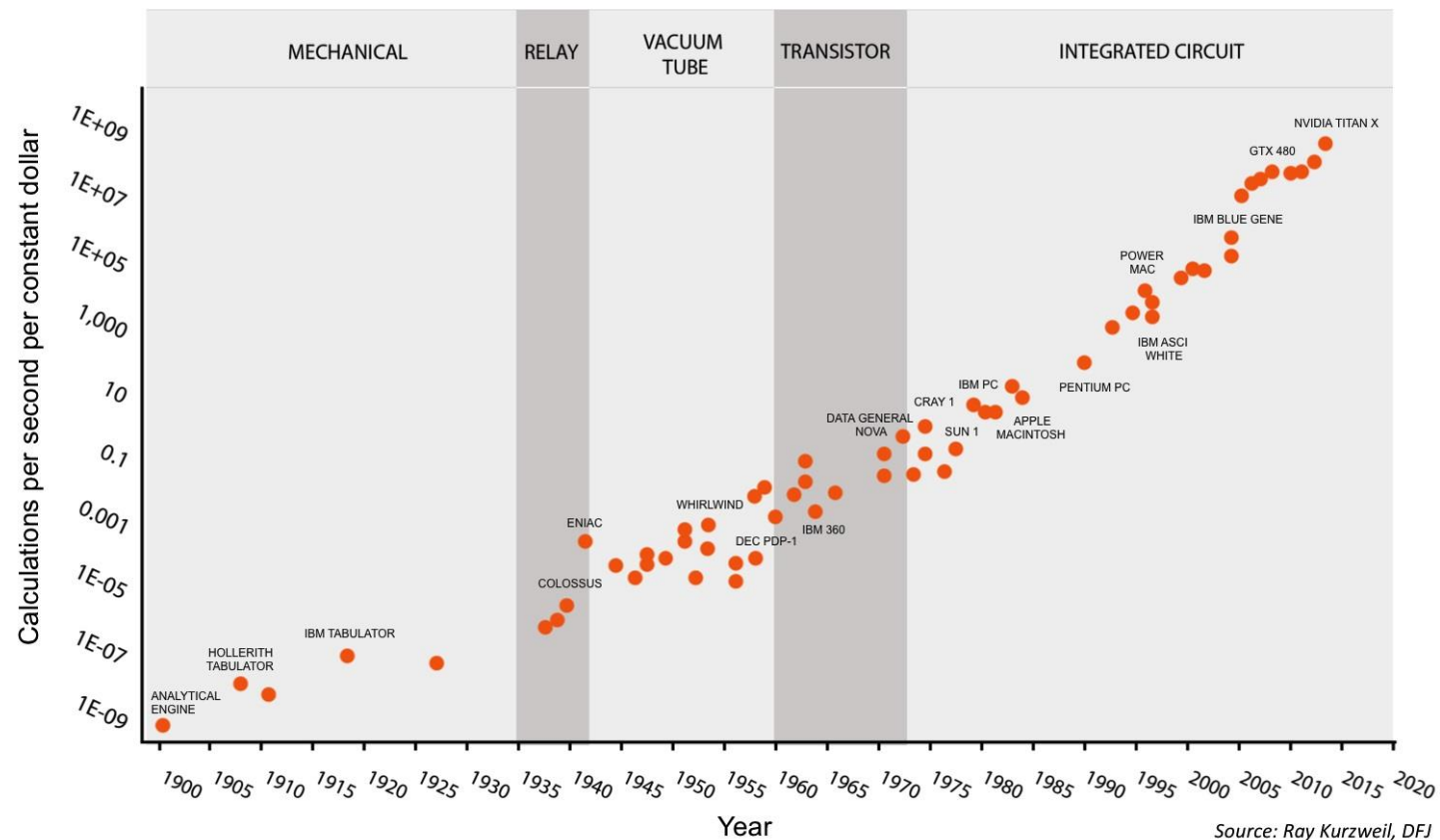- It began to show signs of slowing in 2015-2017.

Microprocessor Transistor Counts 1971-2011 & Moore's Law

https://en.wikipedia.org/wiki/Moore's_law

Moore's Law.

Ray Kurzweil has taken an alternative look at this over 120 years!

120 Years of Moore's Law

Source: Ray Kurzweil, DFJ

– After Steve Jurvetson –
  • https://www.flickr.com/photos/jurvetson/31409423572/, CC BY 2.0,
   https://commons.wikimedia.org/w/index.php?curid=55002144

Moore's Law Implications?

- Things that are hard to do today are easy tomorrow.
- The cost of equivalent computing power is halving on a similar time scale.
- Plan ahead for implementations.
- Do not design for today.
- Design for the deployment date.
- Moore's Law: https://en.wikipedia.org/wiki/Moore's_law

Gilder's Law: Bandwidth Doubling

- Bandwidth grows at least three times faster than computing power.
- While computer power doubles every 18 months (Moore's Law), communications power doubles every six months.
  - Telecosm: How Infinite Bandwidth Will Revolutionize Our World
    - *https://books.google.com/books?isbn=074321594X*
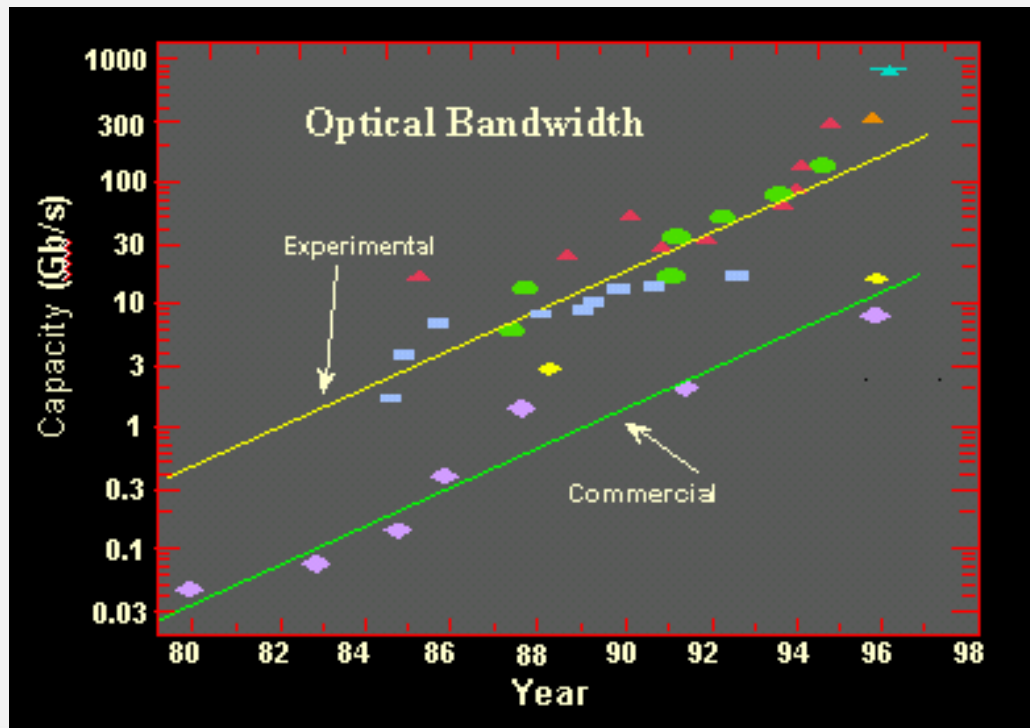
Metcalfe's Law

- The Value of a network scales as the square of the number of those connected to it.
  - Value: economic, personal, societal,....
  - Double the network = four times the value!
  - "network economics" or "network externalities"
- Implications?   If my network is bigger than your network, I can derive more value from it.
- Bob Metcalf -inventor of Ethernet, 3Com founder.

First left is **Bob Metcalf** and then **Mikhail Gorbachev** at a meeting of the Mass Technology Leadership Council. **Jack Wilson** is top right.

Detailed calculation of Metcalfe's Law

- If you have **N** items
  - Could be computers, people, or other interacting things.
- Those **N** items have **N-1** other items to connect to!
- Thus there are **N(N-1)** possible connections.
- But each connection is duplicated. There is no difference between the connection from item 1 to item 2 and the same connection from item 2 to item 1. Thus we need to divide by two to correct for the duplication.
- Connections = **N(N-1)/2**
- However, as the number of things gets large then this equation is dominated by **N²**.
  - In 2016, Facebook had **1.79 Billion** users.
  - Google had **2.2 Billion** users.
  - Amazon had **183 million** users per month.
- Metcalfe shows how they dominate!
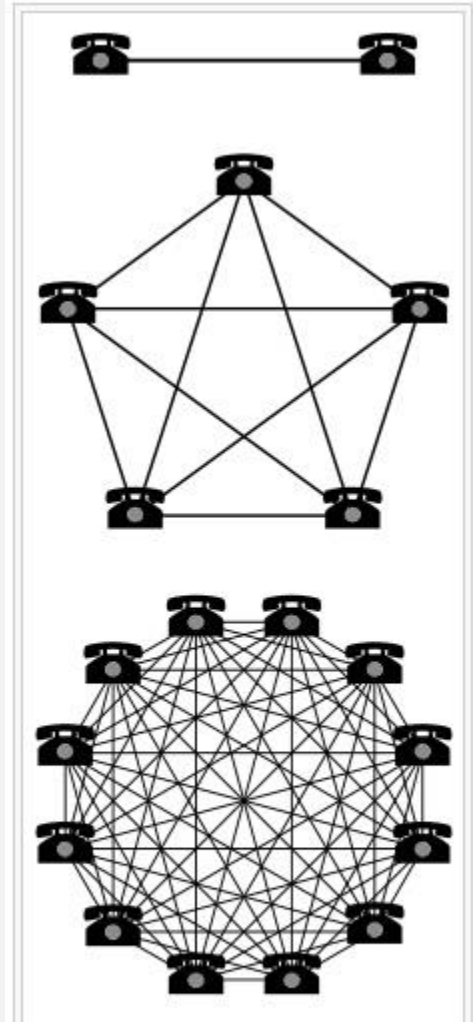
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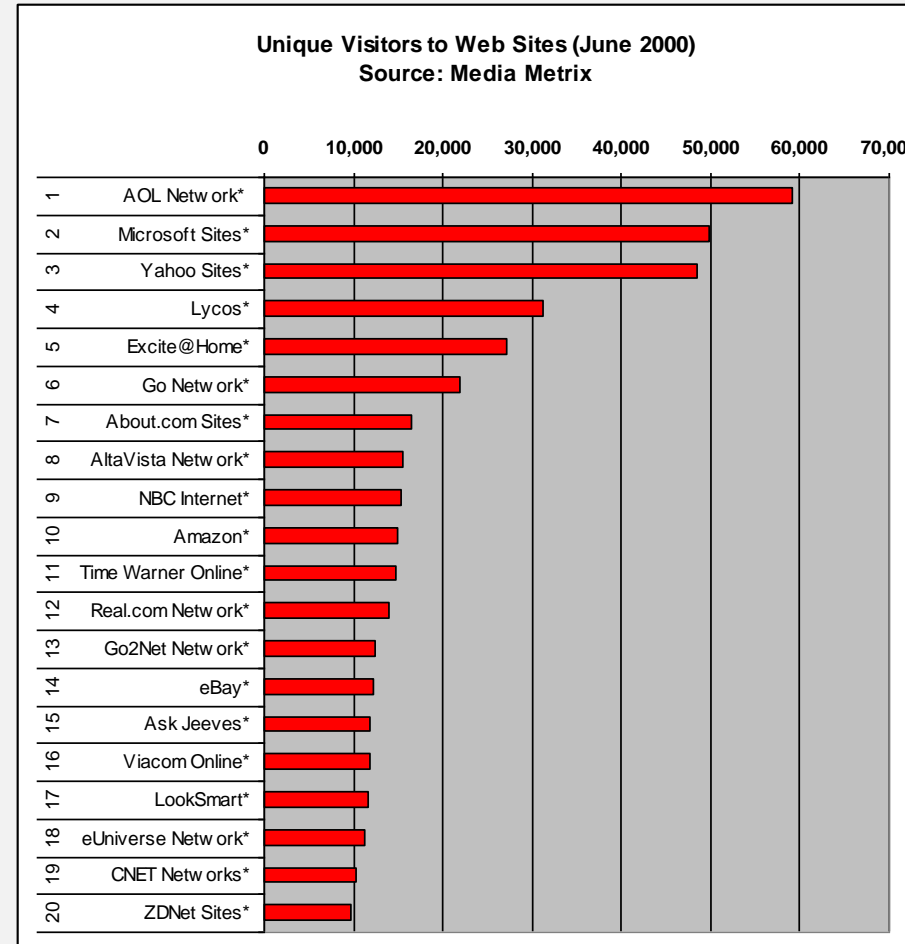
Metcalf's Law

- Positive Feedback:
  - If I can do that, then my network will continue to grow!
  - That makes mine bigger still.
  - Ouch, it hurts to be on the losing side

- Winner take all markets
- Many legal and economic experts think monopolies are normal (not necessarily desirable) in eBusiness!
- This is what let later arrivals like Google eclipse earlier search engines like Alta Vista or Yahoo. Once Google got more users, it became so much more valuable than Yahoo, that more and more users moved to Google.
- Once Facebook got more users than MySpace, it made all users want to be on Facebook.

Network Size
Example of Time Warner merging with AOL in 2000

- Who has the power?
- Implications?   If I am Time Warner and I want to merge with AOL, how good is my bargaining position?
-
- Questions:
- How to grab the largest network size
- How to defend my network size
- How to avoid being crunched by the large players
- Is "network economics" destiny?
- Why are eyeballs valuable?
- Many legal and economic experts think monopolies are normal in eBusiness! Not good, but almost inevitable.

Unique Visitors to Web Sites (June 2000)
Source: Media Metrix

#	Site	
1	AOL Network*	
2	Microsoft Sites*	
3	Yahoo Sites*	
4	Lycos*	
5	Excite@Home*	
6	Go Network*	
7	About.com Sites*	
8	AltaVista Network*	
9	NBC Internet*	
10	Amazon*	
11	Time Warner Online*	
12	Real.com Network*	
13	Go2Net Network*	
14	eBay*	
15	Ask Jeeves*	
16	Viacom Online*	
17	LookSmart*	
18	eUniverse Network*	
19	CNET Networks*	
20	ZDNet Sites*	

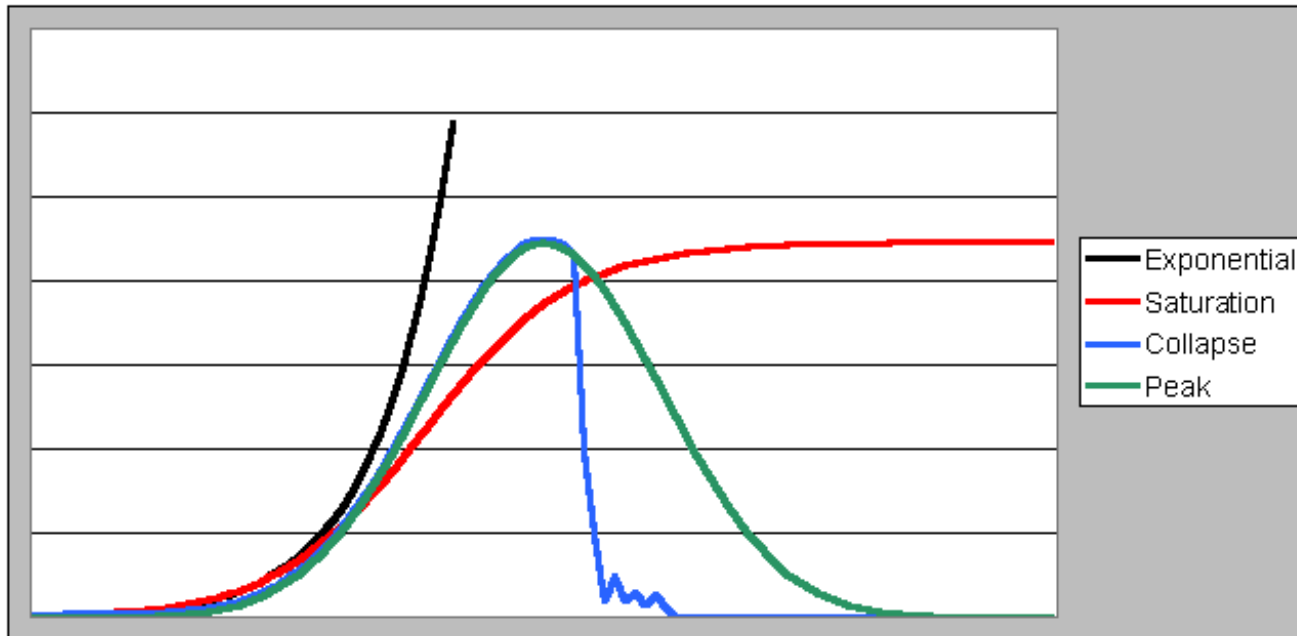Axis: 0, 10,000, 20,000, 30,000, 40,000, 50,000, 60,000, 70,000

Exponential Growth

- Consider the growth of Internet Hosts
- Note that this growth is exponential with a doubling time of approximately 18 months.
-
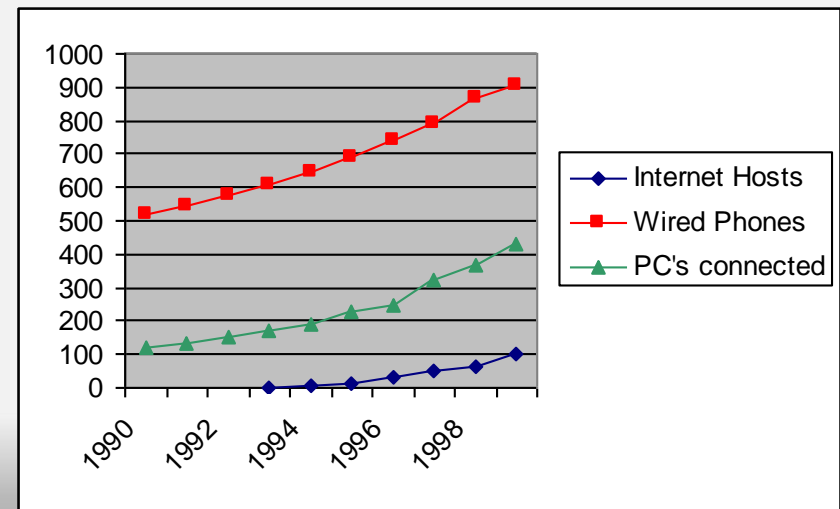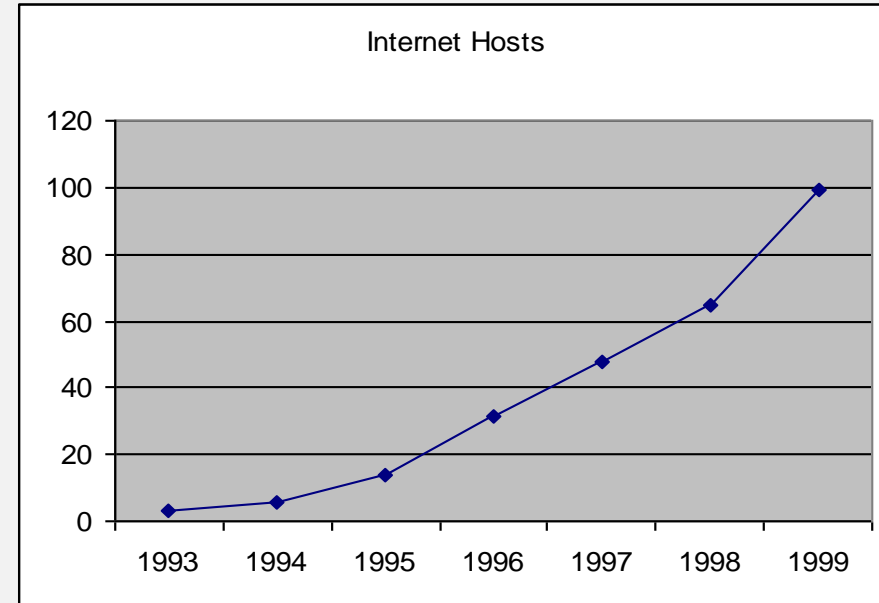
Exponential Growth

- There is no such thing as exponential growth outside of mathematics.
  - there are things that look like exponential growth for awhile.
- Implications?   All good things must end somehow.
  - How will they end?
    - Saturation (Red)- levels off at a higher level
    - Peaking (green)- shrinks as it had once grown
    - Collapse (blue)- catastrophic reversal of fortune.

The network

In the beginning there was the network (tcp-ip), and it needed to survive nuclear war (ARPANet, NSFNet, NYSERNet, BitNet, etc.)

- 1991: Timothy Berners Lee invents the World Wide Web (www) to help high energy physicists exchange data through a hyper text transfer protocol (http) on the internet.

- Marc Andreessen, Eric Bina and others invent Mosaic to make the web accessible to others in the computing community.

- Jim Clark and Marc Andreessen create Netscape and make the browser widely available.

- Bill Joy at Sun creates Java. "Write once- run anywhere!"

- Microsoft embraces Java and then extends it. - Fight!

- Java loses momentum on the client and becomes the defacto eBusiness standard on the server.

- XML (eXtensible Markup Language) invented to extend html

- Web services

Driving the future

- These three "Laws" have been driving the development of computing, communications, and cognition for the last thirty years.

- They are responsible for
  - the rise of the internet
  - The creation of social media
  - The revolution in buying, selling, and marketing.

- They have created companies like:
  - Facebook, Google, Amazon, eBay, Tinder, Cisco,

January 2017 –Companies by Market Cap

- Companies marked with the asterisk own much of their success to Moore's Law, Gilder's Law, and Metcalfe's Law.

- Most of the other companies also have some of their success due to deployment of IT technologies.

Company	Cap Rank	Market Cap
-	on 1/26/17	on 1/26/17
Apple *	1	650.2
Alphabet *	2	590.7
Microsoft *	3	499.7
Berkshire Hathaway	4	407.8
Amazon.com *	5	398.7
Facebook *	6	382.7
Exxon Mobil	7	355.0
JPMorgan Chase	8	309.8
Johnson & Johnson	9	304.3
Wells Fargo	10	286.8
General Electric	11	266.7
AT&T	12	256.5
Alibaba Group *	13	255.3
Bank of America	14	246.5
China Mobile *	15	232.6
Royal Dutch Shell	16	221.9
Procter & Gamble	17	221.4
Chevron	18	220.0
Wal-Mart Stores	19	205.1
Verizon *	20	200.5
Visa	21	194.8
Pfizer	22	189.8
Comcast *	23	180.7
Coca-Cola	24	180.3
Intel *	25	178.0