Porter's Laws and Disruptive Technologies

NBAY 1620
February 29, 2016
Donald P. Greenberg
Lecture 1

Course Website

- http://www.graphics.cornell.edu/academic/nba6120/

Required Reading

- Michael E. Porter. How Competitive Forces Shape Strategy, Harvard Business Review, March-April 1979, pp. 137-145.(Search http://erms.library.cornell.edu/
- Joseph L. Bower and Clayton M. Christensen. Disruptive Technologies: Catching the Wave, Harvard Business Review, January-February 1995, pp. 43-53. (Search http://erms.library.cornell.edu/)

Optional Reading

- Jill Lepore. "The Disruption Machine," The New Yorker, June 23, 2014. http://www.newyorker.com/reporting/2014/06/23/140623fa_fact_lepore?currentPage=all

NBA 6120

DISRUPTIVE TECHNOLOGIES

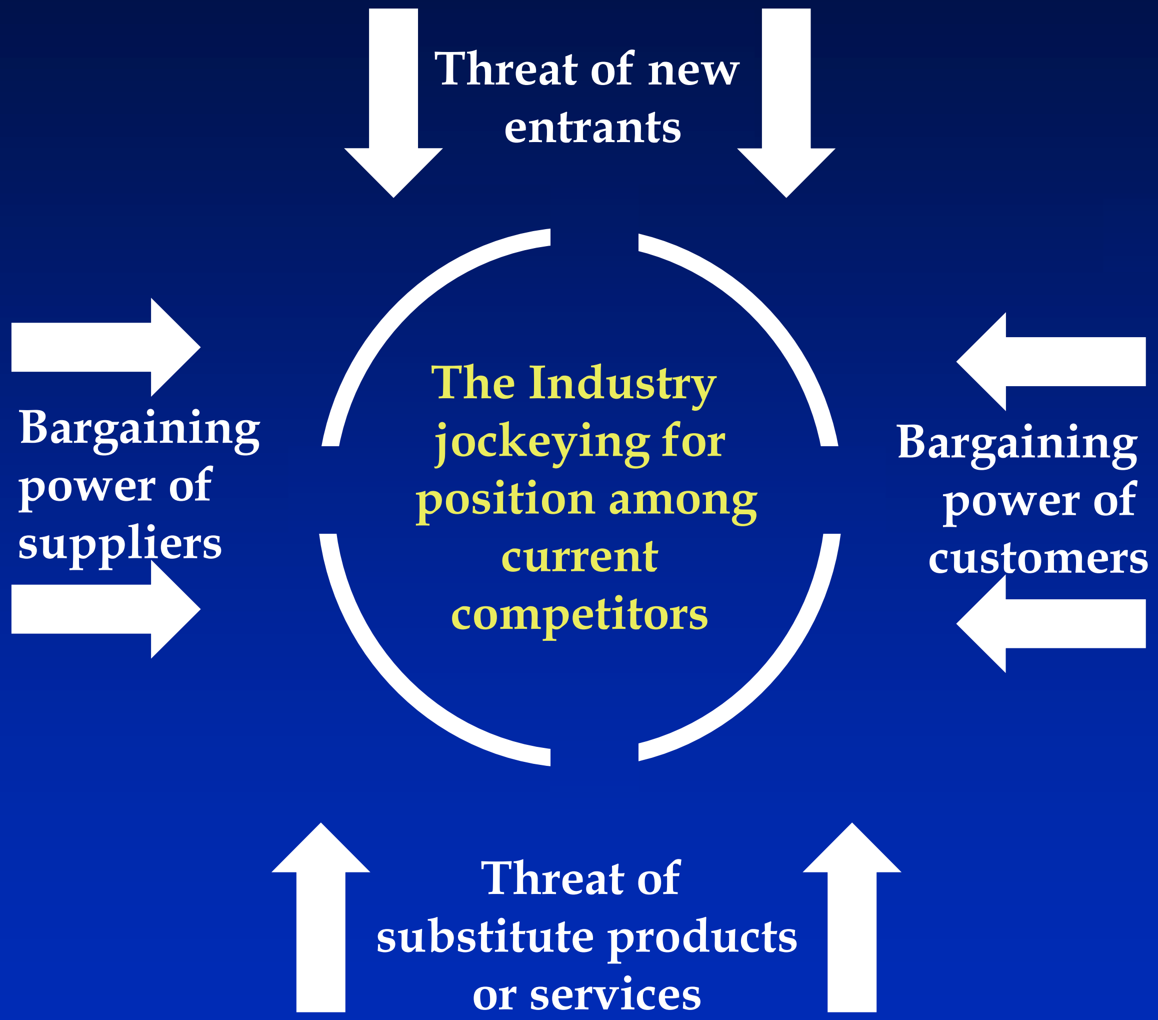
NBA 6120

DISRUPTIVE TECHNOLOGIES

Porter's Rules

"The essence of strategy formulation is coping with competition"

Professor Michael Porter
<u>Harvard Business Review</u>
March/April 1979


Threat of new entrants
Bargaining power of suppliers
The Industry jockeying for position among current competitors
Bargaining power of customers
Threat of substitute products or services

Technology Threats (Opportunities?)

- New substitutes with different attributes
- New substitutes based on technology changes:
- Exponentially increasing price/performance ratio
- Relative rates of change
- Knowledge of where the system bottlenecks exist

Stack Fallacy

If only a few companies dominate -
increases supplier power
easier to integrate forward

Threat of new entrants

Internet -
increases threat
reduces barriers to entry
easy distribution channels
low cost

Bargaining power of suppliers

Who are your competitors?

Bargaining power of customers

Technology changes -
increases substitution threat with rapidly changing price/performance

Threat of substitute products or services

Internet -
increases customer power
comparison shopping,
search engines,
auctions

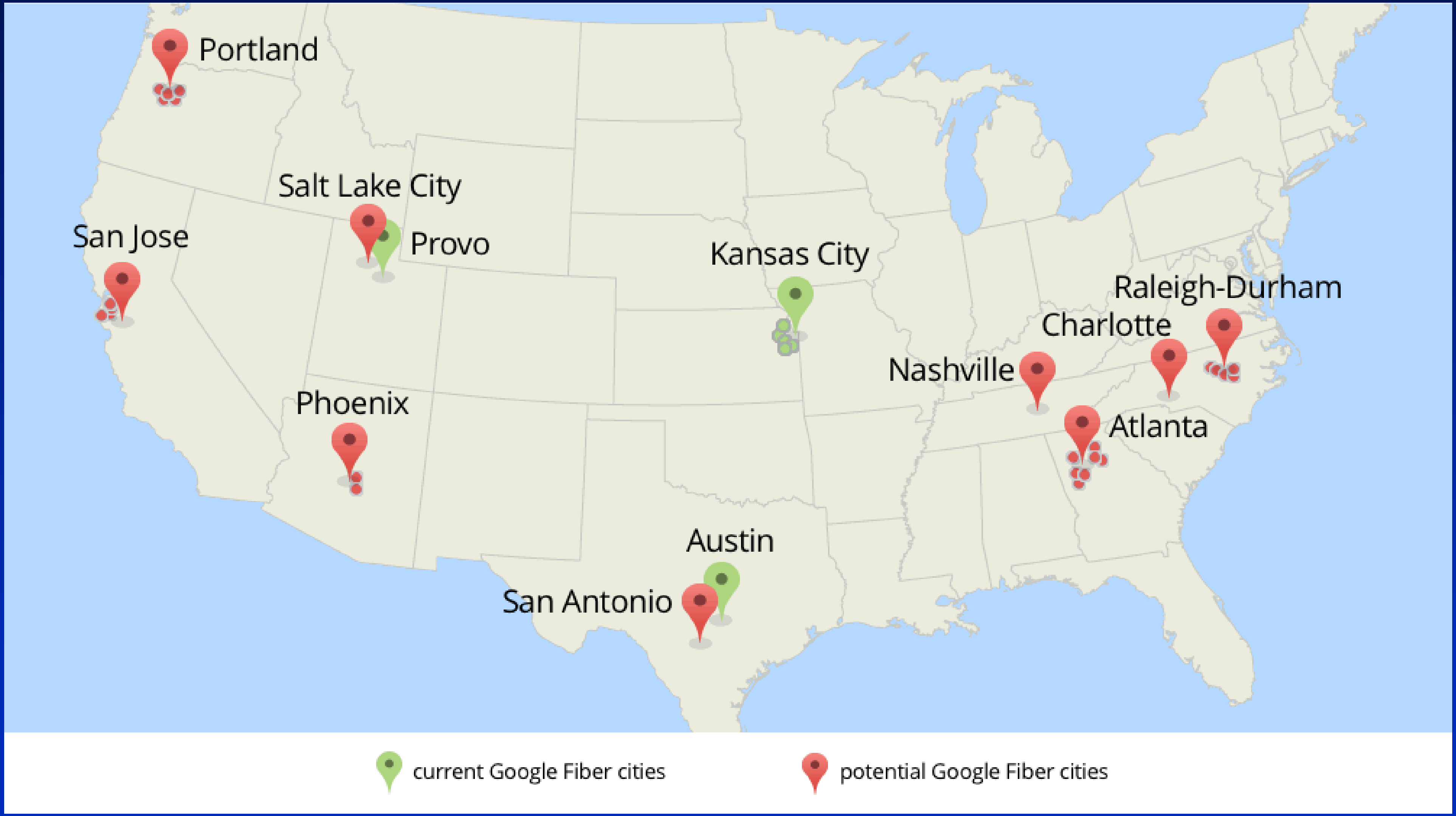
Porter's Suggestions:

1. Position company to provide best defense
2. Influence balance of forces through strategic moves
3. Anticipating shifts in the underlying forces and responding

Examples

- Oracle buying Sun
- Intel buying McAfee (security) and SySDSoft (wireless software firm)
- Qualcomm buying chip manufacturer, Atheros
- Google adding fiber around selected cities

Google Fiber Plans Smart Cities



Examples

- Facebook buying Instagram and Oculus
- Dish trying to acquire Sprint Networks
- Google buying Motorola Mobility
- Amazon buying The Washington Post
- Comcast buying NBC

What Do You Do With The Unexpected?

- Unionization of Uber Drivers?
- Legislation Barring Uber
- Instantaneous Price Changes Based on Demand Which Create Unethical Cancellations

Moore's Law

The number of transistors that the industry would be able to place on a computer chip would double every year.

— Gordon Moore
1965

Moore's Law

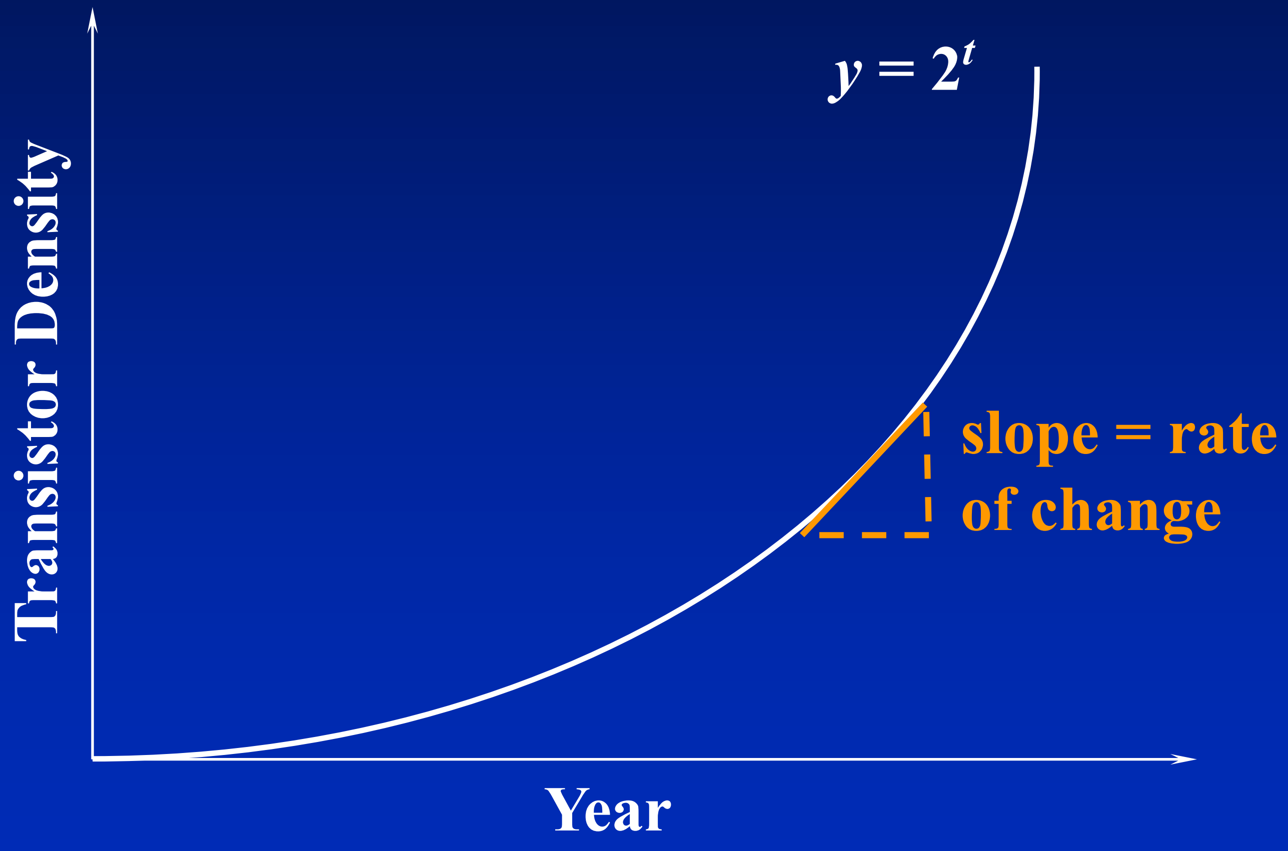
"Chip density doubles every 18 months."

Processing Power (P) in 15 years:

$$P = P_{today}(2)^{\frac{15\ years}{18\ months}} = P_t(2)^{\frac{15}{1.5}}$$

$$= P_t(2)^{10} = 1000P_t$$

Understanding Exponential Growth



Understanding Exponential Growth

$$y = 2^t$$

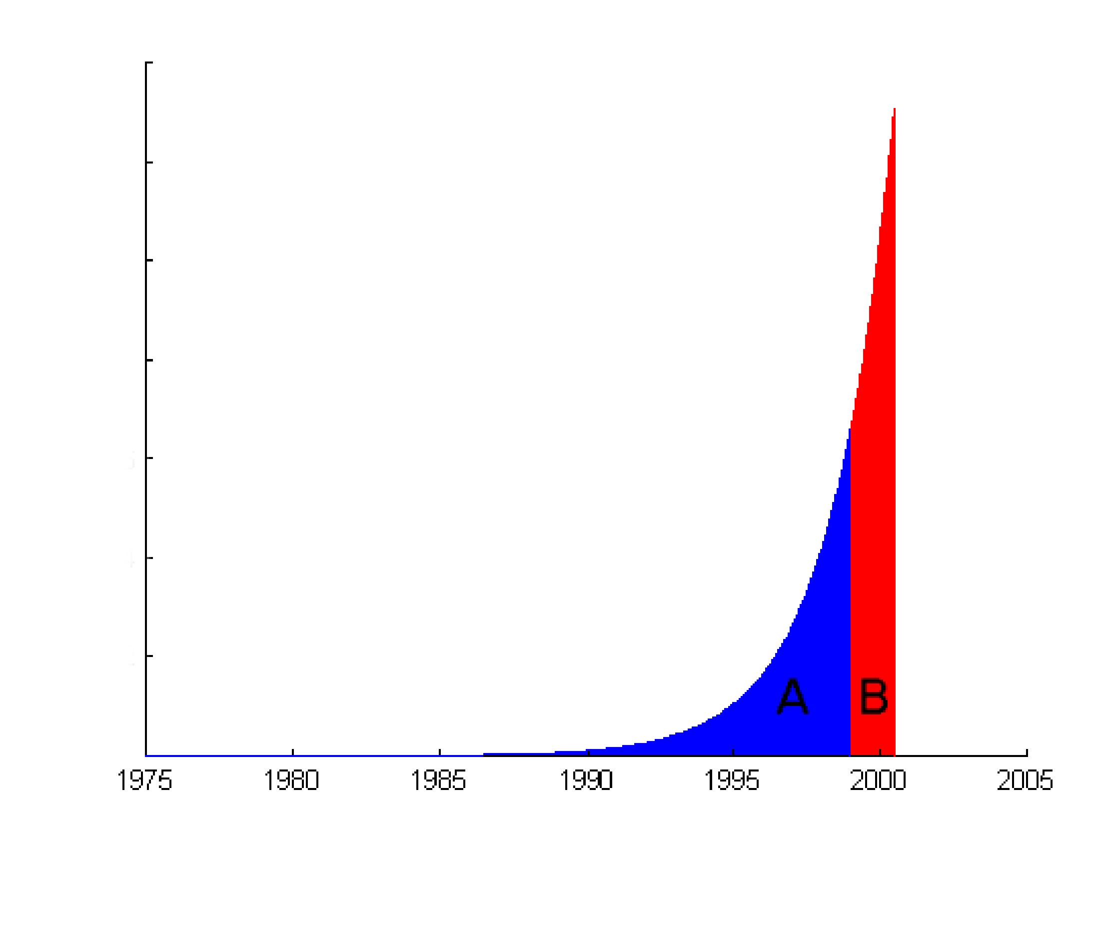
$$\frac{dy}{dt} = \frac{d}{dt}(2^t) = 2^t \log 2$$

y = Performance (transistor density, bandwidth, etc.)

t = in measured doubling time periods

dy/dt = slope = rate of change

Understanding Moore’s Law

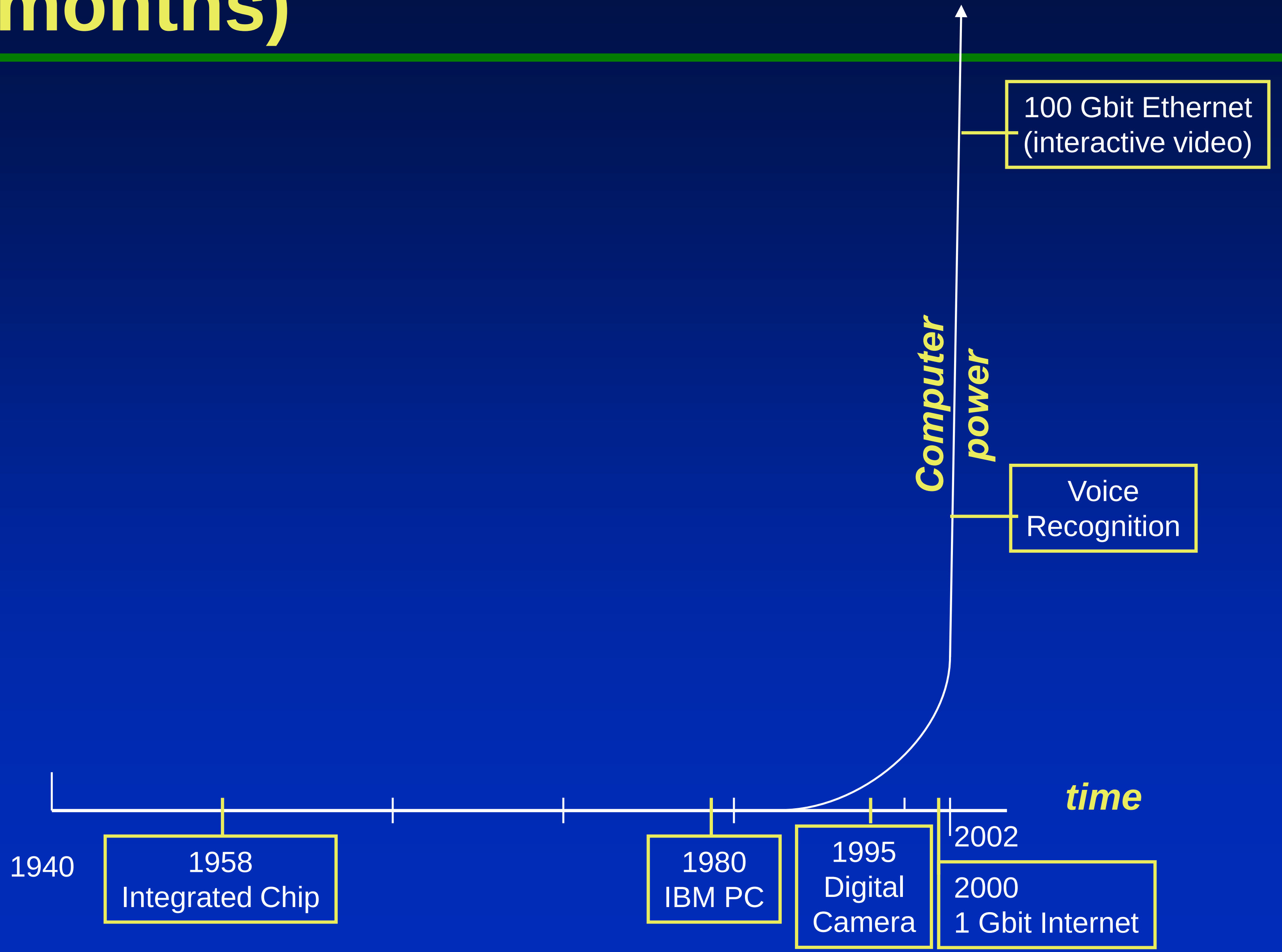


Understanding Moore's Law

- In 2014 Semiconductor production facilities made approximately 250 billion billion (250 x 10^{18}) transistors.
- More transistors were made in 2014 than in all the years prior to 2011.

Transistors, by the Numbers – Dan Hutcheson
IEEE SPECTRUM, ISSN 0018-9235, 04/2015, Volume 52, Issue 4, p. 33

Growth In Computer Power (2x / 18months)



Growth In Computer Power (2x / 18months)

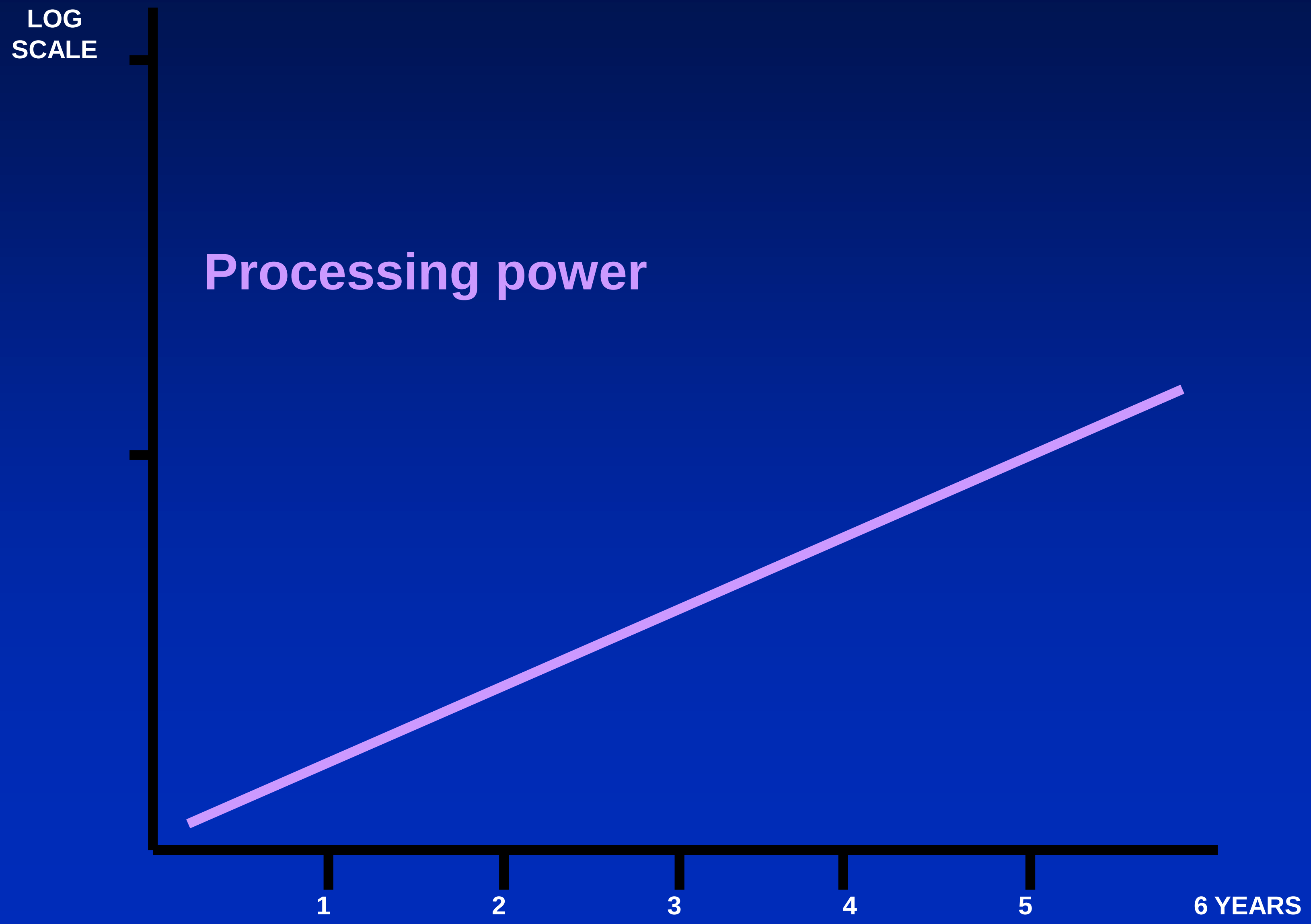
(Top of Curve)

Processing is basically free.

Impact of Abundant Computer Power

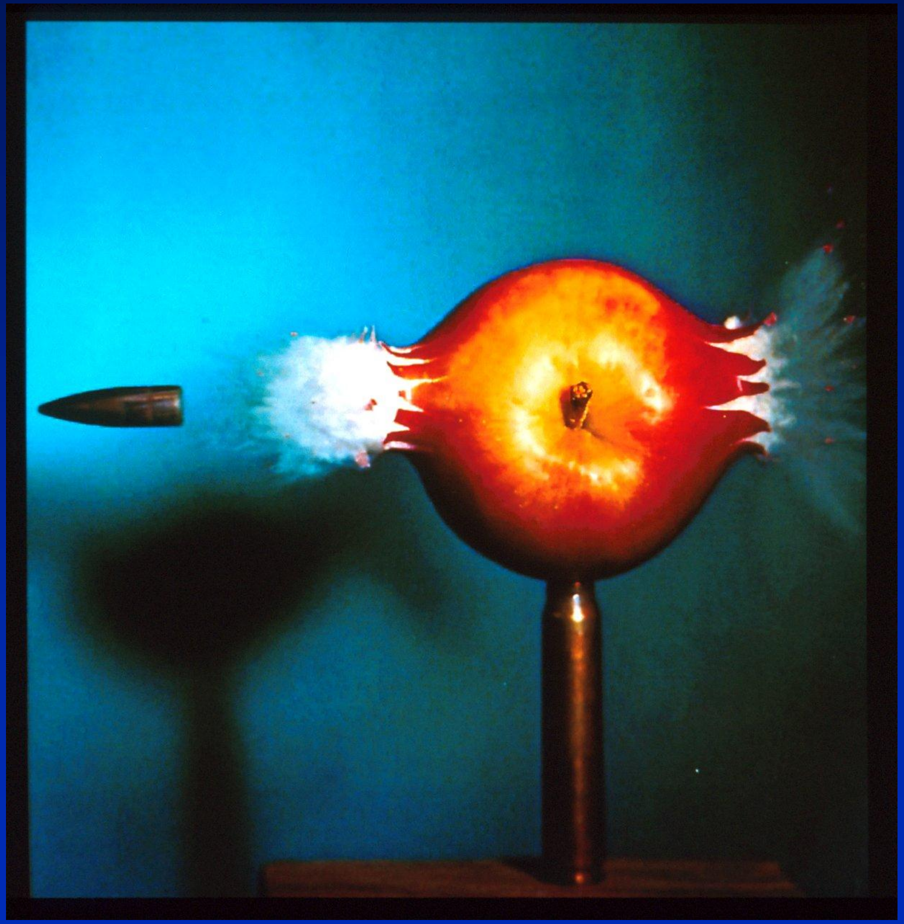
- Needles in a “Haystack” (security monitoring, focused advertising, etc)
- The internet of things (omnipresent sensors)
- Digital health care (remote medical diagnosis)
- MOOCs (Massive open online courses)
- Autonomous driving vehicles
- 3D data acquisition
- 3D printing

Understanding Moore's Law – Log Scale



How many instructions are completed in a 3.6 Ghz PC in the time it takes for the bullet to pierce the apple?

Apple diameter = 3.36”
Bullet velocity = 2800ft/sec
photograph by Harold Edgerton



International Technology Roadmap for Semiconductors

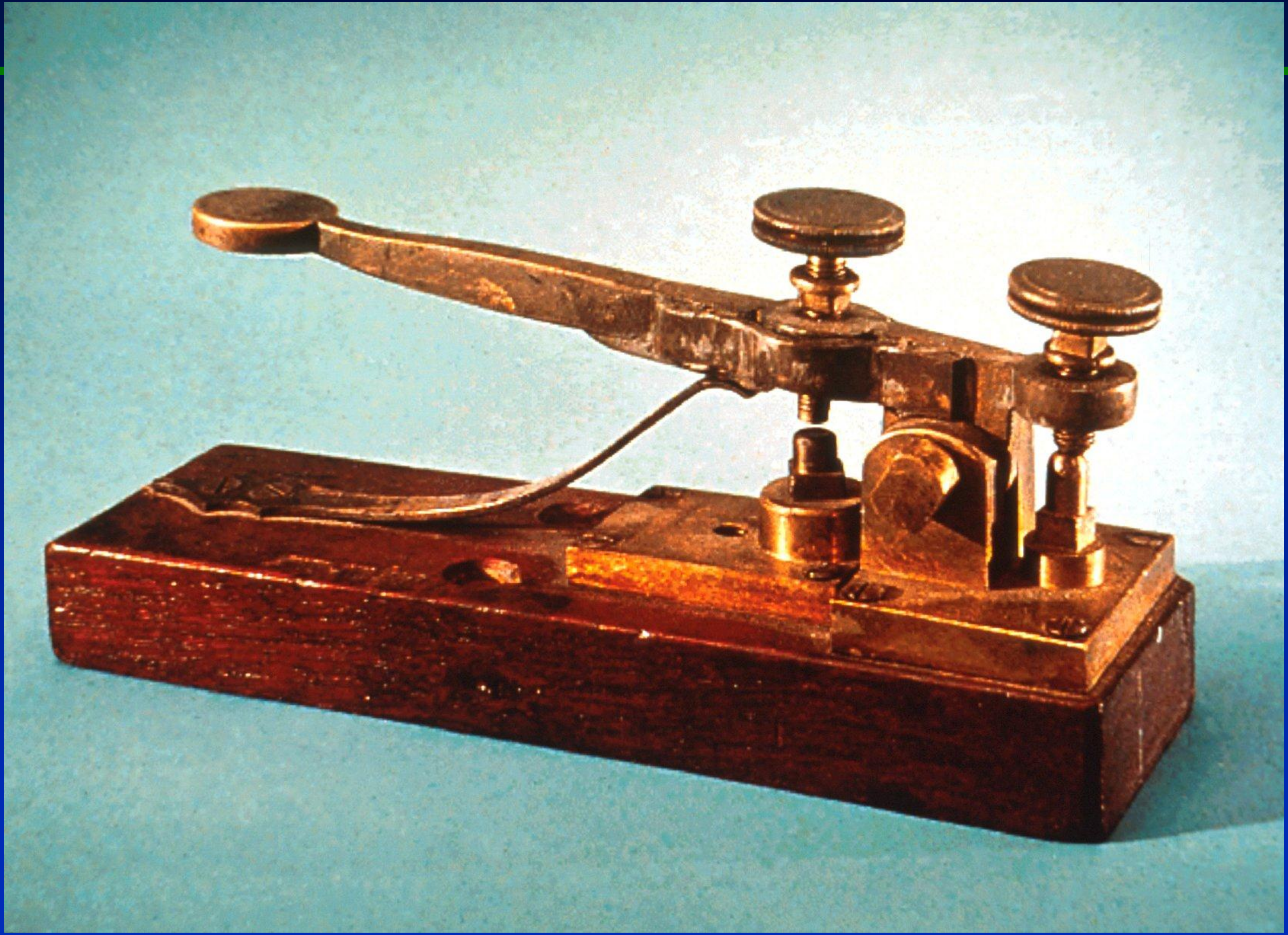
	2001	2004	2007	2010	2013	2016
Technology (nanometers)	**130nm**	**90nm**	**65nm**	**45nm**	**32nm**	**22nm**
Functions per Chip (millions)	97	193	386	1546	3092	6184
Clock Speed (Ghz)	2.5Ghz	4.1Ghz	9.3Ghz	15Ghz	23Ghz	40Ghz
Wafer Size (millimeters)	200mm	300mm	300mm	300mm	450mm	450mm
Chip Size (mm^2)	140 mm^2	14 0 mm^2	140 mm^2	140 mm^2	140 mm^2	140 mm^2

Roughly 0.5 shrink every 3 years 29% cost/reduction/function/yr.

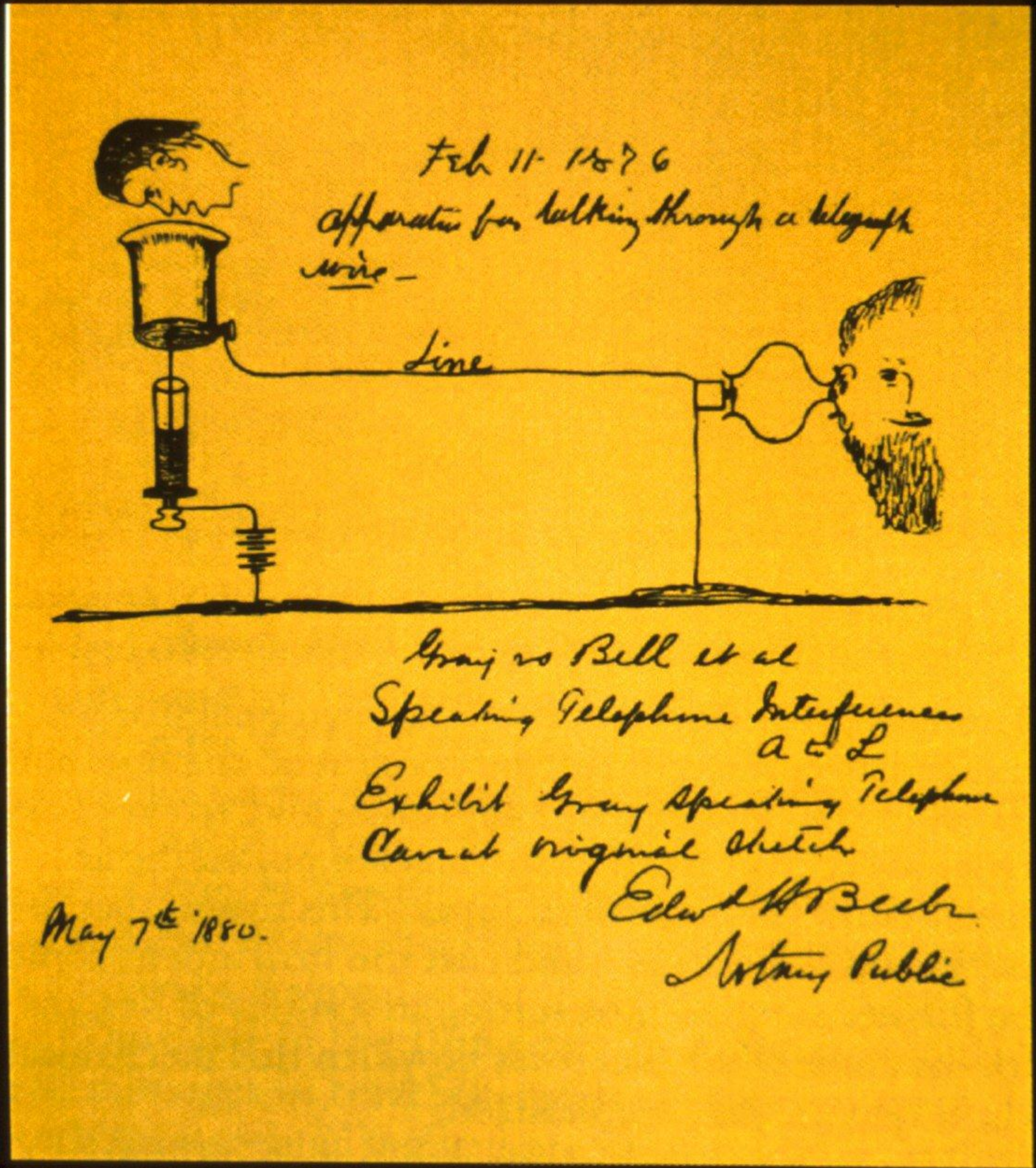
Technology Outlook

High Volume Manufacturing	2008	2010	2012	2014	2016	2018	2020	2022
Technology Node (nm)	45	32	22	16	11	8	6	4
Integration Capacity (BT)	8	16	32	64	128	256	512	1024
Delay Scaling	>0.7			~1?				
Energy Scaling	~0.5			>0.5				
Transistors	Planar			3G, FinFET				
Variability	High			Extreme				
ILD	~3			towards 2				
RC Delay	1	1	1	1	1	1	1	1
Metal Layers	8-9	0.5 to 1 Layer per generation						

http://www.xbitlabs.com/news/cpu/display/20090822094141_Intel_Outlines_Process_Technology_Roadmap.html



Telegraph Key (Smithsonian)


Feb 11 - 1876
Apparatus for talking through a telegraph wire -
Line
Gray vs Bell et al
Speaking Telephone Interferences
A to L
Exhibit Gray Speaking Telephone
Caveat original sketch
Edwd H Beebe
Notary Public
May 7th 1880.

Alexander Graham Bell

Wasserman, Neil H. "From Inventions to Innovation: Long-Distance Telephone Transmission at the Turn of the Century," The John Hopkins University Baltimore and London, 1985.

"This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us."

~ Western Union Internal Memo, 1876

My achievements occurred,

not because of my skating skill,

but my innate ability to skate to where

" the puck will be"!

~ Wayne Gretzky

Everything is a System

Large Scale:

Google → Internet → Mobile device

Desktop:

CPU → Memory/Hard drive → Display

Chip Level:

Memory → Data Movement →
Cache → Instruction Execution

Digital Photography

For digital photography to succeed, it needed:

- Camera
- Storage
- Battery Power
- Printers
- Transmission

Growth Rates of System Components of the Electronic Age

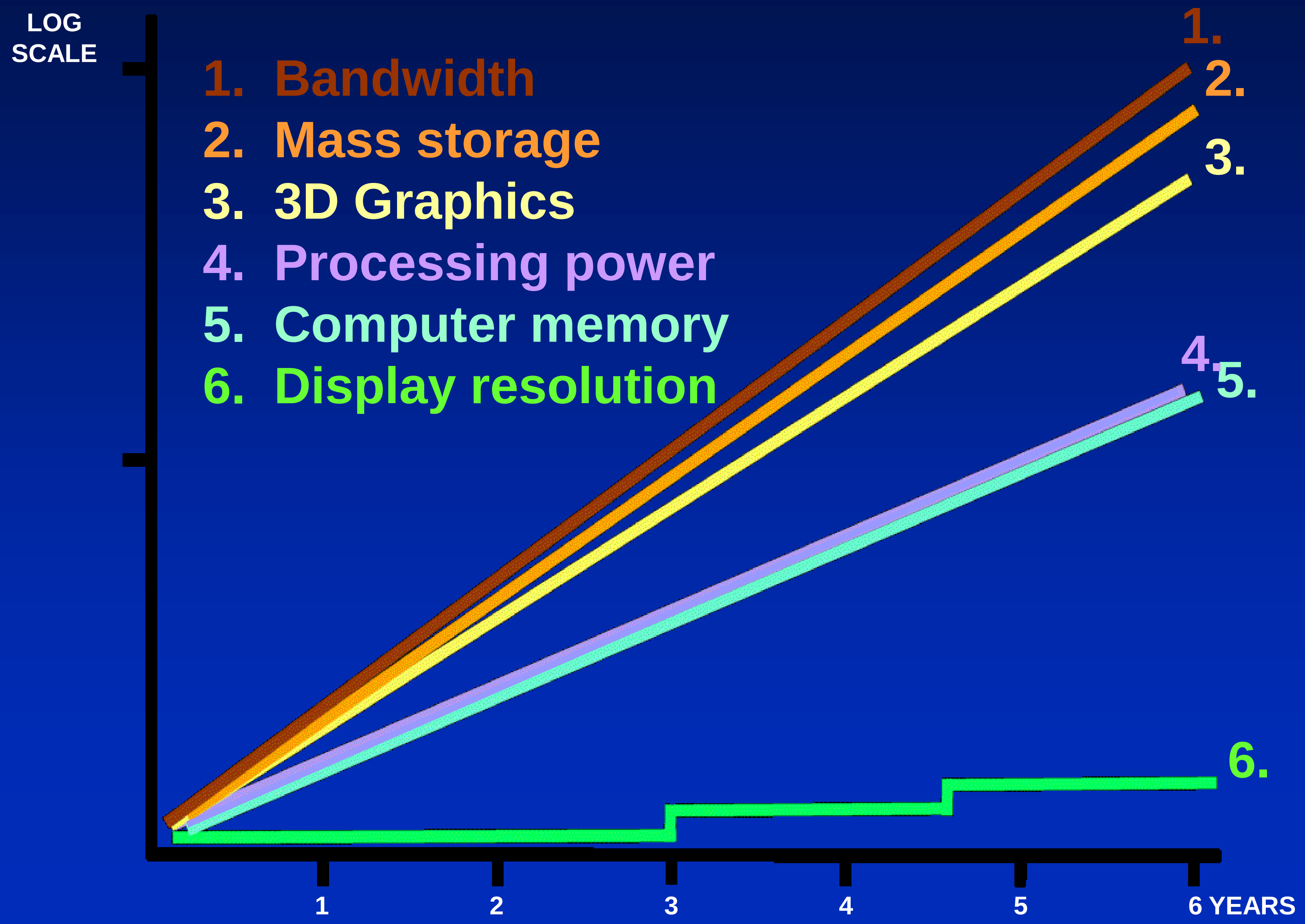
- Processing Power. . . . . 2x /18months
- Computer Memory. . . . . 2x /18months
- Mass Storage. . . . . 3x /18 months
- Bandwidth. . . . . 10x /3 years

Growth Rates of System Components of the Electronic Age

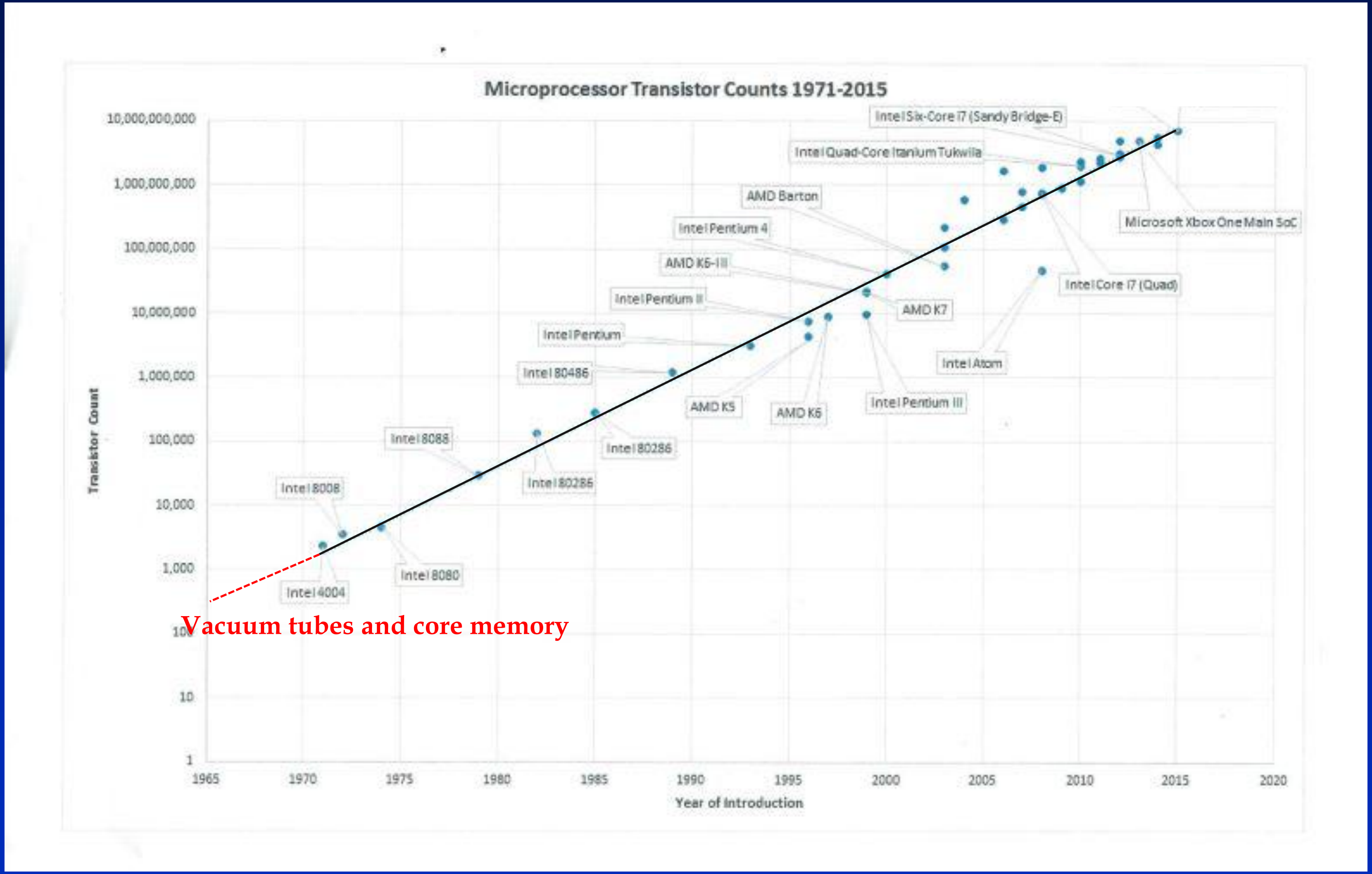
- 3D Graphics
  - Image Capture. . . . . 2x / 18 months
  - Image Display. . . . . 2x / year

    (Hardware, Software)
- Display Resolution. . . . . 2x/50 years
- User Interface
- Product Design

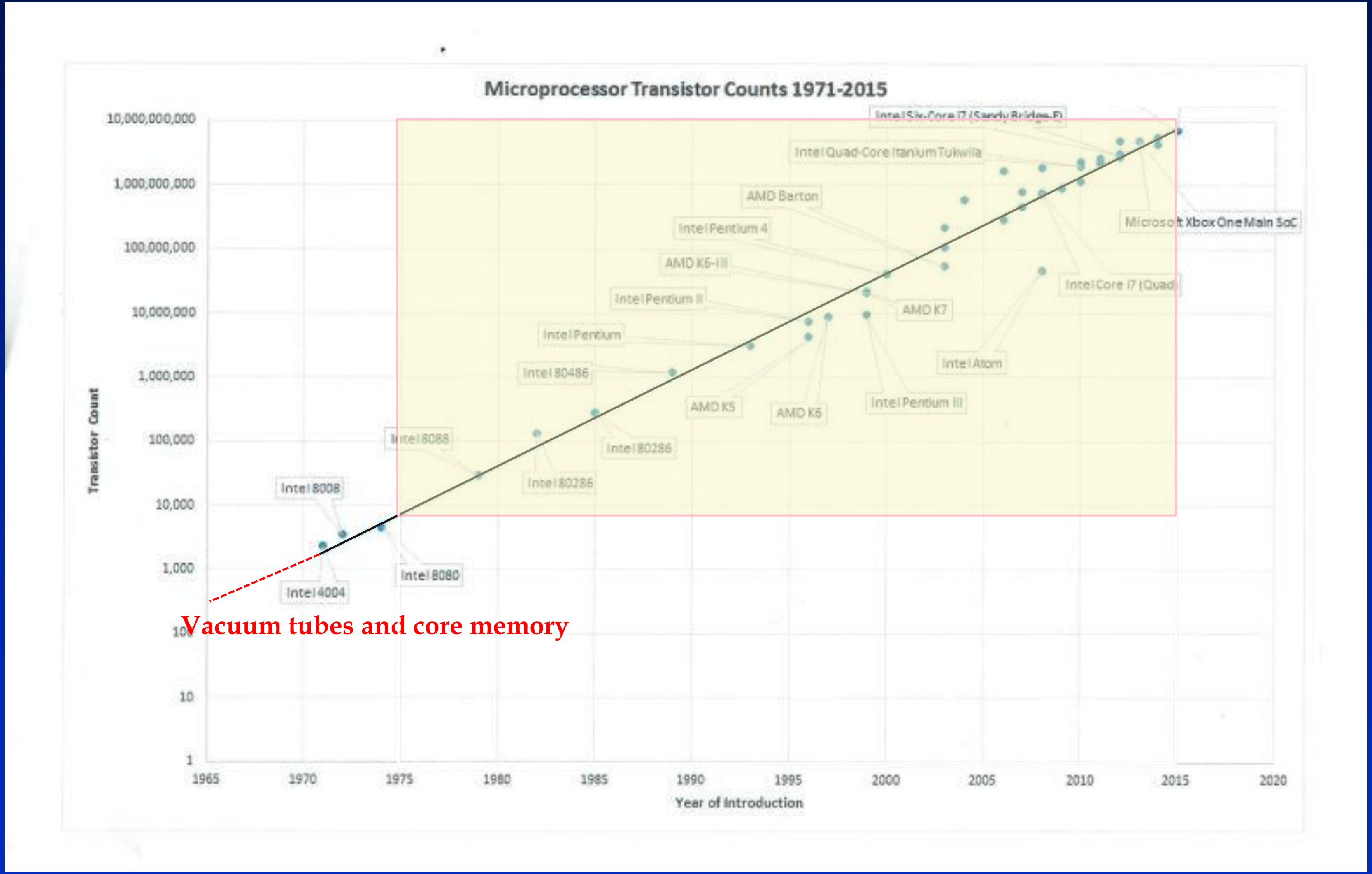
Relative Rates of Growth of Computer System Components



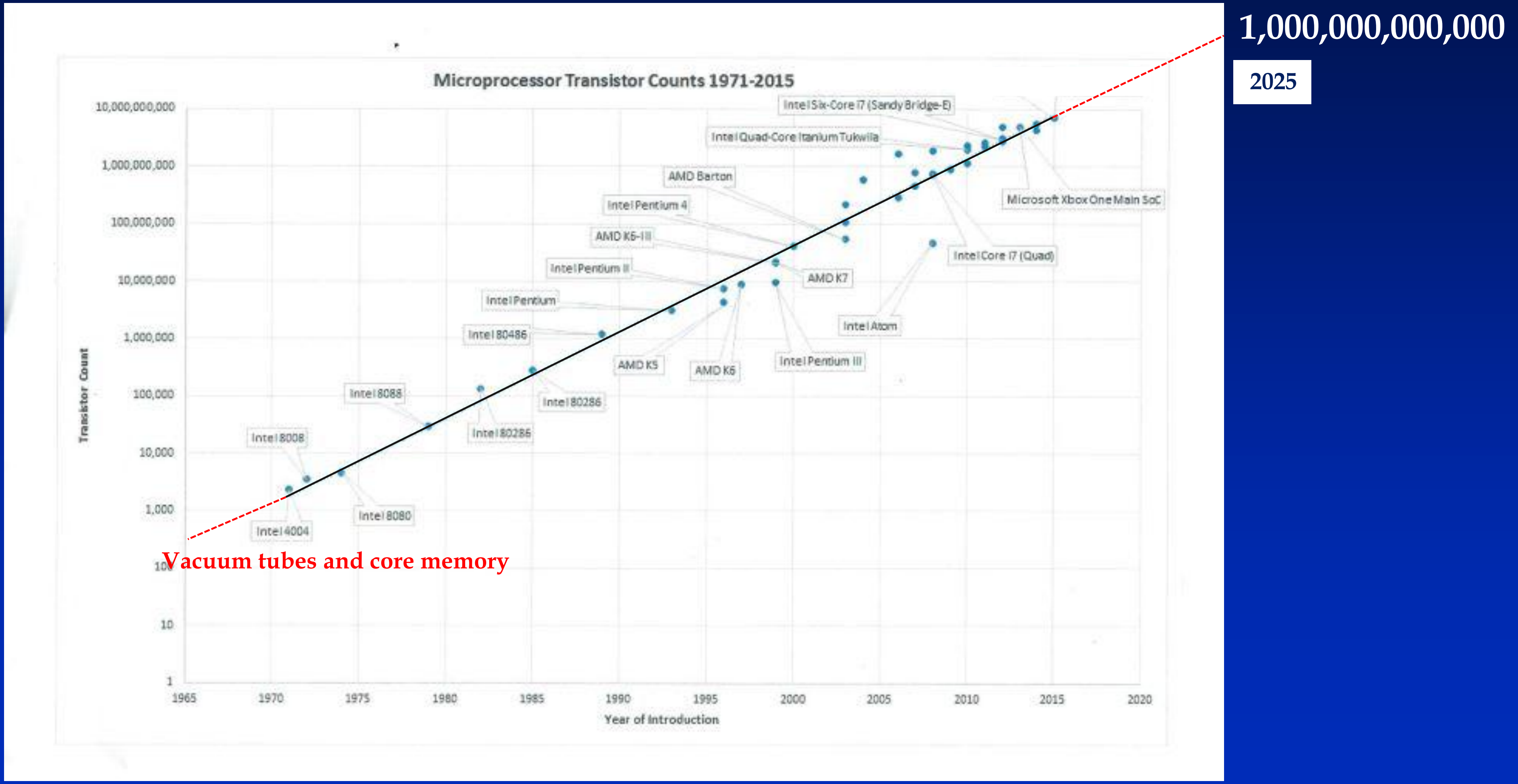
Transistor Density (Processing Power)



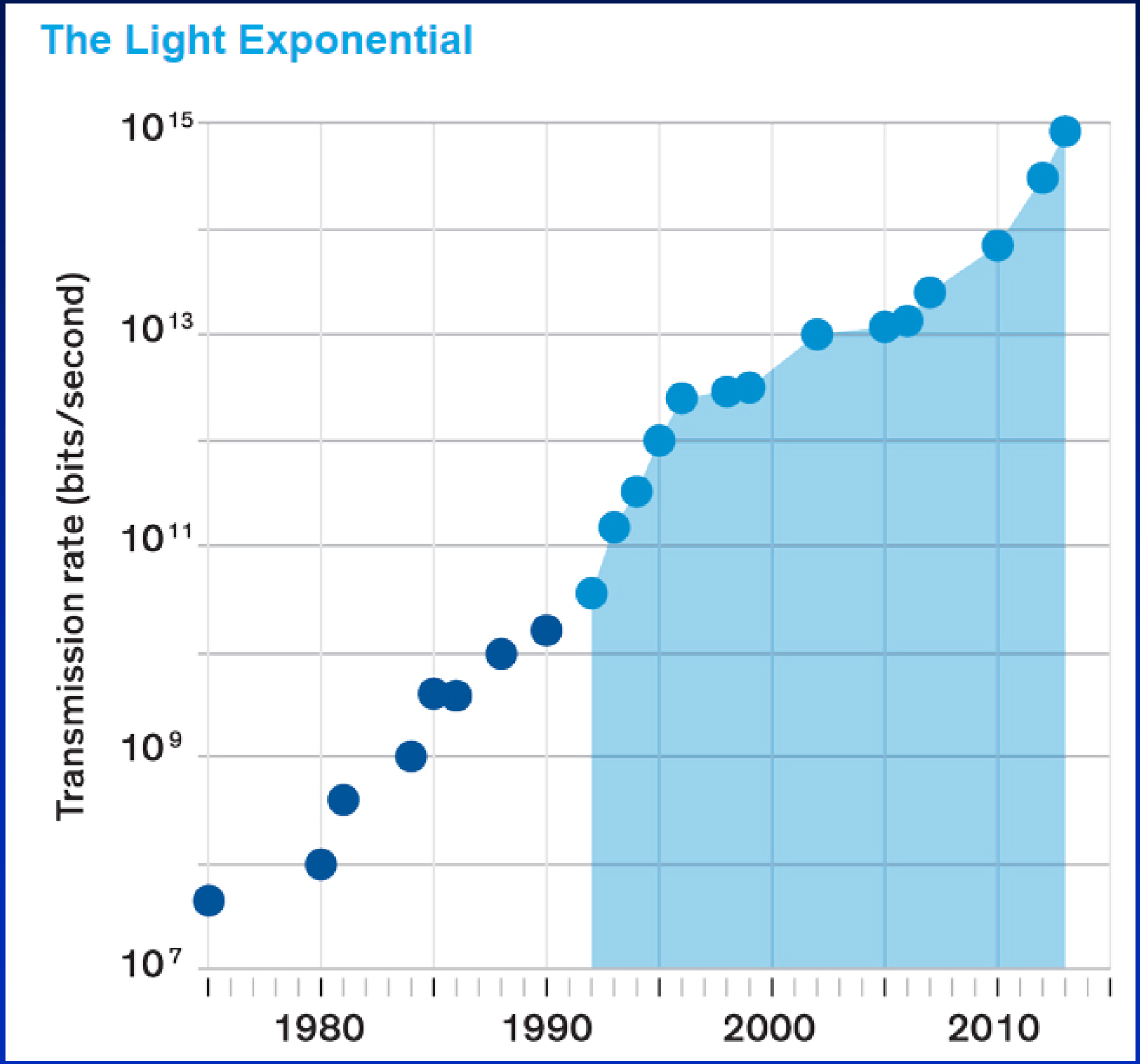
Processing Power 100 Million X



Processing Power One Trillion X

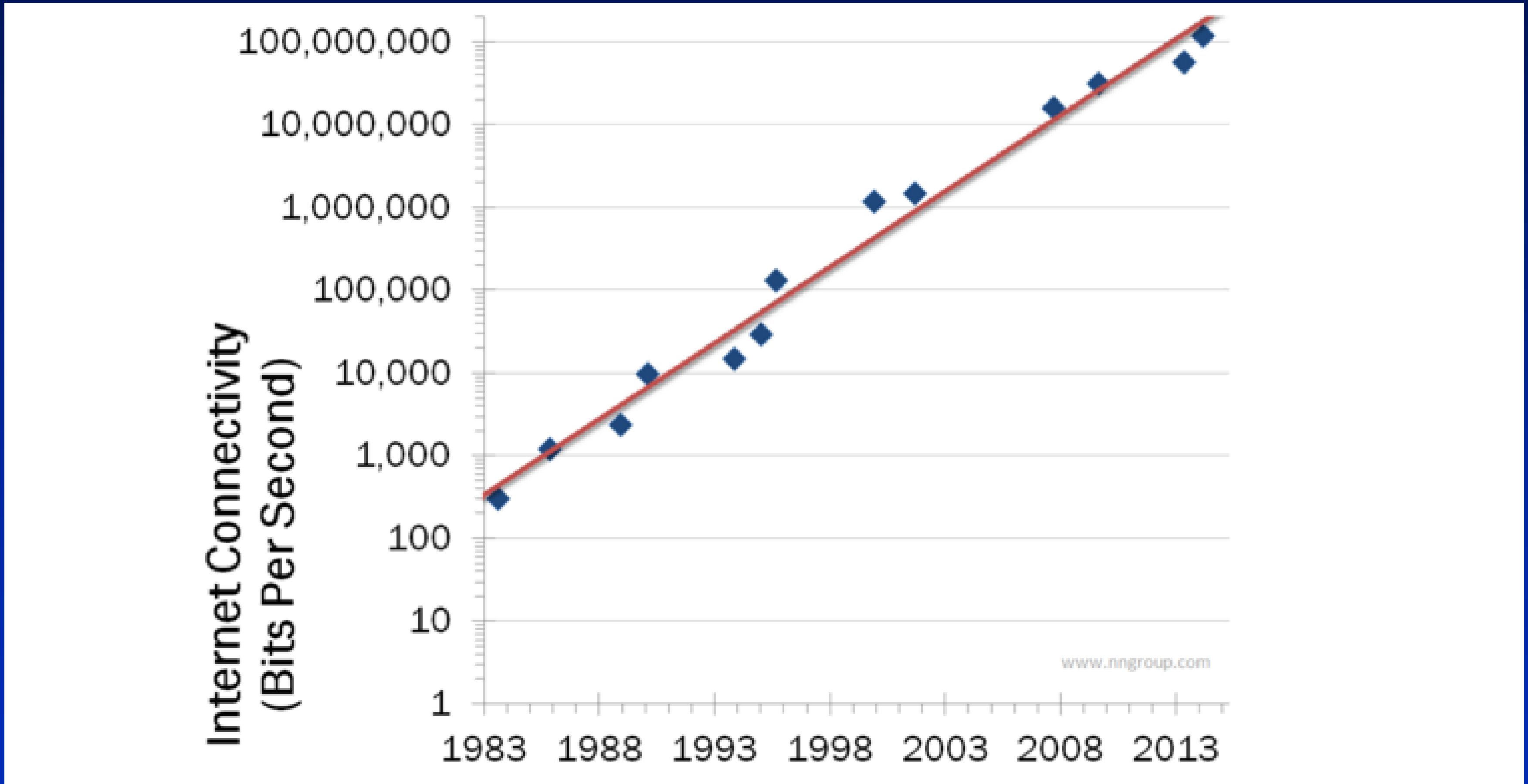


Keck's Law



IEEE Spectrum

Nielsen's Law

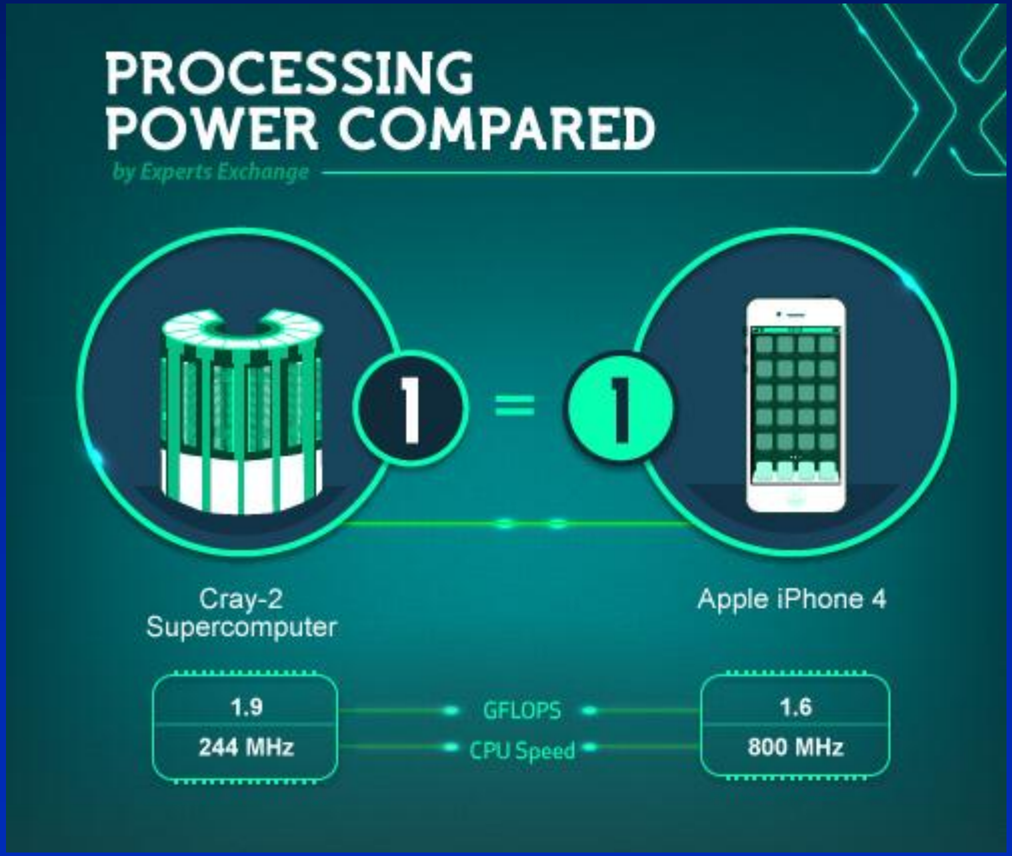


Nngroup.com

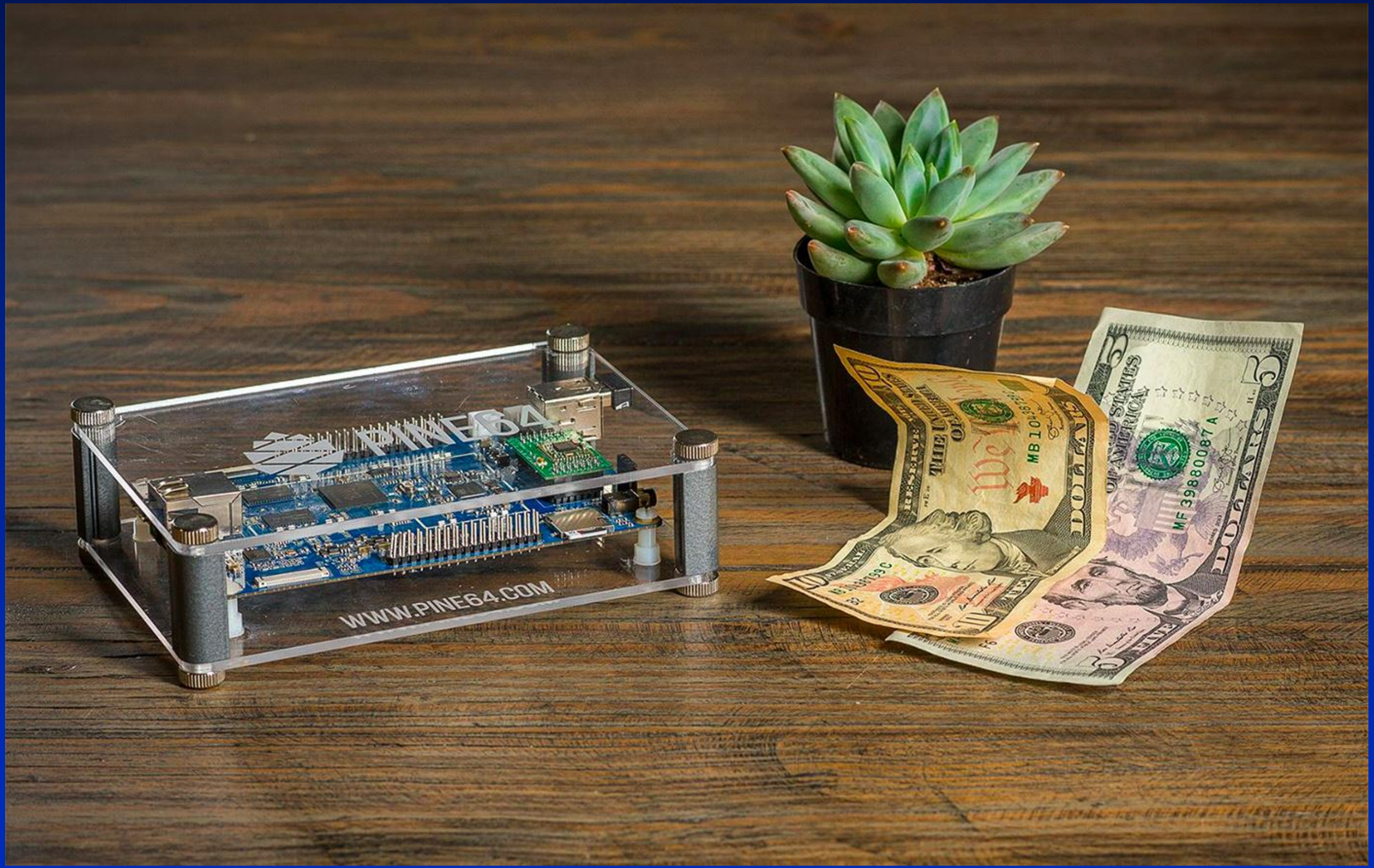
Processing Power Compared

- 2015: iPhone 5 > 1985 Cray-2

  (2.7x)

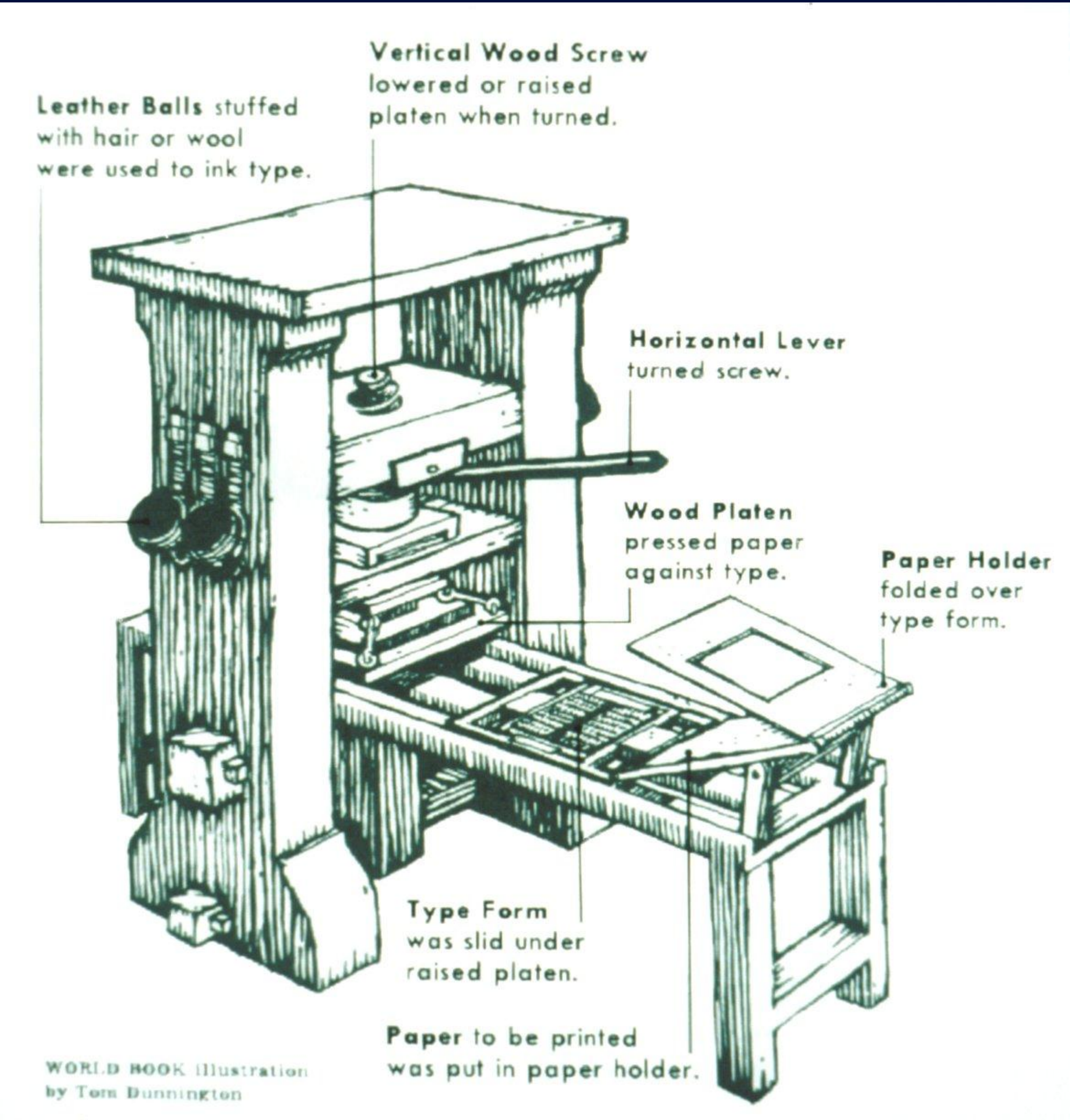


Pine A64



Engadget.com

Powers of 10
Dykstra


Vertical Wood Screw lowered or raised platen when turned.
Leather Balls stuffed with hair or wool were used to ink type.
Horizontal Lever turned screw.
Wood Platen pressed paper against type.
Paper Holder folded over type form.
Type Form was slid under raised platen.
Paper to be printed was put in paper holder.
WORLD BOOK illustration by Tom Dunnington

iPad

- Introduced: 2010 (February)
- Price: starting at $499

The Impact of the iPad

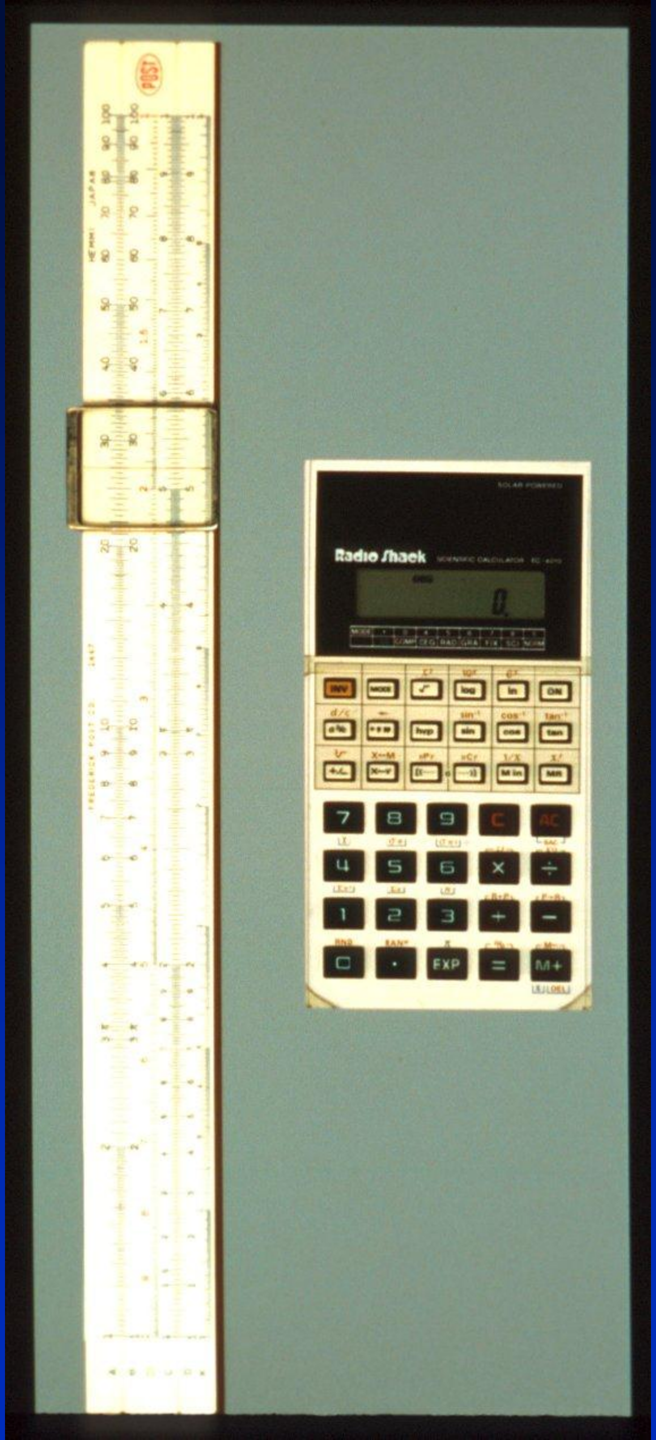
- PC Manufacturers
- Microsoft
- Intel & AMD
- Disk Drive Manufacturers
- Bookstores

Disruptive Technologies

Disruptive Technologies Salient characteristics

- Different package of performance attributes not valued by existing customers
- Performance attributes that are valued can improve at very rapid rates - and invade those established markets

ALARM CHRONO
CASIO
FR 11 3
10:46 55
WATER RESIST
EXERCISE
PULSE
MONITOR


POST
Radio Shack
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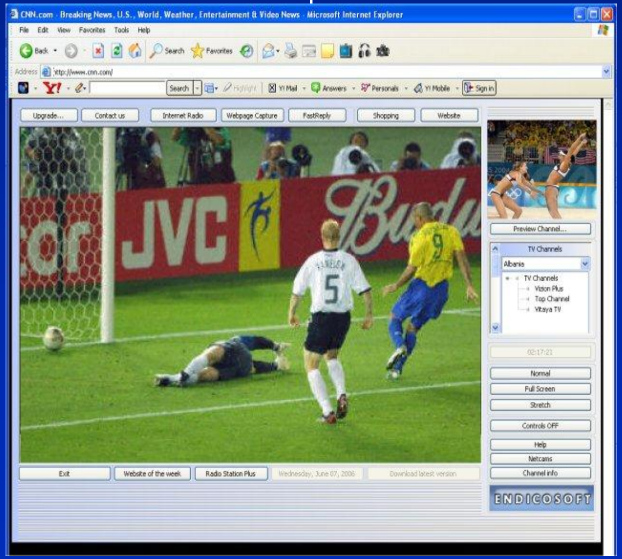
LP

CD or
DVD

iPod or
You Tube

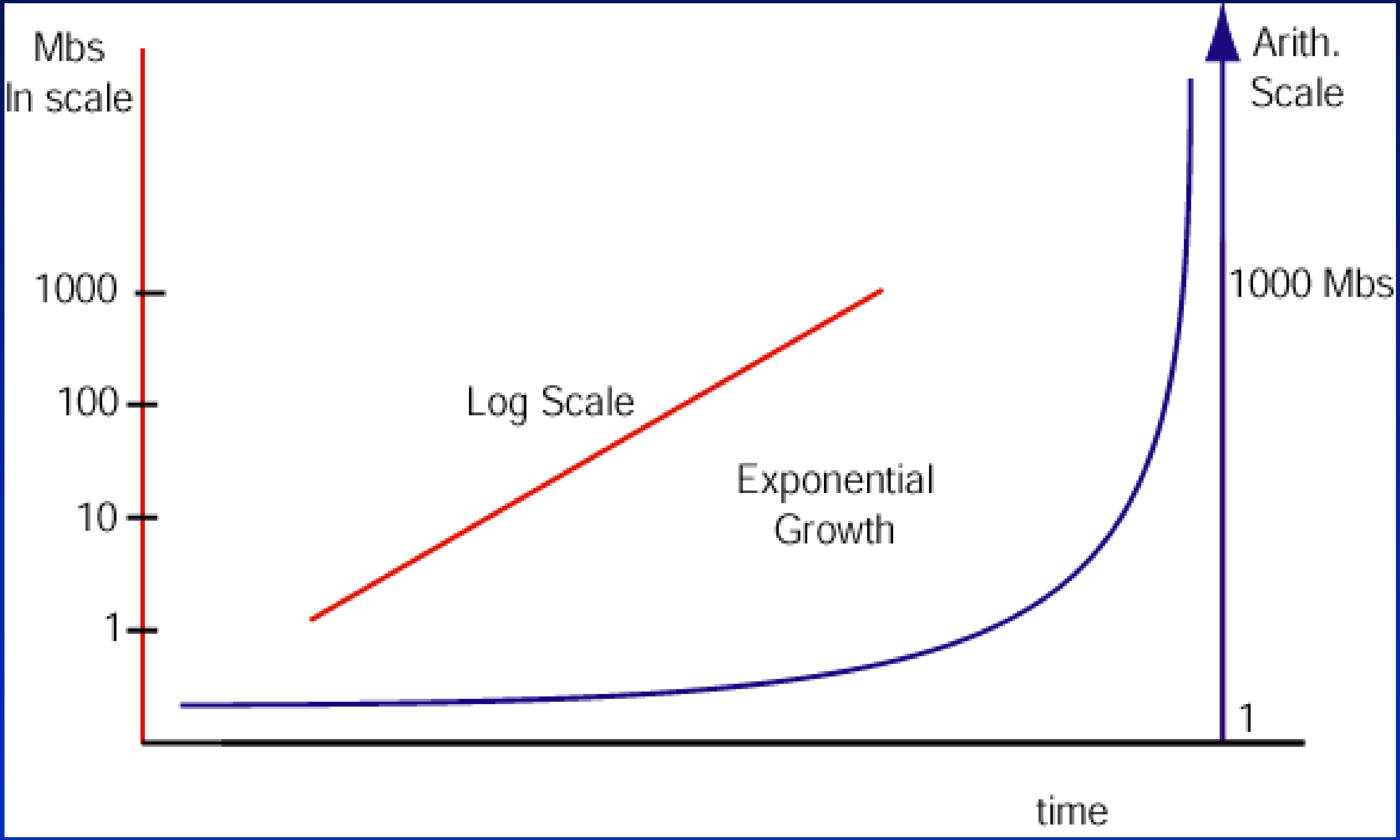


Internet TV

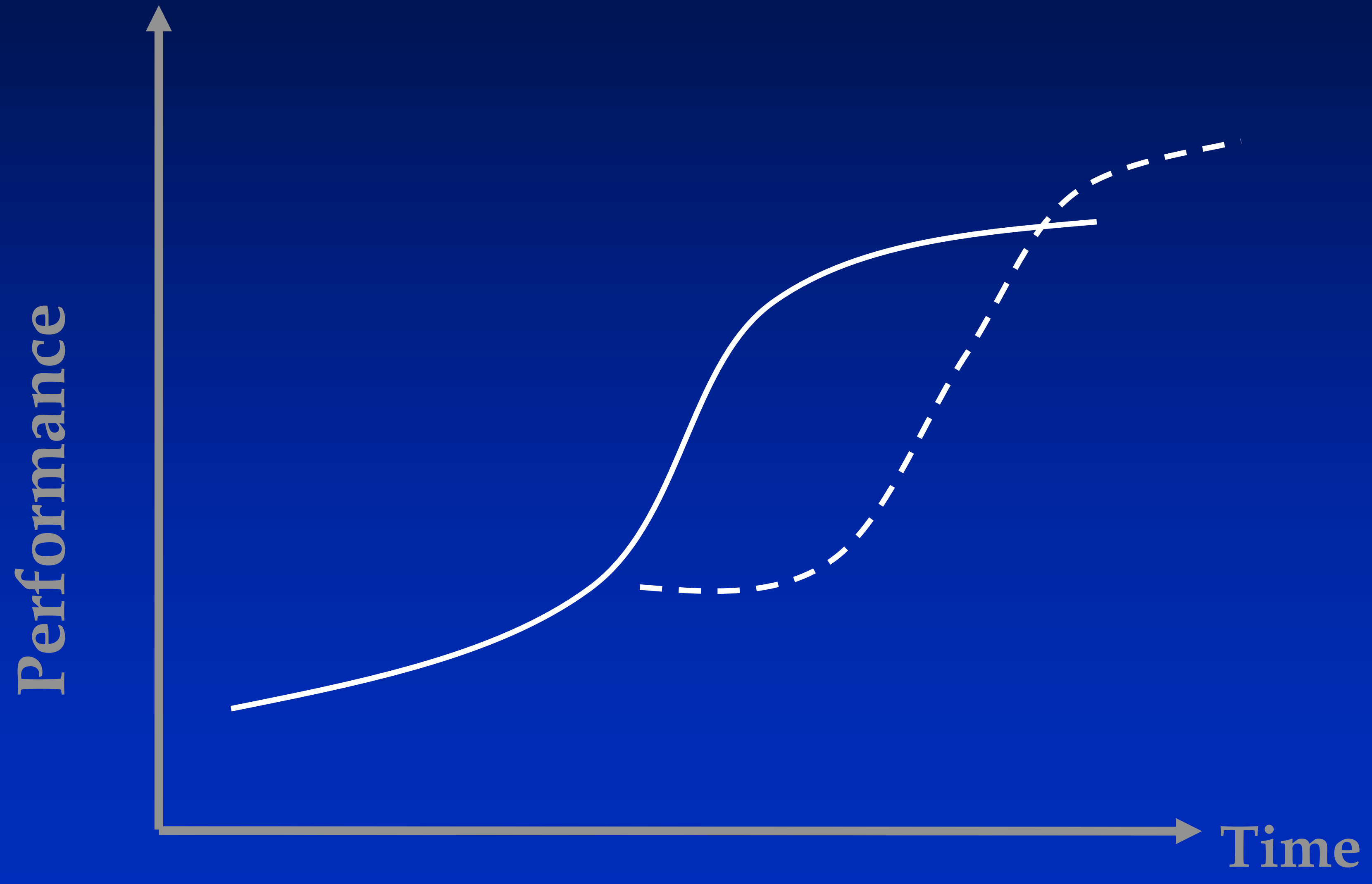
Concept of Performance Trajectories

- Rate at which performance is expected to improve (demand)
- Rate at which performance improves (supply)

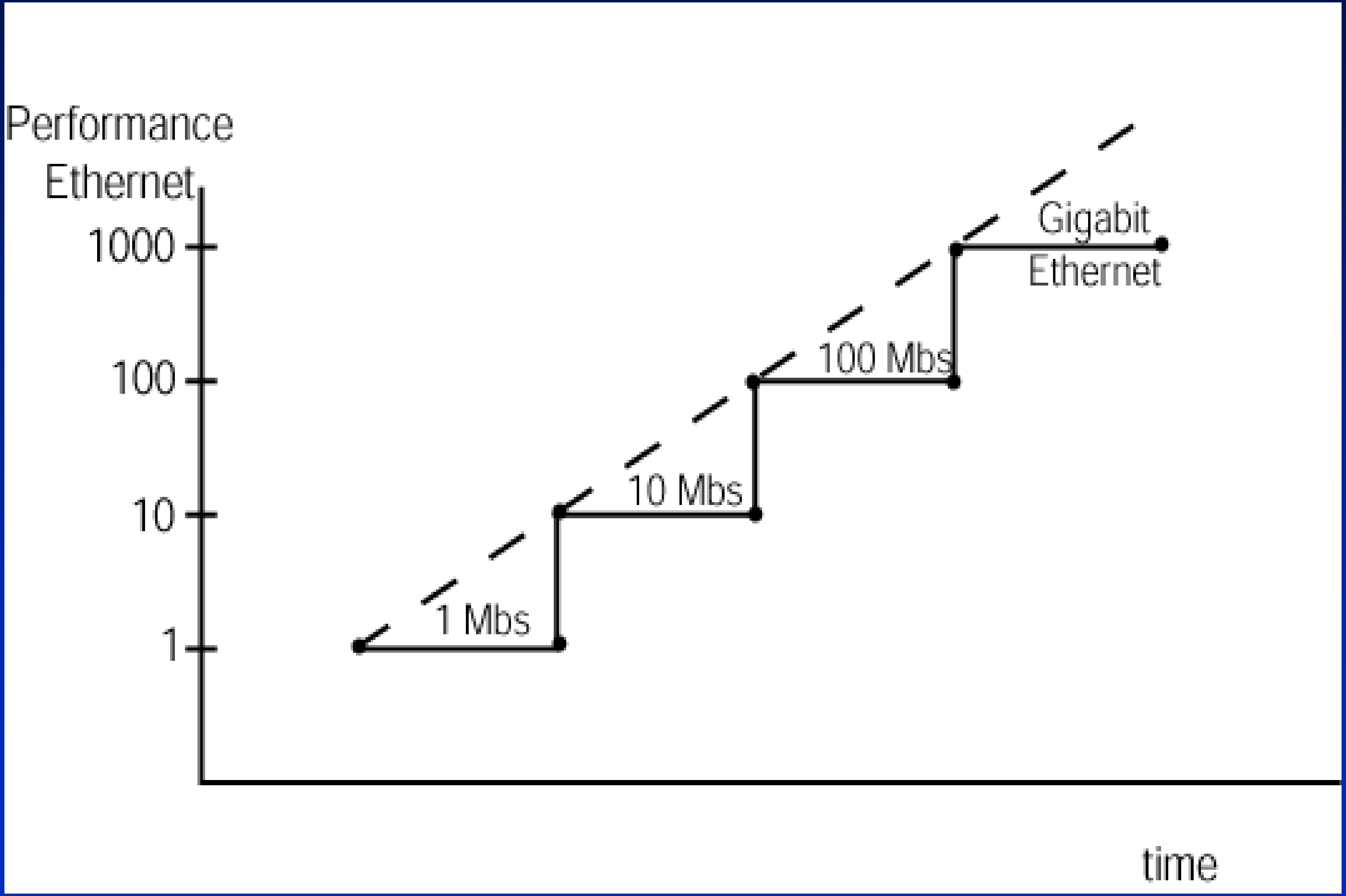
Performance Trajectories: *Log Scale vs. Arithmetic Scale*



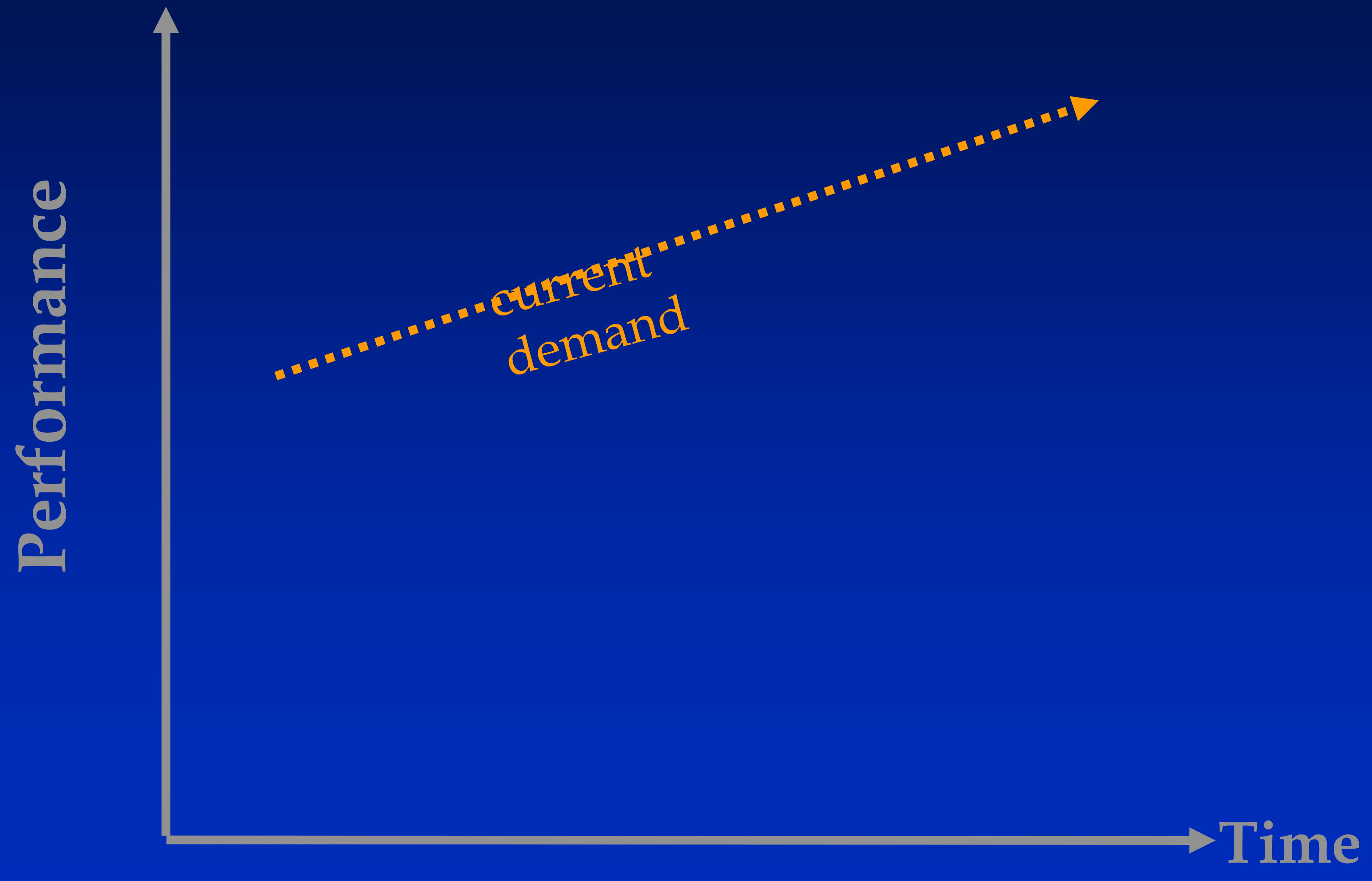
S Shaped Performance Trajectories



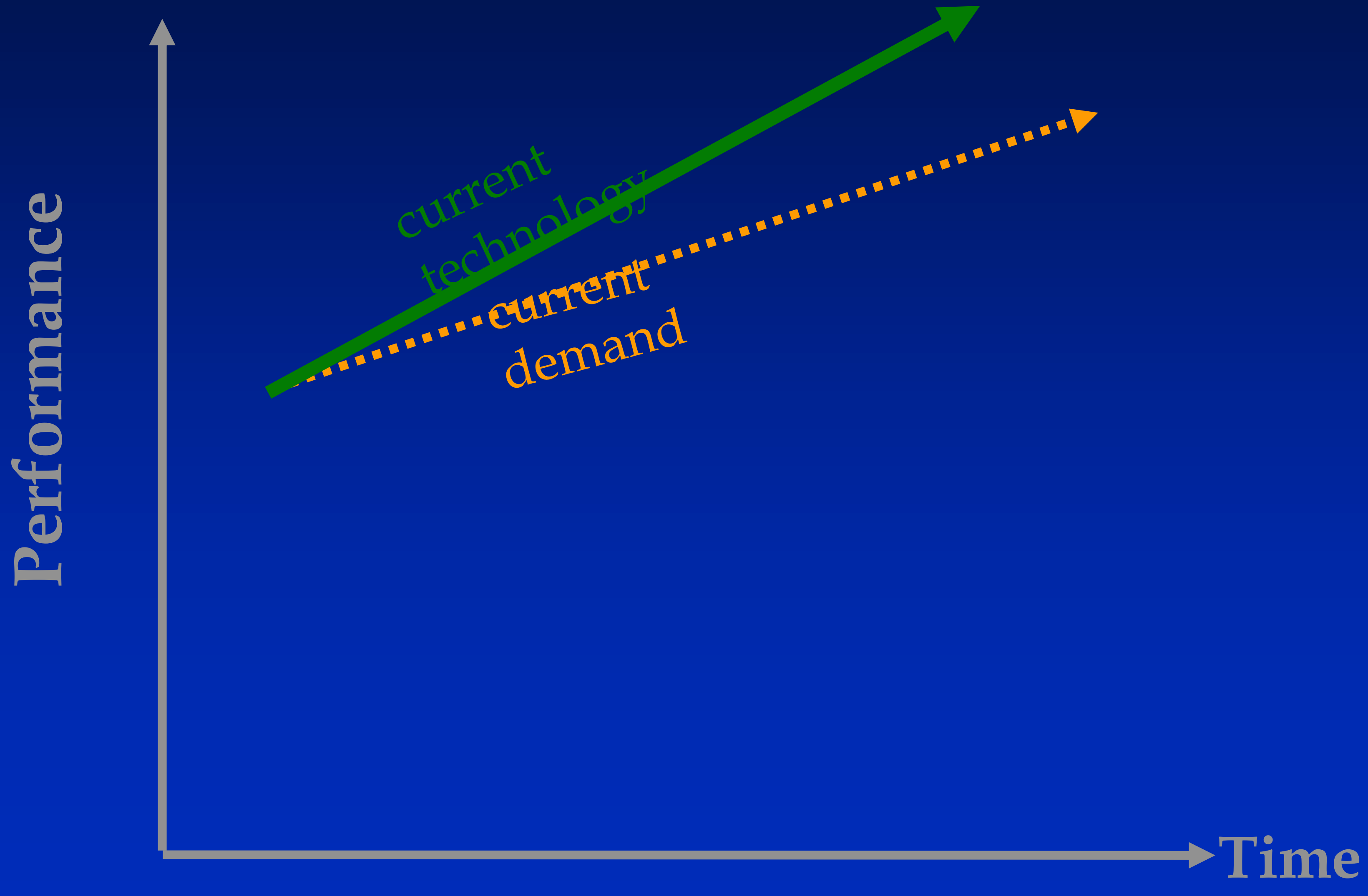
Discrete Performance Trajectories



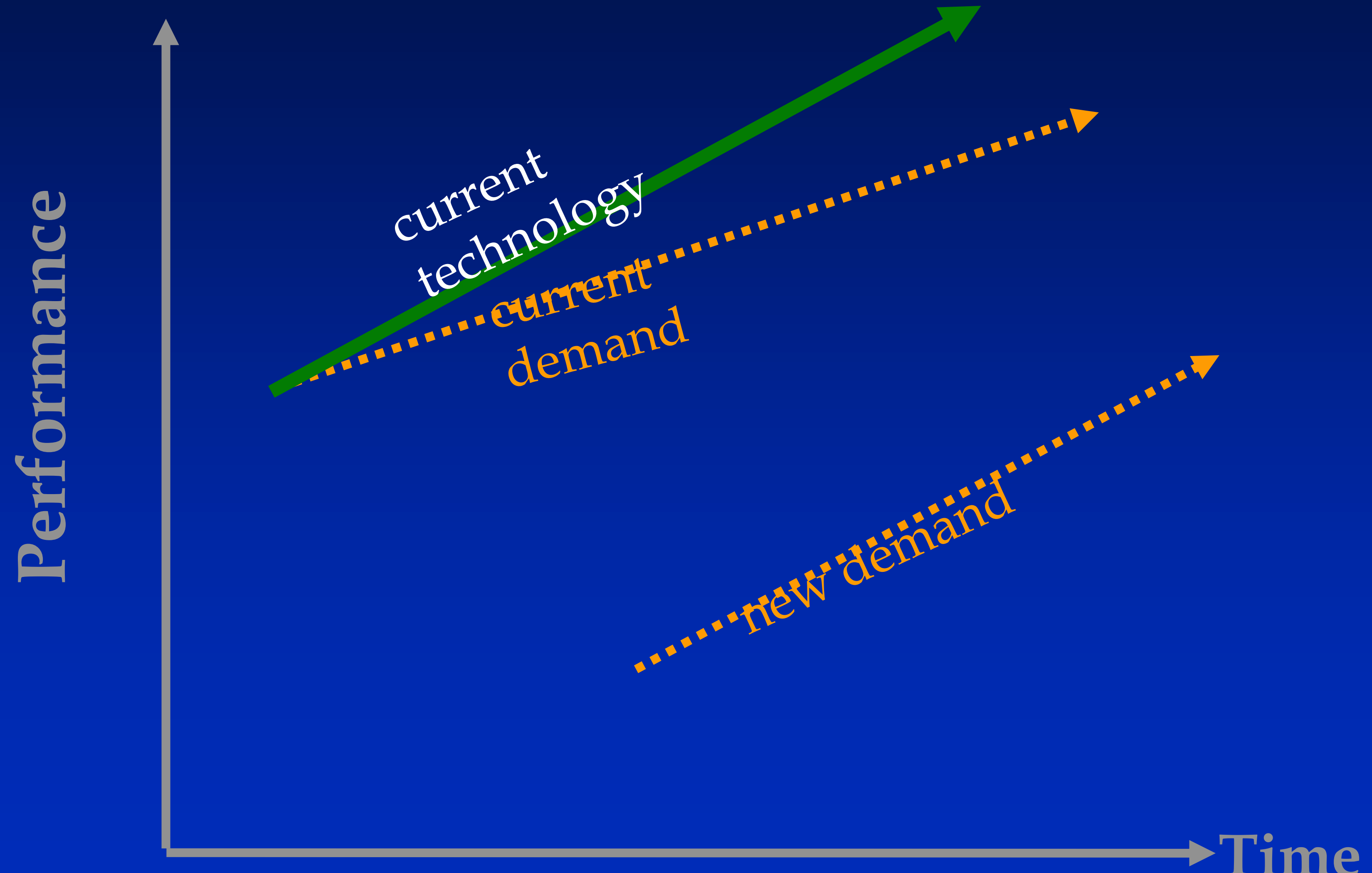
Typical Sustainable Technology



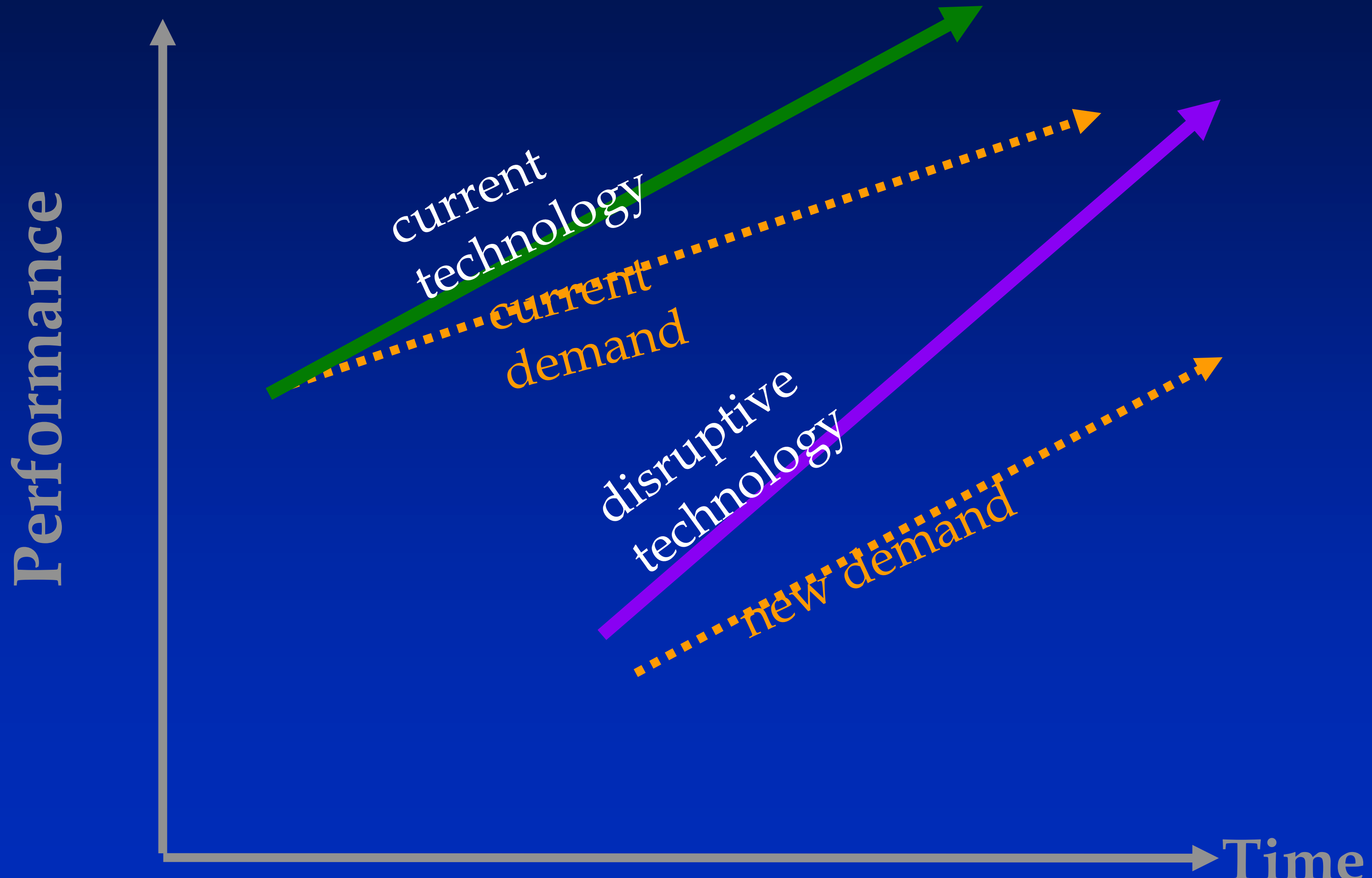
Typical Sustainable Technology



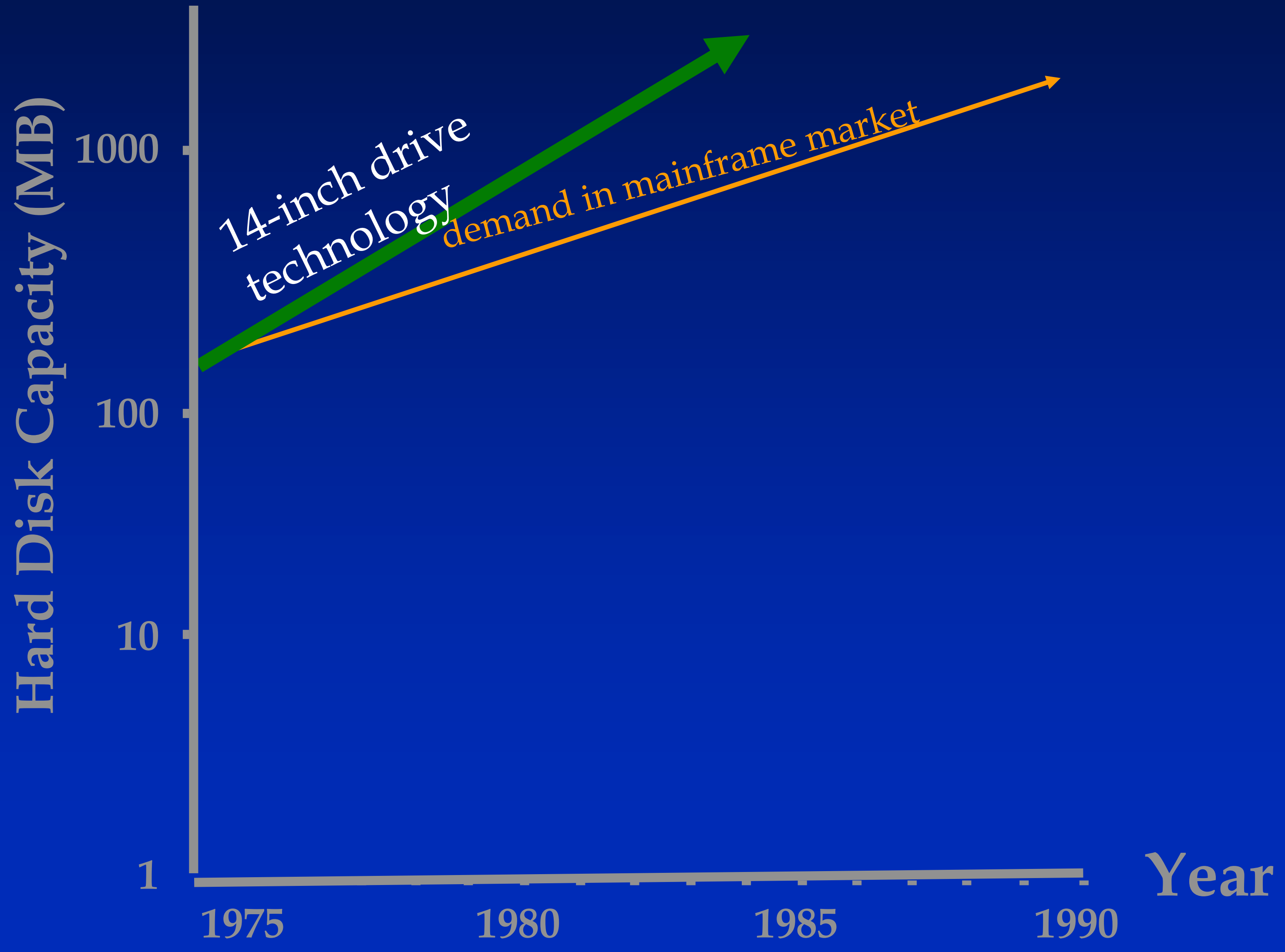
Typical Disruptive Technology



Typical Disruptive Technology



Rigid Disk Drive Industry

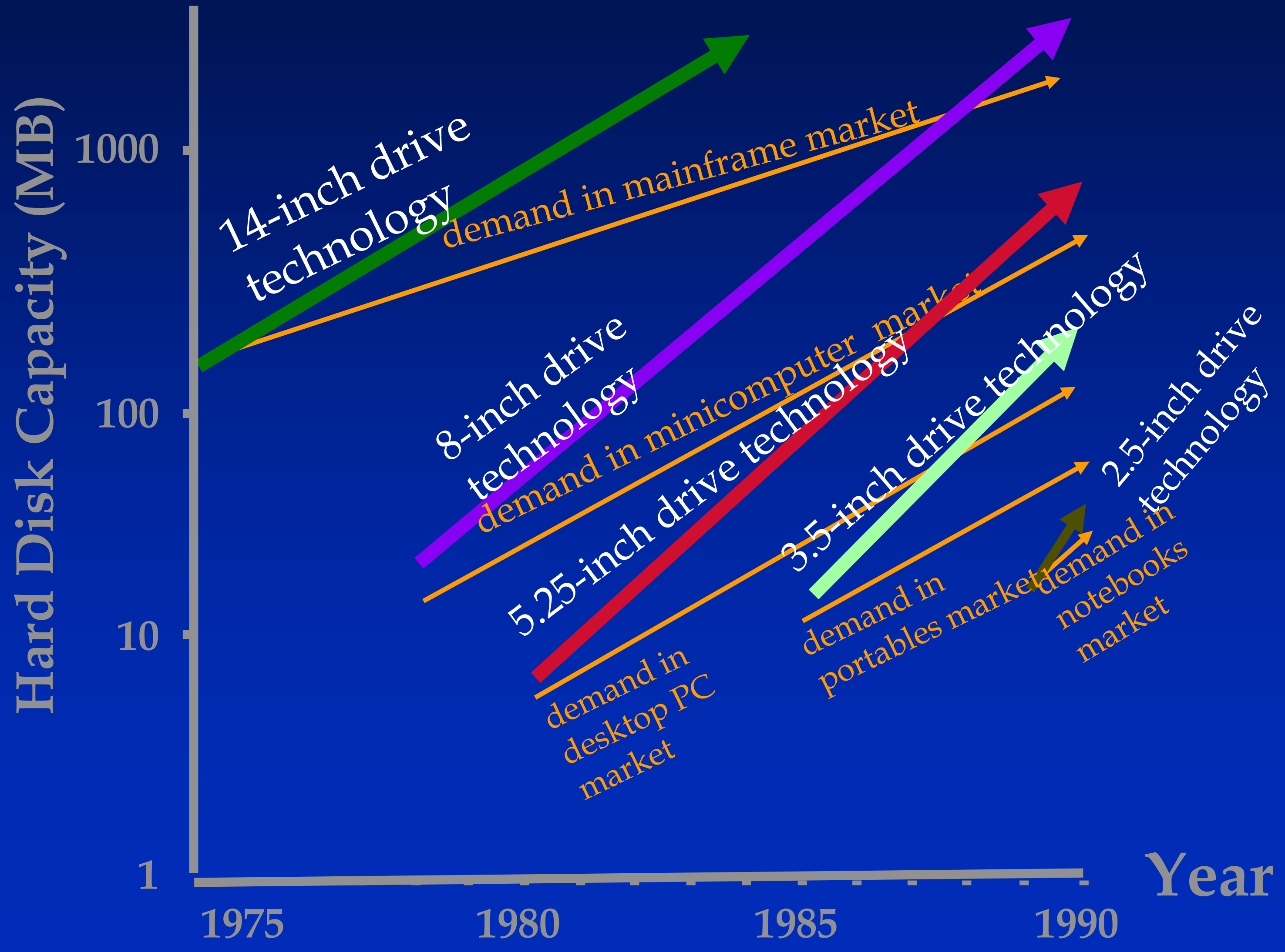


Alan F. Shugart

Developer of Disk Drive Industry

John Markoff. "Alan F. Shugart, 76, A Developer of Disk Drive Industry," NYT, 12/15/06.

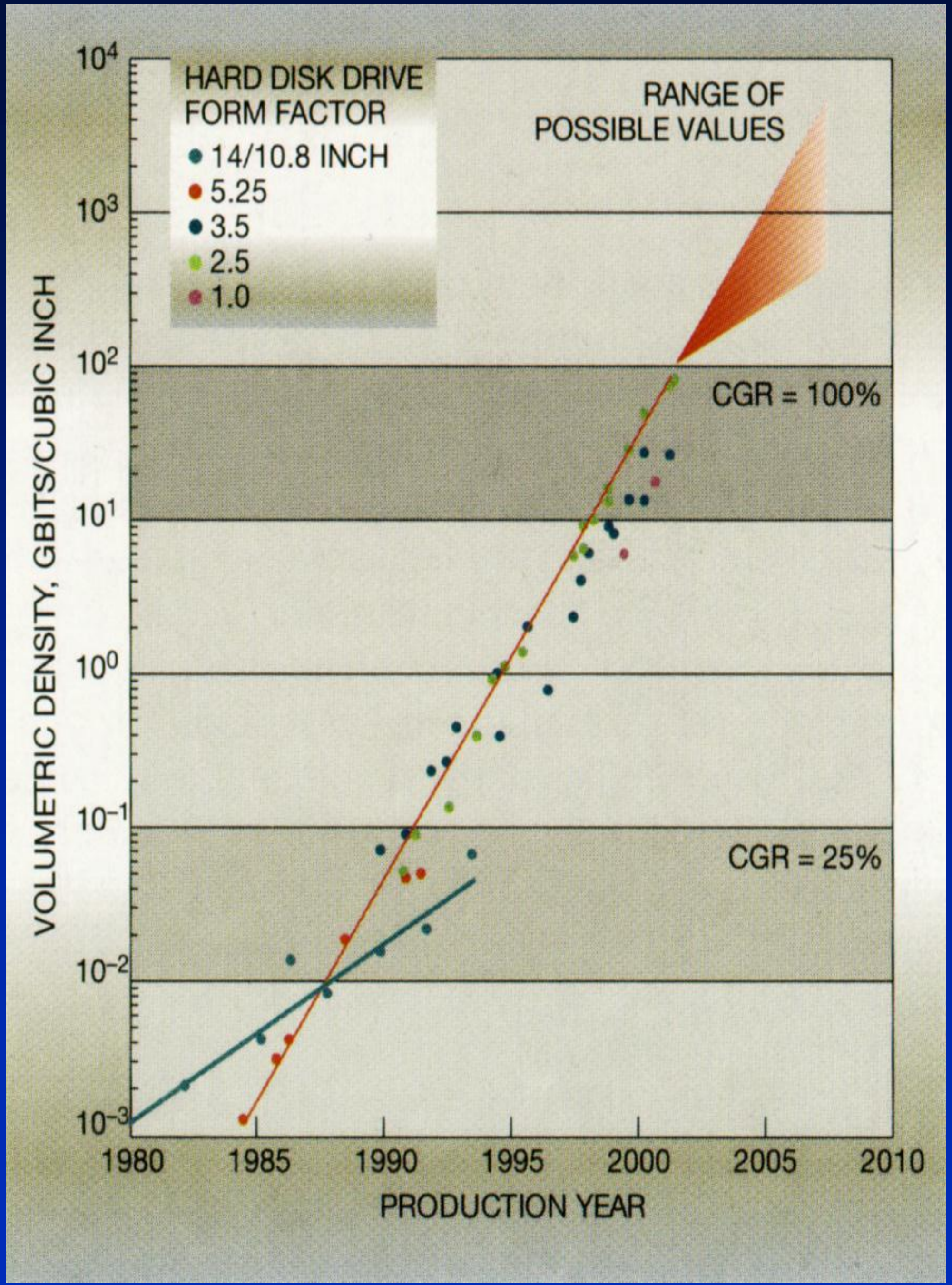
Rigid Disk Drive Industry



Disk Drives

1957 IBM	24” diameter
	50 platters
	5MB capacity
	12kbs sustained read
Fujitsu (~ 2000)	3.5” diameter
	1.1 GB capacity
	6.8 MBs sustained read
Today	1.8” drives for mobile platforms
	1.3” drives for laptops
Flash memory ?	1.0” drives for digital cameras
	0.85” drives for digital cameras

Hard disk drive volumetric density trend



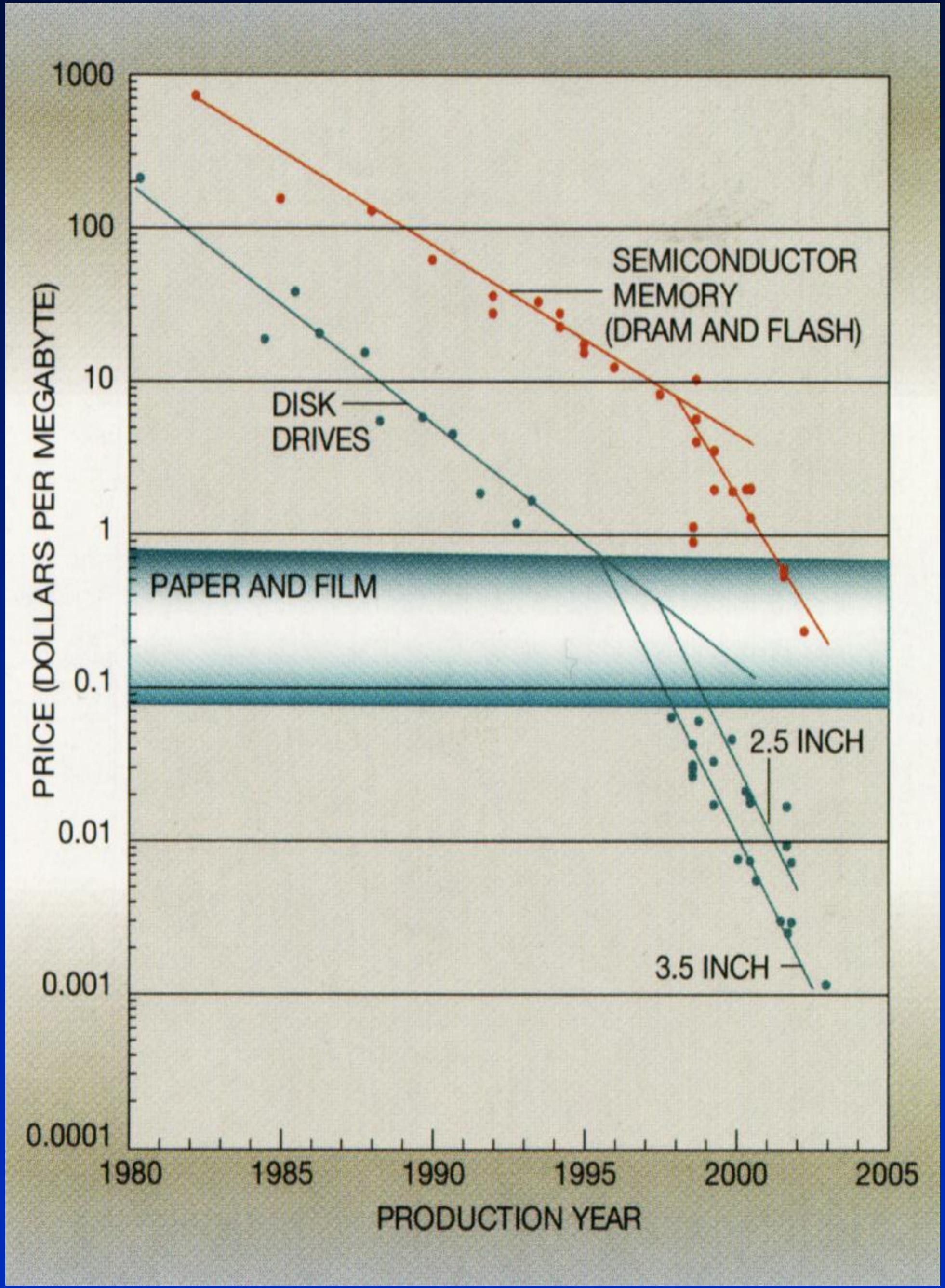
E. Grochowski, R.D. Halem. “Technological impact of magnetic hard disk drives on storage systems,” IBM Systems Journal, vol. 24, no. 2, 2003 p. 339.

Cost of storage for disk drive, paper, film, and semiconductor memory

Will Flash Memory replace Disk Storage?

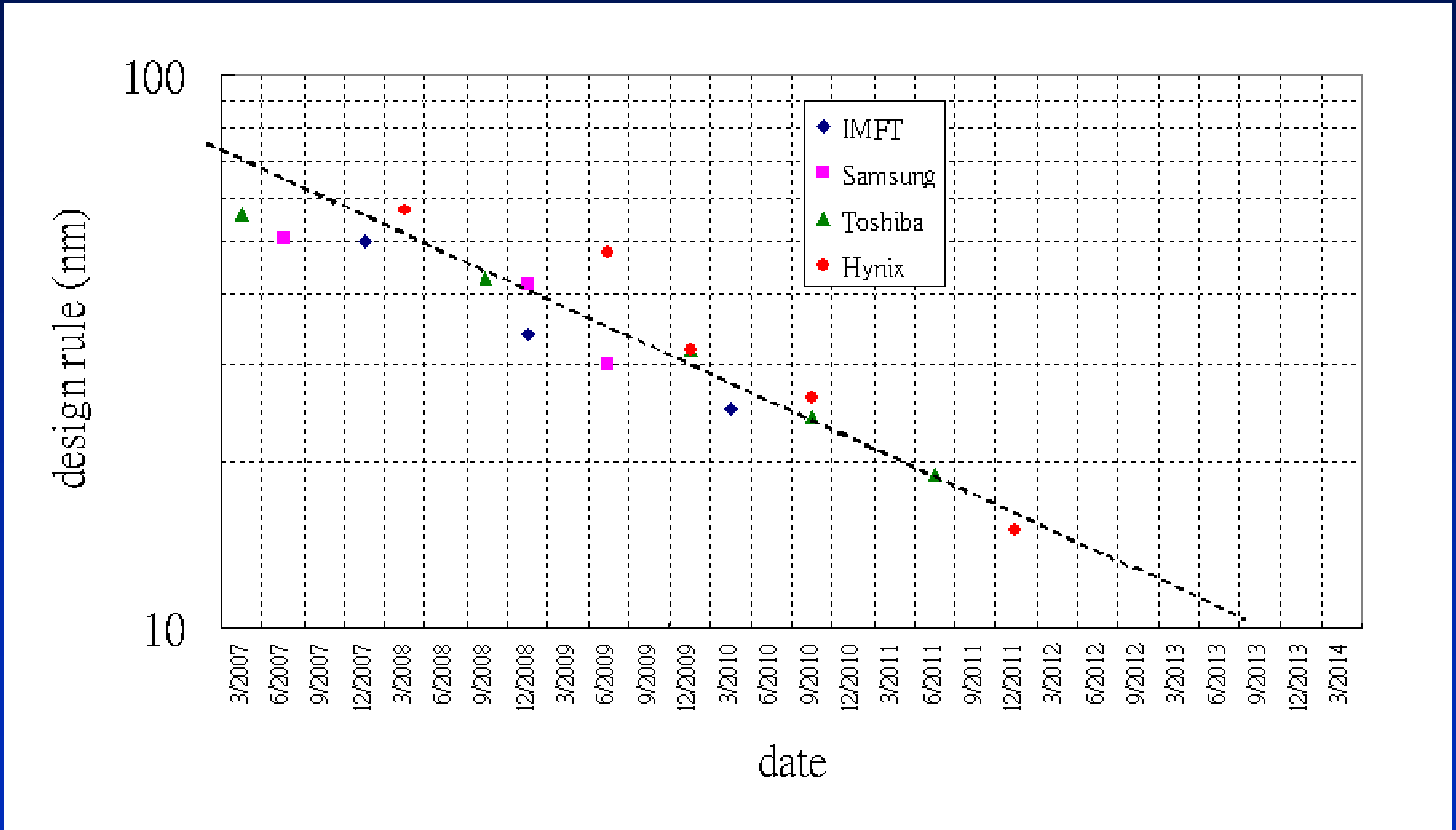
Is this a Disruptive Technology?

Already with 34nm technology Intel and Micron have broken the $1/GB barrier



E. Grochowski, R.D. Halem. "Technological impact of magnetic hard disk drives on storage systems," IBM Systems Journal, vol. 24, no. 2, 2003 p. 339.

Flash Scalability



Disruptive Technologies

- What is typical management and marketing dogma?
- Stay close to your customers!

Disruptive Technologies

Sony Walkman

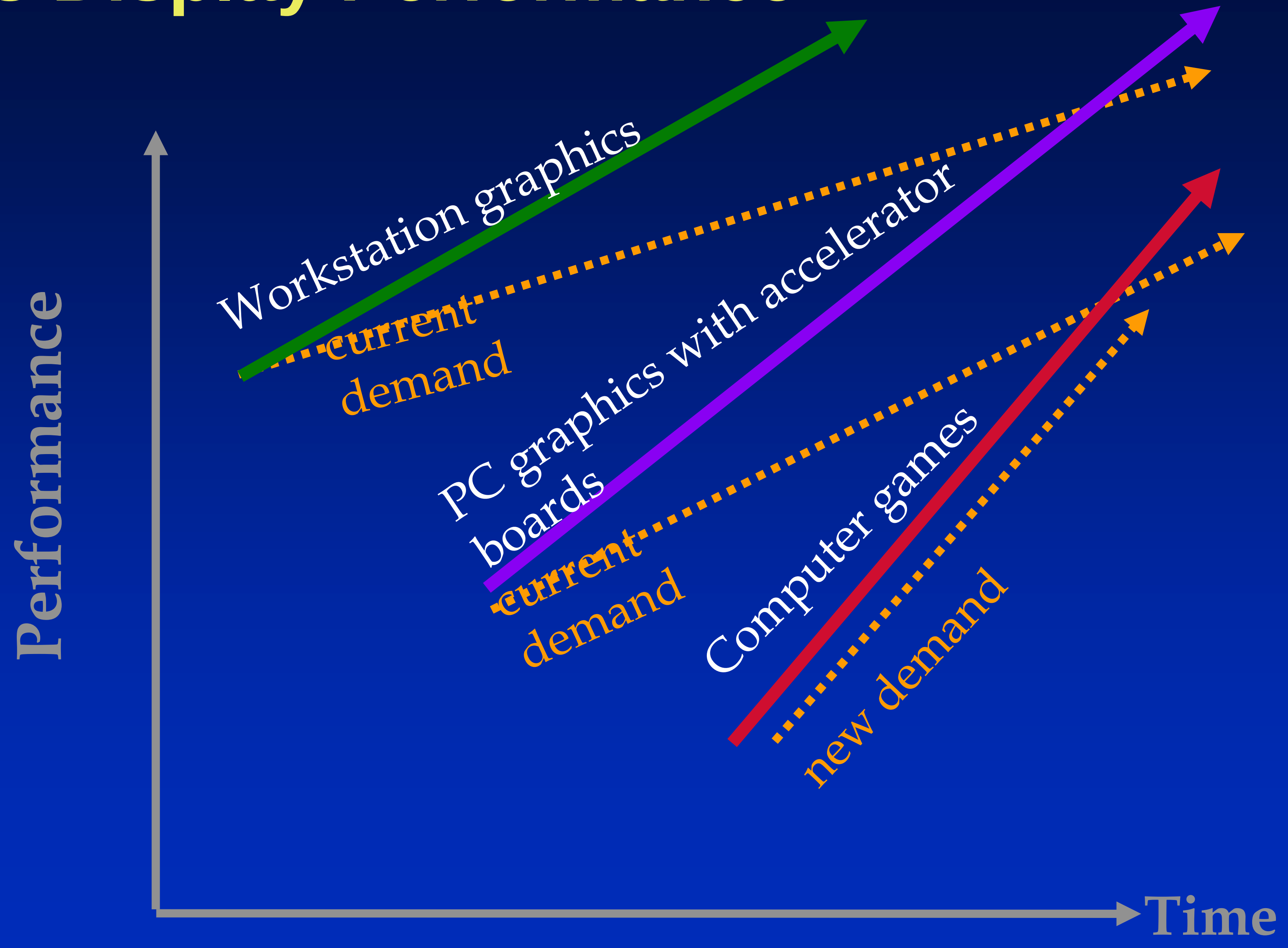
Disruptive Technologies

- What happens when your best customers reject a new technology?
- Xerox's large photocopy centers had no use for small photocopiers
- IBM's large customers had no use for minicomputers

Disruptive Technologies

- What happens when your best customers reject a new technology?
- DEC's minicomputer customers (PDP 11/40-11/70 and VAX 11/780-11/730) had no use for PC's
- SGI's graphics customers had no use for PC graphic boards

Graphics Display Performance




HOW DICK GRASSO IS TRANSFORMING THE NYSE

BusinessWeek

AUGUST 4, 1997 A PUBLICATION OF THE McGRAW-HILL COMPANIES $3.50

THE SAD SAGA OF SILICON GRAPHICS

Its gee-whiz computer graphics brought fame and fortune. But now, dogged by troubles, its market value has dropped by half. Here's the untold tale of what went wrong. Can CEO Ed McCracken fix things?

Internet: www.businessweek.com America Online: Keyword: BW

Disruptive Technologies

- Research shows most well managed companies are ahead of their industries (both with incremental improvements or new approaches PROVIDED THESE TECHNOLOGIES ADDRESS THE NEXT GENERATION NEEDS OF THEIR CUSTOMERS
- These same companies make bad decisions when the technologies do not meet the needs of their main stream customers and appeal only to SMALL OR EMERGING MARKETS

Disruptive Technologies: What choices?

With established companies managers have 2 choices:

- **Go downmarket** -- accept lower profit margins, initially these emerging markets may be lower cost
- **Go upmarket** -- alluringly high profit margins, e.g., margins of IBM mainframes are higher than PCs

SPECIAL REPORT THE BEST IN EXECUTIVE EDUCATION

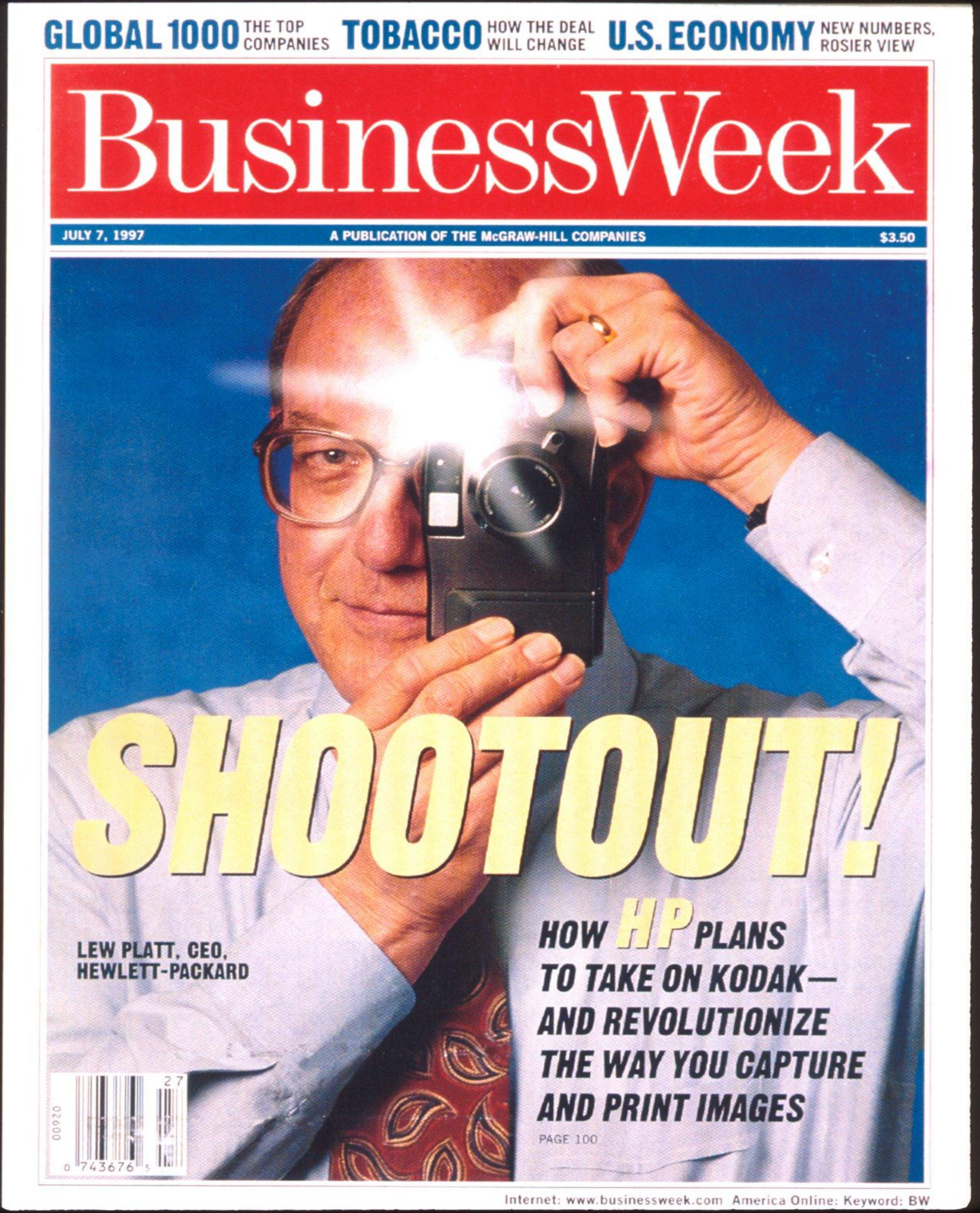
BusinessWeek

OCTOBER 20, 1997 A PUBLICATION OF THE McGRAW-HILL COMPANIES $3.50

CAN GEORGE FISHER FIX KODAK?

PAGE 116

Internet: www.businessweek.com America Online: Keyword: BW


GLOBAL 1000 THE TOP COMPANIES
TOBACCO HOW THE DEAL WILL CHANGE
U.S. ECONOMY NEW NUMBERS, ROSIER VIEW
BusinessWeek
JULY 7, 1997
A PUBLICATION OF THE McGRAW-HILL COMPANIES
$3.50
SHOOTOUT!
LEW PLATT, CEO, HEWLETT-PACKARD
HOW HP PLANS TO TAKE ON KODAK— AND REVOLUTIONIZE THE WAY YOU CAPTURE AND PRINT IMAGES
PAGE 100
Internet: www.businessweek.com America Online: Keyword: BW

Disruptive Technologies

- How does a company allocate resources?

- Existing processes are designed to “weed out” proposed products/technologies that DO NOT ADDRESS CUSTOMERS NEEDS

Netflix

- First CDs, then DVDs
- Then envelope shapes
- Then partnership with Blockbuster refused
- Then streaming video
- Now Comcast

Blockbuster and Redbox

http://www.bloomberg.com/news/2010-07-19/redbox-plots-internet-movie-strategy-in-challenge-to-netflix-on-home-turf.html

Netflix 5-year stock chart

End. . .