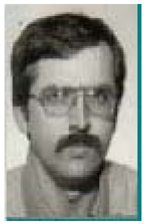
WHAT NEXT, REVEALED 1

Adi Porobic,
May, 2002

Devoted to Fifth Generation Computing Project 1982-1992 , established 20 years ahead of its time.



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Tributes

Eternal inspiration for works of this kind belongs to visionaries :

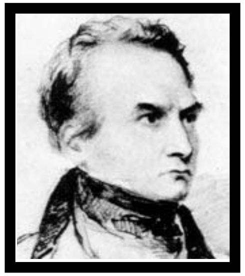
Lewis Branscomb in economy
Information: The Ultimate Frontiers,
Science, Vol 203 No 4376, January 1979
who has described computers by the year 2078.

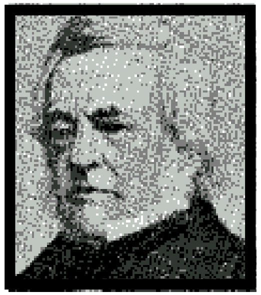
Arthur Clarke in technology
2010: Odyssey Two, 1982
for HAL in the Space.

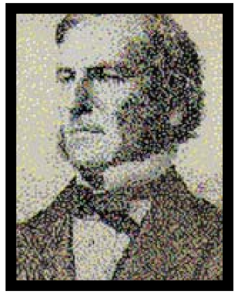
Jim Gray in logic
What Next?A dozen remaining IT problems, 1998
http://www.research.microsoft.com/~Gray/
If I gave some answers here,
they are connected with his questions.
Finding right questions is much harder than the answers.

and thousands Others around the World, who did their best
in contributions, that became this article foundation.

They have started all:







Charles Babbage

1835
On the Economy of Machinery and Manufactures

Economy of computing

Georg Scheutz

1853
The First working difference engine - calculator

Technology breakthrough

George Boole

1854
An Investigation of the Laws of thought

Birth of computing logic

Introduction

Computing power grows fast, why not AI ?

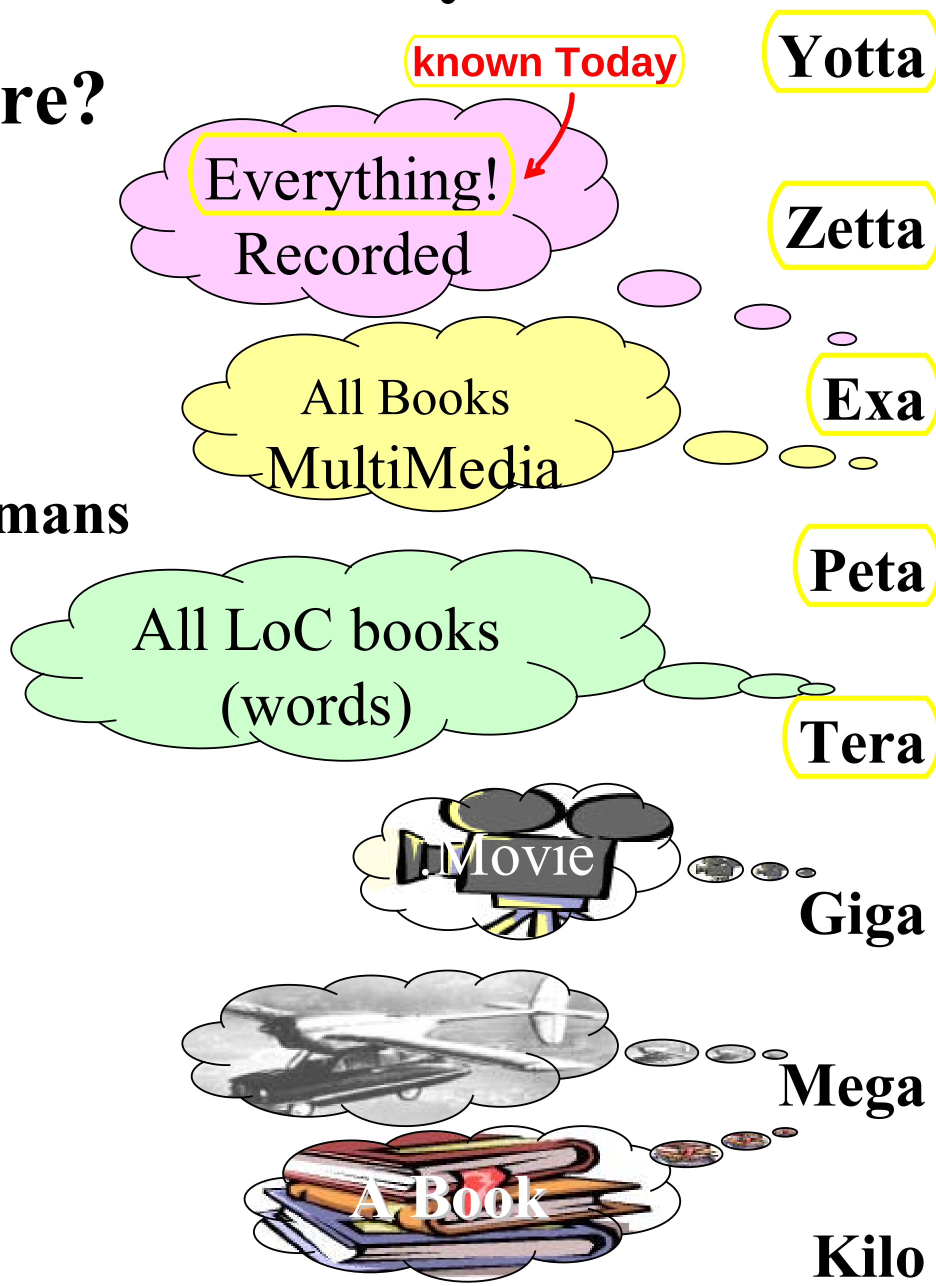
Answer is the end of every question and vice versa

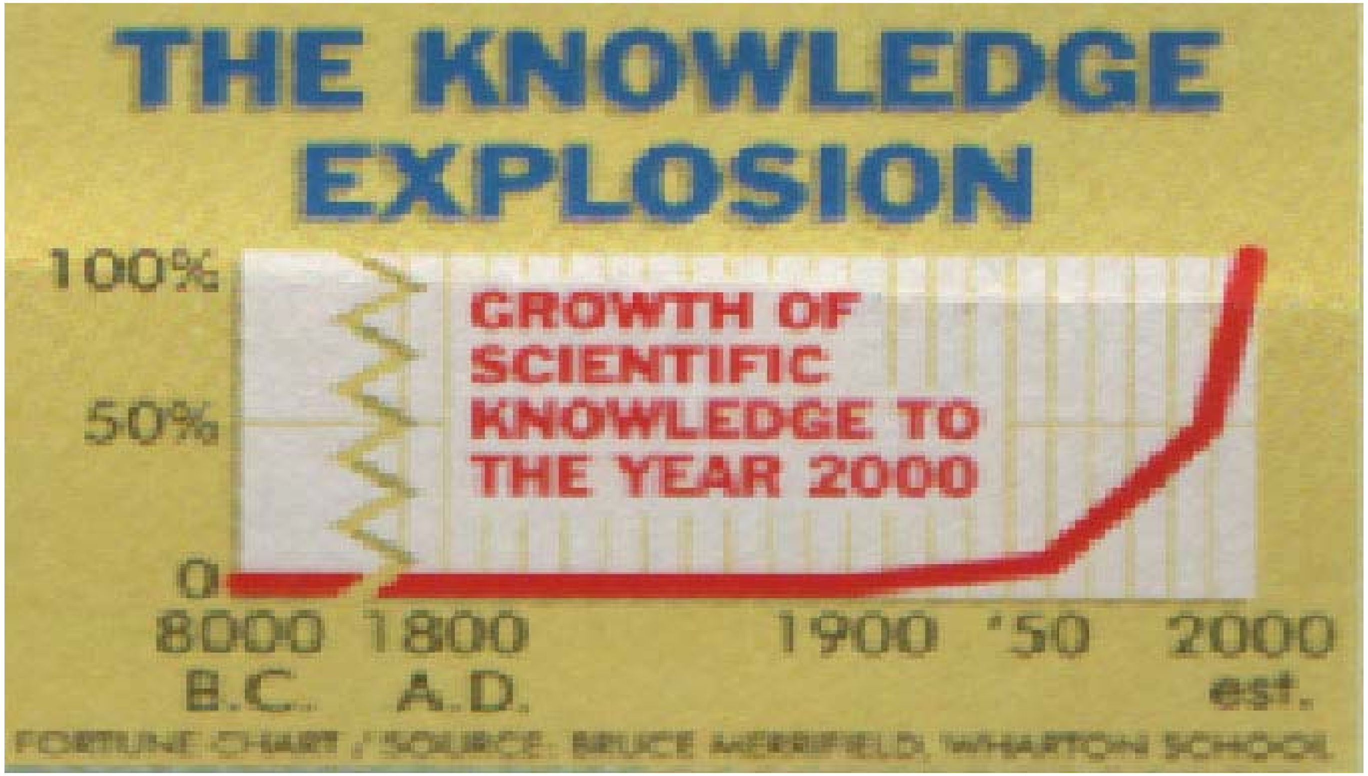
How Much Information in Bytes

Is there?

- **Soon everything can be recorded and indexed**
- **Most data never be seen by humans**
- **Precious Resource: Human attention**
  Auto-Summarization
  Auto-Search
  is key technology.

www.lesk.com/mlesk/ksg97/ksg.html





Scientific knowledge growth is dependent on human intelligence, that is restricted with the environment. Growth rate of the World population from now, is in constant DECLINE. What is the alternative? Use of computers, networks and AI instead of.

The rate of the overall computing power has been amazingly growing for more than one hundred years

Computing efficiency in ops/s/$ had 3 growth curves:

1890-1945

- Mechanical
- Relay
- 7-year doubling

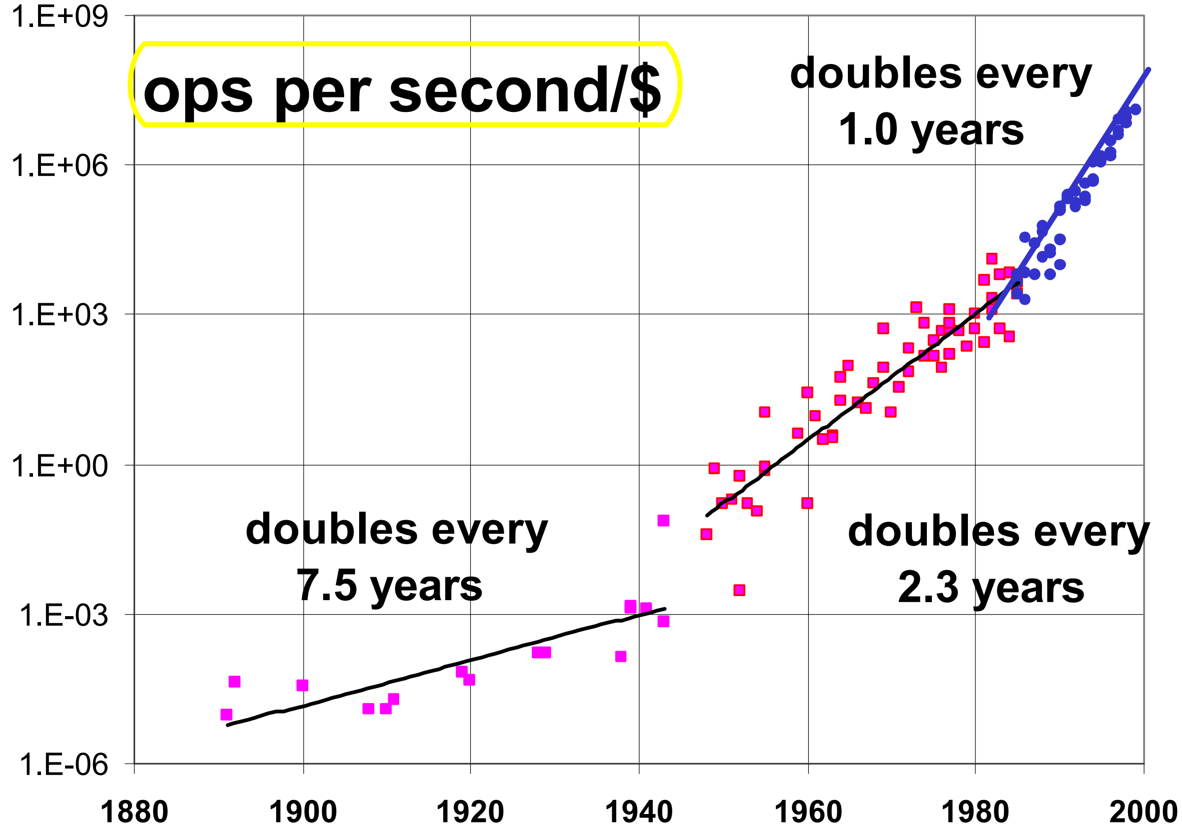
1945-1985

- Tube, transistor,..
- 2.3 year doubling

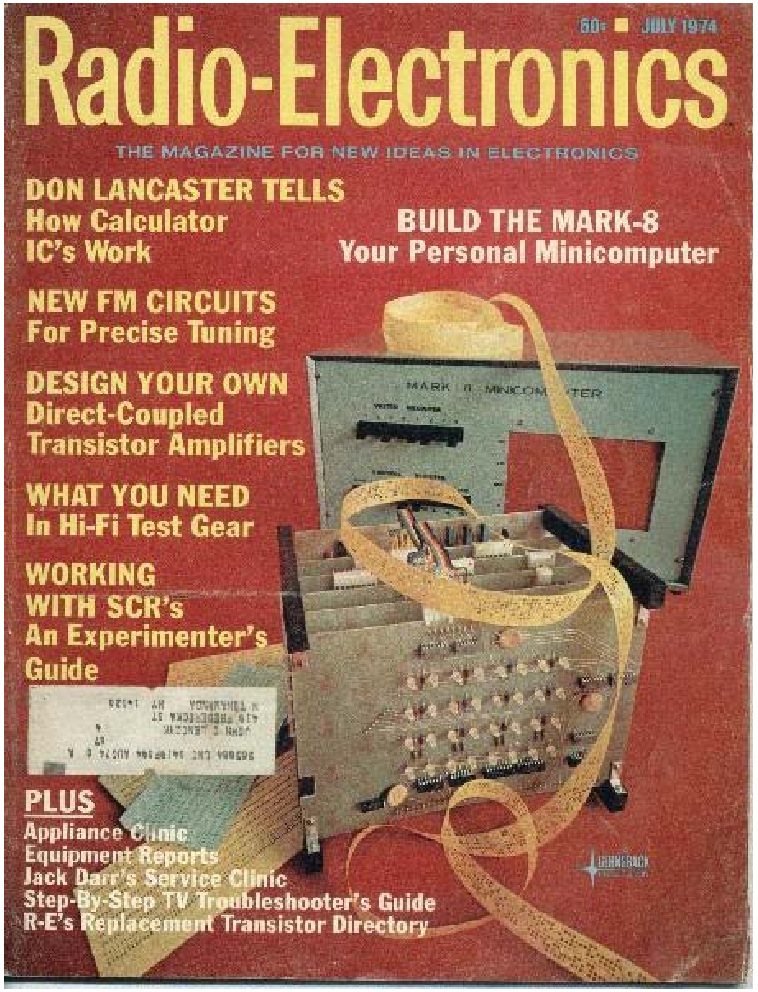
1985-2000

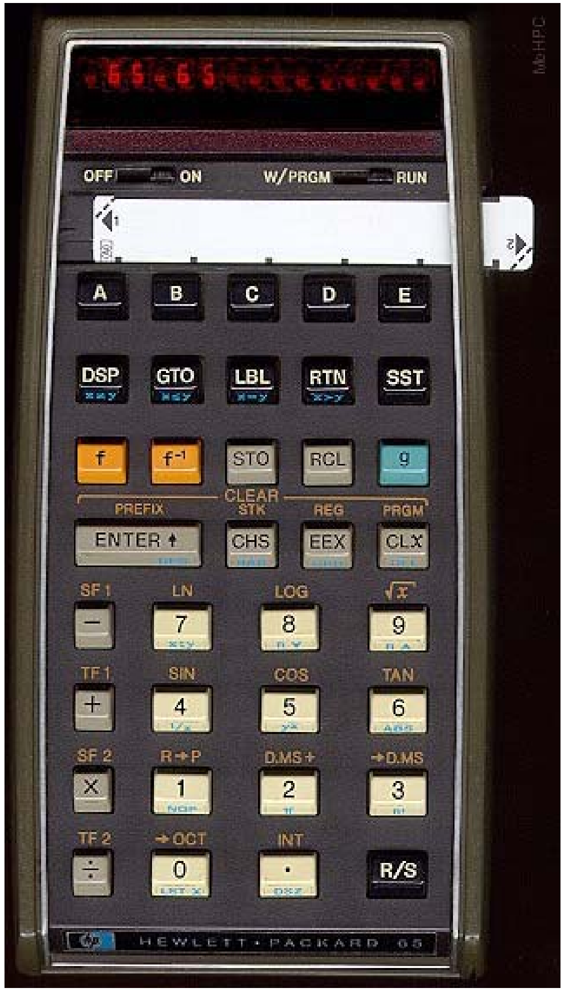
- Microprocessor
- 1.0 year doubling

Combination of Hans Moravac + Larry Roberts + Gordon Bell
WordSize*ops/s/sysprice



How personal computing looked 28 years ago





Two Pretenders for the first Personal Computer, year 1974. MARK-8 with paper tape left and HP-65 with programmable magnetic card right. At the same year Bill Gates wrote his first Basic Interpreter on paper tape and Gordon Moore conceived corrections of the First Law.

AI looks quite primitive, like the first personal computers 28 years ago, from today's stand point.

When Mr. Rutherford, lucky discoverer of atomic nucleus, was asked in 1919 about possible use of nuclear energy, he replied abruptly: rubbish. Then, 26 years later, RUBBISH EXPLODED.

Chapter 1

Are there possibilities in hardware and economy to maintain growth of computing efficiency with similar rate as previous, for the next 26 years?

The answer is: YES

Moore's Laws confusion blowed up

***1965.** Gordon Moore announced his famous First Law of micro electronic components doubling on chip.*

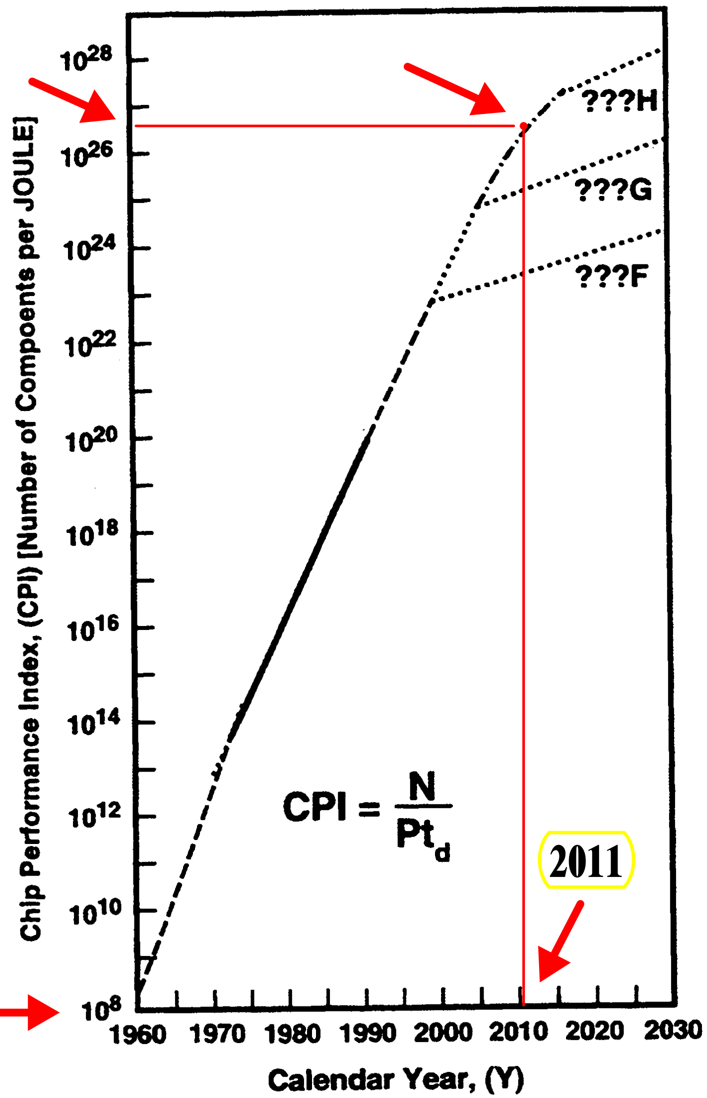
1974. Moore noticed slowdown of rates from the First Law. What was the cause? All transistor could not be connected in one plane on the chip, and multi wire layers emerged. That of course, slowed down the rate of chip' s component doubling. Article published in 1975 is also known as Correction of the First Law.

1995. Intel's investor Rock noticed doubling of prices for the each new chip's fab. Law by inertion was called Moore's Second Law. But, Gordon Moore has nothing directly with it.

2002. There is no more place even for transistors soon, so they are combined in a few layers. Switch should happen in the year 2011 , but doubling rates established in 1974 remains after, taking a new forms of implementation. Only 2 or 3 fabs should remained. That is found in advance in this work. Further slowdowns in doubling rates are unlikely, just as the End of the Moore's Corrected First Law.

2005. Start of transition toward pure nano electronics .

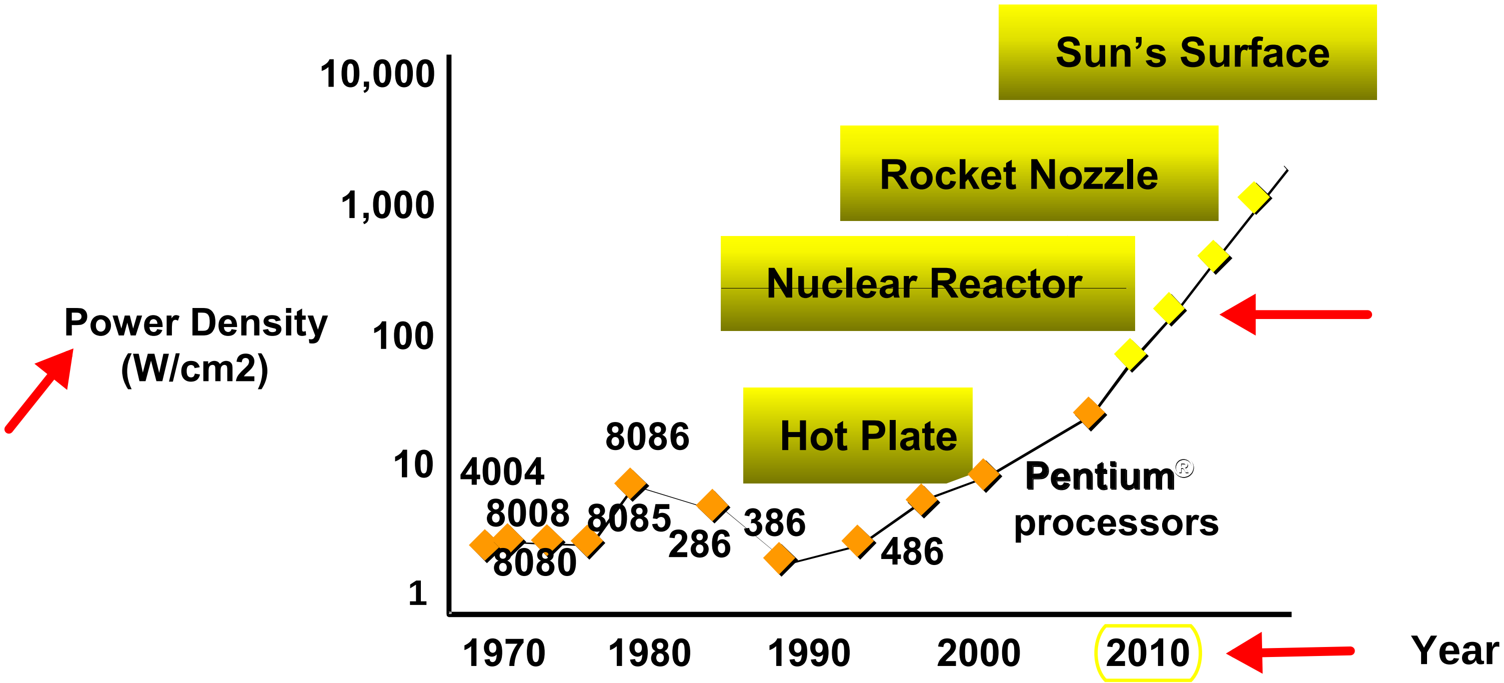
2015. 50th birthday of the Moore's Law. Law continues, but micro electronics is dead.



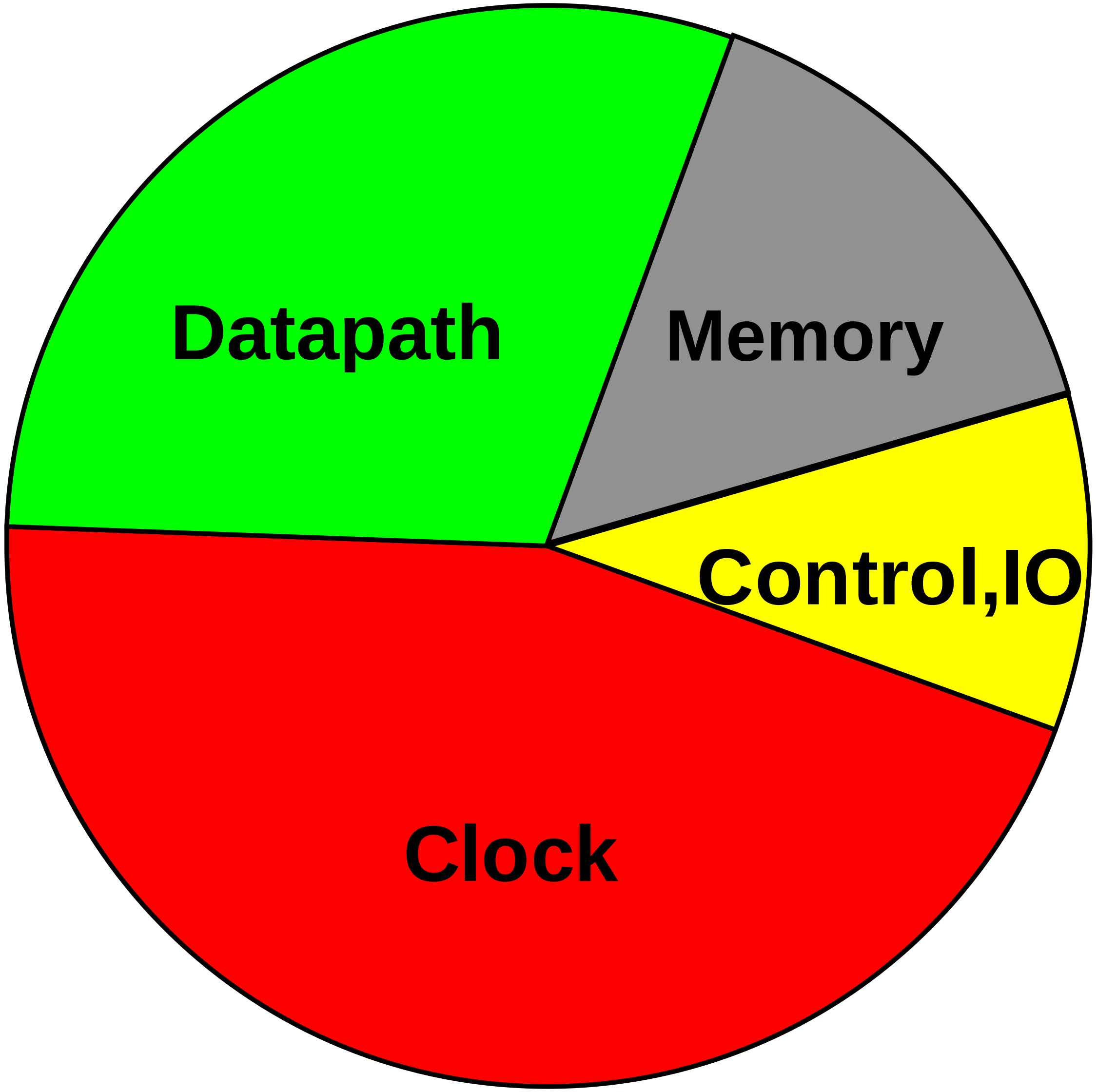
Meindl :

Growth of chip's energy efficiency 1960 - 2010
Unbelievable improvement of 10 exp 19 times.
Will it continue with the same rate ?

Problem: Chip Power Density Growth



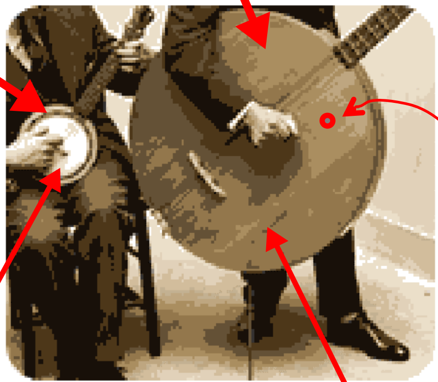
Solution: Efficient cooling technologies up to 1KW/cm2



Power breakdown in a high-performance CPU

660 mm

200 mm

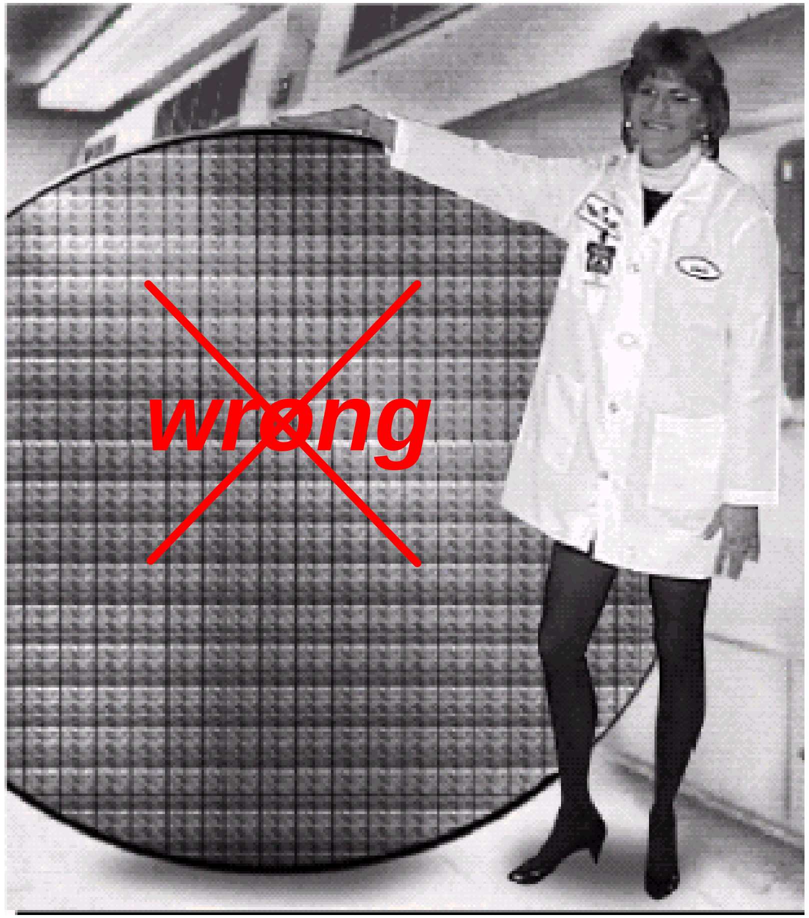


Actual wafer size today

and by the year 2013

18 mm

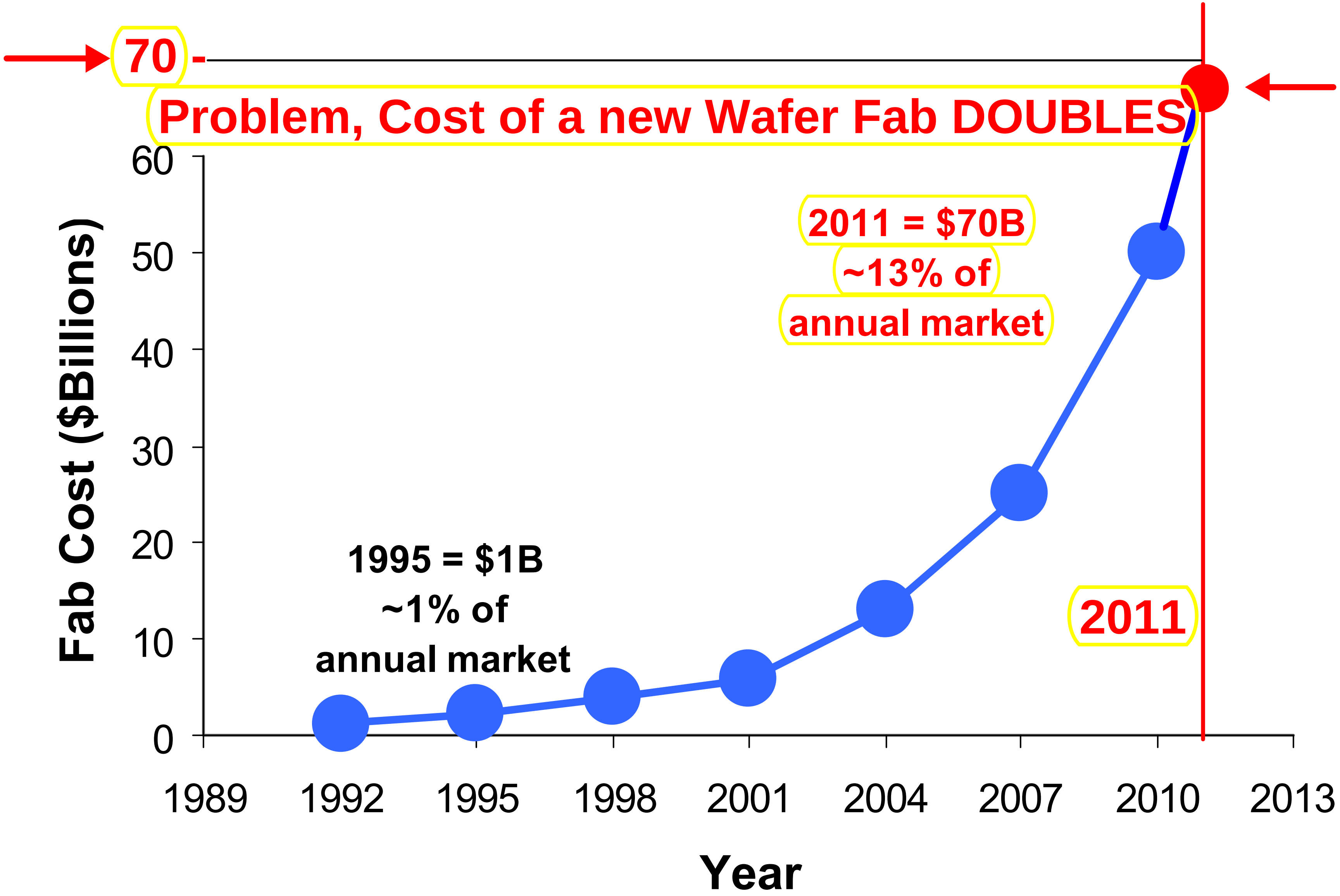
Wafer size in the year 1965 , Moore's First Law announced



Wafer size in the year 2000 due to Moore's 1965 First Law, WRONG

Productivity Grows with square of Wafer size 1965-2013

Moore' s "Second Law"



Semiconductor Industry Growth

DARPA ISAT

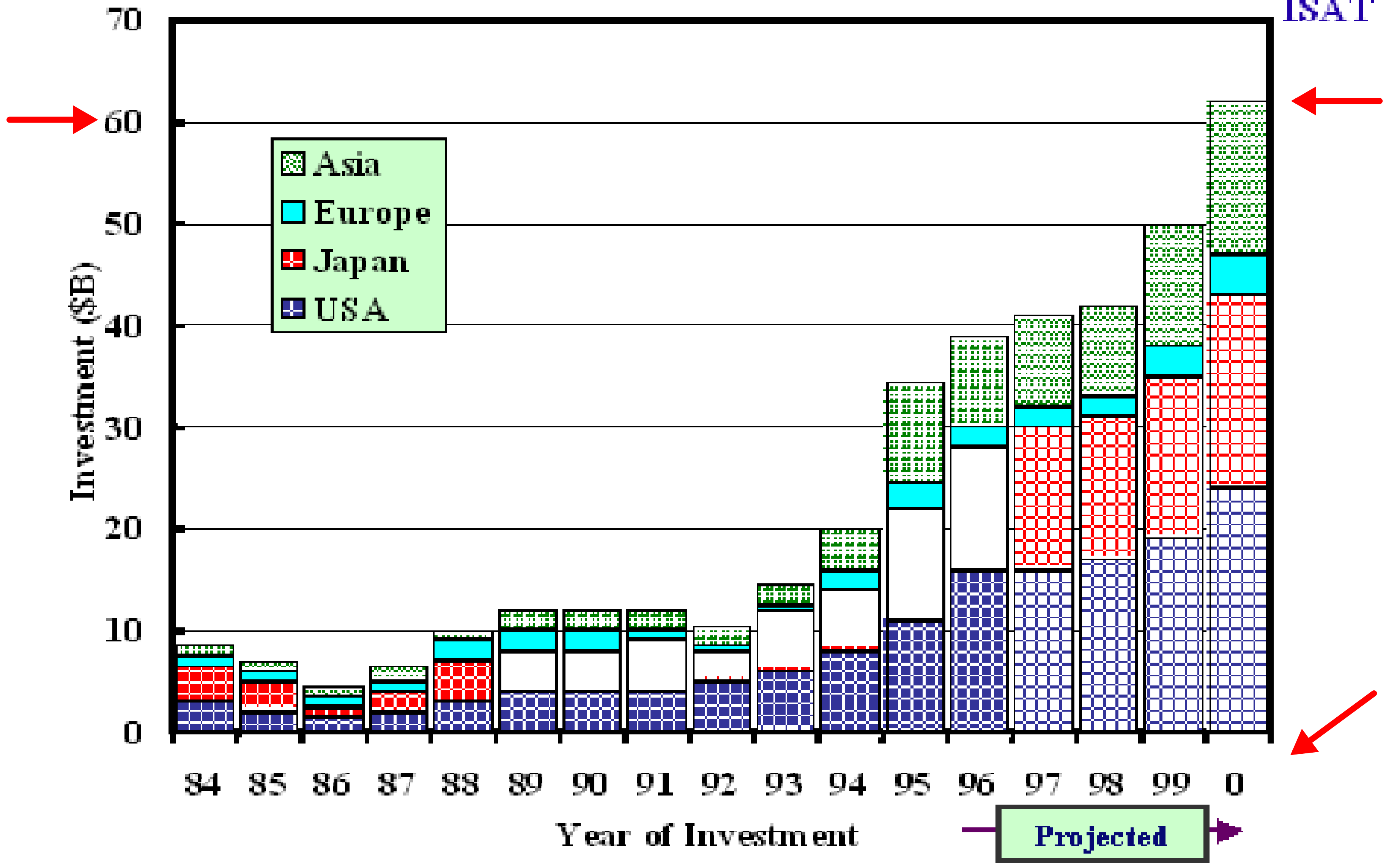
Predictions of Chenming Hu , UC Berkeley in 1996, WRONG

	1995	Steady State? 2030
Semiconductor as % of Electronics	17%	35%
Electronics as % of GWP	4%	8%
Semiconductors as % of GWP	0.7%	3%
CMOS Technology	0.35µm	0.05µm
World Semiconductor Sales	$140B	$12,000B
Annual Growth Rate	16%	8%, same as GWP

Growth rate for the ELECTRONICS industry 1995-2000 was only 7%
SEMICONDUCTOR BUSSINESS MATURING FAST, with 8% growth rate as soon as in 2007. Not attractive for investments in 2015 and after. But nano technologies will be. Do you want to make the fortune? Start nano tech business after 2005.

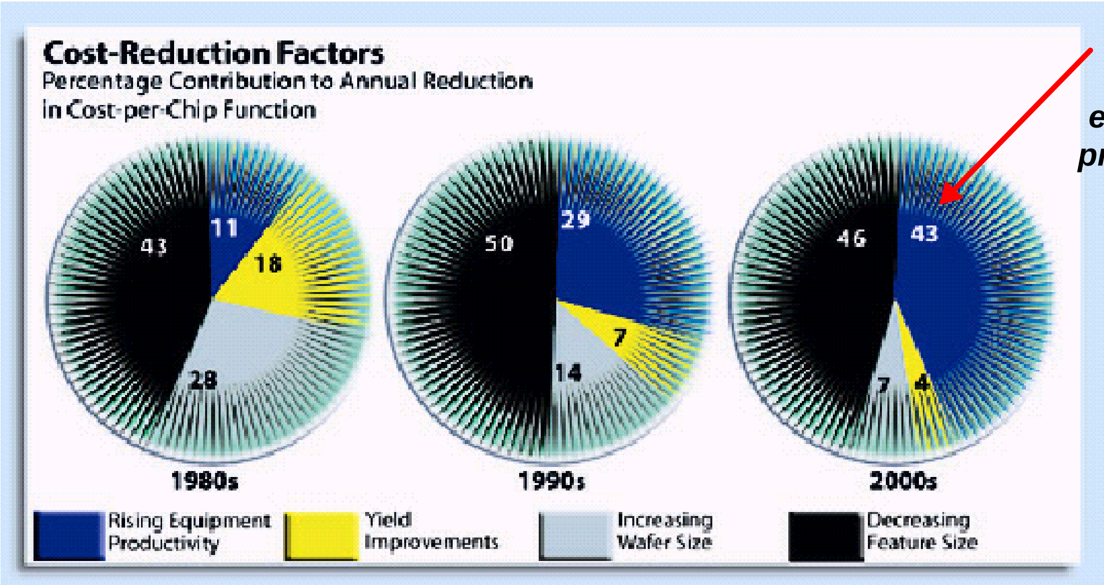
Semiconductor Capital Investment

DARPA ISAT

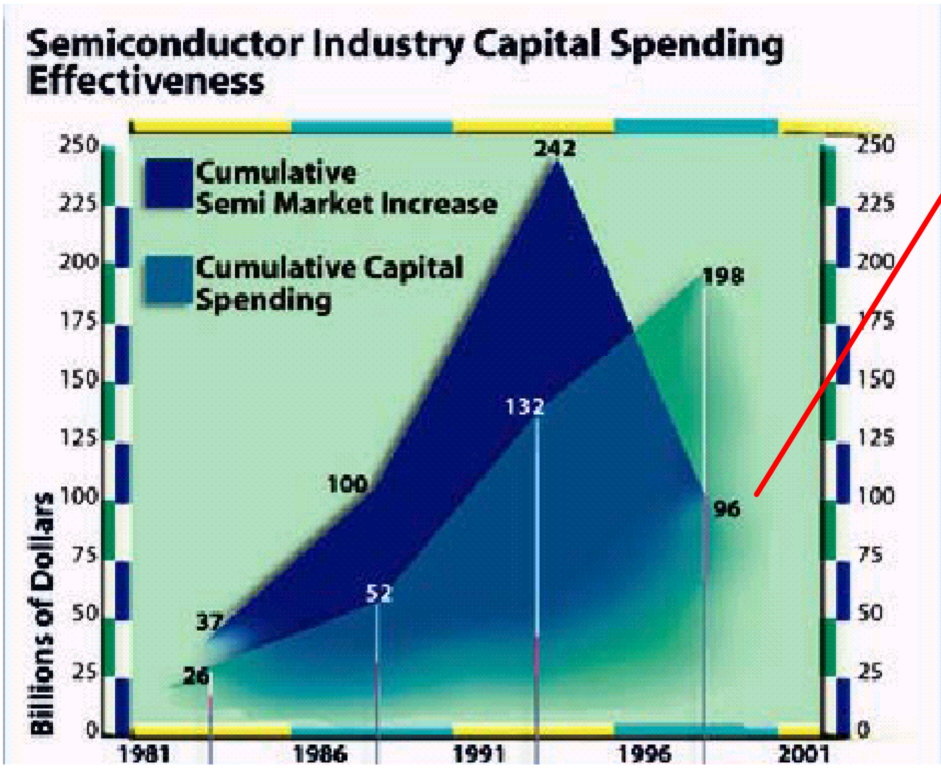


Rising costs of chip manufacturing equipment but rising of productivity also. Cumulative semiconductor market greater then investments only after the year 2005.

NEVER RECORDED BOOM AFTER 2005.



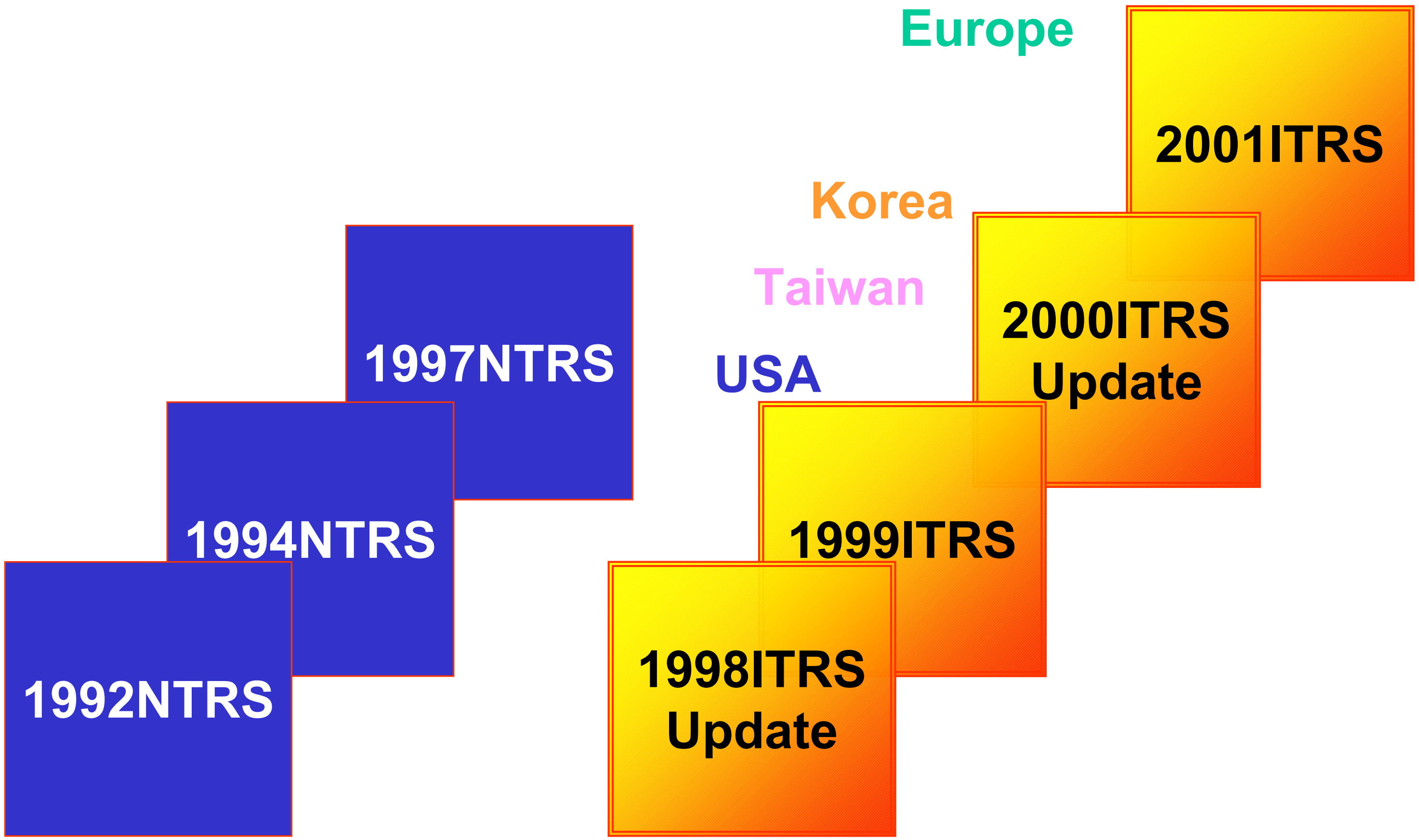
equipment productivity



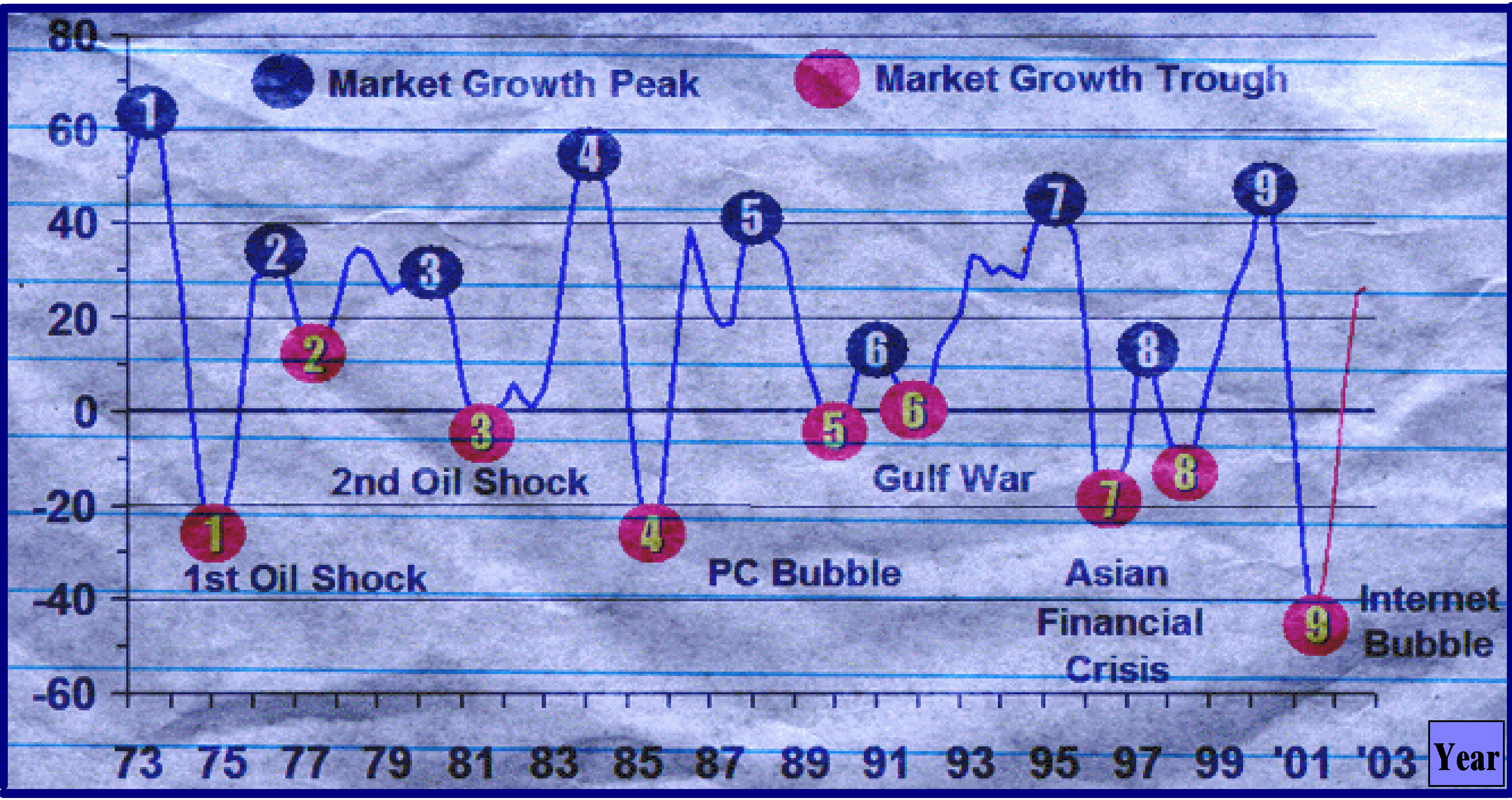
Market rise

SOURCE: SEMATECH, IC INSIGHTS

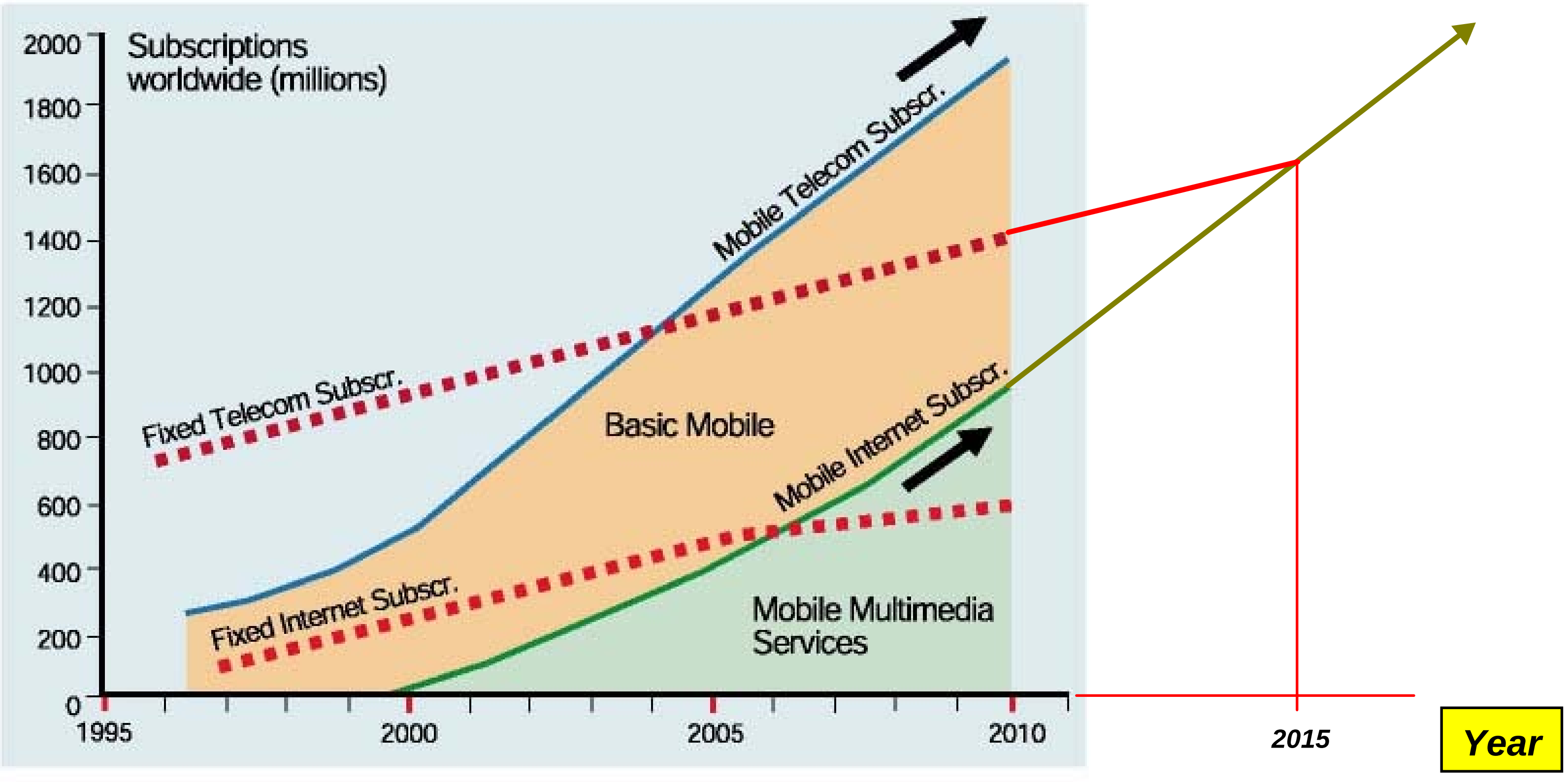
Semiconductor Roadmaps in 10 years
From Company, National to International planning



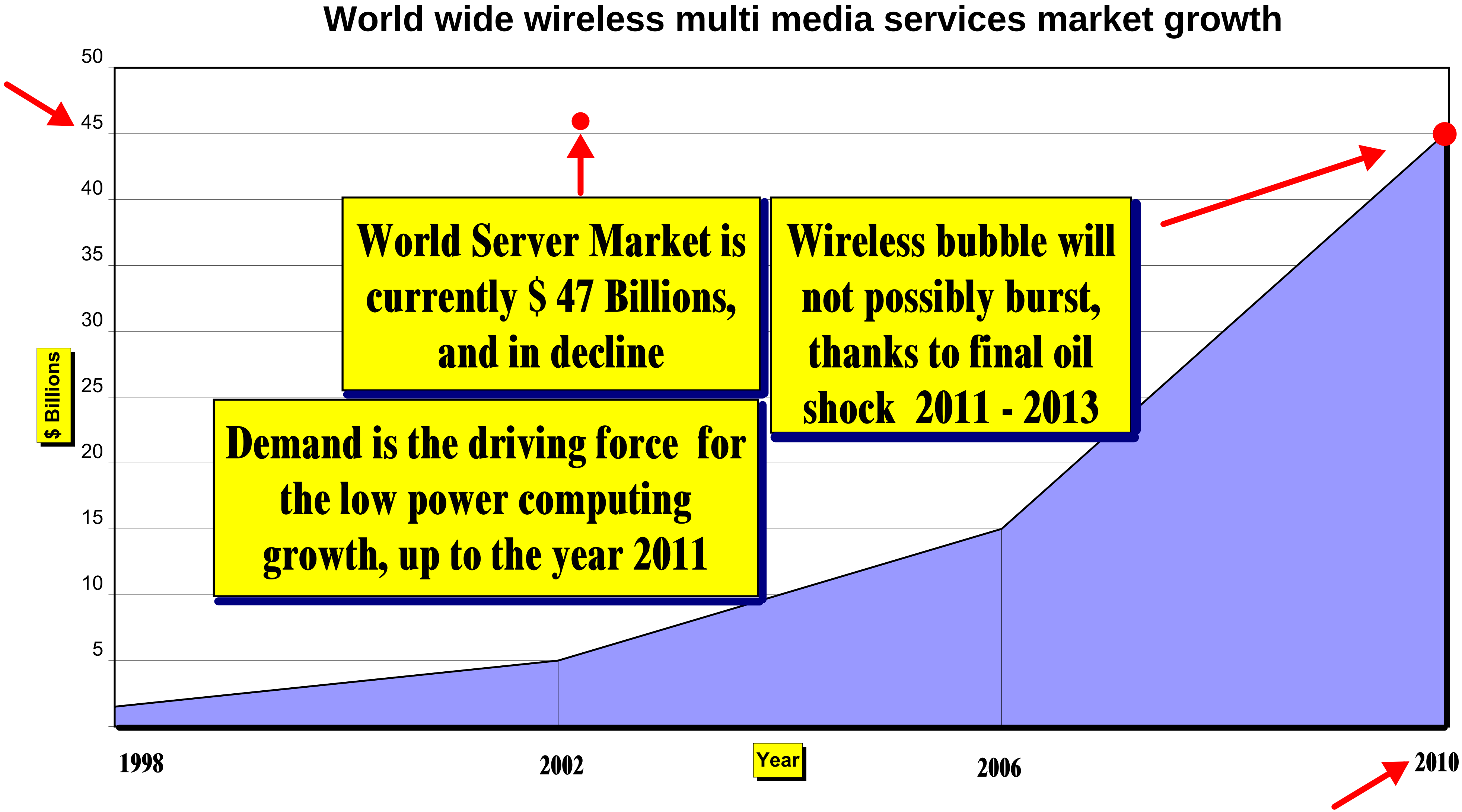
PROBLEM: Semiconductor Cycles , IDF 2002
Percent Change Year Ago



In the year 2015 there will be more than 1,6 Billion users of the Mobile Multimedia Services



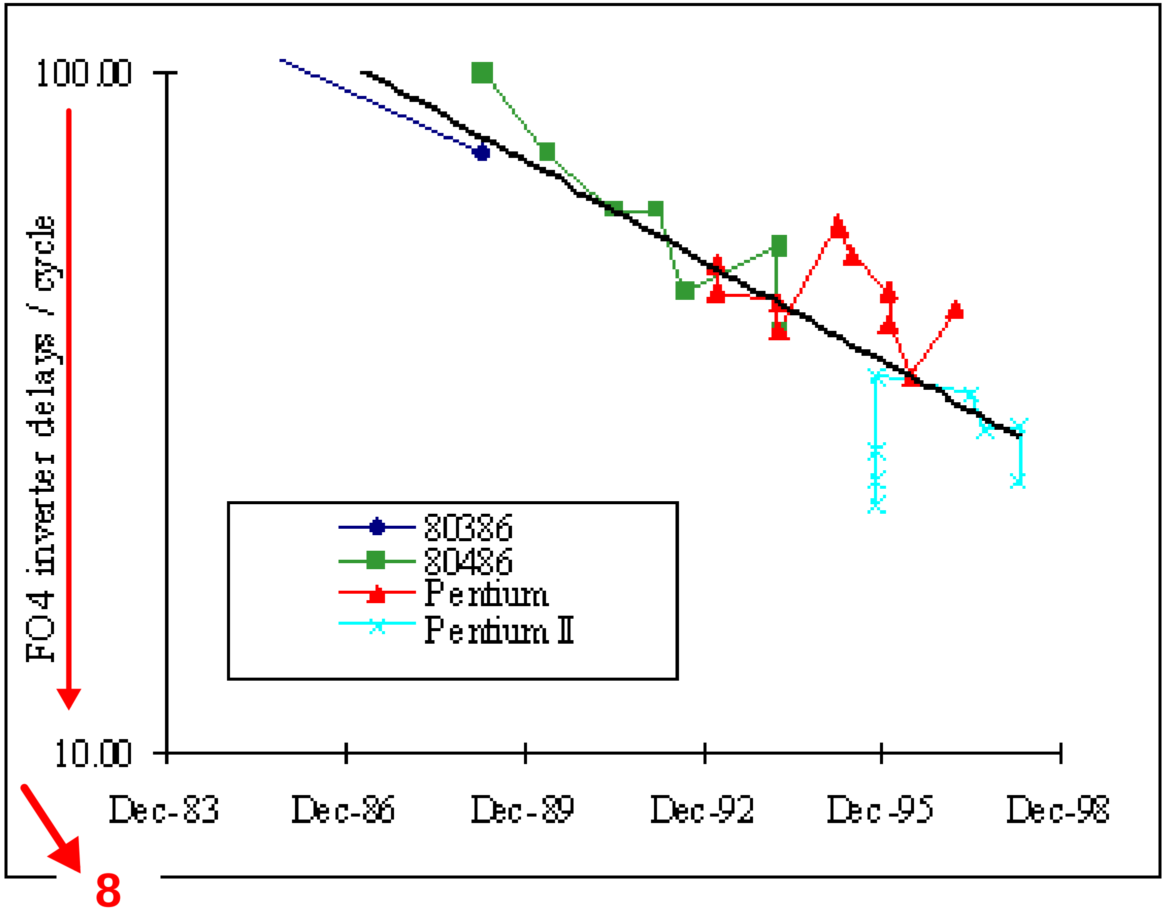
Wireless.NET is EMERGING



Problem: Gates Per Clock

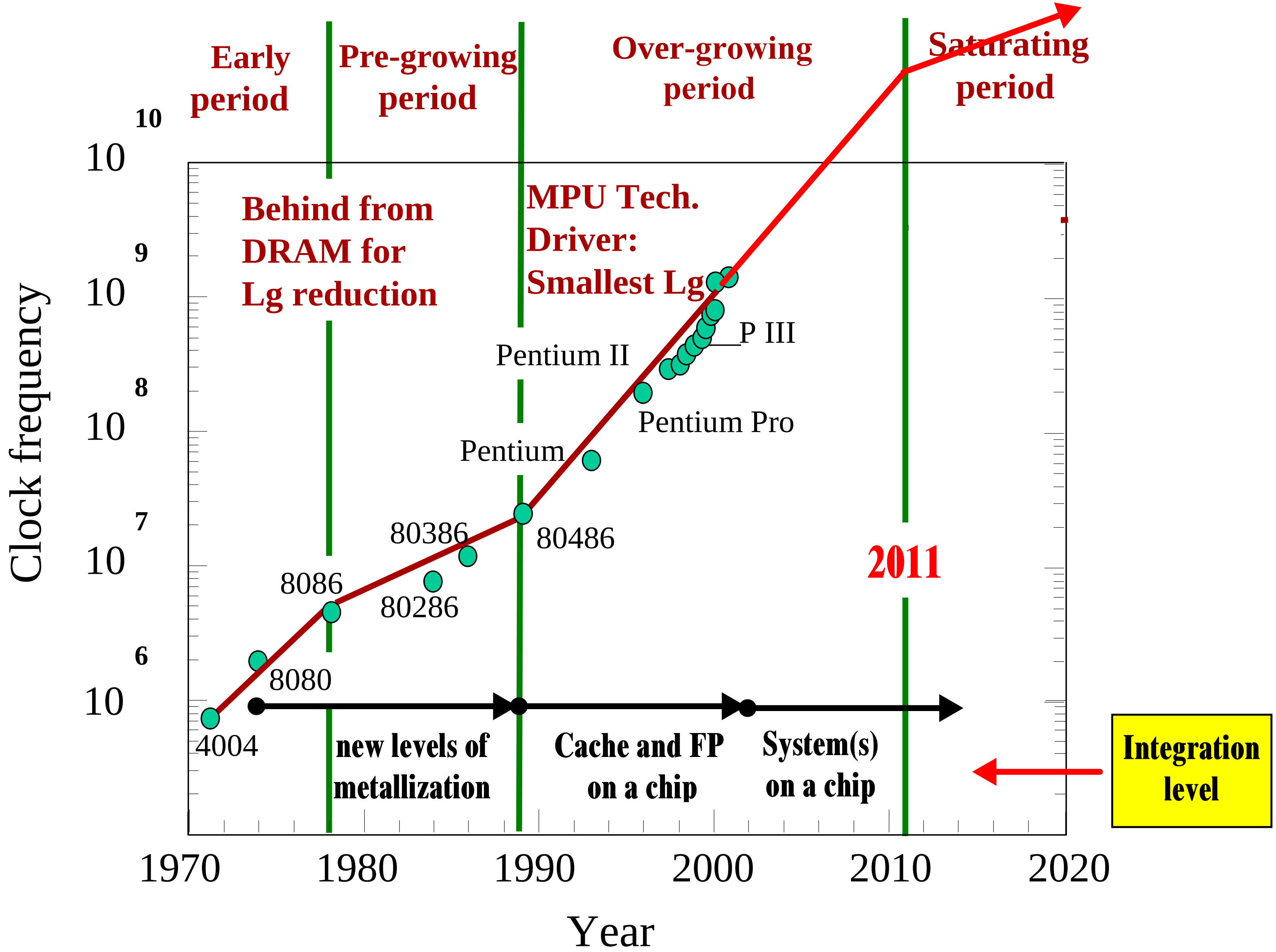
After 2011 slowdown in clock speed growth

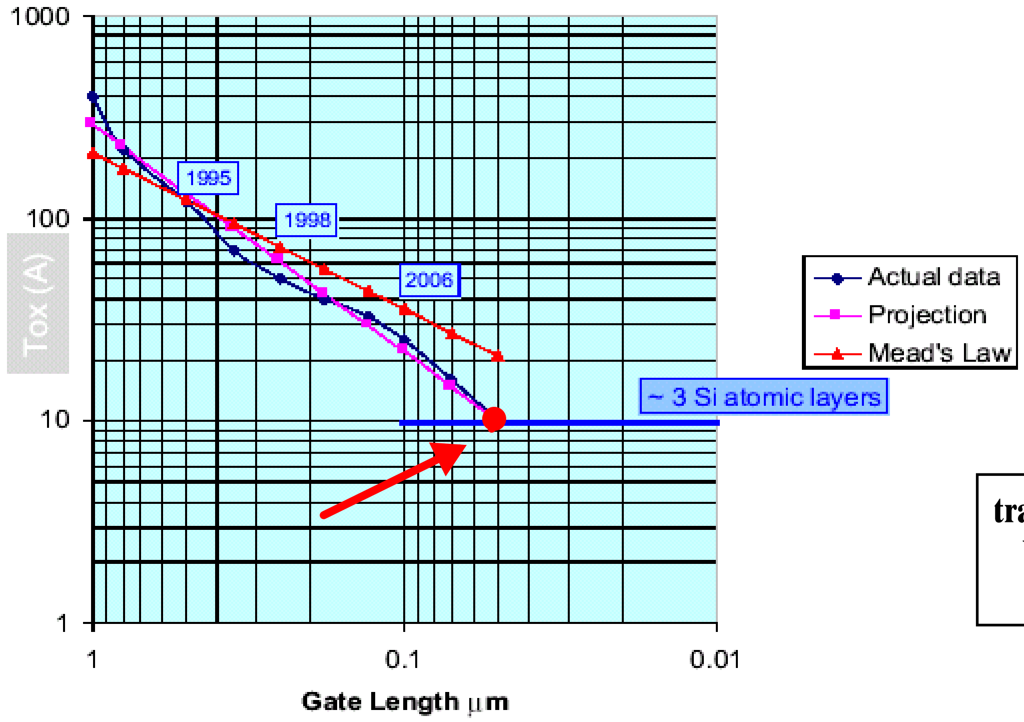
- Clock speed has been scaling faster than base technology
- Number of FO4 delays in a cycle has been falling **slower then clock speed**

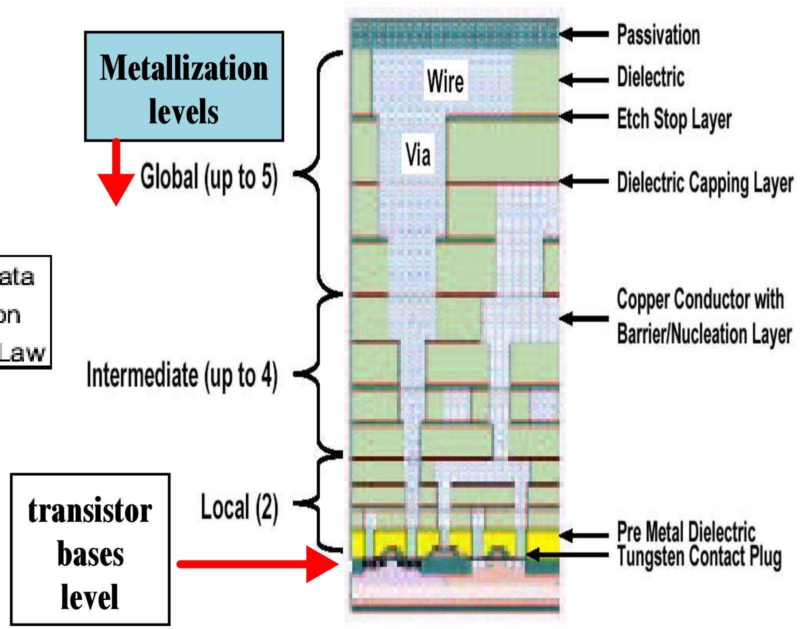


- Number of gates decrease 1.4x each generation
- Caused by:
  - Faster circuit families (dynamic logic)
  - Better optimization
- Approaching a limit:
  - <16 FO4 is hard
  - **Year 2009** < 8 FO4 is very hard

µP clock frequency growth periods. Saturating after 2011 (A. Porobic's prediction)

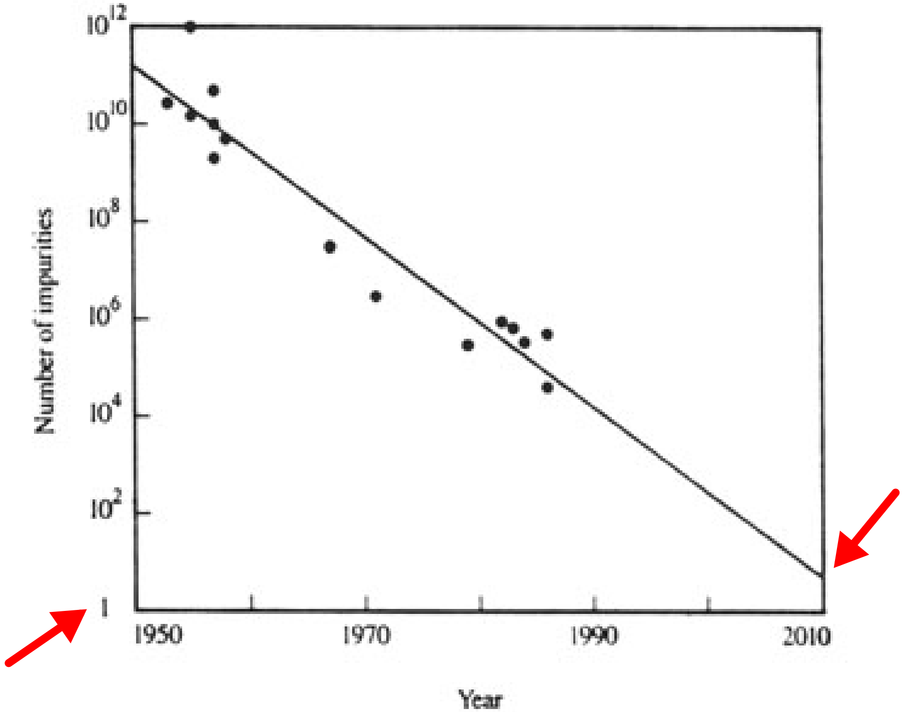






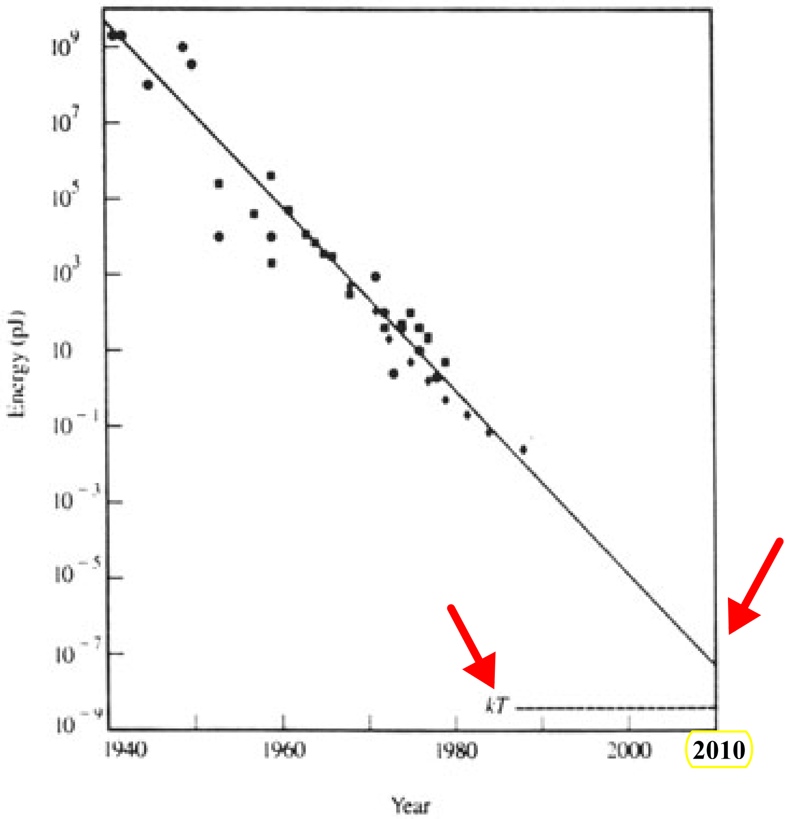
Part of vertical cut of modern microprocessor

First fundamental limit in modern chip design reached in 2005 with thickness of transistor bases Tox ~3 Si atoms, left (At bottom Layer of multi layered chip,right)
Radical change in used materials and devices after



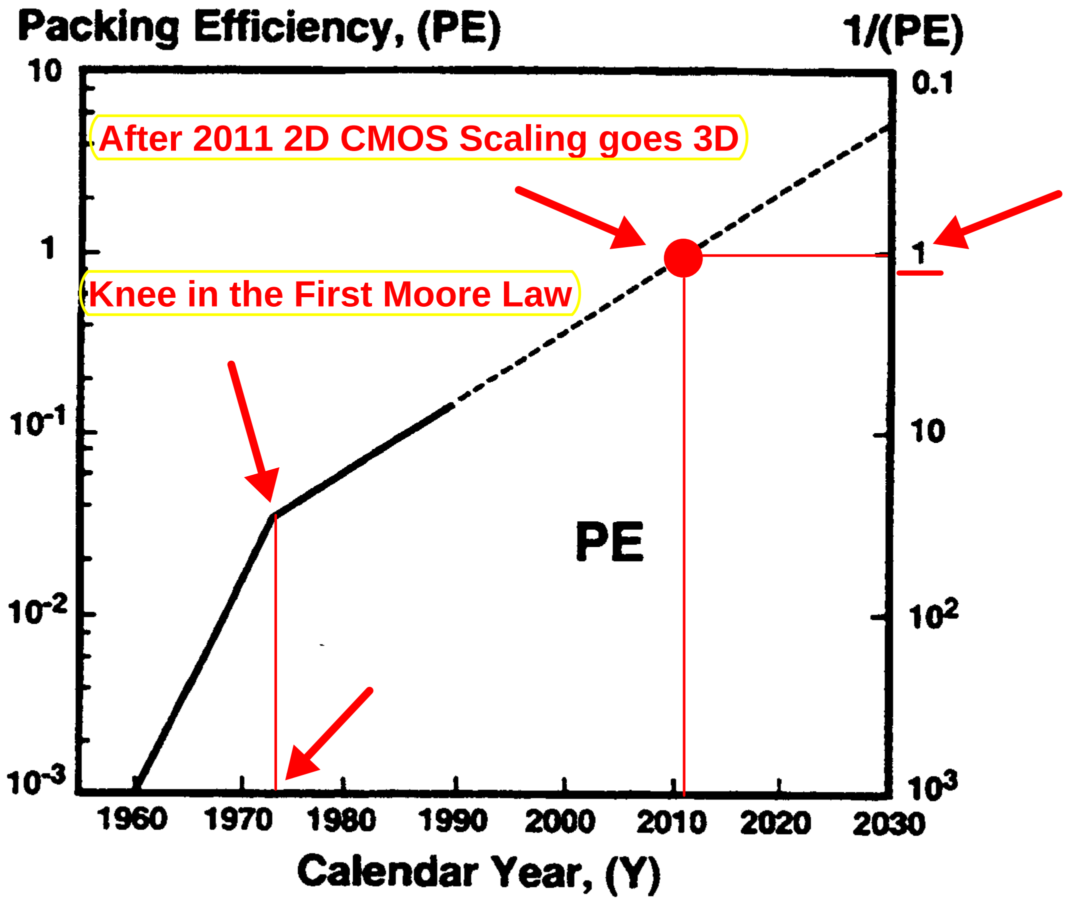
The decreasing number of dopant impurities in base of the bipolar transistor → Limit

"Miniaturization of electronics and its limits"
by R. W. Keyes, IBM J. R&D, V32 N1, Jan 1988, p27



The decreasing energy per logic operation ends in 2010 → Fundamental limit for the room temperature operating

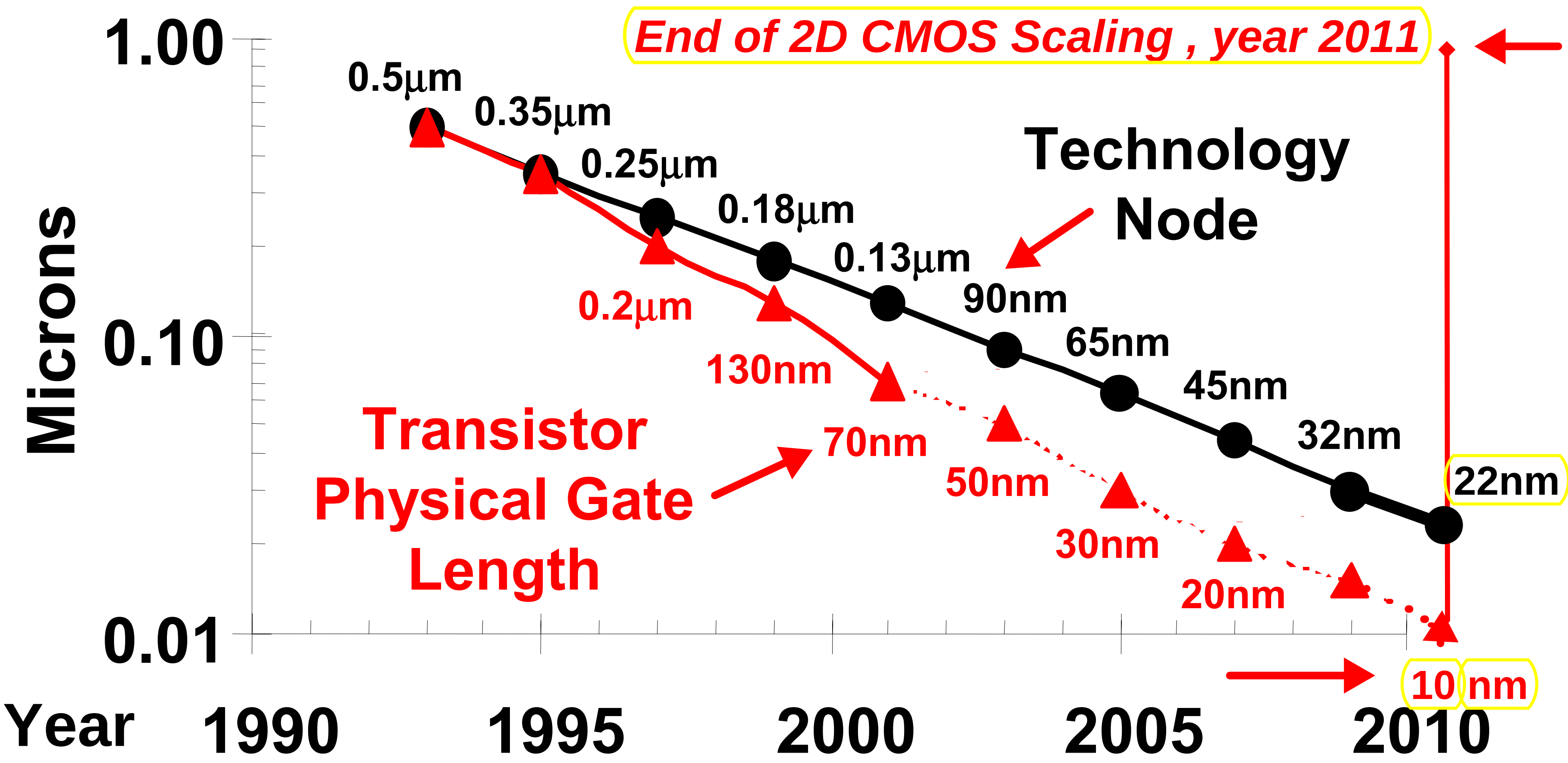
Problems with CMOS transistor scaling after the year 2011, will be compensated with multiple active switching layers, programmable wires and optical I-O .



Meindl : Packing efficiency PE versus calendar year Y. Note that packing efficiency is defined as the number of transistors per minimum feature area.

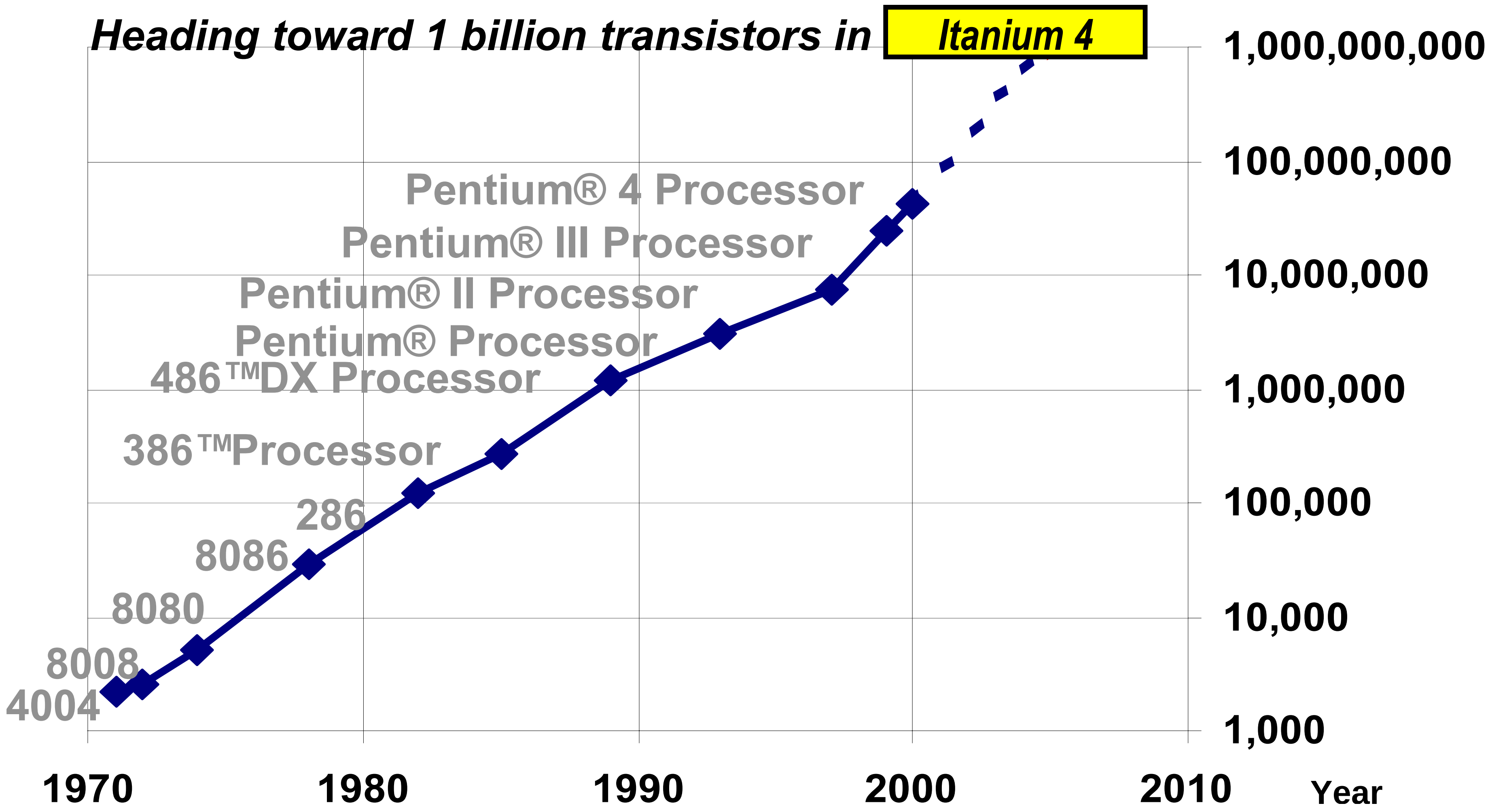
Problem: Transistor Physical Gate Length Limited

Below 10 nm, Scaling is Light Source and Fermi's level limited



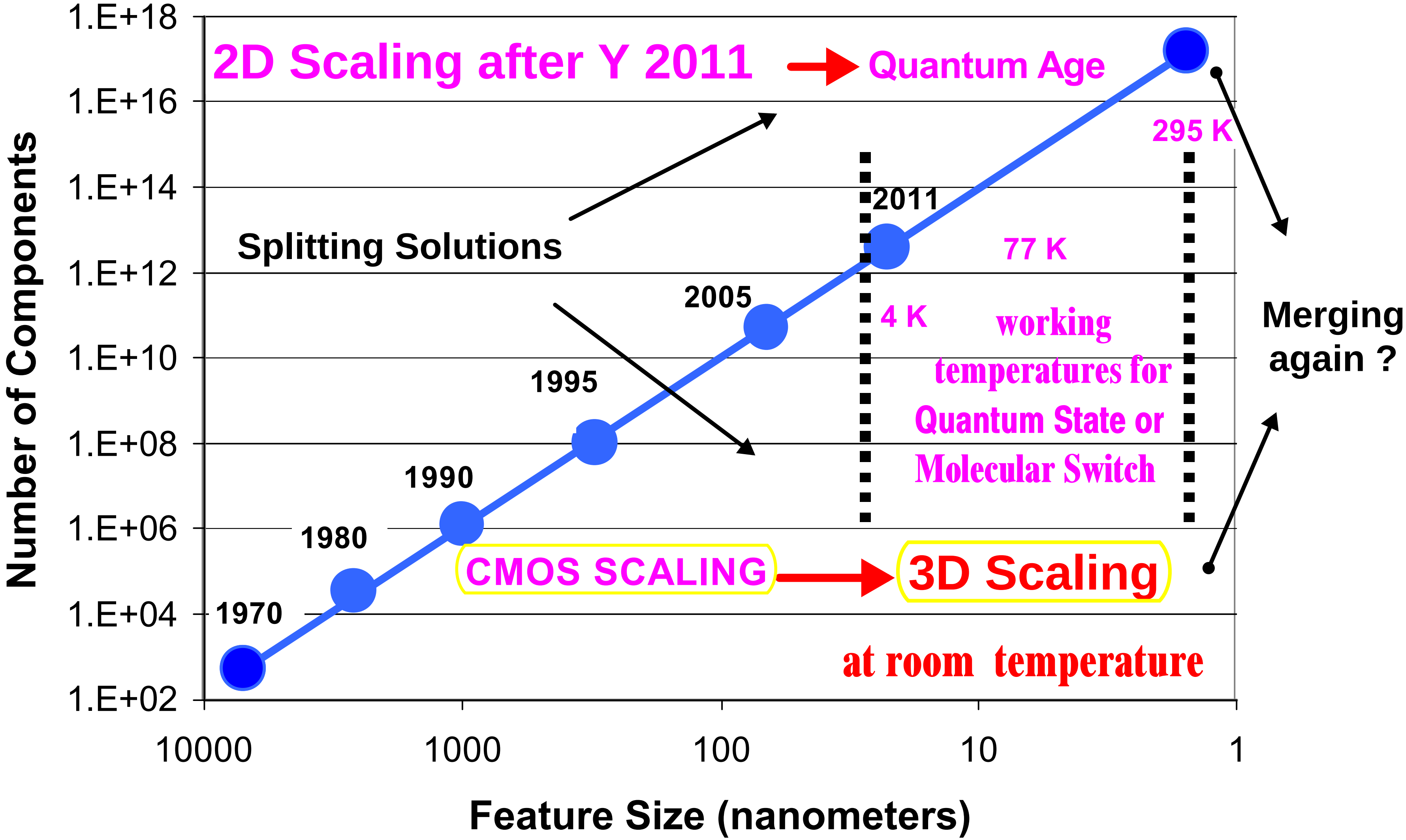
Moore's Law Continues

Transistors doubling every 2 years toward the billion-transistor microprocessor

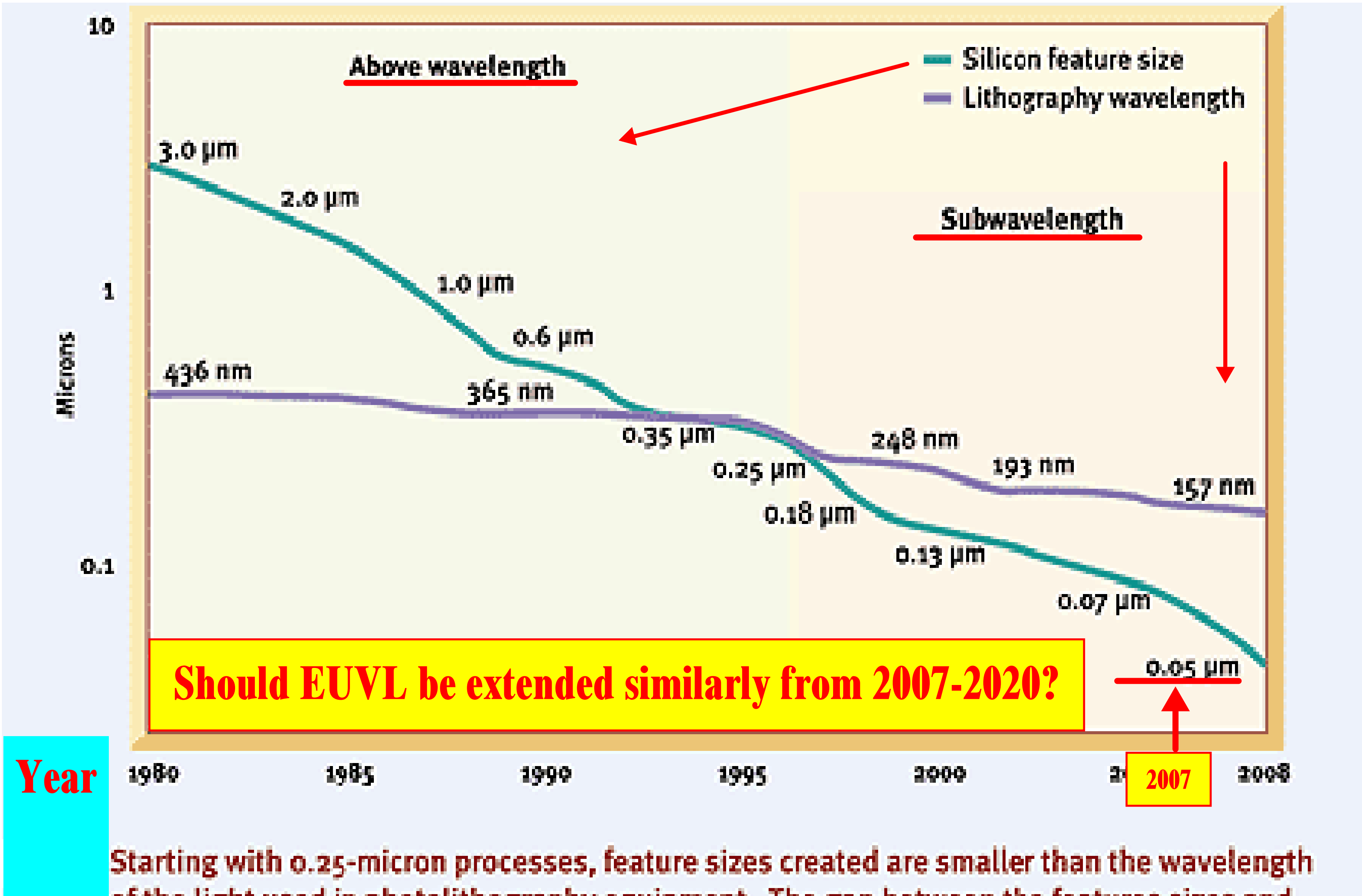


Solutions When Moore' s Law Hits the Wall?

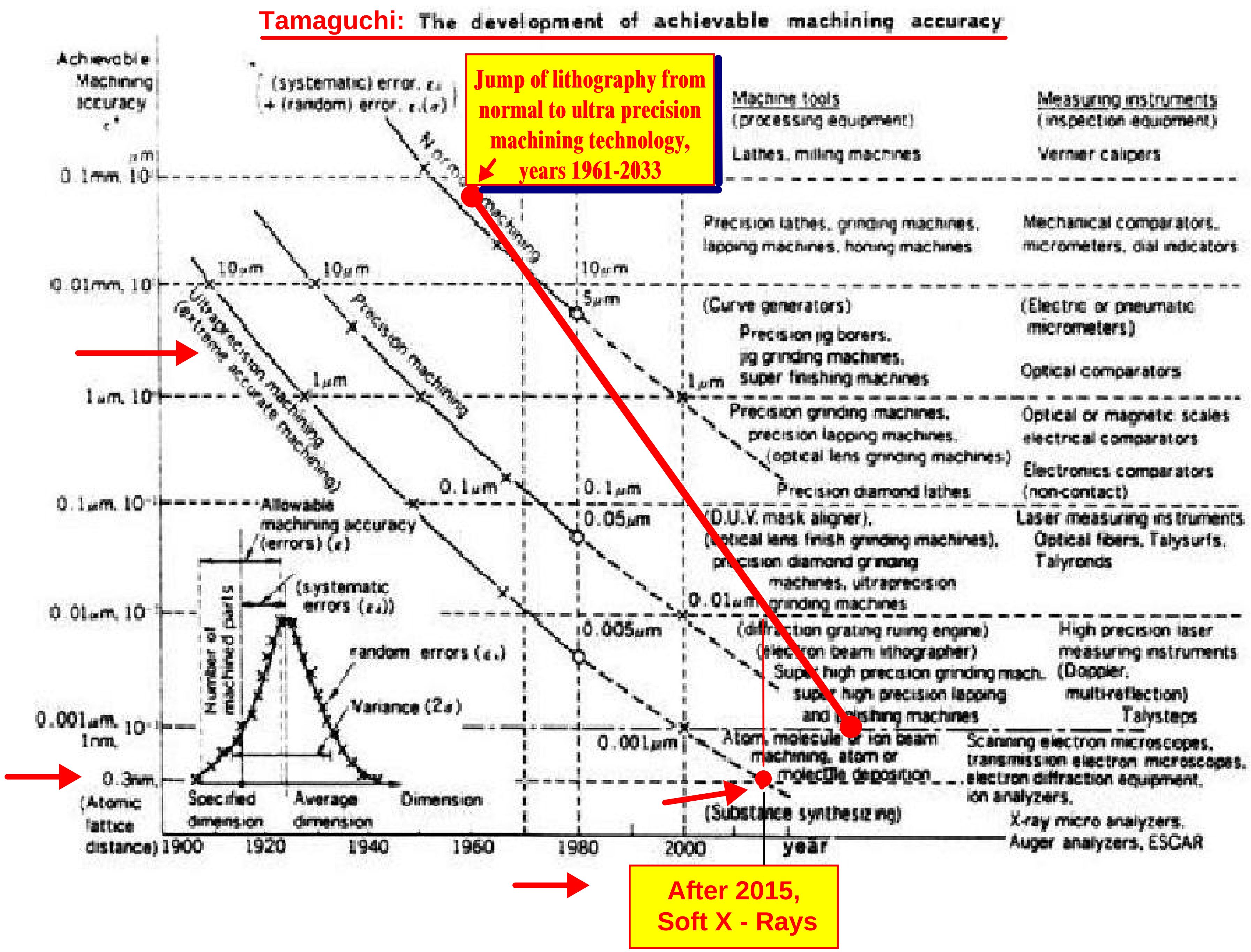
Scaling of CMOS continues, 2D transforms to 3D



Phase shift and other photo lithography based techniques, moved device length below light source length

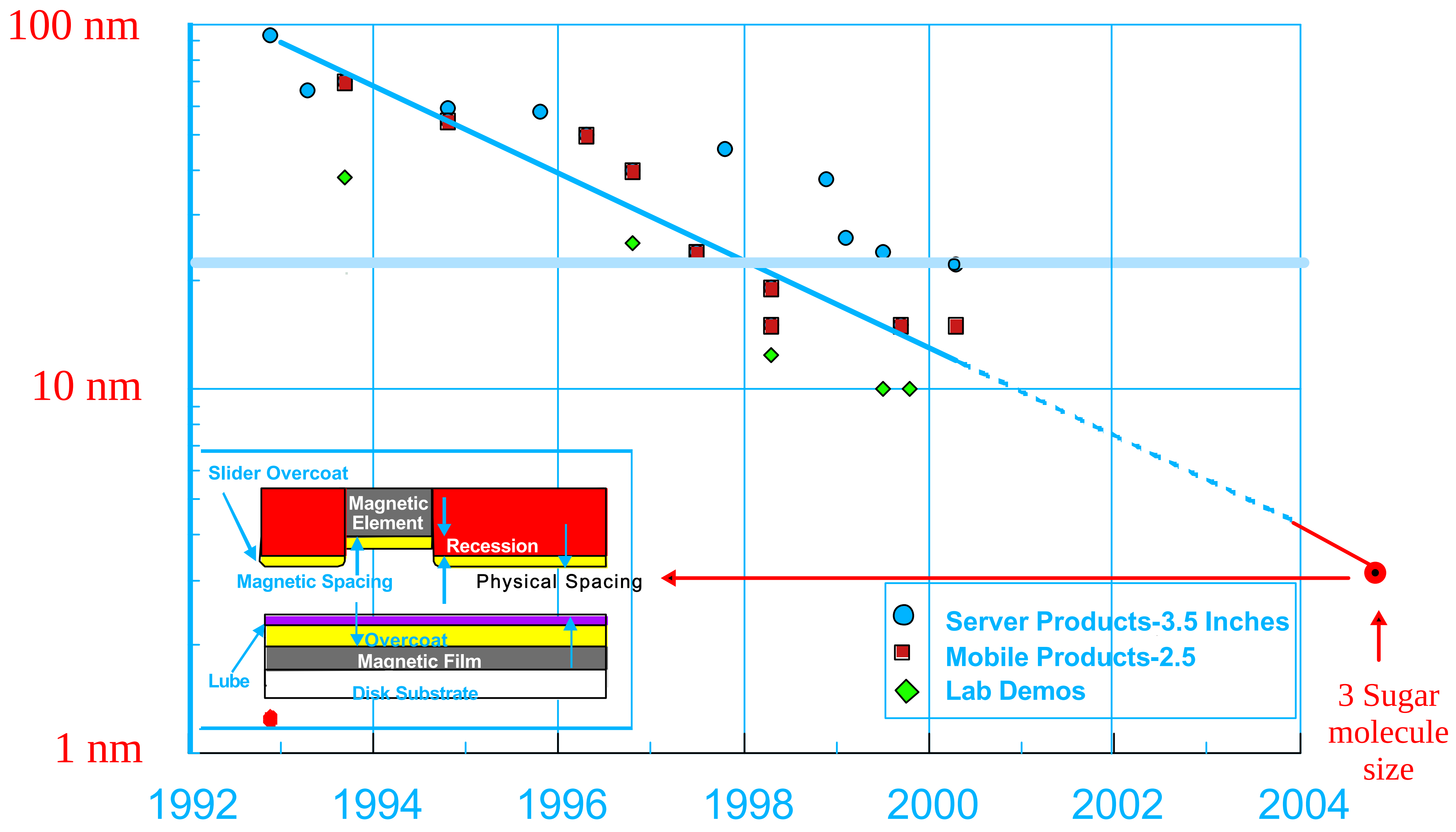


Starting with 0.25-micron processes, feature sizes created are smaller than the wavelength of the light used in photolithography equipment. The gap between the features sizes and the wavelengths widens over time as processes migrate to 0.18, 0.13 and 0.1 micron and below.



Tamaguchi: The development of achievable machining accuracy
Jump of lithography from normal to ultra precision machining technology, years 1961-2033
After 2015, Soft X - Rays
Achievable Machining accuracy
(systematic) error + (random) error
Machine tools (processing equipment)
Measuring instruments (inspection equipment)
Lathes, milling machines
Vernier calipers
Precision lathes, grinding machines, lapping machines, honing machines
Mechanical comparators, micrometers, dial indicators
(Curve generators)
Precision jig borers, jig grinding machines, super finishing machines
(Electric or pneumatic micrometers)
Optical comparators
Precision grinding machines, precision lapping machines, (optical lens grinding machines)
Precision diamond lathes
Optical or magnetic scales electrical comparators
Electronics comparators (non-contact)
(D.U.V. mask aligner), (optical lens finish grinding machines), precision diamond grinding machines, ultraprecision grinding machines
Laser measuring instruments Optical fibers, Talysurfs, Talyronds
(diffraction grating ruling engine) (electron beam lithographer) Super high precision grinding mach. super high precision lapping and polishing machines
High precision laser measuring instruments (Doppler, multireflection) Talysteps
Atom, molecule or ion beam machining, atom or molecule deposition
(Substance synthesizing)
Scanning electron microscopes, transmission electron microscopes, electron diffraction equipment, ion analyzers, X-ray micro analyzers, Auger analyzers, ESCAR
Normal machining
Precision machining
Ultraprecision machining (extreme accurate machining)
Allowable machining accuracy (errors)
(systematic errors)
random errors
Variance
Number of machined parts
Specified dimension
Average dimension
Dimension
0.1mm, 10²
0.01mm, 10¹
1μm, 10⁰
0.1μm, 10⁻¹
0.01μm, 10⁻²
0.001μm, 10⁻³ 1nm
0.3nm (Atomic lattice distance)
10μm
5μm
1μm
0.1μm
0.05μm
0.01μm
0.005μm
0.001μm
1900
1920
1940
1960
1980
2000
year

Physical spacing between disk plate and head



IBM

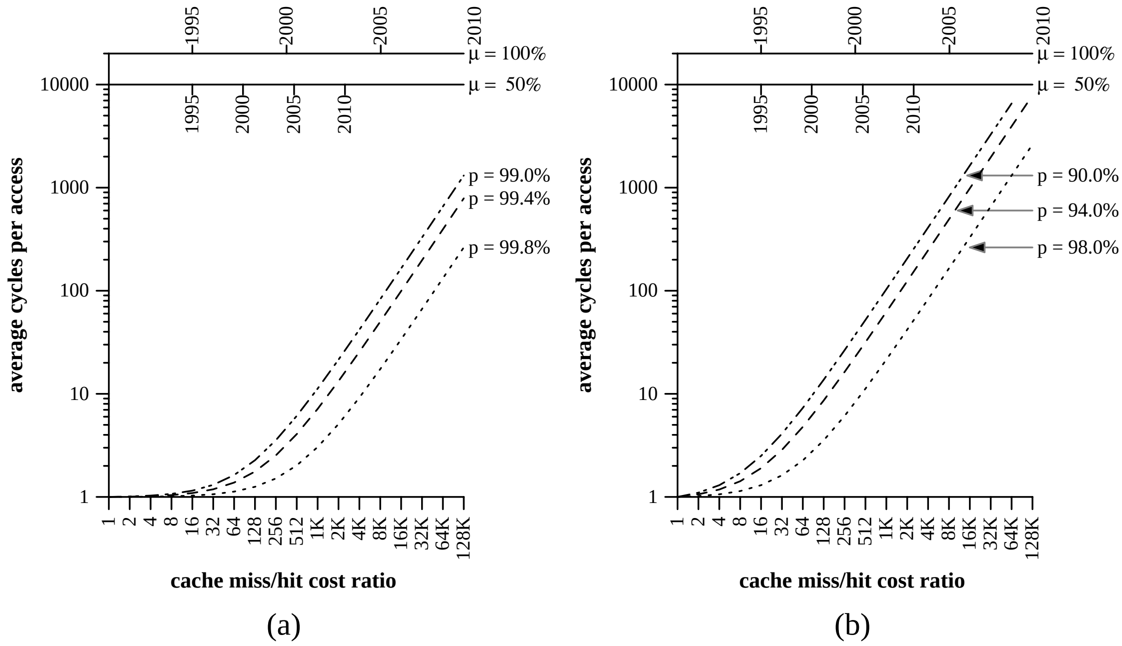
ED GROCHOWSKI at ALMADEN

Years 2005 - 2015 are transitional period between microelectronics and nanoelectronics.

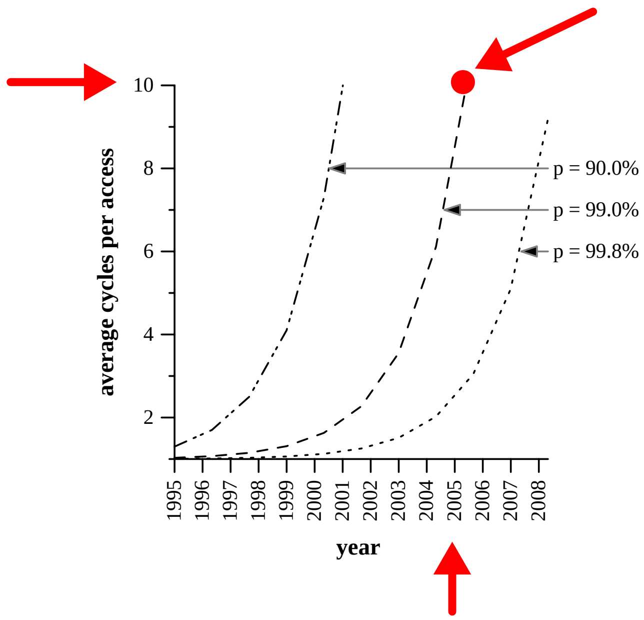
First measured object in Nano world was sugar molecule sized in order of 1nm, in the year 1905 by A. Einstein, exactly one hundred years before.

Pure nano switching device is 3D shaped, that is the real meaning of nano.

Chapter 2
Possible architectural limits out of microprocessor



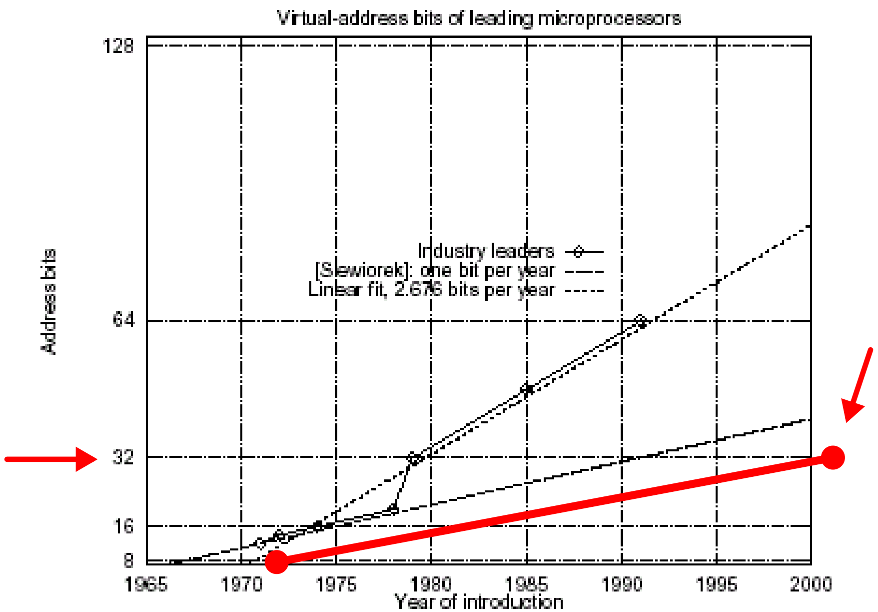
Trends for a Current Cache Miss/Hit Cost Ratio of 16



Average Access Cost for 80% Annual Increase in Processor Performance

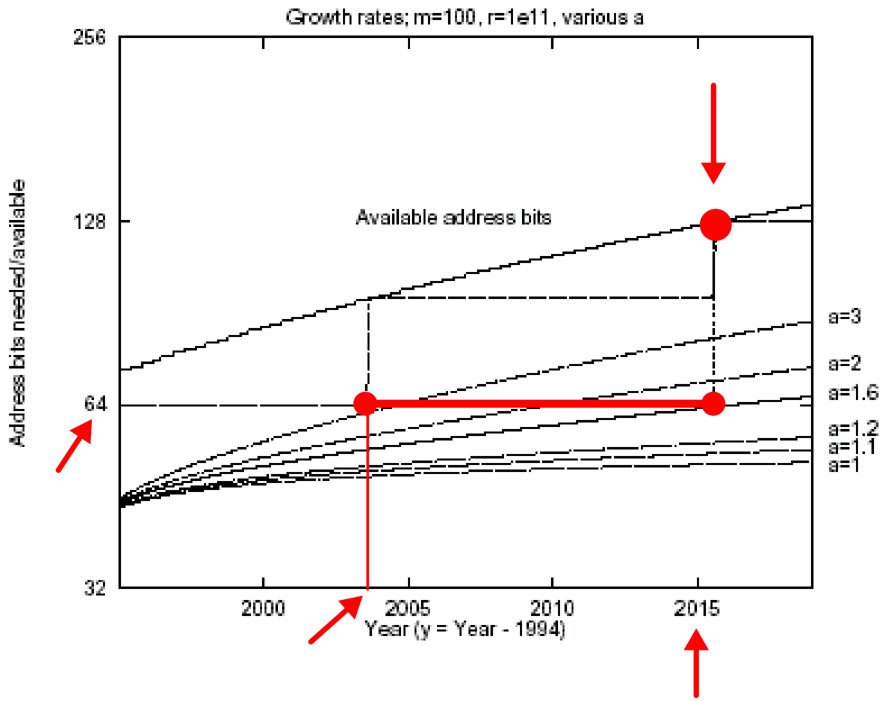
Memory Wall , Year 2005
Multi threading is one way for rising of computing efficiency

Appeared in Computer Architecture News, 23(1):20-24, March 1995.



Growth of address space for leading microprocessors 1972 - 2002

Red line denotes size of physical memory 1972 - 2002

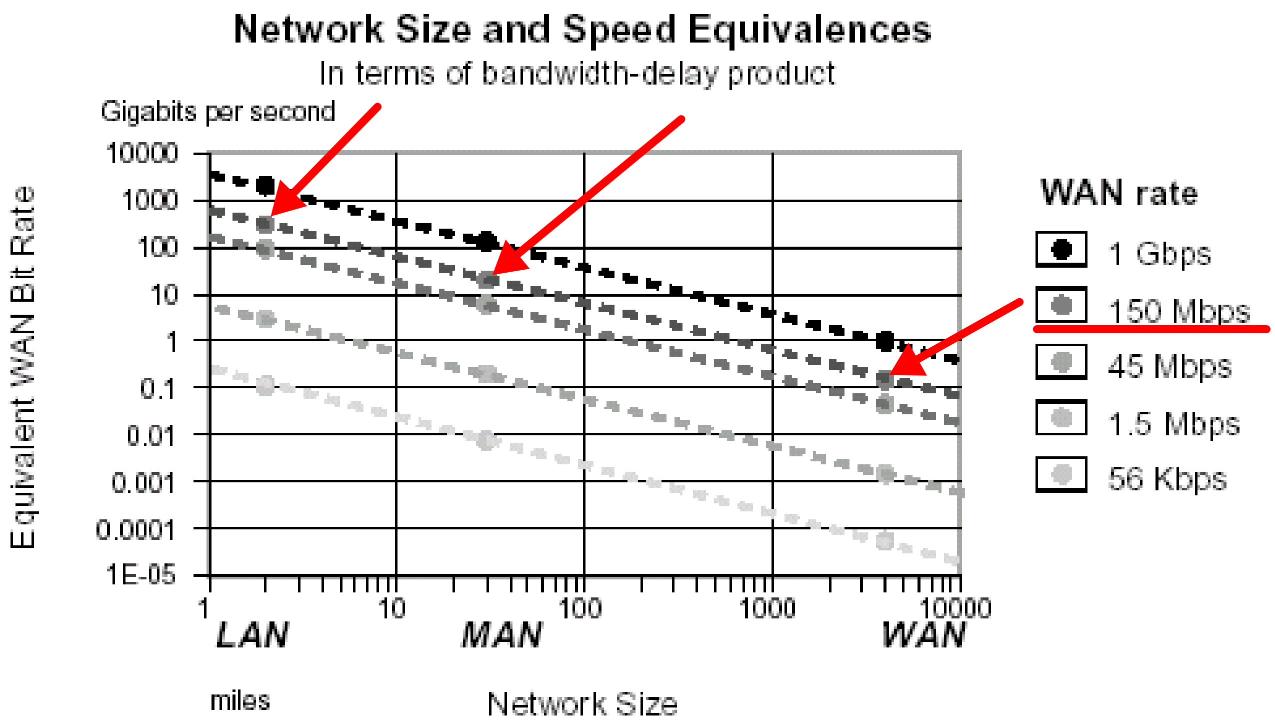


Predictions for upper size limit of address space 1995 - 2020

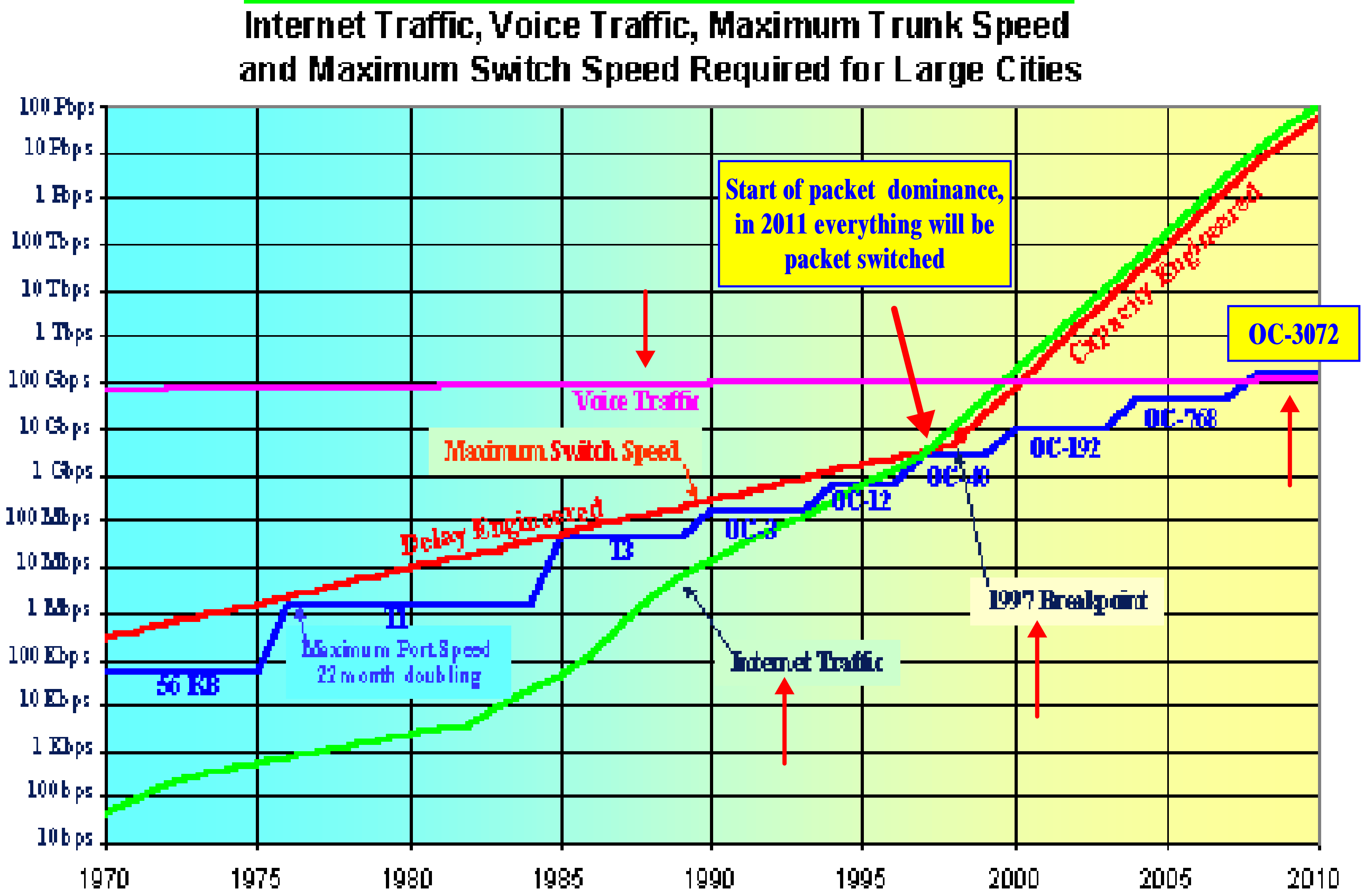
Red line denotes size of unified address space 2004 - 2016

Data transfer bandwidth range is restricted with delay, caused by finite speed c of signal propagation, for any state of art technology

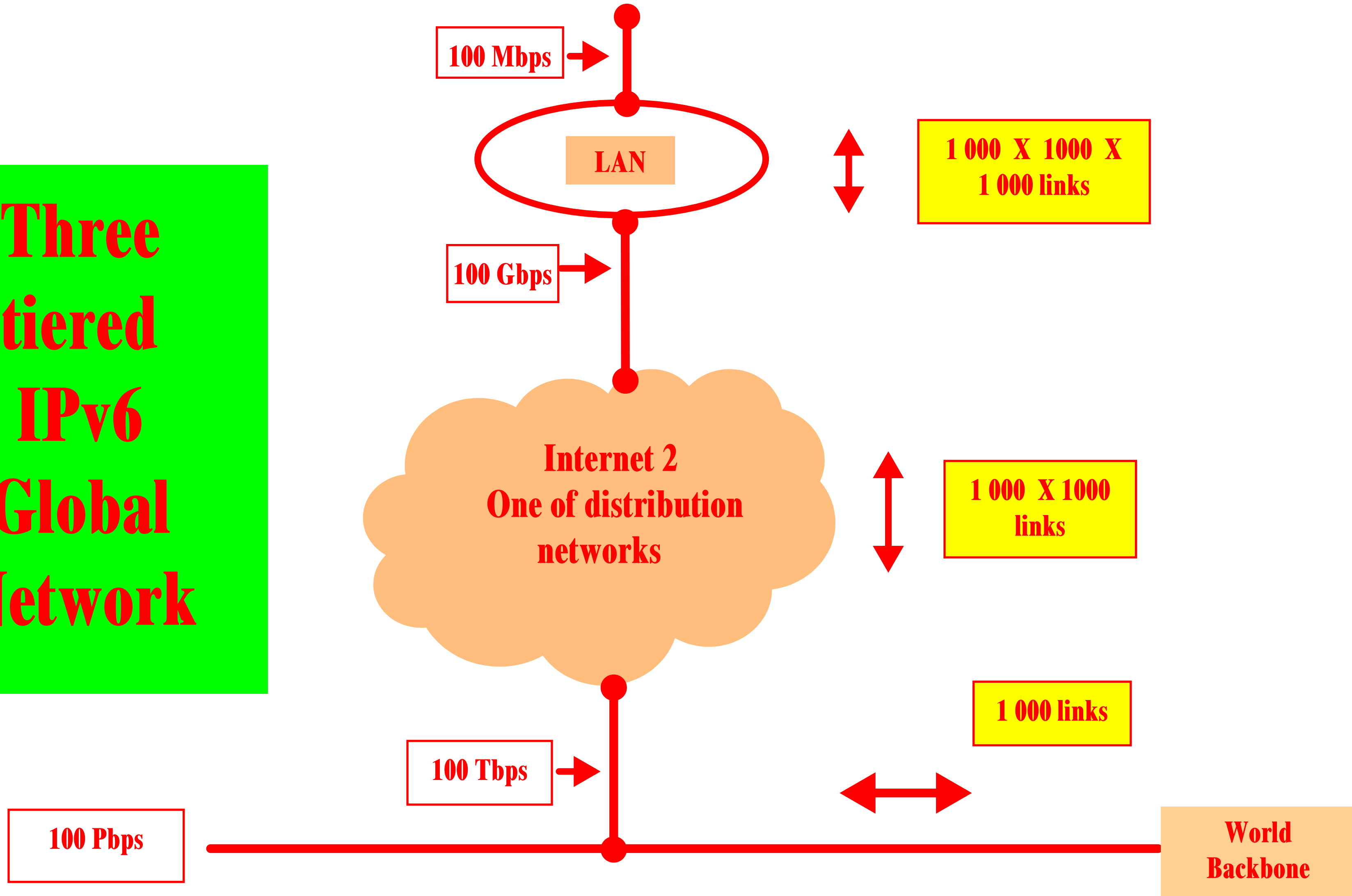
Data communications limits by the year 2011
WAN - 100 Mbits/second
GSM 4G - 100 Mbits/second
Wireless LAN - 1 Gbits/second
MAN - 10 Gbits/second
LAN - 100 Gbits/second
Computer Bus - 1 Tbit/second



Internet trends up to the year 2010

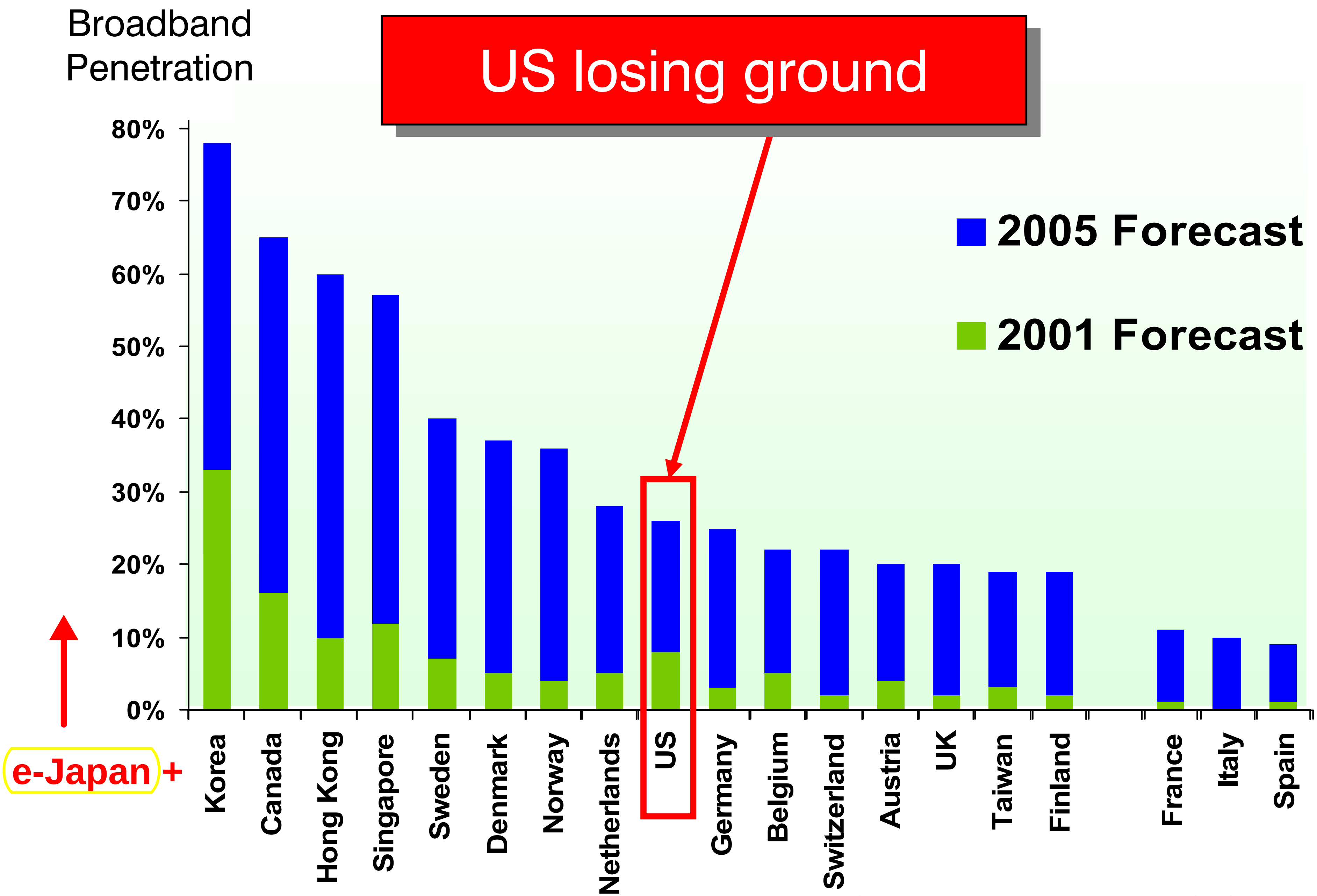


Three tiered IPv6 Global Network



Simple model of possible connected 1 billion Broadband users with 100Mbps each.
The most developed countries could have more than 80 % broad banded population connected all the time, with the unified packet network by the year 2011.

US Projections Lag Broadband Leaders



Source: Forrester, Economist, OECD 2001

2011: Telematics Odyssey
worth of $ 48B worldwide

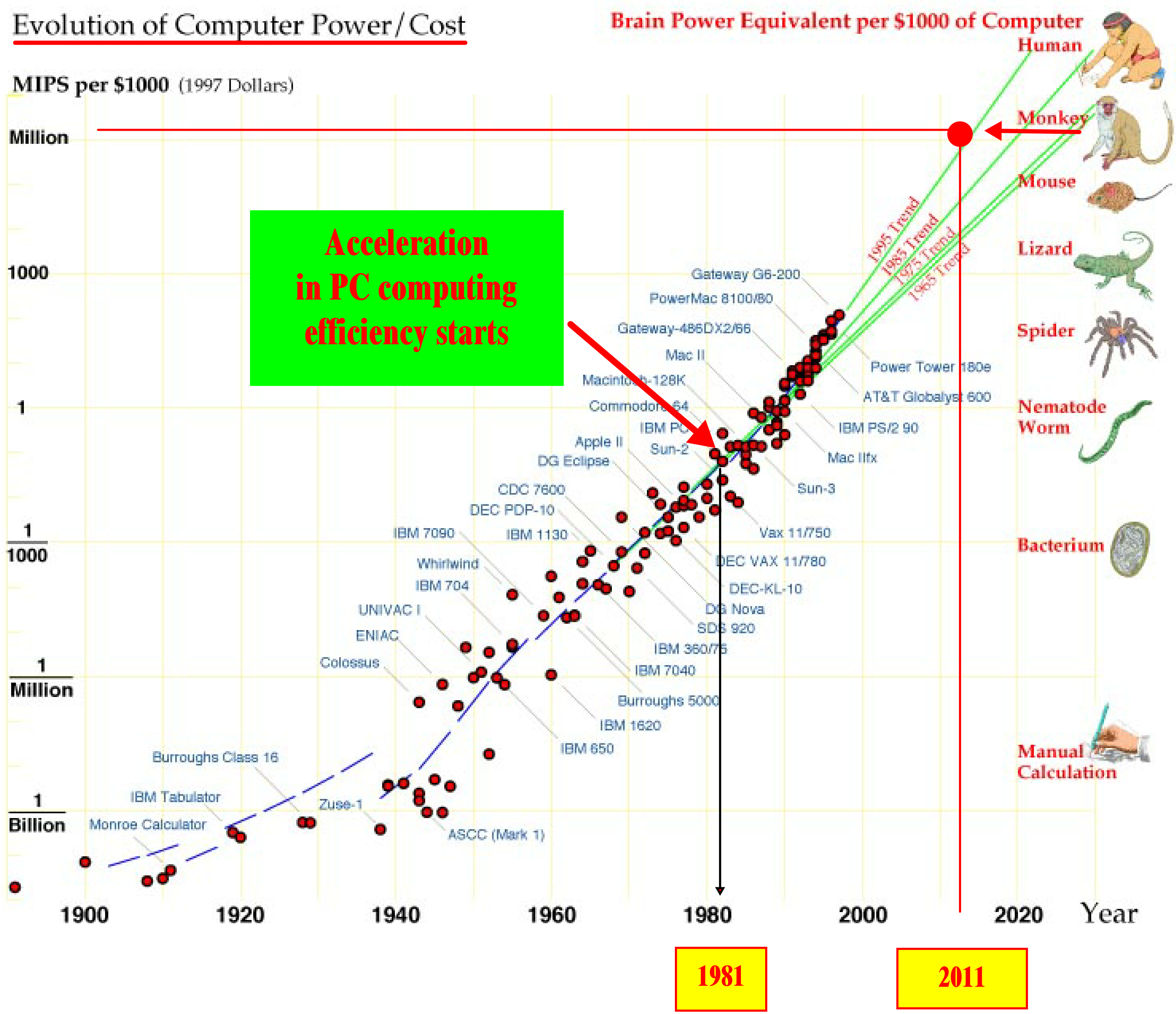
After the year 2011, Internet 2 will reach everything in modern home, building and factory.
Almost nothing could be buyed or sold without it.
When the oil prices start to rise, who could be outside?
For now, only oil dependant Japan realized that.
Thus: is it the last moment for the others to move ?

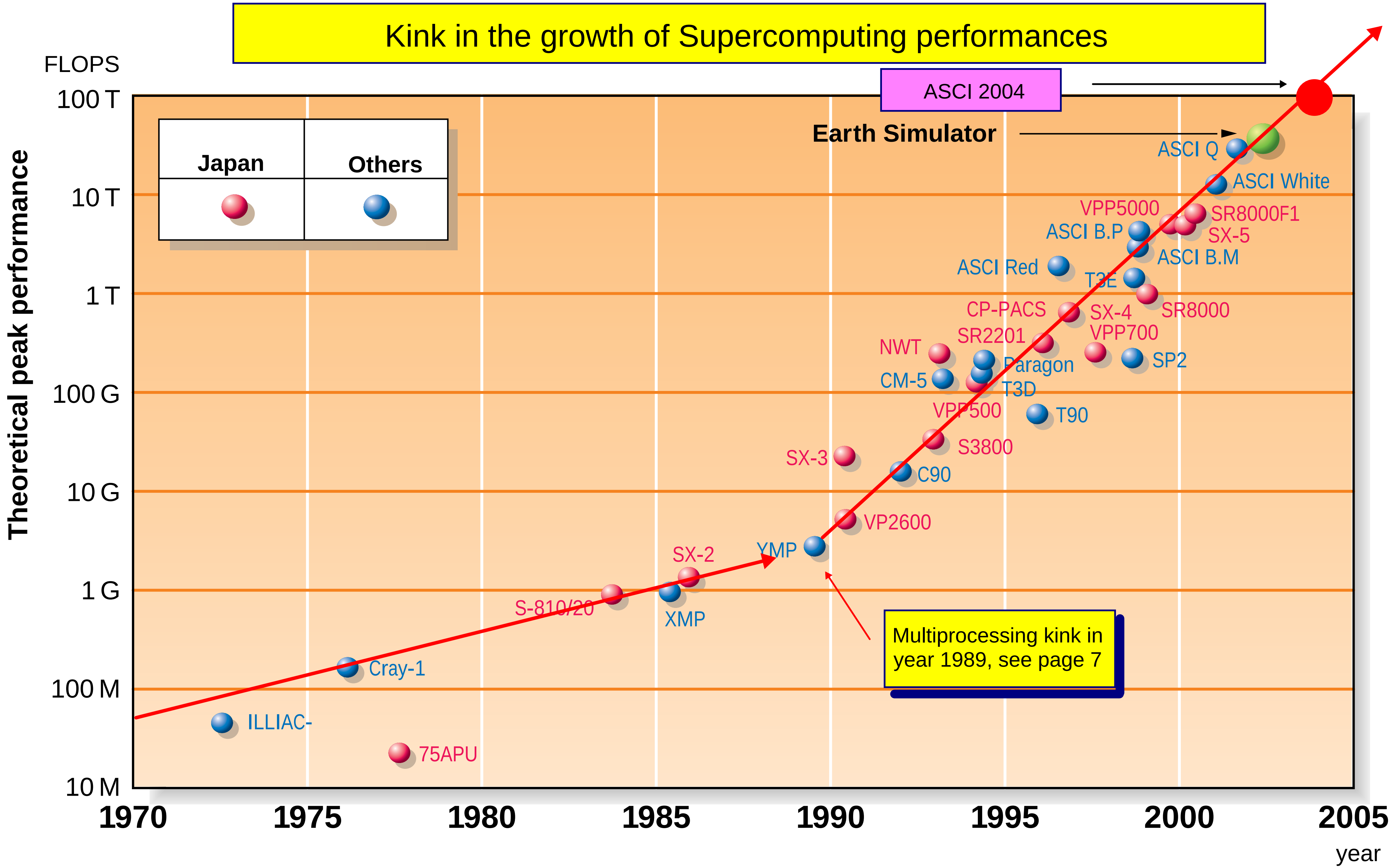
Chapter 3
If all limits can be avoided where is the end?

First look for the data collected and calculated by Hans Moravec,1998

Machine	Year	Cost k$	1997k$	MBytes	MIPS	MIPS/1997k$
By Hand	1892	8.5	142	9.54e-05	1.19e-08	8.37e-11
Ohdner	1891	11	172	1.49e-07	3.33e-09	1.94e-11
Steiger Millionaire	1900	12	187	3.58e-07	1.33e-08	7.12e-11
Hollerith	1908	50	694	0.000286	1.85e-08	2.67e-11
Analytical Engine	1910	1e+03	1.24e+04	0.0244	3.77e-07	3.05e-11
Monroe Calculator	1911	35	470	2.86e-06	2.18e-08	4.64e-11
IBM Tabulator	1919	20	126	2.38e-05	4.12e-08	3.27e-10
Torres Arithmometer	1920	25	141	4.77e-06	3.58e-08	2.53e-10
National-Ellis 3000	1928	15	135	4.29e-06	7.38e-08	5.46e-10
Burroughs Class 16	1929	15	137	4.29e-06	7.38e-08	5.37e-10
Zuse-1	1938	10	111	3.05e-05	4.24e-08	3.82e-10
Zuse-2	1939	10	113	3.05e-05	4.24e-07	3.75e-09
BTL Model 1	1939	50	565	3.81e-06	2e-06	3.54e-09
Zuse-3	1941	50	499	0.000244	2.04e-06	4.09e-09
BTL Model 2	1943	50	422	1.19e-05	1.03e-06	2.44e-09
Colossus	1943	100	844	2.38e-06	0.000224	2.65e-07
BTL Model 3	1943	200	1.69e+03	4.29e-05	2.83e-06	1.68e-09
ASCC (Mark 1)	1944	300	2.52e+03	0.000601	2.33e-06	9.26e-10
Zuse-4	1945	50	412	0.000244	2.04e-06	4.96e-09
BTL Model 5	1946	500	3.61e+03	0.000147	3.29e-06	9.12e-10
ENIAC	1946	600	4.33e+03	9.54e-05	0.00289	6.68e-07
Harvard Mark 2	1947	300	1.77e+03	0.000488	6.22e-06	3.52e-09
IBM SSEC	1948	500	2.71e+03	4.58e-05	0.000597	2.2e-07
EDSAC	1949	100	571	0.00214	0.00255	4.46e-06
SEAC	1950	800	4.4e+03	0.00549	0.00416	9.44e-07
UNIVAC I	1951	930	4.59e+03	0.00537	0.00575	1.25e-06
Zuse-5	1952	100	508	0.000244	9.33e-06	1.84e-08
IBM CPC	1952	100	508	0.000154	0.00176	3.47e-06
IBM 650	1953	200	1.03e+03	0.00488	0.000966	9.4e-07
EDVAC	1954	500	2.57e+03	0.00537	0.0017	6.61e-07
Whirlwind	1955	200	1.03e+03	0.00391	0.0694	6.77e-05
Librascope LGP-30	1955	30	154	0.0146	0.000701	4.56e-06
IBM 704	1955	2e+03	1.03e+04	0.0352	0.0536	5.23e-06
IBM 7090	1959	3e+03	1.42e+04	0.141	0.326	2.29e-05
IBM 1620	1960	200	947	0.0122	0.00103	1.09e-06
DEC PDP-1	1960	150	710	0.0176	0.124	0.000175
Atlas	1961	5e+03	2.38e+04	0.0234	1.4	5.88e-05
Burroughs 5000	1962	1e+03	4.75e+03	0.0254	0.0989	2.08e-05
IBM 7040	1963	560	2.67e+03	0.07	0.063	2.36e-05
Honeywell 1800	1963	1.4e+03	6.67e+03	0.093	0.15	2.25e-05
DEC PDP-6	1964	300	1.42e+03	0.0703	0.169	0.000119
CDC 6600	1964	5e+03	2.37e+04	4	8.76	0.000369
IBM 1130	1965	50	233	0.0156	0.15	0.000644
IBM 360/75	1966	5e+03	2.25e+04	8	2.54	0.000113
IBM 360/65	1967	3e+03	1.35e+04	4	1.24	9.18e-05
DEC PDP-10	1968	500	2.19e+03	0.562	0.655	0.000299
CDC 7600	1969	1e+04	4.23e+04	8	25.7	0.000608
DG Nova	1969	7.6	32.1	0.008	0.117	0.00366
GE-635	1970	2e+03	8.14e+03	0.5	0.649	7.97e-05
SDS 920	1971	100	394	0.25	0.105	0.000266
IBM 360/195	1972	8e+03	3.02e+04	0.5	17.3	0.000573
Honeywell 700	1972	12	45.2	0.031	0.075	0.00166
Prime Computer 100	1973	8.5	28.4	0.031	0.36	0.0127
IBM-370/168	1974	2e+03	5.61e+03	1	8.88	0.00158
MITS Altair	1974	0.5	1.4	0.00024	0.01	0.00713
DG Eclipse	1975	50	129	0.25	0.47	0.00366
DEC-KL-10	1975	500	1.29e+03	4.5	2.3	0.00179
DEC PDP-11/70	1976	150	368	0.125	0.4	0.00109
Cray-1	1976	1e+04	2.45e+04	32	150	0.00612
Apple II	1977	1.3	3.02	0.0039	0.02	0.00662
DEC VAX 11/780	1977	200	464	8	1	0.00215
TRS-80	1977	2	4.64	0.015	0.04	0.00861
Commodore PET	1977	1.5	3.48	0.008	0.06	0.0172
CDC IPL	1978	500	1.08e+03	1	7.5	0.00697
Nanodata VMX200	1979	300	571	2	2.1	0.00367
TRS-80 M3	1980	1.2	2	0.015	0.04	0.02

Sun-1	1980	30	50.1	1	0.484	0.00966
CDC Cyber-205	1981	9e+03	1.39e+04	16	73.2	0.00528
Vic 20	1981	0.279	0.43	0.005	0.04	0.0931
IBM PC	1982	2.5	3.75	0.0469	0.238	0.0634
Sun-2	1982	20	30	2	0.741	0.0247
Commodore 64	1982	0.5	0.75	0.0825	0.2	0.267
TRS-80 M4	1983	1	1.49	0.0635	0.2	0.134
Vax 11/750	1983	50	74.4	4	0.799	0.0107
Macintosh-128K	1984	2.5	3.62	0.125	0.52	0.144
Vax 11/785	1984	200	290	0.0156	2.26	0.0078
Cray-2	1985	1e+04	1.45e+04	1.95e+03	824	0.0569
L.Edge XT-7.16	1985	2	2.89	0.25	0.26	0.09
Atari 800XL	1985	0.85	1.23	0.64	0.165	0.134
Sun-3	1986	10	14.1	4	2.05	0.145
DEC VAX 8650	1986	125	176	16	7.71	0.0438
MIT XT-8	1986	0.5	0.705	0.25	0.534	0.758
Mac II	1987	3	4.11	2	2.5	0.608
Sun-4	1987	10	13.7	16	1.87	0.136
Mac-IIx	1988	9.3	12.1	4	3.9	0.322
CompuAdd 386-16	1988	2.1	2.73	1	2.8	1.02
PC Brand 386-25	1988	2.45	3.2	1	4.3	1.35
Mark 386	1989	12	15.2	2	12.9	0.849
Wang VS 10000	1989	510	646	16	103	0.159
Macintosh SE30	1989	6.49	8.23	5	3.9	0.474
Solbourne 5/500	1989	50	63.3	2	25.5	0.403
Stardent 3000	1990	89	109	32	27.3	0.249
Amiga 2500/30	1990	4.7	5.78	2	19.5	3.37
Acer 1200	1990	11	13.5	4	20	1.48
MVME165	1990	4	4.92	4	16.6	3.37
Power VEISA	1990	5.8	7.13	6	22.1	3.1
Dell 320LX	1990	2.9	3.57	1	12.5	3.5
Mac IIfx	1990	9.87	12.1	4	10	0.824
Amiga 3000	1990	3.3	4.06	2	12.5	3.08
VMPM868KD	1990	2.9	3.57	2	12.5	3.5
Step 486/33	1990	10	12.3	80	17.5	1.42
Gateway-486DX2/66	1991	3.9	4.66	8	30.9	6.64
ACT 468/33	1991	3.4	4.06	4	21.8	5.37
Slimline SP486DX	1991	3.6	4.3	4	21.8	5.07
Mac-Quadra-900	1991	3.3	3.94	8	22	5.58
AST Bravo	1992	1.4	1.62	2	12.9	7.95
IBM PS/2 55-041	1992	2	2.32	4	10.6	4.57
AST Premium II	1992	2.8	3.25	4	13.2	4.07
IBM PS/2 90	1992	9.6	11.1	8	22.4	2.01
NEC Powermate	1992	4.8	5.56	4	21.8	3.92
Aberdeen Mini	1993	2.8	3.15	2	16.2	5.14
IBM Valuepoint	1993	3.6	4.05	4	26.1	6.44
Acer Power	1993	3.5	3.94	4	44.5	11.3
Ambra Desktop	1993	2.4	2.7	2	21.1	7.81
DECpc LPv	1993	2.9	3.26	4	16.6	5.09
AST Pemmia	1993	3.6	4.05	2	16.2	4
NEC 486SL DX2	1994	3.8	4.15	4	31.9	7.68
Vesa	1994	1.2	1.31	4	20	15.3
AT&T System 3260	1994	2.5	2.73	8	44	16.1
IBM 433/DX/Si	1994	1.8	1.97	4	26.1	13.3
Micron 466 Wndsrvr	1994	3.6	3.93	16	54.7	13.9
AST PremiaGXP/90	1994	5.8	6.34	16	98.6	15.6
AT&T Globalyst 600	1994	4.8	5.25	16	98.6	18.8
ZEOS Contenda 386	1994	1	1.09	4	20	18.3
Gateway 2000 486	1994	1	1.09	2	16.2	14.8
PowerMac 7100/66	1994	2.9	3.17	8	100	31.6
PowerMac 8100/80	1994	4.25	4.64	16	120	25.8
PowerMac 8500/120	1995	4	4.24	16	180	42.4
PowerMac 9500/132	1995	5.3	5.62	16	200	35.6
Intel Xpress/60	1995	2	2.12	8	70	33
Gateway P5-75	1996	2	2.06	16	92	44.7
Power Tower 180e	1996	3.3	3.39	16	300	88.4
PowerMac 7600/132	1996	3	3.09	16	160	51.8
Gateway G6-200	1997	2.95	2.95	64	350	119


Evolution of Computer Power/Cost
MIPS per $1000 (1997 Dollars)
Brain Power Equivalent per $1000 of Computer
Human
Monkey
Mouse
Lizard
Spider
Nematode Worm
Bacterium
Manual Calculation
Million
1000
1
1/1000
1/Million
1/Billion
1900
1920
1940
1960
1980
2000
2020
Year
Acceleration in PC computing efficiency starts
1995 Trend
1985 Trend
1975 Trend
1965 Trend
Gateway G6-200
PowerMac 8100/80
Gateway-486DX2/66
Mac II
Macintosh-128K
Commodore 64
IBM PC
Apple II
Sun-2
DG Eclipse
CDC 7600
DEC PDP-10
IBM 7090
IBM 1130
Whirlwind
IBM 704
UNIVAC I
ENIAC
Colossus
Burroughs Class 16
IBM Tabulator
Monroe Calculator
Zuse-1
ASCC (Mark 1)
IBM 650
IBM 1620
Burroughs 5000
IBM 7040
IBM 360/75
SDS 920
DG Nova
DEC-KL-10
DEC VAX 11/780
Vax 11/750
Sun-3
Mac IIfx
IBM PS/2 90
AT&T Globalyst 600
Power Tower 180e
1981
2011



Kink in the growth of Supercomputing performances
FLOPS
Theoretical peak performance
100 T
10 T
1 T
100 G
10 G
1 G
100 M
10 M
1970
1975
1980
1985
1990
1995
2000
2005
year
Japan
Others
ASCI 2004
Earth Simulator
ASCI Q
ASCI White
VPP5000
SR8000F1
ASCI B.P
SX-5
ASCI B.M
ASCI Red
T3E
SR8000
CP-PACS
SX-4
SR2201
VPP700
NWT
Paragon
SP2
CM-5
T3D
VPP500
T90
S3800
SX-3
C90
VP2600
SX-2
YMP
S-810/20
XMP
Cray-1
ILLIAC-
75APU
Multiprocessing kink in year 1989, see page 7

More details after the year 2002 ?

Jim Gray's calculations up to year 2000

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Adi Porobic's extrapolations based on own data up to 2028, with prediction of pure exponential growth of computing efficiency after

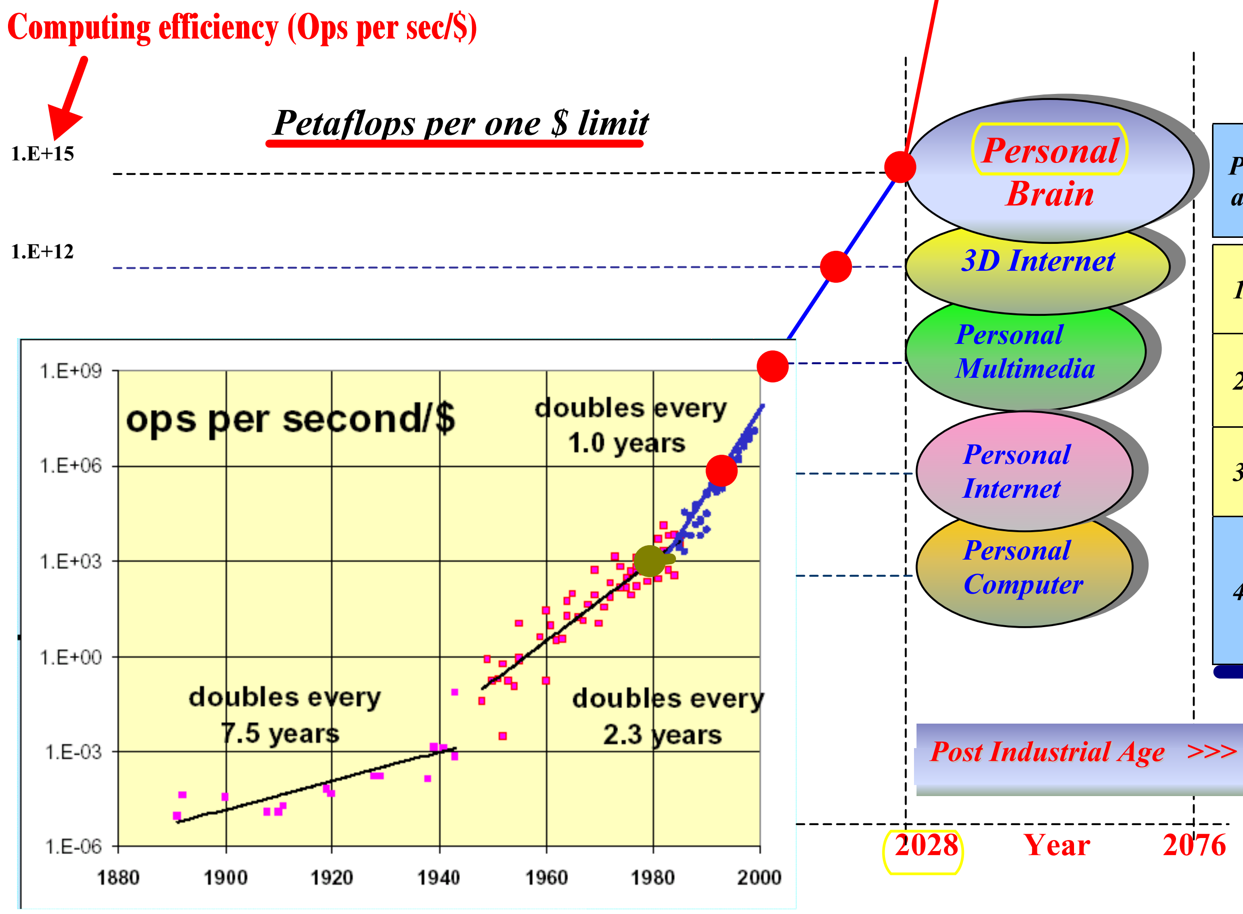
After 2028, Computing efficiency will grow at pure exponential rate

Cheap computing power is the fuel of Post Industrial Age

We are on the half road between the first Personal Computer and the first Personal Brain

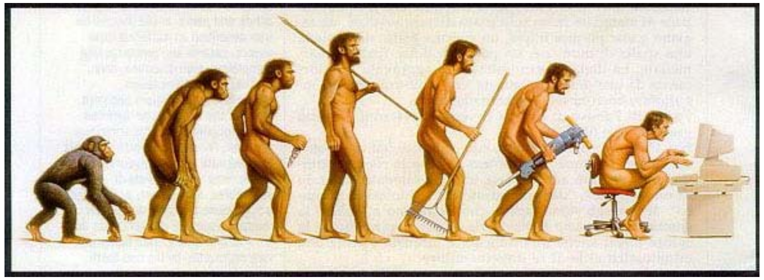
Toward **exponential** growth of computing operations per second per $ since the year 1835

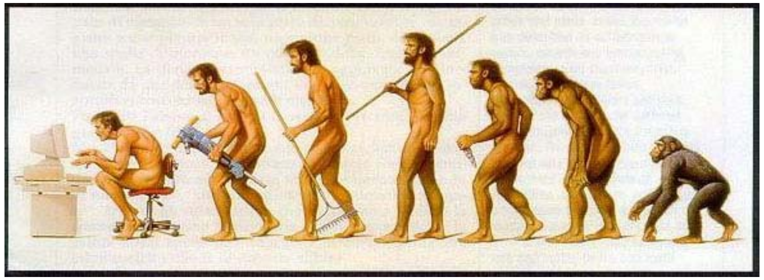
Fourth, pure exponential phase of growth, doubles every 9 months



Ph-ase	Years	Growth rate	Adi Porobic's comments Y= Year-Phase starting year
1	1884-1932	$e^{Y/10}$	First commercial calculators and tabulators
2	1932-1980	$e^{Y/3.2}$	Von Neuman based computing Machine and assembler languages
3	1980-2028	$e^{Y/1.4}$	Von Neuman personal computing C and object languages based
4	2028-2076	e^{Y}	Post Industrial Age,fractal cellular and conscious machines, functional and logic languages

The History and Future of the Humanity





10 Million years before ***Year 2003*** ***150 years after***

The next diagram is based on Vinod Khosla's predictions for the 21. century.

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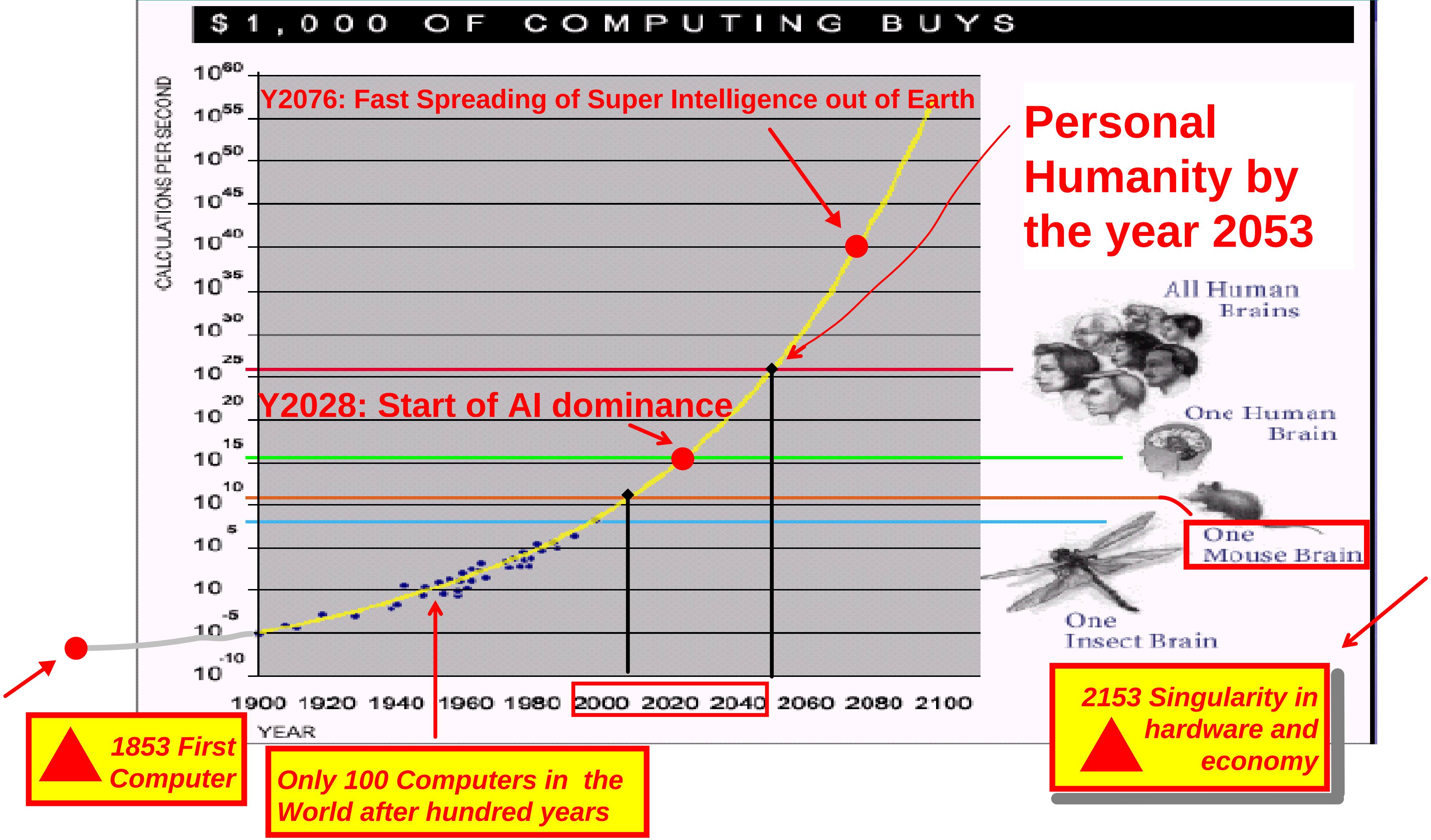
Comments of Adi Porobic

Age of artificial intelligence on the Earth 2011-2053. Explosion of Logic: Computing Logic Laws in 1854, Endless Mind in 2153

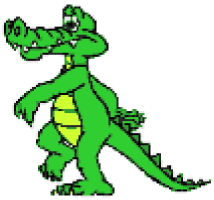


Computing in 300 years

1853 - Only One Computer
1953 - 100 Computers in the Whole World
2003 - Middle time point
2053 - The Whole World in One Computer
2153 - Runaway Singularity

CONCLUSION :

After the first Personal Computer, we are on the half road toward the dominance of AI.
But, in the middle of the TIME between the first and the ultimate Singularity computer also.



After Clarke [1982] , Gray [1999] and finally Gates [2002] we are rushing to the age of large computer networks acting like autonomic nervous system. Without it, by the year 2010, thanks to imposed complexity,
half of the energy the US will be consumed by the IT equipment and there will not be enough people to keep it running.

While the **definition of autonomic computing** will likely transform as contributing technologies mature, the following list suggests eight defining characteristics of an autonomic system.

1 An autonomic computing system needs to "know itself" - its components must also possess a system identity. Since a "system" can exist at many levels, an autonomic system will need detailed knowledge of its components, current status, ultimate capacity, and all connections to other systems to govern itself. It will need to know the extent of its "owned" resources, those it can borrow or lend, and those that can be shared or should be isolated.

2 An autonomic computing system must configure and reconfigure itself under varying (and in the future, even unpredictable) conditions. System configuration or "setup" must occur automatically, as well as dynamic adjustments to that configuration to best handle changing environments.

3 An autonomic computing system never settles for the status quo - it always looks for ways to optimize its workings. It will monitor its constituent parts and fine-tune workflow to achieve predetermined system goals.

4 An autonomic computing system must perform something akin to healing - it must be able to recover from routine and extraordinary events that might cause some of its parts to malfunction. It must be able to discover problems or potential problems, then find an alternate way of using resources or reconfiguring the system to keep functioning smoothly.

5 A virtual world is no less dangerous than the physical one, so an autonomic computing system must be an expert in self-protection. It must detect, identify and protect itself against various types of attacks to maintain overall system security and integrity.

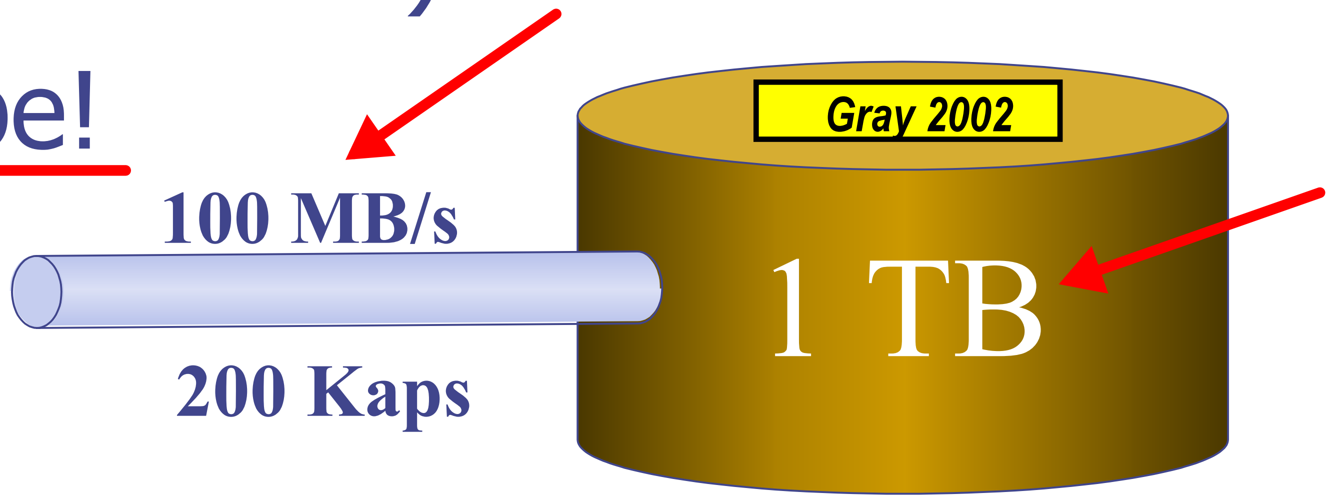
6 An autonomic computing system must know its environment and the context surrounding its activity, and act accordingly. It will find and generate rules for how best to interact with neighboring systems. It will tap available resources, even negotiate the use by other systems of its underutilized elements, changing both itself and its environment in the process -- in a word, adapting.

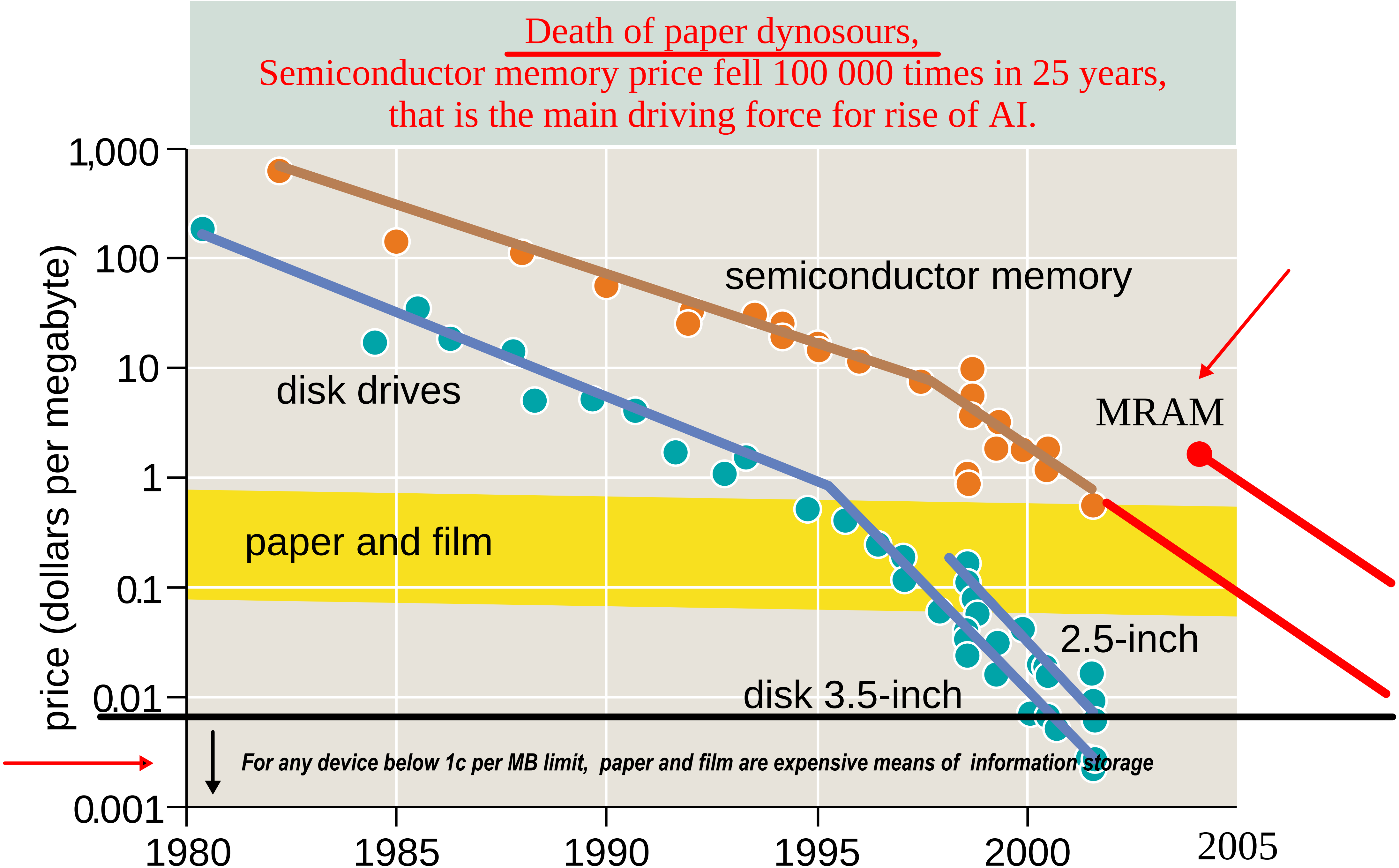
7 An autonomic computing system cannot exist in a hermetic environment. While independent in its ability to manage itself, it must function in a heterogeneous world and implement open standards -- in other words, an autonomic computing system cannot, by definition, be a proprietary solution.

8 An autonomic computing system will anticipate the optimized resources needed while keeping its complexity hidden. It must marshal I/T resources to shrink the gap between the business or personal goals of the user, and the I/T implementation necessary to achieve those goals -- without involving the user in that implementation.

The "Absurd" 10x (=4 year) Disk

- 2.5 hr scan time
  (poor sequential access)
- 1 aps / 5 GB
  (VERY cold data)
- It's a tape!





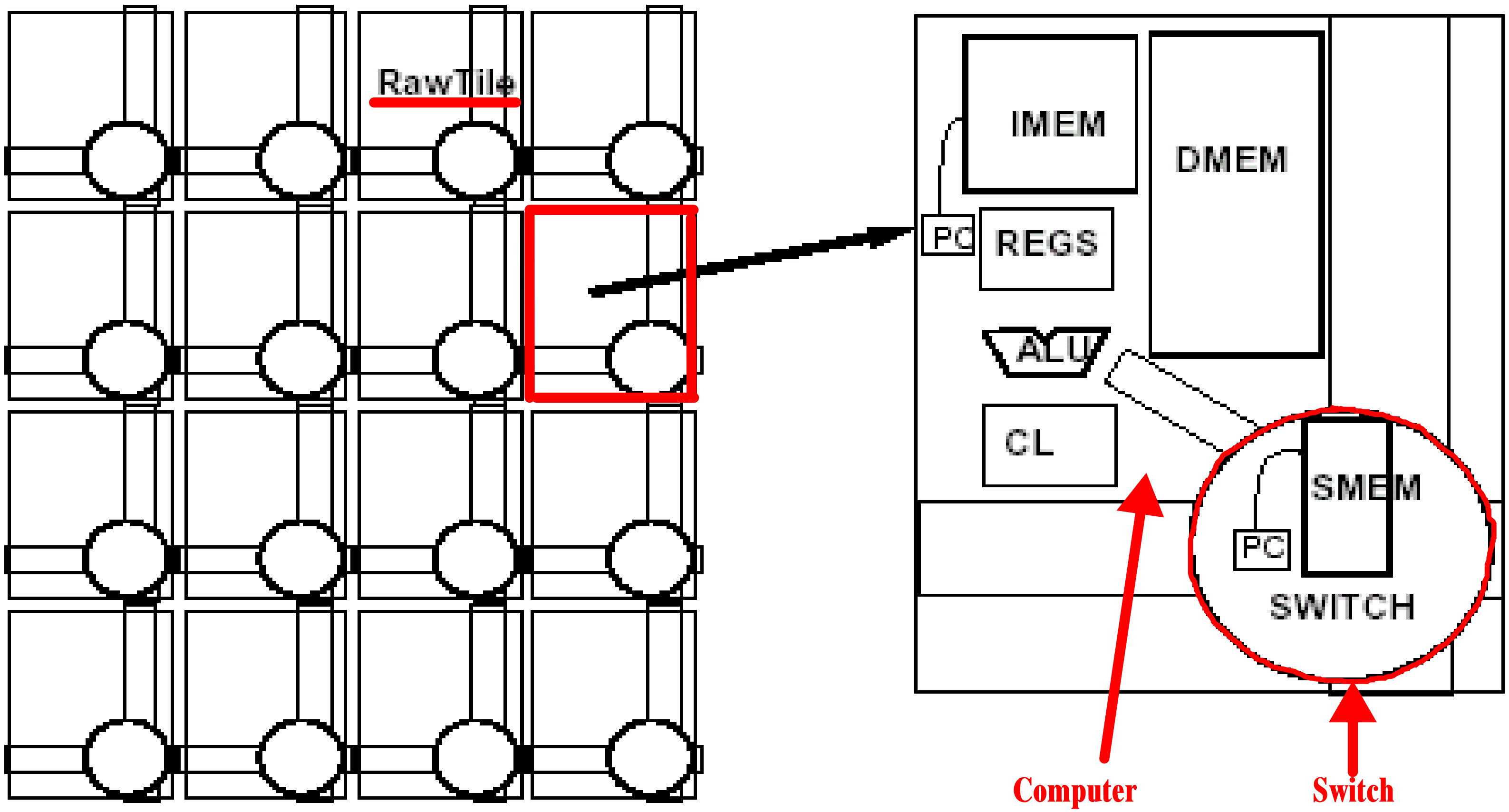
Hayes, Grochowski: American Scientist, 2002

Tape will be replaced by disk and DRAM will become disk substitute after the year 2006

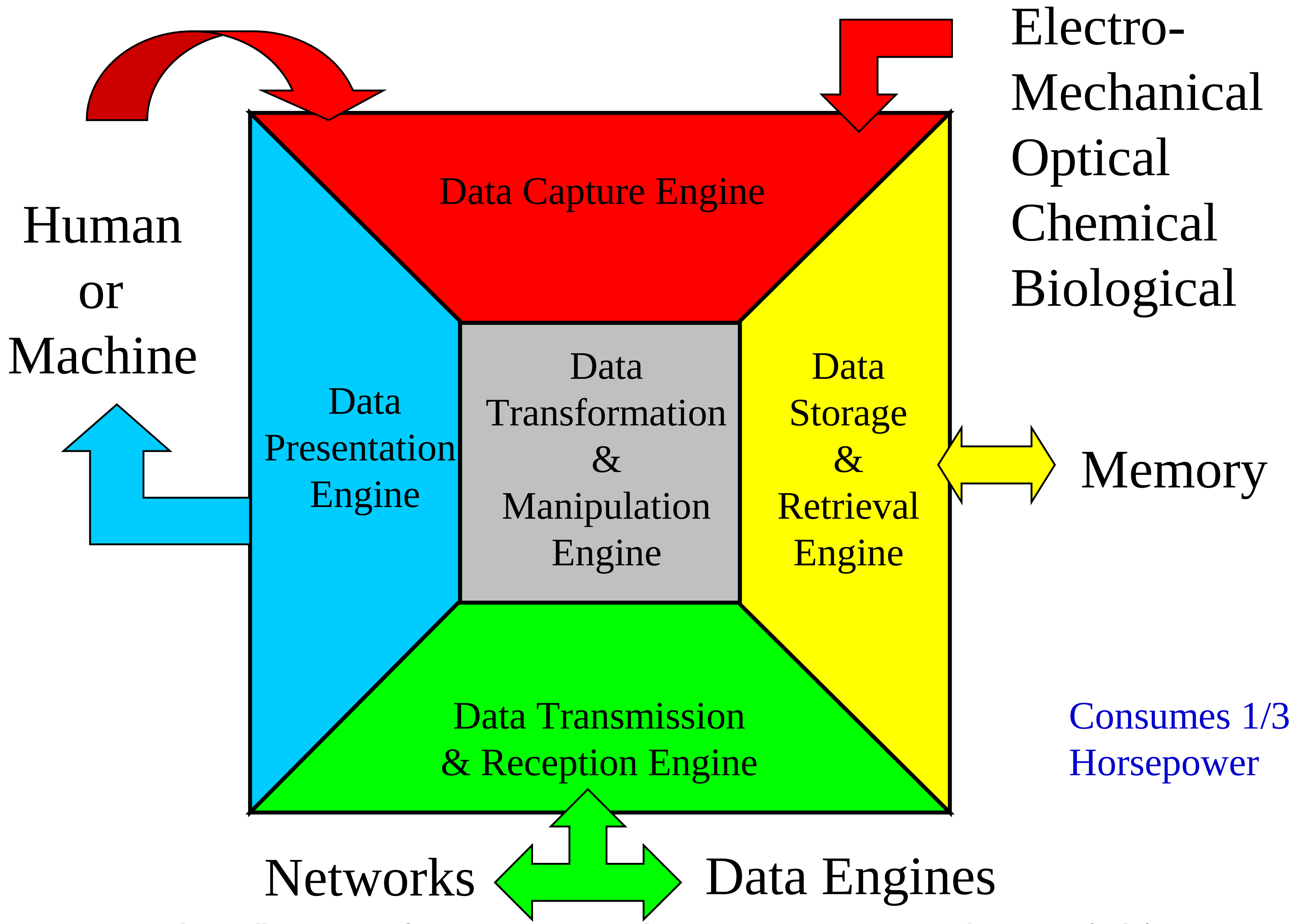
L3 cache on chip will replace DRAM

One large processor will be replaced by network of smaller ones

Possible architecture of the 1 TFLOPS chip from the year 2011, with 16 low power computers and switches on a one chip. Its design has started already, and could be known as ... Playstation 6.



Or like this 2010: Data Engine



Here is the answer for the question from Gray's What Next:
First Turing Test competitive Computers will be available after the year 2011.

1991 Powerful Personal Computer - 1 MFLOPS
2001 Powerful Personal Computer - 1 GFLOPS
2011 Powerful Personal Computer - 1 TFLOPS
- quite enough for Fifth Generation Computing
After year 2011, nano computing is inevitable

Catch 22

Software development has remained a human labor intensive effort. What is the solution? See in the What Next Revealed 2.

Sources of commented diagrams

Jim Gray: What Next, 1998

Vinod Khosla: Red Herring Lecture, 2001

Intel: Terahertz transistor announcement, 2001

ITRS: Roadmap, 2001

ComputerWorld: Interview with Lewis Branscomb, 1999

Hans Moravec, 1998

Other sources available over Internet