Lecture 2: Technology Trends

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Computer Science 252
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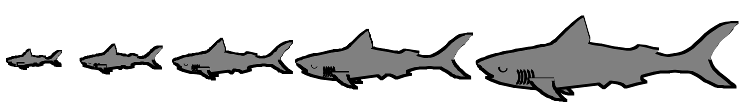
Original Food Chain Picture



Big Fishes Eating Little Fishes

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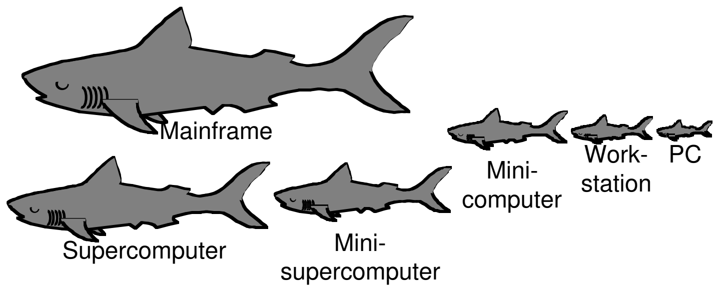
1985 Computer Food Chain



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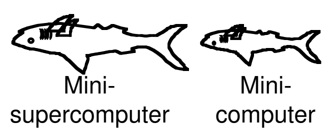
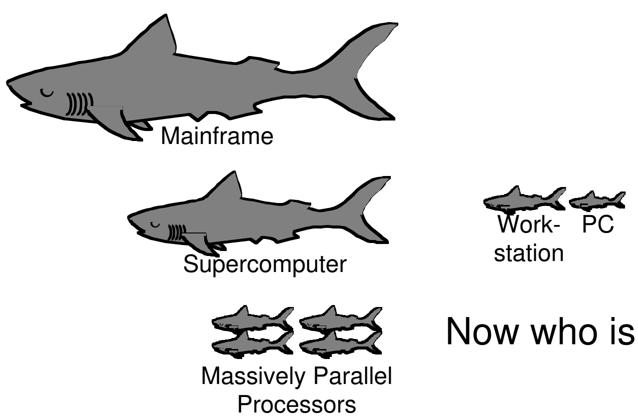


1995 Computer Food Chain



Now who is eating whom?

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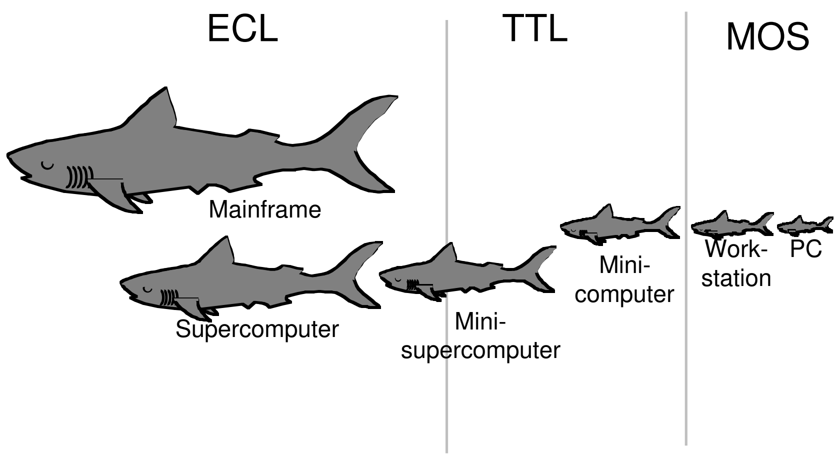
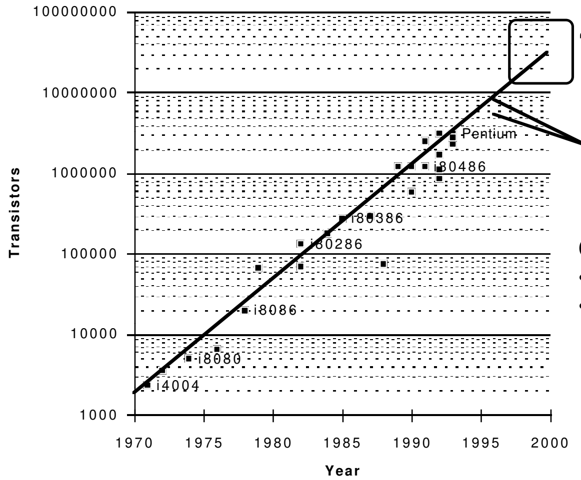
Why Such Change in 10 years?

- Function
  - Rise of networking/local interconnection technology
- Performance
  - Technology Advances
    - » CMOS VLSI dominates TTL, ECL in cost & performance
  - Computer architecture advances improves low-end
    - » RISC, superscalar, RAID, …
- Price: Lower costs due to …
  - Simpler development
    - » CMOS VLSI: smaller systems, fewer components
  - Higher volumes
    - » CMOS VLSI : same dev. cost 10,000 vs. 100,000 units
  - Lower margins by class of computer, due to fewer services

1985 Computer Food Chain Technologies



Technology Trends: Microprocessor Capacity



Pentium Pro: 5.5 million
PowerPC 620: 6.9 million
Alpha 21164: 9.3 million
Sparc Ultra: 5.2 million

CMOS improvements:
- **Die size: 2X every 3 yrs**
- **Line width: halve / 7 yrs**

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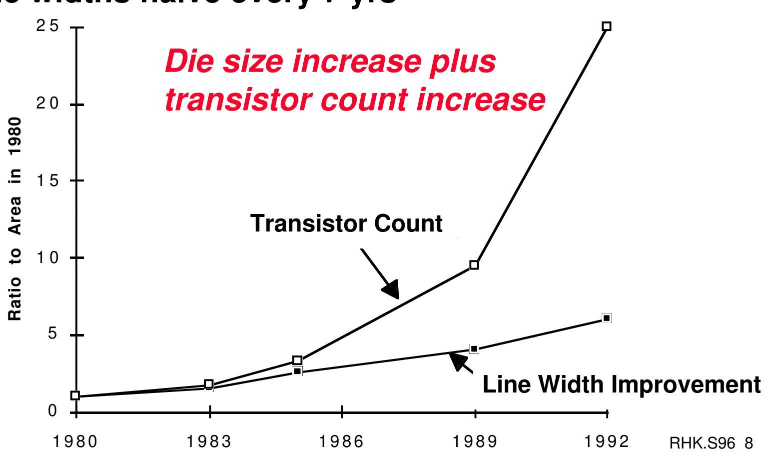
CMOS Improvements

Die size 2X every 3 yrs
Line widths halve every 7 yrs



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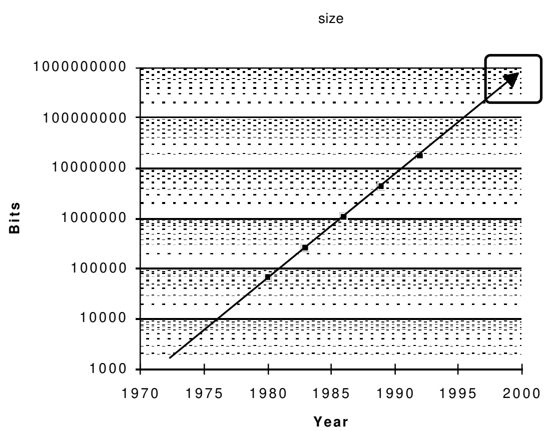
Memory Capacity (Single Chip DRAM)



year	size	cyc time
1980	64 Kb	250 ns
1983	256 Kb	220 ns
1986	1 Mb	190 ns
1989	4 Mb	165 ns
1992	16 Mb	145 ns
1996	64Mb??	??

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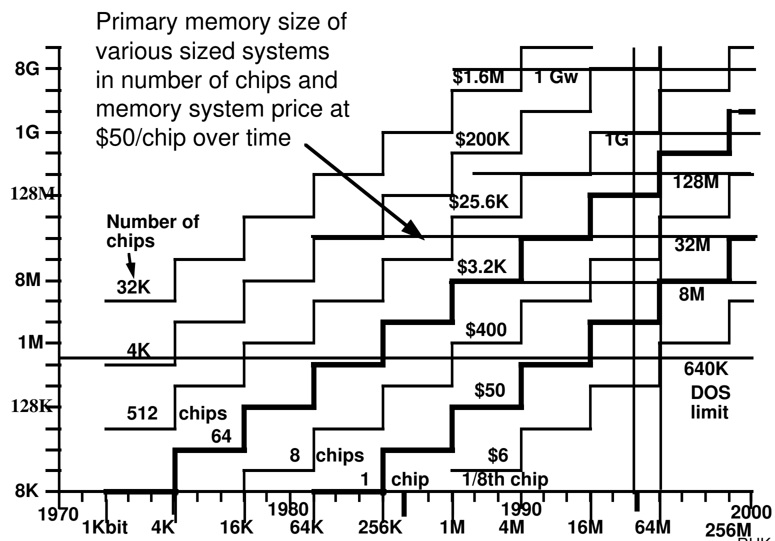
Moore's Law for Memory



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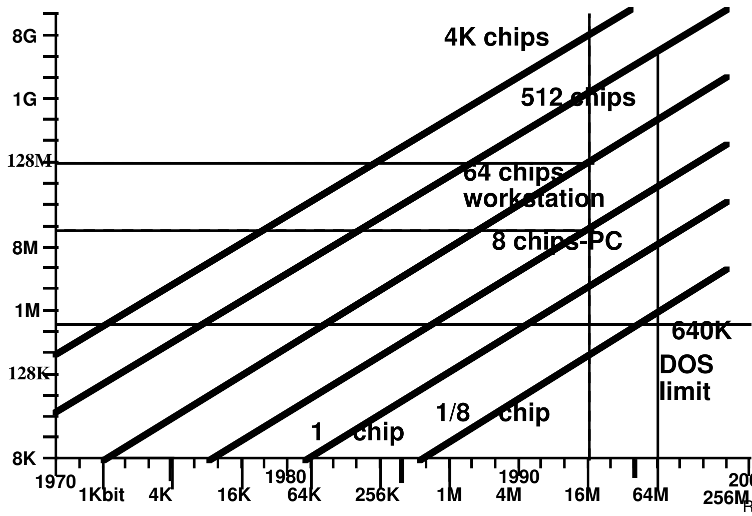
Memory Size of Various Systems Over Time



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Technology Trends (Summary)

	Capacity	Speed
Logic	2x in 3 years	2x in 3 years
DRAM	4x in 3 years	1.4x in 10 years
Disk	2x in 3 years	1.4x in 10 years

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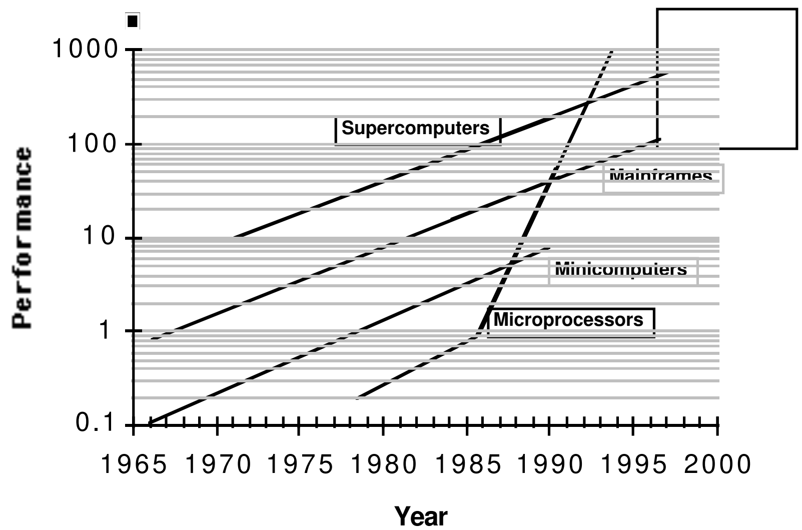
Processor Performance Trends



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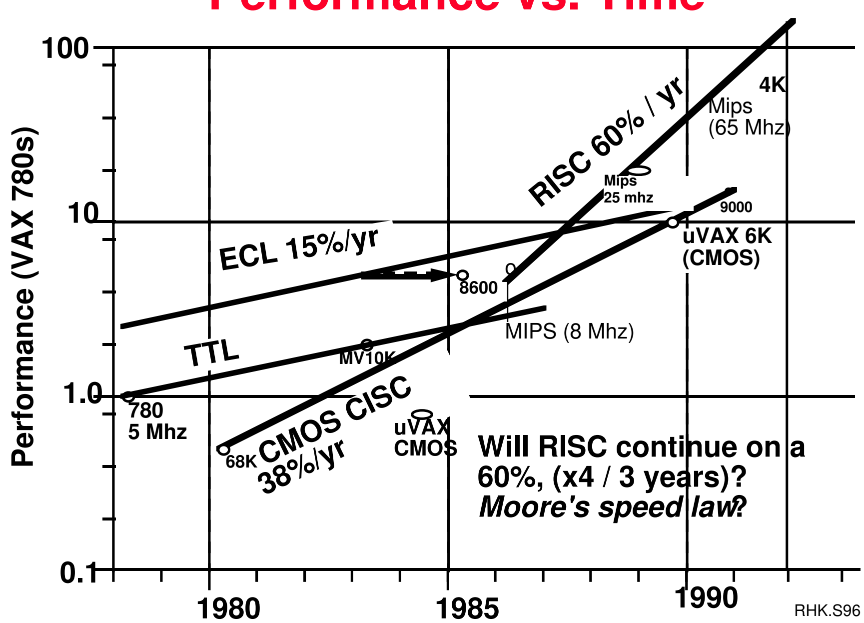
Performance vs. Time



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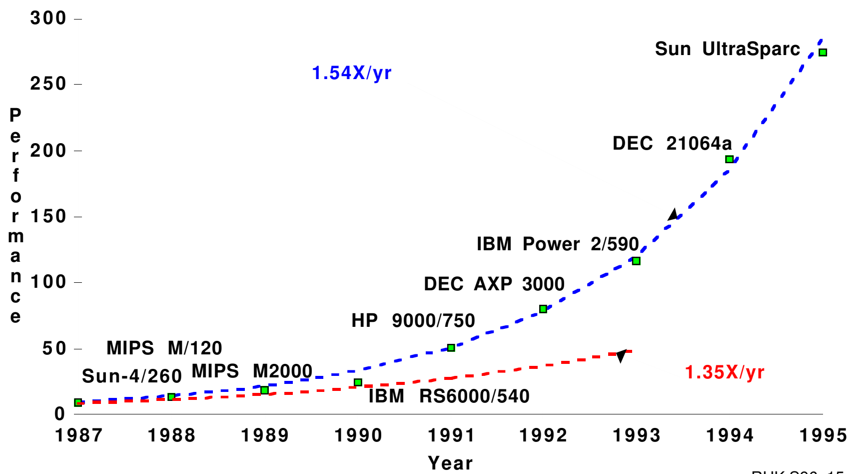
Processor Performance



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Performance Trends (Summary)

- **Workstation performance (measured in Spec Marks) improves roughly 50% per year**
- **Improvement in cost performance estimated at 70% per year**

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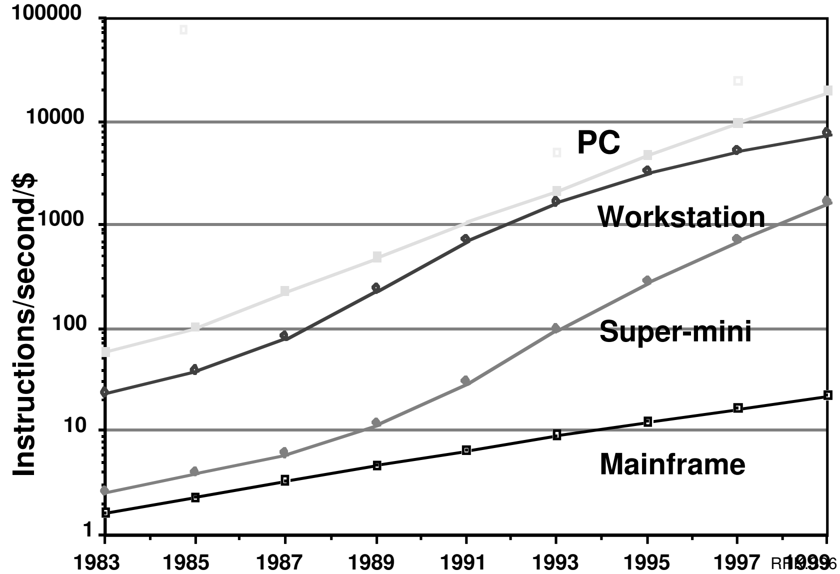
Instructions/Second/$ vs. Time



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Processor Perspective

- Putting performance growth in perspective:

	IBM POWER2 Workstation	Cray YMP Supercomputer
Year	1993	1988
MIPS	> 200 MIPS	< 50 MIPS
Linpack	140 MFLOPS	160 MFLOPS
Cost	$120,000	$1M ($1.6M in 1994$)
Clock	71.5 MHz	167 MHz
Cache	256 KB	0.25 KB
Memory	512 MB	256 MB

- 1988 supercomputer in 1993 server!

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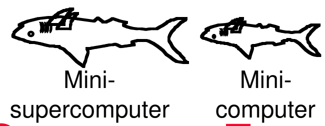
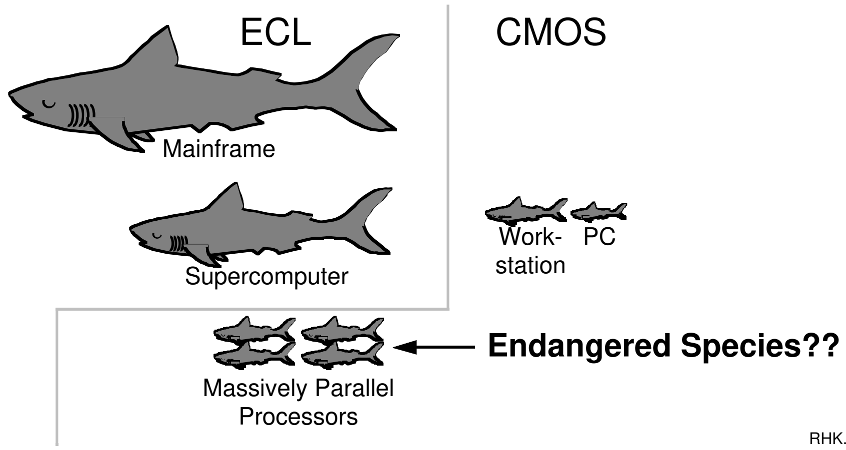


1995 Computer Food Chain Technologies



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Where Has This Performance Improvement Come From?

- **Technology?**
- **Organization?**
- **Instruction Set Architecture?**
- **Software?**
- **Some combination of all of the above?**

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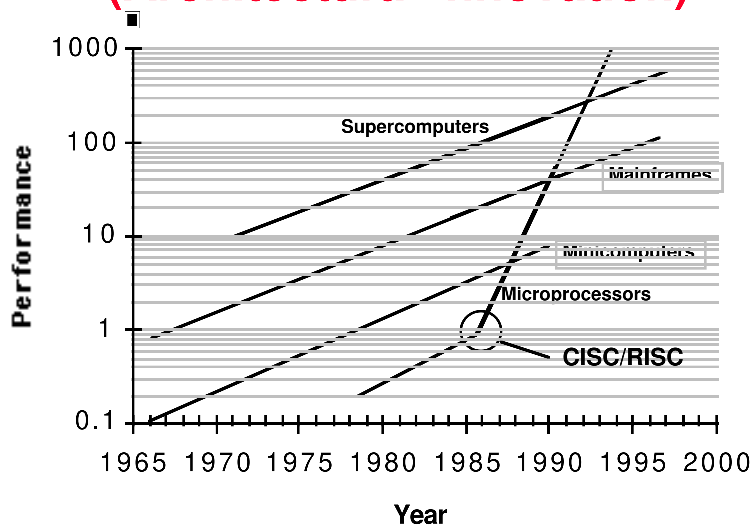
Performance Trends Revisited (Architectural Innovation)



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Performance Trends Revisited (Technology Advances)

Logic Speed: 2x per 3 years

Logic Capacity: 2x per 3 years

Leads to:

Computing capacity: 4x per 3 years

- If can keep all the transistors busy all the time
- Actual: 3.3x per 3 years

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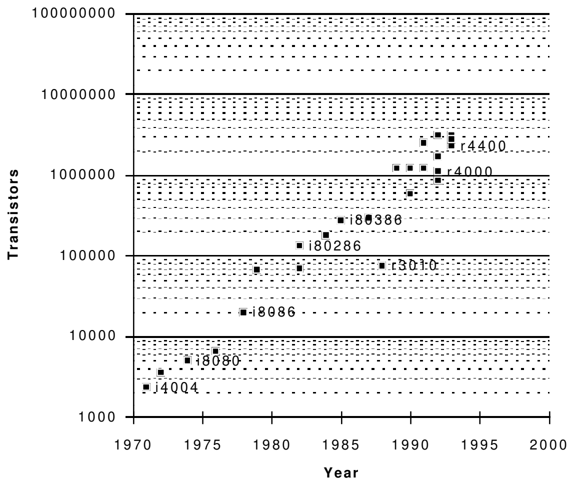
Performance Trends Revisited (Microprocessor Organization)



- **Bit Level Parallelism**
- **Pipelining**
- **Caches**
- **Instruction Level Parallelism**
- **Out-of-order Xeq**
- **Speculation**
- **. . .**

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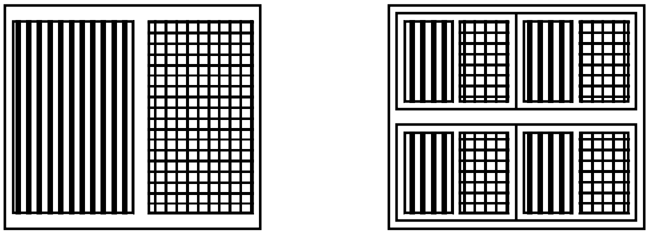
What is Ahead?

- **Greater instruction level parallelism?**
- **Bigger caches?**
- **Multiple processors per chip?**
- **Complete systems on a chip? (Portable Systems)**



- **High performance LAN, Interface, and Interconnect**

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Hardware Technology

	1980	1990	2000
Memory chips	64 K	4 M	256 M-1 G
Speed	1-2	20-40	400-1000
5-1/4 in. disks	40 M	1 G	20 G
Floppies	.256 M	1.5 M	500-2,000 G
LAN (Switch)	2-10 Mbits	10 *(100)*	155-655 (ATM)
Busses	2-20 Mbytes	40-400	

Software Technology

	1980	1990	2000
• Languages	C, FORTRAN	C++, HPF	object stuff??
• Op. System	proprietary	+DUM*	+DUM+NT
• User I/F	glass Teletype	WIMP*	stylus, voice, audio,video, ??
• Comp. Styles	T/S, PC	Client/Server	agents*mobile
• New things	PC & WS	parallel proc.	appliances
• Capabilities	WP, SS	WP,SS, mail	video, ??

- DUM = DOS, n-Unixes, MAC
- WIMP = Windows, Icons, Mouse, Pull-down menus
- Agents = robots that work on information

Computing 2001

- Continue quadrupling memory every 3 years
  - 1K chip in 72 becomes 1 gigabit chip (128 Mbyte) in 2002
- On-line 12-25 Gigabytes;
  $10 1-Gbyte floppies & CDs
- Micros increase at 60% per year
  ... parallelism ≈100
- Radio links for untethered computing

Computing 2001

- Telephone, fax, radio, television, camera, house, ...
  Real personal (watch, wallet,notepad) computers
- We should be able to simulate:
  - Nearly everything we make and their factories
  - Much of the universe from the nucleus to galaxies
- Performance implies: voice and visual
  Ease of use. Agents!

Applications: Unlimited Opportunities

- **Office agents: phone/FAX/comm; files/paper handling**
- **Untethered computing: *fully distributed offices ??***
- **Integration of video, communication, and computing: desktop video publishing, conferencing, & mail**
- **Large, commercial transaction processing systems**
- **<u>Encapsulate knowledge in a computer</u>: scientific & engineering simulation (e.g. planetarium, wind tunnel, ...)**

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Applications: Unlimited Opportunities

- **Generic mathematics; visualization & virtual reality**
- **Computational chemistry e.g biochemistry and matterials**
- **Mechanical engineering without prototypes**
- **Image/signal processing: medicine, maps, surveillance.**
- **Personal computers in 2001 are today's supercomputers**
- **Integration of the PC & TV => TC**

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Challenges for 1990s Platforms

- **64-bit computers & 16 Mbit (2Mbyte DRAM): video, voice, communication, any really new apps?**
- **Increasingly large, complex systems and environments Usability?**
- **Plethora of non-portable, distributed, incompatible, non-interoperable computers: Usability?**
- **Scalable parallel computers can provide "commodity supercomputing": Markets and trained users?**

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Challenges for 1990s Platforms

- **Apps to fuel and support a chubby industry: communications, paper/office, and digital video**
- **Computer commoditization & eventual disappearance (true ubiquitous computing!)**
- **The true portable, wireless communication computer**
- ***Truly* personal *card, pencil, pocket, wallet* computer**
- **Networks continue to limit: WAN, ISDN, and ATM?**

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