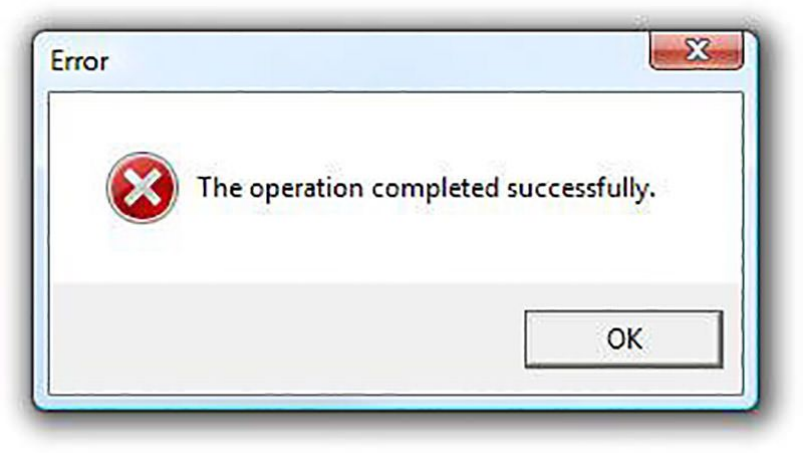


Failures, near-misses, and persistent oversights

Computer marketing history is full of blunders...

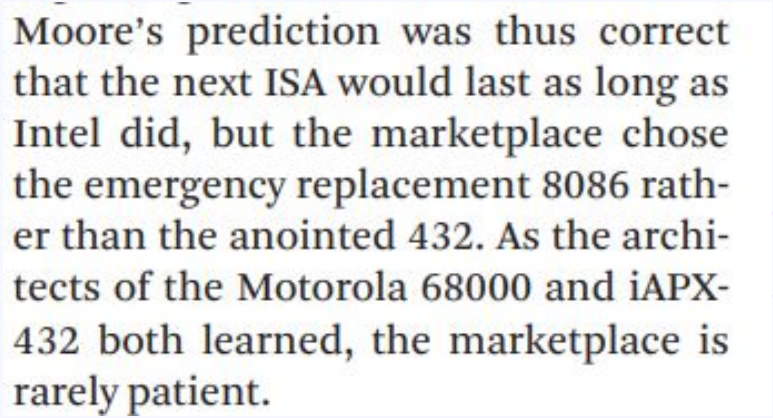
Nvidia GeForce FX 5800 Ultra “dustbuster cooler”

Is there anything you don’t like about the architectural decisions we’ve seen this semester? Or today’s computers in general?

x86 was actually a mistake

(Literally… not editorializing)

- 1976: Intel 8800 (iAPX 432) development begins; with huge teams of PhDs; touted as the permanent future of Intel
- 8800 development ambitious and takes forever
- 1979: need stop-gap 16-bit competitor to Motorola et al; extends 8080 in three calendar weeks – called **8086**
- 1981: IBM goes with version of 8086 over Motorola; sells 100 million units



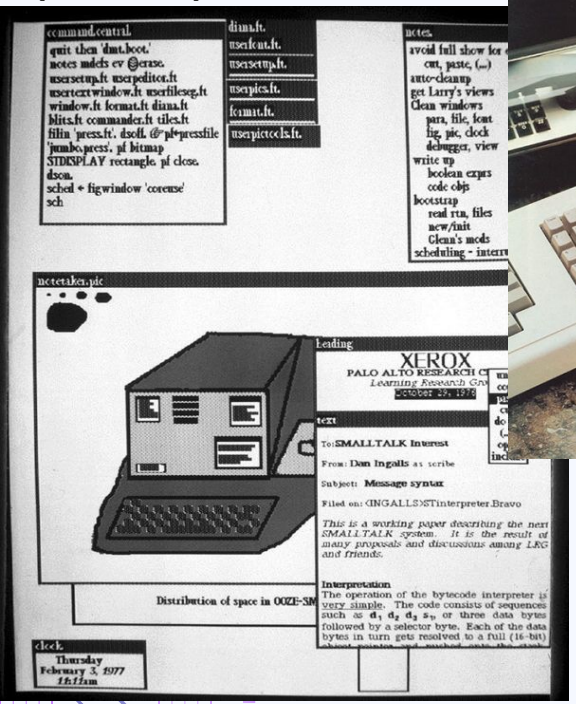
Moore's prediction was thus correct that the next ISA would last as long as Intel did, but the marketplace chose the emergency replacement 8086 rather than the anointed 432. As the architects of the Motorola 68000 and iAPX-432 both learned, the marketplace is rarely patient.

source

How else did market pressures/business decisions shape computers as we know them?

The rise of the GUI; the fall of Lisa

Xerox PARC smalltalk (source)



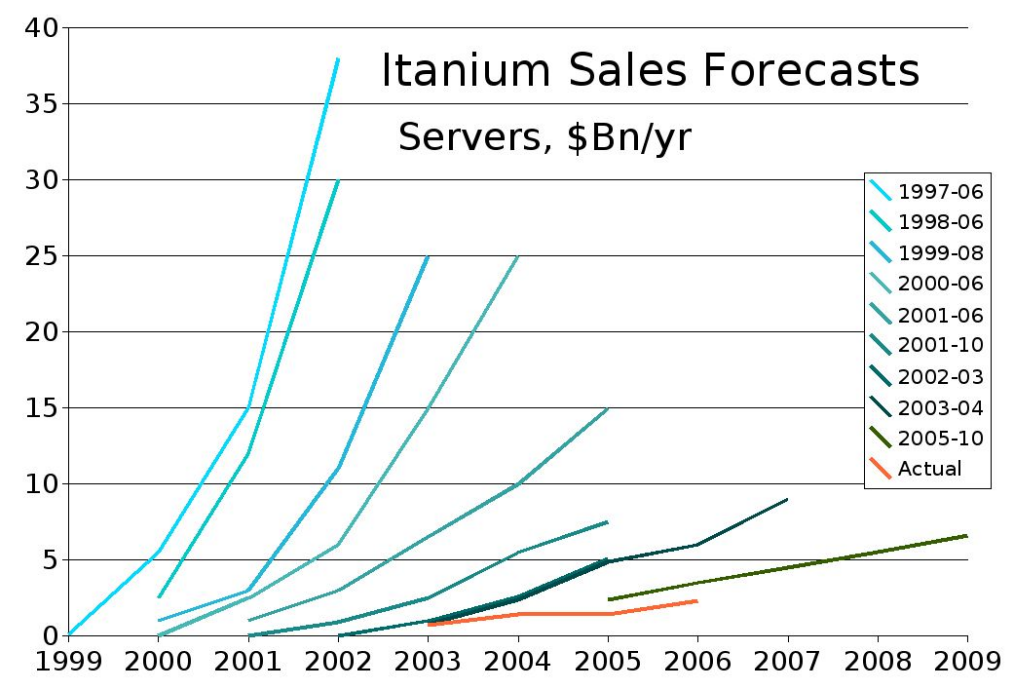
Apple Lisa (1983)
GUI design, multitasking, marketed for office workers, **$10k** (source)

polaroids

Apple Macintosh (1984)
Personal use, fewer fancy features, **$2.5k** (source)

Intel Itanium

VLIW asked “can we do better than RISC or CISC?” (HP + Intel version of VLIW was called EPIC, implemented on the Itanium)



source

why?

“Itanic”/”EPIC fail”

“Buying an Itanium system to run today's desktop applications would be a dumb idea... the chip must shift into an emulation mode ... at the same clock speed, older and cheaper processors can run garden-variety productivity applications faster.”

- Review of the Itanium, 2001

This continues to be one of the great fiascos of the last 50 years, and not because Intel blew too much money on its development or that the chip performed poorly and will never be widely adopted. It was the reaction and subsequent consolidation in the industry that took place once this grandiose chip was preannounced.
- John C. Dvorak, 2009

“The Itanium approach...was supposed to be so terrific—until it turned out that the wished-for compilers were basically impossible to write”
- Donald Knuth

Not just industry: Illiac IV

image source

"First massively parallel computer" – conceived as a project to push the limits of computer architecture

	Expectation	Reality
Budget	$8 million	**$31 million**
Delivery date	1970	**1972+**
Processing elements	256	**64**
MFLOPS	1000	**15**
Home	UIUC	**Ames**

"Reaching for a gigaflop" paper

Why?

- High ambitions
- Poor project management
- Novel changes to hardware manufacturing

...But: dawn of MIMD, realization of semiconductor memory

Politics, war, unrest

1970: Vietnam war seeing large opposition on campuses

DoD is large source of research funding

Military Procurement Act of 1970: increased scrutiny to justify that funding is actually useful to the military

Student newspaper wrote Illiac could be used to manufacture nuclear weapons; students later declared a “day of Illiaction”

PI declared that, as long as Illiac was on campus, it would not be used for classified problems… funders did not like that

from Futurama

What do we notice? Are the issues that lead to “failures” unique to these projects? Have projects with similar issues/risks succeeded?

Common issues in uarchitectures

(A synthesis of forum posts/reviews)

- Deep pipeline combined with terrible branch predictors
- Over-reliance on one mode of computing (multithreaded, integer, FP)
- Penalties for the “bad” case (cache miss, branch misprediction, etc)
- Bad thermals/performance per watt
- Incompatibility/overreliance on suboptimal component

But what’s the course of action (from the consume and the company) when there’s an actual hardware bug?

What’s the point of floating point?

Before floating point standards

Different computers allowed for different representations of variable-magnitude

Mathematics produced different results on different computers … but rounding error is inevitable, so maybe this is OK

“Portable” software packages (Linpack, Eispack) cost a lot to develop

Led to issues when people upgraded their computers (IBM 7094 → System/360 meant doubles worked *worse* than single-precision)

Led to issues based on hardware optimization (early Cray machines)

“Gresham’s Law (“Bad money drives out Good”) for computers would say, “The Fast drives out the Slow even if the Fast is wrong.” – William Kahan

FP division algorithms + errors

Naive algorithm: shift-and-subtract (mimics human mechanics)

Modern implementations: Sweeney, Robertson, Tocher (SRT): uses a lookup table to halve the number of operations needed

> Intel Pentium used a lookup table of 2048 cells (1666 of which needed to be populated with a value in [-2, 2])…. five were not set correctly (explainer paper)

$$\frac{4{,}195{,}835}{3{,}145{,}727} = 1.333739068902037589$$

Pentium bug backlash

Intel said yesterday that it did not believe the chip needed to be recalled, asserting that the typical user would have but one chance in more than nine billion of encountering an inaccurate result as a consequence of the error, and thus there was no noticeable consequence to users of business or home computers. Indeed, the company said it was continuing to send computer makers Pentium chips built before the problem was detected.

New York Times, Nov 24 1994

Statistical Analysis of Floating Point Flaw in the Pentium™ Processor (1994)

Intel Corporation

source

November 30th 1994

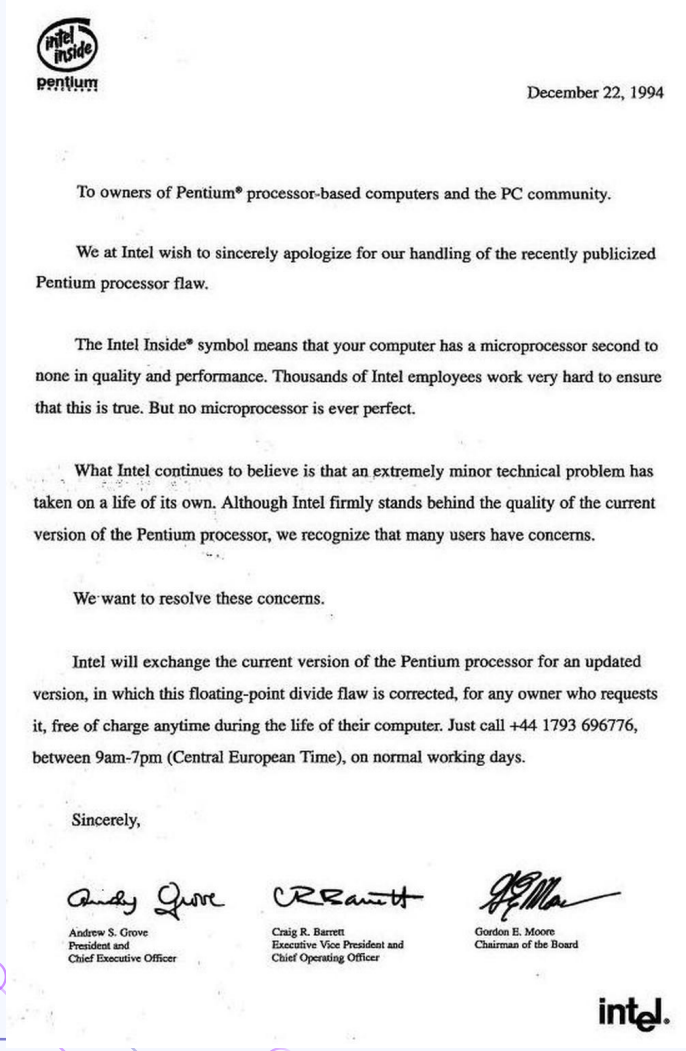
New York Times, Dec 13 1994

I.B.M. Deals Blow to a Rival As It Suspends Pentium Sales

By PETER H. LEWIS

17 Jan 1995 Intel announces a pre-tax charge of 475 million dollars against earnings, ostensibly the total cost associated with replacement of the flawed processors.

source



December 22, 1994

To owners of Pentium® processor-based computers and the PC community.

We at Intel wish to sincerely apologize for our handling of the recently publicized Pentium processor flaw.

The Intel Inside® symbol means that your computer has a microprocessor second to none in quality and performance. Thousands of Intel employees work very hard to ensure that this is true. But no microprocessor is ever perfect.

What Intel continues to believe is that an extremely minor technical problem has taken on a life of its own. Although Intel firmly stands behind the quality of the current version of the Pentium processor, we recognize that many users have concerns.

We want to resolve these concerns.

Intel will exchange the current version of the Pentium processor for an updated version, in which this floating-point divide flaw is corrected, for any owner who requests it, free of charge anytime during the life of their computer. Just call +44 1793 696776, between 9am-7pm (Central European Time), on normal working days.

Sincerely,

Andrew S. Grove
President and
Chief Executive Officer

Craig R. Barrett
Executive Vice President and
Chief Operating Officer

Gordon E. Moore
Chairman of the Board

intel.

Bonus: retrospective and opinions on hardware testing

source and good explainer