

Die kanadische Monatszeitschrift *The Computer Post*, Winnipeg veröffentlicht in mehreren Artikeln in ihrer Januar-Ausgabe 1995 eine exzellente erste Zusammenfassung des Debakels um den Defekt des Pentium-Mikroprozessors [1–2] des Computergiganten Intel.

Im folgenden sowie in den wdv-notes Nr. 330 werden diese Artikel im Original nachgedruckt. Der Dank dafür geht an Sylvia Douglas von *The Computer Post*, 301 – 68 Higgins Avenue, Winnipeg, Manitoba, Canada, Email: *SDouglas@post.mb.ca*. Diese Artikel dürfen auch weiter-

verbreitet werden, wenn dabei die folgenden Spielregeln beachtet werden.

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Intel's top of the line Pentium™ microprocessor chip has turned out to have a slight flaw in its character: when dividing certain rare pairs of floating point numbers, it gives the wrong answer. For anyone who owns a Pentium-based computer, or was thinking about buying one, or is just feeling curious, here are...

The Facts about Pentium

By SYLVIA DOUGLAS

The Computer Post

Like an avalanche, it started small. One little whisper that something was wrong. Suddenly, without any more warning than that, everything was sliding out of control. Giant Intel, the company that makes chips for 80% of the world's PCs, found itself in the middle of the worst PR debacle in its corporate history.

Five years from now, one way or another, this will be an excellent case study for business schools in their crisis management courses – as an example of how not to do it. It was a minor technical problem, Intel management thought, just like many others they have dealt with over the years. Last June, just when Intel was in the midst of ramping up its Pentium production to meet the challenge of the PowerPC chip (coming from Apple, IBM, and Motorola), some of its engineers noticed a wrong answer in one of the multitude of tests they were running on the Pentium.

*» You know postmodern –
Well, this is PostReality. «*

The Computer Post, Winnipeg.

All chips have errors. This is a fact of life in the semiconductor business. Connecting millions of transistors is not something that can be done error-free the first time. The normal practice is to collect up a number of these errors and their design fixes, and apply them to a revised version of the wafer mask which then becomes what the production lines are churning out.

In software this is called a slipstream upgrade; most software companies do it. In hardware, it's called a stepping. Chips can go through 5, 10 or even 20 steppings in the course of their lifetime. Normal practice is to keep at least major chip customers updated with a current list of outstanding bugs in each chip.

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This particular error in the Pentium was in the floating-point divide unit. Intel management was concerned enough about it that they pulled together a special team to assess the implications.

In the words of Andrew Grove, Intel's CEO, posting later to the Internet [3], "We were puzzled as to why neither we nor anyone else had encountered this earlier. We started a separate project, including mathematicians and scientists who work for us in areas other than the Pentium processor group to examine the nature of the problem and its impact."

Inexplicably, though, the now-infamous FDIV bug didn't make its way onto any lists of known bugs. Intel didn't inform even their largest customers.

Instead, the special team did their analysis. In Grove's words, "This group concluded after months of work that (1) an error is only likely to occur at a frequency of the order of once in nine billion random floating point divides, and that (2) this many divides in all the programs they evaluated (which included many scientific programs) would require elapsed times of use that would be longer than the mean time to failure of the physical computer subsystems."

While those months passed by, many more scientists and engineers, persuaded by Intel's advertising that the Pentium was now able to give workstation performance at affordable prices, adopted this platform for critical calculations. The price of Pentiums started to come down, and businesses adopted the platform for calculation-intensive spreadsheet work. After all, one of the advertised advantages of the Pentium was its very fast floating point arithmetic.

In what now turns out to be Intel's one bit of good news, the platform was also adopted by large numbers of consumers looking for a fast, capable multimedia computer to run all the exciting new games and educational software coming to market.

The report produced by the Intel team has now been made public. We have included excerpts from this "White Paper" on page 12 [Editors Note: See [4]]; Intel will send a copy to anyone who asks for it.

Curiously enough, though, it was not Intel that made the first public announcement of the bug. Dr. Thomas R. Nicely of Lynchburg College, a professor of mathematics, was doing some work in number theory that involved taking a lot of reciprocals. To double-check his work, he did it twice – once in floating point, and once in integer arithmetic.

Editorial: The Computer Post – Jan.95

The Way it Will Be

This month you'll find we're reporting a lot of background information on Intel's Pentium problems. In fact, we have never before devoted this much space to any single news story.

We're not just picking on Intel because they're big – although there is a certain fascination in watching such a large corporation being forced by public pressure to reverse a strongly held position. What's new and different about this drama, what deserves serious study by everyone running a business in the second half of this decade, is the role played by online communications.

Let's not exaggerate. The Internet didn't do it all. Intel didn't give in until the Pentium story became widespread enough to affect stock prices and threaten future sales. This still means CNN and USA Today, not a newsgroup and a few Web sites – not yet.

At the rate people are connecting to the Internet now, within a few years the public at large is going to be looking online first for their news and information. More than that, online will be where they can ask their own questions, express their own opinions, and discover what other people think. So it is vital for business to understand the new dynamics of an interactive customer base. Here is a case study of how it happened to one company.

Intel ran into the phenomenon early because of who they are, and who their customers are. They sold the Pentium to scientists and engineers who had been connected to the Internet for some time and were comfortable with expressing themselves that way.

Already, a controversy on the Internet is very, very public. Many business people are now connected, and a rapidly growing number of private individuals. There were more than ten thousand messages posted to comp.sys.intel, and there is no way of determining how many times that number of people scanned the newsgroup for information.

Journalists were certainly among them. This past year, only the leading-edge reporters were using the Internet as an information-gathering tool; two years from now, they will all be doing it. It is a matter of moments to follow up a Web page reference in a newsgroup article and find a detailed source document, or to post a question and

To be continued ...

Back in June, Nicely noticed a small discrepancy between his two sets of results. Of course, it did not occur to him at first that this was a problem with the Pentium chip. He spent a lot of time eliminating other causes, such as compiler artifacts and errors in the PCI bus.

On October 22, after running his test case on a number of 486 and Pentium computers, he became certain the fault was in the Pentium CPU. That day, he contacted Intel tech support. After eight days, they had no answers for him, so on October 30, he sent email messages to a number of people and

Question: *What's the definition of the so-called "tertiary sciences"?*

Answer: *These are sciences using Intel computer platforms – especially Pentium PC's – only, mostly running under Microsoft's DOS & Windows. They never use more reliable platforms or operating systems.*

Read on UseNet [9].

organizations he felt would have access to many Pentium systems, and asked them to check for the problem.

The speed with which events developed from that moment is a graphic illustration of the nature of today's, and tomorrow's, interconnected world. Things are going to work like this from now on. Other businesses of every variety, take note.

Within three weeks, high-powered engineers like Tim Coe of Vitesse Semiconductor [5] and Mike Carleton of USC/ISI [6] had reverse-engineered Intel's floating point division algorithm, and developed a mathematical model which successfully predicted number pairs for which the FDIV instruction would fail. Within six weeks, Coe, together with Cleve Moler of Mathworks, Inc., Terje Mathisen of Norsk Hydro in Norway [7], and Peter Tang of Argonne National Laboratories

Editorial: The Computer Post – Jan.95 continued:

ask anyone in the world who's had a specific kind of experience to make contact by email.

Monthly periodicals like The Computer Post can't expect to be first with a fast-breaking news story – that's the job of radio, TV, and the newswire services. (It was only by luck that Intel's about-face announcement came in time for us to include it.) What we can do is provide some perspective, and enough information to let our readers understand what a news story means, and how it indicates trends.

In our front page story, I wrote that five years from now, business schools will be studying the Intel case. Business executives can't afford to wait five years to grasp the implications of the coming social change.

In 1994 it was only a computer chip. Over the next few years, every business will have to adapt to the fact that customers have acquired a whole new dimension of power.

Sylvia Douglas

had developed a software workaround that could at least be compiled into programs where source code is available [8]. They didn't meet each other in person – all the work was done via the Internet, and all results were posted publicly for the world to see, criticize, and contribute to.

Meanwhile, the implications of the FDIV bug began to sink in. Vaughan Pratt of Stanford University's computer science department started examining the Coe model, and did some analysis of Intel's probability analysis. He wrote, "Internet postings [are] the best medium for the sort of turnaround this time-critical subject needs, with its additional advantage of feedback about mistakes in my analysis – in effect real-time refereeing."

On November 28, Intel posted the statement from Andy Grove quoted above into the comp.sys.intel forum [3]. Having made the one statement, which confirmed that they had known about the bug since early summer, they then lapsed into silence. They were not prepared to be told, over and over again in hundreds of replies, that they were badly missing the point.

A typical furious quote: "Having conclusively demonstrated themselves utterly unworthy of the public's trust, they still seem unable to comprehend what that means."

The anger was fuelled by the growing expert consensus that the problem was worse than Intel was claiming it to be. Pratt of Stanford wrote: "This bug is maximally insidious: it is about as large as it could possibly be without actually triggering warning bells when people review their columns of data. In this way tiny errors of one part in a hundred thousand can over a long period of time sneak into the trillions of calculations done around the world and there is no practical way to spot them short of doing a massively detailed audit of a kind that would have to be tailored to the Pentium FDIV bug and would be entirely unnecessary for a reliable floating point unit."

Meanwhile, on December 12 Intel lost any chance that this issue might slip by with little mainstream attention, when IBM, angered by Intel's failure to inform them, and possibly wanting to dissociate themselves from what looked like disaster in the making, announced that they were stopping shipment of all Pentium-based systems [10].

Since then there have been major focus articles on the subject in the Wall Street Journal, Business Week, and the New York Times. The Gartner Group has recommended that major corporate clients hold off on purchases of Pentiums. The Pharmaceutical Association warned members not to use Pentiums in calculations to be sent to the Food and Drug Administration. Lawsuits were launched.

And, the ultimate humiliation: on the sports page of the New York Times, in a story about the New Jersey Nets basketball team and how their record does not match their ability, there was the headline, "Mentally Speaking, Nets are Pentiums."

Intel's expensively promoted premium brand name, being used as an insult on the sports page!

On December 20, Intel caved in to the pressure. They announced that they would take an unspecified reserve against their fourth-quarter earnings, and "exchange the current version of the Pentium processor for an updated version, for any owner who requests it, free of charge anytime during the life of their computer."

Most of the trouble could have been avoided if, in early summer, Intel had not tried to conceal the defect. They might have lost some workstation-market sales, but the workarounds would have been developed and incorporated into compiler libraries. Even as late as October or November, if Intel had immediately given an offer of unconditional replacement – a position they have been backed into now, anyway – they could have come across as responsible, and concerned about the people who use their computers.

Intel is far too large and cash-rich to go under because of one botched job of public relations. They will not even lose money in the coming quarter. But the lesson is going to be expensive. Lets hope they learn the right one. □

Sonstige Hinweise

■ Die weltweite öffentliche Diskussion der Folgen des Pentium-Defekts wird im Internet vorwiegend in der Newsguppe *comp.sys.intel* geführt. Ohne die Existenz des Internets wäre der Pentium-Fehler für die Öffentlichkeit mit Sicherheit niemals aufgeklärt worden.

Literatur

Alle im folgenden aufgezählten Materialien sind auch elektronisch publiziert und stehen als Dateien (Files) auf dem Ftp-Server *ftp.grumed.fu-berlin.de* im Verzeichnis *PC* zum Kopieren via Internet (*Anonymous Ftp*) zur allgemeinen Verfügung. Auf diesem Ftp-Server sind weitere Infodateien zum Pentium-Defekt archiviert.

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