PROFESSIONAL PRACTICE PROJECT

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Title: INTEL PENTIUM CHIP (FDIV)

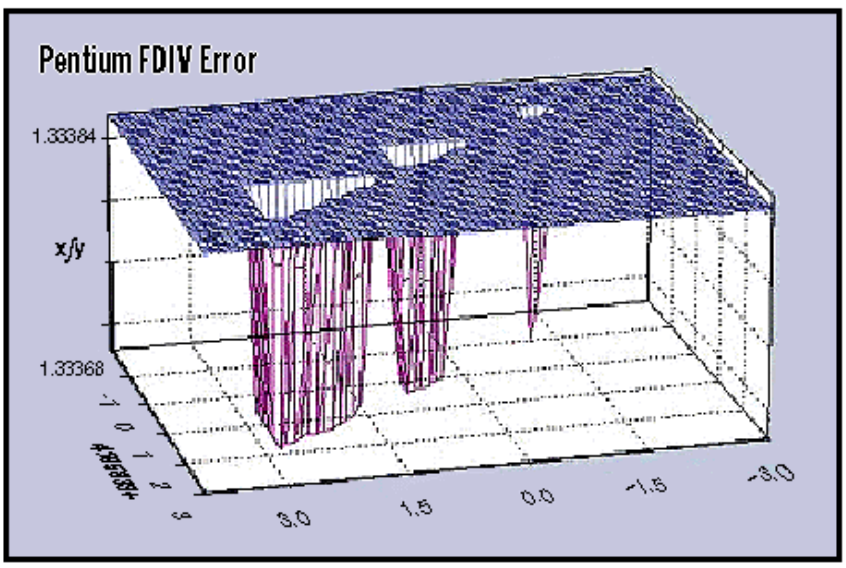

TABLE OF CONTENT

INTRODUCTION:

A worst case scenario for any business is to have its credibility fall so low that it becomes the subject of jokes among its customers and the general public. This nightmare comes true for one large company which has literally millions of customers: Intel Corporation, a leading computer chip manufacturer. Intel's chip designs are inside 80% of personal computers. Intel's nightmare began when one of its chips, the Pentium processor, was found to have a flaw in the portion that does math computations. While the actual math errors affected a small segment of Pentium users, including scientists, engineers, bankers, and the like, Intel's response to its customers' concerns about the chip affected many others, the majority of whom are "nontechnical people." These customers expected a perfectly working chip; Intel insisted that perfection was not necessary. The media got involved and Intel finally relented, but not before jokes like the one quoted above about the Pentium's mathematical inaccuracy and the company's unresponsive attitude began to appear.

CASE STUDY:

The late Dr. Thomas Nicely, a mathematics professor from Lynchburg College (now the University of Lynchburg) in Virginia, found that the latest Intel Pentium processor, known as FDIV (the x86 assembly language acronym for floating point division), had an error—it did not accurately perform floating point mass on certain sets of numbers. Nicely had been working on a project in computational number theory when he realized that the Pentium floating point unit (FPU) was returning incorrect values for certain division operations.

For example, 1/824633702441.0 was being calculated incorrectly (all digits beyond the eighth significant digit were wrong). In an email sent to Intel, Nicely advised it could be verified by using compiled code, a spreadsheet such as Quattro Pro or Excel, or even the scientific mode on the Windows calculator "by computing (824633702441.0)(1/824633702441.0), which should equal 1 exactly (within some extremely small rounding error; in general, coprocessor results should contain 19 significant decimal digits). However, the Pentiums tested return 0.999999996274709702 for this calculation."

He found another error in the calculation of x*(1/x) for most values of x in the interval 824633702418 <= x <= 824633702449, and throughout any interval obtained by multiplying or dividing the above interval by an integer power of 2. "The bug can also be observed by calculating 1/(1/x) for the above values of x. The Pentium FPU will fail to return the original x (in fact, it will often return a value exactly 3072 = 60x200 larger)," he wrote.

Nicely had tested various FDIV chips and tried to locate the issue by trial and error. Eventually he found that there was a fault with the chip's FPU.

In late 1994, the media began to report that there was a flaw in the new Pentium microprocessor produced by Intel. The microprocessor is the heart of a personal computer and controls all of the operations and calculations that take place. A flaw in the Pentium was especially significant, since it was the microprocessor used in 80% of the personal computers produced in the world at that time. Apparently, flaws in a complicated integrated circuit such as the Pentium, which at the time contained over one million transistors, are common. However, most of the flaws are undetectable by the user and don't affect the operation of the computer. Many of these flaws are easily

compensated for through software. The flaw that came to light in 1994 was different: It was detectable by the user. This particular flaw was in the floating-point unit (FPU) and caused a wrong answer when double-precision arithmetic, a very common operation, was performed. A standard test was widely published to determine whether a user's microprocessor was flawed. Using spreadsheet software, the user was to take the number 4,195,835, multiply it by 3,145,727, and then divide that result by 3,145,727. As we all know from elementary math, when a number is multiplied and then divided by the same number, the result should be the original number. In this example, the result was 4,195,579 [InfoWorld, 1994]. Depending on the application, this six-thousandths-of-a-percent error might be very significant. At first, Intel's response to these reports was to deny that there was any problem with the chip. When it became clear that this assertion was not accurate, Intel switched its policy and stated that although there was indeed a defect in the chip, it was insignificant and the vast majority of users would never even notice it. The chip would be replaced for free only for users who could demonstrate that they needed an unflawed version of the chip [InfoWorld, 1994]. There is some logic to this policy from Intel's point of view, since over two million computers had already been sold with the defective chip. Of course, this approach didn't satisfy most Pentium owners. After all, how can you predict whether you might have a future application where this flaw might be significant? IBM, a major Pentium user, canceled the sales of all IBM computers containing the flawed chip. Finally, after much negative publicity in the popular personal computer literature and an outcry from Pentium users, Intel agreed to replace the flawed chip with an unflawed version for any customer who asked to have it replaced. It should be noted that long before news of the flaw surfaced in the popular press, Intel was aware of the problem and had already corrected it on subsequent versions. It did, however, continue to sell the flawed version, and, based on its early insistence that the flaw did not present a significant problem to users, seemingly planned to do so until the new version was available and the stocks of the flawed one were exhausted. Eventually, the damage caused by this case was fixed as the media reports of the problem died down and as customers were able to get unflawed chips into their computers. Ultimately, Intel had a write-off of 475 million dollars to solve this problem.

INTEL'S ORIGINAL PURPOSE:

Intel's plan was to release the chip and just fix the flaw on the future processors. This action would make Intel a great deal of profit, no one would find out, and once the processors sold out, the fixed ones would be released and everything would be normal.

TECHNOLOGICAL CONFLICTS:

- Although there was indeed a defect in the chip, the defect was insignificant and the vast majority of users would never even notice it.
- Intel offers that the chip would be replaced for free only for users who could demonstrate that they needed an unflawed version.
- No one can predict that whether the flaw might be significant in future application
- IBM, a major Pentium user, canceled the sales of all IBM computers containing the flawed chip.
- After much negative publicity in the popular personal computer literature and the daily press, and an outcry from Pentium users, Intel agreed to replace the flawed microprocessor with an unflawed version for any customer who asked to have it replaced.

LEGAL ACTIONS:

- A major New York City bank says it has discovered calculation errors that it attributes to the Pentium chips inside some of its computers.
- A multimedia developer and training company on Long Island says the Pentium caused a miscalculation in a graphics program.
- Scientists at the Brookhaven National Laboratory on Long Island got wrong answers in calculating the impact of colliding subatomic particles, Newsday reported.


As Intel Confronts Broad Fears, Several Companies Say They Have Pentium Problems

Perceptions hurt: The chip industry leader, or a risky-disk operator?

Tracking the Markets

CONCLUSION:

Acting ethically is in Intel's, or any company's best interests. Intel made some ethical errors by not respecting the rights of its customers. The company also made utilitarian errors, some of which were probably caused by lack of information. Intel should have to respect its customer's rights and to implement its final policy at the start. To its credit, Intel finally came around to respecting its customers' rights, which correspondingly promoted their happiness. When it decided to give a new chip to anyone who requested one, to disclose all future chip flaws, and to communicate its concern and solutions to the public, Intel reflected the ethical principles of fairness and the pursuit of the "greatest good." And if the Pentium chip crisis serves to promote these principles industry wide, this will increase happiness for all of us, "nontechnical people" and "technical people" alike.