Understanding the Math-Coprocessor

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Math-coprocessor is an optional feature added to IBM-PC. It is also known as numeric data processor (NDP). In earlier times, computers did not have built in math - coprocessor.To get benefit of such devices in mathematical calculation, external chip (known as math-coprocessor) was required to be plugged on in the main motherboard. But now-a-days both 486-DX and PENTIUM processor has built in math-coprocessor.One thing noticeable here is that 486-SX processor has no built in math-coprocessor.

Intel Corporation produces three math - coprocessor chips that perform complex mathematical calculations, to extend arithmetical capability of the microprocessor. The 8087 chip (math-coprocessor) works with the 8086/8088 based computers. Again, 80287 and 80387 chips work with their cousins 80286 and 80386 respectively. The 80287 and 80387 recognises all 8087 instructions.

The family of 8087,80287,80387 chips are called coprocessor because they share program with the microprocessor. When we run a program that is designed to use the math-coprocessor, the microprocessor executes the instructions that it recognizes and the math- coprocessor executes those instructions that it recognizes. To understand it more clearly ,imgine a situation where a man has two assistants one from China and another one from Japan. Then, the chinese assistant will perform those works that are given in chinese while the Japanese will perform only those instructions that are given in Japanese.

As we know, normal microprocessor can already do some arithmetic, but not much. It can perform only four basic functions-addition subtraction, multiphication and division. On the other hand,math-coprocessor can perform a wide variety of arithmetic, logarithmic and trigonometric functions on integers and real numbers. And as math-coprocessor instructions are built into hardware, it can produce a dramatic speed improvement along with the microprocessor.

Intel claims that math-coprocessor can perform numeric operations about 50 to 100 times faster than the microprocessor which uses software routine to do the same job alone. This means, that if 80386 program requires 2000 microseconds to perform a particular arithmetic operation, using 80387 the same job can be done in only about 20 microseconds.

Internal Register

The math-coprocessor has eight registers, each 80 bits long. They are arranged in the form of a stack. Stack is a special type data structure which is based on the last in first out (LIFO) principle. For clarity, a stack operates like a plate dispenser in the cafeteria. The plate last put in will be the first element to be removed. The name of the eight registers are ST(0), ST(1), ST(2), ST(3), ST(4), ST(5), ST(6) and ST(7). The ST(0) register is usually called as ST, is located at the top of the stack. Numbers are held in the registers while being used for calculations.

Control Register

The math-coprocessor has five control registers ,which are of interest mainly for system programmers. They are the control word, the tag word, the instruction pointer (32 bit) and the operand pointer (32 bit).

Data Types

The 80287 or 80387 can operate on seven types of data. Among them there are three types of integers (word ,short ,long). three types of reals (short ,long and temporary) and the packed decimal.

Data type	Bits	Significant digits	Range
Word integer	16	4 or 5	-32,768 to 32,767
Short integer	32	9	$-2X10^{9}$ to $2X10^{9}$
Long integer	64	18	$-9X10^{18}$ to $9X10^{18}$
Short real	32	6 or 7	10^{-37} to 10^{38}
Long real	64	15 or 16	10^{-307} to 10^{308}
Temporary real	80	19	10^{-4932} to 10^{4932}
Packed decimal	80	18	18 decimal digits + sign

Instruction Set

To access the math-coprocessor directly using software ,assembly language would be the best solution. Any assembly language programmer would be familiar with this type of instruction set. The total instruction set for programming on math-coprocessor is beyond the scope of this writing. However, some most basic instruction sets are described here.

The math-coprocessor instruction set always begins with the letter F,to distinguish it from the normal instruction of microprocessor. Some of the instruction sets are as follows :

FLD : source	Load source into the register
FADD destination,source	Adds source with the destination and holds the result in the destination.
FSUB destination,source	Subtract source from destination
FDIV destination,source:	Divide operation
FMUL destination,source	Multiplication operation

Generally, programs written in high level language such as BASIC, PASCAL,C use the math-coprocessor automatically. So, programmers working on high level language need not have to do any extra work for using the math-coprocessor. But in low level language such as assembly language, extra codes need to be written for math-coprocessor.

The math-coprocessor is a powerful device that can dramatically improve the computer's ability to perform mathematical calculations. The 80 bits long register has accuracy up to 19 significant places. This not only provides us precise result, but minimizes the probability of overflow and underflow error. ●