RAM Speed and CPU Speed: How They're Related

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TOPIC ----------

How are RAM speed and CPU speed related?

DISCUSSION ----------

RAM and CPU speed are related by cycle time and wait states.

Cycle Time

Cycle time is the minimum time it takes the processor to "turn around," or complete execution of an instruction.

On a 25 MHz CPU, the clock generates 25,000,000 pulses per second. That is to say, each pulse comes every 1/25,000,000 second (or after 25,000,000 pulses, one second has elapsed).

One divided by 25,000,000 means each pulse lasts 40 nanoseconds (4.0 x 10 EE-8). So, if the processor were running at top speed, it could write a value to RAM, change it in one cycle, and rewrite it 40 nanoseconds later. In this system, the RAM would have to be able to respond within 40ns, or 40ns RAM. However, 40ns RAM is hard to make and expensive, so someone had the idea to let the processor go fast for everything else it does, but to slow down accesses to RAM.

Wait State

Thus was born the idea of the wait state, in which the processor spins its wheels for one, two, or more cycles, to give the RAM a chance to catch up. So in our mythical 25 MHz machine described above, one wait state would mean we could use plentiful and cheap 80ns RAM. Two wait states would permit 120ns RAM, and so on.

Some designs are easy, and use a fixed number of wait states -- but not the Macintosh. Depending on what activity is being done and whatever else is going on, the Macintosh can impose a variable number of wait states.

Generally, though, if you use the calculation above with recent designs, you can assume one wait state and get the RAM speed.

(1 divided by clock speed) x 2 = ___ ns)

Wait states are not free, however. While the processor is spinning its wheels, that fast CPU and support hardware you paid for is useless. For this reason, cache RAM, which is very fast, can be used to eliminate or reduce wait states to the processor, and then the cache controller is used to write to slower main RAM. Also, though this refers to writes, the same applies to reads.

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