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CompactPCI & AdvancedTCA

Staying cool

The bounty of Moore's Law is something hardware engineers, software developers, and consumers tend to take for granted. Every year or so we're handed faster processors, more powerful peripherals, and bigger and faster memory. Hardware components just get quicker and cheaper. Software development also benefits hugely from Moore's Law. As someone once said, "what the hardware guys giveth the software guys taketh away" has led to ever more powerful software that can be written somewhat inefficiently and still perform well. Life is good. I often wish the growth of my investments year to year would follow Moore's Law. Fat chance.

There is an emerging problem, however, that may practically slow future improvements, and it is fundamental. Keeping gigahertz processors and gigabytes of memory cool enough to perform reliably is becoming more and more difficult. Electronic systems transfer heat three ways: convection, conduction, and radiation.

Convective air cooling has always been the backbone of commercial, industrial, medical, and telecom equipment. While conduction cooling and other exotic and expensive cooling technologies are used in niche applications, notably military and avionics equipment, air cooling is the primary method for cooling any piece of equipment dissipating more than a few dozen watts. Electromechanical fans and blowers have been used for 50 years to do this, and they continue to be the basic technology of choice. Although fan performance continues to improve, industry studies show it improving at a maximum of 5-10 percent per year. That improvement rate just can't keep up with semiconductors' 50+ percent annual growth in speed and transistor count that continues to demonstrate Moore's Law. It is true that semiconductors become somewhat more thermally efficient as feature size and operating voltage decrease. However, those improvements are relatively small and are becoming less so every year. When all is said and done, semiconductor die must be maintained at a temperature below the junction temperature of silicon or failure will occur. As operating temperature rises, reliability decreases not just for silicon, but also for a wide range of electronic components.

Looking at some popular and emerging technologies helps illustrate the issue. Chassis for popular 6U 0.8-inch pitch technologies like CompactPCI and VME can dissipate a maximum of about 1 watt per cubic inch of board volume. This number does not include the additional volume required for ingress and egress air plenums, so the effective dissipation for the entire chassis is probably 20-30 percent less than that. After extensive thermal modeling using sophisticated computational fluid dynamics and thousands of hours of computer time, the specialists developing the thermal specifications for AdvancedTCA were able to improve the board volume dissipation to about 1.25 watts per cubic inch. And even that modest improvement requires very careful board and chassis design to ensure unimpeded and even airflow. Component placement and airflow impedance are important considerations for board design and layout. Simply installing bigger and bigger fans often does not improve the situation unless airflow can truly be increased over hot components. Even a lightly loaded chassis can cause boards to overheat if the majority of air ends up moving through empty slots. Also the acoustic noise produced by big fans and blowers can run afoul of NEBS and OSHA safety requirements.

This issue isn't going away. Our industry needs to proactively address this problem and create not just point solutions, but rather open industry standards that will drive a large number of vendors to provide standardized, inexpensive, and general solutions. Engineers and physicists must think outside the box and explore liquid cooling, spray cooling, and conduction cooling technologies. Working towards developing standardized solutions that can be purchased off-the-shelf and written into open standards is key.

"The limit to the future of electronics is not Moore's Law; it's cooling Moore's Law. There are new ideas and techniques emerging for cooling densely packed electronics at the chip, board, and chassis level. And, many applications from telecom to military are looking for cooling methods more efficient than the traditional conduction or convection cooling techniques used today," said Ray Alderman, Executive Director of the VME International Trade Association (VITA) recently.

VITA has begun exploring some next generation technologies and is sponsoring a new conference devoted to the subject on May 17, 2005 as part of the May 16-17, 2005 MEECC conference in Long Beach, CA. Information about the CoolCon Conference is available on the VITA website, www.vita.com. This is a good start. Over the next few years this issue will become more pressing, requiring the attention of the entire industry. It is a fascinating problem, and I hope to see innovative general solutions emerge in the coming years.

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