Intelligent PCs

Last modified February 6, 2006

His hardware is equipped with more than 200 temperature sensors; your PC most often with less than three.
Courtesy and © Gripen International®

The Human Thought

When using our computer technology as a metaphor for the human thought we let it share similarities with what the *somatic* part of our nervous system is capable of providing, but the human body is also endowed with an *autonomic* one. Functioning below the conscious level, one of the the main tasks for the human autonomic nervous system is to mediate the neuronal regulation of our bodies internal environment; this by centralized coordinated control in our brains' hypothalamus and limbic system due to information provided by receptors.

The personal computer (PC) systems today in general use very few receptors. They also lack central coordinated control of their internal environments, and demand for power. A metaphor for the concept described below could therefore be that the next generation personal computer systems can become improved by being equipped with autonomic nervous systems.

In other words: Personal computer hardware monitoring and control can be much further improved; making it easier to minimize their acoustic noise emissions, energy consumption and heat dissipation, while maintaining the need for further increased performance and reliability.

Man's Imperfection

The optimal technical solutions must be those providing exactly what they are intended for, with no side-effects at all, and as cheaply as possible. Technology without any unwanted side-effects is seldom possible, imperfect as we humans are. Regarding PCs, acoustic noise emission as an unwanted side-effect is just one example of our shortcomings. An other, of growing importance, is heat.

In a perfect World electronic circuits and mechanical devices wouldn't generate any heat at all, and consume only the power needed for their actual work. Today we are able to produce electronic circuits and mechanical devices that run rather cool, and consume little power. If we want them to run as fast as possible - and this is most often what we want, then we still have to accept that they generate a lot of unwanted heat and consume a lot more power than actually needed. Heat do threaten the reliability of electronic circuits and mechanical devices, and must therefore be kept as low as possible.

If heat wasn't an issue PC noise emissions would be easy solved just by enclosing the noise generating components or the whole system unit in noise dampening material. This is rarely possible, because the material that has to be used will at the same time tend to further increase temperature.

Noiseless cooling of PC electronic circuits and mechanical devices using passive convection can be a solution to these machines' heat issues, but current practice often results in separate active cooling solutions for each of the main PC components. Those active cooling solutions being mechanical devices like fans, not only minimize heat, but also tend to add to the other PC technology main unwanted side effect - noise.

Active cooling solutions not only tend to add PC noise, but also needs energy to do their job, increasing the power consumption of PCs.

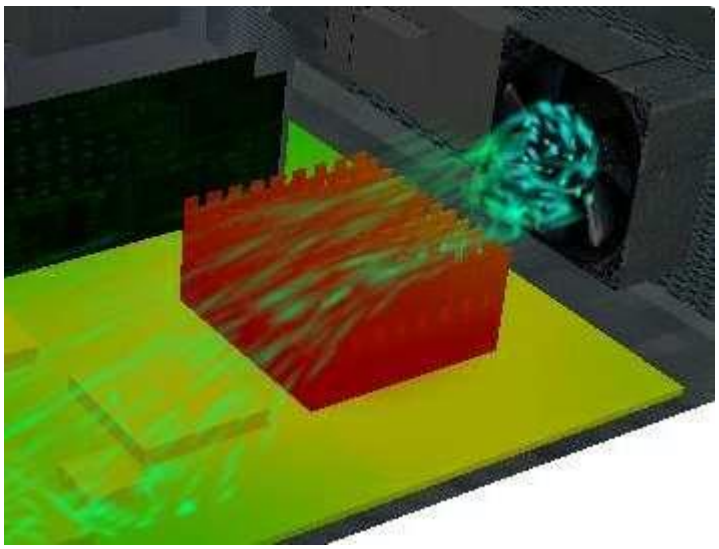


Image of Flotherm® software thermal analysis. Courtesy of Flomerics®

The Challenge

Recent years has the computer industry main solution to the increasing thermal issues of PCs been to add increasing numbers of fans and more efficient fans for cooling. Fans represent an inexpensive and uncomplicated way to cool electronic circuits and mechanical devices, with the disadvantage that they generate acoustic noise and consume some electricity. These fans have for safety reasons, and also because of a lack of coordination of PC components regarding thermal issues, most often been oversized and single speed. This means they have been making more noise and consuming more electricity than actually necessary.

There is an increasing awareness that acoustic noise emissions often make the home and working environment less comfortable, and can make it harder to concentrate. Acoustic noise emissions, heat dissipation and an unnecessary high power consumption of today's personal computers are accepted as the norm. Now is the time to challenge this and begin to make changes.

Are today's PCs Dependent upon a Doctor?

Until now we have seen a few PC hardware manufacturers with foresight inventing special designed solutions for their products regarding power management, thermal monitoring and adjusting cooling according to need. This hardware has most often been associated with a specially designed software interface, and the solution for natural reasons marketed with names including words like "smart" or "intelligent".

Some of the companies in the computer industry have also chosen to use names including "doctor" for solutions for hardware monitoring and control. This fact could be worth analyzing using a metaphor: Does the human body under normal conditions need a doctor for to keep control of its inner environment?

Industrial Cooperation

Now it seems like the time could have come to make the entire personal computer system concept smarter and more intelligent. It could be the time to work for a sustainable solution to PC thermal and reliability issues, the time to work for a sustainable solution to PC noise emissions and electric power consumption. It could be the time for the computer industry to deepen their cooperation on standardization to further improve the inner and outer environments of PCs:

1) The PC system unit as an inner environment in which every component has its unique function for the system, but also have to be made able to report critical common factors like temperature to the system, and have to be made capable of not using more power at any given time than needed.

2) The outer environment the World in which the PC has become a very important utility, but in the future not at any price: Not at the price of an un-optimized acoustic work or home environment. Not at the price of a worsened World environment consuming more electric power than actually necessary for its function.

An Industrial Editorial

In the ElectronicsCooling industrial magazine editor-in-chief Kaveh Azar writes the editorial "Thermal management and good citizenship". Here are a few lines:

"The market is mandating higher frequency, and thus higher power, but are we designing as intelligently as we can? Are we considering all options and consequences before we finalize our designs? Or has our desire to achieve a short time-to-market interval blinded us from seeing the bigger picture?
Whether we like it or not, the decision must be made! If we do not take the initiative on our own to design for less power consumption and less heat dissipation, governmental agencies will make that decision for us." (Volume 7, no 1. Feb. 2001, p1).

ElectronicsCooling is a magazine dedicated to engineers responsible for thermal management in the electronics industry. It is published by Flomerics, Inc.

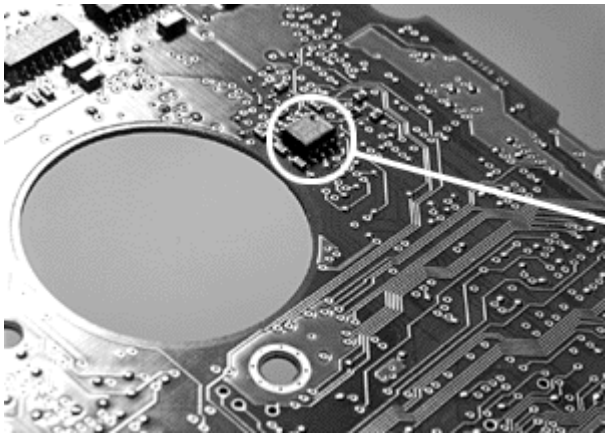
Temperature Monitoring & Control

To be able to control temperature, and secondary to that noise emissions and power consumption, the first step is to start measuring this physical property. It is always possible to measure temperature on the outside of a electronic circuit or mechanical device, but the most accurate measurements are accomplished by measuring within the component itself. Built-in, or as also said, on-die temperature sensors are today already seen in most high quality PC processors (CPUs), and the temperature of these chips can often be checked within the BIOS or within a PC "health" or hardware monitoring software interface. A few advanced PC motherboards already adapts the CPU cooling fan speed according to the CPU chip's inner temperature.

But why should thermal sensoring be limited to CPUs? Today one of the most heat generating components in a PC is the graphic card, most often equipped with a cooling fan of its own. Commonly graphic cards don't feature thermal sensoring, and if they do they have no possibility to report temperature to the motherboard, because motherboards these days are not made able to handle thermal data from graphic cards. Hard disks - some of the main providers of PC noise - generate so much heat that they most often can't be enclosed in noise dampening enclosures - in spite of this they do only on rare occasions feature thermal sensoring - a fact that might be hard to accept if one thinks on how safe ones valuable data actually is on such storage media. Recently even some

motherboard chips has been built so hot-running that they need an active cooling solution - they do not report their inner temperature, and there is no motherboard unit implemented that can handle such data. Some PC power supplies do feature thermal sensoring and regulation of their fan speed according to need but, as with most heat generating components in a PC system unit today, they do not report their temperature anywhere else than to their own electronic circuits.

Today those interested can find themselves utilizing at least three different hardware monitoring software interfaces for just to be aware of and able to control such a basic factor as the PC system temperature. The CPU and motherboard use one, the graphic card an other and the hard disk yet an other. Wouldn't it be better to centralize these measurements and implement *one* software interface for all temperature reporting PC components? Wouldn't this be more "intelligent"?



IBM's Drive Temperature Indicator Processor, DriveTip. IBM was one of the first manufacturers to integrate temperature sensors in hard disks. Courtesy of IBM®.

The Benefits of Coordination

By improving the PC system by making it aware of its parts' demand for **power** in any given situation, and the main PC inner environment issue - **heat** - it will be possible to - directly or indirectly - increase PC reliability, lower PC power consumption, minimize PC noise emissions and at the same time prepare for future technical challenges. To reap these benefits, and maintain an open PC architecture, PCs have to be made aware of power consumption and temperature, and PC cooling capabilities have to become coordinated. This implies that:

1) Standardized temperature sensors, today only half-heartedly utilized in PC systems, have to be built-in not only in all PC components generating a certain amount of heat, but also in all heat *sensitive* PC electronic circuits and mechanical devices.

2) All vital power consuming parts of the system have to be built capable to continuously report their demand for power.

3) A standardized circuit at the motherboard has to be built responsible to handle data on demand for power, and thermal data from all of involved temperature reporting parts, and it has to be made capable to coordinate the regulation of power demand, and cooling for all of them.

4) Motherboards will have to be built with a new standardized bus, or the already existing buses have to be made capable to transmit new data, in order to connect the temperature sensors, and the data on demand for power, with the motherboard thermal/power control circuit, and to connect the motherboard thermal/power control circuit to what has to be controled.

5) Temperature and demand for power reporting have to be included in the "plug-and-play" (PnP) concept, making it easy to create the connection of the demand for power and temperature reporting components to the motherboard circuit.

6) Operating systems have to be made capable of communicating need for power and thermal data.

The Future of Cooling

PC cooling has yet not concluded its role. Taking in account the increasing awareness that acoustic noise emissions often adverse effect human well-being and make it harder to concentrate, and the increasing demand on more energy-efficient computer systems, the near future may sort out three main issues in PC cooling technology:

1) Fan cooling: Improved utilization of fans by making the personal computer system unit aware of and capable of adaptive cooling according to need. It is probable that we will see an increased utilization of slow moving noiseless high efficient cross flow fans. PC case manufacturers will also most probably increase the use of sound insulating material and so called "noise-locks". Sound insulating material will tend to increase system heat, which will make it even more important that the system is aware of this physical property.

2) Watercooling: Those people not satisfied with anything else but the fastest and most capable technology will be utilizing watercooling. This is a technology

far more efficient than utilizing air for cooling. This active cooling technology is also much easier than fans to make run silent. The people that utilize watercooling will be the ones that also are the most interested in knowing what temperature the components in their systems possess. Watercooling systems will also have to be made capable of shutting off the system if something goes wrong with the cooling system, and heat increases. Thus will it be essential with built-in temperature sensors in all heat generating components of the system and a central unit for thermal awareness and control also in watercooling systems.

3) Passive cooling: In addition to many home users, any in the World's public institutions and most ordinary offices, would be fully satisfied with the performance of already existing PCs capable of running with noiseless passive cooling. Passive cooling today is complicated because the temperatures that the system unit components reach is unknown. Being capable of maintaining an open PC architecture and at the same time making it easier to choose to use passive cooling requires the personal computer system to be aware of temperature, and shut it self off if necessary

A watercooled graphic card. Handiwork by BladeRunner - Zero Fan Zone.

The Affordable Cost

Talking to some in the computer industry it seems like the price for a mass produced PC system unit equipped with thermal awareness and adaptive coordinated cooling capabilities would increase by less than 5 US$.

It is understandable that implementing PC thermal awareness, and coordinated adaptive cooling capabilities according to temperature, in the initial phase will cause some compatibility issues to handle, but is there a sustainable alternative?

Some people might object that fullfilling the idea is unnecessary and too costly. They might say that thermal measurements can be left to the computer industry to do as they manufacture the system units and components; like the computer industry always did. Is this self-interest or the greater good? Does the computer industry have an other solution to the heat, noise and electric power consumption issues of electronic circuits and mechanical devices in their hip-pocket? Will Intel®, IBM®, Philips®, AMD®, VIA®, Toshiba®, Hitachi®, Dell®, Fujitsu Siemens Computers®, NEC®, ASUS®, Hewlett-Packard®, Motorola®, Phoenix Technologies®, Panasonic®, Transmeta®, Papst®, Analog Devices®, ST Microelectronics® or any other important company in the computer hardware industry come up with a better solution to these issues in the near future, making implemention of PC thermal awareness, and coordinated adaptive cooling capabilities according to temperature superfluous?

Will we soon reach a state when we will stop building faster and more capable PCs or PC components? A state where people don't find the need for any improved PC performance? A state where PC heat, noise and power consumption issues easy will keep pace with the need for performance? Are these days of heat dissipation of technology just an aside, and will these problems be overcome in the near future? No, probably not. Letting it all be as it has been will most possibly in the long run tend to make it more complicated to improve PC acoustic ergonomy, tend to make it more difficult to improve PC reliability, and tend to conserve an unnecessary high PC electric power consumption.

It is of course sad and uncomfortable, but understandable, that thermal awareness and coordinated adaptive cooling capabilities were not implemented when the personal computer was born: At that time heat dissipation and power consumption of PCs were not that much of a problem. At that time, still living in the era of the industrial society, information technology noise emissions were not much of an issue either

An Aware CPU Manufacturer

Intel® is one of the leading information technology manufacturers working for PC thermal awareness and control.

Intel Pentium® processors (CPUs) have for a long time been equiped with high-quality on-die temperature sensors and solutions for to

slow down or shut off the CPU, if a temperature limit is reached.

Intel is one of the important contributors to the ACPI specifiction.

Intel is behind the BTX form factor, replacing the ATX one. The BTX specification gives developers options to balance thermal management, acoustics, system performance, and size in the system form factors and stylish designs that are desired in today's products.

Intel was the first known CPU manufacturer utilizing integrated heat spreaders for to make the CPU contact surface area to the heatsink as large as possible; for to improve heat evacuation.

In the article Differentiating PCs in a 'Toaster World' does Analog Devices and Intel provide some of the latest knowledge on how Man reacts to noise, rules out the important relation between heat and noise, and tell how it can be minimized by adding thermal awareness to the system.

Note that The Silent PC® is an independent publication and has not been authorized, sponsored, or otherwise approved by any of the companies or other sources at the site mentioned or cited.

An Aware Software Manufacturer

Microsoft®, the World's most important software manufacturer, well-known for its Windows® family of operating systems, is also one of the leading information technology manufacturers working for improved PC thermal awareness and control, and improved PC power management.

PC Ecosystem Advances by Microsoft is a writing that share many of the thoughts at this page:

"Microsoft wants the Windows platform to be a profitable place for partners to invest and innovate. However, for PCs to be compelling, they must be designed from a "whole system" standpoint, taking into account performance, features, stability, business viability, and human factors such as acoustics, aesthetics, and ease of use."

"Think of the PC hardware as an ecosystem that depends on the interactions among the core of the Windows operating system, the core PC architecture, the firmware, and all devices with their drivers, including system-level devices. It is the quality of the interaction of individual components within the platform as a whole that defines the quality of the users experience."

Advantages of PC Thermal Control

Less noise and reduced power consumption

A central temperature controling motherboard unit, equipped with a user interface as a part of the operating system, can be built able to calculate the demands for cooling in the different areas of the PC system unit, and regulate cooling according to actual needs, rather than at full speed as a precaution. Being able to monitor temperature and regulate cooling according to need, PC cooling can become optimized so that it isn't used more than necessary, thus also possible minimizing the noise emissions from what ever cooling technique is used. Lowering the average effect of active cooling will also make it possible to reduce electric power consumption.

Improved reliability

In the future is it most possible that we will see fans being replaced by either other active cooling solutions like watercooling, or more often by noiseless passive cooling solutions - a fact that most probably doesn't make continuous temperature measurement redundant. Even if some in the computer industry can develop cooler running components than the others, they will probably have to build them being able to be used in systems where other components generate so much heat that they can threaten reliability also of their own cool running components.

Motherboards featuring a temperature control unit can be constructed to be responsible for alarming, or shutting off a problematic component or the whole machine, if an upper temperature limit is reached. The control unit can also be built featuring a log system, which can make it easy to find out what component causes problems or the system unit to halt because of overheating.

Enclosing hard disks or whole system units in sound insulating material can become safe with temperature-aware PCs, since it will remove the fear that the PC system unit or some of its components will overheat.

Maintained open PC architecture

Most people today want to be able to update their PC systems. Designed for coordinated adaptive PC cooling, cooling of the system will be built to increase if a new component adds heat, or obstructs air flow. Other advantages with the

concept is that OEM manufacturers of system units, and people wanting to build their own system units, wouldn't have to do external thermal measurements - new system designs can regarding thermal issues be possible to evaluate from within the systems themselves.

Reduced costs

Implementing a central temperature control unit might also in the long run reduce costs of PC hardware, since it will make it unnecesary for every component to be built to protect itself from overheating. The system will take care of such a vital thing, and each manufacturer will only have to ensure that his component provides the necessary data to the thermal control unit.

Improved control

No one would like to drive a car not capable of showing and controling motor temperature. Today's PC users are becomming more and more aware. They want control. Aware PC users want more than today's half-baked hardware monitoring solutions.

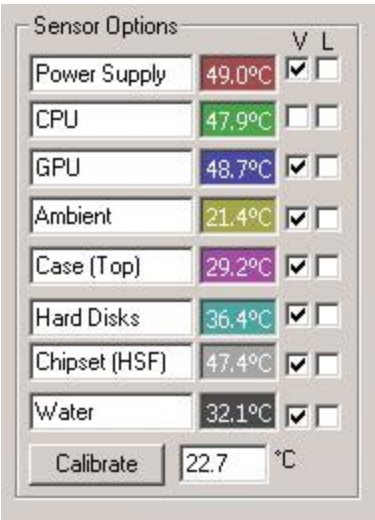
Pressure to produce energy-economic components

Building almost all PC components capable of reporting temperature will make the user aware of which components generate what amount of heat. This will increase the pressure on the industry to produce energy-economic components with less heat dissipation.

Freedom of choice

The consumer will with "plug-and-play" temperature reporting of PC components find it easier to determine if a new component will be sufficiently cooled in his system using a noiseless heatsink, or if it needs an active cooling technique. PC components can be manufactured with an option for passive or active cooling - in an already hot system the consumer has to choose the active solution, in the cool system he or she can choose the passive one. It can with such a standard also become easier to choose if one wants the most extreme and fast, but hot running component, or if one can sacrifice a bit of performance for a reduction of noise - and also at the same time a lower electric power consumption.

Images of the Future



Like this will we possibly in the future be able to check that our PC systems are healthy regarding temperature. In the traybar we see a graph telling us that every main component in the system is within its temperature limit. If we click on the graph the full program shows up.

The images here shows part of the interface for the program **GL Temperature Sensor** made by Jon Cage. He has also built the temperature monitoring circuit for it.

Dynamic Power Consumption

By producing PCs whose components only use as much power as is needed in any given situation, the total PC power consumption can decrease. This will tend to reduce the average temperature of the PC components, at the same time reducing the need for active and - most often - noise generating and electricity consuming cooling solutions. Reducing electric power consumption of personal computers will make them more environmentally friendly.

Psychoacoustic Considerations

When promoting the benefits of dynamic power consumption and dynamic cooling of PCs, you have to be aware of the fact that a continuous higher noise level can be apprehended as less distracting than a noise level that fluctuates too often and too fast, even if this overall noise level is lower than the higher continuous one:

Psychoacoustic considerations must be taken in account when designing circuits for dynamic PC cooling.

In the article "Managing Thermal/Acoustic Trade-Offs in High-Performance Systems" Analog Devices discuss how to best implement dynamic PC power consumption and dynamic PC fan cooling in relation to how humans hear.

System Theory

Core conflicts in all systems are those of autonomy and dependence, of autonomy and subordination.

This page deals with two important systems: That of the personal computer system and that of the computer hardware industry system. Today the components comprising the personal computer hardware system are only partly working in the direction of what must be every system's main goal - to provide what's intended with a minimum of unwanted side effects, with as low costs as possible. It will be possible to improve this fact by subordination of some of the personal computer components in some respects - this way making them better able to cooperate on mastering their unwanted side effects.

The companies constituting the computer industry have been most impressive in working together on standardization, to subordinate on a main goal: To provide the World with the personal computer systems. Having been capable of that it seems like it just should be a matter of interest to also deepen a cooperation on some more standards with the goal to reduce the main unwanted side effects of their systems. If the computer industry choose to do so, might we in some years have even more reasons to be proud of our computer technology, and will have reasons not only to let it share similarities with the human thought, but also with the way our nervous system and body works.

Temperature Controling Motherboard Circuits

Integrated circuits like these can become the circuits that monitors temperature, tells the interested user about it, controls cooling according to need, warns if a high tempeature limit is reached and shuts the system or a problematic component off, if a reliability threatening temperature limit is reached. They can become the center of the the implemented "Intelligent PC" concept.

To take full advantage of the concept should these integrated circuits be made capable of monitoring at least the CPU, graphic card, power supply, motherboard, north bridge chip and hard disk temperature, and capable of controling these components' coresponding active cooling solutions according to need; at the same time as human psychoacoustic considerations are taken in account: Varying speed of cooling solutions must be done carefully - sometimes a continous little higher noise is easier to stand than a varying noise at lower levels. They should also be made capable to interact with the user via the operating system.

Analog Devices® in February 2002 released an integrated circuit, ADM1027, with the purpose to minimize PC acoustic noise emissions: "It can monitor the temperature of up to 2 remote sensor diodes, plus its own internal temperature. It can measure the speed of up to 4 fans and control the speed of up to 4 fans so that they operate at the lowest possible speed for minimum acoustic noise. The Automatic Fan Speed Control Loop optimizes fan speed for a given temperature. Measured values can be read out via a serial System Management Bus, and values for limit comparisons can be programmed in over the same serial bus." Here is the press release for this their first dBCOOL™ chip, and here for the more recent ADT7460 and ADT7463 chips. Image courtesy of Analog Devices.

In the article Differentiating PCs in a 'Toaster World' does Analog Devices and Intel provide some of the latest knowledge on how Man reacts to noise, rules out the important relation between heat and noise, and tells how it can be minimized by adding thermal awareness to the system.

In the article "Managing thermal/acoustic trade-offs in high-performance systems" Analog Devices teach how they are building their latest temperature monitoring and cooling controling circuits so that both reliability considerations and psychoacoustic demands are met. Here can the article be downloaded as a pdf file.

Other circuits from Analog Devices: "The ADM1030 and ADM1031 are single-channel and dual-channel (respectively) remote thermal monitors with a unique programmable and automatic fan speed controler, for use in notebooks, PCs, microprocessor-based office equipment and other thermal management systems. For notebook or portable applications, the ADM1030/31 fan control loop minimizes acoustic noise and battery consumption." Here is Analog Devices' Complete Temperature Sensor Family

MSI™ - their CoreCell™ Chip includes fan speed control according to temperature.

Integrated Technology Express, Inc.®: Their IT8702F chip has twelve logical devices integrated. One of them is a fan speed controler responsible for controling three fan speeds through three 128 steps of Pulse width modulation (PWM) output pins and to monitor three fans' tachometer inputs. Their IT8712 chip also provides the latest Environment Control initiatives, such as H/W Monitor, Fan Speed Controler and ITE's "SmartGuardian" function.

National Semiconductor®: Their PC87366 chip among a lot other functions incorporates fan speed control and monitor (FSCM) for three fans.

Silicon Integrated Systems Corp®: "The SIS950 features the enhanced hardware monitor providing 3 thermal inputs from remote thermistors, thermal diode or diode-connected transistor (2N3904). The device also provides the SiS

innovative intelligent automatic Fan ON/OFF & speed control functions (SmartGuardian) to reduce overall system noise and power consumption."

Winbond Electronics Corporation®: their Winbond 83627HF and Winbond 83697HF (a stripped version of the 83627HF) hardware monitoring chips, used by some motherboard manufacturers, adds the ability to control fan speed as system and/or CPU temperature varies. Here one can read some more on their SmartFan technology.

Examples of Companies

Examples of companies, other than the above integrated circuit manufacturers, now seem to be working in the direction for implementing a temperature and power consumption mastering "PC autonomic nervous system" are National Semiconductor® with their SensorPath™ Interface Technology, ASUS® with their SmartDoctor technology for graphic cards, IBM® with their hard disk Temperature Indicator Processor - Drive-TIP, Intel® with their CPUs with integrated temperature sensor, ACPI and ATX specifications, and Microsoft® with their OnNow design initiative. A motherboard manufacturer that has included fan speed regulating according to need for cooling is Fujitsu Siemens Computers® with their D1184 and other more recent boards. An other aware motherboard manufacturer is AOpen® with their SilentTek and SilentBIOS solutions. AMD® with its Cool'n'Quiet™ technology. The Apple® PowerMac® G5 machines features a thermal zone thinking where fans can be adjusted individually to increase or decrease the temperature of a single zone without affecting the others.

Already existing standards

ACPI

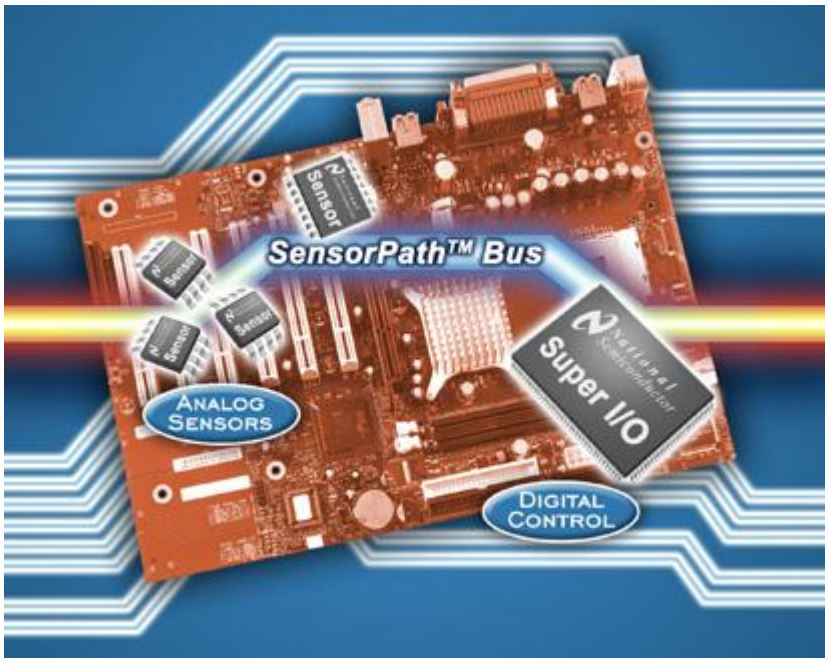
ACPI (Advanced Configuration and Power Interface) is an open industry specification co-developed by Compaq®, Intel®, Microsoft®, Phoenix®, and Toshiba®. It establishes industry standard interfaces for OS-directed configuration and power management on laptops, desktops, and servers. The ACPI specification provides today's most well-reasoned standard for PC power management and thermal regulation according to need.

SensorPath™

SensorPath™ Interface Technology is a new bus invented by National Semiconductor Corporation:

"Today’s PCs present an increasingly difficult challenge for thermal management and control. Continued increases in the clock speed of processors, memory, chip set and graphic chips have dramatically raised temperatures inside PCs and increased the demands of hardware monitoring and, at the same time, prices for PCs and components continue to fall. In addition, new requirements such as minimizing acoustical noise, simplifying board routing, and standardizing platform designs add to the complexity of designing a thermal management solution. The situation promises only to worsen with upcoming generations of PCs, as new high-speed buses like PCI Express™ and smaller form factors emerge.

Until now, the choices have been filled with tradeoffs: integrated digital and analog solutions cramp flexibility because of the difficult analog signal routing. Stand-alone solutions have higher accuracies and route easier, but are more expensive."



Developed as an open standard for all manufacturers the SensorPath™ bus can improve PC thermal and acoustic management.

"It [SensorPath™] isolates temperature and voltage data onto a dedicated bus that is optimized to the purpose, enabling both independent and centralized control of the thermal management system. The bus uses only one wire to connect the SuperI/O and the sensor, simplifying board design and easing placement of components. The interface is digital, so there is no problem routing the signal."

This is the news release for SensorPath™, presented at Intel® Developer Forum, San Jose, Ca, - September 15, 2003.

Cost Effective Partitioning of IO and Management Functions in PCs - Introduction of SensorPath™ Technology

Developed as an open standard for all manufacturers the SensorPath™ bus can improve PC thermal and acoustic management. and other countries.

I2C

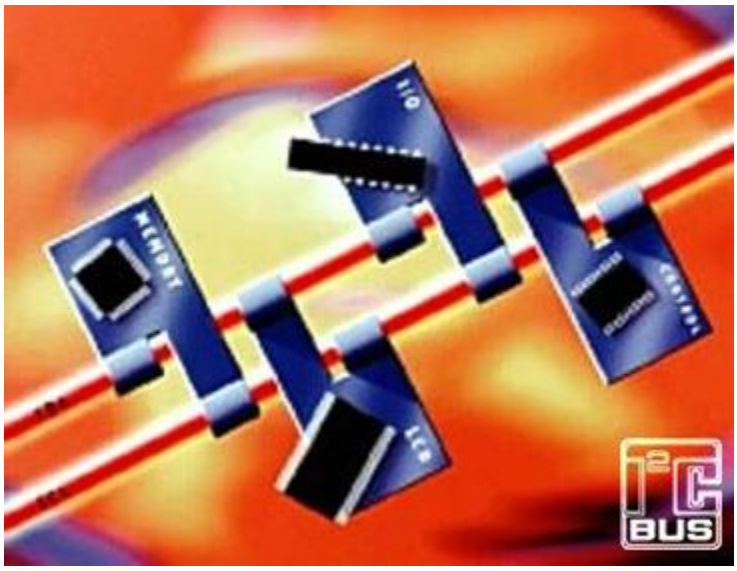
The I2C bus is the worldwide industry standard control bus; providing a communication link between integrated circuits. It is a system management bus that can be utilized for hardware monitoring, like that of temperature sensors, and also for controling active cooling devices. The I2C bus was developed in the early 1980's by Philips semiconductors®. I2C is an acronym for Inter-IC bus.

Here you can read more on I2C:

Philips Semiconductors: An overview on the basic principles of the bus, mostly written so that also ordinary people can understand.

Philips Semiconductors - Logic: Intended for engineers.

I2C Zone: Links to FAQs and more.



The I2C bus. Courtesy and © of Philips Semiconductors, Logic Products Group.

SMBus

The System Management Bus is a two-wire interface through which simple power-related chips can communicate with rest of the system. It uses I2C as its backbone. SMBus was defined by Intel® Corporation in 1995.

With the SMBus, a device can provide manufacturer information, tell the system what its model/part number is, save its state for a suspend event, report different types of errors, accept control parameters, and return its status.

This seems to be the main site for SMBus.

Comparing the I2C Bus to the SMBus: "The I2C bus and the SMBus are popular 2-wire buses that are essentially compatible with each other. Normally devices, both masters and slaves, are freely interchangeable between both buses. Both buses feature addressable slaves (although specific address allocations can vary between the two buses). The buses operate at the same speed, up to 100kHz, but the I2C bus has both 400kHz and 2MHz versions. Obviously, complete compatibility between both buses using all devices is ensured only below 100kHz."

ATX

The ATX form factor was invented by Intel® in 1995. A PC form factor describes the shape and layout of PC motherboards, cases and power supplies. In the ATX Thermal Design Suggestions one can read about fan speed control according to need. The heading is Advanced Thermal Management. Here one can download all the ATX documents including the latest specifications. The ATX power supply form factor already includes additional power signals that can be, but today seldom are, used by motherboards to monitor and regulate fan speed of the PC power supply according to need for cooling.

The PCI Bus

The PCI Bus Power Management Interface Specification and 3.3 Vaux ECR "is a new specification developed to enhance the base PCI Bus Revision 2.1 architecture to include standardized power management capabilities. The new specification is architecturally aligned with the ACPI specification, and as such, enables PCI devices, both motherboard and add-in, to participate in platform-wide operating system-directed power management."

PCI-SIG

PCI-SIG, Peripheral Component Interconnect Special Interest Group, is a group of companies creating specifications for products for the PCI bus. By now they

answer that they are not aware of a proposal to implement temperature sensors in the PCI standard. They say that a system could support temperature sensors independent of the PCI bus.

The PC 2001 System Design Guide

The PC 2001 System Design Guide is a technical reference from Intel® and Microsoft® for designing PCs and peripherals for the Microsoft Windows® family of operating systems.

S.M.A.R.T.

Self-Monitoring, Analysis and Reporting Technology (S.M.A.R.T) is a technology that enables a PC to in some cases predict the future failure of storage devices; like hard disk drives. Some of the most careful hard disk manufacturers have implemented thermal sensoring in their use of this standard; a standard invented for to protect the users valuable data. Here one can read more on S.M.A.R.T: IBM®, Seagate®, Maxtor® and Quantum®.

The Technical Committee T13

The Technical Committee T13 is responsible for all interface standards relating to the popular AT Attachment (ATA) storage interface utilized as the disk drive interface on most personal and mobile computers today. Their ATAPI-6 standard is still in development, so it is impossible to be sure exactly what features and changes it will include. It is possible that built in temperature sensors in hard disks will be a part of the coming ATAPI-6 standard, and that its related SMART

hard disk health monitoring software now also will assist in temperature measurement. A new feature open discussed by the group for the ATAPI-6 standard is "acoustic management": technologies to allow the hard disk to be controled by software, letting the user choose between higher performance or quieter operation.

Accelerated Graphics Port Implementers Forum

Accelerated Graphics Port Implementers Forum: The Accelerated Graphics Port (AGP) interface is a platform bus specification that enables high performance graphics capabilities, especially 3D, for PCs at all price points. It's today unclear if this group works for temperature and power-aware graphic cards.

The Intelligent Input/Output Specification

I2O, Intelligent Input/Output, is a specification which aims to provide an I/O architecture that is independent of both the specific device being controled and the host operating system. It has been proposed by Intel®, and is supported by many major system and peripheral manufacturers. You can read more about it here, and here is a good site too.

The Universal Plug and Play Forum

The Universal Plug and Play Forum "is an industry initiative designed to enable easy and robust connectivity among stand-alone devices and PCs from many different vendors."

Energy Star®

Energy Star "is a dynamic government/industry partnership that makes it easy for businesses and consumers to save money and protect the environment." The current Energy Star specification for computers is based upon and limited to energy consumption during low-power/'sleep' mode.

The Energy Star specification for computers is since 2004 under revision. For the first time, the draft spec introduces power consumption targets while the computer is actually powered on and running. Here is a SilentPCReview article on this subject, and here you find the EPA documents.