TECHNOLOGY BRIEF

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Compaq Computer Corporation

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The Effects of New Technologies on Power and Cooling Requirements

Emerging technologies are affecting the power and cooling requirements of today's business computing equipment. Processors, hard drives, and redundancy are some of the forces driving requirements higher. The trend is affecting small and medium businesses as well as enterprise companies. Changes in the power required for a system and changes in its delivery are important enough to warrant a close look by the customer before making purchase decisions. The implications for a customer's facilities may be negligible or may be significant depending on the equipment and its deployment.

This brief is intended for customers considering moving to a higher-performance system or systems. It will help customers understand why power and cooling requirements are becoming more stringent and why careful facilities planning is needed before purchasing new equipment.

Please direct comments regarding this communication to the ECG Technology Communications Group at this Internet address: TechCom@compaq.com

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The Effects of New Technologies on Power and Cooling Requirements
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INTRODUCTION

Many companies are faced with the challenge of upgrading their computer systems to meet the growing demands of their businesses. To address this need, Compaq servers, workstations, and storage products provide higher performance and larger capacities than ever before. The very nature of computer design dictates, however, that improved performance and storage are burdened with increases in power and cooling requirements. Consequently, power and cooling management issues must be addressed when upgrading a computer system. Customers can eliminate or minimize power and cooling issues by properly designing their computer facilities to accommodate upcoming computing technologies.

This technology brief discusses emerging technologies and their implications for customer planning.

A HISTORICAL PERSPECTIVE

Compaq introduced its first server, the Compaq Systempro only nine years ago. The Systempro evolved from the desktop PC and retained several PC features including the power supplies. In contrast, the ProLiant 7000, introduced in 1997, was totally designed as a high-end, enterprise-class server. Table 1 compares standard features of these two servers and illustrates the evolution of performance, memory and storage that has occurred.

Table 1. Standard Features of two Compaq servers.

	Systempro	ProLiant 7000
Processor	Up to 2 Intel 486DX/66, 486/33, or 386/33 processors	Up to 4 Intel Pentium II Xeon 400 MHz processors
Memory	8 MB or 16 MB of enhanced page memory. Up to 256 MB using optional memory expansion board in dedicated memory slot.	256-MB of ECC buffered EDO memory, expandable to 8 GB using industry-standard DIMMs
Cache Memory	512 KB ServerCache	Integrated 512 KB Level 2 or 1 MB writeback cache per processor
Internal Storage Capacity	4.08 GB	218 GB (hot-plug drives)
External Storage Capacity	29 GB	Up to 6.988 TB of external storage using Fibre Channel Host Controllers, Hubs and Array Storage Subsystems.
Expansion Slots	6 EISA slots	10 total: 9 PCI Hot Plug slots, and 1 ISA modem slot

Increases in performance, memory, and storage carry a price – increased power supply requirements. Figure 1 compares increases in storage to the power required for system operation.

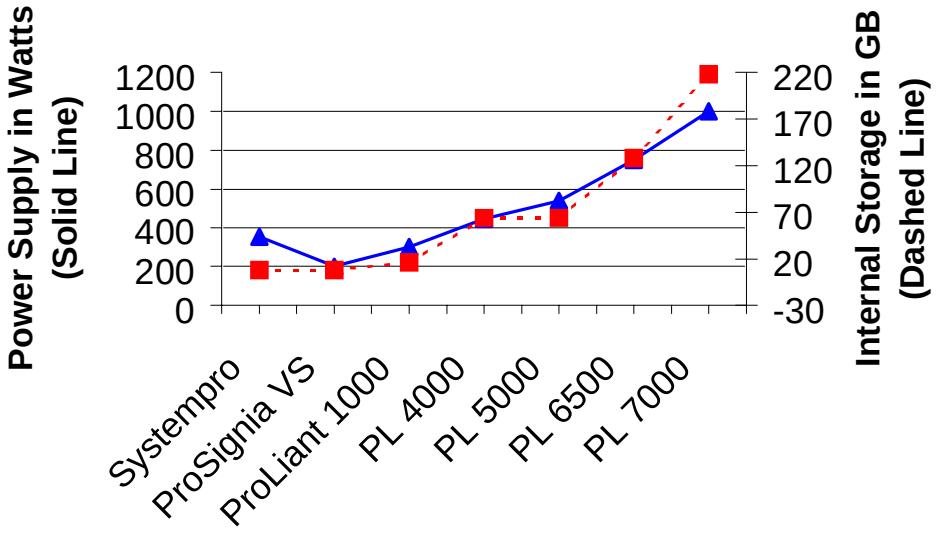

Figure 1. A comparison of internal storage and wattage in Compaq servers. Note the secondary Y-axis on the right.

Today's enterprises have tremendous computing power available at the touch of a button; but computing environment designers must understand and meet the power and cooling requirements of these industry workhorses before deploying them in their business.

NEW TECHNOLOGIES PUSH POWER HIGHER

Several upcoming technologies will increase power requirements of Compaq computing systems. The push for higher power is originating in several different areas from the processor level up to the rack level.

Processors

Computer processors, the heart of any computing system, have undergone radical changes. Processor voltages have dropped from 5 volts (in 1989) to 2.5 volts and will be at 1.8 volts in the next-generation processors. Power distribution techniques have changed. For example, in Compaq servers today a voltage regulator module (VRM) converts the 12-volt supply to the precise voltage required by the processors.

This trend continues with the release of faster Intel Pentium II Xeon processors, and will grow with the processor code named Merced. For example, Figure 2 shows how power requirements for processors have increased.

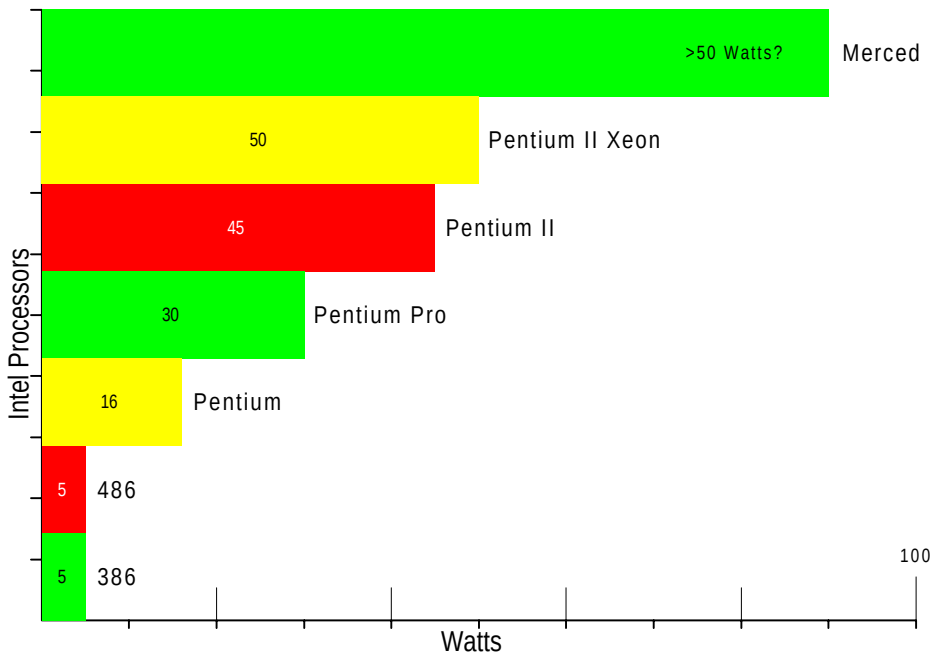

Figure 2. Processor power requirements.

Figure 2, shows that a four-processor Pentium II system draws 180 watts and a four-processor system using Pentium II Xeon draws 200 watts for the processors alone. Merced-based, n-processor systems will draw more power. Eight-processor systems, which Compaq anticipates announcing in early 1999, will consume approximately twice the power of four-processor systems.

Hard Drives

Like other computer subsystems, hard disk drives have also undergone radical changes. The most common drives in the industry are the 7,200-rpm drives. These drives consume approximately 18 watts of power and are rated to 35 degrees Celsius. Second-generation 10,000-rpm (10k-II) drives, introduced in 1997, run at approximately 21 watts and are derated to 30 degrees Celsius. Although power requirements dropped from first- to second-generation 10k drives, cooling is still an important consideration.

Servers, Workstations, and Storage Systems

The issues facing servers and workstations vary with the class of computer and its intended purpose.

Enterprise-Class Servers

The new generations of enterprise-class servers incorporate Pentium II Xeon and eventually Merced processors. These higher wattage processors in multiple processor configurations will require high-line power to run anything more than the minimum configuration. Design limitations dictate that low-line power from next generation power supplies will be approximately one-half that of high-line power. This is an important change, since present power supplies provide approximately two-thirds of the power of high-line voltage. Moreover, customers will not get maximum value or functionality from power supplies of these high-end servers if they operate on low-line power.

Low-line power – 100 to 127 volts AC, 50 or 60 Hertz

High-line power – 208 to 240 volts AC, 50 or 60 Hertz

Future enterprise-class servers will also contain more processors (up to eight), more memory (up to 16 GB), larger capacity hard drives (18 GB), and more drive controllers. These subsystems produce a powerful, high-performance server but bring with them additional power and cooling requirements. Compaq develops servers to maximize cooling with heavy-duty fans to draw air though the unit and a chassis designed to direct airflow over hard drives and processors. Nevertheless, power and cooling issues remain. The next generation of power supplies for high-end servers is optimized to handle the power requirements imposed by four- and eight-processor servers.

Departmental Servers and Storage Systems

Departmental servers and storage boxes face a slightly different challenge than enterprise-class servers. For those servers equipped with N+1 redundant power supplies and a small form factor (5U or 3U), the large number of cables in a rack environment can be a concern (Figure 3). Next-generation storage boxes will be available with N+1 redundant power supplies as well, which adds to the cable proliferation issue. Switching to high-line power can satisfy the need for extra power and reduce the number of power cables needed. Careful cable layout and use of cable management arms within the rack will help reduce cable issues.

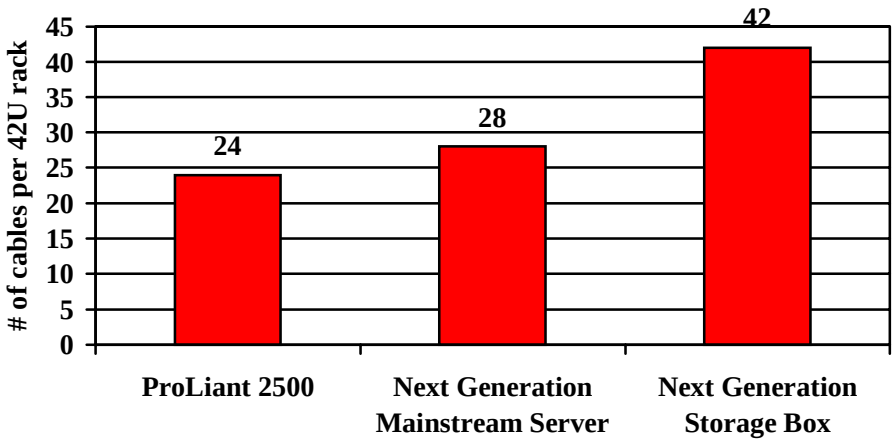

Figure 3. The number of cables is increasing to answer customer requirements for N+1 redundancy and more storage.

Density of workgroup servers and storage boxes requires special planning and placement of the rack. High-density systems require good ventilation to remain within the required temperature specifications. In areas other than appropriately designed computer rooms, cooling requirements require extra attention.

Workstations

Workstations are often found in the same dense rack configurations as departmental or workgroup servers and storage boxes; therefore, cabling and cooling are of concern. For example, a rack filled with eight workstations running at 110 Volts AC would require three 110-volt power distribution units. However, if the workstations are run at 220 Volts AC, only two power distribution units would be required. This calculation does not take into account the move to the more powerful processors in late 1998 and 1999.

IMPLICATIONS/CONSEQUENCES

Compaq has responded to customer requests for high-performance, cost-effective computing solutions. However, these solutions will cost the customer more in terms of raw electrical power and cooling provisions.

Densification of systems is one of the causes of increased power and cooling requirements. Today, as compared to 1989, there is more processing power and data storage per cubic inch. Components are smaller and component-level power consumption is less, but an increase in the number of components per cubic inch has increased overall power consumption. This means that the input power the customer supplies from the facility has also increased.

The following is an example of the issues surrounding high-end server deployment and power concerns.

Compaq power supplies currently output 750 watts at 208 volts AC, but only 500 watts at 110 volts AC because they are limited by the 110 volt line cord and typical fuse configurations. If running a four-processor ProLiant 5500 or ProLiant 6500 server (7U form factor) which contains two power supplies, a customer can get almost to a full configuration at 110 volts AC and still remain in a redundant mode. Almost means that the system cannot have every processor, full memory configuration, all 10k drives, and every PCI slot loaded with a 25-watt card and still remain redundant, but it can be close to redundant.

The ProLiant 6000 or ProLiant 7000 (14U form factor), contain three power supplies. Two are used to power the base unit, the third is for redundancy. As a result, these servers can run a fully loaded server on 110 volts AC.

When Compaq moves to eight-processor Xeon servers, this will change. If running an eight processor, 14U server, a customer can get almost to a full configuration at 110 volts AC and still remain in redundant mode. Almost means that the system cannot have every processor, full memory configuration, all 10k drives, and every PCI slot loaded with a 25-watt card and still remain redundant, but it can be close to redundant. This is again because there are three power supplies and two can be used to power the base unit with the third for redundancy. It is impossible to run an 8P, 7U server with only two power supplies on 110 volts AC.

Table 2 depicts the maximum low-line power configurations for the Compaq ProLiant 6000 and 7000 servers.

Table 2: Maximum ProLiant 6000 and ProLiant 7000 configurations supported with low-line input power.

Power Supplies	Input Power	Processors	Hard Drives	Memory	PCI/EISA Expansion Cards
1	100 to 120V	Up to 4	Up to 6	64MB to 4GB	Up to 6
1	200 to 240V	Up to 4	Up to 6	64MB to 4GB	Up to 9
2	100 to 120V	Up to 4	Up to 12	64MB to 4GB	Up to 11
2	200 to 240V	Up to 4	Up to 18	64MB to 4GB	Up to 11

For dense form factor units, such as some departmental or workgroup servers, storage boxes and workstations, rack cable management must be carefully planned and implemented.

FACILITIES PLANNING

Computer facilities are classified in one of two categories:

- A *dedicated computer room* with the majority of computing equipment residing in one specially designed room
- A *distributed environment* in which equipment is spread throughout a facility or facilities

Customers may have one or both types of facilities. There are varying concerns based on the configuration a customer implements. These concerns are described below.

Dedicated Computer Room

A properly designed computer room has the appropriate high-line power feeds installed. In addition, power sources may be redundant. The two power sources usually come from the same external power grid but occasionally may originate from different grids or even different sources entirely. The typical practice is to split power coming from the source and provide two feeds into the computer room. On occasion, a customer will have access to two separate sources (two different substations, for example) and have feeds coming in from each. Providing separate feeds into a computer room allows redundancy, but it can be expensive to implement. The additional cost may be justified by the critical nature of the data.

In N+1 redundant server systems, the usual practice is to connect two power supplies to one feed and connect the third power supply to the second feed. However, if power to the circuit that feeds the two power supplies goes out, the remaining power supply will probably be unable to handle the entire load. Running three feeds into the computer room, which would solve the problem, may be cost-prohibitive for many companies.

Uninterruptable power supplies (UPSs) offer a measure of security for business-critical systems. In the event of a power failure, UPSs can provide power for as little as a few minutes (to allow graceful system shutdown) or up to several hours (to allow uninterrupted service). UPSs are available as rack-mountable or free-standing units.

A properly designed computer room normally also has adequate ventilation and cooling for racks of servers and storage devices.

Distributed Computing

A distributed computing environment presents a very different set of challenges for customers. A distributed environment often contains a wide variety of computer systems, servers, racks, and workstations. Density of some workgroup servers and workstations will continue to increase while adding more processing capabilities. This makes cooling a priority for rack-mounted units. Cooling can be especially problematic when a rack of servers, workstations, or storage devices is installed in a room or area where no provisions have been made for maintaining an even temperature. Costs associated with providing proper cooling and power may deter some customers from making necessary improvements, but losses due to system failures caused by overheating or lack of power can cost even more.

PLAN FOR THE FUTURE

Approached logically, planning for future power needs can be relatively painless. Customers should:

- Learn about power planning. Numerous resources available in print and on the Web explain how to plan computer facilities. It may also help to enlist the expertise of a facilities engineer.

- Set realistic goals about computer system needs for the next three to five years (when the next generation of products will be available, including the switch to Pentium II Xeon-based products) and plan any facilities upgrades accordingly.
- Consider upgrading power and cooling systems now, so an infrastructure is in place for the new products.
- Consider over-designing power upgrades to ensure that any unexpected additions are covered.
- Use Compaq power management and planning products such as Rack Builder Pro and UPSs to simplify power handling and help avoid or resolve some power and cooling issues.

CONCLUSION

Power and cooling have evolved slowly, but they have reached a level that now demands careful planning if customers are going to move to the next generation of Compaq products. Compaq designs its products to be energy efficient and run as cool as possible. However, the environments in which Compaq products are deployed greatly impacts their cooling and power performance. By staying abreast of new technology and planning computer system requirements for the long term, customers can avoid potential power and cooling issues.