Figure 3.59  Pentium 4 processor.

The main technical details for the Pentium 4 include:

- Speeds range from 1.3GHz to 1.7GHz and beyond.
- 42 million transistors, 0.18-micron process.
- Software compatible with previous Intel 32-bit processors.
- Processor (front-side) bus runs at 400MHz.
- Arithmetic logic units (ALUs) run at twice the processor core frequency.
- Hyper-pipelined (20-stage) technology.
- Very deep out-of-order instruction execution.
- Enhanced branch prediction.
- 20KB L1 cache (12KB L1 execution trace cache plus 8KB L1 data cache).
- 256KB on-die, full-core speed 128-bit L2 cache with eight-way associativity.
- L2 cache can handle up to 4GB RAM and supports ECC.
- SSE2—144 new SSE2 instructions.
- Enhanced floating-point unit.
- Multiple low-power states.
Intel has abandoned roman numerals for a standard Arabic numeral 4 designation. Internally, the Pentium 4 introduces a new architecture Intel calls NetBurst microarchitecture, which includes hyper-pipelined technology, a rapid execution engine, a 400MHz system bus, and an execution trace cache. The hyper-pipelined technology doubles the instruction pipeline depth as compared to the Pentium III, meaning more and smaller steps are required to execute instructions. However, it also enables much higher clock speeds to be more easily attained. The rapid execution engine enables the two integer arithmetic logic units (ALUs) to run at twice the processor core frequency, which means instructions can execute in 1/2 a clock cycle. The 400MHz system bus is a quad-pumped bus running off a 100MHz system clock transferring data four times per clock cycle. The execution trace cache is a high-performance Level 1 cache that stores approximately 12k decoded micro-operations. This removes the instruction decoder from the main execution pipeline, increasing performance.

Of these the high-speed processor bus is most notable. Technically speaking, the processor bus is a 100MHz quad-pumped bus that transfers four times per cycle (4x), for a 400MHz effective rate. Because the bus is 64 bits (8 bytes) wide, this results in a throughput rate of 3,200MB/sec. This matches the speed of the dual-channel RDRAM, which is 1,600MB/sec per channel, or 3,200MB/sec total. The use of dual-channel RDRAM means that RIMMs must be added in matched pairs. Dual banks of PC1600 DDR would also match this bandwidth, and that might be an option in the future as new chipsets arrive.

In the new 20-stage pipelined internal architecture, individual instructions are broken down into many more sub-stages, making this almost like a RISC processor. Unfortunately, this can add to the number of cycles taken to execute instructions if they are not optimized for this processor. Early benchmarks running existing software showed that existing Pentium III or AMD Athlon processors could easily keep pace with or even exceed the Pentium 4 in specific tasks; however, this is changing now that applications are being recompiled to work smoothly with the Pentium 4’s deep pipelined architecture.

The Intel Pentium 4 also introduces a new CPU socket, more stringent memory configuration, and even new power supply and case requirements.

The Pentium 4 is the first Intel CPU to use Socket 423, which has 423 pins in a 39x39 SPGA arrangement. Voltage selection is made via an automatic voltage regulator module installed on the motherboard and wired to the socket.
DVD-RAM specifications are shown in Table 13.28.

<table>
<thead>
<tr>
<th>Table 13.28</th>
<th>DVD-RAM Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage capacity</td>
<td>2.6GB single-sided, 5.2GB double sided</td>
</tr>
<tr>
<td>Disc diameter</td>
<td>80mm–120mm</td>
</tr>
<tr>
<td>Disc thickness</td>
<td>1.2mm (0.6mm x 2: bonded structure)</td>
</tr>
<tr>
<td>Recording method</td>
<td>Phase change</td>
</tr>
<tr>
<td>Laser wavelength</td>
<td>650nm</td>
</tr>
<tr>
<td>Data bit length</td>
<td>0.41–0.43 microns</td>
</tr>
<tr>
<td>Recording track pitch</td>
<td>0.74 microns</td>
</tr>
<tr>
<td>Track format</td>
<td>Wobbled land and groove</td>
</tr>
</tbody>
</table>

**DVD-R**

DVD-R is a write-once medium very similar to CD-R. As such, it is ideal for recording archival data or distribution discs. DVD-R discs can be played on standard DVD-ROM drives.

DVD-R has a single-sided storage capacity of 3.95GB—about six times that of a CD-R—and double that for a double-sided disc. These discs use an organic dye recording layer that allows for a low material cost, similar to CD-R.

To enable positioning accuracy, DVD-R uses a wobbled groove recording, in which special grooved tracks are pre-engraved on the disc during the manufacturing process. Data is recorded within the grooves only. The grooved tracks wobble slightly right and left, and the frequency of the wobble contains clock data for the drive to read, as well as clock data for the drive. The grooves are spaced more closely together than with DVD-RAM, but data is recorded only in the grooves and not on the lands (see Figure 13.15).

![Figure 13.15 DVD-R wobbled groove recording.](image-url)

Table 13.29 has the basic specifications for DVD-R drives.
Table 13.29 DVD-R Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage capacity</td>
<td>3.95GB single-sided; 7.9GB double-sided</td>
</tr>
<tr>
<td>Disc diameter</td>
<td>80mm–120mm</td>
</tr>
<tr>
<td>Disc thickness</td>
<td>1.2mm (0.6mm×2: bonded structure)</td>
</tr>
<tr>
<td>Recording method</td>
<td>Organic dye layer recording method</td>
</tr>
<tr>
<td>Laser wavelength</td>
<td>635nm (recording); 635/650nm (playback)</td>
</tr>
<tr>
<td>Data bit length</td>
<td>0.293 microns</td>
</tr>
<tr>
<td>Recording track pitch</td>
<td>0.80 microns</td>
</tr>
<tr>
<td>Track format</td>
<td>Wobbled groove</td>
</tr>
</tbody>
</table>

**DVD-RW**

The DVD Forum introduced DVD-RW in March 1998. Created mainly by Pioneer, DVD-RW also uses a phase-change technology and is somewhat more compatible with standard DVD-ROM drives than DVD-RAM. Drives based on this technology began shipping in late 1999. Although newer DVD-type drives have become more compatible with the CD-R/CD-RW standards, a major problem still exists in harmonizing the many types of writable DVD formats. As with the old Beta-versus-VHS battle, even the introduction of a superior specification complicates the process of accepting a single specification as an industry standard.

**DVD+RW**

DVD+RW, also called DVD Phase Change Rewritable, is destined to be the premier DVD recordable standard because it is the least expensive, easiest to use, and most compatible with existing formats. It was developed and is supported by Philips, Sony, Hewlett-Packard, Mitsubishi Chemical, Ricoh, Yamaha, Verbatim, and Thompson, who are all part of an industry standard group called the DVD+RW Alliance (http://www.dvdrw.com). In addition, companies such as Ahead Software (Nero Burning ROM software) and Roxio (CD Creator and DirectCD software) have announced they are developing support software for DVD+RW. In fact, more than 19 independent software vendors and equipment manufacturers pledged their support for DVD+RW and announced software availability, making DVD+RW the most well supported of all the DVD rewritable formats.

DVD+RW is the only rewritable format that provides full compatibility with existing DVD-Video players and DVD-ROM drives for both real-time video recording and random data recording across PC and entertainment applications. DVD+RW is designed to not only be useful for PC data storage, but to also directly record video in the DVD-Video format. This is the breakthrough the recordable DVD industry has been waiting for, and as such, DVD+RW is destined to replace the VCR in consumer-level home recorders.

Some of the features of DVD+RW includes are as follows:

- Single-sided discs (4.7GB).
- Double-sided discs (9.4GB).
- Up to 4 hours video recording (single-sided discs).
- Up to 8 hours video recording (double-sided discs).
- Bare discs—no caddy required.
- 650nm laser (same as DVD-Video).
- Constant linear data density.
the software running on your system. The software that makes calls to the video BIOS can be a stand-alone application, an operating system, or the main system BIOS. The programming in the BIOS chip enables your system to display information on the monitor during the system POST and boot sequences, before any other software drivers have been loaded from disk.


Figure 15.10  The Hercules 3D Prophet II GTS Pro is a typical example of a mid-range video card optimized for gaming. Like most recent graphics cards, it uses a nonremovable flash BIOS.

The video BIOS also can be upgraded, just like a system BIOS, in one of two ways. The BIOS uses a rewritable chip called an EEPROM (electrically erasable programmable read-only memory) that you can upgrade with a utility the adapter manufacturer provides. Alternatively, you might be able to completely replace the chip with a new one—again, if supplied by the manufacturer and if the manufacturer did not hard solder the BIOS to the printed circuit board. A BIOS you can upgrade using software is referred to as a flash BIOS, and most current-model video cards that offer BIOS upgrades use this method.

Video BIOS upgrades are sometimes necessary to use an existing adapter with a new operating system, or when the manufacturer encounters a significant bug in the original programming. As a general rule, the video BIOS is a component that falls into the “if it ain’t broke, don’t fix it” category. Try not to let yourself be tempted to upgrade just because you’ve discovered that a new BIOS revision is available. Check the documentation for the upgrade, and unless you are experiencing a problem the upgrade addresses, leave it alone.

The Video Processor

The video processor, or chipset, is the heart of any video adapter and essentially defines the card's functions and performance levels. Two video adapters built using the same chipset often have many of the same capabilities and deliver comparable performance. Also, the software drivers that operating systems and applications use to address the video adapter hardware are written primarily with the chipset in mind. You often can use a driver intended for an adapter with a particular chipset on any other adapter using the same chipset. Of course, cards built using the same chipset can differ in the amount and type of memory installed, so performance can vary.

Several main types of processors are used in video adapters:

- Frame buffer controllers
- Coprocessors
- Accelerators
- 3D graphics processors

Table 15.6 compares these technologies.

<table>
<thead>
<tr>
<th>Processor Type</th>
<th>Where Video Processing Takes Place</th>
<th>Relative Speed</th>
<th>Relative Cost</th>
<th>How Used Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame-buffer</td>
<td>Computer's CPU</td>
<td>Very slow</td>
<td>Very low</td>
<td>Obsolete; mostly ISA video cards</td>
</tr>
<tr>
<td>Graphics coprocessor</td>
<td>Video card's own processor</td>
<td>Very fast</td>
<td>Very high</td>
<td>CAD and engineering workstations</td>
</tr>
<tr>
<td>Graphics accelerator</td>
<td>Video chip draws lines, circles, shapes; CPU sends commands to draw them</td>
<td>Fast</td>
<td>Low to moderate</td>
<td>All mainstream video cards</td>
</tr>
<tr>
<td>3D graphics processor</td>
<td>Video cards 3D graphics processing unit (in accelerator chipset) renders polygons, adds lighting and shading effects as needed</td>
<td>Fast 2D and 3D display</td>
<td>Most price ranges depending on chipset, memory, and RAMDAC speed</td>
<td>All gaming optimized video cards and most mainstream video cards</td>
</tr>
</tbody>
</table>

Integrated Video/Motherboard Chipsets

Although built-in video has been a staple of low-cost computing for a number of years, until recently most motherboard-based video simply moved the standard video components discussed earlier in this chapter to the motherboard. Many low-cost systems—especially those using the semiproprietary LPX motherboard form factor—have incorporated standard VGA-type video circuits on the motherboard. The performance and features of the built-in video differed only slightly from add-on cards using the same or similar chipsets, and in most cases the built-in video could be replaced by adding a video card. Some motherboard-based video also had provisions for memory upgrades.

See "LPX," p. 201.

However, in recent years the move toward increasing integration on the motherboard has led to the development of chipsets that include 3D accelerated video and audio support as part of the chipset design. In effect, the motherboard chipset takes the place of most of the video-card components listed
Connectors for Advanced Features

Many of the newest sound cards are designed for advanced gaming, DVD audio playback, and sound production uses and have additional connectors to support these uses, such as

- **MIDI in and MIDI out.** Some advanced sound cards don’t require you to convert the game port (joystick port) to MIDI interfacing by offering these ports on a separate external connector. This permits you to use a joystick and have an external MIDI device connected at the same time. Typical location: external device.

- **SPDIF (also called SP/DIF) in and SPDIF out.** The Sony/Philips Digital Interface receives digital audio signals directly from compatible devices without converting them to analog format first. Typical location: external device. SPDIF interfaces are also referred to by some vendors as “Dolby Digital” interfaces.

**Note**

SPDIF connectors use cables with the standard RCA jack connector but are designed to work specifically at an impedance of 75ohms—the same as composite video cables. Thus, you can use RCA-jack composite video cables with your SPDIF connectors. Although audio cables are also equipped with RCA jacks, their impedance is different, making them a less desirable choice.

- **CD SPDIF.** Connects compatible CD-ROM drives with SPDIF interfacing to the digital input of the sound card. Typical location: side of audio card.

- **TAD in.** Connects internal modems with Telephone Answering Device support to the sound card for sound processing of voice messages. Typical location: side of audio card.

- **Digital DIN out.** This supports multispeaker digital speaker systems, such as those produced by Cambridge for use with the SoundBlaster Live! series. Typical location: external device.

- **Aux in.** Provides input for other sound sources, such as a TV tuner card. Typical location: side of audio card.

- **I2S in.** This enables the sound card to accept digital audio input from an external source, such as two-channel decoded AC-3 from DVD decoders and MPEG-2 Zoom Video. Typical location: side of audio card.

Sometimes, these additional connectors are found on the card itself, or sometimes they are attached to an external breakout box or daughtercard. For example, the Sound Blaster Live! Platinum 5.1 is a two-piece unit. The audio adapter itself plugs into a PCI slot, but some additional connectors are routed to a breakout box called the LiveDrive IR, which fits into an unused drive bay, as seen in Figure 16.2.

Figure 16.3 shows a Voyetra Turtle Beach’s Santa Cruz audio adapter card with the internal connectors common on today’s 3D sound cards.

Volume Control

Some older audio adapters include a thumbwheel volume control next to the input/output jacks, although sophisticated sound cards have no room for it. This control is usually redundant because the operating system or the software included with the adapter typically provides a combination of keys or a visual slider control you can use to adjust the volume. In fact, the volume wheel can be troublesome; if you aren’t aware of its existence and it is turned all the way down, you might be puzzled by the adapter’s failure to produce sufficient sound.
Figure 16.2  The Sound Blaster Live! Platinum 5.1 comes with the LiveDrive IR to support its many features.

Figure 16.3  Voyetra Turtle Beach's Santa Cruz is a typical example of an advanced 3D sound card.
Figure 20.4  An Ethernet 10BASE-2 NIC configured as the last station in a Thin Ethernet network.

Figure 20.5  An Ethernet 10BASE-T NIC with a UTP cable attached.
Virtually all standard and Fast Ethernet NICs made for client-PC use on the market today are designed to support twisted-pair cable exclusively. If you are adding a client PC to an existing network that uses some form of coaxial cable, you have three options:

- Purchase a combo NIC that supports coaxial cable as well as RJ-45 twisted-pair cabling.
- Purchase a media converter that can be attached to the coaxial cable to allow the newer UTP-based NICs to connect to the existing network.
- Use a switch or hub that has both coaxial cable and RJ-45 ports. A dual-speed (10/100) device is needed if you are adding one or more Fast Ethernet clients.

**Network Cables**

For maximum economy, NICs and network cables must match, although media converters can be used to interconnect networks based on the same standard, but using different cable.

**Thick and Thin Ethernet Coaxial Cable**

The first versions of Ethernet were based on coaxial cable. The original form of Ethernet, 10BASE-5, used a thick coaxial cable (called Thicknet) that was not directly attached to the NIC. A device called an attachment unit interface (AUI) ran from a DB15 connector on the rear of the NIC to the cable. The cable had a hole drilled into it to allow the “vampire tap” to be connected to the cable. NICs designed for use with thick Ethernet cable are almost impossible to find as new hardware today.

10BASE-2 Ethernet cards use a BNC (Bayonet-Neill-Concilman) connector on the rear of the NIC. Although the thin coaxial cable (called Thinnet or RG-58) used with 10BASE-2 Ethernet has a bayonet connector that can physically attach to the BNC connector on the card, this configuration is incorrect and won’t work. Instead, a BNC T-connector attaches to the rear of the card, allowing a thin Ethernet cable to be connected to either both ends of the T (for a computer in the middle of the network) or to one end only (for a computer at the end of the network). A 50 ohm terminator is connected to the other arm of the T to indicate the end of the network and prevent erroneous signals from being sent to other clients on the network. Combo cards with both BNC and RJ-45 connectors are still available but can run at only standard Ethernet speeds.

Figure 20.6 shows an Ethernet BNC coaxial T-connector, and Figure 20.7 illustrates the design of coaxial cable.

![An Ethernet coaxial cable T-connector.](image)

**Figure 20.6** An Ethernet coaxial cable T-connector.

![Coaxial cable.](image)

**Figure 20.7** Coaxial cable.