Appendix III

Speed and Cost of Calculations

The performance and cost of a number of computing systems will be briefly summarized. We arrive at an overall computing capability compared with a CRAY-1A. This emphasizes numeric calculations. (The PCs, for example, are relatively faster for general calculations). The approximate cost of the computer is used to calculate a cost per equivalent CRAY-1A. The comparisons are only approximate, but give some indication of costs across computers and across time. No allowance is made for the changing value of the dollar with time; this would increase the drop in price of computing.

Note: This will be an appendix in computing paper.

1. Supercomputers at NCAR

This series of fast computers is described in more detail in the appendix "Main Computers at NCAR."

<table>
<thead>
<tr>
<th>Year</th>
<th>Memory</th>
<th>Cost ($1K)</th>
<th>Speed index vs CRAY-1A</th>
<th>Cost per CRAY-1A Equiv. ($1000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>CDC 6600</td>
<td>guess $6,000</td>
<td>0.044</td>
<td>136,400</td>
</tr>
<tr>
<td>1971</td>
<td>CDC 7600</td>
<td>$8,200</td>
<td>0.22</td>
<td>36,000</td>
</tr>
<tr>
<td></td>
<td>(5.0 x a 6600)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>CRAY-1A</td>
<td>8MB</td>
<td>1.0</td>
<td>8,900</td>
</tr>
<tr>
<td></td>
<td>(4.5 x a 7600)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>CRAY X-MP/4</td>
<td>8x8 MB</td>
<td>8.0</td>
<td>2,510</td>
</tr>
<tr>
<td>(Oct.)</td>
<td>(8.5ns)</td>
<td>(incl. SSD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.0 x one Cray 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>CRAY Y-MP/8</td>
<td>8x64 MB</td>
<td>22.4</td>
<td>893</td>
</tr>
<tr>
<td>(May 21)</td>
<td>(2.8 x an X-MP/4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Some Mid-cost Computers

Information for a few mid-cost computers is summarized. Note that the amount of available memory is quite large, even by supercomputer standards.

At NCAR, the Ardent was used for some ocean models. The Ardent at CSU was used for mesoscale modeling. The computers include a very good color monitor and good graphics capability. Each group found that the processing capability of each Ardent processor was 1/15 of one X-MP processor for their tasks. The Linpak speed would peg the Ardent at about 0.48 of a CRAY-1A. I will use the ratio 1/15 of an X-MP/1 to obtain about 0.27 CRAY-1A.

Ardent cost examples:
- October 1988 system price for CSU was $80K (list was $120K)
- April 1989 price for NCAR was $63K (list was $130K)

Also note that the cost of maintenance on each system was $6000 per year.
Some Fast Smaller IBM Computers

This set of IBM-6000 computers was introduced starting Spring 1990. To meet price competition by Hewlett Packard, IBM reduced the price on May 7, 1991. With this change, IBM felt that their prices were somewhat better than HP for normal calculations. The comparison here seems to indicate that for heavy calculations, HP may be more price competitive. Both are very good.

In August 1990, the price of the 16 MB model 6000 with monochrome monitor was $18K, list price. CSU obtained a system for $9K. They found that the one processor had an output of 11% of a processor on the X-MP.

Even after the drop in price in May 1991, universities are able to obtain a discount on these IBM-6000 computers. For example, Ian Paegle (Univ. of Utah) obtained a model 550 in July 1991 with memory and disks as given below. It has a 19-inch black and white monitor. The price was $26,500 under a "software development discount." He doesn’t have to deliver software, but the computer must be for academic use. He is including an Exabyte tape drive and another enhancement to bring the cost to $30,000. This is a lot of computing power for that price! This cost is only $30,000 per CRAY 1-A (which cost $8,900,000 in 1977). This is an improvement in cost/benefit by a factor of 30 in only 14 years. The official price in the table below is higher.

In 1990, it became fashionable to call the collection of small, inexpensive computers "killer micros", which referred to their impact on large computers for most jobs.

Some Fast Hewlett Packard Computers

These computers are impressively fast. They were introduced about Spring 1991 and the prices are valid as of then.
5. Some Calculation Rates of Fast PCs

The costs given below for a system include a good color monitor (14-inch, 1,000 x 800), a 200 MB disk and two floppy disks. The prices are from good companies, but are near the 20% low-end of the pricing spectrum. From some large companies, the equipment may cost twice as much, or more.

<table>
<thead>
<tr>
<th>Chip</th>
<th>Dhrystones</th>
<th>MIPS</th>
<th>Linpack Single</th>
<th>Linpack Double</th>
<th>Calc vs CRAY-1A</th>
<th>Cost June 1991</th>
<th>Cost per CRAY-1A ($Ks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel 386/33 MHz</td>
<td>15,800</td>
<td>8.2</td>
<td>.47 Mf</td>
<td>.38 Mf</td>
<td>.017</td>
<td>$3200</td>
<td>$188</td>
</tr>
<tr>
<td>Intel 486/25</td>
<td>26,300</td>
<td>11.4</td>
<td>1.16</td>
<td>1.07</td>
<td>.047</td>
<td>$3600</td>
<td>$76.6</td>
</tr>
<tr>
<td>Intel 486/33</td>
<td>35,000</td>
<td>15.2</td>
<td>1.5</td>
<td>1.44</td>
<td>.063</td>
<td>$4200</td>
<td>$66.7</td>
</tr>
</tbody>
</table>
Appendix IV

Main Computers at NCAR

A brief history of the main computers at NCAR is presented. This also is a history of most of the world's fastest computers, because NCAR usually obtained a fast computer within a year or two of the time that they became available. Table 1 reviews some of the characteristics of the main computers at NCAR. Table 2 gives information about the disks.

Table 1: Speed and Cost of Main NCAR Computers

<table>
<thead>
<tr>
<th>Delivered to NCAR</th>
<th>Computer</th>
<th>Total Sys. Cost ($M)</th>
<th>Speed vs Previous</th>
<th>Speed vs CRAY-1A</th>
<th>No. Proc.</th>
<th>Cycle Time</th>
<th>Memory Words (bits/word)</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>CDC 3600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 1966</td>
<td>CDC 6600</td>
<td>3.0x</td>
<td>.044</td>
<td></td>
<td>1</td>
<td>100 ns</td>
<td>65K words (60-bit)</td>
</tr>
<tr>
<td>1971</td>
<td>CDC 7600</td>
<td>$8</td>
<td>5.0x</td>
<td>.22</td>
<td>1</td>
<td>27.5 ns</td>
<td>65K words (60-bit)</td>
</tr>
<tr>
<td>1977</td>
<td>CRAY-1A</td>
<td>$8.86</td>
<td>4.5x</td>
<td>1.0</td>
<td>1</td>
<td>12.5 ns</td>
<td>one megaword (64-bit)</td>
</tr>
<tr>
<td>1983</td>
<td>2nd CRAY-1A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct. 1986</td>
<td>CRAY X-MP/48</td>
<td>$20.1</td>
<td>8.0x</td>
<td>8.0</td>
<td>4</td>
<td>8.5 ns</td>
<td>8 megawords (64-bit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and 256 megawords SSD</td>
</tr>
<tr>
<td>May 1990</td>
<td>CRAY Y-MP/8/64</td>
<td>2.8x</td>
<td>22.4</td>
<td></td>
<td>8</td>
<td>6.0 ns</td>
<td>64 megawords (64-bit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and 256 megawords SSD</td>
</tr>
</tbody>
</table>

Table 2: Disks on the NCAR Computers

<table>
<thead>
<tr>
<th>Computer</th>
<th>Disks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC 6600 (1966)</td>
<td>One disk (70 mega characters, average access 225 ms). This disk had such a slow access time that it was a bottleneck on getting work done. Later, NCAR got six drums, four mega characters each, access 34 ms, to speedup data flow (each character used 6 bits).</td>
</tr>
<tr>
<td>CDC 7600 (1971)</td>
<td>Two disks (800 mega characters each, access 85 ms). Prior to the CRAY, each character had 6 bits, not 8.</td>
</tr>
<tr>
<td>CRAY-1A (1977)</td>
<td>16 disks, 300 MB each and control (cost $1.0M). Access time 53 ms, data rate 35 mbits/sec.</td>
</tr>
<tr>
<td>CRAY X-MP/48 (1986)</td>
<td>16 disks, 1219 MB each (cost $2.24M)</td>
</tr>
<tr>
<td>CRAY Y-MP (1990)</td>
<td>The same 16 disks (1219 MB each) plus 8 disks that each hold 5200 MB.</td>
</tr>
</tbody>
</table>
Solid State Disks (SSD)

Large models often cannot keep all of their gridpoint information in main memory so most of the gridpoints are on disk or SSD, while calculations are done on a subset. The access times or the data flow rates of disks became too slow to keep very fast CPUs completely busy. Therefore, an SSD was obtained with the X-MP at NCAR (in 1986).

The reader might ask "why not just build the main computer with more memory and forget about the SSD?" Usually, there is a large difference in the cost of memory between main memory and SSD.

Some Comments About the Series of Fast Computers at NCAR

1. CDC 6600 (Dec. 1966): At first the operating system was poor, so that the speed was only 1.5x a CDC 3600. When this was made more efficient, the speed was 3x a 3600. This computer was retired in mid-1976.

2. CDC 7600 (1971): I have good memories about this computer. It seemed like a good solid design. The processor had a cycle time of 27.5 ns. Its speed was about 5.0x the CDC 6600.

3. CRAY-1A (1977): The NCAR sale was the first real sale for Cray and helped to give their company a much needed start. This computer was the first with a good vector processing unit that had a fast vector startup time.

   The CRAY’s overall speed increase compared to the 7600 was a factor of 4.5. The speedup on scalar jobs was a little over the cycle time ratio (it was about 2.3). The system cost was $8.86 million ($7.9 million, plus one million for disks). Some of the components are:
   
   - One processor with a cycle time of 12.5 ns
   - 16 disks, 303 MB each, and control (cost $960,00, or $198 per MB)
   - Memory 8 MB (one million words), 64 bits per word

   The CDC 7600 wasn’t removed until 1983. The overlap between machines made the transition to the CRAY-1A quite easy. A second CRAY-1A was obtained in April 1983, when the 7600 departed.

   The last CRAY-1A at NCAR was turned off on Feb. 1, 1989. It was the one obtained in 1977.

4. CRAY X-MP/48 (Oct. 1986): NCAR obtained the first X-MP that had a cycle time of 8.5 ns, not 9.5 as before. The basic cost was $14.6M, plus $3.5 for the solid state disk (256 mwords), plus $2.0M for the disks. NCAR was going to get a 128 mword SSD; by waiting two months on delivery, we were able to obtain 256 mwords for the same cost.

   - Four processors, each 8.5 ns cycle time
   - Memory 64 MB (8 mwords)
   - Cost of basic computer and memory $14,000,000
     - annual maintenance $564,060
   - Solid state disk, 256 mwords (cost $3.5M)
• 16 disks, 1219 MB each $125,000 (cost $2.0M) and 4 disk control units $60,000 each (cost $240,000). Total of $2.24 million

• Software for front end connection $180,000
  — Annual payment $66,000

• Total cost $20,512,000
  — Annual maintenance, etc. $809,620

The speedup from cycle time alone is 1.47 x a CRAY-1A. The overall speed compared to a CRAY-1A is a factor of about 2.0 per processor.

The transition to the X-MP was very smooth for users. The operating system was basically the same as for the two CRAY-1As that we had at NCAR.

5. CRAY Y-MP/8-64

An 8-processor Y-MP was delivered to NCAR on May 21, 1991. It has 64 megawords of memory. It has a cycle time of 6.0 ns, compared to 8.5 ns on the X-MP. This gives a speedup of 1.42 per processor. However, the system appears to add some to the time, so that we should use a speedup of 1.35 to 1.4. We will use a factor of 2.8 for the increase in speed of the whole Y-MP (8 processors), compared with the X-MP (4 proc.).

5.1 Cost of YMP processors and Memory

<table>
<thead>
<tr>
<th>Processors</th>
<th>Memory</th>
<th>Total Computer Cost ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>32 MW</td>
<td>14.75</td>
</tr>
<tr>
<td>6</td>
<td>64 MW</td>
<td>16.5</td>
</tr>
<tr>
<td>6</td>
<td>128 MW</td>
<td>18.7</td>
</tr>
</tbody>
</table>

Note: The increase in cost to obtain 8 processors instead of 6 is $2.5 million.

Note: MW means megaword (each 64 bits).

5.2 On-Line Disks for YMP:

On each CRAY-1A there were 16 disks, 300 MB each. On the XMP48, there were 16 disks, 1219 MB each (called DD49's). These have a data rate of 12 Mbytes/sec.

For the YMP, NCAR kept the 16 disks from the XMP. The YMP also has 8 DD4R disk drives, each with a controller. Each drive holds 5.2 Gbytes. The data rate from each drive is 9.6 Mbytes/sec, and the access time is 13 MS. These drives are packaged as four drives and four controllers in a DS4R disk unit that holds 20.8 Gbytes and which cost $1.00 million in May 1990. In summary, the eight disk drives hold 41.6 Gbytes and cost $2 million. In July 1992, NCAR was able to upgrade four of the eight drives so that each held 9.73 GBytes instead of 5.2 GBytes. The cost to upgrade all four drives was $120,000.
5.3 Solid State Disk (SSD)

The XMP had a 256 MW SSD. There was an option to buy a new 512 MW SSD for the YMP for $4.5M. By trading in the XMP SSD, this could be reduced to $2.1M. Another option was used to reduce costs. NCAR paid $0.35 M to rewire the XMP SSD (256 MW) so that it would work on the YMP. Note that 256 MW is the same as 2.048 Gbytes.

The transfer rate from SSD to XMP or YMP is a real 1000 MBytes/sec on each of two channels. The startup time is very fast. Actually the peak speed could go up to 1250 MBytes/sec, especially on the XMP. For some reason, the slower XMP was faster on this transfer than the YMP.

6. THE CRAY RESEARCH C90 (April 1992)
(The C90 is not at NCAR now)

The first C90 was shipped about 1 February 1992, and was accepted about mid-March. Cray is building them as fast as it can and will ship 7 in 1992 and 12-15 in 1993. About 9 have now been purchased (Apr. 1992). Nearly all of the first year’s computers will have a full 16-processors. The April 1992 prices are as follows:

- A C90 with 16 processors and 256 MWords of memory costs $30,500,000. On-site maintenance is $54,000/month. It has two IO clusters which are necessary.

- Solid state disks cost:

<table>
<thead>
<tr>
<th>Cost/Megabyte</th>
<th>512 MWord</th>
<th>$2,250,000</th>
<th>$549</th>
</tr>
</thead>
<tbody>
<tr>
<td>1024</td>
<td>3,750,000</td>
<td>$458</td>
<td></td>
</tr>
<tr>
<td>2048</td>
<td>6,000,000</td>
<td>$366</td>
<td></td>
</tr>
</tbody>
</table>

- Disks

<table>
<thead>
<tr>
<th>Cost/Megabyte</th>
<th>DS 41s 20.8 GB</th>
<th>$600,000*</th>
<th>$28.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS 60 1.96 GB</td>
<td>$45,000</td>
<td>$22.96</td>
<td></td>
</tr>
<tr>
<td>DS 61 2.23 GB</td>
<td>$31,875</td>
<td>$14.29</td>
<td></td>
</tr>
</tbody>
</table>

*Maintenance for this unit costs $2800 per month
Note: A word is 64 bits (8 bytes)

The DD 61 disk is somewhat slower than the DD 60.

The computer is called a C90 because they first planned to start shipping this series about 1990. When technology is this hard, a number of dates can slip.
NCAR COMPUTING FACILITY

Control Data 6600

DEFINITIONS

- A character (char) is a letter or number, etc., such as B, Y, 3, +, or 7.
- For volume comparison there are about 5,000,000 char in the King James version of the Bible.
- Six binary bits are used to store each character.
- A binary bit is a 0 or a 1.
- A Control Data 6600 memory word is 60 binary bits long.
- One second = 1000 milliseconds (ms) = 1,000,000 microseconds (µs) = 1,000,000,000 nanoseconds (ns).

INFORMATION MEMORY

- 65,000 words (60 bits each) of high-speed memory.
- 4,000,000 characters can be written on each drum (6 drums).
- 70,000,000 characters can be written on the disk.
- 17,000,000 characters can be written on each tape (~3,000 tapes).
- 80 characters can be stored on a normal punch card.

INFORMATION INPUT

- From cards at 1,200 cards/min (1,600 char/sec).
- From magnetic tape at 120,000 char/sec (after a wait of 5 to 50 ms).
- From drums at about 1,000,000 char/sec (after a wait of 0 to 34 ms).
- From disk at about 650,000 char/sec (after a wait of 35 to 235; 225 ms average).

SPEED OF CALCULATION

- Time to add is 0.4 microseconds. Time to multiply is 1.0 microseconds.
- Several calculations may be done simultaneously, such as one addition, two multiplications, and one division.

INFORMATION OUTPUT

- Print on paper at 1,000 lines/min (2,200 char/sec).
- Print on microfilm at about 60,000 lines/min using the dd80 output recorder.
- Record graphical output on microfilm at 30 frames/sec maximum using the dd80 output recorder.
- Punch cards at 250 cards/min (330 char/sec).
- Write on tapes, drums, or disk at input rates.

Note: The tapes had 7 tracks, 800 bytes (6 bits each) per inch. Note that (800 bytes/inch) (150 inch/sec) equals 120,000 characters per second as given above.
DEFINITIONS

- A character (char) is a letter, number, or symbol such as B, Y, 4, +, or 7.
- For volume comparison, there are about 5,000,000 char in the King James version of the Bible.
- Six binary bits are used to store each character.
- A Control Data memory word is 60 bits (10 char) long.
- One second (sec) = 1,000 milliseconds (msec) = 1,000,000 microseconds (usec) = 1,000,000,000 nanoseconds (nsec).

MEMORY SIZE

<table>
<thead>
<tr>
<th></th>
<th>6600</th>
<th>7600</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed core</td>
<td>650,000 char (65,000 words)</td>
<td>650,000 char / Small Core Memory (65,000 words)</td>
</tr>
<tr>
<td>Slower speed core</td>
<td>---</td>
<td>5,120,000 char / Large Core Memory (512,000 words)</td>
</tr>
<tr>
<td>Drum</td>
<td>4,000,000 char (on 6 drums)</td>
<td>---</td>
</tr>
<tr>
<td>Disk</td>
<td>70,000,000 char</td>
<td>1,600,000,000 char (on 2 disks)</td>
</tr>
<tr>
<td>Magnetic tape (~10,500)</td>
<td>17,000,000 char</td>
<td>17,000,000 char</td>
</tr>
<tr>
<td>Punch card</td>
<td>80 char</td>
<td>80 char</td>
</tr>
</tbody>
</table>

DATA INPUT RATES

<table>
<thead>
<tr>
<th></th>
<th>6600</th>
<th>7600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punch cards</td>
<td>1,600 char/sec</td>
<td>1,600 char/sec</td>
</tr>
<tr>
<td>Magnetic tape</td>
<td>120,000 char/sec</td>
<td>120,000 char/sec</td>
</tr>
<tr>
<td>Drums</td>
<td>1,000,000 char/sec</td>
<td>---</td>
</tr>
<tr>
<td>Disks</td>
<td>650,000 char/sec (after average wait of 225 msec)</td>
<td>6,000,000 char/sec (after average wait of 85 msec)</td>
</tr>
</tbody>
</table>
CALCULATION SPEED

<table>
<thead>
<tr>
<th></th>
<th>6600</th>
<th>7600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to add</td>
<td>400 nsec</td>
<td>110 nsec</td>
</tr>
<tr>
<td>Time required to multiply</td>
<td>1,000 nsec</td>
<td>137 nsec</td>
</tr>
</tbody>
</table>

**Note:** Several calculations may be done simultaneously, such as 1 addition, 2 multiplications, and 1 division.

MAXIMUM DATA OUTPUT RATES

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Print on paper</td>
<td>1,000 lines/min</td>
<td>1,200 lines/min</td>
</tr>
<tr>
<td>Print on microfilm (maximum of 128 char/line)</td>
<td>60,000 lines/min</td>
<td>60,000 lines/min</td>
</tr>
<tr>
<td>Record graphical material on microfilm</td>
<td>30 frames/sec</td>
<td>30 frames/sec</td>
</tr>
<tr>
<td>Punch cards</td>
<td>330 char/sec</td>
<td>330 char/sec</td>
</tr>
<tr>
<td>Record on tapes, drums or disks</td>
<td>at input rates</td>
<td>at input rates</td>
</tr>
</tbody>
</table>

NOTES

- The 6600 and 7600 share access to the 16 tape drives. They can also communicate with each other directly through channel-to-channel couplers.

- The 6600 is powered by a 40 KVA motor generator set. The motor generator set for the 7600 is rated at 125 KVA. The motor generator sets are used to convert the 60-cycle power to 400 cycles for the machines, affording a significant reduction in the size and weight of the transformers. Some additional 60-cycle power is also used in each machine. (For comparison purposes, the usual load of a private home with electric stove and electric clothes dryer is about 10 KVA.)

- The refrigeration plant which provides chilled water for cooling the computers and chilled air for cooling the computer room has a maximum capacity of 180 tons. The average cooling load is approximately 120 tons.

Note added in 1992:

<table>
<thead>
<tr>
<th>Year</th>
<th>Computer</th>
<th>Word Size (in bits)</th>
<th>Byte Size (in bits)</th>
<th>Basic Cycle Time (in nanoseconds)</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>CDC 6600</td>
<td>60</td>
<td>6</td>
<td>100</td>
<td>5 x 6600</td>
</tr>
<tr>
<td>1971</td>
<td>CDC 7600</td>
<td>60</td>
<td>6</td>
<td>27.5</td>
<td>5 x 6600</td>
</tr>
<tr>
<td>1977</td>
<td>Cray 1A</td>
<td>64</td>
<td>8</td>
<td>12.5</td>
<td>4.5 x a 7600</td>
</tr>
</tbody>
</table>
## Control Data 7600 Computer

<table>
<thead>
<tr>
<th>Item</th>
<th>Volume</th>
<th>Total Cost</th>
<th>On-Line cents per bit</th>
<th>Off-Line cents per bit</th>
<th>Maximum transfer rate (megabits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7600 small core</td>
<td>64 K words</td>
<td>$2,000,000</td>
<td>50</td>
<td></td>
<td>3000</td>
</tr>
<tr>
<td>7600 large core</td>
<td>500 K words</td>
<td>2,000,000</td>
<td>7</td>
<td></td>
<td>3000</td>
</tr>
<tr>
<td>Each 7638 disk on 7600</td>
<td>$4.8 \times 10^9$ bits</td>
<td>$400,000$</td>
<td>.008</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>8 disks, new CDC 844</td>
<td>$12.4 \times 10^9$</td>
<td>314,000</td>
<td>.0025</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>8 disks, new CDC disk pads</td>
<td>$7.0 \times 10^9$</td>
<td>314,000</td>
<td>.004</td>
<td>$1.1 \times 10^{-4}$</td>
<td></td>
</tr>
<tr>
<td>8 tape drives (800 BPI)</td>
<td></td>
<td>250,000</td>
<td>.031</td>
<td>$10^{-5}$</td>
<td>.7/chan.</td>
</tr>
<tr>
<td>IBM 3300-11 disk</td>
<td>$13.0 \times 10^9$ bits</td>
<td>(EST) 320,000</td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

*60 bits each word

- IBM 360 - 195 memory ~25c/bit
- 370 - 168 memory ~6c/bit

One Storage Tech Super Disk = $6.4 \times 10^9$ bits (8 disks/contr)

June 1974
NCAR CHOOSES COMPUTER

Representatives of NCAR and Cray Research, Inc., watch Francis Bretherton sign the contract for the new computer. Standing are (left to right): Lionel Dicharry, Paul Rotar, G. Stuart Patterson, Clifford Murino, and John Firon, all of NCAR. Seated are Noel Stone, assistant secretary of Cray Research, Inc.; Seymour Cray; Francis Bretherton; and Harriet Crowe of UCAR. (Photo by Anthony Galvin III.)

UCAR has awarded the contract for a new fifth-generation computer. In a brief ceremony on Wednesday, 12 May, UCAR president Francis Bretherton signed the contract with Seymour Cray, president of Cray Research, Inc., of Minneapolis, for delivery of a CRAY-1A computer to NCAR on 1 July 1977.

More than three years of planning by UCAR, NCAR, and NSF preceded the decision. "The new computer will be the world's most advanced system devoted to the study of the earth's atmosphere, and hundreds of researchers from universities and other institutions in the United States and around the world will be using it to answer basic scientific questions," says Clifford Murino, director of NCAR's Atmospheric Technology Division. "We are pleased that UCAR has completed this major step in the plan for augmenting NCAR's computing capability." The computer will aid in the modeling of terrestrial, planetary, and stellar atmospheres and in the processing and analyzing of vast quantities of data from field experiments, including information from satellites, rockets, balloons, aircraft, ground-based instrumentation, and oceanographic probes.

The CRAY-1A will be on line in time to speed the handling of data from the Global Atmospheric Research Program (GARP) when the First GARP Global Experiment (FGGE) gets under way in 1978-79. FGGE will be a worldwide field and modeling effort to improve large-scale weather prediction. The CRAY will also be capable of handling data from numerous other large experiments of the late 1970s and the 1980s.

The machine's central processing unit (CPU) will be only 1.22 m (4 ft) in diameter. Seymour Cray explained the size to a Computing Facility seminar on Wednesday morning as a function of his design effort to reduce total computation time. Since there will be no wires longer than 1.22 m, the clock or cycle time (time to "crunch one
number") can be very short. The CRAY will have a cycle time of 12.5 ns.

The CPU will have scalar and vector hardware. It will come with one million 64-bit words of memory and 40 billion bits of high-speed disk storage. This last figure should be compared with the current 20 billion bits available on the Control Data 7600 disk system in the Computing Facility.

There will also be refrigeration and power units and a maintenance control unit consisting of a NOVA Eclipse minicomputer that will continuously monitor the hardware in the CRAY.

The vector hardware has been designed to handle extremely short vectors, having as few as two elements, very efficiently. A compiler to be supplied by Cray Research will produce vector code from programs written in FORTRAN, and the objective will be to make the computer as easy as possible for users to work with.

"The machine should be extremely cost-effective for NCAR," says G. Stuart Patterson, manager of the Computing Facility. "On our estimated job mix, we expect to have a computer that is five times faster than the Control Data 7600." The contract calls for delivery of the computer for a total cost of $8.86 million.

"Improved understanding of our weather and our environment is a major goal of the atmospheric science community and the National Science Foundation," says Francis Bretherton, "and this computer will therefore be an important tool in programs of significance for all the nations of the world."
Appendix V

The Intel i860 Chip (includes a vector processor)

Intel announced its first full-scale RISC processor about March 1989, the i860 (or 80860). It has been called a one-chip supercomputer and referred to as "Intel’s CRAY on a chip," which refers to a CRAY-1A. It includes a vector unit for floating point processing. The i860 eliminates the need for support chips such as floating point accelerators, vector processors, digital signal processor chips, and graphic coprocessors (Margulis, 1989). Margulis is Intel’s Chief Applications Engineer for high performance processors.

The chip has a dual instruction mode which initiates two instructions at once, one for the RISC core and one for the floating point unit (FPU). The FPU achieves one floating point result per clock cycle and has "dual-operation" instructions in which an add and a multiply can execute simultaneously. Dual instructions and dual operations can be combined to achieve three operations per clock cycle.

One common measure of integer performance is millions of instructions per second. The VAX-11/780 delivers 1.0 MIPS. At 40 MHz, the i860 processor rates at 33 VAX MIPS (based on Stanford integer benchmark suite) and performs 80,000 and 85,000 Dhrystones on two versions of timing tests.

The Whetstone is often used to gauge scalar floating point performance. The i860 delivers 24 million whetstones at 40 MHz (cycle time 25 ns). The peak floating point speeds of the i860 are 80 Mflops in single precision (32 bit) and 60 Mflops in double precision. In the LINPACK Benchmark, the i860 delivers over 10 Mflops.

The cycle time of the CRAY-1A was 12.5 ns (a new computer in 1977); this is exactly half of the i860 time (25 ns) used in the above tests. Both the CRAY and the i860 have excellent vector capability. Overall, the i860 should be very close to half the speed of the CRAY-1A. Intel thinks that the i860 should finally achieve output close to a full CRAY 1A. In any case, it is a very impressive chip, especially since I understand that the wholesale cost was around $1000 in 1990.

Note added March 1992: This chip seems to rarely produce over 10 Mflops, and usually it is less.
Appendix VI

Personal Computers (with Intel Chips)

Some detailed information about PC computers, and their price changes is given.

1. Speed of PCs that use Intel Chips

   Speed ratings for IBM PCs and compatibles are given in Table T2. The speed has increased from about 3.1 MIPS on the 386/SX (16 MHz) to 15.2 MIPS on the 33 MHz 486 (Intel 80486 chip). The SI index shows relative computing power, where the original PC XT (8088 chip, run at 3.77 MHz) had a speed of 1.0.

2. Relative speed of Intel computer chips

   The IBM personal computers, and compatibles (called clones) all use the Intel computer chips. Table N gives relative speeds of computers from the PC AT (introduced 1984) to the 25 MHz 80486 (first products about Sept. 1989). The table includes speed comparisons relative to the PC AT for ordinary computing work, for floating point calculations, and for applications (word processing and spreadsheets). The results are based on timing for individual machines as given by Diehl, 1990. Compared to a PC AT, an 80486/25 MHz is about 6.5 times faster for ordinary computing, 28 times faster for scientific calculations, and 5.5 times faster for common applications.

3. PC Coprocessors

   PC labs made some speed tests on co-processor chips that go with the Intel 80386 chip (Kane, 1990). The co-processors speed up the mathematics. The chips tested were the Intel 80387 and Cyrix’s 83D87. The Cyrix chip was 30 percent faster than the 80387, but there was no significant speed difference in applications such as Lotus 1-2-3 and AutoCAD. The benchmark looped through a series of floating point calculations. With no coprocessor, the same calculations are performed in RAM using a floating point emulation program. The performance times (in seconds) are:

<table>
<thead>
<tr>
<th>Case</th>
<th>Time for FP Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>no coprocessor</td>
<td>3.90 sec</td>
</tr>
<tr>
<td>Intel 80387 DX-25</td>
<td>0.33 sec</td>
</tr>
<tr>
<td>FasMath 83D87-25</td>
<td>0.22 sec</td>
</tr>
</tbody>
</table>

   In the case of the Intel 80486 chip, a fast coprocessor is built into the chip itself.

4. Price of 486 systems (Sept. 1990)

   The first Intel 80486 computer systems started appearing on the market about August 1989. By early 1990, many companies offered systems (all 25 MHz).

   A review and test of 24 machines with 80486 chips was in the Sept. 11, 1990 PC Magazine (Sey- more, 1990). For the sake of price comparisons, they defined a standard configuration that included 4 MB RAM, a 100 MB hard disk or better, one floppy disk drive (1.2 or 1.44 MB), a color VGA display, at least one parallel and two serial ports, a keyboard, and the DOS (operating system). All the PCs reviewed included a reasonably close match to these specifications. The prices for the
different computer systems were as follows: $5449, 5449, 10944, 5636, 5795, 5670, 4497, 9892, 6265, 10525, 4970, 5570, 4999, 8525, 5830, 7000, 8945, 6150, 5495, 6024, 11119, 5295, 5555, 6995. As one can see, the prices vary considerably for roughly the same hardware, but one can buy an excellent system for about $5000 (Sept. 1990). These machines have speeds of about 11.4 MIPS and do 64-bit arithmetic at a rate of about 1.0 Mflops (40% of the speed of world supercomputers during 1971-77).

5. **Price of PC Systems (Sept. 1990)**

The cost of five PC systems is reviewed in such a way that the cost is a function of the increasing power of the computer chip, and memory, etc., is held constant (Table B2). Note that the price increase to go from a 286/12MHz to a 386/16MHz SX chip is usually only about $200. The base price of a 386/SX is about $800 including 1 MB of memory and one floppy. To move from 386/SX to a 386/25MHz costs about an additional $400 to $500. It is amazing how much computing power can be purchased for these prices.

6. **Price Changes of PC Systems**

A study was made of price changes in PC systems from June 1989 to July 1990 (Table B1). The prices of 80386 systems with very good hard disks and color monitors, for three speeds: 20 MHz, 25MHz, and 33 MHz were $2995, $4495, and $6995 respectively, in June 1989. Thirteen months later the prices of these systems from the same company had dropped by about 30%, 36%, and 41% respectively, when normalized for approximately equal value (of disks, monitor, mouse, software) between the two dates.

7. **Tests of the Speeds of PCs**

The following tables give information about the speed of various PC processors, and the price changes over time.
Table T2. PC Speed. Three speed indices show the relative speed of computers that use Intel chips. These are called IBM PCs and compatibles. Many companies make good products. In the table "C" means the CPU has cache memory. Typical speed values are given together with the approximate range from different machines. The dates given are the approximate dates when the first 2 to 5 companies advertised machines.

<table>
<thead>
<tr>
<th>Processor</th>
<th>MIPS</th>
<th>SI</th>
<th>Landmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>486/50 C, Sept. 1991</td>
<td>22.6</td>
<td>78.8</td>
<td>225</td>
</tr>
<tr>
<td>486/33 MHz C, Oct. 1990</td>
<td>15.2</td>
<td>101 (52-101)</td>
<td>155 (140-155)</td>
</tr>
<tr>
<td>386/33 C, Mar. 1989</td>
<td>8.2 (7.2 - 8.3)</td>
<td>45.8 (38-47)</td>
<td>58.7 (55-60)</td>
</tr>
<tr>
<td>386/25 C</td>
<td>6.2 (5.4-6.2)</td>
<td>31 (29-32)</td>
<td>41 (38-44)</td>
</tr>
<tr>
<td>386/25</td>
<td>4.3 (4.1-4.4)</td>
<td>28 (26.6-29.5)</td>
<td>34 (30-35)</td>
</tr>
<tr>
<td>386/20 C (with cache)</td>
<td>4.8 (4.6-5.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>386/20</td>
<td></td>
<td>23 (22.5-23)</td>
<td>28 (26.5-30)</td>
</tr>
<tr>
<td>386/SX/16</td>
<td>3.1 (2.5-3.2)</td>
<td>18 (15.3-18.7)</td>
<td>21 (16-23)</td>
</tr>
<tr>
<td>(AT) 286/20</td>
<td></td>
<td>20 (20-23)</td>
<td>26</td>
</tr>
<tr>
<td>(AT) 286/12</td>
<td>2.3</td>
<td>15.2</td>
<td>15.8 (14-16)</td>
</tr>
<tr>
<td>(XT) 8088/10 MHz</td>
<td></td>
<td>2.1</td>
<td></td>
</tr>
</tbody>
</table>

Note: The SI computing scale is relative to a PC/XT running at 4.77 MHz (SI rating 1.0). For some reason the SI benchmark is consistently low on 486/25 machines.
Table N. Speed of PC Computers

Computing speed indices based on an 8 MHz PC/AT with a speed of 1.0 MIPS and megaflops are also given. Each computer has a co-processor to speed up the math. The range of indices is approximate and is based on several computers listed in the original table (Diehl, 1990). CPU measures overall computing speed and FPU measures floating point calculations. The ratios for the word processor and spreadsheet applications are similar to these when none of the computers has a coprocessor (from separate table, Diehl, 1990). The columns for speed (not indices) in MIPS and megaflops (64-bit processor) are from other sources.

<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Relative Speed</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIPS</td>
<td>Mflop</td>
<td>CPU</td>
<td>FPU</td>
<td>Word Proc. &amp; Spreadsheet</td>
<td></td>
</tr>
<tr>
<td>PC XT (4.77)</td>
<td>.22</td>
<td></td>
<td>.71</td>
<td>.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC AT 286/8MHz</td>
<td>1.0</td>
<td></td>
<td>1.0</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 386/SX, 16</td>
<td>3.1</td>
<td>1.9-2.4</td>
<td>4.0-5.2</td>
<td>2.2-2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 386/20</td>
<td>4.8</td>
<td>.19</td>
<td>2.7-3.8</td>
<td>6.9-8.3</td>
<td>2.6-3.2</td>
<td></td>
</tr>
<tr>
<td>PC 386/25</td>
<td>6.0</td>
<td>.24</td>
<td>3.8-4.7</td>
<td>8.8-10.3</td>
<td>3.4-3.9</td>
<td></td>
</tr>
<tr>
<td>PC 386/33 (Mar.89)</td>
<td>8.2</td>
<td>.38</td>
<td>4.8-6.1</td>
<td>14.2-15.7</td>
<td>4.0-5.3</td>
<td></td>
</tr>
<tr>
<td>PC 486/25 (Sep.89)</td>
<td>11.3</td>
<td>.96</td>
<td>6.2-6.8</td>
<td>27.8-28.8</td>
<td>5.2-5.9</td>
<td></td>
</tr>
<tr>
<td>PC 486/33 (Oct. 90)</td>
<td>15.2</td>
<td>1.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 486/50 (Sept. 91)</td>
<td>22.6</td>
<td>e2.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparisons with world class supercomputers:

<table>
<thead>
<tr>
<th>Years</th>
<th>Computers</th>
<th>Speed in Mflops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>IBM 7090</td>
<td>About 0.25</td>
</tr>
<tr>
<td>1966-71</td>
<td>CDC 6600</td>
<td>0.5</td>
</tr>
<tr>
<td>1971-77</td>
<td>CDC 7600 (27 ns)</td>
<td>3.0 (and faster than this with special code)</td>
</tr>
<tr>
<td>1977-82</td>
<td>CRAY-1A (1 proc, 12.5 ns)</td>
<td>27 (estimated average)</td>
</tr>
<tr>
<td>1986-90</td>
<td>CRAY X-MP (4 proc. 8.5 ns)</td>
<td>220 sustained rate at NCAR, measured</td>
</tr>
<tr>
<td>1990-91</td>
<td>CRAY Y-MP (8 proc. 6 ns)</td>
<td>620, estimated sustained rate</td>
</tr>
</tbody>
</table>

Note: These speeds represent real production on the computers at NCAR, not the higher peak speeds that are commonly advertised. The speeds apply only to the time that processors are busy (CPU hours), which is usually about 65% of the time in a year.
Table B1. Prices of personal computers from Gateway Company. All have Intel computer chips. These prices include a 14-inch color monitor, two floppy disks, and a hard disk. All of the 486 computers have a cache to speed data from memory to CPU. In the table, ch means there is a cache, and nch means "no cache" for 25 and 33 MHz 386 computers. The table gives megabytes of memory followed by megabytes of hard disk. The word "same" means same as the line above. Note how rapidly the costs have dropped. Example: The 386/25 MHz PC computer cost $3995 in March 1989, and had only one MB of memory and an 80 MB disk. By Nov. 1991 an improved version of the computer cost only $1995.

<table>
<thead>
<tr>
<th></th>
<th>286/16 MHz</th>
<th>386/20 MHz (4.8 MIPS)</th>
<th>386/25 MHz (6.2 MIPS)</th>
<th>386/33 MHz (8.2 MIPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 89</td>
<td>$2695 1MB,80MB,EGA</td>
<td>$2995 1,80,EGA</td>
<td>$3995 1,80,nch,VGA</td>
<td>6995 4,150,ch,1024</td>
</tr>
<tr>
<td>Jun 89</td>
<td>same</td>
<td>2995 same</td>
<td>4495 4,150,nch,VGA</td>
<td>5995 same</td>
</tr>
<tr>
<td>Sep 89</td>
<td>2395 2,40,VGA</td>
<td>2995 1,80,VGA</td>
<td>4495 4,160,nch,VGA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>386.SX (16 MHz)</td>
<td></td>
<td>(cache add $500)</td>
<td></td>
</tr>
<tr>
<td>Feb 90</td>
<td>2695 4,65,1024</td>
<td>2995 same</td>
<td>3395 4,160,1024</td>
<td>4395 4,160,ch,1024</td>
</tr>
<tr>
<td>Jun 90</td>
<td>2195 2,65,1024</td>
<td>2995 same</td>
<td>3095 4,110,nch,1024</td>
<td>3995 4,150,ch,1024</td>
</tr>
<tr>
<td>Aug 90</td>
<td>2195 same</td>
<td>2995 same</td>
<td>3095 4,110,nch,1024</td>
<td>3995 same</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(cache add 400)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 90</td>
<td>1995 2,40,1024</td>
<td>2595 4,80,1024</td>
<td>3395 4,110,ch,1024</td>
<td>3695 same</td>
</tr>
<tr>
<td>Dec 90</td>
<td>1995 4,40,1024</td>
<td>--end--</td>
<td>2495 4,80,nch,1024</td>
<td>3495 4,200,ch,1024</td>
</tr>
<tr>
<td>Jan 91</td>
<td>1895 same</td>
<td>2395 4,80,nch,1024</td>
<td>2395 4,80,nch,1024</td>
<td>3195 same</td>
</tr>
<tr>
<td>Mar 91</td>
<td>1895 same</td>
<td>386/20SX</td>
<td>2395 4,80,nch,1024 NI</td>
<td>3195 4,200,ch,1024 NI</td>
</tr>
<tr>
<td></td>
<td>below</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 91</td>
<td>1895 same</td>
<td>2395 same</td>
<td></td>
<td>3195 same</td>
</tr>
<tr>
<td>Jun 91</td>
<td>1595 2,40,1024</td>
<td>1995 4,80,1024</td>
<td>2295 same</td>
<td>2995 same</td>
</tr>
<tr>
<td>Aug 91</td>
<td>1495 same</td>
<td>1895 same</td>
<td>2095 same</td>
<td>2795 same</td>
</tr>
<tr>
<td>Nov 91</td>
<td>1495 same</td>
<td>1795 same</td>
<td>1995 same</td>
<td>2495 same</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1795/4/120/ch, 1024 NI*</td>
</tr>
</tbody>
</table>

"1024" means a monitor with 1024 x 768 resolution. NI means "non-interlaced" (Introduced March 1991). This stops the flickering on the screen.

<table>
<thead>
<tr>
<th>Intel 486/25 MHz (11.4 MIPS)</th>
<th>Intel 486/33 MHz (15.2 MIPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 90 4MB,150MB,1024</td>
<td>$3995 8MB,200MB,1024NI</td>
</tr>
<tr>
<td>Oct. 90 same</td>
<td>3395 same</td>
</tr>
<tr>
<td>Dec. 90 8,200,1024</td>
<td>2995 same</td>
</tr>
<tr>
<td>Jan. 91 same</td>
<td>--gone--</td>
</tr>
<tr>
<td>Mar. 91 8,200,1024NI</td>
<td>May 92 2795 same*</td>
</tr>
<tr>
<td>May 91 same</td>
<td>June 92 2695 same*</td>
</tr>
<tr>
<td>June 91 4,200,1024 NI</td>
<td>Nov. 91 2995 same</td>
</tr>
<tr>
<td>Aug. 91 same</td>
<td>Nov. 91 2795 same*</td>
</tr>
<tr>
<td>Nov. 91 same</td>
<td>May 92 2795 same*</td>
</tr>
<tr>
<td></td>
<td>June 92 2695 same*</td>
</tr>
</tbody>
</table>

Note: In Fall 1991, extra memory from Gateway cost $50 per megabyte.

*Also includes even extra software worth $300

Note: In June 1992 a 486 50 MHz computer (DX2) costs $2795 (8 MB, 200 MB)
Table B2: Price Changes for PC Systems, June 1989 to July 1990. These prices are based on ads by Gateway, an established company that has prices toward the lower-end of the range. They were one of the first companies to strongly push 1024 x 768 color monitors. There are several good companies in this price range.

NOTES:

- All of systems include a 14-inch 1024 x 768 SVGA resolution color board and monitor except that in June 1989, two systems had lower resolution VGA.
- All of the systems have two floppy disks (1.2 MB and 1.44 MB).

<table>
<thead>
<tr>
<th>June 1989 Systems</th>
<th>386/20 MHz</th>
<th>386/25</th>
<th>386/33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory (MB RAM)</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hard disk (MB/MS)</td>
<td>80/28</td>
<td>150/16.5</td>
<td>150/16.5</td>
</tr>
<tr>
<td>Monitor</td>
<td>color VGA</td>
<td>color VGA</td>
<td>SVGA above</td>
</tr>
<tr>
<td>Price</td>
<td>$2995 (+$500 for 4 MB)</td>
<td>$4495</td>
<td>$6995 (128K cache)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oct. 1989 Systems</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory (MB)</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hard disk</td>
<td>40/28</td>
<td>150/16.5</td>
<td>150/16.5</td>
</tr>
<tr>
<td>Price</td>
<td>$2395</td>
<td>$4295</td>
<td>$5495</td>
</tr>
<tr>
<td></td>
<td>(cache add $500)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>July 1990 Systems</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory (MB)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hard disk</td>
<td>65/28</td>
<td>110/--</td>
<td>150/--</td>
</tr>
<tr>
<td>Also windows, mouse</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Price</td>
<td>$2595</td>
<td>$3095</td>
<td>$3995</td>
</tr>
<tr>
<td></td>
<td>(64K cache add $300)</td>
<td>(cache add $400)</td>
<td>(has 64K cache)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change June 1989 to July 1990 (13 months)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Comments</td>
<td>more color</td>
<td>more color</td>
<td>less cache</td>
</tr>
<tr>
<td>more memory</td>
<td>more memory</td>
<td>less disk</td>
<td></td>
</tr>
<tr>
<td>less disk</td>
<td>less disk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real price drop about</td>
<td>$700+200</td>
<td>$1400+200</td>
<td>$2700+200</td>
</tr>
</tbody>
</table>

NOTE: The value of the windows software and mouse included in July 1990 is about $200. Gateway has had a very intensive advertisement campaign during the period. Their sales of all systems (including slower chips) has increased from 300 units in 1986 to 4000 in 1988, 25,000 in 1989 and an estimated 100,000 in 1990.
Cost of Intel PC chips (quantities of 1000)

<table>
<thead>
<tr>
<th>Model</th>
<th>Oct. 1990</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 MHz 286</td>
<td>$ 12</td>
<td></td>
</tr>
<tr>
<td>16 MHz 386 SX</td>
<td>$ 62</td>
<td>other costs to build a computer are the same</td>
</tr>
<tr>
<td>20 MHz SX</td>
<td>$106</td>
<td></td>
</tr>
<tr>
<td>33 MHz 386</td>
<td>$227</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model</th>
<th>Apr. 1991</th>
<th>May 1991</th>
<th>Previous Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 MHz 486</td>
<td>--</td>
<td>$588</td>
<td>$950 - cost in June 1989</td>
</tr>
<tr>
<td>33 MHz 486</td>
<td>$445</td>
<td>$667</td>
<td>$1056 - when first sold in May 1990</td>
</tr>
<tr>
<td>50 MHz 486</td>
<td>$665</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

May 1992 Chip Costs (OEM)

50 MHz 486 chip $570
50 MHz 486 chip (DX2) $517

Note: The DX2 has an internal speed of 50 MHz, and an external speed of 25 MHz.

CHEAPER CHIP: Intel is slashing the list price of its 486SX microprocessor chip, which serves as a personal computer’s brains. Intel says the cut, which starts July 1, will help reposition the 486SX as the entry-level chip of choice. That could hurt PC clone makers, which have relied on the slower 386 chip. Intel says a smaller size and higher production volume make the price cut possible. In quantities of 1,000, the 486SX will sell for $119, down from $282.

INTEL GETS SLIGHTLY MORE PRICE-COMPETITIVE

A look at Intel’s recent price cuts on PC processors demonstrates that the 486SX is part of a marketing plan, not a technical innovation. The 486SX’s price establishes it as a direct competitor to AMD’s AM386 chip and an alternative to faster 386s. The higher price for 486DX chips maintains the premium that Intel places on math coprocessing. These prices are for lots of 1,000 on Intel’s chip; AMD’s is for lots of 100.

<table>
<thead>
<tr>
<th></th>
<th>First Quarter 1991</th>
<th>Second Quarter 1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel 486DX/33</td>
<td>$860</td>
<td>$667</td>
</tr>
<tr>
<td>Intel 486DX/25</td>
<td>$871</td>
<td>$588</td>
</tr>
<tr>
<td>AMD AM386/40</td>
<td>N/A</td>
<td>$297</td>
</tr>
<tr>
<td>Intel 486SX/20</td>
<td>N/A</td>
<td>$258</td>
</tr>
<tr>
<td>Intel 386DX/33</td>
<td>$214</td>
<td>$208</td>
</tr>
</tbody>
</table>
Intel officially announces 80486, 33-MHz 80386

At Comdex in April, Intel officially announced the 80486 microprocessor (see "The Intel 80486" in the June issue of MIPS) and the 33-MHz version of the 80386. The press briefing for the new chips featured Microsoft's Bill Gates running OS/2 on the 80486.

Gates took pains to point out that the 80486 has no significant new instructions compared to the 80386. He noted that 386-specific code is also 486-specific, although a few code optimizations can help programs run faster on the 486 while keeping 386 compatibility. Philippe Kahn of Borland noted that the 486's on-chip 80387-compatible math coprocessor would raise the least common denominator for microcomputers and suggested that 80386 buyers make sure to buy an 80387 for their computers. This will prepare the system for new programs that take advantage of, or even assume the presence of, math support from a 486 or a 386 plus-387 combination.

The 33-MHz 80386 received support from many companies, with 11 companies announcing products for availability in 1989. The Comdex show floor gave further evidence of this widespread support, with several clone makers displaying systems based on the new faster chip.

Intel took another step in the direction of ever-faster 80386-compatible processors by announcing that Intel and Prime are working together on an Emitter Coupled Logic (ECL) implementation of the 80486. ECL devices are much faster than Complementary Metal Oxide Semiconductor (CMOS) devices such as current single-chip microprocessors, but ECL devices are far less dense. To duplicate the 1.2 million transistors found on the Intel chip, the ECL board will be 8 x 10 inches square and 3 inches thick and will be water-cooled. This processor module is projected to be about six times faster than a 25-MHz 80486 and capable of outrunning current mainframes.

Other Intel chip announcements included a low-power, smaller-size version of the 80386SX for use in laptops and a new 82385SX cache controller suitable for use in desktop or laptop systems.

An 80486 will deliver "15 to 20 VAX MIPS."
— This is about 3x a 80386 chip running at 25 MHz.

An 80486 should have integer performance of 2x to 4x a 80386 at the same clock speed.

On the 80486, floating point performance should improve even more. At 25 MHz, the performance will be about:
— 1.1 MFlop of 32-bit precision arithmetic
— 1.0 MFlop of 64-bit precision arithmetic

Note: The new chip in the article above will be about 6x the speed of a 80486 (run at 25 MHz).
— Thus, about 100 MIPS
— Perhaps 64-bit floating arithmetic will run at five Mflops or more on this

Note: A Vax 11/780 delivers 1.0 MIPS

Chip Cost (June 1989)

• 80486 chip (includes coprocessor and cache), 25 MHz: $950.
• 80386 chip, plus 80387 coprocessor, plus cache, 33 MHz: $1,000.
New taste sensations

Although Intel's newly released 33-MHz 486 is expected to outsell the 25-MHz version by 1992, an 1586 should outsell both of them by 1994.

<table>
<thead>
<tr>
<th>Year</th>
<th>1486 25 MHz</th>
<th>1586 33 MHz</th>
<th>Total 486/586</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>10,000</td>
<td>0</td>
<td>10,000</td>
</tr>
<tr>
<td>1990</td>
<td>400,000</td>
<td>10,000</td>
<td>390,000</td>
</tr>
<tr>
<td>1991</td>
<td>1,110,000</td>
<td>400,000</td>
<td>1,510,000</td>
</tr>
<tr>
<td>1992</td>
<td>700,000</td>
<td>1,110,000</td>
<td>1,810,000</td>
</tr>
<tr>
<td>1993</td>
<td>500,000</td>
<td>1,510,000</td>
<td>2,010,000</td>
</tr>
<tr>
<td>1994</td>
<td>400,000</td>
<td>2,010,000</td>
<td>2,410,000</td>
</tr>
</tbody>
</table>

While 486-based machines are not a huge jump in cost above a 386-based machine and actually rate well in performance, they are generally still above the level that is acceptable to corporate buyers. "They have to get below the $5,000 threshold before corporate buyers will start buying them," says Leslie Fiering, an analyst at Gartner Group, Inc.

A major constraint for the 486 is that neither DOS nor OS/2 at its current stage of development fully taps the processor's potential. In fact, there is still very little software that takes full advantage of the expanded instruction set or 32-bit architecture of the 386, never mind the 486.

"People are still running applications [on the 486] that were written for their ATs and even the original 8088/86 PCs," says Phil Magney, director of sales and marketing at ARS/Workstation Laboratories, a technology research firm in Irving, Texas.

Intel Move Helps to Fight Off Rival CPU Makers

Low-Cost 486SX Remaps PC Midrange

20-MHz Chip Lacks Regular 486's Math Coprocessor

386SX Leads Chip Parade

<table>
<thead>
<tr>
<th>CPU</th>
<th>1990</th>
<th>1991</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-MHz 386SX</td>
<td>4,245,000</td>
<td>3,990,000</td>
<td>2,400,000</td>
</tr>
<tr>
<td>20-MHz 386SX</td>
<td>479,000</td>
<td>2,531,000</td>
<td>3,600,000</td>
</tr>
<tr>
<td>25-MHz 386DX</td>
<td>1,414,000</td>
<td>2,383,000</td>
<td>2,800,000</td>
</tr>
<tr>
<td>33-MHz 386DX</td>
<td>812,000</td>
<td>885,000</td>
<td>2,100,000</td>
</tr>
<tr>
<td>20-MHz 486SX</td>
<td>0</td>
<td>230,000</td>
<td>1,100,000</td>
</tr>
<tr>
<td>25-MHz 486DX</td>
<td>281,000</td>
<td>469,000</td>
<td>446,000</td>
</tr>
<tr>
<td>33-MHz 486DX</td>
<td>65,000</td>
<td>546,000</td>
<td>1,200,000</td>
</tr>
</tbody>
</table>

The 486SX should rapidly achieve strong sales, according to Instat estimates. Overall, 386SX chips are the biggest sellers, and in each chip family, the highest performer is growing most quickly.

Torn between two options

The large installed base of older-technology PCs represents both an attractive upgrade lure and an indication that many users are content with their current systems

<table>
<thead>
<tr>
<th>U.S. installed base (in millions)</th>
<th>1990</th>
<th>1991*</th>
</tr>
</thead>
<tbody>
<tr>
<td>8088</td>
<td>14.6</td>
<td>13.1</td>
</tr>
<tr>
<td>80286</td>
<td>15.5</td>
<td>17.7</td>
</tr>
<tr>
<td>80386SX</td>
<td>2.6</td>
<td>6.0</td>
</tr>
<tr>
<td>80386</td>
<td>4.2</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Chipping away

Systems based on Intel's 1486 chip have a long way to go before they can be considered rivals to the 80386- and 386SX-based systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>159,804</td>
<td>133,694</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>136,675</td>
<td>121,798</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>153,418</td>
<td>161,335</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>146,907</td>
<td>197,201</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Instat, Inc.  CW Chart: Doreen Ruble
packages 2, 3 and 4 include lotus bundle!

<table>
<thead>
<tr>
<th></th>
<th>Pkg. #1</th>
<th>Pkg. #2</th>
<th>Pkg. #3</th>
<th>Pkg. #4</th>
</tr>
</thead>
<tbody>
<tr>
<td>386-25</td>
<td>$1395</td>
<td>$1995</td>
<td>$2495</td>
<td>$2995</td>
</tr>
<tr>
<td>386-33</td>
<td>$1495</td>
<td>$2095</td>
<td>$2595</td>
<td>$3095</td>
</tr>
<tr>
<td>486SX-20</td>
<td>$1595</td>
<td>$2195</td>
<td>$2695</td>
<td>$3195</td>
</tr>
<tr>
<td>486-33</td>
<td>$1795</td>
<td>$2395</td>
<td>$2895</td>
<td>$3395</td>
</tr>
</tbody>
</table>

Add $200 to any price for a 128K cache.

incredible zeos package #3
Add even more memory, a larger drive. And more Savings! You now receive:
- 4 full Megabytes of Ultra High Speed 53ns DRAM.
- Your fast 130MB IDE hard drive with its own cache.
- Both 1.2MB and 1.44MB floppies.
- Your Diamond VGA Plus card with 1MB DRAM.
- ZEOS 14" 1024x768 VGA Color Monitor w/Tilt & Swivel.
- Lotus 1-2-3 for Windows, Ami Pro 2.0, Microsoft Windows, DOS 5.0 plus a Microsoft mouse!

package #1
- The Processor and Speed of your choice plus future upgradeability.
- 1MB of High Speed 53ns DRAM, expandable to a system total of 32MB right on the motherboard.
- 42MB High Speed IDE hard drive with its own cache.
- 1.2MB or 1.44MB Teac’ floppy drive.
- ZEOS 14" flat screen Hi-Ros amber monitor with Tilt/Swivel base.
- Shadow RAM and EMS support for enhanced performance.
- ZEOS/RS 101 key SpaceSaver keyboard.
- Two Serial, one Parallel & one Game Port built right onto the motherboard.
- 71618-bit expansion slots. 80887 math co-processor support for 386 systems.
- Rugged ZEOS SpaceSaver case with twin cooling fans for added reliability and product life.
- Seven drive bays and our custom 300 Watt power supply for your future expansion!
- Includes ZEOS 24 Hour a Day Toll Free Technical Support and Customer Satisfaction package.

incridible zeos package #2
We take Package #1 and upgrade your ZEOS Modular System to include:
- 2 full Megabytes of Rip-roaring 53ns DRAM.
- Our incredible 85MB IDE hard drive with its own built-in cache.
- Both the Teac’ 1.2MB and 1.44MB floppy drives.
- The awesome Diamond SpeedStar Plus VGA graphics card Complete with 1MB DRAM.
- ZEOS 14" High Res VGA Mono Monitor with Tilt & Swivel base.
- Lotus 1-2-3 for Windows, Ami Pro 2.0, Microsoft Windows, DOS 5.0 plus a genuine Microsoft mouse!

package #2

<table>
<thead>
<tr>
<th>Package</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>1 MB</td>
<td>2 MB</td>
<td>4 MB</td>
<td>8 MB</td>
</tr>
<tr>
<td>Disk</td>
<td>42 MB</td>
<td>85 MB</td>
<td>130 MB</td>
<td>210 MB</td>
</tr>
<tr>
<td>Monitor</td>
<td>Amber</td>
<td>VGA</td>
<td>S VGA</td>
<td>S VGA</td>
</tr>
<tr>
<td>Floppies</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: The faster i486/33 computer only costs $400 more than the slower i386/25 computer when the package is held constant. Also, the i486 includes a co-processor for fast arithmetic.

the ultimate zeos package #4
Now, Memory goes to 8MB and the drive to 210MB. The ultimate Power User’s Dream Machine!
- 8 full Megabytes of High Speed 53ns DRAM.
- Your screaming 210MB IDE hard drive with its own built-in cache.
- Both Teac’ floppy drives, the 1.2MB and 1.44!
- The Diamond VGA Plus card with 1MB DRAM.
- ZEOS 14" 1024x768 VGA Color Monitor w/Tilt & Swivel.
- Lotus 1-2-3 for Windows, Ami Pro 2.0, Microsoft Windows, DOS 5.0 plus a Microsoft mouse!

package #4

Figure ______. Cost of 4 PC computers when the rest the configuration is constant.

Ad: ~ Dec 1991

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ZEOS International, Ltd. 530 5th Avenue NW, St. Paul, MN 55112 USA © 1991

ClibPDF - www.fastio.com
50-MHz 486 Lines Up Against RISC

The 50-MHz version of Intel's 486 chip—the next plateau for PC power users and a major weapon in Intel's struggle against Reduced Instruction Set Computer (RISC) chips—has arrived. Well, almost. While both chip and systems based on it debuted in June, Intel won't deliver the 486/50 in quantity until the fourth quarter.

Like its slower compadres, the 486/50 is a high-powered 386 superset with 8K of cache and an integrated math coprocessor. It is priced fairly aggressively at $665, considering that a 486/33 costs manufacturers $445.

As it did with the 486/25, IBM became the first vendor to unveil a product based on the new chip: a processor swap-out for XP models that should boost system prices past $15,000. By ship time, expect just as many 50-MHz PCs from Compaq, Dell, and others. All will carry a hefty price premium and appeal initially to a small handful of users running client-server network applications, CAD packages, and other CPU-hungry software.

That means Intel is throwing its new champion up against the RISC onslaught, notes Computer Intelligence analyst Dan Ness. In fact, the 486/50 beats the market-leading Sparstation 2 in some benchmarks and "will be very competitive against all comers," promises Intel marketing manager Tim Keating.

Intel "has been able to keep up with RISC processors in integer performance, but it's somewhat behind in floating-point," notes Michael Slater, editor of the Microprocessor Report. He expects RISC chips shipping later this year to be significantly faster and predicts Intel's next play in this power game will be the 586 rather than a faster 486.

While most 486 machines remain specialty items, Keating points out that a million have shipped to date, and Intel expects to double that by year-end. But most new sales will be of relatively inexpensive 486SX PCs, says market researcher Instat, which predicts shipments of only 10,000 486/60 PCs this year.

Hyperspeed for 860 times two

Hyperspeed Technologies has announced two new 860 coprocessor boards. One board uses a single 860, and the second uses two of the 64-bit chips. Both AT-compatible coprocessor boards can act as bus masters and run in a standard PC-DOS environment.

For its Dual-860 board, Hyperspeed claims a peak performance rate of 130 MFLOPS and over 60 MIPS. This product has two 33-MHz 860 chips on a 16-bit board with 2 or 4 Mbytes of DRAM, expandable to 8 or 16 Mbytes. The Single-860 uses one 33-MHz 860 with the same RAM options.

Hyperspeed supports both boards with an interactive debugging and download program, C cross compiler, and an 860 assembler. The company provides user manuals and source code for graphics, signal processing, math, and simulation applications.

Hyperspeed prices the Single-860 coprocessor with software at $7500 and the Dual-860 at $9000.

Future options for the boards include the Graphics Interface with a 24-bit-per-pixel frame buffer, z-buffer, 1024 x 768 resolution, NTSC input/output with genlock, and RGB video output. Also under development are boards for networking and image capture and processing.

Intel rolls out ‘superchips’; software makers unveil uses

CHICAGO (AP) — Intel Corp. unveiled its i486 computer chip yesterday while at least seven computer and software makers announced plans to produce new products based on the chip.

"This is not really an Intel event, this is an industry event," Intel vice president Dave House said in announcing the i486 at the Comdex trade show. "It's our alliance with the software industry that brings out the strength in our products."

The company also announced a faster version of its 80386 chip and a lower-power version of its less-expensive 80386SX chip that is suited for laptop computers.

The new i486, also known as the 80486, puts Intel into head-to-head competition with Motorola Inc.'s 68040 chip announced less than two weeks ago, industry analysts said. It crams 1.2 million transistors onto a piece of silicon just over a half-inch square.

The 80386, in contrast, contains one-fourth as many transistors, or 275,000.

A computer with the chip will perform operations 50 times faster than the original IBM personal computer and will be able to run any software developed for the 80386, House said.


In addition, Prime Computer Inc. said it would work with Intel to design processors based on the i486 that would run eight times faster than the i486 alone.

"The i486 is a fantastic advance. It's a major improvement in speed, but it is the same architecture as the 386," said Microsoft chairman Bill Gates. "The most exciting thing is the protection it offers the "investment" users have made in software.

The chip will not be available until fall, and won't be produced in quantity until late this year, Intel said in a news release.

The new 80386 chip, called the 80386DX, will run at 33 million cycles per second and is 25 times faster than the original IBM PC, House said.

Computer and software makers, meanwhile, praised the announcement of the i486 and emphasized the importance of the new chip's compatibility with the 80386.

"That level of compatibility ensures that the software you run today will run on future workstations," said John Frank, president of Zenith Data Systems.

"Now we'll see a stable platform for software development over the next several years that will allow the full capabilities of the 386 architecture to be implemented," said Rod Canion, president and chief executive of Compaq Computer Corp.

Karl Koessel, technical editor of PC World magazine, called the chip "the next generation" of computer technology.

"It's much faster, and it is compatible," Koessel said. "What people want is compatibility, and the i486 does everything the 386 does."

Source: Electronic Buyers' News

ASSOCIATED PRESS

News of 80404 is released two weeks before Intel's 80486 debut.

THE 68040 is unveiled.

THE 16-BIT 8086 chip is introduced.

THE 8/16-BIT 8088 is unveiled.

APPLE COMPUTER INC. picks 68000 for their computers.

IBM CORP. picks the 8086 for its personal computer.

THE 80286 debuts.

THE 68010 CHIP is produced.

IBM INTRODUCES the PC XT using the 8088.

THE 32-BIT 68020 is unveiled.

IBM INTRODUCES the PC AT using the 80286.

THE 32-BIT 80386 is introduced.

THE 68030 is introduced.

THE 80486 is unveiled in April.

April 11, 1989
In Search of a Faster 80287

The world of floating-point coprocessors is one of desire. If you don’t have one, you want one. When you’ve got one, you want a faster one.

Enter the IIT-2C87, a pin-for-pin, instruction-for-instruction replacement for the 80287 coprocessor. The designers of the 2C87 have hot-rod the chip. It looks like an 80287 to the CPU, but it executes floating-point operations in fewer cycles.

I pitted the 2C87 against an 80287 using BYTE’s floating-point benchmark tests; both FPs were running at the same clock speed inside an 8-MHz AT. All the tests ran without a hitch. The 2C87 doesn’t seem to suffer from any compatibility problems.

The Livermore Loops test showed the 2C87 performing at nearly twice the rate of the 80287: 0.045 million floating-point operations per second versus 0.024 MFLOPS. On the LINPACK benchmark, the 2C87 chip performed about 1.7 times faster than the 80287. This agreed closely with our low-level FPU benchmarks, which showed the 2C87 to be, on average, 1.8 times faster than the 80287.

MFLOPS at RISC

The PL1250 32-bit Floating-Point Array Processor from Eighteen Eight Laboratories will give you 12.5 million floating-point operations per second, 50 percent more than the company’s previous version.

The PL1250 also comes with software that will manage up to eight PL processors in a single system, which provides a capacity of 100 MFLOPS, Eighteen Eight claims.

Key to the board’s performance is a 16-bit RISC processor. It has 21 16-bit registers and completes nearly all instructions in a single 160-ns cycle time. And because DRAM memory can’t support the memory-access rates required by the RISC chip, each board has 60K bytes of on-board static memory.

To best use the board’s parallel-processing capabilities, Eighteen Eight includes support software in the basic package. You write a FORTRAN, C, or Pascal control program that calls fundamental library routines supplied by the PL processor.

The library comprises 473 routines that perform logical and arithmetic operations on arrays, vectors, and matrices in PL memory. Typical control programs first transfer data to PL memory, make calls to operate on the data in PL memory, and finally transfer results to the host system for display or storage.

You can run the PL1250 on XTs, ATs, and compatibles through an 8-bit bus slot.

Price: $2695.

Contact: Eighteen Eight Laboratories, 771 Gage Dr., San Diego, CA 92106, (619) 224-2158.

Inquiry 1129.
A Brief History of Personal Computers

The personal computing industry was probably created in the late 1970s by companies like Apple, Texas Instruments and Tandy. They sold computers like the Apple II, TI 99/4 and the TRS-80. The real PC industry began on Aug. 12, 1981, when IBM introduced its own personal computer.

The IBM PC generated a lot of excitement and sales, but looking back, the configuration seems "small" and the price rather high. The standard "system unit" had an 8088 Intel microprocessor, 16 Kbytes of RAM, a keyboard, five expansion ports, and a cassette player jack for storage and to load programs (the user supplied the cassette player). The IBM PC cost $1,265. Users who chose 256K of memory and a 5.25-inch floppy disk drive paid more than $3,000. Monochrome monitors were another $345. Within 18 months of IBM's announcement, there were some IBM clones from other companies. Much later, an ad for a clone XT (4.77 MHz) in Oct. 1986 gave a cost of $1,160. The clone had 640K RAM, two disk drives (360 Kbytes each) and a 13-inch RGB color monitor. Systems with one disk drive then sold for $900. There were heavily configured PC AT systems that cost over $10,000 at that time.

About 2 years after the big Aug. 1981 announcement, IBM introduced its $4,000 PCxT, in 1983. The PCxT used the same 8088 CPU and ran at the same speed as before, at 4.77 MHz. However, the XT came with 128K of RAM, a 10-MB hard disk drive and eight expansion ports. An optional 8087 math co-processor was available to help crunch numbers. The older programs still worked on this computer. In later years, the XT could run at speeds of either 4.77 or 10 MHz clock rate.

A big step forward came with the introduction of the PC AT in 1984. The PC AT's new processor, the Intel 80286, was faster (6 or 8 MHz). It had 16-bit words (like the PC and XT), and it used 16-bit words in data channels instead of the 8-bit words of the PC and XT. The AT had a 1.2-MB disk drive and a 20-MB standard hard drive. The article in Personal Computing, Oct. 1986 said that it cost $6,000. I did not remember a price this high, but maybe it was.

Let us examine the changes in price of the original IBM PC over a period of five years (Personal Computing, Oct. 1986, p.57):

<table>
<thead>
<tr>
<th>Date</th>
<th>Memory in Kbytes</th>
<th>Floppy Disks</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 1981</td>
<td>64</td>
<td>One 160K Drive</td>
<td>$2,325</td>
</tr>
<tr>
<td>May 1982</td>
<td>64</td>
<td>One 360K Drive</td>
<td>$2,405</td>
</tr>
<tr>
<td>Mar 1983</td>
<td>64</td>
<td>One 360K Drive</td>
<td>$2,104</td>
</tr>
<tr>
<td>Jun 1984</td>
<td>256</td>
<td>Two 360K Drive</td>
<td>$2,420</td>
</tr>
<tr>
<td>Apr 1985</td>
<td>256</td>
<td>Two 360K Drive</td>
<td>$2,295</td>
</tr>
<tr>
<td>Apr 1986</td>
<td>256</td>
<td>Two 360K Drive</td>
<td>$1,995</td>
</tr>
<tr>
<td>Aug 1986</td>
<td>256</td>
<td>Two 360K Drive</td>
<td>$1,595</td>
</tr>
</tbody>
</table>

Note: These PCs did not include a hard disk.
Some History of IBM Personal Computers

- Summer 1980: IBM decided to enter the personal computer market and they set up a 12-member development team.
- Aug. 1981: The IBM PC is announced. With 16 Kbytes of memory, it cost $1,565. The first one was shipped in Sep. 1981.
- Mar. 1983: IBM PC XT is introduced (clock speed was 4.77 MHz).
- Nov. 1983: IBM PC Junior introduced for $669. It was never a big hit.
- Feb. 1984: IBM portable PC was introduced. I never heard much about it.
- Aug. 1984: IBM PC AT introduced for $3,995. This was a great computer.
- Apr. 1986: IBM PC XT hard disk increased from 10 MB to 20 MB; IBM PC AT speed increased from 6 MHz to 8 MHz; portable PC taken off the market.

This information was from an article by Barney in the Aug. 11, 1986, issue of Computerworld.

Sales of Personal Computers

From 1975 to 1980, about 1.5 million personal computers were sold worldwide. In the next five years, more than 39 million PCs were shipped.

William Lowe reported that in 1980, when IBM decided to get into the PC business, IBM had no idea how pervasive personal computers would become (Personal Computing, Oct. 1986). "A dozen people started with the idea of building a personal productivity machine. We expected to install fewer than 250,000 machines in the life of the product. Five years and 10,000 employees later, IBM's PC enterprise had grown to become a major division within the company. Recently, IBM shipped its 3 millionth PC" (written Oct. 1986). Lowe was the head of the PC division of IBM.

Lowe (Oct. 1986) also said that on a large computer system, the cost of processing a fixed amount of data was $14.54 in 1955 (it took 375 seconds to process data) and became four cents in 1986 (it took 0.4 seconds to process data).
The following sales information is for several top personal computers since the product was introduced (*Personal Computing*, Oct. 1986)

<table>
<thead>
<tr>
<th>Personal Computer</th>
<th>Unit Sales</th>
<th>Projected Sales in 1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM PC family</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC (1981-on)</td>
<td>2,164,000</td>
<td>311,000</td>
</tr>
<tr>
<td>XT (1983-on)</td>
<td>881,000</td>
<td>892,000</td>
</tr>
<tr>
<td>AT (1984-on)</td>
<td>282,000</td>
<td>492,000</td>
</tr>
<tr>
<td>PC Junior</td>
<td>350,000</td>
<td>--</td>
</tr>
<tr>
<td>Commodore 64</td>
<td>2,750,000</td>
<td>350,000</td>
</tr>
<tr>
<td>Commodore VIC20</td>
<td>1,310,000</td>
<td></td>
</tr>
<tr>
<td>Apple II series</td>
<td>2,172,000</td>
<td>865,000</td>
</tr>
<tr>
<td>Apple Macintosh</td>
<td>445,000</td>
<td>291,000</td>
</tr>
<tr>
<td>TRS 80 Color Computer</td>
<td>1,170,000</td>
<td></td>
</tr>
<tr>
<td>Tandy, Models 1-4</td>
<td>750,000</td>
<td></td>
</tr>
<tr>
<td>ATT 6300</td>
<td>215,000</td>
<td></td>
</tr>
<tr>
<td>Compaq portable</td>
<td>213,000</td>
<td></td>
</tr>
</tbody>
</table>

Trends in the PC industry were described by Honan in 1986. Honan gave charts of total sales for 1981-1986, and he presented graphs of the sales in the business, home, and educational markets. The charts represented sales by about six companies. There were additional sales also. For example, Honan’s charts showed about 1.3 million sales to business in 1984, but his text showed about 2.5 million total sales to businesses. The total sales to home and business markets (the education market was smaller) were about as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Thousands of Units</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Home</td>
<td>Business</td>
</tr>
<tr>
<td>1981</td>
<td></td>
<td>350</td>
<td>300</td>
</tr>
<tr>
<td>1982</td>
<td></td>
<td>2,000</td>
<td>690</td>
</tr>
<tr>
<td>1983</td>
<td></td>
<td>3,000</td>
<td>1,600</td>
</tr>
<tr>
<td>1984</td>
<td></td>
<td>3,100</td>
<td>2,500</td>
</tr>
<tr>
<td>1985</td>
<td></td>
<td>1,700</td>
<td>3,100</td>
</tr>
<tr>
<td>1986</td>
<td></td>
<td>e 1,600</td>
<td>e 3,700</td>
</tr>
</tbody>
</table>

*e* means based on preliminary information

Unit sales of PCs to the home market in 1990 and 1991 were 4.0 and 3.8 million, respectively (*Wall Street Journal*, Jan. 3, 1992).
What Was a Home Computer Like?

Most people probably tried to purchase a home computer that cost about $1,000 or less. I believe that the high sales rates during 1990-1991 to the home market (about 4 million units per year) was because very good computers were then getting down to this price range (about $1,400 or less).

Consider a few of the home purchases that I know about:

Commodore 64 Computers, about 1983 -

A colleague at NCAR purchased a Commodore 64 for his family about 1982 or 1983. The 64 referred to 64 Kbytes of memory. He used a TV set for the display. Data input or output was via a standard tape recorder that he got for about $30. The price was about $350, but it dropped to $150 two months later. The Commodore VIC20 cost even less. The table on the previous page shows that over 4 million units of these two computers (C64 and VIC20) sold during a several-year period.

Radio Shack TRS 80 Color Computer -

A friend purchased one of these computers for her family around 1983. It had a low-resolution color monitor (probably about $350). With a low-cost printer (print was fuzzy) and a few programs, the cost was under $1,000. The kids in the family spent a lot of time using this computer—for about 7 years—for school work, for programming, and for games.

Purchased a Personal Computer in Dec. 1986 -

I purchased a computer for my sister, Linda, from Radio Shack in Dec. 1986. She was finishing 2 years of computer classes, post BA degree. This was a Tandy computer, and it was compatible with IBM PCs. It came with the Deskmate software (six application programs in one package). The price breakdown follows:

- Tandy 1000 Ex  $799
  - Has EM-S color monitor worth $300 (640 x 200 resolution)
  - Has one 5.25-inch floppy disk drive
  - Has 256 Kbytes of memory
  - No hard disk
- Printer ($100 off)  $250
  - 18-pin, near letter perfect
- One game  30
- 500 sheets of paper, 3 blank disks  15

TOTAL  $1,094 (also add 7.8% tax)
The printer worked with the test program, but it took over 6 months to obtain enough information to get it to work with the software supplied with the computer. This statement is included because it happens too often, and with many companies.

During 1990-1992, this computer was used by my sister’s daughter, at the University of Washington.

*Computer For My Daughter (Serena Jenne) in July 1990 -*

I purchased a Gateway computer with an Intel 80386SX chip (16 MHz). It has 2 MB of main memory, two floppy disk drives (1.2 and 1.44 MB), 65-MB hard disk drive, and a high-resolution (1024 x 768) color monitor (14-inch size). Also a mouse was free, DOS 4.01 came with it, and the new Windows 3.0 software was included. The cost was $2,195 plus $75 for shipping. If I had purchased another 2 MB of memory, it would have cost $250 more. The computer has worked well.

In April 1992, the equivalent computer (but only a 40-MB hard disk drive), costs $1,445. However, this includes a choice of additional software that is worth $300 to $400.
Double discs
Push a button and the HP 125 Model 30 personal computer saves data on its 5¼-in., 4.8 million byte hard-disc system. Or push another and data goes to a 5¼-in. floppy disc for transferring information between machines. Including 64 kilobytes of memory, it's $8,250.

June 1982

The Intel Shuffle
Just as Intel Corp. 1486-based systems start to appear, the 4-year-old Intel 80386 chip will finally surpass the 80286 in 1990

Sales and costs of PC-AT computers

Make your deal now
Bill Lempesis, a PC industry analyst at Dataquest, Inc. in San Jose, Calif., said the first half of this year will be a prime time for users looking for good deals on 286s. An average 286 system is currently selling for about $2,000. Lempesis said he expects prices to drop between $1,000 and $1,500 in the next few months.

About 5.7 million 286-based systems were shipped worldwide last year, Dataquest reported. That figure is expected to climb to 6.5 million this year, according to Dataquest's projections.

Better prices are the result of oversupply. In the beginning, the 286 market attracted clone makers because it offered better margins. As more vendors jumped into the 286 market, users have been the big winners. They have a choice among suppliers who are willing to deal to get their business.

Computerworld
February 6, 1989
28K Commodore VIC
PERSONAL COMPUTER Only $299.00
Special Sale Price

GREATEST BUY IN AMERICA
It has color, sound and music with a powerful 6502 microprocessor (Like Apple). 20,000 Bytes ROM with a 16K Microsoft extended Level II Basic built in, 8,000 Bytes RAM plug in expandable to 32K RAM, Cursor, Real time, Full size easy to use 68 key professional typewriter keyboard, 62 key graphics, 4 programmable function keys, High resolution graphics, 512 displayable characters, 128K Memory, 23 lines 22 characters, 16 colors. With optional Disk-Plug In Cartridges. Has low priced plug in peripherals, Connects to any TV or monitor, Upper and Lower Case, AC adapter, RF modulator, Switch box, cables and self teaching instruction book - all in a beautiful Creme Colored Console Case. This is a powerful full-sized extra featured computer for only $299.00.

WHY SUCH A LOW PRICE?
Selling on a direct to customer basis, we save you the profit margin normally made by computer stores and distributors. We are willing to take a small margin to develop volume to cut our cost of operation.

COMPETITIVE LIST PRICES
APPLE II PLUS T.I. $525, ATARI $399.95, RADIO SHACK TRS-80 color with only 12K memory sells for $399.50.

LOW COST PLUG IN EXPANSION
Expansion accessories plug directly into this computer, extra RAM memory, Controllers, a Cassette, A Telephone Modem for only $199.00, an 80 Column Printer for $375.00, even the 170K Disk Drive plugs in direct. You do not have to buy an expensive expansion interface.

GET JOB OPPORTUNITIES NOW
Every newspaper has several pages of want ads for computer people. You can learn to operate and program a computer for these extra jobs. Go to the public computer centers. This computer has extended Level II Basic with floating point decimal, Integer and String routines, Direct Statement Execution, Multi-statement Line Tape, Cursor, Full screen editing, Color Command Keys, Graphics, Scrolling, File Management, Upper-Lower Case, Direct Memory Access, Peek and Poke and much more! Assembly machine language is available. We have easy to follow self teaching books and programs.

INVEST IN YOUR CHILDREN
Educate your children while they play. Every kid wants to play electronic games. (We have some of the best). The next natural step for their curiosity is to try simple programming. They can do this in 20 minutes with our simple self teaching instruction book. High schools are teaching computer math, science and practical computer science start in grammar school. If you provide this computer instead of a T.V. and Tutor at home, before you know it your child will be writing computer programs. You can use your T.V. to EDUCATE not frustrate your family and eliminate T.V. boredom with programs that challenge, stimulate and entertain the whole family. We have a wide variety of games, recreational, home finance and educational programs to choose from. Why pay $140.00 to $295.00 for an electronic game when you can buy this powerful computer for only $299.00.

COMMUNICATE WITH THE WORLD
Plug in your VIC telephone modem. Now you can get all the information through your telephone, plus electronic mail. Just dial up the information you want. UPI wire service, stock market, historical information by topic from over 80 magazines, including New York times, Airline information, order tickets, get weather information anywhere in the world, restaurant and hotel information, thousands of categories are on line for you, business, finance, education, entertainment, games etc. YOU'LL BE THE TALK OF YOUR NEIGHBORHOOD. Our telephone modem price is by far the lowest available.

IMMEDIATE REPLACEMENT WARRANTY
If your computer fails because of warranty defect within 90 days from date of purchase, you simply send your computer to us via United Parcel Service prepaid. We will immediately send you a replacement computer at no cost to you via United Parcel Service prepaid. No one knows you this kind of warranty service. Most computer warranty service takes 30 to 90 days to handle - then ends the "immediate replacement warranty" is backed by COMMODORE COMPUTER, a MAJOR national brand electronics manufacturer.

WHAT A SMART INVESTMENT!!!
- For Students and Schools
- Learn to program a computer
- Learn to operate a computer
- For Programmers & Teachers
- For Labs, Engineers, etc.
- For Small Businesses
- For The Home Owner

PLUG IN EXPANSION

SPECIAL SALE PRICE $299.00
For only $299.00 you get the powerful 28K COMMODORE VIC with 20K ROM, 8K RAM and Extended Level II Basic, The professional 66 keyboard, color, sound, music, self teaching instruction book, AC adapter, RF modulator, TV switch box, owners manual, plus all of the other extra features listed, in a beautiful Creme Colored Console Case.

SPECIAL SALE PRICE $379.00
For only $379.00 you get the more powerful 41K COMMODORE VIC with 20K ROM, 21K RAM and Extended Level II BASIC, plus all of the extra features shown for the 28K COMMODORE VIC!

"15 DAY FREE TRIAL"

DON'T MISS THIS SALE ORDER NOW

- Please send me the 28K Commodore VIC Computer for $299.00
- Please send me the 41K Commodore VIC Computer for $379.00
- Special Data Cassette $99.00

We ship C.O.D. and honor Visa and Master Card.

Name ________________________________

Address ____________________________________________

City ____________________________ State ______ Zip Code ______

Credit Card No. ____________________________ Expiration Date ______

Add $10.00 for shipping, handling and insurance. Illinois residents please add 6% tax. Ask $20.00 for CANADA, PUERTO RICO, HAWAII orders. WE DO NOT EXPORT TO OTHER COUNTRIES.

Enclose Cashiers Check, Money Order or Personal Check. Allow 14 days for delivery (21 days for Personal Check orders). 2 to 7 days for phone orders. Canceled orders must be in U.S. dollars.

PROTECTO ENTERPRISES (FACTORY-DIRECT)
BOX 550, BARRINGTON, ILLINOIS 60010
Phone 312/382-5244 to order
Computer capability available to scientists, valid about August 1983. This chart was prepared by T. Krishnamurti for the Indo-US Science and Technology Agreement (Monsoon Research) signed by the countries in 9/83.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>COMPUTER CAPABILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INDIA</td>
</tr>
<tr>
<td></td>
<td>IMD New Delhi</td>
</tr>
<tr>
<td>Type</td>
<td>IBM 360-44</td>
</tr>
<tr>
<td>Physical Memory</td>
<td>512 k bytes (1 byte = 8 bits)</td>
</tr>
<tr>
<td></td>
<td>128 k words 32 bit words</td>
</tr>
<tr>
<td>Tape/disk</td>
<td>8 disk drives 3 tape drives</td>
</tr>
<tr>
<td>Tape</td>
<td>9 track 800 bpl</td>
</tr>
<tr>
<td>Speed (MIPS)</td>
<td>1</td>
</tr>
<tr>
<td>Baroclinic model 2° mesh 67 x 36 mesh</td>
<td>2.5 hr</td>
</tr>
<tr>
<td></td>
<td>1 hr time step 96 hr time forecast (total core 70,000 words)</td>
</tr>
<tr>
<td>Multilevel grid point p.e. model 1° mesh</td>
<td>80 hr</td>
</tr>
<tr>
<td></td>
<td>10 vertical levels 6 min time step 96 hr forecast (total core 156,000 words)</td>
</tr>
</tbody>
</table>
Appendix VII
Users of the NCAR Computers

There are many users of the computers at NCAR. They are from both NCAR and the university community. Following are the number of users during three periods of time.

Only people with approved computing projects can do calculations at NCAR. This includes many users. The numbers of different users of Scientific Computing Division (SCD) computers were:

<table>
<thead>
<tr>
<th>Year 1984</th>
<th>For all Year</th>
<th>Only Apr 1984</th>
<th>Apr 84 Users/day</th>
<th>Apr 84 Jobs/day</th>
<th>Storage access per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR users</td>
<td>432</td>
<td>270</td>
<td>127.5</td>
<td>1084</td>
<td>670</td>
</tr>
<tr>
<td>University</td>
<td>709</td>
<td>260</td>
<td>95.6</td>
<td>525</td>
<td>454</td>
</tr>
<tr>
<td>Totals</td>
<td>1141</td>
<td>520</td>
<td>223</td>
<td>1609</td>
<td>1124</td>
</tr>
</tbody>
</table>

Note: In 1984 NCAR had 2 CRAY-1A computers

---

<table>
<thead>
<tr>
<th>Year 1988</th>
<th>Any SCD Computer</th>
<th>CRAY Computers</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR Users</td>
<td>477</td>
<td>366</td>
</tr>
<tr>
<td>University Users</td>
<td>675</td>
<td>554</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Year 1991</th>
<th>Use Any SCD Computer</th>
<th>CRAY-YMP Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR users</td>
<td>514</td>
<td>425</td>
</tr>
<tr>
<td>University users</td>
<td>726</td>
<td>638</td>
</tr>
<tr>
<td>CRAY grants, sales</td>
<td>148</td>
<td>144</td>
</tr>
<tr>
<td>Totals</td>
<td>1388</td>
<td>1207</td>
</tr>
</tbody>
</table>

Any of these users can access the data archives at NCAR. Some users do; some only run models or use their own data.

Year 1991: Number of CRAY-YMP users, according to the amount of CPU time used. A few users (mostly small) are left out of this list, which accounts for the difference in total users compared to the list above. There are many users who each use a lot of time. The numbers are given for the whole year and for a single month.

### NUMBER OF USERS BY TOTAL CPU HOUR USAGE

<table>
<thead>
<tr>
<th>CPU HOUR RANGE</th>
<th>FY91</th>
<th>Oct '91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 100 cpu hours</td>
<td>87</td>
<td>10</td>
</tr>
<tr>
<td>10 to 100 cpu hours</td>
<td>284</td>
<td>73</td>
</tr>
<tr>
<td>1 to 10 cpu hours</td>
<td>309</td>
<td>171</td>
</tr>
<tr>
<td>under 1 cpu hour</td>
<td>447</td>
<td>466</td>
</tr>
<tr>
<td>TOTAL NUMBER OF USERS</td>
<td>1127</td>
<td>720</td>
</tr>
</tbody>
</table>
The new HP Apollo RISC workstations will give you the edge for as little as $12K for 57 MIPS and 17 MFLOPS, or $20K for 76 MIPS and 22 MFLOPS.

The new HP Apollo Series 700 RISC workstations.
1-800-637-7740, Ext. 2054.

HP pushes RISC workstations

BY J. A. SAVAGE
CW STAFF

PALO ALTO, Calif. — Leaping ahead in the market for reduced instruction set computing (RISC) systems, Hewlett-Packard Co. will announce a series of engineering workstations March 26 that will leave behind the Domain operating system acquired when HP bought Apollo Computer, Inc.

The HP 9000 Series 700 workstations, with the company’s next generation of RISC architecture, will run at 57 to 76 million instructions per second (MIPS). The entry-level system will offer twice the performance at roughly half the price of systems currently offered by Sun Microsystems, Inc. and IBM, according to HP.

The workstations will be the first in which the Apollo division has taken the engineering lead, an Apollo spokesman said.

However, despite Apollo engineers’ input, the systems will not run Domain, the old Apollo operating system, said Doug Eltoft, president of the Apollo Users Group. “Users are resigned to the fact that Domain is going to go away. They are putting their hope into OSF/1,” Eltoft said.

Work to do

HP/Apollo is having trouble keeping pace with Sun’s growth in the workstation market.

Percent of worldwide market share (by shipments) 1990 1991 *
Sun** 34.2% 43.3%
HP/Apollo 24.0% 22.5%
DEC 20.0% 18.6%
IBM 5.5% 6.9%
Total shipments 433,316 526,730
*Projected  **Only includes Sparc

Source: Workgroup Technologies, Inc.

Friedman, an analyst at Bear Stearns & Co. in New York.

At the high end, the Model 750 will run at a faster clock speed and will generate over 70 MIPS, Friedman said. That computer will cost about $30,000.

At the entry level, the HP workstation will cost $227 per MIPS. HP’s current RISC multi-user systems run at $2,750 per MIPS for its HP 9000 Model 852S. Comparatively, at the low end, Sun’s 28.5-MIPS Sparcstation 2 costs $526 per MIPS, and IBM’s 29.5-MIPS RISC System/6000 Powerstation 320 costs $472 per MIPS.

At the high end, Sun charges $4,420 per MIPS for the Sparcserver 490, and IBM charges $2,443 per MIPS for its Powerstation 550.

HP’s current generation of RISC machines, the HP 9000 Series 800, is aimed at multi-user, commercial environments. Floating-point performance and graphics are usually associated with single-user engineering workstations.

16M bytes of memory and a 19-in. monochrome monitor. It will be priced between $12,000 and $13,000, according to Cliff

Model 720 running at 57 MIPS, according to Jim Hammons, an analyst at The Sierra Group, Inc. in Tempe, Ariz. The basic model will be diskless and will have
Hewlett-Packard succeeds in slipping under $5,000

"That's quite awesome for that price range," observed another analyst who listened in on the briefing. A similarly priced workstation from Sun Microsystems, Inc., for example, runs at 20.1 Specmarks.

The HP offering will undoubtedly shake the trees at Sun and Digital Equipment Corp. Both vendors have similarly low-priced systems in the $5,000 range, but they run at significantly lower performance levels than the HP system will deliver, analysts noted.

Closer to the $10,000 mark, HP will also introduce the Model 710 Bushmaster, a high-performance workstation available in both color and gray-scale versions, sources said. HP will also introduce improved three-dimensional solid modeling products integrated with the Precision Architecture RISC chip. Users of current Series 700 workstations can upgrade their systems with the 3-D graphics boards.

"HP has done a good job. You have to give them credit," said Duane Elms, a program manager in technical computing at General Electric Co. in Bridgeport, Conn. "Two years ago, I wouldn't have put a dime in their stuff, and now they're very impressive."

The appearance of an HP workstation at less than $5,000 is surprising in light of remarks a company vice president made last month after DEC's low-end workstation announcement.

Lewis Platt, an HP executive vice president and head of the computer systems organization, said his company would not reach as low as $4,000 to $5,000 with its upcoming low-end models. Apparently what has changed is HP's ability to deliver the Model 705 earlier than expected, sources close to the company said. "Customers have been asking for it, so the strategy didn't change. The timing did," the source said.

Compatible partners
Analysts noted how the addition of competitively priced low-end machines to the Precision Architecture RISC line gives HP a binary compatible reach from the desktop to mainframe-class systems — an attractive lure for corporate accounts.

"HP has clearly recognized that while the high end is an interesting place to be, they can see the way the workstation business is going," said Laura Conigliaro, an analyst at Prudential Securities Research in New York. She pointed to HP's success of the Model 720, its current low-end workstation with a base price of about $12,000 for 59.5 Specmarks.

In the past, HP has been excluded from some accounts because of its segmented product line, which includes its own proprietary MPE architecture, the Series 400 workstations based on Motorola, Inc.'s 68040 chip, and the Precision Architecture RISC products.
DEC offers sneak peak at Alpha

Processors will have CMOS technology, clock speed of 150 to 200 MHz

BY SALLY CUSACK
CW STAFF

HUDSON, Mass. — Eager to prove that there is indeed a tangible product hidden behind the curtains, Digital Equipment Corp. last week offered several additional details on its next-generation, 64-bit reduced instruction set computing (RISC) architecture, Alpha.

DEC revealed that initial Alpha processors, which will be largely workstations, will incorporate DEC’s CMOS-4 technology. The Alpha EV-4 RISC chips, which sources said will be unveiled next month, will operate at speeds ranging from 150 MHz to 200 MHz and will ship in all first-generation Alpha systems.

The keys to Alpha

The firm is incorporating key new technology into Alpha, including a very thin gate oxide, short channel length, lower voltage requirements and use of cobalt silicide in chip fabrication, according to R. J. Hollingsworth, a DEC corporate consulting engineer.

Most chip manufacturers are using titanium, which has limits in manufacturing, Hollingsworth said. Cobalt allows features to be scaled smaller, which allows for fast transistors and increased speed. The EV-4 will incorporate 1.68 million transistors, 8K bytes of instruction cache and 8K bytes of data cache and will provide 400 million instructions per second and 200 million floating point operations per second at a peak issue rate of 200 MHz.

William Sines, an analyst at Technology Investment Strategies Corp., a consulting and research firm based in Framingham, Mass., said the recent announcement makes it clear that DEC has jumped on leading-edge technology cycles. However, he cautioned that the company must keep a balance between design and manufacturing costs.

“It is such an expensive proposition to develop these chips that DEC will have to have success in the merchant marketplace. This is difficult for DEC — [as] they are already a member of ACE, it would be hard to create or join a chip consortium.”

DEC is clearly banking its future on the success of Alpha, and customers have been watching the evolution of the architecture with interest.

“I think Alpha is going to be a big win for DEC,” said Robert W. Forster, manager of DEC systems at the Sikorsky Aircraft Division of United Technologies, Inc. in Stratford, Conn. With its 30 DEC midrange systems and 300 to 400 DEC workstations, Sikorsky will most likely implement Alpha technology on single-user workstation platforms, Forster said.

Terry Shannon, a principal at Gander Resources, a consulting firm based in Ashland, Mass., said that existing DEC customers seem fairly confident that it will be as easy to migrate from the VMS to Alpha architecture as DEC has promised.
User replaces Cray XMP with network of RS/6000s

By Joanne Cummings

LIVERMORE, Calif. — The University of California's Lawrence Livermore National Laboratory last week said it has awarded IBM a $1 million contract to replace a Cray Research, Inc. XMP supercomputer here with a networked cluster of IBM RISC System/6000 servers.

Livermore Lab is counting on the networked server cluster to deliver the same level of performance as the quad-processor Cray XMP at a fraction of the cost of purchasing a supercomputer to replace the loaner unit it returned to another lab.

IBM will supply Livermore Lab with 14 RS/6000 POWERserver 550s. Together, the devices will form Livermore Lab's Open Computer Facility Unix Compute Server and provide users with 2.9G bytes of memory capacity vs. the Cray XMP's 64M bytes.

The lab needs the increased memory capacity to support user applications that the Cray, which was a relatively low-end supercomputer, had not been able to handle in the past, said Eugene Brooks (continued on page 71)

Brooks, project leader for the massively parallel computing initiative at Livermore Lab.

"The RS/6000 is what we call a 'killer micro,'" Brooks said. He noted that servers like the IBM machines can outperform the Cray in certain applications, such as evaluating the shielding strength of a nuclear reactor.

Due to the nature of the code in these applications, the RS/6000s "can — CPU-to-CPU — beat the latest supercomputer in performance," Brooks said.

Livermore Lab, which is one of the Department of Energy's largest research labs, will use the networked server cluster to support its compute-intensive research, including such diverse applications as calculating the motion of a supernova and performing weather simulations.

The RS/6000s will support an average of 50 concurrent users working at terminals or Sun workstations running the X Window System. When a user logs on to the network, the client workstation displays a table showing the least busy processor (see graphic, page 1). This information is gathered by software on the RS/6000s, which constantly polls the servers. Utilization statistics are relayed to X Window clients, so users can log on to the server that will give them the best performance.
The IBM RISC System/6000 family

Talk about precocious. Just a little over one year ago, when we proudly announced the arrival of the RISC System/6000™ POWERstations and POWERServers, they were already way ahead of the other kids in their class, delivering amazingly high performance for their diminutive price range.

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<th>Hardware Price</th>
<th>MFLOPS</th>
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*Clock Speed: 25 MHz

The RISC System/6000 family. Choose your weapon.

There’s a RISC System/6000 POWERstation or POWERServer to conquer any need, from a single user’s desktop requirements to the demands of an army of concurrent users. Each member of the family comes in a wide variety of configurations, so you can choose among display sizes and disk storage and graphics processing capabilities. For low cost-per-user LAN solutions, there’s even a new, high-performance IBM Xstation 120.
Big Blue has big plans for RISC System/6000

CONTINUED FROM PAGE 1

Ron Barsena, an engineering vice president at Air Products and Chemicals, Inc. in Allentown, Pa. His site has a mixed environment of Unix workstations, personal computers and an IBM mainframe.

Alberto Finol, assistant general manager for Venezuelan oil company Maravan SA in Lagunillas, expressed a similar sentiment. "We want to see what advantages we can gain for our two main areas: seismic processing and reservoir simulation," said Finol, whose firm is planning to add 12 RS/6000s to the two now used at its Caracas headquarters.

IBM plans to sell clustered RS/6000s for batch or parallel processing applications, with the average configuration including about 15 machines and costing close to $1 million, Hester said. In IBM's vision of its Unix future, RS/6000 clusters will off-load production applications from mainframes that increasingly function as huge database repositories and file servers.

The expanding line of "general-purpose" supercomputers will travel a forked path, with System/390 vector mainframes available now and RS/6000-based highly parallel clustered systems reaching the market next year and in 1994. Today, IBM counts 550 installed supercomputer/vector mainframes worldwide, said Irving Wladowksy-Berger, assistant general manager of supercomputing systems at IBM.

IBM executives also told users to watch for the following:

- RS/6000 clusters moving to high-speed interconnect technology within two years via the 1G bit/sec. Fiber Channel Standard, which IBM is already prototyping. Once ready for market, it will outperform the 100M bit/sec. Fiber Distributed Data Interface communications pathway.
- An initial boost in the RS/6000's mediocre graphics capabilities when GT4 and GT4X adapter cards start shipping this summer. Coming next: much greater performance through tighter hardware integration between the CPU and the graphics subsystem.
- General availability this summer of the High Availability/6000 software, a set of systems software services providing close to crash-proof environments. A handful of customers in financial, telecommunications and emergency dispatch businesses are now using HA/6000 software on special order.

IBM has no intention of creating fault-tolerant RS/6000 systems, however, and will continue reselling Stratus Computer, Inc. machines as the IBM System/88s. "There will always be a market for fault tolerance, but that will shrink as Unix high availability gets ready for prime time," Hester said, referring to commercial site use rather than scientific or technical.

COMPUTERWORLD

MAY 4, 1992
The ACE gospel according to DEC

BY MARYFRAN JOHNSON
CW STAFF

MAYNARD, Mass. — With the evangelical fervor of the new convert, Digital Equipment Corp. is grabbing every industry pulpit available these days to talk about its dedication to the Advanced Computing Environment (ACE).

As one of the lead companies in ACE, a 60-vendor alliance hoping to set a new standard for Unix-based and reduced instruction set computing (RISC) products, DEC has swiftly elevated the initiative to strategic status.

“All of the software coming out of DEC will have the ACE-compliant label,” Kurt Friedrich, manager of DEC’s open software group, told a gathering of analysts and press recently. “Everything we sell, we will try to push on the ACE platform. That is clearly our direction.”

Friedrich summed up DEC’s view of what ACE will provide to users succinctly and optimistically: “Lots of hardware. Lots of software. Lots of companies. And distribution channels up the wazoo.”

During the next year, a few of the developments customers will see from DEC on the ACE front include the following:

- A new class of RISC servers from DEC, more powerful price/performers than the current Decsystem 5500 and Decstation 5000. The new systems will be equipped with Turbochannel networking expertise and produce layered software products to enhance and extend the initial ACE operating system from SCO.

DEC plans to produce a slew of such products, including device drivers, real-time capabilities, graphics packages, multimedia applications development on its Unix-based workstations.

- A late 1991 shipping date for the initial ACE operating system, which will be The Santa Cruz Operation’s (SCO) Open Desktop integrated with DEC’s Ultrasparc and the Open Software Foundation’s OFS/1.

To make money on the hardware end, DEC will concentrate on building high-end workstations and servers, leaving the low end to vendors such as Compaq Computer Corp. In software, DEC will push its own media software and PC integration.

“ACE will have two advantages: our size and support capabilities and our strong focus on distributed networking,” Friedrich said. “The big ‘if’ is whether the industry will go for it.”

Indeed, this “all-for-one” Musketeer alliance business is bound to generate some pitched market battles as companies with similar products pursue the same customers.

“Something running on SCO Unix from DEC has to run on all ACE systems, but if somebody else’s Pathworks or C++ is the best version, that’s what people will buy,” Friedrich acknowledged. “There will be some skirmishes, but hopefully we will all settle into more profitable modes. The advantage of ACE is that a lot of us will quit losing money on Unix.”

The ACE members recently received the 150-page Advanced RISC Computing (ARC) specification, which defines minimum hardware standards to ensure that shrink-wrapped applications will run on ARC-compliant systems.

One key feature that is supposed to give ACE members the flexibility to innovate — in other words, make money — with ARC-compliant systems is the combination of a hardware abstraction layer and device drivers. Those software layers lie between the operating systems and the hardware itself, giving systems vendors a much-needed place to “add value” while preserving binary compatibility for applications and operating systems.

Software developers will have the choice of writing source code to SCO’s Open Desktop or to Microsoft Corp.’s New Technology operating system.

“ACE adds credibility to DEC’s open system strategy — credibility they didn’t have before,” said Peter Schay, an analyst at Gartner Group, Inc. in Stamford, Conn. “There is a big upside potential for them with ACE.”

Meeting that potential, analysts said, is highly dependent on time to market with real ACE products — not just current-model Decstations slapped with an ACE label.

“What will dictate the winner is whoever sells the most out there,” said David Evancha, an analyst at Workgroup Technologies, Inc. in Hampton, N.H.
Data General presents
the AViiON 7000
and 8000 systems.

The Economist (London)
March 30, 1991

Data General’s AViiON 7000 and 8000 systems have 171 MIPS of mainframe power that fits in a pizza box!
That’s right. The brains of these next-generation Open Systems occupy the same space as your basic large pie.
Thanks to our new disk array technology, you can get an amazing 48 gigabytes of storage on fault tolerant disks. Best of all, this mainframe power is yours for a price starting at less than $100,000—and it’s available right now! And we don’t scrimp on software.
These binary compatible UNIX-based systems support all the leading databases, business applications and communications software.

DG extends Aviion line, adds 4600 RISC server

BY SALLY CUSACK
CW STAFF

WESTBORO, Mass. — Data General Corp. expanded its Aviion line of Unix-based workstations and servers across the board last week with products for high-end, low-end and midrange users.

Leading the announcement of 33-MHz Motorola, Inc. 88100-based systems was the Aviion 4600 reduced instruction set computing (RISC) server.

Priced from $19,995, the machine was developed under the code name Rolling Rock. It offers between 39 million and 78 million instructions per second performance.

DG also unveiled the Aviion 530 RISC workstation, priced at $13,500, and the high-performance Aviion 5225/6225 RISC server, priced at $43,500.

The 5225/6225 can accommodate 414 users and is positioned for larger database applications, the company said.

Performance boost
All of the new machines feature single- and dual-processor configurations and support DG/UX 5.4, an upgrade of DG’s Unix operating system that provides for symmetric multiprocessing capabilities. “I find it significant DG took steps to increase the I/O performance and memory performance of the system — it allows the machine to function in the real world,” said Tom La-Marche, information systems manager of the Flood Control District of Maricopa County in Phoenix.

The Flood Control District has been using the Aviion platform since its introduction in 1988; the shop currently uses 21 workstations and one server.

Agreement signed
DG also announced that it has signed a licensing agreement with Unix System Laboratories to offer the Tuxedo System Transaction Manager Release 4.2 and its workstation extension on the Aviion line.

Known as System/T, the transaction manager software product will provide a framework for building on-line transaction processing applications in the Unix V operating system environment.

DG has also dropped the price on the Aviion 4100 entry-level RISC server by more than 50%, from $21,390 to $9,995.
Sun’s latest means to prevent market eclipse

BY J. A. SAVAGE
CW STAFF

Already under assault in the high-performance workstation race, Sun Microsystems, Inc. is scheduled to announce today systems designed to stave off competition looming in low-priced systems.

Sun said it will replace the Sparcstation SLC with the ELC model. Priced the same as the earlier model at $4,995, the ELC has a faster clock and is rated at 20.1 Specmarks (the benchmark of the Systems Performance Evaluation Cooperative), up from 8.8. Sun will also reduce the price of its IPC model, introduce a higher-performance IPX and improve the performance of the Sparcstation 2.

However, analysts said last week that the interim measures of increased performance and decreased cost on Sun’s current line pale under the threat of low-priced workstations expected from IBM and Hewlett-Packard Co. by the end of the year.

Sun remains the dominant player in the market for reduced instruction set computing systems with more than 50% of sales, but both HP and IBM have raised the ante with high-end systems that offer either a price or a performance advantage.

Steve Tirado, product line manager at Sun, acknowledged that HP’s Model 700 has better I/O performance but said Sun’s products remain less expensive. “We may not beat them, but we’re close,” he said.

Prospects dimming?
Not everyone sees it that way. “From what I can see, Sun is lagging behind,” said Bill Grundy, software program manager at Hitachi America Ltd.’s Semicon-

ductor and Integrated Circuit Division in Brisbane, Calif. Grundy said he is evaluating new Sun machines, but “HP looks like a clear winner.”

Sun has said it would have a high-end multiprocessing system by the end of 1991, and despite persistent speculation to the contrary, the company is sticking to that time frame, a spokesman for the firm said.

Following that system, according to sources, Sun will develop its next-generation line around the next release of the Scalable Processor Architecture (Sparc). Chips from that version are expected to become available later this year.

According to Joe Nichols, director and vice president of marketing at Ross Technology, Inc. in Austin, Texas, the Sparc chip that Sun will be using in its next generation of workstations, code-named Pinnacle, should have “slightly higher” millions of instructions per second rating than HP’s 76 MIPS.

A shake-up in sight
Momentum alone may be sufficient to keep Sun in the No. 1 market share position over the short term. But, said Andrew Al-

lison, editor of the “RISC Management Newsletter” in Los Altos, Calif., “next year, things might change” in the face of increased competition from HP, IBM and the Advanced Computing Environment consortium.

In the meantime, Sun is expected this week to release the price of the Sparcstation IPC, a color, disk-full model, from $9,995 to $6,995. The IPX, the successor to the IPC, is priced at $13,495, with speed more than doubling, from 11.8 Specmarks to 24.2.

Last, Sun will provide a performance boost to its Sparcstation 2, which was introduced in November 1990. Its Specmarks will jump from 21.2 to 24.7, utilizing a software compiler preprocessor from Kuck and Associates, Inc. in Champaign, Ill., that will not be available for 90 days. The price will increase from $14,995 to $15,495.

JULY 22, 1991

Computer World

Overshadowing concerns
Sun Microsystems, Inc., which gained fame with low-cost, high-performance systems, has seen Hewlett-Packard Co. and IBM muscle in on its turf

Cost per specmark

Hewlett-Packard
Series 9000
Model 730 6RX

IBM RISC System/6000
Powerstation 320

Sun
Sparcstation 2

$277

$566

$627

CW Chart, Janell Genovese
Vaxstation, Decstation prices to slip

BY MAURA J. HARRINGTON

An announcement by Digital Equipment Corp. last week that it will cut prices of its low-end Vaxstation and Decstation 2100 and 3100 workstations, among other products, is yet another symbol of the volatility and competitiveness of the workstation market, analysts said.

"It used to be that you could anticipate workstation price and changes on an annual basis. Now, you can’t even go on vacation without a change in the market," said Peter Kastner, vice-president of Aberdeen Group, a market research firm in Boston.

DEC’s workstation price cuts — as well as cuts in prices of its memory upgrades, monitors and disk drives for the low-end models and bundling of factory-installed software in the Vaxstation 3100 — were announced with the VMS and Ultrix product lines, said Chris DeMers, DEC’s marketing manager for VMS workstation products.

The price-cut announcements included that DEC will reduce the price of its Vaxstation 1100 Model 30 diskless workstation from $7,950 to $5,950 for the 19-in. monitor monochrome monitor system and from $10,950 to $8,950 for the 15-in. color monitor system, DeMers said. DEC also will cut pricing on memory upgrades for the Vaxstation and Decstation 2100 and 3100 products to $250 per megabyte, DeMers added.

"In all honesty, this really turns out to be a leapfrog [move] in the industry. We really see the workstation industry opening up for us ... and I think that these offerings are very competitive," DeMers said.

While the price cuts may not be earth-shaking news to workstation users, analysts said, they represent a necessary strategic move for DEC, which says it is facing more competition than ever since IBM announced its RISC System/6000 workstation last month.

Chuck Barney, an analyst at Workgroup Technologies, a market research firm based in Hampton, N.H., said DEC, Hewlett-Packard Co. and HP’s Apollo division are all likely to lose some of their present workstation market share to IBM’s RS/6000. However, IBM probably will not leapfrog the two firms in market share by 1993 [see chart] if DEC and HP as well as its Apollo division continue their competitive strategies, Barney added.

"Workstation prices are falling fast across the board, so really, [vendors] almost have to keep slashing prices to stay in the same arena as their competitors," said Martin Ressinger, a vice-president at Duff & Phelps, Inc., an investment research firm in Chicago.

While the price cuts may seem like just another typical day in the fast-paced workstation arena, Ressinger noted that the market is so competitive that users — faced with price decreases and workstation products coming out almost every month — are no longer taking the first offer that comes along.

DEC slashes RISC prices

MAYNARD, Mass. — Digital Equipment Corp. last week announced price reductions and new configurations for its Decstation line of Unix-based reduced instruction set computing (RISC) systems.

The Decstation 3100 workstation dropped in price from $6,995 to $4,995, effectively replacing the Decstation 2100 system as DEC’s entry-level RISC workstation. DEC also knocked $2,000 off the color versions of the Decstation 3100, which now start at $7,495 and $8,995 for 16- and 19-in. configurations.

Prices for all models of the Decstation 5000 family have been reduced by $1,500, and the company introduced a new monochrome version of the Decstation 5000 Model 200 MX for $12,495. The Decstation 5000 also received a memory boost to a maximum of 480M bytes.

COMPUTERWORLD

JULY 23, 1990
**Analyzing Massive Speculation**

Massive parallel computing, for years part of Cray Research, Inc.'s long-range research and development efforts, is now firmly part of the vision for the products Cray plans for the end of the decade. The question is: Will Cray build its own parallel processor, or will it acquire one?

Cray's current top-of-the-line computer, the Y-MP/8, uses eight processors; a 16-processor machine, with 20 times the performance of the existing line, is planned for delivery in 1992. A follow-on to the Y-MP/16, with a peak performance of more than 100G floating-point operations per second (FLOPS) and 64 or more processors, is in the planning stages for a 1995 target date, according to Cray sources.

In parallel systems, hundreds — or even thousands — of relatively simple processors attack a computational problem. There has been a stumbling block to the approach, however. Parallel systems require computer code that is "parallelized" — broken into pieces and parcelled out to the individual processors. Other issues include how to optimize the work of each processor, how to manage communications between processors and how to handle data dependency in parallel environments, where the solution to one problem is dependent on the answer to a previously solved problem.

At Cray's annual meeting last month, for example, Cray officials stated the firm's intention to reach a one-trillion-FLOPS machine by the end of the decade, but acknowledged that reaching that goal will require a new computing architecture.

"Our view is that [massively parallel] systems are a form of special processors, and we're looking at a strategy to tightly couple these to a general-purpose processor," said Lester T. Davis, executive vice-president at Cray's Chippewa Falls, Wis., center for engineering and development, during an interview with Computerworld.

Davis added that it would be "a long struggle" for massively parallel systems to replace general-purpose machines. He also said Cray had spent the past year examining the massively parallel approaches of other vendors.

While Cray executives continue to argue that existing massively parallel systems are best extended...

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**Parallel Tracks**

Cray Research acknowledges that the growth path from its current Y-MP family requires massively parallel technology...

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**Mirror, Mirror on the Wall Whose Computer is Fastest of All?**

When best known for the microprocessors that serve as the brains of IBM-type personal computers, Intel Corp. is also a leader in massively parallel computers. These machines have hundreds of microprocessors and quickly solve complex problems using each processor for a piece of the puzzle.

Intel and archival Thinking Machines Corp. in Cambridge, Mass., are now fighting over bragging rights for the fastest massively parallel computer. In June, Intel boasted that its newest supercomputer, the Touchstone Delta System installed at the California Institute of Technology, had topped the world speed record set a few months earlier by Thinking Machines. Outfitted with 528 of Intel's two-year-old i860 reduced instruction-set computing (RISC) processors, the Delta breezed through 8.6 gigaflops, or billions of floating-point operations per second. A week later, Thinking Machines edged back on top, claiming 9.03 gigaflops for its CM-200 machine.

That same day, Intel unveiled a souped-up RISC chip, the i860 XP. It will be the heart of a new class of massively parallel supercomputers called Touchstone Sigma. Intel expects to demonstrate that technology late this year and projects a peak speed of 150 gigaflops. In the meantime, the Caltech machine has reclaimed the lead at 11.9 gigaflops.

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**Small Packages**

By the year 2000, a single computer chip could potentially solve problems that a supercomputer the size of a refrigerator handles today. Intel Vice President David House predicts his firm will lead the way in providing the computer brainpower by introducing a series of three new microprocessing chips over the next 10 years, each one more than quadrupling the speed and power of its predecessor. The i586 chip is slated for 1993, to be followed by the i686 chip in 1996 and the i786 chip by the turn of the century.
AST Introduces Computer Line Using 486 Chip

BY G. PASCAL ZACHARY
Staff Reporter of The Wall Street Journal
AST Research Inc. introduced a line of personal computers based on Intel Corp.'s powerful 486 microprocessor that cost about half the price of comparable models sold by competitors.

The new AST machines range in price from $3,955 for a machine without a hard-disk drive to $5,365 for a computer with a 200 megabyte hard-disk drive. Analysts said that AST's aggressive pricing should help kindle interest in 486-based PCs, which is Intel's most powerful microprocessor, but that prices for these models will continue to command a premium for some time over PCs that use Intel's 386 chip.

"You are certainly going to see 486 prices come down strongly in the next 12 months," said Will Zachmann, a computer analyst in Duxbury, Mass. "But this isn't the start of a price war."

Prices for 486-based PCs can only come down so far, so fast. Intel, sole supplier of the chip, charges $722 for a 25 megahertz 486 when purchased in large volume, down from a $850 price 16 months ago. Intel charges $953 for its faster 33-megahertz 486, which sold for $1,056 when first released in May.

Sales of 486-based PCs have been disappointing so far this year, largely because these machines sport price tags of $10,000 on average, making them far higher than conventional PCs. The high prices have chased away customers from PC retailers, who sold a mere 1,400 486-based PCs in August, according to Storeboard, a market researcher. That figure was up from a dismal 233 in February.

Most 486-based PCs, such as those supplied by Compaq Computer Corp., are being sold by resellers who specialize in high-priced machines. But even these "valued-added" resellers are having a tough time finding buyers. According to Computer Reseller News, a trade weekly, some dealers are selling Compaq's 486 PC at just 6% above cost to spark interest.

Intel reveals its plans for 1586

BY CHRIS BARTON
SPECIAL TO CWW

AUCKLAND, New Zealand — Intel Corp. expects to introduce the four million-transistor 1586 microprocessor by 1993 and also plans an I686 with 22 million transistors by 1996 and an I786 chip with 100 million transistors by 2000.

Intel Australia Managing Director Bruce Patterson recently told attendees at the Compaq Technology Forum in Sydney that the 32-bit 80386 architecture "has made it possible to have PCs that are real computers" and that the 386 architecture is a complete architecture with room to grow "all the way to 2001 and beyond." Patterson said he believes the 1990s will herald a migration to a new standard — the full 32-bit platform, where CPUs and all auxiliary functions, I/O buses and software will be 32-bit.

Patterson said the 386 was the first implementation of this architecture, followed by the 1486 with its full binary, forward and backward compatibility with the 386 processor. He stressed that the 1486 implements the 386 architecture and that such stability will provide a solid platform for the future. Intel expects to announce a 50-MHz version of the 1486 by the end of the year, Patterson added.

Patterson also revealed some of Intel's projections about the kind of microprocessor it could produce by 2000. Intel engineers have dubbed this chip the Micro 2000 and expect it to about 2.5cm by 2.5cm and to contain 100 million transistors. It is expected to integrate four CPU execution units with five million transistors per unit operating in parallel.

There will also be two vector units operating in parallel with 10 million transistors; a graphics and self-testing sector, each with five million transistors; and a cache storage area of 40 million transistors. Patterson said the chip would employ "CISC, RISC, fine-grain parallel processing and probably a lot more of those kind of acronyms and buzzwords."

Barton is a reporter at Computerworld New Zealand.
Digital Signal Processors Promise Multimedia—Cheap

Multimedia is about to get a big boost from a single inexpensive multipurpose chip: the digital signal processor. Priced on a par with modern chip sets, the new DSPs from Analog Devices, AT&T, Motorola, and Texas Instruments can handle it all: fax-modem, voice mail, speech recognition, stereo sound, and image compression. Later this year, you'll be able to buy add-in cards and new PCs with any or all of these functions.

For ten years, application-specific DSPs have been used in everything from telephones to cars. In sports cars, DSP-based "mufflers" cancel out engine noise and DSP-based "shock absorbers" respond to bumps in the road with equal and opposite forces. In the PC arena, DSPs are currently used in high-speed modems; a Motorola DSP is built into the NeXT machine and a DSP from Analog Devices handles the audio portion of Intel's Digital Video Interactive (DVI)-based ActionMedia 2 Delivery Board.

A DSP is best thought of as a "funny floating-point processor," says Steve Edelson, architect of the Continuous Edge Graphics chip and founder of Edsun Laboratories. Like RISC chips and math coprocessors that are optimized for certain functions, DSPs have a set of signal processing commands built in. "They're really good at doing certain kinds of computations, like filtering. And they're fast enough to keep up with sound, for instance, in real time," says Edelson. This ability to perform complex algorithms in real time is what makes DSPs suited to multimedia applications such as image compression and speech recognition. Another advantage is their programmability.

Analog Devices recently announced DSP chips optimized for multimedia.

A New CPU Every 18 Months?

In the PC industry, customers have gotten used to a new generation of microprocessors every three years. The next generation is likely to arrive on schedule: Intel's next CPU, code-named the P5 (probably to be called the 586), is expected this summer. But future generations may show up more quickly.

Faced with increased competition from new RISC chips that are expected to be able to run standard software, Intel's follow-up to the P5 will probably be out 18 months later. Code-named the P6, it will probably be called the 686 and should have even more RISC-like features than the P5. And the P7, another generation, is expected about 18 months after the P6.

According to Dave House, Intel's senior vice president, the P6 is halfway through development. Intel can turn on a new generation out faster than in the past because, he says, "We are devoting more spending and more teams to development."

Rated at 100 mips (million instructions per second), the 586 (P5) is expected to be 2.5 times faster than the 50-MHz 486 DX2, and industry sources expect the P6 to be another leap forward. "It's too early for any details on the P7.

Intel has been facing more competition in the mainstream chip market. Meanwhile, Windows NT will run on MIPS's R4000 RISC chip, and Microsoft has endorsed DEC's new Alpha RISC chip. Are we ready for two advances in chip generations in the next two years? Intel is counting on it. "Customers certainly say they’re ready," said House. "They're beating down our doors."

Michael Slater, editor of Microprocessor Report, thinks he knows why chip customers would want another CPU so quickly. "In 18 months, the market won't be crying for something to replace the P5. But the P6 probably won't be aimed at the same customer as the P5.

The P6 may let customers build systems with fewer parts or do other things to decrease cost. You can't move the mainstream market that quickly, but you can at the high end."

—Christopher Barr

MAY 26, 1992  PC MAGAZINE  29
Cray un wraps 'low-end' supersystem

BY ELLIS BOOKER
CW STAFF

EAGAN, Minn. — Cray Research, Inc., the Ferrari of computer makers, recently introduced the supercomputer industry's equivalent of an economy model, an entry-level system targeted at cost-conscious companies.

The Cray Y-MP EL is an air-cooled, one-to-four-processor system architecturally compatible with Cray's flagship Y-MP line.

The $300,000 to $1 million EL puts supercomputing technology "within easy reach of hundreds of new customers," said Cray Research Chairman and Chief Executive Officer John A. Rollwagen. Cray claims to have already received 18 orders for the EL, which will begin shipping this quarter.

The EL is capable of operating at 133 million floating-point operations per second. The 11-square-foot computer comes with a 30-nanosecond clock, 256 Mbytes of memory, and, like the larger Y-MP line, uses Unicos, Cray's Unix operating system implementation. It supports up to four integrated I/O subsystems per CPU, with data transfer via a variety of standard network protocols.

A high-performance parallel interface will be available by mid-1992, Cray said. The EL is the successor to the Cray XMS, a system based on technology acquired in Cray's June 1990 purchase of Santa Clara, Calif.-based Supertek Computers, Inc.

Value-added relationships
As part of its move into the low-end market, Cray also announced its first relationships with value-added resellers. The three companies - Cognisys Development, Inc. and Timeslice Technology, Inc., both in Houston, and France-based Biostructure - will be able to sell the EL and add their own software products to the platform.

Gary Smaby, president of the Smaby Group, Inc. in Minneapolis, said Cray is arguably in the best position to realize the potential of a "mini-Cray."

"The minisupercomputer marketplace, defined as customers who wanted but couldn't afford a Cray, was something of a phantom," Smaby said. He noted that one company often described as a Cray competitor, Convex Computer Corp. in Richardson, Texas, has historically sold against Digital Equipment Corp., not Cray.

A supercomputer first is claimed

BY KIM S. NASH
CW STAFF

RICHARDSON, Texas — Convex Computer Corp. recently claimed that it has developed the first real-time supercomputers.

Based on the company's C2 and C3 supercomputers, the new Preemptor 5000 series reportedly can run at up to 800 million floating-point operations per second (MFLOPS) and incorporates features such as internal real-time clocks, user-programmable interval timers and the ability to send timer output signals to users in response to events and computations inside the machine.

The Preemptor 5500, which is slated to ship this year, performs at 50 to 800 MFLOPS, with an I/O rate of up to 200 Mbytes/sec. Prices start at $495,000. The smaller Preemptor 5300, with a base price of $349,000, can operate at 50 to 200 MFLOPS, with an I/O bandwidth of 80 Mbytes/sec.; it is scheduled to ship during the first quarter of 1992.

Convex also announced ConvexRTS, a new real-time, multitasking operating system that includes four separate packages: a real-time kernel, a time-sharing Unix development environment, a system debugger and a performance analyzer.

COMPUTERWORLD
Nov 11, 1991

JUNE 24, 1991
Cray unveils entry-level, ‘air-cooled’ supercomputer

By Ellis Booker
CW Staff

Minneapolis — With a price tag ranging from $2.2 million to $5.6 million, Cray Research, Inc. last week introduced its Y-MP2E “starter” supercomputer as a stepping-stone to its larger systems. Company officials downplayed its strategic function as a defense to “minisuper” technologies from other vendors.

The Y-MP2E is less than half the price of the smallest machine in Cray’s existing Y-MP line. Unlike that line, which requires liquid refrigerant plumbing, the 2E uses a self-contained cooling apparatus; it can also be tied into standard water-cooling plumbing. Cray said it hopes to deliver the first Y-MP2E to a customer in October.

“It opens up the possibility of real supercomputing to a much wider community of users,” said Cray Chairman and Chief Executive Officer John Rollwagen at the company’s annual shareholders’ meeting.

Other Cray officials in Minneapolis described the new model as an “entry point” to Cray’s larger machines, which can cost $20 million. But they rebutted the idea that the Y-MP2E is a defensive product that will protect Cray’s market from minisupercomputer vendors whose machines are less powerful but less expensive than Cray’s offerings. “You can’t make a business killing the competition,” said Cray Senior Vice-President of Marketing Edward A. Masi. “You make it by growing customers.”

“The first and most obvious customer will be existing Cray 1 or Cray X-MP users,” Masi said. He added that this migration will be attractive because “we estimate maintenance, power and cooling costs for the SE will be 70% less [than the X-MP] over five years.”

Nevertheless, comparisons with the C-240, the top-of-the-line minisupercomputer sold by Richardson, Texas-based Convex Computer Corp., abound in the 2E literature. Cray stated that the single-processor 2E is 3.5 to five times faster than the four-processor C-240, which also lists at $2.2 million.

Convex officials said the performance comparisons are distorted and pointed out that the new Cray is still far more expensive than their average $1 million systems.

Convex co-founder and Senior Vice-President Steve Wallach also said Cray’s claims of an “air-cooled” supercomputer are deceptive. Wallach also pointed out that the system actually relies on the same refrigerant used in the larger Y-MP models but employs a separate air- or water-cooled system, called a heat exchange unit, to remove the heat.

Nevertheless, analysts and existing Convex and Cray customers said that Cray had made the right move by bringing out an entry-level machine.

“They finally realized where they were weak in the market,” said Jane Barutt, a schedule development analyst at Northwest Airlines in Minneapolis. Last April, Northwest purchased a Convex C-220 over a Cray to handle its computationally intensive flight-crew scheduling application.

“It makes a lot of sense for Cray to have a computer a little easier to install and maintain,” said Dieter Fuss, deputy associate director for computation at Lawrence Livermore National Laboratory in Livermore, Calif.

The 2E can be configured with one or two processors. Like the bigger systems, the 2E runs Unicos, Cray’s implementation of AT&T Unix System V. The memory configurations for the 2E can have 16 million, 32 million or 64 million words of memory. A 128 million-word version is planned, Cray said.
CONVEX WANTS TO BE A FULL-FLEDDGED HEAVYWEIGHT

But can its new supercomputer spar in the Cray class?

For Convex Computer Corp., life has been one big blast since 1982, when it began building the first high-speed number-crunchers for engineering and science labs that couldn't afford $10 million supercomputers. Convex's minicomputers can do everything from design drugs to simulate car crashes, but they cost as little as $300,000. Their success has enabled Convex, based in Richardson, Tex., to outlive a raft of competitors, win some 400 customers, and grow to $209.3 million in sales last year.

Round Two. To keep revenues growing at 15% to 20% a year, Chief Executive Robert J. Paluck reckons he now must push into the larger, more-demanding market for midrange supercomputers, which have up to five times the speed of minisuper. By now, companies such as Digital Equipment Corp. and IBM have responded to Convex' older machines by adding special hardware to their computers. But the move into full-fledged supercomputers puts Convex on a collision course with the industry's dominant force, Cray Research Inc.

Cray, searching for growth, is also pushing into the midrange market—if only to keep Convex from winning customers who one day might want a full-size Cray. Last year, Cray began shipping the Y-MP2E, a $3.3 million midrange super.

FIRST BLOOD. Already, the sparks are flying. Knowing that Convex planned a May introduction of its first midrange super, the $2 million-to-$8 million C3, Cray made a preemptive strike. On Apr. 8, it announced the Y-MP4E, a $5.5 million-and-up big brother to the Y-MP2E.

Both machines are aimed at customers who felt they couldn't afford Crays. "We must do more to make our products cheaper," says Cray CEO John A. Rollwagen. Cray figures that the two small Y-MPs together will account for 30% of its 1991 installations.

Convex, meanwhile, plans to launch the C3 on May 7. It's not providing many technical details yet, except to say the eight-processor machine will be 2.5 times faster than its current C2 line of processor will perform about 125 million arithmetic operations per second, putting it within reach of the Y-MP4E (table). "The C3 is clearly going to be the company's engine of growth for the next several years," says Barry F. Willman of Sanford C. Bernstein & Co., a securities firm, who predicts it will account for about 25% of Convex' revenues this year and 40% in 1992.

Convex and Cray Research bring different strengths to the midrange market. Because it sells cheaper machines, Convex has more customers. And they are more likely to move up to a C3 than to switch to Cray. However, Cray is a $804 million company with enormous prestige and clout in supercomputing. "Where the battle will be is for the not-as-yet committed," says analyst Jeffrey Canin of Montgomery Securities.

Convex faces mounting pressures. It says that first-quarter earnings will be lower than analysts' expectations. And it will have to sell to a new audience, including the CEOs of its customer companies, rather than just to engineering departments. Selling pricier systems will also take more time and patience. "Convex is going into a marketplace that they aren't as familiar with as we are," says René Copeland, Cray's marketing director.

MEMORIALIZED. Talk like that doesn't intimidate gung-ho Paluck, who co-founded Convex with former Data General Corp. computer architect Steven J. Wallach. Paluck is confident that Convex can outmaneuver Cray. And he's hardly ignoring the still-lucrative minisuper market. When it takes the wraps off the C3, Convex is also expected to announce an enhanced C2 minisuper.

As they go head-to-head with Cray, Paluck and Wallach are very mindful of the vagaries of the computer business: On a patio at the company's headquarters, there are 20 names etched in cement: Compumatrix, ETA Systems, etc. are the companies that started alongside Convex in supers, but fell by the wayside. The lesson, says Paluck: "You've got to have a brilliant strategy, and you have to actually execute it. Otherwise, you become a tombstone."

By Stephanie Anderson Forest in Richardson, Tex., with bureau reports.
WILL FAST AND CHEAP BE DATA GENERAL’S SALVATION?

Ronald Skates’s high-risk gambit: Slash R&D and build hot boxes

Until December, Data General CEO Ronald L. Skates had spent five years in the shadow of the minicomputer company’s legendary founder, Edson D. de Castro. True, Skates had risen from a minor financial post to chief operating officer and then CEO. But de Castro, as chairman, ruled—and the company drifted. At de Castro’s Data General, advanced technology seemed to come before advanced profits.

After five consecutive quarterly losses, though, Data General Corp.’s directors decided they had had enough. On Dec. 12, they ousted de Castro and put Skates fully in charge, just in time to see a $75 million cut in annual operating expenses yield a $15 million quarterly operating profit. That restructuring, plus a hot new line of computers, suddenly gives the Westboro (Mass.) company its best prospects in years. Wall Street certainly thinks so: In the past two months, DG’s stock has risen 185%, to 113%, or 12 times the increase in Standard & Poor’s computer index.

The price of this rapid turnaround is greater vulnerability. To make DG profitable again, Skates is paring the company down and planning its future around a single, relatively bare-bones product line, called Avion. He’s taking Data General back to its roots as a lean, mean maker of the fastest computers for the lowest prices. And he’s leaving most programming chores and specialization up to the customers. That’s how de Castro built up DG in the 1970s, developing “hot box” minicomputers that outran whatever Digital Equipment Corp. built.

Skates has had to wield a heavy ax to get back to that strategy. He has pulled funding from several major development programs, including one with Nippon Telegraph & Telephone Corp. to build a special computer for telephone companies and another to build superspeedy versions of Motorola Inc.’s 88000 reduced instruction-set (RISC) microprocessor. A promising office automation software project was spun off into a Japanese-funded startup named HyperDesk Corp. All told, Skates has cut total research and development spending to about 8% of annual sales, well below de Castro’s absolute minimum of 12%.

His latest move, on Mar. 12, is to sell DG’s Japanese arm, Nippon Data General, to Omron Corp. for $46 million.

ECLIPSED PROFITS. All that, Skates says, should leave DG better able to concentrate on what must now become its flagship products, the Avion workstations and minicomputers introduced in 1989. They’re based on Motorola’s 88000 chips and are designed to compete with similar machines from Sun Microsystems, IBM, and DEC. Sales of DG’s older Eclipse minis, which produce the bulk of its $1.2 billion in revenues, fell 24% last year. The company is counting on Avion sales, about $120 million last year, to pick up the slack.

The danger, though, is that DG may not be able to push Avion’s price and performance fast and far enough to succeed in today’s fiercely competitive “open systems” market. There, all computers run essentially the same industry-standard software packages, beginning with American Telephone & Telegraph’s Unix operating system. With little room to differentiate products via software, every supplier is pushing hardware price and performance. To succeed, DG will have to outrun the pack.

To Skates, it’s all in the engineering. New Avions, scheduled for release on Mar. 18, will run three times as fast as DEC’s VAX 9000 mainframe but will sell for a third of the price—around $100,000 and up. Barry F. Bosak, an analyst at Smith Barney, Harris Upham & Co., reckons that the new machines will drive DG’s profits to $46.5 million in 1991 on flat sales of $1.2 billion. Says Skates: “It won’t take much for us to be back in the swing of things.”

Easier said than done. The new Avions may have only a fleeting moment on top. Hewlett-Packard Co., eager for a comeback in workstations, plans to unveil machines on Mar. 26 that is says will be even faster and cheaper than the new Avions. DG contends that it’s still in shape to keep up in such games of technological leapfrog. But, says Judith S. Hurwitz, a market researcher at Patricia Seybold’s Office Computing Group in Boston: “When you cut R&D that much, you have to ask: Long-term, how is DG going to compete with Hewlett-Packard, IBM, Sun, and DEC?”

Pursuing the hot technology/low price strategy also involves wrenching boom-and-bust cycles between generations of new products. So even though Data General seems to be on its way up again, Skates had better hang on to his hat. Data General is back on its roller coaster ride.

By Gary McWilliams in Westboro, Mass.
FOR THE RECORD:

MIPS ratings published August 2 in Computerworld's "Annual Hardware Round-Up" were not those submitted by Control Data, but rather CW's own estimates.

Here's a comparison of the two sets of figures:

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We think it is important to set the record straight.

If you'd like to know more, please call your local Control Data systems sales representative.

CONTROL DATA

BIG BLUE BEefs UP ITS MINIS

IBM is set to revamp its line of AS/400 minicomputers. The AS/400 was launched in 1988 and has enjoyed strong sales—estimated at more than $10 billion including software and services—to small businesses and corporate departments. But sales momentum has slowed recently, prompting IBM to bring out a handful of all-new models offering more performance per dollar. Unveiling is set for Apr. 23.

DG readies a four-pack

This week, DG is expected to roll out four 33-MHz, 88K-based Avion workstations. Code-named Rolling Rock, the project has been on the drawing board for about a year now, sources say, and the new single and dual processors will make the current 16-MHz 4020 and 3200 machines offered by DG obsolete. Priced between $8,000 and $10,000, the new entries will compete directly with HP's recently announced entry-level RISC server.
IBM Fills Performance Gap
By Bringing Out 3081-G

By Tom Henkel
CW Staff

RYE, N.Y. — Analysts repeatedly said IBM's 3081 Model Group D pro-
cessor did not fit into the price/performance pattern set by the 3083 and
3081 Model Group K. IBM solved that apparent discrepancy when it
recently announced a replacement processor, the 3081-G.

Like the 3081-D and 3081-K, the
Model Group G is a dyadic processor available with main memory config-
urations of 16M, 24M or 32M bytes. IBM said the processor offers "slightly"
more power than the 3081-D, but a company spokesman could not say exactly how much more power is
available.

IBM stated that users of 3083-B pro-
cessors can field-upgrade to the 3081-
G. That means users of the 3083-E, the
smallest member of the 3080 se-
ries, can field-upgrade up to a 3084
without going through a major hard-
ware exchange.

A 3081-G processor with a 3082 pro-
cessor controller and coolant dis-
tribution unit ranges in price from
$3.54 million for a 16M-byte pro-
cessor with 16 I/O channels to $4.09
million for a 32M-byte, 24-channel
system, IBM said. The system leases
for $128,045/mo and $133,515/mo, re-
spectively; rental prices are
$147,555/mo and $166,890/mo, the
vendor said.

IBM Unveils 3084, New Top of Its Line

IBM Cuts Prices
But Raises Rent
Of 3081-D, K

RYE, N.Y. — In addition to an-
nouncing two new processors (story
on Page 1), IBM cut prices on its 3081
Model Group D and K processors by
up to 10%.

However, the vendor raised lease
and rental prices on those same ma-
chines by 10% while decreasing the
minimum monthly maintenance
charges by up to 25%.

And in a move that analysts view as
an appeasement to customers who are
currently using 3081 Model Group D processors, IBM is offering
a $200,000 price reduction on the
3081 Model Group D to Model Group
K processor upgrade package. The
same price decrease is available to us-
ers of the new Model Group G pro-
cessor if those users decide to up-
grade to a Model K processor before
the end of the year.

The Model Group D or G-to-K up-
grade normally costs $600,000. Users
can now buy that package for
$400,000 if:
• A Model Group D processor is in-
stalled on or before Sept. 30.
• The effective date of purchase of
installed 3081 D or G is on or be-

The New Lineup

IBM Unveils 3084, New Top of Its Line

(Continued from Page 1)
48M or 64M bytes of main memory.

The processor can be operated as
two independent dyadic systems or
as one four-processor system. An
IBM spokesman last week could not
tightly coupled multiprocessor, the
3084's instruction rate is about 1.9
times that of the 3081-K in com-
mercial and scientific environments,
IBM said.
Changed Industry
Computers Become
A Kind of Commodity,
To Dismay of Makers
Sep 5, 1991
Excess Capacity, Fast Pace
Of Innovation Keep Prices
Declining and Profits Low
But Corporate Buyers Benefit

By William M. Bulkeley
Staff Report of The Wall Street Journal

Computers are closing plants and firing tens of thousands of workers. There is excess capacity around the world. Industry leaders face years of restructuring.

The steel industry in the 1970s. Yup. And the computer industry in the 1990s.

Computers, except for the biggest machines, are becoming commodities that customers buy as cheaply as possible. And the computer industry will never be the same again. While the recession has aggravated the problems, analysts predict that commodity pricing will keep plugging the companies until their number has dropped considerably.

"Profitability of every sector of the computer industry now is under pressure or becoming nonexistent," says Barry Bosak, an analyst at Smith Barney. Harris Upham & Co. And with the companies constantly leapfrogging each other with machines that run the same software, the industry is condemned to ceaseless innovation, price cutting and product cycles that are nasty, brutish and short.

Repeated Innovations

The ever-more-rapid pace of innovation is demonstrated by Sun Microsystems Inc., which has spurred many of the changes. Sun introduced eight generations of computers in its 9½-year existence. In the old days, product cycles took three to five years, and companies had plenty of time to recoup research and development costs.

Instead of having twice the profit margin on sales of average industrial companies, as they did in 1984, computer companies now have returns 20% lower than average, McKinsey & Co. consultants calculate. Over the past five years, profit margins for the 11 largest U.S. computer companies averaged just 6.5% in the previous five years, they averaged 11.5%, Technology Research Corporation.

All that dismays a business that just 10 years ago—when Americans were smarting at their loss of leadership in steel and machine tools—was hailed as the model of U.S. industrial success.

The changes are good for buyers, which enjoy the fruits of innovation and the ability to play computer makers off against one another to get lower prices. Software makers, which can easily differentiate their products, benefit because their programs run on a wider variety of computers. The business of helping companies integrate various kinds of computers into networks is growing.

Meanwhile, virtually every computer maker is trying to reinvent itself. Wang Laboratories Inc. is offering to sell International Business Machines Corp. computers instead of its own models. Prime Computer Inc. is moving to become a computerized-design software company instead of a hardware maker. Digital Equipment Corp. is relying on outside companies to develop both the operating system and the microprocessor brains of its high-powered workstations. And IBM is asking archival Apple Computer Inc. for help in designing its future desktop computers.

These companies have ample reason to change. With prices falling so fast, Pier Carlo Falotti, who heads Digital's big European operations, complains, "We have to sell 70% more [unit] volume every year just to stay even in revenue." Companies such as IBM, Digital and Compaq Computer Inc., long accustomed to double-digit sales growth and profit margins, now often report shrinking computer revenue and paper-thin profits—and huge restructuring charges.

Changed Job Picture

For workers, computer companies once offered lifetime jobs, generous benefits and ample opportunity for advancement in a white-collar environment. Today, even profitable companies are laying people off, and money-losers such as Unisys Corp. and Wang are cutting staffs to barely half their peak levels. Computer industry jobs fell 4.3% last year to 424,000—the 1980 total.

But the computer industry differs from others in the U.S. that turned from leaders to laggards: Vicious competition among U.S. companies themselves, rather than from foreign rivals, is causing most of the pain. And compared with other U.S. industries, "the computer industry is five years ahead of the curve in realizing it has to hold onto market share," says Ira Magaziner, a Providence, R.I., consultant.

But holding on is likely to produce skimpier and skimpier profits. For one thing, the ability to build computer hardware, once scarce, has become commonplace. Hundreds of companies are building powerful personal computers, not just in Silicon Valley and Japan but also in Korea and Taiwan—and North Sioux City, S.D.

The PC has become a commodity because Intel Corp., which makes microprocessors (the PC's brains), and Microsoft Inc., which makes the operating system software, are in effect monopolies that sell their technologies to practically all comers. The companies that assemble PCs from those components press suppliers of all other parts—screens and disk drives and memory chips—to slash prices and push technology.

The upshot: With most buyers looking primarily at price, IBM and Compaq, the high-priced market leaders, had to slash their PC prices earlier this year.

Now, the commodity battlefront is moving up to more expensive, sophisticated workstations that use the UNIX operating system. UNIX, developed by American Telephone & Telegraph Co., has become the standard because it works on all the computer makers' fastest workstations. At one point, customers were afraid to mix in computers that were incompatible with a proprietary operating system, and they waited patiently until their vendor caught up with competitors. Now, every time a workstation maker leapfrogs the competition with higher speed or a lower price, many customers switch.

Although various versions of UNIX differ a bit, they are similar enough that software vendors can make applications for one system work with another. Parametric Technology Corp., of Waltham, Mass., brings out new versions of its computerized design software on seven different UNIX workstations within a few weeks every time it upgrades the product.

Price and Performance

"We're enjoying the workstation wars today. Can you top this?" goes on constantly," says Roger Herman of ITT Corp.'s aerospace communications division, a user of Parametric's Pro Engineer. At Northern Telecom's Ottawa engineering department, Marc Duhde, a manager, comments, "At any particular time, the choice comes down to price-performance." Engineers designing everything from switch cabinets to telephones hands used to work on terminals hooked to IBM mainframes. Three years ago, Northern switched to Pro Engineer on workstations and now buys from Sun, Silicon Graphics Inc. and Hewlett-Packard Co.

Makers of bigger computers haven't reached the commodity stage. Companies with IBM mainframes find it expensive to rewrite all their software to run on UNIX-based mainframes. But software developers are writing more and more software programs for the UNIX operating system, and some customers are tempted by cheaper standard systems. And makers of UNIX-based computers that create one powerful system from several microprocessors offer equal power at a fraction of mainframe prices.

Two years ago, Richard Cascio, chief financial officer at JFK Medical Center in Atlantic, Fla., decided to replace his two-year-old, $2 million IBM 3080 mainframe with six Data General Corp. UNIX-based Avion computers costing a total of $700,000. "In the first year, the pure bottom-line savings are $500,000," he says. In addition to the cost benefits, the Avion systems are easier to use and can be kept running more consistently, he says.
Changed Industry: Computers Are Almost Like a Commodity Now

'Devastating' Pressure

In terms of pricing pressure, "it's devastating," says John Levinson, an analyst at Goldman, Sachs & Co. "Chief information officers, and more importantly the boardroom, now understand that open systems are a lot cheaper and more flexible and don't lock you in." Makers of proprietary midrange and mainframe computers have to discount list prices sharply to keep existing customers.

The pressures on mainframes will worsen as engineers figure out how to use multiprocessor UNIX computers to run huge data bases such as airline reservation systems and big banks' customer accounts. Oracle Corp., the leading independent maker of database software, recently demonstrated that it could run its database on a $1.7 million nCUBE Corp. supercomputer at about 1,000 transactions per second—half the speed of the fastest online transaction-processing software on one of IBM's biggest, $20 million mainframes. Moreover, Oracle's data base is more flexible and easier to program.

The lower prices for computer systems have badly hurt proprietary-system makers accustomed to high gross margins.

Russell Planitzer, chairman of Prime Computer, longingly recalls the days when a midrange Prime 50 costing $300,000 carried a 55% gross margin—profit before taxes, interest and overhead as a percentage of price. If a salesman sold four of them a year, Prime had a gross profit of $760,000. "The equivalent performance in our UNIX family has a $150,000 price tag and a 40% gross margin," Mr. Planitzer says. To bring in a $760,000 gross profit, the salesman would have to sell 13 systems a year, Mr. Planitzer calculates.

Some PC companies have adjusted to the new economics by avoiding the expense of big sales forces, cutting down R&D spending to less than half the computer-industry norm of 10%, and accepting after-tax profit margins under 5%. But for larger systems, most companies believe that R&D spending must remain high, and they cut costs elsewhere.

Analysts say Sun Microsystems is virtually the only big maker of more-powerful computers that has a business model fully geared to the commodity hardware business. Sun, founded in 1981, embraced the UNIX standard from the beginning, buying all parts rather than designing and building them itself. It also didn't set up multiple factories. "We built this company from scratch using a business model that didn't involve much infrastructure or employees," says Lawrence W. Hamby, Sun's vice president of marketing.

Sun accepts a profit margin well under historic industry norms. In its recently completed fourth quarter, Sun's profit margin hit a three-year high of 7%—anemic by the standards of the industry winners in the 1970s. But because investment has been so low, its return on equity was 18%, well above average for U.S. companies. With 12,500 workers and $3.2 billion in sales, Sun has one-quarter the sales and one-tenth the employees that Digital does. "Sun invented the new economics of computing," says an admiring Mr. Planitzer.

Most older vendors are trying to copy Sun's approach for their industry-standard products: buying parts from suppliers, cutting costs and producing new products annually. Most hope to continue selling high-profit proprietary systems to existing customers for a few more years. However, almost all of them are holding onto those customers by promising to help them switch to UNIX in the future.

Only a few companies will have the economies of scale to build UNIX computers profitably. The rest will buy them and add software or hardware enhancements before reselling them, as Prime and Wang already do. Steven Milunovich, an analyst at First Boston Corp., predicts that by the end of the decade, there will be only three European computer makers, four or five Japanese makers and four to six large U.S. manufacturers. "I can't help but be negative about the whole hardware industry," he says.

Besides helping computer buyers, all that change spells opportunity for consulting and integration companies such as the consulting arm of Arthur Andersen & Co. and General Motors Corp.'s Electronic Data Systems subsidiary. And many software companies are doing well; their customers don't want to switch software once they have learned one program. In fact, most hardware companies are trying to build their own software and integration services business: Digital gets about 40% of its revenue from those areas.

For most hardware companies, the changes are crippling, although a few have made the adjustment. Analysts say Hewlett-Packard and AT&T's NCR Corp. have stayed profitable while moving to UNIX. Data General has stabilized its proprietary-system sales while expanding its UNIX business.

The Giants' Big Bets

The industry's giants, IBM and Digital Equipment, are betting that customers will continue to want their proprietary mid-
Powerful new Compaq desktop computers unveiled

By Reuters

NEW YORK — Compaq Computer Corp. unveiled a new line of desktop computers yesterday that are so powerful they will cut into sales of larger minicomputers, already facing a slump.

The announcement sharply boosted Compaq's stock price and hurt other technology issues, including International Business Machines Corp. and Digital Equipment Corp.

The three new Compaq machines are based on a souped-up version of Intel Corp.'s 80386 microprocessor that runs at a breakneck speed of 33 megahertz. Houston-based Compaq said the new models can crunch numbers up to 35 percent faster than machines built around the older 25-megahertz 80386 chip.

The three models of the Deskpro 386/33 are designed for data-intensive jobs like computer-aided design, financial modeling and software development. They are priced between $10,000 and $18,000.

Analysts said Compaq's new models represent an assault by relatively inexpensive desktops on terrain once held exclusively by the minicomputers of IBM and Digital, which sell in the $100,000 range. Jobs that once needed a minicomputer can now be tackled by a personal computer or its high-powered cousin, the engineering workstation.

Compaq stock soared $3.125 on the New York Stock Exchange to $87.125, while IBM fell $1.25 to $109.875 a share.

How Fast Is It?

Very fast. Although the accompanying chart doesn’t reflect it, test software showed speed to be within 10 percent of the 16Mz Compaq 386. I used PC Labs Benchmark Release 4.2 tests and two you can do yourself when shopping for accelerator boards.

The chart gives speed comparisons for a 4.77Mz motherboard, a 286/12Mz clone and the 386XT board. The first four lines are the PC Labs Benchmark tests and the last two are speed tests for recalculation of a Lotus file and doing a WordStar find and replace operation. You can easily duplicate the last two tests for comparisons of your own.
486 Chip Pushes Envelope

Intel Stresses 386 Compatibility

PC World July 1989

PCs built around Intel's 1.2-million-transistor processor will begin appearing in late 1989 or early 1990.

Buy now and realize immediate productivity gains, or wait a year for the next chip generation that will make today's offerings obsolete. That's the conundrum PC buyers have faced ever since micros were introduced.

But Intel's powerful new i486 processor breaks that cycle and brings much greater functionality without abandoning its predecessor, the 80386. A more complete processor system than earlier designs, the i486 integrates many coprocessing enhancements formerly provided by discrete components at extra cost, enabling it to work two to four times as fast as the 386. Equally important, the i486 shows that the industry's prime CPU supplier has finally settled on a single processor platform.

In fact, the i486 should be seen as part of the 386 family rather than as a next-generation chip, points out Claude Leglise, marketing director. Based on a superset of the 386 architecture, it maintains complete binary compatibility with current applications written under DOS, OS/2, and UNIX. Like the 386, the i486 offers 32-bit memory addressability plus built-in capabilities to protect multiple applications from bumping into each other and to run multiple virtual 8086 machines.

Like the i860, Intel's recently announced Reduced Instruction Set Computer (RISC) chip, the i486 features next-generation silicon technology and houses 1.2 million transistors—compared to 275,000 on the 80386. Intel also has added an 8K read/write cache, an 82385-compatible cache.

(continues on page 68)

The price from Gateway was $5300 in June 1990 and $3000 in Aug 1991

Intel

(continued from page 64)

controller, a paging memory-management unit, and a floating-point coprocessor that's compatible with the 80387 math coprocessor. Putting these formerly discrete components on board reduces the lag involved with interchip communications. And, depending on the application, on-chip caching eliminates the processor's need to go to external memory 95 percent of the time.

The i486 also incorporates RISC techniques for commonly used instructions, which therefore execute more quickly than on 386 and 286 processors. For example, on the 386, a load operation takes four clock cycles and a store takes two, while either instruction requires only one tick on the i486. Leglise maintains that the i486 can match the Sun Microsystems SPARC or Motorola 88000 RISC chip running at the same speed.

Additionally, the i486 is optimized for managing multiple application "threads" from multiple processors, boosting multiprocessor machines like Zenith's Z-1000 UNIX box. OS/2 doesn't yet support this kind of multiprocessing. But Michael Slater, editor of the Microprocessor Report, expects to see suitable i486-specific OS/2 and Windows implementations in the not-too-distant future.

Despite these additions, the i486 can be easily integrated into 386 systems. Once a prototype chip arrived, "we had it up and running within 3 hours," says James Cannavino, head of IBM's Entry Systems Division.

With system prices expected to start between $10,000 and $15,000, the i486 won't be for everyone. Of course, that's what we heard when the 286 and 386 appeared, and they penetrated the market with striking speed. But the i486 is likely to settle in at a slower pace, if only because Intel now offers 32-bit processors for most budgets—including the low-end 386SX and a range of 386 models. And software vendors have been slow to exploit 32-bit systems. —Mike Hogan

Eric Brown is a PC World associate editor, and Mike Hogan is PC World's news editor.
Motorola to announce 68040, 50-MHz 68030 rumored

Motorola will not officially announce its 68040 processor until the third quarter, but the company's "preannouncement" and discussions with sources close to the company yield a general outline of what the new chip will be like.

The 68040 will combine a 68030-compatible integer processing unit (IPU), a floating-point unit almost completely compatible with the 68882, memory management, and separate instruction and data caches on a 1.2-million-transistor die. Initial clock speeds will probably be 25 MHz and 33 MHz. The company claims that 68040 performance is 50 percent higher than an Intel 80486 at a given clock speed. Sources confirm that the chip's initial price will be under $700.

The 68040 includes multiprocessing features, the most noteworthy being an efficient bus snooping unit. According to Roy Druien, a manager for high-end products at Motorola, the snooping controller monitors the address bus for memory accesses to cached locations, to invalidate cache data if needed. It also checks the data being put on the data bus. If data being written is the same as the data stored in the cache, the validity of the cache line is preserved, rather than automatically invalidated on any write.

The key to the IPU is in bringing RISC concepts to a CISC chip. The 68040 has a RISC core that executes several instructions in one clock cycle, while non-core instructions are in microcode and take additional clocks to execute. All 68000-family CPU instructions are supported by hardware. The FPU is not completely compatible in hardware. The FPU itself supports the most commonly used instructions; others are emulated in software, using code provided by Motorola, and in a way that should be transparent to the programmer or end user. The IPU and FPU can execute concurrently, and optimized code is produced by mixing IPU and FPU instructions so that both units are continually busy.

Caching is the area in which the 68040 may obtain a competitive advantage over competing chips such as the 80486. It is also the area in which Motorola is saying the least about its new processor. The 80486 has a single 8-Kbyte shared instruction and data cache and a single paging unit with a shared Translation Lookaside Buffer (TLB) for addresses and data. The 68040 will have separate instruction and data caches of not-yet-revealed size and separate Address Translation Caches (ATCs) for instructions and data.

Motorola, Inc., 10700 N. De Anza Blvd., Cupertino, CA 95014, (408) 993-0500. Inquiry 1

NeXT to sell for $9995 at Businessland

On March 30, Steve Jobs of NeXT, Inc. took the stage at Fort Mason in San Francisco to announce that starting in May, the NeXT Computer System will sell for $9995 at Businessland. The 8-Mbyte system is like the one that so far has been sold only to the higher education market.

The $9995 price includes the cubical NeXT system unit with a 25-MHz 68030 CPU and 68822 FPU, digital sound processor (DSP) and I/O channel processor, 8 Mbytes of RAM, 256-Mbyte optical disk, and keyboard and mouse. The price does not include a floppy drive and 2 MB of RAM. Options include the NeXT 400 dpi laser printer for $3495, a 330-Mbyte hard disk for $3695, and technical documentation for $299. No modem was listed among currently available or upcoming NeXT or third-party products.

The Businessland NeXT con-
Hitachi claims super to be world’s fastest

BY LORI VALIGRA
IDG NEWS SERVICE

TOKYO — Hitachi Ltd. has introduced a family of supercomputers that it claims is the speediest in the world.

The company introduced six Hitac S-3800 and four Hitac S-3600 models, the fastest of which runs at 32 billion floating-point operations per second (GFLOPS) in a four-processor configuration. In a single-processor configuration, it runs at 8 GFLOPS.

The new lineup boosts previous storage, increases data transfer speed and enhances image output. There are also improvements to the HI-OSF/1-MJ Unix and VOS3/AS operating systems that run on the supercomputers, Hitachi said.

Market targets

The company said it is aiming the supercomputers at the manufacturing and service sectors, including machinery, automotive, data service and other businesses. These users are adopting supercomputers to shorten research time and reduce development costs, a Hitachi spokesman said. To date, supercomputers have been used mostly by universities and government research laboratories in Japan.

Another new market segment is financial institutions, which are using supercomputers for economic forecasting. Hitachi said that with these new, broader applications, there is more demand for a wider range of product performance and distributed systems.

Hitachi first joined the supercomputer market in August 1982 with the Hitac S-810 series, which operated at 630 MFLOPS, a world record at the time, the spokesman said.

The S-3800 series uses multiprocessor technology, advanced semiconductors and state-of-the-art packaging to achieve its high processing speeds. Advanced microchips include a 25,000-gate logic chip with a delay time of 60 picoseconds. Four of the six models are air-cooled, and the other two are water-cooled.

With the four S-3600 models, the 10 supercomputers range from entry-level to top-of-the-line models, with a 100-fold performance span from low- to high-end systems.

The company has also introduced several high-density disk drives with a maximum of 2G bytes of main memory and 32G bytes of extended memory. Incorporated into the drives is a high-speed, I/O interface, a high-performance parallel interface.

The OSF/1-MJ is a version of the Open Software Foundation, Inc.’s Unix that Hitachi enhanced with networking and support for a facility to allow parallel handling of Fortran statements. It includes a program development system that enables all processes, from writing to the execution of Fortran programs, to be carried out on a Hitachi 3050 engineering workstation.

The operating system can also run on Hitachi’s high-end M-series mainframes.

Leasing fees range from $65,385 to $961,536 per month for the supercomputers and $10,769 for the OSF/1-MJ operating system. The S-3600 processors are due to be shipped this summer and the S-3800 early next year.

APRIL 20, 1992

COMPUTERWORLD

Senate Passes Legislation To Develop Supercomputers

By a WALL STREET JOURNAL Staff Reporter

WASHINGTON — The Senate passed, without opposition, legislation to develop new supercomputers and a high-speed supercomputer network that will work at speeds 100 times faster than current technology.

The bill parallels an interagency effort by the Bush administration to advance supercomputing. The House approved legislation similar to the Senate’s in July, and the two bills will have to be reconciled in conference.

Congress also needs to pass legislation to pay for the new initiative. The administration is asking for $638 million for supercomputing in the fiscal year beginning Oct. 1, an increase of 30% from the current fiscal year, and the entire project is expected to cost about $2 billion over five years. The advanced computers would be used on such problems as forecasting hurricanes, studying cancer genes and designing space ships.

The Pentagon’s Defense Advanced Research Projects Agency plays a crucial role in developing the new computer network and hardware. The Senate bill, along with several other related measures, contains provisions requiring agencies to award supercomputing contracts only after full and open competition.

Some computer vendors have charged that the Pentagon research agency unfairly favors computer makers that participate in its programs.

Jan 12, 1991

Wall st Journal
Cray Unleashes Its Most Powerful Supercomputer

The Y-MP outperforms its predecessor, harboring two to three times more power.

BY MARY KATHLEEN FLYNN

Cray Research Inc. has unveiled its most powerful product to date. Two of the new machines, each of which carries a $20 million price tag, have already been sold, Cray reports.

The Cray Y-MP/832, which extends the supercomputer maker’s X-MP series, comes to market a year later than planned. The Y-MP is the latest product designed for Cray by Steve Chen, its former chief architect and senior vice president. Chen left the company last September and subsequently founded Supercomputer Systems Inc., Eau Claire, Wis., which recently received financial backing from IBM.

With eight central processing units, the Y-MP boasts systems performance two to three times that of the four-processor X-MP and 30 times that of the Cray-1, which was introduced in 1976. The only other eight-processor computers on the market are the ETA 10 series, from ETA Systems, St. Paul.

Cray’s latest offering is based on the new 2560 macrocell gate array chip made by Motorola Inc., Schaumburg, Ill. Like Cray’s earlier models, the Y-MP runs on Unix, a proprietary operating system based on Unix System V. Software written on the X-MP will run on the Y-MP, says Cray.

The vendor has also introduced a network interface called the FEI-1 that provides an interface from the Y-MP to equipment from Control Data Corp., Data General, Digital Equipment Corp., Honeywell Bull, IBM, and Unisys.

The first Y-MP is scheduled to ship in the third quarter. CRAY RESEARCH INC., Minneapolis. CIRCLE 207

Timing of the Older FX/8 versus new FX/80 (Mar 88), From Alliant:

<table>
<thead>
<tr>
<th>Cycle Time</th>
<th>Peak Mflops</th>
<th>Actual Mflops</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX/8</td>
<td>85.0 ns</td>
<td>94</td>
</tr>
<tr>
<td>FX/80</td>
<td>47.2 ns</td>
<td>188.8</td>
</tr>
</tbody>
</table>

**Sato’s Test**

<table>
<thead>
<tr>
<th>Mflops</th>
<th>Estimates</th>
<th>Mflops</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX/8, 1 Proc</td>
<td>FX/80, 1 Proc</td>
<td>E 7.6</td>
</tr>
<tr>
<td>FX/8, 8 Proc</td>
<td>FX/80, 8 Proc</td>
<td>E 42</td>
</tr>
</tbody>
</table>

**NOTE 1:** Same code on 1 proc of XMP gives 120 mflops

**NOTE 2:** This code is optimal for vector machines (little scalar code). However, the vectors are just 64 words in length.

Models moving from the CRAY 1A to XMP had speed-ups of 1.5 to 2.0; probably 1.5 to 1.6 was typical.

**COSTS:** For $300K (Here is what you get, a 2 processor machine)

- Computational elements (CE)
- Interactive Processors (IP)
- 32 MBytes memory
- 1.1 GBytes disk
- $59K per additional CE

Thus, an 8 CE FX/80 costs $654K.

Roy Jenne
21 June 1988
NEW YORK — Sun Microsystems, Inc. set a new performance standard in the workstation market last week with the introduction of a 10-million-instructions-per-second machine offering power comparable to a Digital Equipment Corp. VAX 8800 — at one-tenth the price.

The Sun-4/200 series, with starting prices of $39,900, effectively offers double the performance of major competitors' products and is positioned to take on minicomputer offerings that now serve as engineering hosts, analysts said.

"This puts [Sun] in a very strong position to replace minicomputers in an engineering environment," said Robert Hersh, senior technology analyst at Hambrecht & Quist, Inc. in San Francisco. "They are offering a strong economic incentive to switch over."

An entry-level Sun-4/260 workstation, which is a desk-side, diskless model, comes with 8M bytes of main memory and a 19-in. high-resolution monochrome monitor. A desk-side model with 32M bytes of main memory, a color monitor with resolution of 1,152 by 900 pixels, a 560M-byte disk subsystem and a 69M-byte 1/4-in. tape cartridge is priced at $85,500.

Server configurations range from $36,900 for a pedestal model with 8M bytes of main memory to $199,900 for a high-end server with 2.3G bytes of disk storage, 128M bytes of main memory and a 1/4-in. tape drive. They support up to 25 workstations or 50 terminals.

A DEC VAX 8800 with 32M bytes of memory and no disk or tape drives lists for $650,000.

Sun unit
FROM PAGE 1

In typical configurations, the DEC 8000 series ranges in price from $141,000 to $836,000 and supports from a dozen to several hundred users.

"With the price and performance of this, they could really take some business away from DEC," said Michael Orsak, an analyst with Robertson, Colman & Stephens.

Last week's announcement also marks Sun's first step in its long-intended plan of becoming a broad range computing vendor.

The Sun-4/200 series more than doubles the performance of its current 4 MIPS high-end offering, and the vendor claimed that with the new microprocessor used in this system, it will be able to provide 100 MIPS machines by the early 1990s.

The Sun-4/200 series is based on a reduced instruction set computing (RISC) microprocessor that Sun designed with Fujitsu Microelectronics, Inc. Analysts said it is part of a bigger scheme under way at Sun that involves greatly expanding at the high-end with this technology while also broadening its low-end. The low-end move could involve an Intel Corp. 80386-based machine to be released later this year, analysts speculated.

While the Sun-4/200 series was applauded by many industry observers, some users and analysts raised concerns that the new proprietary system may depart from industry standards, which Sun has always embraced. Its previous machines have been based on Motorola, Inc. 68000-series processors.

Sun claimed the new line is source code compatible with current Sun workstations.

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Sun claimed the new line is source code compatible with current Sun workstations.

It runs under the Sun version of the Unix operating system, and the vendor said approximately 90 third-party software developers have either already ported or intend to port their software to the new system.

The new workstations are aimed at compute-intensive and floating-point applications. Primary markets include mechanical and electrical computer-aided design and artificial intelligence development.

The workstations were designed around a 32-bit scalable processor architecture for supercomputing workstations (Sparc), which uses typical RISC features such as single-cycle, simple-format instructions, delayed control transfer and optimizing compilers. Sparc's engine is a full 32-bit microprocessor with gate logic array that reportedly can process 10 MIPS at a clock speed of 16.67 MHz.

Since the new workstations use the same 12-slot backplane as the Sun 3/260, upgrades can be facilitated through a CPU board swap, the firm said. Cost of the upgrade is $13,900.

Sun also reduced prices by 5% to 19% on its Sun-3/200 workstation series. The company also launched what it called its Symbolic Programming Environment, which consists of software development tools for the development of AI applications on Sun workstations.

The repositioned Sun-3/200 workstation line now ranges in price from $28,900 to $36,900. The two 8M-byte servers in the family cost $25,900 and $26,900, respectively. It costs $3,500 and is set to be available on a site license basis.
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The SPARCstation 1™ from Sun Microsystems.

A miracle of RISC miniaturization, integration and innovation, the SPARCstation 1 sets a new benchmark of price, performance and functionality by which all others must be judged.

Simply put, for less than $9,000* the SPARCstation 1 gives you more power integrated with more features than any other desktop computer in the world. Making it the world's most powerful desktop.

The SPARCstation 1 is smaller than an IBM PC yet it gives you 12.5 Dhrystone MIPS and 1.4 Mflops of double precision performance.

- List price $9,000
- Get 17" monochrome monitor and 8 MB of memory
- The price to NCAR is $6,000.

Other prices about June 1989:

1. Dec. Station 3100
   - List $11,900
2. MIPS RS 2030 (16.67 MHz)
   - List $14,000
3. Everett 8820 (20.0 MHz), 4 MB
   - List $15,000

The SPARCstation 1 comes packed with a full eight megabytes of RAM. Expandable up to 16 megabytes. With your choice of a high resolution monochrome/grayscale or color display.
Minisupers are the new kids in town

BY NELL MARGOLIS and JULIE PITTA

A riveting battle of East and West start-ups enlivened the workstation territory this year as Sunynvyle, Calif.-based Ar- dent Computer Corp. and Newton, Mass.-based Stellar Computer, Inc. attempted to blast out on the fresh market niche. In March, both companies wedded super-speed computing to high-voltage graphics to produce what has come to be known as the minisuper workstation.

What made the competition particularly interesting was the fact that the companies, both venture-capital-backed start-ups headed by seasoned computer entrepreneurs, took different technolog- ical paths to strikingly similar ends.

Ardent’s four-model Titan line is built largely on third-party technology: a Mips Computer Systems, Inc. reduced instruction set computing (RISC) processor, used in combination with a custom-made vector processor, and a Silicon Graphics, Inc. board set. Titan’s might is gauged at 40 million instructions per second (MIPS) integer and 64 million floating-point operations per second (MFLOPS) peak, according to Ardent.

Stellar’s GS1000, designed in-house, harnesses 45 application-specific integrated-circuit CMOS microprocessors to yield 25 MIPS integer and 40 MFLOPS double-precision, according to Stellar.

Industry watchers say the two systems look similar.

Both the Titan and GS1000 are priced at less than $100,000 — less than half the price users would have to pay for minisupers offering comparable computing power.

And they’re not alone. Apollo Computer, Inc. has already put one foot into the new market niche with its Domain 10000/Prism Architecture announcement. By year’s end, analysts expect entries by Sun Microsystems, Inc. and Sili- con Graphics, Inc. as well.

Silicon Graphics defended its niche, the market for three-dimensional graphics workstations, as other vendors eyed the arena. Silicon Graphics added a high-end workstation, expected to compete with the Ardent and Stellar class of machines — and hinted that it would introduce a $15,000 3-D graphics workstation before the end of the year. A low-end system would give Silicon Graphics a complete range of 3-D graphics workstations.

For a niche that didn’t exist at this time last year, the minisuper corner is getting crowded fast.

It’s there, but...

"The market for these machines really is out there," says John Logan, executive vice-president of the Aberdeen Group, a Boston-based market research firm. The question is, how big is it? Vicki Brown, director of systems research at Framing- ham, Mass.-based International Data Corp. says, "We never expect [the minisuper workstation niche] to exceed 5% of the total market. The number of users who can pay the price for the power are limited."

High-end users such as scientists, engi- neers and researchers who need — but formerly couldn’t afford — super or minisupercomputer power currently make up the bulk of the minisuper workstation cus- tomer base. While the workstation vendors all talk about extending into commercial applications and finance and architecture, for instance, most analysts believe it will be a long time before the minisuper workstation moves beyond technical markets.

On the other hand, as IDC’s Brown points out, while the number of potential sales is limited, each sale is a big-ticket item. A successful minisuper workstation offer- ing, he says, will be a good profit-maker for its manufacturer.

"We’re going to see about 18 months of Ardent and Stellar pumping these ma- chines into the pipeline," Logan says. "What comes after 18 months? That’s hard to say. But in the meantime, the win-

ner is going to be the end user."

Apollo seemed ready to emerge from the shadow of archival Sun Microsyst- ems, Inc. Then, the Chelmsford, Mass.-based firm, generally credited with creating the workstation market, crashed into a wall of corporate woes that riveted Wall Street and left industry analysts divided in their opinions about the company’s future.

The early March announcement of the Domain 10000, the 60-MIPS flagship of Apollo’s parallel reduced instruction set multiprocessor (PRISM) architecture, was hailed as a technological milestone.

It was also a marketing coup — a far less frequent occurrence at Apollo, ana- lysts agree — giving Apollo the first entry (if only by hours) in the emerging

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1988 OCTOBER 3, 1988

COMPUTERWORLD
Workstation price war raging

BY JULIE PITTA and WILLIAM BRANDEL
CW STAFF

Workstation manufacturers are waging a price war that rivals any other battle in the computer industry.

Looking to buy market share, companies such as Data General Corp. and Digital Equipment Corp. have introduced Unix-based workstations at eye-catching prices during the first half of this year. Even Sun Microsystems, Inc. — the leader in the workstation market until Hewlett-Packard Co. and Apollo Computer, Inc. recently agreed to join forces — has felt compelled to keep pace.

How competitive is it? “There’s a big difference between what you could get for $10,000 last year vs. this year,” said David Burdick, a vice-president at Dataquest, Inc. in San Jose, Calif. “For $10,000 last year, you got a 4-MIPS machine with 8M bytes of RAM. This year, you get a 10- to 12-MIPS box with 8M bytes of RAM.”

Fortunate Sun
Industry watchers say these vendors are suffering from squeezed margins. “Sun is the lucky one,” said Peter Rogers.

Price war
FROM PAGE 1

Struggling DG is not so lucky. Sluggish sales for its other products are not likely to compensate for thin margins on its new Avion workstation. Avion, a Unix workstation running at 17 MIPS, is priced at an eye-popping $7,450.

Many in the industry are calling the Avion DG’s last-gasp attempt to gain market share. Some have ventured that DG will make little if any money on the machine, a contention that DG officials deny.

“Data General is in survival mode,” said Robert Herwick, industry analyst at Hambrecht & Quist, Inc. in San Francisco. “For all these companies, it’s a volume game and a market-share game. These vendors are looking more at return on assets than profit margins.”

I T’S A VERY competitive market, and our goal is to win the desktop. But we’re not giving things away.”

A DEC SPOKESMAN

“Struggling DG is in a very different position,” said a DEC spokesman who declined to comment on any discounts the company is offering. “We’re not giving things away.

“Price-cutting is the law of this technology,” he continued. “How far are prices going to drop? I don’t think anyone can answer that.”

The workstation is a loss leader,” Friedman admitted. “We would give it away if the customer would buy our solution.”

If there is any winner in this pricing battle, it is the customer. “If memory does get really cheap, it would allow the masses to get to the power platforms,” said Jack Baumann, end-user computing manager at Hughes Aircraft Co. in Long Beach, Calif. “We would be able to go down a road we haven’t before.”

Frank Smith, a systems integrator at Lockheed Missiles & Space in Sunnyvale, Calif., said “I can envision three-dimensional, real-time models on a workstation. That kind of thing takes...”

SOURCE: SUN MICROSYSTEMS, INC.
CW CHART: JOHN YORK

Then ... and now

<table>
<thead>
<tr>
<th>Sun-4/200</th>
<th>Sparcstation 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction date</td>
<td>July 1987</td>
</tr>
<tr>
<td>MIPS</td>
<td>10</td>
</tr>
<tr>
<td>Main memory</td>
<td>8M bytes</td>
</tr>
<tr>
<td>Disk storage</td>
<td>280M bytes</td>
</tr>
<tr>
<td>Price</td>
<td>$39,900</td>
</tr>
</tbody>
</table>

mum,” Mayer said. “Acceptable for us is in the 10% to 15% range.”

A minicomputer vendor such as DEC has a cushion in this regard. Sales from its VAX systems can make up for reduced margins on the low end of its line. A base configuration of its Decstation 3100 — a Unix-based workstation offering 14 million instructions per second of performance — sells for $11,900.

DEC is willing to discount workstations “because they feel the desktop is strategically important to their overall business,” Rogers said. DEC is re-

Continued on page 4

etc
Use benchmarks to your best advantage

BY PHILIP MAGNEY

Contrary to what is often suggested, benchmarking computer systems is not a black art, but caution is urged when evaluating them.

One issue is understanding which benchmarks to look at for your intended application. The benchmarks listed (see chart) measure various aspects of performance:

- The Khornertone benchmark is representative of computer performance for a mix of business and scientific applications. It is based on the results of 22 tests measuring CPU, disk I/O and floating-point performance.

- The transaction processing benchmark measures performance in a multiuser setting of 20 users. The test is very disk-intensive and is representative of commercial applications.

- The Ghraphstone (graphics) benchmark is based on 122 tests measuring drawing rates for a variety of graphics elements. The results shown for workstations represent graphics performance within an X Window System environment.

Benchmarks cannot tell you everything, however. For example, notice that the presence of a dual processor on the Compaq

Magney is general manager at Workstation Laboratories, an independent hardware testing lab in Irving, Texas.

COMPUTERWORLD

.............................................................................................................

Systempro does not result in performance improvement. To measure the advantages of a multiprocessor system, you need to modify the benchmarks.

An extended use of benchmarks is to use them to determine price/performance. The simplest way is to divide the list price of the system by the appropriate benchmark, obtaining a dollar-per-benchmark figure. Lower values represent a better price/performance. •

Finish line

Representative system benchmarks show the ALR and Mobius machines to be nearing – and meeting – workstation price/performance

<table>
<thead>
<tr>
<th>System</th>
<th>CPU/MHz</th>
<th>Khornertone</th>
<th>Ghraphstone</th>
<th>Trans. Proc.</th>
<th>Price/Perf.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM RS/6000/320</td>
<td>54,661</td>
<td>29,384</td>
<td>35,64</td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>DECstation 5000</td>
<td>26,456</td>
<td>31,940</td>
<td>18,29</td>
<td>.79</td>
<td></td>
</tr>
<tr>
<td>DECstation 3100</td>
<td>15,285</td>
<td>15,493</td>
<td>12,85</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>Sun Sparstation 1</td>
<td>12,899</td>
<td>26,935</td>
<td>19,15</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>Mips Magnum</td>
<td>29,626</td>
<td>20,542</td>
<td>11,96</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>Compaq DP486/25</td>
<td>1486/25</td>
<td>13,513</td>
<td>8,232*</td>
<td>18.71</td>
<td>1.68</td>
</tr>
<tr>
<td>Compaq Sys. Pro</td>
<td>1386/33 (2-CPU)</td>
<td>9,289</td>
<td>n/a</td>
<td>26.3</td>
<td>4.21</td>
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<tr>
<td>Compaq DP386/33</td>
<td>1386/33</td>
<td>9,272</td>
<td>7,939*</td>
<td>17.68</td>
<td>2.27</td>
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<tr>
<td>ALR Powercorche</td>
<td>1486/33</td>
<td>18,644</td>
<td>11,760</td>
<td>26.3</td>
<td>1.08</td>
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<tr>
<td>Altos 486/5000</td>
<td>1486/25</td>
<td>12,953</td>
<td>n/a</td>
<td>20.22</td>
<td>3.24</td>
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<tr>
<td>AST Prem. 486/25</td>
<td>1486/25</td>
<td>11,754</td>
<td>6,484*</td>
<td>23.32</td>
<td>1.37</td>
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<tr>
<td>Mobius PMS-425</td>
<td>1486/25</td>
<td>11,169</td>
<td>18,226</td>
<td>21.53</td>
<td>1.16</td>
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<tr>
<td>IBM PS/2-555X</td>
<td>386SX/16</td>
<td>2,714</td>
<td>2,890*</td>
<td>n/a</td>
<td>1.92</td>
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<tr>
<td>IBM PS/2-70</td>
<td>1386/25</td>
<td>6,800</td>
<td>4,476*</td>
<td>n/a</td>
<td>1.94</td>
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<tr>
<td>Acer 1100</td>
<td>1386/16</td>
<td>3,094</td>
<td>3,343*</td>
<td>n/a</td>
<td>1.92</td>
</tr>
<tr>
<td>Televideo 386</td>
<td>1386/16</td>
<td>2,817</td>
<td>1,624*</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Compaq DP 286</td>
<td>286/12</td>
<td>1,295</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Epson Eq. III+</td>
<td>286/10</td>
<td>833</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>IBM PC/XT</td>
<td>8088/4.77</td>
<td>321</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Graphics conducted using VGA graphics; all others have 1024-by-768-pixel or higher resolution displays

**Price/performance in this case was determined by dividing system price by the Khornertone rating. The resulting figure is dollars per Khornertone.

All ratings are linear

The Khornertone rating is expressed in Khornertones per second; the Ghraphstone is expressed in Ghraphstones per second; the Transaction Processing test is expressed in transactions per second for a system with 20 users.

Source: Workstation Laboratories

CW Chart: Doreen St. John

NOVEMBER 12, 1990
World’s Fastest Processor

A 32-bit microprocessor that can work at 80-negahertz has been introduced by Bipolar Integrated Technology (BIT), Beaverton, Ore. The reduced-instruction-set processor is based on scalable processor architecture and the company claims its speed is double that of any available microprocessor.

Other new microprocessors announced recently use complementary metal-oxide (CMOS) technology, while the B5000 Integer Unit uses emitter-coupled logic. The B5000 performs at a rate of 50 to 65 million instructions per second and makes up to 14 million floating-point operations per second (Mflops). In contrast, the Cray 1 supercomputer operates at 12 Mflops.

However, don’t expect to see the B5000 in your next PC. The six-chip set that contains the B5000 costs $2,300 in quantities of 100. A spokesman for BIT estimated that a workstation incorporating the chip set could cost as much as $200,000.

Weitek moves the Abacus to the 80486

The Abacus 4167, with sixteen 64-bit data registers, is Weitek’s floating-point coprocessor designed to outperform the math operations of the 80486’s on-chip floating-point unit.

Weitek claims the new chip will enable a 486-based system to run numerically intensive applications two to three times faster than the 486 alone. Company performance data says that a 486-based PC operating at 25 MHz performs 17 single-precision MWhetstones with a 4167 chip, 7 MWhetstones without.

The company says that this performance is based on a memory-mapped protocol, indicating that the Abacus 4167 gets instructions and data from the 486’s address and data buses, respectively. This protocol means that the 486 requires fewer clock cycles to provide instructions and data to the Abacus.

All applications that currently support Weitek’s Abacus 3167 coprocessor for 386-based systems will also support the Abacus 4167 chip, which will plug into a 142-pin socket on a 486 system board.

Weitek will price the Abacus 4167 in 1,000-unit quantities at $565. Limited quantities are scheduled for shipment in December.

Weitek Corp., 1060 E. Arques Ave., Sunnyvale, CA 94086, (408) 738-8400. Inquiry 1

May 1989, Popular Super incredible Science

Design computer circuitry in three dimensions and you eliminate circuit boards, chip packages, and connectors, say engineers at Hughes Aircraft. What’s left is 90 percent silicon circuitry which increases processing speed dramatically and reduces power consumption significantly. The point: The company is using the 3-D idea to build a supercomputer that’s capable of performing 10 billion operations per second—and it fits in your hand. A small-scale version has been demonstrated, and Hughes is working on development of a large-scale prototype along with software.

Personal Mainframe for Your AT

How much number-crunching is enough? Opus Systems thinks there’s plenty of room for improvement over a standard AT clone; in fact, the company would like to lift the lid of your machine and drop a new computer inside.

The Personal Mainframe Series 400 consists of a coprocessor board that contains a Motorola 88000 RISC CPU and 4 megabytes of RAM—enough to run Unix, which also comes with the system.

Opus is offering the Series 8000, which consists of a Series 400 coprocessor inside an Everex Step/286. The resulting systems are rated at 35,000 Dhrystones and 17 MIPS, according to Opus. Price: Series 400, $5000; Series 8000, $9995.

Contact: Opus Systems, 20863 Stevens Creek Blvd., Bldg. 400, Cupertino, CA 95014, (408) 446-2110, or Everex Systems, 48431 Milmont Dr., Fremont, CA 94538, (415) 498-1111. Inquiry 1124.

A Glimpse of the R3000/R3010

The host system for the MIPS Computer Systems R2030 RISCStation we tested is a RISCComputer M/2000 network server with a 20-MHz R3000 and R3010 combination. As part of the effort to get our benchmarks compiled and running on the R2030, we executed them on the RISCComputer.

Although these tests were informal, optimized code yielded results of 20,000 KWhetstones for single-precision and over 40,000 Dhrystones. Sony has announced its intention to build an R3000-based machine, and DEC, Silicon Graphics, and MIPS Computer Systems are likely candidates to follow suit. If such a workstation can approach the M/2000 network server’s results, it will be as fast as or faster than any workstation we have yet tested.

MIPS Jul 1989, PSo

continued

May 1989 - BYTE 65
Two sides of a coin
A new low-end 3090S features a relatively expensive price/performance factor, while the new 4381E is less expensive than the former low end.

<table>
<thead>
<tr>
<th></th>
<th>Base price/ Fully configured</th>
<th>MIPS</th>
<th>Cost per MIPS</th>
<th>Relative performance¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>3090 Model 100S</td>
<td>$795,000/$853,660</td>
<td>5.2</td>
<td>$164,165</td>
<td>70% of Model 120S</td>
</tr>
<tr>
<td>3090 Model 120S</td>
<td>$985,000/$1,039,830</td>
<td>7.4</td>
<td>$140,518</td>
<td></td>
</tr>
<tr>
<td>4381 Model 90E</td>
<td>$395,000/$397,861</td>
<td>3.8</td>
<td>$102,016</td>
<td>80% of Model 91E</td>
</tr>
<tr>
<td>4381 Model 91E</td>
<td>$556,500/$580,361</td>
<td>4.7</td>
<td>$123,481</td>
<td></td>
</tr>
</tbody>
</table>

¹Based on internal throughput rates from IBM

SOURCE: INTERNATIONAL DATA CORP.
CW CHART: FRANK O'CONNELL

August 1989 -

"Racing at 8.2 MIPS,* Zenith shatters the 33 MHz speed barrier with one of the fastest Intel386™ workstations ever built."
Roy Jenne  
24 January 1984

Staff Needs on NCAR VAXs

These notes from a talk with Ray Bovet, NCAR, are included to give some information about the configuration of NCAR VAX's and the staff needed to make them work.

Mesoscale Research
- 1 Gbyte disks on one VAX-780
- 1 tape controller, 2 drives
- Has 2 people full time (one is Ray Bovet), one of whom spends much of the time on applications
- People do program development on this VAX, run small programs, do lots of interactive graphics on field data and model output data.

Field Observing
- VAX-780 to handle radar data
- Has 1250 megabytes of disk storage
- Has 2 tape controllers and 3 tape drives
- Has 3 people plus technician. Set up system and developed software to process radar data as a turnkey operation.

Atmospheric Analysis and Prediction
- Getting 2 VAX-780's (cost about $700K, tapes and disks can be shared on the two systems.
- 3 * 450 megabytes disks
- Two people. Manage system and prepare software tools.

High Altitude Observatory
- Have 2 VAX-750's and 1170, four people. Doing many applications on the side.

Cost of a simple VAX-780 system is about $350,000. Includes about a Gbyte of disks and a controller and 2 drives. A 450 mbyte disk drive costs $20K from DEC.

To keep a small computing system going requires:
- A systems manager

- A systems programmer

- One or two operators if tapes must be mounted and paper must be torn during 40 hour weeks. The second person is for backup, vacations, etc. None of the NCAR VAXs have dedicated operators. People mount their own tapes and tear paper.

- Ray Bovet started as the only person for their VAX, but had the problem that there was no one to answer questions when he was gone.

- Perhaps another person to get additional software on the machine. Costs are reduced by obtaining existing software for many tasks.

- Have to decide how much software to develop for the system and whether it is worth it. Any number of people can be involved in such efforts. One needs to look at the support cost per user or per project, etc., to see if it appears reasonable.

- With just 10 or 20 users, not much time will be needed for teaching and consulting time.

Note by R. Jenne: At NCAR, users run much of their work on the Crays, which have operators, graphics output, etc.