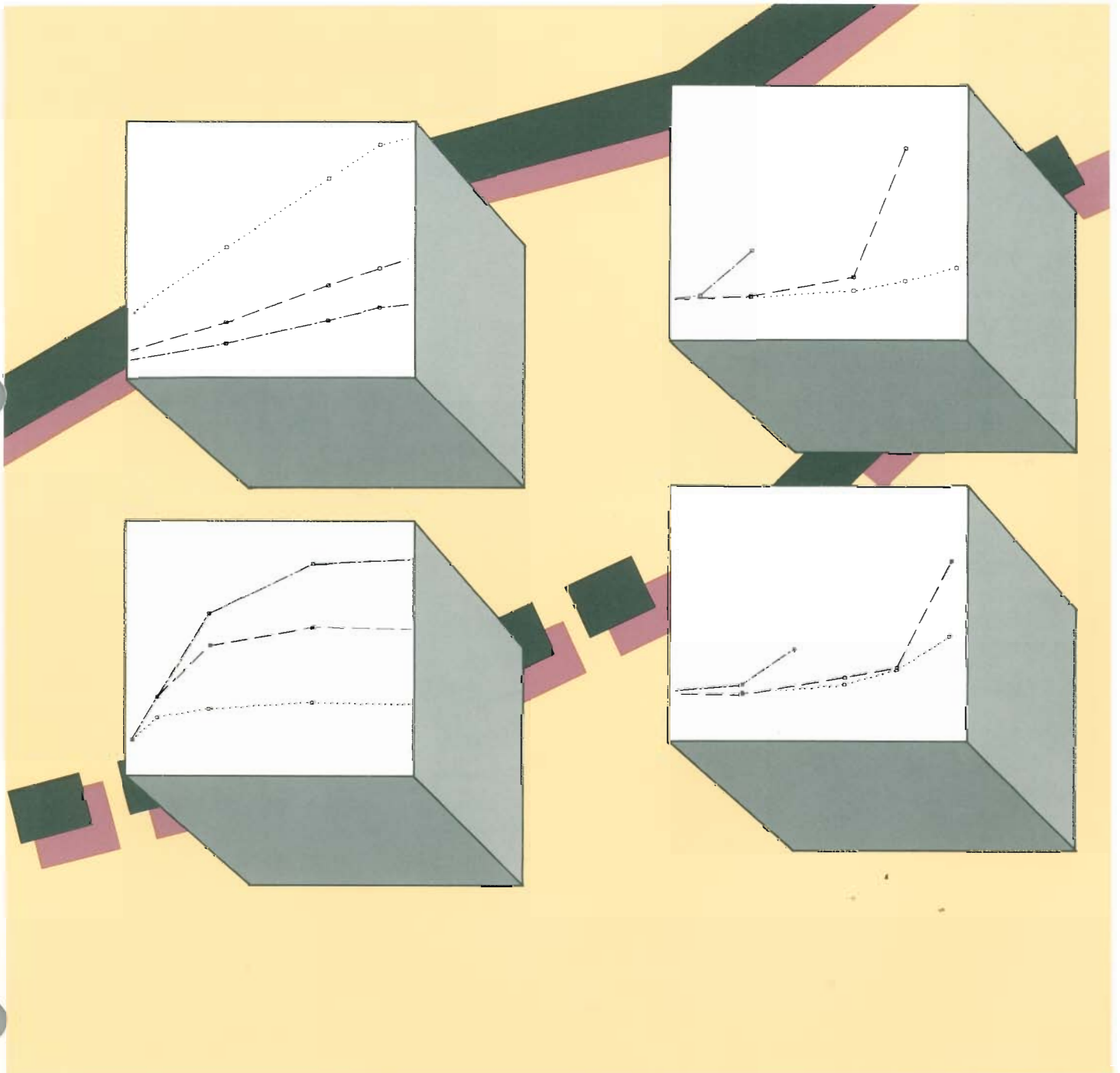


HP 9000 Series 300

HP-UX Multi-User Performance Brief



The performance of HP 9000 Series 300 computers and related products is dependent on the application. The performance obtained depends on the particular workload. The measurements indicated in this guide relate only to the workloads described.

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I. Introduction

Because performance is critical to the productivity and success of your business, selecting the right system is an important decision. The right system means having the right performance for your application needs . . . at the right price. This system must offer an affordable solution to your needs and grow as your business grows.

Hewlett-Packard has designed the HP 9000 Series 300 to meet all of these needs. It may be applied in a variety of physical configurations and performance levels to meet your technical computing requirements. Your application might demand stand-alone dedicated workstations, a network of engineering workstations, a multi-user system, or some combination of these. The choices offered by the Series 300, such as CPU choice, amount of memory, and peripheral and I/O configuration allow you to achieve maximum performance for your application.

Products Tested

The products tested were the Models 310, 320, 330 and 350 with the following configurations. The lower memory configurations approximate some of the Series 300 bundled systems. The higher memory configurations were used to look at improvements in multi-user performance. Where more than one disc is specified, the larger disc was generally used for the 32-user tests. The additional MUX cards are used in a similar manner. The Model 318M was specifically excluded from these tests. The performance of the 318M is equivalent to a 330 with 4 Mb of memory.

310/2 Mb

CPU: 68010 at 10 MHz
Memory: 1 Mb on CPU board, plus 1 Mb; SPU RAM at low memory
I/O: 98625B high-speed disc interface and DMA; two 98642A MUX cards
Expander: passive
Disc: 7914 (20 Mb swap space, 48% free space)
Display: 35721A medium-resolution monochrome on built-in video interface

310/7 Mb

CPU: 68010 at 10 MHz
Memory: 1 Mb on CPU board, plus 6 Mb; SPU RAM at low memory
I/O: 98625B high-speed disc interface and DMA; eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 48% free space)
Display: 35721A medium-resolution monochrome on built-in video interface

320/4 Mb

CPU: 68020 at 12.5 MHz, with 68881 chip at 16.7 MHz
Memory: 4 Mb
I/O: 98625B high-speed disc interface and DMA; four or eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 48% free space) or 7912 (12 Mb swap space, 34% free space)
Display: 35721A medium-resolution monochrome on 98204B interface card

320/7 Mb

CPU: 68020 at 12.5 MHz, with 68881 chip at 16.7 MHz
Memory: 7 Mb
I/O: 98625B high-speed disc interface and DMA; eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 50% free space)
Display: 35721A medium-resolution monochrome on 98204B interface card

330/4 Mb

CPU: 68020 at 16.7 MHz, with 68881 chip at 16.7 MHz
Memory: 4 Mb on CPU board
I/O: built-in DMA, four or eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 51% free space) or 7912 (12 Mb swap space, 34% free space)
Display: 98786A high-resolution monochrome on 98544B interface card

330/8 Mb

CPU: 68020 at 16.7 MHz, with 68881 chip at 16.7 MHz
Memory: 4 Mb on CPU board, plus 4 Mb; SPU RAM at low memory
I/O: built-in DMA, high-speed disc interface; four or eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 50% free space)
Display: 98786A high-resolution monochrome on 98544B interface card

350/8 Mb

CPU: 68020 at 25 MHz, with 68881 chip at 20 MHz
Memory: 8 Mb
I/O: built-in high-speed disc interface and DMA; eight 98642A MUX cards
Expander: passive, plus 9888A
Disc: 7914 (20 Mb swap space, 50% free space)
Display: 35721A medium-resolution monochrome on 98204B interface card

Note: All configurations used Series 300 HP-UX release 5.2, configured without LAN; tty's driven at 2400 baud.

II. Application Load Testing

Introduction

Application load testing gives an understanding of system performance with different hardware configurations while applications are executing. Performance data is given for program development including computation and interactive editing. With some caution, these results can aid you in specifying the optimum configuration for your application.

This section describes the characteristics of the system under multi-user loads. "Users" are characterized as tasks sent from a terminal. Similar characteristics will be seen by treating additional background tasks generated at a single terminal as additional "users".

Test Applications

The most important consideration in configuring a Series 300 is the expected application. Figure 1 shows a simplified model of "application space". The corners of the triangle represent computation, interactive, and disc I/O intensive applications. The tests run were typical of real applications and span the application space. The test environments are simulated using the Terminal Emulator Performance Evaluator (TEPE) system. An HP3000 Series 40 was used to drive the TEPE tests up to 16 users. Two Series 40s were used for more than 16 users.

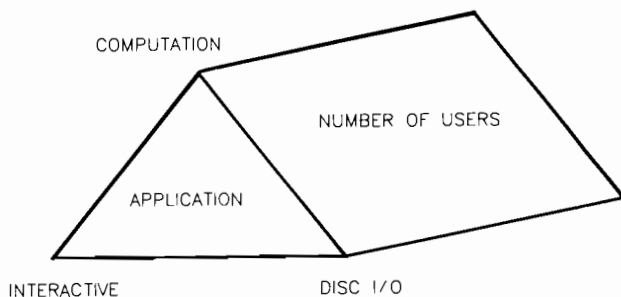


Figure 1: Application Space Triangle

FORTRAN Program Development

The program development environment uses a 930-line, 20,000 byte FORTRAN program derived from the B1D Whetstone benchmark. The automated sequence for each user is:

- Compilation of the program with errors
- Edit session (using vi editor) correcting all but one error
- Compilation of the program with one remaining error
- Edit session to correct error
- Successful compilation and link of the program
- Execution of a C program (derived from the B1D benchmark)
- Other commands executed from the shell, including ls, ll, who, ps -ef, mv, pwd and date

Application Load Test Graphs

FORTRAN Program Development Throughput for Bundled Configurations

Figure 2 shows the difference in performance between the Models 310, 320, 330 and 350 for CPU and memory configurations that approximate some of the Series 300 bundled systems. The Model 350 obviously gives the best performance in a multi-user FORTRAN program development environment. The 320 and 330 are close to each other and can support a smaller number of users. Although the 310 can provide adequate execution time performance for certain applications, a 310 is not a good fit for multi-user software development environments. Further, the 32-user product is not supported on the 310. Peak throughput on a 350 is about 1.9 times the peak on a 330, 2.3 times a 320 and 11.6 times a 310.

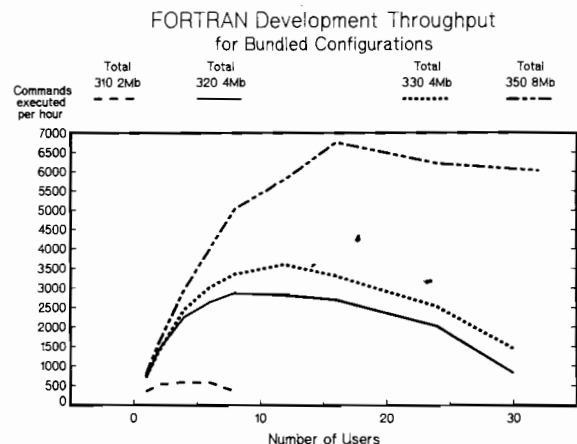


Figure 2

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FORTTRAN Program Development Throughput for Extra Memory Configurations

Figure 3 gives performance numbers for the configurations with additional memory. Since the FORTRAN program development test is fairly memory-intensive, adding memory to the system should improve its multi-user performance if excessive swapping has become the system bottleneck.

Past TEPE tests on a 350 have shown that 8 Mb is adequate for the memory demands of this test environment. Adding memory to the 350 configuration will not improve its throughput in the test; adding memory on the other S300 SPU's, however, does improve their throughput.

In the 330, peak throughput actually drops when RAM is increased to 8 Mb. This is because the added memory has a slower access time than the 4 Mb on the CPU board. Other TEPE tests have shown that the optional high-speed disc interface improves performance, and therefore it is recommended with additional RAM to partially offset the drop in system throughput due to slower memory. The additional memory helps system performance for more than 16 users on this test (see also Figure 4), where extra RAM reduces swapping enough to compensate for its slower memory access time.

The 320 with 7 Mb has slightly higher peak throughput than with 4 Mb. It does not show any performance loss because all the 320 memory has the same access speed.

The 310 performance is improved with the addition of more RAM. However, Figure 3 is misleading in that it suggests that because throughput is level, many users can be supported in a software development environment. Figure 4 better illustrates the performance degradation that is actually happening.

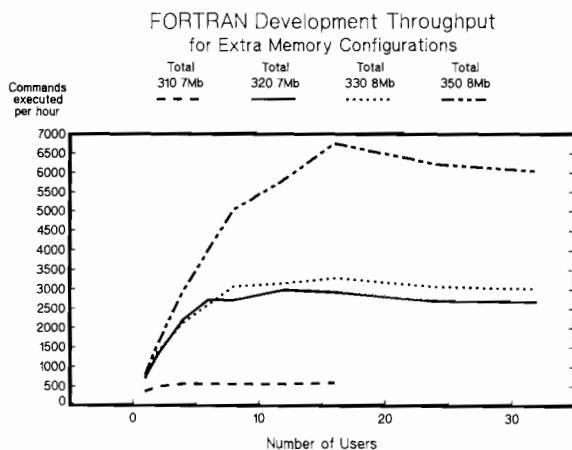


Figure 3

FORTTRAN Compile Execution Times

Figure 4 is a graph of the time to execute a FORTRAN compile (fc) on a medium-sized program (840 lines). As more users are put on any given S300 system, the execution time increases; as more memory is added to a system, the execution time generally improves on a heavily-loaded system.

The 350 again is clearly the best multi-user system. It has the fastest execution time at any number of users. Alternatively, using a 10-minute FORTRAN compile (600 seconds) as an arbitrary threshold of system performance degradation, the system does not reach this threshold until there are 26 users on the system.

The 330 shows a crossover point at about 20 users; up to that time, the 4 Mb system is faster; after that the 8 Mb system is faster. The 10-minute threshold is reached at about 12 users in the 8 Mb system and about 15 users in the 4 Mb system.

The 320 (although not shown in Figure 4) does not reach this 10-minute threshold until about 11 users are on the system.

The problem with supporting many users in a development environment on the 310 is more obvious here: the 310 has the slowest fc time to begin with and degrades the fastest. The sixteenth user on the system would wait about 50 times as long for this compile as on a single-user 310 system. The system degrades to the 10-minute threshold after 4 users even with 7 Mb of RAM installed.

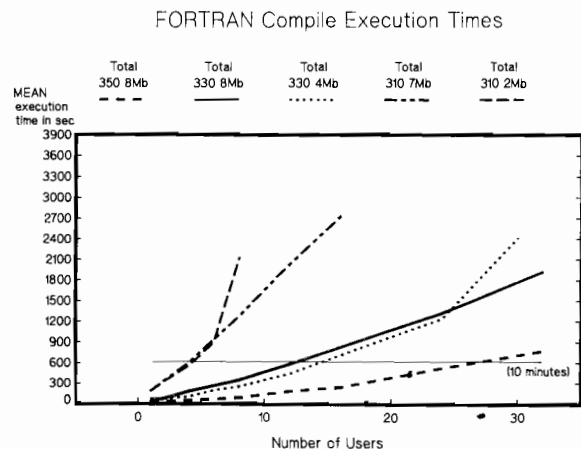


Figure 4

III. Benchmarks

The only sure way to know how fast an application will run on a computer is to run the application. But this is not always the most expedient way to compare one computer to another. As a result, industry-standard benchmarks have been developed to provide a means of comparison. All of these benchmarks were run with the lower memory configurations. This section presents the results of several such benchmarks.

Whetstone

The Whetstone benchmarks were originally written in FORTRAN, but have been converted to C and Pascal to test those languages also. The double-precision benchmark shown in Table 1 is referred to in the industry as the Whetstone B1D benchmark. Similarly, the single precision test is known as B1S. The programs are derived from an analysis of 1000 ALGOL 60 programs as an attempt to represent an average program instruction mix. They include many different operations, among them floating point and integer calculations, transcendentals, array manipulation, and conditional jumps. The measurement is expressed in terms of a unique entity known as a Whetstone instruction. One loop through represents 1,000,000 Whetstone instructions. Whetstone results are usually expressed in thousands of Whetstone instructions per second (KWIPS) as shown below. The results are based on elapsed times (real as reported by /bin/time) and shown in KWIPS.

Table 1: Whetstone benchmarks

	Model 310 2 Mb	Model 320 4 Mb	Model 330 4 Mb	Model 350 8 Mb
FORTRAN				
Single Precision	73.1	859.1	952.4	1312.4
Double Precision	26.8	739.7	872.6	1149.4
C				
Single Precision		667.6	746.3	1018.3
Double Precision		624.2	740.7	990.1
Pascal				
Single Precision	71.8	731.0	809.1	1111.1
Double Precision	27.3	611.3	691.6	961.5

Sieve of Eratosthenes

The Sieve of Eratosthenes is a benchmark of CPU speed and C compiler efficiency. The benchmark is a simple procedure for finding prime numbers without using multiplication or division, providing a comparison of operations that occur in many programs.

In the sieve procedure, all natural numbers are arranged in order, then passed through a "sieve", crossing

out every second number after 2, every third number after 3 and every nth number after n. The numbers not crossed out are prime.

The Sieve of Eratosthenes program primarily exercises looping and array access capabilities of the language and system. The use of integer addition is secondary. Note that the Series 300 performs all integer calculation using 32-bit integers. Results are based on elapsed times as in the previous table.

Table 2: Sieve of Eratosthenes

	Model 310 2 Mb	Model 320 4 Mb	Model 330 4 Mb	Model 350 8 Mb
FORTRAN	4.9	1.3	1.0	0.6
C	6.5	1.6	1.2	0.7

Linpack

This floating point intensive benchmark solves a dense system of linear equations of the order 100 in a FORTRAN environment. The results are measured in thousands of floating point operations per second (KFLOPS) for single precision and double precision. Series 300 Linpack benchmarks results are shown in KFLOPS.

Table 3: Linpack

	Model 310 2 Mb	Model 320 4 Mb	Model 330 4 Mb	Model 350 8 Mb
Single Precision	6.9	88.6	97.7	130.2
Double Precision	4.5	72.7	86.4	112.1

Dhrystone

The Dhrystone benchmark simulates a high-level C programming environment. The program statements represent a balance of statement type, operand type and operand access (53% assignments, 32% control statements, 15% procedure and function calls). The program was originally translated from Ada®. The first version, Revision 1.0, was widely used, but contained some bugs. Revision 1.1 fixed those bugs. The Dhrystone benchmark results are measured in Dhrystones per second, again a unique measure.

Table 4: Dhrystone

	Model 310 2 Mb	Model 320 4 Mb	Model 330 4 Mb	Model 350 8 Mb
Revision 1.0	769	2430	3056	5555
Revision 1.1	695	2229	2649	4915



IV. Effects of Disc Selection and Configuration

Overall system performance can be affected by the choice of discs and configuration of the system. Several important factors include:

- DMA
- High-Speed Disc Interface
- Disc Performance

It is strongly recommended that the system disc be placed on the high-speed disc interface, if installed (built-in on the 350). The high-speed interface can support several discs simultaneously, as long as they are all high-performance devices. Slower devices such as printers, plotters, and tape cartridge units should be placed on a separate HP-IB, typically the internal HP-IB.

Other factors can also affect system performance. For instance, applications requiring significant swapping may

improve by adding more memory. The performance of multiple processes can be helped with swap space on more than one disc.

The selection of the types and number of discs is dependent on the application. Generally, in a heavily-loaded system, two smaller discs are better than one larger one. This allows disc seek times to overlap. The different disc families have different performance. See Table 5 for the performance characteristics of the discs. The measurements in the last three columns are described beneath the table.

A word of caution: interpret these numbers carefully! An application may emphasize only certain characteristics of the disc. For instance, if an application does not require truly random reads, then that disc characteristic will be of little significance for that application's performance.

Table 5: Disc Drive Characteristics

Disc Type	Capacity	Average Seek Time	I/Os Per Second	Random 8K Read Throughput	Maximum Transfer Rate to Op. Sys.
7914CT	132 Mb	28 Msec	21.8	144.4	298
7937H	571 Mb	19 Msec	26.8	177.7	363
7945A	56 Mb	30 Msec	17.9	110.2	148
7957A	80 Mb	28 Msec	21.6	145.6	305
7958A	131 Mb	28 Msec	21.6	145.6	305
9133L*	44 Mb	40 Msec	16.4	74.2	113

* The performance of the 9133L will be dramatically affected by the interleave. For optimal results, consult '/etc/disktab' for the recommended values. The other discs listed above are not affected by the interleave. The 9133L Option 001 (1024-byte sectors) is also recommended.

Table Notes:

- I/O's per second is the average number of random reads of 1K blocks per second from the disc. It is a good measure of how rapidly the disc mechanism can seek across the entire disc surface.
- Random 8K Read Thruput is the average throughput in Kbytes per second randomly reading 8K blocks from the disc.
- Maximum transfer rate is the maximum observed transfer rate from the disc to a user process using 8K requests in Kbytes per second. It is a good measure of the transfer rate of the data from the disc surface to the disc controller combined with the data burst rate across the interface bus.

UNIX is a registered trademark of AT&T in the U.S. and other countries. Ada is a registered trademark of the U.S. Government (AJPO). HP-UX 5.2, HP's implementation of AT&T's UNIX System V Release 2.0, has been tested using the AT&T System V Verification Suite and conforms to the Base System plus Kernel Extensions as specified in Issue 2 of the AT&T System V Interface Definition.

