HP Business Desktops

June 2003

invent

Technology Brief

# Configuring DDR Memory in Intel-based HP Business Desktops

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## Abstract

As chipsets in today's business desktop environment get ever faster, memory is becoming a performance bottleneck.

Memory performance is improving as standards evolve from PC2100 to PC2700 to PC3200 – but still lags behind the 533 MHz or 800 MHz offered by current front-side buses. However, through the introduction of chipsets that support dual-channel DDR memory, memory bandwidth has effectively doubled, leading to significant performance improvements.

This white paper describes how to select and configure appropriate dual-channel DDR memory configurations for Intel®-based HP business desktops. In addition, the white paper provides information on performance tests designed to benchmark various DDR memory configurations.

The results of the performance tests show that dual-channel memory out-performs single-channel memory by up to 10% for regular business applications and up to 70% for memory-intensive applications.

## Introduction

Today's business desktop user needs the power to run multiple applications and access large media files – simultaneously. However, while processor speeds have been getting faster and faster, memory has become a system bottleneck. Minimizing this bottleneck – and maximizing system performance – may be as simple as deploying dual-channel DDR memory.

Additional – or better configured – memory can offer the user many benefits:

- New applications – More memory can lead to faster start-up with fewer delays during routine operations.
- New multimedia capabilities – New video cards, for example, demand more memory and faster access.
- New peripheral devices – Printers and scanners must manipulate larger, higher resolution files.
- New operating system – Each new operating system release places a heavier load on memory.

New systems can be better configured to help meet the customer's needs; upgrades to the installed base are convenient and economical.

Table 1 offers an overview of DDR memory configurations supported by new and existing HP business desktop product offerings.

***Table 1. DDR memory configurations supported by new and current HP business desktops***

| | d220 | d230 | D310 | D315 | D320 | d325 | d330 | D510 | d530 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CMT/ SFF | USDT |
| PC2100 support | X | X | X | X | X | X | X | X | X | X |
| PC2700 support | X | X | | | X | X | X | | X | X |
| PC3200 support | | | | | | | X | | X | X |
| Maximum memory (GB) | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 4 | 2 |
| DIMM slots | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 4 | 2 |
| Dual-channel support | | | | | | X | X | | X | X |

- CMT – convertible minitower
- SFF – small form factor
- USDT – ultra-slim desktop

## Enhancing Memory Performance

Taking full advantage of today's most intensive business applications requires optimal memory performance. This white paper explores a number of methods for enhancing memory performance:

- Deploying additional memory
- Deploying faster memory
- Configuring dual-channel memory (where supported)

### Deploying Additional Memory

Deploying additional memory has different implications for desktops with single- or dual-channel support.

- Single channel – Performance tests carried out by HP indicate that deploying additional memory in a single-channel configuration offers a performance improvement, particularly for memory-intensive applications.
- Dual channel – Since the performance tests also indicated that dual-channel memory outperforms single-channel, HP recommends creating a dual-channel configuration (if supported on the particular platform) rather than deploying additional memory in an existing channel.

### Deploying Faster Memory

HP business desktops offer support for PC2100 (266 MHz), PC2700 (333 MHz) or PC3200 (400 MHz) DDR memory. The performance tests showed an improvement in system performance after upgrading from PC2100 to faster PC2700 memory – particularly for memory-intensive applications.

However, memory speed is constrained by the speed of the system's front-side bus. To help customers select the optimal memory for their systems, Table 2 shows the maximum theoretical memory speeds available with particular front-side buses.

***Table 2. Maximum memory speeds***

| Front-side bus | Maximum memory speed | | |
|---|---|---|---|
| | **PC2100** (DDR 266 MHz) | **PC2700** (DDR 333 MHz) | **PC3200** (DDR 400 MHz) |
| 400 MHz | 266 MHz | | |
| 533 MHz | 266 MHz | 333 MHz | |
| 800 MHz | 266 MHz | 320 MHz | 400 MHz |

In a configuration with multiple DIMMs deployed, actual memory speed defaults to the speed of the slowest DIMM.

## Deploying Dual-channel Memory

New HP Compaq Business Desktop models support single- and dual-channel memory configurations.

- Single channel – With single-channel memory, the memory bus is 64-bits wide. Memory bandwidth is significantly less than that of the processor's front-side bus; the processor often wastes valuable CPU cycles waiting for access to memory.
- Dual channel – With dual-channel memory, the memory bus becomes128-bits wide, doubling memory bandwidth. Memory performance improves significantly over a single-channel deployment.

HP recommends using a dual-channel memory configuration to optimize system performance (if supported on the particular platform).

### Memory Bandwidth

Table 3 lists the maximum theoretical single- and dual-channel bandwidths available using various memory types.

***Table 3. Memory bandwidth***

| Memory type | Memory speed | Bandwidth (GBps) | |
|---|---|---|---|
| | | **Single-channel** | **Dual-channel** |
| PC2100 | 266 MHz | 2.1 | 4.2 |
| PC2700 | 333 MHz | 2.7 | 5.4 |
| PC3200 | 400 MHz | 3.2 | 6.4 |

HP calculated the bandwidths listed in Table 3 based on a 64-bit bus (single channel) or a 128-bit bus (dual channel). Each byte has eight bits.

For example, for PC2100 memory:

- Nominal bandwidth (single-channel) = [266 million data transfers per second] x [8 bytes per transfer] = 2.1 GBps
- Nominal bandwidth (dual-channel) = 2.1 GBps x 2 = 4.2 GBps

## Configuring Dual-channel Memory

This section describes how to configure dual-channel memory (if supported); recommendations and configuration guidelines are offered.

HP Compaq Business Desktop systems with dual-channel memory support may feature two or four DIMM slots. Figure 1 illustrates a four-slot platform with DIMMs installed in slots 1 and 2.

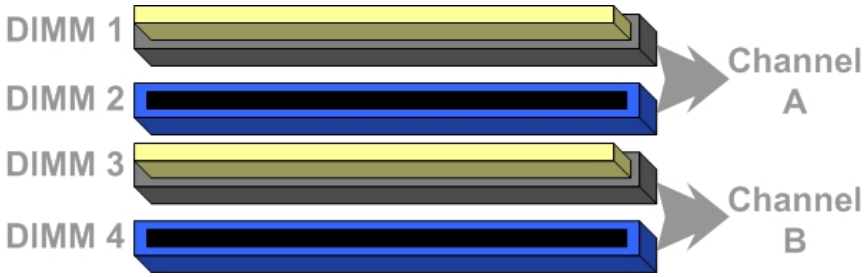


***Figure 1: DIMMs installed in slots 1 and 3, creating a dual-channel configuration***

Intuitive color coding allows DIMMs to be installed in the appropriate slots. For a dual-channel configuration, install a matched pair of DIMMs in the black slots; for additional memory, install a second matched pair of DIMMs in the blue slots.

> ✎ In a four DIMM configuration, all DIMMs should match; however, differently sized pairs are supported. For example, the Channel A DIMMs can be 128 MB while the Channel B DIMMs are 256 MB.

Table 4 lists configuration options for the DIMM slots shown in Figure 1.

| Channel A | | Channel B | | Memory configuration |
|---|---|---|---|---|
| **DIMM 1** | **DIMM 2** | **DIMM 3** | **DIMM 4** | |
| DIMM | | | | Single channel |
| | DIMM | | | Single channel |
| | | DIMM | | Single channel |
| | | | DIMM | Single channel |
| DIMM | DIMM | | | Single channel* |
| | | DIMM | DIMM | Single channel* |
| DIMM | | DIMM | | Dual channel |
| | DIMM | | DIMM | Dual channel |
| DIMM | DIMM | DIMM | DIMM | Dual channel |

* These DIMMs should be reconfigured to create more powerful dual-channel memory.

## Matched Memory

To maximize performance in a dual-channel configuration, matched pairs of DIMMs are required.

- All DIMM characteristics should match – sizes, DRAM technologies, bus widths, external banks, organizations and speeds should be the same
- DIMMs should be installed in matched (symmetrical) slots – for example, as shown in Figure 1, slots DIMM1 and DIMM3 are matched; slots DIMM1 and DIMM4 are mismatched.

Mismatched memory defaults to single-channel operation.

The following sections provide more information on matched memory.

### Matching DIMMs

Table 5 lists DIMM characteristics that must be matched to maximize memory performance.

***Table 4. Matching DIMMs***

| Characteristic | Comments |
|---|---|
| Size | DIMMs must be the same size, for example: 128 MB or 256 MB. |
| DRAM technology | DRAM chips on each DIMM must be the same density, for example: 128 Mb or 256 Mb. |
| Bus width | The DRAM bus width on each DIMM must be the same, for example: 8-bit or 16-bit. |
| External DRAM banks | DIMMs must have the same number of external DRAM banks, either one or two. (Both DIMMs must be either single-sided or double-sided.) |
| Organization | DIMMs must be organized the same way: for example, 16M x 64 or 32M x 64. |
| Speed | DIMM speeds should be matched because the speed of the entire memory configuration slows to that of the slowest DIMM. For example, if memory is configured with one PC2100 DIMM and one PC2700 DIMM, the maximum possible memory speed is 266 MHz. |

### Examples

Figure 2 offers two examples of pairs of mismatched DIMMS.

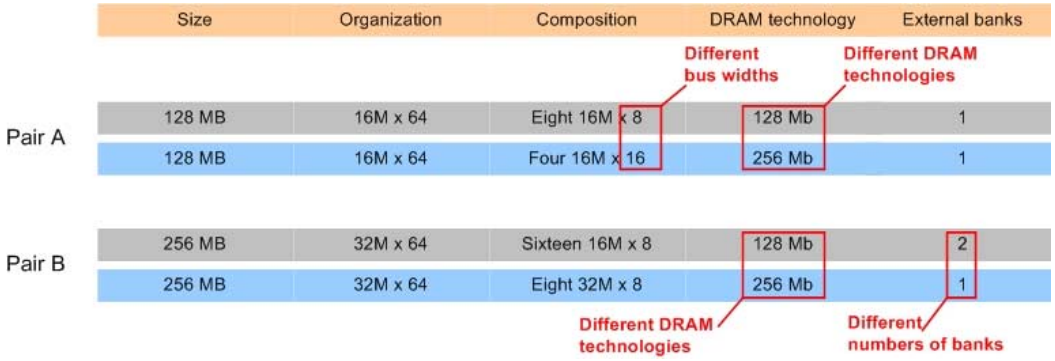


***Figure 2: Examples of mismatched DIMMs***

If the user attempts to deploy a dual-channel memory configuration using either pair of DIMMs shown in Figure 2, memory automatically defaults to single-channel operation.

## Matching DIMM slots

DIMMs must be installed in matched slots to create a dual-channel memory configuration. Figures 3 and 4 show examples of matched (symmetrical) and mismatched (asymmetrical) memory installations.

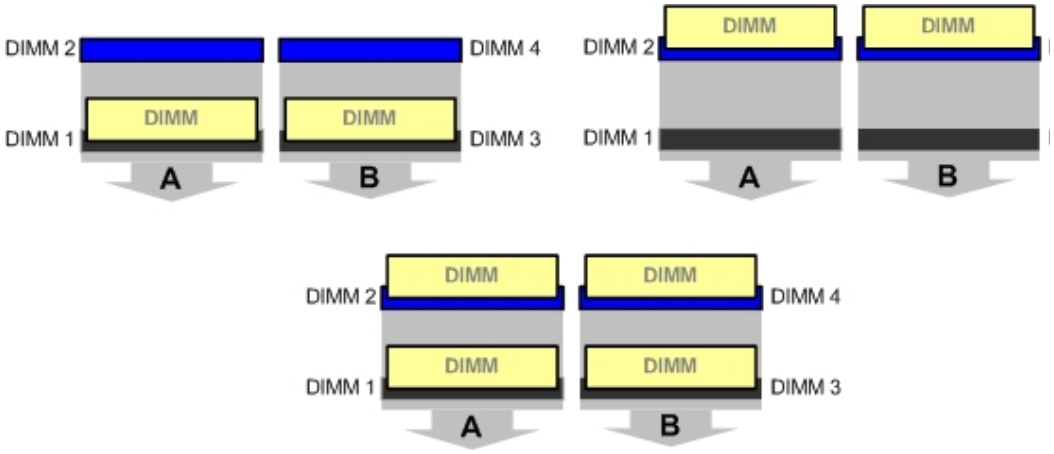


***Figure 3: Matched DIMM installations (dual-channel memory)***

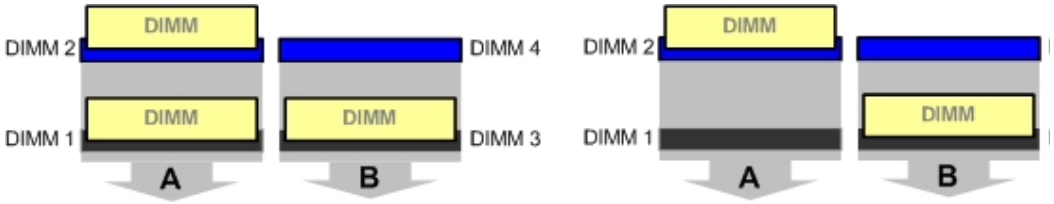


***Figure 4: Mismatched DIMM installations (single-channel, by default)***

If the user attempts to create dual-channel memory using either of the mismatched installations shown in Figure 4, memory automatically defaults to single-channel.

## Using HP-branded Memory

To be assured that all memory characteristics match (as detailed in Table 5), HP recommends using HP-branded DDR memory.

Table 6 lists part numbers for HP-branded DIMMs.

***Table 5. Part numbers for HP-branded DIMMs***

| DIMM type | DIMM size | | | |
|---|---|---|---|---|
| | 128 MB | 256 MB | 512 MB | 1 GB |
| PC2100 (DDR 266 MHz) | DC163A | DC164A | DC165A | DC166A |
| PC2700 (DDR 333 MHz) | DC338A | DC339A | DC340A | DC341A |
| PC3200 (DDR 400 MHz) | DE465A | DE466A | DE467A | DE468A |

## Performance Testing

To offer the customer guidance on upgrading memory in existing systems or specifying appropriate memory for a new system, HP carried out a series of tests designed to benchmark the performance of various DDR memory configurations:

- Deploying faster memory – upgrading from PC2100 to PC2700
- Deploying dual-channel memory – upgrading from single-channel to dual-channel DDR memory

Actual results may vary depending on model, configuration and usage. HP makes no representations or warranties as to the results of these tests.

## Deploying Faster Memory

HP tested a business desktop to determine the performance advantage of single-channel PC2700 memory over single-channel PC2100 memory.

### Tested Configuration

Table 7 summarizes the configuration of the tested system.

***Table 6. Summary of tested configuration***

| Component | Description |
|---|---|
| BIOS | 786B2 0.12 |
| Operating system | Microsoft XP SP1 |
| Processor | Pentium 4, 3.06 GHz |
| Memory type | PC2700 or PC2100 |
| System memory | 256 MB, single channel |
| Video controller | 82865G |
| Video driver | 3471 |
| Video RAM | 64 MB |
| Video resolution | XGA |
| Video color level | 32-bit |
| Video frequency | 85 Hz |
| Disk storage | 40 GB |
| Disk file format | NTFS |
| Disk speed | 7200 RPM |

## Test Results

Table 8 summarizes the results of the PC2700/PC2100 benchmarking.

***Table 7. Summary of test results (faster memory)***

| Benchmark | | PC2700 | PC2100 | PC2700 advantage |
|---|---|---|---|---|
| Winbench 99 2.0 | Business disk | 5950 | 5540 | 7% |
| | High-end disk | 23700 | 23500 | 1% |
| | Business graphics | 190 | 172 | 10% |
| | High-end graphics | 802 | 748 | 7% |
| Winstone | Business 2002 1.0.1 | 27.4 | 27.0 | 1% |
| | Multimedia Content Creation 2003 1.0.0 | 44.2 | 43.0 | 3% |
| Mad Onion PCMark 2002 | Processor | 7453 | 7411 | 1% |
| | Memory | 5642 | 5255 | 7% |
| | Disk | 1268 | 1065 | 19% |
| Mad Onion PCMark 2002 | | 2088 | 1820 | 15% |

For a sample of individual test results, refer to Appendix A.

## Deploying Dual-channel Memory

HP tested a business desktop to determine the performance advantage of dual-channel memory over single-channel memory.

HP designed the testing to benchmark the following memory configuration:

1. One DIMM (single-channel)
2. Two DIMMs (single-channel)

In practice, HP strongly recommends reconfiguring single-channel memory with two DIMMs into more powerful dual-channel memory.

3. Two DIMMs (dual-channel)
4. Four DIMMs (dual-channel)

## Tested Configuration

The tested configuration was based on a business desktop configured with the following components: Pentium 4, 2.6 GHz processor; 40 GB hard drive; and Microsoft Windows XP SP1.

Table 9 lists the various memory configurations tested. (For more information, refer to Figure 1.)

***Table 8. Tested memory configurations***

| Channel A | | Channel B | | Memory configuration |
|---|---|---|---|---|
| **DIMM 1** | **DIMM 2** | **DIMM 3** | **DIMM 4** | |
| DIMM | | | | Single channel |
| DIMM | DIMM | | | Single channel* |
| DIMM | | DIMM | | Dual channel |
| DIMM | DIMM | DIMM | DIMM | Dual channel |

* These DIMMs should be reconfigured to create more powerful dual-channel memory.

## Benchmark Tests

Table 10 offers an overview of the benchmark tests used by HP.

HP used a wide range of benchmarks to give the customer some indication of the value of dual-channel memory for particular business needs.

***Table 9. Benchmark overview***

| Benchmark | Description |
|---|---|
| SYSMark | SYSMark measures system performance on business-oriented applications in a Windows-based environment. The test suite includes Microsoft Excel, Microsoft PowerPoint, Microsoft Word, CorelDRAW, Adobe Photoshop, Adobe Premiere, Windows Media Encoder and others. |
| Content Creation Winstone | Content Creation Winstone measures system performance when running content creation applications simultaneously in a Windows-based environment. The test suite includes Adobe Premiere, Macromedia Director, Macromedia Dreamweaver, Netscape Navigator and Sonic Foundry Sound Forge. |
| Business Winstone | Business Winstone measures system performance with Windows-based 32-bit applications. |
| Mad Onion 3D | Texturing tests, filtering tests, image quality tests and others provide an overview of system performance. |
| Stream | Stream is a simple synthetic benchmark that measures sustainable memory bandwidth. Stream has been designed to work with datasets that are much larger than the system's cache, mimicking very large, vector-style applications. |
| SiSoft Sandra | System Analyzer, Diagnostic and Reporting Assistant (Sandra) is a synthetic Windows benchmark that can evaluate different PC subsystems. HP used Sandra to evaluate CPU Raw Performance, Multimedia Instruction Set and Memory Bandwidth Performance.<br>While the tests are synthetic, results offer an overview of system performance and can identify strengths and weaknesses. |
| Viewperf | Viewperf measures the 3D rendering performance of systems running OpenGL 3D. Viewperf works with large datasets; tests include lighting, smooth shading, blending, line anti-aliasing, z-buffering and some texture mapping. |
| Monte Carlo | Monte Carlo is an internal HP benchmark used for evaluating system performance with multiple threads in Excel. |

### Test Results

The test results summarized in Table 11 show the performance advantages of certain memory configurations over others:

1. Dual-channel memory over single-channel memory
2. Fully-populated dual-channel memory (four DIMMs) over partially-populated dual-channel memory (two DIMMs)

Test results showed a slight performance advantage – typically less than 2% – for single-channel memory with two DIMMs over single-channel memory with one DIMM.

If two DIMMs are available, HP recommends configuring dual-channel memory to optimize system performance.

***Table 10. Summary of performance gains (dual-channel memory)***

| Benchmark | Dual channel (2 DIMMs) over Single channel (1 DIMM) | Dual channel (4 DIMMs) over Dual channel (2 DIMM) |
|---|---|---|
| SYSMark | 7.0% | 2.5% |
| Winstone (Content Creation) | 6.9% | No gain with some applications |
| Winstone (Business) | 9.2% | No gain with some applications |
| Mad Onion 3D | 22.0% | 2.0% |
| Stream | 33.0% – 70.0% | No gain with some applications |
| Sandra (Integer and Floating Point) | 61% | No benefit |
| ViewPerf | 9% | Little benefit |

For more information on individual performance test results, refer to Appendix B.

## Conclusions

The results of performance tests carried out by HP indicated that, with the configurations described, dual-channel memory installed in Intel-based HP business desktops out-performs single-channel memory:

- Up to 10% improvement for regular business applications
- Up to 70% improvement for memory-intensive applications

Backed by these test results, HP offers the general recommendations shown in Table 12 for configuring memory for better performance.

***Table 11. HP recommendations***

| Configuration | Expected result | Comments |
|---|---|---|
| More memory | Good | |
| Faster memory | Better | Make sure that front-side bus speed does not constrain actual memory speed. |
| Dual-channel memory | Best | Use a matched-pair of DIMMs. |

Customers can consult the individual benchmarks to determine which memory configuration best meets their needs.

## Appendix A – Benchmarks (P2700/PC2100)

Figure 5 shows sample test results from the PC2700/PC2100 benchmarking.

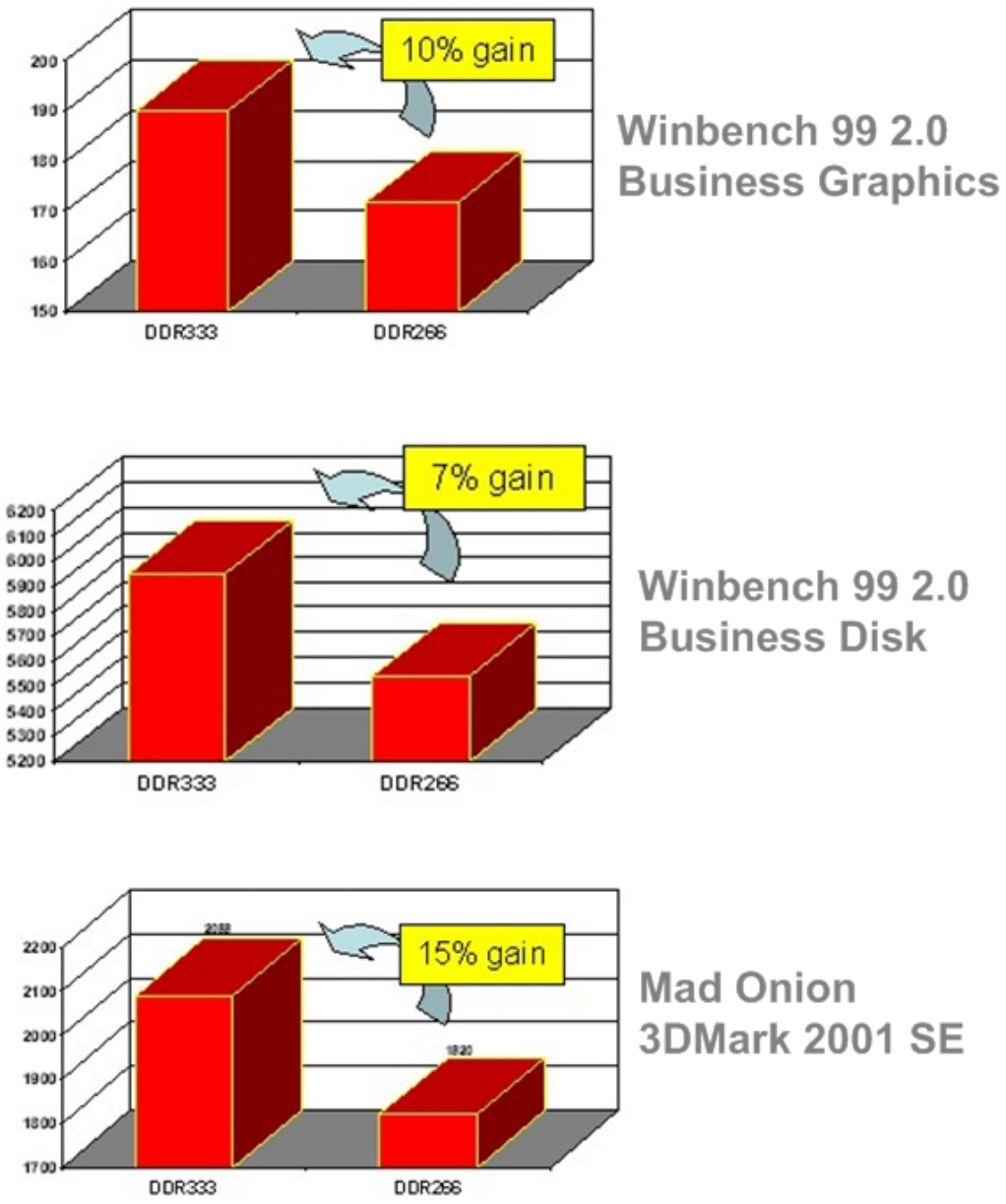


***Figure 5: Sample PC2100/PC2700 benchmarks***

## Appendix B – Benchmarks (Single-channel/Dual-channel)

Figures 6 – 11 show test results from the single-channel/dual-channel benchmarking.

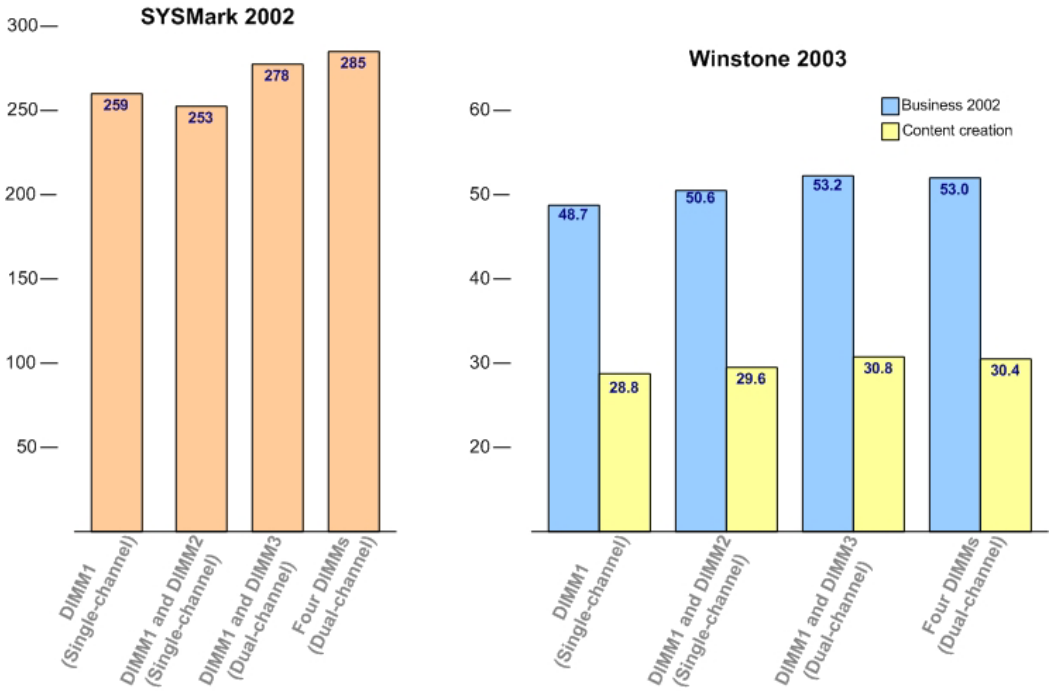


*Figure 6: SYSMark 2002 and Winstone 2003 benchmarks*

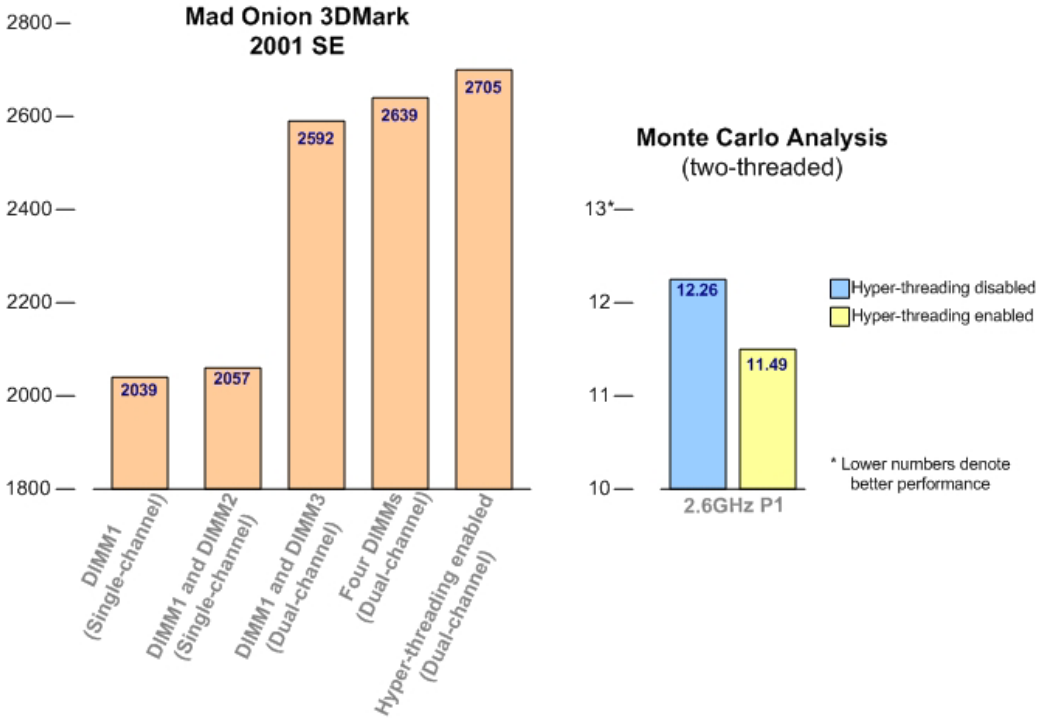


*Figure 7: Mad Onion and Monte Carlo benchmarks*

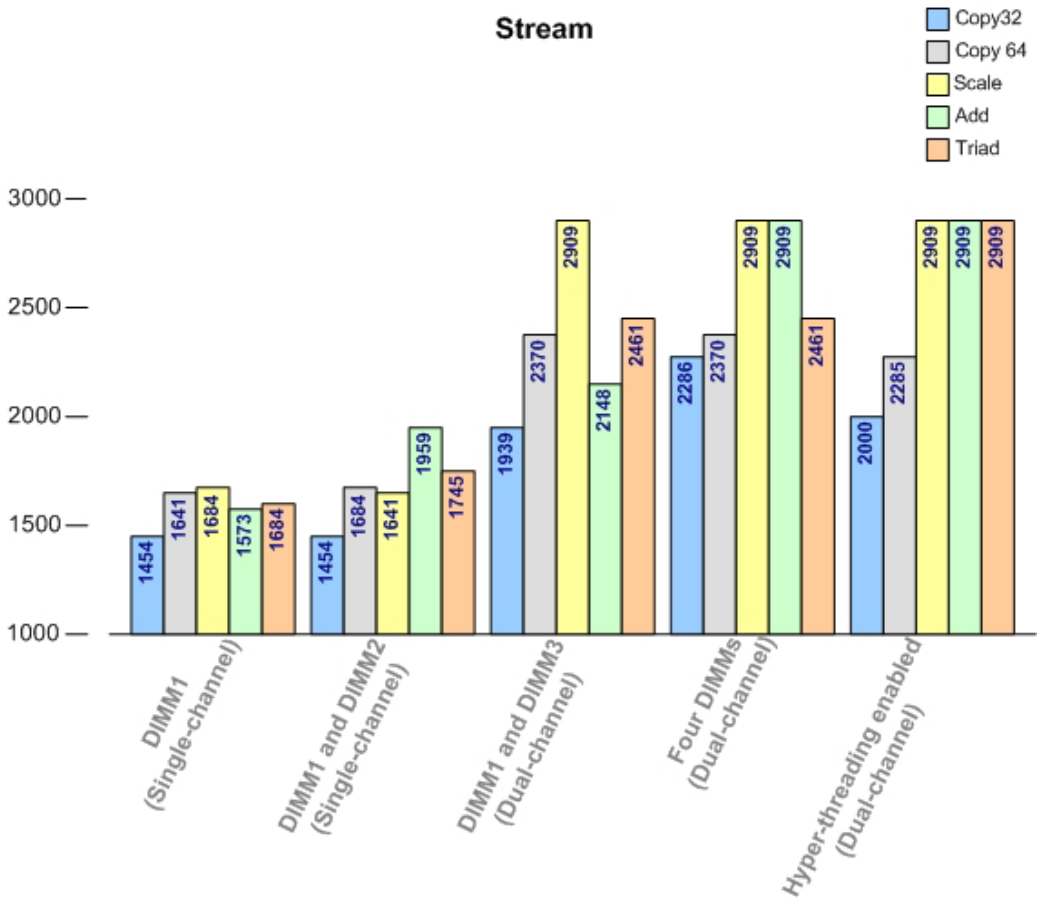


***Figure 8: Stream benchmark***

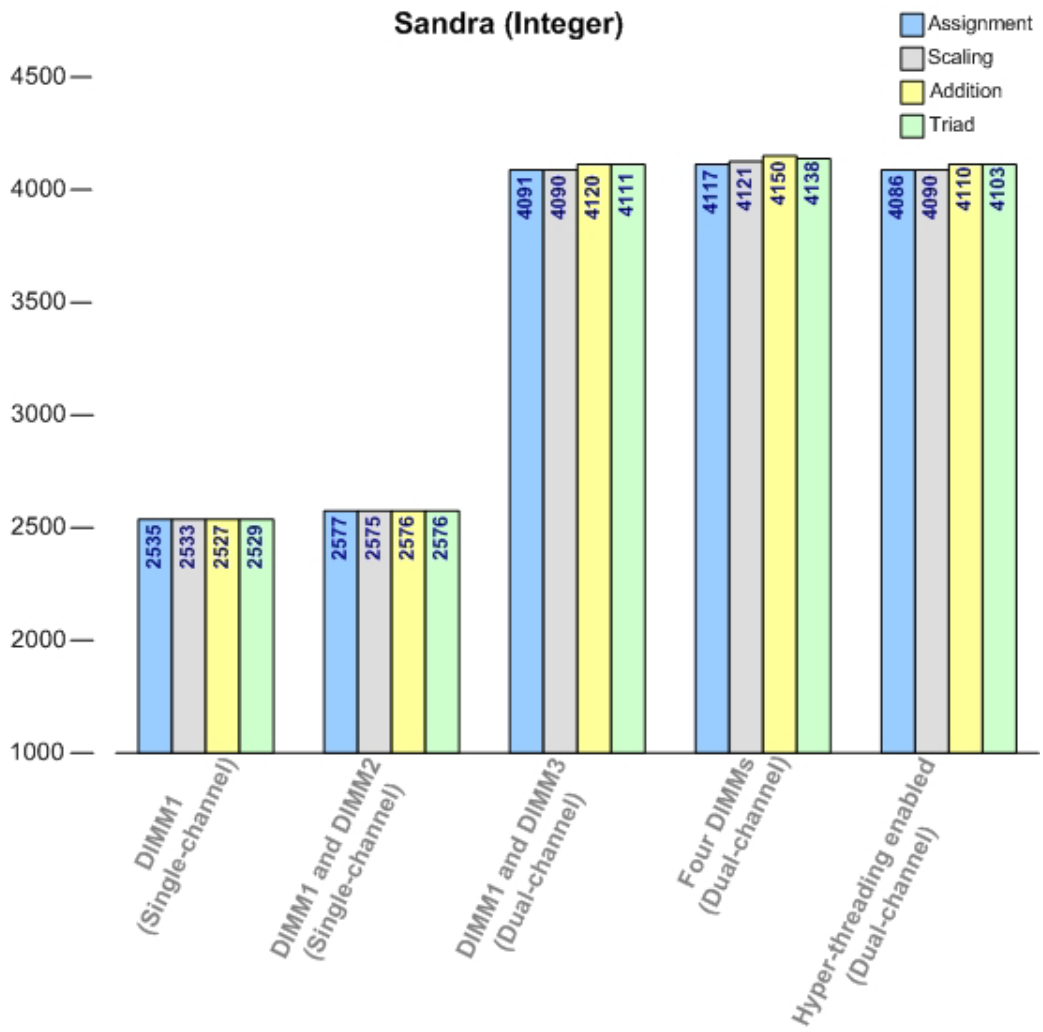


***Figure 9: Sandra (Integer) benchmark***

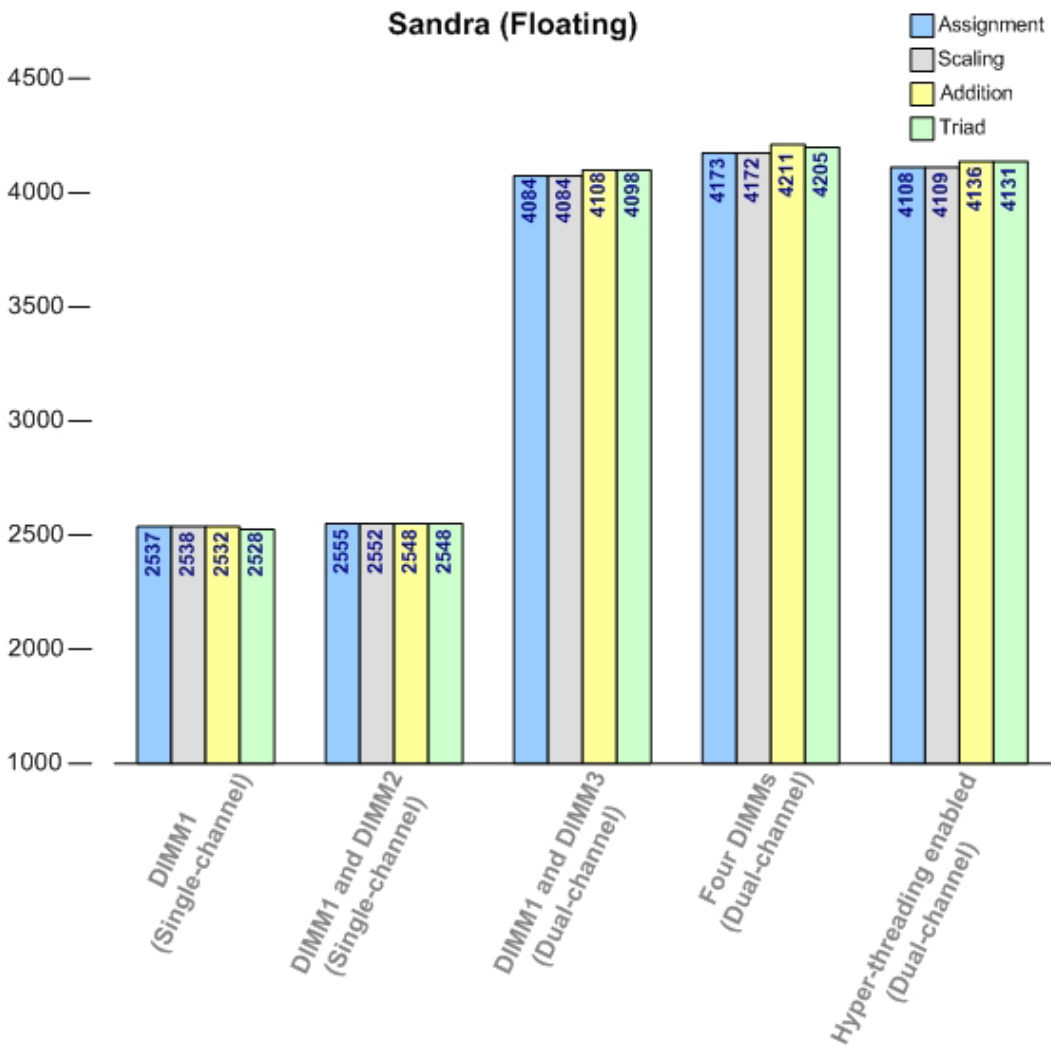


*Figure 10: Sandra (Floating) benchmark*

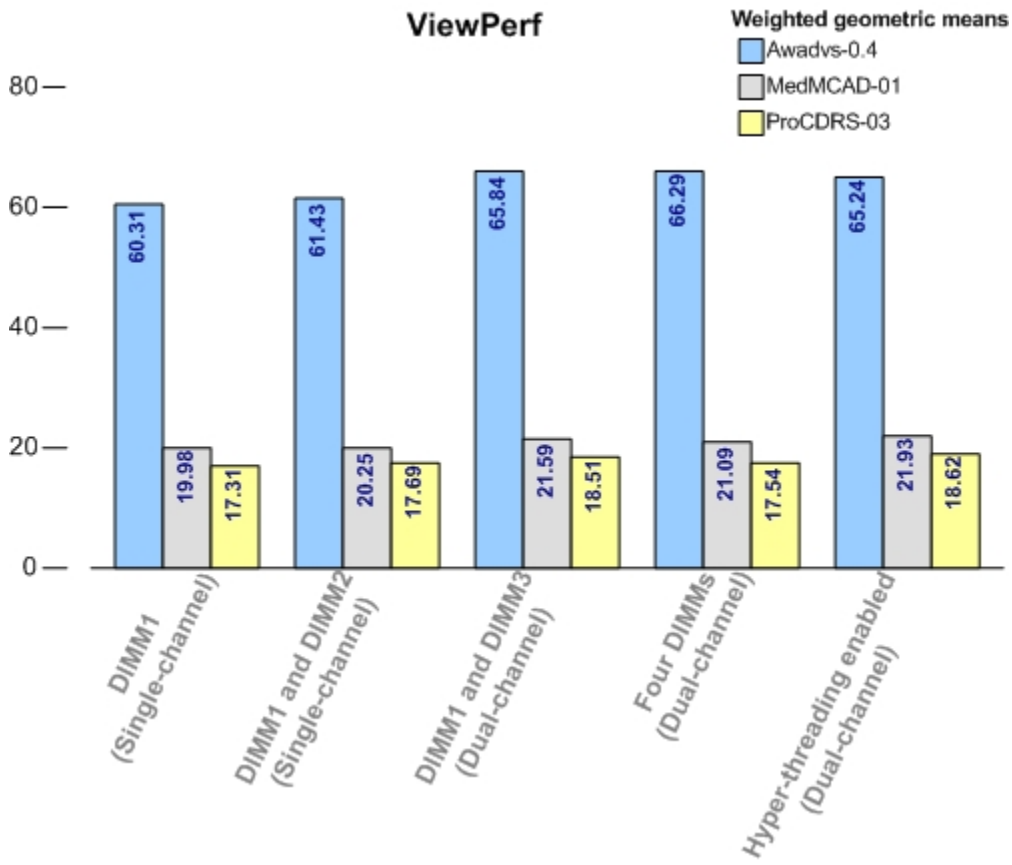


***Figure 11: ViewPerf benchmark***

## Feedback

Please direct comments regarding this communication to Bob Ducey, Memory & Storage Product Line Marketing Manager, Business PC (bPC) GBU, at this Internet address: bob.ducey@hp.com

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06/2003

342219-001

5981-8029EN