RAM Allocation with Microsoft Windows XP and HP Commercial Desktops

Introduction

This white paper discusses the limitation of RAM allocation using a 32-bit operating system such as Microsoft Windows XP on HP x86-based commercial desktop PCs. The Intel 945-based chipset, as well as older commercial desktop systems are covered by this paper.

The current world consists of 32-bit and 64-bit operating systems (OSes). Both the home and professional versions of Microsoft Windows XP are 32-bit operating systems. Microsoft Windows XP Professional x64 is a 64-bit OS. Windows XP Home/Professional, along with all other 32-bit OSes, supports a memory address range of up to 4 GB for both virtual and physical memory addresses. In practice, available RAM is always less than 4 GB because system components require some available memory addresses, resulting in less memory available for the operating system. The reasons for this limitation are explained below.

Windows XP Professional x64 is a 64-bit operating system and it supports up to 32 GB of memory addressing. However, this is just one component to large addressing. In addition to the OS, the entire system must support greater than 4 GB of memory addressing for large addressing to occur. This includes the processor, chipset, physical memory capacity, and so on.

HP commercial desktop systems with Intel 865, Intel 915, Intel 945, and ATI RS480 chipsets support up to 4 GB of RAM. There are currently no HP commercial desktop systems that support more than 4 GB of RAM. Certain systems can physically accommodate more than 4 GB of RAM on the system board, but the excess memory is not used because of 32-bit desktop chipset limitations.

Why the 4-GB limit?

In addition to the 64-bit OS requirement necessary to support greater than 4 GB system memory, there are other hardware requirements, including the processor, chipset, and the amount (greater than 4 GB) of physical system memory configured in the PC. All 32-bit x86 processors have 32-bits of addressing capability. With 32 address lines, 4 GB of memory space can be addressed logically:

232 = 4,294,967,296 = 4 GB

To go beyond the 4-GB limit, a processor must have greater than 32-bit addressing. There are two ways of accomplishing this: PAE and 64-bit processing.

Physical Address Extension (PAE) is a mode allowing a 32-bit x86 processor to use an additional 4 bits for addressing, creating a 36-bit address:

236 = 68,719,476,736 = 64 GB

A 64-bit capable x86 processor, such an Intel Pentium 4 with EM64T, uses 64-bit addressing. This processor can run 64-bit OSes.

264 = 18,446,744,073,709,551,616 = 16 EB (exabyte 1018)

Note: Although in theory a processor can address up to 16 EB, the OS and the chipset it is supporting can have a much lower limit. For example, Microsoft Windows Professional x64 can only address up to 32 GB, and a 32-bit chipset is still limited to 4 GB.

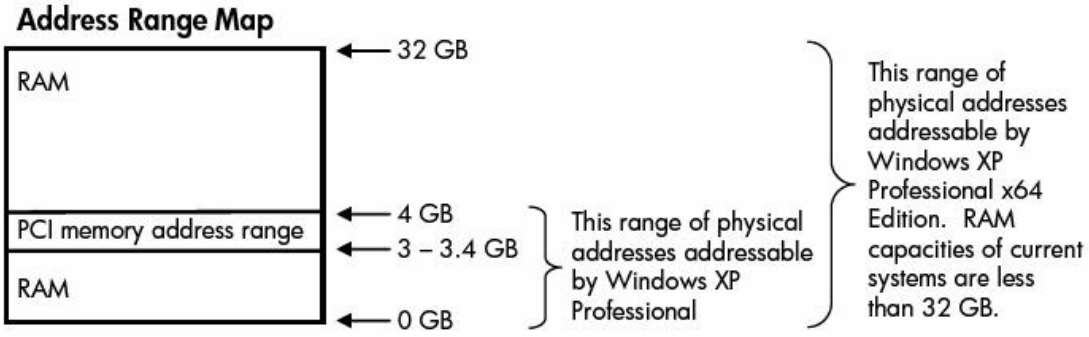
Note: Do not confuse total physical memory and memory addressing with the amount of virtual memory available to the OS. No matter how much physical memory is in the system, a 32-bit OS will have 4 GB of virtual memory through paging.

How does the limit work?

Physical memory addresses are divided into two sections: the PCI memory address range (also known as Memory Mapped I/O), and the RAM available to the operating system. This explains why even with 4 GB of memory, available RAM is less than 4 GB.

PCI memory address space is used to transfer data by the BIOS, I/O cards, networking, PCI hubs, bus bridges, PCI Express, and graphics cards. It starts at the top of memory at 4 GB and takes memory addressing to lower address ranges. PCI Express alone takes up 256 MB of address space, and each component also requires an additional amount. Therefore, it is very easy for a system with 4 GB of physical memory to lose 512 MB or more address space before any RAM addressing is allocated.

RAM addressing starts at 0 MB and takes memory addresses to higher address ranges up to the bottom of the PCI memory address space, which is around 3 to 3.4 GB. The bottom of PCI memory address space may fall outside of this range depending on system configuration, especially if more than one graphics card is installed.



What is being done?

The 4 GB memory limitation is a well-known industry architectural problem, and HP is working toward a 64-bit commercial desktop solution. In the near future, HP commercial desktop PCs will have all the components (processor, chipset, and OS) necessary to support 64-bit computing with greater than 4 GB of physical memory.

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