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Virtual Memory: How It Differs On Power Macintosh (7/96)

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TOPIC --

Why is the RAM requirement lower for a program when virtual memory (VM) is
running? When you do a Get Info on an application on a Power Macintosh you get
an additional message that gives a lower memory requirement if you have virtual
memory turned on. Since this still looks like RAM to the application, why is
there a lower RAM requirement?

This article answers these questions and describes how you can reduce the memory
requirements for Power Macintosh native applications that require large amounts
of RAM, such as Microsoft Excel or Word.

DISCUSSION ---

Overview
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With the introduction of Power Macintosh, virtual memory, the ability to assign
part of a hard drive as if it were additional physical memory, gains advantages
over previous systems. By enabling virtual memory, Power Macintosh computers are
able to utilize a feature called file mapping, which can significantly reduce
the amount of physical memory required to launch a native application. Enabling
Virtual Memory reduces the overall memory requirements of large native Power
Macintosh applications. After enabling Virtual Memory, the Application Partition
is substantially smaller and the System Partition increases by a relatively
small amount.

In a recent sampling of native Power Macintosh applications, we found the
average RAM required to launch an application was almost 2 MB less when virtual
memory was enabled.

In the past, the only reason to enable virtual memory was to simulate the
addition of real memory to a system. With Power Macintosh, simply enabling
virtual memory without adding any virtual space has the desirable effect of
reducing the application RAM footprint.

Excerpts from "Inside Macintosh: PowerPC System Software"
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Without Virtual Memory

When virtual memory is not enabled, the application's Stack (temporary data
storage), Heap (dynamically allocated storage), and all Code Fragments
(Executable PowerPC code) must load into the Application Partition, resulting in
increased launch times and RAM requirements for large applications.

With Virtual Memory

With Virtual Memory enabled, only the application's Stack and Heap load into the
Application Partition, reducing the launch times and RAM requirements for native
applications. The application's Code Fragments are then tracked by the Virtual
Memory Manager, which only writes the Code Fragments to the System Partition
when needed, resulting in fewer Code Fragments loaded into memory at one time.

As an additional benefit, the Operating System assumes the application's code
section is always read-only, meaning that, when it's time to remove some of the
application's code from memory (to page in other code or data), the Virtual
Memory Manager doesn't need to write the code back to the hard disk. Instead, it
simply purges the code from the System Partition and writes new code to the
System Partition, reducing the time required to load applications code.

Virtual Memory Benefits

So, by enabling Virtual Memory you have these benefits:

• Reduce the RAM required for Application Partitions.
• Increase the System Partition. (But, to a lesser extent than
  the Application Partition)
• Reduce the start up time for applications.

How Virtual Memory on Works on 680x0 Macintosh
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On a 680x0 Macintosh, the Segment Loader loads as much of the application as
possible into memory, which is dictated by both the amount of available memory
and the application's heap size (set using the Finder's Get Info dialog). If you
want to increase an 8 MB system to 12 MB by using Virtual Memory, the system
creates a 12 MB space on disk. When instructions or data are accessed by the
system, and are not resident in memory, a "page fault" occurs. A page fault
causes the system to write the least recently used "page" to disk and then
satisfies the page fault by "swapping" in the page which contains the required
data. This mechanism is designed to keep the most frequently used pages in
physical memory ("working set") and the least frequently used ones on disk. The
task of keeping all the locations straight is the job of virtual memory and the
Memory Management Unit (MMU).

How Power Macintosh VM Is Different
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With native applications on Power Macintosh, there is no Segment Loader. When
virtual memory is disabled, applications are loaded into memory as a contiguous
block. The amount of space required for all of the code in a single application
can be quite large. However, Power Macintosh applications are written to a
strict new specification for the types of data that reside in the data and
resource forks. In particular, the data fork contains read-only data for the
application, whereas the resource fork contains information that can be
modified. This is an important distinction because these rules, with virtual
memory enabled, let the Code Fragment Manager (CFM) take advantage of file
mapping.

With file mapping active, only some of the resource fork needs to be loaded into
memory. Items in the data fork of the application can remain on disk and will be
"mapped" into memory by the CFM as needed. This has the advantage of
dramatically reducing the amount of data that has to immediately copied into
memory at application launch time. Additionally, read-only items in the data
fork can be trashed when a page fault occurs, rather than writing the old
information out to disk. This reduces a write-read cycle, to a single read. This
is why Power Macintosh virtual memory performance is improved over 680x0, even
though the core code is unchanged.

The Modern Memory manager does not affect how the Virtual Memory Manager handles
Code Fragments. So, enabling Virtual Memory and not enabling the Modern Memory
has the same result.

Virtual Memory Diagram
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The following diagram may be helpful in describing how Virtual Memory affects
RAM requirements. The left column lists possible memory configuration for a
Power Macintosh with three native applications with virtual memory enabled. The
right column is for three native applications with virtual memory not enabled.
The center column provides possible memory requirements.

Begin_Table

Power Macintosh with Virtual Memory Enabled	Physical RAM	Power Macintosh with Virtual Memory not Enabled
System Software	1MB	System Software
System Partition	***	System Partition
Application A, Code Section 1	2MB	Application A Partition
Application B, Code Section 1	***	Heap
Application C, Code Section 1	3MB	Stack
Application A Partition	***	Application A, Code Section 1
Heap	4MB	Application A, Code Section 2
Stack	***	Application A, Code Section 3
Application B Partition	5MB	Application A, Code Section 4
Heap	***	Application B Partition
Stack	6MB	Heap
Application C Partition	***	Stack
Heap	7MB	Application B, Code Section 1

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   Stack                        ***        Application B, Code Section 2
                                8MB        Application B, Code Section 3
                                ***        Application B, Code Section 4
                                9MB     Application C Partition
                                ***        Heap
                                10MB       Stack
                                ***        Application C, Code Section 1
                                11MB       Application C, Code Section 2
                                ***        Application C, Code Section 3
                                12MB       Application C, Code Section 4
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End_Table

Because of file-mapping and the Code Fragment Manager, most Power Macintosh
users will want to activate virtual memory. For those wishing to take advantage
of increased memory space, Apple recommends setting virtual memory on Power
Macintosh computers to 50% more than the amount of physical memory.

Example: If you have 8MB of RAM, set the system to 12 MB in the Memory
         control panel.

Customers who want the highest performance possible, but still want the benefits
of the reduced application footprint of file-mapping, can set virtual memory to
the minimum amount of 1 MB more than physical RAM.

Example: If you have 8 MB of RAM, set the system to 9 MB in the Memory
         control panel.

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