
About Virtual Memory

Virtual memory is the part of system 7.0 that allows any Macintosh computer equipped with an MMU to extend the available amount of memory beyond the limits of physical RAM. Virtual memory extends the logical address space by using part of the available secondary storage (such as a hard disk) to hold portions of programs and data that are not currently in use. When an application needs to operate on portions of memory that have been transferred to disk, the Operating System loads those portions back into physical memory by making them trade places with other, unused segments of memory. This process of shuttling portions (or **pages**) of memory between physical RAM and the hard disk is called **paging**.

For the most part, virtual memory operates invisibly to applications and to the user. Most applications do not need to know whether virtual memory is installed unless they have critical timing requirements, execute code at interrupt time, or perform debugging operations. The only time that users need to know about virtual memory is when they configure it in the Memory control panel. One visible cost of this extra memory is the use of an equivalent amount of storage on a backing device, such as a SCSI hard disk. Another cost of using virtual memory is a possible loss of speed as paged-out segments of memory are pulled back into physical memory. Performance degradation when using virtual memory ranges from unnoticeable to severe, depending on the ratio of virtual to physical RAM and the behavior of the actual applications running.

The principal benefit of using virtual memory is that users can run more applications at once and work with larger amounts of data than would be possible if the logical address space were limited to the available RAM. Instead of equipping a machine with amounts of RAM large enough to handle all possible needs, a user can install only enough RAM to meet average needs. Then, when more memory is occasionally needed for large tasks or many applications, virtual memory can provide the extra amount of memory required. When virtual memory is present, the perceived amount of RAM can be extended to as much as 14 MB on systems with 24-bit addressing and as much as 1 GB on systems with 32-bit addressing.

There are two main requirements for running virtual memory. First, the Macintosh must be running system 7.0 or later. Second, the Macintosh must be equipped with an MMU or PMMU. Apple's 68030-based machines have an MMU built into the CPU and are ready to run virtual memory with only a software upgrade to system 7.0; no additional hardware is needed. A Macintosh II (68020-based) can take advantage of virtual memory if it has the 68851 PMMU coprocessor on its main logic board in place of the standard address management unit. (The PMMU is the same coprocessor needed to run A/UX.) Apple's 68000-based machines cannot take advantage of the virtual memory capability of system 7.0, even though they can run system 7.0 if they have at least 2 MB of RAM.

Users control and configure virtual memory through the **Memory** control panel. Controls in this panel allow the user to turn virtual memory on or off, set the size of virtual memory, and set the volume on which resides the invisible backing-store file (the file that the Operating System uses to store the contents of non-resident portions of memory). Other memory-related user controls are combined in this control panel. These include settings for the disk cache and for 24-bit or 32-bit **Memory Manager** addressing. If users

change the virtual memory, addressing, or disk cache settings, they must restart the machine in order for the changes to take effect.

Note that the amount of virtual memory that users select in the control panel is the *total* amount of memory that is to be available to the system (and not simply the amount of memory to be added to available RAM). Also, the backing-store file is as large as the amount of virtual memory. This backing-store file might be located on any HFS volume that allows block-level access. (This volume is known as the **paging device** or **backing volume**.) Because the paging device must support block-level access, users cannot select as the paging device a volume that they mount using AppleShare. Also, users cannot select removable disks, including floppy disks, as paging devices.