The Adaptation of Virtual Memory

A Solution to Limited Physical Memory

Andrew H. Rohn

University of Maryland University College

**Abstract**

Virtual memory refers to the management of memory addresses for an application in such a way that it appears as though the application has access to a large contiguous address space in the main memory. The need for virtual memory arose from the desire to reduce the amount of unused memory due to fragmentation and to increase available memory by utilizing second memory in tandem with primary memory. Due to its ability to maximize limited physical memory space, virtual memory management has been widely adopted.

**A Solution to Limited Physical Memory**

In the early years of computers, physical memory was incredibly limited in size. In the early 1940’s, a computer large enough to fill up a warehouse could only hold 128 kilobytes ("Virtual Memory," n.d.). Therefore, computer memory had to be conservatively allocated. If multiple programs were to be used, memory had to be manually allocated in large contiguous segments of memory addresses to each program. This resulted in fragmentation as gaps of unused memory formed that were not large enough to be allocated to another program, lest previously allocated memory addresses be overwritten. To address this problem, a German physicist by the name of Fritz-Rudolph [Güntsch](https://en.wikipedia.org/w/index.php?title=Fritz-Rudolf_G%C3%BCntsch&action=edit&redlink=1) developed the memory management technique known as “virtual memory” in 1956 (Biscontini, 2016). This technique functions by piecing together non-contiguous physical memory addresses into a contiguous virtual memory address space for an application to use. This eliminates the need for an application to manage memory addressing and instead leaves the task to a hardware component in the CPU called the Memory Management Unit (MMU).

Virtual memory also increases the size of available memory addresses for an application by combining available primary and secondary memory addresses through a process called “paging”. In modern computers, this entails the storage and retrieval of data from a hard drive (secondary) for use in the main memory (primary). With this memory management technique, an application can store data that exceeds the size of the available main memory. Nowadays this isn’t all that necessary as modern computers tend to have in excess of 4GB of RAM (main memory) at their disposal. However, prior to the late 1970’s, computer memory was very expensive and using any method of increasing available memory without the need to purchase more physical memory, translated into huge cost savings (Denning, 1996). This contributed to the mass-implementation of virtual memory addressing in computer systems from then on.

**The Adaptation of Virtual Memory**

Despite the theoretical advantage of virtual memory being known, it wasn’t until 1969 that the concept was proven, when IBM showed that computer systems implementing virtual memory management could consistently outperform those that used manual memory management. Throughout the 1970’s, the concept of virtual memory was perfected and by the end of the decade most commercial computer systems began utilizing virtual memory in one way or another. The rise of personal computers in the 1980’s led Intel to offer virtual memory in their new 386 microprocessor in 1985. In 1995, virtual memory was implemented along with multiprogramming in Windows 3.1 ("Virtual Memory," n.d.).Operating systems have since utilized virtual memory.

**Conclusion**

Virtual memory management was developed to solve the longstanding problem of limited physical memory that plagued early computer systems. It maximizes available memory by taking non-contiguous memory addresses, logically connecting them, and presenting them as a single address space for an application to use. Also, it extends primary memory by allowing data to be stored and called from secondary memory. For these reasons, virtual memory was implemented into modern computer systems.

**References**

Biscontini, T. (2016). Computer memory. *Salem Press Encyclopedia of Science*. Retrieved October 13, 2018, from http://eds.b.ebscohost.com.ezproxy.umuc.edu/eds/detail/detail?vid=3&sid=a1b7cd4f-94d5-4a2d-8711-dd0b2e9fcdca@pdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ==#AN=87321582&db=ers

Denning, P. J. (1996). Virtual memory. *ACM Computing Surveys,* *28*(1), march 1996, 213. Retrieved October 14, 2018, from http://eds.b.ebscohost.com.ezproxy.umuc.edu/eds/detail/detail?vid=11&sid=a1b7cd4f-94d5-4a2d-8711-dd0b2e9fcdca@pdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ==#AN=edsgcl.18573405&db=edsgic

Virtual Memory. (n.d.). Retrieved October 13, 2018, from http://denninginstitute.com/itcore/virtualmemory/vmhistory.html