Virtual memory was the first application of virtualization concepts to commercial computers. It allowed

multiprogramming and eliminated the need for users to tailor their applications to the physical memory

available on individual systems. Paging and segmentation are the two mechanisms supporting virtual

memory. Paging was developed for the Atlas Computer, built in 1959 at the University of Manchester.

Independently, the Burroughs Corporation developed the B5000, the first commercial computer with virtual memory, and released it in 1961. The virtual memory of the B5000 used segmentation rather

than paging.

In 1967 IBM introduced the 360/67, the first IBM system with virtual memory, expected to run

on a new operating system called TSS. Before TSS was released, an operating system called CP-67

was created. CP-67 gave the illusion of several standard IBM 360 systems without virtual memory.

The first VMM supporting full virtualization was the CP-40 system, which ran on a S/360-40 that was

modified at the IBMCambridge Scientific Center to supportDynamic Address Translation, a key feature

that allowed virtualization. In CP-40, the hardware’s supervisor state was virtualized as well, allowing

multiple operating systems to run concurrently in separate virtual machine contexts.

In this early age of computing, virtualization was driven by the need to share very expensive hardware

among a large population of users and applications. The VM/370 system, released in 1972 for large IBM

mainframes, was very successful. It was based on a reimplementation of CP/CMS. In the VM/370 a new

virtual machine was created for every user, and this virtual machine interacted with the applications.

The VMM managed hardware resources and enforced the multiplexing of resources. Modern-day IBM

mainframes, such as the zSeries line, retain backward compatibility with the 1960s-era IBM S/360 line.

The production of microprocessors, coupled with advancements in storage technology, contributed

to the rapid decrease of hardware costs and led to the introduction of personal computers at one end of

the spectrum and large mainframes and massively parallel systems at the other end. The hardware and

the operating systems of the 1980s and 1990s gradually limited virtualization and focused instead on

efficient multitasking, user interfaces, the support for networking, and security problems brought in by

interconnectivity.

The advancements in computer and communication hardware and the explosion of the Internet, partially

due to the success of theWorldWideWeb at the end of the 1990s, renewed interest in virtualization

to support server security and isolation of services. In their review paper, Rosenbloom and Grafinkel write

[308]: “VMMs give operating system developers another opportunity to develop functionality no longer

practical in today’s complex and ossified operating systems, where innovation moves at a geologic pace.”