Report

Linux – Competing but

Misunderstood Kernel or… OS?

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A Fundamentals of Operating System

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9th April 2021

1368 words

Summary

This report discusses the Memory Management and Virtual Management of the Linux OS Kernel. A small description of what an OS and Kernel is, further covering the differences and connection between the two. This description is to set a basic understanding required for further talk about Linux's Virtual Memory Management.

Key points covered :

- Operating System vs Kernel
- Linux – OS or Kernel
- GNU/Linux vs Linux OS Kernel
- Virtual Management of Kernel

The information has been gathered using resources found on the infamous Google and attached at the bottom of the page.

The report has been prepared for submission as Report for the course COIS 3320H A Fundamentals Of Operating Systems in Trent University.

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1. Introduction

All the applications, games, technology are a waste if we do not have a good Operating System installed in out computer. What is an OS? Unless we are a “Computer Science” student or a really smart and knowledgeable person, we might not know what exactly an operating system is; and we definitely might not know what a kernel is.

2. Operating System vs Kernel

Operating system is a collection of basic programs that allow your machine to communicate with users, read and write data to hard discs, tapes, and printers, manage memory, and run other software. Managing of the memory and processes as well all of its software and hardware is the responsibility of Operating System. It ensures that users can run and operate applications in safe and efficient manner. A kernel on the other hand is the minimal set of functions that care necessary to manage the system resources safely and efficiently. A Kernel is a critical part of an OS. Without a Kernel, an OS cannot be generic. Kernel acts as a bridge between the user applications and the hardware. It is the core part of the Operating System with the sole aim to manage communication between the user level software and the hardware – CPU, memory. It is safe to say that kernel is a basic component of an operating system and a kernel can provide the lowest-level abstraction layer for resources like processors and I/O devices. Providing an abstraction layer means hiding the working details of a subsystem.

3. Linux

The most common types of operating systems that almost every human has heard of are Microsoft Windows, macOS and Linux. The general public has been debating since a few years on Windows vs macOS. While the minor and 'higher' community of nerds dealing with prodigious computer knowledge understand the greatness of Linux. Linux is an open – source operating system – this means that it can be modified and distributed by anyone around the world. Linux was modelled on the Unix operating System as a multi-tasking and multi-user system. The OS is easy to install on any hardware – mobile phone, tablet, video game console and of course general computers and laptops.

4. GNU/Linux vs Linux

GNU is an operating system that was designed as a replacement for Unix with many software programs. GNU has its own kernel, The Hurd. Used with kernel Linux, the combination makes an operating system which is mistakenly called as Linux. A large collection of free software tools have been created by the GNU Project for use with Unix-like OS such as Linux.

The OS is actually GNU/Linux, however Linux is the generic term people use to refer to the family of Unix-like computer operating systems that use the kernel Linux. Being free source, all the code is free and can be modified and redistributed by anyone under licenses such as the GNU General Public License. And thus Linux Kernel has had a lot of modifying and contributions from developers all over the world.

5. Virtual Memory Management in Linux

5.1 Memory Management

Memory management is the functionality of an operating system that conducts the management of the primary memory of Central Processing Unit and is responsible for moving the processes back and forth between the main memory and disk during execution.

5.2 Virtual Management

Virtual management and memory management can be confused with memory management and knowing the difference is important. Under Virtual memory management, OS is responsible for extending the capacity of the main memory to execute large programs using the hard disk. This extension is done by being able to use the secondary memory can be used as if it were a part of the main memory itself. Virtual memory uses the hardware and software to allow computer to compensate for the shortage of physical memory by temporarily transferring the data from RAM to disk storage.

Linux memory management system has a lot of configurable settings and hence can be a complex system. It has evolved a lot over the years by getting more and more functionalities and thus going from MMU-less microcontrollers to supercomputers.

5.3 Huge

With Virtual Memory, every memory access gets a virtual address which is translated to a physical address that memory controller can understand when CPU decodes the instruction that is read/written from/to system. The physical memory is divided into page frames or pages and each page has a specific size. Choosing of appropriate page for an instruction is done at kernel level by an appropriate kernel configuration option. Now, each page can be mapped as one or more virtual pages or the page tables. The page tables are organized hierarchically.

The hierarchy is such that the tables at the lowest level of the hierarchy contains physical address of the actual page being used by software and the higher levels contain physical addresses of the pages belonging to lower levels. The pointer is in this top-level page table register and this register is used by CPU for address translation. During this address translation, CPU needs lot of memory access and that can decrease speed for CPU. To avoid this CPU maintain a cache of such translations called Translation Lookaside Buffer (TLB). Modern CPU allow mapping of memory pages directly to higher level page table and these pages are called *huge* in Linux. Using Huge decreases the pressure on TLB and improves overall performance of the system by improving TLB hit rate.

5.4 HugeTLB filesystem and Transparent HugePages

Linux has two mechanisms for mapping of the physical memory with huge. The first is *HugeTLB filesystem* and the second is *Transparent HugePages.*

The first method uses RAM as its back storage and the files created in this filesystem have the data stored in memory and mapped using huge pages. This support is built on top of multiple page size support that is provided by today's new architecture. The latter mechanism conversely requires the users to configure what parts of the system memory can be mapped to the huge pages. These mappings are transparent to the users and hence the name.

5.5 Zones

Sometimes it is harder to access physical memory because of the hardware. To avoid this, Linux groups the memory pages into *zones* based on their possible usages. For instance, ZONE_DMA will contain the memory that can be used by devices DMA, and another zone ZONE_HIGHMEM will contain the memory that is not mapped permanently into kernel's address space. The layout of zones usually depends on hardware since it is to overcome the problems caused by hardware.

5.6 Nodes

There are Non-Uniform Memory Access systems. The memory in these systems are arranged into banks whose access latency depends on the distance from the processor. In Linux, each bank is referred as *Node* and for each node an independent memory is created with their own management subsystem. Each node will have its own zones, pages and other counters.

5.7 Page Cache

To control the memory, files are kept in *page cache* to avoid expensive disk access on subsequent reads. Similarly, when a file is written, the data does in page cache and these pages are marked as dirty. When these pages are not to be reused by Linux for long, the file contents are synchronized with updated data.

5.8 Anonymous memory

The memory that is not backed up by a filesystem is called the anonymous memory. They only define virtual memory areas that program has access to. Read accesses created page table with page filled with zeroes. Write access makes a regular physical page filled with the written data.

6. Conclusion

Users are provided with immense freedom of choice in their software using Linux such as choosing from dozen different command line shells and several graphical desktops. Also, Linux is better able to run more than one program at the same time and is less likely to crash.

When talking about virtual memory management alone, one can write a long report (that goes a lot over the word limit). But, Linux has a good way of managing the memory and hence avoiding ‘crashes’ unlike other the most used OS. This is the reason that Linux is being accepted by many business and other platforms today.

7. References

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