

# Building Blocks of a Microkernel: Lessons from sel4 and a Teaching Microkernel

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## Abstract

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## Introduction

Kernel is a piece of code that serves as the core of an operating system. It manages the system's resources and provides a layer of abstraction between the hardware and software. The kernel is responsible for handling tasks such as memory management, process scheduling, device drivers, and input/output (I/O) operations. All these operations take place in a privileged mode, also known as kernel mode. On the other hand, programs operate in user mode which doesn't allow them to directly access hardware resources. Instead, they need to utilize the operating system to access these resources via different abstractions and interfaces.

Over the years this privileged code has increased with addition of newer technologies and this is as dangerous as useful. If any malicious access is allowed here that could compromise the entire system. This has occurred on many mainstream systems. Linux kernel comprises of 20 Million lines of source code, it is estimated that it contains tens of thousands of bugs.[1] This idea is captured by saying that Linux has a large trusted computing base (TCB), which is defined as the subset of the overall system that must be trusted to operate correctly for the system to be secure.[2]

The idea behind a microkernel design is to drastically reduce the TCB to have a secure base to build a system. In a well-designed microkernel, such as sel4, it is of the order of ten thousand lines of source code. As seen in Figure 1 the monolithic kernel structure provides every functionality from kernel mode,

i.e. privileged mode making the TCB large. On the other hand, the microkernel structure provides only the bare minimum functionality from kernel mode and the rest of the functionality is provided by user mode programs. This makes the TCB small and secure. However the downside of this approach is that it requires a lot of user mode programs to be written to provide the functionality and this incurs a performance penalty.

In this report we will be looking at the building blocks of a microkernel and how they are implemented in sel4. We will also be looking at the design to build a teaching microkernel using gem5 simulator.[3]

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\*Supervised by: Prof. Debadatta Mishra

Submitted: Apr 20, 2023

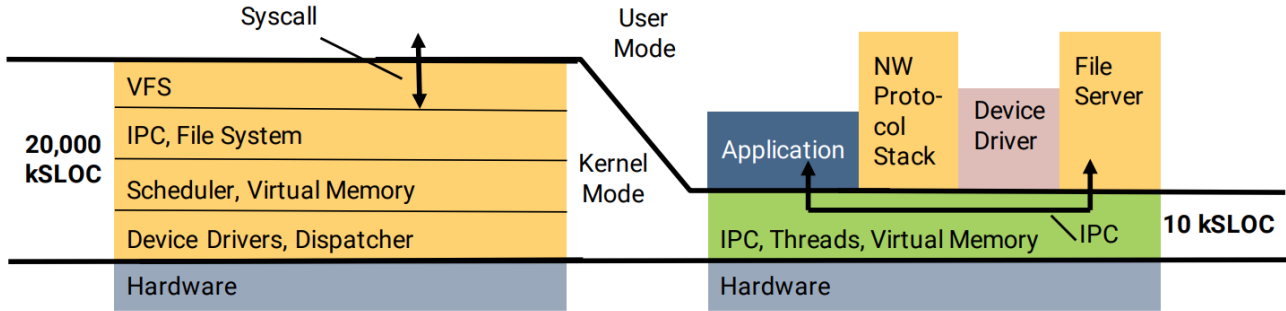


Figure 1: To left is a monolithic structure and microkernel structure on right [2]

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## Methodologies

### Sample Sites & Processing

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Table 1: Example single column table.

Location		
East Distance	West Distance	Count
100km	200km	422
350km	1000km	1833
600km	1200km	890

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Table 2: Example two column table with fixed-width columns.

Location		Count
East Distance	West Distance	
100km	200km	422
350km	1000km	1833
600km	1200km	890



Figure 2: Anther of thale cress (*Arabidopsis thaliana*), fluorescence micrograph. Source: Heiti Paves, <https://commons.wikimedia.org/wiki/File:Tolmukapea.jpg>.

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Discussion

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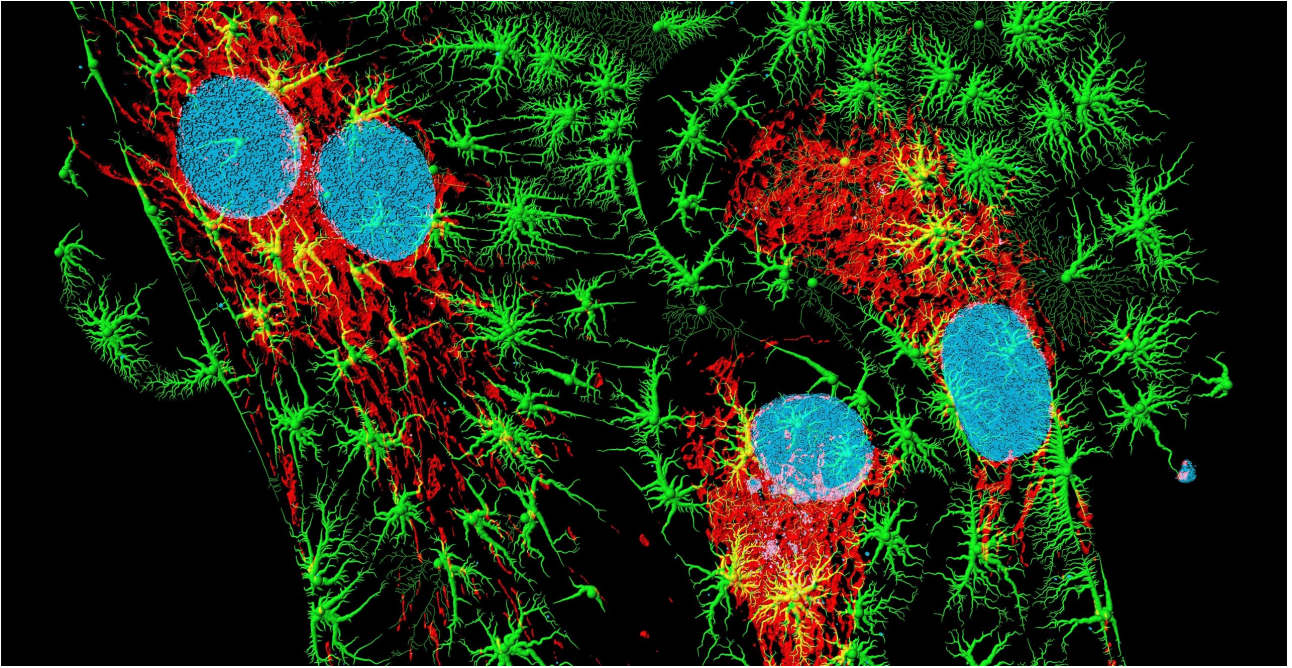
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**Figure 3:** Bovine pulmonary artery endothelial cells in culture. Blue: nuclei; red: mitochondria; green: microfilaments. Computer generated image from a 3D model based on a confocal laser scanning microscopy using fluorescent marker dyes. Source: Heiti Paves, <https://commons.wikimedia.org/wiki/File:Fibroblastid.jpg>.

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## References

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