Secure Resource Sharing for Embedded Protected Module Architectures

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DISTRINET RESEARCH GROUP

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1. Embedded Problem Domain
2. Protected Module Architectures
3. Motivation
4. Logical File Access Control
5. Conclusion

> *“Embedded-systems security is, for lack of a better word, a mess.”*
>
> – John Viega & Hugh Thompson

VIEGA John, THOMPSON Hugh, *The state of embedded-device security (spoiler alert: It's bad)*, IEEE Security & Privacy (10.5), September 2012, pp. 68-70.

Software Isolation

Conventional

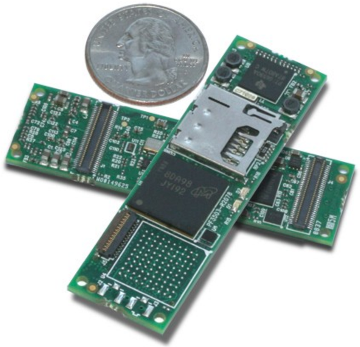
- Relatively expensive
- Power-consuming

=> Virtual memory & kernel mode

Embedded

- Cheap
- Low power

=> *Single-address-space*



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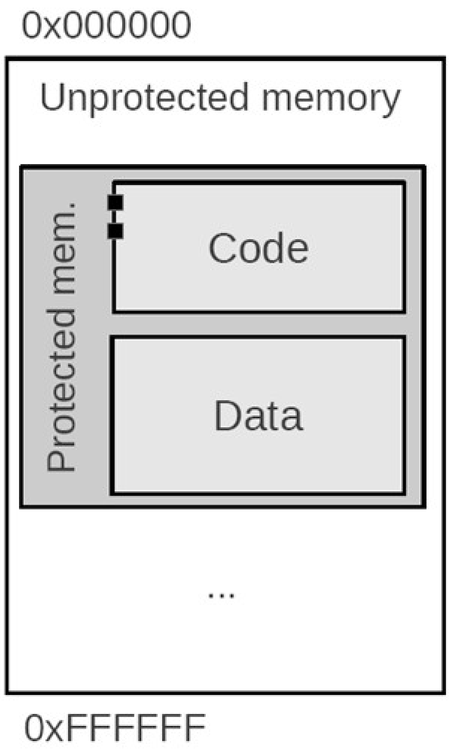
Protected Module Architectures

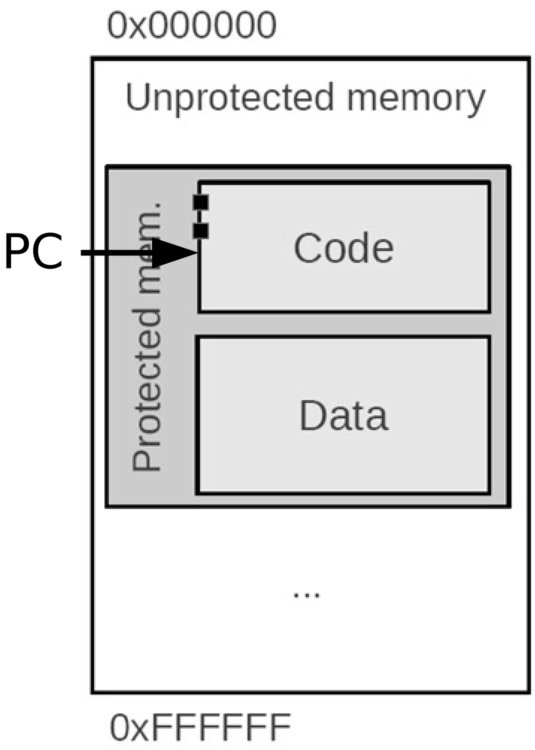


- **Isolated execution** areas in a single-address-space
- **Program counter** based access control mechanism

From \ to	Protected			Unprotected
	Entry	Code	Data	
Protected	r-x	r-x	rw-	rwx
Unprotected / other SPM	r-x	r--	---	rwx

STRACKX Raoul et al., *Protected Software Module Architectures*, ISSE 2013 Securing Electronic Business Processes, Springer Fachmedien Wiesbaden, 2013, pp. 241-251.

Protected Module Architectures



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Sancus

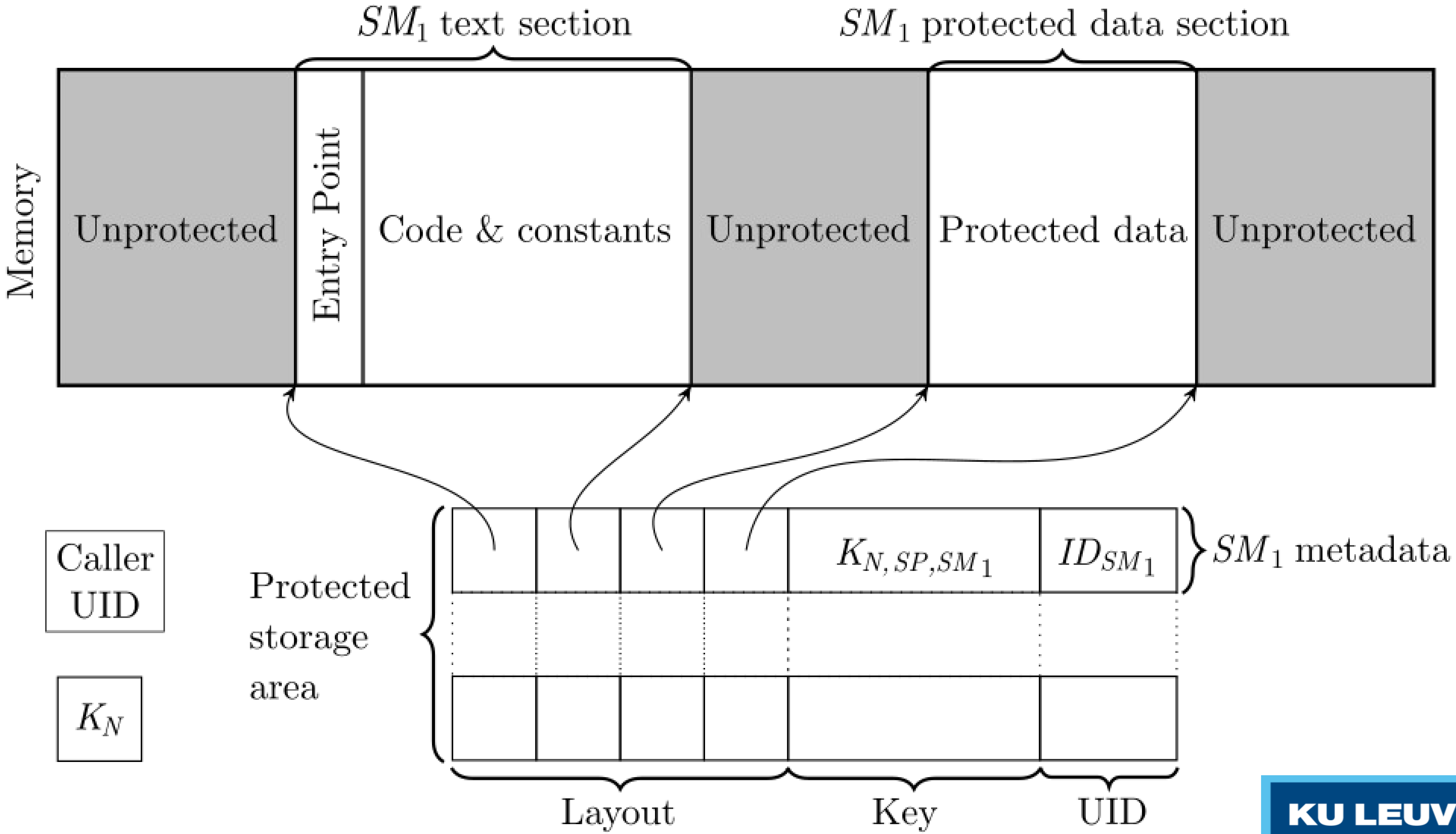
- **Hardware**-level PMA
- **Zero-software TCB**

  → strong attacker model
- SM == unit of **protection** / **authentication**

  → hardware UID and cryptographic key per SM

  → `sancus_verify_address & sancus_get_caller_id`

NOORMAN Job et al., *Sancus: Low-cost Trustworthy Extensible Networked Devices with a Zero-software Trusted Computing Base,* Proceedings of the 22nd USENIX conference on Security symposium, 2013, pp. 479-494.



SM_1 text section

SM_1 protected data section

Memory

Unprotected

Entry Point

Code & constants

Unprotected

Protected data

Unprotected

Caller UID

K_N

Protected storage area

K_{N,SP,SM_1}

ID_{SM_1}

SM_1 metadata

Layout

Key

UID

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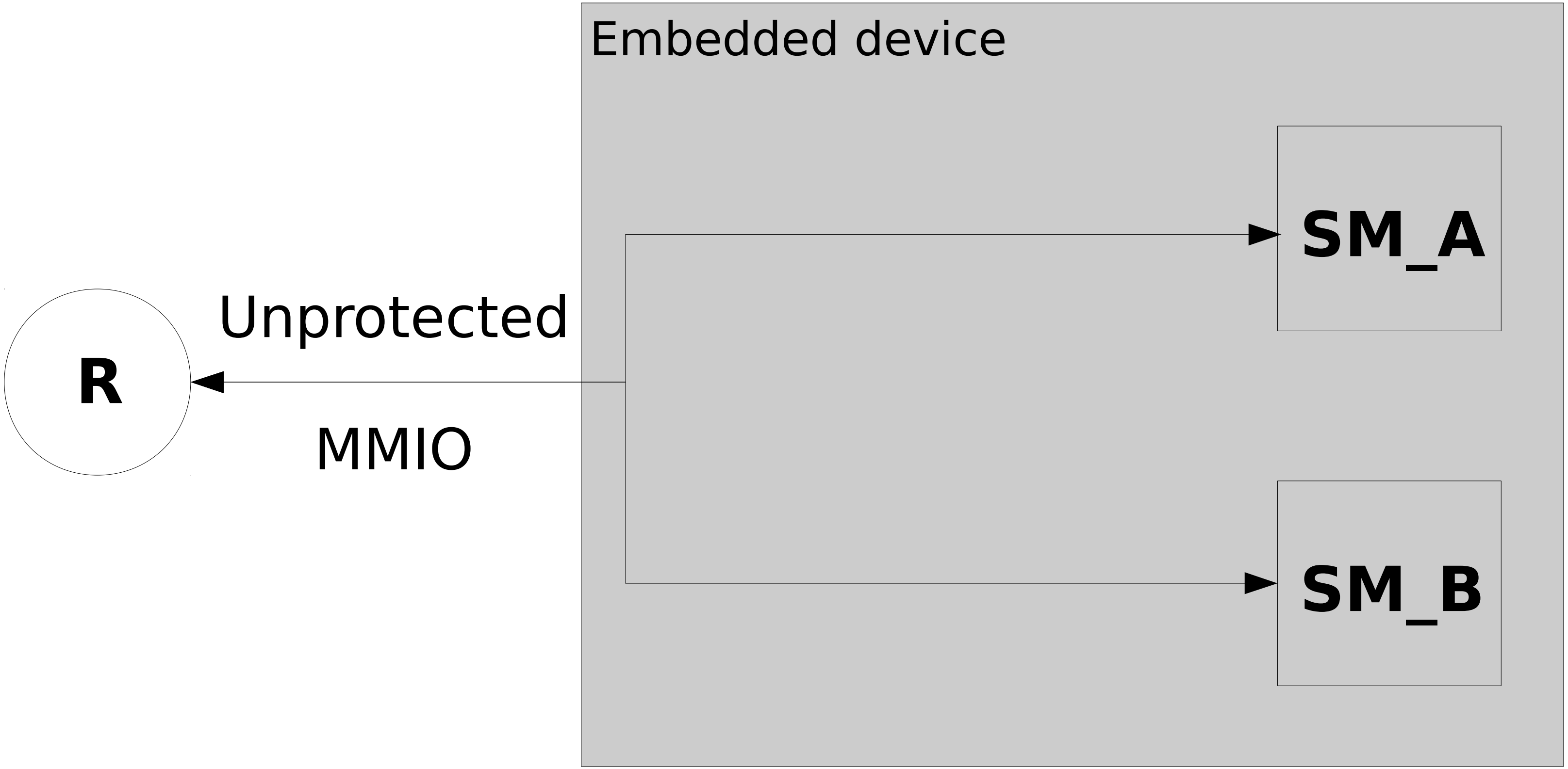
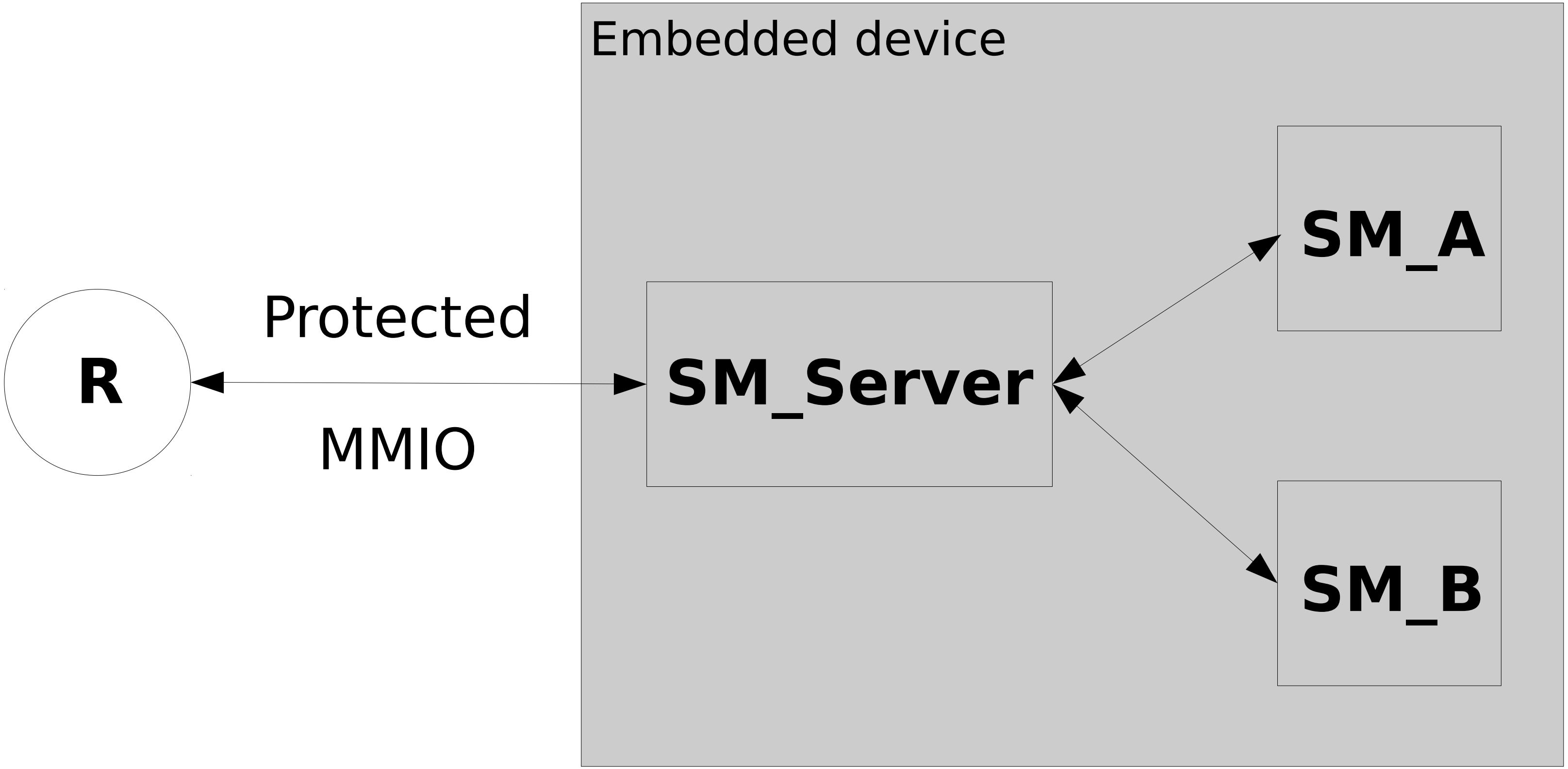
Resource Sharing Approach



Resource Sharing Approach



Secure Resource Sharing

Sancus secludes SMs in protection domains:

☺ hardware-enforced **security guarantees**
☹ no **secure sharing** of platform resources

=> *protected "OS" modules* to supplement hw

<> monolithic privileged kernel
~ extreme microkernel idea

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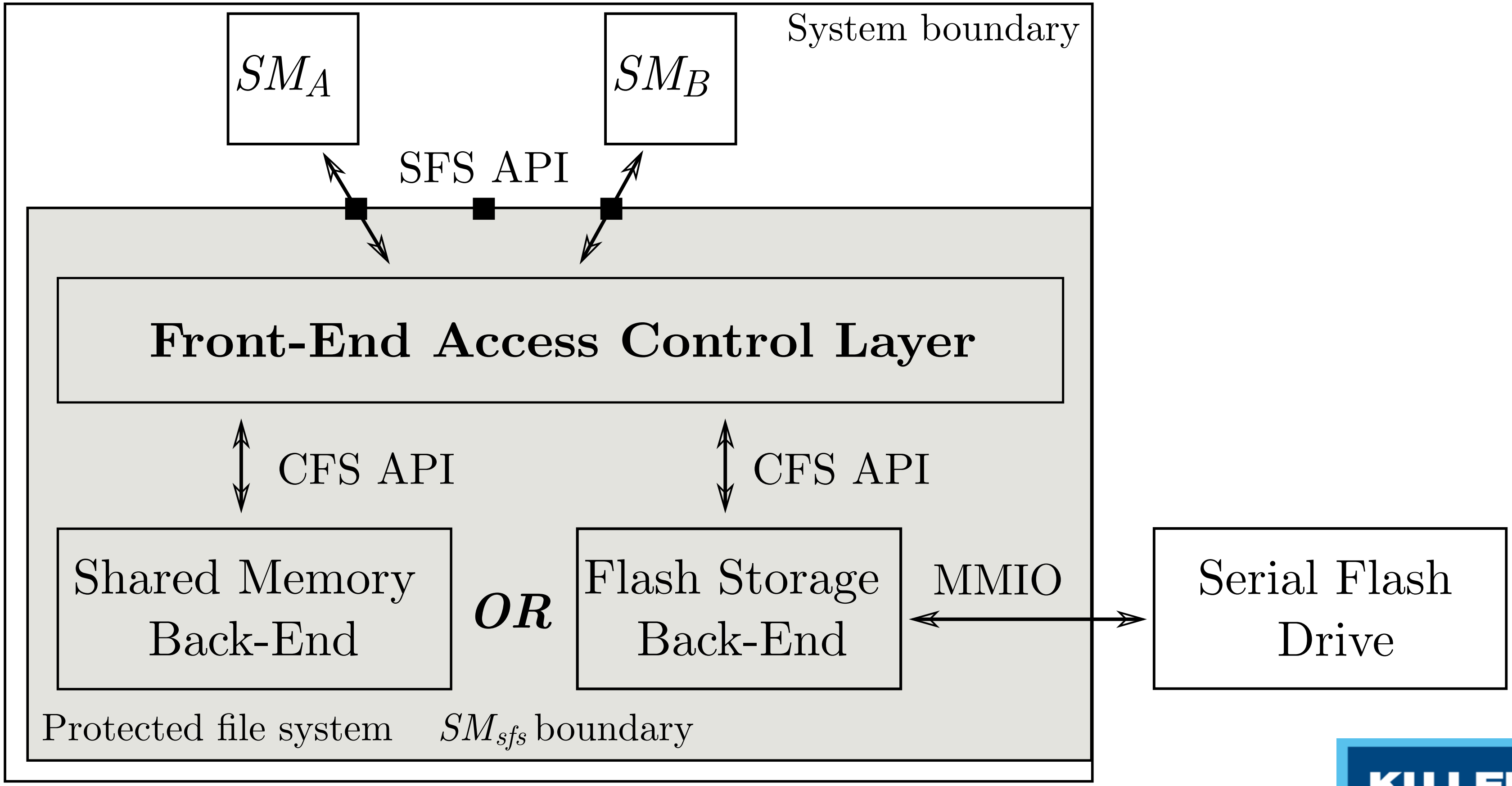
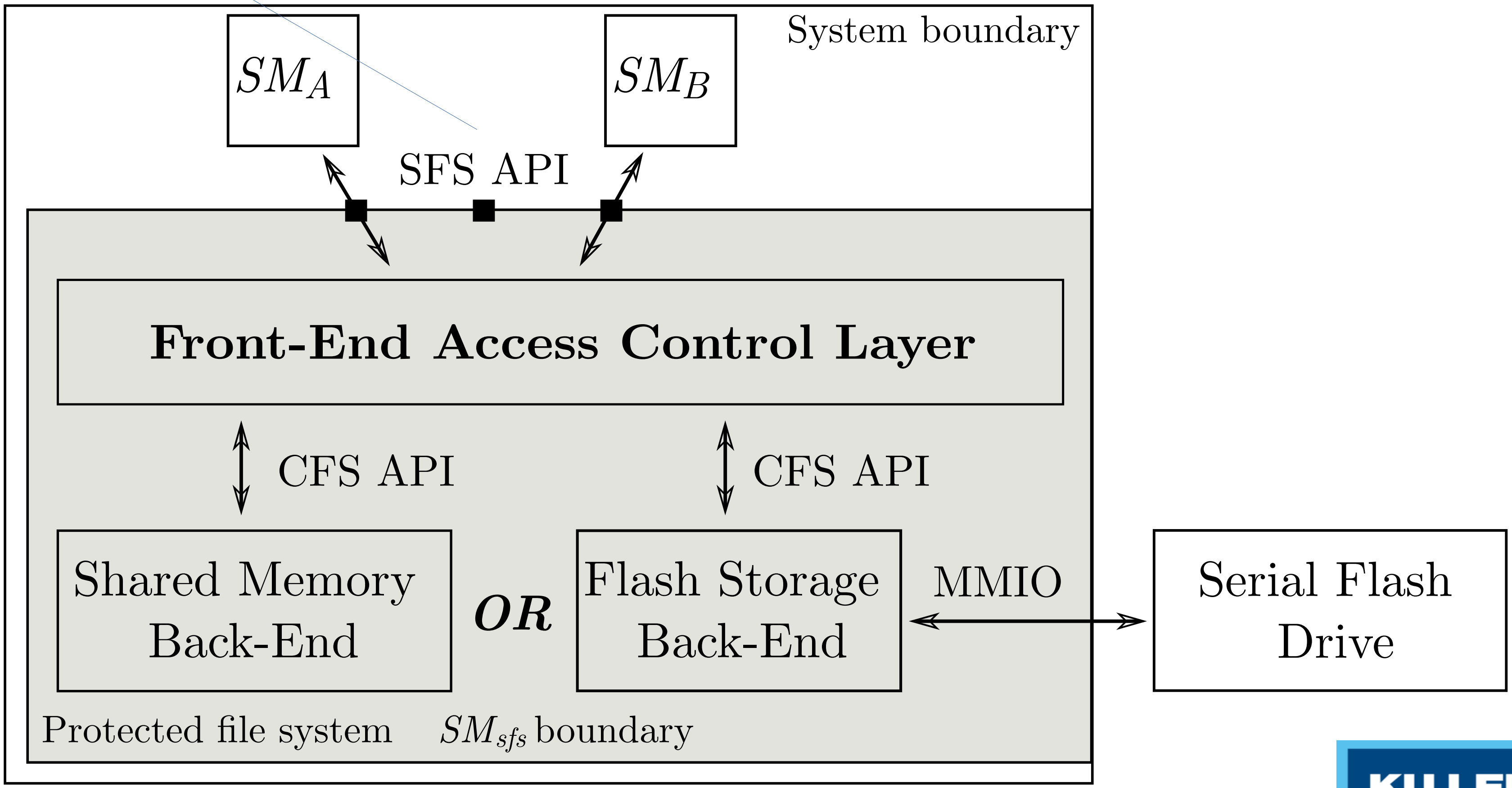
Sancus File System (SFS)



Sancus File System (SFS)

UNIX like file system API (incl. chmod)



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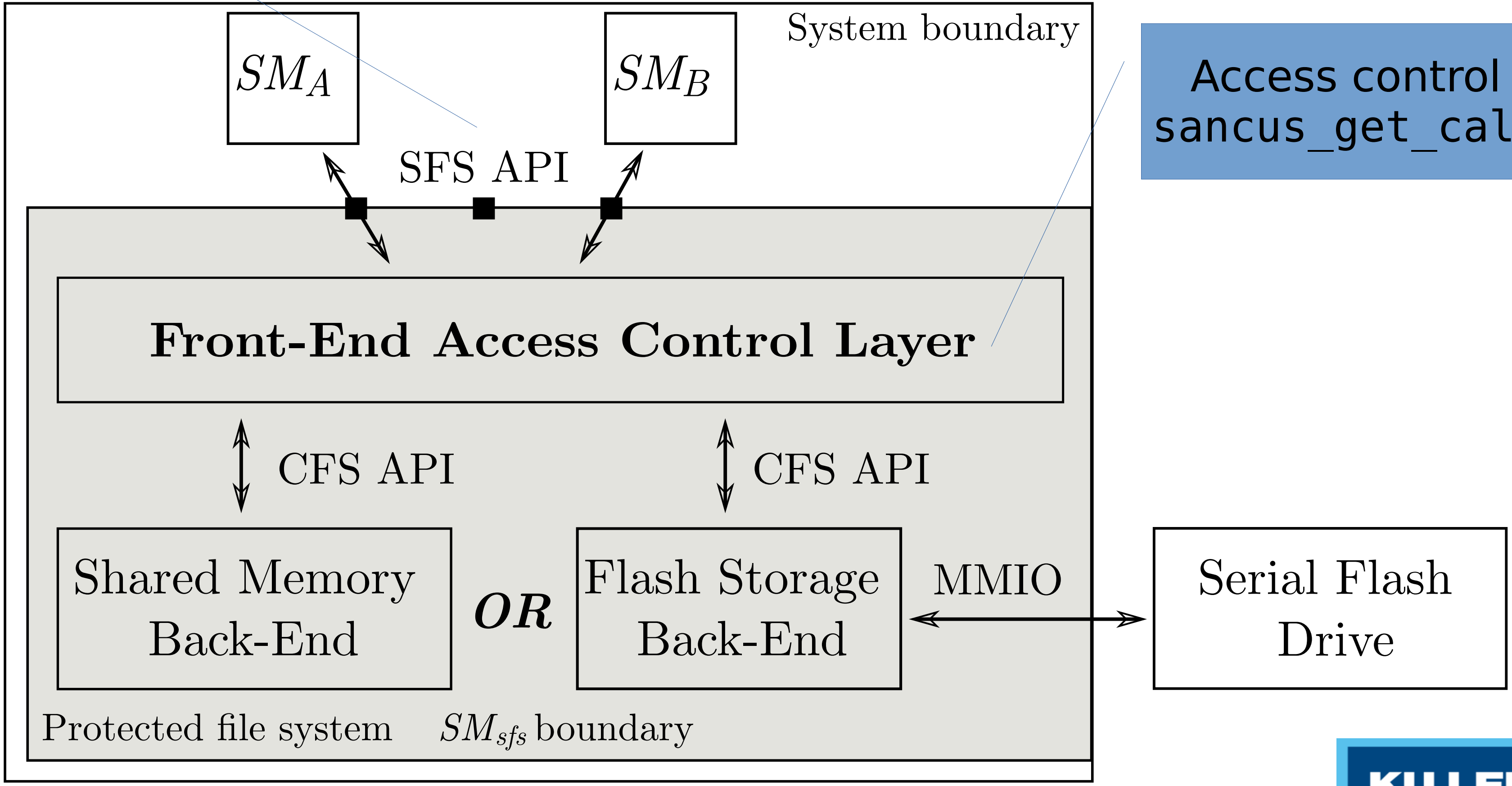
Access control using `sancus_get_caller_id`



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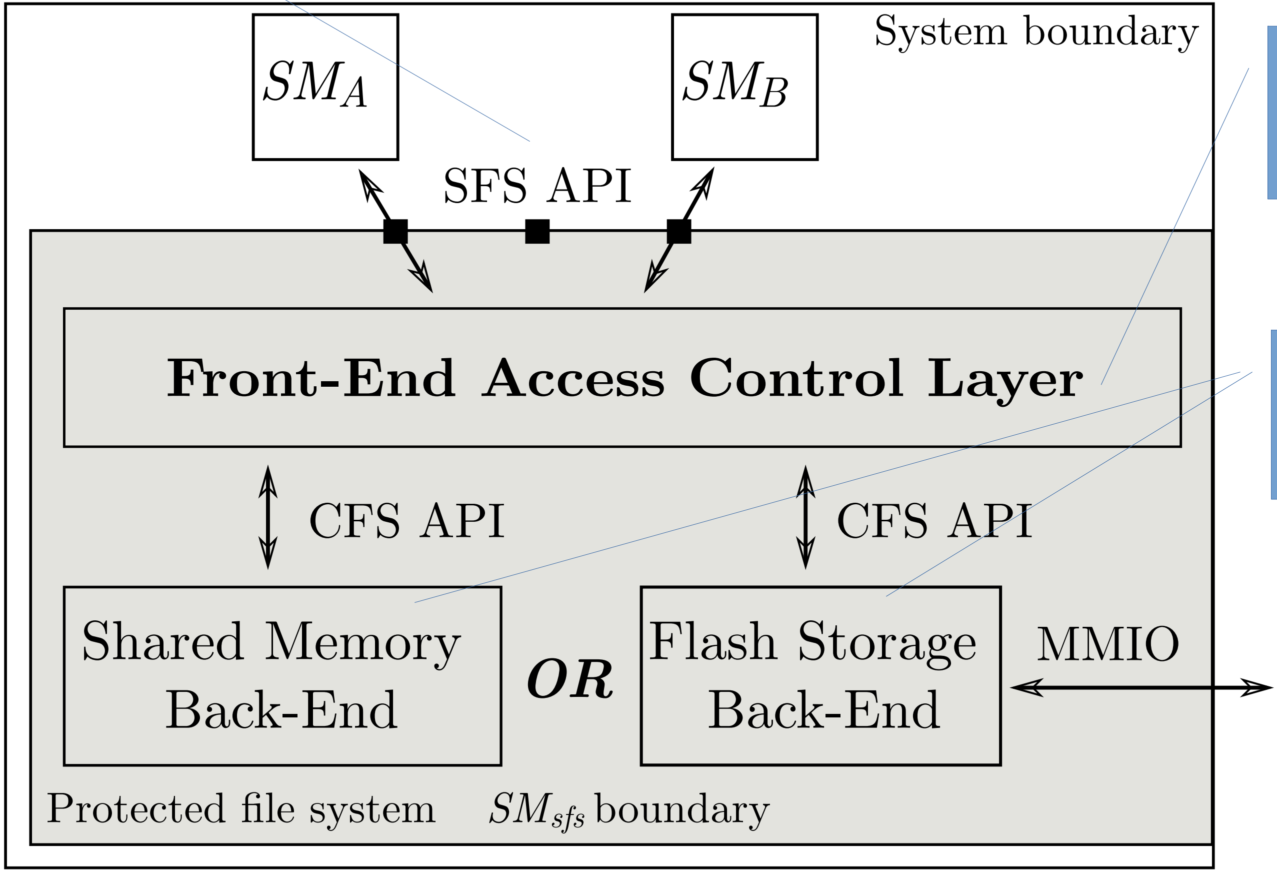

Access control using `sancus_get_caller_id`

Pluggable private back-end encapsulating resource

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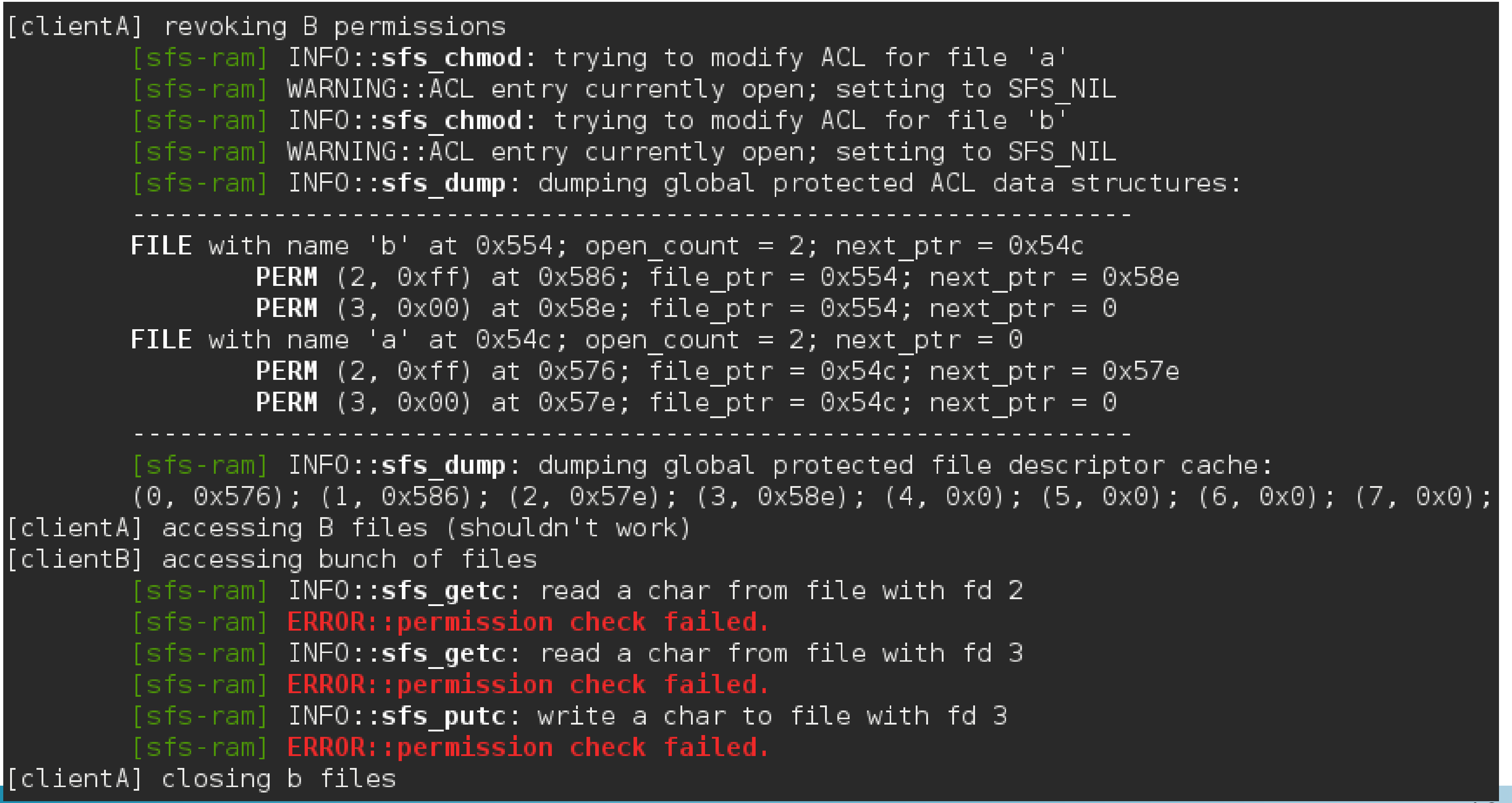

```
[clientA] revoking B permissions
        [sfs-ram] INFO::sfs_chmod: trying to modify ACL for file 'a'
        [sfs-ram] WARNING::ACL entry currently open; setting to SFS_NIL
        [sfs-ram] INFO::sfs_chmod: trying to modify ACL for file 'b'
        [sfs-ram] WARNING::ACL entry currently open; setting to SFS_NIL
        [sfs-ram] INFO::sfs_dump: dumping global protected ACL data structures:
        ----------------------------------------------------------------
        FILE with name 'b' at 0x554; open_count = 2; next_ptr = 0x54c
                PERM (2, 0xff) at 0x586; file_ptr = 0x554; next_ptr = 0x58e
                PERM (3, 0x00) at 0x58e; file_ptr = 0x554; next_ptr = 0
        FILE with name 'a' at 0x54c; open_count = 2; next_ptr = 0
                PERM (2, 0xff) at 0x576; file_ptr = 0x54c; next_ptr = 0x57e
                PERM (3, 0x00) at 0x57e; file_ptr = 0x54c; next_ptr = 0
        ----------------------------------------------------------------
        [sfs-ram] INFO::sfs_dump: dumping global protected file descriptor cache:
        (0, 0x576); (1, 0x586); (2, 0x57e); (3, 0x58e); (4, 0x0); (5, 0x0); (6, 0x0); (7, 0x0);
[clientA] accessing B files (shouldn't work)
[clientB] accessing bunch of files
        [sfs-ram] INFO::sfs_getc: read a char from file with fd 2
        [sfs-ram] ERROR::permission check failed.
        [sfs-ram] INFO::sfs_getc: read a char from file with fd 3
        [sfs-ram] ERROR::permission check failed.
        [sfs-ram] INFO::sfs_putc: write a char to file with fd 3
        [sfs-ram] ERROR::permission check failed.
[clientA] closing b files
```

Access Control Overhead

Majority of cycles caused by **SM switching**

Relative access control overhead decreases with the <u>amount of work done in the back-end</u>

☹ Protected shared memory back-end

☺ Flash Coffee FS: 20% for `getc` and 15% for `putc`

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Conclusion

- Generic **resource sharing** mechanism
- Confined and explicit **TCB**:

  → attestable via `sancus_verify`

  → principle of least privilege

- **Supplement** hw-enforced security guarantees

  → build upon hw primitives (isolation + caller auth)

  → sw-based access control guarantees

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https://distrinet.cs.kuleuven.be/software/sancus/wistp2015/

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