The JX Operating System

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A Dancing Bear

This is a "dancing bear" paper -- it's not how well the bear dances, but that it dances at all.
And this bear dances.

Anonymous Reviewer

Outline

- Motivation
- JX Architecture
  - Protection domains
  - Communication mechanism
  - The Microkernel
- System-level programming in Java
- Performance

Why another OS?

Abstraction levels in software engineering

Assembler

↓ portability, productivity, robustness

C

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Smalltalk, Java, C#

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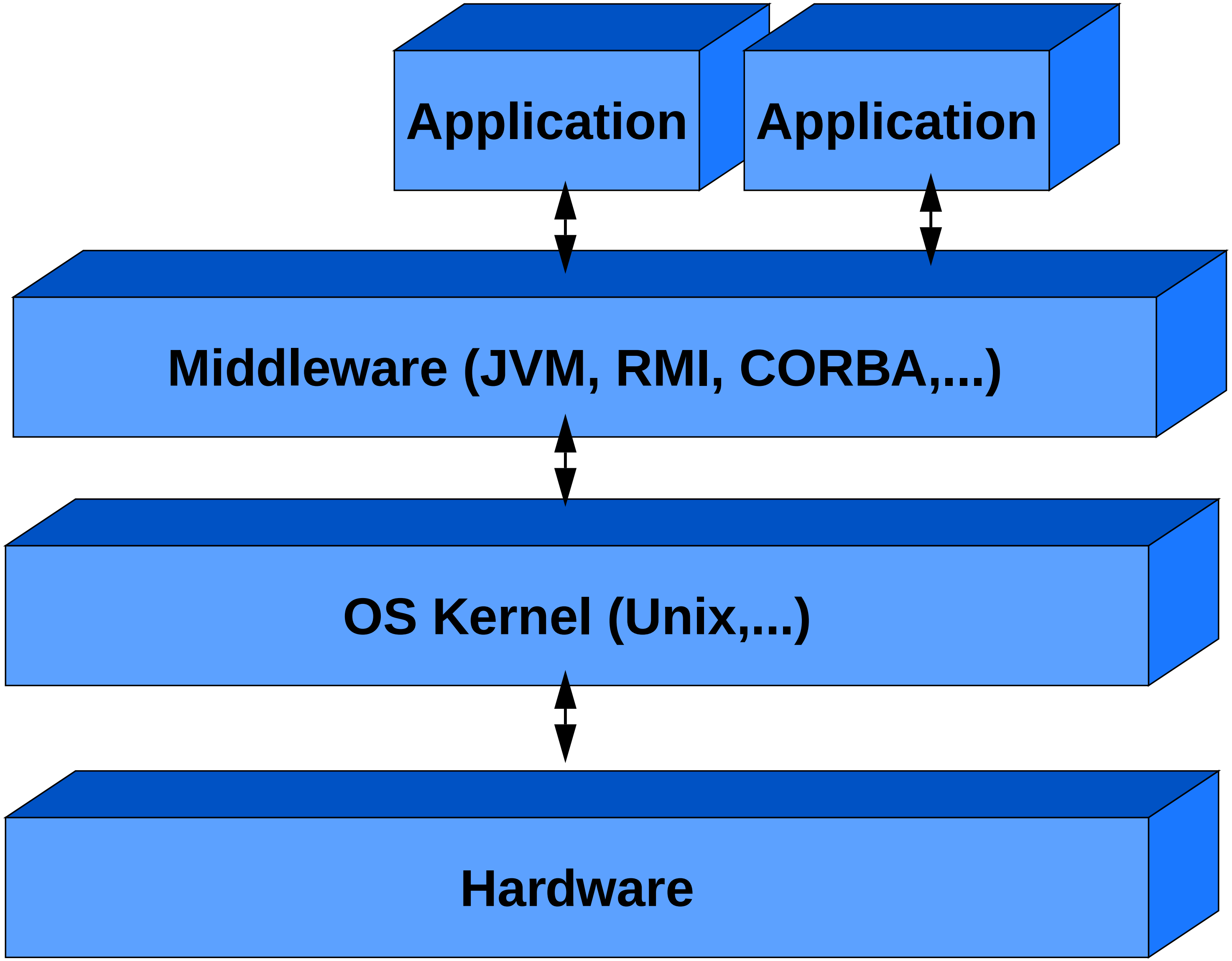
Applications

Operating Systems

Typical System Structure



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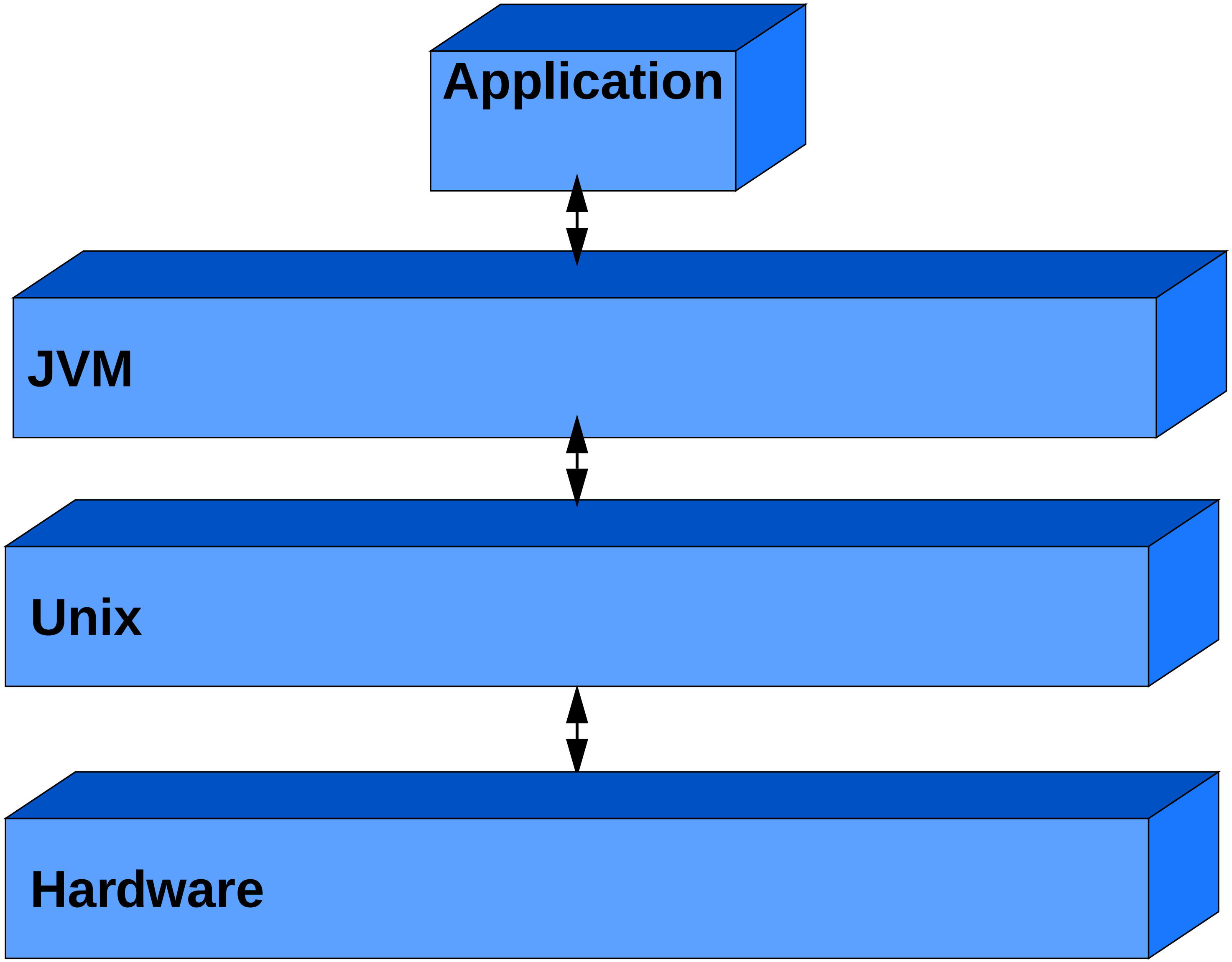

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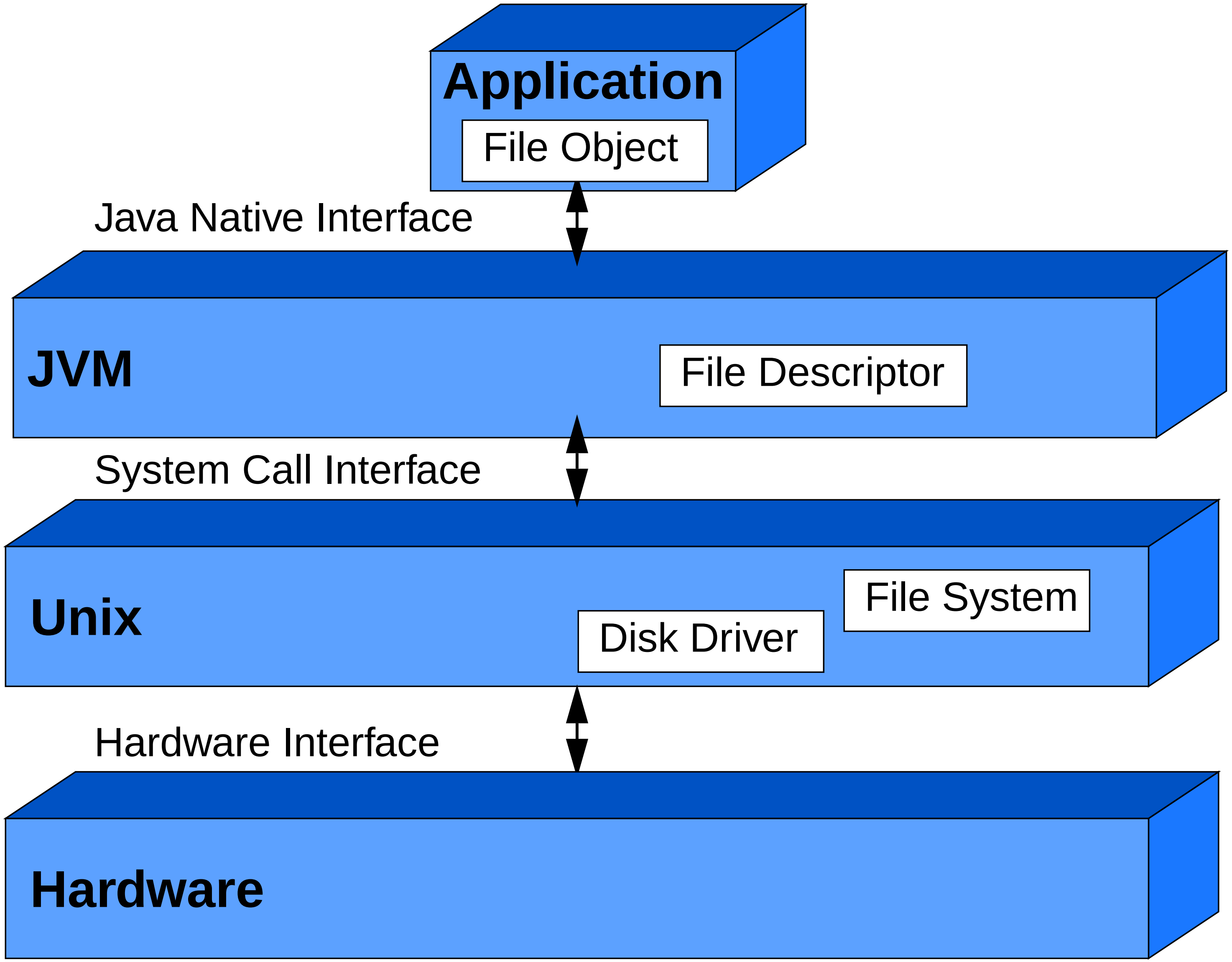

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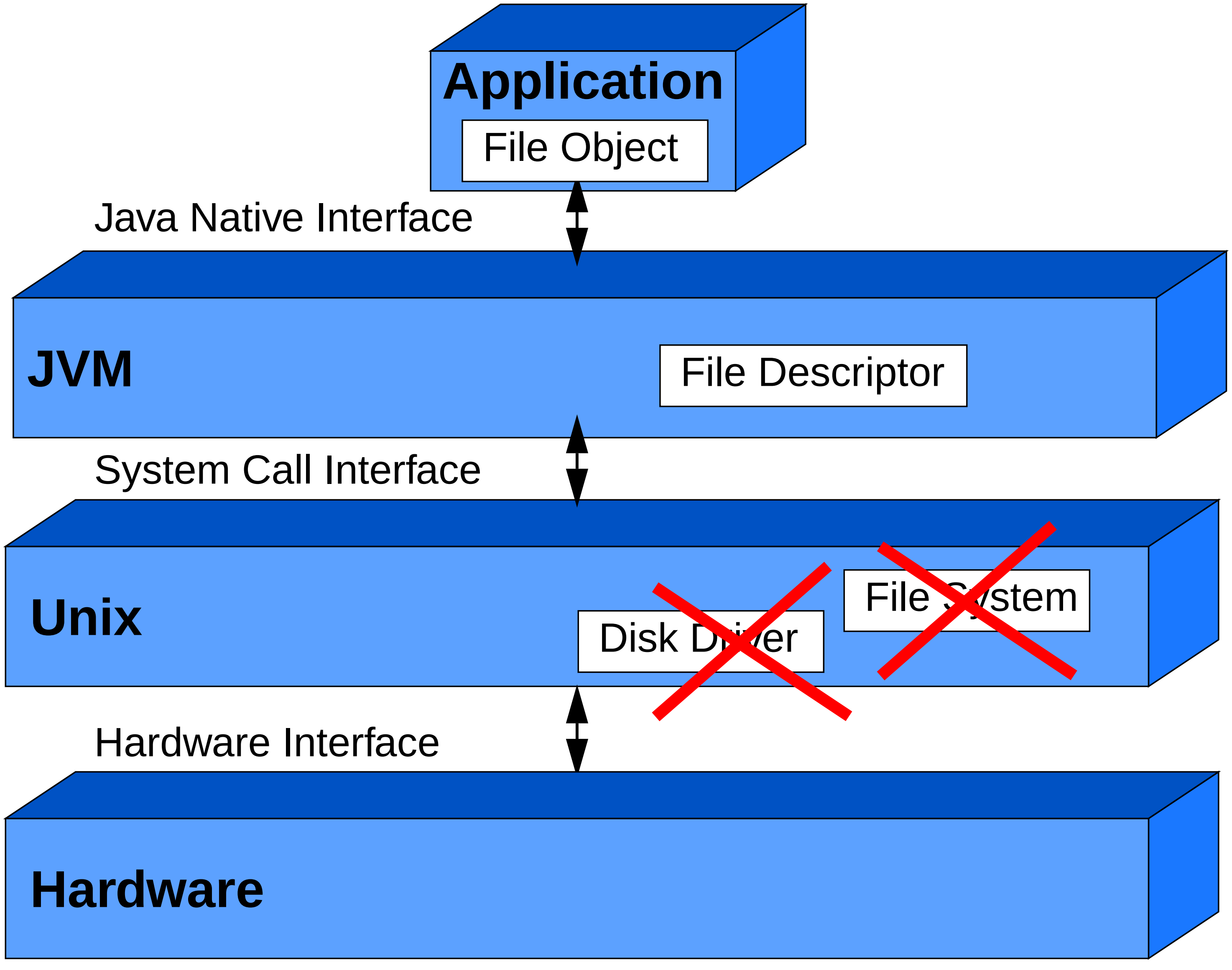

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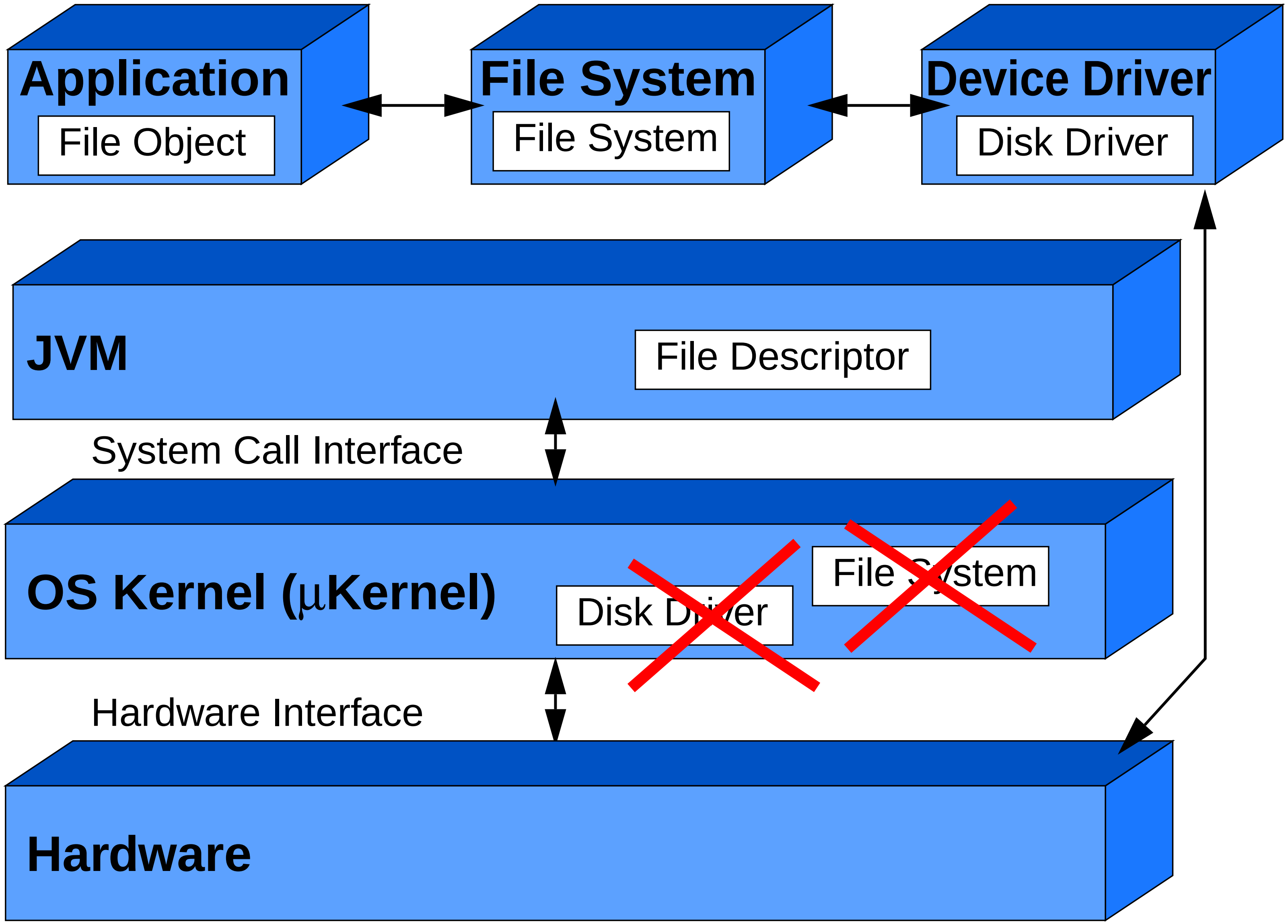

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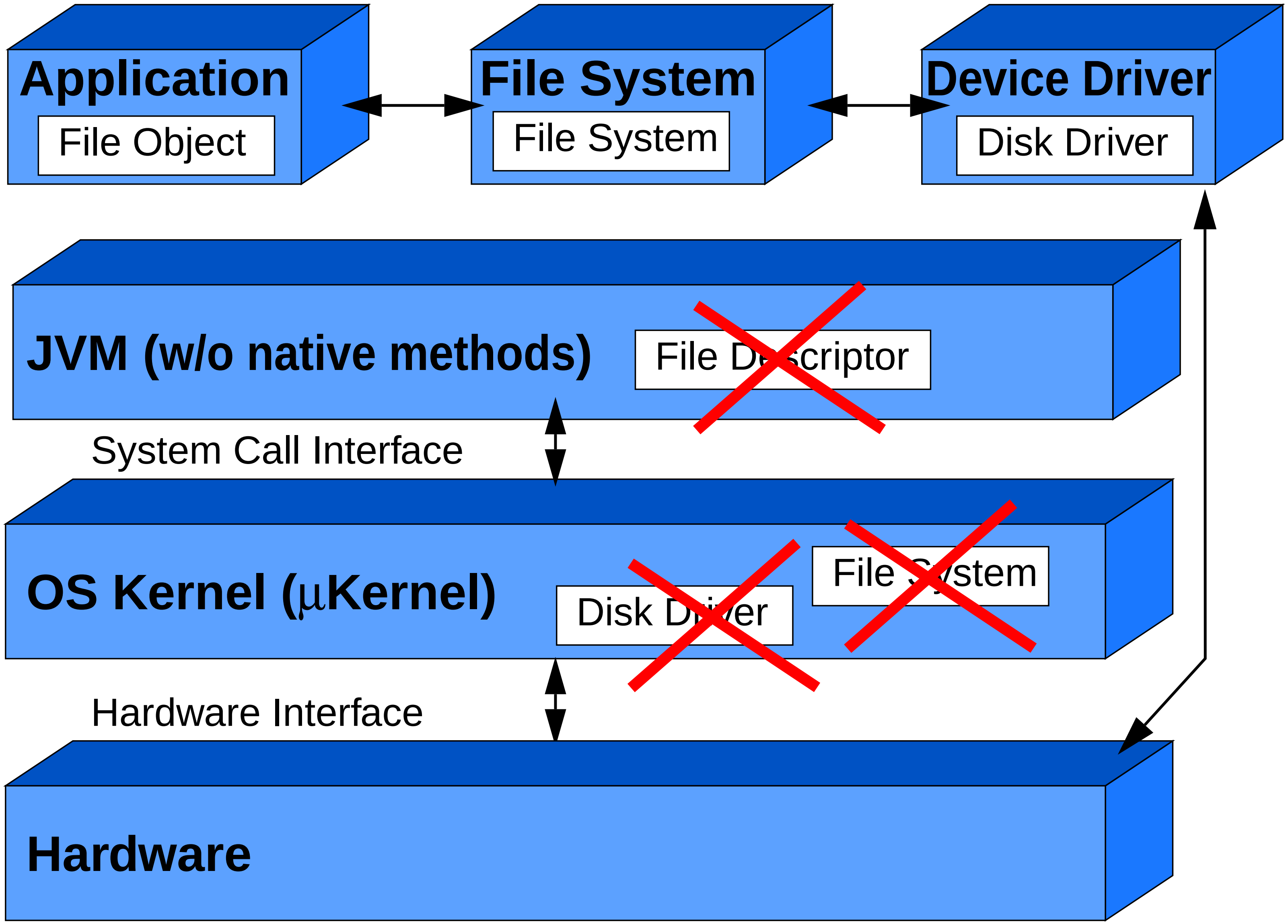

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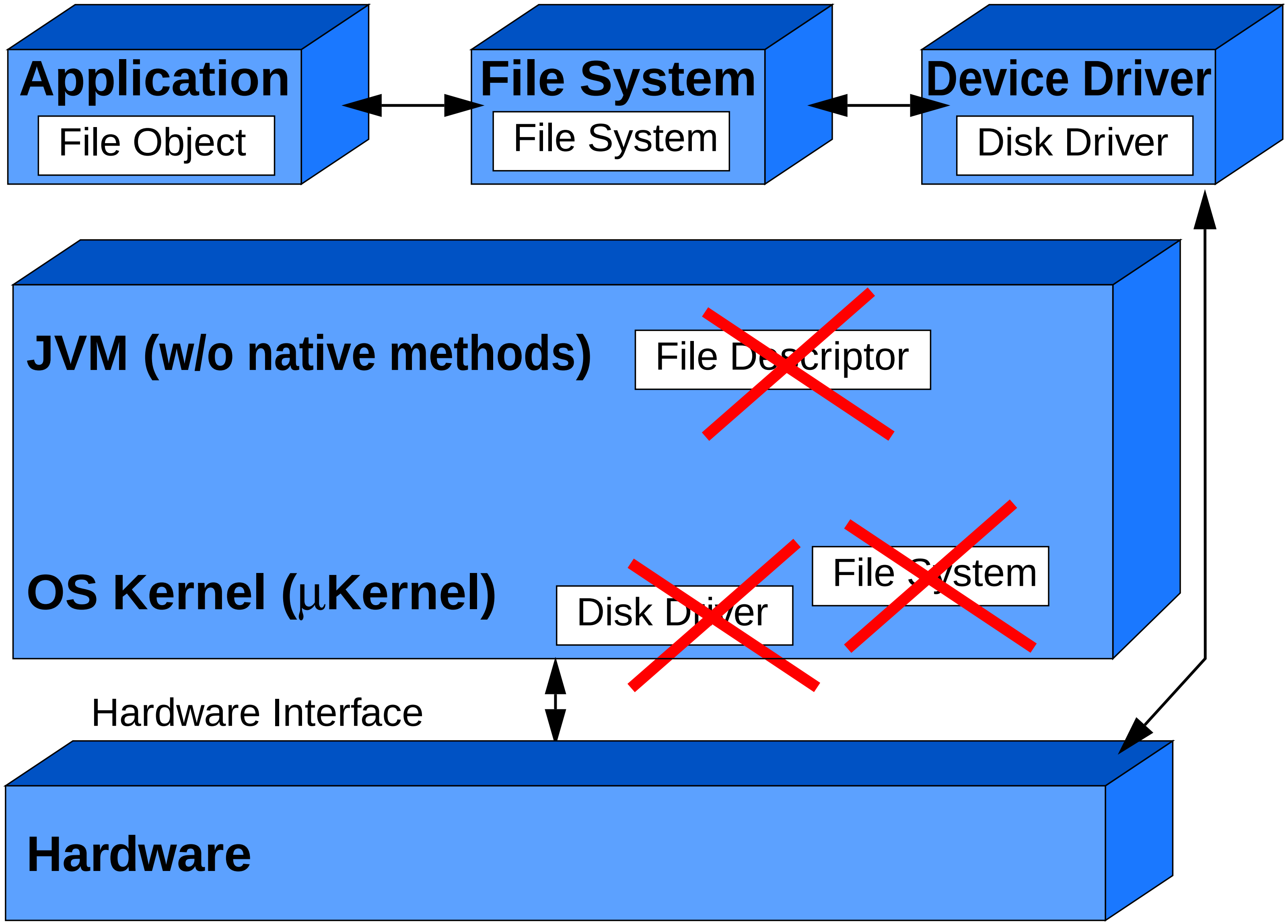

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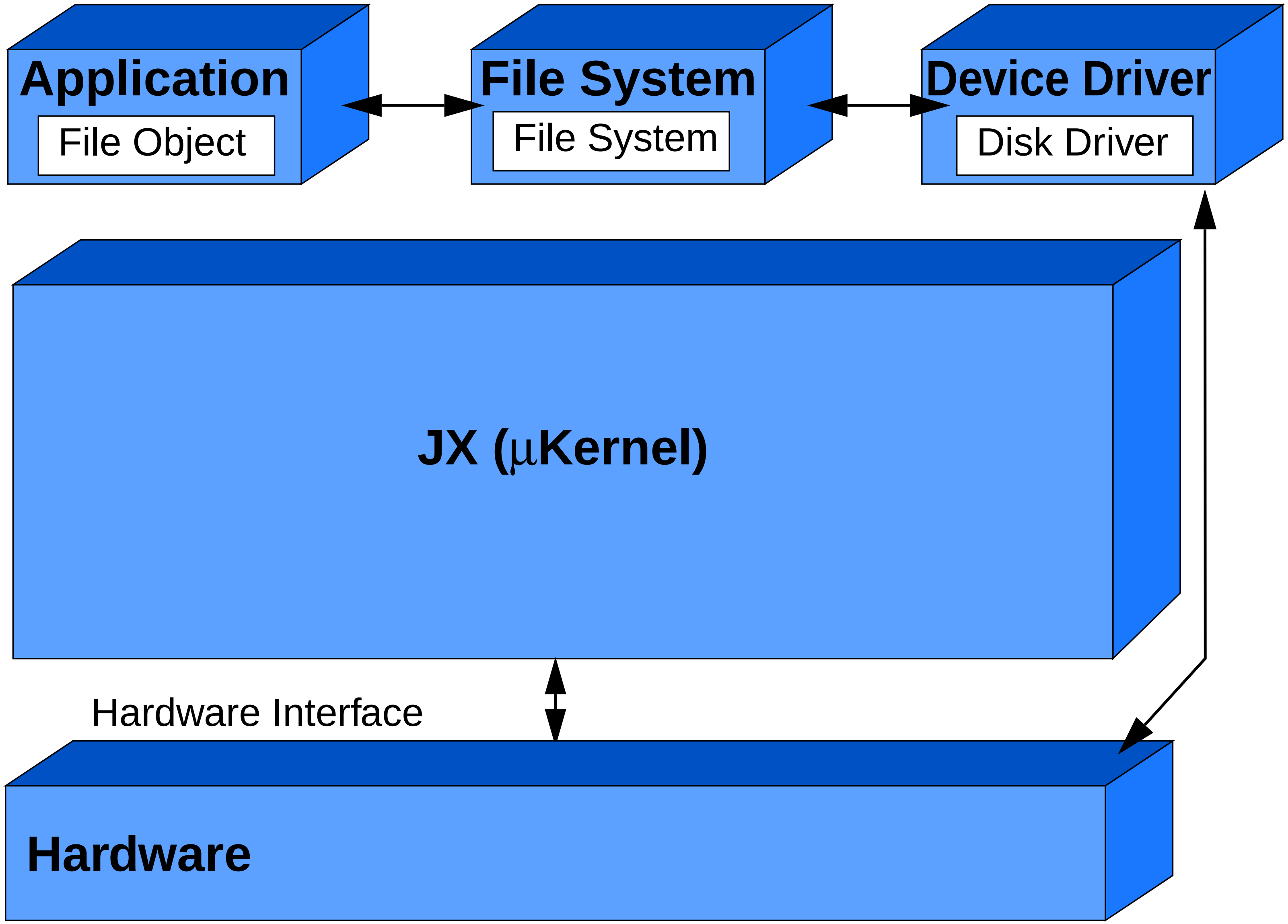

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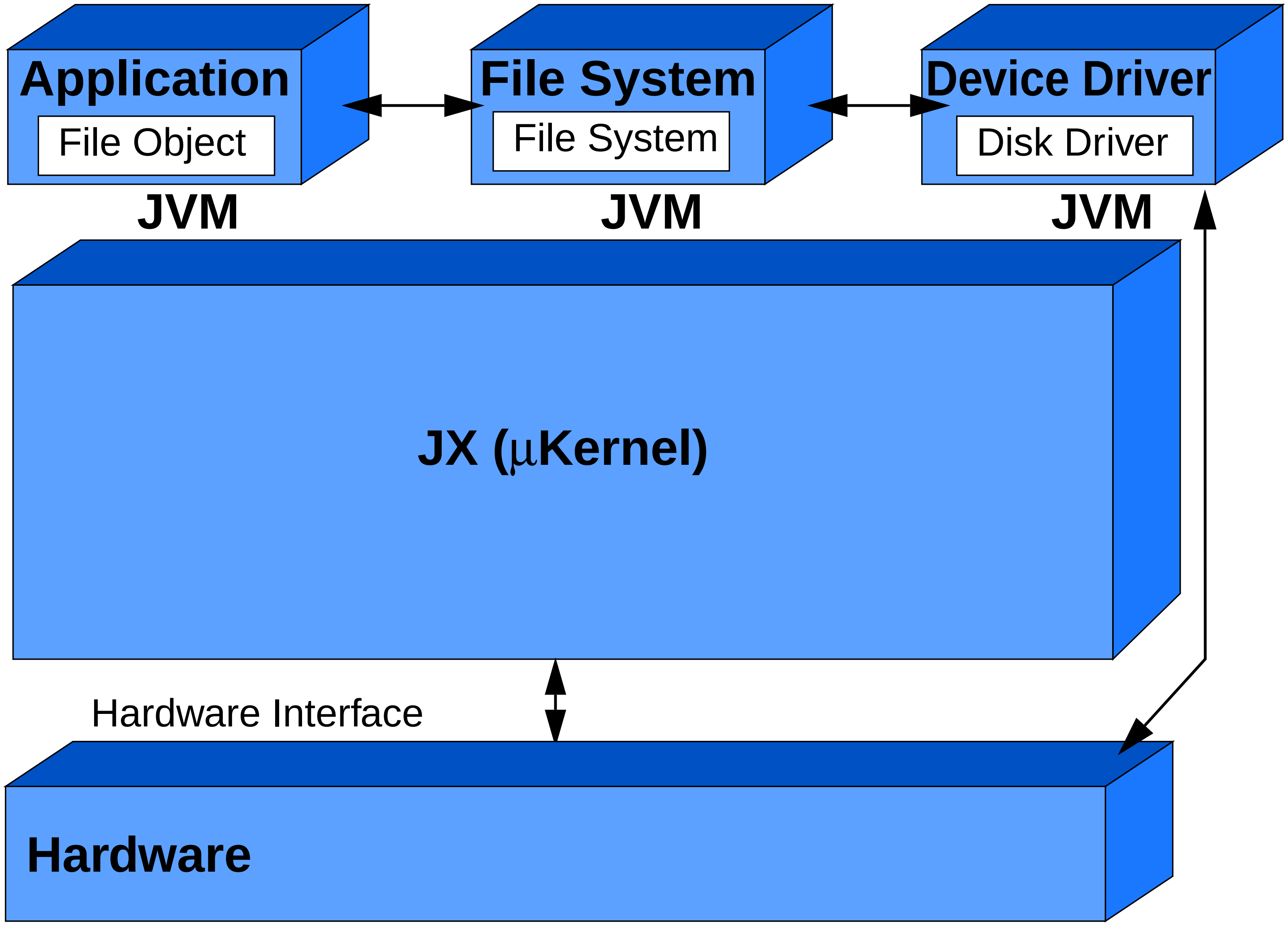

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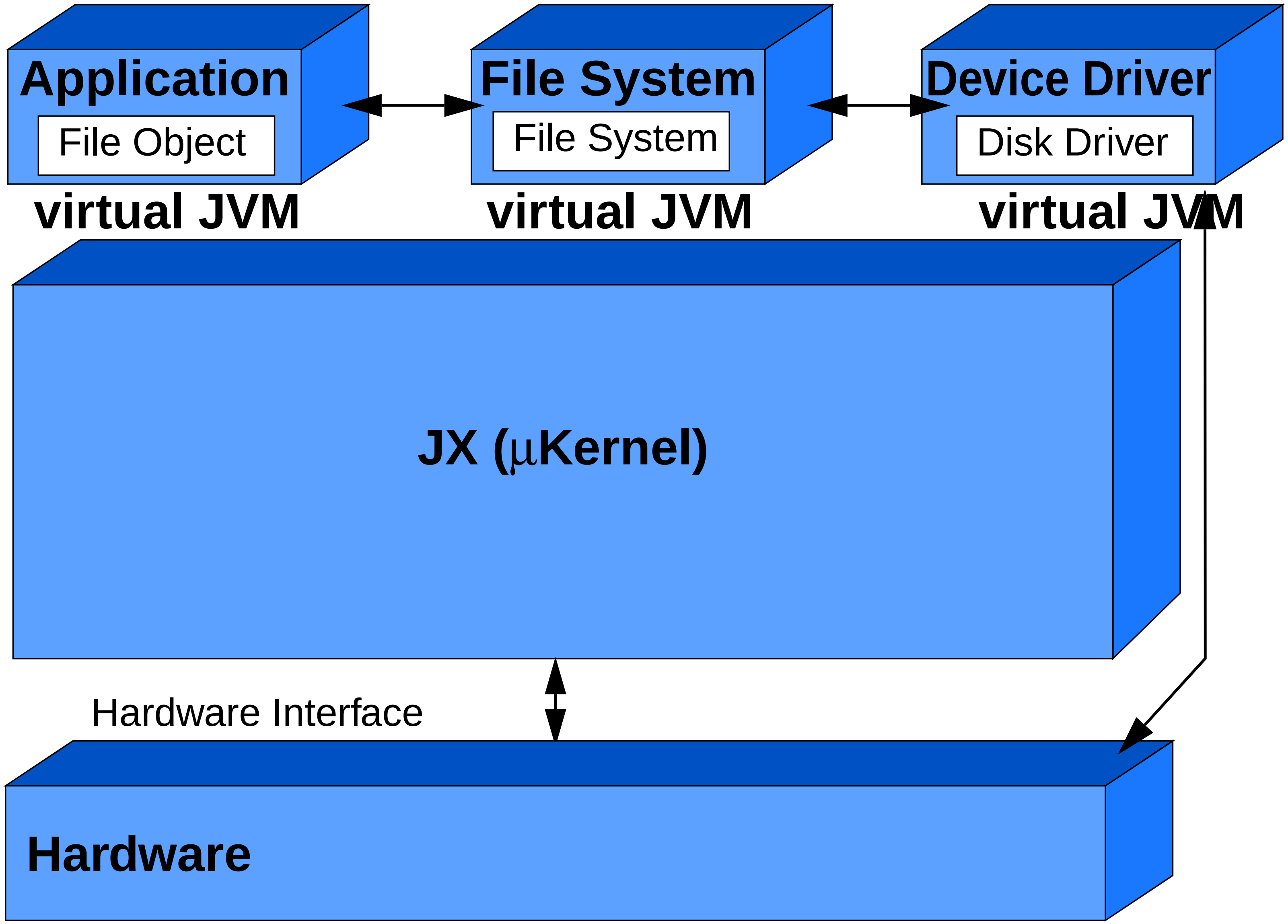
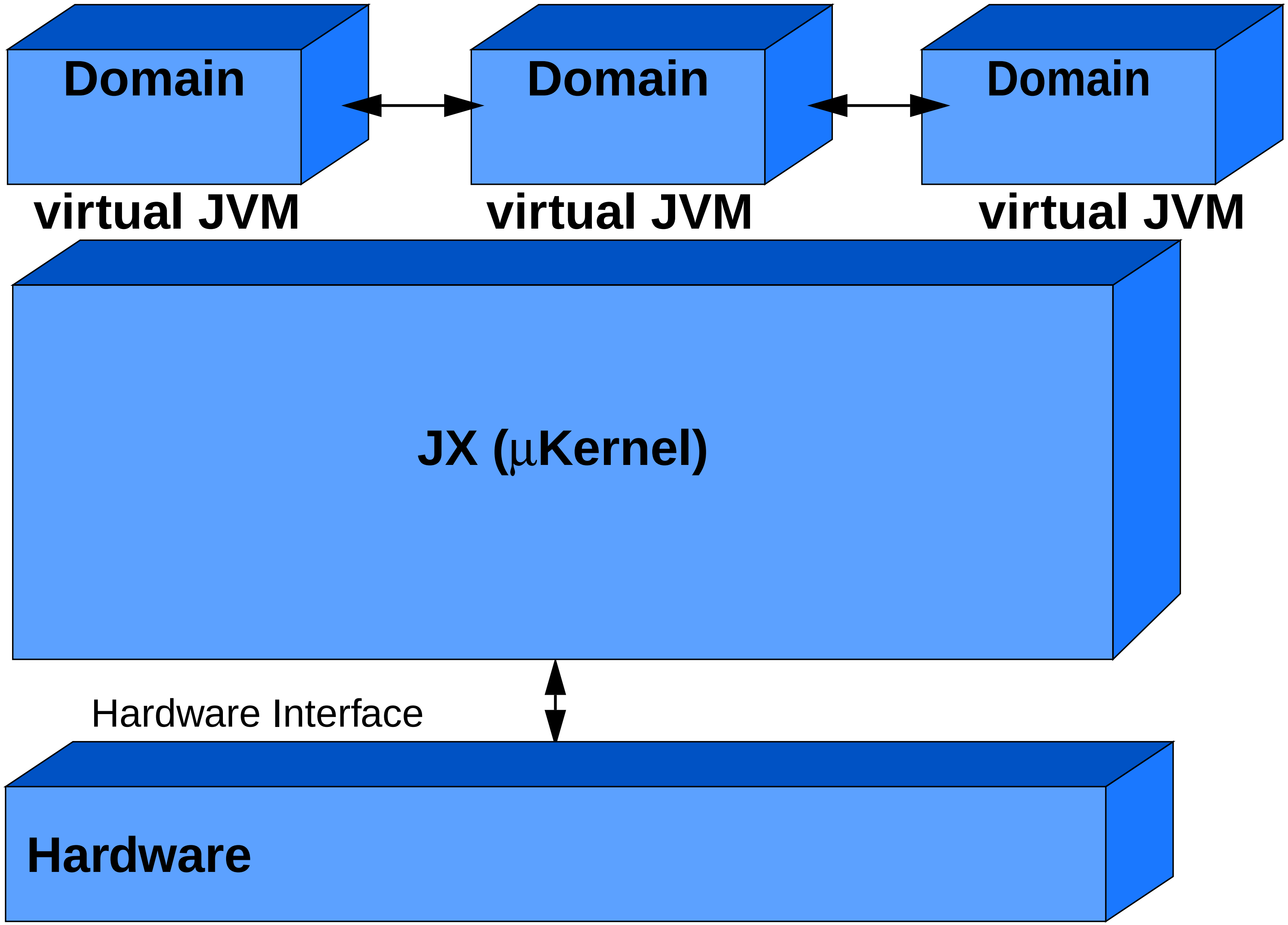


Protection Domains



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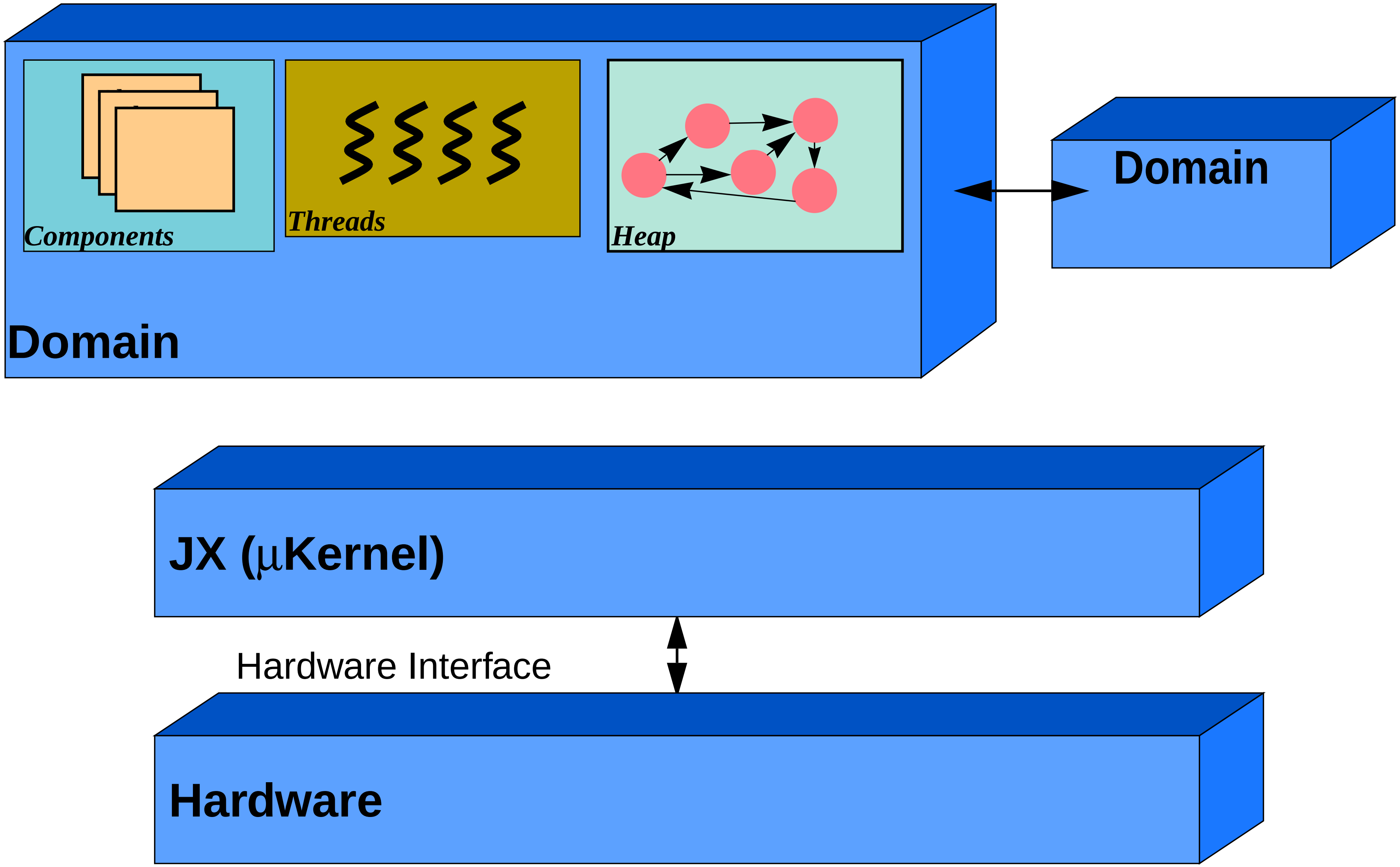
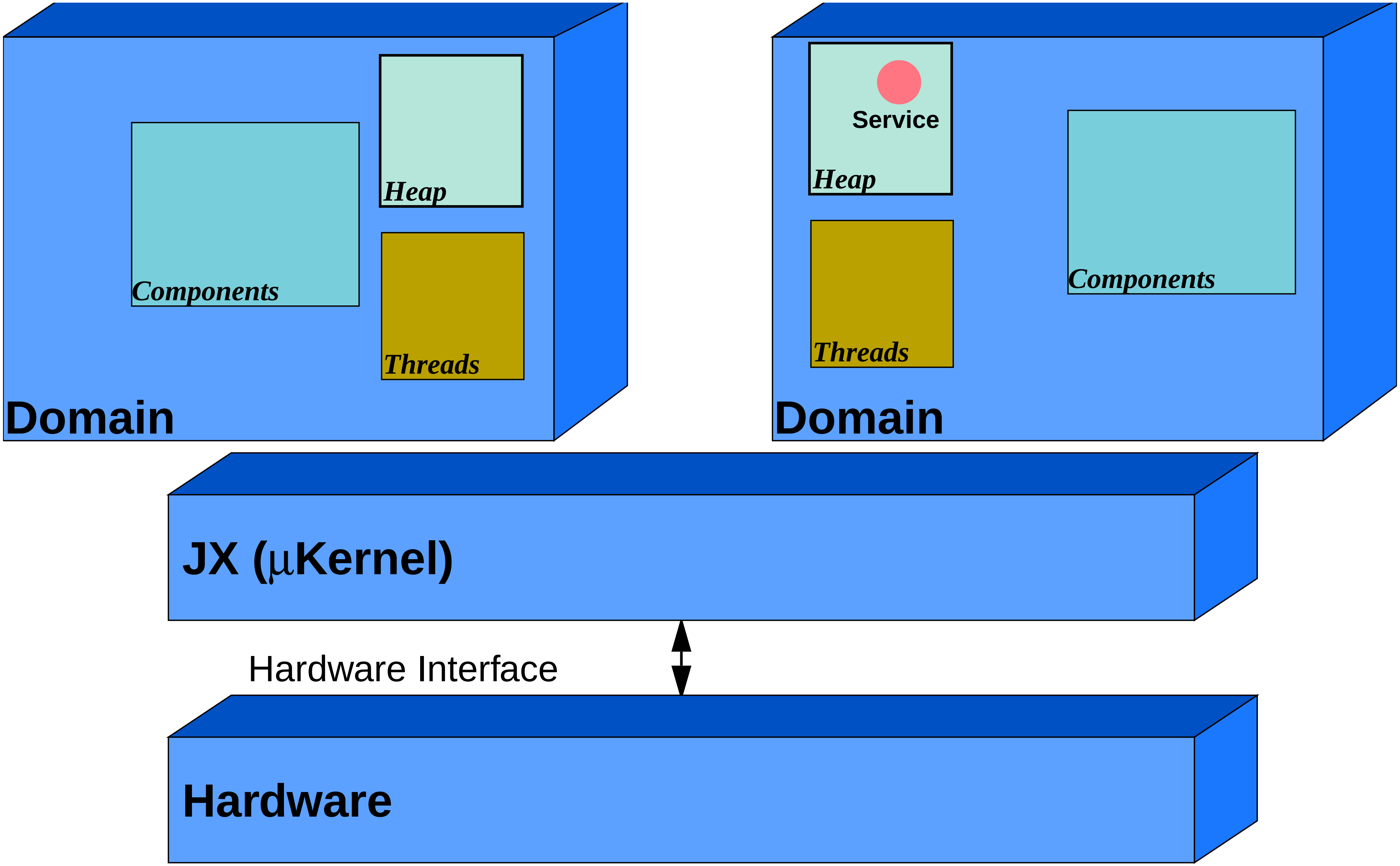


Communication: Portals



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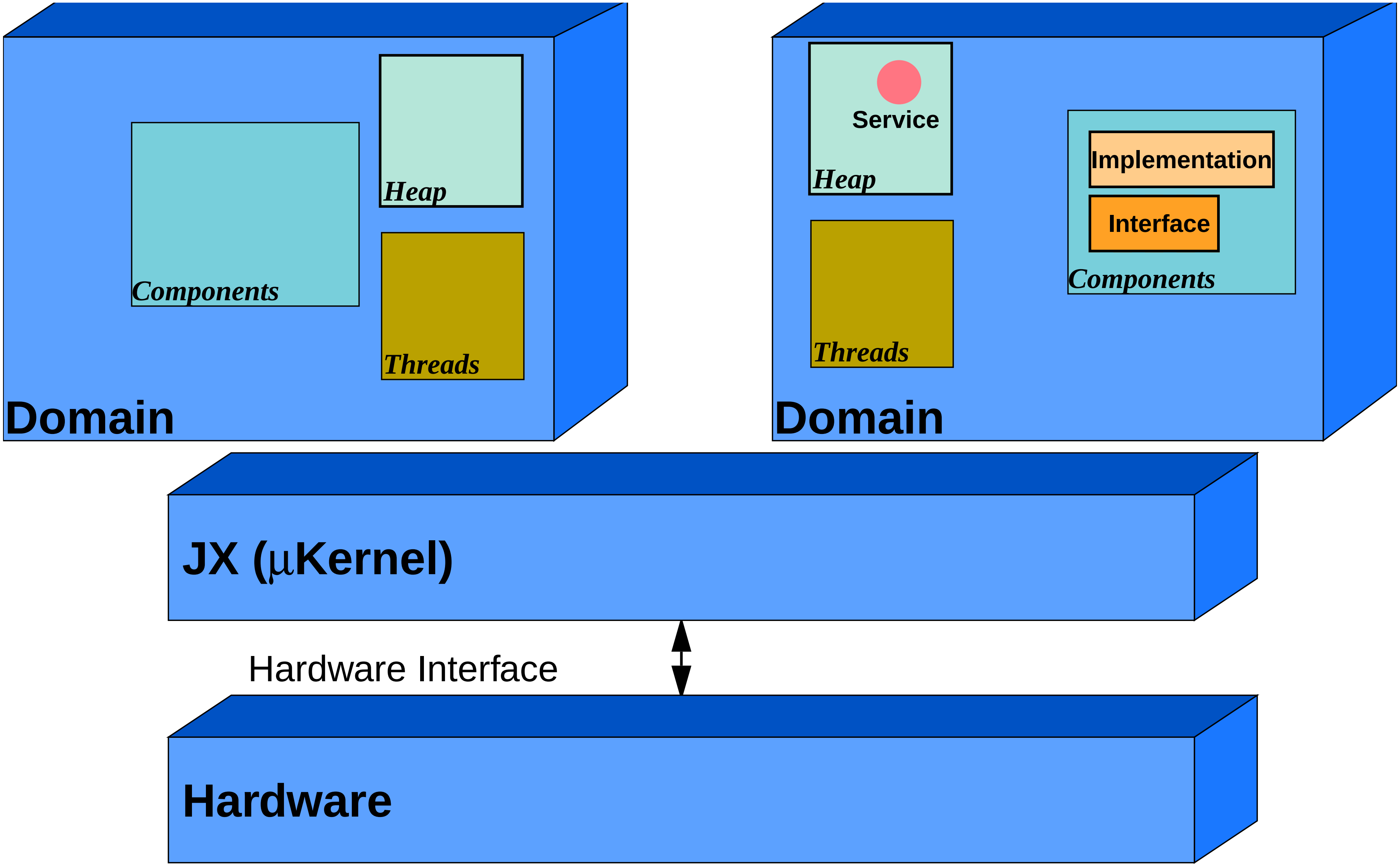

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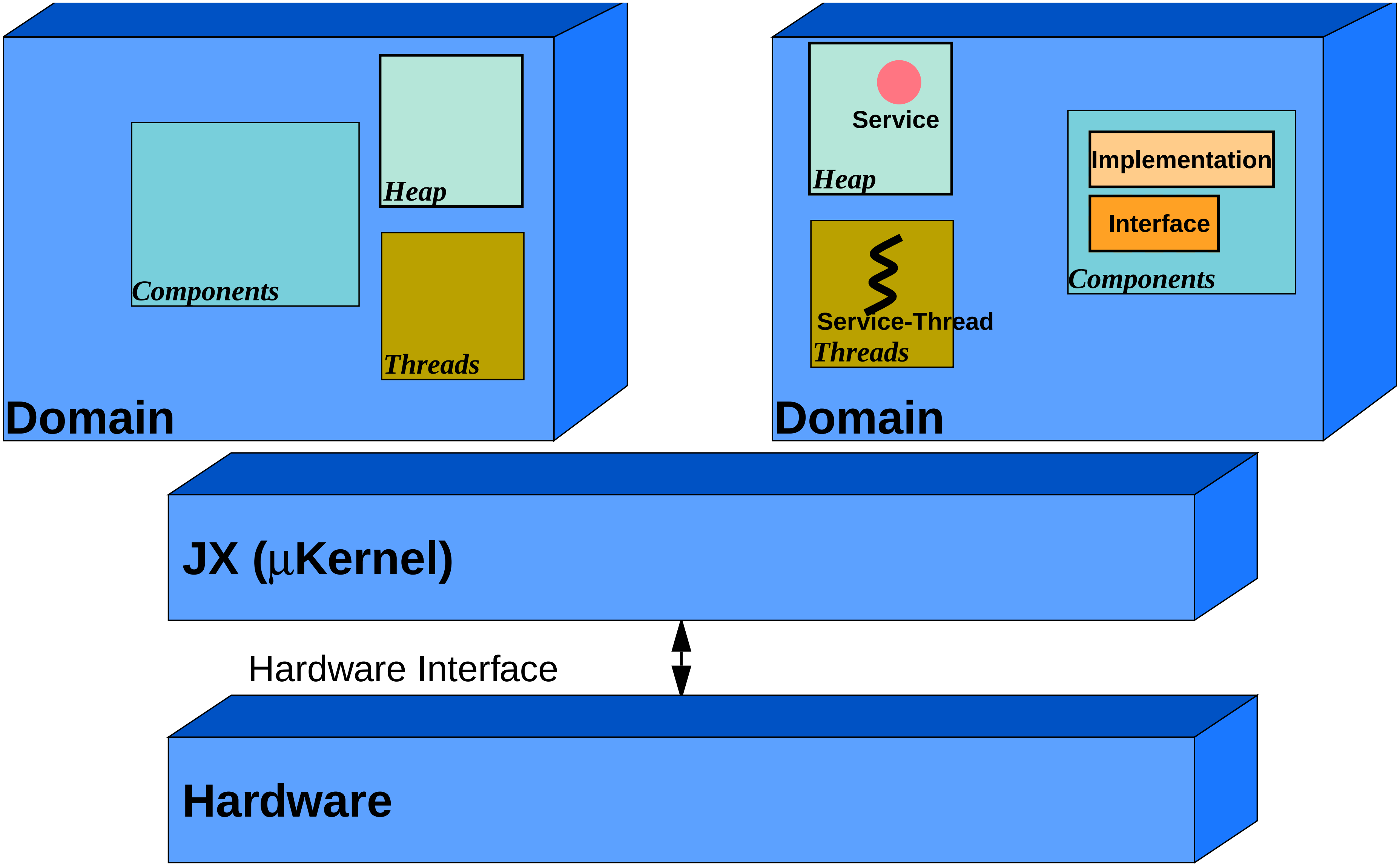

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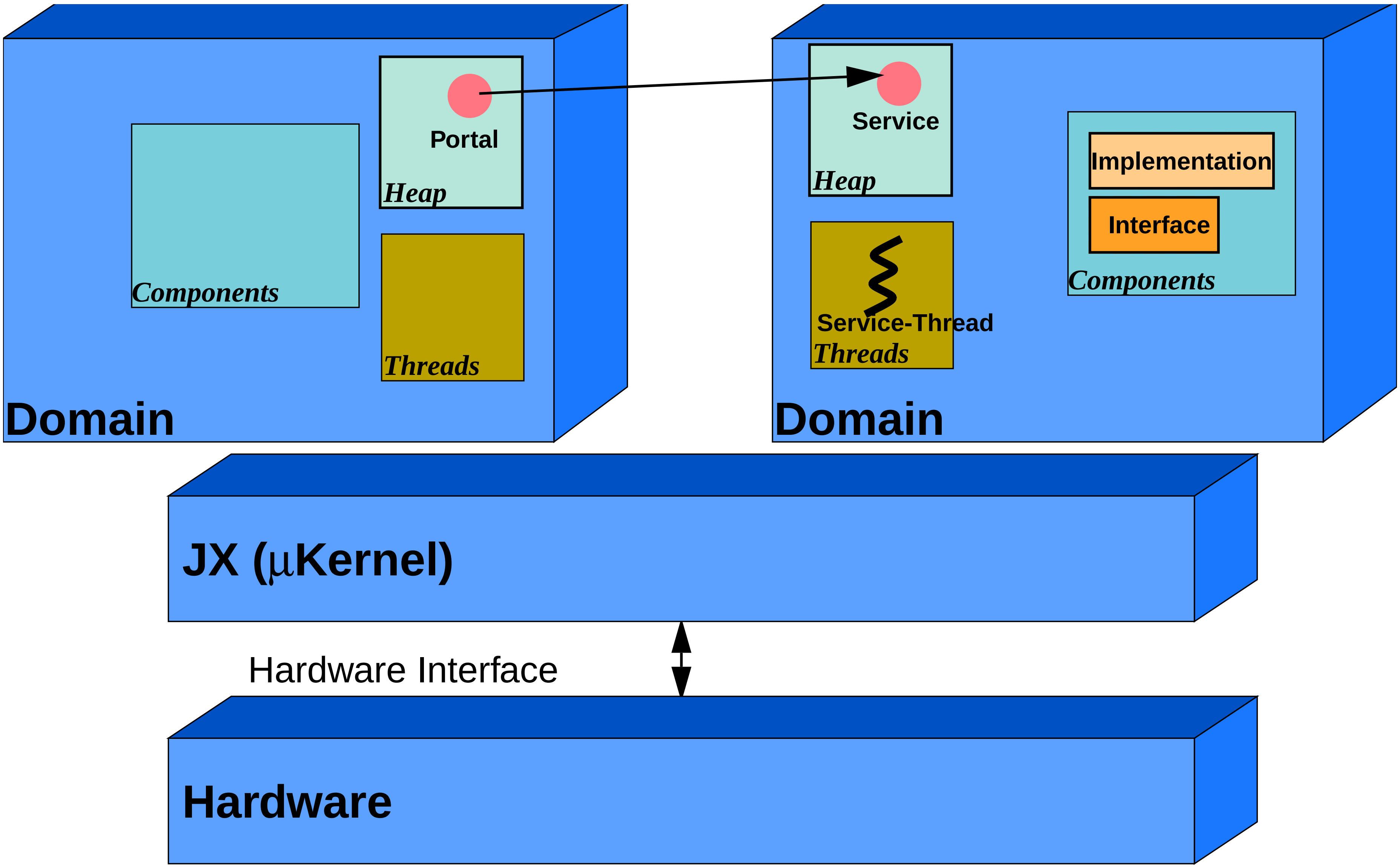

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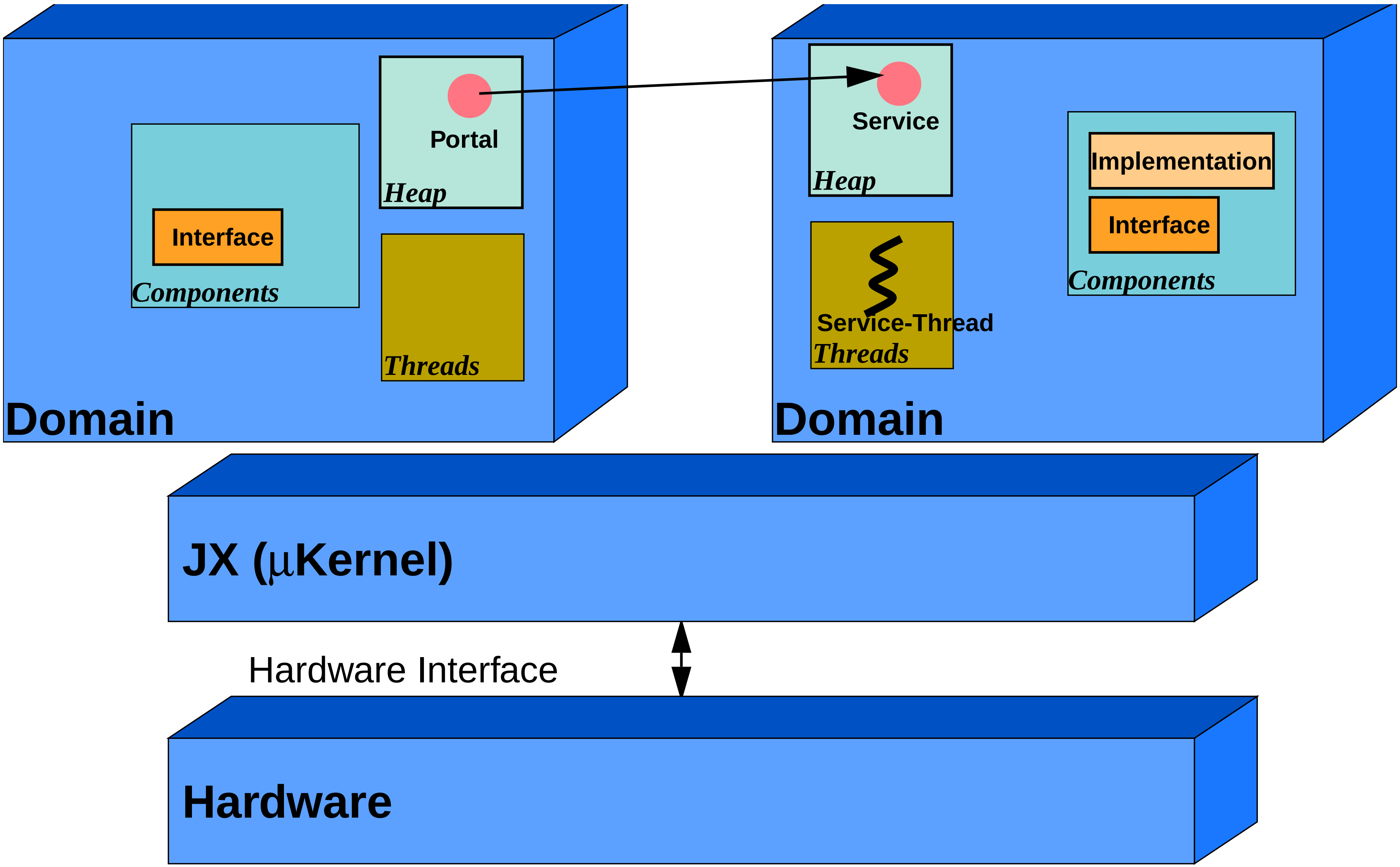

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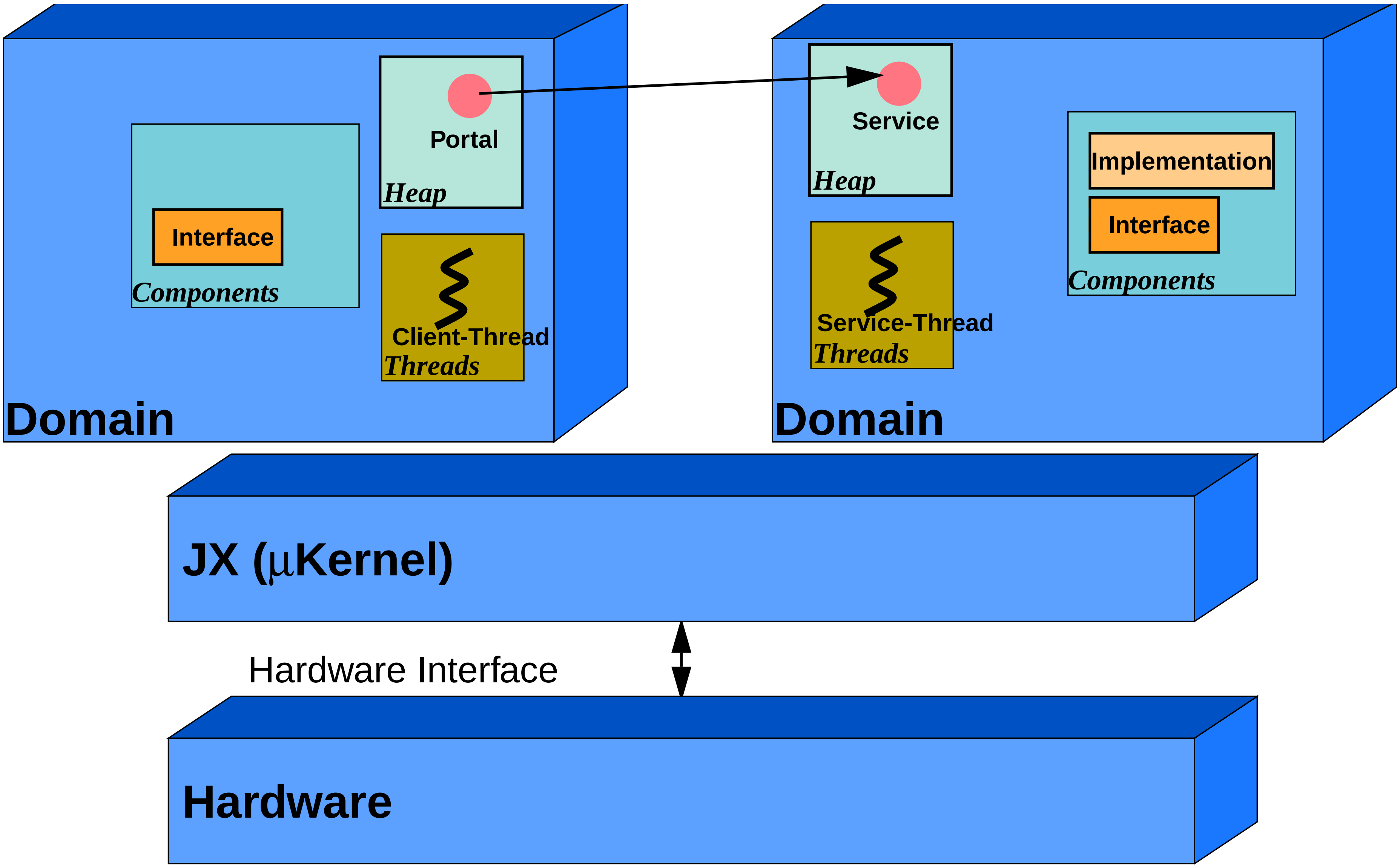
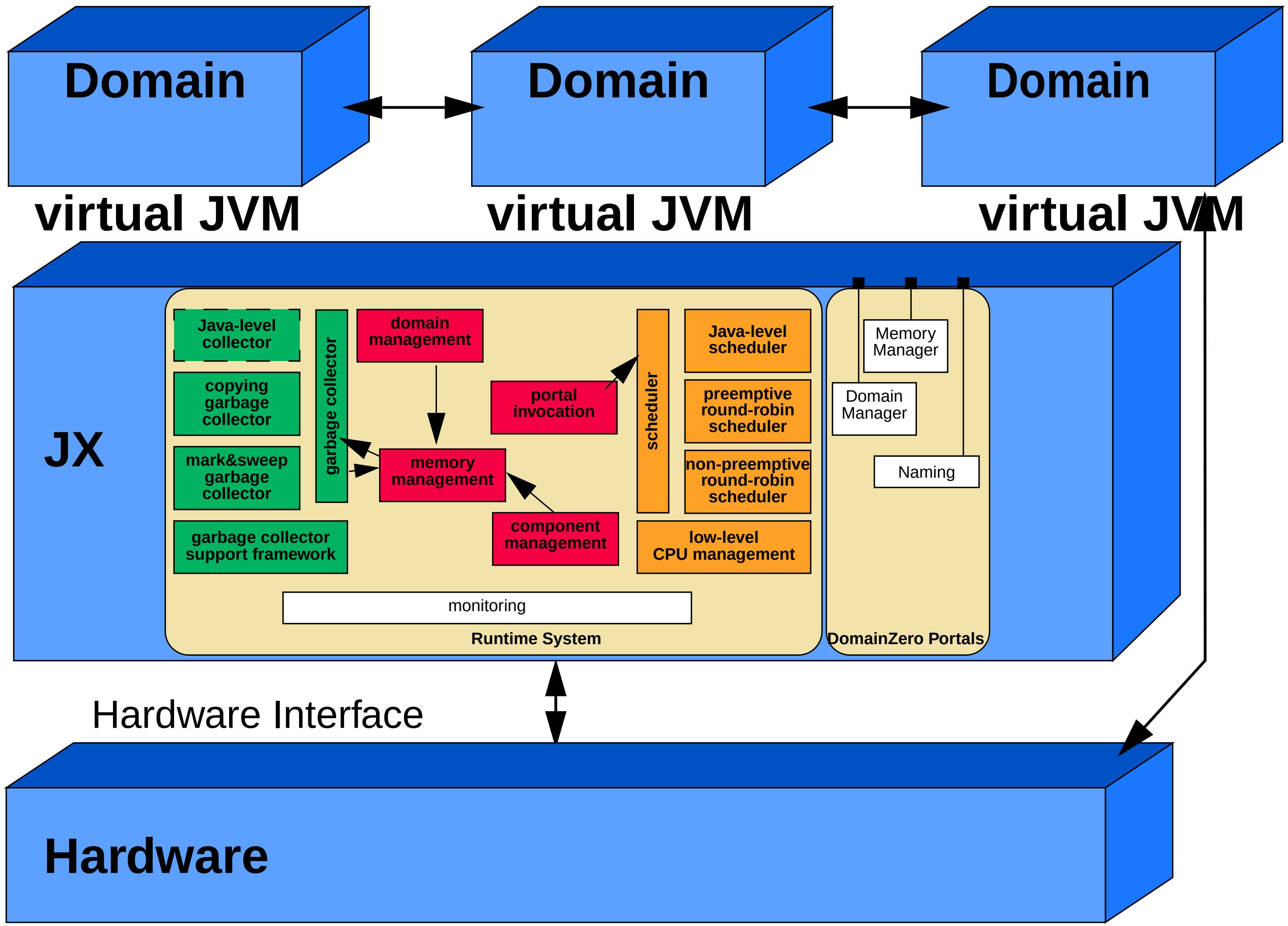


Protection Domains

- Each domain has its own heap
  - no shared objects → no accounting problems (memory, GC time)
  - no GC dependencies → no scalability problems
  - explicit application boundaries → confinement
- Each domain has its own threads
  - no migrating threads → no domain termination problems
- Each domain has its own code
  - no trusted code → improved security

The Microkernel



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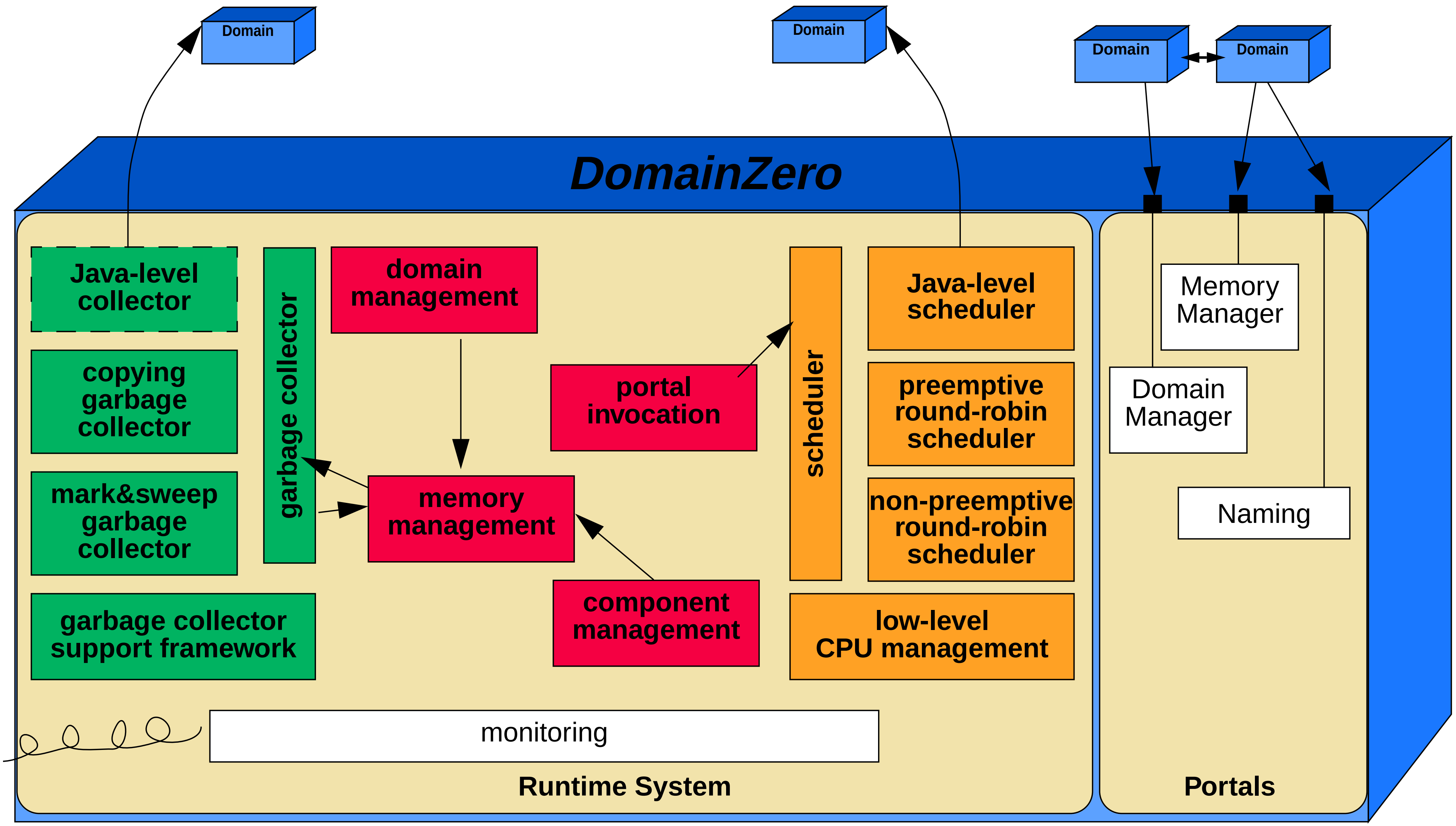

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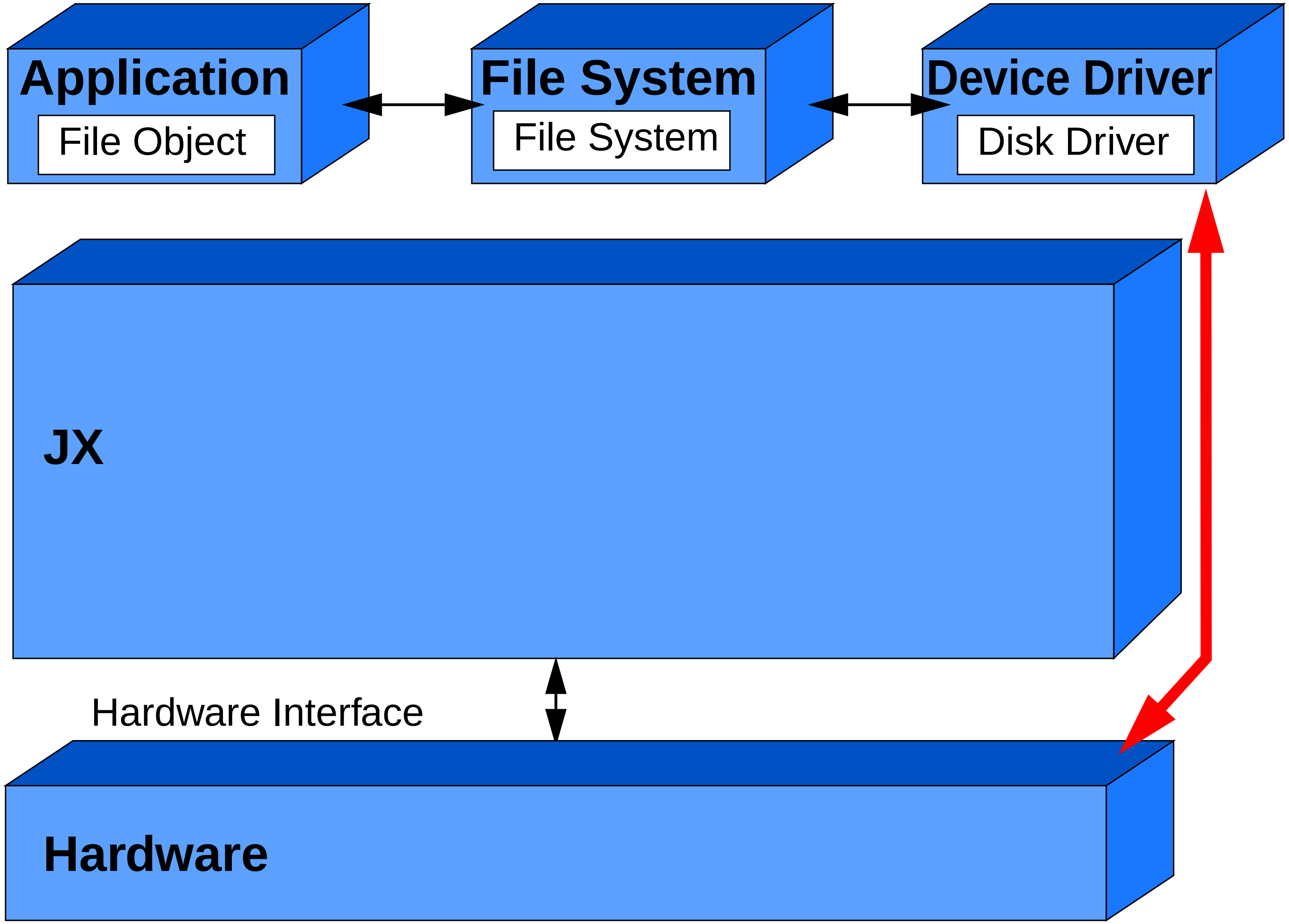
  - Communication mechanism
  - The Microkernel
- **System-level programming in Java**
- Performance

System-level Programming in Java



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- Requirement
  - No changes to the language or bytecode instruction set

Memory

- Manage large memory areas
  - disk blocks, network buffers, ...
- Access special memory areas
  - video memory, device registers, ...
- Disadvantages of arrays:
  - no explicit interface
  - no specializations possible
  - located on heap, can be moved (DMA!)
  - can only be passed by copying

Memory Portals

- Explicit interface
- Can be subtyped
- Can be used to access arbitrary memory areas
- Can be treated specially by the translator
- Share data between domains
- Pass subranges to other domains
- Revoke access

Fast Portals

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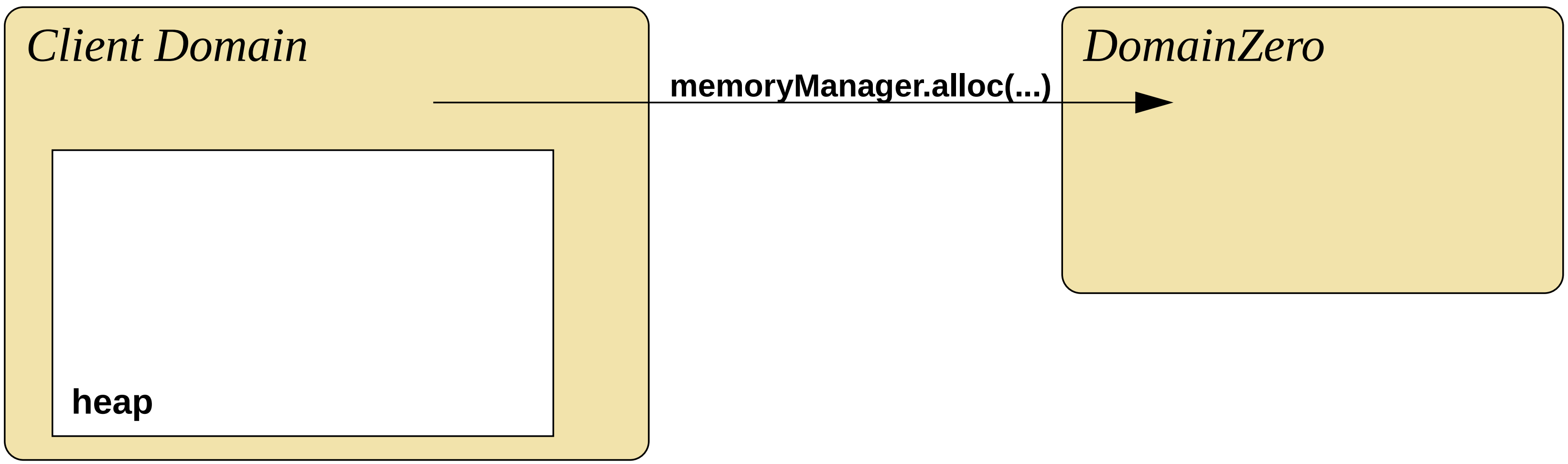

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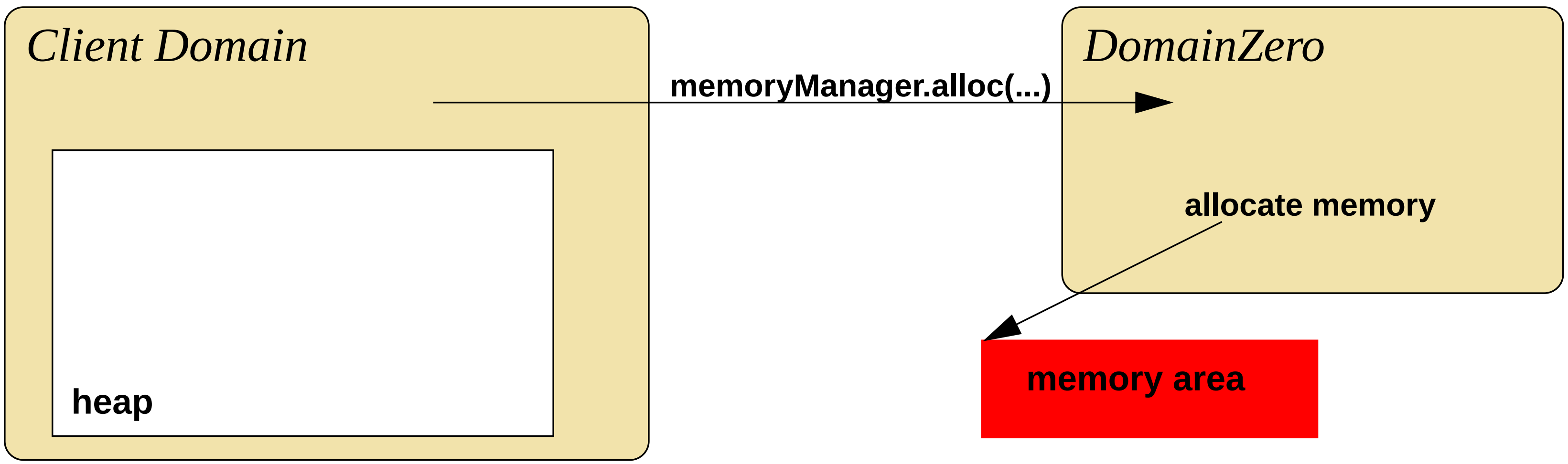

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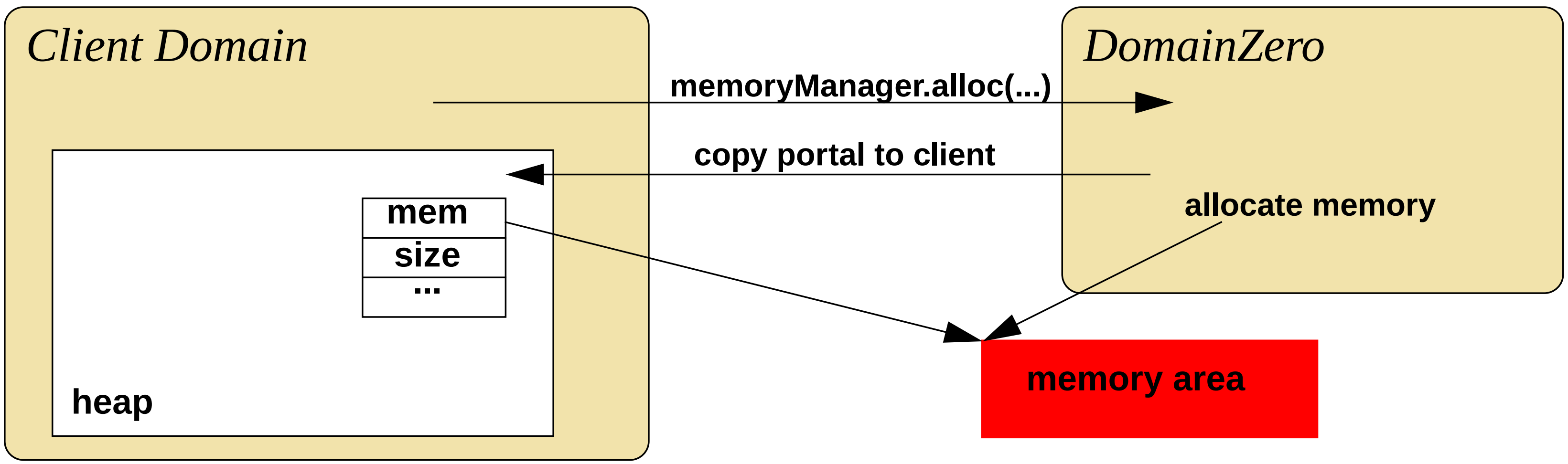
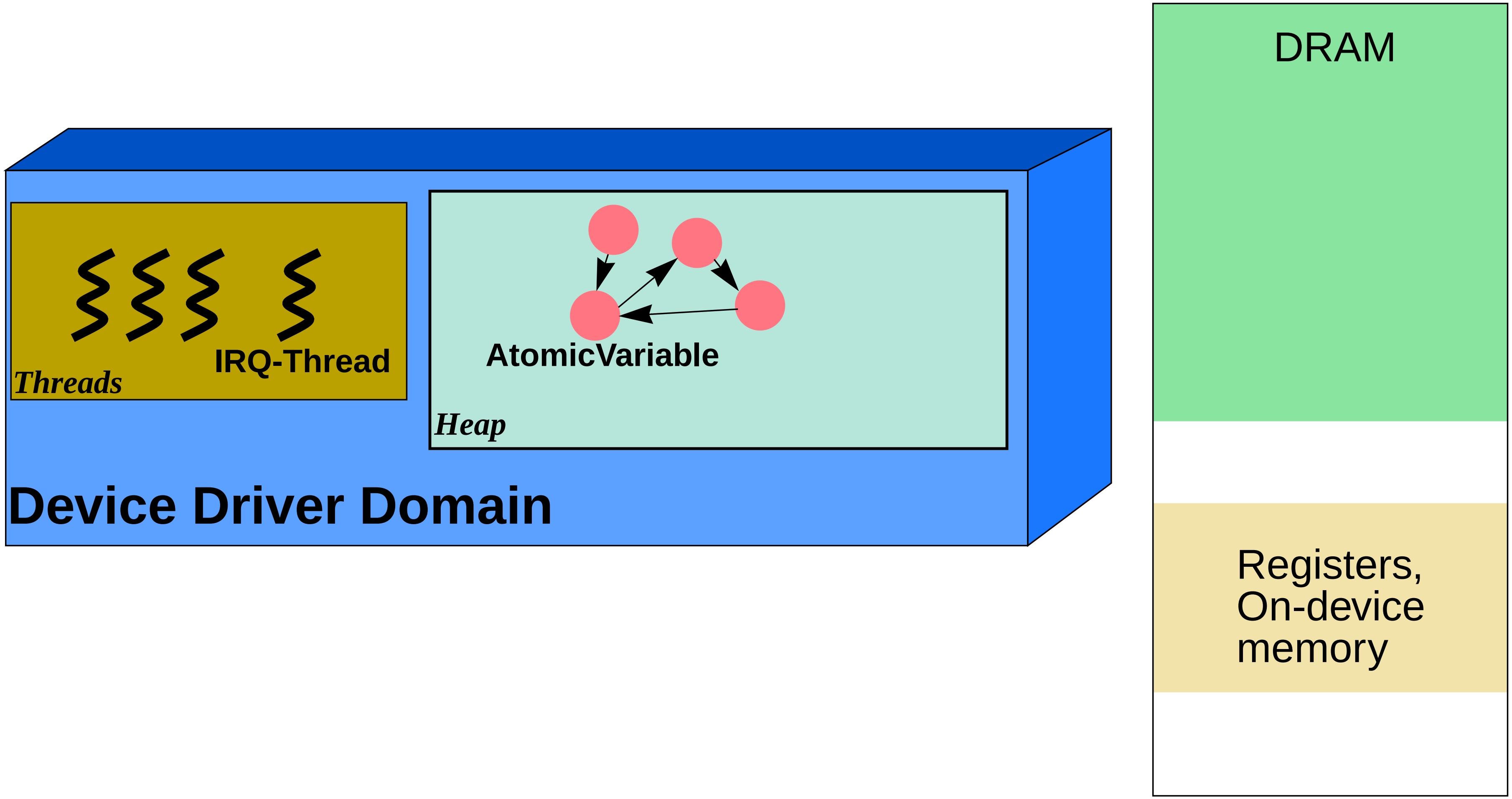


Interrupt Handler

- Interrupts handled in own thread with interrupts disabled
  - must not run in endless loop → verifier
  - must not invoke portals except fast portals
  - must synchronize with other threads without blocking
    - AtomicVariable
      - **`setValue(...)`**, **`unblock(...)`** used in interrupt thread
      - **`blockIfEqual(...)`** used outside interrupt thread
    - → Single Producer / Single Consumer Queue

System-level Programming in Java



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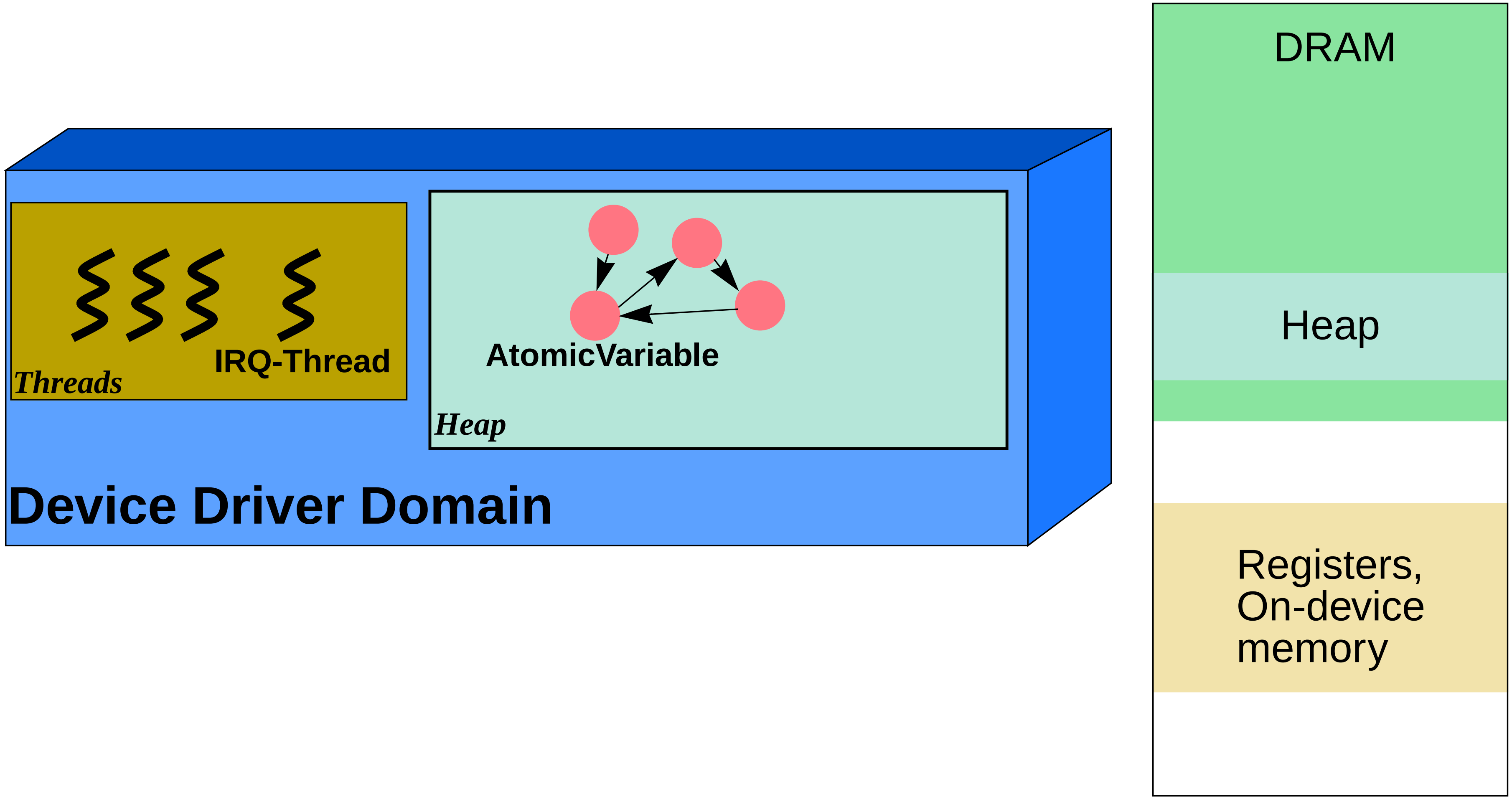

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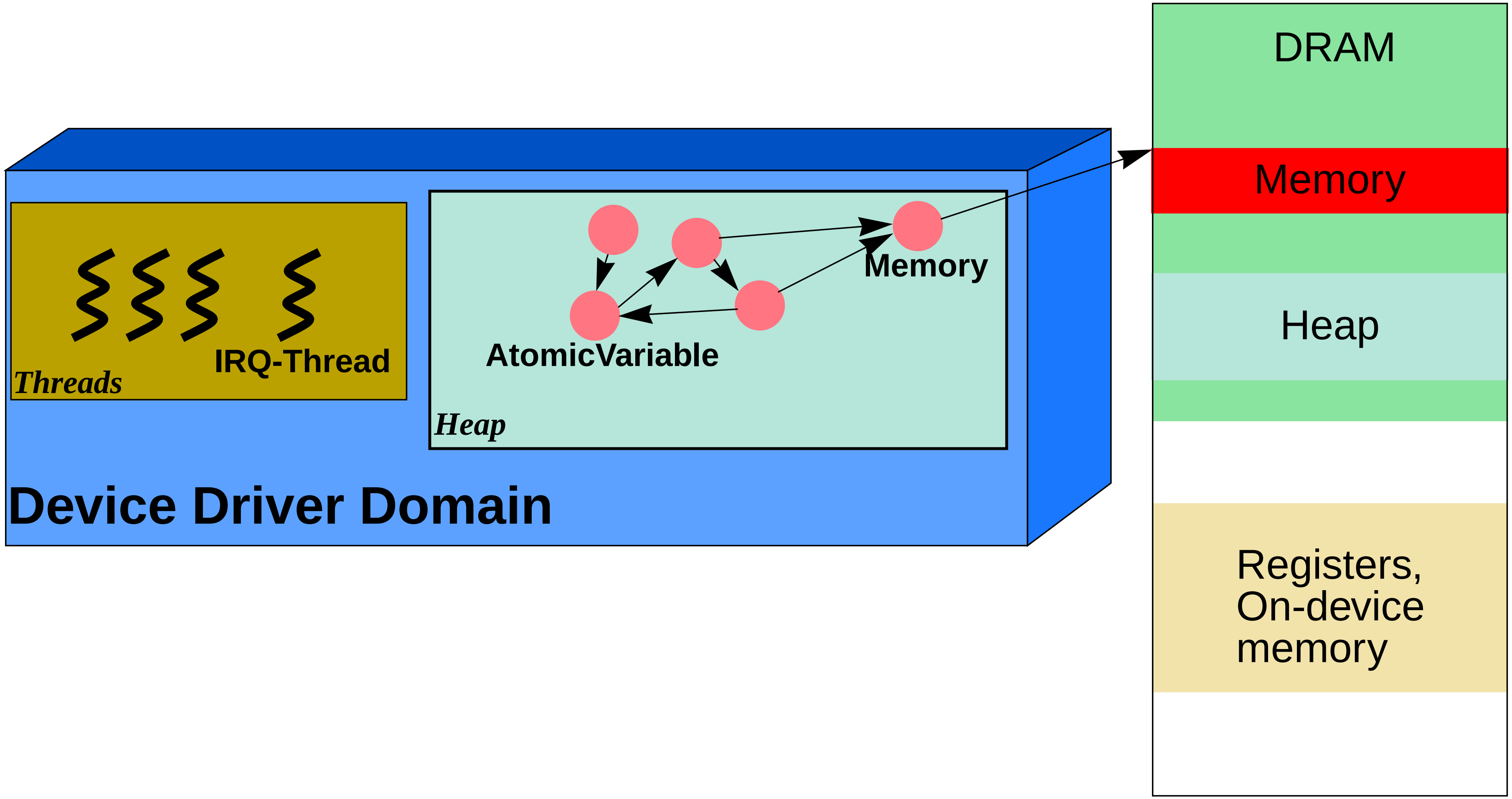

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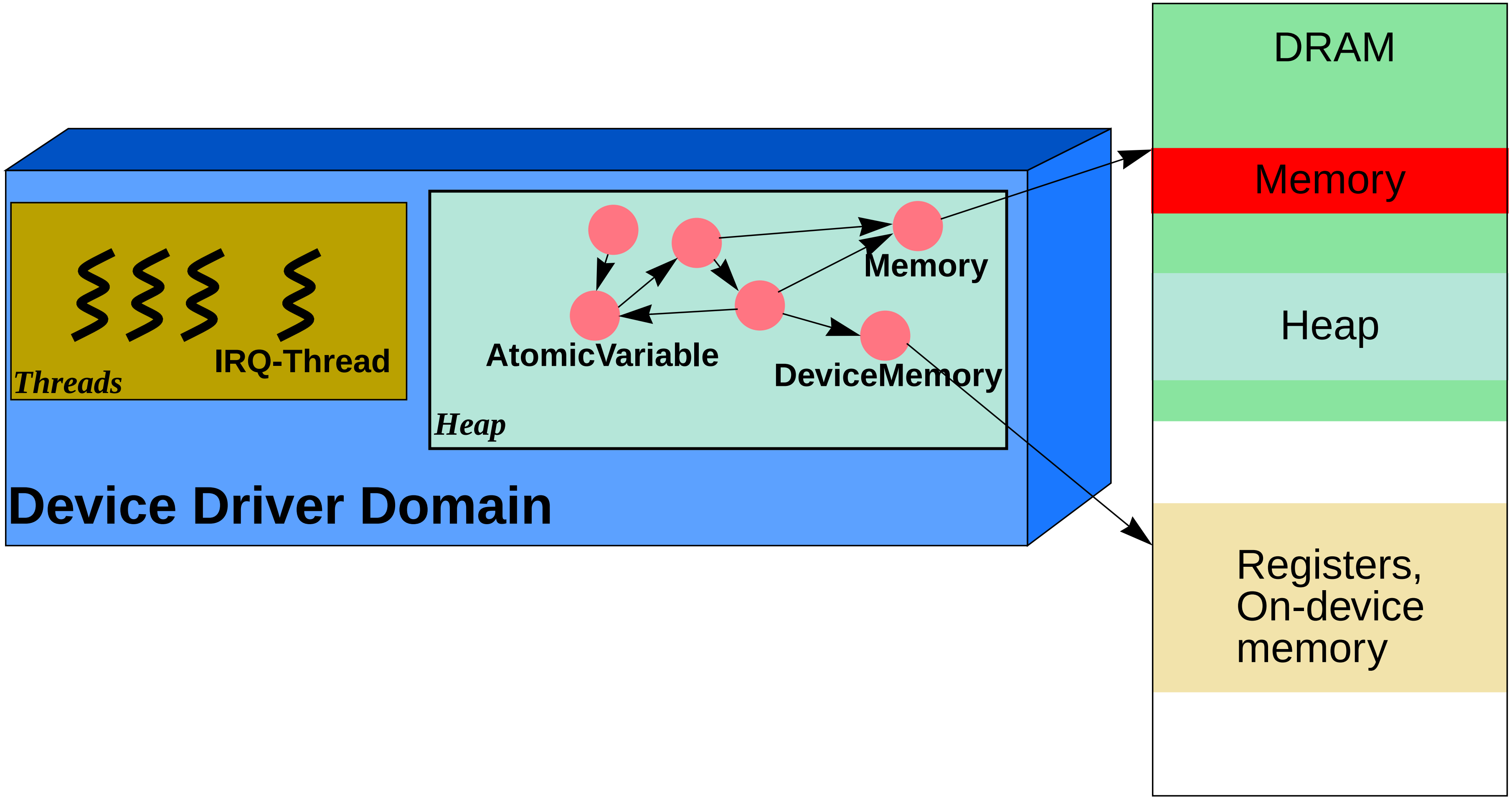

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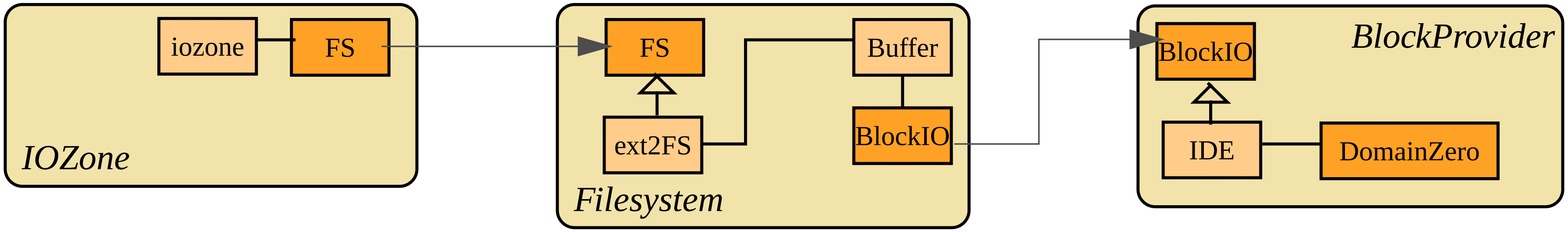
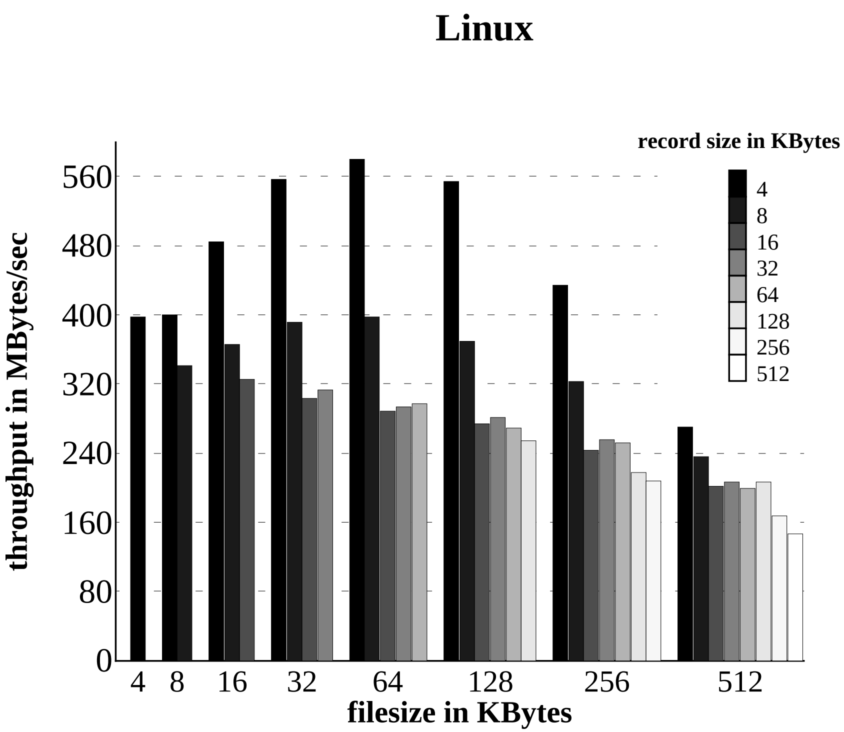
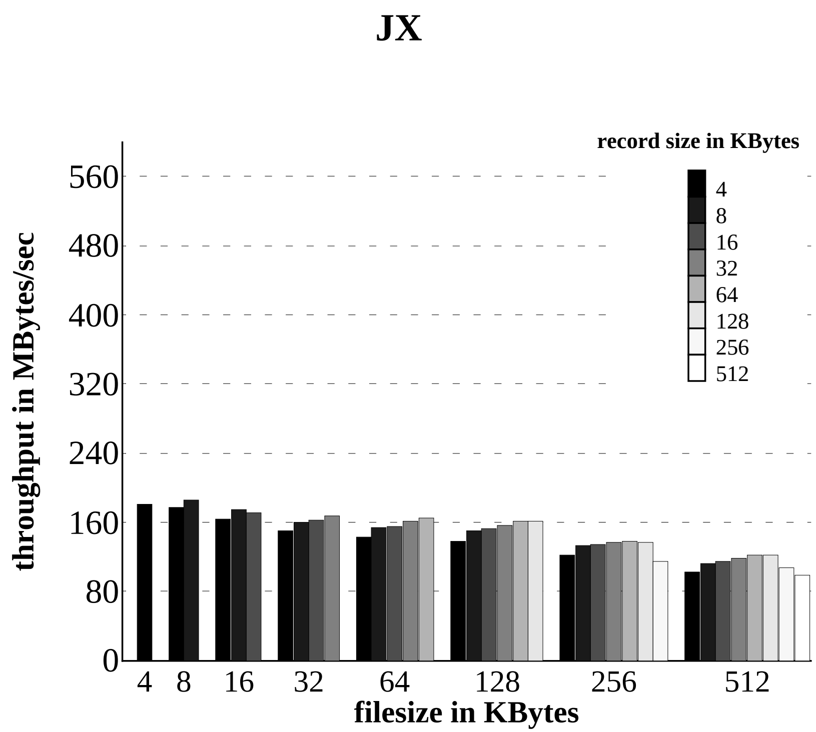
  - **IOZONE**
  - **NFS**

IOZone: Multi-domain Config







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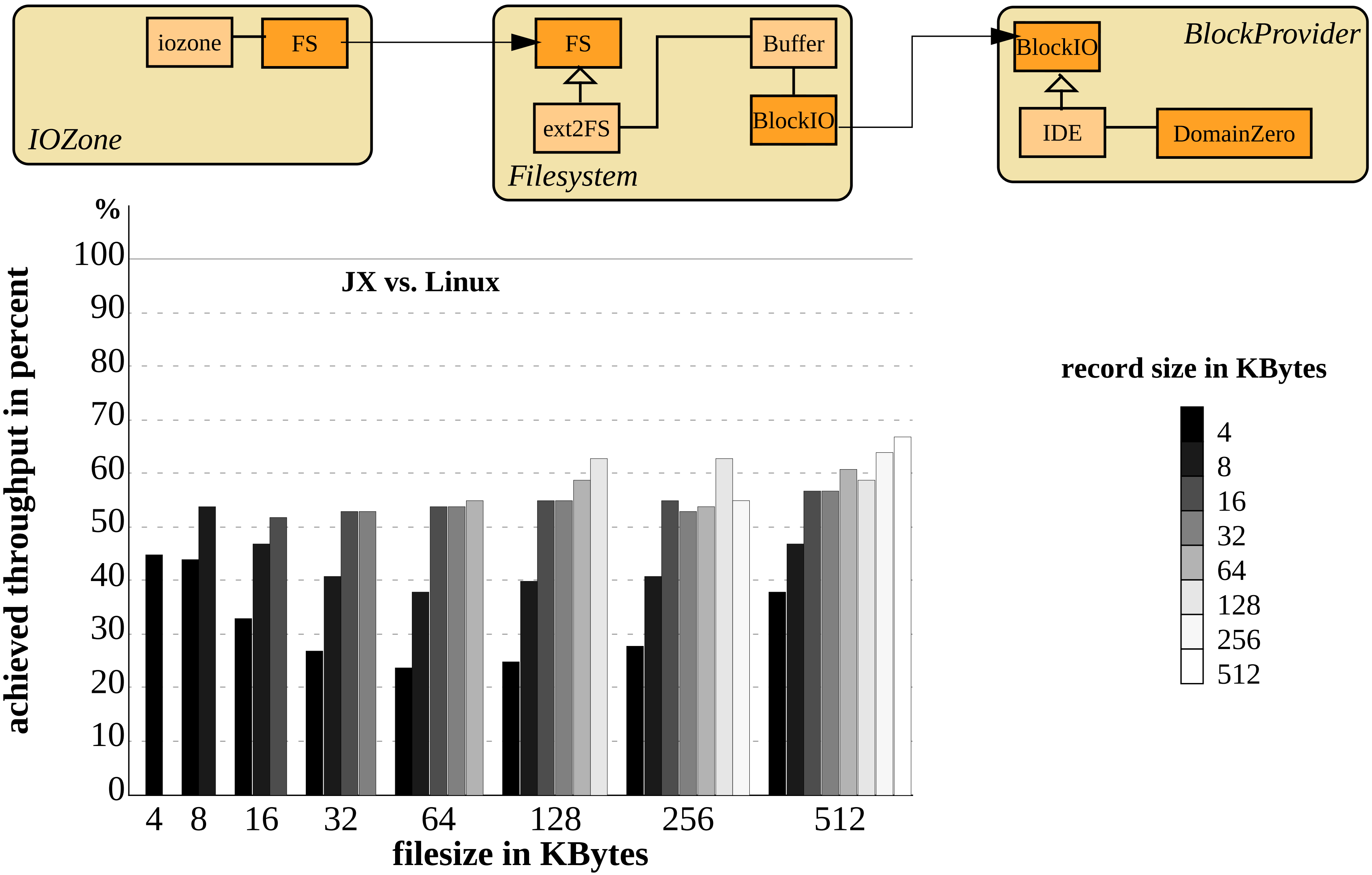

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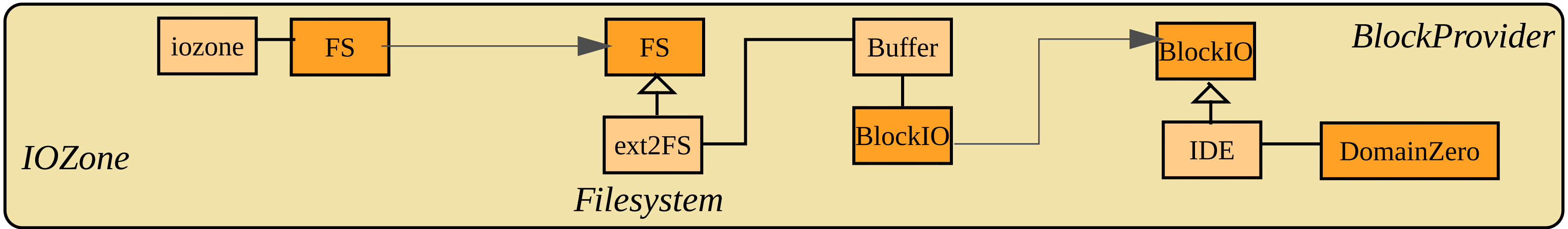

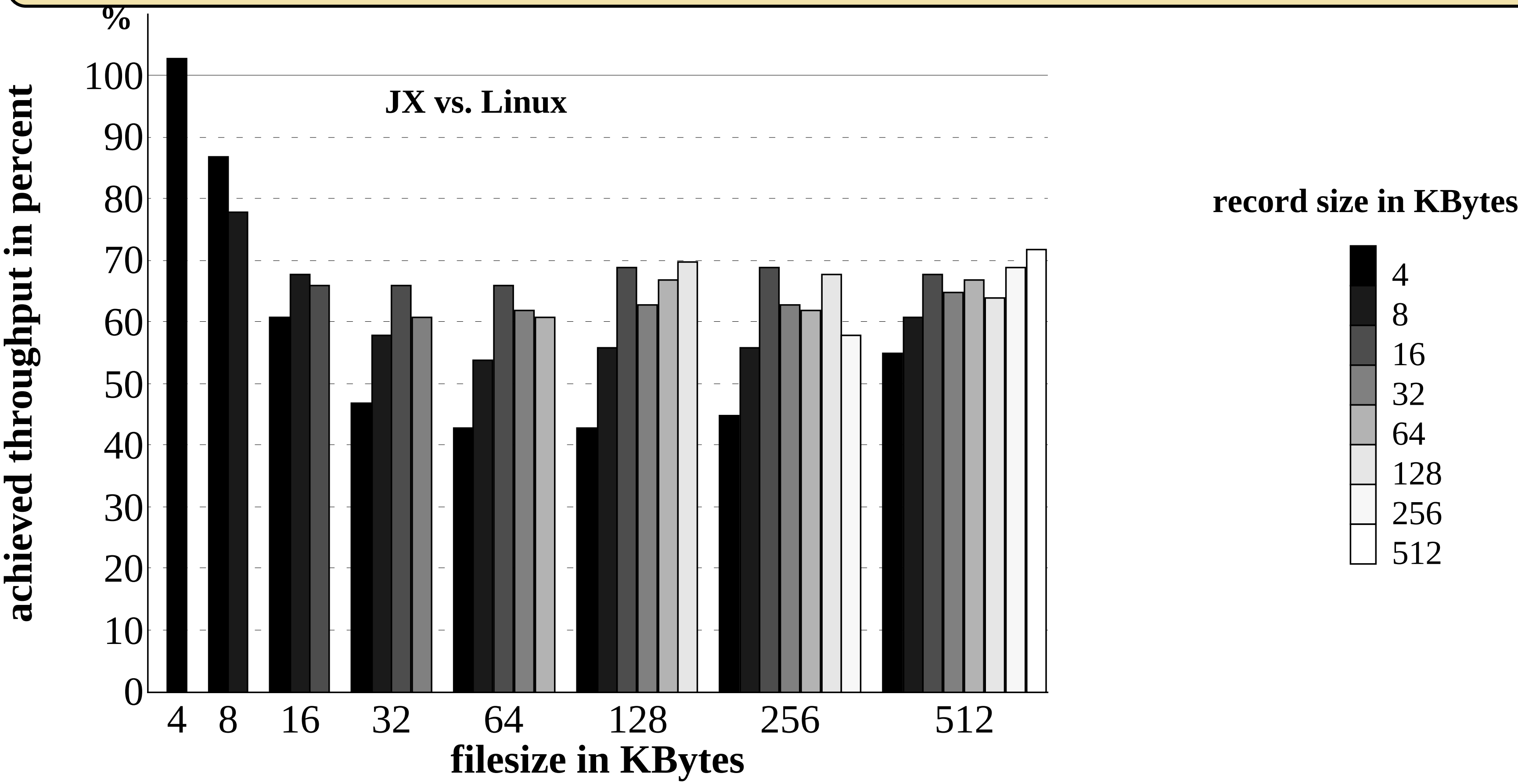

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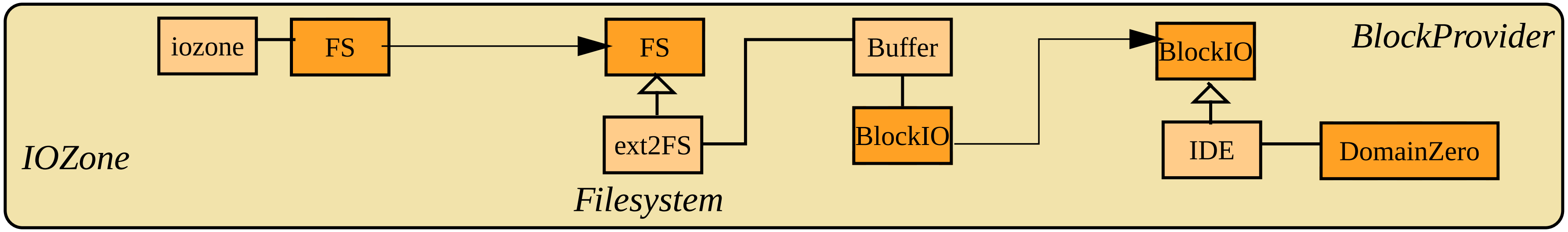
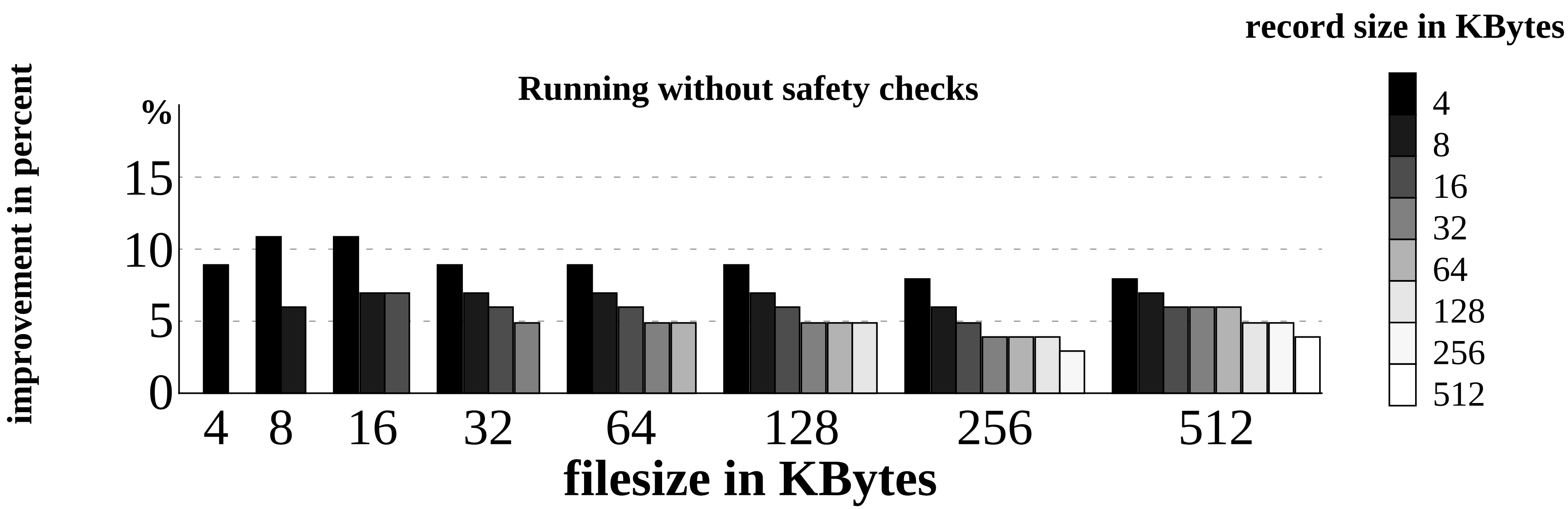
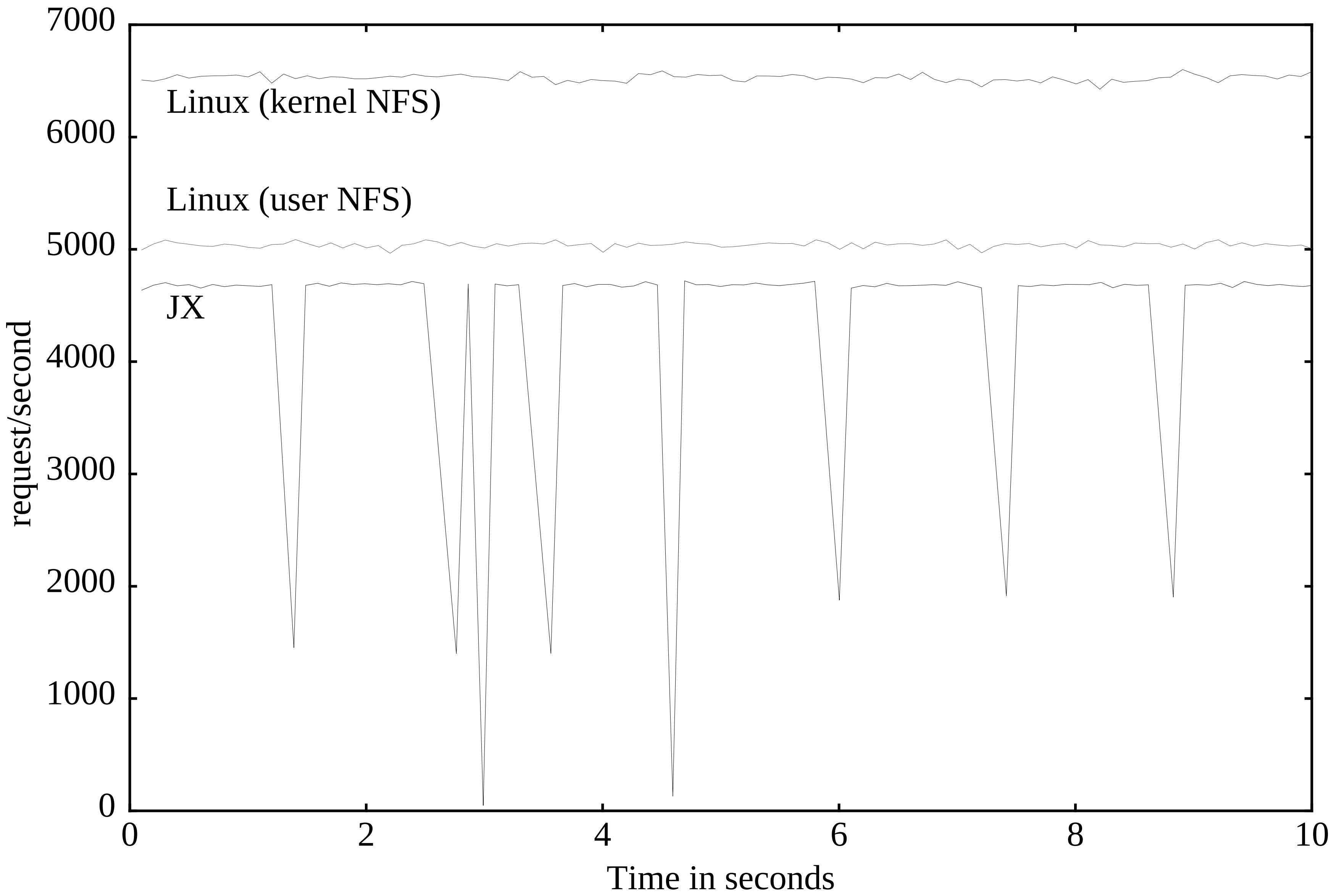




NFS: *getattr* request rate



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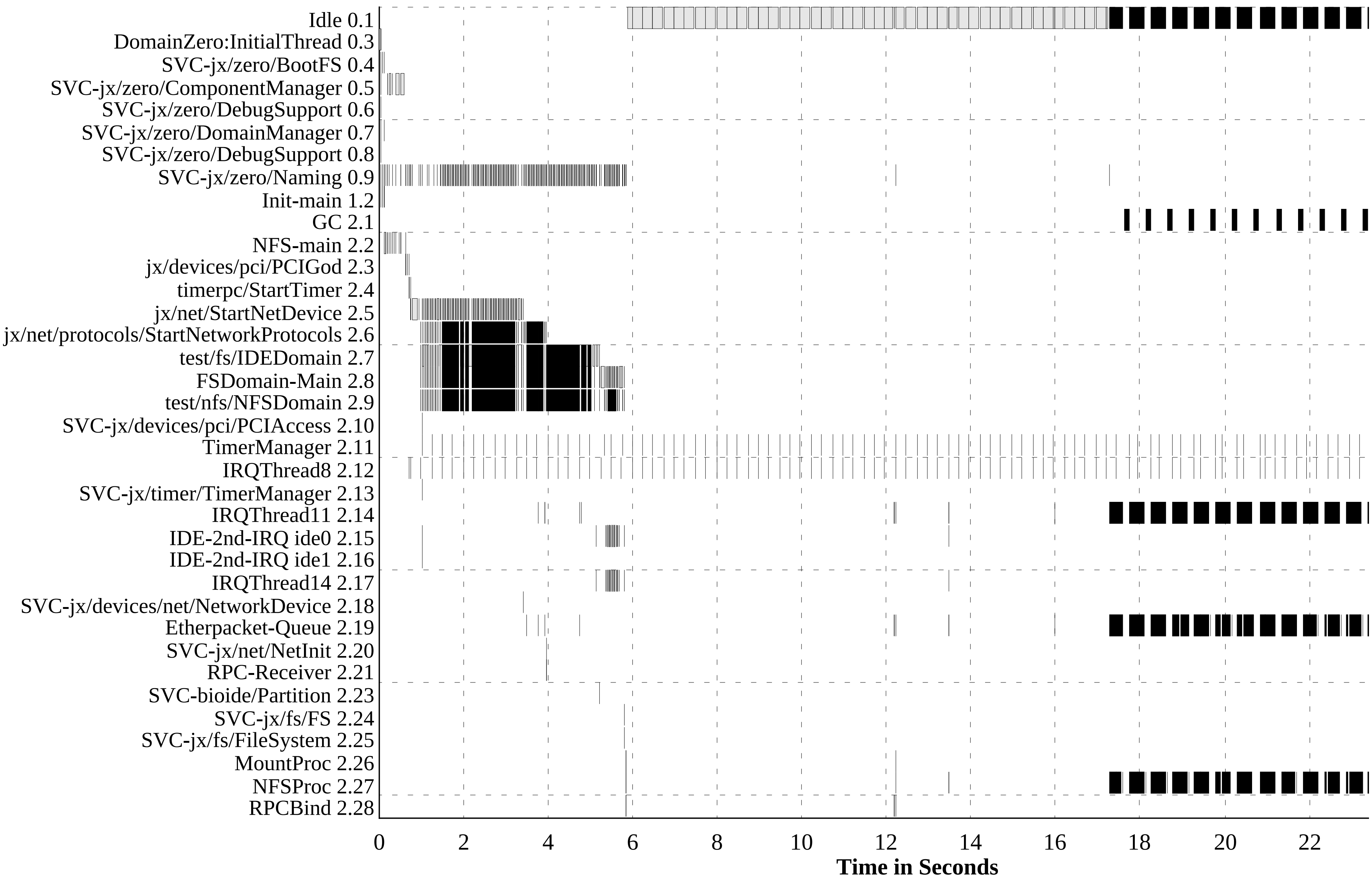

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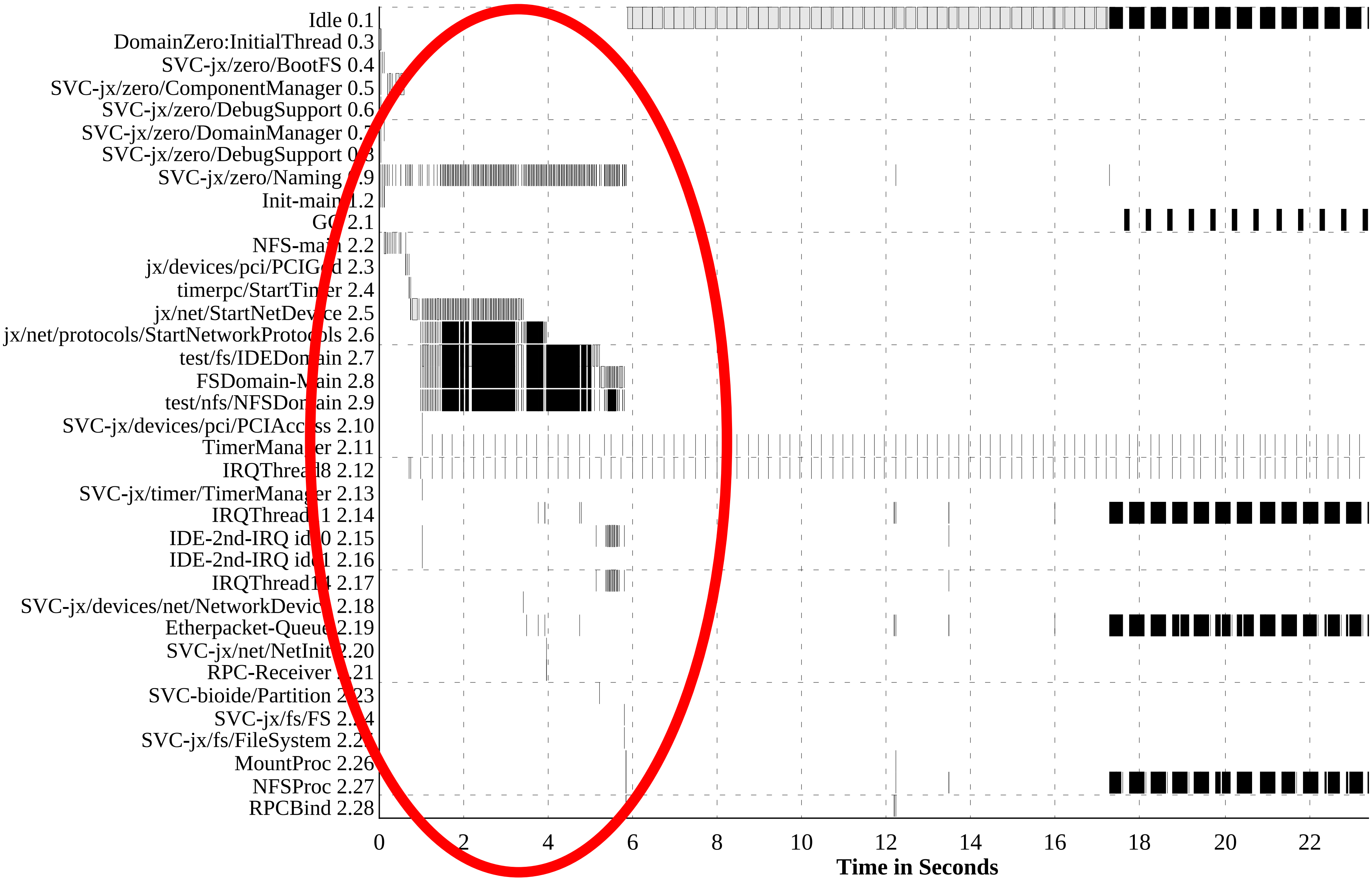

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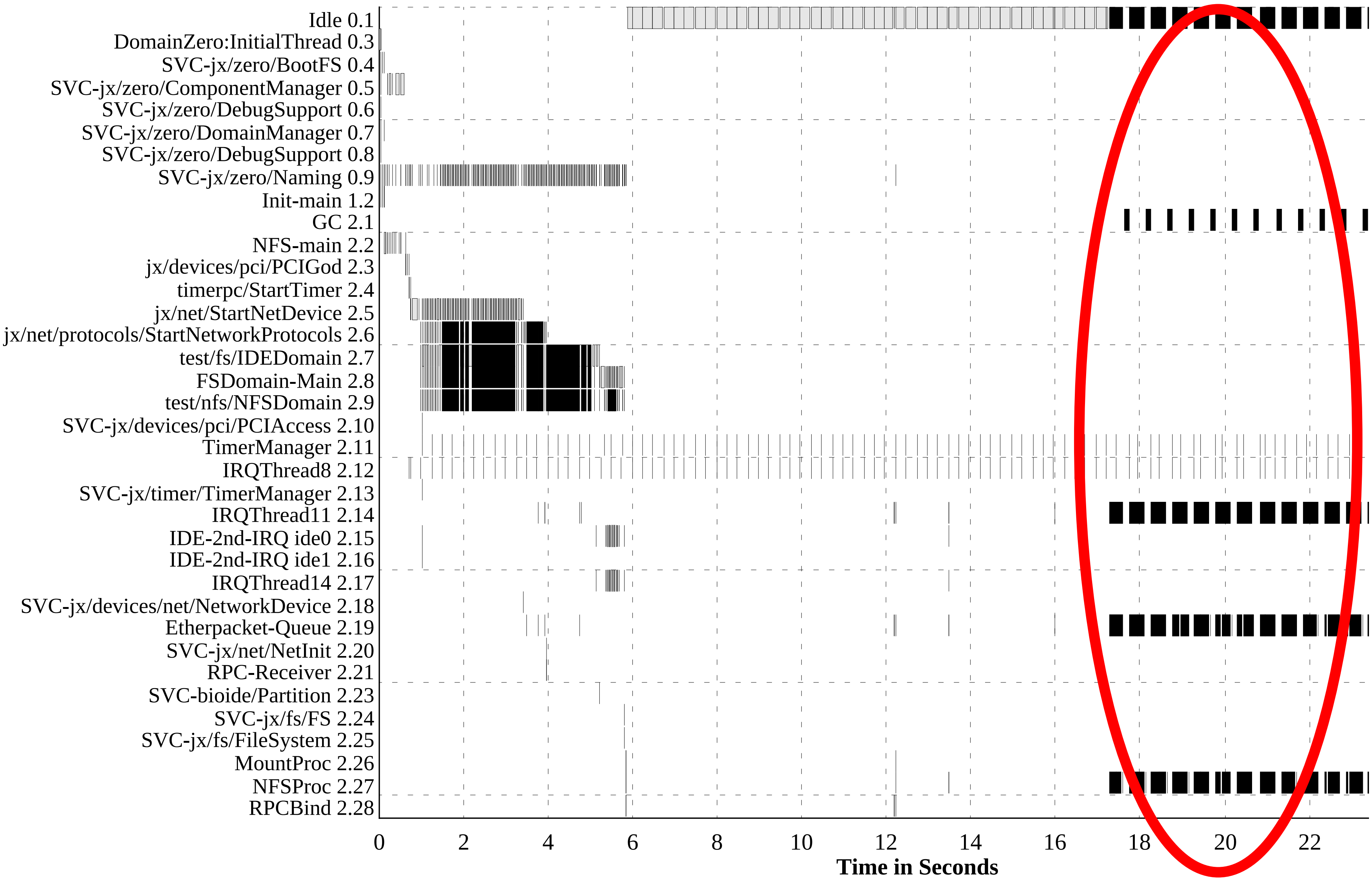

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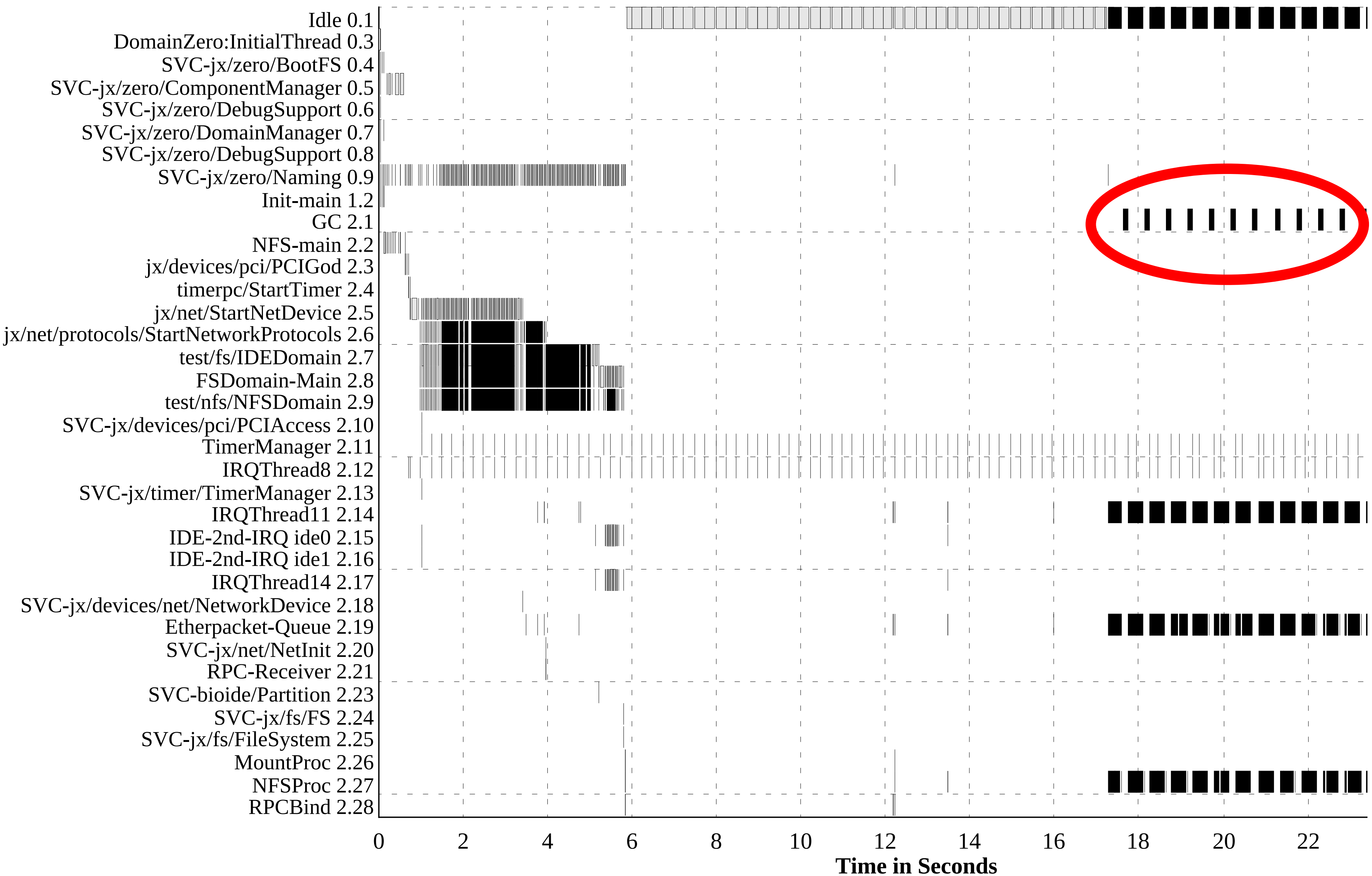

Conclusion

- It is possible to build an OS based on type-safe protection
  - Isolation of protection domains
  - System-level programming without language extensions
- OS takes advantage of advanced language technology
  - Increased robustness of system components
  - Modular system
  - Flexibility in system configuration
  - Extensibility using domains
- Performance is sufficient for most applications
  - → http://www4.cs.fau.de/Projects/JX