CS420: Operating Systems

Kernel I/O Subsystem

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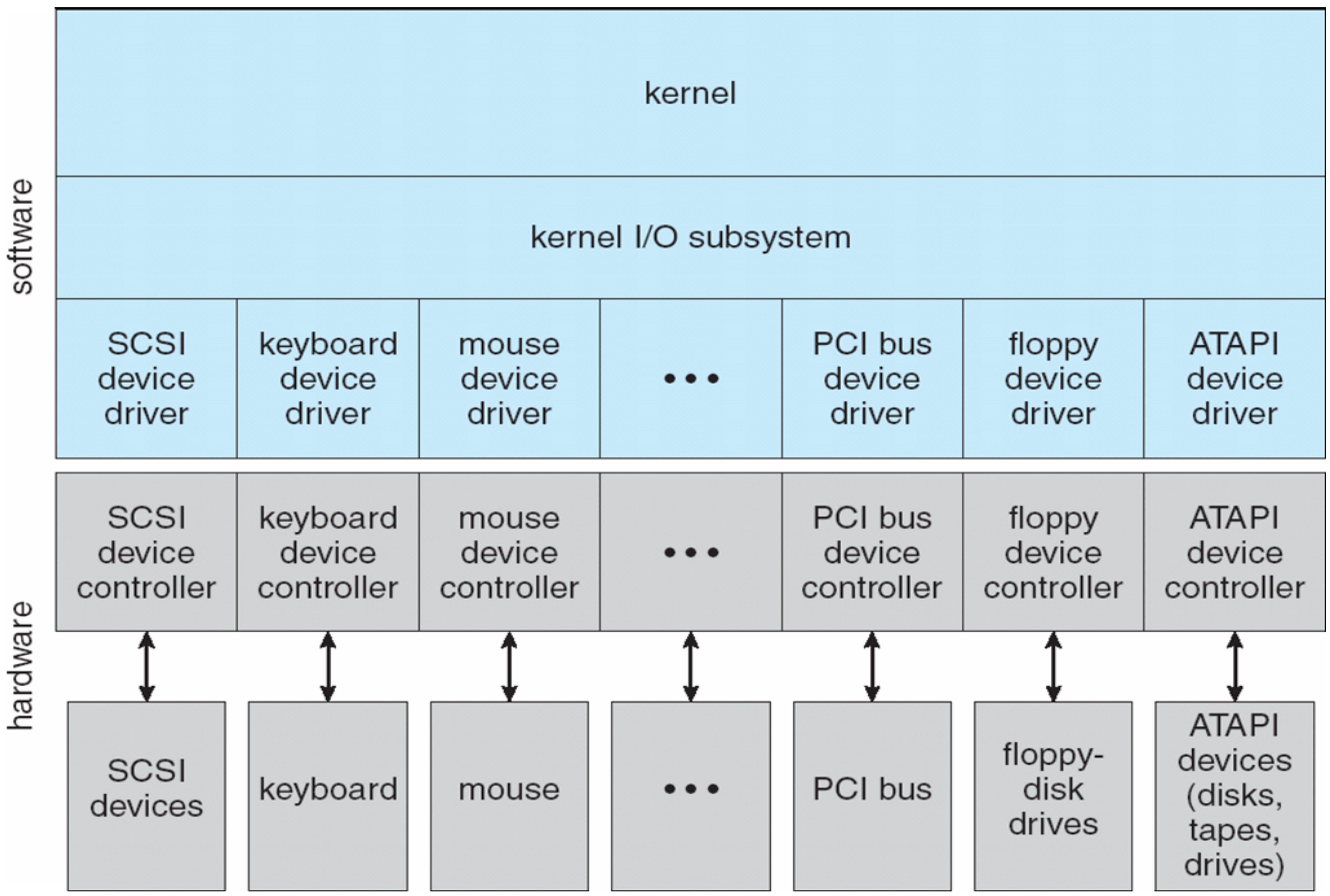
A Kernel I/O Structure



Kernel I/O Subsystem

- **The kernel provides many services related to I/O**
  - Scheduling
  - Buffering
  - Caching
  - Spooling
  - Device reservation
  - Error handling

Kernel I/O Subsystem

- **Scheduling**
  - Some I/O request ordering via per-device queue
    - Attempt to use devices optimally while still providing priority
  - Some implement Quality of Service (i.e. IPQOS)

- **Buffering - store data in memory while transferring between devices**
  - Helps cope with device speed mismatch
  - Helps cope with device transfer size mismatch
  - To maintain "copy semantics"
    - Data is first copied from user application memory into kernel memory
    - Data from kernel memory is then written to device
    - Prevents application from changing contents of a buffer before it is done being written

Kernel I/O Subsystem

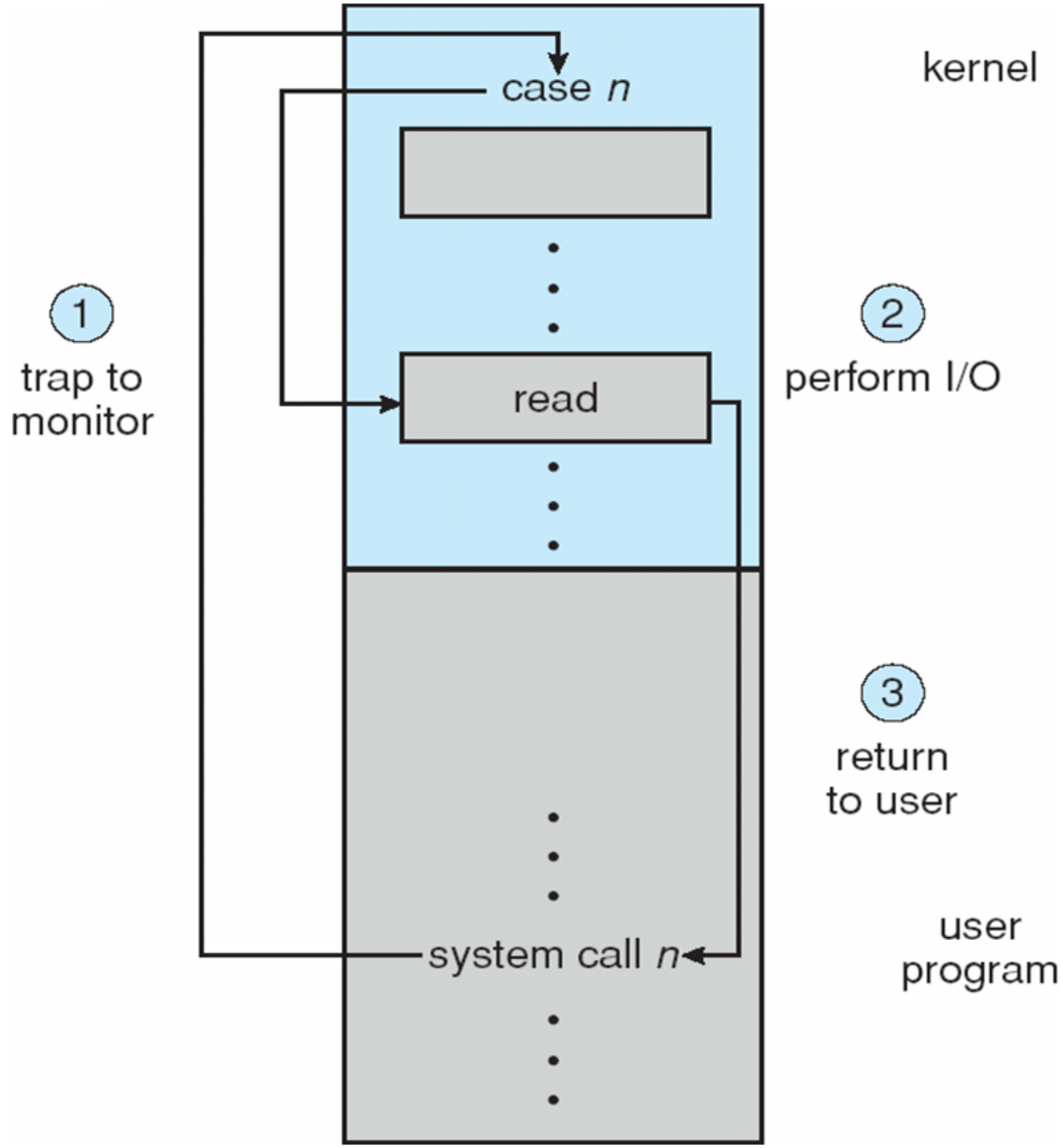
- **Caching - possible to reuse buffers in main memory for caching**
  - Cache files that are read/written frequently
  - Increases performance
- **Spooling - a buffer that holds output for a device that cannot accept interleaved data streams**
  - If device can serve only one request at a time
  - Allows a user to see individual data streams and remove streams if desired
  - i.e., Printing
- **Device reservation - provides exclusive access to a device**
  - System calls for allocation and de-allocation
  - Watch out for deadlock

Error Handling

- **OS can recover from disk read, device unavailable, transient write failures**
  - Retry a read or write, for example
  - Some systems more advanced – Solaris FMA, AIX
    - Track error frequencies, stop using device with increasing frequency of retry-able errors
- **Most operating systems return an error number or code when I/O request fails**
  - `errno` in UNIX/Linux environments
- **System error logs hold problem reports**

I/O Protection

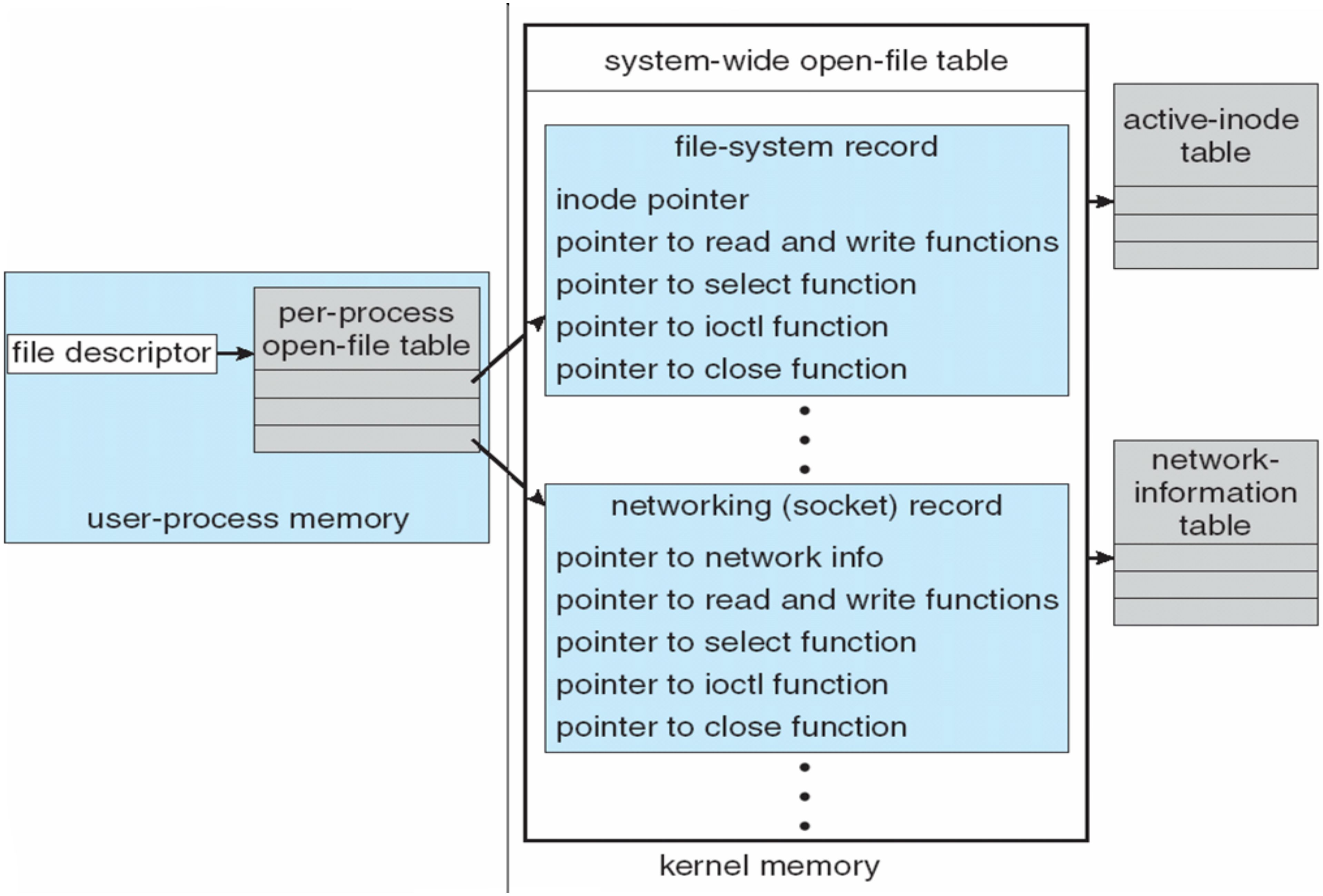
- **User process may accidentally or purposefully attempt to disrupt normal operation via illegal I/O instructions**
  - All I/O instructions defined to be privileged
    (i.e. kernel must perform I/O)
  - I/O must be performed via system calls
    - Memory-mapped and I/O port memory locations must be protected too



Kernel Data Structures

- **Kernel keeps state info for I/O components, including open file tables, network connections, etc.**
- **Many complex data structures to track buffers, memory allocation, "dirty" blocks**
- **Some operating systems use object-oriented methods and message passing to implement I/O**
  - Windows uses message passing
    - Message with I/O information passed from user mode into kernel
    - Message modified as it flows through to device driver and back to process

UNIX I/O Kernel Structure

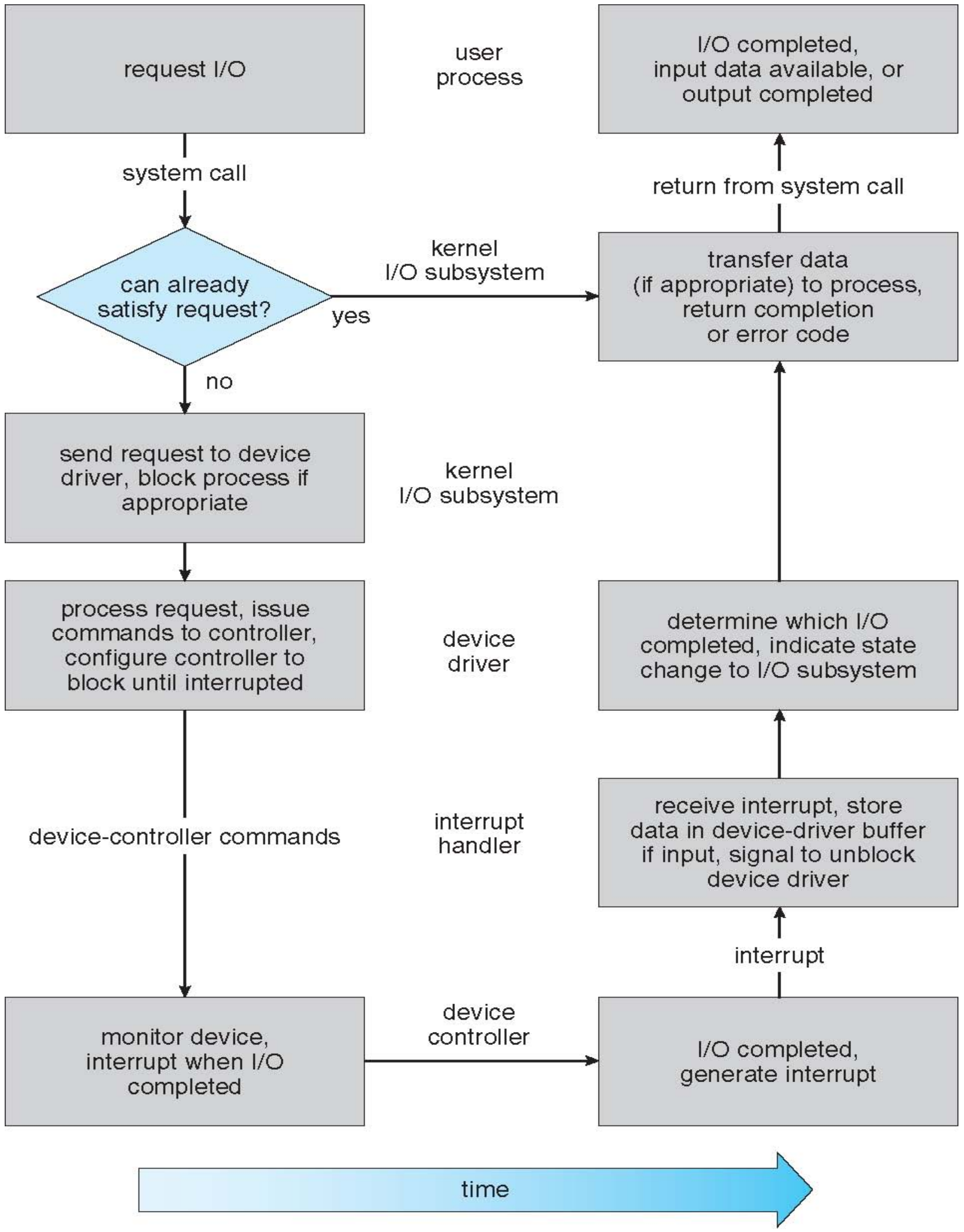


I/O Requests to Hardware Operations

- **Consider reading a file from disk for a process:**
  - Determine device holding file
  - Translate name to device representation
  - Physically read data from disk into buffer
  - Make data available to requesting process
  - Return control to process

Life Cycle of An I/O Request

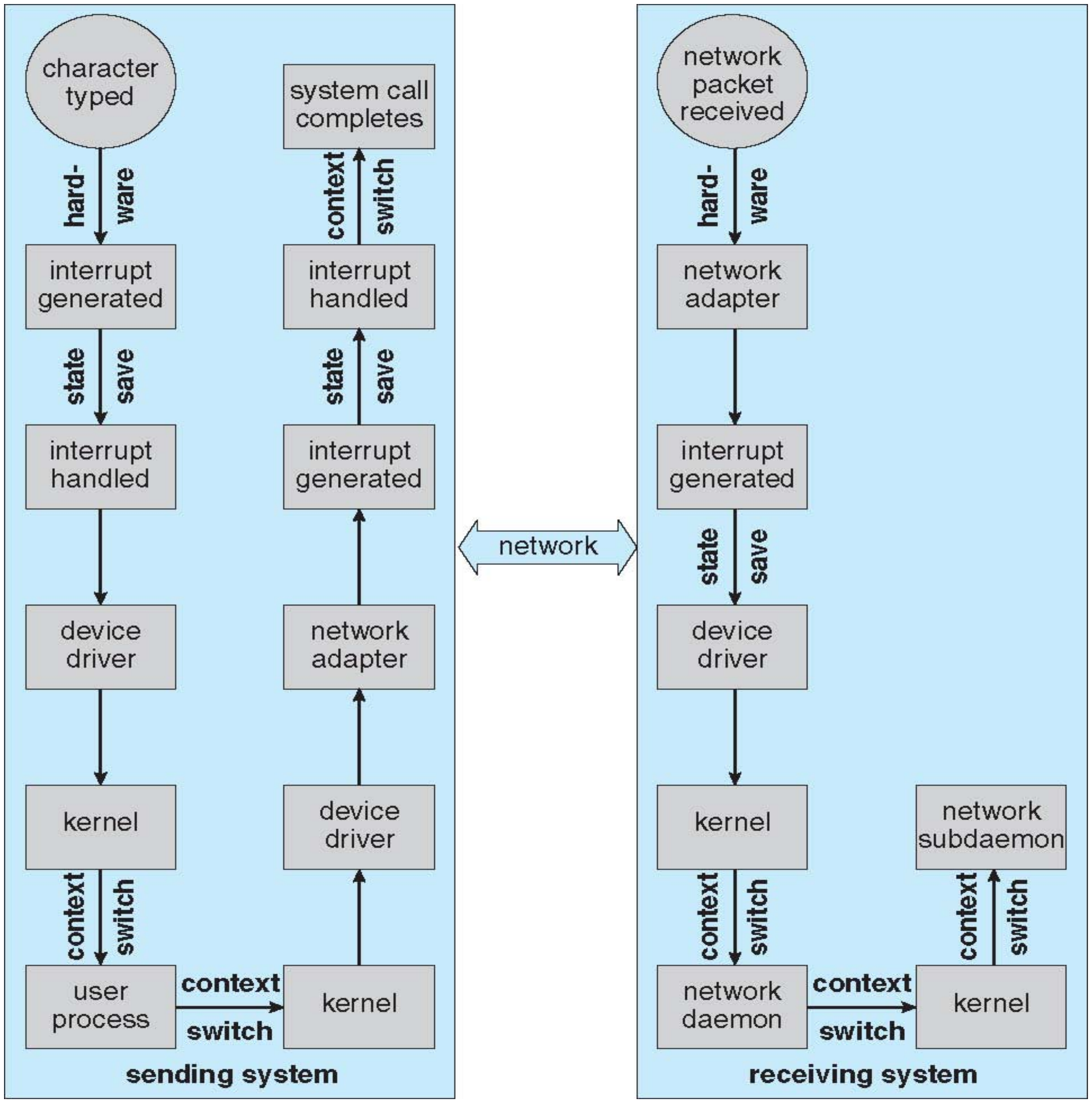
In buffer cache?



Performance

- **I/O a major factor in system performance:**
  - Demands CPU to execute device driver, kernel I/O code
  - Context switches due to interrupts
  - Data copying
  - Network traffic especially stressful

Intercomputer Communications



Methods to Improve System Performance

- **Reduce number of context switches**
- **Reduce data copying when passing data between device and application**
- **Reduce frequency of interrupts by using large transfers, smart controllers, polling**
- **Use DMA controllers to offload simple data copying from the CPU**
- **Use smarter hardware devices that can do more of the work**
- **Move user-mode processes / daemons to kernel threads**

Device-Functionality Progression