I/O Buffering

- Processes must wait for I/O to complete before proceeding
  - To avoid deadlock certain pages must remain in main memory during I/O
- It may be more efficient to perform input transfers in advance of requests being made and to perform output transfers some time after the request is made.

Block-oriented Buffering

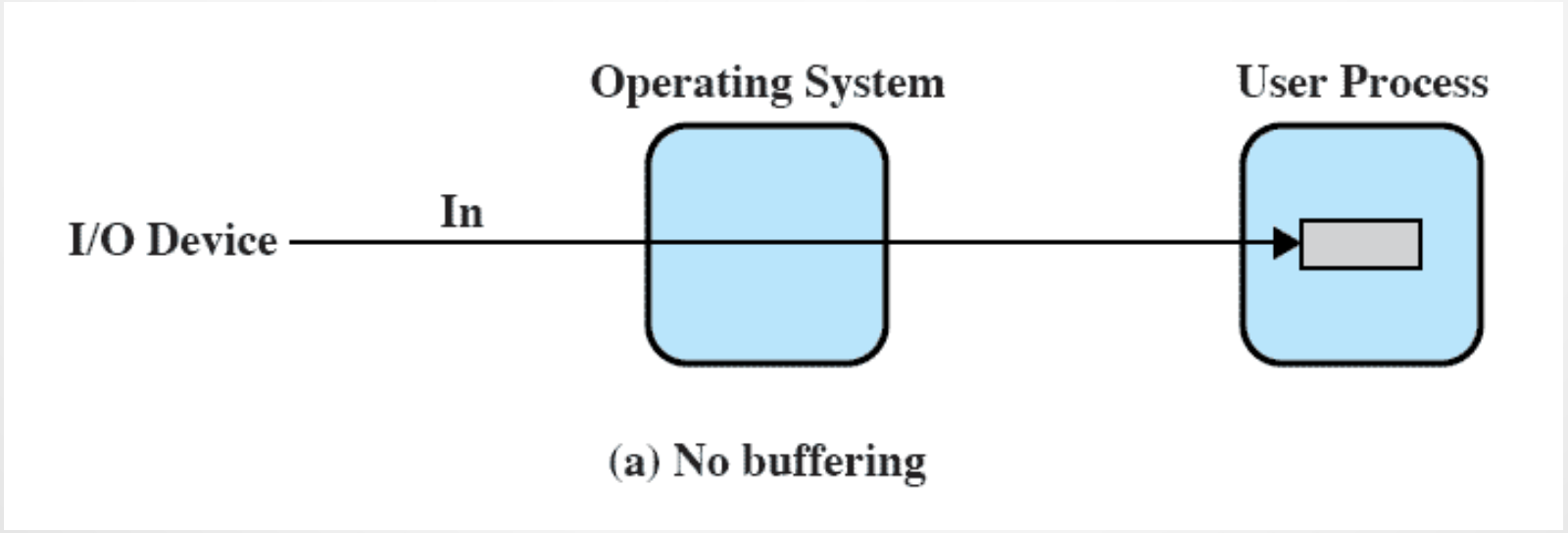
- Information is stored in fixed sized blocks
- Transfers are made a block at a time
  - Can reference data by block number
- Used for disks and USB keys

Stream-Oriented Buffering

- Transfer information as a stream of bytes
- Used for terminals, printers, communication ports, mouse and other pointing devices, and most other devices that are not secondary storage

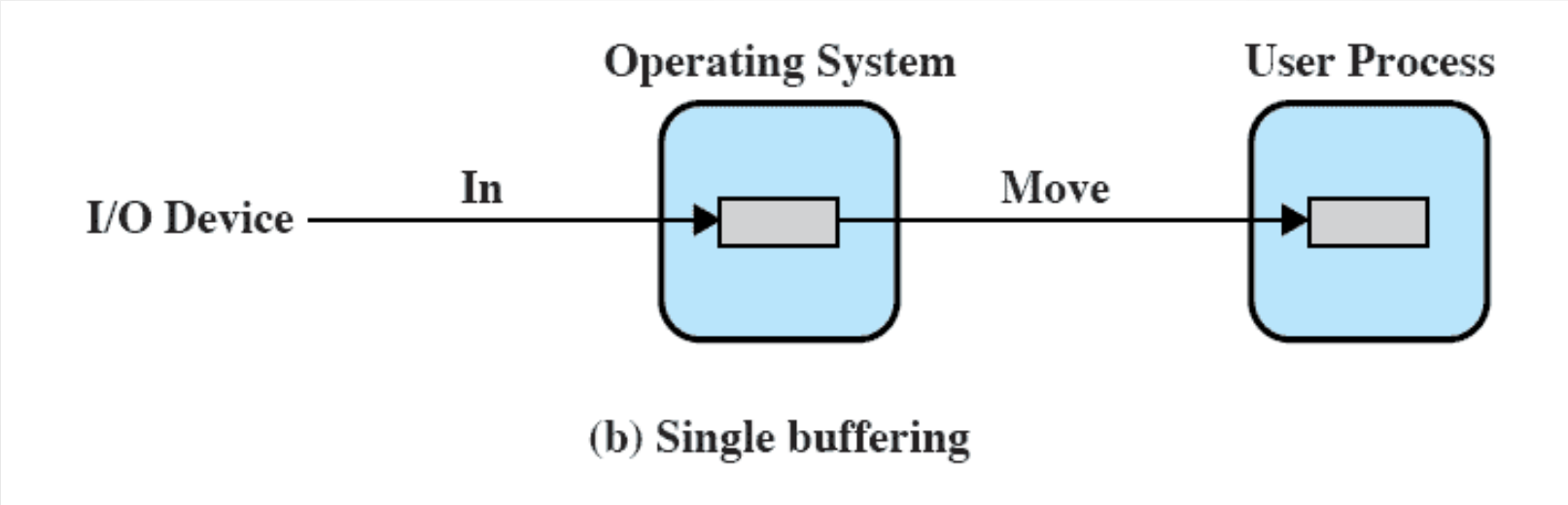
No Buffer

- Without a buffer, the OS directly access the device as and when it needs



Single Buffer

- Operating system assigns a buffer in main memory for an I/O request



(b) Single buffering

Block Oriented Single Buffer

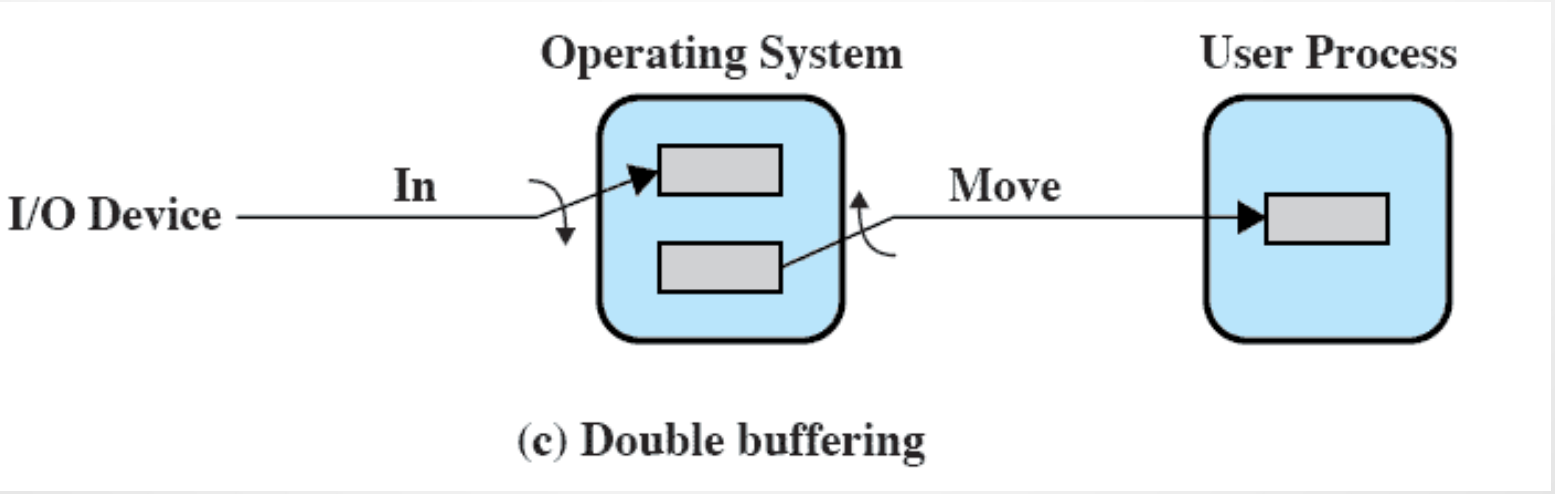
- Input transfers made to buffer
- Block moved to user space when needed
- The next block is moved into the buffer
  - *Read ahead* or *Anticipated Input*
- Often a reasonable assumption as data is usually accessed sequentially

Stream-oriented Single Buffer

- Line-at-time or Byte-at-a-time
- Terminals often deal with one line at a time with carriage return signaling the end of the line
- Byte-at-a-time suites devices where a single keystroke may be significant
  - Also sensors and controllers

Double Buffer

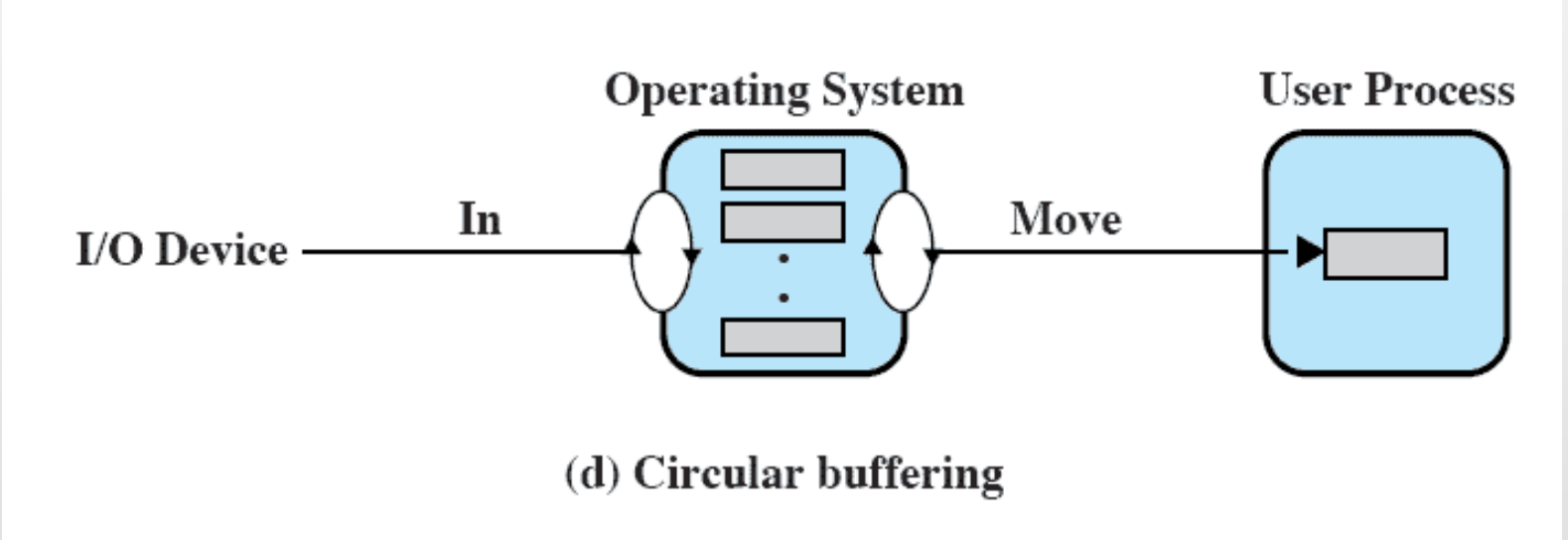
- Use two system buffers instead of one
- A process can transfer data to or from one buffer while the operating system empties or fills the other buffer



(c) Double buffering

Circular Buffer

- More than two buffers are used
- Each individual buffer is one unit in a circular buffer
- Used when I/O operation must keep up with process



(d) Circular buffering

Buffer Limitations

- Buffering smoothes out peaks in I/O demand.
  - But with enough demand eventually all buffers become full and their advantage is lost
- However, when there is a variety of I/O and process activities to service, buffering can increase the efficiency of the OS and the performance of individual processes.