The Fundamental Knowledge of System Design — (6) — Buffer

The main purpose of the buffer is to carry out traffic shaping, to organize a large number of small-scale I/Os into a stable small number of large-scale I/Os, so as to reduce the number of responses. In other words, the buffer is used to balance the processing speed at both ends of the system. For example, you cannot write the hard disk with a little bit of data, but accumulate a certain amount of data and write it together in one block.

It is the sixth series of the fundamentals knowledge of system design. You can read my previous articles.

The fundamental knowledge of System Design — (1)

Today, I will share the fundamental knowledge of system design.

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The fundamental knowledge of System Design — (2)

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The fundamental knowledge of System Design — (3)

Servers are the core of today's computational world. Server performance depends on throughput and latency. Generally…

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The fundamental knowledge of System Design — (4)

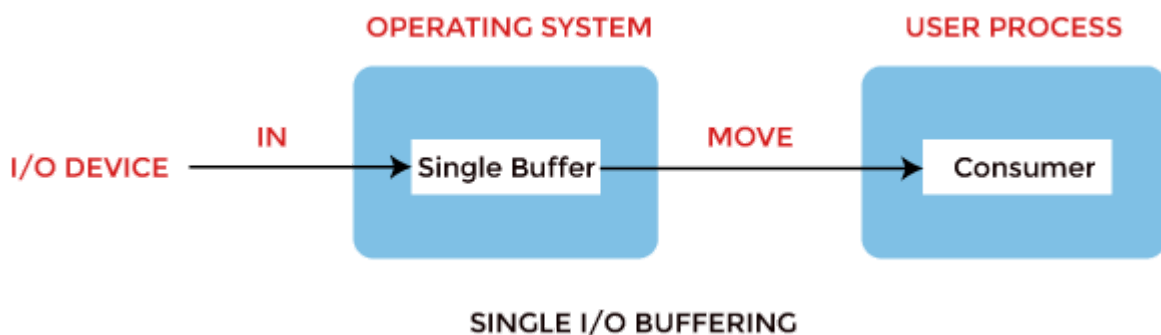System Availability = Availability = Uptime ÷ (Uptime + downtime)

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The Fundamental Knowledge of System Design — (5)

The cache is an intermediate layer introduced to bridge the gap between high-speed devices and low-speed devices, to…

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The storage structure of cache and buffer is different.

https://www.javatpoint.com/buffering-in-operating-system

A buffer is a block of memory that stores data exchanged with external memory. CPU cannot communicate directly with the external memory. For the external memory, the read and write speed is much slower. The buffer is used to store data transmission between 2 devices with different speeds or different priorities. Hence, the buffer can reduce the waiting time for **inter-process communication.** When a device with a faster storage speed communicates with a device with a slow storage speed. To store data from the device with a slower storage speed, the system will store data in the buffer first, and then read the

buffer data when the device with a faster storage speed reaches a certain level. At the same time, a device with a faster storage speed can do other tasks.

For example, **Binary Terrain (BT) format** is used to store elevation grids. BT download requires a long time to hang up, and the computer may run continuously for 24 hours, but the data downloaded by BT is fragmented, which is also reflected in the hard disk writing because the hard disk is a mechanical addressing device. Such fragmented writing will cause long-term high-load mechanical movement of the hard disk, resulting in premature aging and damage to the hard disk. Hence, the newly released BT software applies the concept of the buffer to the memory. The data was temporarily written into the buffer, up to a certain size (512M), and then written to the hard disk at one time. This method greatly reduces the high-load mechanical movement of the hard disk.

For example, if you watch a video online, the video player will preload a few seconds of video resources into the buffer at the beginning. The rate at which you consume the video is the normal playback of the video resource. Under such conditions, the video can be played smoothly. If the network speed is strong, more video resources will be downloaded and accumulated, until the buffer is full, temporarily stop loading, wait for part of the buffer to be emptied and start loading again. Even though the download speed of the video fluctuates, the video you watch is stable in terms of playback rate.

For example, when you have resources to write to the hard disk, the minimum writes size of the hard disk is often a block, usually 4KB. So, the 4KB of data will be stored in the buffer, then will be written to the hard disk, instead of preparing a byte of data each time. At this time, the disk consumes data at a rate of 4KB each time.

During the network connection process, the **Transmission Control Protocol (TCP)** connection maintained in the kernel may have a large amount of data written into the TCP buffer due to the network speed. It is because the application program corresponding to the socket may not be able to consume the data in time.
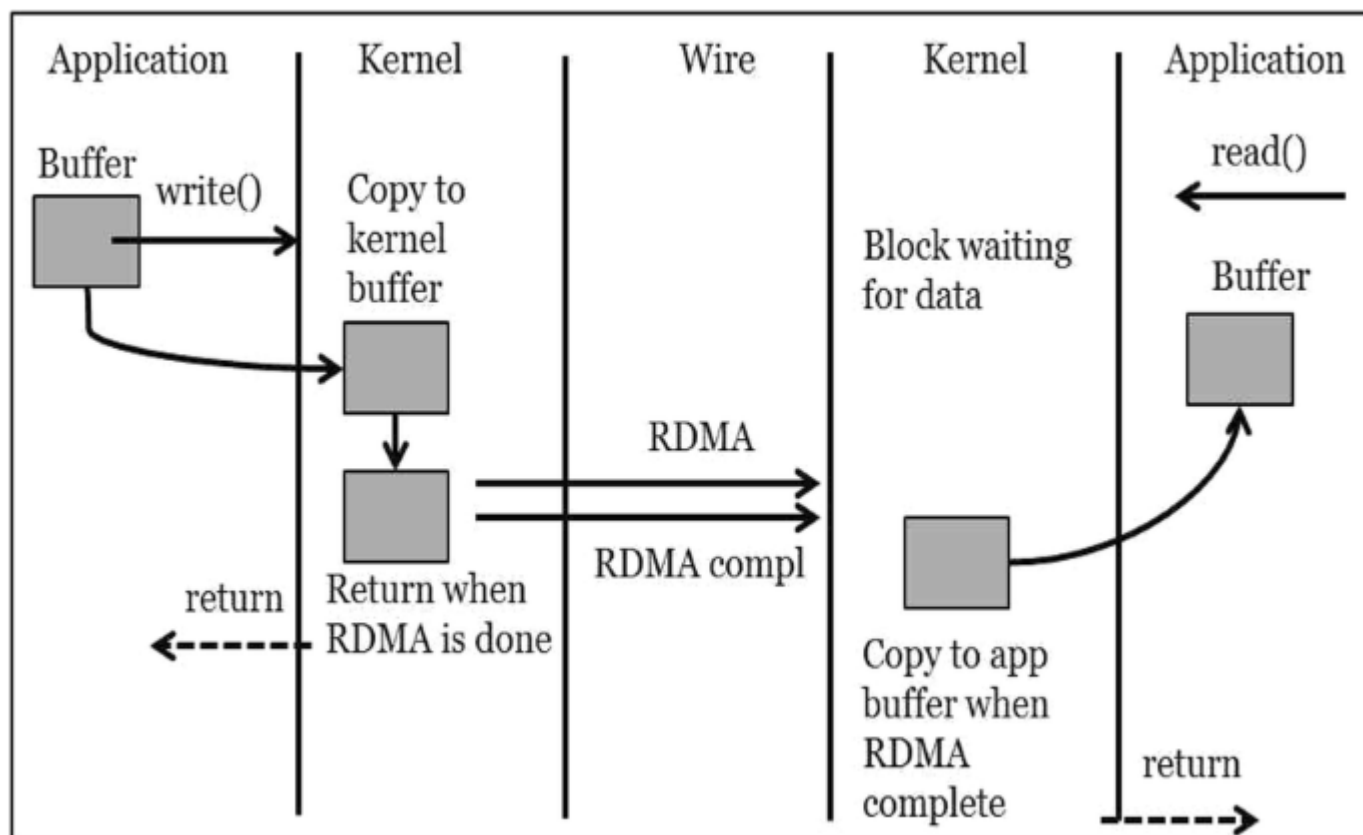
The cache is a storage that is between CPU and memory, increasing the access time by considering the read and write speed of CPU and memory, and allocating data based on the principle of locality. For example, for the spatial locality, the system will add data to the cache which is next to memory blocks. For temporal locality, the least frequently used (LFU) will be applied to remove the data from the cache.

Difference between Buffer and Cache :

S.No.	BUFFER	CACHE
1.	Buffer is used to compensate for difference in speed between two processes that exchange or use data.	Cache is a smaller and fastest memory component in the computer.
2.	It is mostly used for input/output processes.	It is used during reading and writing processes from the disk.
3.	It is a normal storage area on ram for temporary storage.	It is a high-speed storage area for temporary storage.
4.	It stores the original copy of data.	It stores the copy of original data.
5.	It is always implemented in the main memory (RAM).	It is implemented in RAM as well as in Disk.
6.	It is made from dynamic ram.	It is made from static ram.
7.	It does not increase the accessing time.	It increase the accessing speed of CPU.
8.	It can be used in keyboards to edit typing mistakes .	It does not posses such feature.

https://www.geeksforgeeks.org/difference-between-buffer-and-cache/?ref=gcse

Read buffer & Write Buffer

https://hcis-journal.springeropen.com/articles/10.1186/s13673-019-0170-0

The data of the read buffer is not always valid but is generated in real-time. Whenever the buffer is full or the buffer is actively flushed, a read is triggered. For small data, this can reduce the number of reads. For large data, this amount of data read is normalized according to the buffer size. It means that the data fed to the buffer first must be read. it is an obvious sequential access feature.

The write buffer is the corresponding read buffer. For small data writing, it needs to fill up the write buffer. For large data, the big data will be divided into buffer sizes and written in batches. Writing 4K at a time is the most efficient for a certain device. Accumulate small data to 4K in the buffer, write-once or divide large data into 4K for each fragment, write multiple times.

The Various Buffering Techniques

Single buffer

SINGLE I/O BUFFERING

https://www.javatpoint.com/buffering-in-operating-system
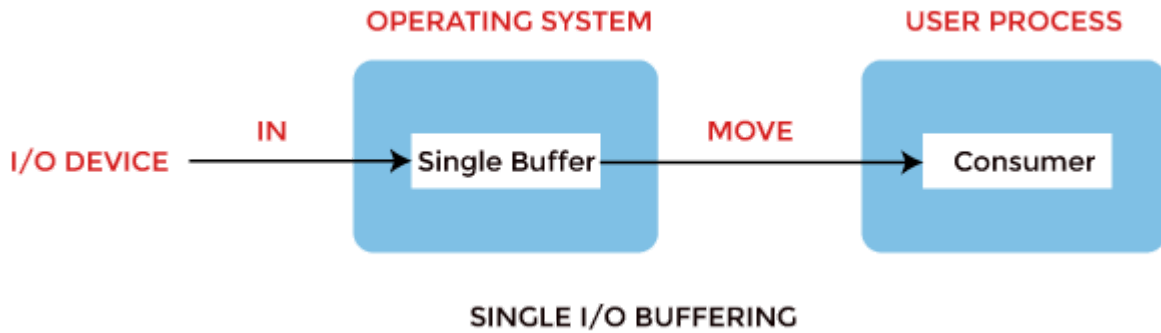
- only one buffer is used

- The producer produces one block of data into the buffer. The consumer consumes the buffer. Once the buffer is empty again, the next block of data will be moved to the buffer.

- Most of the time, a connection always uses a buffer.

- The goal of a single buffer is to provide absoluteI/O consistency, ensure I/O performance, and reduce memory usage as much as possible.

Double buffer

DOUBLE I/O BUFFERING

https://www.javatpoint.com/buffering-in-operating-system
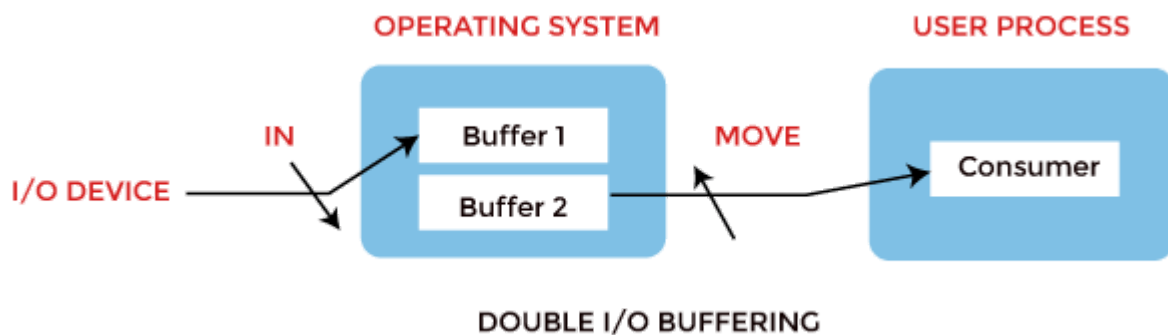
- only two buffer is used

- The producer produces one block of data into buffer 1. While the consumer consumes buffer 2 simultaneously. So, there is no need to wait for filling the buffer. When buffer 1 is full, swap buffer 1 to buffer 2, and the consumer consumes the data of buffer 1.

- It is also known as buffer swapping

- It can reduce the lock time as much as possible because the producer and consumer do not operate on the same buffer. In a small fraction of the time, it is still possible for them to operate on the same buffer

- However, the complexity of the process gets increased. If the process performs rapid bursts of I/O, it may be deficient.
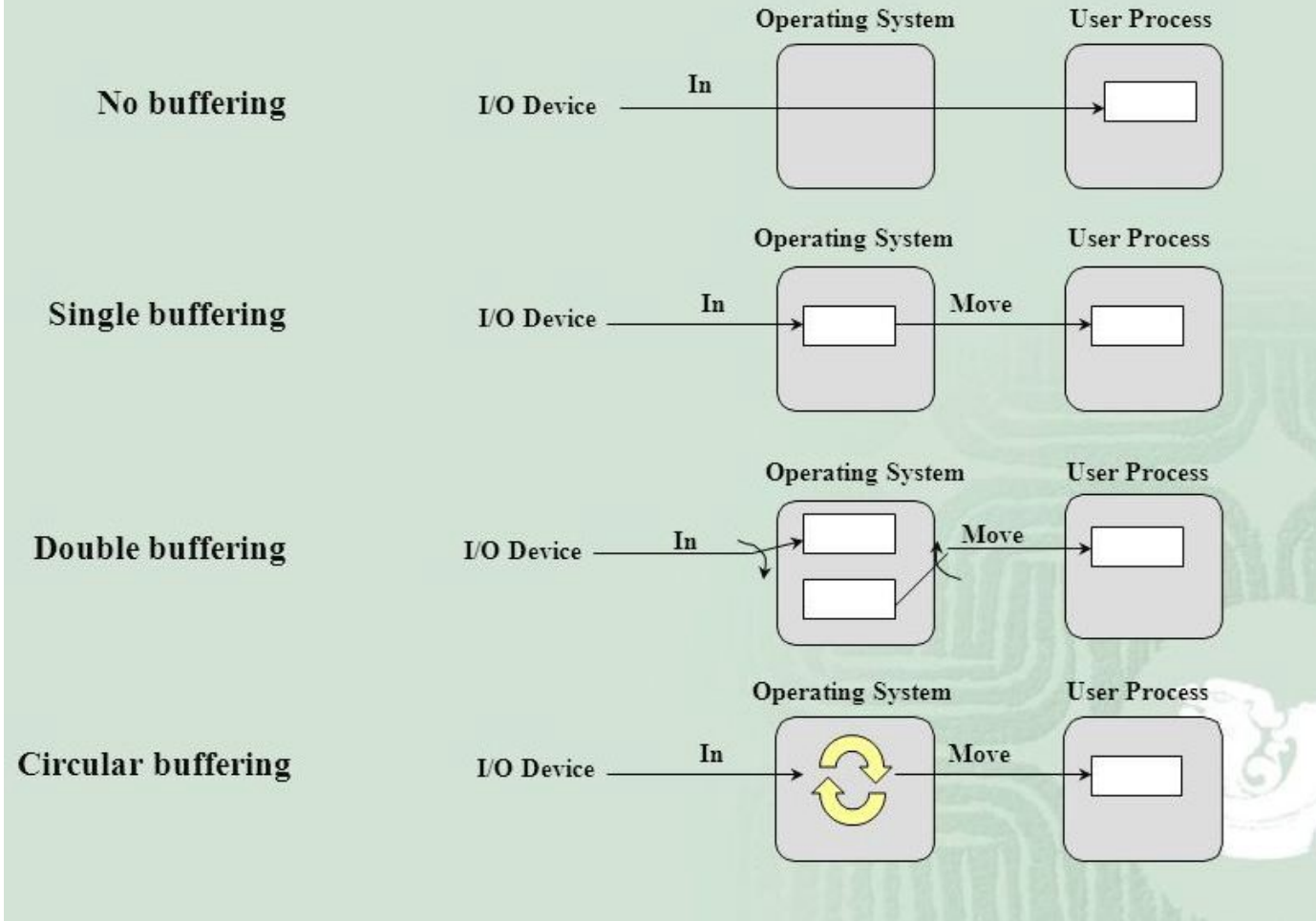
Circular buffer

https://www.javatpoint.com/buffering-in-operating-system
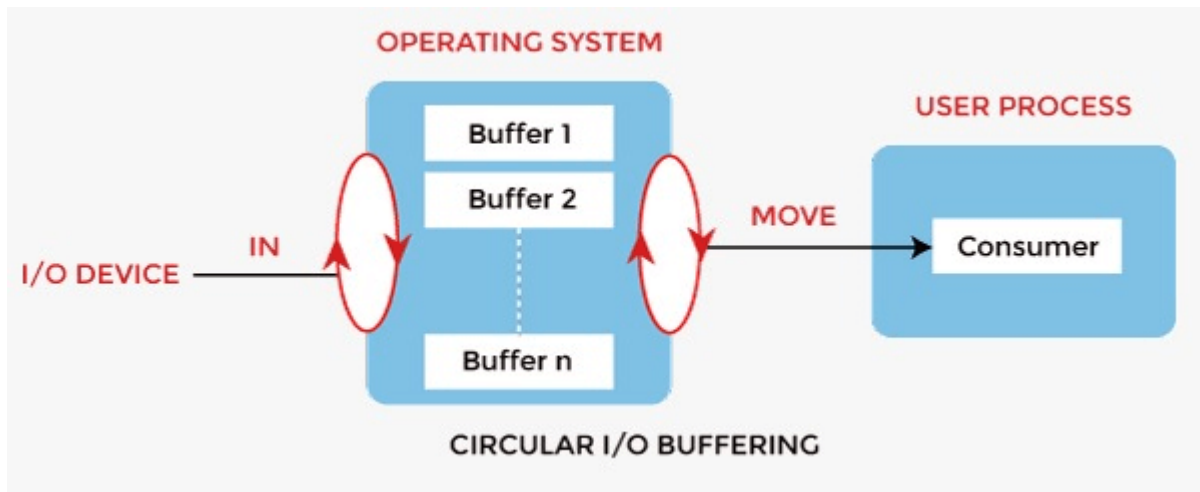
- Only when more than 2 buffers are used.

- The collection of buffers can be called a circular buffer or a ring buffer

- The producer can only fill up to a buffer (n-i) while data in a buffer (i) is waiting to be consumed

- According to the Wikipedia "**Circular buffer**", there are 3 characteristics such as the length of the buffer is fixed, first-in-first-out, and when removing elements to the buffer, the positions of other elements remain unchanged.

- The data transfer rate will increase using the circular buffer rather than the double buffering. It is suitable for the process that performs rapid bursts of I/O.

https://www.ques10.com/p/25210/discuss-input-output-buffer-in-detail/