Sound Card Architecture

Audio Card Buffers

- A buffer is an array of raw uncompressed audio sample data
- The sound that the card produces comes from data in the **primary buffer**
- The audio card may use several **secondary buffers**
- Software may provide additional secondary buffers
- The secondary buffers are combined (mixed) into the primary buffer

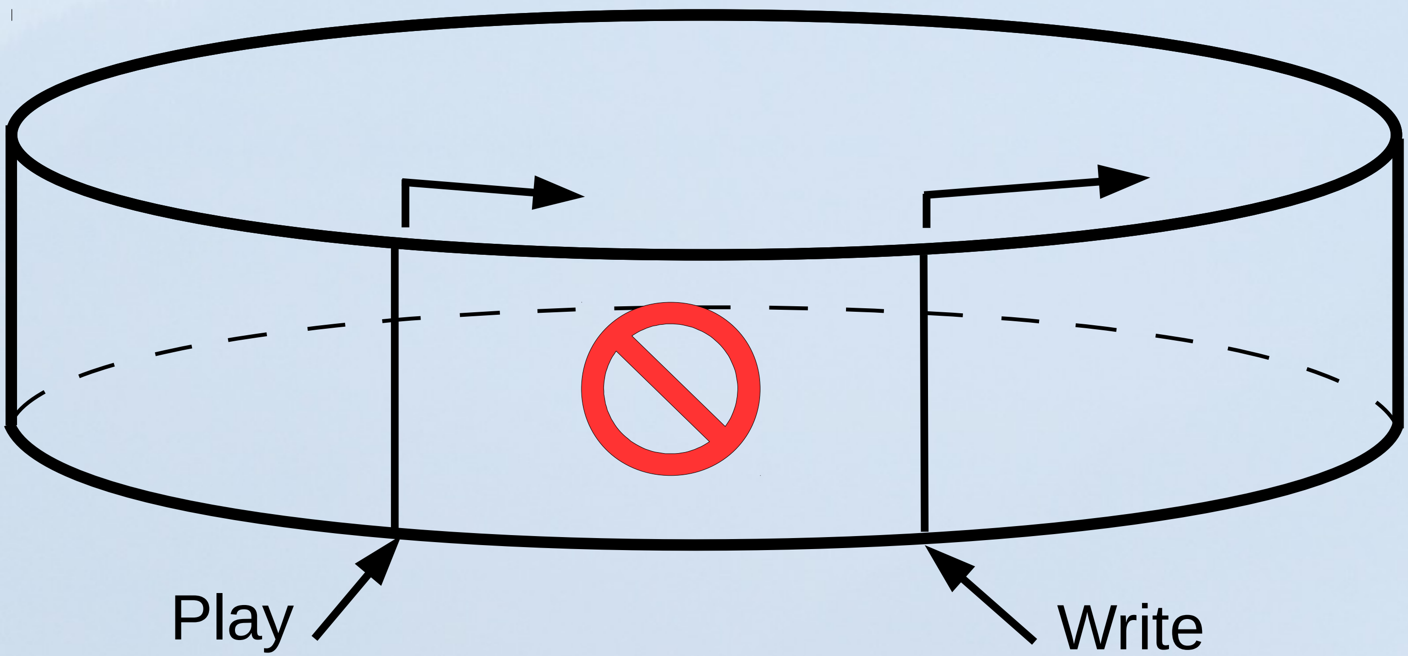
Circular Buffers (1)

- Buffer I/O is circular
  - If the buffer stores *N* frames of audio data the data is accessed at indices

    0,1,2,...,N-1,0,1,2,...,N-1,0,1,2, ... etc ...
- The current position (index) in the buffer is sometimes called the **cursor** position
- Data is written-to and read-from the buffer simultaneously
  - I/O is usually performed in blocks
  - We should not read and write data to the same buffer location at the same time

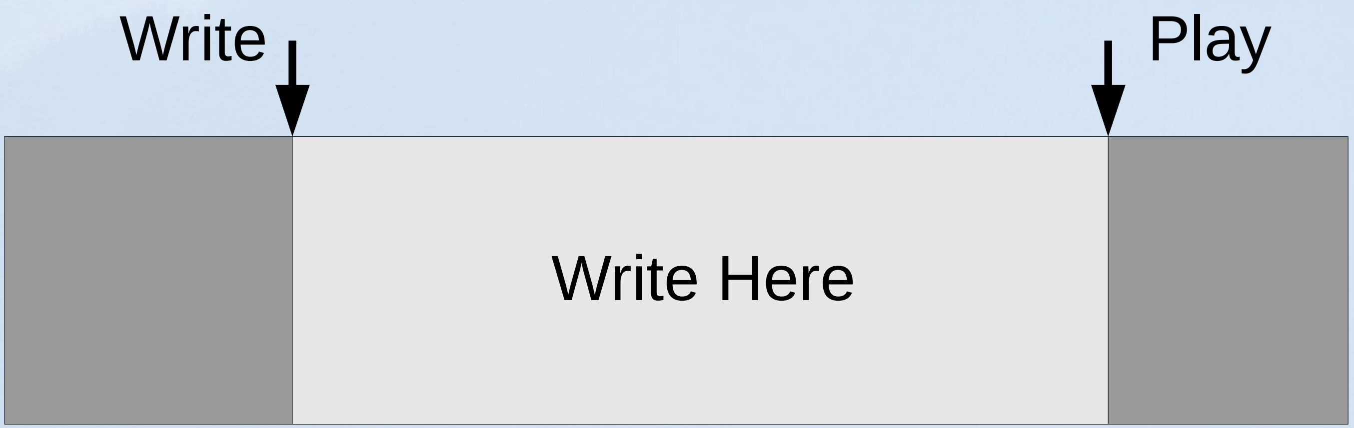
Circular Buffers (2)

- **Play cursor** – index of the next read operation
- **Write cursor** – index of the next safe write operation
- Data should not be written between the two



Circular Buffers (3)

- When writing to the buffer, there are 2 cases
  - *(write cursor)* < *(play cursor)*: only one section needs to be written



Circular Buffers (4)

- *(play cursor)* < *(write cursor)*: two sections need to be written

Circular Buffer Example

- Suppose a circular buffer has length of $N = 400$ frames
  - We write a block of $B = 100$ frames, starting at index $I = 35$. The index J of the next write is

    $$J = I + B = 35 + 100 = 135 \text{ (no wrap)}$$

  - We write a block of $B = 150$ frames, starting at index $I = 345$. The index J of the next write is

    $$J = (I+B) \bmod N = (345+150) \bmod 400 = 95$$

    (wrapped: first block has size *55,* second has size *95*)

Latency

- The time lag between an event and its manifestation is called the **latency** of the event
  - Example: the time between hitting a key on a keyboard and the time we hear start of the note
- Digital audio latency of < 100 ms is desirable
- Circular buffer strategy to maintain a maximum latency time *L*
  - Write at most *RL* frames ahead of the play cursor (where *R* is the sampling rate)

Buffer Latency Example (1)

- Suppose the circular buffer has length $N = 400$ frames, and we want to have a maximum latency of $RL = 60$ frames.
  - If the play cursor is at index $P = 50$, and we are to write starting at index $I = 90$, how many frames should we write?

    max index: $P + RL = 50 + 60 = 110$

    frames to write: $(max\ index) - I = 110 - 90 = 20$

Buffer Latency Example (2)

- [$N = 400$ frames, $RL = 60$ frames]
  - If the play cursor is at index $P = 380$, and we are to write starting at index $I = 10$, how many frames should we write?

    max index: $(P + RL) \bmod N = (380 + 60) \bmod 400 = 40$

    frames to write: $(\text{max index}) - I = 40 - 10 = 30$

  - If $P = 350$, and $I = 390$, how many frames should we write?

    max index: $P + RL = 350 + 60 = 410$

    frames to write: $(\text{max index}) - I = 410 - 30 = 20$