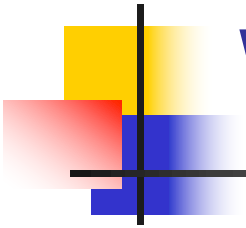
COMP231

External Sort



Why Sort?

- A classic problem in computer science!
- Data requested in sorted order
  - e.g., find students in increasing *gpa* order
- Sorting is useful for eliminating *duplicate copies* in a collection of records
- Problem: sort 1Gb of data with 1Mb of RAM.

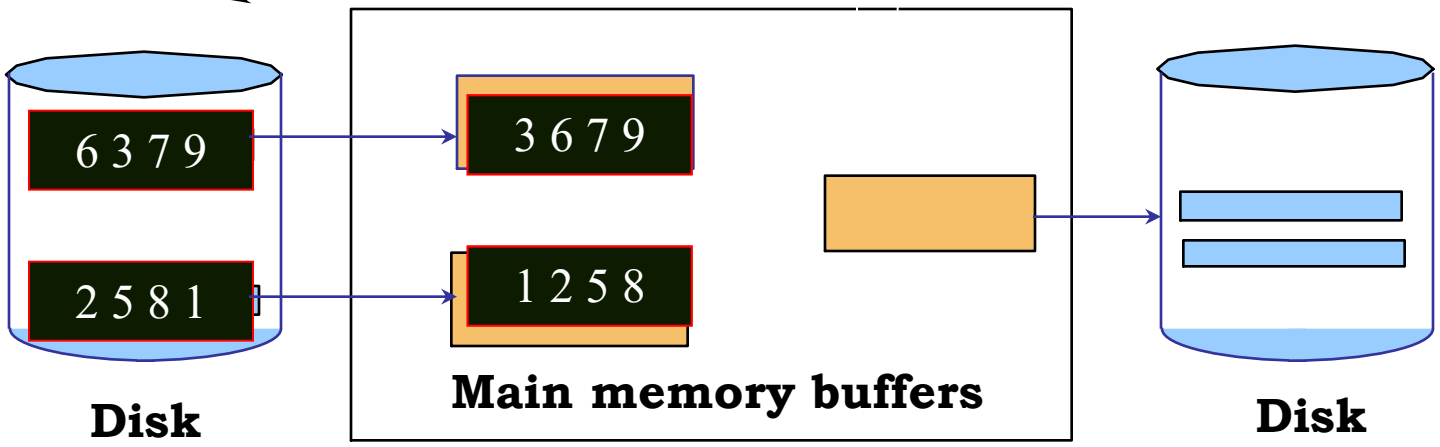
2-Way Sort: Requires 3 Buffers

Cost:

2 pages (reading)

Suppose that 1 page contains 4 numbers.
There are 2 pages.

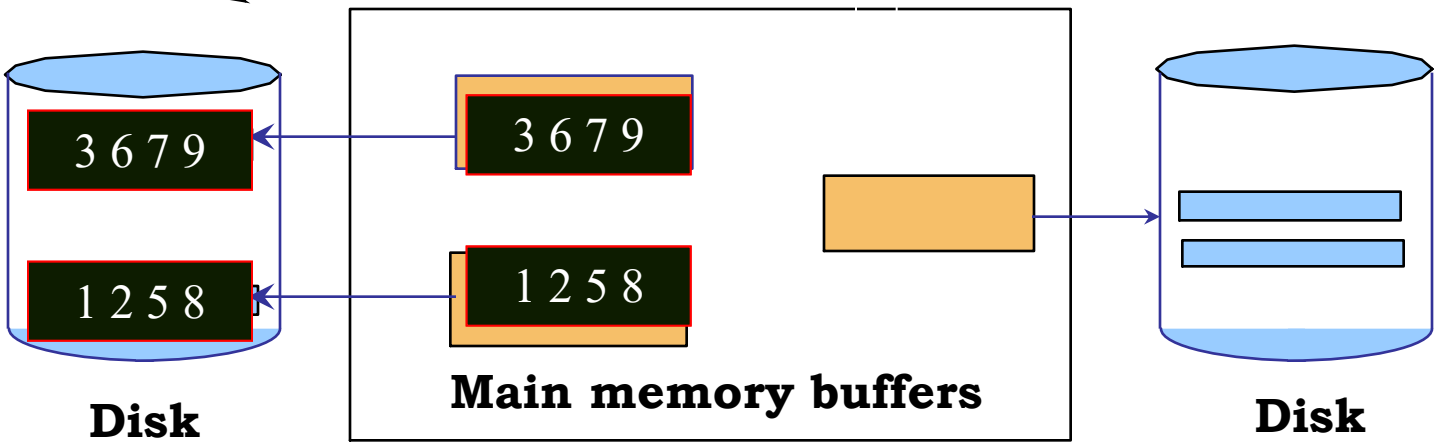
In this example,
•The cost of reading is 2 pages



2-Way Sort: Requires 3 Buffers

Cost:	
Pass 0	2 pages (reading)
Pass 0	2 pages (writing)

In this example,
- The cost of writing is 2 pages

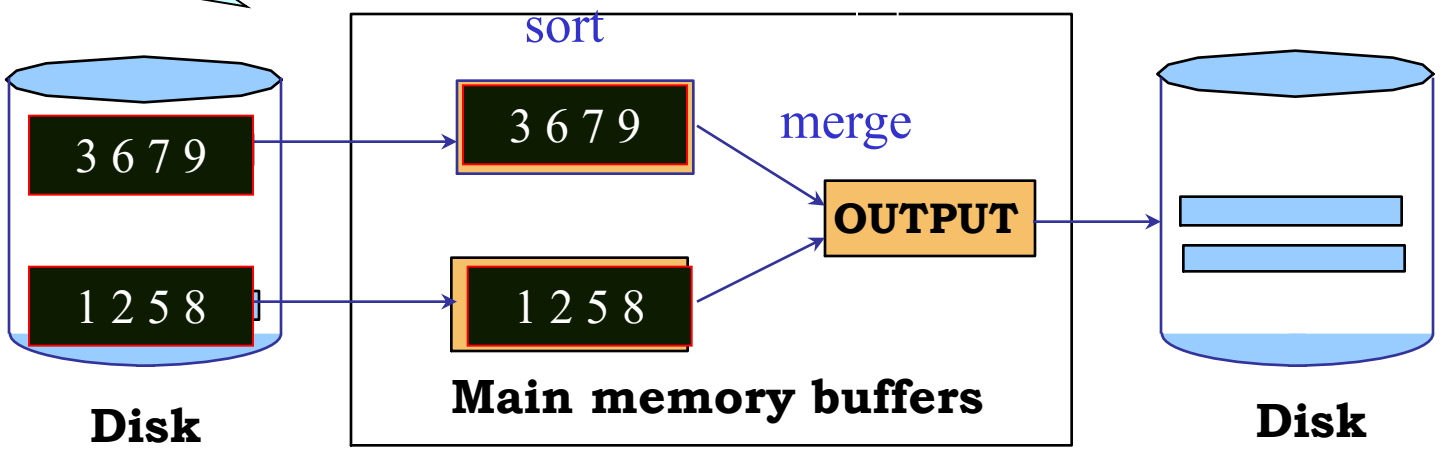


Pass 0

2-Way Sort: Requires 3 Buffers

Cost:	
Pass 0	2 pages (reading)
Pass 0	2 pages (writing)
	2 pages (reading)

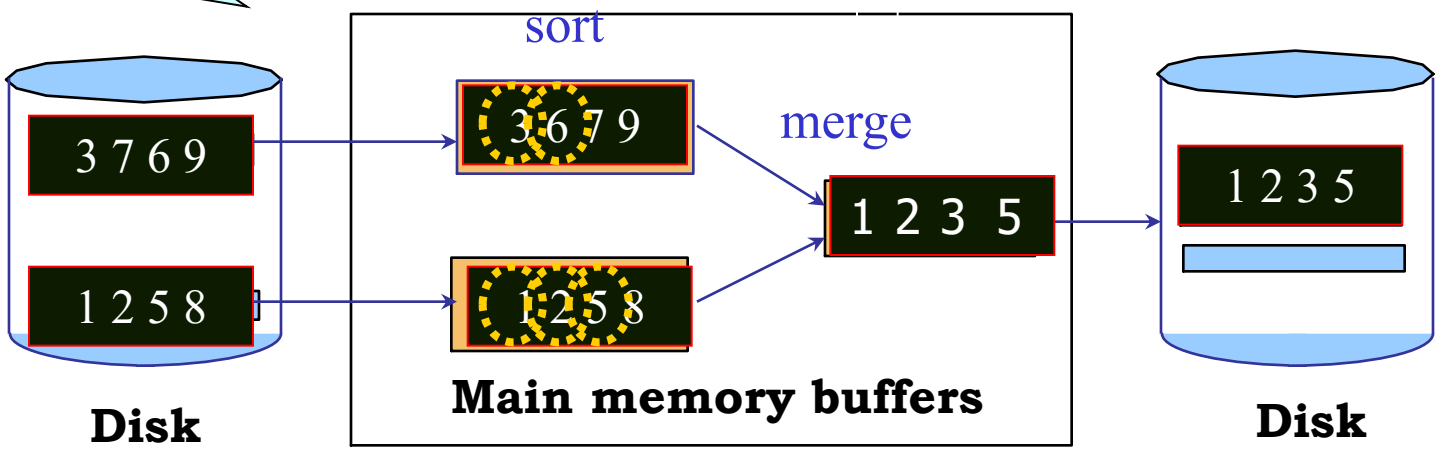
In this example,
- The cost of reading is 2 pages



2-Way Sort: Requires 3 Buffers

Cost:	
Pass 0	2 pages (reading)
Pass 0	2 pages (writing)
	2 pages (reading)
	1 page (writing)

In this example,
- The cost of writing is 1 page

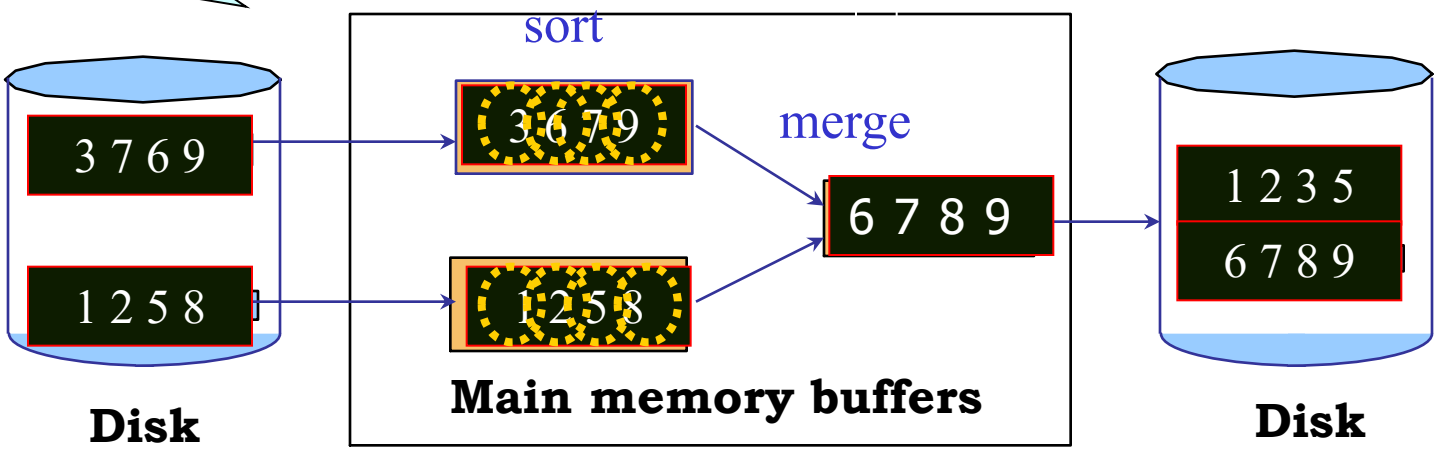


2-Way Sort: Requires 3 Buffers

Cost:	
Pass 0	2 pages (reading)
Pass 0	2 pages (writing)
Pass 1	2 pages (reading)
Pass 1	1 page (writing)
Pass 1	1 page (writing)

Total Cost = 8 pages

In this example,
- The cost of writing is 1 page



Two-Way External Merge Sort

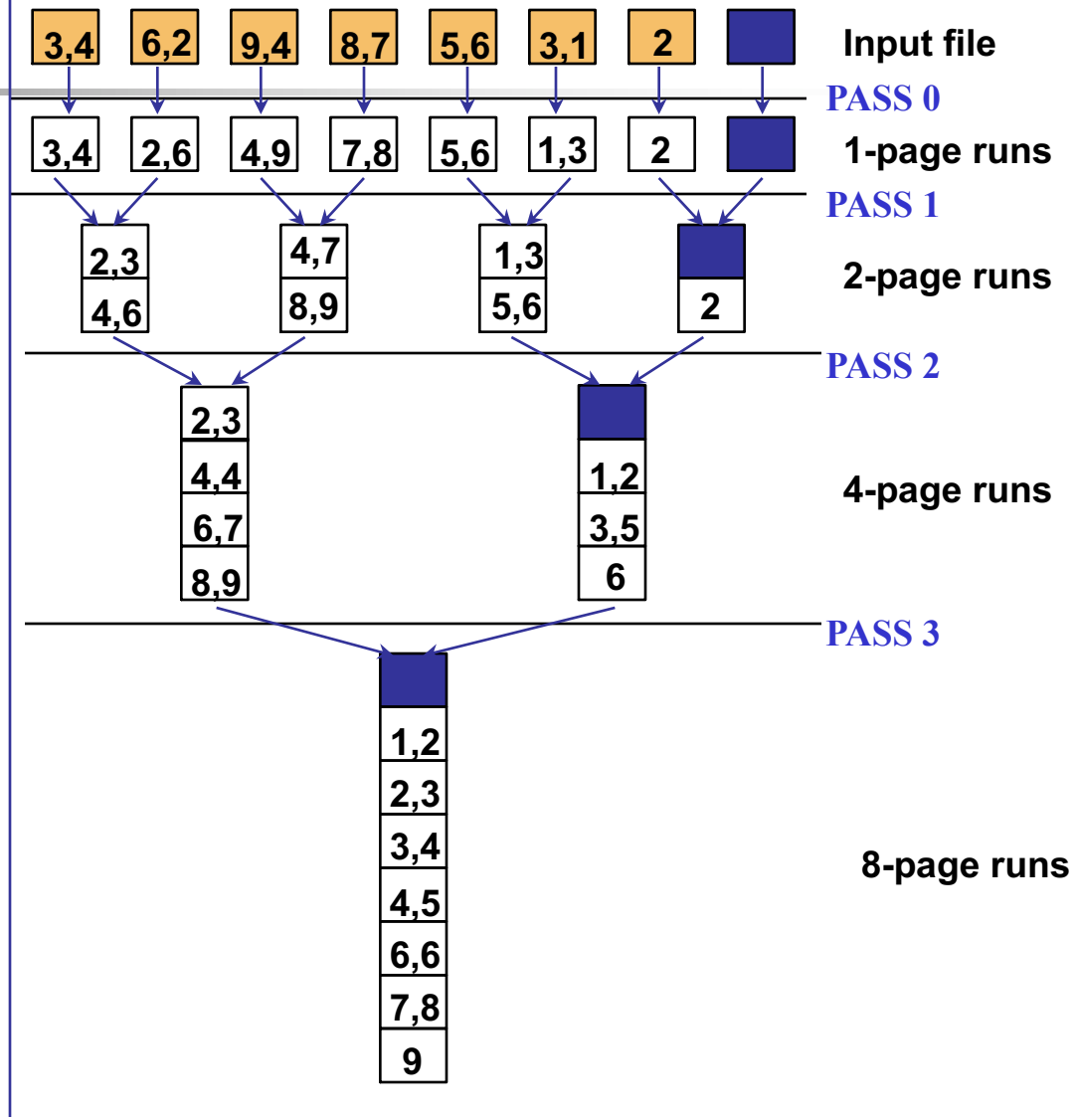
- Each pass we read + write each page in file.
- N pages in the file => the number of passes

$$= \lceil \log_2 N \rceil + 1$$

- So total cost is:

$$2N\left(\lceil \log_2 N \rceil + 1\right)$$

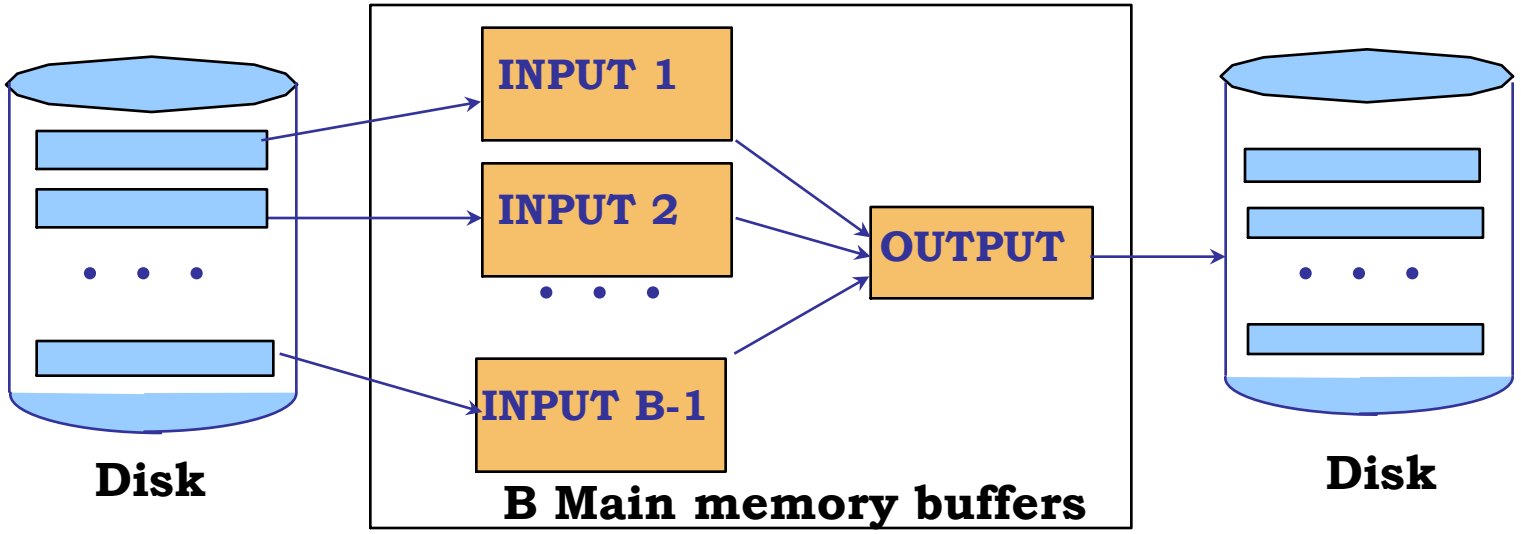
- *Idea:* ***Divide and conquer:*** sort subfiles and merge



General External Merge Sort

☛ *More than 3 buffer pages. How can we utilize them?*

- To sort a file with *N* pages using *B* buffer pages:
  - Pass 0: use *B* buffer pages.
    Produce $\lceil N / B \rceil$ sorted runs of *B* pages each.
  - Pass 2, …, etc.: merge *B-1* runs.



Cost of External Merge Sort

- E.g., with 5 buffer pages, to sort 108 page file:
  - Pass 0: $\lceil 108 / 5 \rceil$ = 22 sorted runs of 5 pages each (last run is only 3 pages)
  - Pass 1: $\lceil 22 / 4 \rceil$ = 6 sorted runs of 20 pages each (last run is only 8 pages)
  - Pass 2: $\lceil 6 / 4 \rceil$ =2 sorted runs of 80 pages and 28 pages
  - Pass 3: Sorted file of 108 pages
- Number of passes: $1 + \lceil \log_{B-1} \lceil N / B \rceil \rceil$
- Cost = 2N * (# of passes)

Number of Passes of External Sort

N	B=3	B=5	B=9	B=17	B=129	B=257
100	7	4	3	2	1	1
1,000	10	5	4	3	2	2
10,000	13	7	5	4	2	2
100,000	17	9	6	5	3	3
1,000,000	20	10	7	5	3	3
10,000,000	23	12	8	6	4	3
100,000,000	26	14	9	7	4	4
1,000,000,000	30	15	10	8	5	4