Deliverables Lessons 7 and 8

Sistemas Operativos

Grado en Ingeniería Informática

Departamento de Ingeniería Informática
Universidad de Cádiz

Deliverable 8.2 Exercise 1

20 minutes

I/O techniques

Consider a disk with blocks of 1 KiB, the data registers of the device controller are 256 bytes and the file records are 128 bytes.
If a process needs to read 15 file records:

1. How many blocks must read the process?
2. How many interruptions will be produced to read these blocks in each of these techniques?
    1. Programmed I/O
    2. Interrupt-driven I/O
    3. Direct Memory Access (DMA)

Solution Deliverable 8.2 Exercise 1

Block = 1KiB, File records = 128 bytes, Read 15 records

1. No. records in 1 block = Block size / Record size
   No. records in 1 block = 1 KiB/128 B/record = 2^{10} B/2^7 B/records = 8 records
   For reading 15 records, we need to read 2 blocks.
2.
   1. Programmed I/O $\longrightarrow$ 0 interruptions
   2. Interrupt-driven I/O $\longrightarrow$ There are 8 interruptions because the device driver data register is 256 bytes (2 records) and we need to read 2 disk blocks (16 records).
   3. DMA $\longrightarrow$ There is 1 interruption after reading 2 file blocks.

Deliverable 8.2 Exercise 2

45 minutes

Linked and indexed allocations

Consider one file with these characteristics:

- Current number of records: 30.000
- Maximum number of records: 38.000
- Record size: 178 B

The disk where the file is saved has blocks of 4 KiB. Addresses in the system are 64 bit width and it uses fixed blocking. Calculate:

1. Blocking factor
2. Number of data blocks assigned to the file.
3. Number of index blocks assigned to the file (only for indexed allocation).
4. Internal fragmentation in the file.
5. If we want to access to the records 10.000 and 10 in this order, how many I/O operations are needed?

Answer the previous questions for:

1. Linked allocation.
2. Indexed allocation with linked indexes.

Deliverable 8.2 Exercise 2 Solution

Linked allocation

Data

1. Current number of records: 30.000
2. Maximum number of records: 38.000
3. Record size: 178 B
4. Block size: 4 KiB
5. Addresses width: 64 bit

1. Blocking Factor

Blocking Factor = Block size / Record size

Blocking Factor = (4 KiB/block - 8 B/block) / 178 B/record
= 4088 B/block / 178 B/record = 22,97 records/block $\rightarrow$ 22 records/block

2. Number of data blocks

Number of data blocks = Current number of records / Blocking Factor

Number of data blocks = 30.000 records / 22 records/block =
1363,63 blocks $\rightarrow$ 1364 blocks

Deliverable 8.2 Exercise 2 Solution

Linked allocation

4. Internal fragmentation

Internal fragmentation = Allocated Space - Used space

Used space = 30.000 records $\times$ 178 B/record = 5.340.000 B

Allocated Space = 1364 blocks $\times$ (4096 - 8) B/block = 5.576.032 B

Internal Fragmentation = 5.576.032 B - 5.340.000 B = 236.032 B

5. I/O operations to access records 10.000 and 10

Record number 10.000 is in block 10.000 / 22 = 454,54 $\rightarrow$ 455

Record number 10 is in the first block of the file.

In order to know which is the first block of the file we need to read the directory file, it is saved in memory and we only need to read it once (1 I/O operation).

As linked allocation presents sequential access we need to do 455 I/O operations in order to access the record number 10.000 and one operation for the record number 10.

Total = 457 I/O operations

Deliverable 8.2 Exercise 2 Solution

Indexed allocation

Data

1. Current number of records: 30.000
2. Maximum number of records: 38.000
3. Record size: 178 B
4. Block size: 4 KiB
5. Addresses width: 64 bit

1. Blocking Factor

Blocking Factor = Block size / Record size

Blocking Factor = 4 KiB/block / 178 B/record = 23,01 records/block $\rightarrow$ 23 records/block

2. Number of data blocks

Number of data blocks = Current number of records / Blocking Factor

Number of data blocks = 30.000 records / 23 records/block = 1.304,35 blocks $\rightarrow$ 1.305 blocks

Deliverable 8.2 Exercise 2 Solution

Indexed allocation

3. Number of index blocks

Number of addresses per block = Block size / Address size

Number of addresses per block = 4 KiB/block / 8 B/address = 512 addresses/block
For 1305 data blocks we need:
1305 addresses / 511 addresses/block = 2,55 blocks $\rightarrow$ 3 index blocks

4. Internal fragmentation

Internal fragmentation = Allocated Space - Used space

Used space = 30.000 records $\times$ 178 B/record = 5.340.000 B

Allocated space = 1305 blocks $\times$ 4096 B/bloque = 5.345.280 B

Internal fragmentation = 5.345.280 B - 5.340.000 B = 5.280 B

Deliverable 8.2 Exercise 2 Solution

Indexed allocation

5. Number of I/O operations to access records 10.000 and 10

Record number 10.000 is in block number 10.000 / 23 = 434,78 $\rightarrow$ 435 (indexed in the first index block).
Record number 10 is in the first data block of the file.
As indexed allocation presents direct access, we need:

- 1 I/O operation to access the directory.
- 1 I/O operation to access the first index block.
- 2 I/O operations to access the data blocks.

Total: 4 I/O operations.

Deliverable 8.4 Exercise 1

ext2 file system

Consider one file with these characteristics:

- Current number of records: 30.000
- Maximum number of records: 38.000
- Record size: 178 B

The disk where the file is saved has blocks of 4 KiB. Addresses in the system are 64 bit width and it uses fixed blocking in an ext2 file system. Calculate:

1. Blocking factor
2. Number of data blocks assigned to the file.
3. Number of index blocks assigned to the file.
4. Internal fragmentation in the data blocks.
5. Internal fragmentation in the index blocks.
6. If we want to access to the records 10.000 and 10 in this order, how many I/O operation are needed?

Deliverable 8.4 Exercise 1 Solution

ext2 file system

1. Blocking Factor

Blocking Factor = Block size / Record size

Blocking Factor = 4 KiB/block / 178 B/record = 23 records/block

2. Number of data blocks

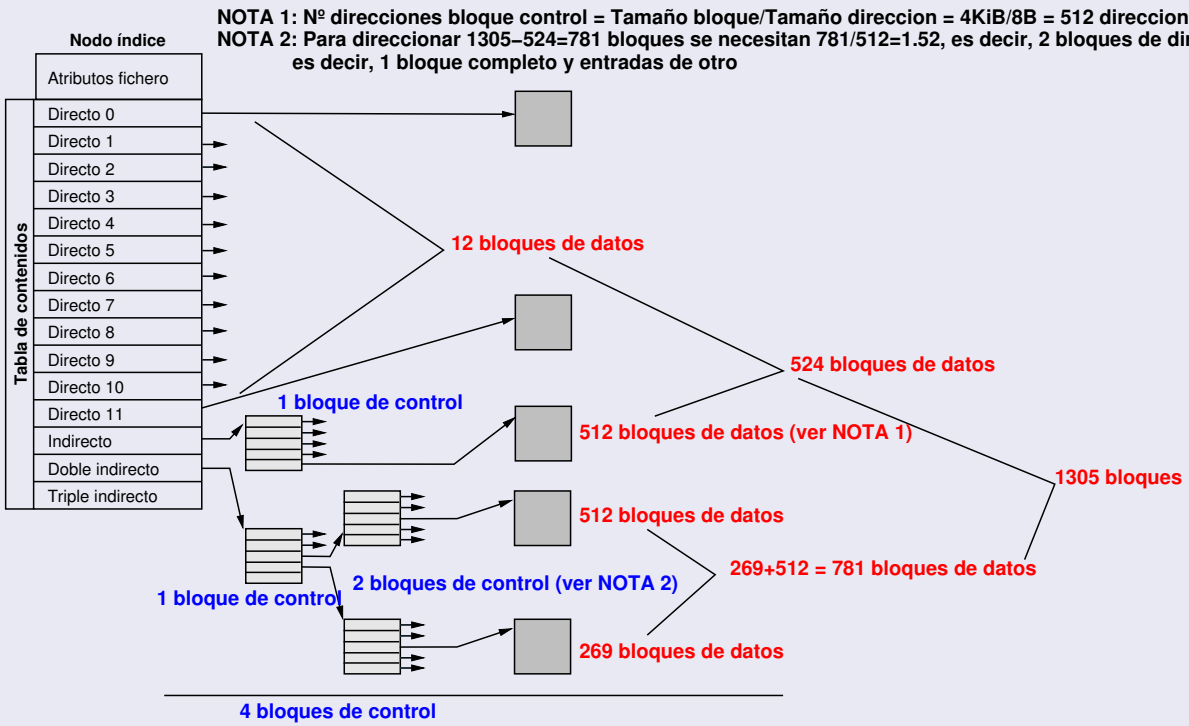
No. of data blocks = Current number of records / Blocking Factor

No. of data blocks = 30.000 records / 23 records/block = 1.304,35 blocks $\rightarrow$ 1.305 blocks

Deliverable 8.4 Exercise 1 Solution

ext2 file system

3. Number of index blocks



Deliverable 8.4 Exercise 1 Solution

ext2 file system

4. Internal fragmentation in data blocks

Internal fragmentation = Allocated space - Used space

Used space = 30.000 $\times$ 178 B = 5.340.000 B

Allocated space = 1.305 blocks $\times$ 4.096 B/block = 5.345.280 B

Internal fragmentation = 5.345.280 B - 5.340.000 B = 5.280 B

Deliverable 8.4 Exercise 1 Solution

ext2 file system

5. Internal fragmentation in index blocks

- The file uses 4 control blocks. Each one can store 512 addresses.
- The control block addressed by the indirect pointer is full, then its internal fragmentation is 0.
- The control block addressed by the double indirect pointer only stores 2 addresses, then its internal fragmentation is:
  512 addresses - 2 addresses = 510 addresses
  510 addresses $\times$ 8 B/address = 4080 B
- Two control blocks are addressed by these pointers, the first one is full (IF=0), the second one stores 269 addresses, then its internal fragmentation is: 512 addresses - 269 addresses = 243 addresses
  243 addresses $\times$ 8 B/address = 1944 B
- Total Internal Fragmentation = 4080 B + 1944 B = 6024 B

Deliverable 8.4 Exercise 1 Solution

ext2 file system

6. Number of I/O operations to access records 10.000 and 10

- Record number 10.000 is in block no. 10.000 / 23 = 434,78 $\rightarrow$ 435 (we must read the index block pointed by indirect simple entry).
- Record number 10 is in the first block of the file, it is pointed by the i-node.
- As ext2 presents direct access:
  - 1 I/O operation to access the directory.
  - 1 I/O operation to access the i-node.
  - 1 I/O operation to access the index block pointed by indirect simple entry.
  - 2 I/O operation to access data blocks.

Total = 5 I/O operations