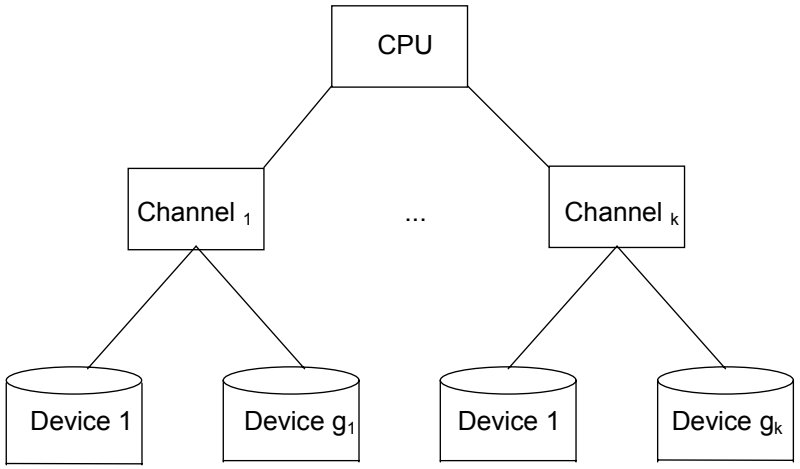
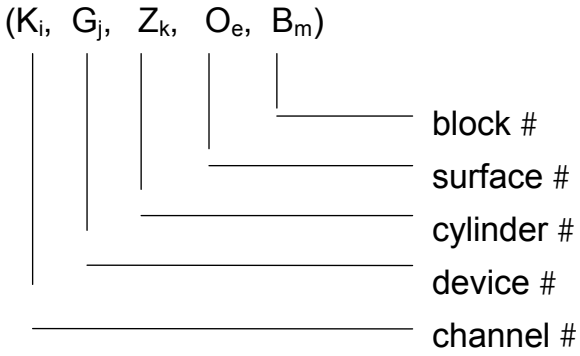
Chapter 1.6.1 File-System

Physical Disk Storage



Address of a disk block:



i.e. interface **PPS** : physical peripheral storage with physical blocks (P-Block)

Operations of PPS:

„start channel programm“ in main frames
„call disk driver“ in WS and PC

Abstract peripheral disk store: APS

- Objects: Sets of logical blocks
  e.g. Drive, Minidisk, Segment
  often: | Block | ≠ | P-Block |

- Adressing: as uniformly as possible
  e.g. N x N

- Operations: **read** (Blockaddr, Bufferaddr)
  write (Blockaddr, Bufferaddr)

Motivation for APS:

Segments are freely configurable
  Size of segment, | Block |
  change dynamically
  shadowing of defect P-Blocks
simple addressing, management of free storage

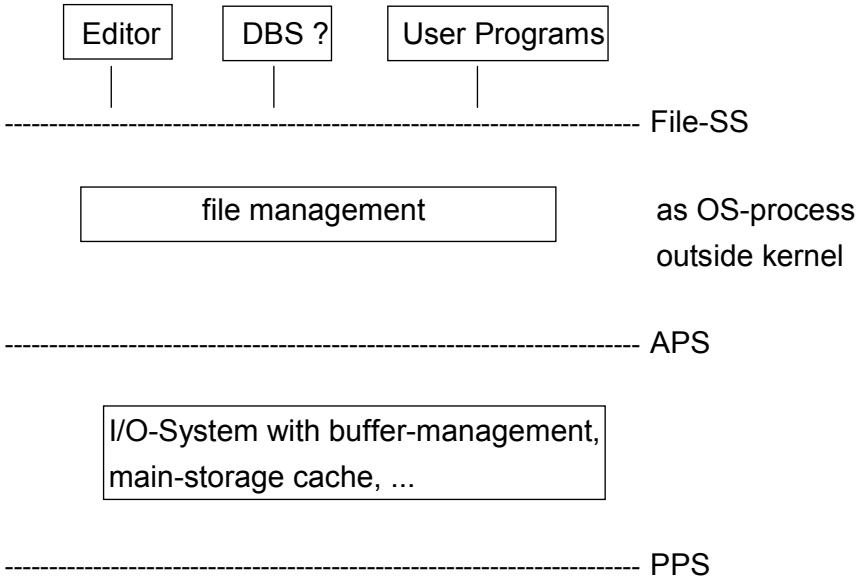
File-Interface, File-System:

- Objects: Files of Records
  rich structure of files and record
  e.g. sequential, random,
  index- sequential via record-keys, ...

- Addressing: various methods, depending on file and record type

- Operations: get, put, ...
  open, close, EOF, ...

Architecture of File-Systems:



Tasks of the I/O-systems

1. Creation and management of block-sets

2. Increase, decrease block-sets

3. Management of P-blocks (free storage)
   mapping: { blocks } $\longrightarrow$ { P-blocks }
   with | block | $\neq$ | P-block |
   replace (shadow) P-blocks
   address book, dictionary

4. Execution of read / write operation calls
   i.e. interpret parameters
   evaluate (search) dictionary
   start and manage PPs calls
   e.g. start I/O
   process interrupts

5. Buffer-Management: mainstore-cache
   disk-caches of main frames in **E**xtended **S**torage **S**ystem (ESS)
   i.e. semiconductor storage with block-interface

Tasks of the file-system

1. create, delete files

various file types
(large variety for mainframes)

2. manage file catalogues
   catalogue = special type of file
   embedding technique, like DB-Schema

3. Storage management for files
   mapping: { Records } ⟶ { block areas }
      e.g. for B-Trees
      tree-node → block
      internal node-structure?

4. Access rights: manage and enforce
   UNIX: via catalogue
   MVS: via RACF

5. Reords: find, read, write
   i.e. extract form blocks and insert into blocks (CPU intensive!!)

Chapter 1.6.2 UNIX File-System

Abstract file system **UNIX**

File-SS ____ Directory-tree

---------- i-Node-SS:
flat set of files
N x N

APS _____ Cache-SS

---------- Block-SS

PPS _____ PPS

1. PPS-Interface:

| P-block | = 512 Bytes

disk format is configurable, tendency towards ≥ 4 KB
   diskread (P-block-Addr., Buffer-Addr.)
   diskwrite (P-block-Addr., Buffer-Addr.)

Intermediate Consideration:

Performance and size of P-blocks

Transfer rate: 3 MB/s

average access time: 15 ms

pure transfer time for | P-block | = 512 B:

$$\frac{512\ \text{B/P-BI}}{3\ \text{MB/s}} = \frac{512\ \text{B} * \text{s}}{3 \cdot 10^6\ \text{B} * \text{P-BI}} \approx 0.2\ \text{ms/P-BI}$$

pure transfer time for | P-block | = 4 KB ≈ 1.6 ms/P-BI

Effective performance with 512 B/P-BI:

$$\frac{512\ \text{B}}{15.2\ \text{ms}} = \frac{512\ \text{KB}}{15.2\ \text{s}} = 33.7\ \frac{\text{KB}}{\text{s}} \approx 1.1\%$$

Effective performance with 4 KB:

$$\frac{4096\ \text{B}}{16.2\ \text{ms}} = \frac{4\ \text{MB}}{16.2\ \text{s}} = 252.8\ \frac{\text{K}}{\text{s}} \approx 8.4\%$$

Effective performance of disks grows nearly linearly with P-block size!!

(general formula?)

2. Block-SS:

- Objects: logical devices with dev #
  ~ block-sets
  | block | = 512 B

- Addressing: (dev #, block #)
  0, 1, 2, ...

- Operations: **strategy** for read and write
  with **control-block** for parameters:

R/W-Flag
Addr. of a Cache-Block in AS
Block-Addr.
Error-Flags
Done-Flag (for asynchronous read, write: interrupt triggered?)

open
close
mount
} for exchanging of devices

3. Cache - SS

- Objects and addressing: (dev #, block #)
  i.e. identical with Block-SS

- Operations:

READS	:	read synchronously
READA	:	read ahead, asychronously e.g. for Editor
WRITES	:	synchronous write, i.e. write immediately and wait
WRITEA	:	asynchronous write, i.e. write immediately, don`t wait
WRITED	:	write deferred, leave open time of physical write, large potential for optimization
FLUSH Buffer	:	physical write through to disk of all pending WRITES, WRITEA, WRITED orders, which have not been completed yet.

all physical operations with strategy
most frequently: READS; WRITED

Example for optimization:

Reduction of physical transports between disk and AS and of arm positioning

WRITED (3,17)
READS (3,17)
WRITED (3,17)
WRITEA (3,17)
WRITED (3,18)

Other Caches:

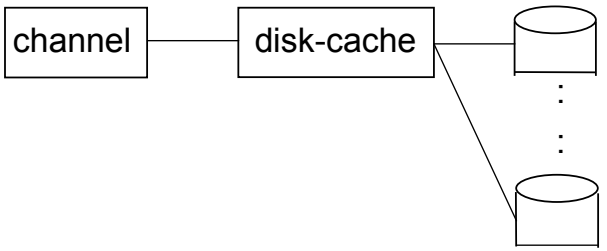
HW-Cache: CPU — Cache — AS

on Chip

today > 95% of all storage accesses from Cache

DB-Cache: see later, chapter 5.5

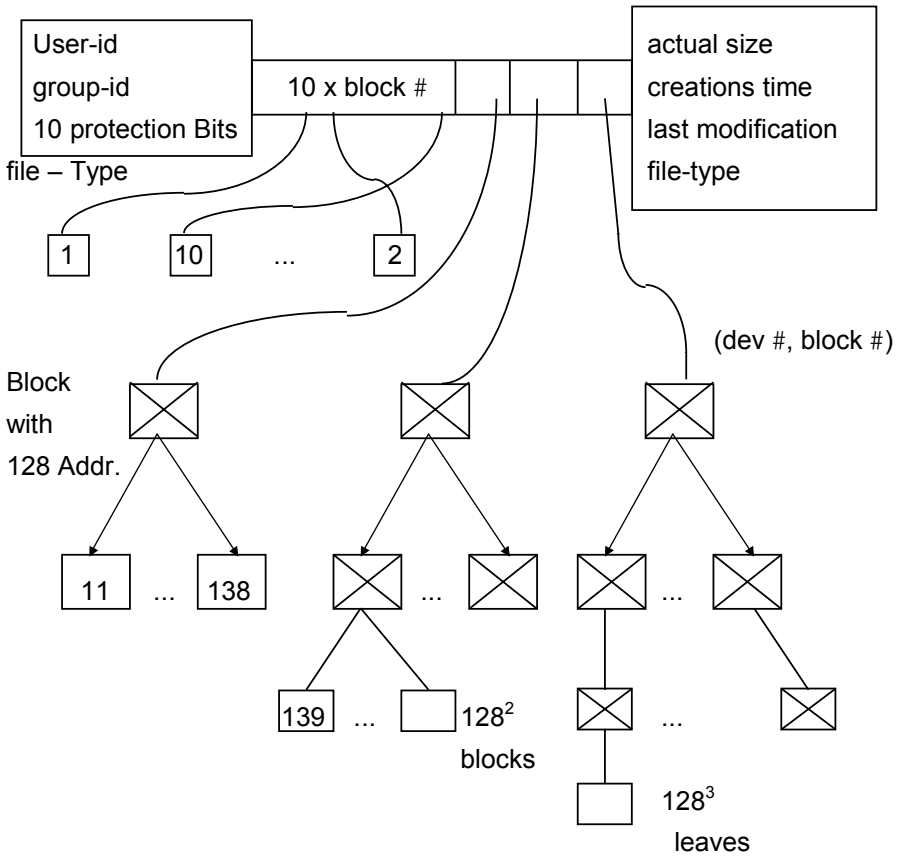
Disk-Cache: channel — disk-cache



4. i-Node SS:

i ~ file # ~ Index of i-Node entry in special table = i-List (flat catalogue)

i - Node ~ file descriptor with fixed format:



2 113 674 blocks

maximal file size ~ 1 GB

1.082.201.088 Bytes

today by far too small e.g. for OMNIS and in general for DB applications

block assignment to files dynamically, i. e. only little physical clustering or random accesses even for sequential reading of a file (compensation by caching techniques)

- Objects: files of D-blocks
  D-block = leaf of i-Node tree

- Addressing: (i, b #)
  Dictionary: {(i, b#) → {(dev #, block #)}
  evaluation via i-Node tree

- Location of i-List: fixed, known area on Device

- Operations:
  i-Nodes: create, delete, read, write
  i-Node list: manage tree storage!
  Block-assignment to files dynamic, implicite
  Evaluation of dictionary:
  e.g. i-read (7, 19) → READS (2,326)
  (i, b #) → (dev #, block #)

5. Directory and File-SS

Directory-tree above flat i-Node files. Directory is special file with references

(pointers) to sons, father, itself.

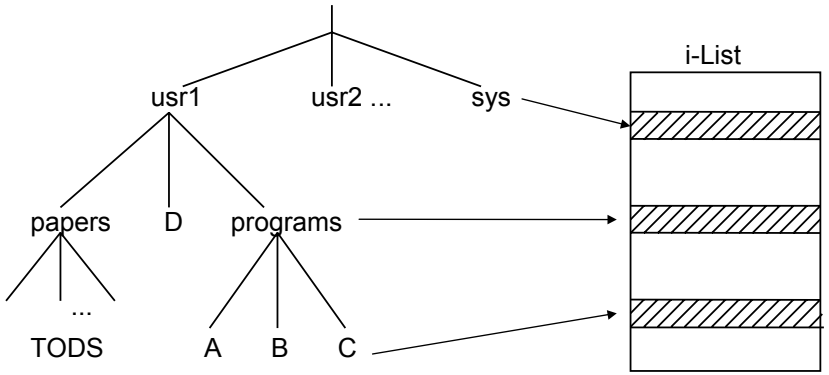
3 variants of files:

- directories
- „normal“ files
- „device files“ (devices are treated like files)

Directory Tree

Internal nodes are directories

Leaves are normal files or Devices



Path names: /usr1/papers/TODS

Current directory: e.g. /usr1

Identification of files:

- complete path names: /usr1/ papers/TODS
- rel. to current directory: papers/TODS
  without / in front

Directory Structure: only references to i-Nodes, Info about file in i-Node:

•	i_1
• •	i_2
papers	i_3
D	i_4
programs	i_5

{for usr1 itself}

{for father-node}

content of usr1 → this directory file „user 1“ has itself i-Node with # i_1

similar directories for

/, usr2, sys, papers, programs

Note: i-Node tree is optimized for directories?

Sequence of Operations at Cache-SS

for /usr1/D

READS (1,1) {read block from i-List with i-Node # 1 for /-directory, location is known}

extract 1-node

READS {search D-blocks of /-directory for (usr1, j)}
READA

with Index j compute Block # J of that block of the i-List, which contains i-Node j for directory usr1.

READS (1, J)

extract i-Node with # j for usr1

READS {search D-blocks of usr1-directory for
READA entry (D, k)}

with Index k compute Block K, which contains i-Note k for File D

READS (1, K)

extract i-Node with # k for D

{up to here opening procedure for file D}

READS ... {read leaves of D, e.g. sequentially}

General Access Pattern:

for directories: 1. fetch i-Node (with direct access to i-list)
2. search leaves of directory file for desired entry

for normal files: 1. fetch i-Node
2. process leaves of i-Node tree

accesses to blocks of i-list are very frequent, caching!

i-Node itself is root of an access structure tree, needed very frequently,

where should it be stored?

- Cache
- file-management
- address space of the process who manages the file

Operations:

for dir files: <name>.dir

- MKDIR
- RMDIR
- CHDIR
- LS

for normal files:

CREATE	
UNLINK	update of the corresponding directories
LINK	
OPEN	fetch i-node
CLOSE	
READ	sequentially n bytes from file position,
WRITE	position file show Info in i-list entry
SEEK	
STAT	

Access Control in UNIX:

- no passwords on file level, only via user-id and user group
- every file has owner
- 10 Protection Bits
  - 9 are read/write/execute for owner/group/all others
  - 1 bit for privileged programs (i.e. special rights during access to file,
    only indirectly via authorized program)

Operations:

CHMOD: change access rights
(only for owner)

CHOWN: change owner

Note: DBS needs more refined access control, e.g. single attributes
views, etc.