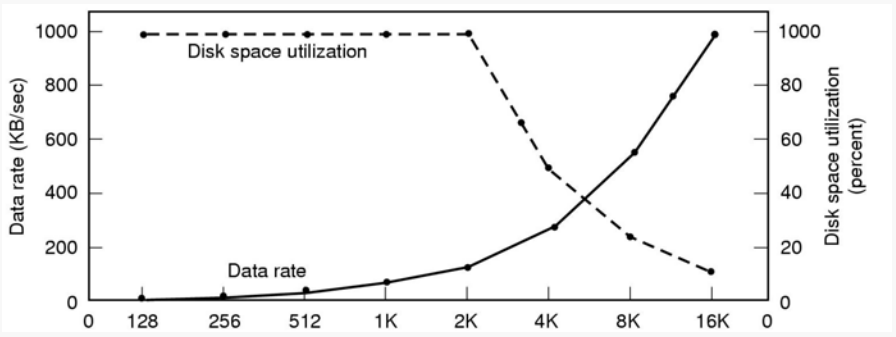
Blocksize Trade-Offs

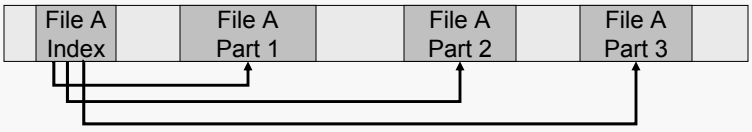


Assume all files are 2KB in size (observed median filesz is about 2KB)

- Larger blocks: faster reads (because seeks are amortized & more bytes per transfer)
- More wastage (2KB file in 32KB block means 15/16th are unused)

Source: Tanenbaum, Modern Operating Systems

Indexed Allocation

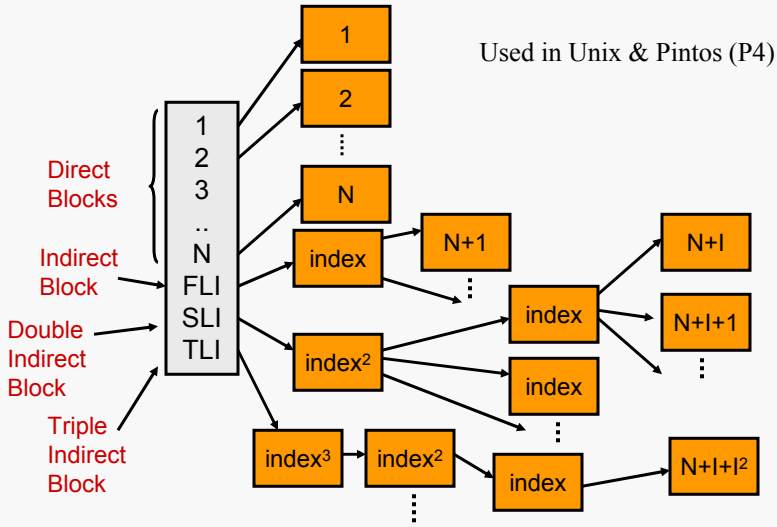


Single-index: specify maximum filesize, create index array, then note blocks in index

- Random access ok – one translation step
- Sequential access requires more seeks – depending on contiguous allocation

Drawback: hard to grow beyond maximum

Multi-Level Indices



Multi-Level Indices

If filesz < N * BLKSIZE, can store all information in direct block array

- Biased in favor of small files (ok because most files are small…)

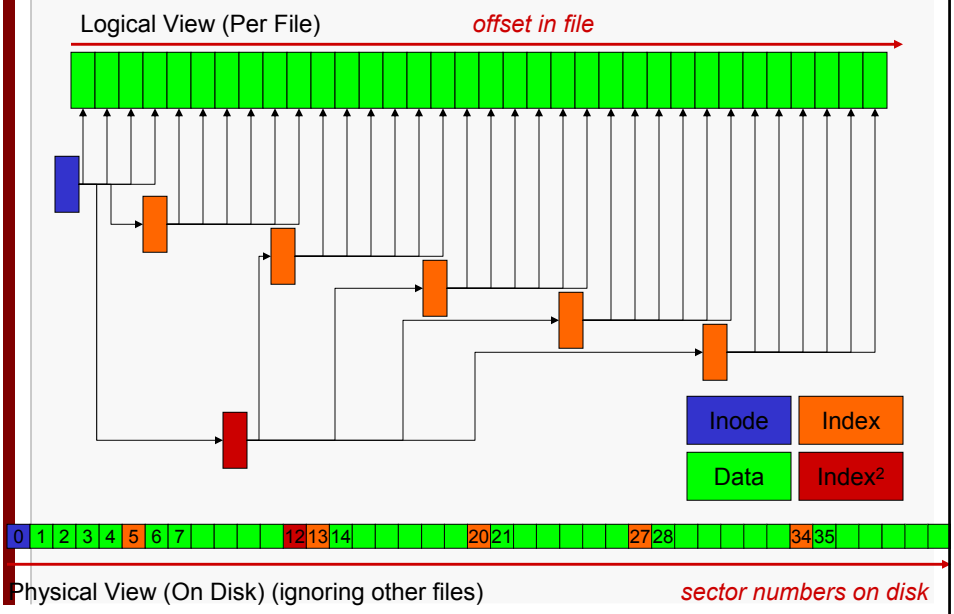
Assume index block stores I entries

- If filesz < (I + N) * BLKSIZE, 1 indirect block suffices

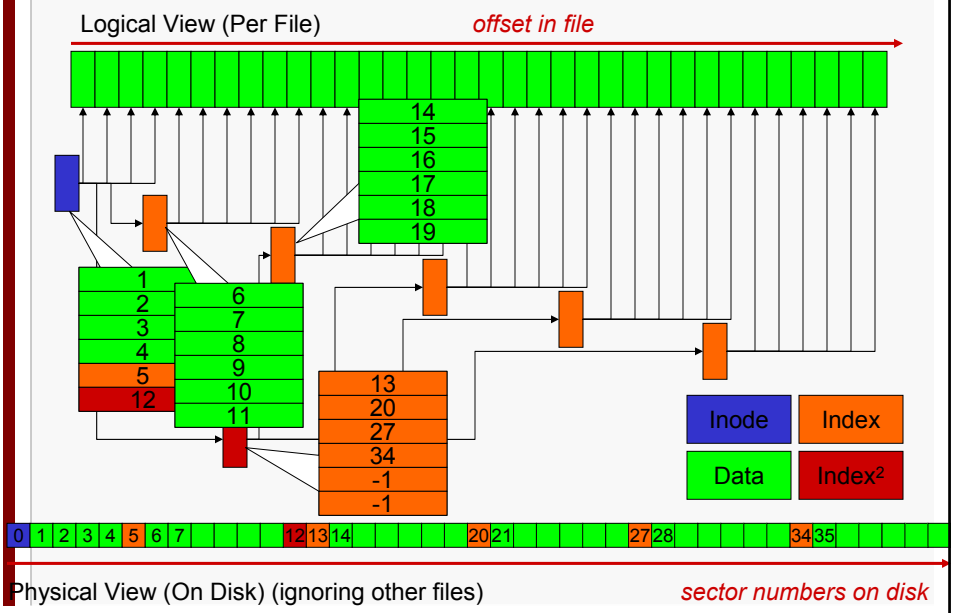
Q.: What's the maximum size before we need triple-indirect block?

Q.: What's the per-file overhead (best case, worst case?)

View

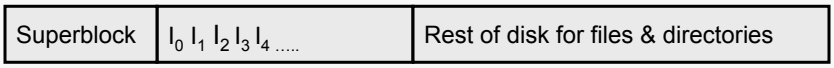


Details

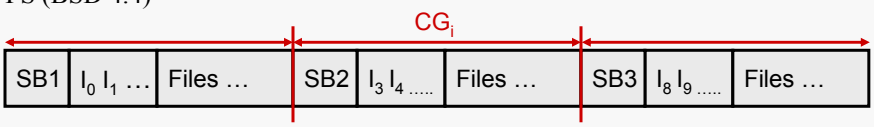


Storing Inodes

Unix v7, BSD 4.3



FFS (BSD 4.4)



Cylinder groups have superblock+bitmap+inode list+file space

Try to allocate file & inode in same cylinder group to improve access locality

Positioning Inodes

Putting inodes in fixed place makes finding inodes easier

- Can refer to them simply by inode number
- After crash, there is no ambiguity as to what are inodes vs. what are regular files

Disadvantage: limits the number of files per filesystem at creation time

- Use “df –ih” on Linux to see how many inodes are used/free

Directories

Need to find file descriptor (inode), given a name

Approaches:

- Single directory (old PCs), Two-level approaches with 1 directory per user

Now exclusively hierarchical approaches:

- File system forms a tree (or DAG)

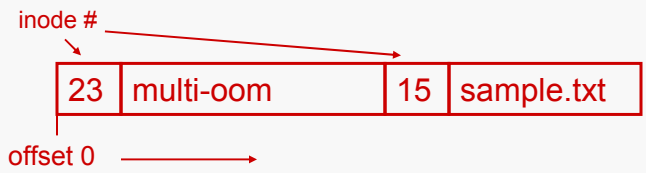
How to tell regular file from directory?

- Set a bit in the inode

Data Structures

- Linear list of (inode, name) pairs
- B-Trees that map name -> inode
- Combinations thereof

Using Linear Lists



Advantage: (relatively) simple to implement

Disadvantages:

- Scan makes lookup (& delete!) really slow for large directories
- Could cause fragmentation (though not a problem in practice)

Using B-Trees

Advantages:

- Scalable to large number of files: in growth, in lookup time

Disadvantage:

- Complex
- Overhead for small directories

Absolute Paths

How to resolve a path name such as "/usr/bin/ls"?

- Split into tokens using "/" separator
- Find inode corresponding to root directory
  - (how? Use fixed inode # for root)
- (*) Look up "usr" in root directory, find inode
- If not last component in path, check that inode is a directory. Go to (*), looking for next comp
- If last component in path, check inode is of desired type, return

Name Resolution

Must have a way to scan an entire directory without other processes interfering -> need a "lock" function
- But don't need to hold lock on /usr when scanning /usr/bin

Directories can only be removed if they're empty
- Requires synchronization also

Most OS cache translations in "namei" cache – maps absolute pathnames to inode
- Must keep namei cache consistent if files are deleted

Current Directory

Relative pathnames are resolved relative to current directory
- Provides default context
- Every process has one in Unix/Pintos

chdir(2) changes current directory
- cd tmp; ls; pwd vs (cd tmp; ls); pwd

lookup algorithm the same, except starts from current dir
- process should keep current directory open
- current directory inherited from parent

Hard & Soft Links

Provides aliases (different names) for a file

Hard links: (Unix: ln)

- Two independent directory entries have the same inode number, refer to same file
- Inode contains a reference count
- Disadvantage: alias only possible with same filesystem

Soft links: (Unix: ln –s)

- Special type of file (noted in inode); content of file is absolute or relative pathname – stored inside inode instead of direct block list

Windows: “junctions” & “shortcuts”