OPERATING SYSTEMS

File Management

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Implementing File-Systems – Disk Space Allocation Methods

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Slides Credits for all the PPTs of this course

- The slides/diagrams in this course are an **adaptation**, **combination**, and **enhancement** of material from the following resources and persons:

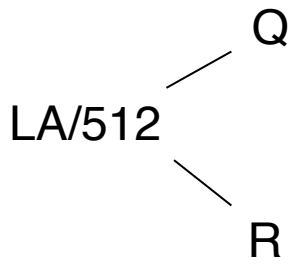
1. Slides of Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne - 9th edition 2013 and some slides from 10th edition 2018
2. Some conceptual text and diagram from Operating Systems - Internals and Design Principles, William Stallings, 9th edition 2018
3. Some presentation transcripts from A. Frank – P. Weisberg
4. Some conceptual text from Operating Systems: Three Easy Pieces, Remzi Arpaci-Dusseau, Andrea Arpaci Dusseau

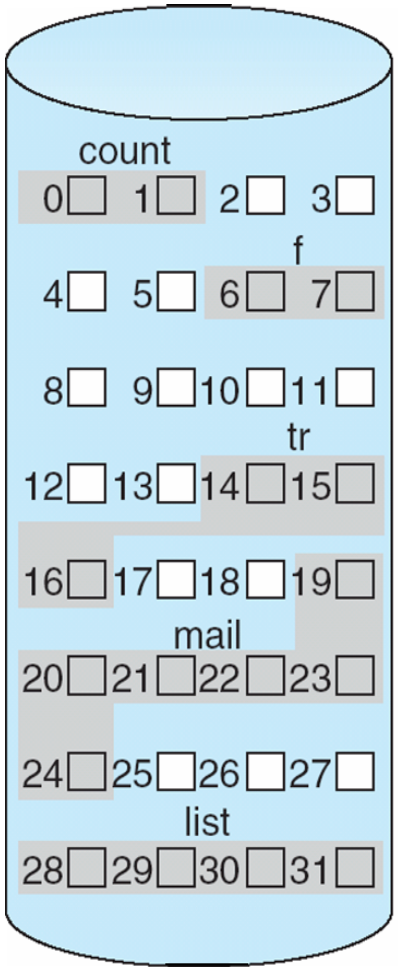
Allocation Methods - Contiguous

- An allocation method refers to how disk blocks are allocated for files:
- **Contiguous allocation** – each file occupies set of contiguous blocks
  - Best performance in most cases
  - Simple – only starting location (block #) and length (number of blocks) are required
  - Supports both sequential and direct access
  - Problems include finding space for file, knowing file size, external fragmentation, need for **compaction off-line** (**downtime**) or **on-line**

Contiguous Allocation

- Mapping from logical to physical





directory

file	start	length
count	0	2
tr	14	3
mail	19	6
list	28	4
f	6	2

- LA – Length of the area allocated for this file
- Q = displacement into index table
- Block to be accessed = Q + starting address
- Displacement into block = R

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Extent-Based Systems

- Many newer file systems (i.e., Veritas File System) use a modified contiguous allocation scheme
- Extent-based file systems allocate disk blocks in extents
- An **extent** is a contiguous block of disks
  - Extents are allocated for file allocation
  - A file consists of one or more extents

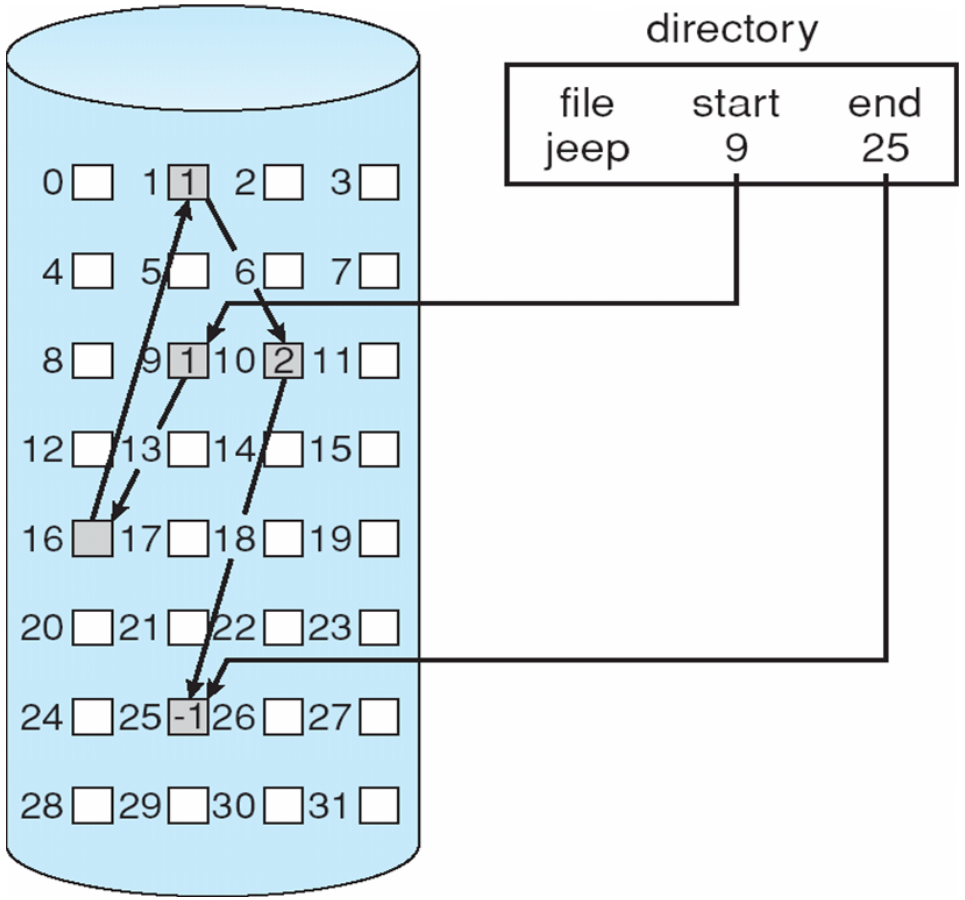
Allocation Methods - Linked

- **Linked allocation** – each file a linked list of blocks
  - File ends with null pointer
  - No external fragmentation
  - Each block contains pointer to next block
  - No compaction, external fragmentation
  - Free space management system called when new block needed
  - Improve efficiency by clustering blocks into groups but increases internal fragmentation
  - Reliability can be a problem
  - Locating a block can take many I/Os and disk seeks

Allocation Methods – Linked (Cont.)

- FAT (File Allocation Table) variation
  - Beginning of volume has table, indexed by block number
  - Much like a linked list, but faster on disk and cacheable
  - New block allocation simple

Linked Allocation



- Each block contains a pointer to the next block.
- If each block is 512 bytes and a disk address (pointer) requires 4 bytes then the user sees blocks of 508 bytes (i.e. some disk space is wasted)
- Collect blocks into multiples called **clusters** and allocate clusters rather than blocks

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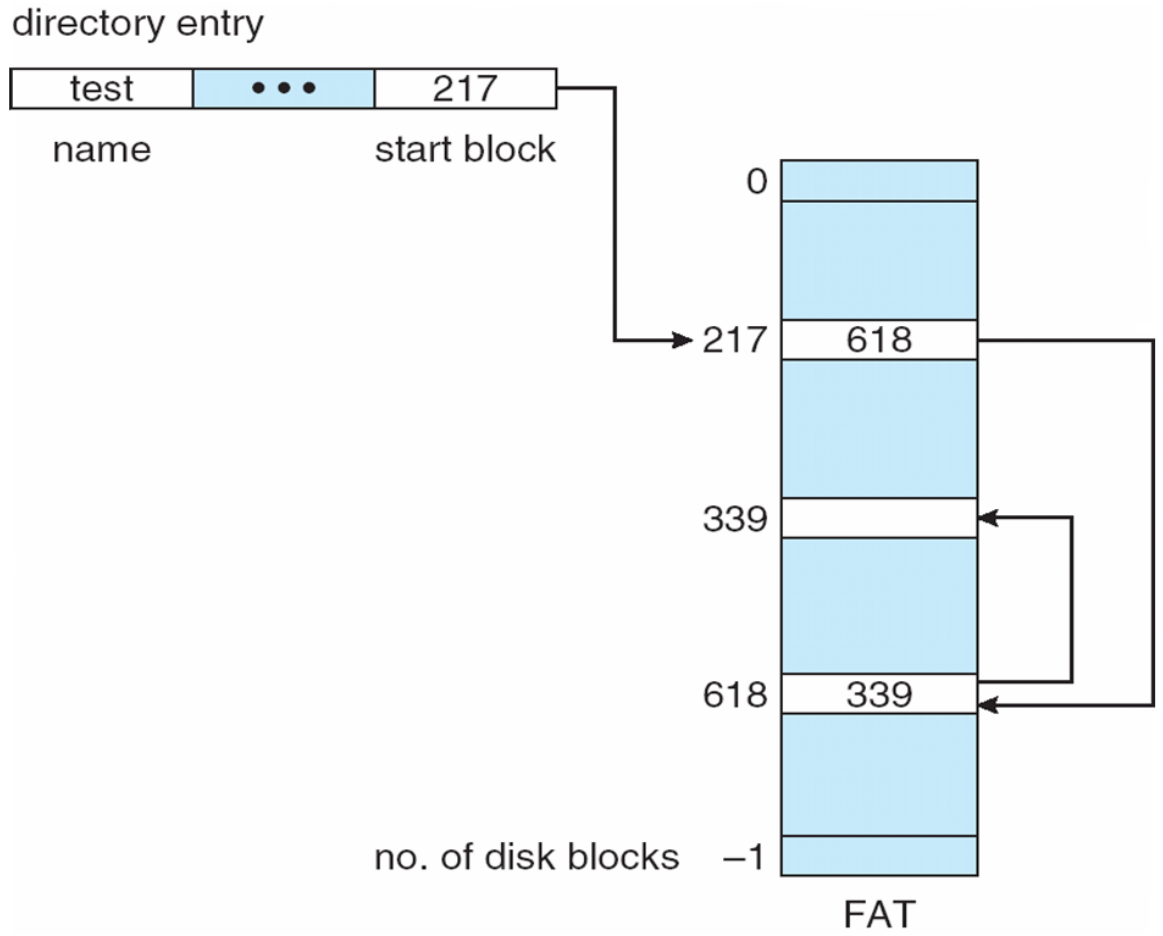
File-Allocation Table (variation on linked allocation)

- Unused block is indicated by a table value of 0
- To allocate a new block to a file, find the first 0-valued table entry and replace the previous EOF value with the address of the new block.
- Then replace 0 with EOF value

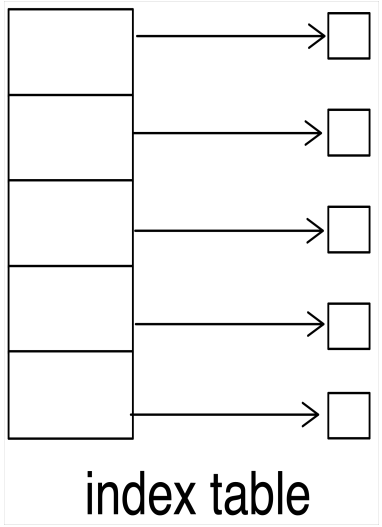


Allocation Methods - Indexed

Indexed allocation

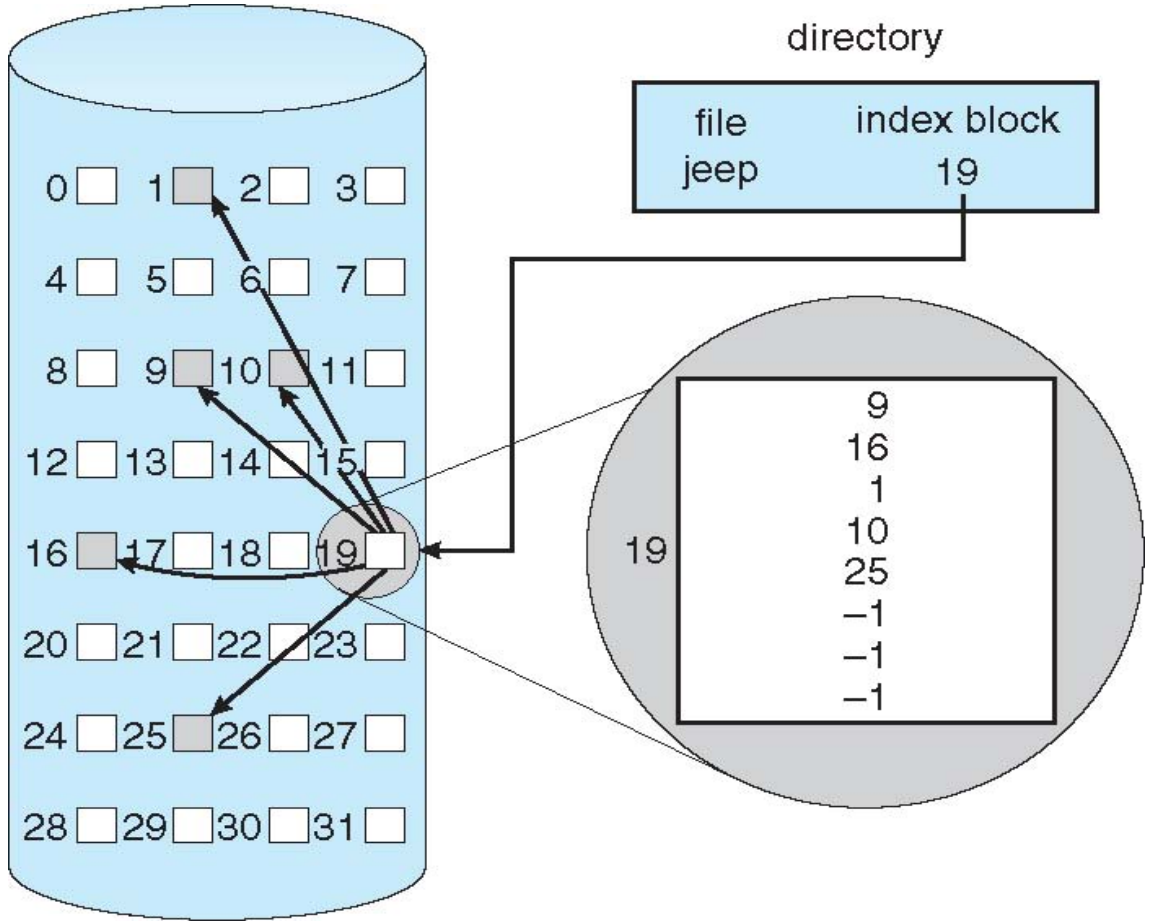
- Each file has its own **index block**(s) of pointers to its data blocks

- Logical view



Example of Indexed Allocation

- In this scheme, a special block known as the **Index block** contains the pointers to all the blocks occupied by a file.
- Each file has its own index block. The ith entry in the index block contains the disk address of the ith file block.
- The directory entry contains the address of the index block as shown in the figure.



Allocation Methods – Indexed (Cont.)

Advantages:

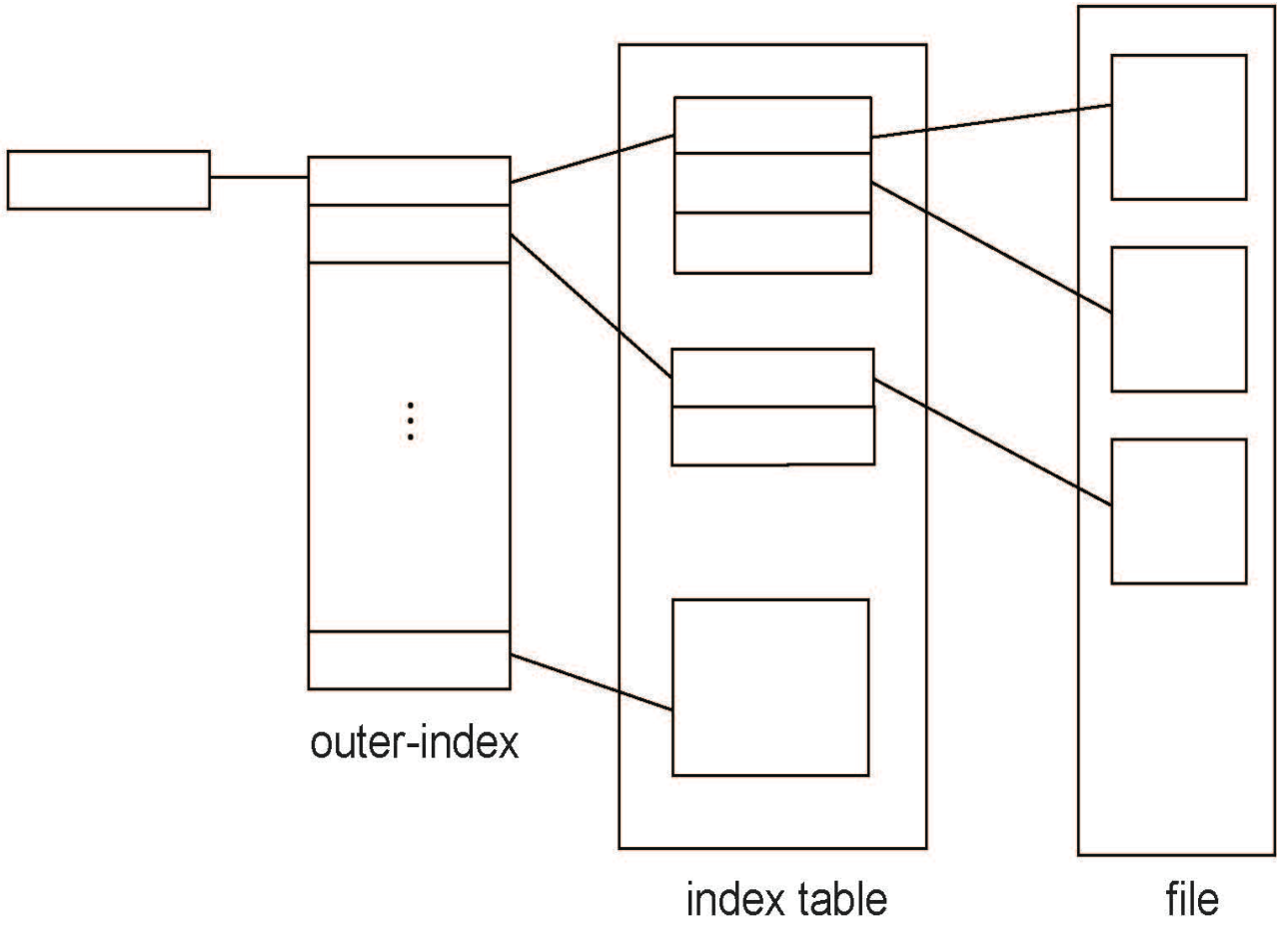
- This supports direct access to the blocks occupied by the file and therefore provides fast access to the file blocks.
- It overcomes the problem of external fragmentation.

Disadvantages:

- The pointer overhead for indexed allocation is greater than linked allocation.
- For very small files, say files that expand only 2-3 blocks, the indexed allocation would keep one entire block (index block) for the pointers which is inefficient in terms of memory utilization. (Note: In linked allocation we lose the space of only 1 pointer per block.)

Indexed Allocation – Mapping (Cont.)

- For files that are very large, single index block may not be able to hold all the pointers.
- Other Schemes such as Linked scheme, Multilevel index and Combined Scheme are used.



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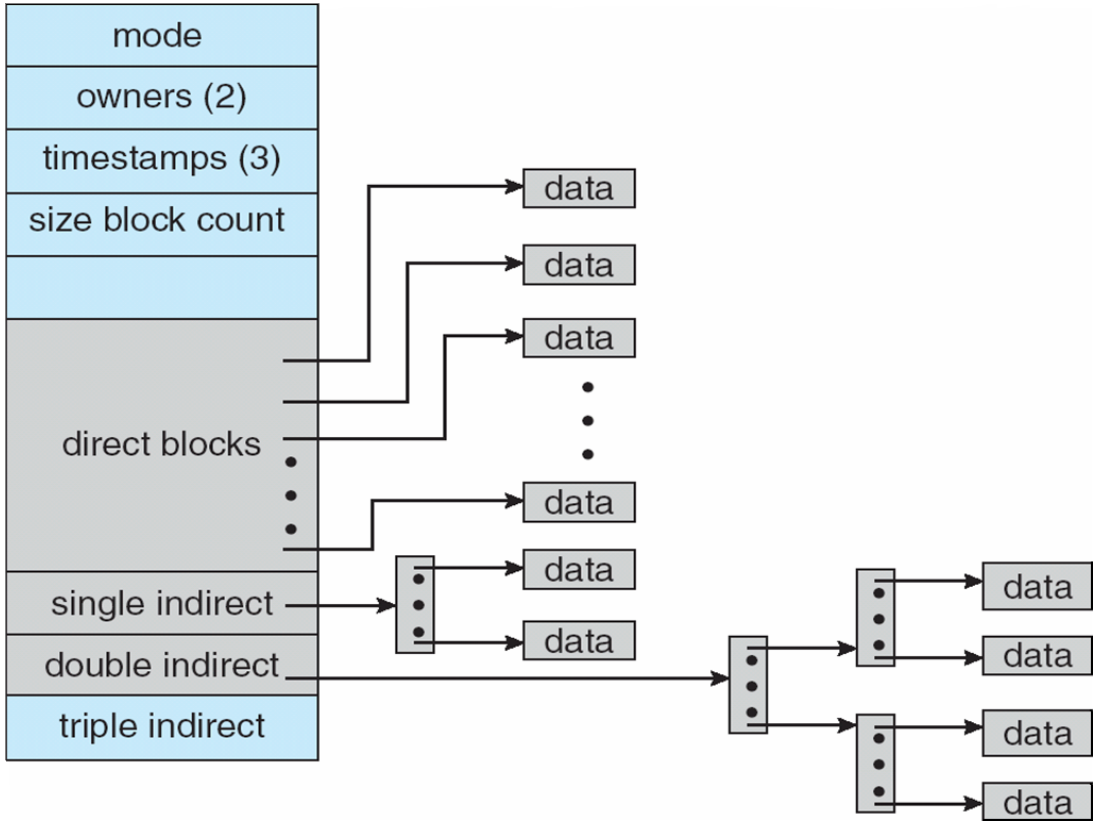
Combined Scheme: UNIX UFS

4K bytes per block, 32-bit addresses



More index blocks than can be addressed with 32-bit file pointer

Performance

- Best method depends on file access type
  - Contiguous great for sequential and random
- Linked good for sequential, not random
- Declare access type at creation -> select either contiguous or linked
- Indexed more complex
  - Single block access could require 2 index block reads then data block read
  - Clustering can help improve throughput, reduce CPU overhead

THANK YOU

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