

# EE445M/EE380L.12

## Embedded and Real-Time Systems/ Real-Time Operating Systems

### Lecture 8: Filesystems

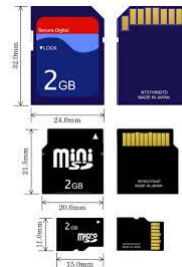
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## Lab 4 File System

- Layered software architecture
  - SSI <-> SDC
  - eDisk <-> physical blocks
    - Optional DMA for transfers
  - eFile <-> logical data



Reference EE445M book, Chapter 7

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## Know Your problem

- Read access
  - Sequential versus random access
- Write access
  - Sequential versus random access
  - Insert/Append/Remove
  - Write once (data logger, flight recorder)
- Size, bandwidth, response time
- Reliability
- Security (fail-safe)

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## Know your disk

- Block size
- Disk size
- Read/write speed
- Types and chances of error
  - Wear leveling
  - Conditional probability



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## File System Responsibilities

- Logical to physical translation
  - Byte number to block number
- Directory
  - File name to physical translation
- Free space
  - Used
  - Free
  - Damaged



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## File System Performance

- File size
- Disk size
- Number of files
- Speed
  - Time to create, open, close
  - Write bandwidth
  - Read bandwidth
- Fragmentation
  - External if  $\text{max file size} < \text{total free space}$



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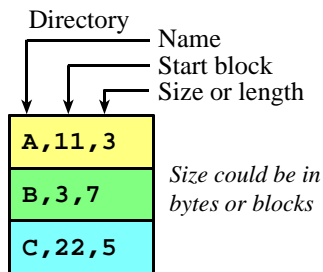
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## File System Allocation (1)

- Contiguous allocation

- First fit
- Best fit
- Worst fit



Good for sequential write, never erase  
Fast random read access

Internal fragmentation: on average, each file wastes 1/2 block  
External fragmentation: largest file size to allocate < free space

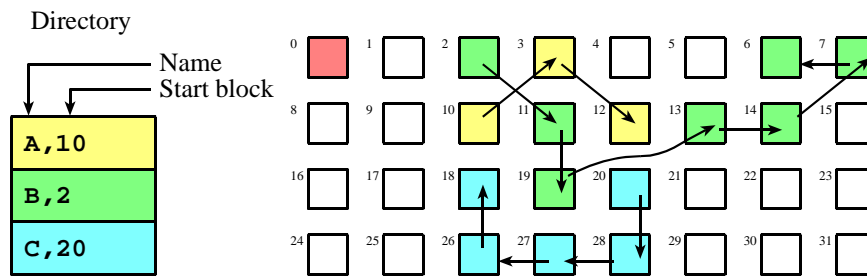
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## File System Allocation (2)

- Linked allocation



Good for erase, append, delete  
Slow for random access  
Internal fragmentation: on average, each file wastes 1/2 block  
No external fragmentation

*Each block has a link and a size*

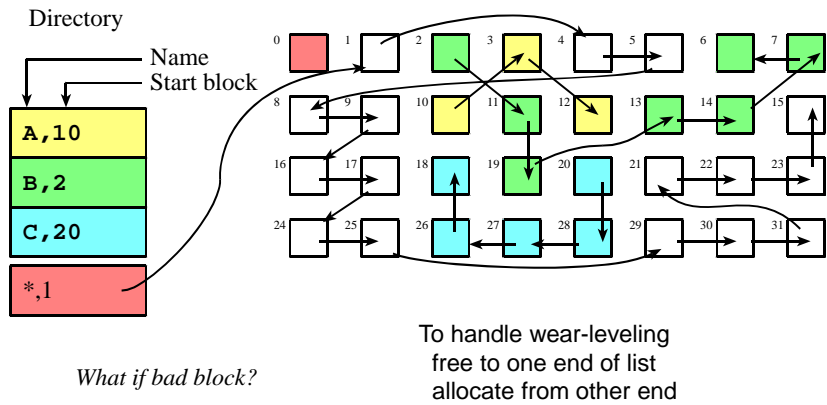
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# Free Space Management

- Linked allocation of free space



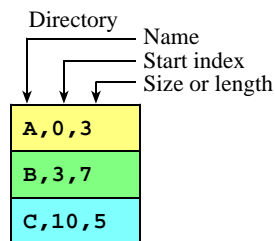
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# File System Allocation (3)

- Indexed allocation



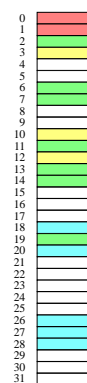
Good for erase, append, delete  
Fast for random access  
No external fragmentation

*Reliable?*

Index table

0	10	
1	3	File A
2	12	
3	2	
4	11	File B
5	19	
6	13	
7	14	
8	7	
9	6	
10	20	
11	28	File C
12	27	
13	26	
14	18	
15	-	
16	-	
17	-	
18	-	
19	-	
20	-	
21	-	
22	-	
23	-	
24	-	
25	-	
26	-	
27	-	
28	-	
29	-	
30	-	
31	-	

Disk



*Two level index table?*

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## Directory

- Name, Type, Date, Size, How to access

Directory in Block 0

'jv1'
2
519
'tree'
3
20
'Jon'
6
1040

Block1	Block2	Block3	Block4	Block5	Block6
0	1	0	5	0	4
11	508	20	508	24	508
Data 'jv1'	Data	Data 'tree'	Data	Data 'Jon'	Data
Free	'jv1'	Free	'Jon'	Free	'Jon'

Internal fragmentation

How many files?

2 bytes for link to next block  
2 bytes for size

Disk smaller than 32Meb

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## Directory

- Name, Type, Date, Size, How to access

Directory in Block 0

'jv1'
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519
'tree'
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1040

Block1	Block2	Block3	Block4	Block5	Block6
0	1	0	5	0	4
11	508	20	508	24	508
Data 'jv1'	Data	Data 'tree'	Data	Data 'Jon'	Data
Free	'jv1'	Free	'Jon'	Free	'Jon'

Internal fragmentation

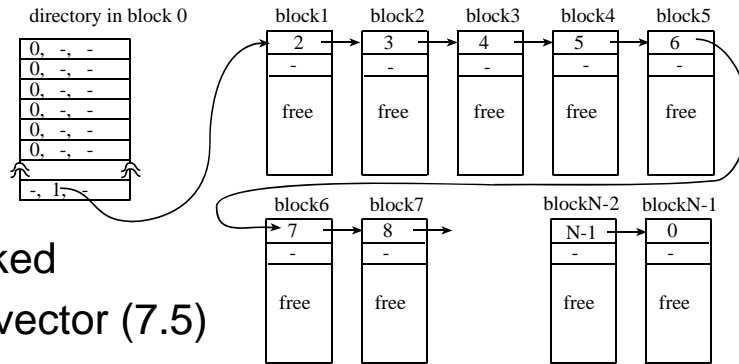
How many files?

4 bytes for link to next block  
2 bytes for size

Disc larger than 32Meb

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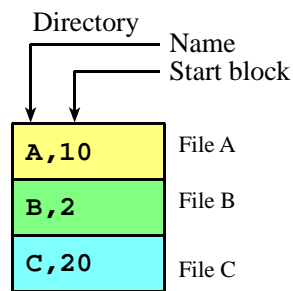
# Free Space Management



- Linked
- Bit vector (7.5)

What percentage of the disk is wasted using a) linked; b) bit vector?

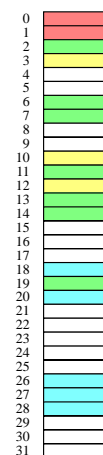
# File Allocation Table (FAT)



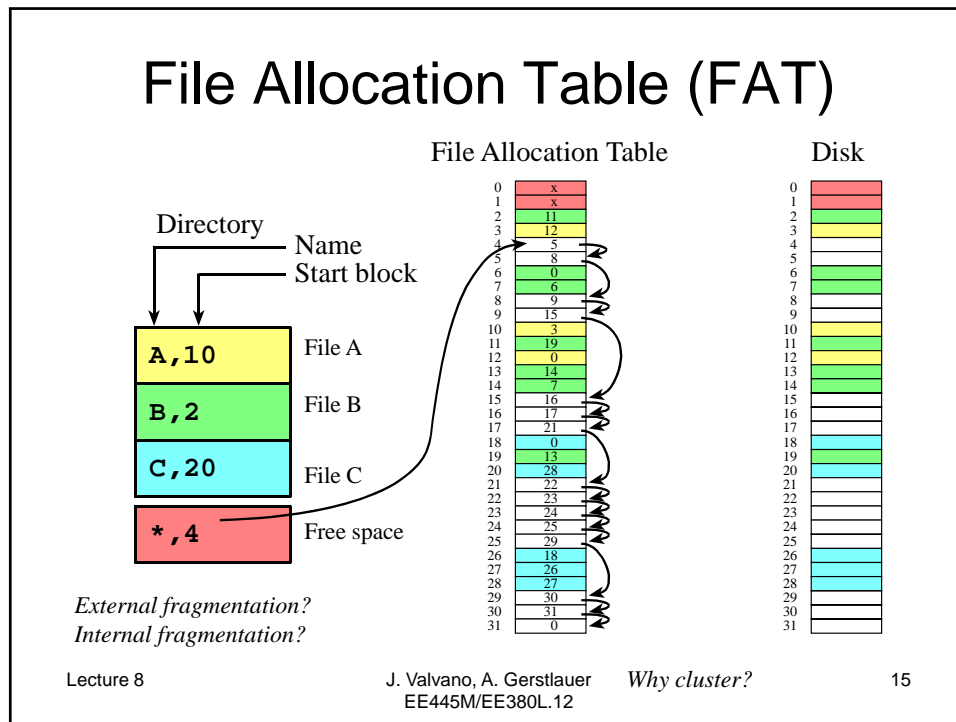
File Allocation Table

0	x
1	x
2	11
3	12
4	-
5	-
6	0
7	6
8	-
9	-
10	3
11	19
12	0
13	14
14	7
15	-
16	-
17	-
18	0
19	13
20	28
21	-
22	-
23	-
24	-
25	-
26	18
27	26
28	27
29	-
30	-
31	-

Disk



Derive a relation between FAT size and disk size



- ## File System Summary
- Internal fragmentation
  - External fragmentation
  - Speed
    - Random versus sequential
    - Read versus write
  - Reliability, recover from errors
    - Error detection
    - Redundant Array of Independent Disks
    - Wear-leveling
  - Clustering
  - Size
  - Number of files
  - Legacy
  - Low voltage
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