

File Systems

Now where did I put that?



OS Manages Resources

- Memory
- CPU
 - Processes
- **I/O Devices**
- **Information**
 - **Files**

Sharing
Nicely

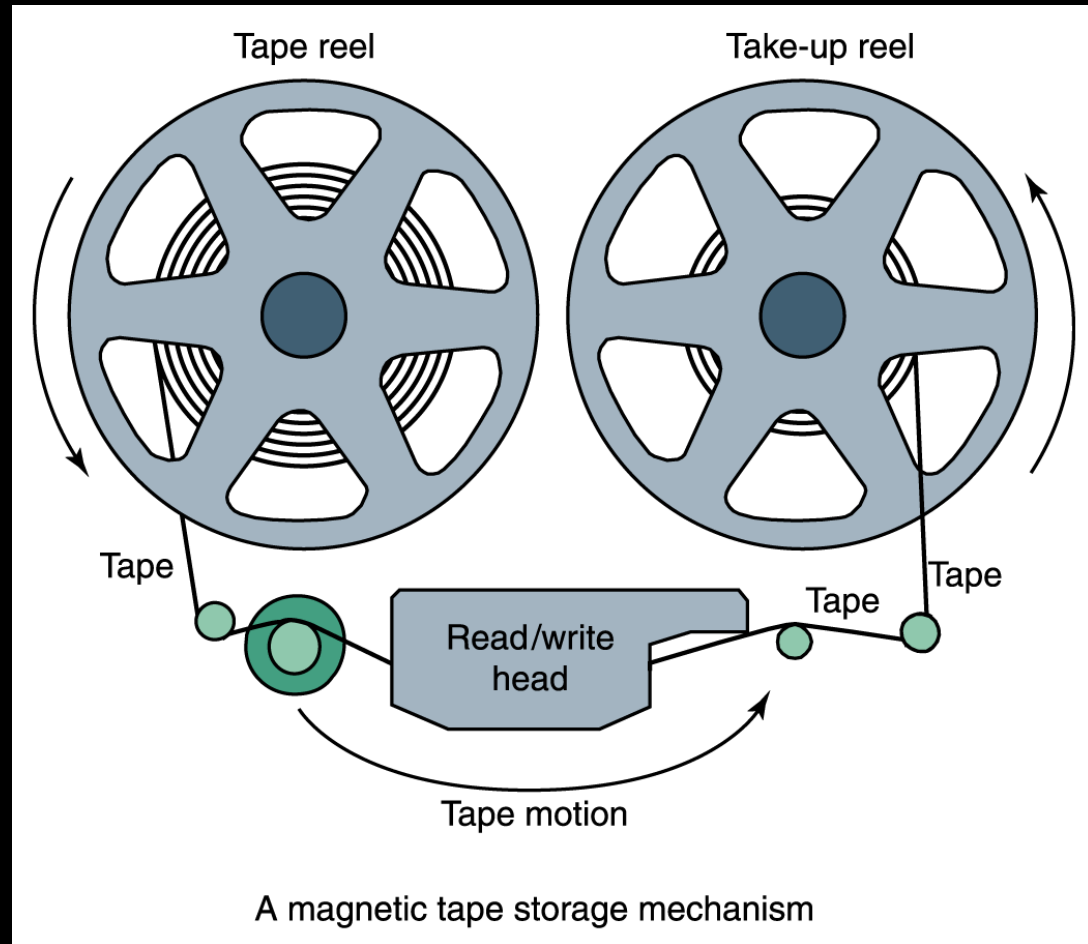


File Systems

- **FILE** – a named collection of related data
 - "document" to the uninitiated
- **FILE SYSTEM** – collection of files managed by the Operating System
- **DIRECTORIES** – way of organizing groups of files
 - "folders" to the *hoi polloi*



Magnetic Tape



A magnetic tape storage mechanism

IBM TS1130







File Operations

Create

```
f = open(fn, 'w')  fopen(fn, 'w')
```



File Operations

Create

```
f = open(fn, 'w')  fopen(fn, 'w')
```

Write

```
f.write(data)  fwrite(data)
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
eros. Sed
erat. In in
velit quis
arcu
ornare
laoreces i.



File Operations

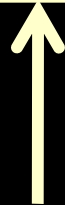
Create

```
f = open(fn, 'w')  fopen(fn, 'w')
```

Write

```
f.write(data)  fwrite(data)
```

Lorem
ipsum
dolor sit
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elit. Nam
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File Operations

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Write

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velit quis
arcu
ornare
laoreet.
Curabitur
adipiscing
luctus
massa.
Integer ut
purus ac
augue
commodo
commodo.
Nunc nec
mi eu justo
tempor



File Operations

Create

```
f = open(fn, 'w')    fopen(fn, 'w')
```

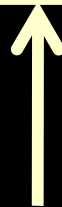
Write

```
f.write(data)        fwrite(data)
```

Close

```
f.close()            fclose(fpos)
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
eros. Sed
erat. In in
velit quis
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Curabitur
adipiscing
luctus
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Integer ut
purus ac
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Nunc nec
mi eu justo
tempor



Create

```
f = open(fn, 'w')    fopen(fn, 'w')
```

Write

```
f.write(data)       fwrite(data)
```

Close

```
f.close()           fclose(fpos)
```

↑

```
>Lorem  
ipsum  
dolor sit  
amet,  
consectetu  
er  
adipiscing  
elit. Nam  
nibh. Nunc  
varius  
facilisis  
eros. Sed  
erat. In in  
velit quis  
arcu  
ornare  
laoreet.  
Curabitur  
adipiscing  
luctus  
massa.  
Integer ut  
purus ac  
augue  
commodo  
commodo.  
Nunc nec  
mi eu justo  
tempor
```



Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

↑

```
Lorem  
ipsum  
dolor sit  
amet,  
consectetu  
er  
adipiscing  
elit. Nam  
nibh. Nunc  
varius  
facilisis  
eros. Sed  
erat. In in  
velit quis  
arcu  
ornare  
laoreet.  
Curabitur  
adipiscing  
luctus  
massa.  
Integer ut  
purus ac  
augue  
commodo  
commodo.  
Nunc nec  
mi eu justo  
tempor
```



Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
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Integer ut
purus ac
augue
commodo
commodo.
Nunc nec
mi eu justo
tempor



Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

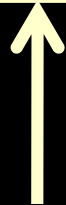
Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
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Integer ut
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commodo
commodo.
Nunc nec
mi eu justo
tempor



Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

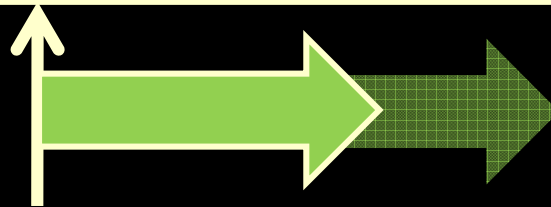
Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
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Nunc nec
mi eu justo
tempor



Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

Write

```
f.write(data) fwrite(data)
```

Close

```
f.close()
```

```
fclose(fpos)
```

↑
Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
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Integer ut
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commodo
commodo.
Nunc nec
mi eu justo
tempor



File Operations

Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

Append

```
f = open(fn, 'a') fopen(fn, 'a')
```

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
eros. Sed
erat. In in
velit quis
arcu
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laoreet.
Curabitur
adipiscing
luctus
massa.
Integer ut
purus ac
augue
commodo
commodo.
Nunc nec
mi eu justo
tempor



File Operations

Create

```
f = open(fn, 'w') fopen(fn, 'w')
```

Open

```
f = open(fn, 'r') fopen(fn, 'r')
```

Read

```
f.read(data, size) fread(size)
```

Write

```
f.write(data) fwrite(data)
```

Close

```
f.close() fclose(fpos)
```

Append

```
f = open(fn, 'a') fopen(fn, 'a')
```

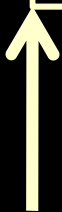
Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
eros. Sed
erat. In in
velit quis
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ornare
laoreet.
Curabitur
adipiscing
luctus
massa.
Integer ut
purus ac
augue
commodo
commodo.
Nunc nec
mi eu justo
tempor
consectetu
er. Etiam
vitae nisi.
In
dignissim
lacus ut
ante. Cras
elit lectus,
bibendum
a,
adipiscing



File Operations

Create	<code>f = open(fn, 'w')</code>	<code>fopen(fn, 'w')</code>
Open	<code>f = open(fn, 'r')</code>	<code>fopen(fn, 'r')</code>
Read	<code>f.read(data, size)</code>	<code>fread(size)</code>
Write	<code>f.write(data)</code>	<code>fwrite(data)</code>
Close	<code>f.close()</code>	<code>fclose(fpos)</code>
Append	<code>f = open(fn, 'a')</code>	<code>fopen(fn, 'a')</code>

Lorem
ipsum
dolor sit
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Integer ut
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Nunc nec
mi eu justo
tempor
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In
dignissim
lacus ut
ante. Cras
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bibendum
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File Operations

Create	<code>f = open(fn, 'w')</code>	<code>fopen(fn, 'w')</code>
Open	<code>f = open(fn, 'r')</code>	<code>fopen(fn, 'r')</code>
Read	<code>f.read(data, size)</code>	<code>fread(size)</code>
Write	<code>f.write(data)</code>	<code>fwrite(data)</code>
Seek	<code>f.seek(pos)</code>	<code>fseek(fpos)</code>
Close	<code>f.close()</code>	<code>fclose(fpos)</code>
Append	<code>f = open(fn, 'a')</code>	<code>fopen(fn, 'a')</code>

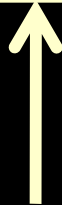
Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam nibh. Nunc varius facilisis eros. Sed erat. In in velit quis arcu ornare laoreet. Curabitur adipiscing luctus massa. Integer ut purus ac augue commodo commodo. Nunc nec mi eu justo tempor consectetur. Etiam vitae nisi. In dignissim lacus ut ante. Cras elit lectus, bibendum a, adipiscing



File Operations

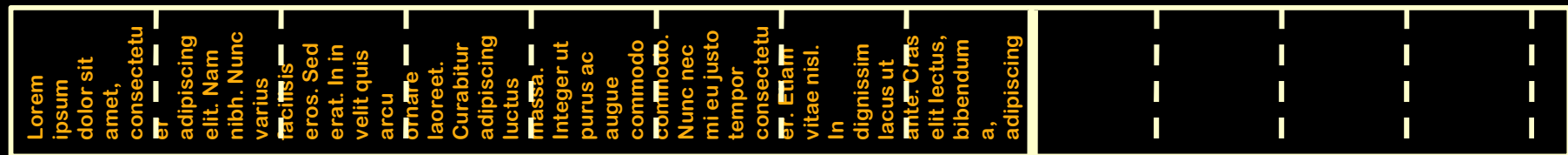
Create	<code>f = open(fn, 'w')</code>	<code>fopen(fn, 'w')</code>
Open	<code>f = open(fn, 'r')</code>	<code>fopen(fn, 'r')</code>
Read	<code>f.read(data, size)</code>	<code>fread(size)</code>
Write	<code>f.write(data)</code>	<code>fwrite(data)</code>
Seek	<code>f.seek(pos)</code>	<code>fseek(fpos)</code>
Close	<code>f.close()</code>	<code>fclose(fpos)</code>
Append	<code>f = open(fn, 'a')</code>	<code>fopen(fn, 'a')</code>

Lorem
ipsum
dolor sit
amet,
consectetu
er
adipiscing
elit. Nam
nibh. Nunc
varius
facilisis
eros. Sed
erat. In in
velit quis
arcu
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laoreet.
Curabitur
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luctus
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Integer ut
purus ac
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tempor
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vitae nisi.
In
dignissim
lacus ut
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elit lectus,
bibendum
a,
adipiscing



Fixed Size Blocks

- Faster seeks
 - inch = blocks
- Re-write a block
 - "del" or "null" characters
 - Leave some extra ones just in case



Multiple Files

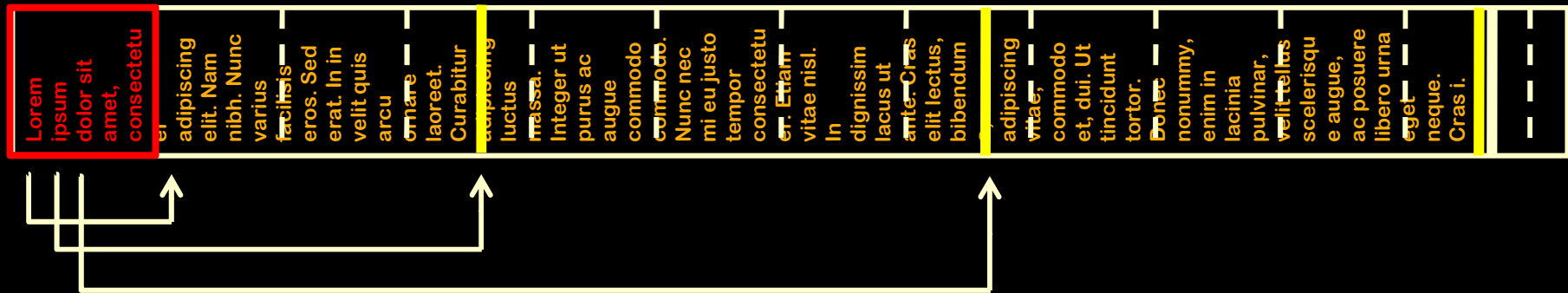
- Find "EOF" markers quickly
- Can't append except to last file

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nam nibh. Nunc varius facilisis eros. Sed erat. In in velit quis arcu ornare laoreet. Curabitur ac adipiscing luctus massa. Integer ut purus ac augue commodo. Nunc nec mi eu justo tempor consectetur. Etiam vitae nisl. In dignissim lacus ut ante. Cras elit lectus, bibendum adipiscing vitae, commodo et, dui. Ut tincidunt tortor. Donec nonummy, enim in lacinia pulvinar, velit. scelerisque augue, ac posuere libero urna eget neque. Cras i.



"Directory File"

- First [n] blocks
- Name files
- Find "EOF" markers more quickly
 - inches = blocks



Data Storage

	Size	\$/GB retail	Permanence	Laser
IBM TS1130	700 MB x 1K	0.21	30-100 yrs	
CD	700 MB	0.40	30-100 yrs	780 nm
CD-R	700 MB	0.70	2-50yrs	780 nm
CD-RW	700 MB	1.40	?	780 nm
DVD-R	5 GB	0.40	5-50 yrs	650 nm
Blu-Ray	50-100 GB		?	405 nm



Data Storage

	Size	\$/GB retail	Permanence	Laser
IBM TS1130	700 MB x 1K	0.21	30-100 yrs	
CD	700 MB	0.40	30-100 yrs	780 nm
CD-R	700 MB	0.70	2-50yrs	780 nm
CD-RW	700 MB	1.40	?	780 nm
DVD-R	5 GB	0.40	5-50 yrs	650 nm
Blu-Ray	50-100 GB		?	405 nm
Flash	128 GB	2.50	10 yrs	
DRAM	8 GB x n	30.00	Power	

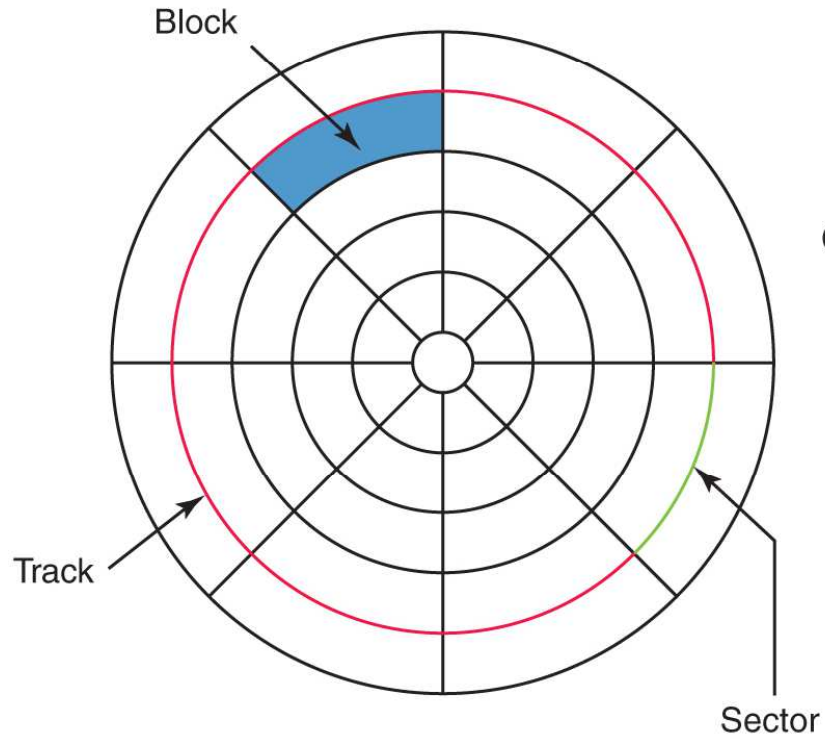


Data Storage

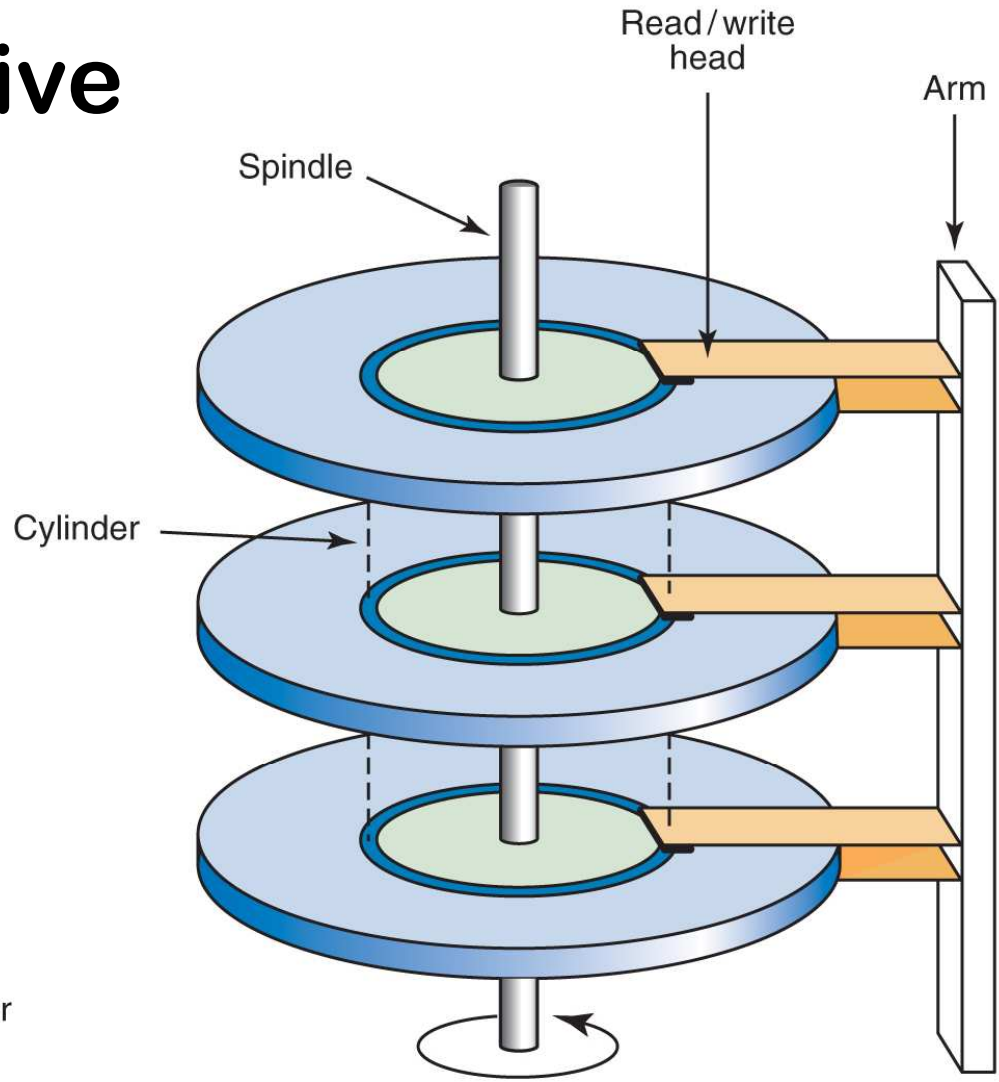
	Size	\$/GB retail	Permanence	Laser
IBM TS1130	700 MB x 1K	0.21	30-100 yrs	
CD	700 MB	0.40	30-100 yrs	780 nm
CD-R	700 MB	0.70	2-50yrs	780 nm
CD-RW	700 MB	1.40	?	780 nm
DVD-R	5 GB	0.40	5-50 yrs	650 nm
Blu-Ray	50-100 GB		?	405 nm
Flash	128 GB	2.50	10 yrs	
DRAM	8 GB x n	30.00	Power	
Disk	2 TB	0.08	5 yrs	



Logical Disk Drive



(a) A single disk



(b) A hard disk drive

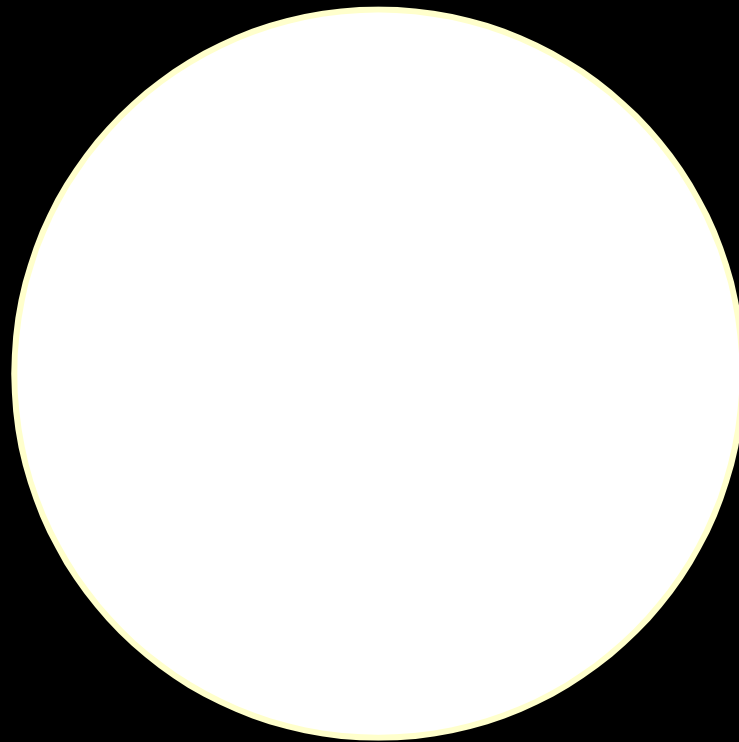
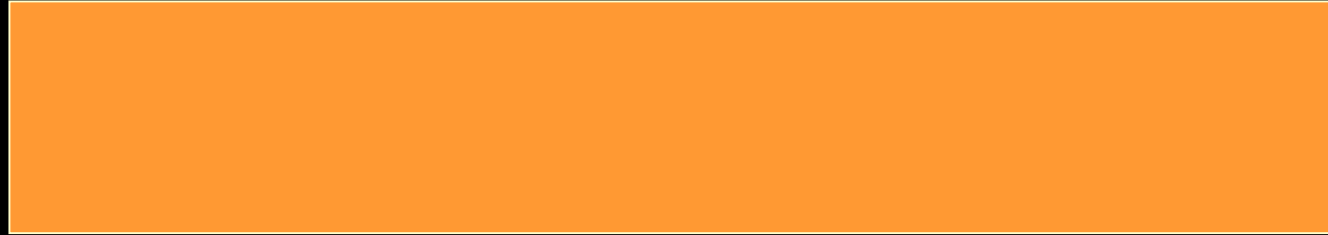


Western Digital AV-25 320GB

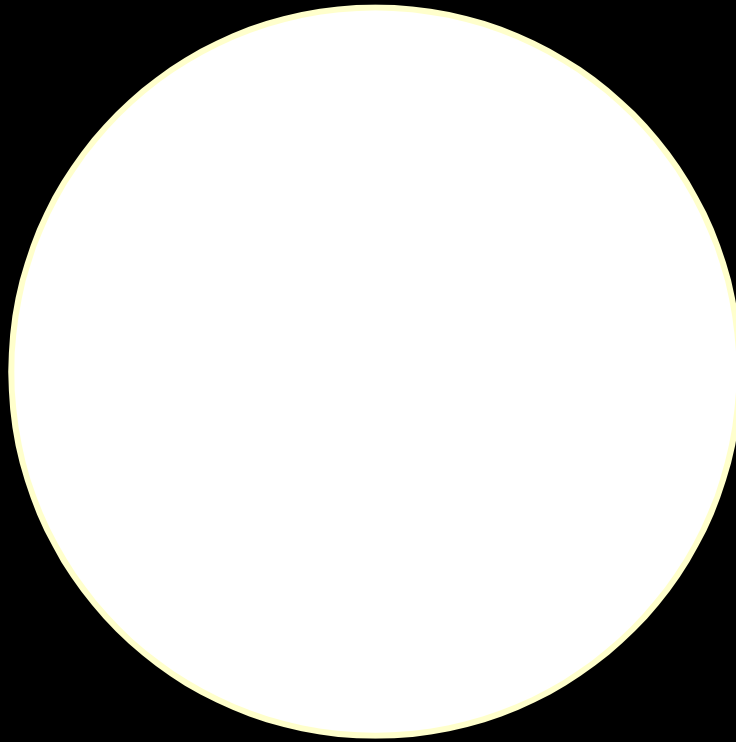
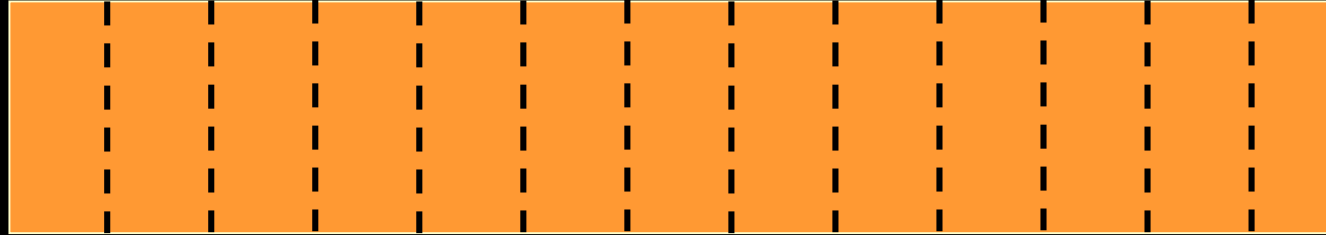
- SATA Interface
- 2½" form factor
- 3 2½" platters
- 5400 rpm
- 5.5 ms average latency
- 8.9 ms random read seek
- 108 MB/sec sustained transfer rate
- 1.6 W R/W, 0.6 W idle, 0.20 W standby
- 625,142,448 512-byte sectors



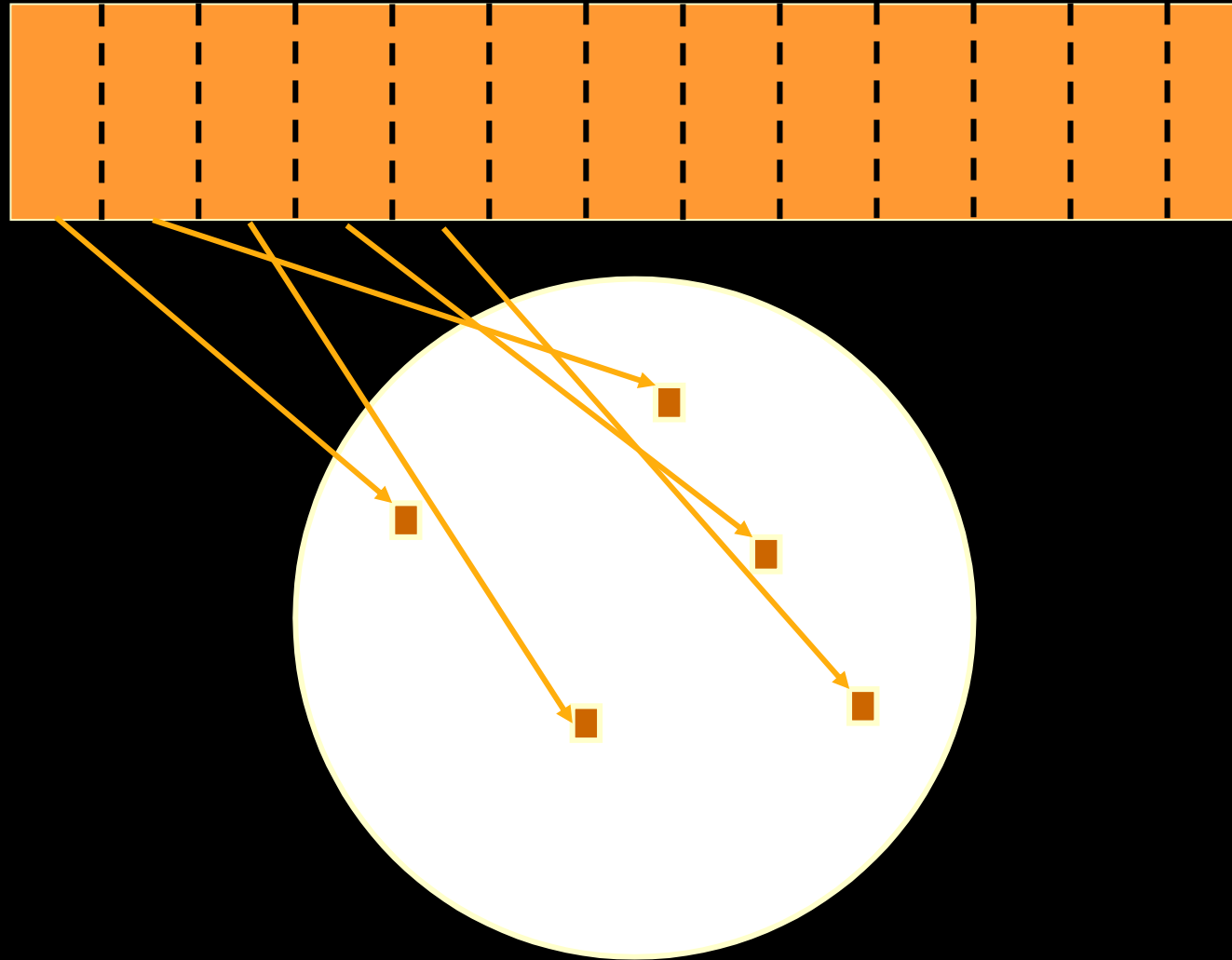
File on Disk



File on Disk



File on Disk



Disk Defragmenter

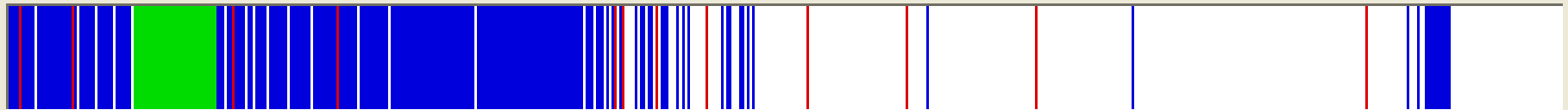


File Action View Help

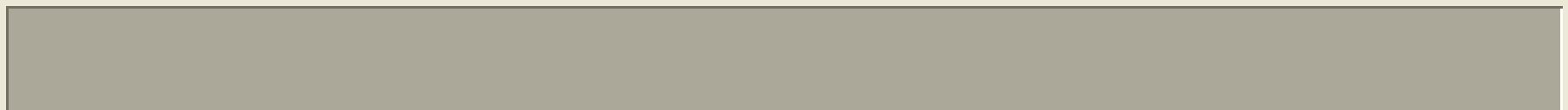


Volume	Session Status	File System	Capacity	Free Space	% Free Space
(C:)	Analyzed	NTFS	74.53 GB	42.40 GB	56 %

Estimated disk usage before defragmentation:



Estimated disk usage after defragmentation:



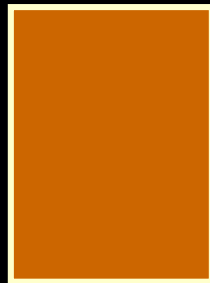
Analyze Defragment Pause Stop View Report

Fragmented files Contiguous files Unmovable files Free space

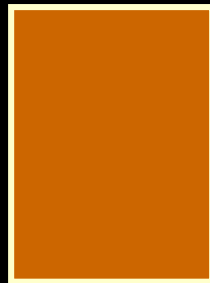


File Made of Linked Blocks

Logical
Block
Addresses



17345



45424



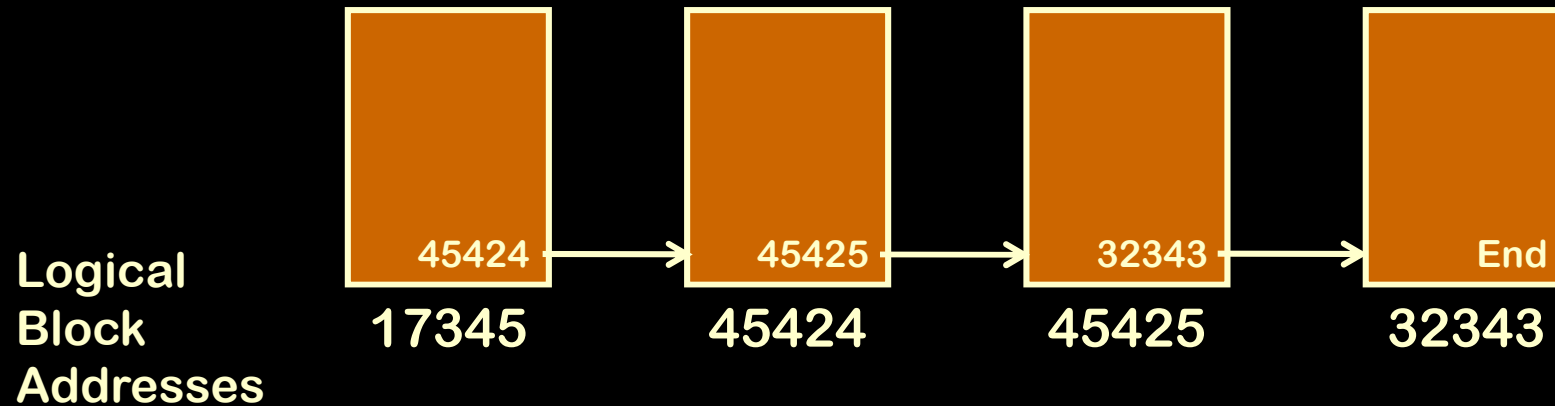
45425



32343



File Made of Linked Blocks

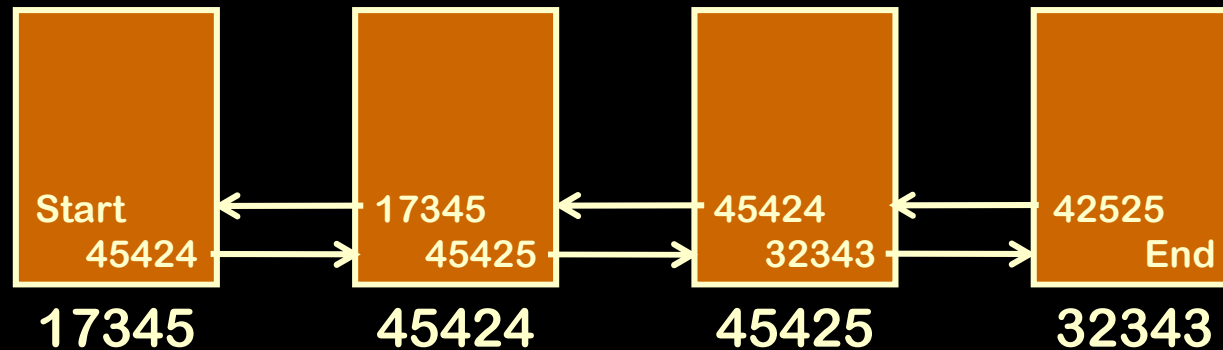


Linked List

- Forward "pointers" to next block



File Made of Linked Blocks

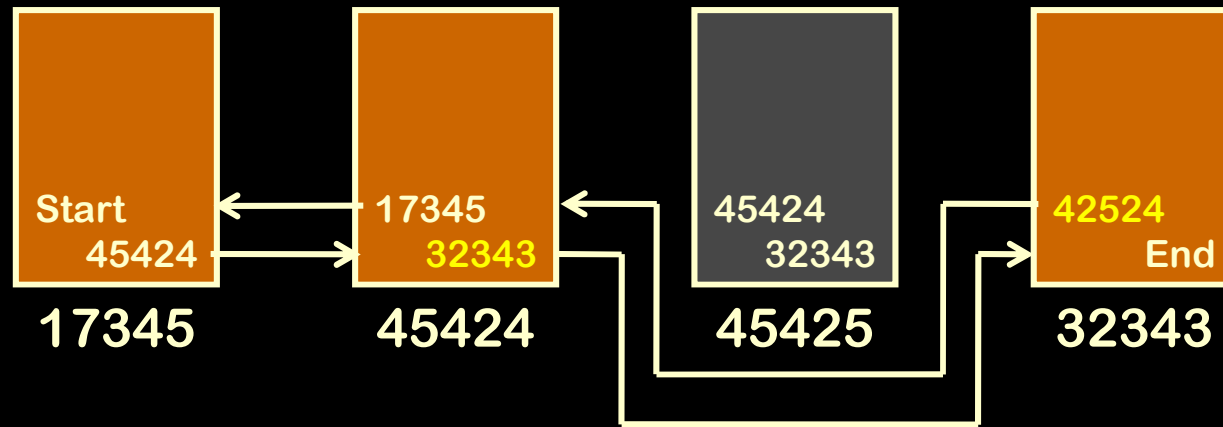


Linked List

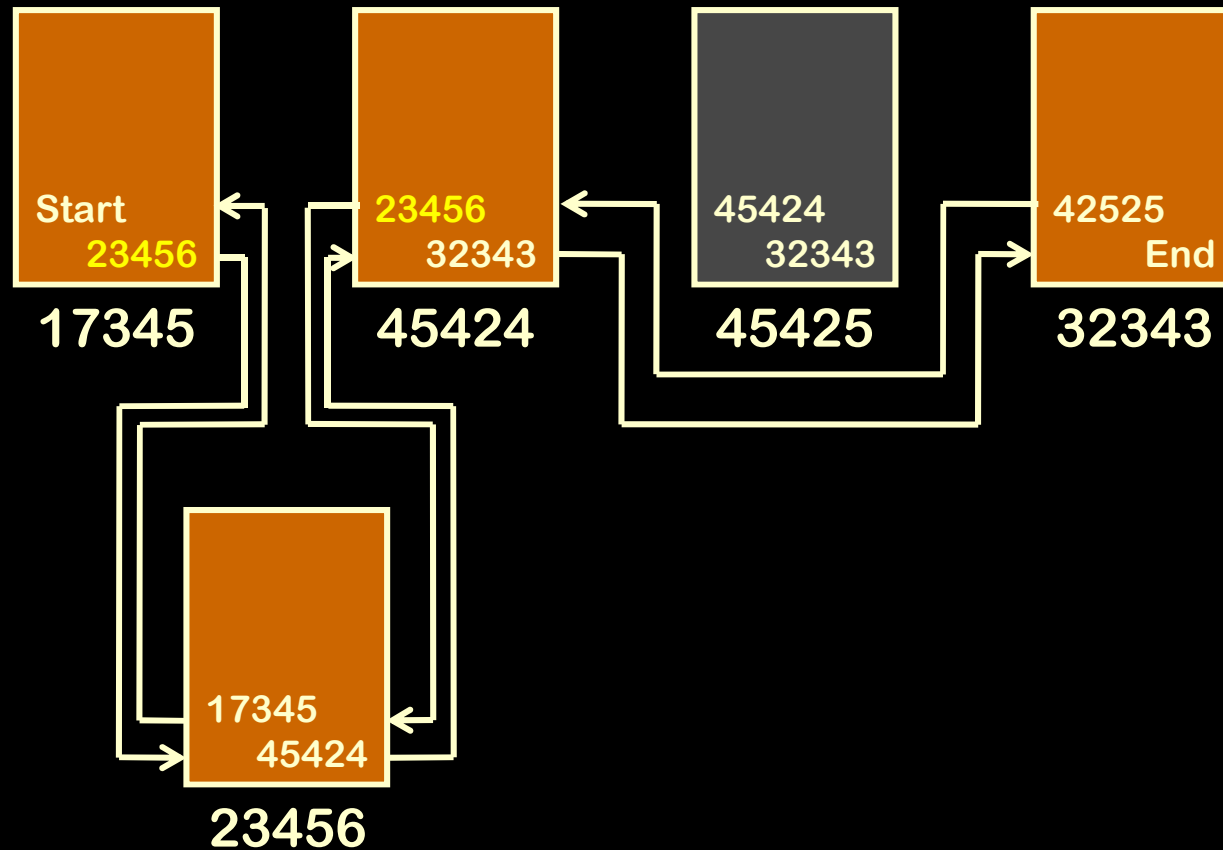
- Forward "pointers" to next block
- Backward to previous



Delete a block

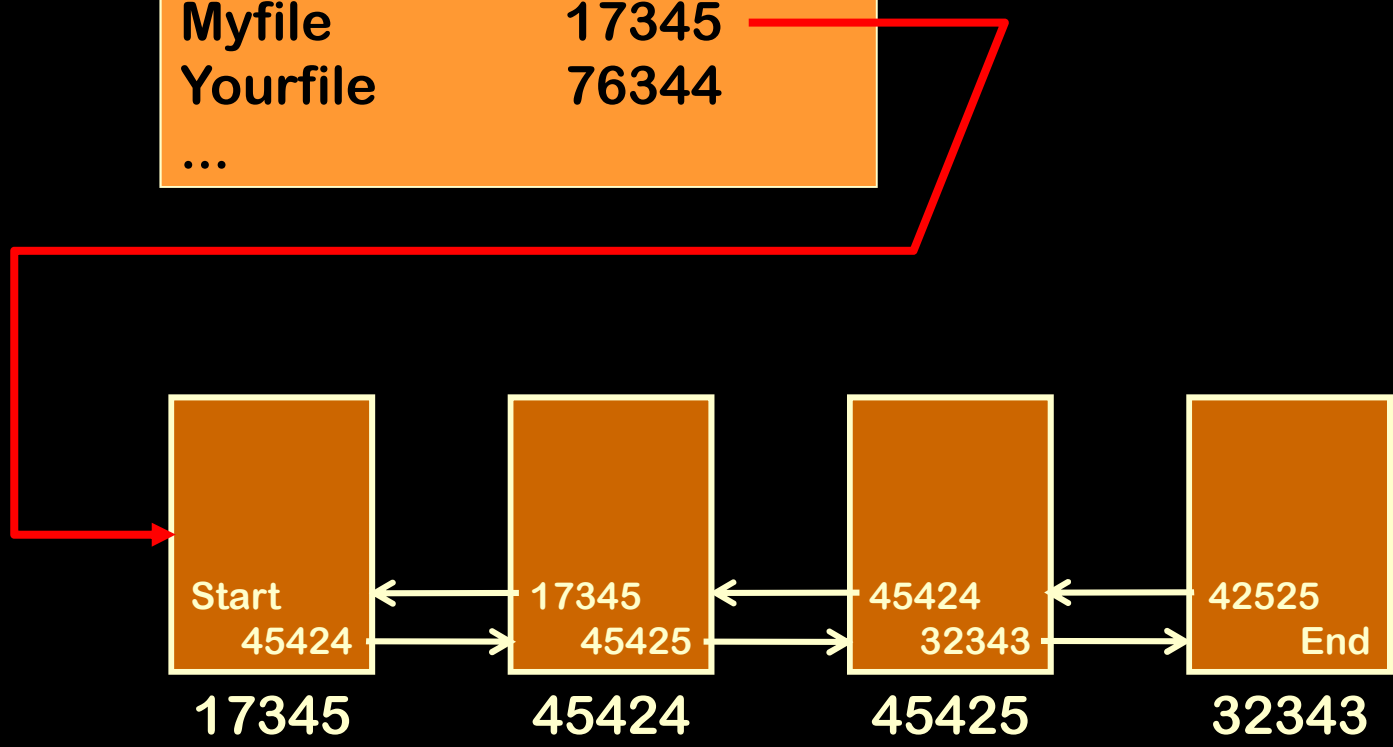


Insert a block



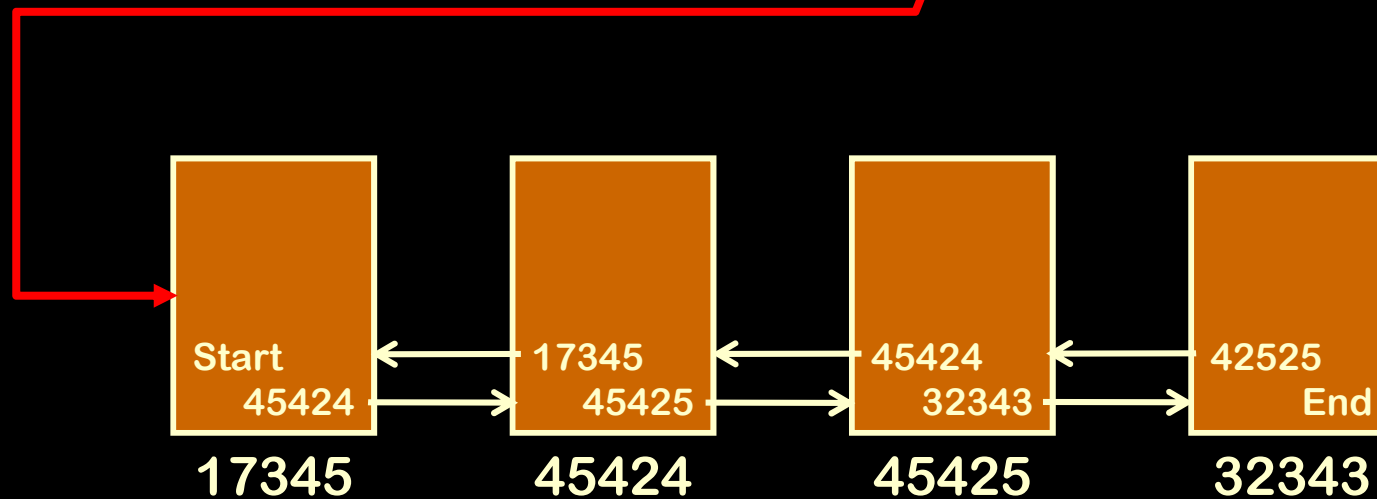
Directory File

File1	13434
File2	34224
...	
Myfile	17345
Yourfile	76344
...	



Delete a File

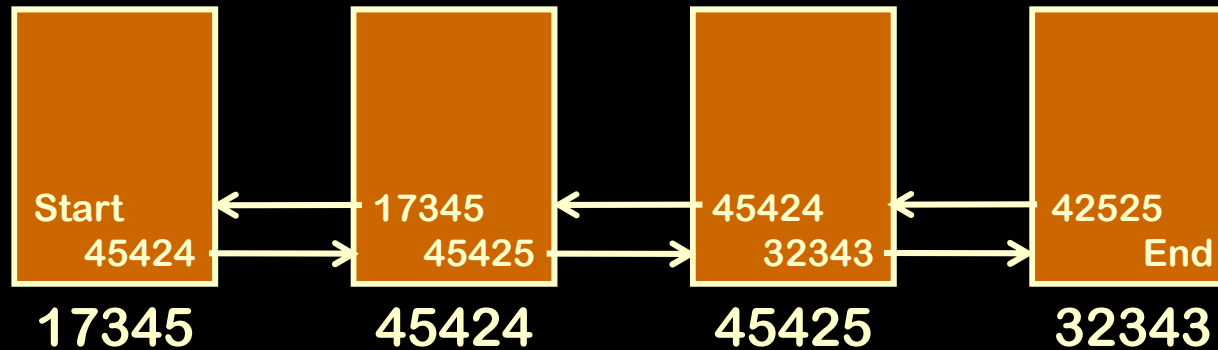
File1	13434
File2	34224
...	
Yourfile	76344
...	



Delete a File

File1	13434
File2	34224
...	
Yourfile	76344
...	

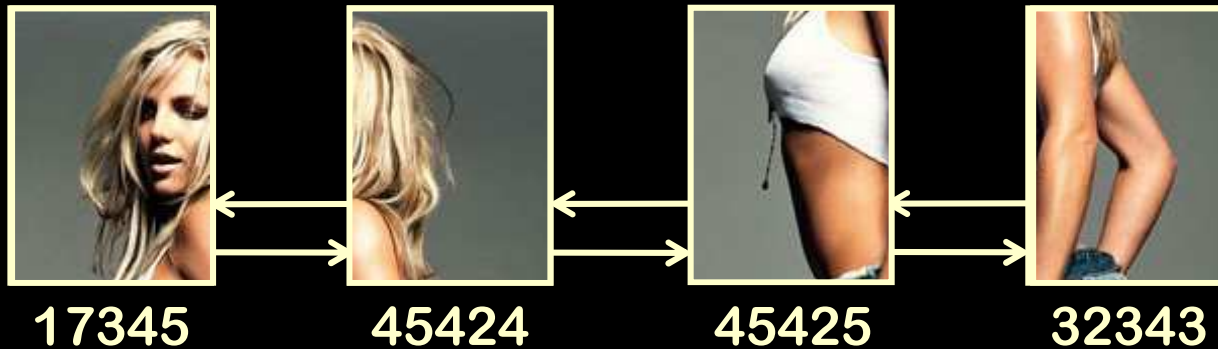
*Free
Blocks*



Delete a File

File1	13434
File2	34224
...	
Yourfile	76344
...	

*Free
Blocks*



(Re-)use a Free Block

File1	13434
File2	34224
...	
newfile	45425
Yourfile	76344
...	

m ipsum
dolor sit
amet,
consectetur
adipiscing
elit. Nam
nibh. Nunc
varius

45425

*Free
Blocks*



17345

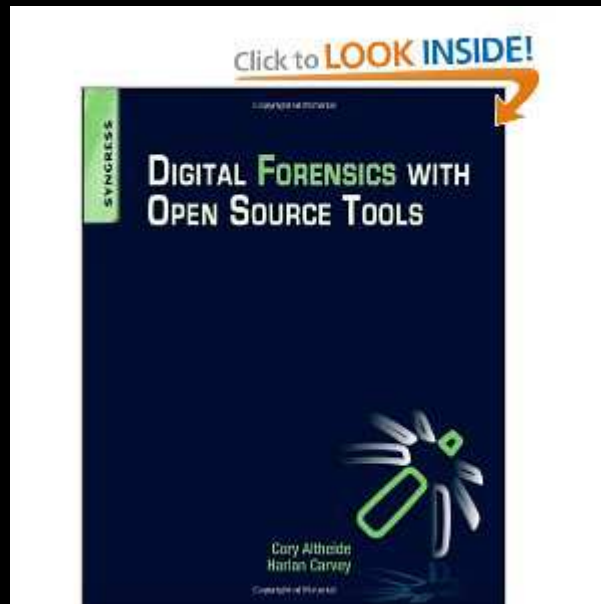


45424



32343

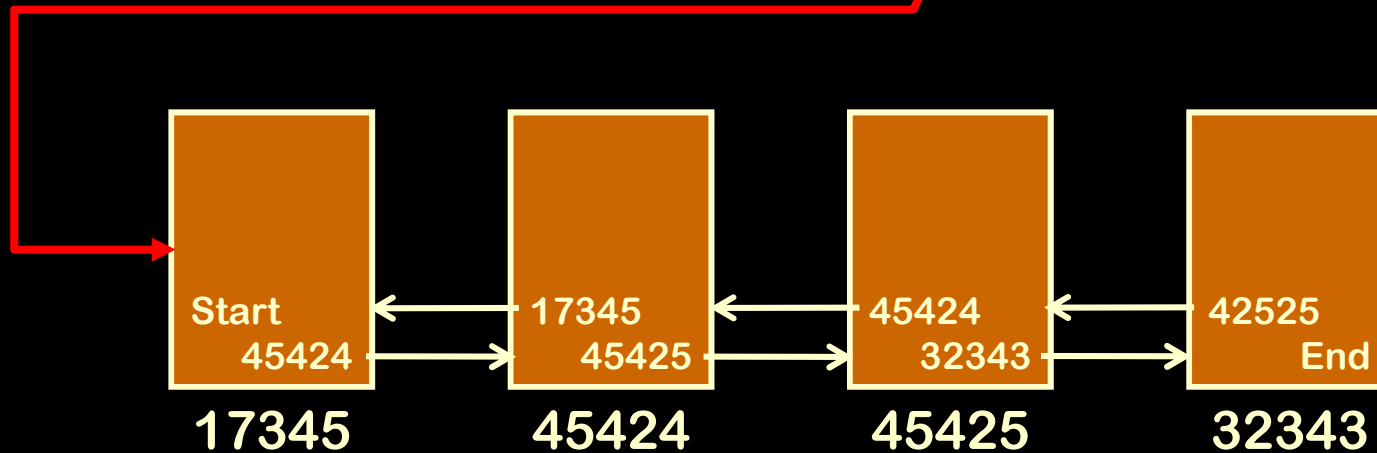
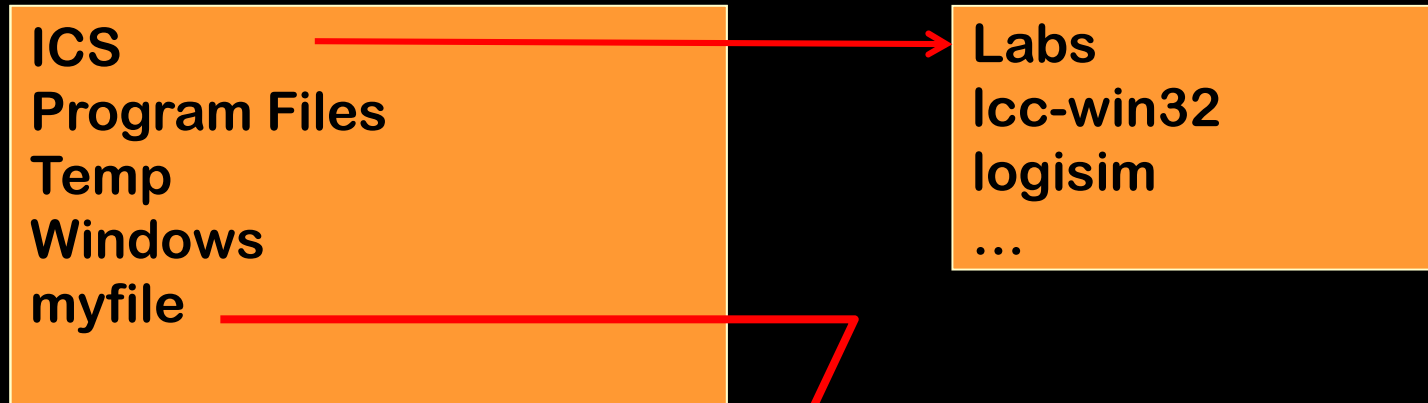




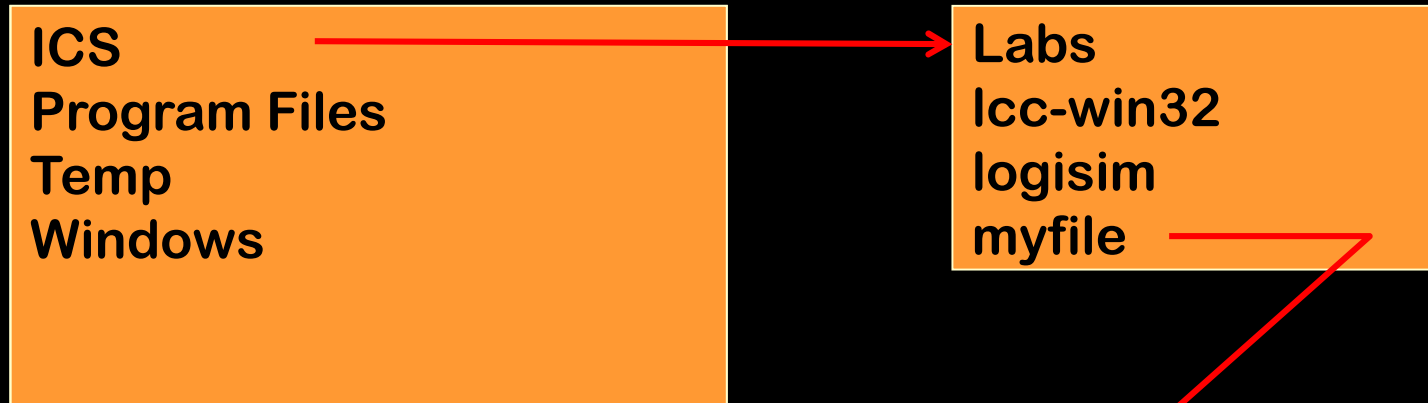
...the definitive book on investigating and analyzing computer systems and media using open source tools. \$43.74

- H block

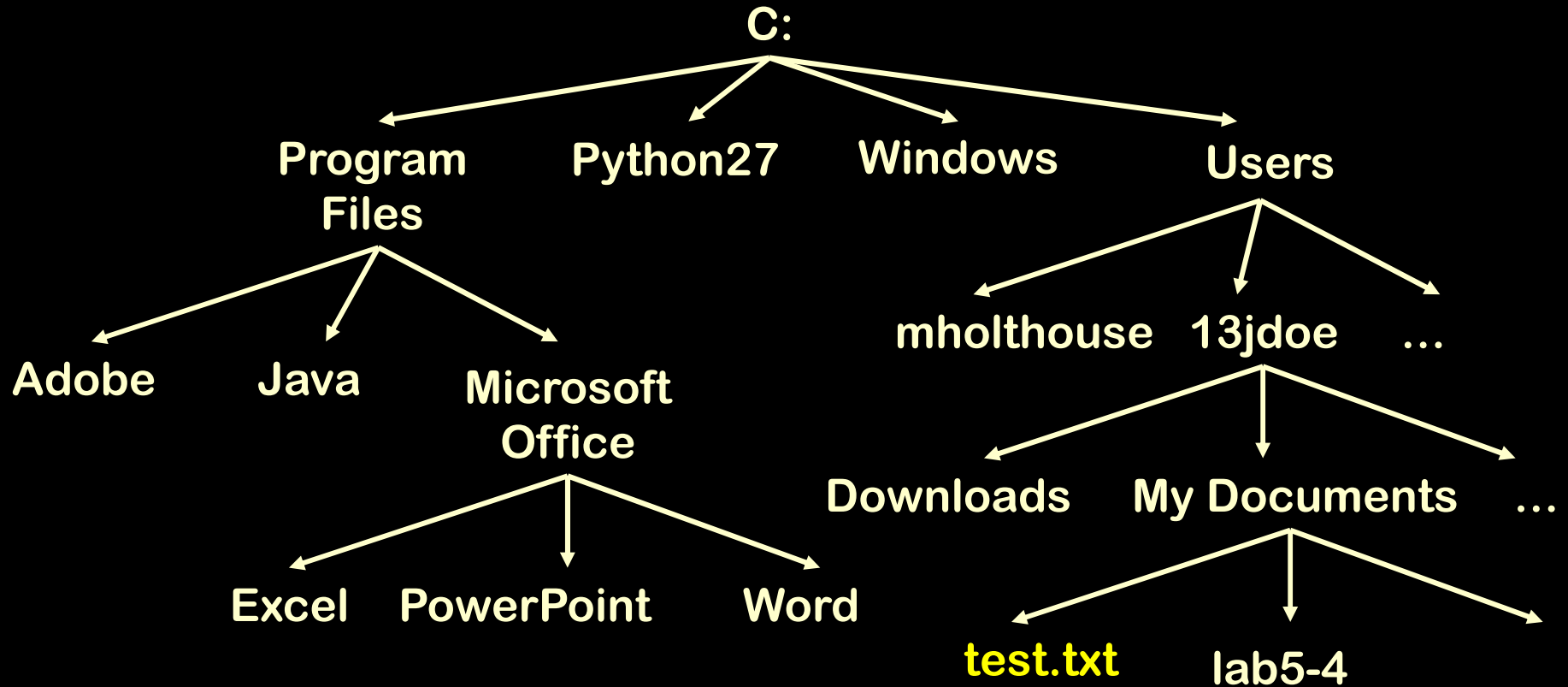
Directory Tree



Move a File



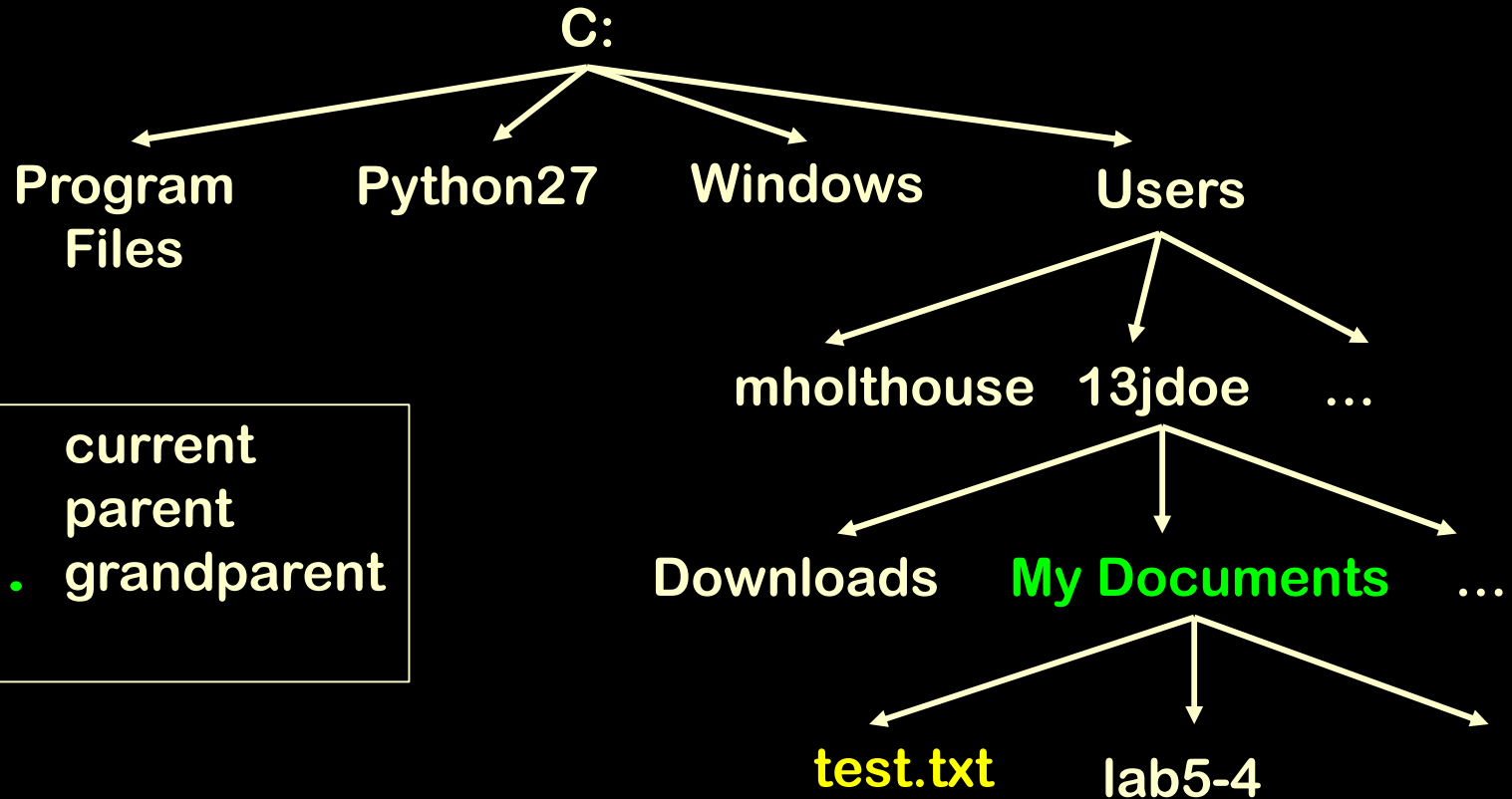
Directory Tree



`c:\Users\13jdoe\My Documents\test.txt`



Relative Path Name

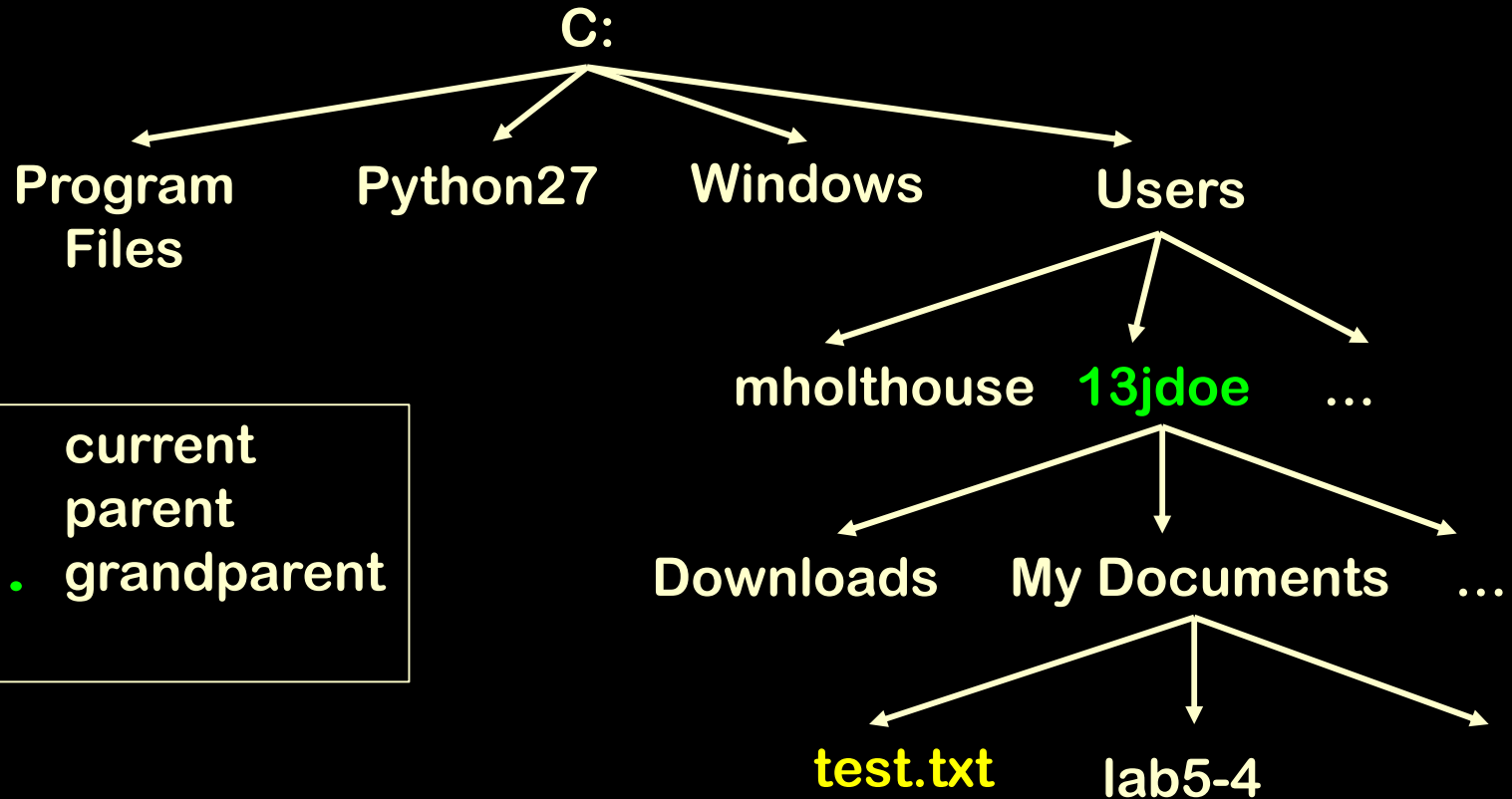


. current
.. parent
..\..\ grandparent
etc.

c:\Users\13jdoe\My Documents\test.txt
test.txt



Relative Path Name



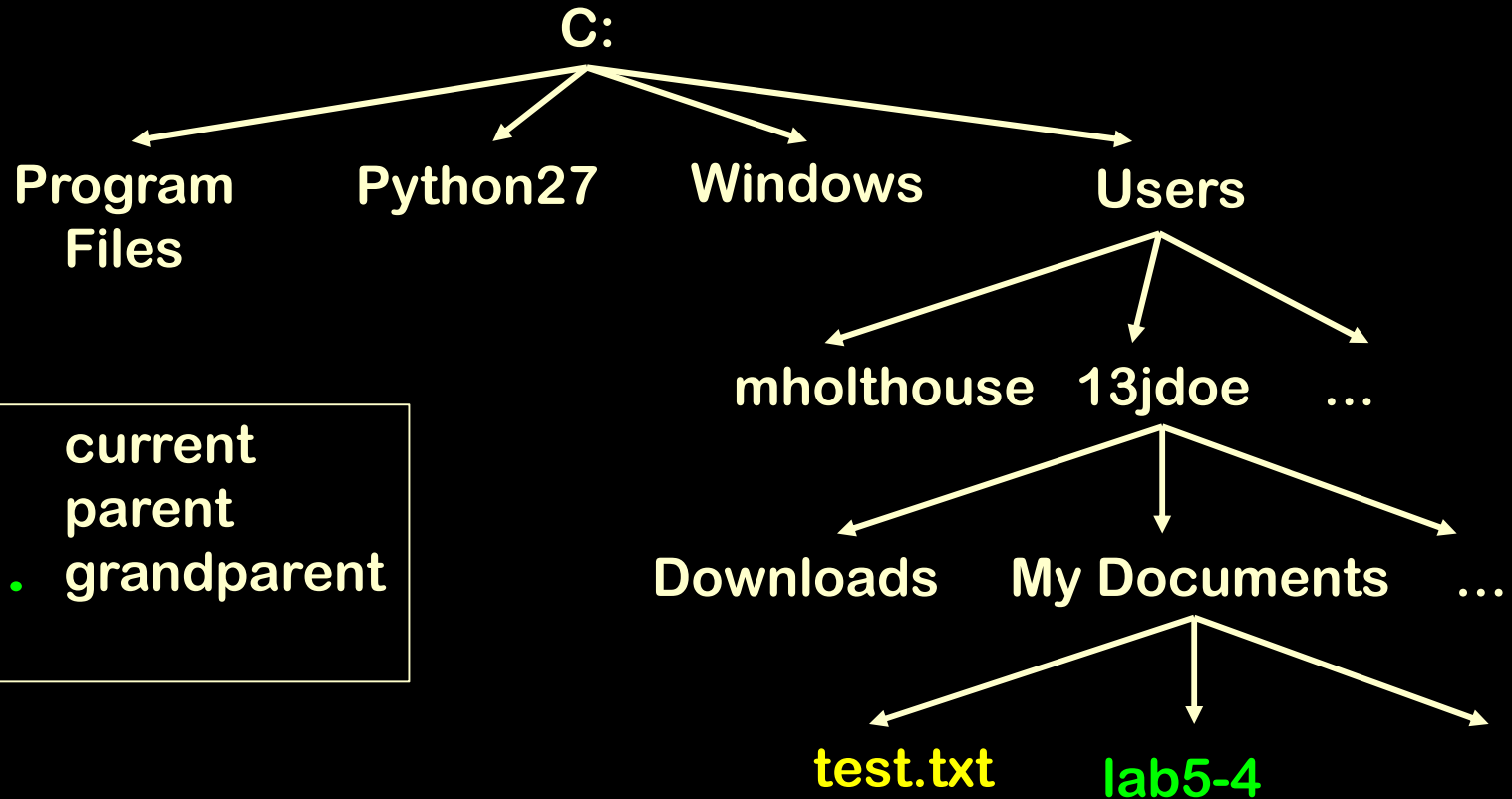
.	current
..	parent
..\..	grandparent
etc.	

`c:\Users\13jdoe\My Documents\test.txt`

`My Documents\test.txt`



Relative Path Name



. current
.. parent
..\..\ grandparent
etc.

c:\Users\13jdoe\My Documents\test.txt

..\test.txt



/ vs. \

Windows `c:\Users\13jdoe\My Documents\test.txt`

Unix `/Users/13jdoe/My Documents/test.txt`

Python `C:/Users/13jdoe/My Documents/test.txt`
`C:\\Users\\13jdoe\\My Documents\\test.txt`
`C:\Users\\13jdoe\\My Documents\\test.txt`

Sharing the Disk

- FIFO queue
 - First in, first out



Sharing the Disk

- FIFO queue
 - First in, first out
- Shortest seek time



Sharing the Disk

- FIFO queue
 - First in, first out
- Shortest seek time
- SCAN
 - Back and forth across disk



Why is my computer so slow?

- You've pegged the CPU at 100%
 - Who's hogging the CPU?



Why is my computer so slow?

- You've pegged the CPU at 100%
 - Who's hogging the CPU?
- You're page faulting like crazy
 - Who's hogging memory?
 - Add more?



Why is my computer so slow?

- You've pegged the CPU at 100%
 - Who's hogging the CPU?
- You're page faulting like crazy
 - Who's hogging memory?
 - Add more?
- You're beating your disk to death
 - Are you fragmented?



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And we haven't even gotten to the internet yet...

