EXT3 File Recovery via Indirect Blocks

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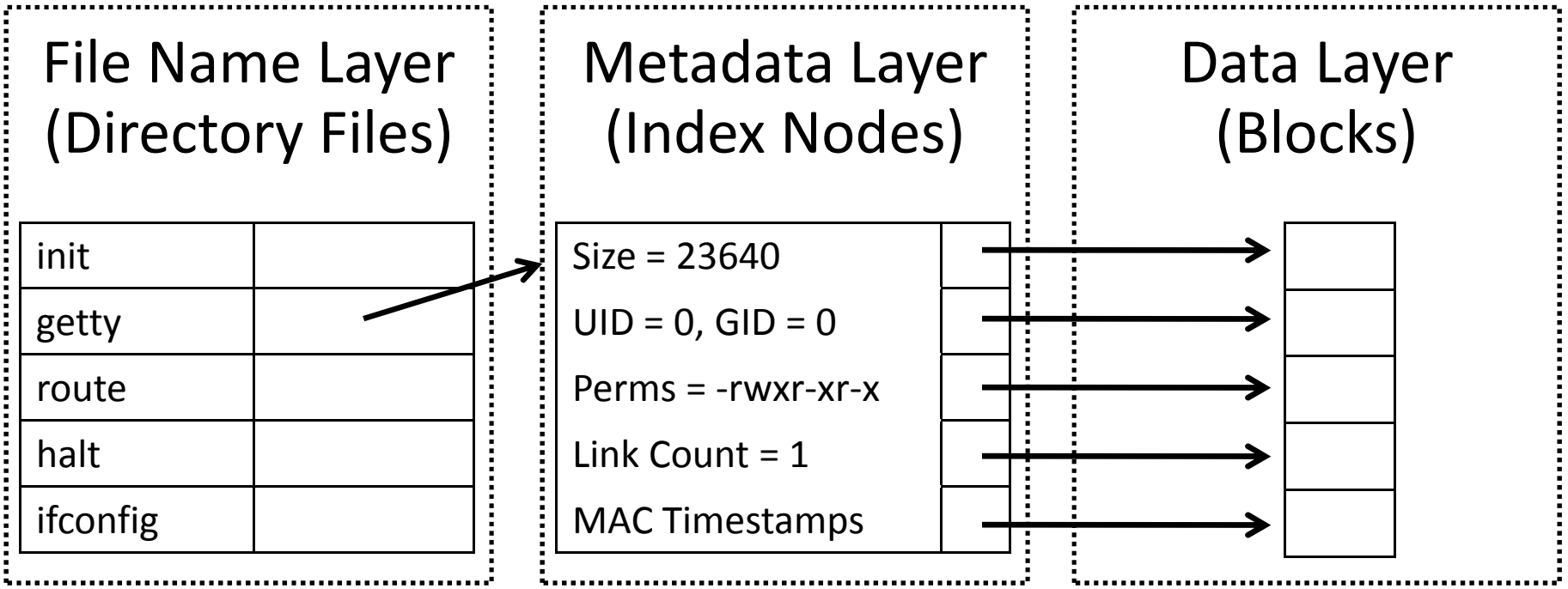
Agenda

- EXT File System Review
- Recovering Deleted Data
  - Issues with Traditional File Carving Tools
  - How Indirect Blocks Can Be Leveraged
  - Tools to Recover Data
- Wrap Up
  - Looking Ahead to EXT4

EXT File System Review

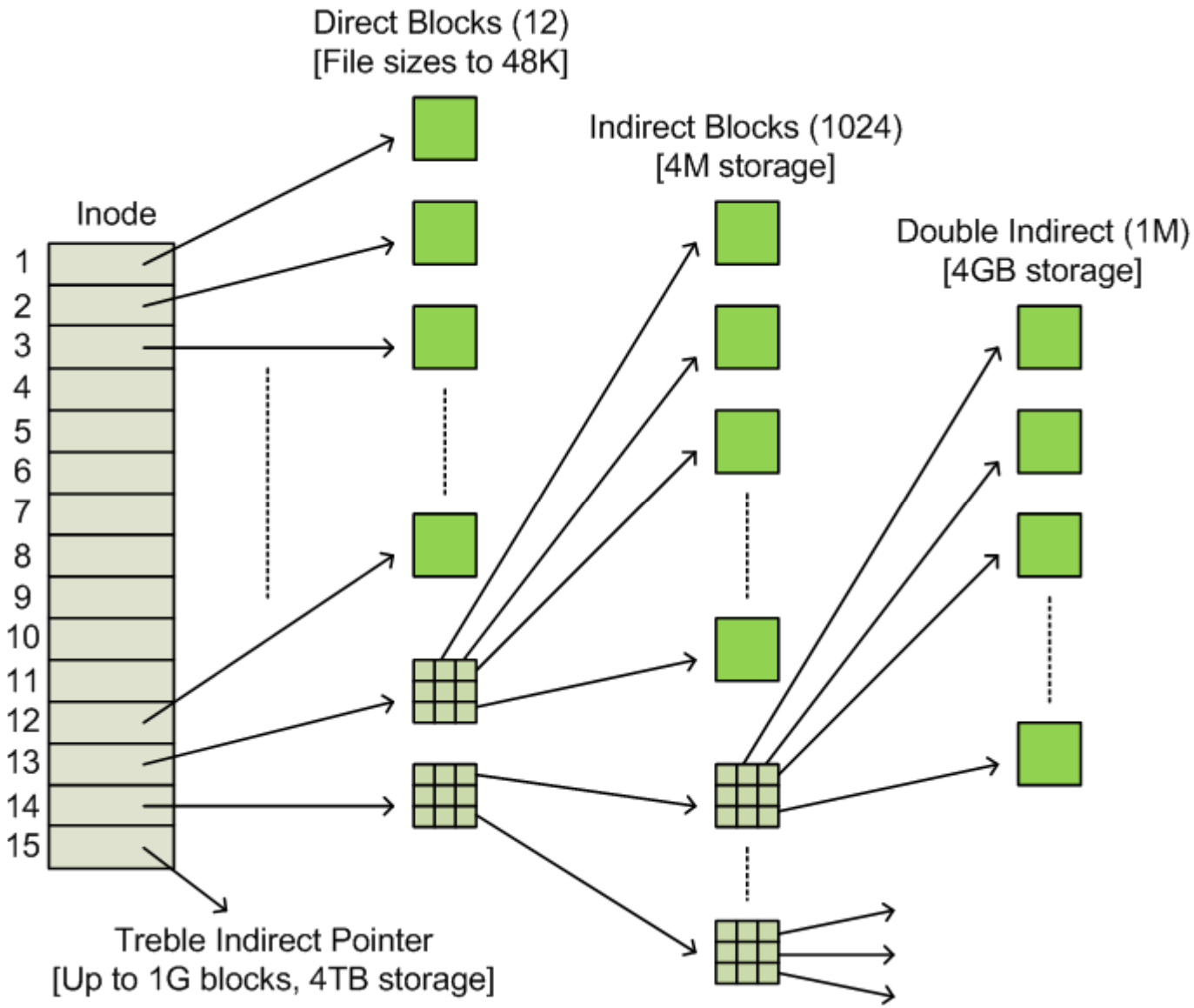
EXT File System Layers



File System Layer (Superblock, Group Desc Tables)

Metadata Layer

- Inodes store typical file metadata:
  - File permissions
  - Ownership info
  - File size, number of links, etc
  - MAC timestamps
- Inode also has fixed number of pointers to the file content (data blocks)…


Direct Blocks (12)
[File sizes to 48K]
Indirect Blocks (1024)
[4M storage]
Double Indirect (1M)
[4GB storage]
Inode
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Treble Indirect Pointer
[Up to 1G blocks, 4TB storage]

A Word About Data Blocks

- Data blocks (and inodes) organized into logical "Block Groups" (typically 32K blocks/group)
- Contents of a directory will be allocated to the same block group
- Blocks in a file will be allocated consecutively, if possible, using "first-available" algorithm
- Slack space is null-filled

File Deletion in EXT

Data vs. Metadata

- Data blocks are simply marked as unallocated
  - Content remains on disk until blocks re-used

- Treatment of metadata varies by EXT version
  - EXT2: Simply mark inode as unallocated

    (File recovery is trivial)
  - EXT3: Zeroes block pointers, marks as unallocated

    (File recovery? Ummmm….)

Quick Example: EXT2 Recovery

1. Examine unallocated inodes with ils

```
$ ils ext2-simple.img
st_ino|st_alloc|…|st_size|st_block0|st_block1
1713|f|…|0|10753|0
1714|f|…|2300|8705|8706
```

File size is non-zero

2. Use icat to recover original file content

```
$ icat ext2-simple.img 1714
This is a deleted file
This is a deleted file
This is a deleted file
…
```

So What About EXT3?

- Traditional techniques rely on "file carving":
  - Determine a "signature" for start of file
  - Start grabbing blocks until end of file "signature" or until size limit is reached

Problems w/ Carving EXT3

- Many Unix file types have no viable signatures
- Indirect blocks (metadata) in data runs
- File fragmentation, particularly on larger files

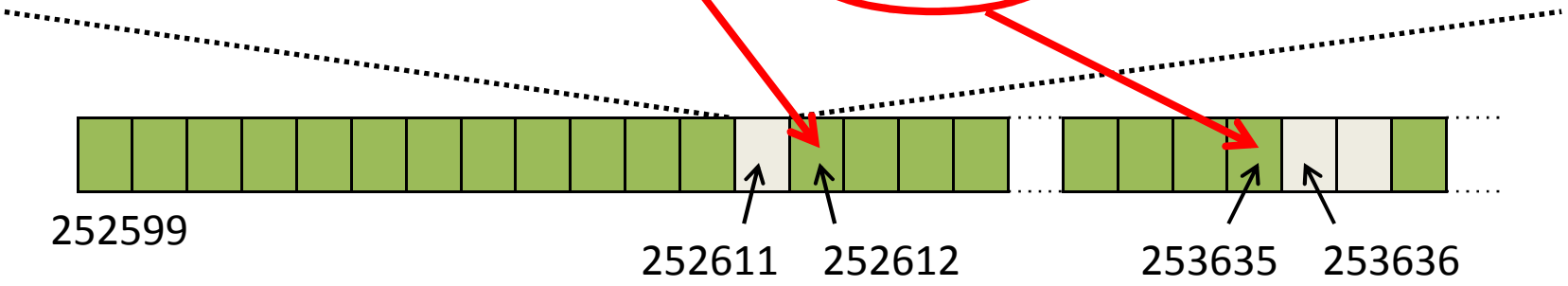
Leveraging Indirect Blocks

Pertinent Questions

- Why are we just ignoring indirect block data?
- Couldn't we use it do recover file content?
- Can we rebuild the entire original file?

Looking At an Indirect Block

```
# blkcat -h ext3-example.img 252611
0       c4da0300 c5da0300 c6da0300 c7da0300   .... .... .... ....
16      c8da0300 c9da0300 cada0300 cbda0300   .... .... .... ....
32      ccda0300 cdda0300 ceda0300 cfda0300   .... .... .... ....
48      d0da0300 d1da0300 d2da0300 d3da0300   .... .... .... ....
64      d4da0300 d5da0300 d6da0300 d7da0300   .... .... .... ....
80      d8da0300 d9da0300 dada0300 dbda0300   .... .... .... ....
 ...
4048    b8de0300 b9de0300 bade0300 bbde0300   .... .... .... ....
4064    bcde0300 bdde0300 bede0300 bfde0300   .... .... .... ....
4080    c0de0300 c1de0300 c2de0300 c3de0300   .... .... .... ....
```



Simple File Recovery Strategy

- Find beginning of file via signature
- Does the 13th block look like an indirect block?
- If so, dump associated data blocks
- If last block address is not null, keep going

We can do this manually…

There's an App for That…

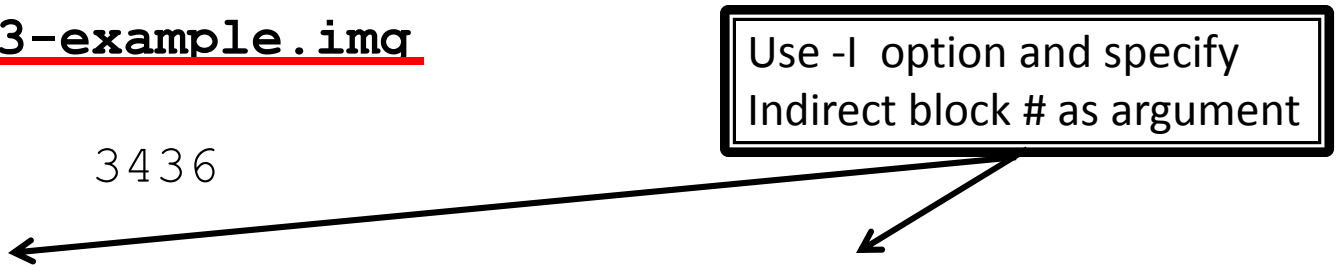
```
# sigfind -b 4096 1F8B0800 ext3-example.img
Block size: 4096  Offset: 0  Signature: 1F8B0800
Block: 251904 (-)
Block: 252096 (+192)
Block: 252293 (+197)
Block: 252599 (+306)
…
# frib ext3-example.img 252599 >recovered.gz
# tar ztf recovered.gz
  …
perl-5.10.1/patchlevel.h
perl-5.10.1/Configure
#
```

Don't Have a File Signature?

- Indirect blocks have a signature:
  - *Any block N whose first 4-bytes == N+1*
- Use relative location of indirect blocks to put file contents back together
- Beginning of file data will (hopefully) be the 12 blocks before the first indirect block

There's an App for That Too…

```
# fib ext3-example.img
…
252611       3436
…
# frib -I dblks ext3-example.img 252611>indblks
# ls -lh *blks
-rw-r--r-- 1 hal hal 48K 2011-01-16 08:09 dblks
-rw-r--r-- 1 hal hal 14M 2011-01-16 08:09 indblks
# cat dblks indblks >recovered2.gz
# ls -l recovered*.gz
-rw-r--r-- 1 hal hal 14118912 2011-01… recovered2.gz
-rw-r--r-- 1 hal hal 14118912 2011-01… recovered.gz
# diff recovered*.gz
```



Fragmentation

- Not a problem if fragmentation occurs within data runs from indirect blocks

- Real problem if fragmented in first 13 blocks:
  - Start with signature, can't find first indirect block
  - Start from indirect block, can't find true file start

All is Not (Necessarily) Lost

- Use fib/frib to recover the majority of the file using indirect blocks strategy
- May be able to use file content signatures to piece together the first 12 blocks
- Reduce your search space:
  - Data blocks will tend to be in same block group
  - "First available" algorithm means start of file will usually be found in lower block numbers

Wrapping Up

Looking Ahead: EXT4

- These techniques *will not work* with EXT4
- EXT4 uses *extents* (start block + run len) rather than inefficient pointer strategy of EXT2/3
- Extents are zeroed when inode is deallocated– back to file carving again
- Good news:
  - "Delayed allocation" == less fragmentation
  - No more indirect block meta-data in data runs

EXT3 will be with us for a long time…

That's It!

- Any final questions?
- Thanks for listening!

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