Timestomping NTFS

(with emphasis on directory index records)

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Research question (1)

What forms of NTFS timestamp tampering can be detected by inspecting NTFS structures?

Timestamps on NTFS (1)

MACB timestamps:

- **M**odified [1]
- **A**ccessed [2]
- **C**hanged [3]
- **B**irth [4]

[1] mOdified - cOntents
[2] updates turned of by default in recent Windows versions
[3] chAnged - metAdata
[4] but what does that mean, anyway

Timestamps on NTFS (2)

In the Master File Table entries:

- **SI** - STANDARD_INFORMATION attribute. User-modifiable through `SetFileInformationByHandle` and `ZwSetInformationFile` routines.
- **FN** - FILE_NAME attribute. Files can have multiple of these, in different namespaces. They are not exposed to userspace.
- Inside directory indices: timestamps reflecting **SI** timestamps, but embedded inside an **FN** attribute...

Maximum number of timestamps:
4 (MACB) * (1 SI, 3 FN, 3 directory index entries) = 28!

Tampering techniques

How does one tamper with timestamps ("timestomping") ?

- Through APIs, as classic `timestomp.exe`[5] does. Not perfect.
- Direct modification of on-disk NTFS structures. Current cream of the crop: later versions of `SetMace`[6].

[5] James Foster Vinnie Lin, Blackhat 2005

[6] Joakim Schicht, 2011-2014

Research question revisited

What forms of NTFS timestomping can be detected by inspecting NTFS structures?

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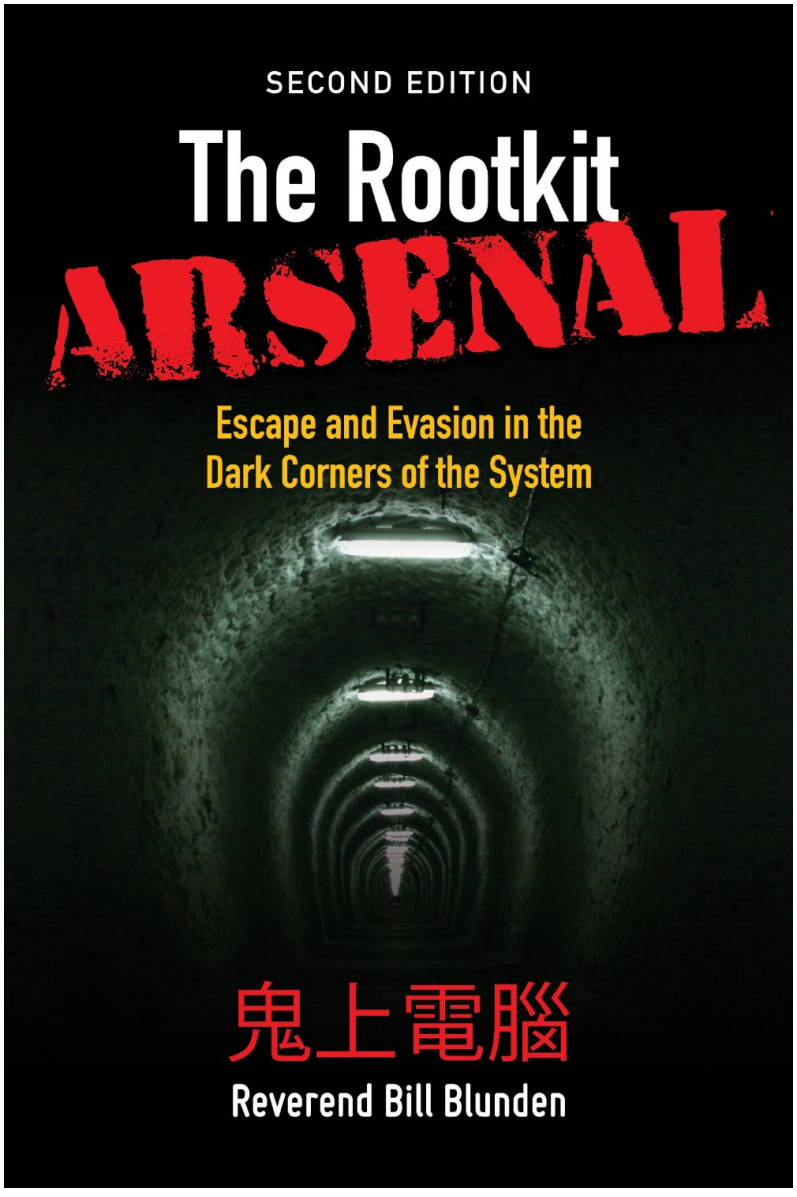
Subquestions:

- What is the form, function, and location of all these timestamps? How do they relate to each other?
- What timestomping techniques are available to modify each timestamp?
- What inconsistencies (if any) do the techniques introduce?

Timestomping detection



Timestomping detection

subtlety is key!

> This highlights the fact that you should *aspire to subtlety*, but when it's not feasible to do so, then you should at least be consistent. If you conceal yourself in such a manner that you escape notice on the initial inspection but are identified as an exception during a second pass, it's going to look bad. The investigator will know that something is up and call for backup. If you can't change time-stamp information uniformly, in a way that makes sense, then don't attempt it at all.

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Common slip-up: Forgetting about the 100ns timestamp resolution: `2014-01-01 12:12:34.000000`

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Generally: look for inconsistencies

Timestomping: Inconsistencies

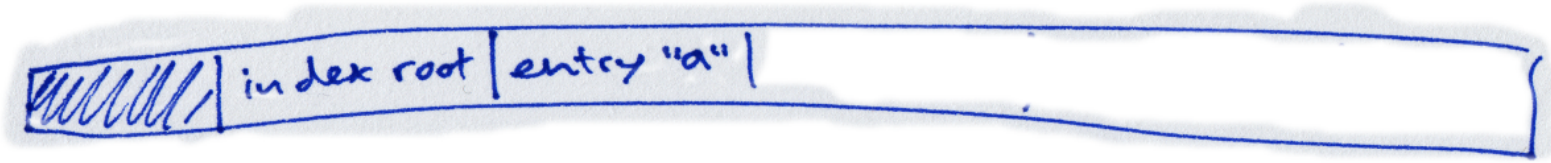
- Causal relationships (*happened-before*): allocators, sequence numbers. Willassen, 2008.
- Deriving past operations from the NTFS journal. Cho, 2012.
- Explicit second source of timestamps: directory index entries in B-tree slack (INDEX_ALLOCATION): `INDXParse.py`, Ballenthin, 2011-2014.

Parsing the INDEX_ROOT attribute

With the *Hachoir* framework:

```
181
182 class IndexRoot(FieldSet):
183     # Carrier 370 13.12
184     def createFields(self):
185         yield Enum(textHandler(UInt32(self, "ixtype", "indexed attribute type"), hexadecimal), ATTR_NAME)
186         yield UInt32(self, "collsort", "collation sorting rule")
187         yield UInt32(self,"ixrecsz(b)", "size of each index record (bytes)")
188         yield UInt8(self,"ixrecsz(c)", "size of each index record (clusters)")
189         yield PaddingBytes(self, "padding[]", 3)
190         yield IndexNodeHeader(self, 'nodeheader')
191         while self._current_size//8 <= self['nodeheader/used_offset'].value: # <=; for the lists ends with an
            empty entry with 'last' flag set
192             yield DirectoryIndexEntry(self, 'entry[]')
193
194
195 class IndexNodeHeader(FieldSet):
196     # Carrier 373 13.14
197     def createFields(self):
198         yield UInt32(self, "start_offset", "offset to start of index entry list")
199         yield UInt32(self, "used_offset", "offset to end of used portion of index entry list")
200         yield UInt32(self, "alloc_offset", "offset to end of allocated portion of index entry list")
201         yield Bit(self, "haschildren", "one or more ixentries in this node point to child nodes in $INDEX_ALLOCATION")
202         yield NullBits(self, "reserved[]", 31)
203         seekfwd = self['start_offset'].value*8 - self._current_size
204         if seekfwd:
205             yield RawBytes(self, "padding[]", seekfwd)
206
```

Growing a directory index



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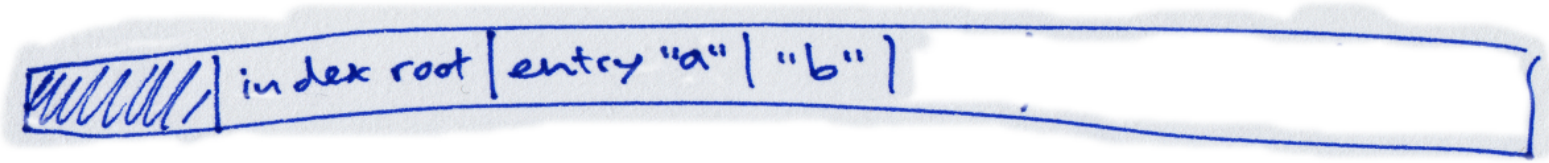

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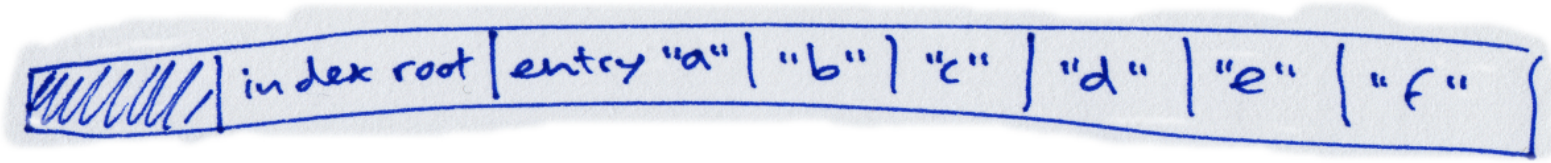

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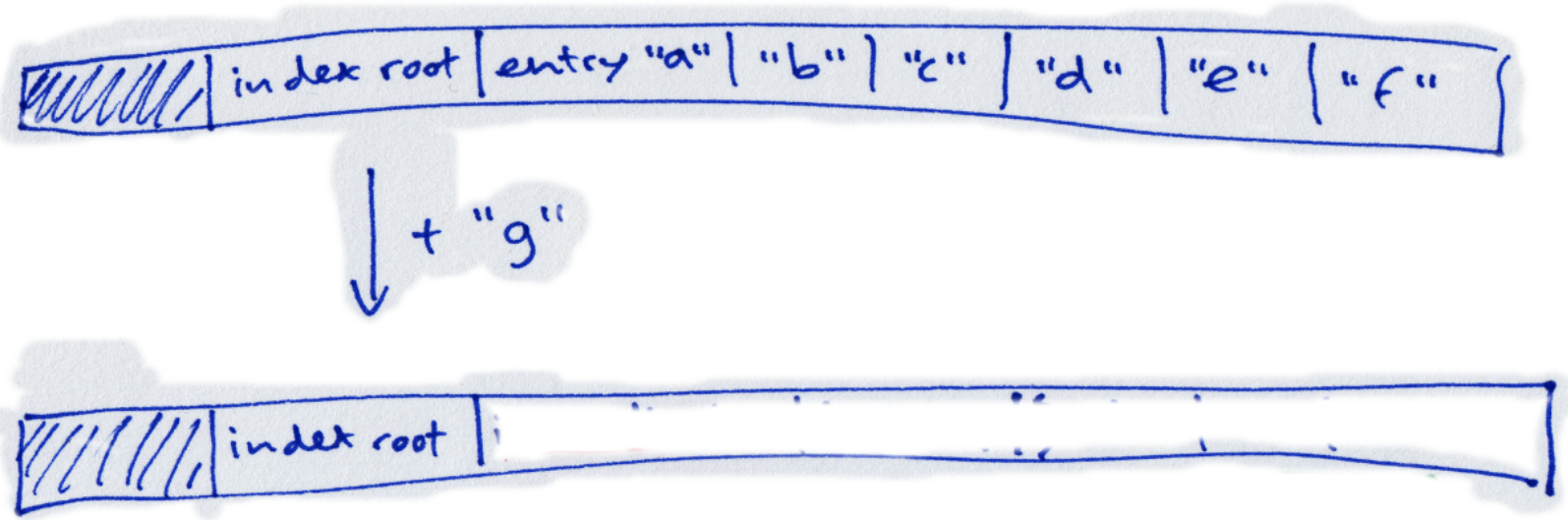

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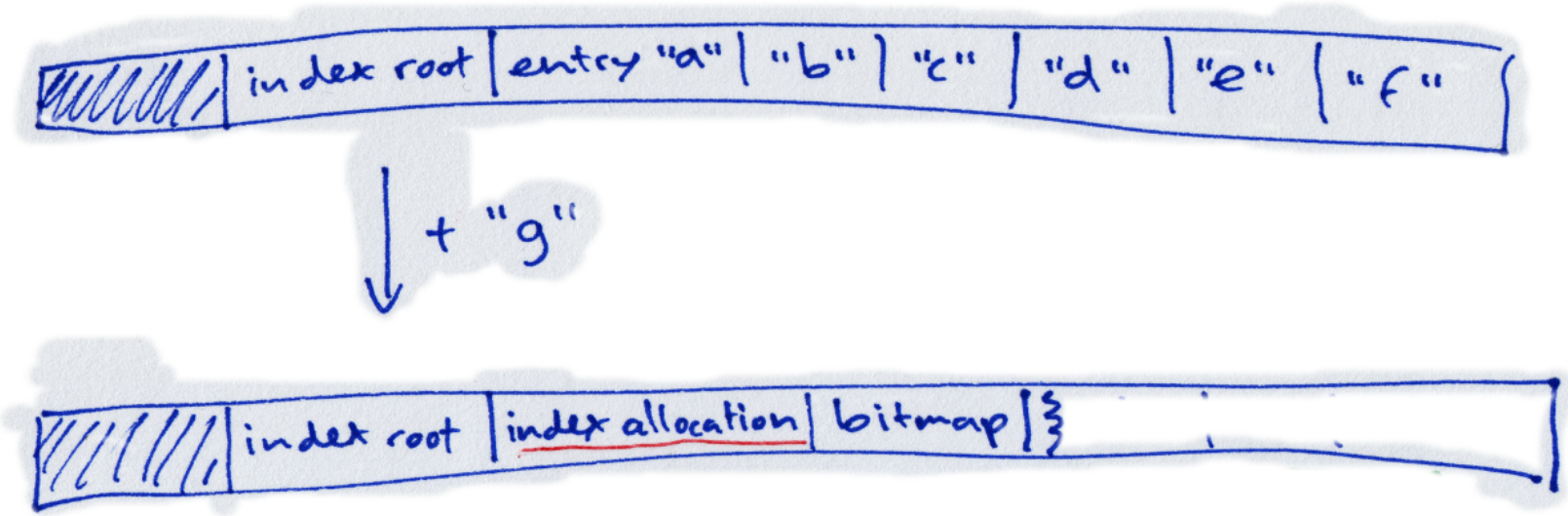

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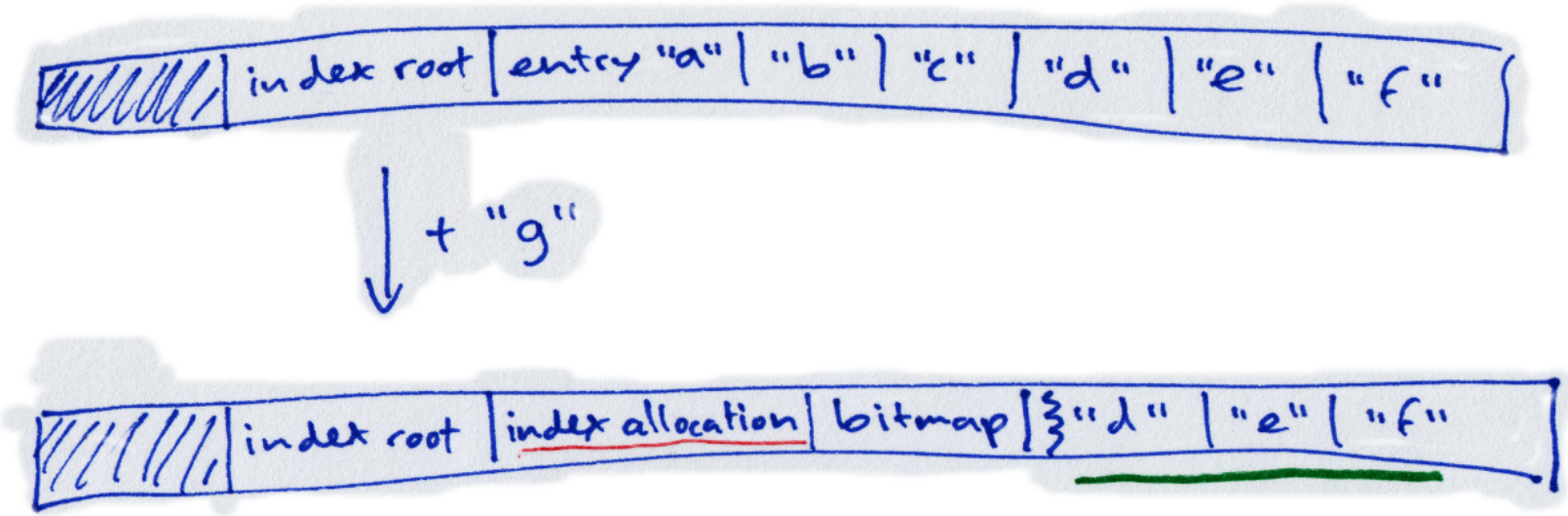

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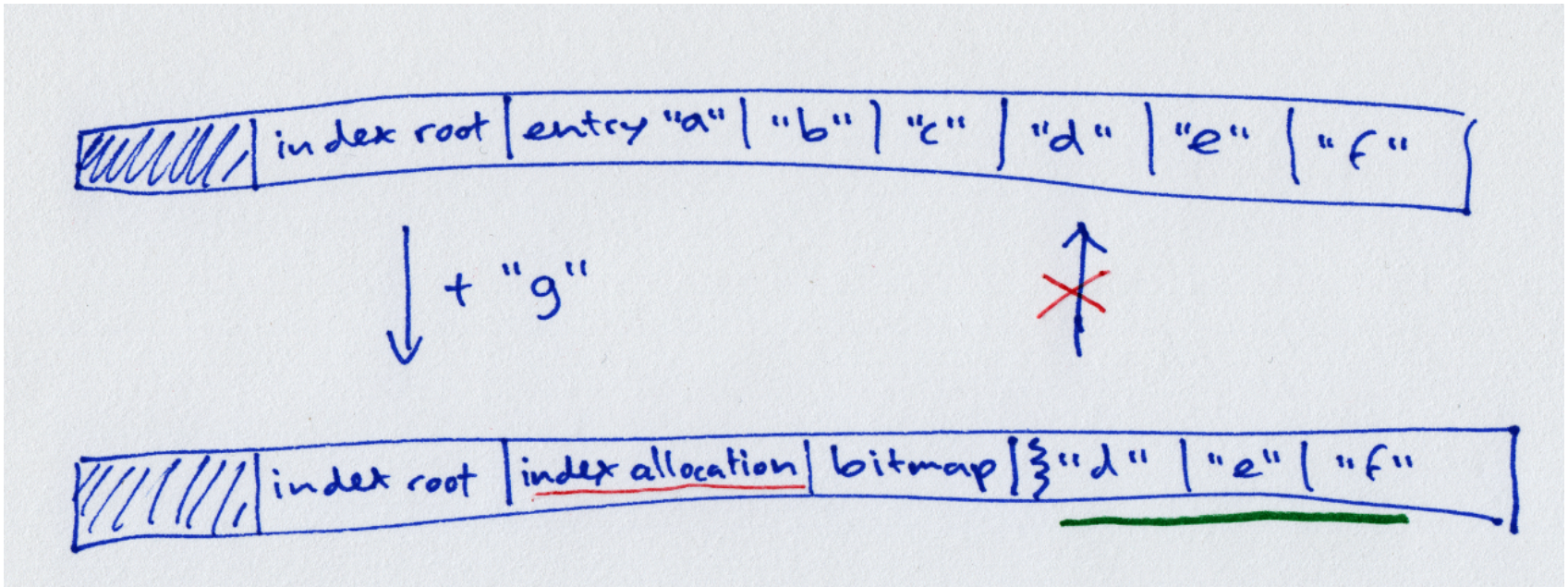
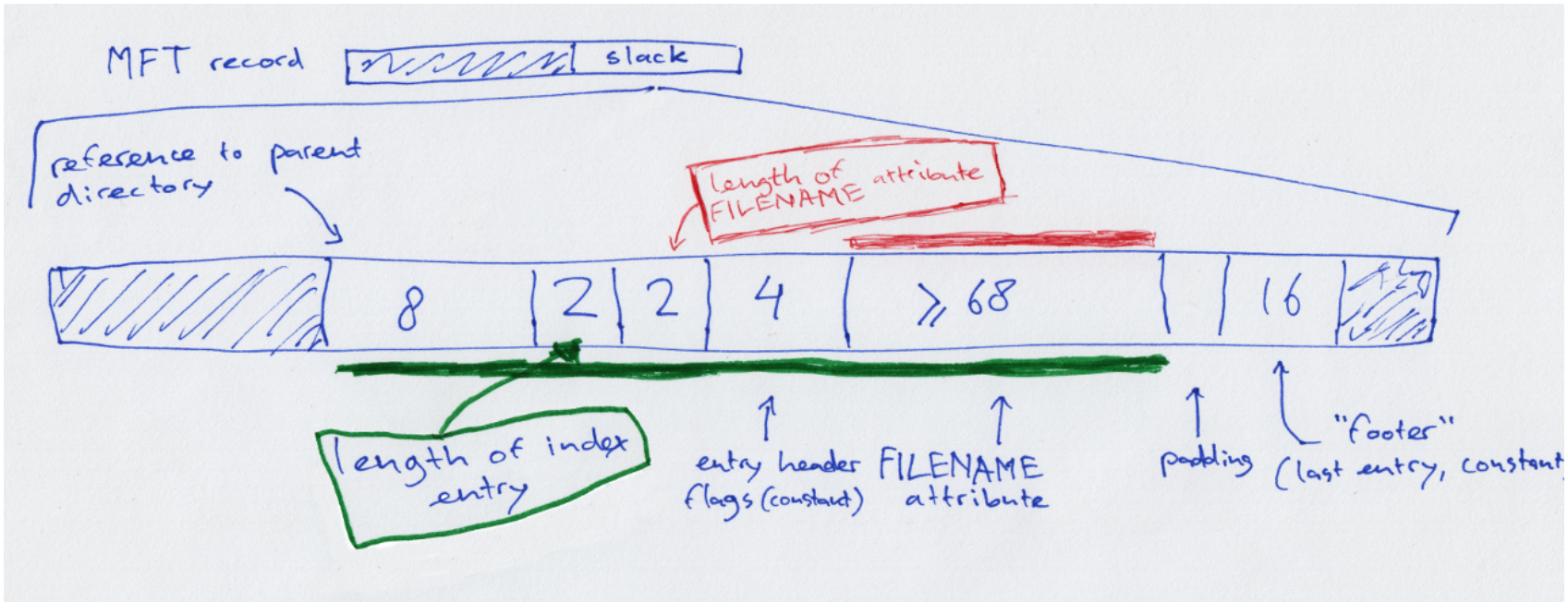
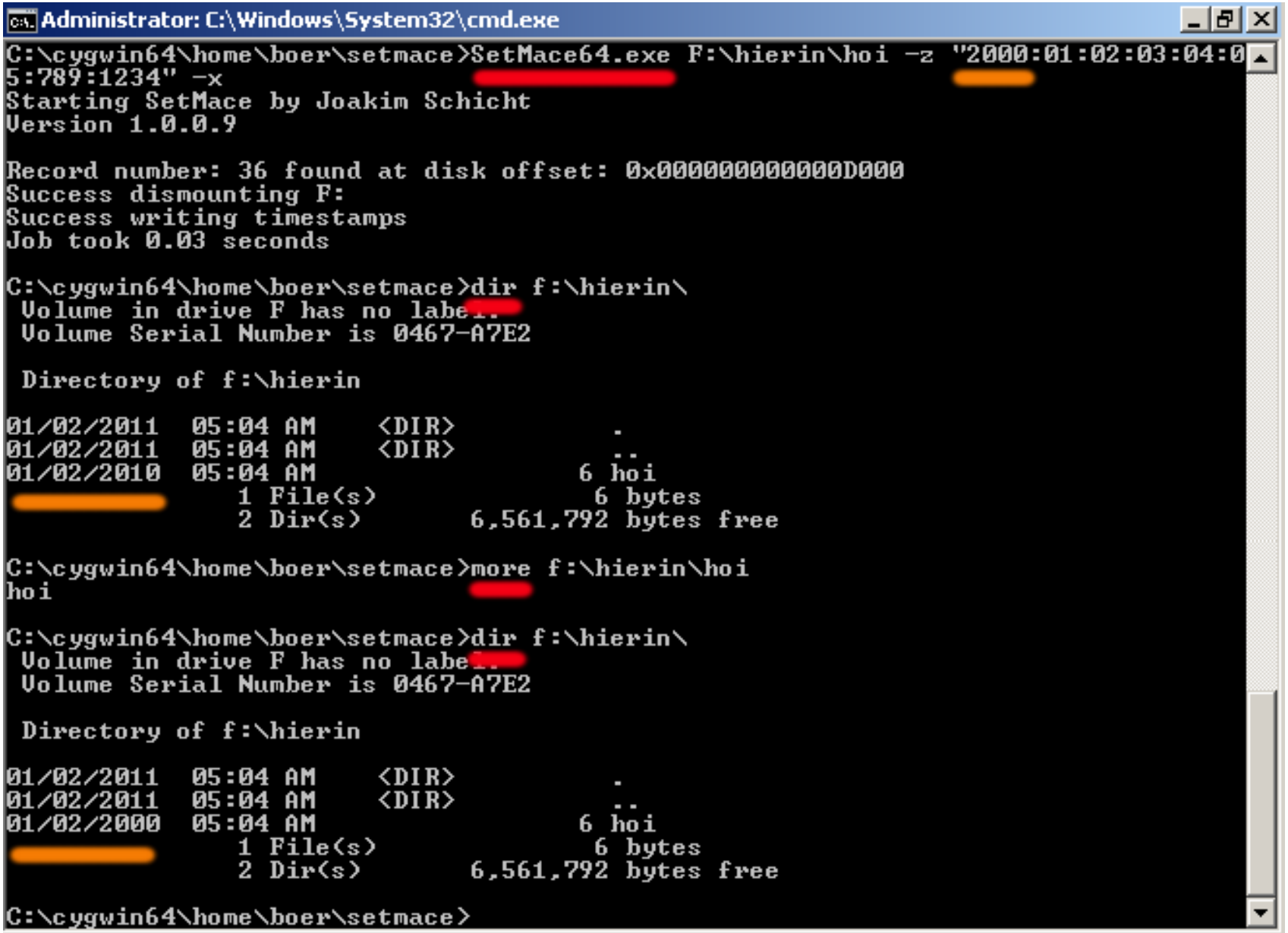


Carving root index entries from MFT slack



SetMACE directory indices



Fingerprinting timestamp relations (1)

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As the FILE_NAME timestamps are a snapshot of some earlier state of the STANDARD_INFORMATION timestamps... the former should always be less or equal to the latter, right?

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What about self-inconsistencies in time stamps?
As the FILE_NAME timestamps are a snapshot of some earlier state of the STANDARD_INFORMATION timestamps... the former should always be less or equal to the latter, right?

```
sqlite> .headers off
sqlite> select count() from mft
   ...> where isdir = 0 and isalloc = 1;
116660
sqlite> select count() from mft
   ...> where isdir = 0 and isalloc = 1
   ...> and sim >= fnm;
28534
sqlite> select count() from mft
   ...> where isdir = 0 and isalloc = 1
   ...> and sim < fnm;
88126
```

Fingerprinting timestamp relations (2)

An example fingerprint:

.

```
sia = sib < sim < fna = fnb = fnc = fnm < sic
```

.

Total number of possible configurations [7] :

$$\sum_{x=1}^{7} \binom{7}{x-1} = 55581$$

[7] Sum of binomial coefficients

Wildtype timestamps

A skewed, but long-tailed distribution. Example: Cumulative distribution of timestamp fingerprints of EXE files on 1.5 years old Windows 7 system.

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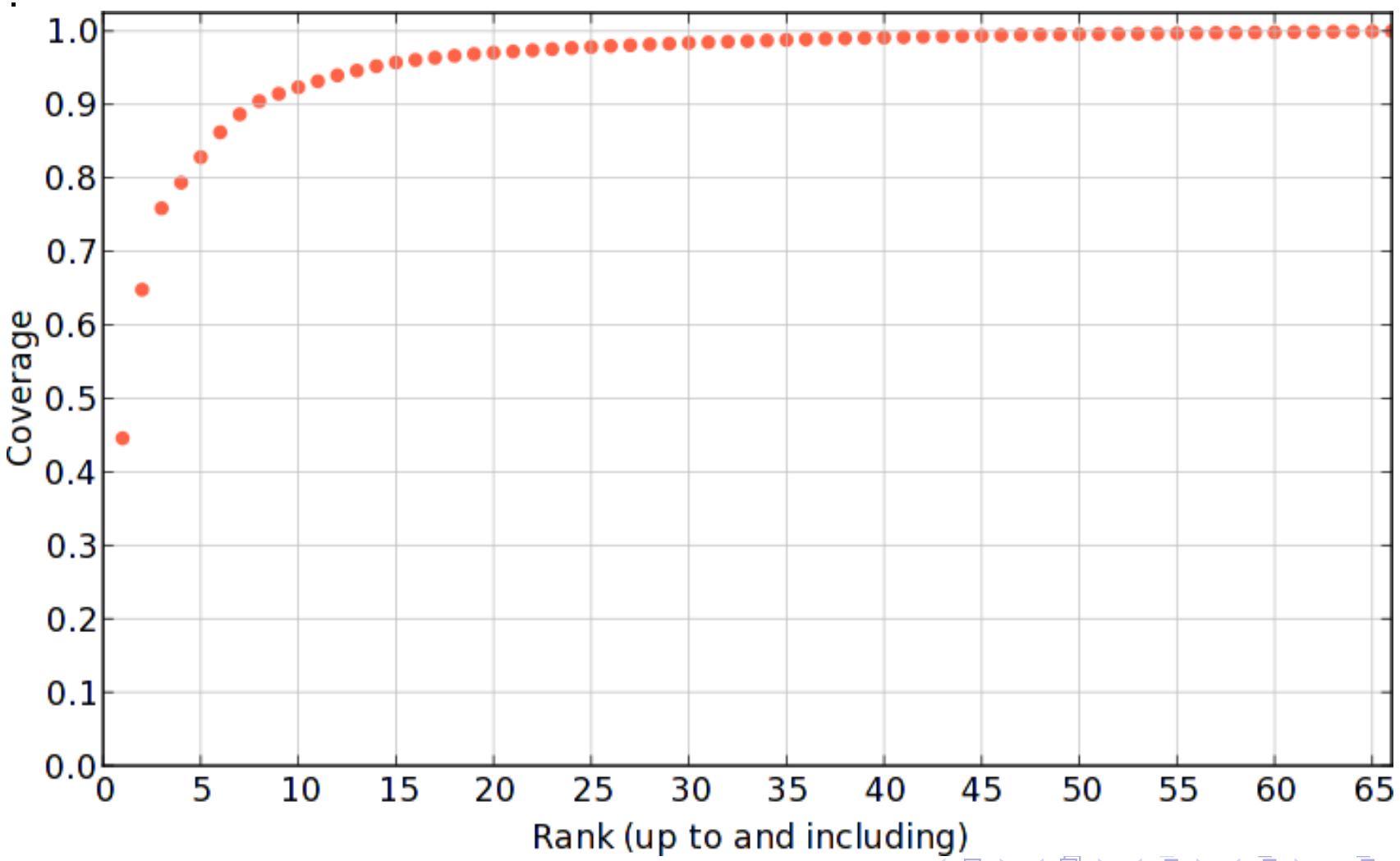

Conclusions

What forms of NTFS timestamp tampering can be detected by inspecting NTFS structures?
→ *It depends.* When it comes to finding inconsistencies;

- Index records *may* be overlooked by direct-access timestomping tools. However, Windows helpfully repairs resulting inconsistencies.[8]
- Old index records *may* be found in slack space.
- Wildtype timestamp configurations do not follow intuitions. Anomaly detection based on wildtype timestamp configuration frequencies *may* be of some use in the ranking phase.

[8] Next step: Extended consistency checker, for instance, cross-check each of the FN attributes in the multiple namespaces *and* the directory indices