CMSC389R

Forensics I

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

announcements

Midterm next week

14 multiple choice, 1 bonus

64 total points

today’s topics

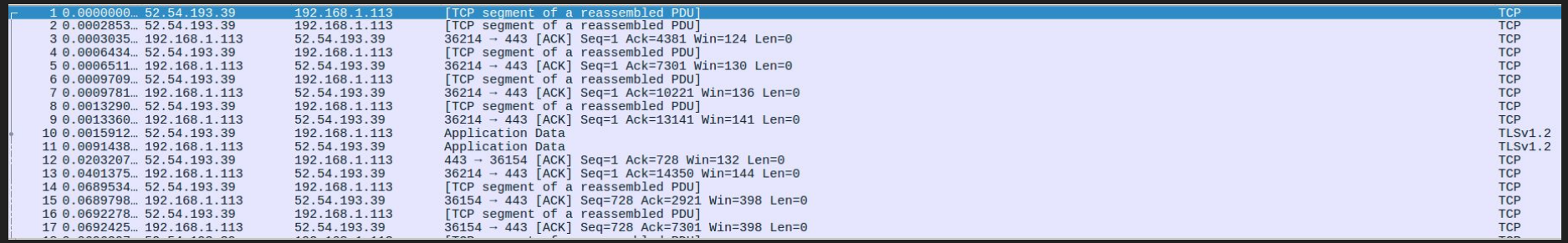
- Digital forensics overview
- Data recovery and/or extraction
- Basic analysis techniques (tool-based)
  - Metadata scanning
  - String/pattern searching
  - Steganographic analysis

what is (digital) forensics?

- The recovery/extraction and analysis of data from a storage medium
- Who does digital forensics?
  - Law enforcement: local and federal crimes
  - The courts: legal discovery
  - Malware analysts
  - Pentesters

data recovery/extraction

- Various sources:
  - physical media (HDDs/SSDs/thumb drives/SIM)
    - Even partially destroyed media!
  - storage formats (disk images, archives)
  - “live” sources (RAM dumps, packet captures)



1	0.0000000…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
2	0.0002853…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
3	0.0003035…	192.168.1.113	52.54.193.39	36214 → 443 [ACK] Seq=1 Ack=4381 Win=124 Len=0	TCP
4	0.0006434…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
5	0.0006511…	192.168.1.113	52.54.193.39	36214 → 443 [ACK] Seq=1 Ack=7301 Win=130 Len=0	TCP
6	0.0009709…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
7	0.0009781…	192.168.1.113	52.54.193.39	36214 → 443 [ACK] Seq=1 Ack=10221 Win=136 Len=0	TCP
8	0.0013290…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
9	0.0013360…	192.168.1.113	52.54.193.39	36214 → 443 [ACK] Seq=1 Ack=13141 Win=141 Len=0	TCP
10	0.0015912…	52.54.193.39	192.168.1.113	Application Data	TLSv1.2
11	0.0091438…	192.168.1.113	52.54.193.39	Application Data	TLSv1.2
12	0.0203207…	52.54.193.39	192.168.1.113	443 → 36154 [ACK] Seq=1 Ack=728 Win=132 Len=0	TCP
13	0.0401375…	192.168.1.113	52.54.193.39	36214 → 443 [ACK] Seq=1 Ack=14350 Win=144 Len=0	TCP
14	0.0689534…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
15	0.0689798…	192.168.1.113	52.54.193.39	36154 → 443 [ACK] Seq=728 Ack=2921 Win=398 Len=0	TCP
16	0.0692278…	52.54.193.39	192.168.1.113	[TCP segment of a reassembled PDU]	TCP
17	0.0692425…	192.168.1.113	52.54.193.39	36154 → 443 [ACK] Seq=728 Ack=7301 Win=398 Len=0	TCP

data recovery: physical media

- Copying files is not sufficient!
  - We want deleted files, bad sectors*, …
- We need to take an image:
  - Byte-by-byte copy of the media
  - Don’t attempt to interpret, just save
  - Common extensions: .iso, .img
    - Your OS install image is one of these!

* Copying bad sectors requires us to go beneath OS-level copies

data recovery: physical media

```
$ sudo dd if=/dev/sdX of=sdX.img bs=4M
```

- Legend:
  - `if=` : input file (SATA device in ex.)
  - `of=` : output file (.img file in ex.)
  - `bs=` : block size (4MB here, for speed)
- See `man dd` for more information

data recovery: formats

- Sometimes we just want a single file/archive
  - Which means we'll need to know how to parse different file formats (next lecture!)
- Copy the file, tear it apart
  - Record file metadata (when/who created, etc)
  - Automated analysis (in a bit)

data recovery/extraction

- We have the data; now what?
- Golden rule(s) for digital forensics:
  - All good forensics begins with a verified copy
  - Never do forensics work on the “master”
  - If you can’t verify your copy, it’s worthless (legally speaking)
- So: how do we copy and verify?

copy and verify

- First, take a strong cryptographic hash of the image file (more on this in crypto):

```
$ sha512sum sdX.img
```

- Give the hash to a trusted/authoritative party
  - e.g., legal counsel
- Copying: use `dd` again (`if=sdX.img`), or `cp`!
- Make sure your copy has the same hash!

copy and verify

- What does this accomplish?
  - Makes tampering difficult: third party has own copy and hash, so modifications appear as hash changes
  - Not just about trust: keeps forensic samples from being mixed up, corrupted
    - Lots of legal cases are lost because of unverified digital evidence (analysis done on file w/ different hash)

analysis techniques

- How should we analyze our copy?
  - Depends on what we’re looking for!
- Content-agnostic analysis
  - Often just string/pattern searching
  - Generally less accurate/more verbose
- Content-aware analysis
- Metadata analysis
- Steganographic analysis

analysis techniques: content-agnostic

- We often don’t know what we’re looking for...
  - So we turn to generic tools!
- General strategy:
  - Maintain a list of interesting signatures*
  - Scan input for each signature
  - Give the user a list of offsets corresponding to signature matches

* or just look for ranges: ASCII, decimals, UTF-8, ...

content-agnostic analysis: strings

- `strings` does exactly what it says:
  - Finds strings of printable characters in binary files
  - Options for min length, encoding, whitespace
  - Some additional executable searching features
    - Why might this be a problem? (hint: `libbfd`)
  - Available on pretty much every Linux/*nix

```
$ strings /bin/bash # try it out on any file
```

$ strings -n 15 /bin/bash

```
show-all-if-unmodified
skip-completed-text
$else found without matching $if
completion-prefix-display-length
print-completions-horizontally
/var/tmp/rltrace.%ld
readline_callback_read_char() called with no handler!
unknown expansion error
event not found
bad word specifier
substitution failed
unrecognized history modifier
no previous substitution
LS_COLORS: syntax error: %s
unparsable value for LS_COLORS environment variable
LS_COLORS: unrecognized prefix: %s
p->minfo.mi_magic2 == 0x5555
bcoalesce: CHAIN(mp2) != mp1
malloc: %s:%d: assertion botched
free: called with already freed block argument
free: called with unallocated block argument
free: underflow detected; mh_nbytes out of range
free: start and end chunk sizes differ
malloc: block on free list clobbered
```

strings in practice

- `strings` isn't very useful on its own
  - No filtering, lots of garbage "text"
- So use `grep` (or another tool) to filter!

```
$ # search for "error" with 1 line of context
$ strings /bin/bash | grep -C1 "error"
$ # search for things that look like env vars
$ strings /bin/bash | grep -P "\S+=\S+"
```

content-agnostic analysis: binwalk

- `binwalk` is a great tool for unpacking multiple files stuck together:
  - (Partial) disk image, embedded photos and videos in other formats, archives…

```
$ man binwalk
$ binwalk my_file.bin
$ binwalk -e my_file.bin
$ binwalk --dd=”png:png”
```

content-agnostic analysis: file

- Files don’t necessarily need to have a filename extension
  - They don’t even need to have a *correct* one
- `file` tells you what kind of file based on magic bytes
  - https://www.garykessler.net/library/file_sigs.html

```
$ file flag.png
JPEG image data, JFIF standard 1.01 ...
```

content-aware analysis

- If we know the format of the file, we can analyze it more precisely!
- Fingerprinting: figure out who generated it based on *how* they generated it
  - Binaries: every compiler has its own quirks
  - Android Compiler Fingerprinting
- PDFs/rich documents: embedded scripts, embedded changelogs, default field values, references to other files…

analysis techniques: metadata

- Files have all kinds of metadata in them
  - Chain of authors, original computer, …
  - Particularly: PDFs, DOCs, JPG/PNG/MP4, …
- Images (JPG/PNG) can be especially interesting:
  - GPS tags, time taken tags
  - Device/vendor/software tags
    - Why might this be interesting? (think vuln scanning)

Learned the hard way

metadata analysis

- `exiftool` is great for both viewing and modifying image/audio/video metadata:

```
$ sudo apt install exiftool

$ # dump all tags in the file
$ exiftool my_image.jpg

$ # wipe all tags from the file
$ exiftool -all= my_image.jpg
```

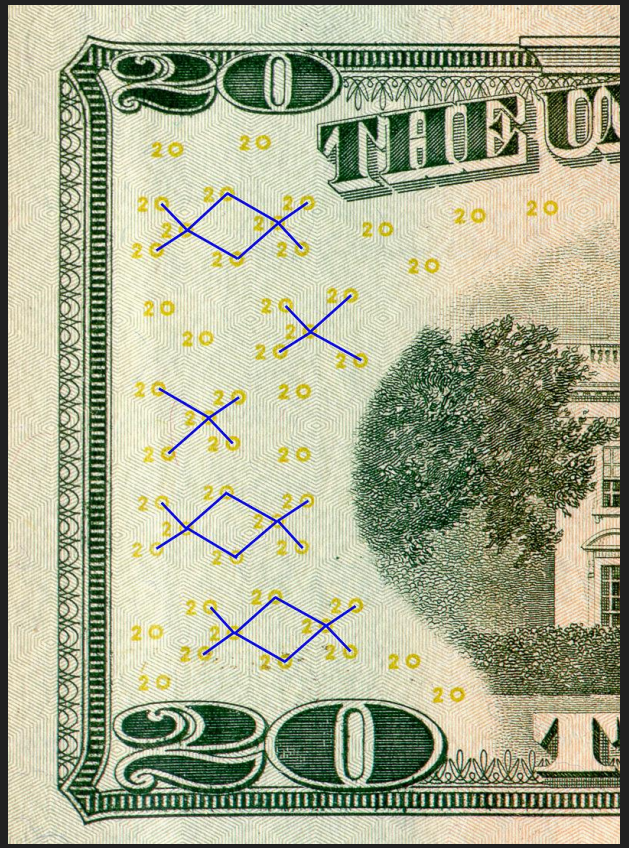
$ exiftool foo.jpg

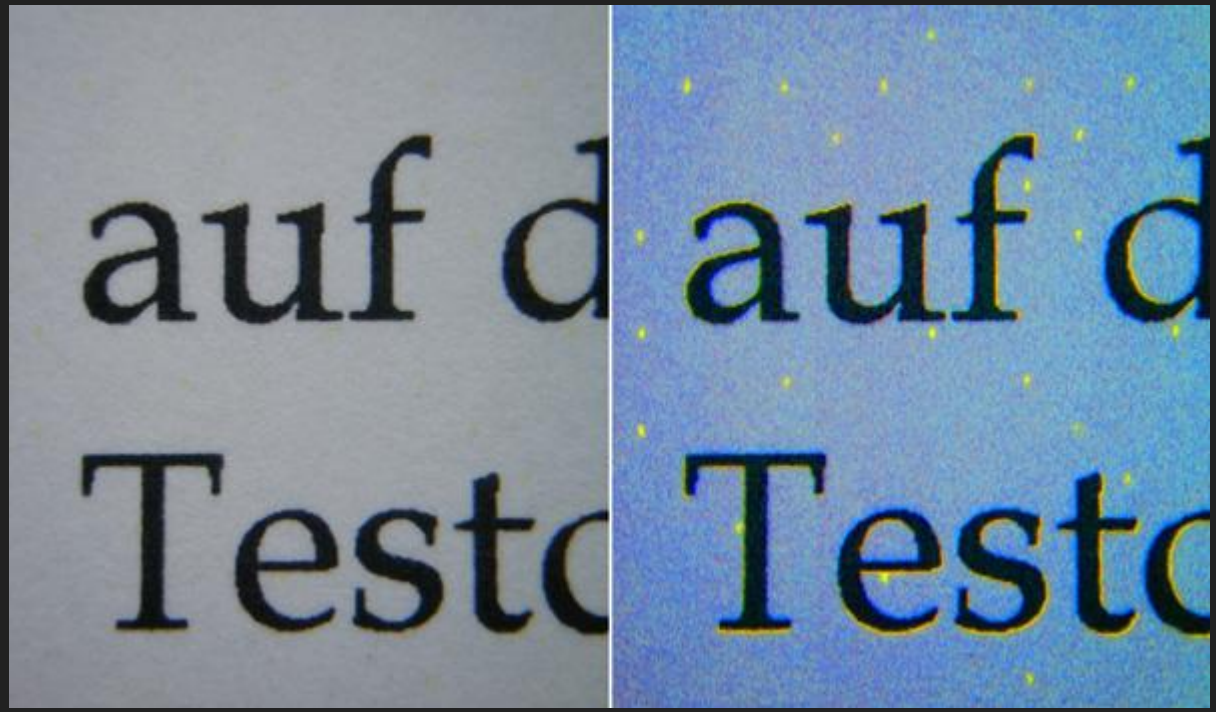
```
File Type                       : JPEG
File Type Extension             : jpg
MIME Type                       : image/jpeg
Exif Byte Order                 : Big-endian (Motorola, MM)
Make                            : OnePlus
Camera Model Name               : ONEPLUS A5000
Orientation                     : Unknown (0)
X Resolution                    : 72
Y Resolution                    : 72
Resolution Unit                 : inches
Software                        : OnePlus5-user 7.1.1 NMF26X 327 release-keys
Modify Date                     : 2017:11:28 13:34:38
Y Cb Cr Positioning             : Centered
Exposure Time                   : 1/33
F Number                        : 1.7
Exposure Program                : Not Defined
ISO                             : 1600
Exif Version                    : 0220
Date/Time Original              : 2017:11:28 13:34:38
Create Date                     : 2017:11:28 13:34:38
Components Configuration        : Y, Cb, Cr, -
Shutter Speed Value             : 1/33
Aperture Value                  : 1.7
Brightness Value                : -3.74
Metering Mode                   : Center-weighted average
Flash                           : Off, Did not fire
```

analysis techniques: steganography

- Steganography is the practice of concealing information within other information.
  - Encoding text in the RGB values of an image, in the opcodes of an executable, …
  - Often used for physical tracking/linking:
    - Printer dots (link paper documents to a printer)
    - Anti-counterfeiting (detect attempts to photocopy money)
    - Anti-piracy (detect attempts to duplicate a film)
    - User tracking (screenshot watermarking)
- *Not* encryption, but can be used to store encrypted information

analysis techniques: steganographic

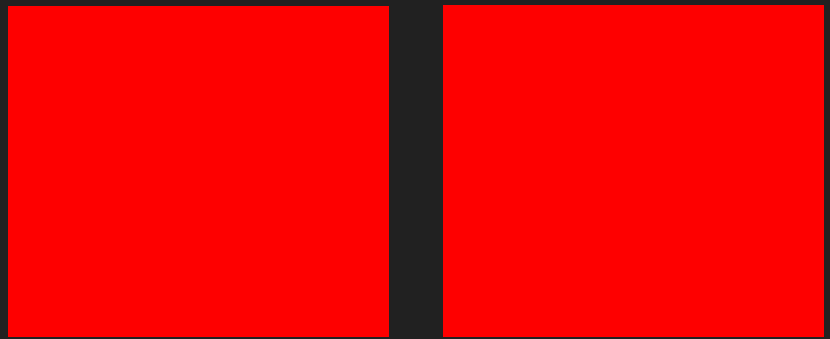




Resources: EFF Printer Tracking, Coded Anti-Piracy, EURion Constellation

analysis techniques: steganographic

- How does image steg work?
  - 24-bit RGB colorspace: 8 bits per red/green/blue
    - 1-bit changes to each color -> 3 bits/px ~> 3 px/byte
  - 32-bit RGBA colorspace: 8 bits per red/green/blue/alpha
    - 1-bit changes to each color -> 4 bits/px ~> 2 px/byte
  - Works because 1-bit changes to colors are (almost) imperceptible:



- Left: #FE0000
- Right: #FF0000

steganographic techniques: steghide

- `steghide` can be used to hide data in the RGB/sound values of common image/audio formats
  - JPEG, BMP, WAV, AU
  - Data can be password-protected

```
$ sudo apt install steghide
$ # store data from stdin w/ pass ‘hunter2’
$ steghide embed -cf foo.jpg -ef - -p hunter2
$ steghide extract -sf foo.jpg -xf out.txt
```

homework #7

has been posted.

Let us know if you have any questions!

This assignment has 2 parts.

It is due by 3/14 at 11:59PM.