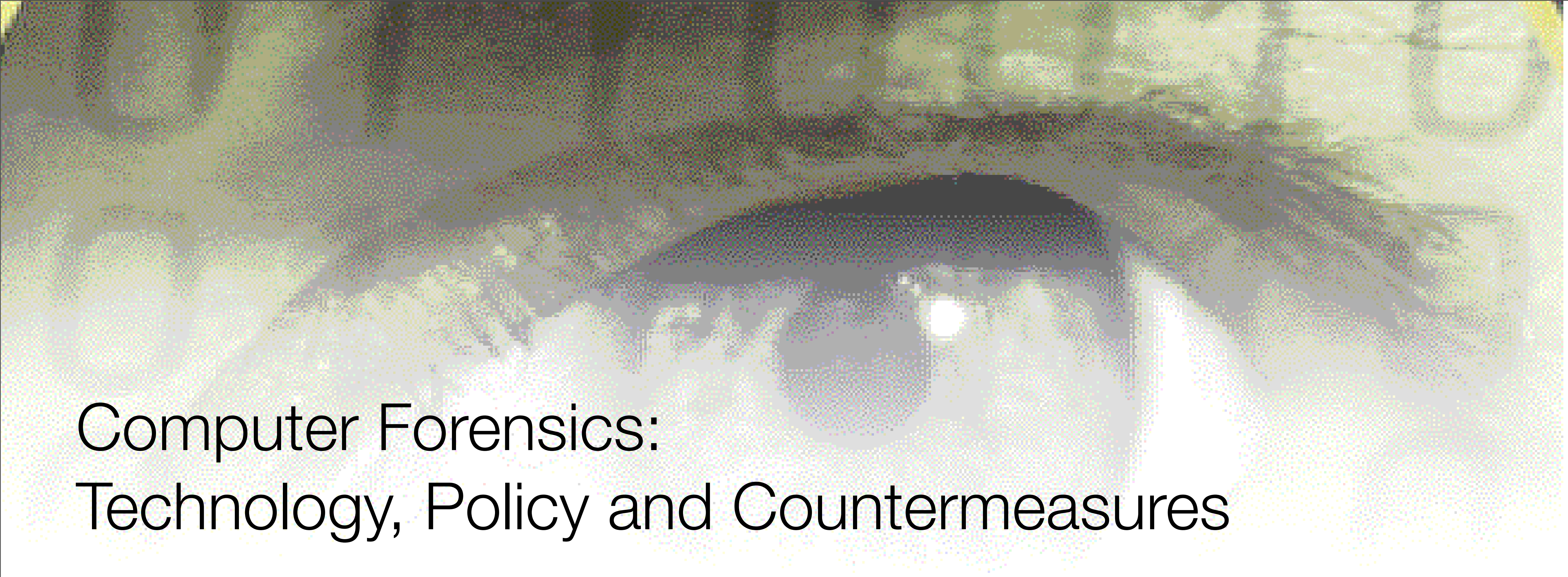


Computer Forensics: Technology, Policy and Countermeasures

Simson L. Garfinkel, Ph.D.
Naval Postgraduate School

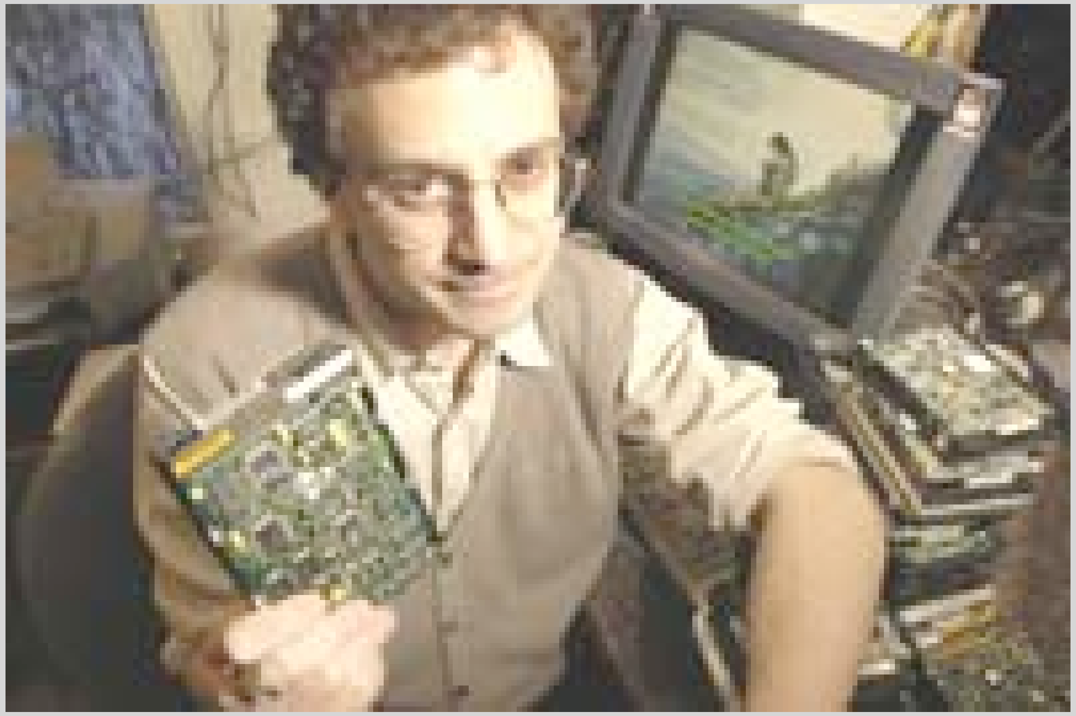
May 1, 2007
Computers, Freedom & Privacy 2007

A bit about me

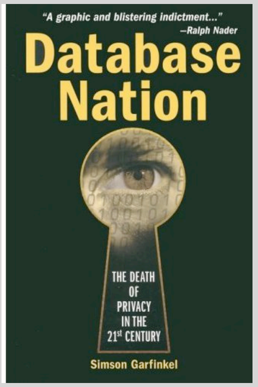
Tech Journalist: 1985--2002
Entrepreneur: 1995--2002
Vineyard.NET
Sandstorm Enterprises, Inc.
MIT EECS: 2003--2005

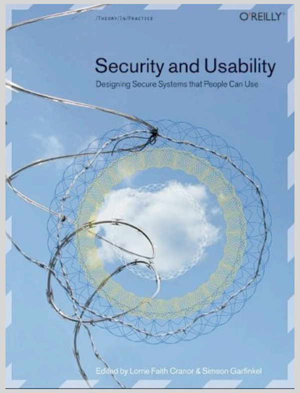
Harvard Center for Research on Computation and Society: 2005-2007

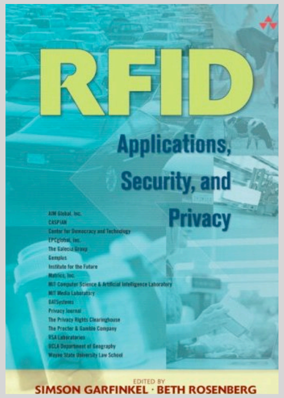
Naval Postgraduate School: 2007-



"Used Hard Drives Reveal Secrets."


"A graphic and blistering indictment..."
—Ralph Nader
Database Nation
THE DEATH OF PRIVACY IN THE 21st CENTURY
Simson Garfinkel


/Theory/In/Practice
O'REILLY
Security and Usability
Designing Secure Systems that People Can Use
Edited by Lorrie Faith Cranor & Simson Garfinkel


RFID
Applications, Security, and Privacy
AIM Global, Inc.
CASPIAN
Center for Democracy and Technology
EPCglobal, Inc.
The Galecia Group
Gemplus
Institute for the Future
Matrics, Inc.
MIT Computer Science & Artificial Intelligence Laboratory
MIT Media Laboratory
OATSystems
Privacy Journal
The Privacy Rights Clearinghouse
The Procter & Gamble Company
RSA Laboratories
UCLA Department of Geography
Wayne State University Law School
EDITED BY
SIMSON GARFINKEL · BETH ROSENBERG

Forensics: Dual Meaning

fo·ren·sics n. (used with a sing. verb)

1. The art or study of formal debate; argumentation.

2. The use of science and technology to investigate and establish facts in criminal or civil courts of law.

(American Heritage Dictionary, 4th Edition)

Computer Forensics: Multiple Meanings

1. "Involves the preservation, identification, extraction, documentation, and interpretation of computer data."
   (*Computer Forensics: Incident Response Essentials,* Warren Kruse and Jay Heiser.)
2. "The scientific examination, analysis, and/or evaluation of digital evidence in legal matters."
   (*Scientific Working Group on Digital Evidence, http://www.swgde.org*)

So what's digital evidence?

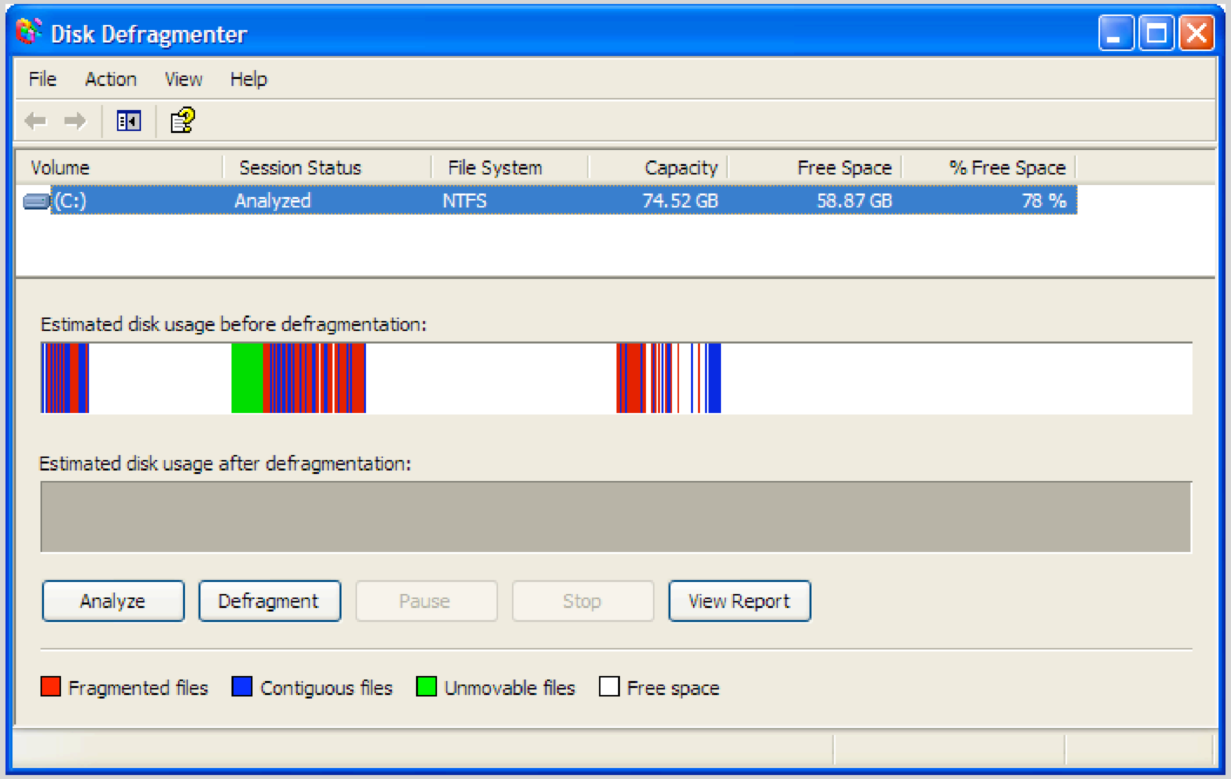
Computer Forensics is like a magic camera

Tools can go “back in time...”

- View previous versions of files
- Recover “deleted” files
- Find out what was typed
- Discover visited websites

Why does this work?

- Computers keep extensive logs
- Most data is not encrypted
- free() doesn’t erase memory
- DELETE doesn’t erase files
- FORMAT doesn’t wipe disks



Volume	Session Status	File System	Capacity	Free Space	% Free Space
(C:)	Analyzed	NTFS	74.52 GB	58.87 GB	78 %

Estimated disk usage before defragmentation:

Estimated disk usage after defragmentation:

🟥 Fragmented files 🟦 Contiguous files 🟩 Unmovable files □ Free space

Digital Evidence is evidence found in digital systems.

Brian Carrier’s PhD has several definitions for digital evidence:

- “Information stored or transmitted in binary form that may be relied upon in court” [Int02]
- “Information of probative value that is stored or transmitted in binary form” [Sci05]
- “Information and data of investigative value that is stored on or transmitted by a computer” [Ass05]
- “Any data stored or transmitted using a computer that support or refute a theory of how an offense occurred or that address critical elements of the offense such as intent or alibi” [Cas04]

All of these definitions assume a **legal process**.
Forensics can be used for much more.

Computer Forensics are typically used *after* a crime is suspected

Computer break-ins:

- Determine how a computer was compromised.
- Determine extent of damage

Make a claim about the computer's owner:

- Possession of contraband information
- Copyright infringement
- Theft of intellectual property
- Confirm/disprove an alibi

Forensics can also be used for auditing

Evaluate the privacy properties of a system

Understand what’s actually going over a network

Audit application performance & security

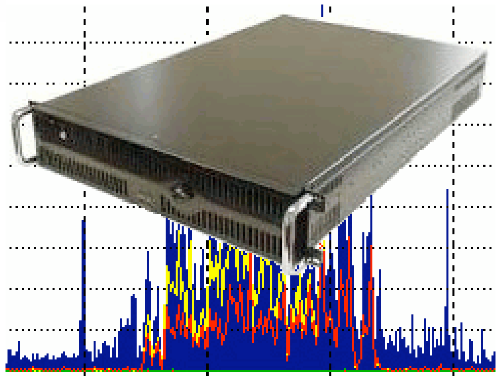
Spot-check regulatory compliance:

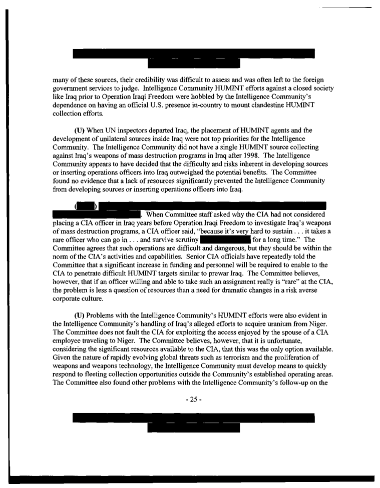
- Data disposal policies
- Data flow across boundaries

Audit internal information flows

This tutorial looks at the range of forensic techniques currently in use

1. The Forensic Process
2. Legal Standards
3. Specific Forensic Techniques
    - Disk Forensics
    - Network Forensics
    - Document Forensics
    - Memory Forensics
    - Cell Phone Forensics
    - Software Forensics
4. Anti-Forensics
5. Civil and Criminal Applications





[redacted]

many of these sources, their credibility was difficult to assess and was often left to the foreign government services to judge. Intelligence Community HUMINT efforts against a closed society like Iraq prior to Operation Iraqi Freedom were hobbled by the Intelligence Community's dependence on having an official U.S. presence in-country to mount clandestine HUMINT collection efforts.

(U) When UN inspectors departed Iraq, the placement of HUMINT agents and the development of unilateral sources inside Iraq were not top priorities for the Intelligence Community. The Intelligence Community did not have a single HUMINT source collecting against Iraq's weapons of mass destruction programs in Iraq after 1998. The Intelligence Community appears to have decided that the difficulty and risks inherent in developing sources or inserting operations officers into Iraq outweighed the potential benefits. The Committee found no evidence that a lack of resources significantly prevented the Intelligence Community from developing sources or inserting operations officers into Iraq.

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- 25 -

[redacted]

```
printf(“%d, %f”, i, f);
     i++; f+=3.0;
    g = fmod(f,i);
```

The Forensic Process

Computer Forensics turns computer systems into courtroom testimony.

Five basic steps:

1. Preparation
2. Collection
3. Examination
4. Analysis
5. Reporting

Source:
Electronic Crime Scene Investigation Guide,
National Institute of Justice

Step 1: Preparation
Identify potential sources of evidence

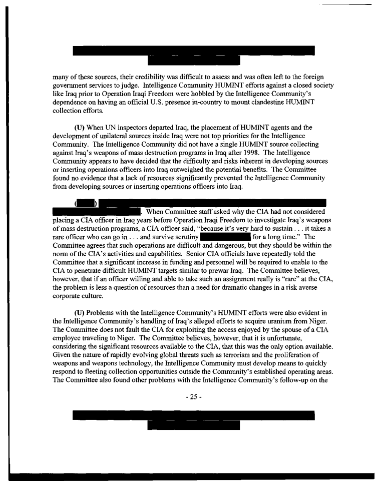
Computer system components:

- Hard drives
- Memory / flash / configuration
- Physical configuration

Web Pages on other computers

Files

Communication networks



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[redacted]

Each source may need its own personnel, tools, training & procedures.

One of the most difficult tasks is determining what to include & exclude.

Step 2:
Collect and Preserve the evidence

If the activity is ongoing, your choices include:

- Passive Monitoring
- Experimental Probing

If the activity is over, choices include:

- Make a copy
- Seizure

Issues to consider:

- What tools are used? Are they validated?
- Is the copy accurate? Is it complete?
- How can you prove that the copy wasn't modified at a later time?

Step 3: Examination.
Make evidence “visible” and eliminated excess.

Disk Analysis:

- Examine partitions and file systems
- Resident files & delete files
- “Slack space” at end of files
- Unallocated space between files

File based evidence:

- Document text
- Deleted text
- Metadata (creation date; author fields; etc.)

Network Evidence:

- Device configuration
- Categorize packets; discard what isn’t needed

Step 4: Analyze to determine "significance and probative value"

Build a hypothesis about what happened.

Look for evidence to prove or disprove hypothesis.

Examples:

- Hypothesis: Suspect is arrested on suspicion of child pornography
- Evidence: Known child pornography on suspect's hard drive

- Hypothesis: Suspect broke into a telephone company computer and stole confidential documents.
- Evidence: Hacker tools; confidential information from telco.

BUT: Investigators rarely look for count-evidence

Build a hypothesis about what happened.

Look for evidence to prove or disprove hypothesis.

Examples:

- Hypothesis: Suspect is arrested on suspicion of child pornography
- Evidence: Known child pornography on suspect’s hard drive
- Counter Evidence: Root kit allowing remote access

- Hypothesis: Suspect broke into a telephone company computer and stole confidential documents.
- Evidence: Hacker tools; confidential information from telco.
- Counter Evidence: Documents publicly available

Step 5: Reporting and Testimony

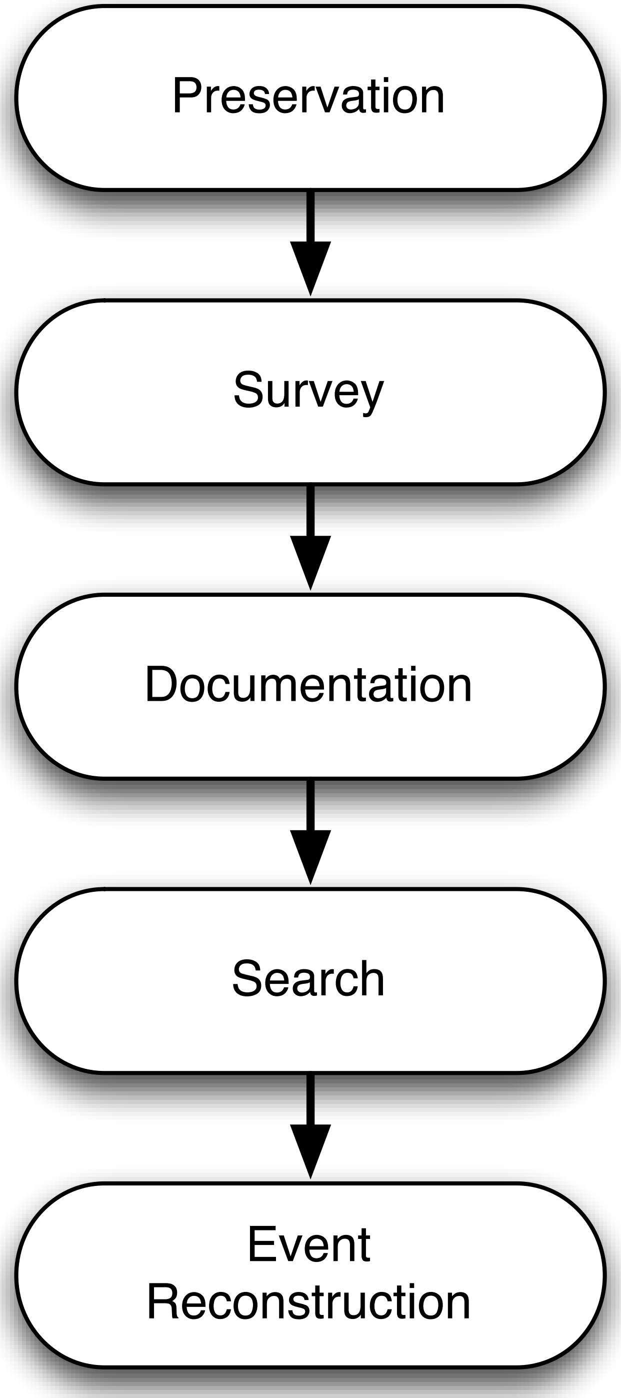
There are many kinds of testimony:

- Written reports
- Depositions
- Courtroom testimony

Testimony needs to include several key points:

- The tools used and procedures that were followed
- What was found
- Examiner’s interpretation of what it means

The Digital Crime Scene Investigation model has five similar steps.



This isn’t really what happens in reality. Instead, investigations are guided by “hypotheses.”

Goal of most investigations is to explain evidence that is observed.

- Investigations asked to answer questions about previous states or events.
- Investigator encounters the machine.
- Investigator uses tools to extract and preserve information from machine

  “Because the observation of the data is indirect, a hypothesis must be formed that the actual data is equal to the observed data”

  “Hypotheses also need to be formulated about the data abstractions that exist and the previous states and events that occurred.”

- The investigator searches for data that supports or refutes the hypotheses.
- Information may be used for confirming/eliminating a hypotheses even if the information itself is inadmissible in court.

A Hypothesis-Based Approach to Digital Forensic Investigations,
Brian D. Carrier, PhD Thesis, June 2006

Legal Standards

US Federal Rules of Evidence
Daubert

US Federal Rules of Evidence article VIII regulates the testimony of “experts”

Rule 702. Testimony by Experts

Rule 703. Bases of Opinion Testimony by Experts

Rule 704. Opinion on Ultimate Issue

Rule 705. Disclosure of Facts or Data Underlying Expert Opinion

Rule 706. Court Appointed Experts

These rules apply in the Federal Court; many states follow the rules as well

- http://www.law.cornell.edu/rules/fre/

Rule 702. Testimony by Experts

“If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if

(1) the testimony is based upon sufficient facts or data,

(2) the testimony is the product of reliable principles and methods, and

(3) the witness has applied the principles and methods reliably to the facts of the case.”

Rule 703. Bases of Opinion Testimony by Experts

“The facts or data in the particular case upon which an expert bases an opinion or inference may be those perceived by or made known to the expert at or before the hearing.

If of a type reasonably relied upon by experts in the particular field in forming opinions or inferences upon the subject, the facts or data need not be admissible in evidence in order for the opinion or inference to be admitted.

Facts or data that are otherwise inadmissible shall not be disclosed to the jury by the proponent of the opinion or inference unless the court determines that their probative value in assisting the jury to evaluate the expert's opinion substantially outweighs their prejudicial effect.”

Rule 704. Opinion on Ultimate Issue

(a) Except as provided in subdivision (b), testimony in the form of an opinion or inference otherwise admissible is not objectionable because it embraces an ultimate issue to be decided by the trier of fact.

(b) No expert witness testifying with respect to the mental state or condition of a defendant in a criminal case may state an opinion or inference as to whether the defendant did or did not have the mental state or condition constituting an element of the crime charged or of a defense thereto. Such ultimate issues are matters for the trier of fact alone.

The “Daubert Standard” is supposed to keep “junk science” out of the courts.

Daubert turns federal judges “gatekeepers.”
Daubert v. Merrell Dow Pharmaceuticals, 509 US 579 (1993)

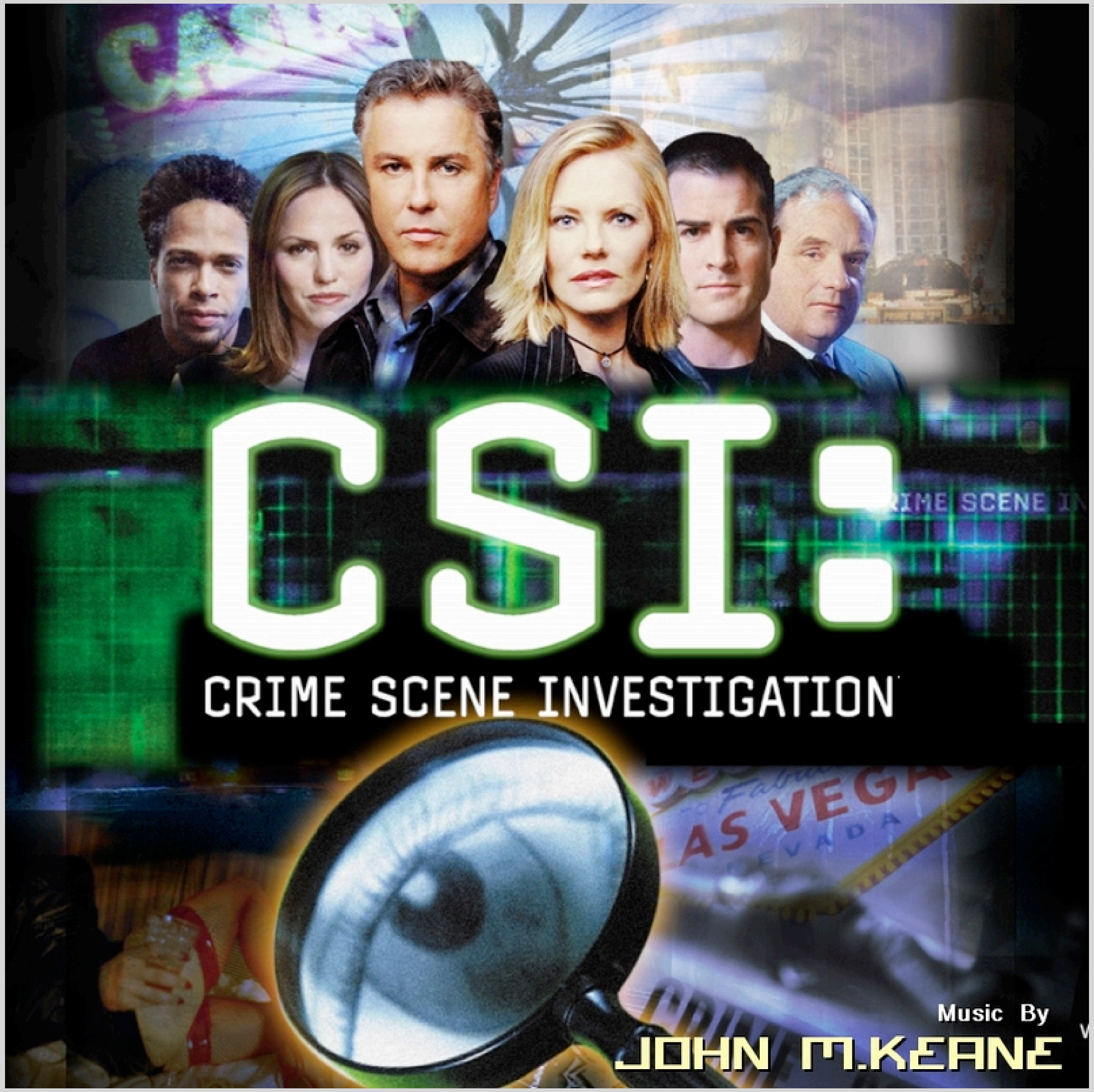
- Evidence must be “relevant”
- Evidence must be “reliable” (ie, scientific)
  - Subject to peer review (has been published)
  - Generally accepted by the relevant professional community
  - Standards for the technique’s operation
  - Known error rate

Surprisingly, digital evidence may not meet this standard.
[Carrier 2006, pp. 1-4]

The “CSI Effect” causes victims and juries to have unrealistic expectations.

Prosecutors & Jurors:

- Think it’s impossible to delete anything.
- Expect highly produced presentations.
- Have no tolerance for ambiguity.
-



This tutorial looks at the range of forensic techniques currently in use

✓ The Forensic Process

✓ Legal Standards

3. Specific Forensic Techniques
   - Disk Forensics
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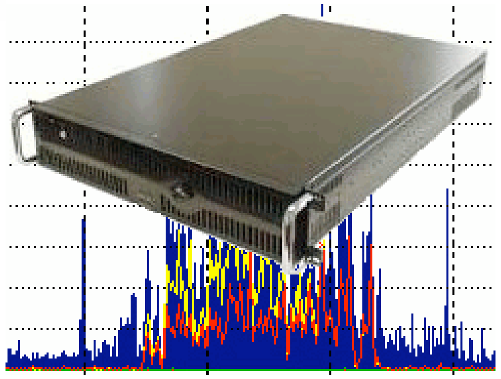

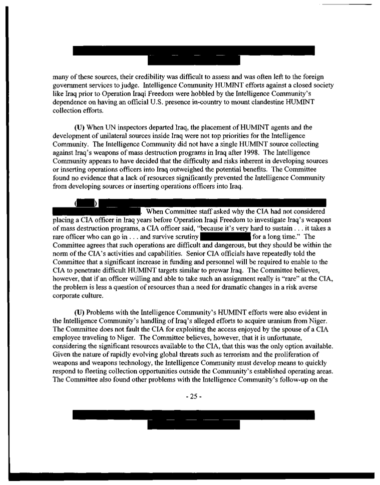

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[redacted]

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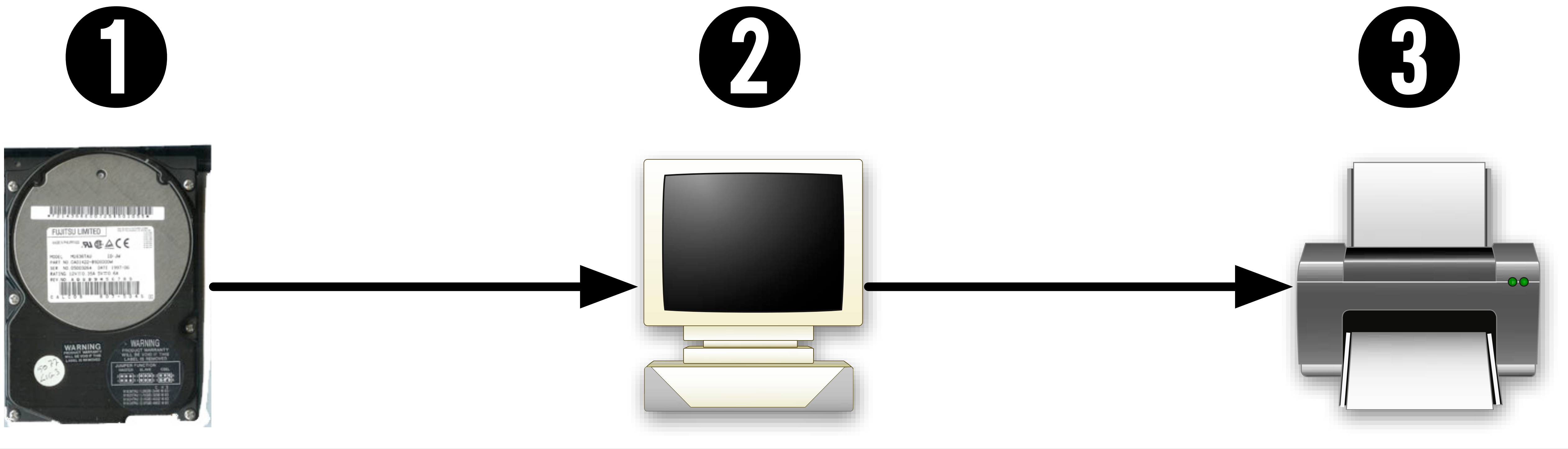
```



Disk Forensics

Hard drive forensics:
Typical tasks

Recover:

- Deleted files
- Child pornography

Recreate:

- Timelines - when did the computer do what?
- Flow of information
- Evidence of Inappropriate use

Gather Intelligence:

- Names of associates
- Meeting places

Hard drive forensics:
Tools of the trade

Local acquisition:

- Write-Blockers prevent modification
- Create an "image file"

Mirror Disks:

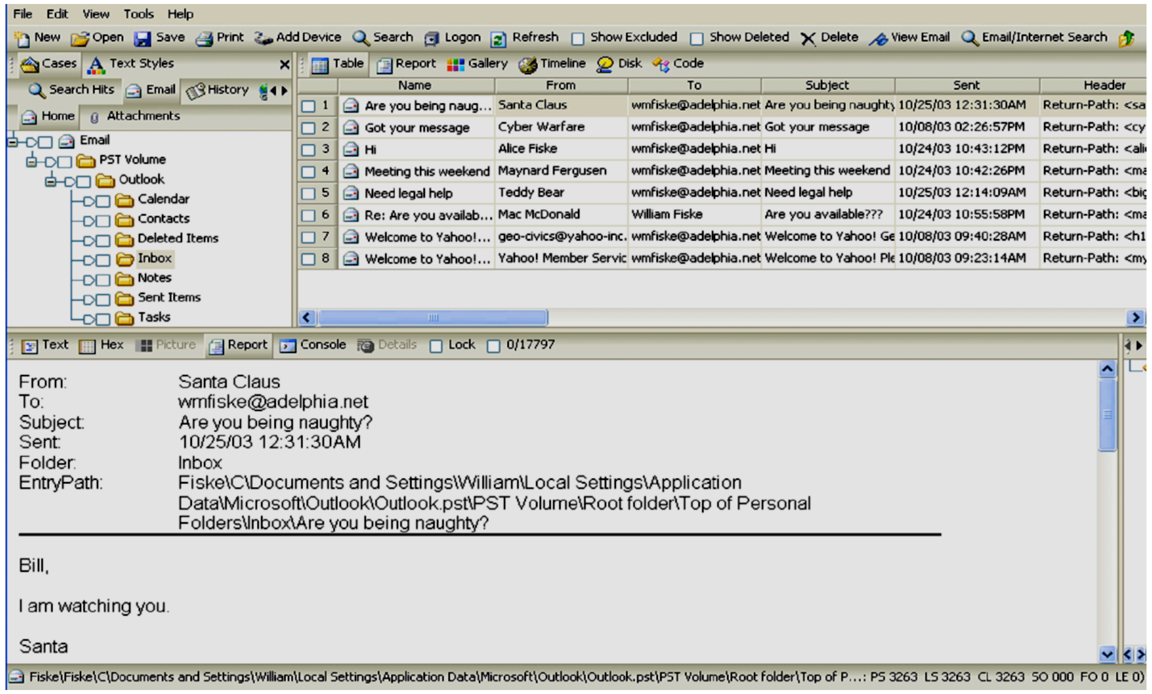
- Work with a "mirror" of original disk

Network acquisition

- "Encase Enterprise" allows remote forensics on live system

GUI-Based Programs:

- Forensic Tool Kit
- Encase (Guidance Software)
- Forensic Toolkit (Accessdata)


File Edit View Tools Help
New Open Save Print Add Device Search Logon Refresh □ Show Excluded □ Show Deleted Delete View Email Email/Internet Search
Cases Text Styles
Search Hits Email History
Home Attachments
Email
PST Volume
Outlook
Calendar
Contacts
Deleted Items
Inbox
Notes
Sent Items
Tasks
Table Report Gallery Timeline Disk Code
Text Hex Picture Report Console Details □ Lock □ 0/17797

	Name	From	To	Subject	Sent	Header
□ 1	Are you being naug...	Santa Claus	wmfiske@adelphia.net	Are you being naughty	10/25/03 12:31:30AM	Return-Path: <sa
□ 2	Got your message	Cyber Warfare	wmfiske@adelphia.net	Got your message	10/08/03 02:26:57PM	Return-Path: <cy
□ 3	Hi	Alice Fiske	wmfiske@adelphia.net	Hi	10/24/03 10:43:12PM	Return-Path: <ali
□ 4	Meeting this weekend	Maynard Fergusen	wmfiske@adelphia.net	Meeting this weekend	10/24/03 10:42:26PM	Return-Path: <ma
□ 5	Need legal help	Teddy Bear	wmfiske@adelphia.net	Need legal help	10/25/03 12:14:09AM	Return-Path: <big
□ 6	Re: Are you availab...	Mac McDonald	William Fiske	Are you available???	10/24/03 10:55:58PM	Return-Path: <ma
□ 7	Welcome to Yahoo!...	geo-civics@yahoo-inc.	wmfiske@adelphia.net	Welcome to Yahoo! Ge	10/08/03 09:40:28AM	Return-Path: <h1
□ 8	Welcome to Yahoo!...	Yahoo! Member Servic	wmfiske@adelphia.net	Welcome to Yahoo! Ple	10/08/03 09:23:14AM	Return-Path: <my

From: Santa Claus
To: wmfiske@adelphia.net
Subject: Are you being naughty?
Sent: 10/25/03 12:31:30AM
Folder: Inbox
EntryPath: Fiske\C\Documents and Settings\William\Local Settings\Application Data\Microsoft\Outlook\Outlook.pst\PST Volume\Root folder\Top of Personal Folders\Inbox\Are you being naughty?

Bill,

I am watching you.

Santa

Fiske\Fiske\C\Documents and Settings\William\Local Settings\Application Data\Microsoft\Outlook\Outlook.pst\PST Volume\Root folder\Top of P...: PS 3263 LS 3263 CL 3263 SO 000 FO 0 LE 0)

The important thing about disk imaging: get the data off the suspect drive, onto your drive.

Imaging options:

- dd if=/dev/hda of=diskfile.img
- aimage /dev/hda diskfile.img
- LinEn

Most tools will:

- copy the raw device to a file
- Compute MD5 & SHA1

Some tools will:

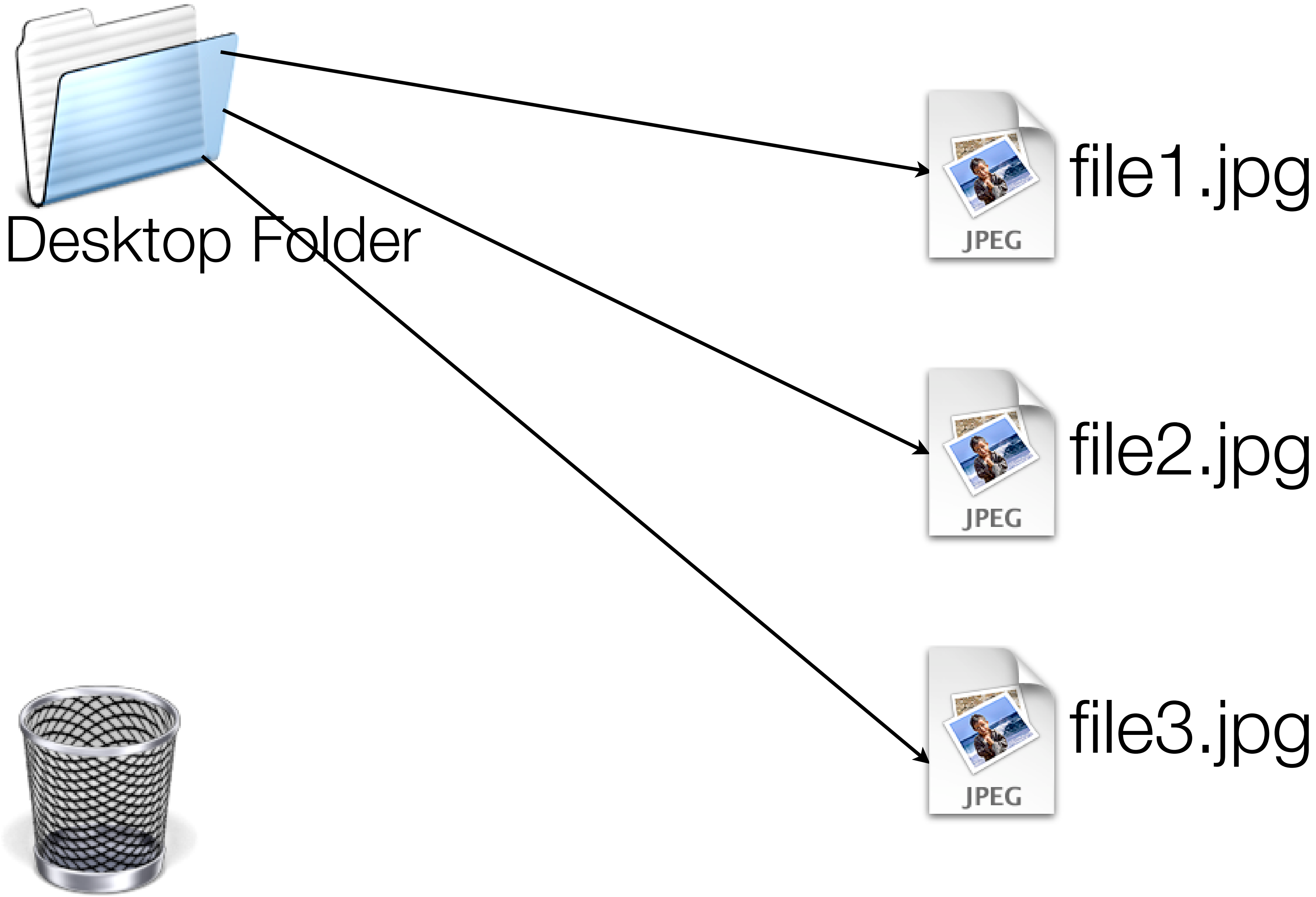
- Compress image
- Capture metadata like s/n
- Record investigative notes

Once data is imaged, the investigator has many options:

Typical “first steps” include:

- Inventory all files (resident & deleted) on disk
- Show files modified during a certain time period
- Search disk for files with “known bads” (hacker tools, child porn)
- Scan for key words

“Deleted files” are left on the disk because “delete” doesn’t overwrite the actual files.



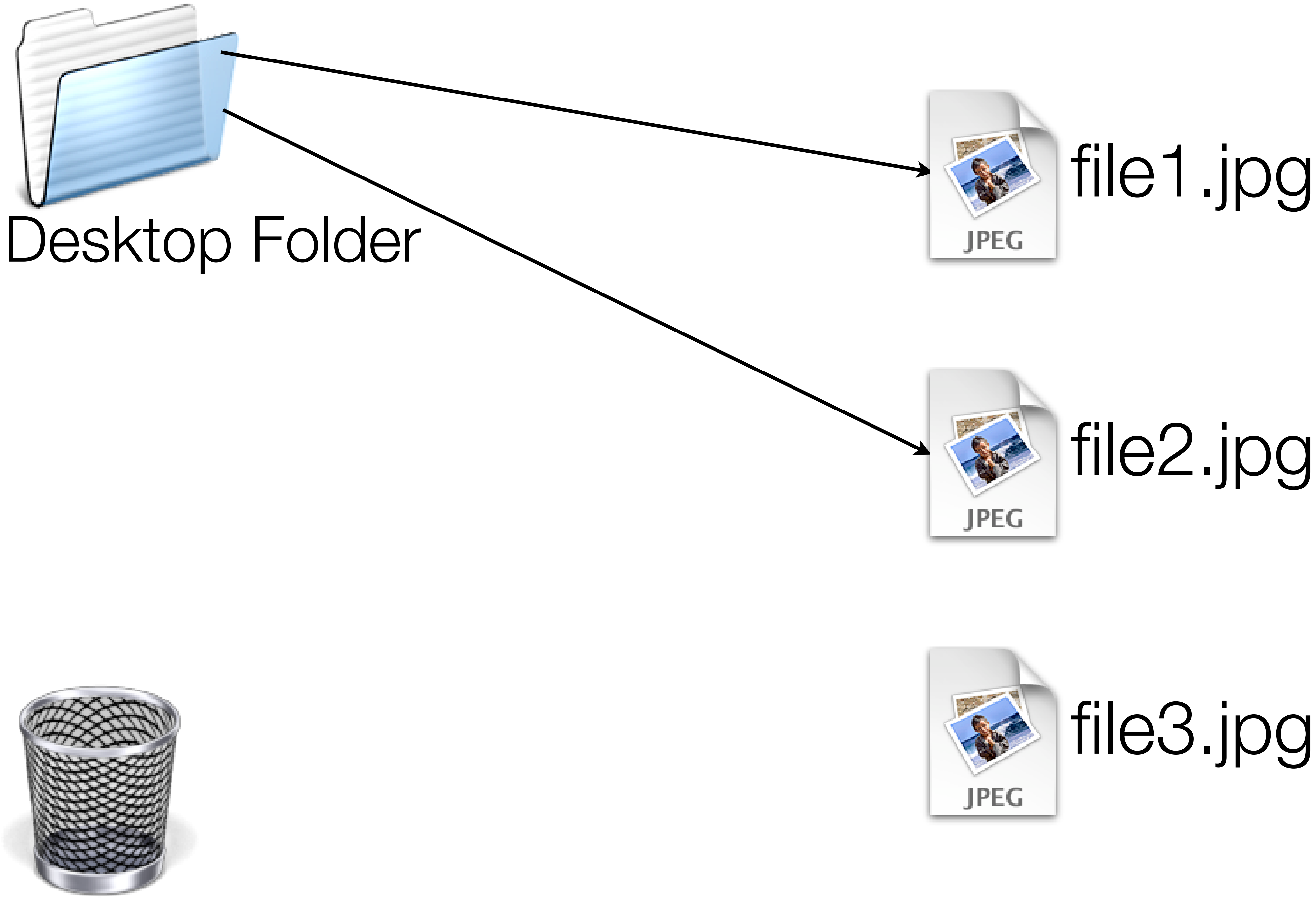
Desktop Folder

file1.jpg

file2.jpg

file3.jpg

“Deleted files” are left on the disk because “delete” doesn’t overwrite the actual files.



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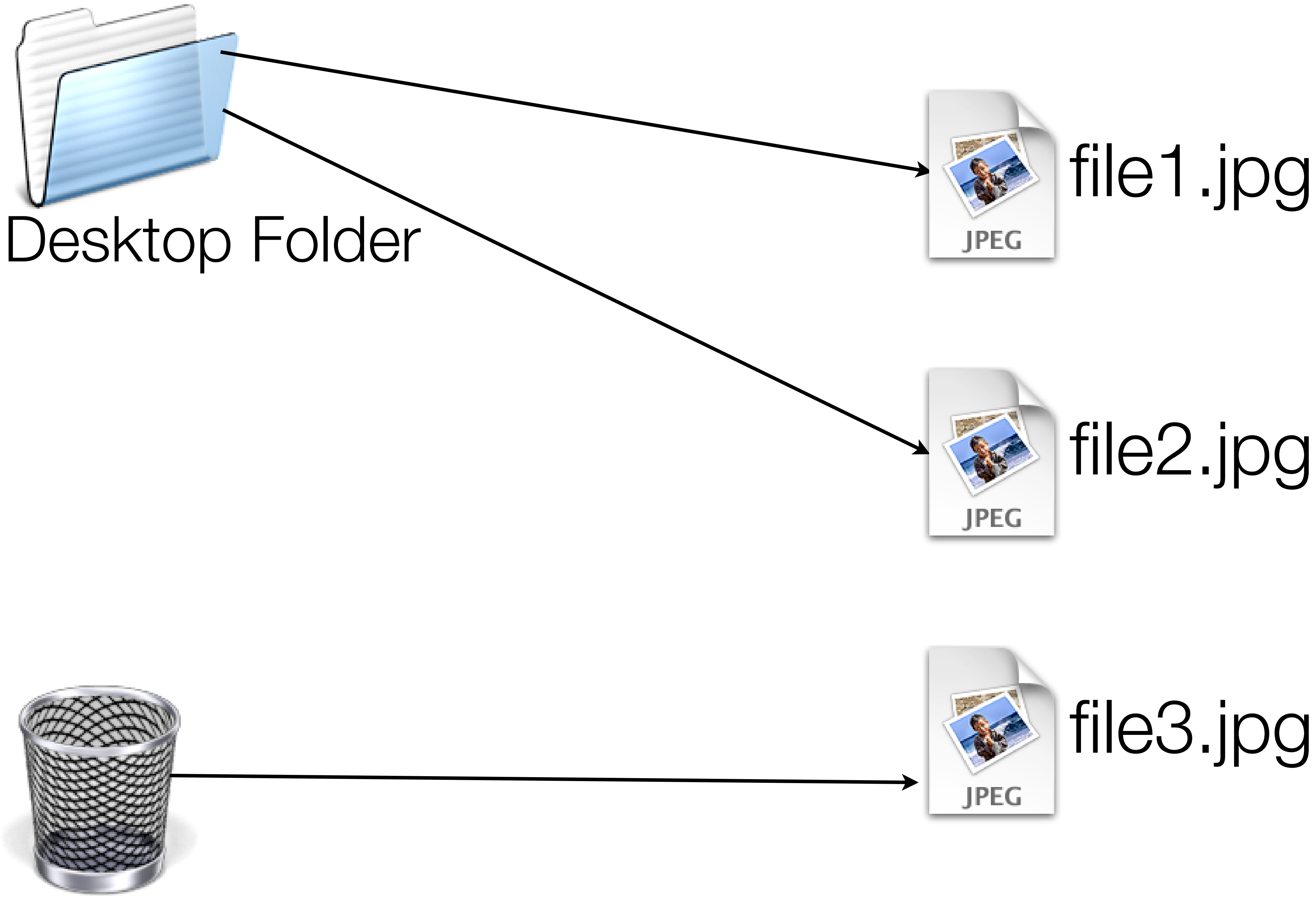

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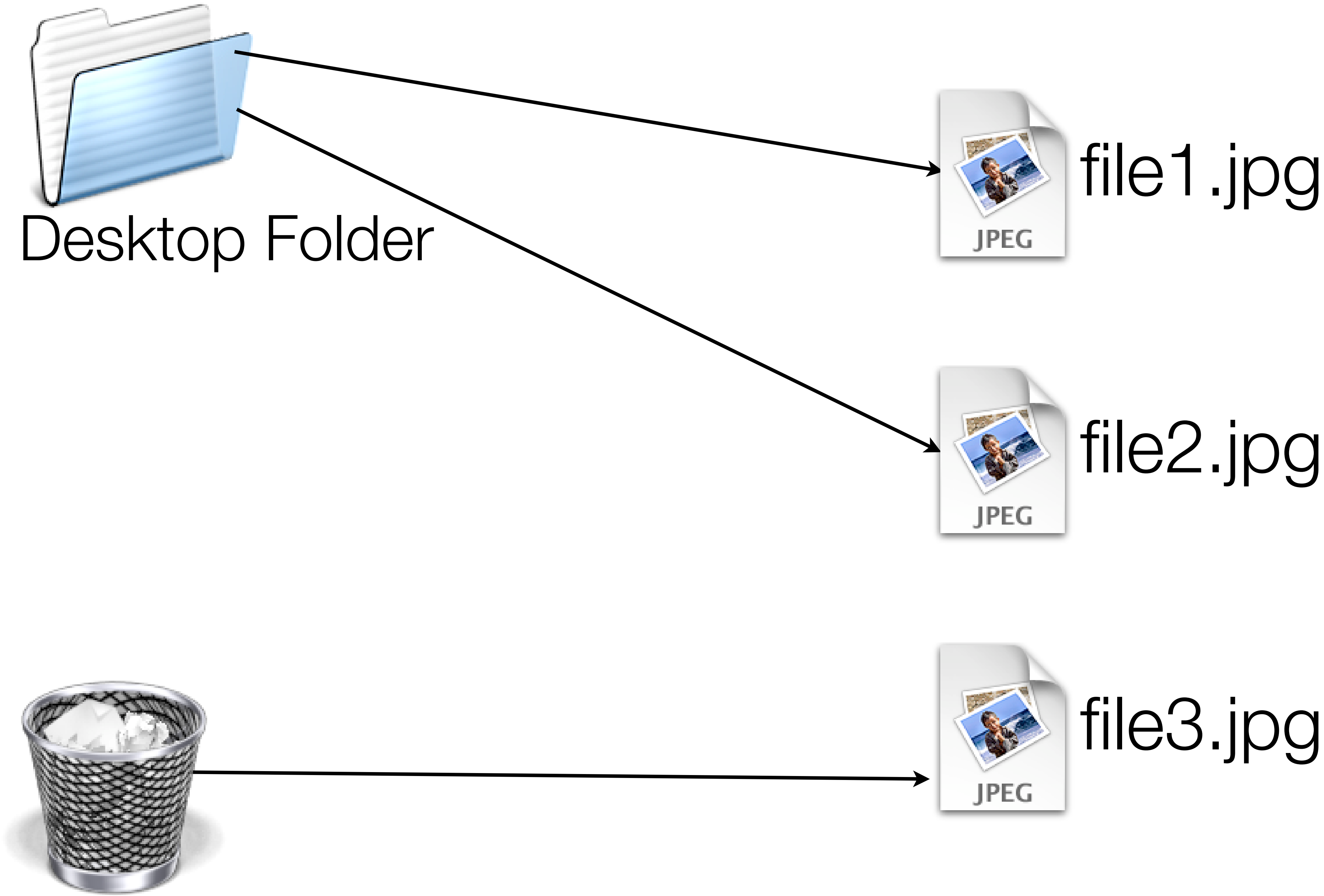

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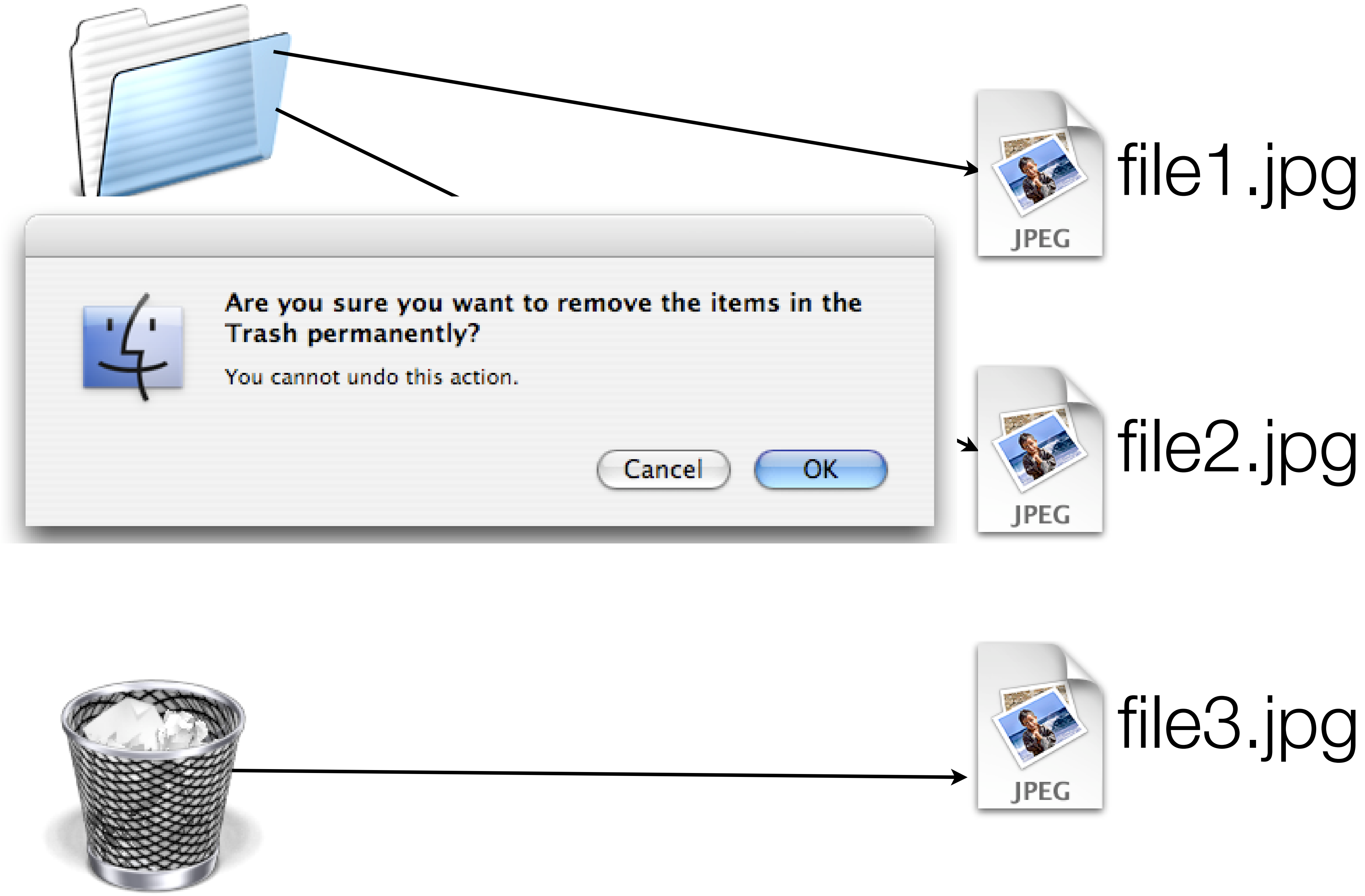
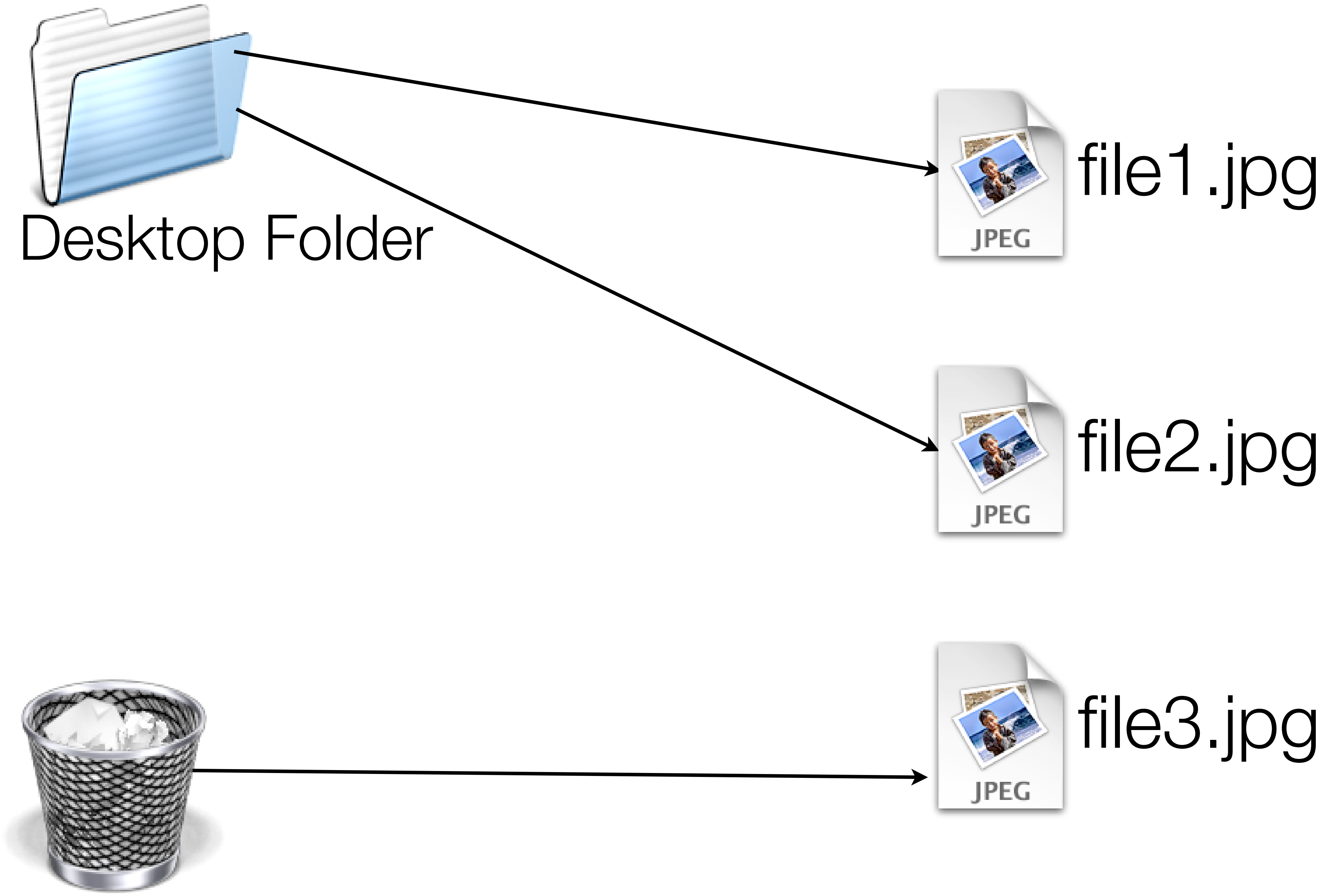


Are you sure you want to remove the items in the Trash permanently?

You cannot undo this action.

“Deleted files” are left on the disk because “delete” doesn’t overwrite the actual files.



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file3.jpg

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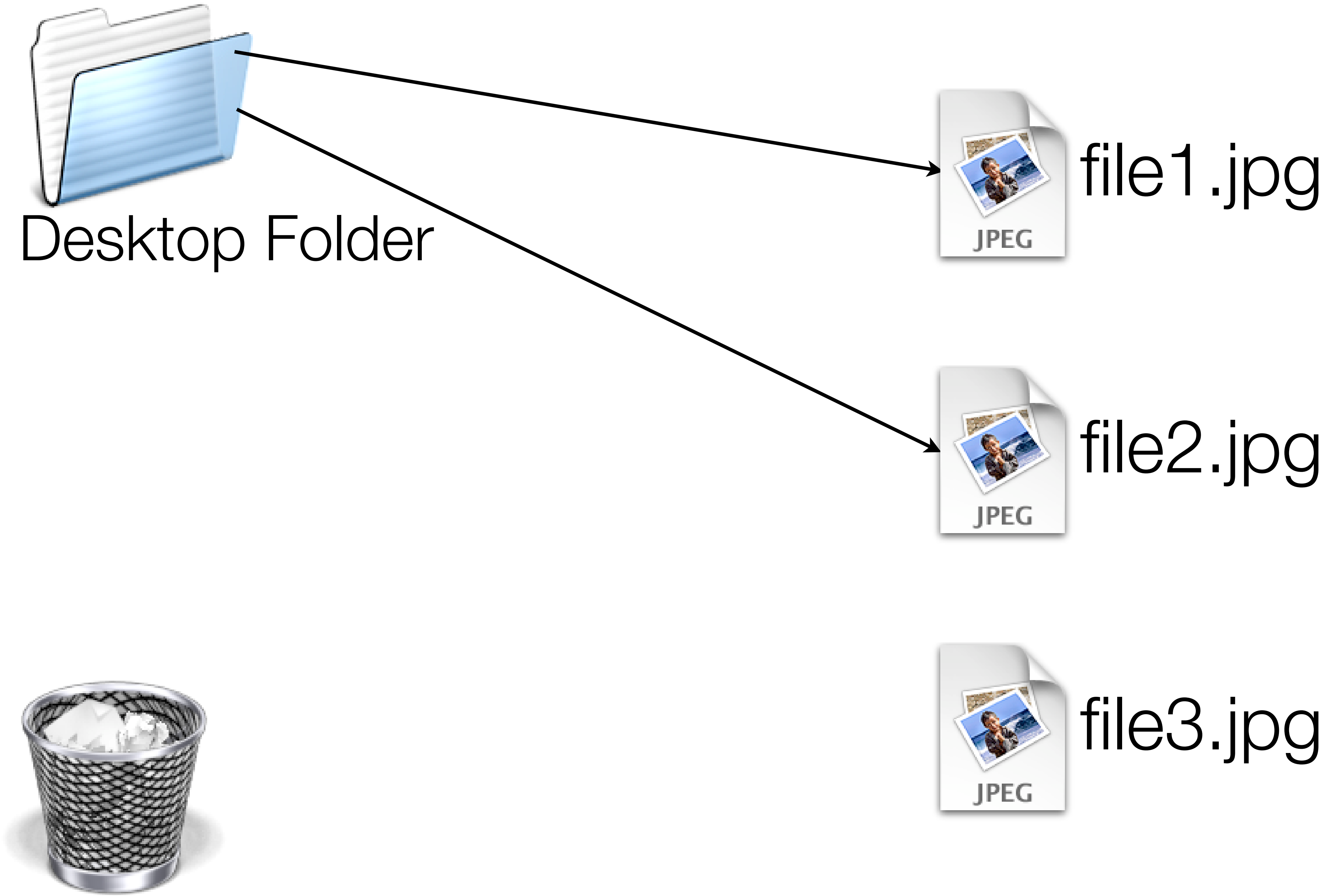


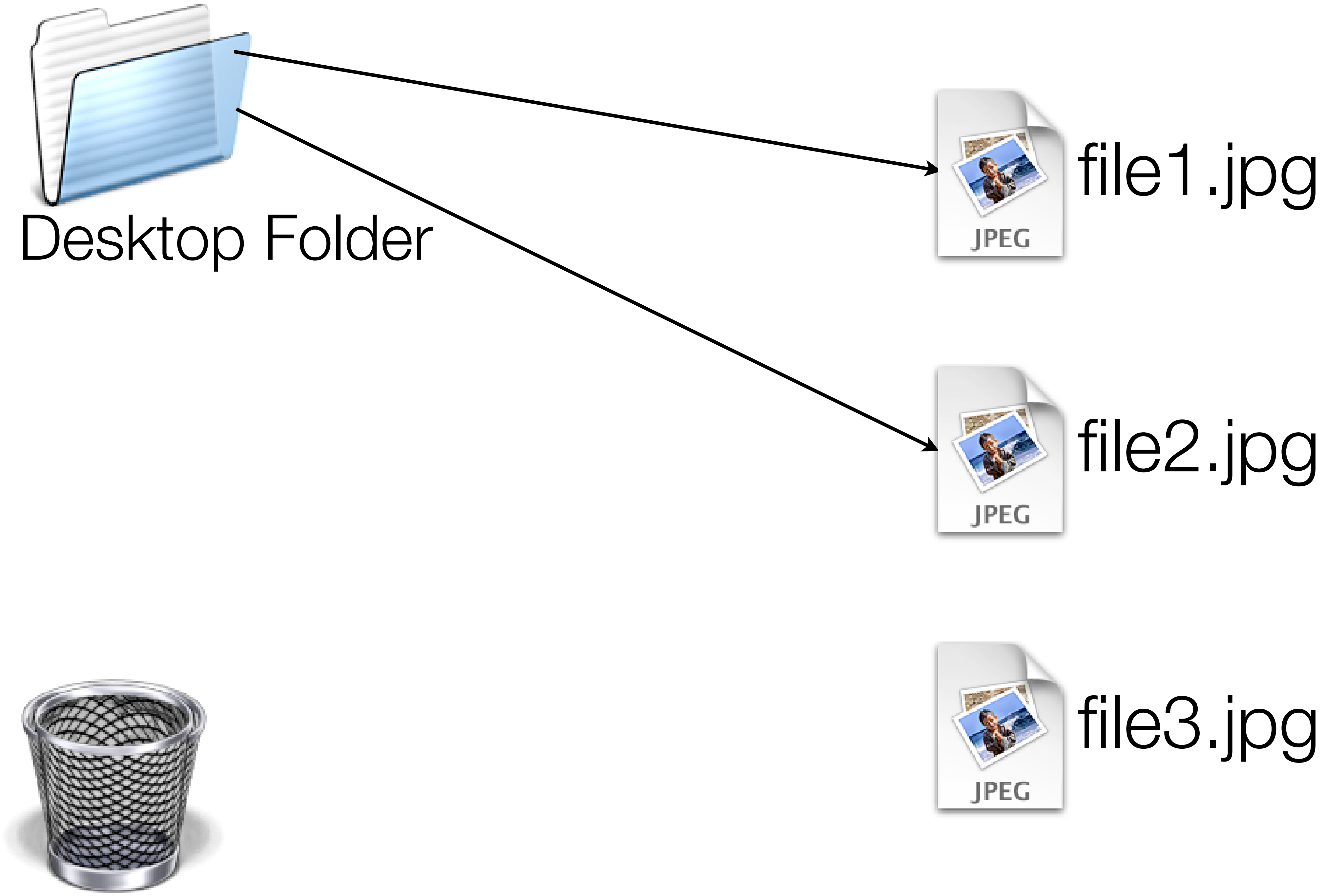
Desktop Folder

file1.jpg

file2.jpg

file3.jpg

“Deleted files” are left on the disk because “delete” doesn’t overwrite the actual files.



Desktop Folder

file1.jpg

file2.jpg

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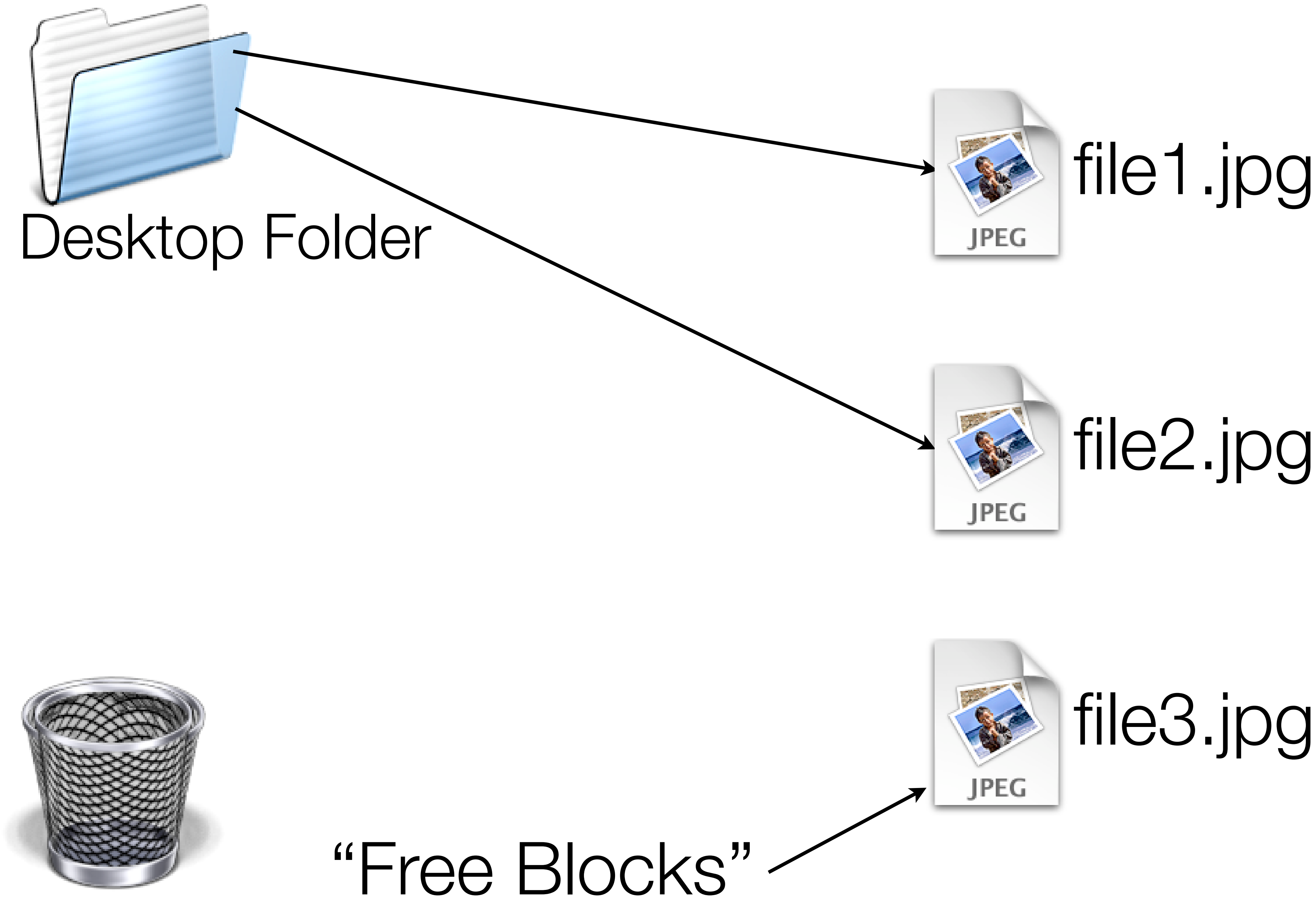


Desktop Folder

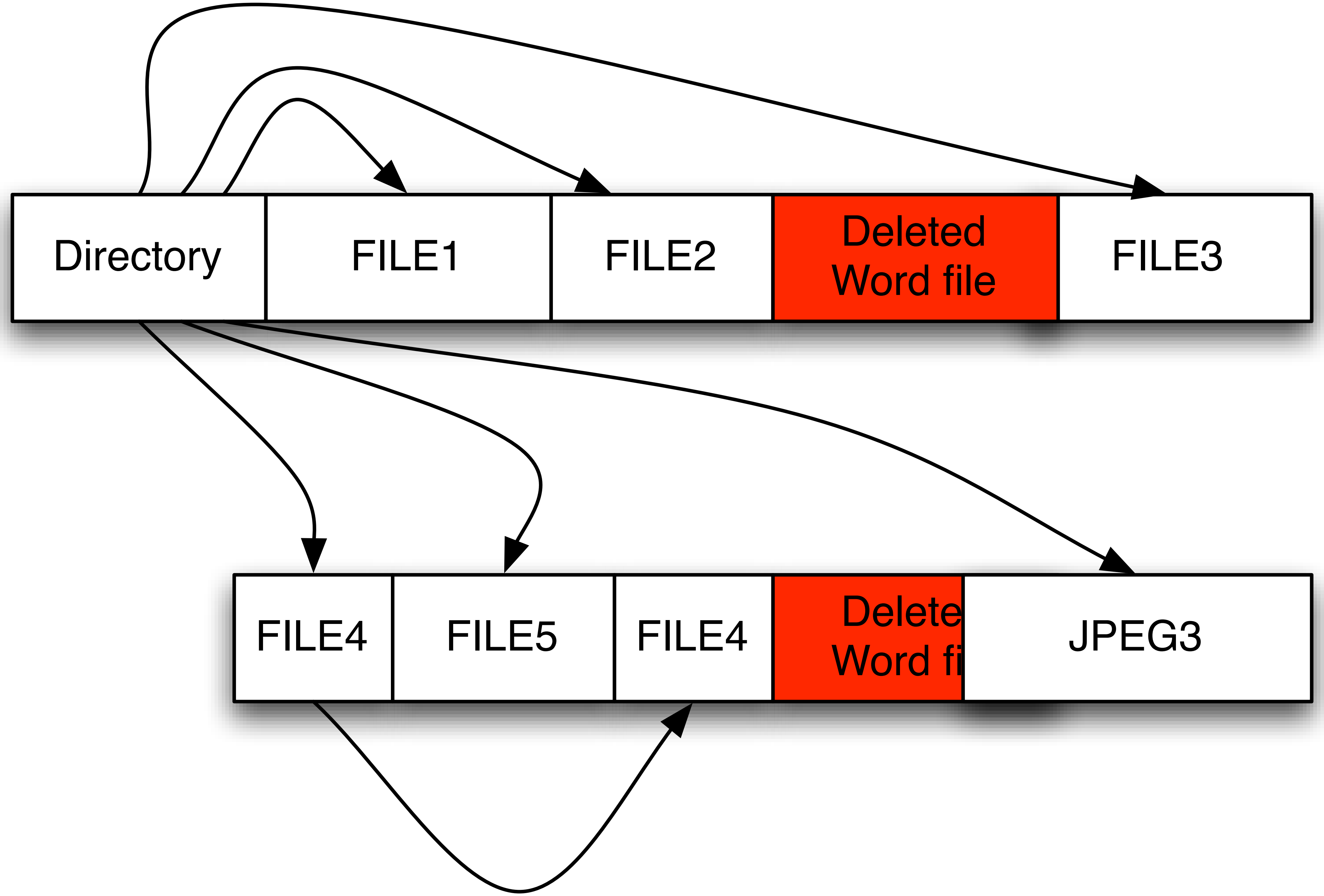
file1.jpg

file2.jpg

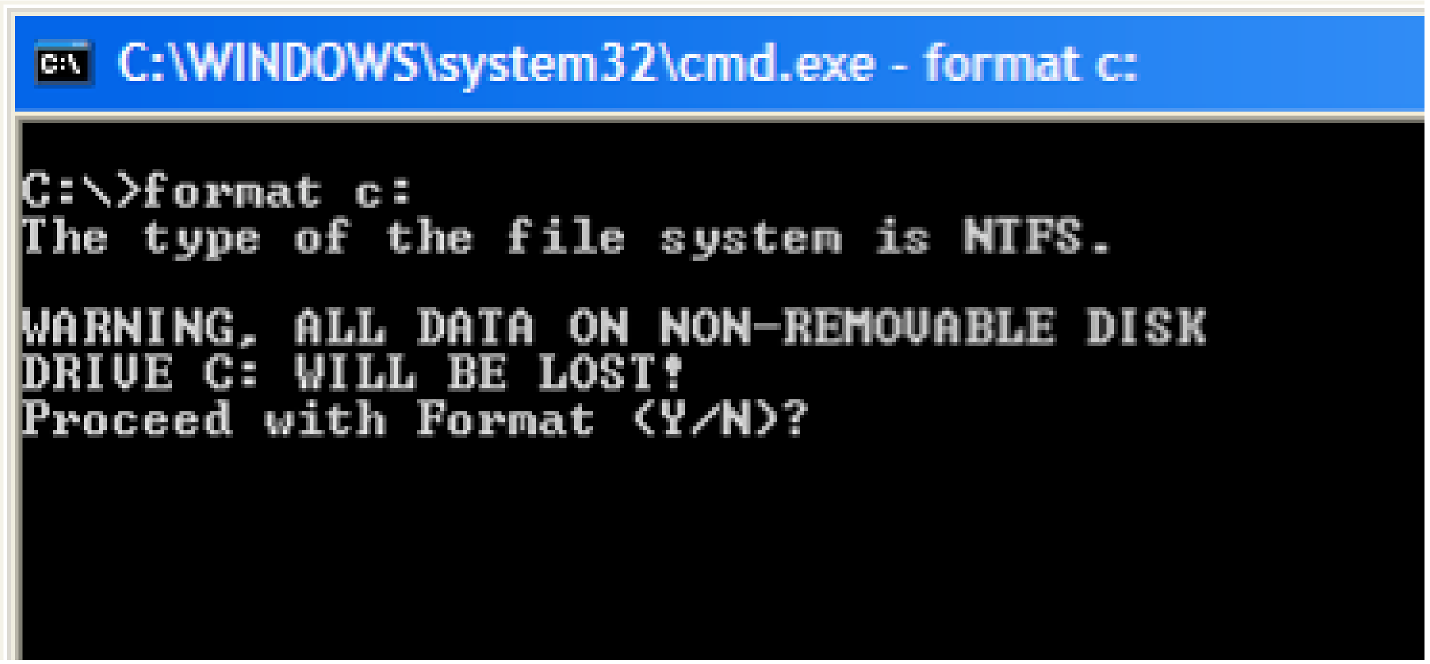
file3.jpg

“Free Blocks”

As a result, a typical disk has many kinds of files and data segments on it:



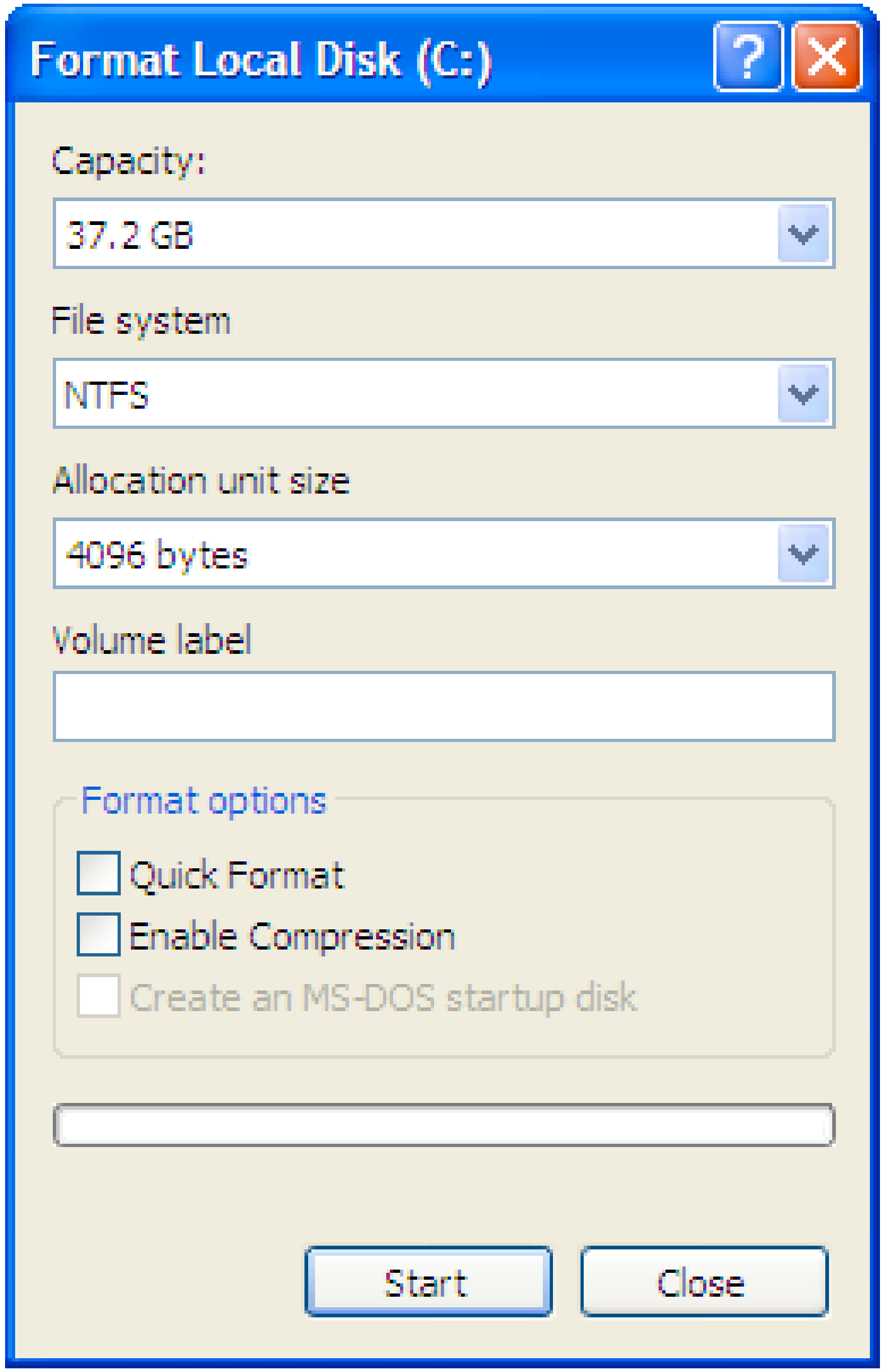
Formatting a disk just writes a new root directory.



C:\WINDOWS\system32\cmd.exe - format c:

```
C:\>format c:
The type of file system is NTFS.

WARNING, ALL DATA ON NON-REMOVABLE DISK
DRIVE C: WILL BE LOST!
Proceed with Format (Y/N)?
```



Format Local Disk (C:)

Capacity: 37.2 GB

File system: NTFS

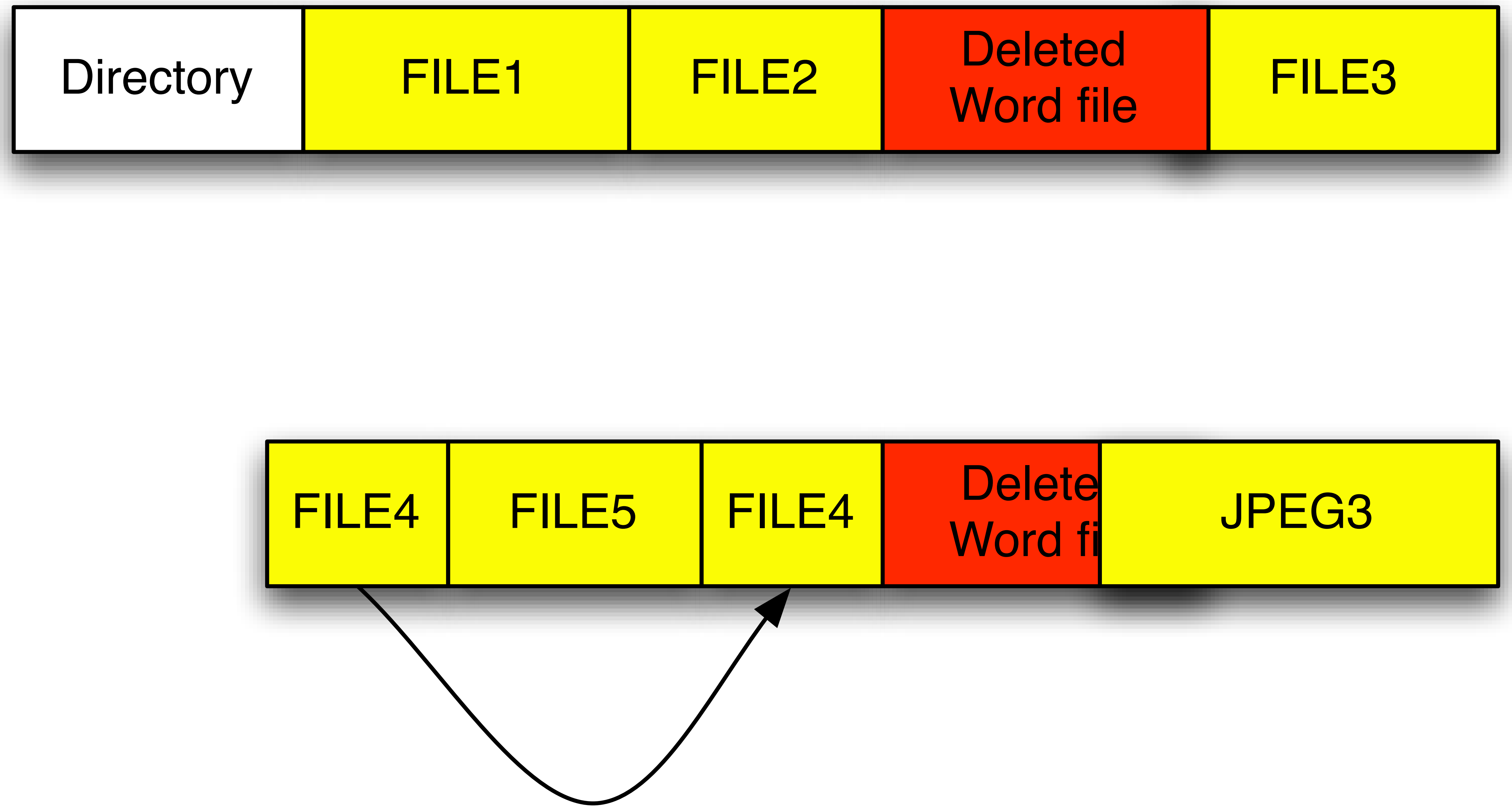
Allocation unit size: 4096 bytes

Volume label:

Format options

- □ Quick Format
- □ Enable Compression
- □ Create an MS-DOS startup disk

Formatting a disk just writes a new root directory.



Example: Disk #70: IBM-DALA-3540/81B70E32

Purchased for $5 from a Mass retail store on eBay

Copied the data off: 541MB

Initial analysis:

- Total disk sectors: 1,057,392
- Total non-zero sectors: 989,514
- Total files: 3

The files:

```
drwxrwxrwx 0 root      0 Dec 31 1979 ./
-r-xr-xr-x 0 root 222390 May 11 1998 IO.SYS
-r-xr-xr-x 0 root      9 May 11 1998 MSDOS.SYS
-rwxrwxrwx 0 root  93880 May 11 1998 COMMAND.COM
```

Image this disk to a file, then use the Unix “strings” command:

```
% strings 70.img | more
Insert diskette for drive
and press any key when ready
Your program caused a divide overflow error.
If the problem persists, contact your program vendor.
Windows has disabled direct disk access to protect your lo
To override this protection, see the LOCK /? command for m
The system has been halted. Press Ctrl+Alt+Del to restart
You started your computer with a version of MS-DOS incompatible
version of Windows. Insert a Startup diskette matching this
OEMString = "NCR 14 inch Analog Color Display Enchanced SV
Graphics Mode: 640 x 480 at 72Hz vertical refresh.
XResolution = 640
YResolution = 480
```

% strings cont...

```
ling the Trial Edition
----------------------------
IBM AntiVirus Trial Edition is a full-function but time-li
evaluation version of the IBM AntiVirus Desktop Edition pr
may have received the Trial Edition on a promotional CD-RO
single-file installation program oveœr a network. The Tria
is available in seven national languages, and each languag
provided on a separate CC-ROM or as a separa
EAS.STCm
EET.STC
ELR.STCq
ELS.STC
```

% strings 70.img cont...

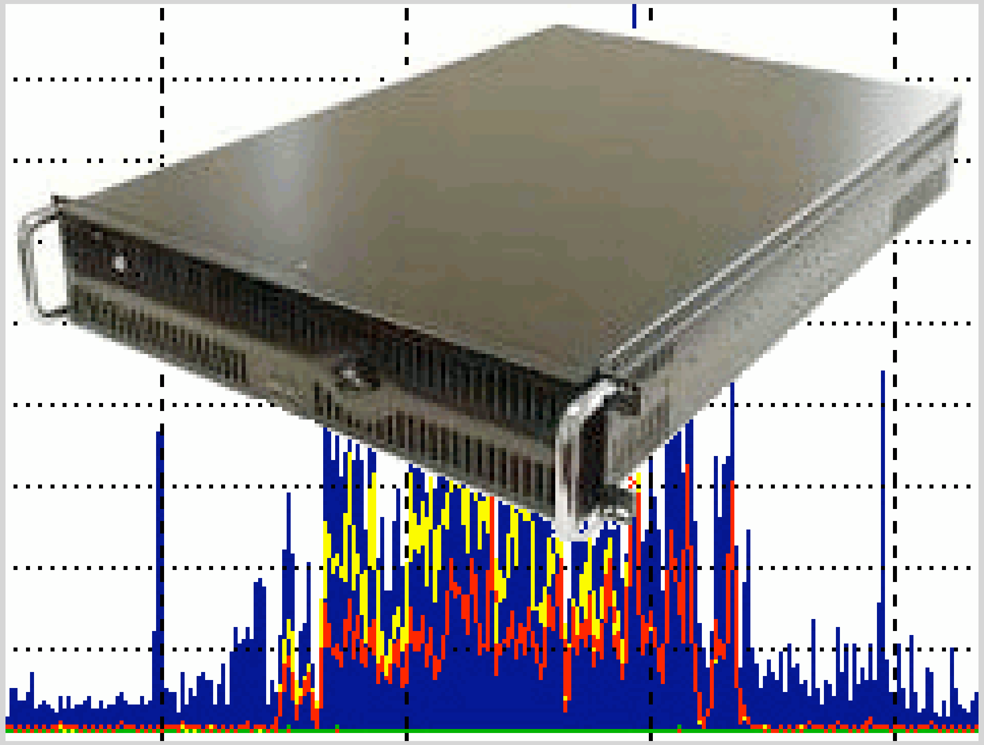
```
MAB-DEDUCTIBLE
MAB-MOOP
MAB-MOOP-DED
METHIMAZOLE
INSULIN (HUMAN)
COUMARIN ANTICOAGULANTS
CARBAMATE DERIVATIVES
AMANTADINE
MANNITOL
MAPROTILINE
CARBAMAZEPINE
CHLORPHENESIN CARBAMATE
ETHINAMATE
FORMALDEHYDE
MAFENIDE ACETATE
```

Roughly 1/3 of the discarded hard drives have significant amounts of confidential data.

From sampling 150 hard drives collected between 1998 and 2002, we found:

- Thousands of credit cards
- Financial records
- Medical information
- Trade secrets
- Highly personal information

[Garfinkel & Shelat 03]



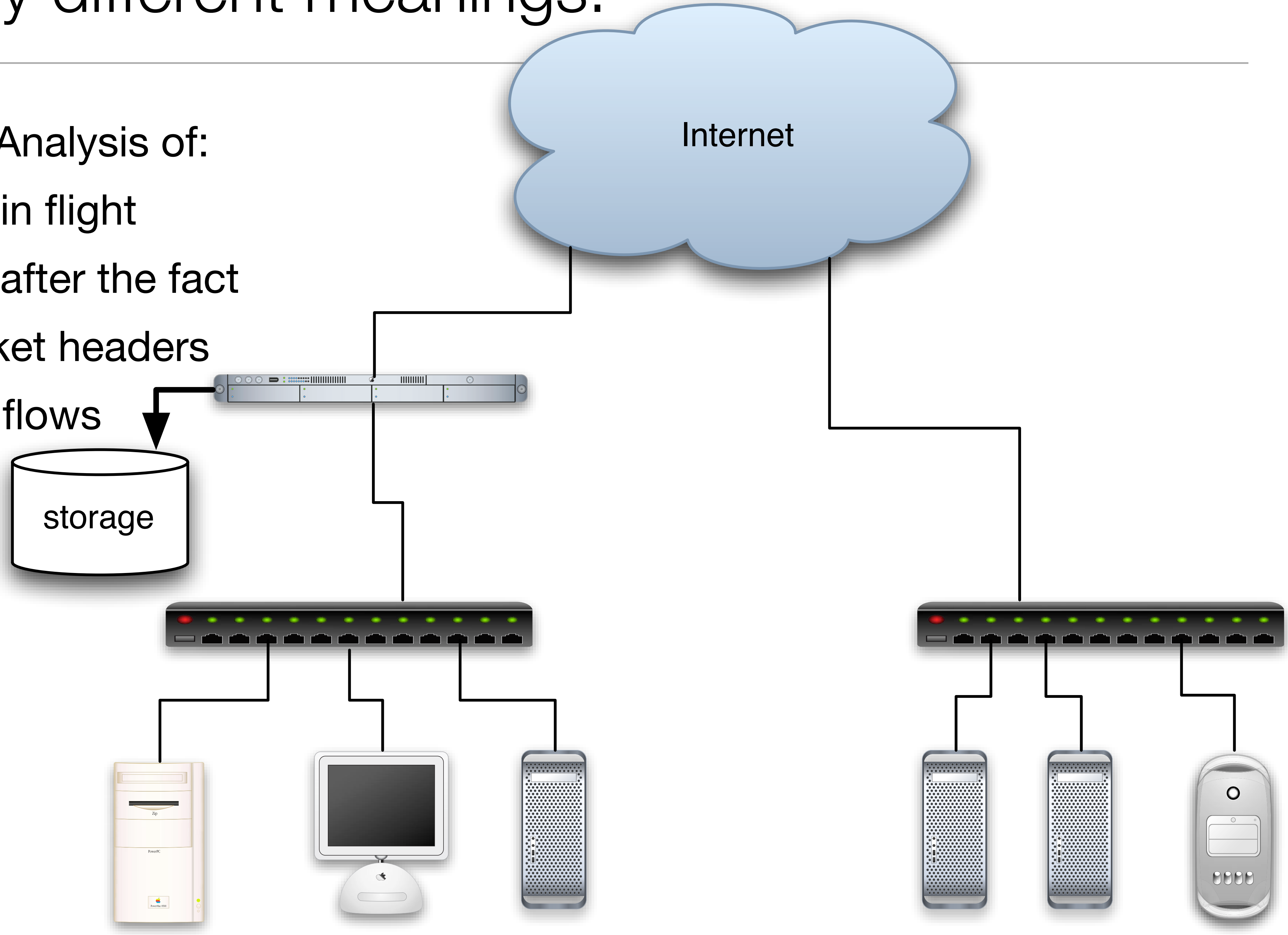
Network Forensics

- packets
- flows
- logfiles

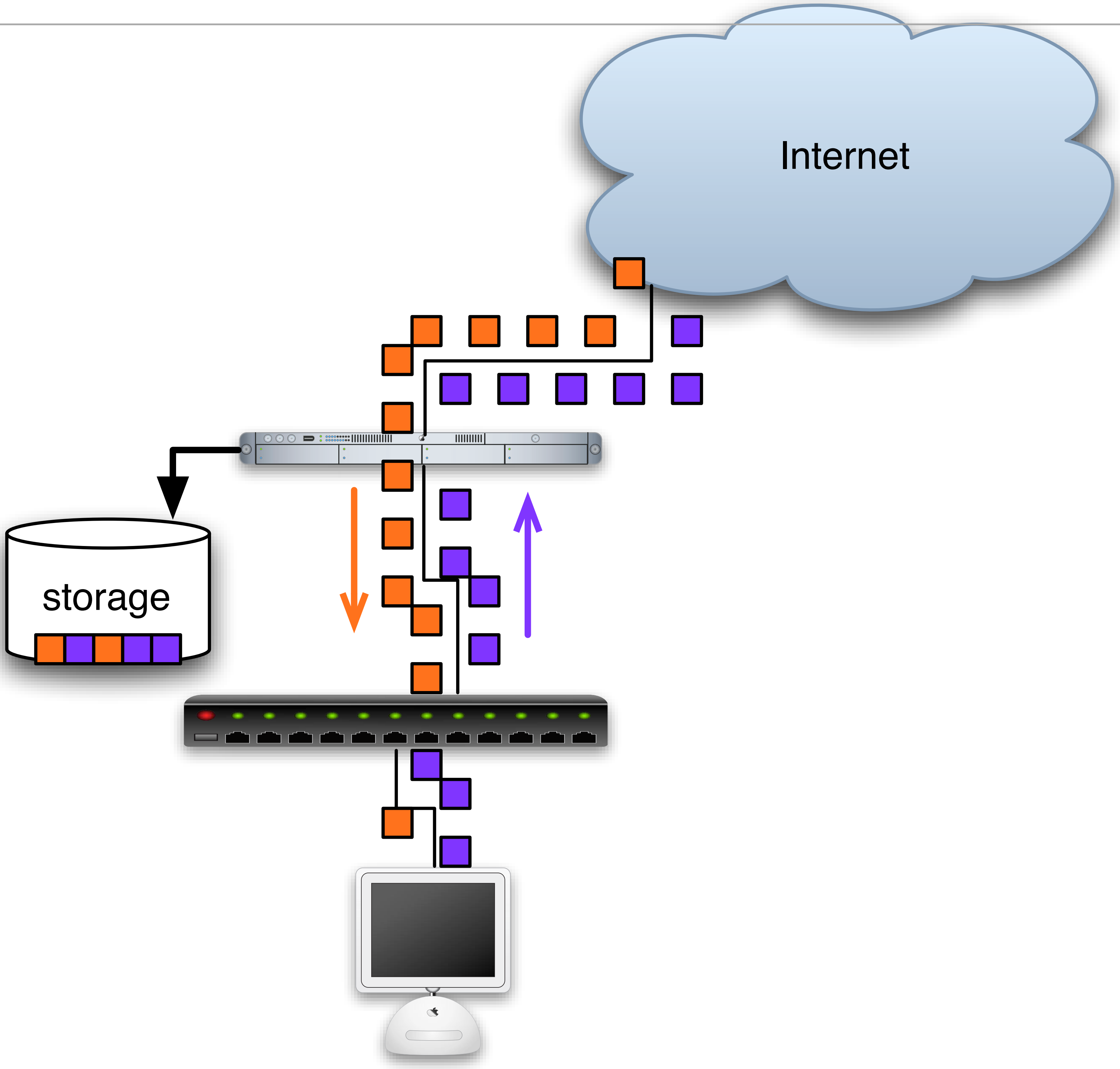
“Network Forensics” has many different meanings.

Capture and Analysis of:

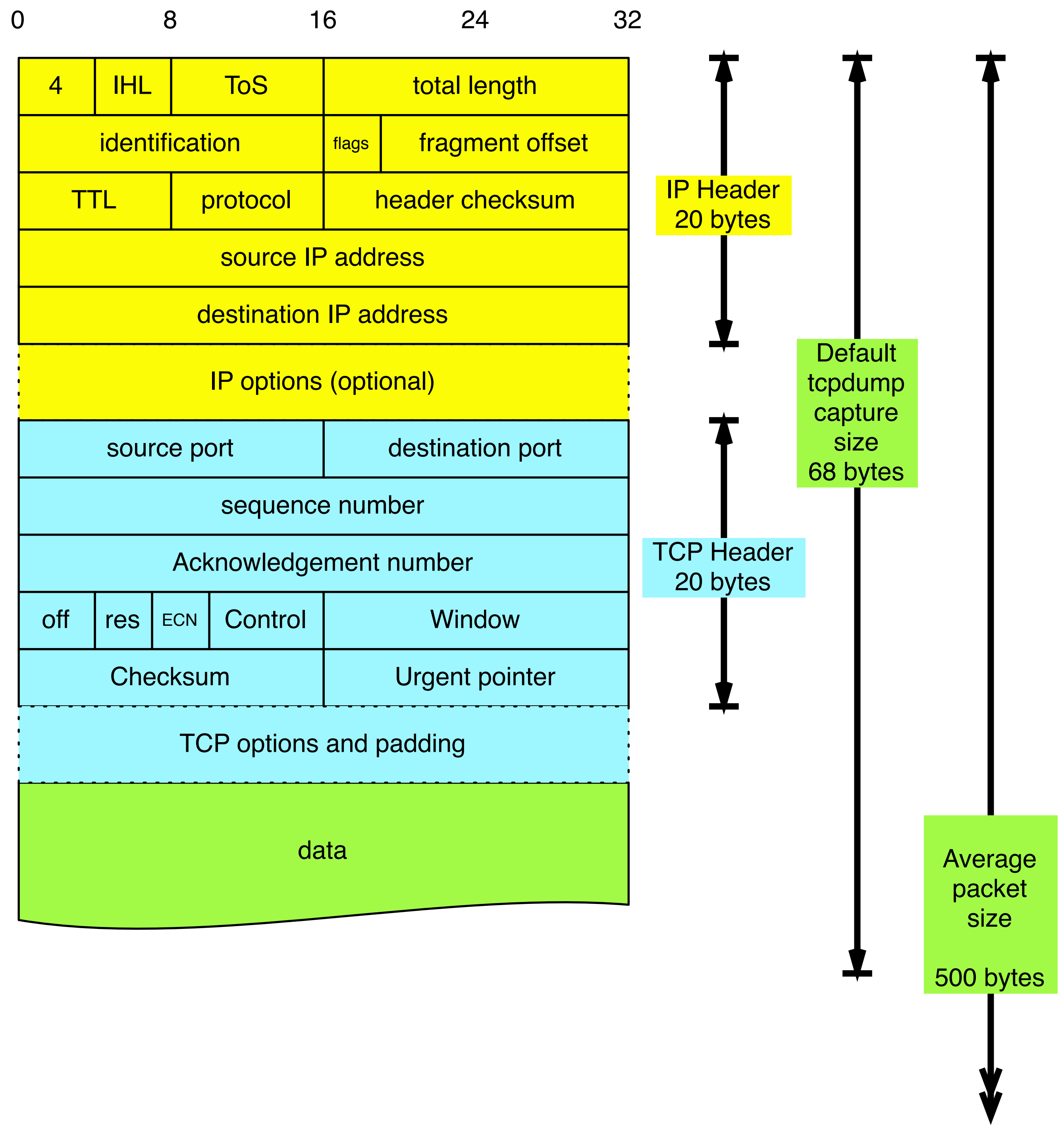
- packets in flight
- packets after the fact
- just packet headers
- network flows
- log files



Packets can be analyzed in flight or after capture.



Systems can capture the *entire packet* or *just the packet header*



0 8 16 24 32

4 | IHL | ToS | total length

identification | flags | fragment offset

TTL | protocol | header checksum

source IP address

destination IP address

IP options (optional)

source port | destination port

sequence number

Acknowledgement number

off | res | ECN | Control | Window

Checksum | Urgent pointer

TCP options and padding

data

IP Header
20 bytes

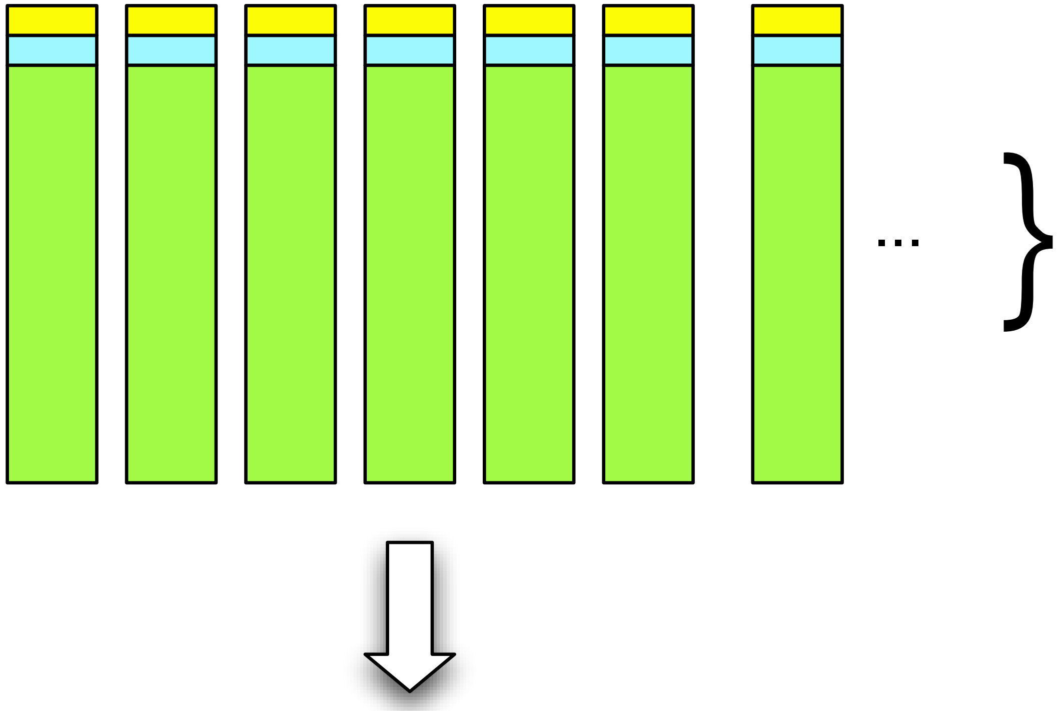
TCP Header
20 bytes

Default
tcpdump
capture
size
68 bytes

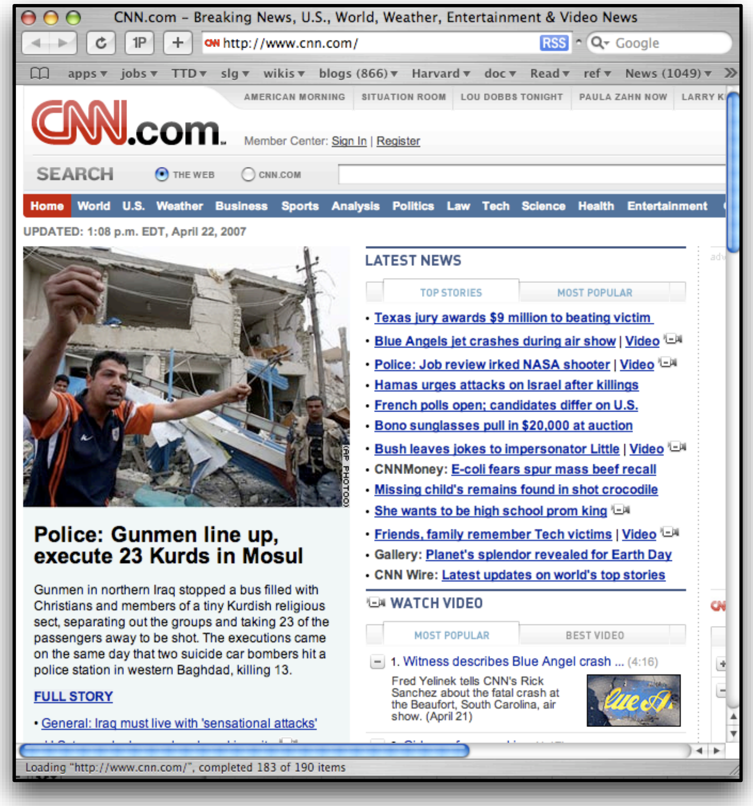
Average
packet
size

500 bytes

Complete packets allows for reconstruction.



525 complete packets



Member Center: Sign In | Register

UPDATED: 1:08 p.m. EDT, April 22, 2007

Police: Gunmen line up, execute 23 Kurds in Mosul

Gunmen in northern Iraq stopped a bus filled with Christians and members of a tiny Kurdish religious sect, separating out the groups and taking 23 of the passengers away to be shot. The executions came on the same day that two suicide car bombers hit a police station in western Baghdad, killing 13.

FULL STORY

- General: Iraq must live with 'sensational attacks'

LATEST NEWS

- Texas jury awards $9 million to beating victim
- Blue Angels jet crashes during air show | Video
- Police: Job review irked NASA shooter | Video
- Hamas urges attacks on Israel after killings
- French polls open; candidates differ on U.S.
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- She wants to be high school prom king
- Friends, family remember Tech victims | Video
- Gallery: Planet's splendor revealed for Earth Day
- CNN Wire: Latest updates on world's top stories

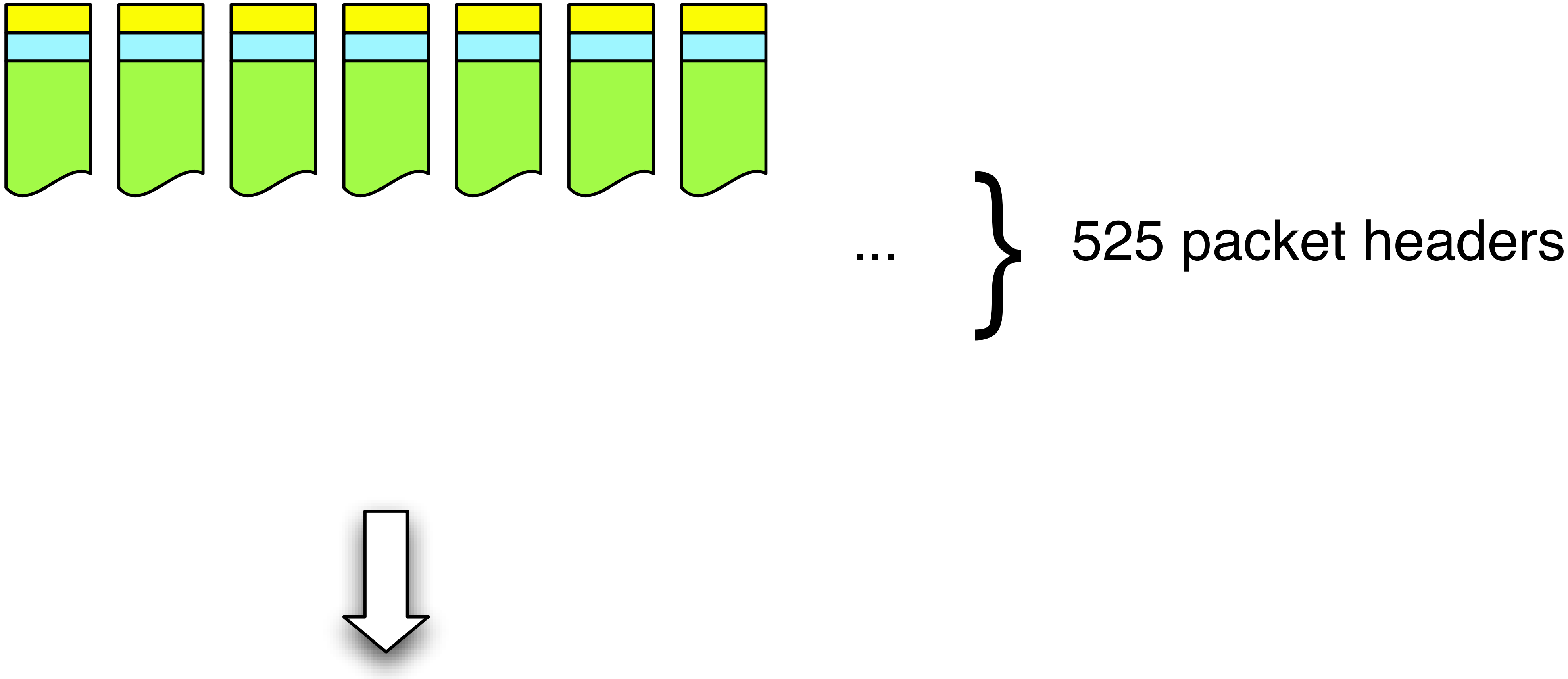
WATCH VIDEO

1. Witness describes Blue Angel crash ... (4:16)

Fred Yelinek tells CNN's Rick Sanchez about the fatal crash at the Beaufort, South Carolina, air show. (April 21)

Loading "http://www.cnn.com/", completed 183 of 190 items

With just headers, you can only get source, destination, size, timestamps, ports, etc.



```
10:52:16.294858 IP 192.168.1.102.58754 > www2.cnn.com.http: S
10:52:16.370616 IP www2.cnn.com.http > 192.168.1.102.58754: S
10:52:16.370700 IP 192.168.1.102.58754 > www2.cnn.com.http: .
10:52:16.371114 IP 192.168.1.102.58754 > www2.cnn.com.http: P
10:52:16.455120 IP www2.cnn.com.http > 192.168.1.102.58754: .
10:52:19.956986 IP i7.cnn.net.http > 192.168.1.102.58755: .
10:52:19.961475 IP i7.cnn.net.http > 192.168.1.102.58755: .
10:52:19.981228 IP cnn1.dyn.cnn.com.http > 192.168.1.102.58766:
10:52:19.983731 IP cl4.cnn.com.http > 192.168.1.102.58761: P
```

Packet headers can be used to reconstruct “flows”

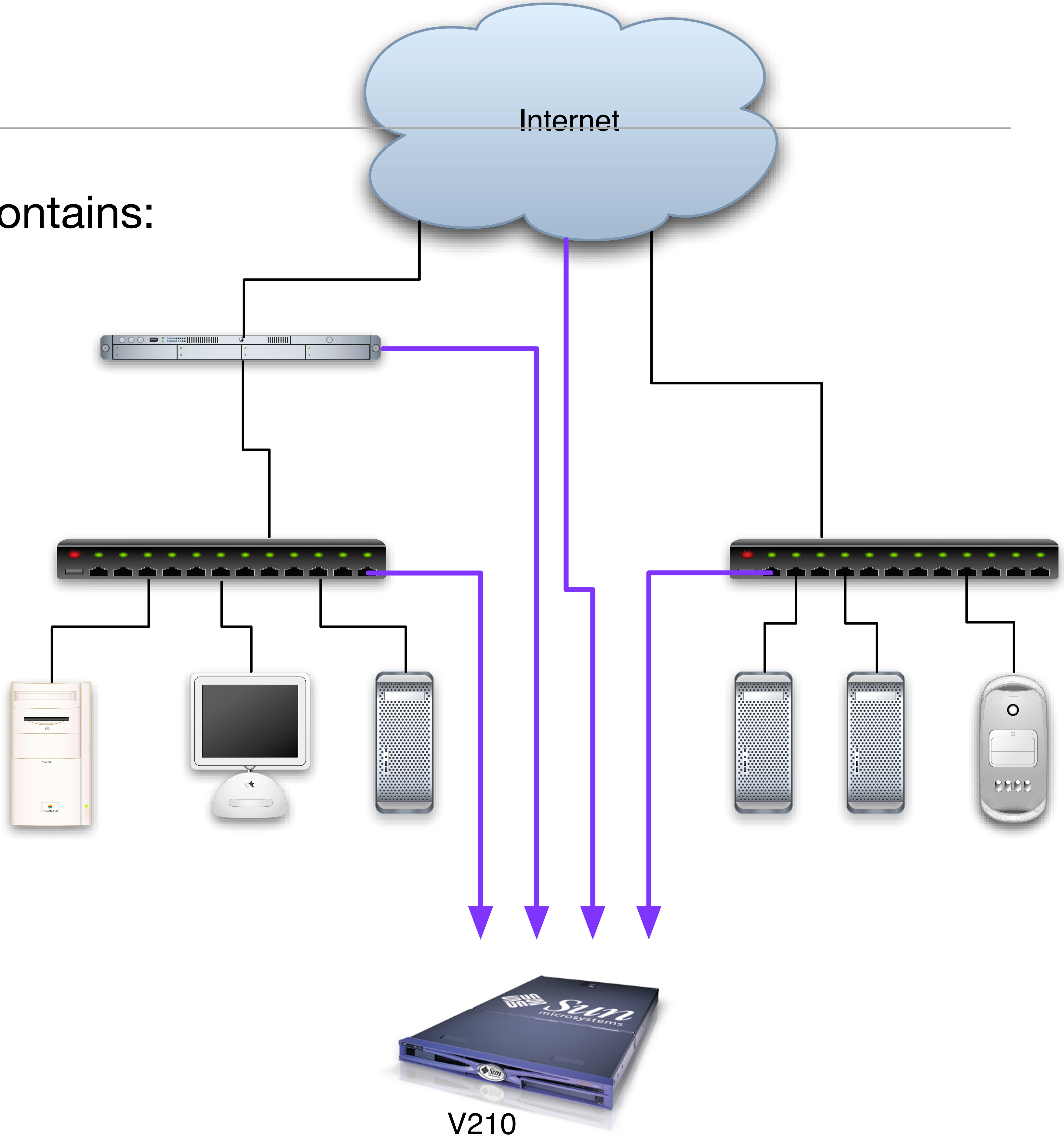
```
10:52:16.294858 IP 192.168.1.102.58754 > www2.cnn.com.http: S
10:52:16.370616 IP www2.cnn.com.http > 192.168.1.102.58754: S
10:52:16.370700 IP 192.168.1.102.58754 > www2.cnn.com.http: .
10:52:16.371114 IP 192.168.1.102.58754 > www2.cnn.com.http: P
10:52:16.455120 IP www2.cnn.com.http > 192.168.1.102.58754: .
10:52:19.956986 IP i7.cnn.net.http > 192.168.1.102.58755: .
10:52:19.961475 IP i7.cnn.net.http > 192.168.1.102.58755: .
10:52:19.981228 IP cnn1.dyn.cnn.com.http > 192.168.1.102.58766:
10:52:19.983731 IP cl4.cnn.com.http > 192.168.1.102.58761: P
```

```
Count         Source     >   Destination
  46 i7.cnn.net.http     > 192.168.1.102.58755
  34 192.168.1.102.58755 > i7.cnn.net.http
  26 69.22.138.51.http   > 192.168.1.102.58776
  24 www2.cnn.com.http   > 192.168.1.102.58754
  21 192.168.1.102.58776 > 69.22.138.51.http
  19 192.168.1.102.58765 > i7.cnn.net.http
  17 64.236.29.63.http   > 192.168.1.102.58758
  17 192.168.1.102.58754 > www2.cnn.com.http
  16 i7.cnn.net.http     > 192.168.1.102.58765
  14 192.168.1.102.58759 > 64.236.29.63.http
  13 72.32.153.176.http  > 192.168.1.102.58769
  13 192.168.1.102.58769 > 72.32.153.176.http
  13 192.168.1.102.58758 > 64.236.29.63.http
  12 64.236.29.63.http   > 192.168.1.102.58759
  10 64.236.29.63.http   > 192.168.1.102.58778
  10 64.236.29.63.http   > 192.168.1.102.58757
```

Many switches and routers will report “netfow” data directly.

Each Cisco NetFlow record contains:

- Total bytes & packets
- S&D IP addresses
- S&D ports (UDP or TCP)
- flags
- start & end time
- min & max packet size
- VLANs & ifaces
- Vendor proprietary data



Each computer and router generates log files. Here’s what’s on my MacBook:

Date & Time of:

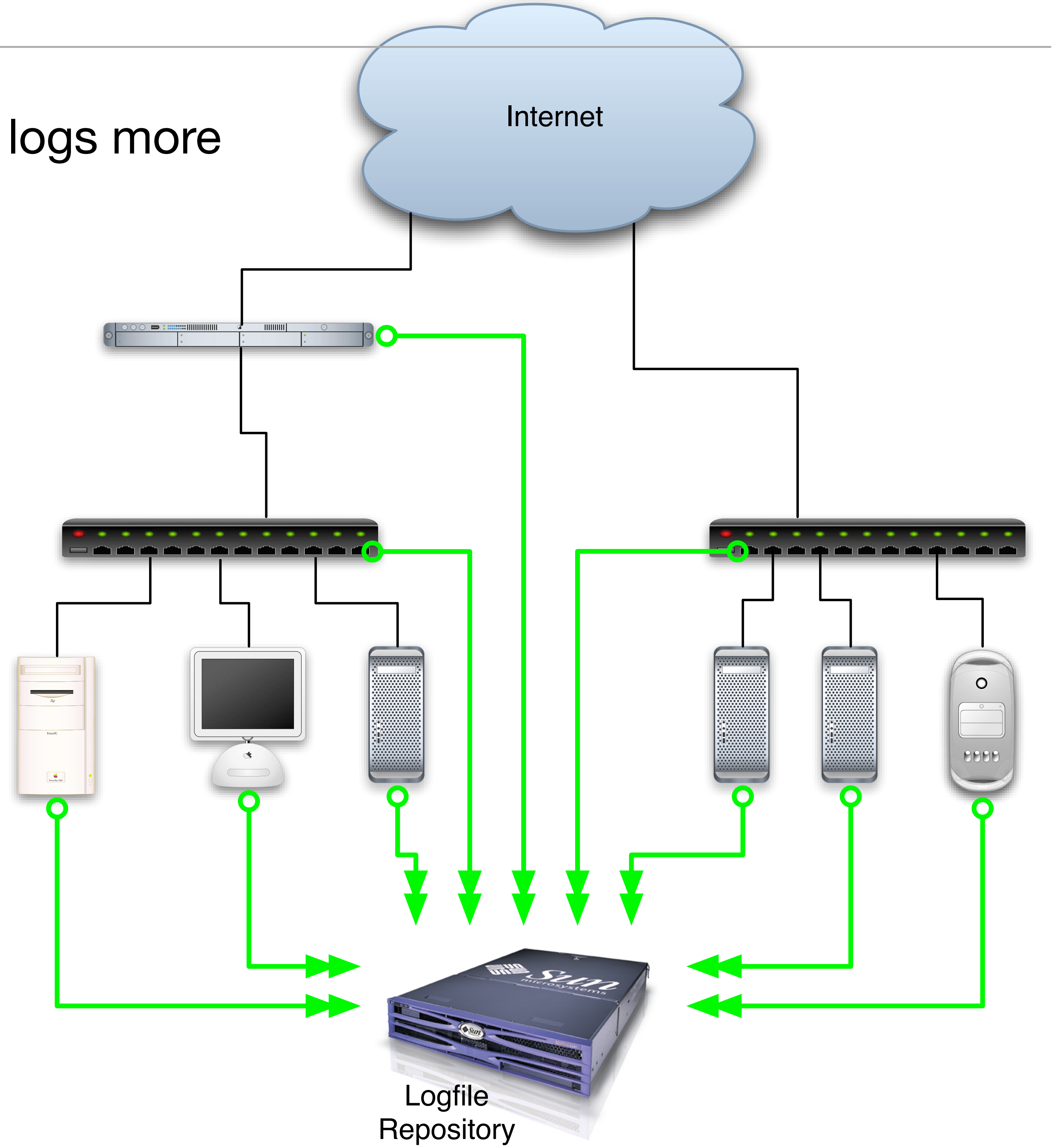
- OS installation
- Calendar syncs
- Wake from sleep & time slept
- Every program that crashed
- Every file installed
- Every log-in and log-out

Other information:

- Daily amount of free space
- Every 802.11 network found
- Every associated network
-

Log files are kept on each host; they can be aggregated into a central location

A central repository makes the logs more resistant to attack.



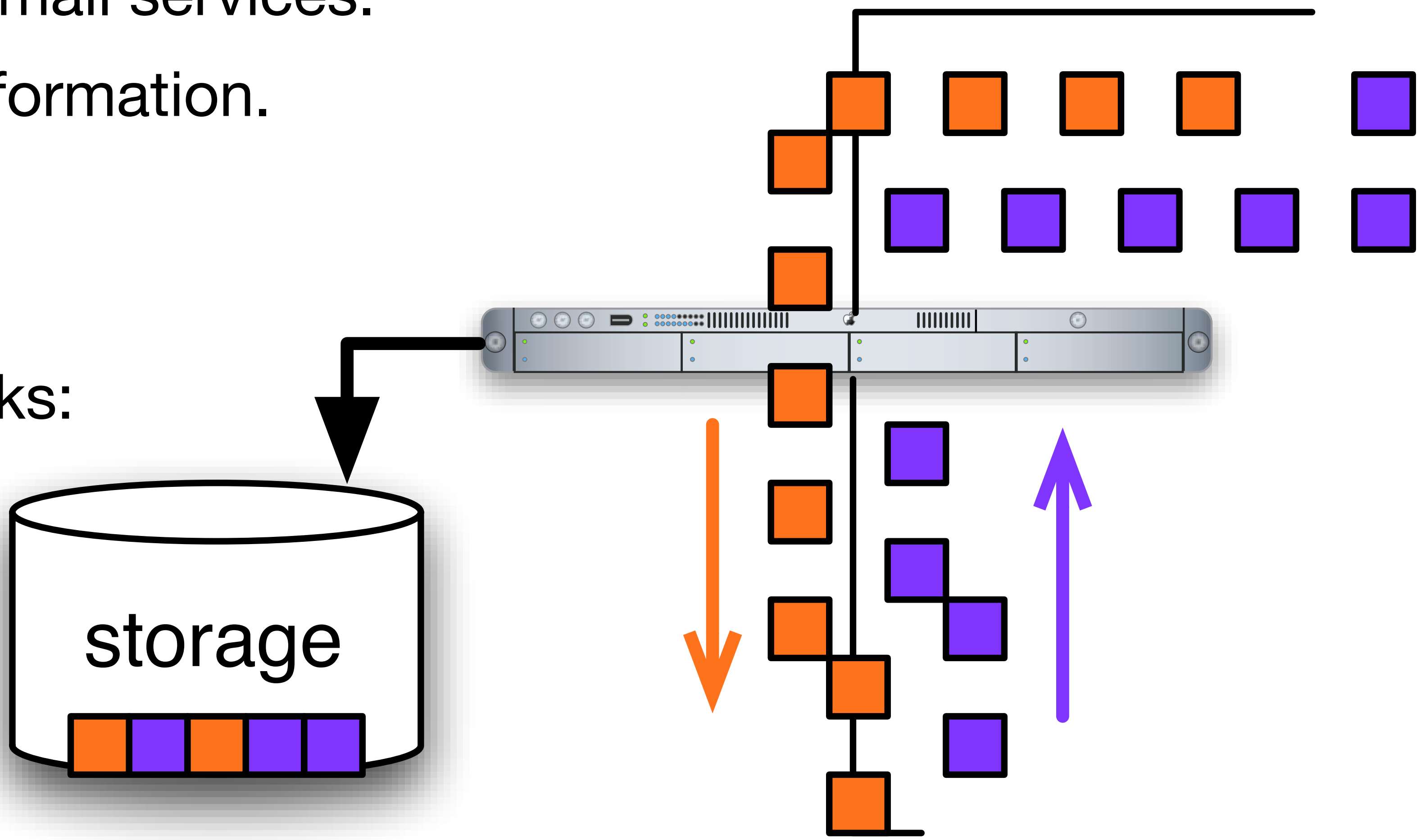
Some vendors call this “deep packet inspection” or “deep packet analysis.”

Primary use is to discover inappropriate data transfer or service use:

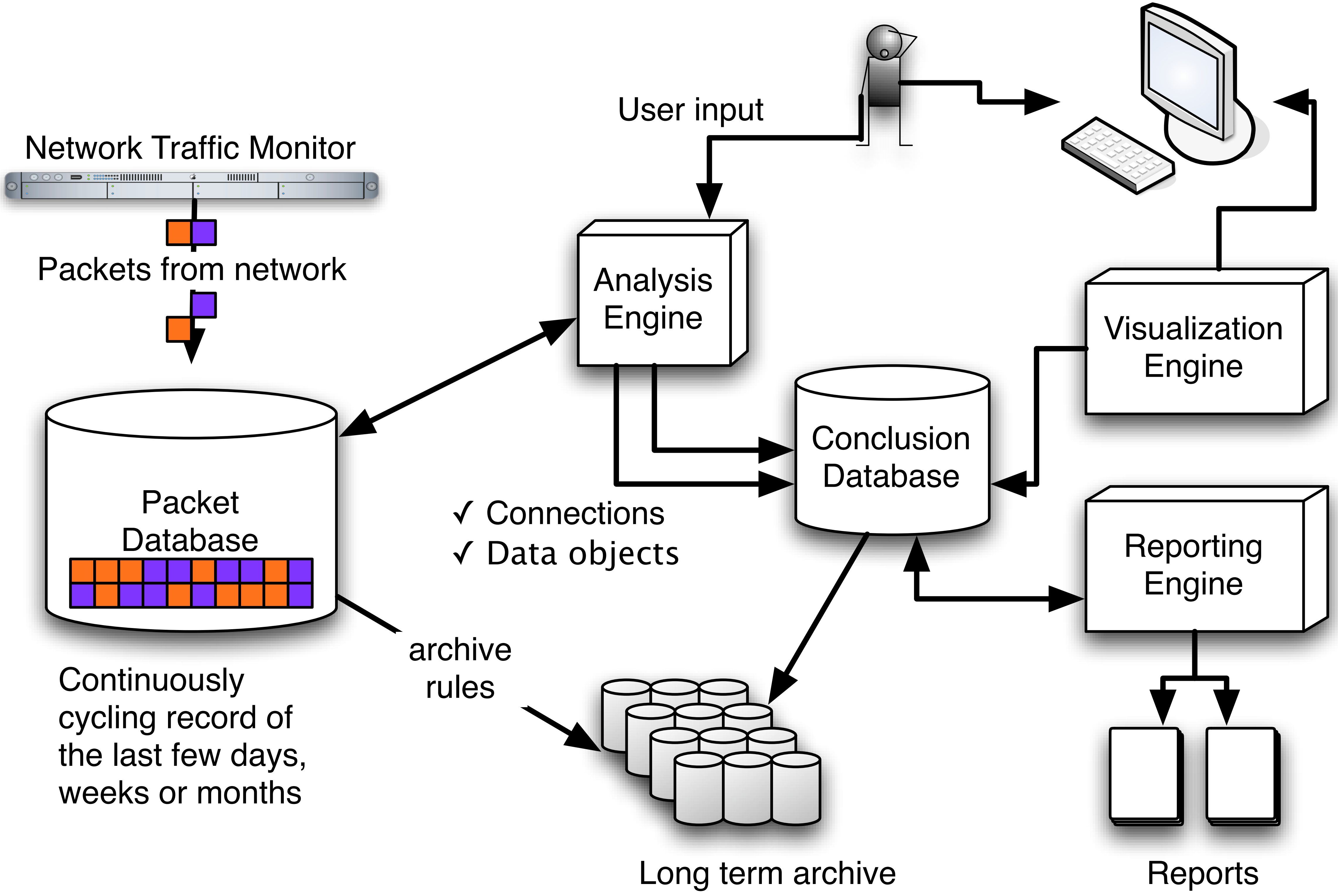
- Use of outside chat or web mail services.
- Leaking protected health Information.
- Restrict information

Also good for debugging networks:

- Duplicate requests
- Incomplete transactions
- Discovery of vulnerabilities without scanning
- Cleartext usernames & passwords



Network Forensics Architecture



Packet monitoring is similar to wiretapping.

Passive Monitoring Options:

- Use an ethernet “hub” with a packet sniffer.
- Set up a switched monitoring port.
- Full-duplex networks may require *two* monitoring ports.

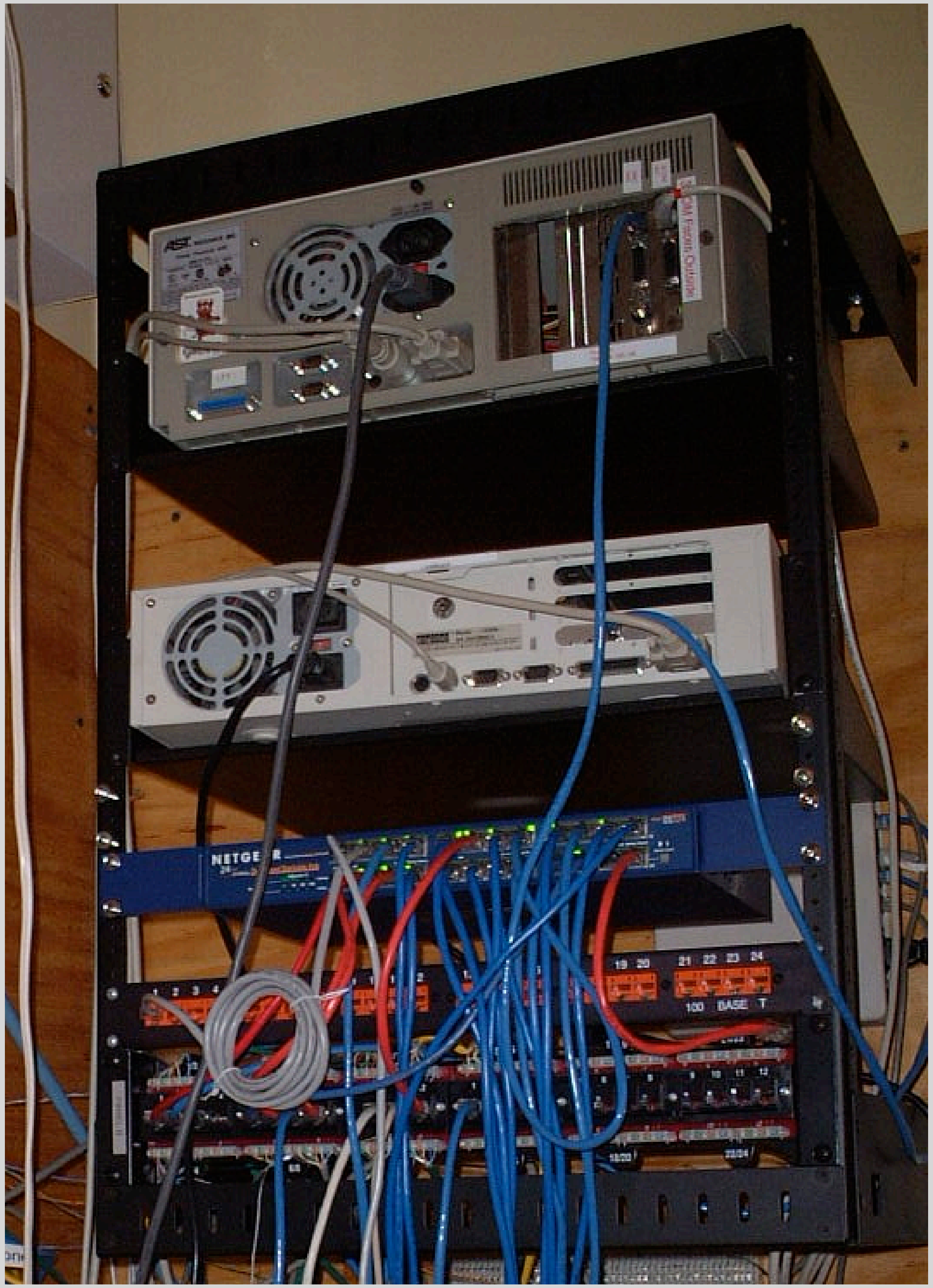
Active Monitoring Options:

- Monitor with a proxy or router.
- Monitor packets at endpoints

Critical uses:

- Attack assessment
- Policy enforcement

“A DVR for an Internet connection.”



Internet Wiretapping History

1983 — Netwatch – Graphical display of Internet Traffic

1990 — First reports of hostile packet sniffers

1995 — Ardita (Harvard FAS monitored by FBI)

1997 — FBI / DOJ / Carnivore

1999 — Emergence of commercial tools

2003 — Cisco Systems adds “Lawful Intercept Controls” to switches to allow eavesdropping on VoIP conversations “without detection”

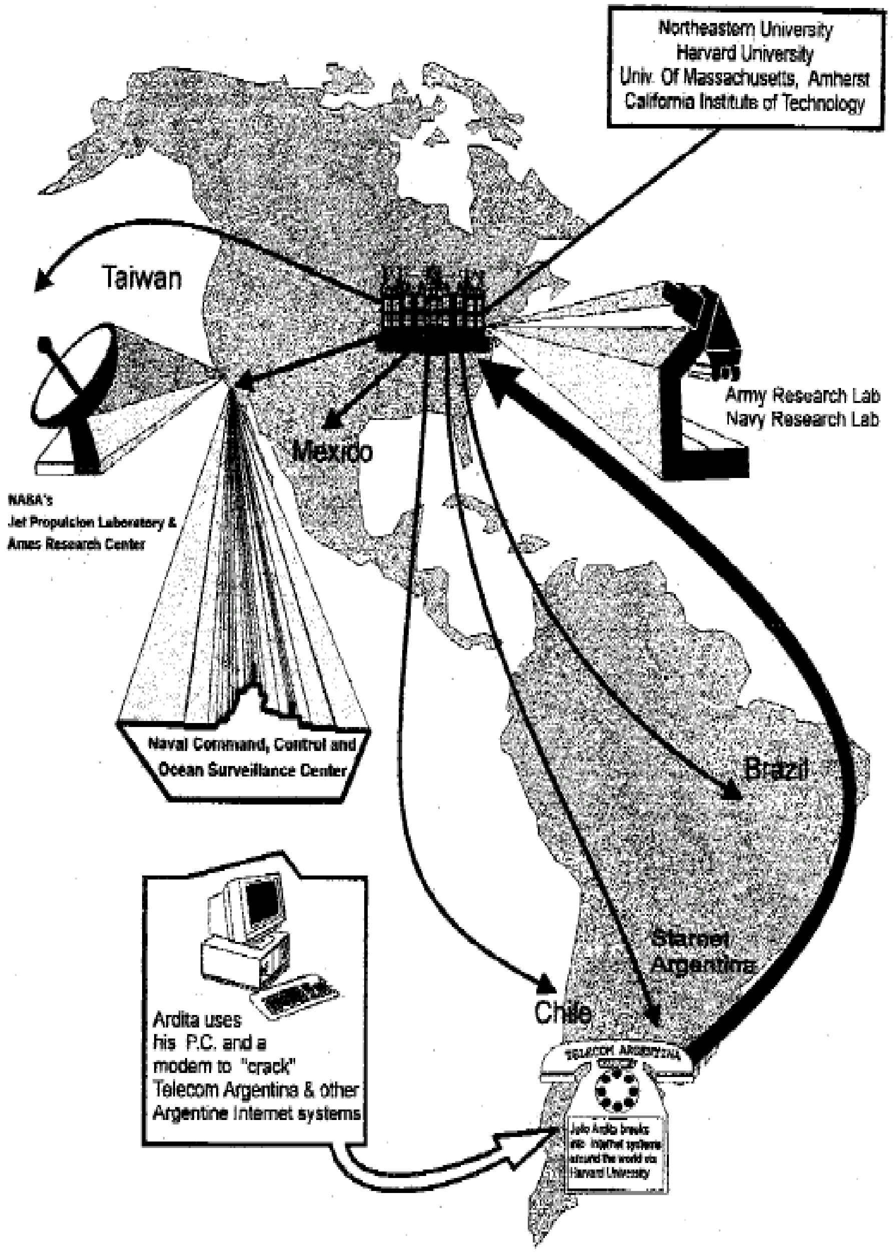
2007 — FBI reportedly adopts large-scale Internet surveillance techniques.

1996: Julio Caesar Ardita used Harvard FAS as a jump-off point

From Harvard, Ardita penetrated military and commercial systems throughout the world.

FBI installed TCP/IP stream reassembler with keyword trigger developed by US Army

Details at: http://www.simson.net/ref/1996/ardita.pdf

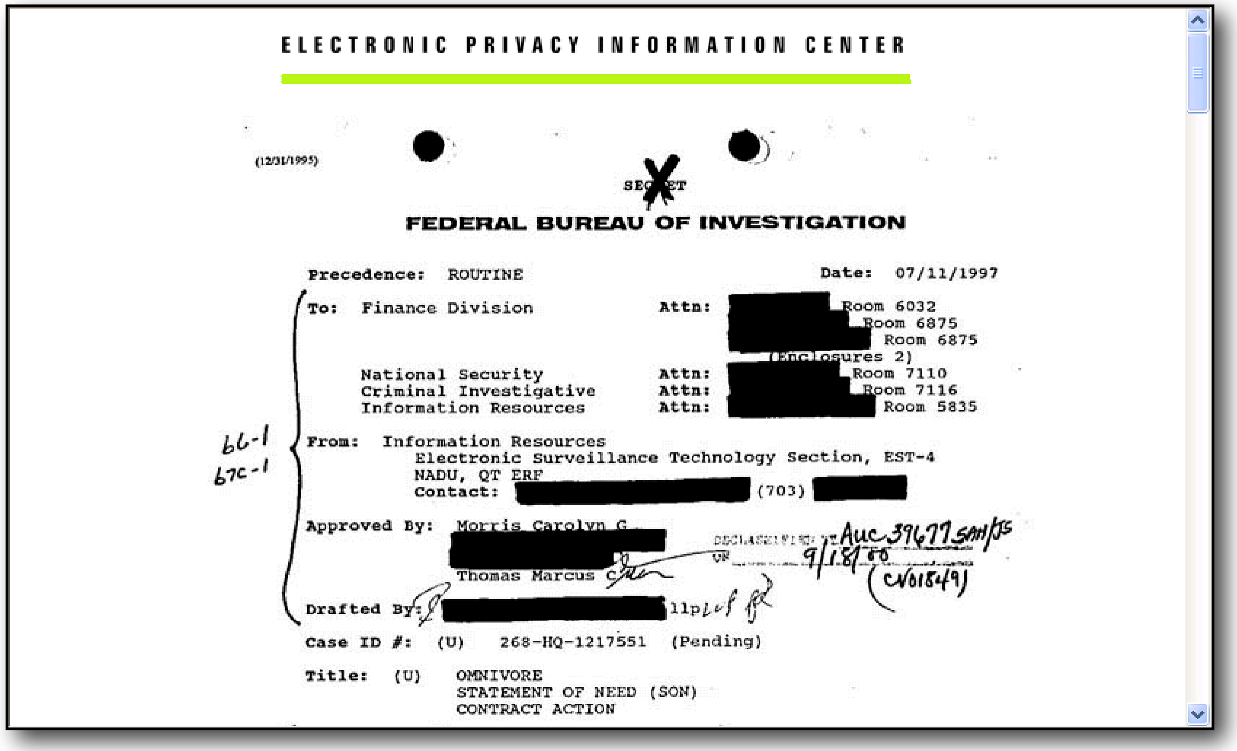


1997:
US Department of Justice develops “Omnivore”

Hodge-podge of technologies:

- Monitoring of IP and [redacted] protocols
- Intercepts stored on ZIP disks
- Solaris X.86
- Triggers on:
  - SMTP username
  - RADIUS

$2,315,000 development cost



ELECTRONIC PRIVACY INFORMATION CENTER

(12/31/1995)

~~SECRET~~

FEDERAL BUREAU OF INVESTIGATION

Precedence: ROUTINE Date: 07/11/1997

To: Finance Division Attn: [redacted] Room 6032
Room 6875
Room 6875
(Enclosures 2)

National Security Attn: [redacted] Room 7110
Criminal Investigative Attn: Room 7116
Information Resources Attn: Room 5835

b6-1
b7c-1

From: Information Resources
Electronic Surveillance Technology Section, EST-4
NADU, QT ERF
Contact: [redacted] (703) [redacted]

Approved By: Morris Carolyn G
[redacted]
Thomas Marcus C

DECLASSIFIED BY Auc 39677 SAH/JS
ON 9/18/00
(CV01849)

Drafted By: [redacted] llp

Case ID #: (U) 268-HQ-1217551 (Pending)

Title: (U) OMNIVORE
STATEMENT OF NEED (SON)
CONTRACT ACTION

http://www.epic.org/privacy/carnivore/omnivoreproposal.html

1998: Omnivore renamed “Carnivore” (“gets at the meat”)

Targeting Techniques:

- email usernames, RADIUS username
- IP address, DHCP mac address

Analysis:

- Logins & Logouts
- Email “pen register” (SMTP & RFC822)
- telnet

Apparently designed for medium-sized dial-up ISPs.

Renamed Digital Collection System 2000 (DSC2000)

Reportedly abandoned in favor of commercial and open source tools

Is it reasonable to capture all the packets?

In 1991, Los Alamos captured all information in and out of the lab's T1 on DAT tape:

- 8 gigabytes/day (50%)

Disks have gotten bigger faster than network connections have gotten faster.

This is an engineering problem.

Connection	GB/Day (50%)
T1	8 GB
10 Mbit	54 GB
T3	170 GB
OC3	512 GB
OC12	2,000 GB

Network Forensic issues:

Scaling issues:

- Amount of data
- Quality of data (lost packets)

Analysis issues:

- String search
- Correlation

Ultimate goal of work:

- Reconstruction
- Exploration

Vendor:

- Open Source
- Commercial

Full-content “deep analysis” solutions:

Open Source

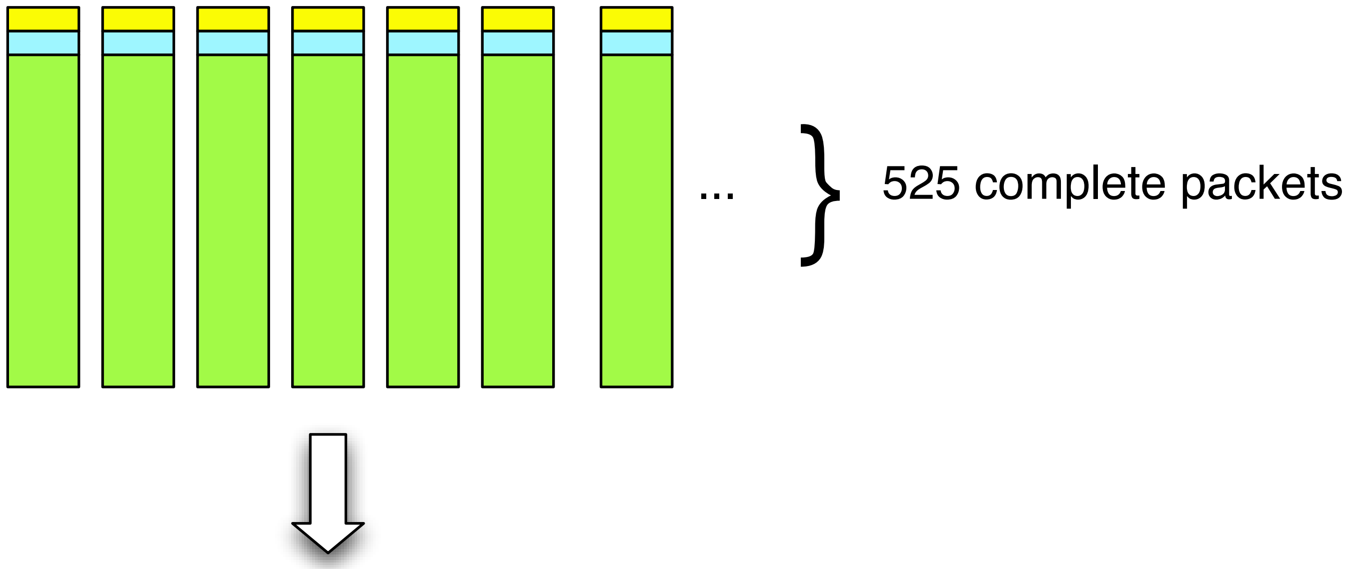
- Wireshark
- Snort
- Squil

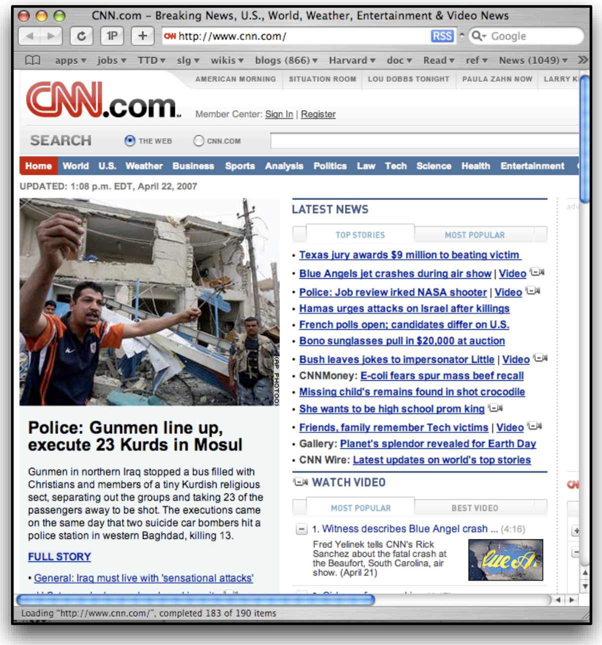
Commercial in-memory:

- NFR
- Intrusic
- McAfee
- NetWitness

Commercial archiving systems:

- CA eTrust Network Forensics
- Chronicle Solutions
- NIKSUN NetDetector
- Sandstorm NetIntercept
- Network Intelligence




CNN.com – Breaking News, U.S., World, Weather, Entertainment & Video News
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RSS
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apps jobs TTD slg wikis blogs (866) Harvard doc Read ref News (1049)
AMERICAN MORNING | SITUATION ROOM | LOU DOBBS TONIGHT | PAULA ZAHN NOW | LARRY K
CNN.com
Member Center: Sign In | Register
SEARCH ● THE WEB ○ CNN.COM
Home World U.S. Weather Business Sports Analysis Politics Law Tech Science Health Entertainment
LATEST NEWS
TOP STORIES
MOST POPULAR
WATCH VIDEO
MOST POPULAR
BEST VIDEO
FULL STORY
(AP PHOTO)

UPDATED: 1:08 p.m. EDT, April 22, 2007

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Fred Yelinek tells CNN's Rick Sanchez about the fatal crash at the Beaufort, South Carolina, air show. (April 21)

Loading "http://www.cnn.com/", completed 183 of 190 items

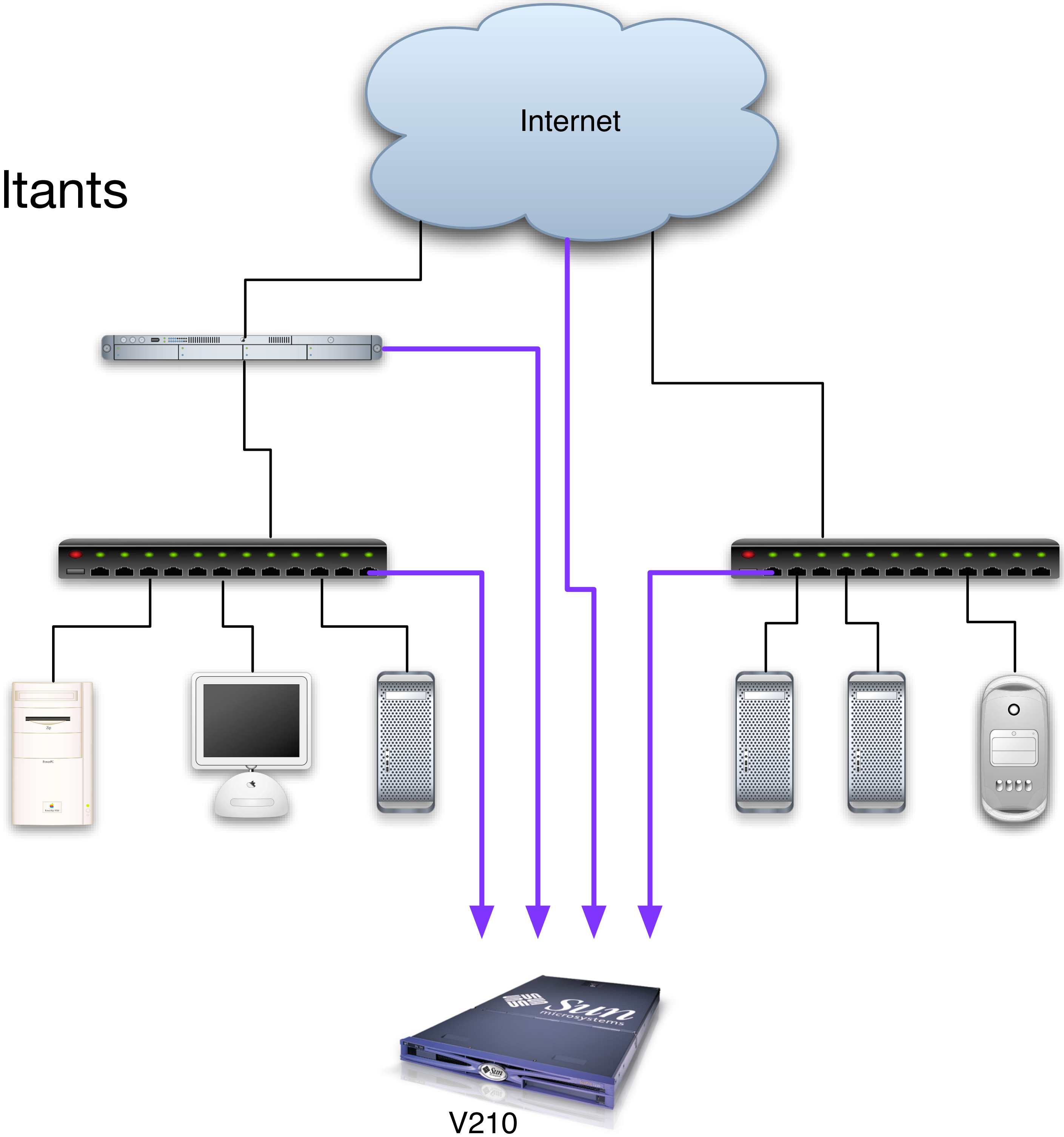
Flow-based systems: “blind” to data

Advantages:

- More economical
- Finds rogue servers and consultants

Can’t discover:

- Missing encryption
- Inappropriate encryption
- Protocols on wrong ports



Flow-based vendors

Arbor Networks

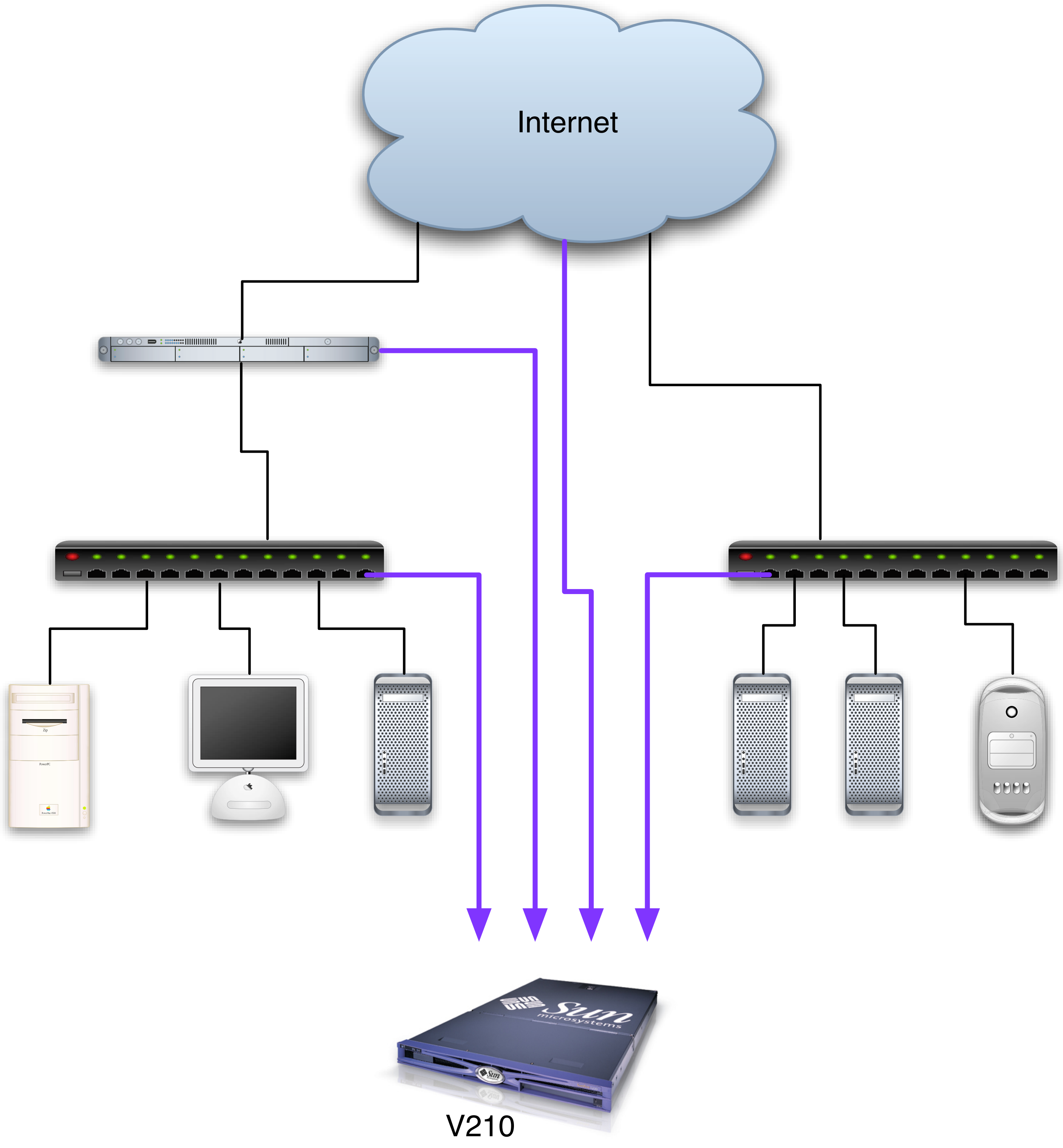
GraniteEdge Networks

Lanscope

Mazu Networks

Q1 Labs

...and many more



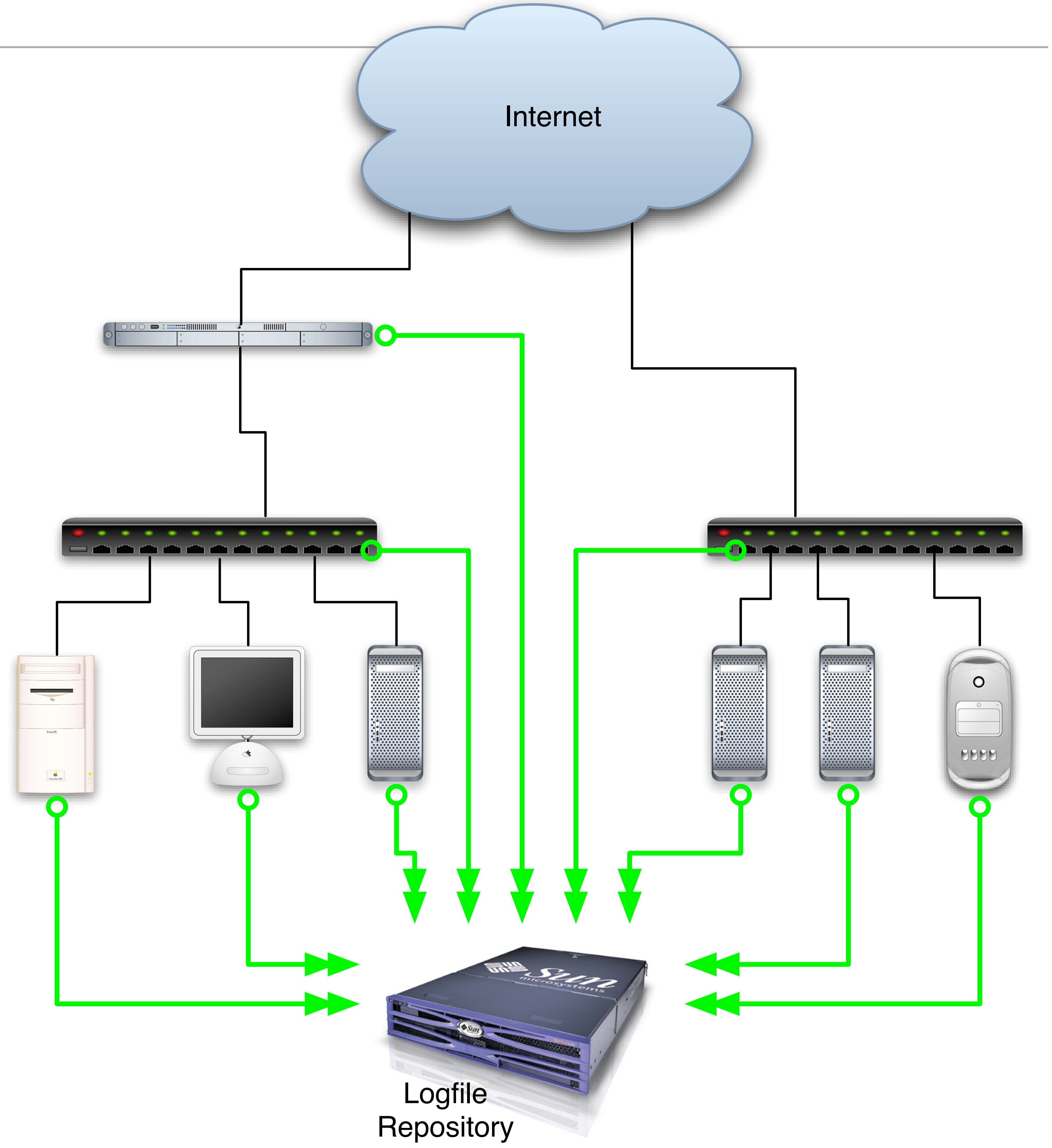
Log files: options

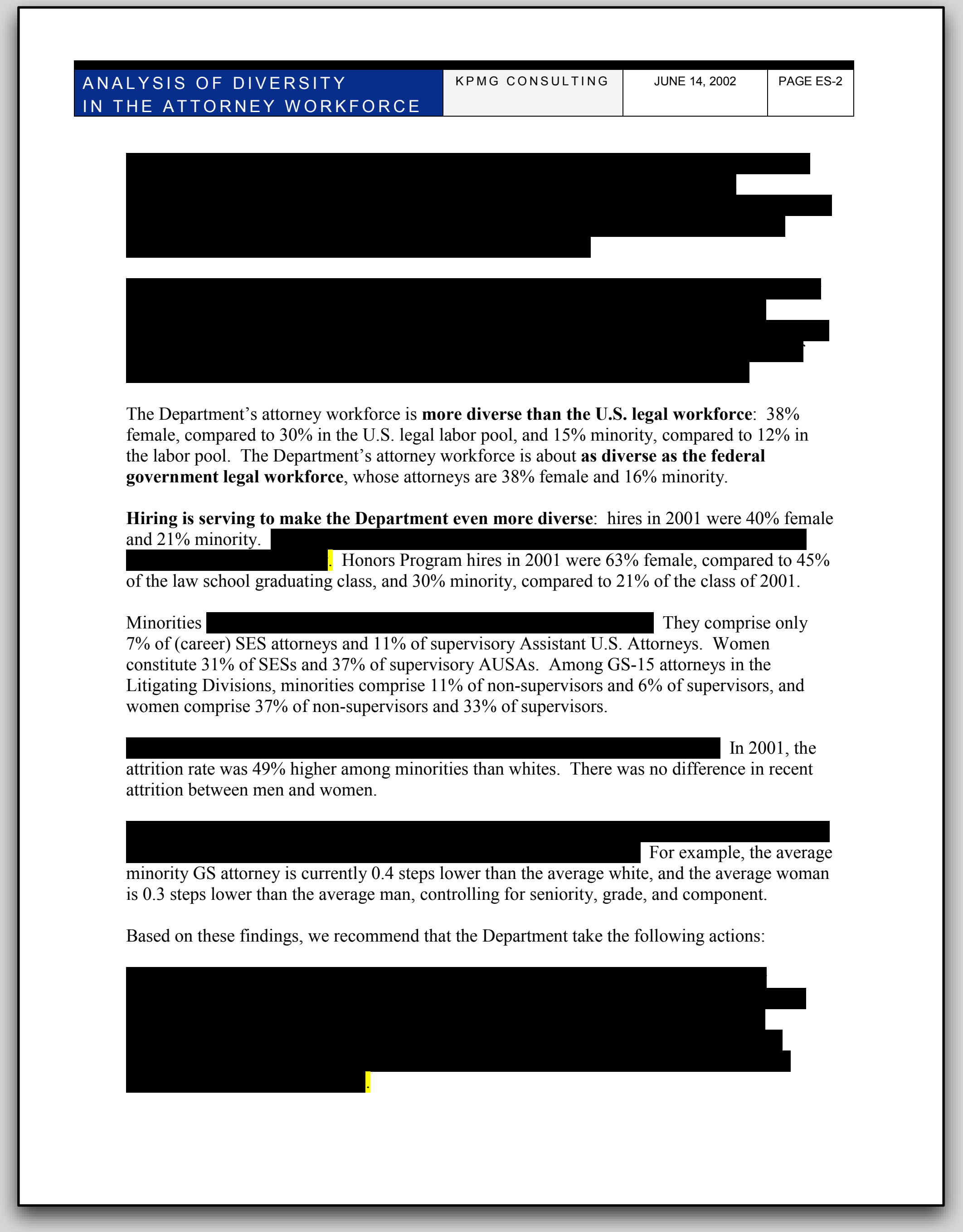
Open Source Options:

- syslog

Commercial Options:

- LogLogic
- Netforensics
- Q1 Labs
- Many other options...





ANALYSIS OF DIVERSITY IN THE ATTORNEY WORKFORCE | KPMG CONSULTING | JUNE 14, 2002 | PAGE ES-2

[redacted]

[redacted]

The Department's attorney workforce is **more diverse than the U.S. legal workforce**: 38% female, compared to 30% in the U.S. legal labor pool, and 15% minority, compared to 12% in the labor pool. The Department's attorney workforce is about **as diverse as the federal government legal workforce**, whose attorneys are 38% female and 16% minority.

Hiring is serving to make the Department even more diverse: hires in 2001 were 40% female and 21% minority. [redacted]. Honors Program hires in 2001 were 63% female, compared to 45% of the law school graduating class, and 30% minority, compared to 21% of the class of 2001.

Minorities [redacted] They comprise only 7% of (career) SES attorneys and 11% of supervisory Assistant U.S. Attorneys. Women constitute 31% of SESs and 37% of supervisory AUSAs. Among GS-15 attorneys in the Litigating Divisions, minorities comprise 11% of non-supervisors and 6% of supervisors, and women comprise 37% of non-supervisors and 33% of supervisors.

[redacted] In 2001, the attrition rate was 49% higher among minorities than whites. There was no difference in recent attrition between men and women.

[redacted] For example, the average minority GS attorney is currently 0.4 steps lower than the average white, and the average woman is 0.3 steps lower than the average man, controlling for seniority, grade, and component.

Based on these findings, we recommend that the Department take the following actions:

[redacted].

Document Forensics

Uses for Document Forensics

Which computer generated this document?

Who edited this document?

What was changed? When?

Is this document “authentic?”

Approaches for Data and Document Analysis:

Look for hidden data:

- Deleted information; previous versions
- GIDs embedded in Microsoft Word document

Look for characteristic data:

- Indicates authorship
- Indicates program used to create document.

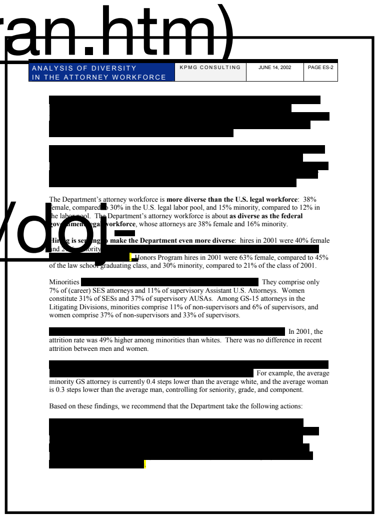
Look for inconsistent data:

- Indicates possible tampering.

Privacy and Security violations result when improperly sanitized documents are released.

Adobe PDF files:

- The New York Times published a PDF file containing the names of Iranians who helped with the 1953 coup. (2000) (http://cryptome.org/cia-iran.htm)
- US DoJ published a PDF file “diversity report” with embarrassing redacted information. (2003) (http://www.thememoryhole.org/feds/doj-attorney-diversity.htm)
- Multinational Force-Iraq report (2005)



ANALYSIS OF DIVERSITY IN THE ATTORNEY WORKFORCE | KPMG CONSULTING | JUNE 14, 2002 | PAGE ES-2

[redacted]

[redacted]

The Department’s attorney workforce is **more diverse than the U.S. legal workforce**: 38% female, compared to 30% in the U.S. legal labor pool, and 15% minority, compared to 12% in the labor pool. The Department’s attorney workforce is about **as diverse as the federal government legal workforce**, whose attorneys are 38% female and 16% minority.

Hiring is serving to make the Department even more diverse: hires in 2001 were 40% female and 2[illegible]% minority [redacted]. Honors Program hires in 2001 were 63% female, compared to 45% of the law school graduating class, and 30% minority, compared to 21% of the class of 2001.

Minorities [redacted] They comprise only 7% of (career) SES attorneys and 11% of supervisory Assistant U.S. Attorneys. Women constitute 31% of SESs and 37% of supervisory AUSAs. Among GS-15 attorneys in the Litigating Divisions, minorities comprise 11% of non-supervisors and 6% of supervisors, and women comprise 37% of non-supervisors and 33% of supervisors.

[redacted] In 2001, the attrition rate was 49% higher among minorities than whites. There was no difference in recent attrition between men and women.

[redacted] For example, the average minority GS attorney is currently 0.4 steps lower than the average white, and the average woman is 0.3 steps lower than the average man, controlling for seniority, grade, and component.

Based on these findings, we recommend that the Department take the following actions:

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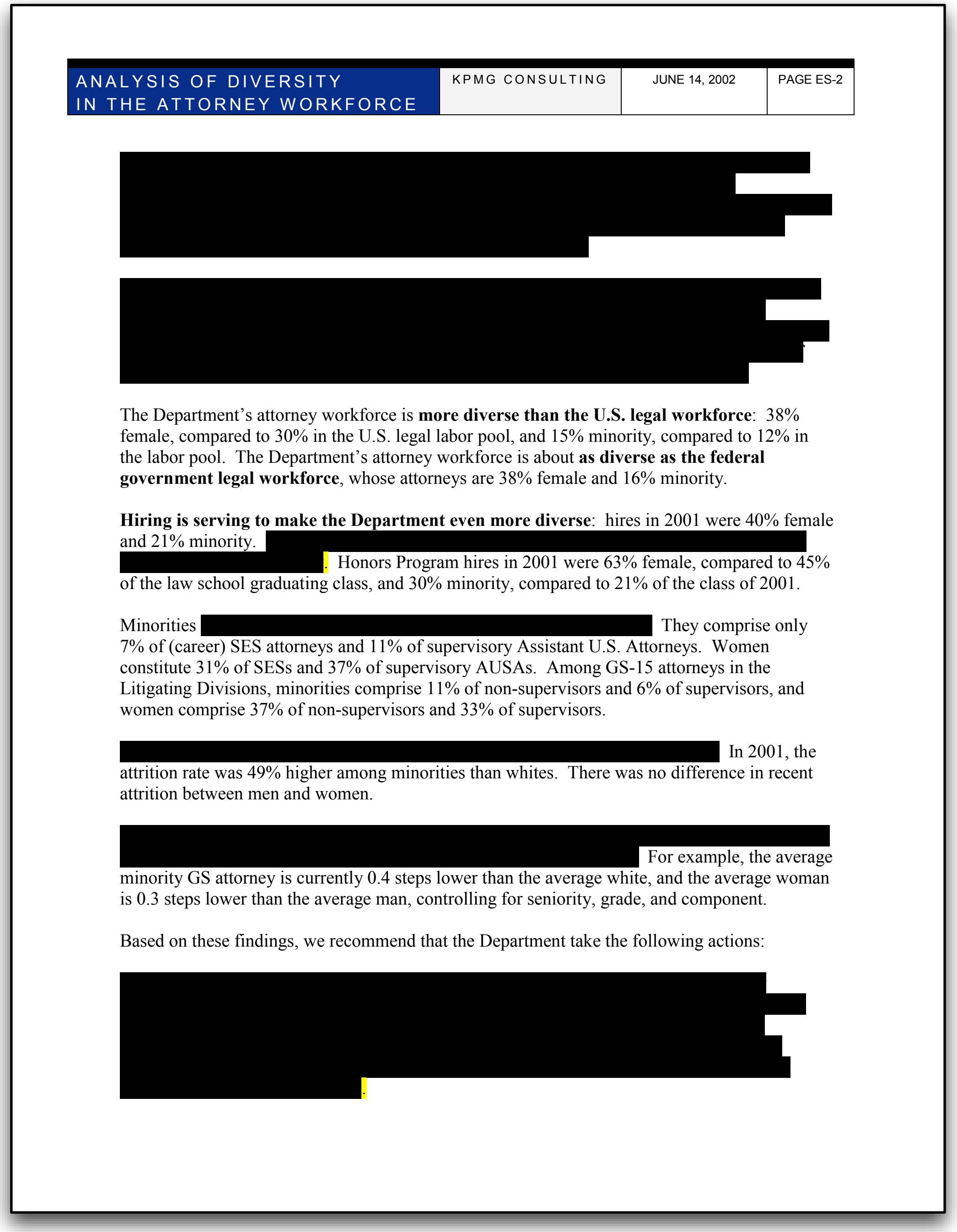
Microsoft Word Files:

- SCO Word file revealed its anti-Linux legal strategy. (2004)
- Intelligence report by Blair Government was found to be plagiarized from a postgraduate student at the Monterey Institute of International Studies based on transaction log (2003) (http://www.computerbytesman.com/privacy/blair.htm)

Why is data left in documents?

1. Confusion between “covering data” and removing it.
2. Failure to implement “complete delete.”
3. Information that is written but never read.

Most Acrobat leakage is a result of Microsoft Word.



ANALYSIS OF DIVERSITY IN THE ATTORNEY WORKFORCE | KPMG CONSULTING | JUNE 14, 2002 | PAGE ES-2

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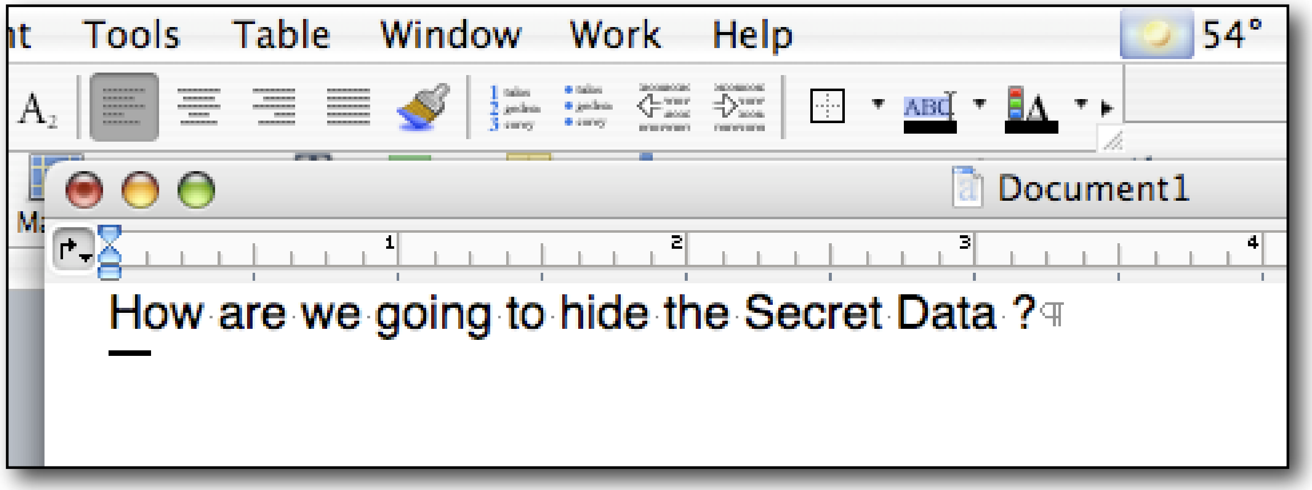
Microsoft Word encourages people to use the highlight feature to eradicate data.



How are we going to hide the Secret Data ?¶

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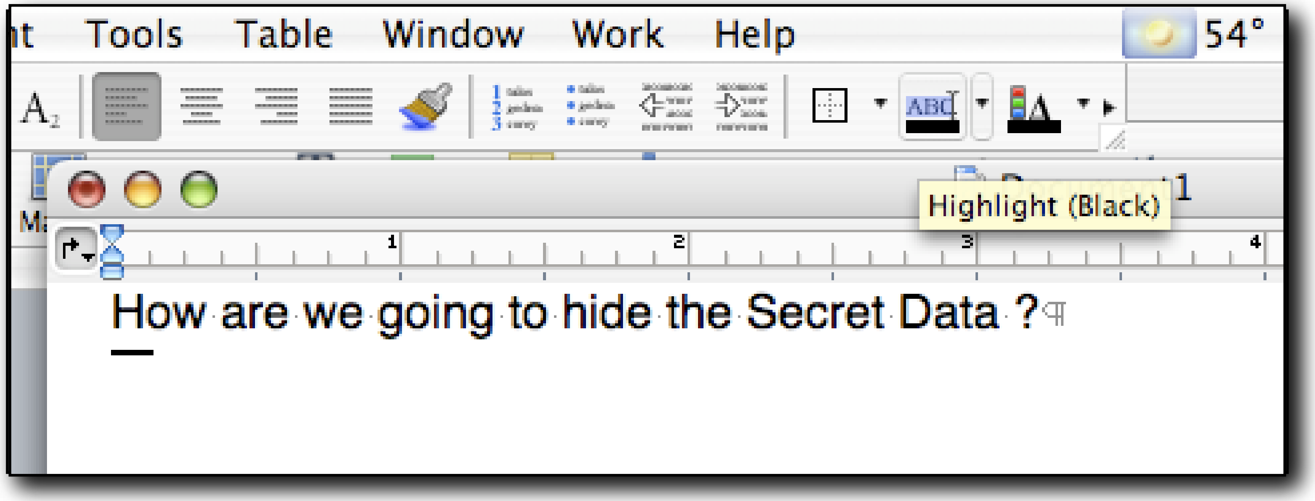

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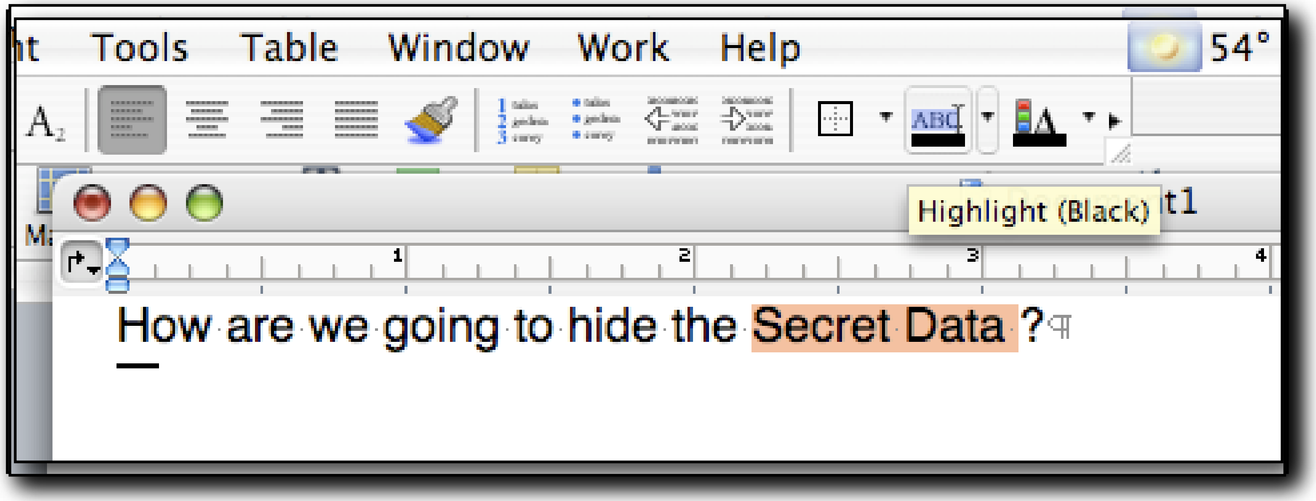

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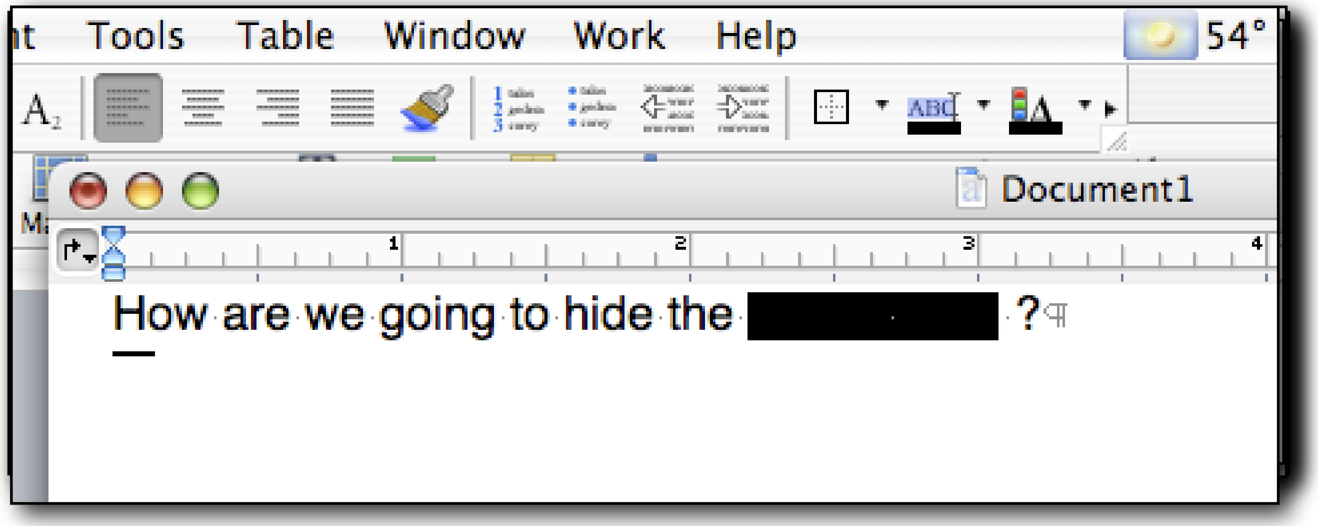
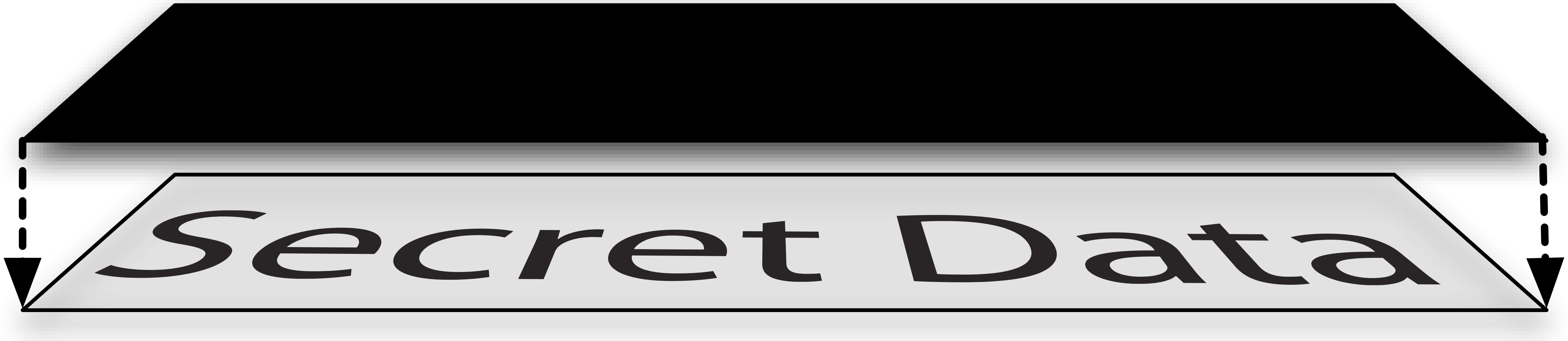


How are we going to hide the [redacted] ?¶

When Microsoft Word generates the PDF file, "Secret Data" is covered with the black box



Tools for recovering hidden data in Acrobat files:

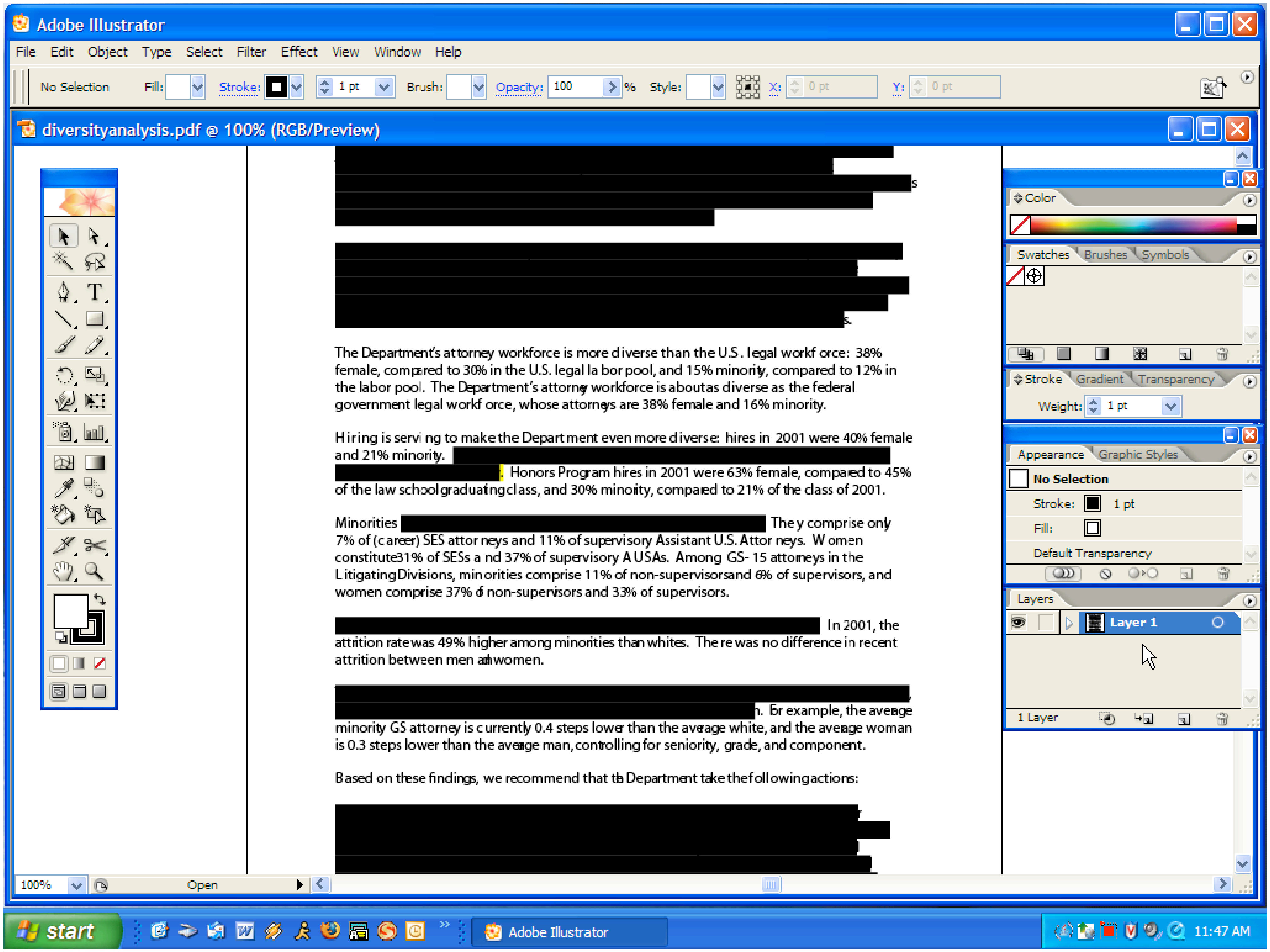
Adobe Illustrator

- Move the boxes
- Turn the boxes yellow

Adobe Acrobat Reader

- Select and copy the text

Adobe’s Illustrator can read and edit PDF files.



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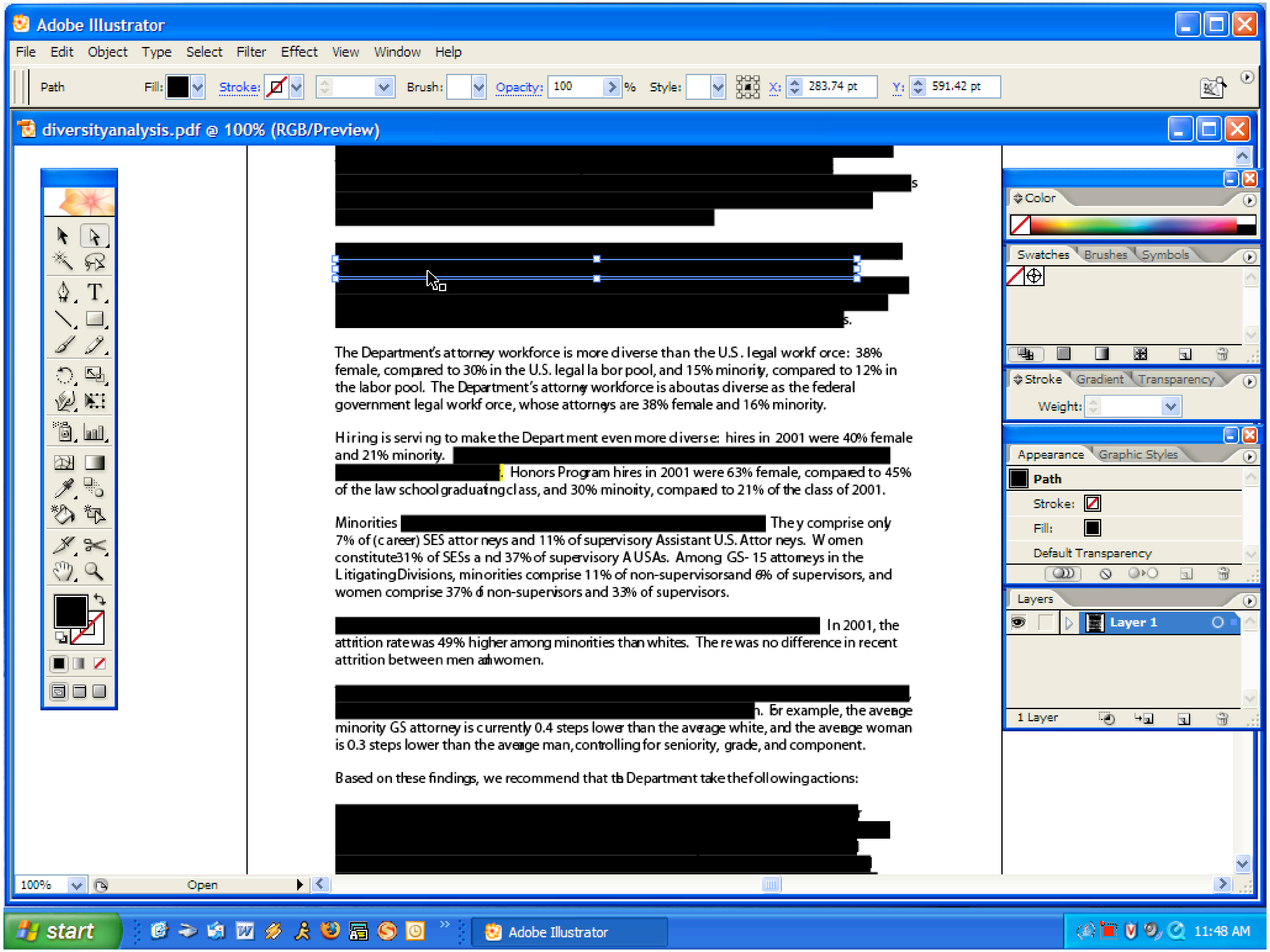
[redacted]

Select each “block box.”


Adobe Illustrator
File Edit Object Type Select Filter Effect View Window Help
Path Fill: Stroke: Brush: Opacity: 100 % Style: X: 283.74 pt Y: 591.42 pt
diversityanalysis.pdf @ 100% (RGB/Preview)
Color
Swatches Brushes Symbols
Stroke Gradient Transparency
Weight:
Appearance Graphic Styles
Path
Stroke:
Fill:
Default Transparency
Layers
Layer 1
1 Layer
100%
Open
start
Adobe Illustrator
11:48 AM

[redacted]

[redacted]

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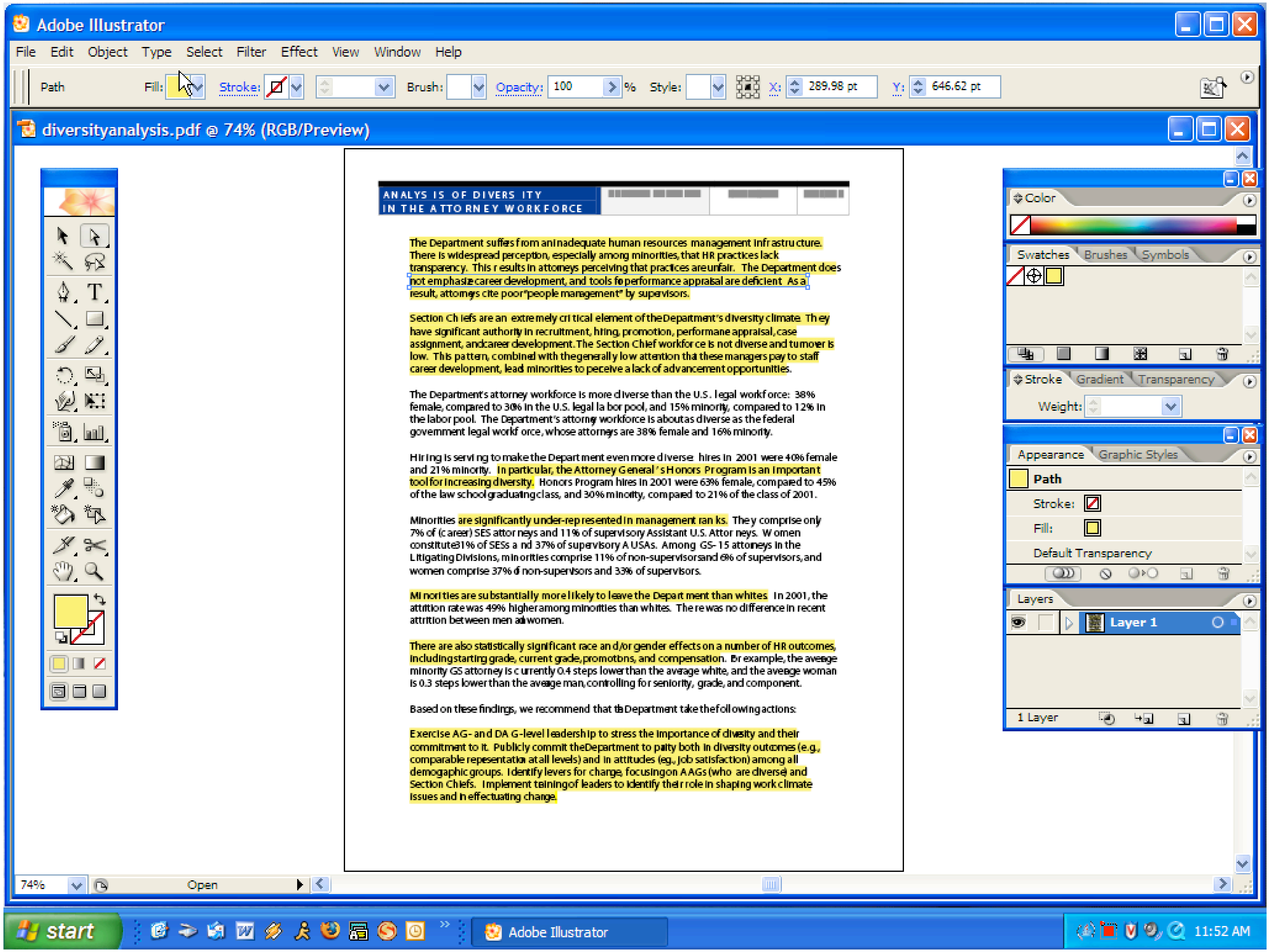
Change the color of the box to yellow.



Path Fill: Stroke: Opacity: 100 % X: 289.98 pt Y: 646.62 pt

diversityanalysis.pdf @ 74% (RGB/Preview)

Path
Stroke:
Fill:
Default Transparency

Layer 1
1 Layer

74%
Open

ANALYSIS OF DIVERSITY
IN THE ATTORNEY WORKFORCE

The Department suffes from an inadequate human resources management infrastructure. There is widespread perception, especially among minorities, that HR practices lack transparency. This results in attorneys perceiving that practices are unfair. The Department does not emphasize career development, and tools fo performance appraisal are deficient As a result, attomeys cite poor "people management" by supervisors.

Section Chiefs are an extremely critical element of the Department's diversity climate. They have significant authority in recruitment, hiring, promotion, performane appraisal, case assignment, andcareer development. The Section Chief workforce is not diverse and tumover is low. This pattern, combined with the generally low attention tha these managers pay to staff career development, lead minorities to pecelve a lack of advancement opportunities.

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Minorities are significantly under-represented in management ranks. They comprise only 7% of (career) SES attorneys and 11% of supervisory Assistant U.S. Attorneys. Women constitute31% of SESs and 37% of supervisory AUSAs. Among GS-15 attorneys in the Litigating Divisions, minorities comprise 11% of non-supervisorsand 6% of supervisors, and women comprise 37% of non-supervisors and 33% of supervisors.

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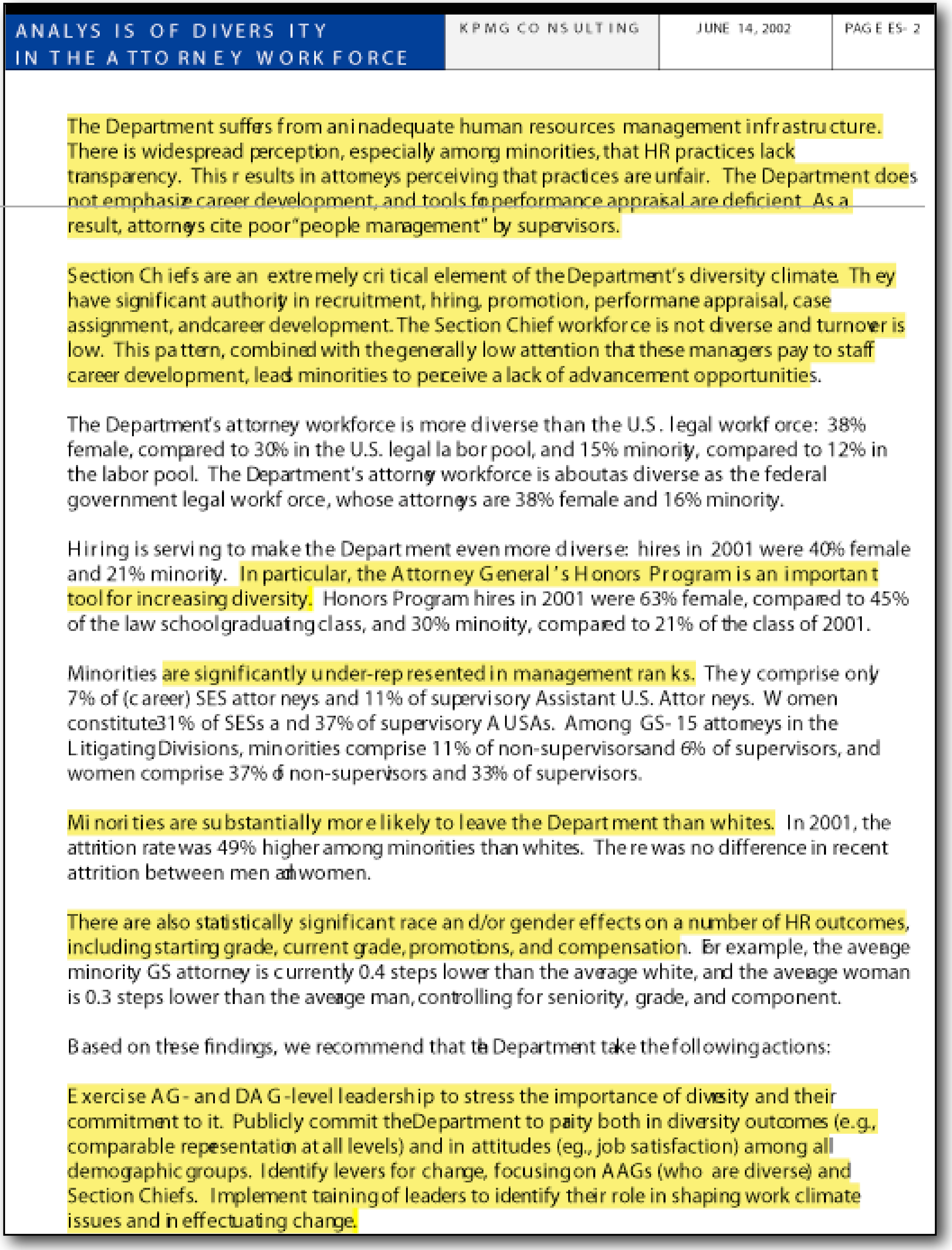
Behold the “redacted” data.



ANALYSIS OF DIVERSITY IN THE ATTORNEY WORKFORCE | KPMG CONSULTING | JUNE 14, 2002 | PAGE ES-2

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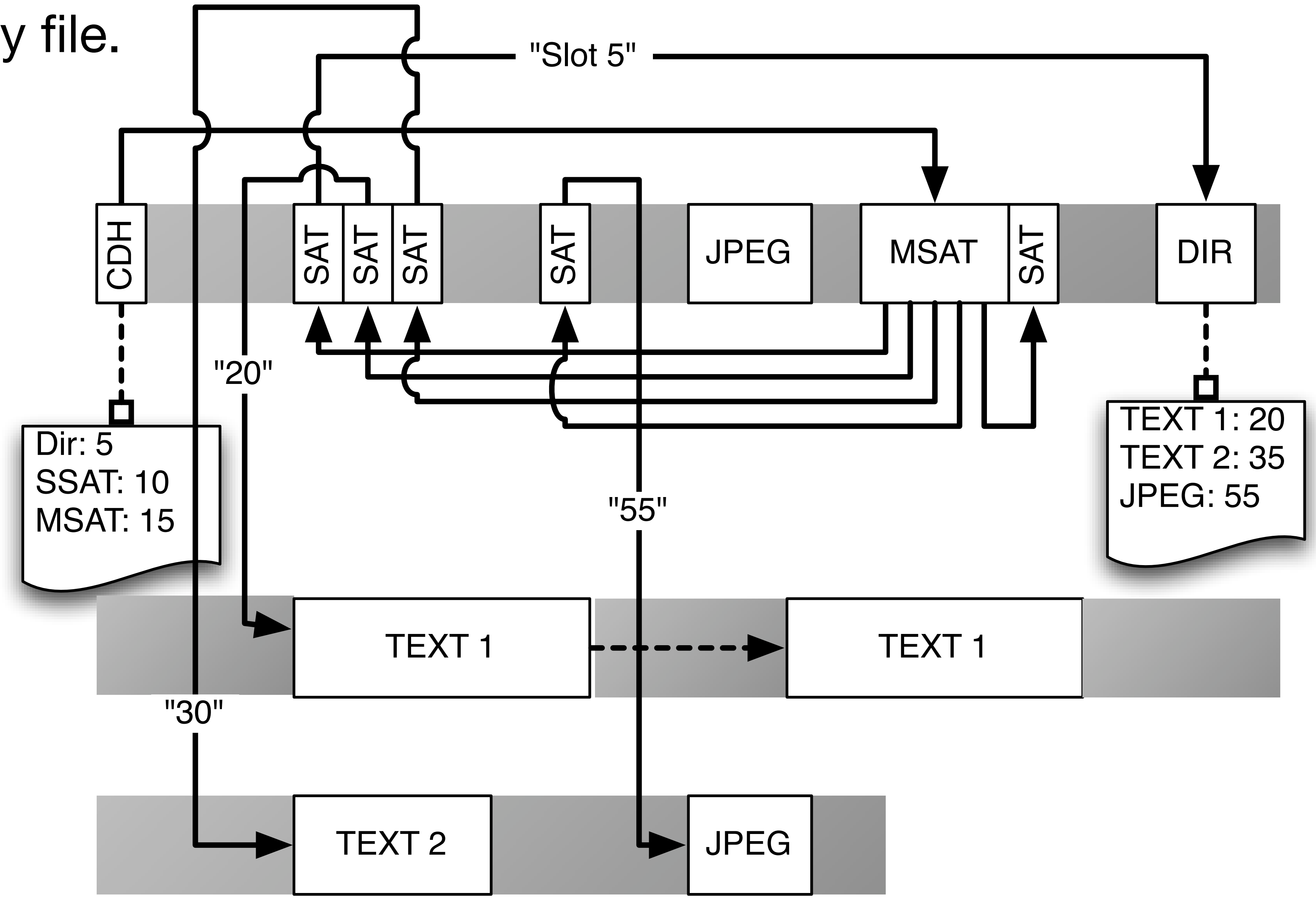
Data can be left in a Word document in unallocated sectors.

Microsoft Word implements a “file system” inside every file.



Tools for recovering hidden Word data:

Unix strings(1) command reveals:

- Deleted text
- Names and/or usernames of author and editors
- Paths where document was saved
- GUID of system on which it was saved

  Note: Text may be UTF16 (remove NULLs or use more intelligent processing)

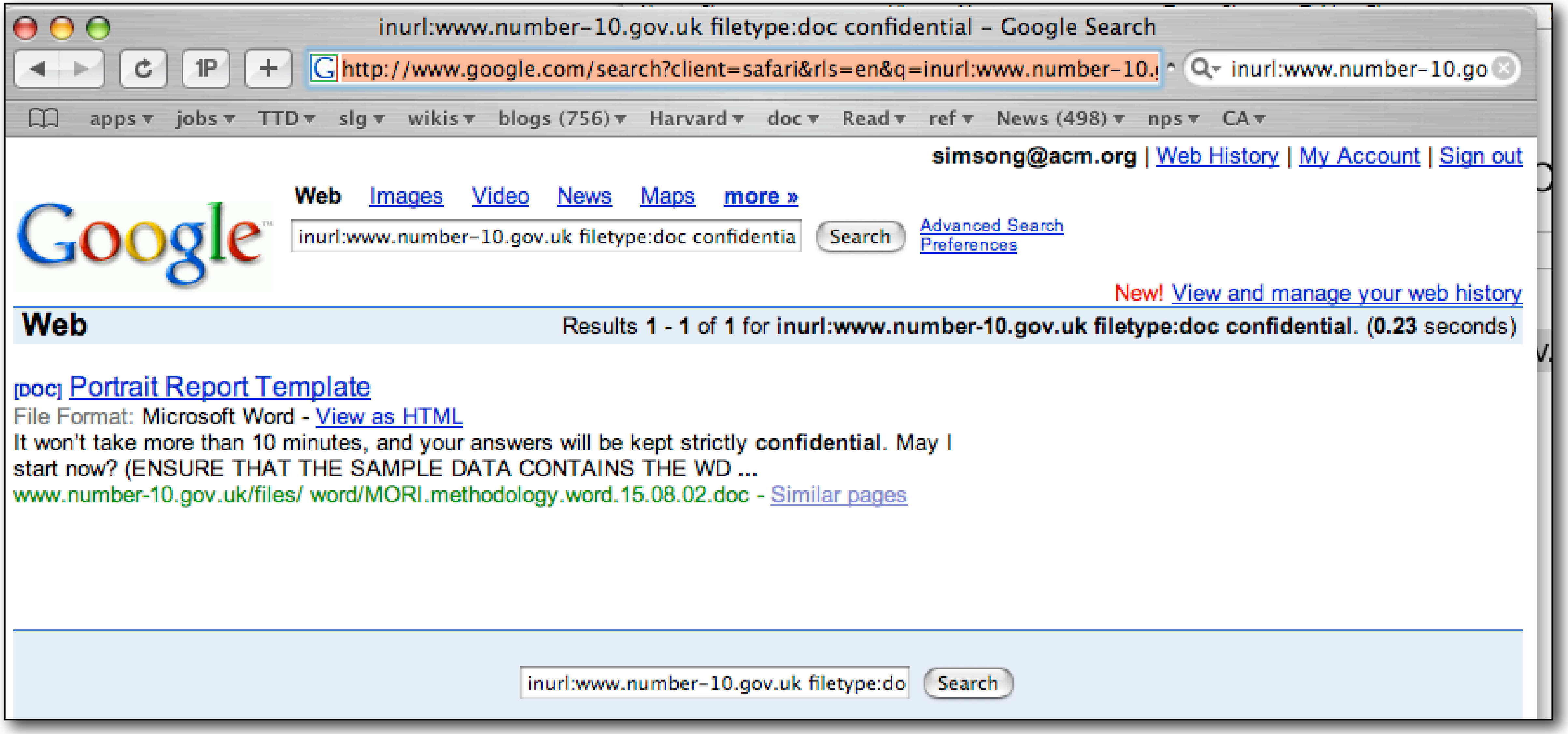
Other tools:

- Antiword (http://www.winfield.demon.nl/)
- catdoc
- wvText
- MITRE’s Heuristic Office File Format Analysis toolkit (HOFFA)

Tools for finding Microsoft Word files

Use Google!

- inurl:www.number-10.gov.uk filetype:doc confidential

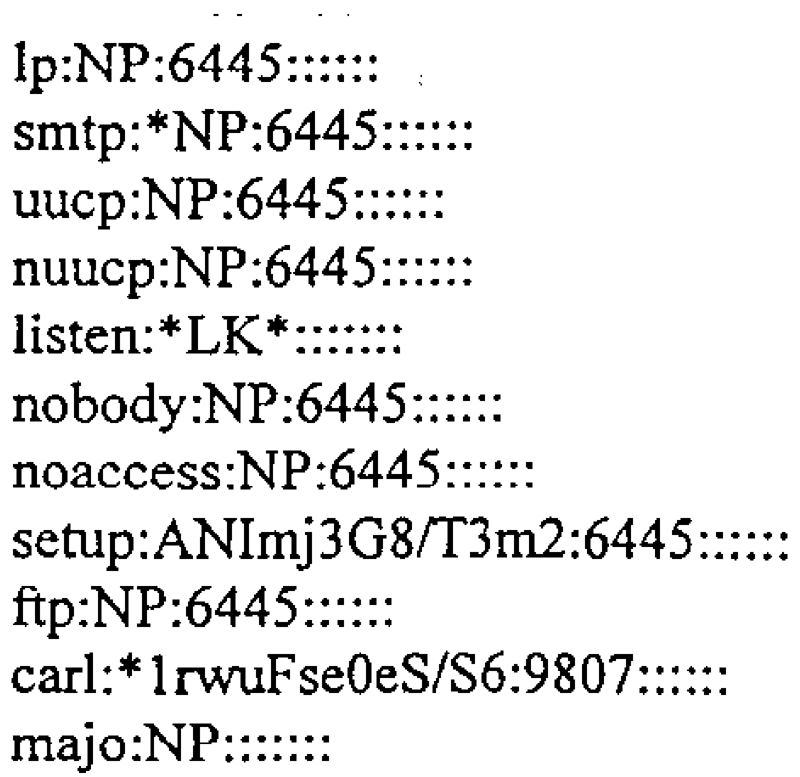


inurl:www.number-10.gov.uk filetype:doc confidential - Google Search
http://www.google.com/search?client=safari&rls=en&q=inurl:www.number-10.
inurl:www.number-10.go
apps ▾ jobs ▾ TTD ▾ slg ▾ wikis ▾ blogs (756) ▾ Harvard ▾ doc ▾ Read ▾ ref ▾ News (498) ▾ nps ▾ CA ▾
simsong@acm.org | Web History | My Account | Sign out
Web Images Video News Maps more »
inurl:www.number-10.gov.uk filetype:doc confidentia
Search
Advanced Search
Preferences
New! View and manage your web history
Web

Results **1** - **1** of **1** for **inurl:www.number-10.gov.uk filetype:doc confidential**. (**0.23** seconds)

[DOC] Portrait Report Template
File Format: Microsoft Word - View as HTML
It won't take more than 10 minutes, and your answers will be kept strictly **confidential**. May I start now? (ENSURE THAT THE SAMPLE DATA CONTAINS THE WD ...
www.number-10.gov.uk/files/ word/MORI.methodology.word.15.08.02.doc - Similar pages

Case study of inconsistent data: State of Utah vs. Carl Payne



```
lp:NP:6445::::::
smtp:*NP:6445::::::
uucp:NP:6445::::::
nuucp:NP:6445::::::
listen:*LK*:::::::
nobody:NP:6445::::::
noaccess:NP:6445::::::
setup:ANImj3G8/T3m2:6445::::::
ftp:NP:6445::::::
carl:*1rwuFse0eS/S6:9807::::::
majo:NP:::::::
```

State of Utah vs. Carl Payne

State’s Claims:

- Victim ISP suffered devastating attack on November 6th, 1996.
  - All files erased
  - All router configurations cleared.
- Carl Payne, one of the company’s founders, had a falling out with the company and was terminated on October 30th, 1996.
- Payne had the necessary knowledge to carry out the attack.
- Payne created a “back door” on his last week of employment.
- Payne’s accounts were used for the attack.

State of Utah vs. Carl Payne

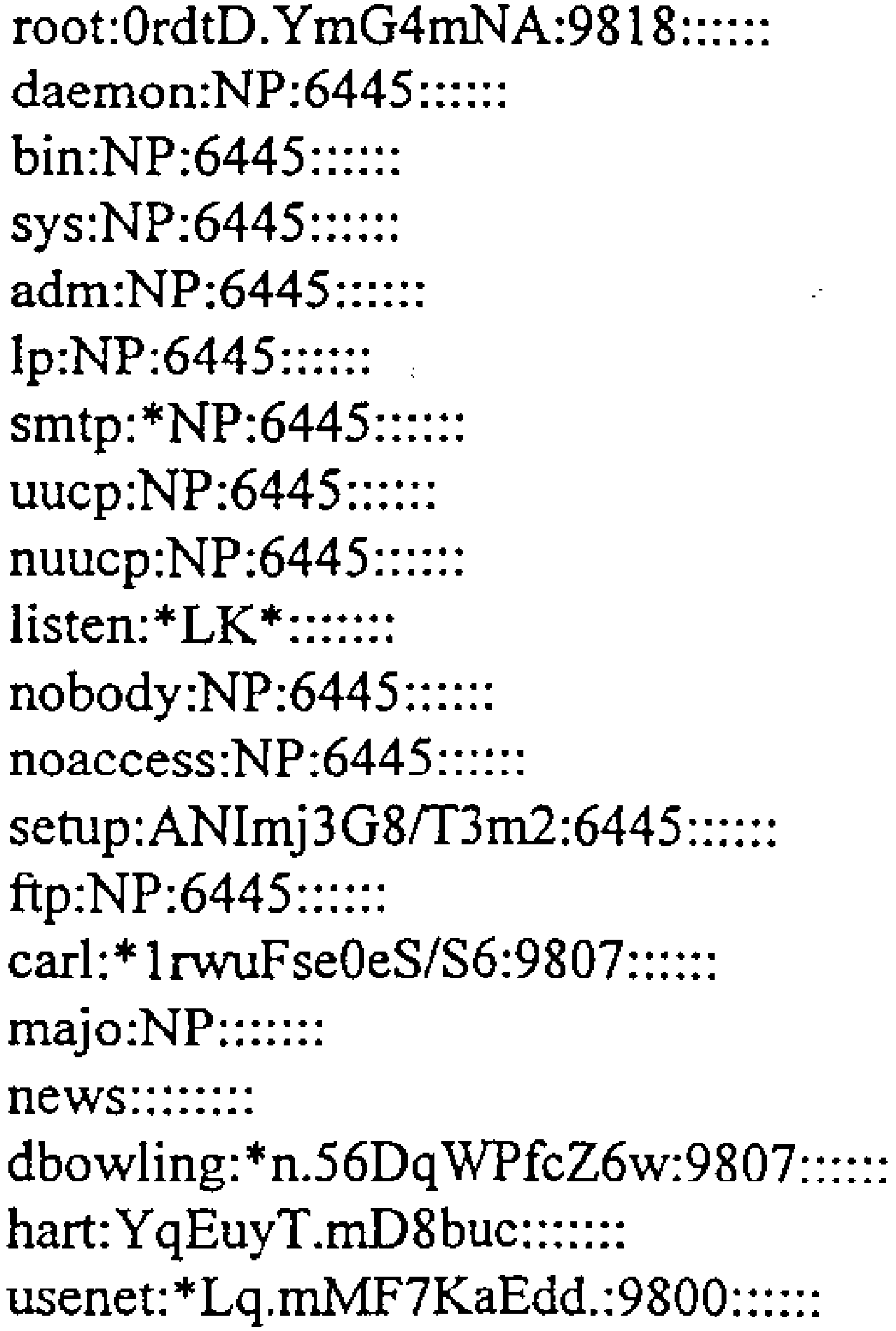
State’s Evidence:

- 140 pages of printouts made by a local expert on the day of the attack.
- Testimony of the expert.
- Testimony of the Fibernet employees

Payne’s Defense:

- “I didn’t do it.”
- All of Payne’s account passwords had been changed when he was terminated.
- Alibi defense: was having breakfast with a friend when attack took place.

/etc/shadow
(printed November 6, 1996)



```
root:0rdtD.YmG4mNA:9818::::::
daemon:NP:6445::::::
bin:NP:6445::::::
sys:NP:6445::::::
adm:NP:6445::::::
lp:NP:6445::::::
smtp:*NP:6445::::::
uucp:NP:6445::::::
nuucp:NP:6445::::::
listen:*LK*:::::::
nobody:NP:6445::::::
noaccess:NP:6445::::::
setup:ANImj3G8/T3m2:6445::::::
ftp:NP:6445::::::
carl:*1rwuFse0eS/S6:9807::::::
majo:NP:::::::
news::::::::
dbowling:*n.56DqWPfcZ6w:9807::::::
hart:YqEuyT.mD8buc:::::::
usenet:*Lq.mMF7KaEdd.:9800::::::
```

Solaris /etc/shadow:
setup:ANlmj3G8/T3m2:64455::::::

Field 1: Username

Field 2: Encrypted Password

Field 3: Password Aging

- Number of days since January 1, 1970

Source: Solaris Documentation

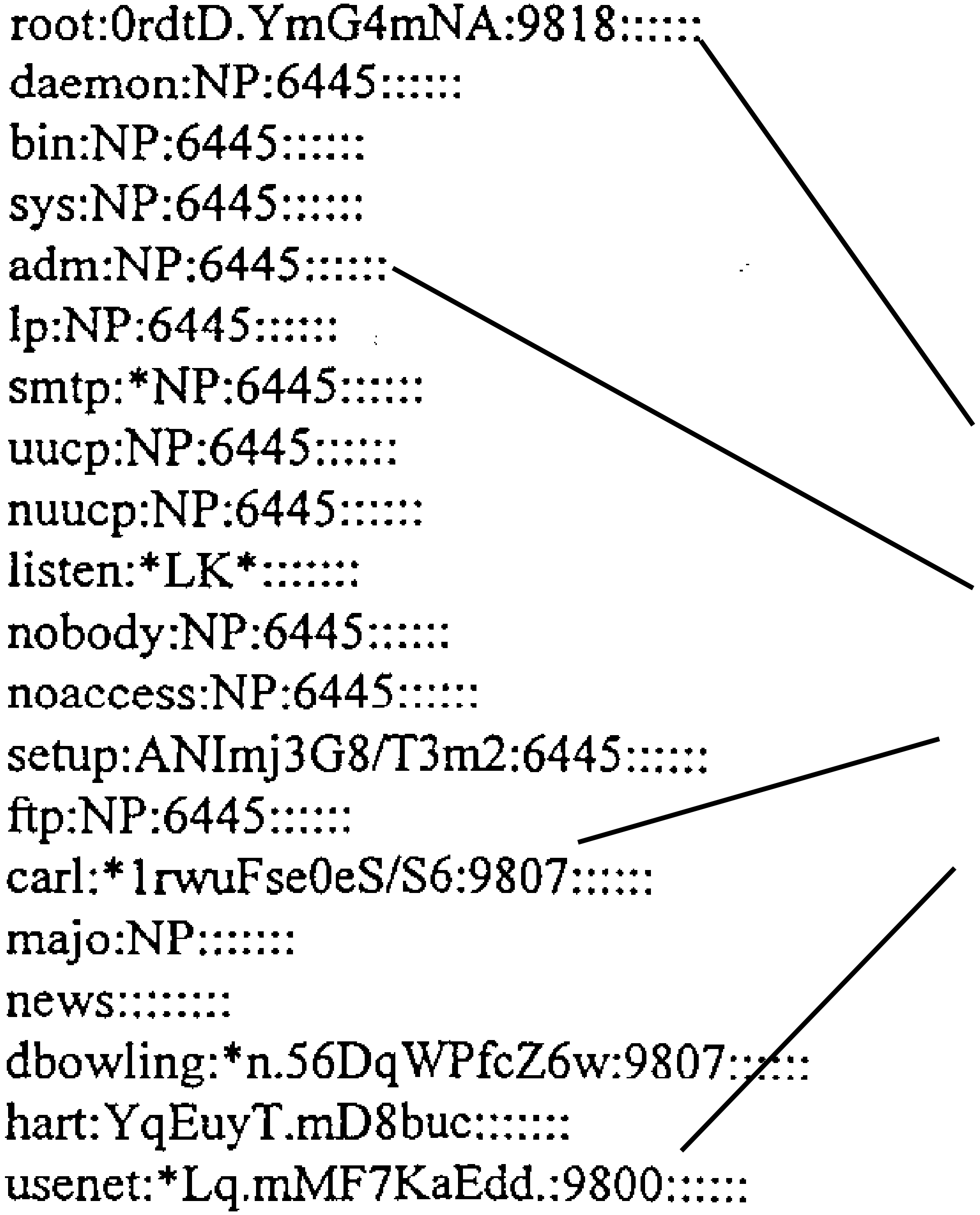
Decoding “6645”

- August 25, 1987

```
mysql> select from_days(to_days'1970-01-01')+6445);
+-------------------------------------+
| from_days(to_days('1970-01-01')+6445) |
+-------------------------------------+
| 1987-08-25                            |
+-------------------------------------+
1 row in set (0.00 sec)

mysql>
```

/etc/shadow
(Printed November 6, 1996 by prosecution expert witness)



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root:0rdtD.YmG4mNA:9818::::::
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adm:NP:6445::::::
lp:NP:6445::::::
smtp:*NP:6445::::::
uucp:NP:6445::::::
nuucp:NP:6445::::::
listen:*LK*:::::::
nobody:NP:6445::::::
noaccess:NP:6445::::::
setup:ANImj3G8/T3m2:6445::::::
ftp:NP:6445::::::
carl:*1rwuFse0eS/S6:9807::::::
majo:NP:::::::
news::::::::
dbowling:*n.56DqWPfcZ6w:9807::::::
hart:YqEuyT.mD8buc:::::::
usenet:*Lq.mMF7KaEdd.:9800::::::
```

9818 = November 18, 1996

6445 = August 25, 1987

9807 = November 7, 1996

9800 = October 31, 1996

Lessons of Utah vs. Payne

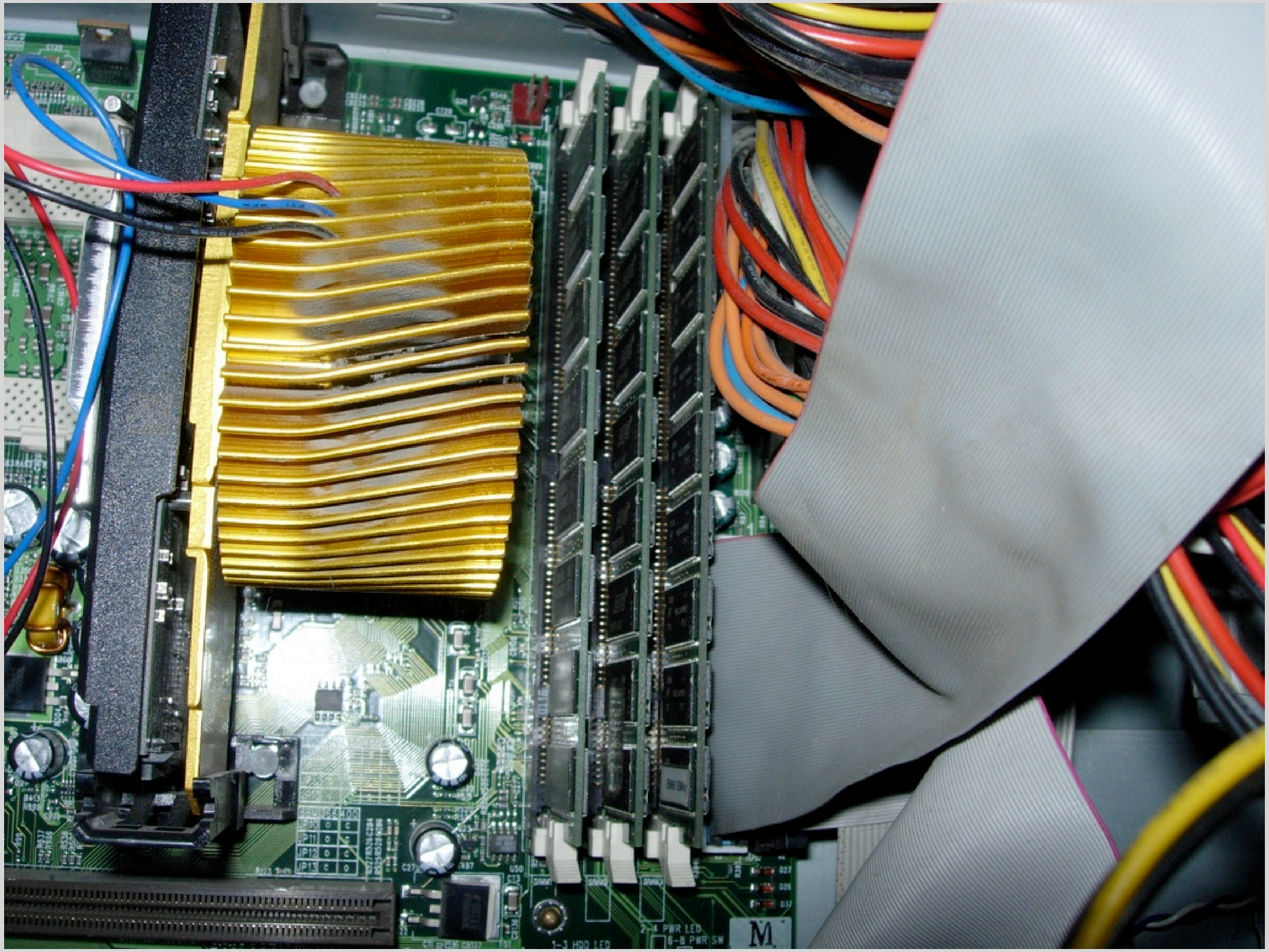
Not all “Evidence” is equal (Chain-of-custody is vital)

Evidence may not prove what you think it proves

Computer evidence lends itself to forgery

Most data isn’t tampered...

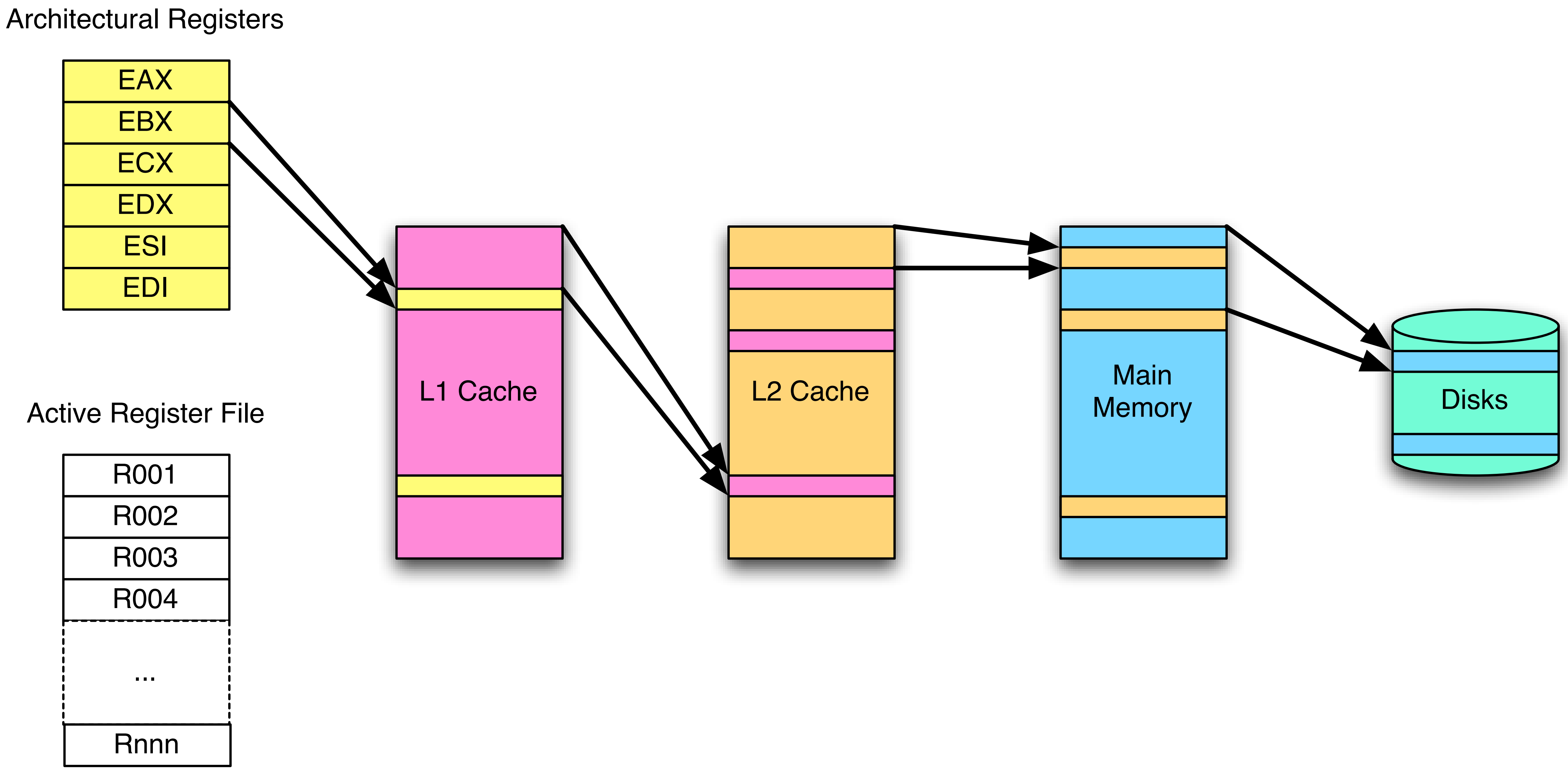
- ... but most data isn’t used for evidence.
- If data *is* going to be used for evidence, there is an incentive to tamper with it.



Memory Forensics

What was *really* happening on the subject's computer?

Computer systems arrange memory in a hierarchy.



Architectural Registers

EAX
EBX
ECX
EDX
ESI
EDI

Active Register File

R001
R002
R003
R004
...
Rnnn

L1 Cache

L2 Cache

Main Memory

Disks

There are many ways to get access to the memory.

Unix/Linux: /dev/mem

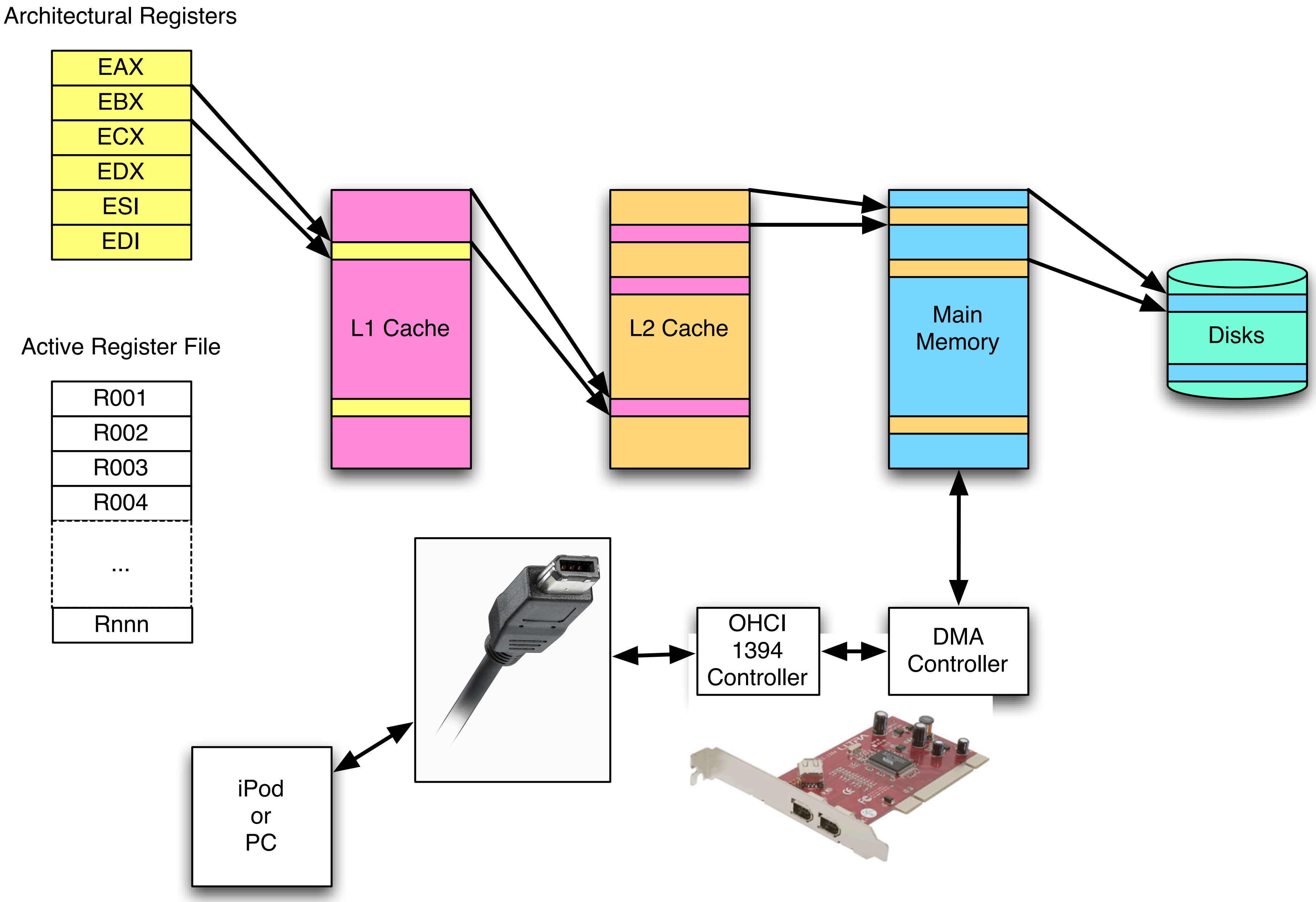
Windows: Device Drivers

Hardware memory imagers

Firewire

- Firewire designed as a replacement for hard drives.
- ATA drives support DMA
- So Firewire supports DMA

It’s pretty easy to attack a system with an iPod



Architectural Registers

EAX
EBX
ECX
EDX
ESI
EDI

Active Register File

R001
R002
R003
R004
...
Rnnn

L1 Cache

L2 Cache

Main Memory

Disks

iPod or PC

OHCI 1394 Controller

DMA Controller

Many different kinds of information can be retrieved from a computer's memory.

Reading:

- Current contents of the screen
- Cryptographic Keys
- Passwords (BIOS & programs)
- Programs
- All data

Writing:

- Patch programs on the fly
- Change security levels

DMA bypasses the operating system and the CPU.

Cell Phone Forensics

Who did you call?
Where have you been?

Cell Phone Forensics: What can be done

PHONE: Recovery of personal information (even after deletion)

- SMS messages
- Phone log
- Phone book

PHONE: Recovery of service information

- Cell sites passed, used

CELL SITES: Recovery of phone information

- Phones in the area

Cell phone forensics: Precautions

Turning on the phone can damage data!

- But sometimes you can’t access the data any other way

Paraben’s tools for cell phone forensics

Paraben “Device Seizure” to image the phone’s content.

- Acquires phone flash and some of GSM SIM card
- Understands some of the phone’s internal databases
- Views some of the photos, messages, etc.
- Only covers specific phones

“Device Seizure Toolbox” has lots of different cables.

“StrongHold Box” prevents phone from calling home.

Project-a-Phone captures screens

http://www.paraben-forensics.com/

Cell Phone Forensics: References & Resources

Guidelines on Cell Phone Forensics (NIST SP 800-101)

- August 2006
- http://csrc.nist.gov/publications/drafts/Draft-SP800-101.pdf

Cell Phone Forensic Tools: An Overview and Analysis (NISTIR 7250)

- http://csrc.nist.gov/publications/nistir/nistir-7250.pdf

PDA Forensic Tools: An Overview and Analysis (NISTIR 7100)

- http://csrc.nist.gov/publications/nistir/nistir-7100-PDAForensics.pdf

```
if(dirlist.size()==0){
    if(argc!=2){
        fprintf(stderr,"Please specify a directory or just two AFF files.\n\n");
        usage();
    }
    /* Must be copying from file1 to file2. Make sure file2 does not exist */
    if(access(argv[1],R_OK)==0){
        errx(1,"File exists: %s\n",argv[1]);
    }

    vector<string> outfiles;
    outfiles.push_back(argv[1]);
    return afcopy(argv[0],outfiles);
}
```

Software Forensics

Who authored a program?
Are two programs similar?
How old is a program?

Quantum
Quantum Trailblazer
WARRANTY VOID IF SEAL BROKEN

What is Anti-Forensics?

Computer Forensics: *“Scientific Knowledge for collecting, analyzing, and presenting evidence to the courts” (USCERT 2005)*

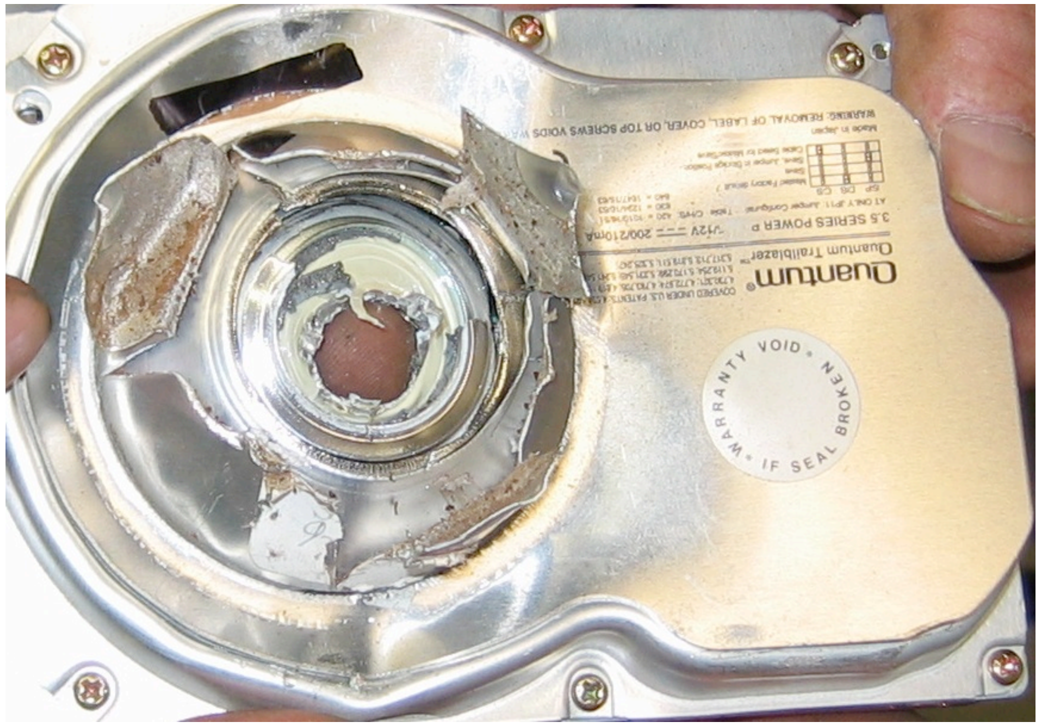
Anti-Forensics: *tools and techniques that frustrate forensic tools, investigations and investigators*

Goals of Anti-Forensics:

- *Avoiding detection*
- *Disrupting information collection*
- *Increasing the examiner’s time*
- *Casting doubt on a forensic report or testimony (Liu and Brown, 2006)*

- *Forcing a tool to reveal its presence*
- *Subverting the tool — using it to attack the examiner or organization*
- *Leaving no evidence that the AF tool has been run*

Physical destruction makes forensic recovery impossible.



One traditional Anti-Forensic technique is to overwrite or otherwise destroy data.

Overwriting: Eliminate data or metadata (e.g. disk sanitizers, Microsoft Word metadata “washers,” timestamp eliminators.)

Disk Sanitizers; Free Space Sanitizers; File Shredders

- Microsoft **Remove Hidden Data Tool**; **cipher.exe; ccleaner**

Metadata Erasers

- Example: **timestomp**

Hard problem: *What should be overwritten?*

Anti-Forensic tools can hide data with cryptography or steganography.

Cryptographic File Systems (EFS, TrueCrypt)

Encrypted Network Protocols (SSL, SSH, Onion Routing*)

Program Packers (PECompact, Burneye) & Rootkits

Steganography

Data Hiding in File System Structures

- Slacker — Hides data in slack space
- FragFS — Hides in NTFS Master File Table
- RuneFS — Stores data in “bad blocks”
- KY FS — Stores data in directories
- Data Mule FS — Stores in inode reserved space
- Host Protected Areas & Device Configuration Overlay

*Onion routing also protects from traffic analysis

Anti-Forensics 3: Minimizing the Footprint

Overwriting and Data Hiding are *easy to detect.*

- Tools leave tell-tale signs; examiners know what to look for.
- Statistical properties are different after data is overwritten or hidden.

AF tools that minimize footprint avoiding leaving traces for later analysis.

- Memory injection and syscall proxying
- Live CDs, Bootable USB Tokens
- Virtual Machines
- Anonymous Identities and Storage

(don’t worry; we have slides for each of these)

Memory Injection and Userland Execve: Running a program without loading the code.

Memory Injection loads code without having the code on the disk.

- **Buffer overflow** exploits — run code supplied as (oversized) input

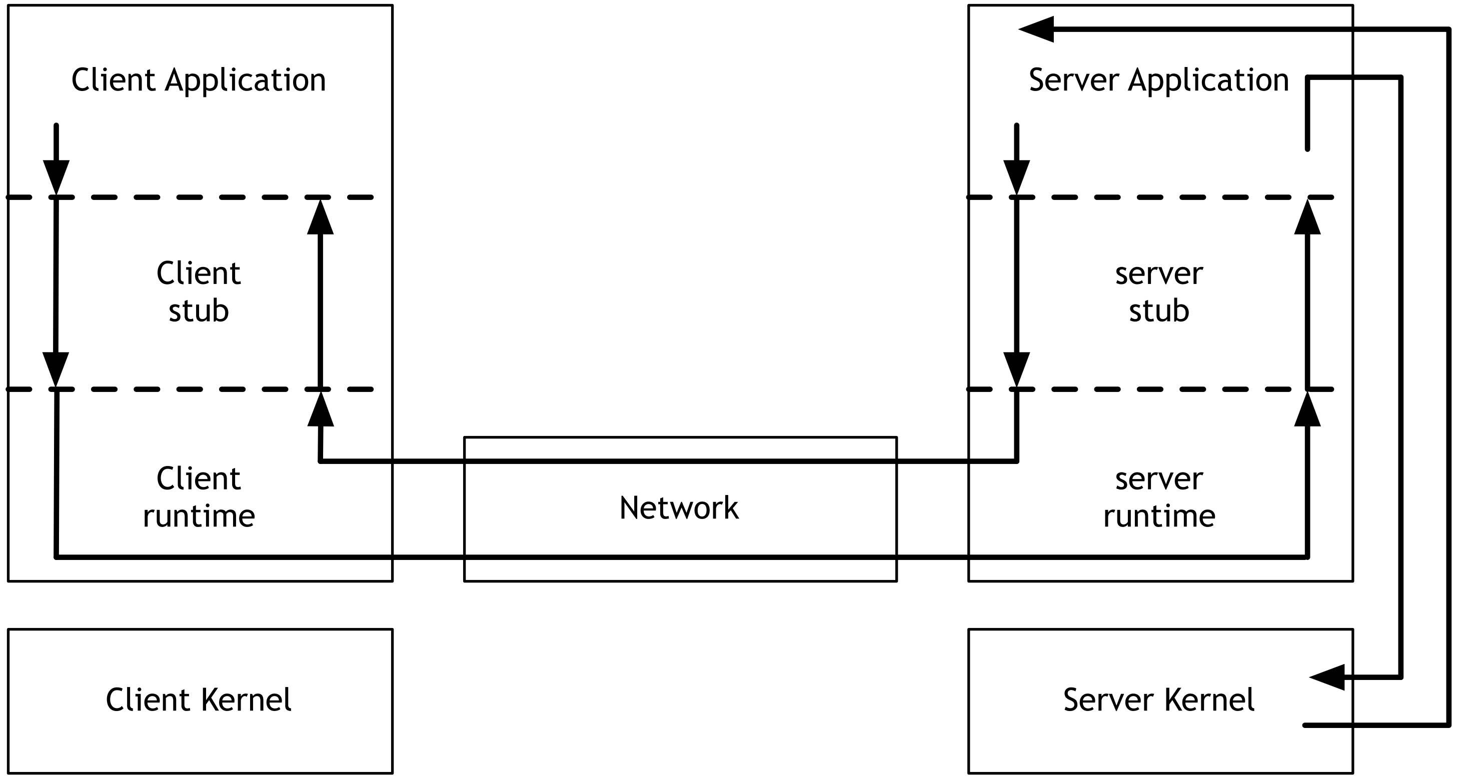
Userland Execve

— Runs program without using execve()
— Bypasses logging and access control
— Works with code from disk or read from network

Syscall proxying:
Running a program without the code!

Syscall Proxying

- Program runs on one computer, syscalls executed on another.
- Program not available for analysis
- May generate a lot of network traffic
- Developed by Core Security; used in **Impact**



Live CDs, Bootable USB Tokens, Virtual Machines: Running code without leaving a trace.

Most forensic information is left in the file system of the running computer.

These approaches keep the attacker's file system segregated:
— In RAM (CDs & Bootable USB Tokens)
— In the Virtual Machine file (where it can be securely deleted)

Anonymous Identities and Storage: The attacker’s data may be anywhere.

Attackers have long made use of anonymous e-mail accounts.
Today these accounts are far more powerful.

- Yahoo and GMail both have 2GB of storage
- APIs allow this storage to be used as if it were a file system

Amazon’s Elastic Compute Cloud (EC2) and Simple Storage Service (S3) provide high-capability, little-patrolled services to anyone with a credit card

- EC2: 10 ¢/CPU hour (Xen-based virtual machines)
- S3: 10 ¢/GB-Month

With BGP, it’s possible to have “anonymous IP addresses.”

1. Announce BGP route
2. Conduct attack
3. Withdraw BGP address

Being used by spammers today
(http://www.nanog.org/mtg-0602/pdf/feamster.pdf)

Attacking the Investigator: AF techniques that exploit CFT bugs.

Craft packets to exploit buffer-overflow bugs in network monitoring programs like **tcpdump**, **snort** and **ethereal.**

Create files that cause EnCase to crash.

Successful attacks provide:

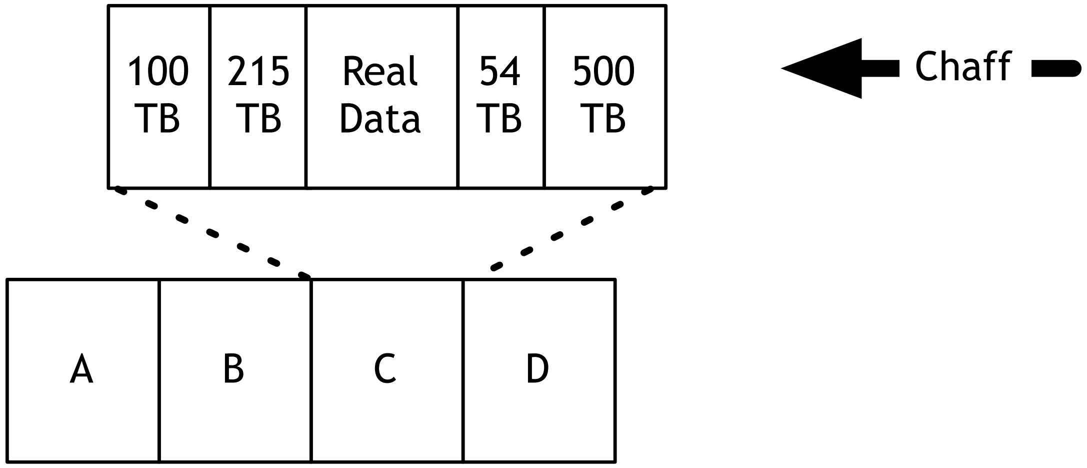
- ➡ Ability to run code on the forensic appliance
- ➡ Erase collected evidence
- ➡ Break the investigative software
- ➡ Leak information about the analyst or the investigation
- ➡ Implicate the investigator

Attacking the Investigator: Denial-of-Service Attacks against the CFT

Any CFT resource whose use is determined by input can be overwhelmed.

- Create millions of files or identities
- Overwhelm the logging facility
- Compression bombs — 42.zip

The clever adversary will combine this **chaff** with real data, e.g.:



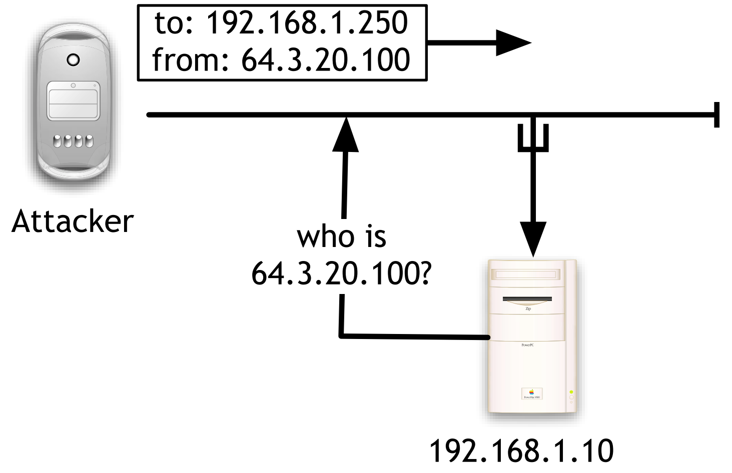
Anti-Forensic Tools can detect Computer Forensic Tools: cat-and-mouse.

SMART (Self-Monitoring, Analysis and Reporting Technology) drives report:

- Total number of power cycles
- Total time hard drive has been on

Network Forensics can be detected with:

- Hosts in “promiscuous” mode responding differently
  - — to PINGs.
  - — to malformed packets
  - — to ARPs
- Hosts responding to traffic not intended to them (MAC vs. IP address)
- Reverse DNS queries for packets sent to unused IP addresses



Countermeasures for Anti-Forensics

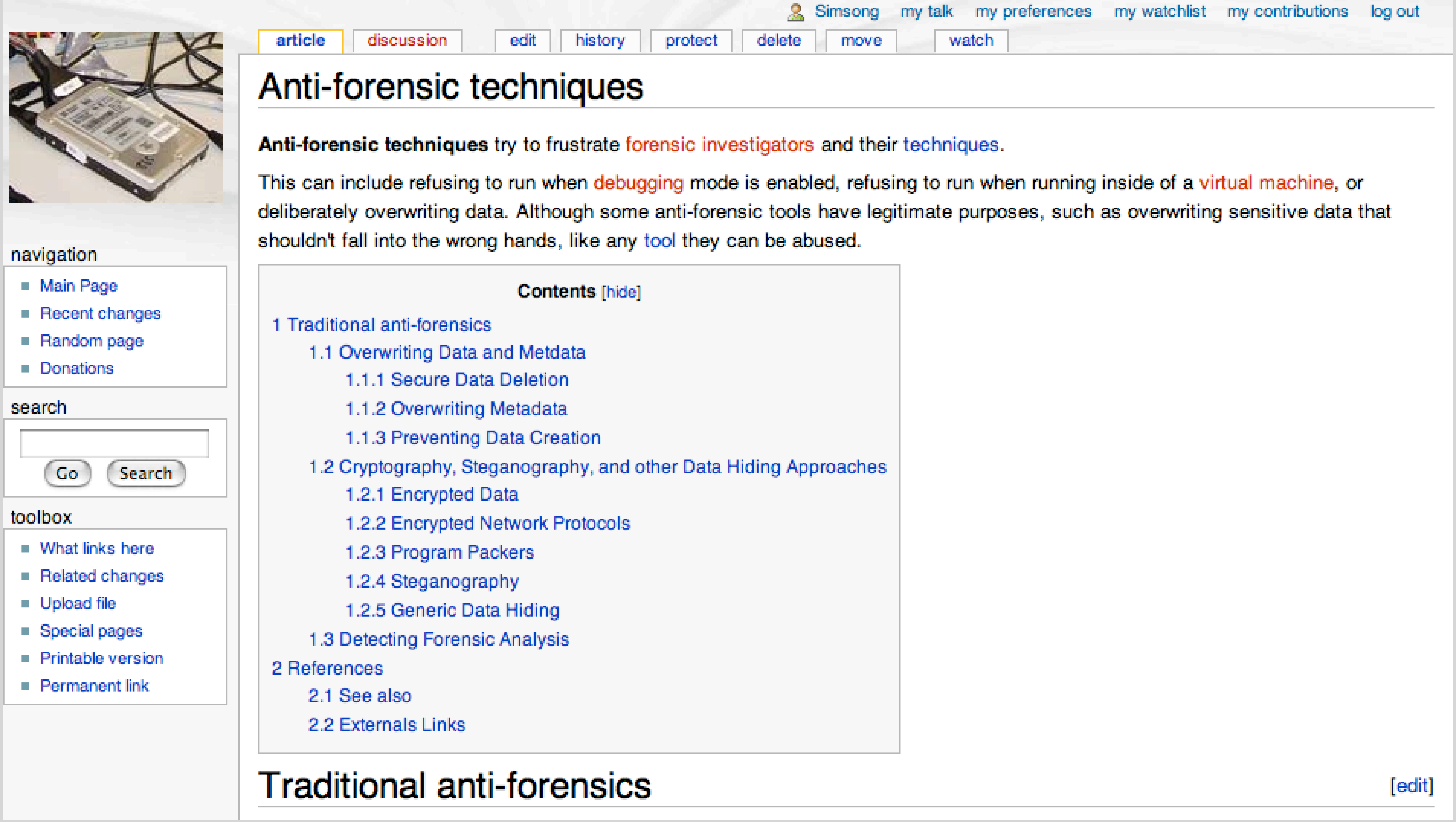
Improve the tools — many CFTs are poorly written.

Save data where the attacker can't get at it:

- — Log hosts
- — CD-Rs

Develop new tools:

- — Defeat encrypted file systems with keyloggers.
- — Augment network sniffers with traffic analysis



Anti-forensic techniques

Anti-forensic techniques try to frustrate forensic investigators and their techniques.

This can include refusing to run when debugging mode is enabled, refusing to run when running inside of a virtual machine, or deliberately overwriting data. Although some anti-forensic tools have legitimate purposes, such as overwriting sensitive data that shouldn't fall into the wrong hands, like any tool they can be abused.

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- 1 Traditional anti-forensics
  - 1.1 Overwriting Data and Metdata
    - 1.1.1 Secure Data Deletion
    - 1.1.2 Overwriting Metadata
    - 1.1.3 Preventing Data Creation
  - 1.2 Cryptography, Steganography, and other Data Hiding Approaches
    - 1.2.1 Encrypted Data
    - 1.2.2 Encrypted Network Protocols
    - 1.2.3 Program Packers
    - 1.2.4 Steganography
    - 1.2.5 Generic Data Hiding
  - 1.3 Detecting Forensic Analysis
- 2 References
  - 2.1 See also
  - 2.2 Externals Links

Traditional anti-forensics [edit]

http://www.forensicswiki.org/

Find out more at the Forensics Wiki:

In Conclusion:

Many forensic techniques in use today can be circumvented

Circumvention tools are widely available

Common approaches:

- Overwriting data
- Encrypting data
- Anonymous identities & resources
- Exploit bugs in computer forensic tools to hide

New approaches:

- Minimizing or eliminating memory footprints
- Virtual machines
- Direct attacks against computer forensic tools

http://www.simson.net/ref/2007/slides-ICIW.pdf

Research directions in Computer Forensics

Environmental Data Survey Projects

- Phone systems
- Hard drives & data storage devices
- Network hosts and traffic

Theory and Algorithm Development:

- Brian Carrier 2006 PhD
- Cross-Drive Analysis
- Carving Fragmented Objects with Validation

Tool Development

- Easy-to-use tools
- Batch tools
- Data correlation

Forensics, Conclusion

Forensic analysis is a growth area.

Being a practitioner is hard:

- Many skills
- Many tools
- In-depth knowledge of many different systems

What is the forensics research agenda?

Other Resources

http://www.forensicswiki.org/

http://www/forensicwiki.com/

http://staff.washington.edu/dittrich/forensics.html

http://faculty.ncwc.edu/toconnor/426/426links.htm