Alternate Data Streams

References:

Nelson, Chapter 5, Section “NTFS Alternate Data Streams”

Introduction to ADS

NTFS can have the contents of a file forked into different or alternate “streams” of data

- *One stream holds the contents of the data that you expect to see*
- *If the file is a shortcut, an alternate stream could contain link information*
- *While metadata (i.e., access rights, ownership, dates of creation, modification, etc.) are usually in the inodes ($MFT file)*
  - Some claim that this represents a stream.

There can be multiple data streams in a single file

- *Including one that you can explicitly put there --* **ADS**

Introduction to ADS

All versions of NTFS support ADS

ADS allows the ability to fork file data into existing files

- *Doesn't affect their "visible" functionality or size*

ADS is completely hidden

- *Is not visible using traditional file browsing utilities like* ***File Explorer***
- *Size doesn't reflect the existence of ADS*

ADS was originally conceived to allow for compatibility with the Macintosh Hierarchical File System (HFS)

- *In HFS, file information is sometimes forked into separate resources*

Legitimate Uses of ADS

Tiny ADS are added within browsers to indicate that files have been downloaded from external sites

- *Google Chrome and Opera:*
  - Zone identifier
  - Referrer URL
  - Host URL
- *Microsoft Edge:*
  - Zone identifier
  - Browser name
- *Firefox and Tor:*
  - Zone identifier

Legitimate Uses of ADS

Alternate Data Streams have been used by a few media players to hold proprietary metadata such as

- *Image thumbnails*
- *Author information*
- ...

Archive/backup metadata

Malicious Uses of ADS

- Alternate Data Streams have also been used for malicious purposes
  - *Some browser helper objects (BHOs) store malicious files inside ADS*
    - Very few anti-spyware/malware tools detect it
  - *ADS has been used to remotely exploit a web server*
    - More on this later

NTFS Attributes

Attributes are data structures that store a specific type of data

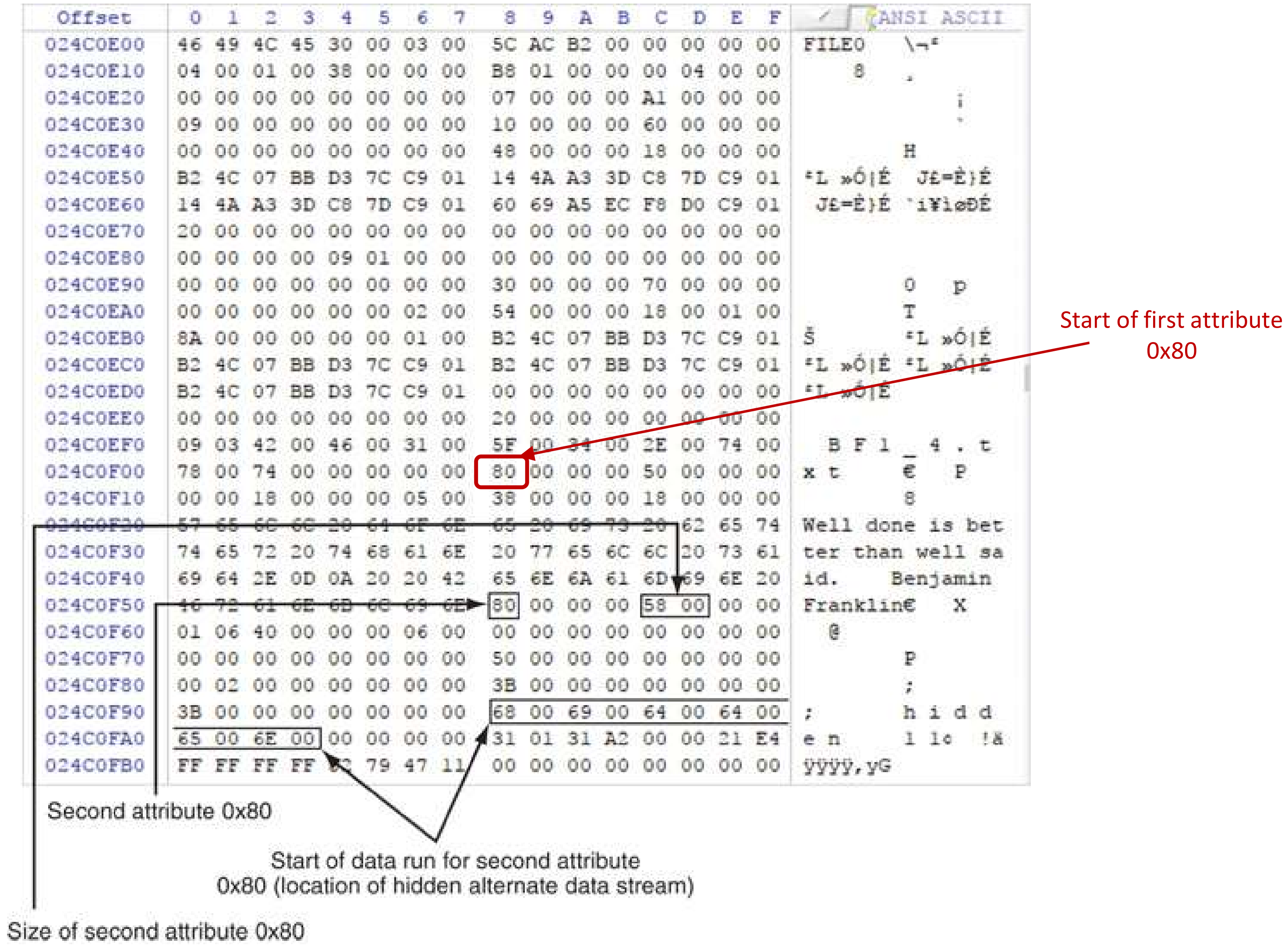
There are many types of attributes, and each has its own internal structure

Every file has a *$DATA* attribute, which contains the file content

If the content is over roughly ~800 bytes in size, it becomes non-resident (stored outside the MFT) and is saved in external clusters

When a file has more than one *$DATA* attribute, the additional attributes are called Alternate Data Streams(ADS)

MFT Record of File with ADS



```
 Offset     0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F   ANSI ASCII
024C0E00   46 49 4C 45 30 00 03 00  5C AC B2 00 00 00 00 00  FILE0   \¬²
024C0E10   04 00 01 00 38 00 00 00  B8 01 00 00 00 04 00 00      8   ¸
024C0E20   00 00 00 00 00 00 00 00  07 00 00 00 A1 00 00 00              ¡
024C0E30   09 00 00 00 00 00 00 00  10 00 00 00 60 00 00 00              `
024C0E40   00 00 00 00 00 00 00 00  48 00 00 00 18 00 00 00          H
024C0E50   B2 4C 07 BB D3 7C C9 01  14 4A A3 3D C8 7D C9 01  ²L »Ó|É  J£=È}É
024C0E60   14 4A A3 3D C8 7D C9 01  60 69 A5 EC F8 D0 C9 01   J£=È}É `i¥ìøÐÉ
024C0E70   20 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
024C0E80   00 00 00 00 09 01 00 00  00 00 00 00 00 00 00 00
024C0E90   00 00 00 00 00 00 00 00  30 00 00 00 70 00 00 00          0   p
024C0EA0   00 00 00 00 00 00 02 00  54 00 00 00 18 00 01 00          T
024C0EB0   8A 00 00 00 00 00 01 00  B2 4C 07 BB D3 7C C9 01  Š       ²L »Ó|É
024C0EC0   B2 4C 07 BB D3 7C C9 01  B2 4C 07 BB D3 7C C9 01  ²L »Ó|É ²L »Ó|É
024C0ED0   B2 4C 07 BB D3 7C C9 01  00 00 00 00 00 00 00 00  ²L »Ó|É
024C0EE0   00 00 00 00 00 00 00 00  20 00 00 00 00 00 00 00
024C0EF0   09 03 42 00 46 00 31 00  5F 00 34 00 2E 00 74 00    B F 1 _ 4 . t
024C0F00   78 00 74 00 00 00 00 00  80 00 00 00 50 00 00 00  x t     €   P
024C0F10   00 00 18 00 00 00 05 00  38 00 00 00 18 00 00 00          8
024C0F20   57 65 6C 6C 20 64 6F 6E  65 20 69 73 20 62 65 74  Well done is bet
024C0F30   74 65 72 20 74 68 61 6E  20 77 65 6C 6C 20 73 61  ter than well sa
024C0F40   69 64 2E 0D 0A 20 20 42  65 6E 6A 61 6D 69 6E 20  id.   Benjamin
024C0F50   46 72 61 6E 6B 6C 69 6E  80 00 00 00 58 00 00 00  Franklin€   X
024C0F60   01 06 40 00 00 00 06 00  00 00 00 00 00 00 00 00    @
024C0F70   00 00 00 00 00 00 00 00  50 00 00 00 00 00 00 00          P
024C0F80   00 02 00 00 00 00 00 00  3B 00 00 00 00 00 00 00          ;
024C0F90   3B 00 00 00 00 00 00 00  68 00 69 00 64 00 64 00  ;       h i d d
024C0FA0   65 00 6E 00 00 00 00 00  31 01 31 A2 00 00 21 E4  e n     1 1¢  !ä
024C0FB0   FF FF FF FF 82 79 47 11  00 00 00 00 00 00 00 00  ÿÿÿÿ‚yG
```

Start of first attribute 0x80

Second attribute 0x80

Start of data run for second attribute 0x80 (location of hidden alternate data stream)

Size of second attribute 0x80

Things You Should Know About ADS

There is no limit on the size of streams and there can be more than one stream linked to a normal file

ADS are not visible in Explorer or via command prompt*

ADS size is not reported by Windows

Stream can be attached not only to files but also to folders and drives

The content of an ADS is not limited to simply text data

Any stream of binary information can constitute a file, which includes executables, Mpeg files, Jpeg files, etc.

** Not exactly true. To be discussed later.*

Things You Should Know About ADS

ADSs have no attributes of their own other than its own separate *$DATA*

The access rights assigned to the named stream are the rights that control any operation on the associated ADSs

- *Examples: creation, deletion, or modification*
- *This means if a user cannot write to a file, that user cannot add an ADS to that file*
- *A user with guest privileges can also create such streams in every file where she has write access*

Things You Should Know About ADS

Windows File Protection prevents the replacement of protected system files

- *It does not prevent a user with the appropriate permissions from adding ADS to those system files*
- *The System File Checker (*sfc.exe*) will verify that protected system files have not been overwritten, but will not detect ADS*

Until Vista, Windows provided no tools or utilities either within the operating system software distribution or the Resource Kits for detecting the presence of ADS

- *More on this later*

Things You Should Know About ADS

The stream can only be executed if called directly by a program with the full path to the file given. It is very difficult and maybe impossible to accidentally execute an ADS.

None of the Internet protocols enabling file transfer such as SMTP, FTP, etc., support streams.

This means that ADS can't be sent via Internet.

However, files containing ADS can be sent across a local LAN provided the target drive is in the NTFS format

Things You Should Know About ADS

In certain cases, streams have been used to remotely exploit a web server

Some web servers are susceptible to having their file source read via the *$DATA* stream

Suppose a server-side script such as PHP or ASP is running on a web server which is not patched properly

- *Instead of getting output as a result of processing a script, the source code of the ASP/PHP file could be viewed by using a URL like this:*
  - http://www.abcde.com/index.asp::$DATA

This is a critical vulnerability

- *The server-side source code could reveal sensitive information including*
  - How the site has been coded
  - How the information is flowing
- *This information could be used by the attacker to launch a specific attack on the server*

Questions

What happens to a file with Alternate Data Streams when you copy it over to a different file system?

The Alternate Data Streams are lost
-- only the primary stream is copied over

A hash value is calculated on files to determine if they have been modified by Intrusion Detection Systems. Does this value change if you add an Alternate Data Stream?

No, it doesn’t. (Hashing tools typically only calculate the hash over the primary data stream.)

ADS Lab

Follow this lab exactly.

The `blue fixed width font` shows exactly what you should type.

Create a Folder

Create the folder `ADSLab` on your RADISH Windows 10 desktop

Open a ***cmd.exe*** window **as Administrator**

Navigate to your new ***ADSLab*** folder

Open ***File Explorer*** and navigate to the ***ADSLab*** folder

Arrange the two windows so that they don't overlap

Keep both ***cmd.exe*** and ***File Explorer*** open so you can watch what is happening

File System Metadata

In the ***cmd.exe*** window, create a visible text file as follows:

```
echo Visible Text File 1 > vis1.txt
```

Verify that it is there. How?

`type vis1.txt` *or*

`notepad vis1.txt` *or*

Double click on **`vis1.txt`** *in your* ***File Explorer***

Close notepad if you have it open

Create a Text ADS Stream

Create a secret ADS file

```
echo You can't see me > vis1.txt:hid1.txt
```

Verify:

Type: `dir`

What do you see?

Only the **`vis1.txt`** file in the dir listing

Type: `notepad vis1.txt`

What do you see?

Only the contents of the vis1.txt file

Close notepad

Type: `notepad hid1.txt`

What do you see?

Notepad is empty. Also, do not create a new file

Close notepad

Type: `notepad vis1.txt:hid1.txt`

What do you see?

The contents of the ADS text file **`hid1.txt`**

Close notepad

Create a WordPad ADS Stream

Create a second hidden text file using ***cmd.exe***:

```
echo Hidden text file 2 > hid2.txt
```

Open ***WordPad***. You can easily do this by typing

```
write.exe
```

*Type in the following text in **WordPad**:*

We will use this ***WordPad*** file as a cover file to hide ***hid2.txt*** by making it an ADS

*Save it in your **ADSLab** folder as the file* ***wp.rtf***

Close ***WordPad***

Put **hid2.txt** into **wp.rtf** as an ADS

```
type hid2.txt  > wp.rtf:hid2.txt
```

Verify What I Just Did

Now, ***using File Explorer***, open **`wp.rtf`** with ***WordPad***

What do you see?

Only the Wordpad file. No text file.

How can you see the hidden text file?

Must extract it to a normal file

Extraction

```
more < wp.rtf:hid2.txt > foo.txt
```

Verify your extraction. How?

Type **`foo.txt`**

Or double-click on **`foo.txt`**

Hiding in a Directory

Create a sub folder named ***stuff*** within your ***ADSLab*** folder. How?

```
md stuff
```

Navigate to your ***stuff*** folder

```
cd stuff
```

*Create an ADS for the folder **stuff***

```
echo hide this in stuff > :hide.txt
```

Can you verify that it's there?

```
more < :hide.txt
```

Some Preparation

Navigate to your ***ADSLab*** folder using your ***cmd.exe*** window

Create a folder ***exec***

Navigate to ***exec***

Copy ***snoop.exe*** from `R:\share\Labs\ADS Lab\` to ***exec***

In ***exec***, create a folder ***en-US***

Open a second ***File Explorer*** window

Copy the following files from

`C:\Windows\system32\en-US` to `ADSLab\exec\en-US\`

notepad.exe.mui

mspaint.exe.mui

Some Preparation

In your ***ADSLab/exec/en-US*** folder

Rename **`notepad.exe.mui`** *to* **`n.exe.mui`**

Rename **`mspaint.exe.mui`** *to* **`p.exe.mui`**

Navigate to your ***exec*** folder

More *Preparation*

Copy **mspaint*.exe*** and ***notepad.exe*** to your ***exec*** folder from your *C:\Windows\system32* directory

You should now have ***mspaint.exe*** and ***notepad.exe*** in your ***exec*** folder

Rename ***notepad.exe*** → ***n.exe*** How?

```
ren notepad.exe n.exe
```

Rename ***mspaint.exe*** → ***p.exe*** How?

```
ren mspaint.exe p.exe
```

Hiding Executable

Hide *the* ***snoop.exe*** executable. How?

Within your ***exec*** folder

```
echo This is a cover file. > cover.txt
type snoop.exe > cover.txt:snoop.exe
ren snoop.exe to s.exe
```

You could delete it

The above command lines hide the executable ***snoop.exe*** as an ADS to ***cover.txt***

You don't know that **snoop.exe** *exists after you rename or delete it*

Running the Hidden Executable

Execute ***s.exe*** to make sure it runs

In your ***exec*** folder, using ***cmd.exe***

```
start .\cover.txt
```

What happens?

- ***Cover.txt*** runs (it's opened in its default application)

Close **cover.txt**

Now, we can execute the hidden executable (i.e., ***snoop.exe***)

How?

```
start .\cover.txt:snoop.exe
```

What happens?

- ***Snoop.exe*** does not run
- It used to run on earlier versions of Windows, but capability was disabled

Running the Hidden Executable

There's a workaround

*Create a symbolic link (i.e., a shortcut) using **cmd.exe***

*Use the **mklink** command*

Type:

```
mklink doit.exe cover.txt:snoop.exe
```

Check to see that you have a symbolic link. How?

In your ***cmd.exe*** window, execute

```
start doit.exe
```

***Snoop.exe** should run*

*Close **snoop.exe***

So that's a way that malware could attach to a file legitimately and secretly run

Detecting ADS’

How to discover Alternate Data Streams

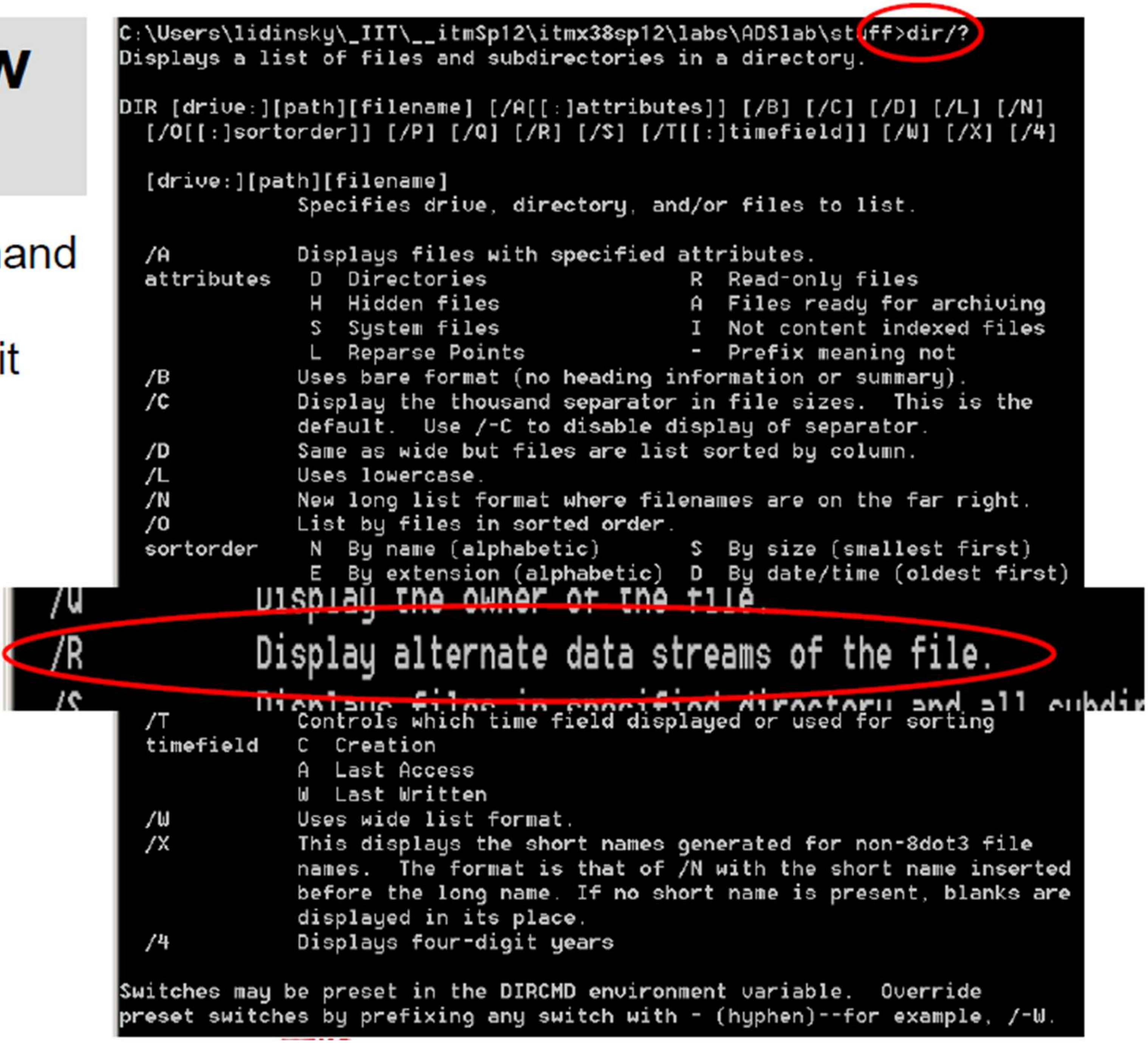
The New *dir*

The `dir` command now has more capability than it use to have

Type `dir /?`

You'll get this

Look at the `/R` switch



```
C:\Users\lidinsky\_IIT\__itmSp12\itmx38sp12\labs\ADSlab\stuff>dir/?
Displays a list of files and subdirectories in a directory.

DIR [drive:][path][filename] [/A[[:]attributes]] [/B] [/C] [/D] [/L] [/N]
  [/O[[:]sortorder]] [/P] [/Q] [/R] [/S] [/T[[:]timefield]] [/W] [/X] [/4]

  [drive:][path][filename]
              Specifies drive, directory, and/or files to list.

  /A          Displays files with specified attributes.
  attributes   D  Directories                R  Read-only files
               H  Hidden files               A  Files ready for archiving
               S  System files               I  Not content indexed files
               L  Reparse Points             -  Prefix meaning not
  /B          Uses bare format (no heading information or summary).
  /C          Display the thousand separator in file sizes.  This is the
              default.  Use /-C to disable display of separator.
  /D          Same as wide but files are list sorted by column.
  /L          Uses lowercase.
  /N          New long list format where filenames are on the far right.
  /O          List by files in sorted order.
  sortorder    N  By name (alphabetic)       S  By size (smallest first)
               E  By extension (alphabetic)  D  By date/time (oldest first)
  /Q          Display the owner of the file.
  /R          Display alternate data streams of the file.
  /S          Displays files in specified directory and all subdir
  /T          Controls which time field displayed or used for sorting
  timefield   C  Creation
              A  Last Access
              W  Last Written
  /W          Uses wide list format.
  /X          This displays the short names generated for non-8dot3 file
              names.  The format is that of /N with the short name inserted
              before the long name. If no short name is present, blanks are
              displayed in its place.
  /4          Displays four-digit years

Switches may be preset in the DIRCMD environment variable.  Override
preset switches by prefixing any switch with - (hyphen)--for example, /-W.
```

The New dir

Now verify that ***:snoop.exe*** is there using ***dir***

Navigate to the ***stuff*** folder

While in the folder ***stuff***, type

```
dir
```

Do you see **hide.txt?**

Now, type

```
dir /R
```

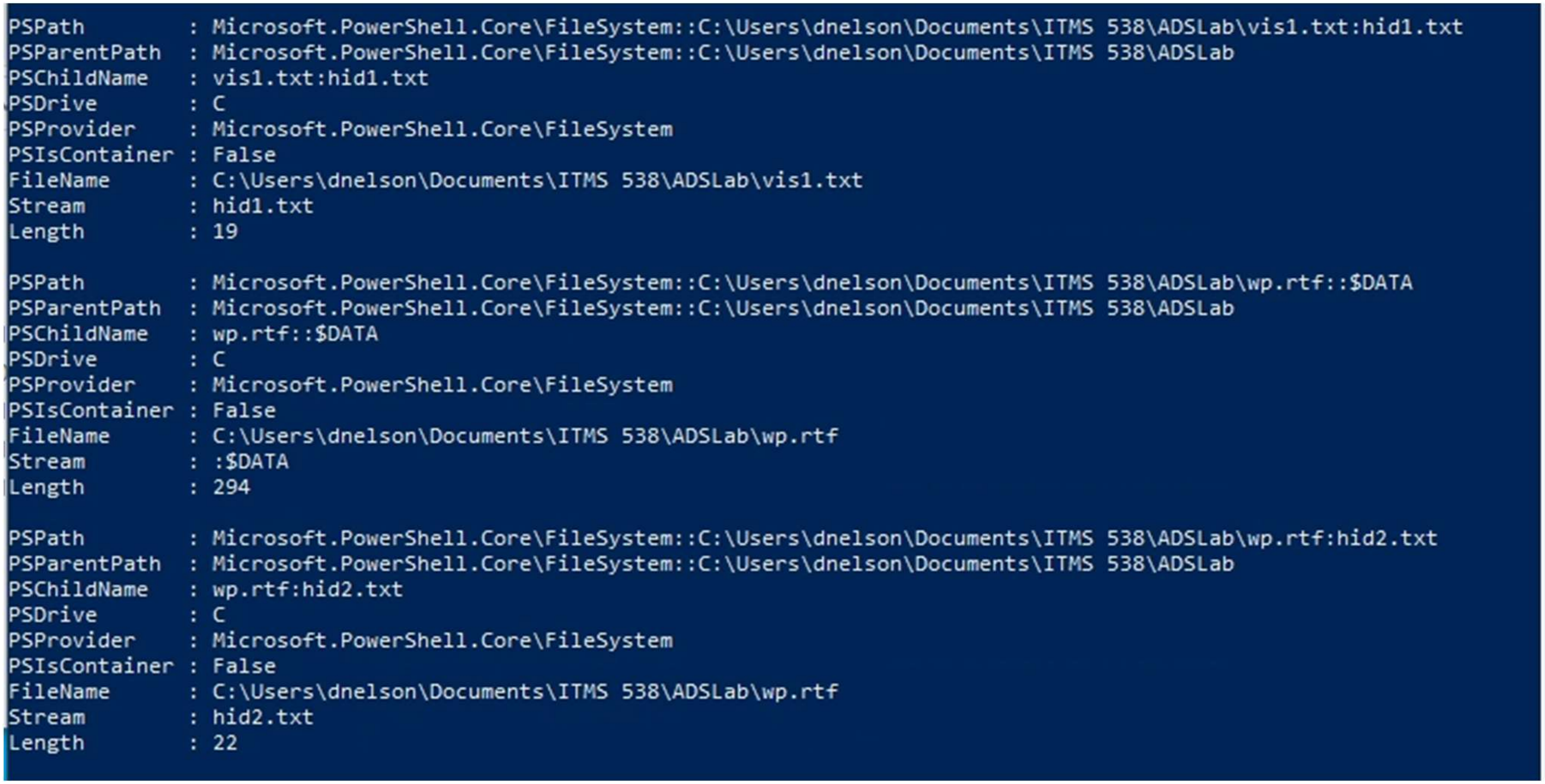
What do you get?

Yet, you don’t see anything in Windows Explorer or via the usual Windows ***dir*** command line tool

Other Ways to Detect ADS

PowerShell:

```
gci -recurse | % { gi $_.FullName `
  -stream * } | where stream -ne ':$Data'
```



```
PSPath        : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab\vis1.txt:hid1.txt
PSParentPath  : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab
PSChildName   : vis1.txt:hid1.txt
PSDrive       : C
PSProvider    : Microsoft.PowerShell.Core\FileSystem
PSIsContainer : False
FileName      : C:\Users\dnelson\Documents\ITMS 538\ADSLab\vis1.txt
Stream        : hid1.txt
Length        : 19

PSPath        : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab\wp.rtf::$DATA
PSParentPath  : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab
PSChildName   : wp.rtf::$DATA
PSDrive       : C
PSProvider    : Microsoft.PowerShell.Core\FileSystem
PSIsContainer : False
FileName      : C:\Users\dnelson\Documents\ITMS 538\ADSLab\wp.rtf
Stream        : :$DATA
Length        : 294

PSPath        : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab\wp.rtf:hid2.txt
PSParentPath  : Microsoft.PowerShell.Core\FileSystem::C:\Users\dnelson\Documents\ITMS 538\ADSLab
PSChildName   : wp.rtf:hid2.txt
PSDrive       : C
PSProvider    : Microsoft.PowerShell.Core\FileSystem
PSIsContainer : False
FileName      : C:\Users\dnelson\Documents\ITMS 538\ADSLab\wp.rtf
Stream        : hid2.txt
Length        : 22
```

Some Detection / Creation ADS Tools

streams.exe

https://docs.microsoft.com/en-us/sysinternals/downloads/streams

LADS (List Alternate Data Streams)

ADS Tools

ADS Spy

ADS Check

Glue