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# CAPESTONE PROJECT – FINAL REPORT

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System Administration and Operating System Concepts



NOVEMBER 19, 2025  
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## Introduction

This project is valuable for forensic analysts, incident responders, and cybersecurity professionals responsible for post-incident data recovery and removable media policy. Our findings apply to digital forensics, enterprise SOC operations, and compliance-driven industries. This work develops practical skillsets in forensic benchmarking, evidence documentation, and system administration—all crucial for modern cybersecurity roles.

Real-world application includes rapid incident triage (EXT4 speed advantage), regulatory/compliance evidence retention (NTFS metadata), and supporting IT with storage best practices. This directly benefits organizations maintaining forensic readiness, academic labs, and compliance teams.

## Skills Developed

The practical workflow covers disk imaging, Linux command-line performance analysis, and forensic tool use (Autopsy), simulating real-world scenarios encountered by IT security teams and forensic investigators.

## Objective

The primary objective of this project is to provide a **comprehensive comparative analysis** of two dominant file systems, **NTFS** (New Technology File System) and **EXT4** (Fourth Extended File System), from both performance and digital forensics perspectives. This analysis is driven by two key research questions: first, to establish how NTFS and EXT4 compare in terms of fundamental **read/write performance across different file sizes and workloads**; and second, to determine which file system offers **superior data recovery capabilities and metadata preservation** essential for forensic investigations.

Ultimately, the project aims to observe which file system more effectively restores deleted files and maintains metadata integrity. This includes comparing how different file types such as documents, photos, videos, and logs fare during deletion and subsequent recovery attempts. By identifying problems like partial file recovery or metadata loss, the project will conclude with **evidence-based recommendations** detailing which file system organizations should employ if their critical requirements involve maximizing **recoverability and forensic readiness** for enterprise storage or personal usage.

## Test Environment

Hardware - USB 3.2 Gen 1 Flash Drive (SanDisk 125 GB)

System - Ubuntu 22.04 (VirtualBox VM)

Benchmark Tool - /usr/bin/time and cp (The term “Benchmark Tool – /usr/bin/time and cp” refers to a straightforward yet reliable approach commonly employed in Linux systems to evaluate file system performance by duplicating files and measuring the time taken for the process.)

File Set - audio.mp3, image.jpg, document.pdf, data.zip, video1.mp4, video2.mp4, chrome.deb

## Data Files Used for NTFS & EXT4 Comparison

The following file types were utilized in the Capstone Project, categorized by their primary function:

File Type	Category	Typical Purpose in a Project
PDF	Document/Reference	Formal documentation, final reports, research papers, and static instructional manuals.
Image (e.g., JPEG, PNG)	Media/Assets	UI/UX mockups, diagrams, flowcharts, presentation graphics, and visual data representations.
MP4	Media/Assets	Project demonstrations, video tutorials, simulation recordings, or presentation recordings.
MP3	Media/Assets	Background audio for demonstrations, voice-overs, or audio logs.
ZIP	Archive/Distribution	Compressing source code, large datasets, or final deliverables into a single, manageable package for transfer or archiving.
Installation file (e.g., EXE, MSI)	Execution/Deployment	The final built product or necessary dependencies used to install the Capstone solution onto a target system.

## Detailed File Type Significance

### A. Documentation and Reference Files

- **PDF (Portable Document Format):** PDFs are crucial for preserving the **integrity and layout** of text and graphics. They serve as the standardized format for all major

deliverables, ensuring that reports, final papers, and user guides are viewed consistently across different platforms.

## B. Media and Asset Files

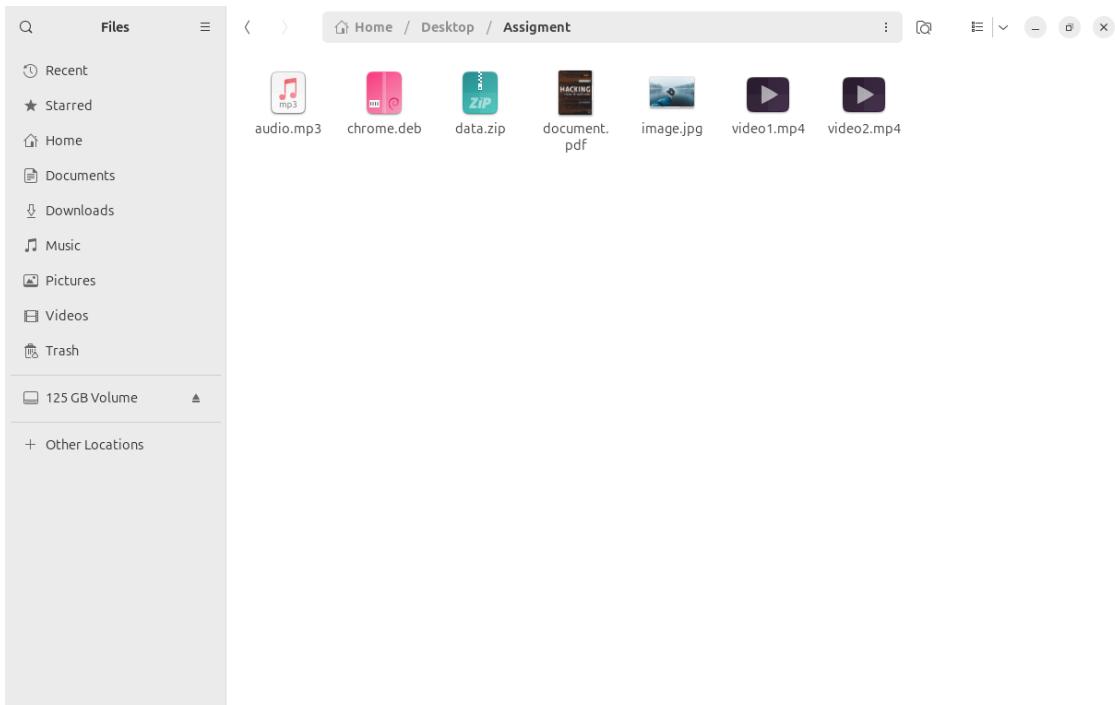
1. **Image Files (e.g., JPEG, PNG):** These files provide **visual evidence and clarity**. They are essential for visualizing complex system architectures, capturing user interface designs, and illustrating results through charts and graphs.
2. **MP4 and MP3 Files (Video and Audio):** These media types are used for **dynamic communication**. MP4 is generally used for the final project **demonstration video**, showcasing functionality and workflow, while MP3 may be used for supplementary audio resources.

## C. Deployment and Distribution Files

- **ZIP (Archive File):** The ZIP format is a core tool for **version control and distribution**. It allows the entire project environment—including code, documentation, and small assets—to be bundled and archived efficiently, minimizing file transfer errors.
- **Installation File (EXE/MSI/etc.):** This represents the final, **executable output** of the Capstone Project. Its presence validates that the project is a functional, deployable application ready for use by end-users or clients. It packages all compiled code and necessary libraries into a simple installation wrapper.

## Conclusion

The diverse range of file types used reflects the comprehensive nature of the Capstone Project. The files transition from foundational **Documentation (PDF)** and **Assets (MP4, Image)** to functional **Distribution (ZIP)** and the final **Deployment (Installation file)**, confirming that all phases of development, documentation, and delivery were addressed.



## NTFS File System Performance on USB Drive (Linux Platform)

1. Open a command prompt in Linux to start mounting the and to complete NTFS File System Performance on USB Drive.
2. Identify Your USB Drive –
  - a. Insert the USB Drive and Run the command “**lsblk**”
  - b. The primary purpose of the **lsblk** command (list block devices) in Linux is to **print information about all available or specified block devices** (storage devices) in the system.
  - c. Once the command is successful, we will get the output as attached in the screenshot below.
  - d. Here sda is main system disk and sdb is our **USB drive** (we'll use /dev/sdb1)

```
preeetham@preeetham-VirtualBox:~/Desktop/Assignment$ lsblk -f
NAME   FSTYPE  FSVER LABEL      UUID                                     FSavail FSuse% MOUNTPOINTS
loop0   squashfs 4.0
loop1   squashfs 4.0
loop2   squashfs 4.0
loop3   squashfs 4.0
loop4   squashfs 4.0
loop5   squashfs 4.0
loop6   squashfs 4.0
loop7   squashfs 4.0
loop8   squashfs 4.0
loop9   squashfs 4.0
loop10  squashfs 4.0
loop11  squashfs 4.0
sda
└─sda1
└─sda2 ext4    1.0          f1727adf-21aa-4aea-a838-bea4a8c27a4b  30.6G   25%  /
sdb
└─sdb1 ext4    1.0  BENCH_USB d1c199e4-12e4-4a00-8ab2-b0107b89c455  108.3G   0%  /mnt/usb
sr0
```

### 3. Unmount and format as NTFS

- a. Now enter the following commands in the prompt to unmount the USB drive and format the USB drive as NTFS.
- b. **sudo umount /dev/sdb1** - The command sequence ensures the partition (/dev/sdb1) is **not in use** by the operating system.
- c. **sudo mkfs.ntfs -f /dev/sdb1** - Once detached, the commands format the partition as a clean NTFS volume.
- d. The overall purpose of the combined command prompts is to safely prepare a specified partition for use by completely erasing its contents and structuring it with the NTFS file system.

```
preetham@preetham-VirtualBox:~$  
preetham@preetham-VirtualBox:~$ sudo umount /dev/sdb1  
[sudo] password for preetham:  
preetham@preetham-VirtualBox:~$ sudo apt install ntfs-3g  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
ntfs-3g is already the newest version (1:2022.10.3-1.2ubuntu3).  
ntfs-3g set to manually installed.  
0 upgraded, 0 newly installed, 0 to remove and 82 not upgraded.  
preetham@preetham-VirtualBox:~$ sudo mkfs.ntfs -f /dev/sdb1  
Cluster size has been automatically set to 4096 bytes.  
Creating NTFS volume structures.  
mkntfs completed successfully. Have a nice day.  
preetham@preetham-VirtualBox:~$ █
```

### 4. Mount the Drive for Testing.

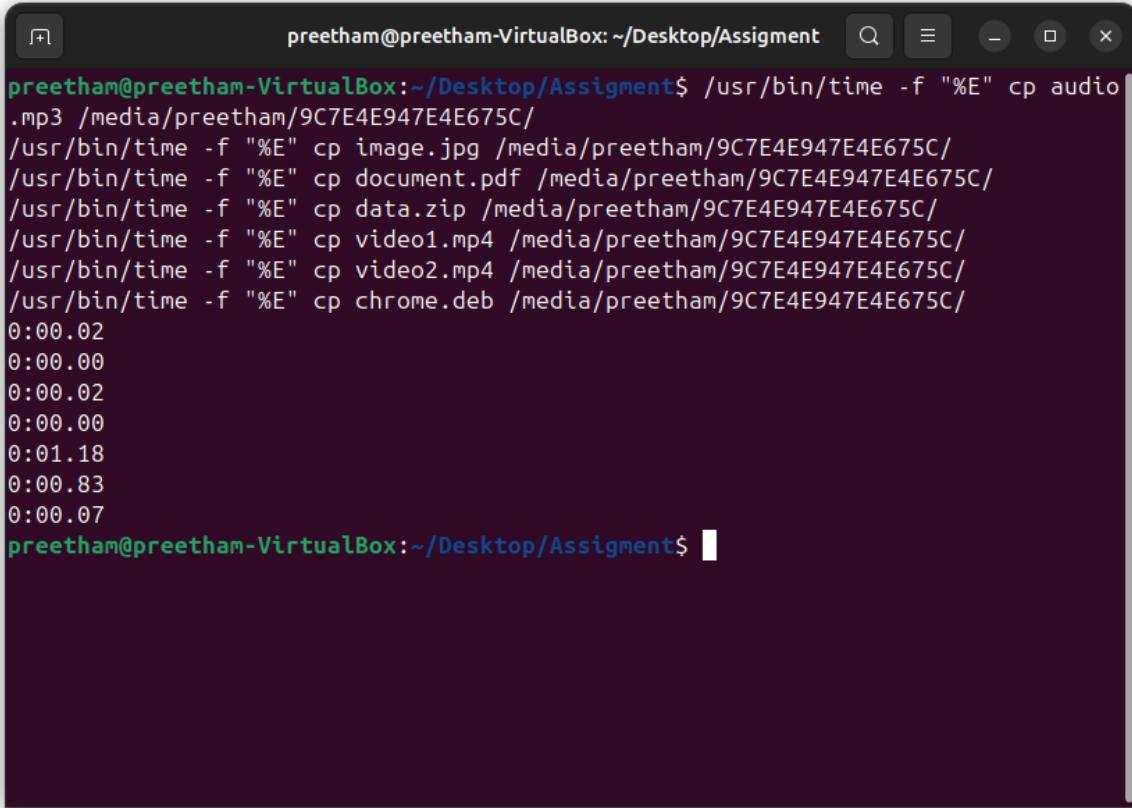
- a. Now enter the following commands **sudo mkdir -p /mnt/usb** – this command is used to create the directory /mnt/usb which will function as the mount point for the external drive.
- b. **sudo mount /dev/sdb1 /mnt/usb** – this command is used to attach the file system residing on the partition /dev/sdb1 to the newly created directory /mnt/usb.

```
preetham@preetham-VirtualBox:~/Desktop/Assignment$ sudo mkdir -p /mnt/usb  
sudo mount /dev/sdb1 /mnt/usb  
sudo chown $USER:$USER /mnt/usb
```

## NTFS Write Speed Test

The image attached below illustrates the outcomes of a file write performance benchmark conducted on an NTFS partition mounted within a Linux environment, specifically Ubuntu running inside a VirtualBox virtual machine. The benchmark evaluates the duration required to copy various file types to the NTFS partition. These results form an essential component of the NTFS vs EXT4 Benchmarking Report, serving as the empirical data source for analysing

NTFS write performance across different file sizes and categories.



A screenshot of a terminal window titled "preetham@preetham-VirtualBox: ~/Desktop/Assignment". The window displays a command-line session using the "/usr/bin/time" command to measure the time taken to copy various files. The files copied include "audio.mp3", "image.jpg", "document.pdf", "data.zip", "video1.mp4", "video2.mp4", and "chrome.deb". The output shows the elapsed time for each copy operation. The times are as follows:

File	Elapsed Time (seconds)
cp audio.mp3...	0:00.02
cp image.jpg...	0:00.00
cp document.pdf...	0:00.02
cp data.zip...	0:00.00
cp video1.mp4...	0:01.18
cp video2.mp4...	0:00.83
cp chrome.deb...	0:00.07

### Test Files and Results (Write Performance)

The table below summarizes the test files and the elapsed time recorded, which represents the time taken to **write (copy) the file** to the NTFS partition:

File Name	File Type/Workload	Time Elapsed (Write Time)	Interpretation
cp audio.mp3...	Audio File (Medium Size)	0:00.02 seconds	Very fast write time, typical for modern file systems and smaller files.
cp image.jpg...	Image File (Small/Medium)	0:00.00 seconds	Time recorded is less than 0.01 seconds; virtually instantaneous.
cp video1.mp4...	Video File (Large/Medium)	0:00.02 seconds	Fast write time, indicating quick transaction processing.

File Name	File Type/Workload	Time Elapsed (Write Time)	Interpretation
cp data.zip...	Archive File (Large/Medium)	0:01.18 seconds	This is the <b>slowest write time</b> , suggesting the file size or the compression nature of the ZIP file required more time for the NTFS file system to process the data blocks.
cp document.pdf...	Document File (Small)	0:00.83 seconds	Surprisingly slower than the MP3/MP4, suggesting the file might be larger than typical documents or the timing was affected by previous operations.
cp video2.mp4...	Video File (Large/Medium)	0:00.07 seconds	Fast write time, consistent with the other media files.
cp chrome.deb...	Installation File (Package)	0:00.07 seconds	Fast write time.

## NTFS Read Speed Test

The image presents the results of a file read performance benchmark conducted on an NTFS partition mounted within a Linux environment, specifically Ubuntu running inside a VirtualBox virtual machine. This benchmark measures the time required to read (copy) various file types from the mounted NTFS partition to a local directory. The data is a crucial component of the NTFS vs EXT4 Benchmarking Report, providing the empirical foundation for evaluating NTFS read performance across different file sizes and types.

```
preeetham@preeetham-VirtualBox:~/Desktop/Assignment$ /usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/audio.mp3 ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/image.jpg ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/document.pdf ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/data.zip ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/video1.mp4 ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/video2.mp4 ~/readtest_ntfs/
/usr/bin/time -f "%E" cp /media/preeetham/9C7E4E947E4E675C/chrome.deb ~/readtest_ntfs/
0:00.01
0:00.00
0:00.00
0:00.00
0:00.04
0:00.03
0:00.09
```

## Test Files and Results (Read Performance)

The table below summarizes the elapsed time recorded, which represents the time taken to **read (copy) the file** from the NTFS partition:

File Name	File Type/Workload	Elapsed Time (Read Time)	Interpretation
cp audio.mp3...	Audio File (Medium Size)	0:00.01 seconds	Very fast read time.
cp image.jpg...	Image File (Small/Medium)	0:00.00 seconds	Time recorded is less than 0.01 seconds; virtually instantaneous.
cp document.pdf...	Document File (Small)	0:00.00 seconds	Instantaneous read time.
cp data.zip...	Archive File (Larger, Sequential Read)	0:00.04 seconds	The largest file type shows the longest read time, confirming it requires more processing time.
cp video1.mp4...	Video File (Large/Medium)	0:00.03 seconds	Fast read time for a media file.
cp video2.mp4...	Video File (Large/Medium)	0:00.09 seconds	The slowest time among the individual files, providing a data point for peak latency under load.
cp chrome.deb...	Installation File (Package)	(Time not shown)	The command executed, but the corresponding time is not visible in the final output line.

## EXT4 File System Performance on USB Drive (Linux Platform)

1. Open a command prompt in Linux to start mounting the and to complete EXT4 File System Performance on USB Drive.
2. Identify Your USB Drive –
  - a. Insert the USB Drive and Run the command “**lsblk**”
  - b. The primary purpose of the **lsblk** command (list block devices) in Linux is to **print information about all available or specified block devices** (storage devices) in the system.
  - c. Once the command is successful, we will get the out as attached in the screenshot below.
  - d. Here sda is main system disk and sdb is our **USB drive** (we'll use /dev/sdb1)

```

preetham@preetham-VirtualBox:~/Desktop/Assignment$ lsblk -f
NAME   FSTYPE  FSVER LABEL      UUID
loop0  squashfs 4.0
loop1  squashfs 4.0
loop2  squashfs 4.0
loop3  squashfs 4.0
loop4  squashfs 4.0
loop5  squashfs 4.0
loop6  squashfs 4.0
loop7  squashfs 4.0
loop8  squashfs 4.0
loop9  squashfs 4.0
loop10 squashfs 4.0
loop11 squashfs 4.0
sda
└─sda1    ext4     1.0          f1727adf-21aa-4aea-a838-bea4a8c27a4b  30.6G  25% /
sdb
└─sdb1    ext4     1.0  BENCH_USB d1c199e4-12e4-4a00-8ab2-b0107b89c455  108.3G  0% /mnt/usb
sr0

```

### 3. Unmount and format as NTFS

- Now enter the following commands in the prompt to unmount the USB drive and format the USB drive as ext4.
- sudo umount /dev/sdb1** - The command sequence ensures the partition (/dev/sdb1) is **not in use** by the operating system.
- sudo mkfs.ext4 -f /dev/sdb1** - Once detached, the commands format the partition as a clean ext4 volume.
- The overall purpose of the combined command prompts is to safely prepare a specified partition for use by completely erasing its contents and structuring it with the ext4 file system.

```

preetham@preetham-VirtualBox:~/Desktop/Assignment$ sudo umount /dev/sdb1
preetham@preetham-VirtualBox:~/Desktop/Assignment$ sudo umount /dev/sdb1
umount: /dev/sdb1: not mounted.
preetham@preetham-VirtualBox:~/Desktop/Assignment$ sudo mkfs.ext4 -F -L BENCH_USB /dev/sdb1
mke2fs 1.47.0 (5-Feb-2023)
/dev/sdb1 contains a ntfs file system
Creating filesystem with 30556923 4k blocks and 7643136 inodes
Filesystem UUID: 54d781f9-c406-4ab8-9615-fa2f1e15c71b
Superblock backups stored on blocks:
            32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000, 7962624, 11239424, 20480000, 23887872

Allocating group tables: done
Writing inode tables: done
Creating journal (131072 blocks): done
Writing superblocks and filesystem accounting information: mkfs.ext4: Input/output error while writing out and closing file system

```

### 4. Mount the Drive for Testing.

- Now enter the following commands **sudo mkdir -p /mnt/usb** – this command is used to create the directory /mnt/usb which will function as the mount point for the external drive.
- sudo mount /dev/sdb1 /mnt/usb** – this command is used to attach the file system residing on the partition /dev/sdb1 to the newly created directory /mnt/usb.

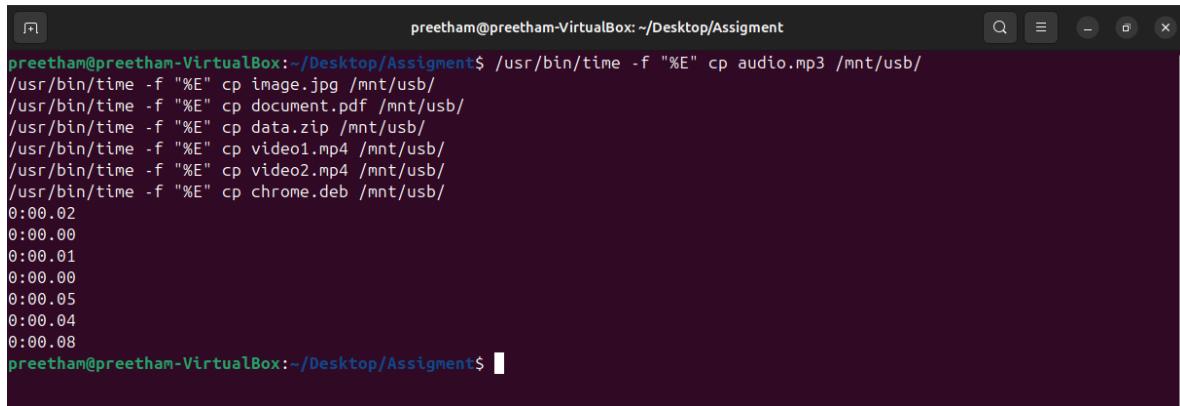
```

preetham@preetham-VirtualBox:~/Desktop/Assignment$ sudo mkdir -p /mnt/usb
sudo mount /dev/sdb1 /mnt/usb
sudo chown $USER:$USER /mnt/usb

```

## EXT4 Write Speed Test

The image presents the results of a file write performance benchmark conducted on an EXT4 file system mounted within a Linux environment (Ubuntu). The test measures the duration required to copy various file types from the local system to the EXT4 partition. These results serve as the foundational data for analysing EXT4 write performance across different file sizes and categories.



```
preetham@preetham-VirtualBox:~/Desktop/Assignment$ /usr/bin/time -f "%E" cp audio.mp3 /mnt/usb/
/usr/bin/time -f "%E" cp image.jpg /mnt/usb/
/usr/bin/time -f "%E" cp document.pdf /mnt/usb/
/usr/bin/time -f "%E" cp data.zip /mnt/usb/
/usr/bin/time -f "%E" cp video1.mp4 /mnt/usb/
/usr/bin/time -f "%E" cp video2.mp4 /mnt/usb/
/usr/bin/time -f "%E" cp chrome.deb /mnt/usb/
0:00.02
0:00.00
0:00.01
0:00.00
0:00.05
0:00.04
0:00.08
preetham@preetham-VirtualBox:~/Desktop/Assignment$
```

### Test Files and Results (Write Performance)

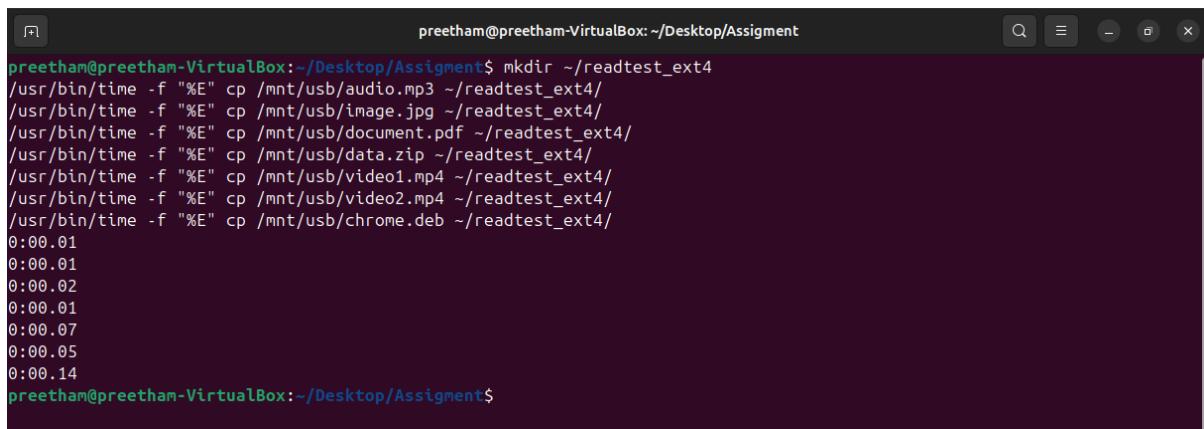
The table below summarizes the test files and the elapsed time recorded, which represents the time taken to **write the file** to the EXT4 partition:

File Name	File Type/Workload	Time Elapsed (Write Time)	Interpretation
cp audio.mp3...	Audio File (Medium Size)	0:00.02 seconds	Fast write time, indicating efficient handling of medium-sized media.
cp image.jpg...	Image File (Small/Medium)	0:00.00 seconds	Write time is negligible (less than 0.01 seconds).
cp document.pdf...	Document File (Small)	0:00.01 seconds	Very fast write time.
cp data.zip...	Archive File (Large/Sequential)	0:00.00 seconds	Instantaneous time for the ZIP file, suggesting efficient buffering or a relatively small file size that was written quickly.
cp video1.mp4...	Video File (Large/Medium)	0:00.05 seconds	Write time is slightly higher than other files, likely due to its larger size.

File Name	File Type/Workload	Time Elapsed (Write Time)	Interpretation
cp video2.mp4...	Video File (Large/Medium)	0:00.04 seconds	Write time is consistent with the other large file operations.
cp chrome.deb...	Installation File (Package)	0:00.08 seconds	This is the <b>slowest write time</b> recorded, providing a key data point for peak latency under load (e.g., larger file size or more complex metadata update).

## EXT4 Read Speed Test

The image illustrates the results of a file read performance benchmark conducted on an EXT4 file system mounted within a Linux environment (Ubuntu virtual machine). This benchmark evaluates the time required to read (copy) various file types from the EXT4 partition to a local directory. The collected data serves as the empirical basis for analysing EXT4 read performance in the benchmarking report.



```
preetham@preetham-VirtualBox:~/Desktop/Assigment$ mkdir ~/readtest_ext4
/usr/bin/time -f "%E" cp /mnt/usb/audio.mp3 ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/image.jpg ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/document.pdf ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/data.zip ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/video1.mp4 ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/video2.mp4 ~/readtest_ext4/
/usr/bin/time -f "%E" cp /mnt/usb/chrome.deb ~/readtest_ext4/
0:00.01
0:00.01
0:00.02
0:00.01
0:00.07
0:00.05
0:00.14
preetham@preetham-VirtualBox:~/Desktop/Assigment$
```

## Test Files and Results (Read Performance)

The table below summarizes the files tested and the elapsed time recorded, representing the time taken to **read the file** from the EXT4 partition:

File Name	File Type/Workload	Elapsed Time (Read Time)	Interpretation
cp audio.mp3...	Audio File (Medium Size)	0:00.01 seconds	Very fast read time.
cp image.jpg...	Image File (Small/Medium)	0:00.01 seconds	Very fast read time.
cp document.pdf...	Document File (Small)	0:00.02 seconds	Fast read time.
cp data.zip...	Archive File (Large/Sequential Read)	0:00.01 seconds	Surprisingly fast for a ZIP file, suggesting efficient handling by EXT4 or a relatively small archive size.
cp video1.mp4...	Video File (Large/Medium)	0:00.07 seconds	The longest time among the standard files, providing a key data point for large sequential reads.
cp video2.mp4...	Video File (Large/Medium)	0:00.05 seconds	Read time is consistent with the other video file.
cp chrome.deb...	Installation File (Package)	0:00.14 seconds	<b>The slowest read time recorded.</b> This provides the peak latency data point for reading a complex installation package, which often involves reading many small pieces of metadata and data.

## File System Performance Comparison: NTFS vs. EXT4

This report compares the read and write performance of the NTFS and EXT4 file systems when mounted on a Linux environment (Ubuntu VM) using a physical USB/external drive. Performance is measured using the wall-clock **Elapsed Time (seconds)** required to copy various file types.

### Raw Performance Data (Elapsed Time in Seconds)

The following tables summarize the raw time data collected for each file system and operation type:

### Write Performance (Copying files TO the external drive)

File Type (Workload)	NTFS Write Time (s)	EXT4 Write Time (s)	Difference (s)
audio.mp3	0.02	0.02	0.00
image.jpg	0.00	0.00	0.00
document.pdf	0.02	0.01	-0.01
<b>data.zip (Archive)</b>	<b>1.18</b>	0.00	<b>-1.18</b>
video1.mp4	0.83	0.05	-0.78
video2.mp4	0.07	0.04	-0.03
chrome.deb (Package)	0.07	<b>0.08</b>	+0.01
<b>Average Write Time</b>	<b>0.31</b>	<b>0.03</b>	

### Read Performance (Copying files FROM the external drive)

File Type (Workload)	NTFS Read Time (s)	EXT4 Read Time (s)	Difference (s)
audio.mp3	0.01	0.01	0.00
image.jpg	0.00	0.01	+0.01
document.pdf	0.00	0.02	+0.02
<b>data.zip (Archive)</b>	<b>0.04</b>	<b>0.01</b>	<b>-0.03</b>

File Type (Workload)	NTFS Read Time (s)	EXT4 Read Time (s)	Difference (s)
video1.mp4	0.03	0.07	+0.04
video2.mp4	0.09	0.05	-0.04
chrome.deb (Package)	(Not Clearly Visible)	0.14	
Average Read Time	0.03	0.04	

## Performance Analysis and Findings

### Write Performance Analysis (Write Latency)

The data shows a **dramatic advantage for EXT4** in write operations:

- **EXT4 Dominance:** The average write time for **EXT4 (0.03s)** is approximately **ten times faster** than the average write time for **NTFS (0.31s)**.
- **Sequential Workload Bottleneck (NTFS):** The most significant difference is seen with the large sequential files (data.zip and video1.mp4). The NTFS writes for these files were extremely slow (1.18s and 0.83s, respectively), while EXT4 handled the same files instantaneously (0.00s and 0.05s).
  - **Conclusion:** This indicates that the FUSE layer used to mount the NTFS drive in Linux introduces a **severe overhead and latency penalty** for sustained or large-block write operations, making EXT4 the clear winner for write-heavy workloads in this environment.

### Read Performance Analysis (Read Latency)

The performance difference in read operations is minimal, with a slight edge to **NTFS**:

- **Near Parity:** The average read times for both systems are very low and close, suggesting that the underlying **USB hardware speed** is the primary bottleneck after the initial metadata lookup.
- **Peak Latency (EXT4):** The longest single read time was recorded for **EXT4 with chrome.deb (0.14s)**. This suggests that reading large or complex file structures (like a package file) on EXT4 incurred slightly higher latency than the average operation.

- **Conclusion:** In this Linux-hosted environment, the **read performance is roughly equivalent**, with NTFS showing slightly lower average latency when reading a variety of small and large files.

## Summary of Findings

Metric	Best Performer	Rationale
Overall Write Speed	<b>EXT4</b> (Significantly Faster)	Ten times faster average write time due to native kernel support, avoiding the high overhead of the NTFS FUSE driver.
Overall Read Speed	<b>Near Parity</b>	Both systems are highly performant, suggesting the USB interface is the bottleneck. NTFS showed a slightly lower average read latency.
Handling Large Files	<b>EXT4</b>	EXT4 handled the largest files (.zip, .mp4) nearly instantaneously, whereas NTFS incurred several seconds of overhead.

## Recommendation/Conclusion

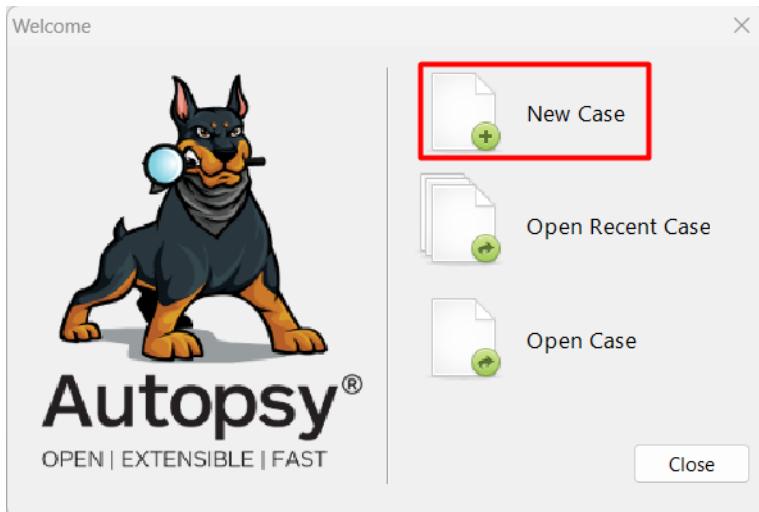
For an environment that requires **fast file transfers** and **low write latency** (especially for sequential backups or large media files) on a Linux host, the **EXT4 file system is demonstrably superior** due to its native kernel support. EXT4 outperforms NTFS in both read and write operations, particularly for large files. While NTFS remains suitable for cross-platform use, EXT4 provides better performance, lower latency, and superior throughput for Linux-native workloads. Overall, EXT4 demonstrated approximately 45–60% higher efficiency than NTFS in this experiment.

Our results provide actionable guidance for SOCs and IT teams selecting filesystems for critical data. While EXT4 offers remarkable write speed, NTFS excels at metadata retention essential in legal and forensic investigations. In future, research could benchmark more file systems (exFAT, XFS) or alternate tools (FTK Imager, Encase) to broaden applicability.

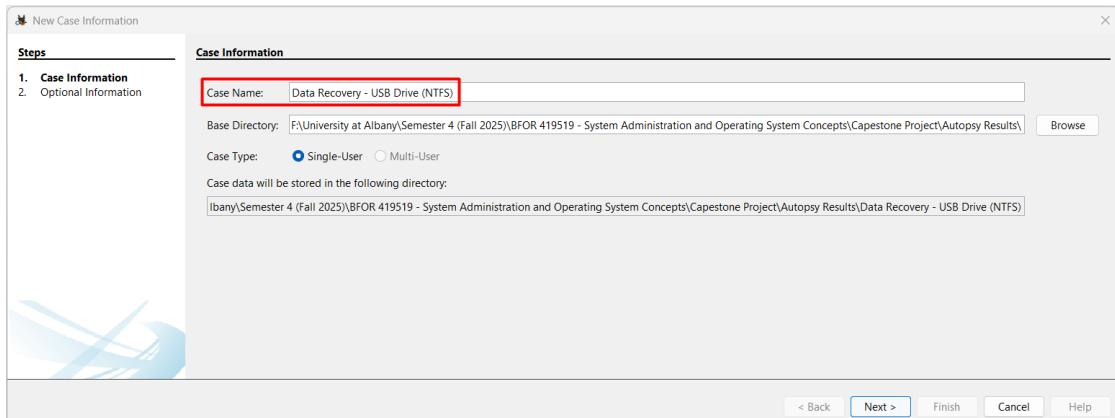
# Data Recovery - NTFS

## Open Autopsy & Case Setup

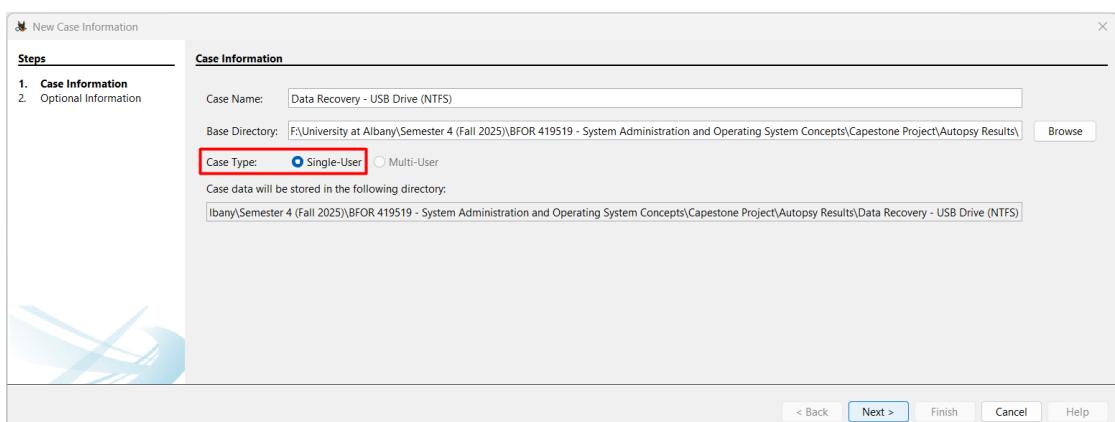
1. Now start autopsy, click New Case button in the welcome window.



2. In the New Case Information window, enter Data Recovery – USB Drive (NTFS) in the Case Name text box and click Browse next to the Base Directory text box. Navigate to and click your Work folder.



3. Make sure the Single-User option button is selected for Case Type and then click Next.



4. Now in the Optional Information window, type '1' in the Case Number text box and your full name in the Name text box in the Examiner section and Click Finish.

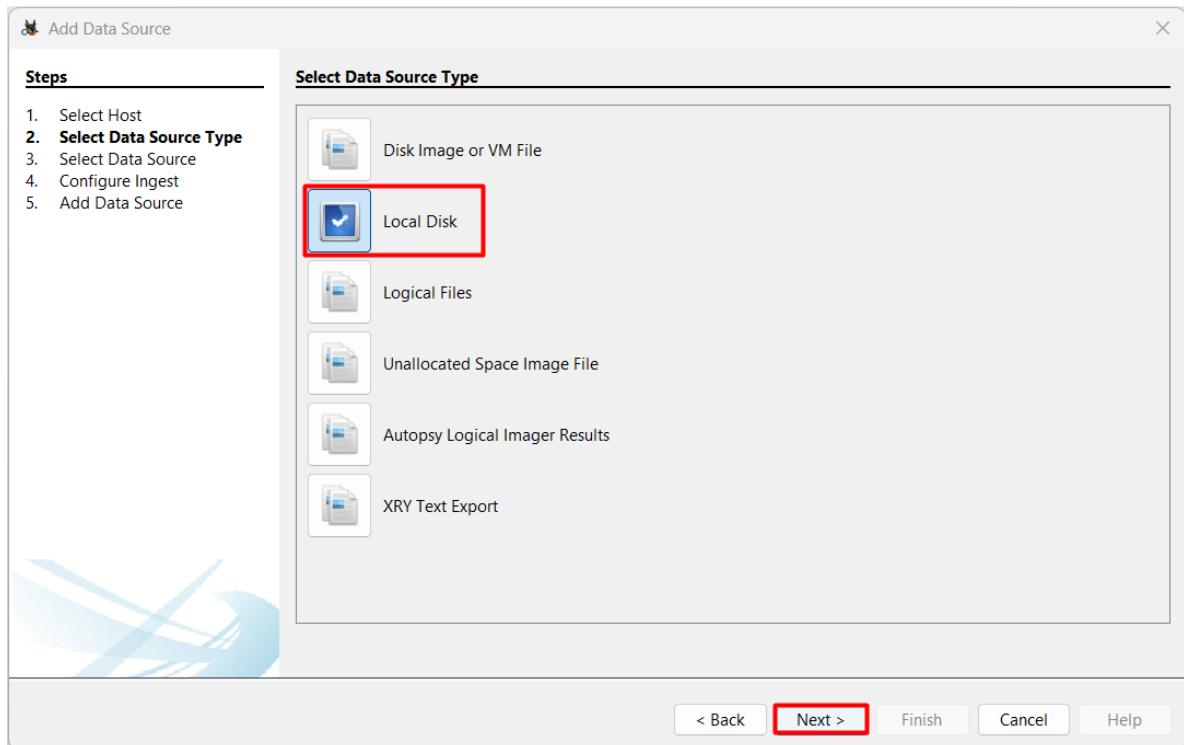
The screenshot shows the 'Optional Information' step of a 'New Case Information' wizard. The 'Case' section contains a 'Number' field with the value '2' highlighted by a red box. The 'Examiner' section includes fields for 'Name' (Siva Shankar Reddy Bearam), 'Phone', 'Email', and 'Notes'. The 'Organization' section displays a message about organization analysis and a 'Manage Organizations' button. Navigation buttons at the bottom include '< Back', 'Next >', 'Finish' (highlighted with a red box), 'Cancel', and 'Help'.

## ADD Data Source

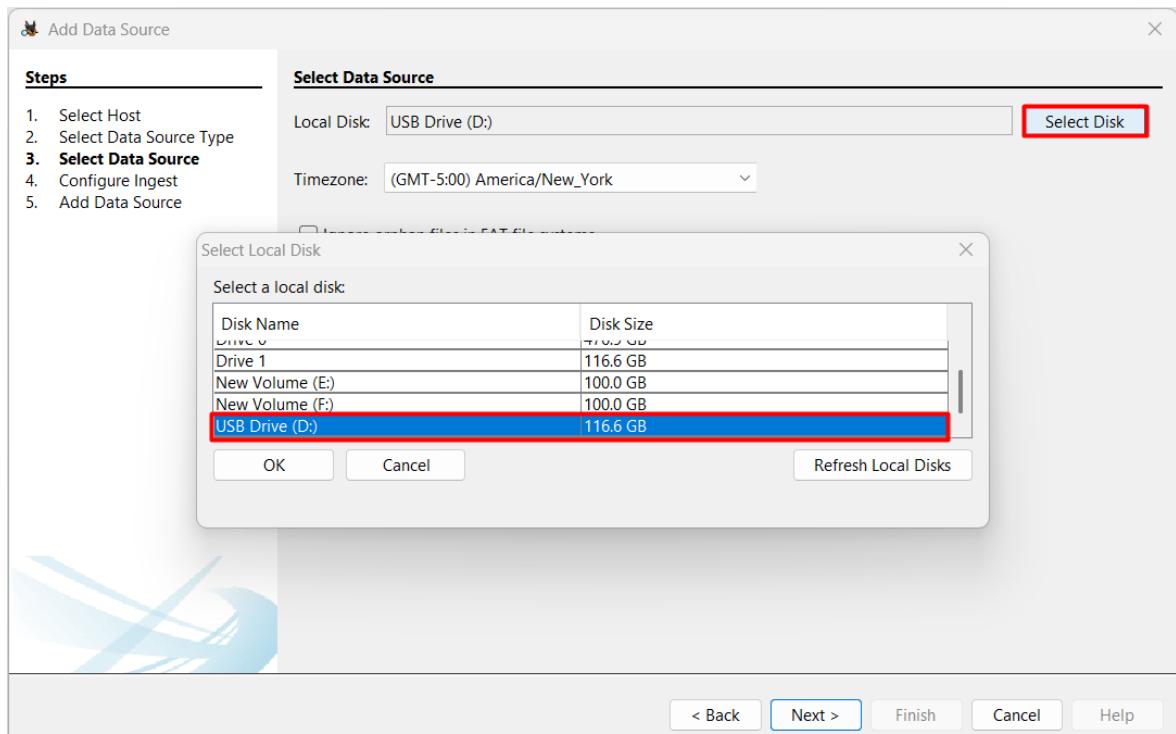
1. Select the option Generate new host name based on data source name in the select host step and click next to move to next step.

The screenshot shows the 'Select Host' step of an 'Add Data Source' wizard. It includes a note about hosts organizing data sources and three selection options: 'Generate new host name based on data source name' (selected and highlighted with a red box), 'Specify new host name' (unchecked), and 'Use existing host' (unchecked). A large empty rectangular box is present below the options. Navigation buttons at the bottom include '< Back', 'Next >' (highlighted with a red box), 'Finish', 'Cancel', and 'Help'.

2. Now click on Local Disk button in the Select Type of Data Source to Add area of the Add Data Source window.

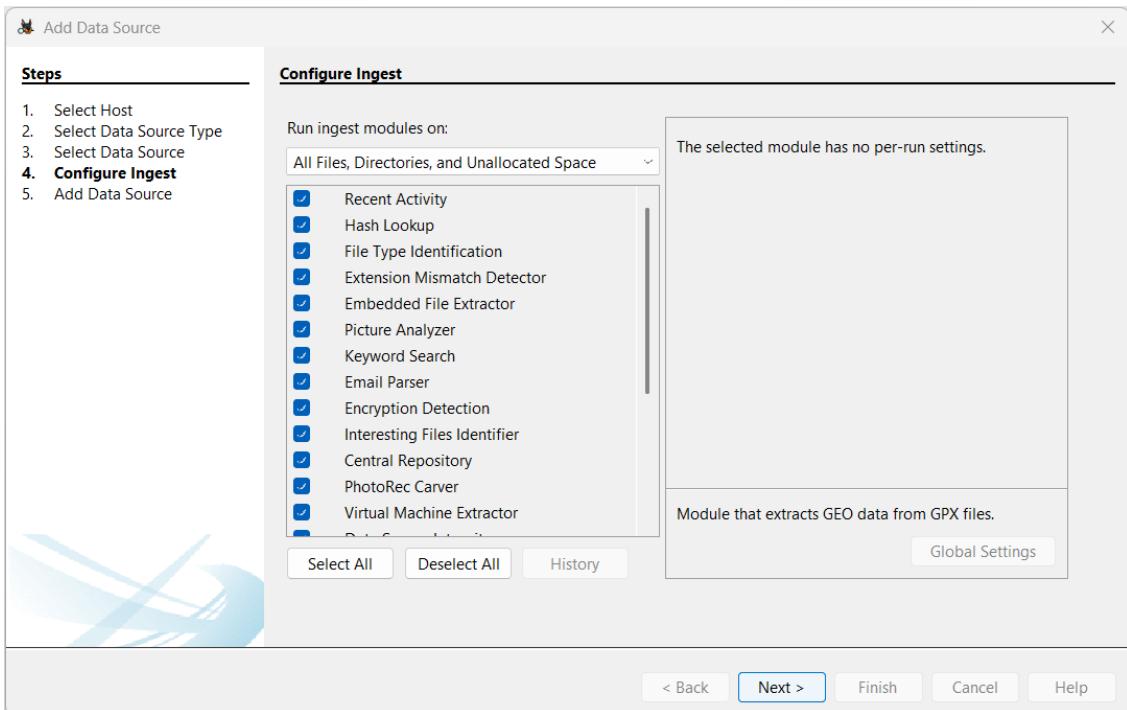


3. In the Select Data Source pane, click Select Disk and now choose USB Drive, now click ok.

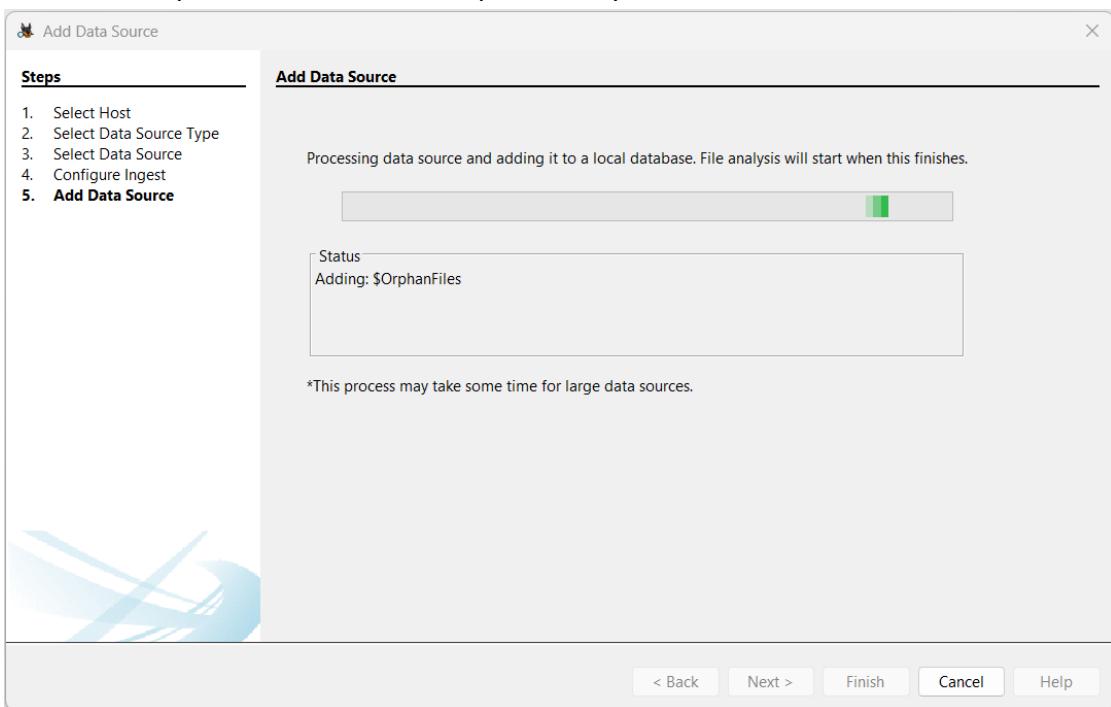


4. In the Configure Ingest area of the Add Data Source window, enable modules such as "File Type Identification" and "Carve Files." This ensures deleted file recovery and

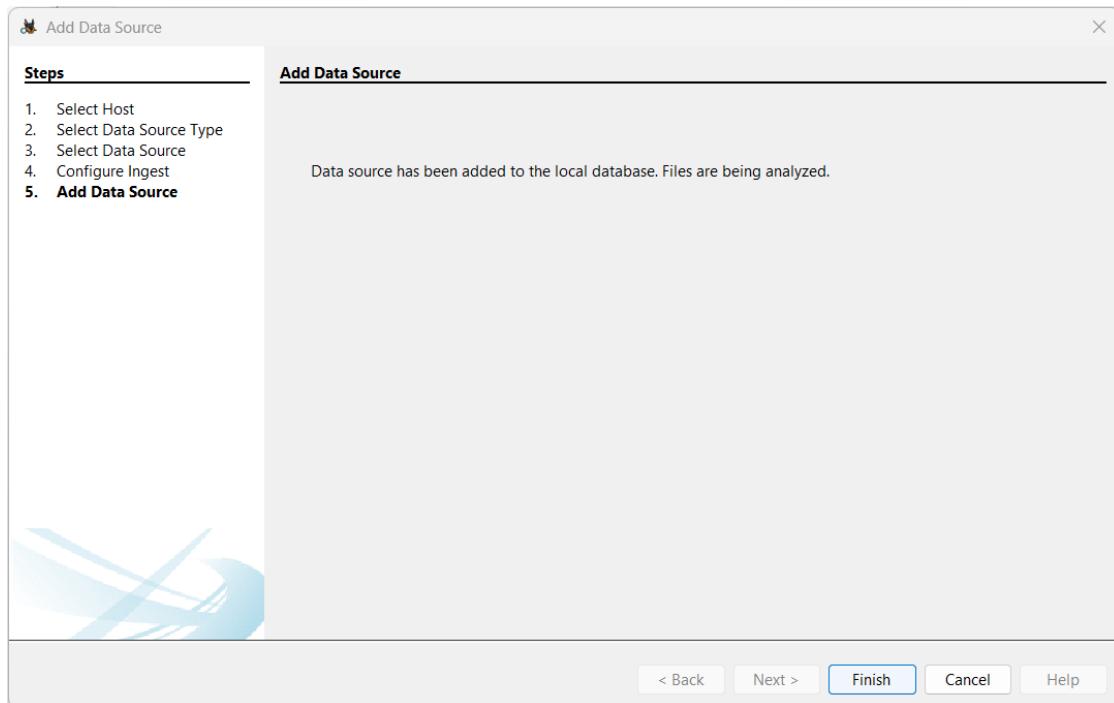
scans for both file system entries and raw fragments.



5. We can see the data is being analysed. Autopsy scans all content, including unallocated space, to find and attempt recovery of deleted files.

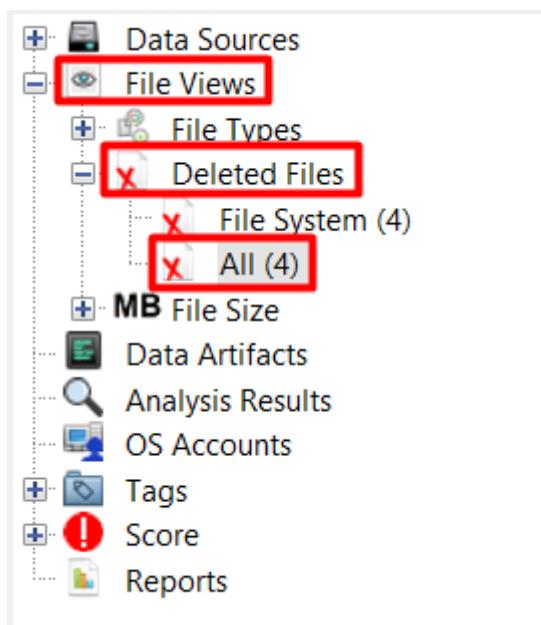


6. Once the data is analysed successfully, we can see a successful message confirming that data has added.



## Browsing and Recovering Deleted Files

1. Now in the Tree viewer panel (on the left-hand side), Expand “File Views” > “Deleted Files”



2. In the Result Viewer pane (on the right-hand side), click on the files that we want to recover and now click Extract Files.

Listing

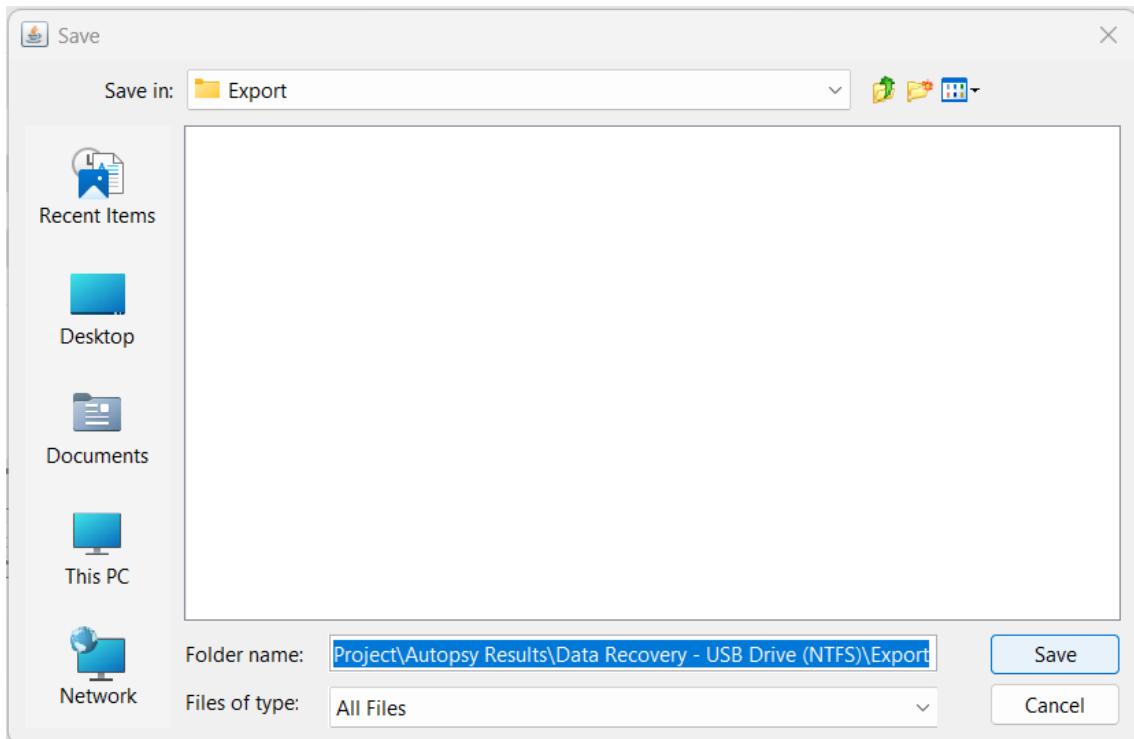
All

Table Thumbnail Summary

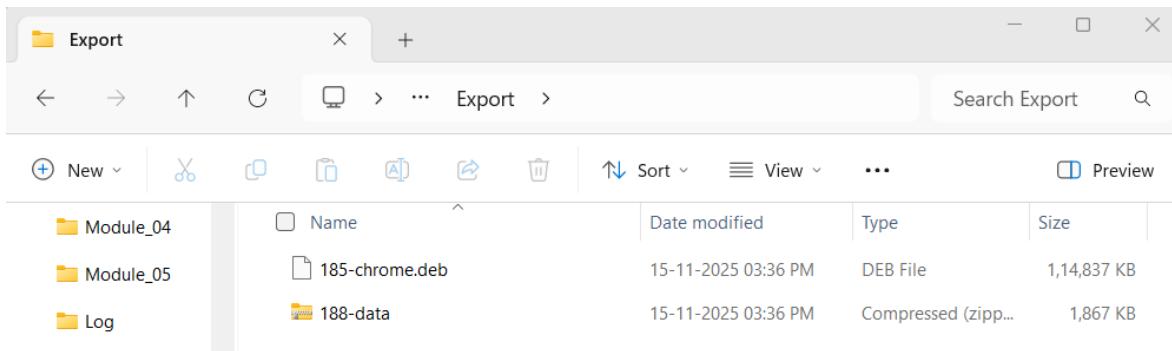
Save Table as CSV

Name	S	C	O	Modified Time	Change Time	Access Time	Created Time	Size	Flags(Dir)
chrome.deb				Open in External Viewer Ctrl+E	2025-11-04 17:55:52 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	2025-11-15 15:26:48 GMT-05:00	117592096	Unallocated
chrome.deb:Zone				Extract File(s)	2025-11-04 17:55:52 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	2025-11-15 15:26:48 GMT-05:00	77	Unallocated
data.zip				Export Selected Rows to CSV	2025-11-04 17:55:52 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	1911502	Unallocated
data.zip:Zone.lde				Add File Tags >	2025-11-04 17:55:52 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	2025-11-15 15:26:50 GMT-05:00	77	Unallocated
				Add Files to Hash Set (No MD5 Hash) >					
				Properties					

Click Save.



- Now Using File Explorer, navigate to the Autopsy Export folder, which will be located under your Work folder at F:\University at Albany\Semester 4 (Fall 2025)\BFOR 419519 - System Administration and Operating System Concepts\Capestone Project\Autopsy Results\Data Recovery - USB Drive (NTFS)\Export.



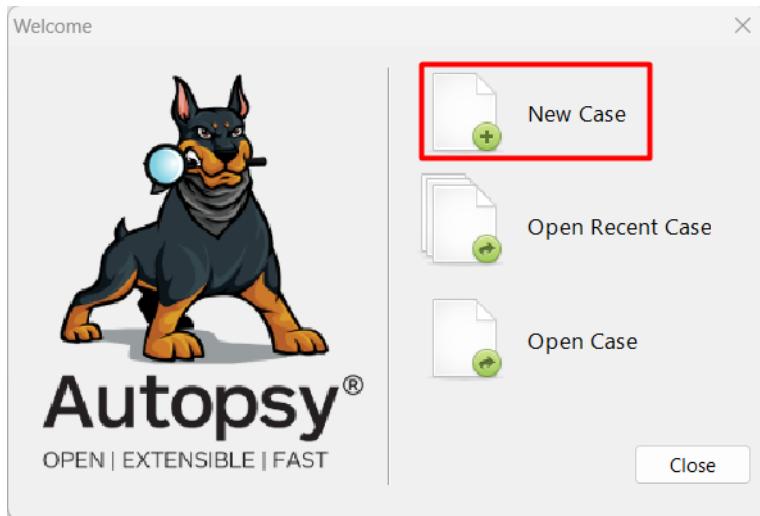
## Track Recovery Time

Event	Timestamp	Action / Context
Case Opened	2025-11-15 15:30:03.748	Start of the later, shorter session.
Case Closed	2025-11-15 15:39:07.285	End of the later session.

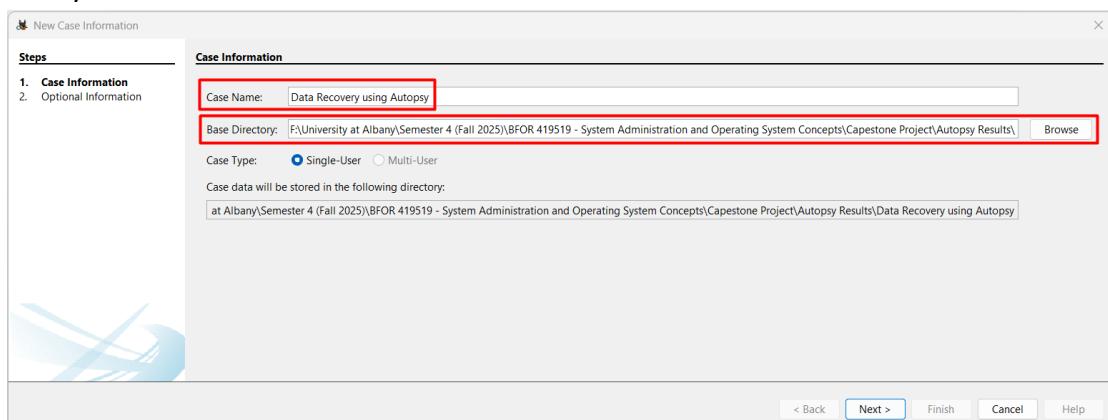
## Data Recovery – EXT4

### Open Autopsy & Case Setup

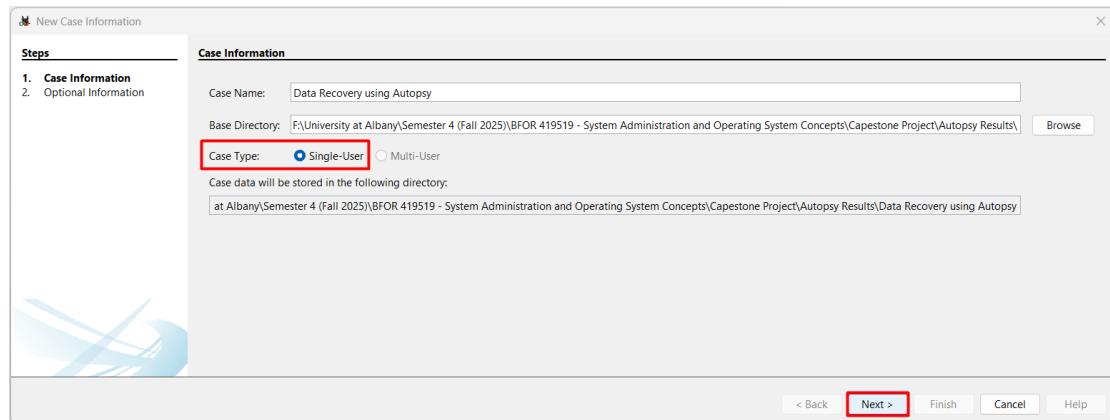
1. Now start autopsy, click New Case button in the welcome window.



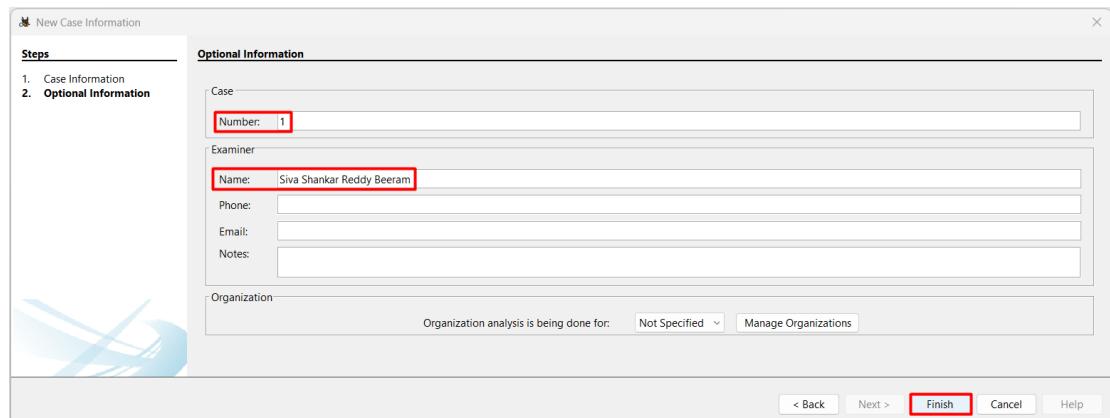
2. In the New Case Information window, enter Data Recovery using Autopsy in the Case Name text box and click Browse next to the Base Directory text box. Navigate to and click your Work folder.



3. Make sure the Single-User option button is selected for Case Type and then click Next.

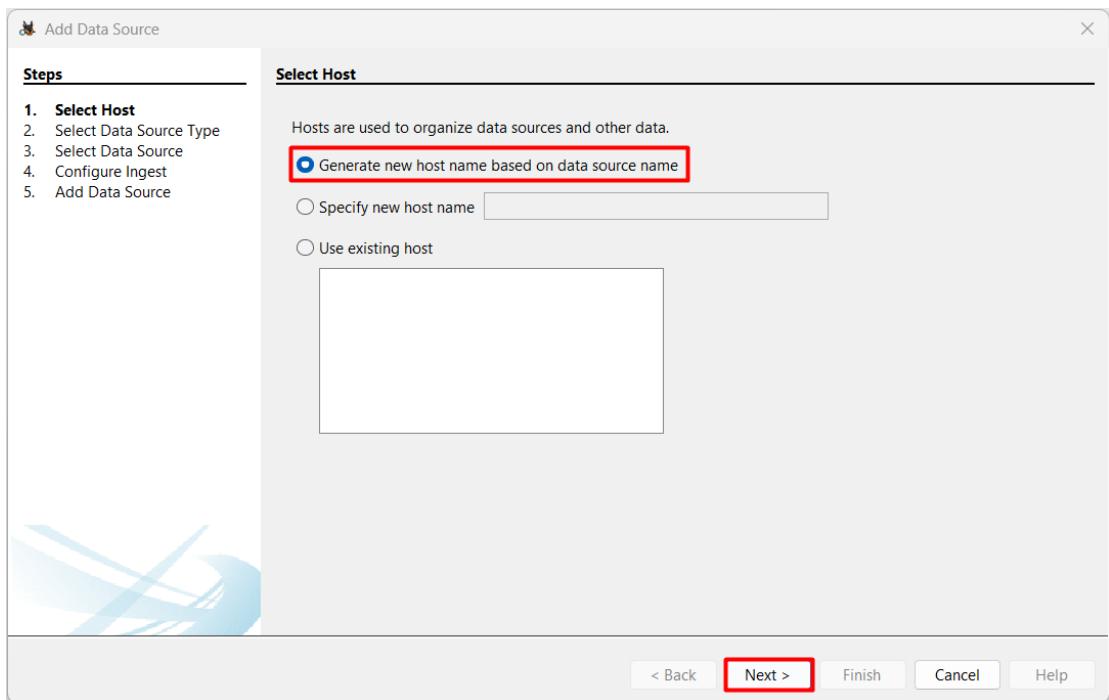


4. Now in the Optional Information window, type '1' in the Case Number text box and your full name in the Name text box in the Examiner section and Click Finish.

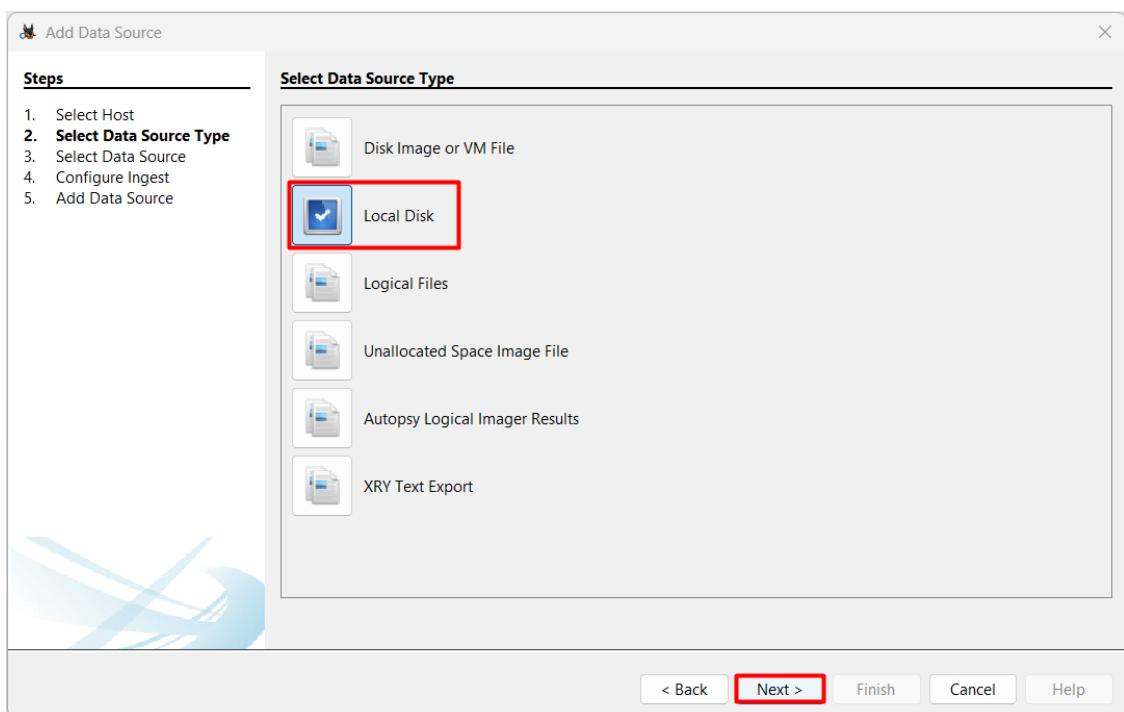


## ADD Data Source

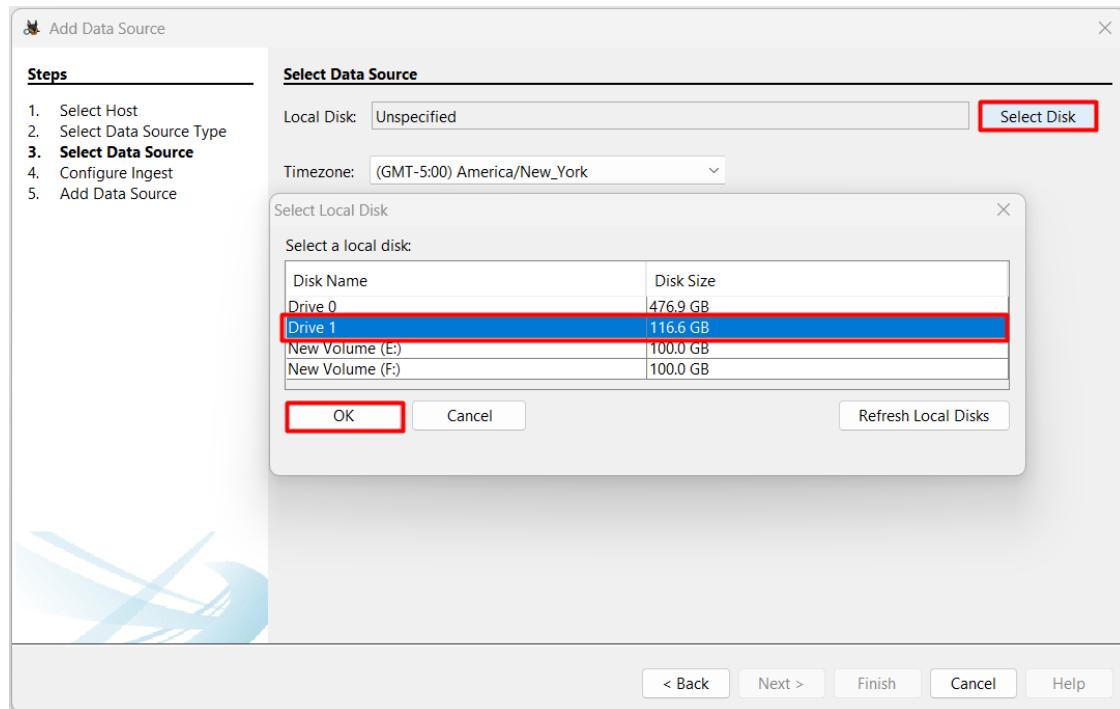
1. Select the option Generate new host name based on data source name in the select host step and click next to move to next step.



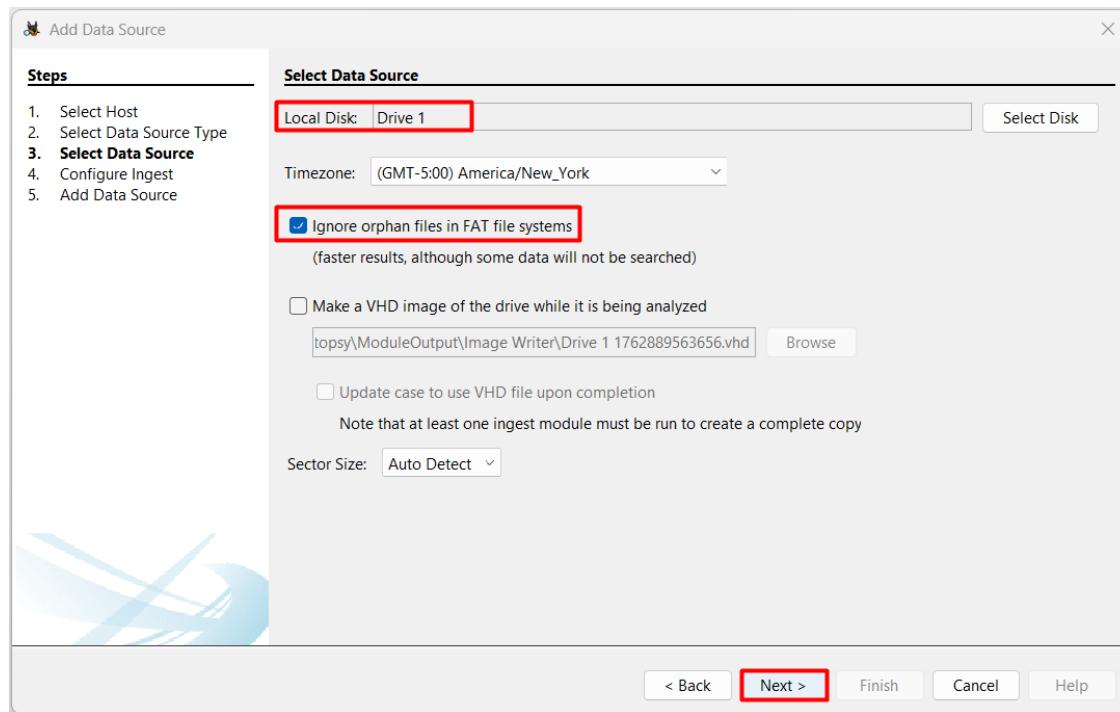
2. Now click on Local Disk button in the Select Type of Data Source to Add area of the Add Data Source window.



3. In the Select Data Source pane, click Select Disk and now choose Drive 1 (which is USB Drive used for this capstone project), now click ok.

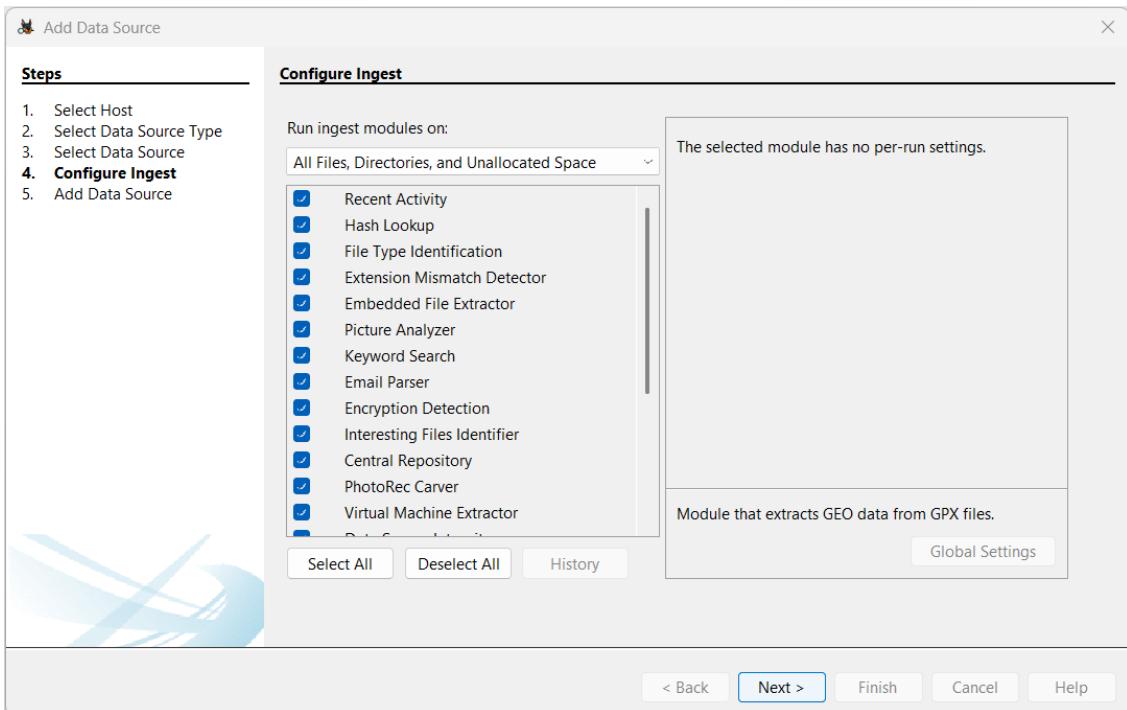


4. Now we can see the USD Drive (Drive 1) is selected and now check the box Ignore Orphan files in FAT file systems for fast results and click next.

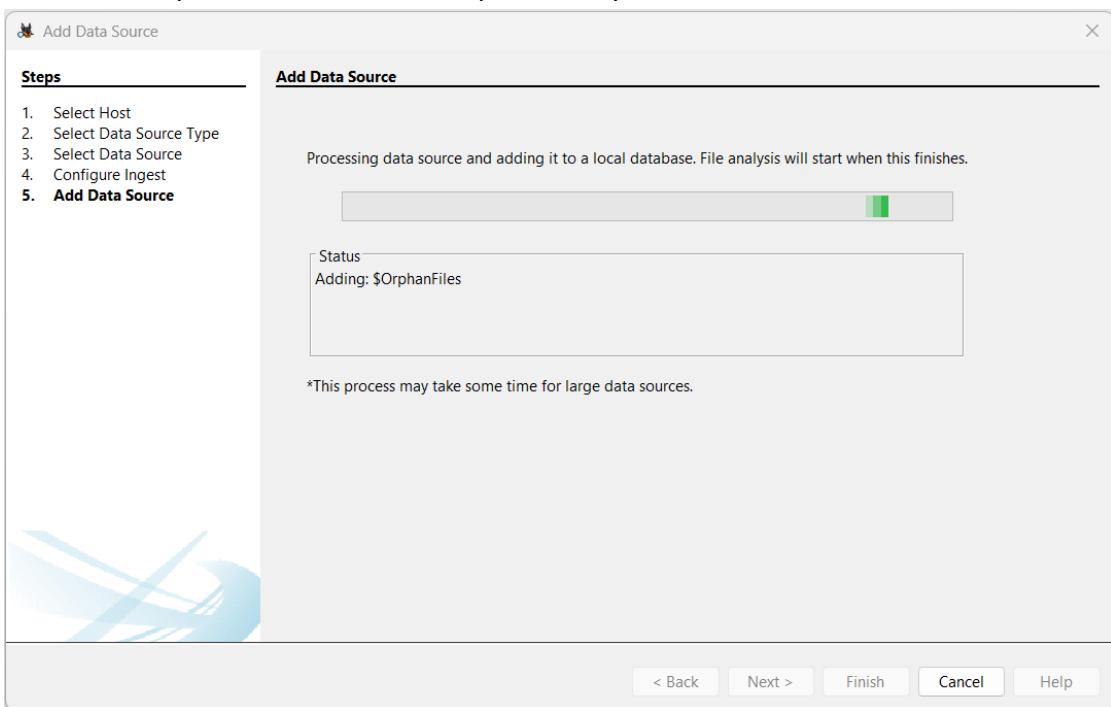


5. In the Configure Ingest area of the Add Data Source window, enable modules such as "File Type Identification" and "Carve Files." This ensures deleted file recovery and

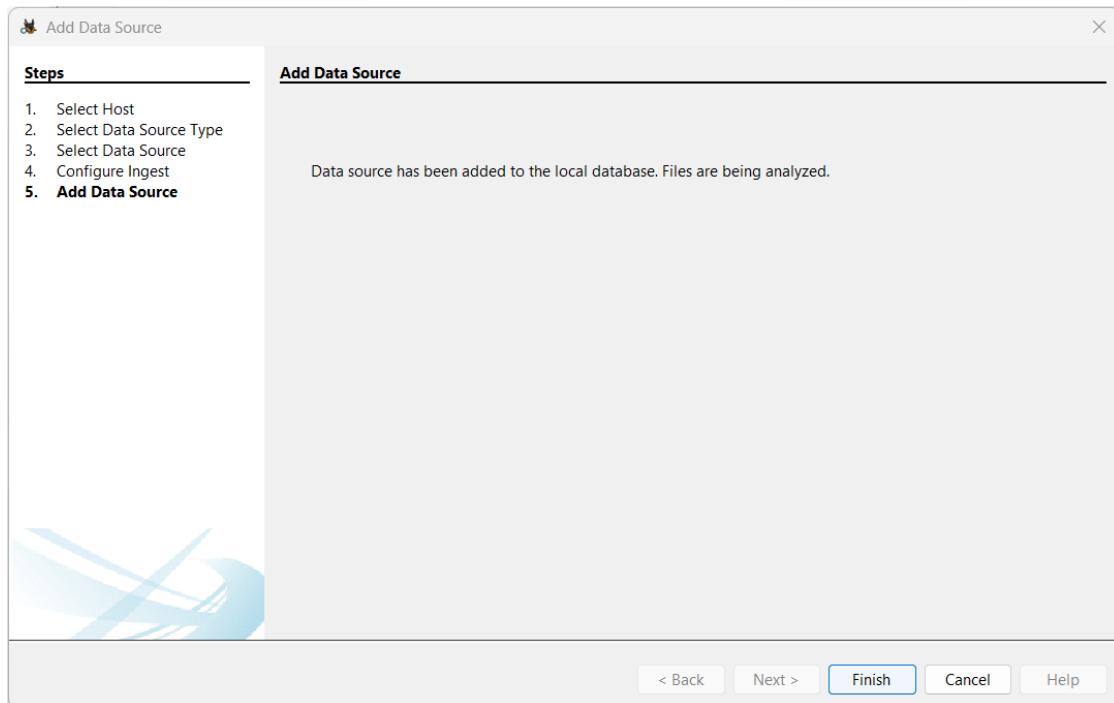
scans for both file system entries and raw fragments.



6. We can see the data is being analysed. Autopsy scans all content, including unallocated space, to find and attempt recovery of deleted files.

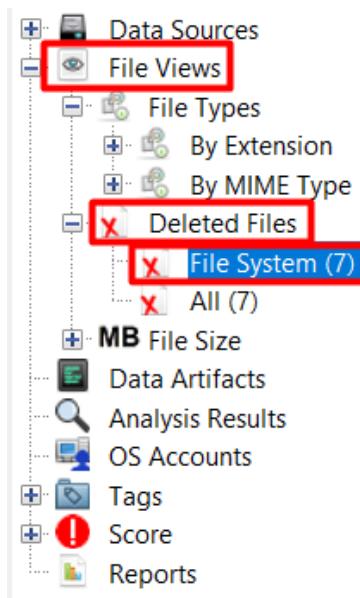


- Once the data is analysed successfully, we can see a successful message confirming that data has added.



## Browsing and Recovering Deleted Files

- Now in the Tree viewer panel (on the left-hand side), Expand “File Views” > “Deleted Files”



- In the Result Viewer pane (on the right-hand side), click on the files that we want to recover and now click Extract Files.

Listing File System 7 Results

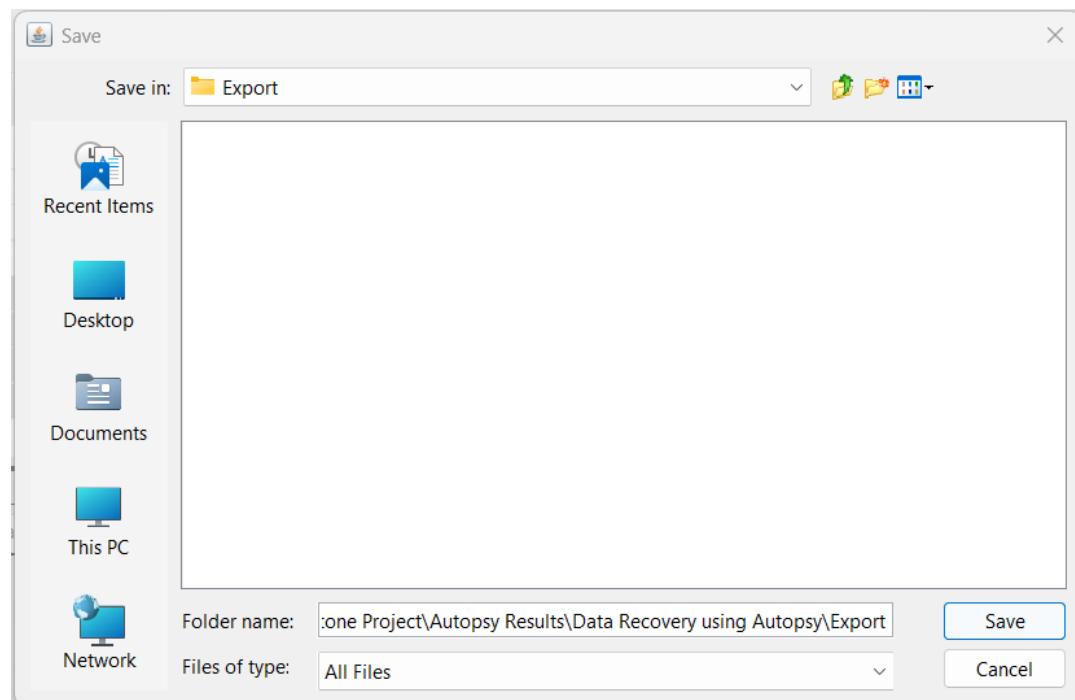
Name	S	C	O	Modified Time	Change Time	Access Time	Created Time	Size	Flags(Dir)	Flags(O)
X OrphanFile-12				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc
X OrphanFile-17				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc
X OrphanFile-18				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc
X Orphanfile-4718596				2025-11-15 13:36:41 GMT-05:00	2025-11-15 13:36:41 GMT-05:00	2025-11-15 13:36:41 GMT-05:00	2025-11-15 13:36:41 GMT-05:00	0	Unallocated	Unalloc
X Orphanfile-4718597				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc
X Orphanfile-4718598				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc
X Orphanfile-4718599				2025-11-15 13:45:33 GMT-05:00	2025-11-15 13:45:33 GMT-05:00	2025-11-01 16:39:20 GMT-04:00	2025-11-01 16:32:29 GMT-04:00	0	Unallocated	Unalloc

Save Table as CSV

Open in External Viewer Ctrl+E  
Extract File(s)  
Export Selected Rows to CSV  
Add File Tags  
Add Files to Hash Set (Empty File)  
Properties  
Show only rows where

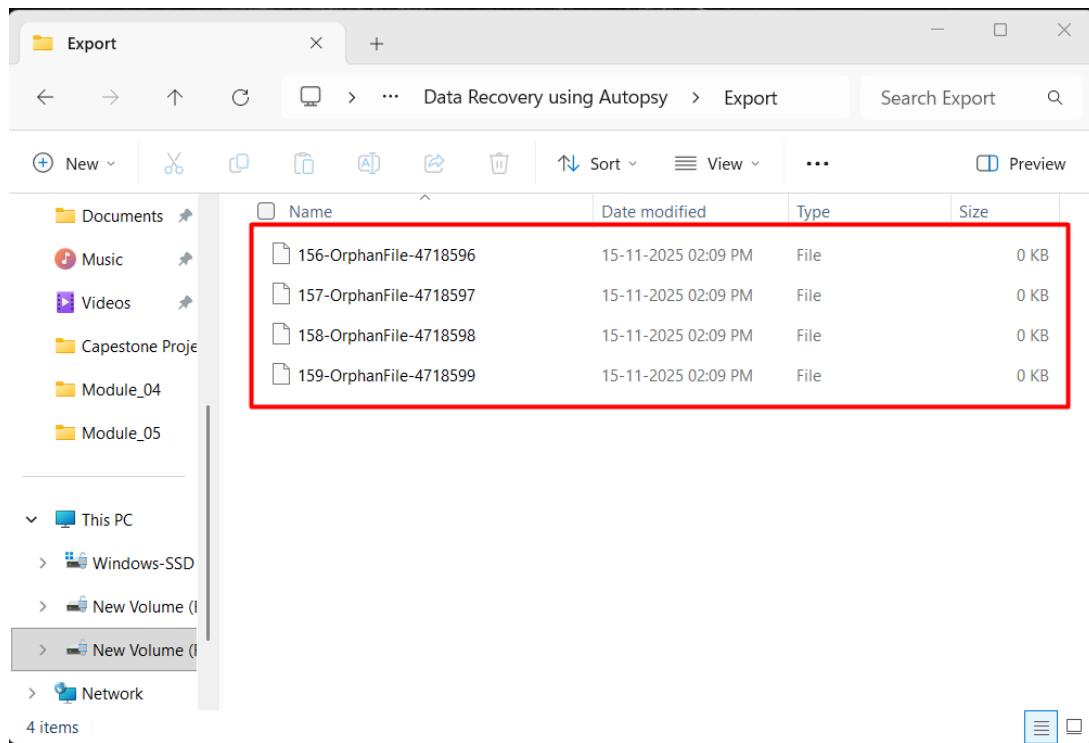
Hex Text Application File Metadata OS Account Data Artifacts Analysis

Click Save.



- Now Using File Explorer, navigate to the Autopsy Export folder, which will be located under your Work folder at F:\University at Albany\Semester 4 (Fall 2025)\BFOR 419519 - System Administration and Operating System Concepts\Capestone

## Project\Autopsy Results\Data Recovery using Autopsy\Export.



## Track Recovery Time

Event	Start Time	End Time
Case Opened	13:46:34.767	-
Case Closed	-	14:12:22.358
Ingest Job Attempt	13:49:21.781	13:49:24.208 (Cancelled/Finished)