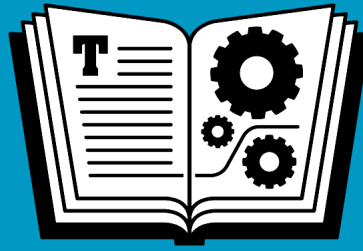


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TAKE CONTROL OF

YOUR DIGITAL STORAGE

**FOR
MAC**

by **JEFF CARLSON**

\$14.99

**2nd
EDITION**

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Read Me First

Welcome to *Take Control of Your Digital Storage, Second Edition*, version 2.3, published in July 2023 by alt concepts. This book was written by Jeff Carlson and edited by Joe Kissell.

This book guides Mac users through their ever-growing digital storage needs, from replacing or adding hard disks and SSDs to using network-attached storage (NAS) devices and cloud services. It demystifies deep-dive topics such as RAID, Apple’s APFS file system, creating and resizing volumes and partitions, and disk encryption, and it offers real-world advice on avoiding data loss due to failing storage, freeing up disk space, and choosing where data resides.

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Settings and Preferences

Until macOS 13 Ventura, you'd go to System Preferences to adjust systemwide preferences such as the size of icons that appear in the sidebar of Finder windows. Ventura changed the name to System *Settings* to be consistent with iOS and iPadOS nomenclature. However, it's not just a new name; System Settings is visually and organizationally different from what came before.

For example, in macOS 12 Monterey and earlier, to access the “Sidebar icon size” menu, you'd go to System Preferences > General. In macOS 13 Ventura and later, it's now located in System Settings > Appearance.

When items diverge like that, I detail both locations. If I need to point you to a setting in a consistent location in all versions, I refer to it as System Settings/System Preferences. For example, the controls that dictate how desktops are arranged over multiple monitors are found in System Settings/System Preferences > Displays.

What's New in Version 2.3

Storage seems like it would be a relatively static topic, but it's always changing. This version 2.3 incorporates the following changes:

- The book has been updated to reflect changes in macOS 13 Ventura and the forthcoming macOS 14 Sonoma, such as the new locations of system settings (see above) and updated screenshots.
- Added PCI Express (PCIe) to the discussion of [Solid-State Drives](#), which is specific to Mac Pro owners.

- It's quite something that Apple's entire Mac lineup now uses solid-state memory, which I've noted in several places, such as the discussion of [Hybrid Drives](#).
- In macOS Ventura, Apple added another level of security to protect against possible hardware attacks. Learn how [Accessory Security Protects Against Nefarious Hardware](#).
- I've removed references to Drobo, the company that made NAS devices but which went out of business in 2023. If you're still using a Drobo unit, it's time to look for an alternative; see [Features to Look for in a NAS](#).
- Backups are important to storage, and one of the big shifts with recent Mac models is that it's much more difficult to make clones that can start up the computer. So I've rewritten references to bootable backups to avoid confusion.
- In the discussion of [Disk Images](#), I recommend using sparse bundles, not sparse images, after reading some compelling data.
- Cloud services such as Dropbox and Google Drive now must store files in a different location on disk. At the same time, they've changed their behavior so files are stored on the cloud primarily, leaving placeholders on disk to conserve storage space. I cover the implications in [Cloud Storage](#).
- I updated some of the "rocket factory" diagrams and added a new one that shows how the system snapshot works in relation to other macOS core components. See [macOS Catalina and Later APFS Startup Volumes](#).
- The section on how to [Use FileVault](#) has been updated with information about how the feature works with Macs with M-series processors or Intel processors with T2 Security Chips.
- I added a section to [Manage Partitions](#) that explains how, under some circumstances, you can enlarge an existing partition that contains data.

What Was New in Version 2.2

The storage landscape continues to be interesting. The version 2.2 release incorporated the following changes:

- Now that SSDs are more common (and preferred), I moved [Solid-State Drives](#) into the first position in [Understand Storage](#).
- Apple’s current Mac lineup is finally populated only with solid-state storage, which is reflected in several areas, such as removal of some details of Fusion drives.
- Added Thunderbolt 4, and the various flavors of USB 3.2 and USB4, to [External Connections](#).
- Added discussion of the current [Cable Conundrums](#) surrounding USB-C cables.
- It’s feasible to [Build Your Own External SSD](#) to get good performance at more affordable costs, but the specs can be confusing. This sidebar explains the important terminology.
- Under [SoftRAID](#), I noted that SoftRAID 6.1 now supports volumes formatted as APFS (but with a limitation).
- Apple has again made APFS more complex under macOS Monterey by running the Mac from a mounted snapshot. See the details in [macOS Monterey and Later APFS Startup Volumes](#).
- I’ve moved [Manage APFS Volumes](#) before [Manage Partitions](#) now that APFS is the default file system.
- Throughout the book I’ve incorporated information for Apple Silicon-based Macs. For example, there’s a new process to [Run First Aid from macOS Recovery on an Apple Silicon Mac](#) and to [Restore an Entire Disk from a Snapshot](#).
- Another consequence of APFS startup volumes is that the built-in security now makes the topic of creating [Bootable Duplicates in macOS Big Sur and Later](#) much more complicated.

- Added a sidebar about the option to [Use the NAS as a Time Machine Destination](#).
- Noted that in macOS Big Sur and later, [Apple's Photos](#) app attempts to mount a network volume if images are stored there. Photos that are stored outside the default Photos library no longer display a special icon.
- Under [Choose Cloud Storage](#), added a note that Microsoft OneDrive now stores files just in the cloud by default, requiring you to take action to keep files and folders saved on disk.
- Disk Utility now has a non-Terminal method to [Manage Snapshots in macOS Monterey and Later](#).

Introduction

In an ideal world, this book wouldn't exist. You should never need to worry about the specifics of where your documents, photos, videos, and other files are stored, only that they're safe and accessible when you want them.

We live in the real world, though, and you're likely reading this because your current storage arrangement needs adjustment: You're running out of disk space. You need to replace or repair a drive that's not working, or you suspect a drive is on its last days. Perhaps you're in the market to buy a network-attached storage (NAS) device, but the sheer number of options is overwhelming. (Or, you might just like to learn new information. Hooray for curiosity!)

Storage mostly recedes into the background—until something goes wrong, or you need more of it, or you get a new computer and realize that what you really *should* do is re-evaluate your entire storage system.

So you dig in...and it's like opening a wall in your house. Which wires carry the electricity? Is that a cold water or hot water pipe? Is it even a water pipe? Are these old connections, or has some new technology emerged to replace them? And how did all that dust and crud get in here?

This is when knowledge of how storage works in your Mac helps immeasurably. The options are varied and can make even the most ardent technologist glaze over. But with an understanding of your storage options at hand, you can make better decisions that let you focus on the data that's important to you, not on finding or dealing with it.

Digital Storage Quick Start

As we expand our digital storage needs to consume more data, we also find ourselves expanding the ways in which we manage and work with that data. Although you don't need to read this book front-to-back, I recommend you go through the [Understand Storage](#) chapter to get a baseline on which the rest of the book is built.

Understand storage basics:

- Learn the differences between internal and external [Hard Drives](#) (and the many ways they connect to your computer).
- Learn the advantages of [Solid-State Drives](#) (SSDs) compared to traditional hard drives, and when to choose one or the other.
- If you're looking to expand your capacity, [How Much Storage Do You Need?](#)
- Learn about [Disk Images](#) and when you'd use them.

Understand RAID:

- Learn what a [RAID](#) is and under what circumstances you'd use one.
- Determine which of the [RAID Levels](#) is best for your situation.

Look to cloud storage:

- Use [Cloud Storage](#) such as Dropbox, iCloud Drive, and Google Drive to store data remotely.
- Learn about which types of data are applicable when you [Choose Cloud Storage](#), including the option to optimize storage on your Mac.

Learn about file systems:

- Understand [APFS](#) (Apple File System), Apple's new underlying file system, and its advantages.

- Learn about other file systems, such as [Mac OS Extended](#), MS-DOS (FAT), and ExFAT.
- [Manage Partitions and Volumes](#) using both APFS and Mac OS Extended, and learn how they work independently and together.

Use disk encryption:

- Use [FileVault](#) to protect your disk's data.
- [Encrypt a Non-Startup Volume](#) for security beyond your startup disk.
- What if you lost your password? [Recover Access to a FileVault-Protected Disk](#).

Manage drives:

- [Format a Disk and Erase Its Contents](#) using Disk Utility.
- [Run First Aid](#) when a disk seems ill (and understand [What First Aid Does](#)).
- [Identify a Failing Drive](#) before it's too late.

Work with Network-Attached Storage (NAS):

- Learn which [Features to Look for in a NAS](#) if you're in the market to buy one.
- Learn how to [Work with Files on a NAS](#).
- Since photography occupies so much storage, learn how to use [NAS for Photography](#). (Thanks to smartphone cameras, we're all photographers now, so don't skip over this section.)

Manage your data:

- [Determine Available Storage](#) on a disk (and know when that number might not be accurate).
- Learn smart strategies to [Free Up Disk Space](#).
- [Take Advantage of Local Snapshots](#) to restore data even when you haven't connected to an external Time Machine drive recently.

Understand Storage

Generally speaking, computer storage comes in two forms: solid-state memory and hard drives. Those can exist inside the computer, outside the computer (in external cases connected by a cable, or flash memory drives and cards), or as memory chips soldered directly to the computer's main logic board. This chapter looks at the structural details of how they work, which we will build on for other topics.

Storage Capacity

We think of drive capacity first when it's time to replace or upgrade storage. This comparison isn't practically relevant now, but bear with me, because it's fun to think about: The original Apple I and Apple II models included no storage, but you could connect a cassette player and store software on the same type of magnetic tape used for listening to music. Even the first Macintosh models relied on floppy disks for storage, not hard drives. In fact, hard drives didn't start to appear regularly on Macs until the Macintosh SE, with its *optional* 20 megabyte (MB) or 40 MB drive.

Today, the smallest capacity you can get for a Mac is 256 gigabytes (GB) of SSD storage (in the MacBook Air, 13-inch MacBook Pro, iMac 24-inch, and Mac mini). To put those numbers into perspective:

- 1 MB = 1,000,000 bytes
- 1 GB = 1,000 MB
- 1 TB = 1,000 GB

So, 1 terabyte is equal to *1 million* megabytes, or 50,000 Macintosh SE hard drives. For many uses, 1 TB is just the beginning—my photo collection alone exceeds 2 TB. As of mid-2023, you can buy single hard drives with capacities up to 22 TB, and external SSDs up to 16 TB. Those numbers will continue to ratchet up: single 26 TB hard drives

have been announced, and you can currently buy an SSD with a capacity of up to 100 TB for only \$40,000. (See [How Much Storage Do You Need?](#) to determine the capacity that will work for you.)

Solid-State Drives

Apple’s entire lineup of computers now uses solid-state media (commonly referred to as a solid state drive, or SSD), which is better than traditional hard disk drives in almost every way.

An SSD stores data in flash memory, which reads and writes data exceptionally fast. There are also no moving parts as in hard disks: no mechanical arm, no spinning platters, no sound, and no worry that a jostle might damage the disk (see [Hard Drives](#)).

The tradeoff with SSDs is capacity, both in terms of cost per unit of storage and overall amount of storage. Solid-state storage is still expensive compared to traditional hard drives, so SSDs offer less capacity for the money. As of mid-2023, \$100 can buy 1 to 4 TB of hard drive storage, but 500 GB to 1 TB of solid-state storage.

How SSDs Work

When a computer adds data to a standard hard disk, it locates a stretch of the platter marked as empty and writes the data in chunks. If an entire file does not fit in a continuous strip, pieces are written onto other areas where space is available; see [Disk Fragmentation \(and Why You Should Ignore It\)](#).

An SSD stores data in memory cells. Although the file system will attempt to write data in contiguous cells, writing and retrieval is so quick that it’s not as important to keep all the bits of a file together (**Figure 1**).

Format and Partition Disks

I'm a terrible handyman, and yet even I know that if you start a project on shaky ground or incorrect measurements, you'll wind up with cascading problems later.

So when we look at managing the data on a hard disk or SSD, we need to start at the base layer and work upward from there. The file system that undergirds macOS is an invisible, but essential, component of the operating system that controls how and where data is written on the sectors on a spinning platter or in the cells of a solid-state memory chip. For years, the file system wasn't anything most people had to think about, but with the arrival of macOS High Sierra in 2017, the default Mac file system changed from Mac OS Extended to APFS (Apple File System).

When you need to format a disk or split it into sub-volumes, you'll want to make an informed choice.

Understand File Systems

To be fair, the file system is still something that most people don't need to think about. If you've upgraded to High Sierra (or later) and your Mac has an SSD, it was automatically upgraded to APFS. You may notice faster copying and other file operations, but otherwise you shouldn't notice a big change—that's a good thing. macOS Mojave and later automatically upgrade the startup disk regardless of type, whether it's an SSD, mechanical, or Fusion drive; secondary or attached drives aren't converted. Before we get to formatting or partitioning a disk later in this chapter, let's cover the file system options you'll encounter and how they differ.

Mac OS Extended

The default Mac file system for years, Mac OS Extended (Journaled) is still in wide use, making it the most compatible option. Also commonly

known as *HFS+* (where HFS stands for Hierarchical File System), it's designed to read and write data to spinning disks using the read/write heads at the end of the armature.

The “journalled” parenthetical in the name refers to a method of error correction used to prevent bad sectors or other data abnormalities. When copying a file, for instance, the operating system may need to write it in pieces to several sectors on the disk; journaling checks to make sure all the pieces are successfully written and the file is intact.

The disadvantage to Mac OS Extended (Journaled), and the reason it's being replaced by APFS, is that it's not optimized for use with solid state storage. The physical location of a piece of data isn't as important within an SSD's memory cells as it is on the surface of a magnetic platter (see [Solid-State Drives](#)).

For our purposes, the important part of Mac OS Extended is the way it allocates space on a disk.

Imagine the disk is a factory that builds rockets. (I suppose I could instead use an office building as a metaphor, but wouldn't you rather imagine spaceships?)

On a disk formatted as Mac OS Extended, the factory is a giant open space where the rockets can be assembled, parts can be stacked in certain areas (or strewn across the floor, because they're all easily located, but the factory manager keeps things orderly). That's the free space on the disk.

There's also a secret door that opens to a hidden room filled with emergency equipment that nobody pays attention to unless something goes wrong on the factory floor. That room represents macOS Recovery, the invisible startup partition that runs a scaled down version of the operating system when you want to run repairs on your main macOS installation (**Figure 27**).

Use Network-Attached Storage (NAS)

When I asked a technical friend for his opinion on which kind of Network-Attached Storage (NAS) device to buy, his response mirrored my own (and perhaps yours, too): He'd been thinking about getting one, but the sheer number of variables involved kept him away from actually making a purchase.

A NAS itself typically looks like an unassuming largish box, sometimes with just a single drive, but more often with two or more drive bays into which you insert bare hard drives or SSDs (making it possible to upgrade the overall storage over time by using higher-capacity drives). The magic that makes it special is that it's also a computer in its own right, with a processor, operating system, and RAM to handle all of its tasks.

The NAS connects to the network via Ethernet cable, making it available to everyone else on the same network. And in many cases, the NAS can be accessed when you're outside the local network. If you arrive somewhere and realize that an important file is stored on a disconnected hard disk (even if you're on the couch downstairs and the drive is in the home office upstairs), it's no problem; that file is available just as if its drive was directly connected to the computer.

Several vendors sell NAS units, such as [Synology](#), [QNAP](#), and [WD](#). And among those, you'll find models designed for personal use, for small offices, and for industrial applications. In this section, I cover the thought process of determining whether you might want to get a NAS, look at the important features and components to help you choose one, and walk through the process of incorporating NAS storage into your situation.

Disclaimer: NAS devices come in many sizes, configurations, feature sets, and price ranges. It would be madness to try to cover all of them. So, in this chapter where I'm covering most of the major features to pay attention to in a NAS, I'm using the one I eventually purchased, a Synology model, as an example, not an endorsement.

Why You Might Consider a NAS

You've probably already put some thought toward this topic, or maybe you're looking at your current storage setup and hoping to streamline it. Let's walk through some of the reasons you'd consider buying a NAS:

- You want more storage, but having a drive physically connected to your computer is limiting. I've used laptops as my main Macs for years, precisely because they're mobile. If I'm working in my living room, I don't have to trudge to my home office and plug in a drive to access files, because I can easily [Mount the NAS Volume in the Finder](#).
- You want that storage to be centrally located. "Out of sight is out of mind," as the saying goes, so if I have to guess which of the various drives on my shelves (and closet, and drawers) contains the files I need, the data may as well not exist. The simplicity of knowing that everything you need is in a central location means you're not expending time and brain power searching.
- You want data to be available to anyone else on your home or work network. Family members or colleagues can access all the same files, or you can set up access for individuals. A NAS isn't just a big hard drive—it has an operating system and sophisticated networking features and user permissions.
- You want private access to files. In many ways, cloud services such as Dropbox or Google Drive perform the same storage tasks as a NAS. However, everything runs through those companies' networks, and can be accessed (in various degrees) by their employees.

Manage Your Data

At one point, having all your data on one internal disk was sufficient, but smaller-capacity SSDs and other factors have made storage more complicated. In this chapter, I recommend strategies for choosing which data belongs where—internal storage, external storage, or in the cloud—and how to free up disk space. The goal, as much as possible, is to make sure your stuff is easily accessible and to avoid any surprises.

Choose Your Own Storage Adventure

It's tempting to start shoving data onto other disks when your primary storage fills up, like cramming stuff into a closet when you need to clean a room quickly. That gets the data out of sight, but also out of mind, making it harder to find later. Plus, some types of information need to stay on the internal disk, while others are more suited to external or cloud storage.

Choose Internal Storage

Setting aside nontrivial components like the system itself and apps, you generally want to keep active project files and documents you use on a daily basis on the internal disk. Basically, that includes anything that would interrupt what you need to do on the computer if the data were unavailable. Leave the `/System` and `/Library` folders alone.

For performance reasons, you may want to keep local scratch files used by Photoshop or video editing apps on your startup disk, even though those can temporarily occupy a lot of space. The speedy solid-state memory built into the latest Mac models will give you better performance than mechanical disks. That said, this is highly dependent on your computer, the amount of RAM installed, and the level of editing you're doing. Serious editing pros typically set up an external drive or a RAID 0 array dedicated solely as a scratch disk.

Note: The flip side of using solid-state storage for scratch files is that the frequent data writes shorten the SSD's lifespan. However, SSDs are designed to last for hundreds of terabytes of use. As always, your mileage may vary.

Choose External Storage

Data you shunt to an external disk is usually old, large, or both. Material you don't need to access day to day can be archived on an external drive; if you have a NAS, you can easily grab the data when you need it (see [Work with Files on a NAS](#)).

Large files seem ideal for transferring to an external disk, since they're usually the first space hogs that you identify when you're looking to [Free Up Disk Space](#). However, that approach can be mixed, depending on the data. Some common considerations include:

- **Virtual machines:** The disk images created by Parallels Desktop and VMware Fusion tend to be huge, because they contain entire operating systems and computing environments. Moving them off your internal storage can slow their performance unless the destination is a fast SSD connected via USB 3.0 or Thunderbolt.
- **Music and videos:** Your Music or iTunes library is composed of many music and movie files you probably don't consume every day, so moving it to an external disk will often free up a lot of disk space. (See [Manage and back up your iTunes media library](#) for detailed steps on how to accomplish the move.) However, the library must be on a disk that's always connected to your Mac, otherwise you can't access the media.

Another option is to keep the Music or iTunes library database on your internal disk, but reference the media files themselves from an external drive. To do this in the Music app, go to Music > Settings/Preferences > Files, and then turn off "Copy files to Music Media folder when adding to library" (**Figure 69**). In iTunes, go to iTunes > Preferences > Advanced, and then turn *off* "Copy files to iTunes Media folder when adding to library." When you import new media

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Shameless Plug

I produce a lot of creative material—something which I'm honored to be able to do—including photographs, books for *Take Control* and

Rocky Nook, the [PhotoActive](#) and [Photocombobulate](#) podcasts, and articles for Macworld, DPReview, CreativePro, and other outlets. Find my work at [jeffcarlson.com](#) and sign up for my [low-volume newsletter](#) to learn about new projects and occasional deals and giveaways. Thank you!

About the Publisher

alt concepts, publisher of Take Control Books, is operated by [Joe Kissell](#) and [Morgen Jahnke](#), who acquired the ebook series from TidBITS Publishing Inc.'s owners, Adam and Tonya Engst, in 2017. Joe brings his decades of experience as author of more than 60 books on tech topics (including many popular Take Control titles) to his role as Publisher. Morgen's professional background is in development work for nonprofit organizations, and she employs those skills as Director of Marketing and Publicity. Joe and Morgen live in Saskatoon, Saskatchewan, Canada, with their two children.

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