



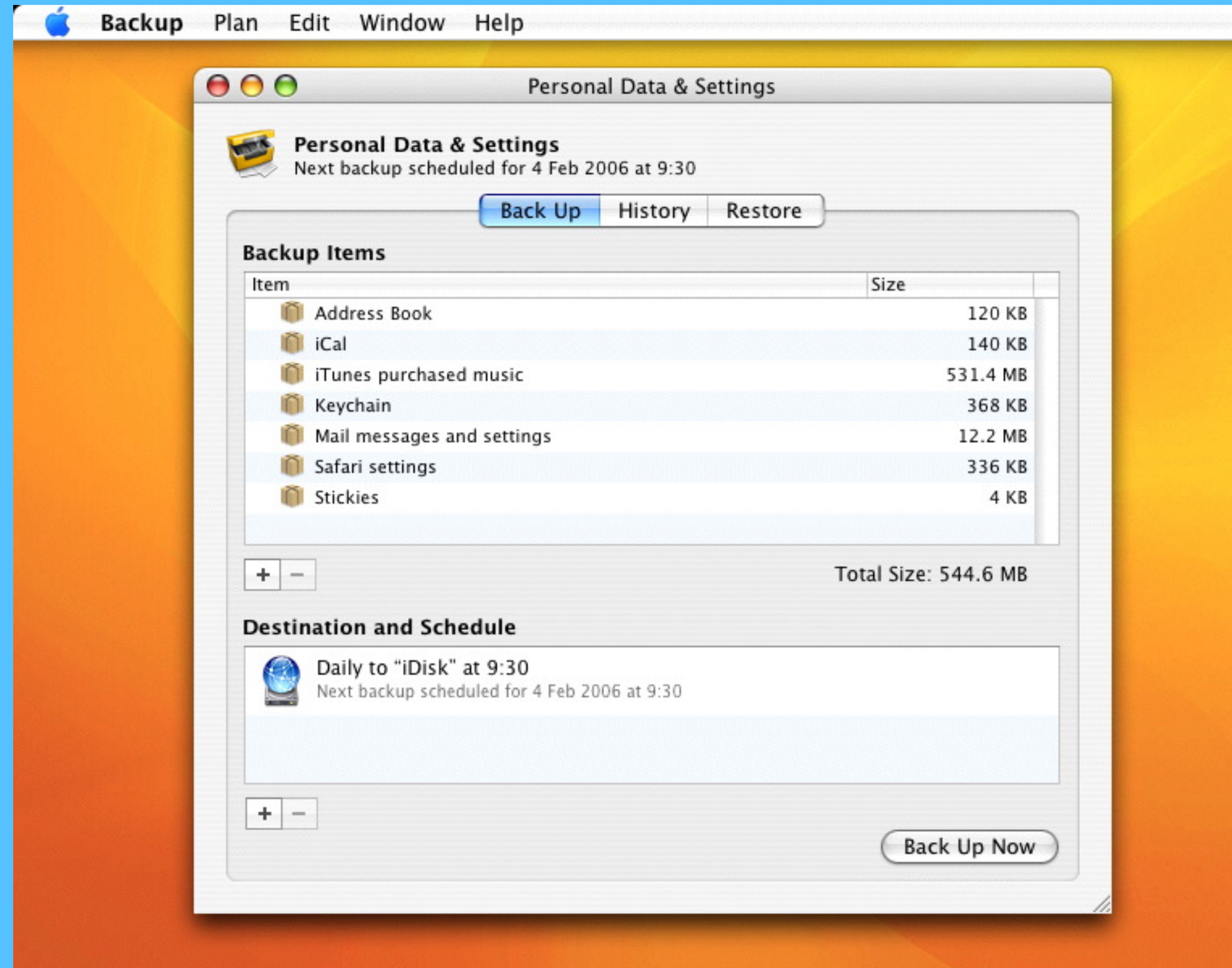
# Time Machine to APFS

a 14-year journey

Howard Oakley



# Backup early 2007







# Time Machine

## October 2007

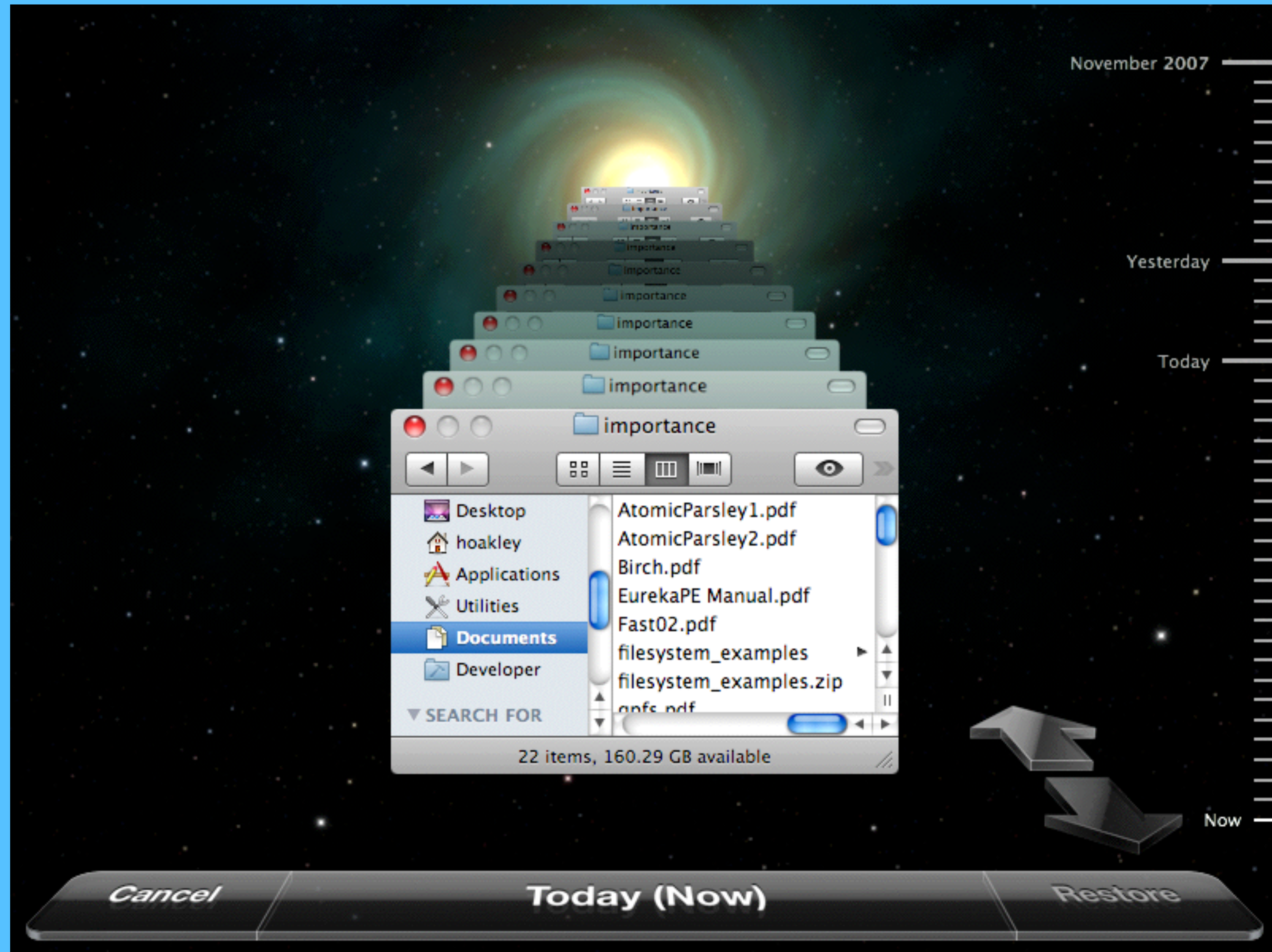






# Time Machine

## October 2007







# Time Machine

**October 2007**

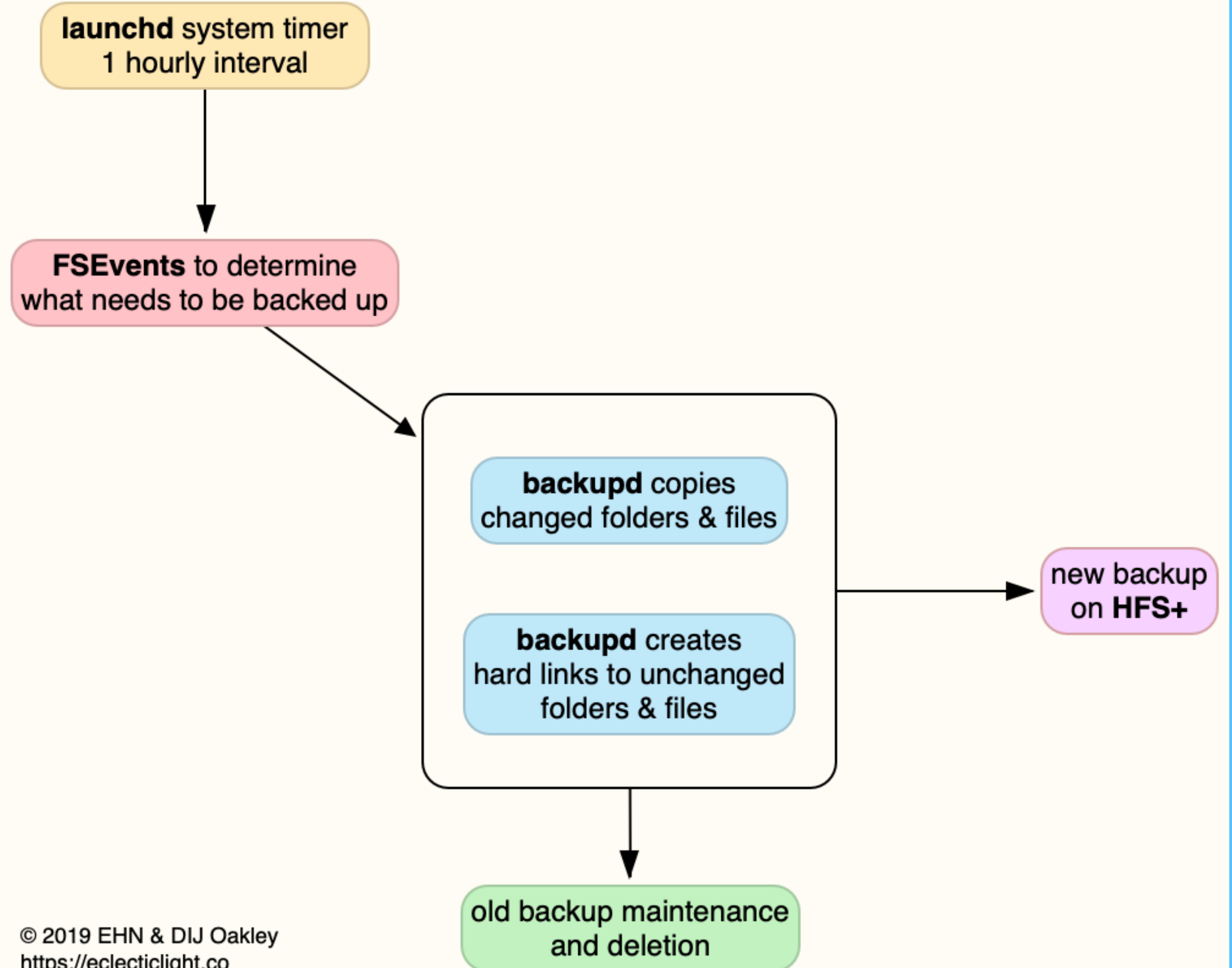
- hourly backups via launchd
- FSEvents scan to discover changed files
- exclusion list
- whole changed files copied
- unchanged directories and files use hard links
- backup tree to create illusion
- all stored in a single HFS+ file system



# Time Machine

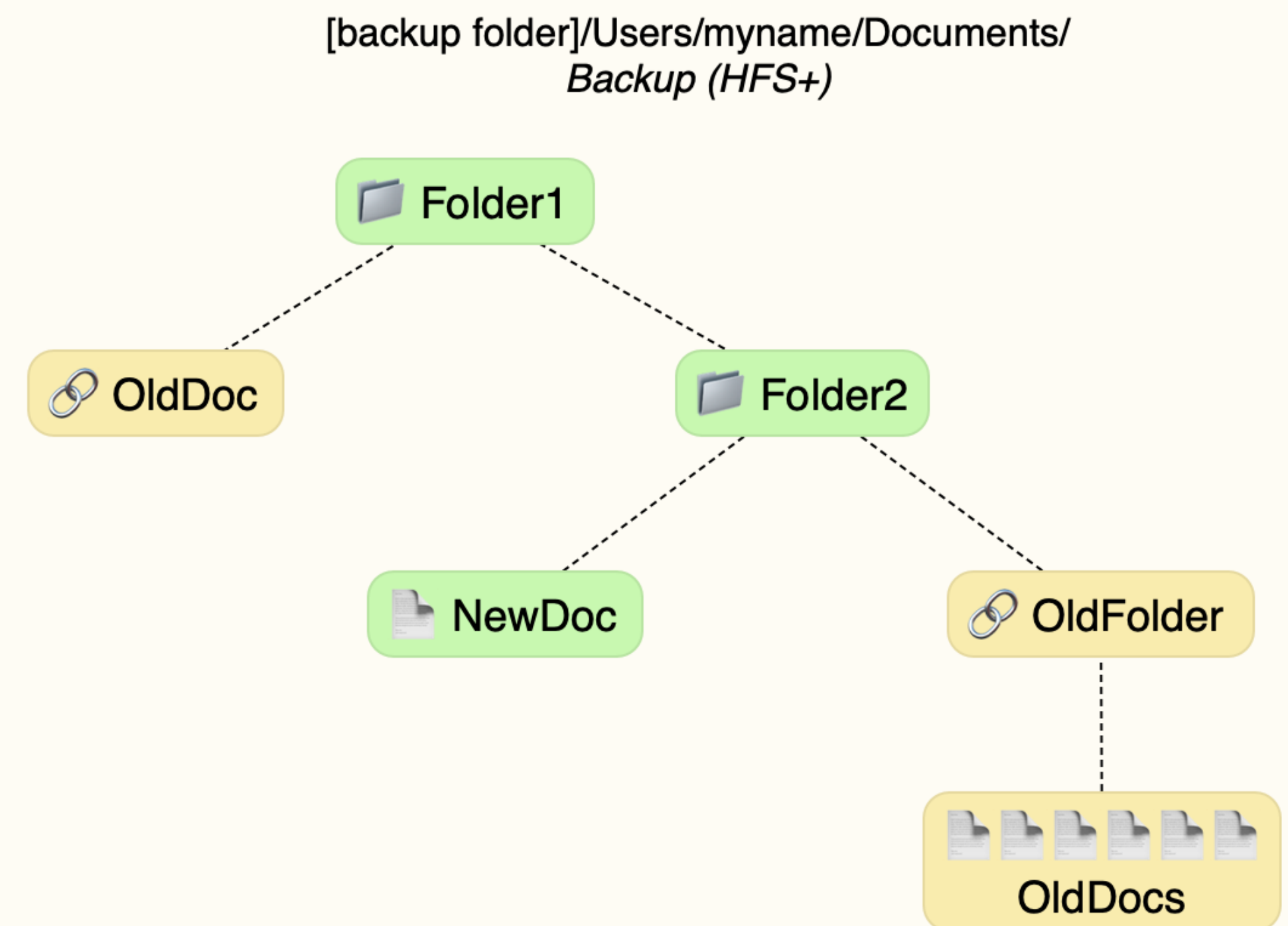
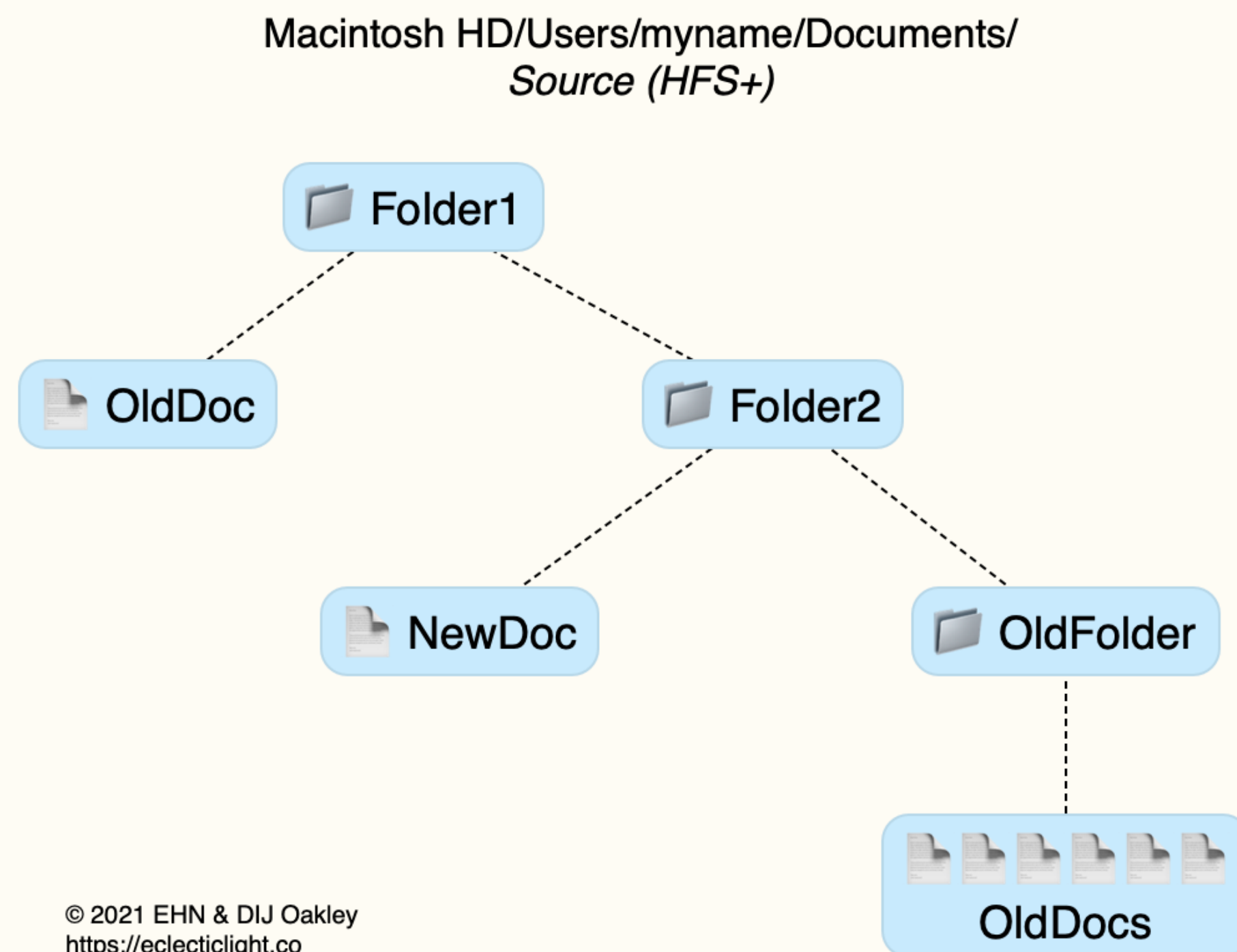
## October 2007

### Time Machine: Mac OS X 10.5





## Traditional HFS+ Backup





# **Time Capsule**

## **February 2008**







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eclecticlight.co

## APPLICATION

## CTS

## DAS

Waiting

DAS rescoring of activities

**DAS assessment**  
DAS CurrentScore > ThresholdScore  
DAS DecisionToRun:0

DAS rescoring of activities

**DAS assessment**  
DAS CurrentScore > ThresholdScore  
DAS DecisionToRun:1

Running

**CTS runs activity**  
DAS told us to run com.apple.backupd-auto  
evaluating activities  
com.apple.backupd-auto state change 1 -> 2  
Initiating XPC Activity: com.apple.backupd-auto  
taking power assertion: com.apple.backupd-auto: 35264

**Runs backupd-auto**  
which then runs backupd to perform backup

**Activity completes**  
com.apple.backupd-auto state change 2 -> 5  
Completed XPC Activity: com.apple.backupd-auto  
Completing DASActivity: 0:com.apple.backupd-auto

**Activity rescheduled**  
Rescheduling XPC Activity: com.apple.backupd-auto  
Submitting DASActivity: <\_DASActivity: "0:com.apple.backupd-auto", Utility, 60s, [12/05/2017, 10:01:23 - 12/05/2017, 10:03:23], Plugin Required, Dark-Wake Eligible>  
releasing power assertion: 35264

Updated in DAS activities



# High Sierra: APFS

**September 2017**

- modern file system
- copy on write for reliability
- snapshots; previous Mobile Time Machine was  $> 10,000$  lines of code
- no directory hard links
- clone files
- sparse files

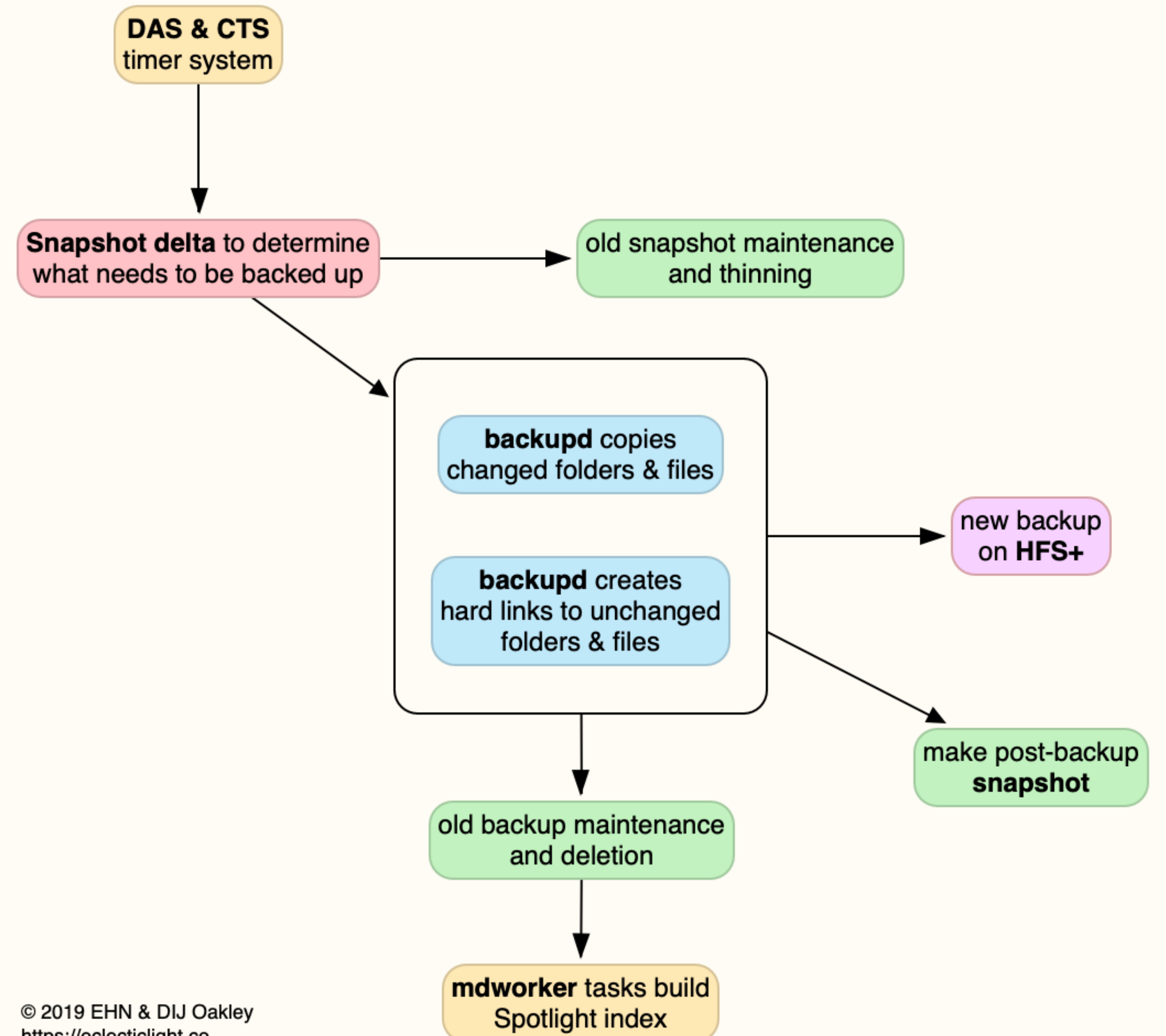




# macOS Mojave

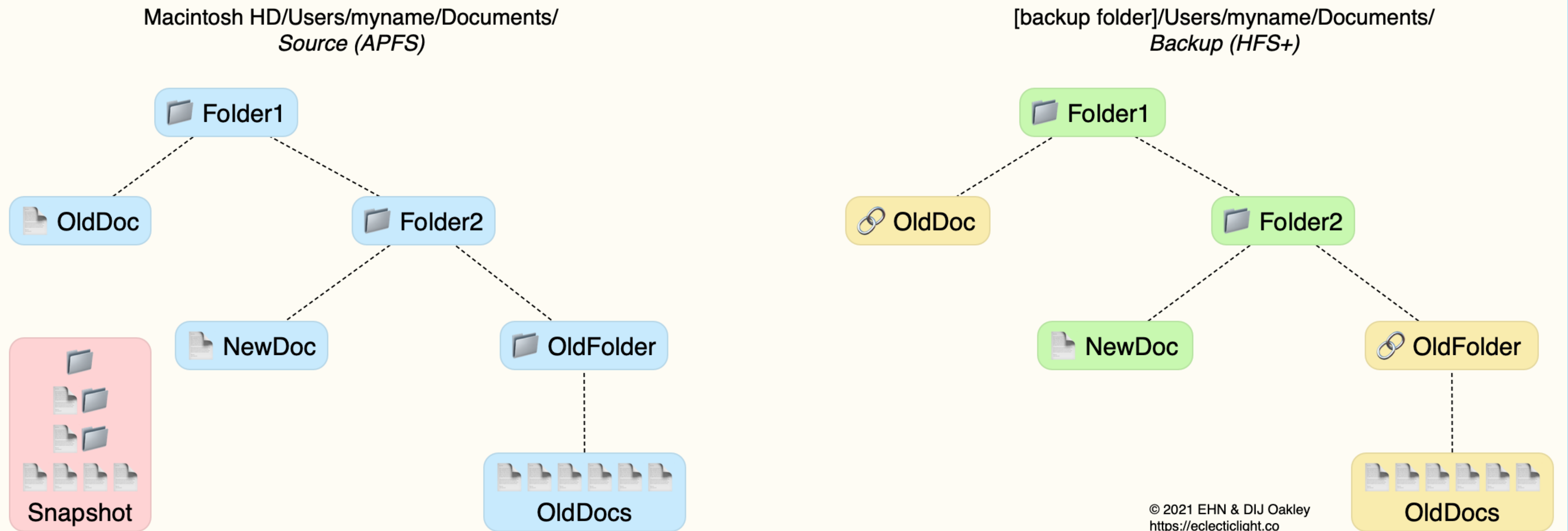
## September 2018

### Time Machine: macOS 10.14 + APFS





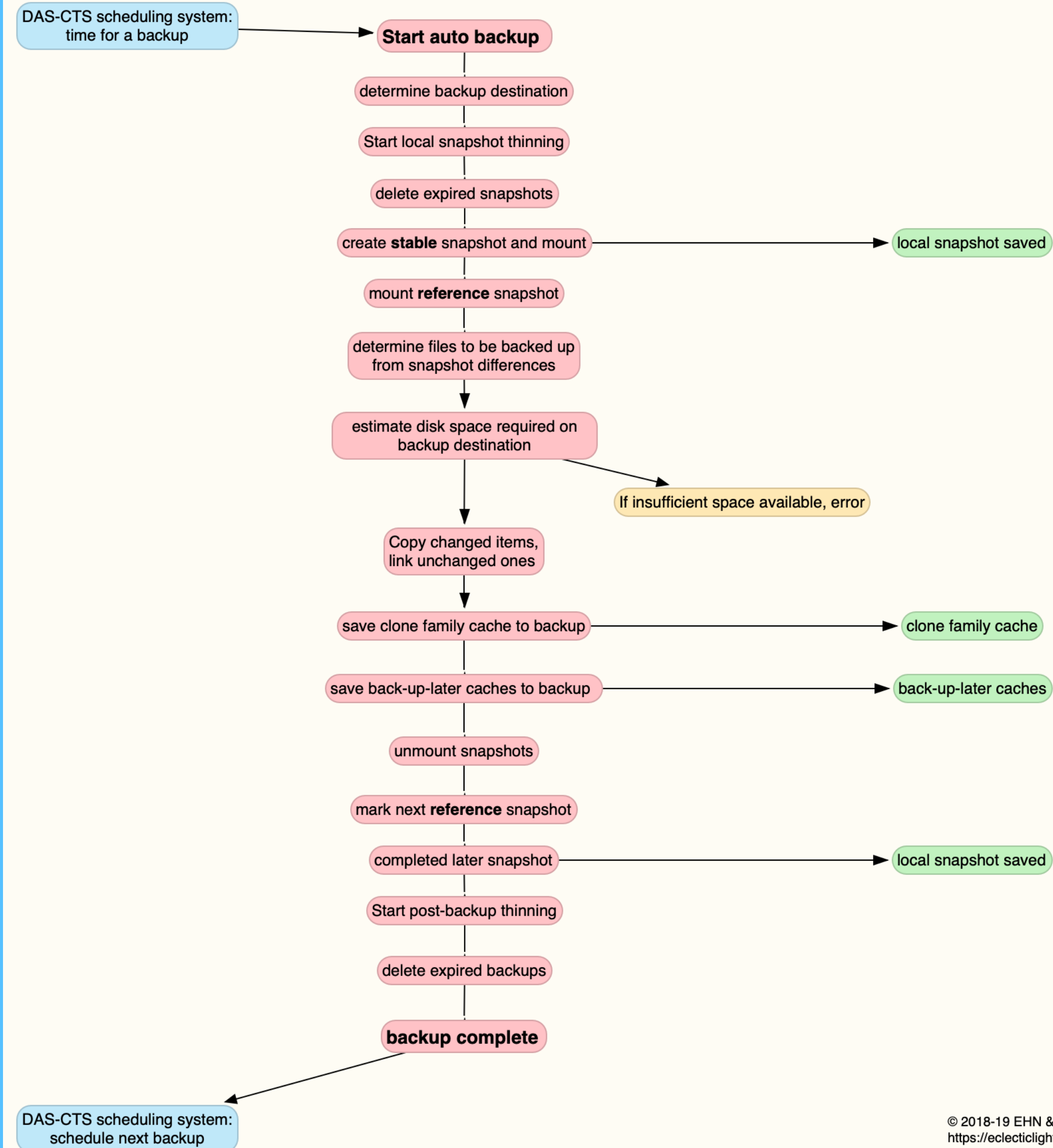
## Mixed APFS & HFS+ Backup







## Time Machine backups from APFS (10.13-10.14)

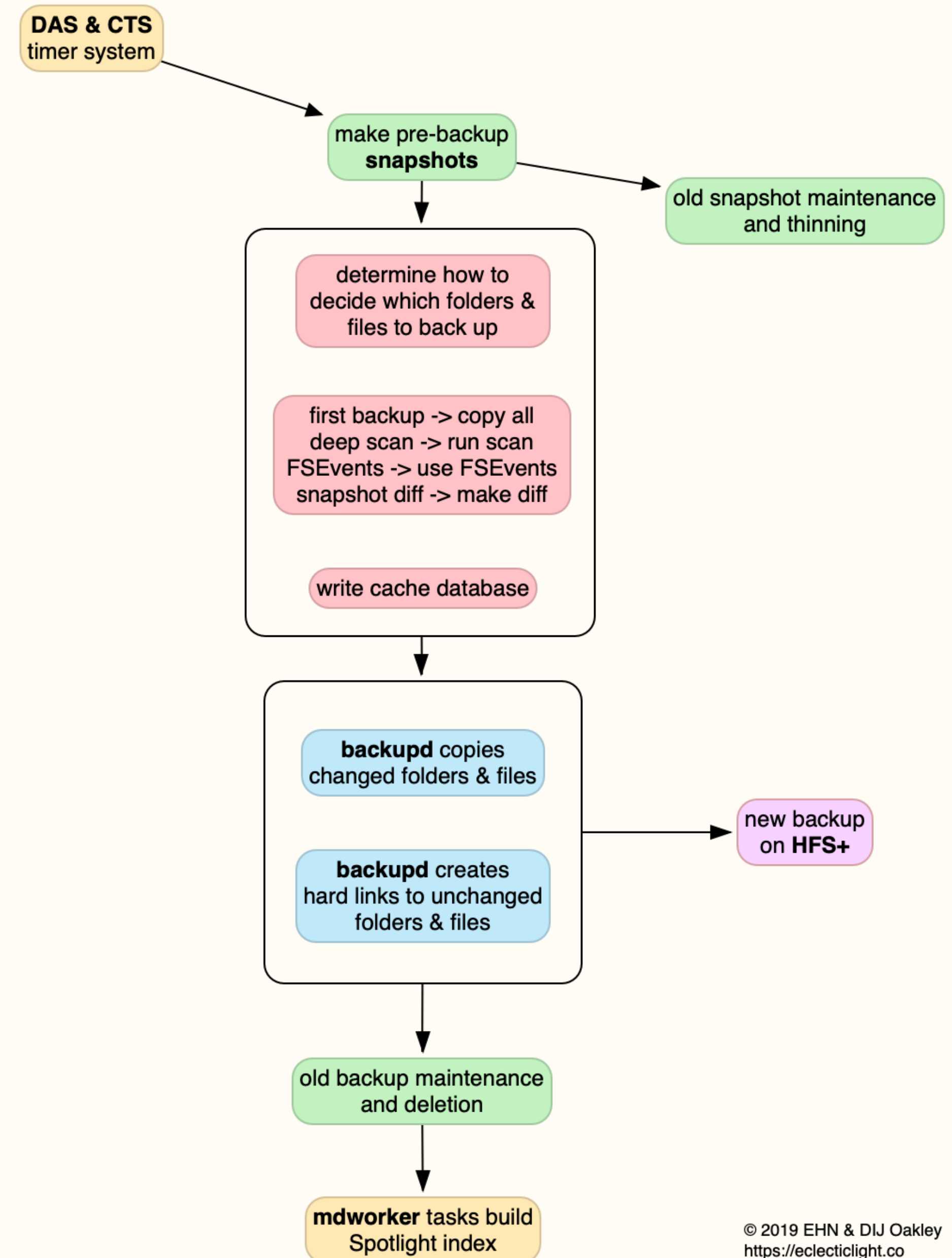




# macOS Catalina

## October 2019

### Time Machine: macOS 10.15 + APFS



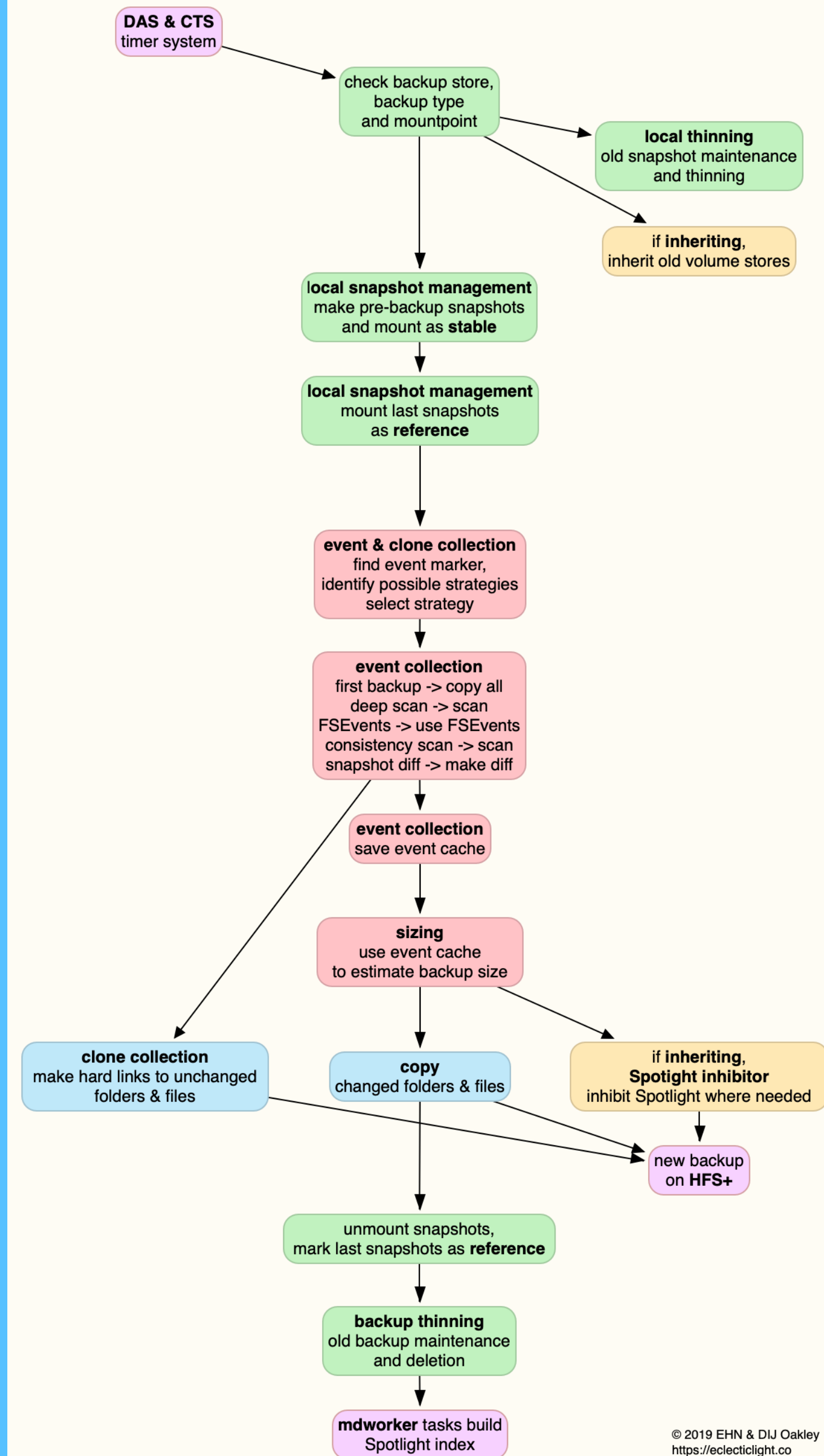




# macOS Catalina

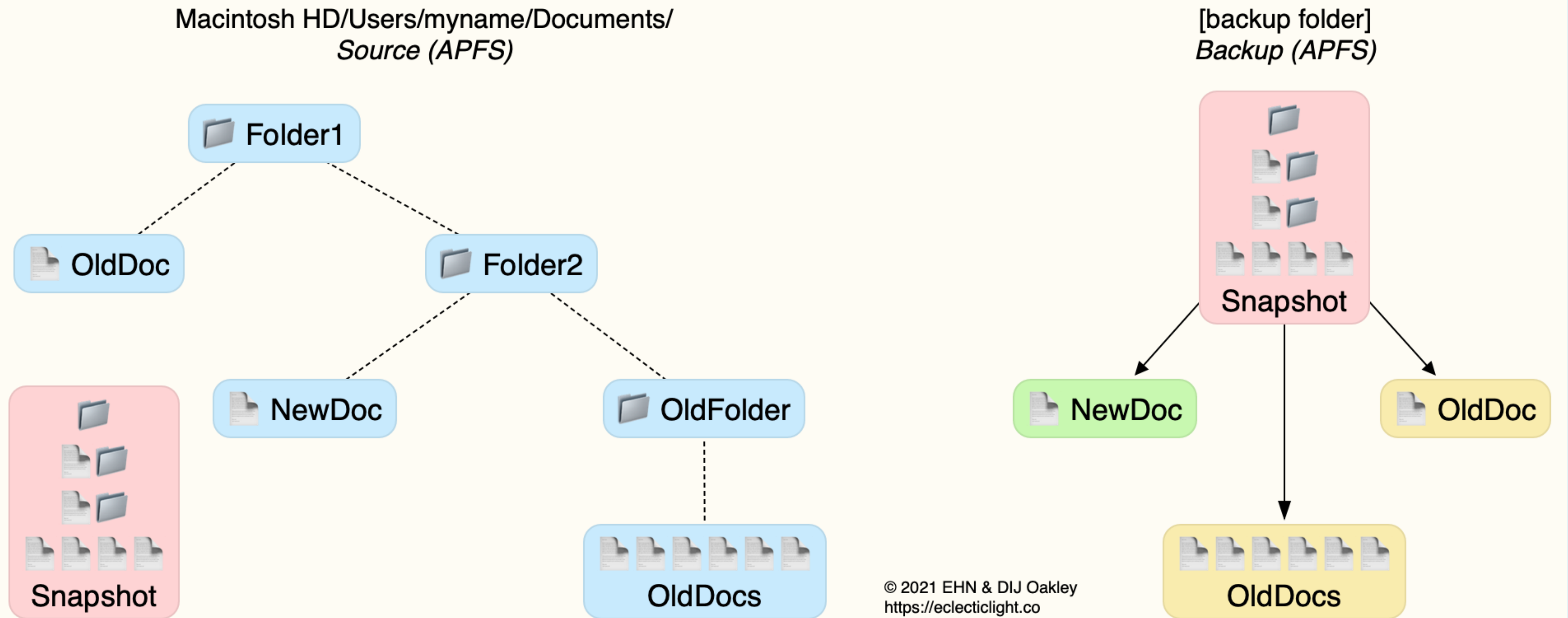
## October 2019

### Time Machine: macOS 10.15.2 + APFS





# New APFS Backup



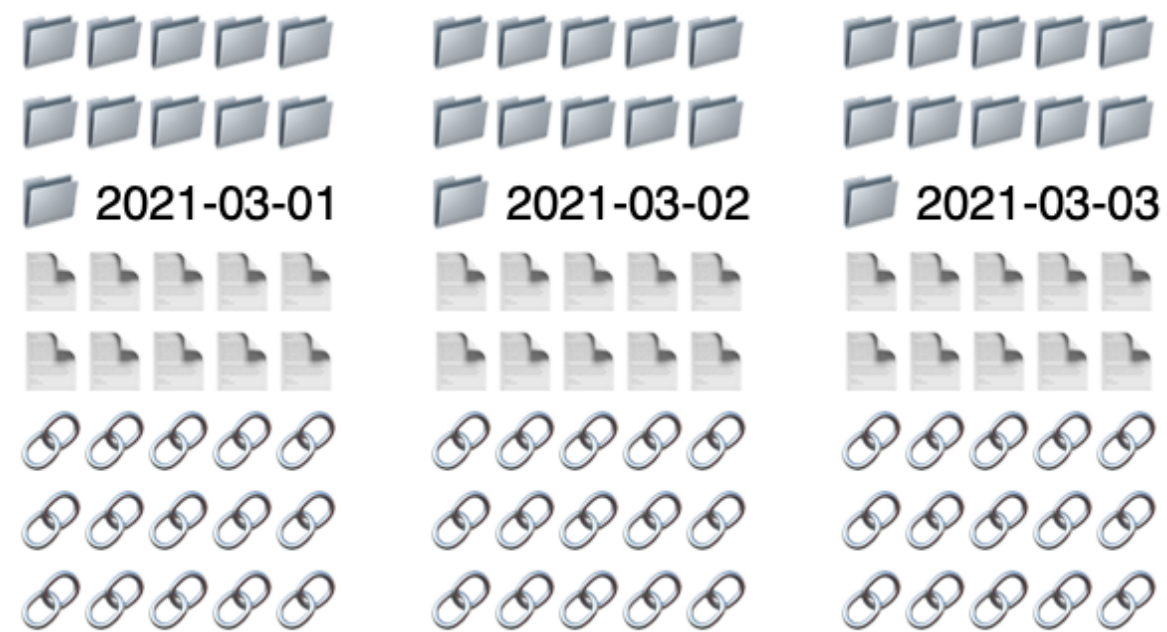




# Comparison of Backup Disk Structure for Time Machine

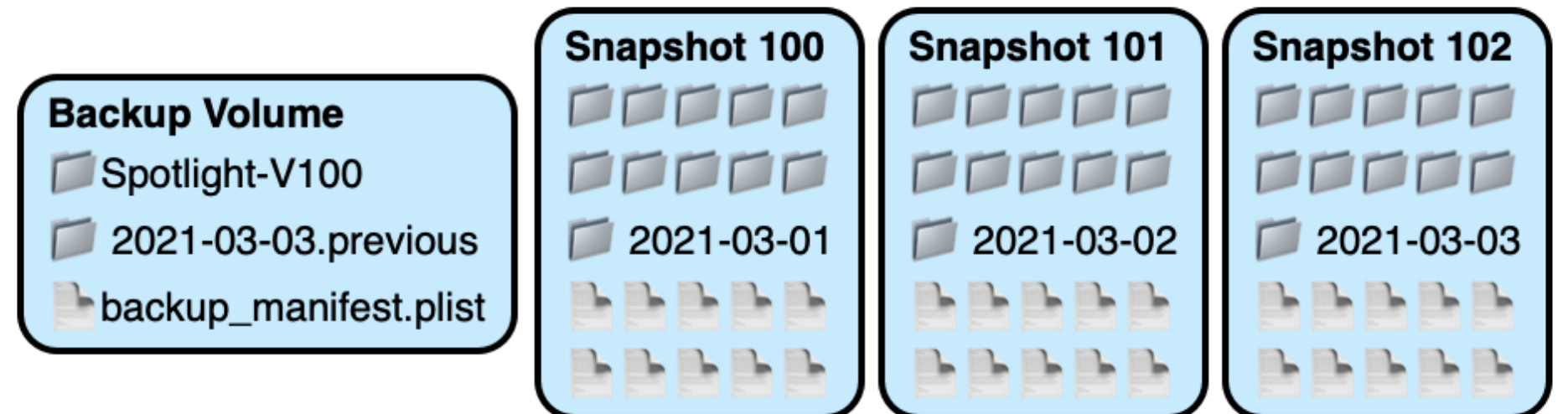
## TMH

HFS+ volume (partition)



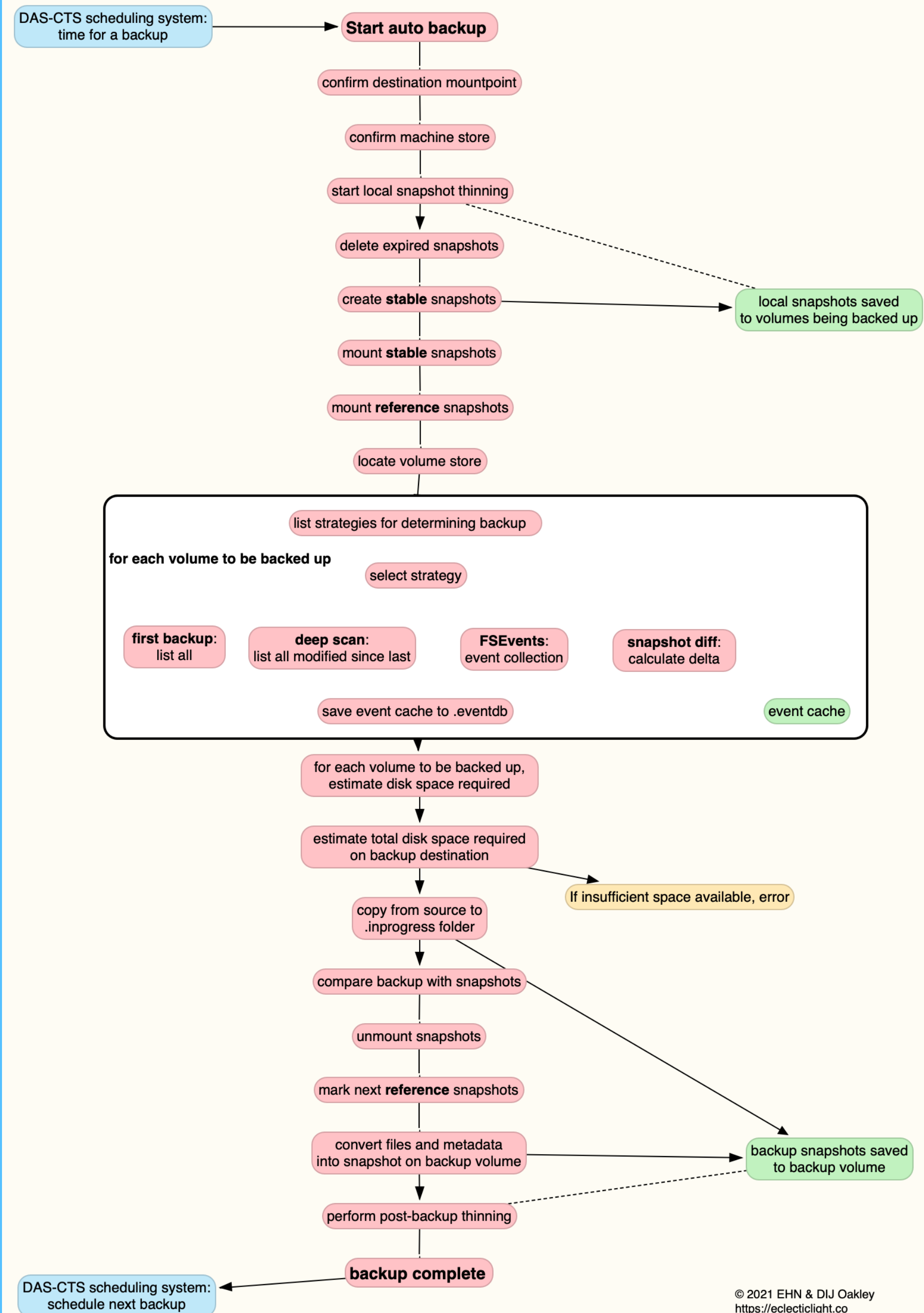
## TMA

APFS container





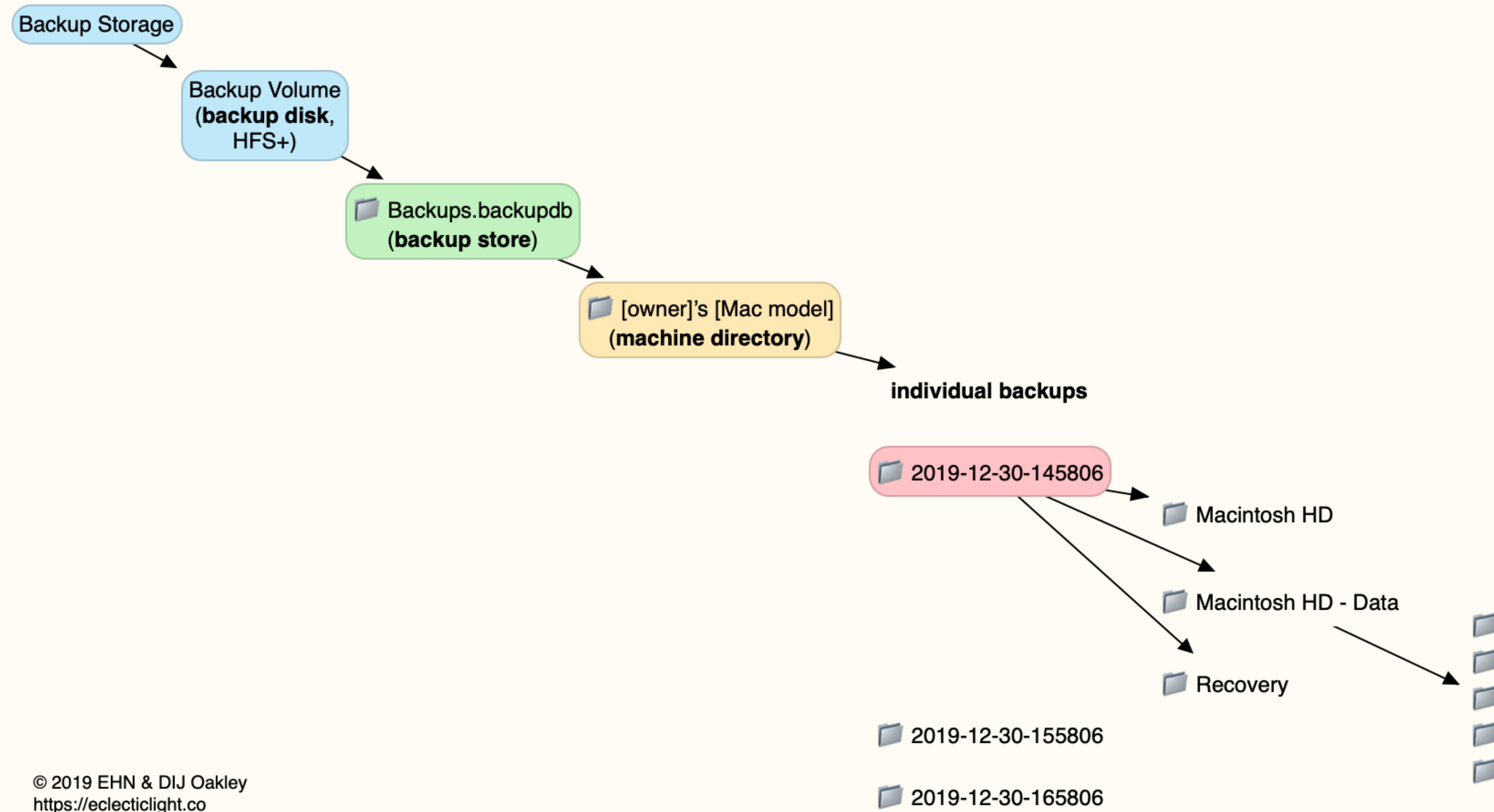
## Time Machine backup to APFS (macOS 11)





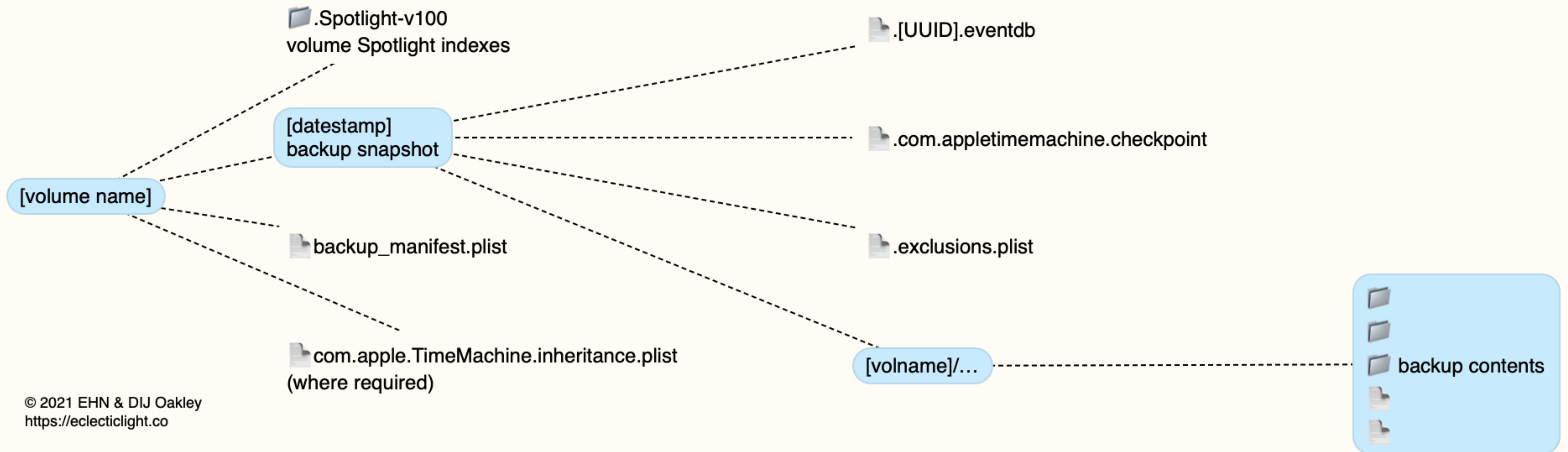


# Structure of Time Machine Backups





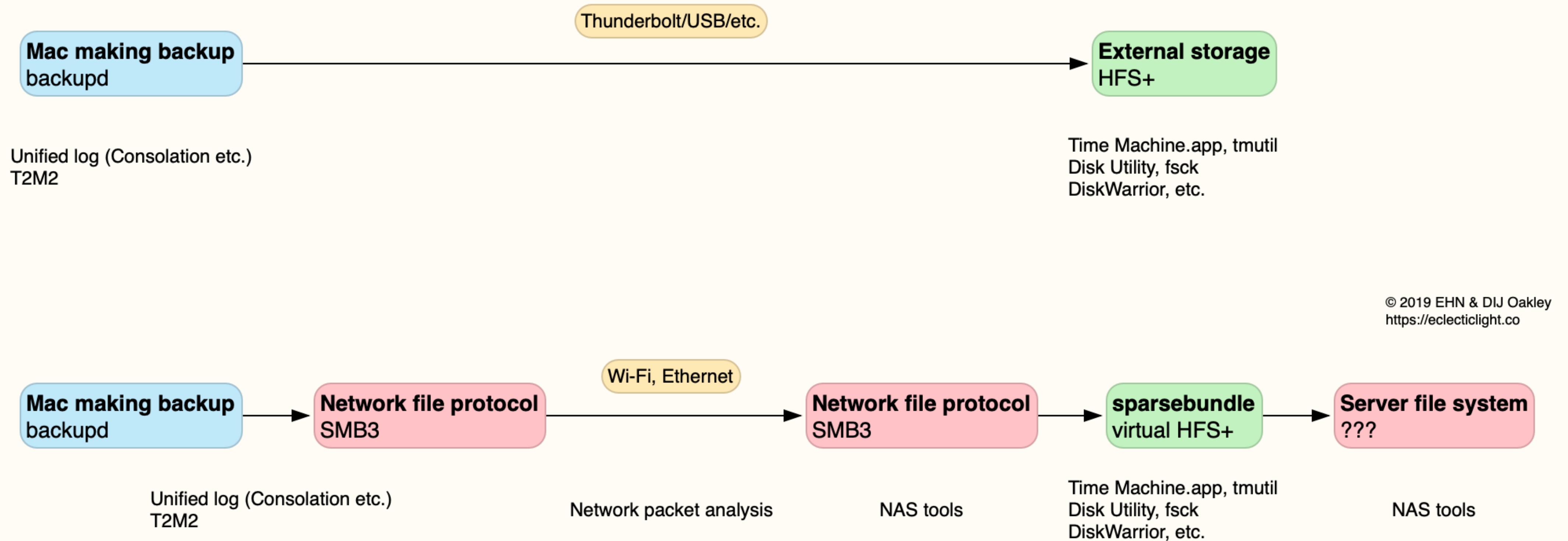
# Time Machine APFS Backup Structure







## Time Machine local –v– network backup





# Time Machine to APFS

**many advantages**

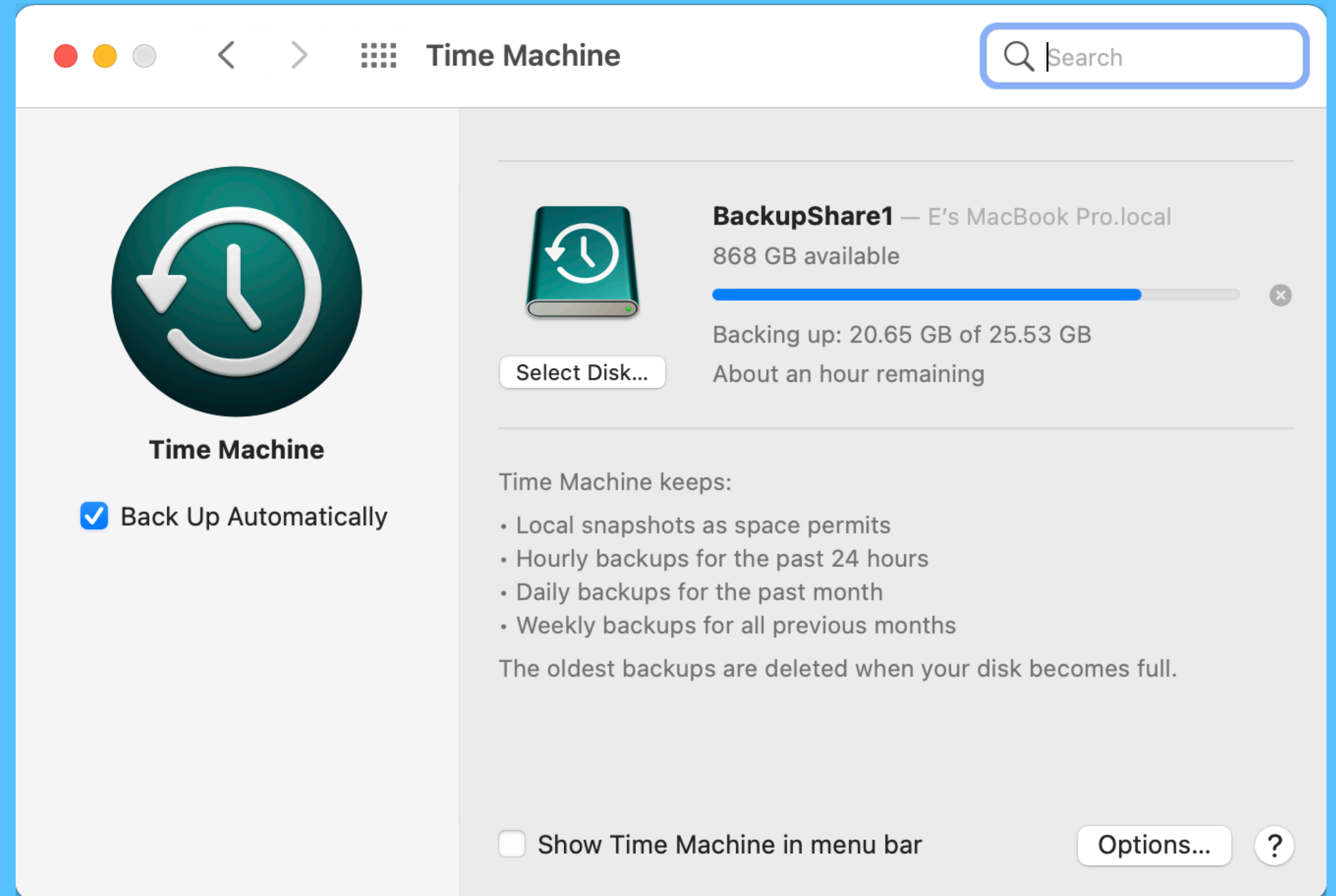
- complete compatibility with source file system (clones, sparse files)
- per-block rather than per-file changes copied
- modern copy-on-write file system
- smaller backups copied faster
- low maintenance, repair rare





# macOS Big Sur

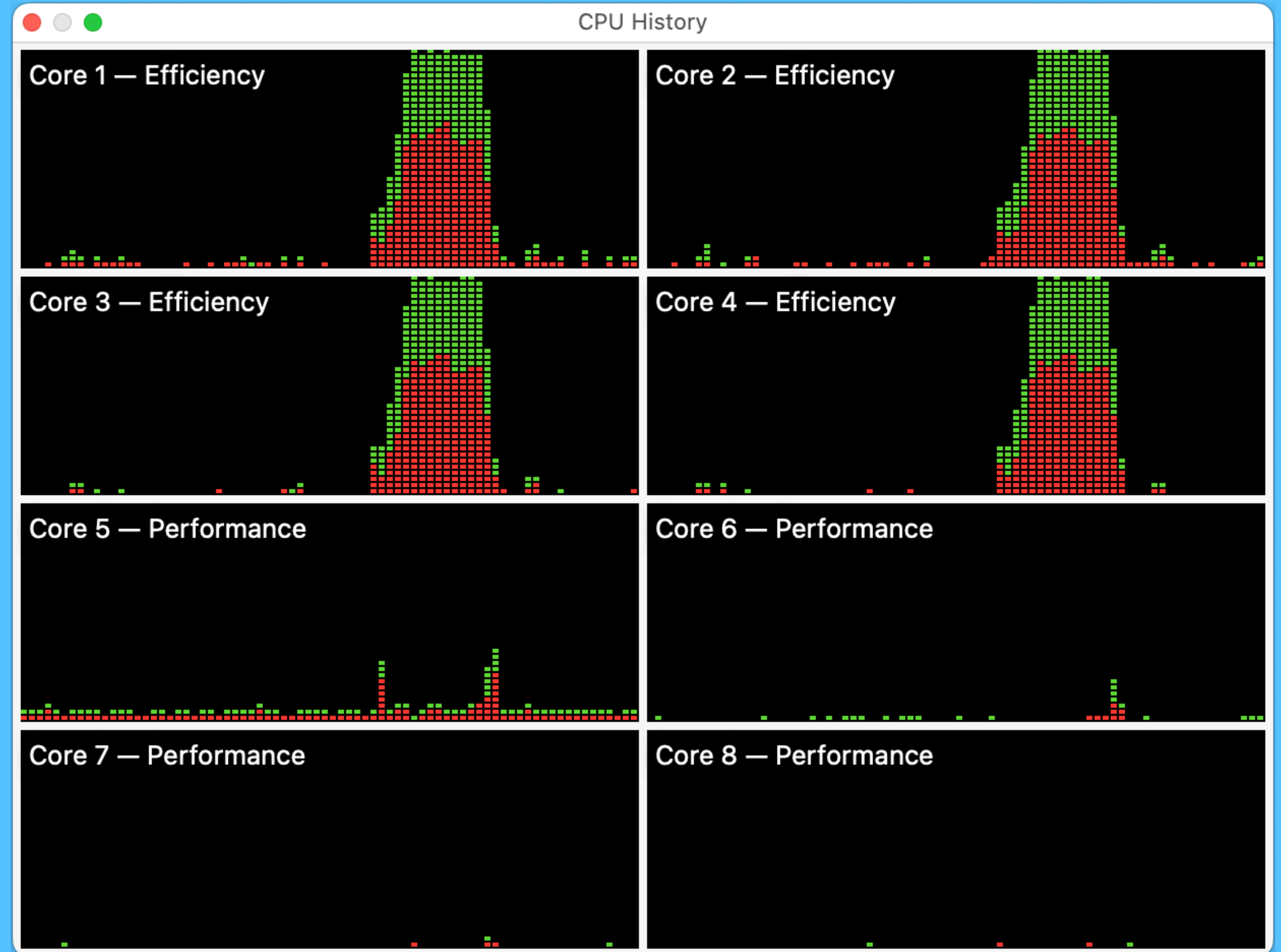
## November 2020





# M1 Mac

## November 2020





# BackupLoupe

soma-zone

BackupLoupe  
Idle

ThunderBay2  
07.09.2021 19:06:27

Time Machine  
Idle

auto  
turbo

Howard's iMac Pro

Icon 1.96 MB

Documents (4) 1.15 MB

Today  
08.09.2021 01:06:58 57.34 kB

This Week  
07.09.2021 23:06:57 577.54 kB

07.09.2021 22:06:41 258.05 kB

07.09.2021 21:06:37 49.15 kB

07.09.2021 20:06:28 3.12 MB

07.09.2021 18:06:12 0 B

07.09.2021 17:06:08 274.43 kB

07.09.2021 16:06:07 0 B

07.09.2021 15:06:05 0 B

07.09.2021 14:06:00 782.34 kB

07.09.2021 13:05:56 81.92 kB

OnewDownloads (4) 1.1 MB

.DS\_Store 53.25 kB

goya (4) 1.1 MB

04blog (4) 1.07 MB

captions.txt 22.44 kB

goyasai...na.jpg 359.92 kB

goyaself...15.jpg 266.66 kB

goyafer...14.jpg 255.62 kB

goyalas...ph.jpg 192.03 kB

La\_últi...anz.jpg 192.03 kB

Ferdina...ya.jpg 255.62 kB

Autorret...15.jpg 266.66 kB

Francis...29.jpg 359.92 kB

Howard's iMac Pro > External1 > Documents > OnewDownloads > goya > 04blog





# Carbon Copy Cloner

## Bombich Software

CCC

TasksVolumes

Macintosh HD - Data

1 TB PCI-Express Volume

Macintosh HD

1 TB PCI-Express Volume

ThunderBay2

2 TB Thunderbolt Volume

ThunderBay4

2 TB Thunderbolt Volume

ThunderBay3

2 TB Thunderbolt Volume

ThunderBay1

2 TB Thunderbolt Volume

External2

2 TB USB Volume

External1

2 TB USB Volume

External1

49%

2 TB

Used

985.65 GB

Snapshots

406.1 MB

Other Volumes

300 MB

Available

1.01 TB

StarTech: .com PM

/Volumes/External1

USB 3.1ownershipNot encryptedAPFS

SidebarPreferencesNew TaskRestorePreviewCompareTask HistoryTipsHelp

SnapshotsRelated Tasks

Snapshot Date	Size	Kind
⌚ Yesterday, 15:06	Zero KB	↻
⌚ Yesterday, 14:05	33 KB	↻
⌚ Yesterday, 13:05	6.3 MB	↻
⌚ Yesterday, 12:05	78 KB	↻
⌚ Yesterday, 11:05	70 KB	↻
⌚ Yesterday, 10:05	10 MB	↻
🌀 Yesterday, 04:15	13 MB	↻
🌀 06/09/2021, 04:15	28.6 MB	↻
🌀 05/09/2021, 04:15	21.7 MB	↻
🌀 04/09/2021, 04:15	18.9 MB	↻
🌀 03/09/2021, 04:15	28.2 MB	↻
🌀 02/09/2021, 04:15	73.6 MB	↻

CCC Snapshots:

?

CCC will create snapshots according to your backup task schedules. CCC will keep, at most:

- One snapshot per hour for the past day
- One snapshot per day for the past month
- One weekly snapshot for previous months
- SafetyNet snapshots will be kept for 7 days

CCC will remove the oldest snapshots when free space is less than 30GB.

Customize...



# T2M2

## The Eclectic Light Co.

