Spotlight – Forensic Goldmine in iOS & macOS

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About

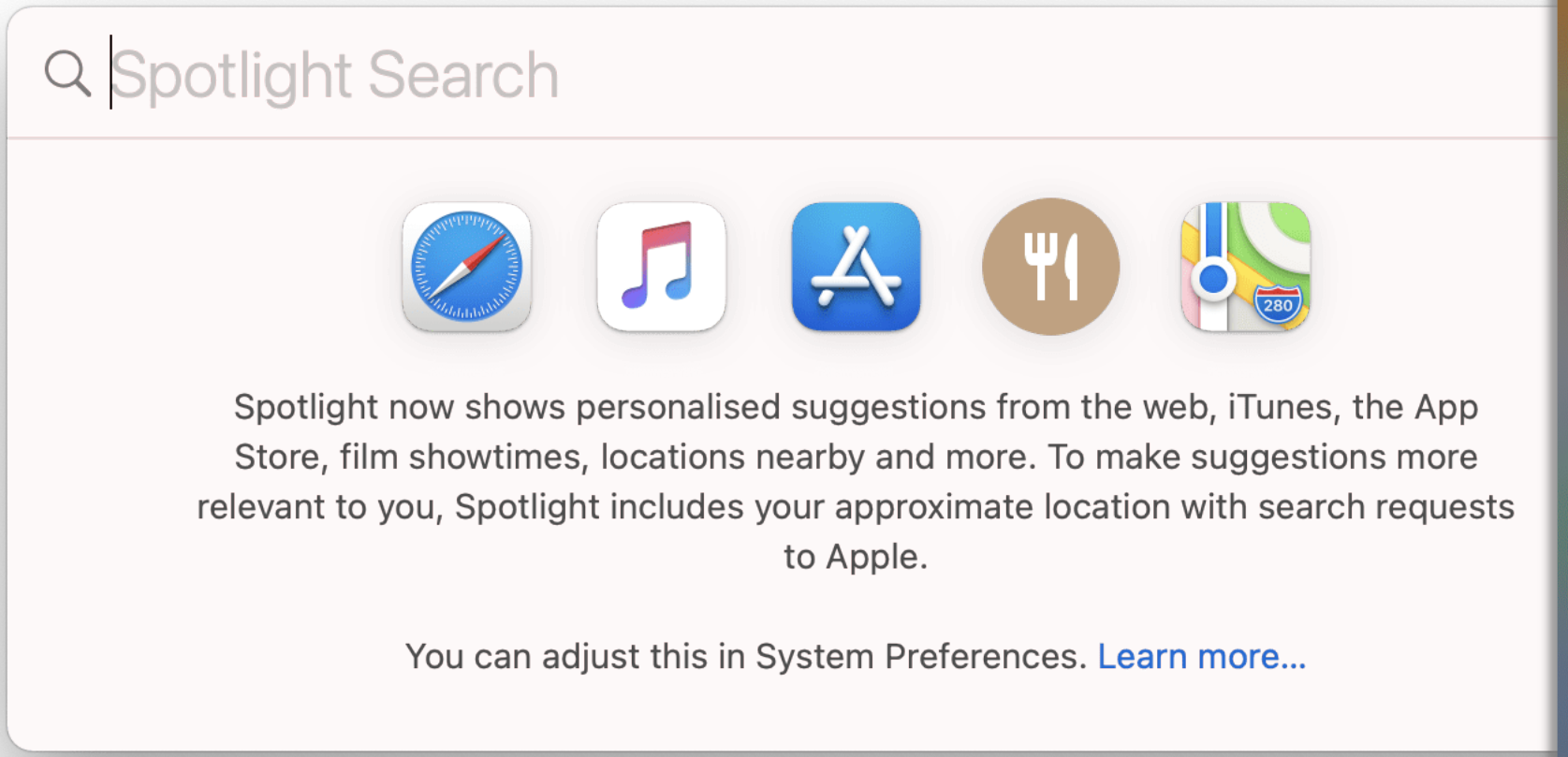
- Yogesh Khatri
- Champlain College
  - Program Director – Digital Forensics
  - Associate Professor
- *15+ years of Forensics & IR*
  - *Industry & Academia*
- Author & Maintainer for ***mac_apt – Artifact Parsing Tool***
  - And several standalone scripts/programs for forensic processing

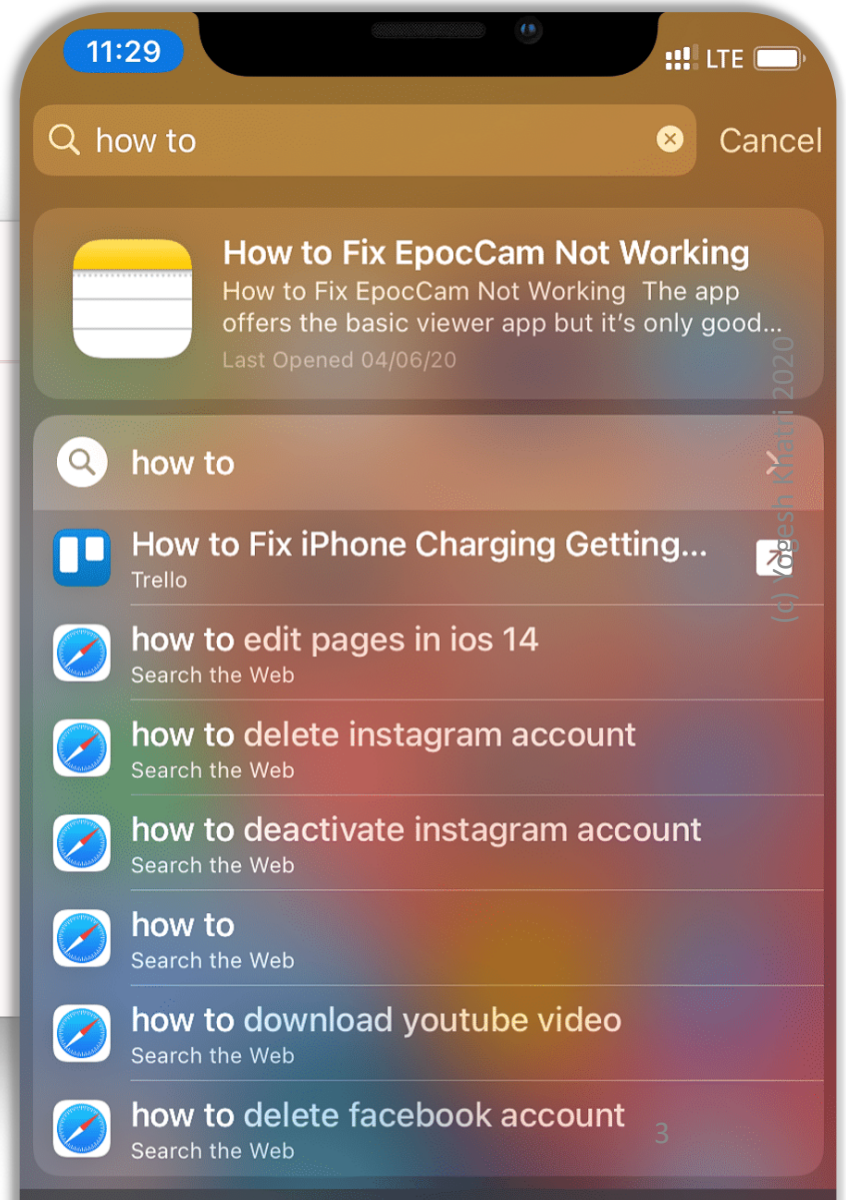
@swiftforensics

https://swiftforensics.com

https://github.com/ydkhatri

What is Spotlight?





Prior research – Tooling (and research) history

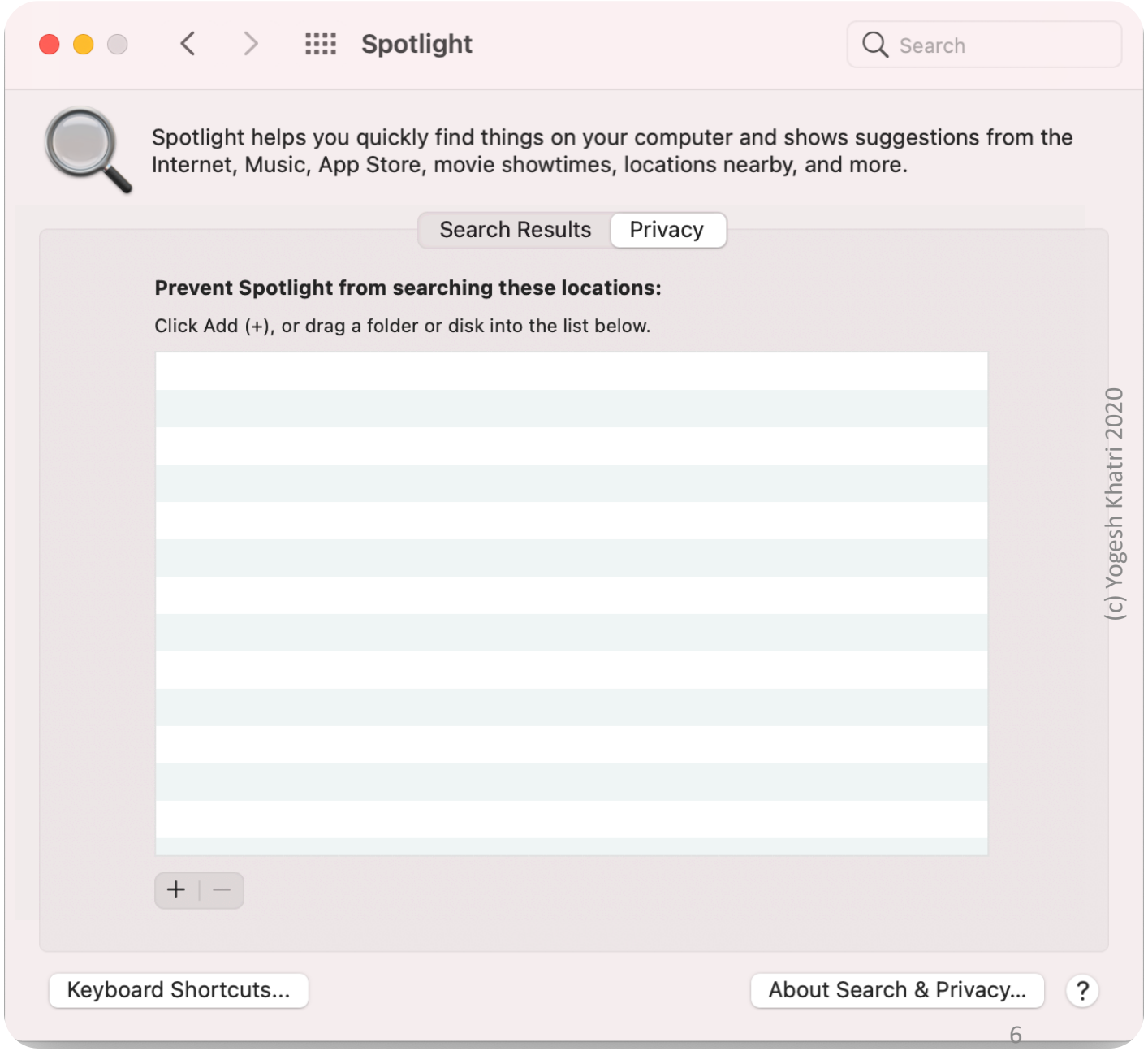
- 2014 – 504ENSICS – Spotlight Inspector tool
  - *Free (but not open source) tool, withdrawn soon after*
- 2018 – Yogesh Khatri – Spotlight parser tool
  - https://www.swiftforensics.com/2018/08/parsing-spotlight-database.html
  - https://github.com/ydkhatri/spotlight_parser , https://github.com/ydkhatri/mac_apt
- 2019 – Yogesh Khatri – Digital Investigation Journal paper
  - Investigating spotlight internals to extract metadata
  - https://www.sciencedirect.com/science/article/abs/pii/S1742287618300860
- 2019 – Atwal, Scanlon, Le-Khac - Digital Investigation Journal paper
  - Shining a light on Spotlight: Leveraging Apple's desktop search utility to recover deleted file metadata on macOS
  - https://www.sciencedirect.com/science/article/pii/S1742287619300295
- 2019 – Vico Marziale (Blackbag Technologies) – Illuminate Tool
  - Shedding Light on the macOS Spotlight Desktop Search Service - SANS DFIR Summit 2019 - https://www.youtube.com/watch?v=Y-vMp3aRlUk
- Other researchers have talked about accessing data from spotlight since at least 2012..
  - Sara Edwards, Lee Whitfield, Howard Oakley, J. Varsalone, ..

Today’s agenda

- Brief overview of Spotlight
  - Database locations
  - Types of data stored
  - macOS & iOS variants
- Extracting and reviewing the information
  - How to interpret the data?
  - Shiny tool demos and walkthroughs

What is indexed?

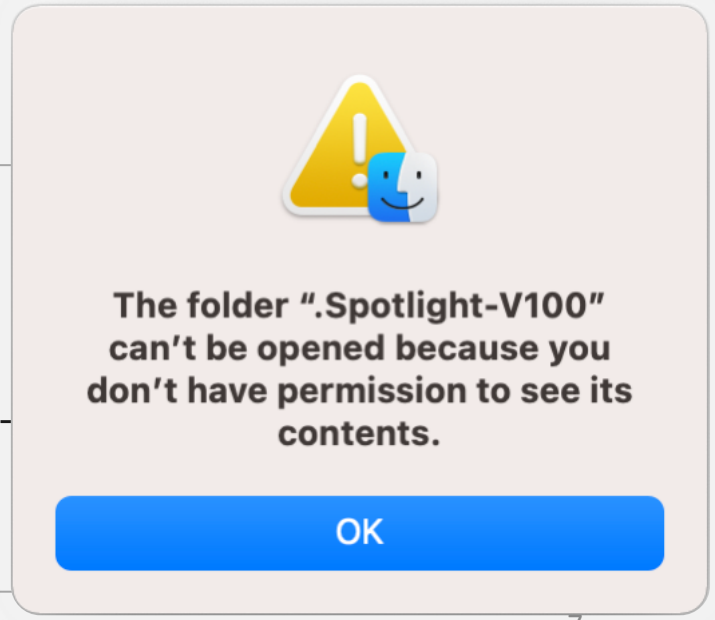
- Everything, by default
- Exclusions can be defined
  - *Hardly ever used!*



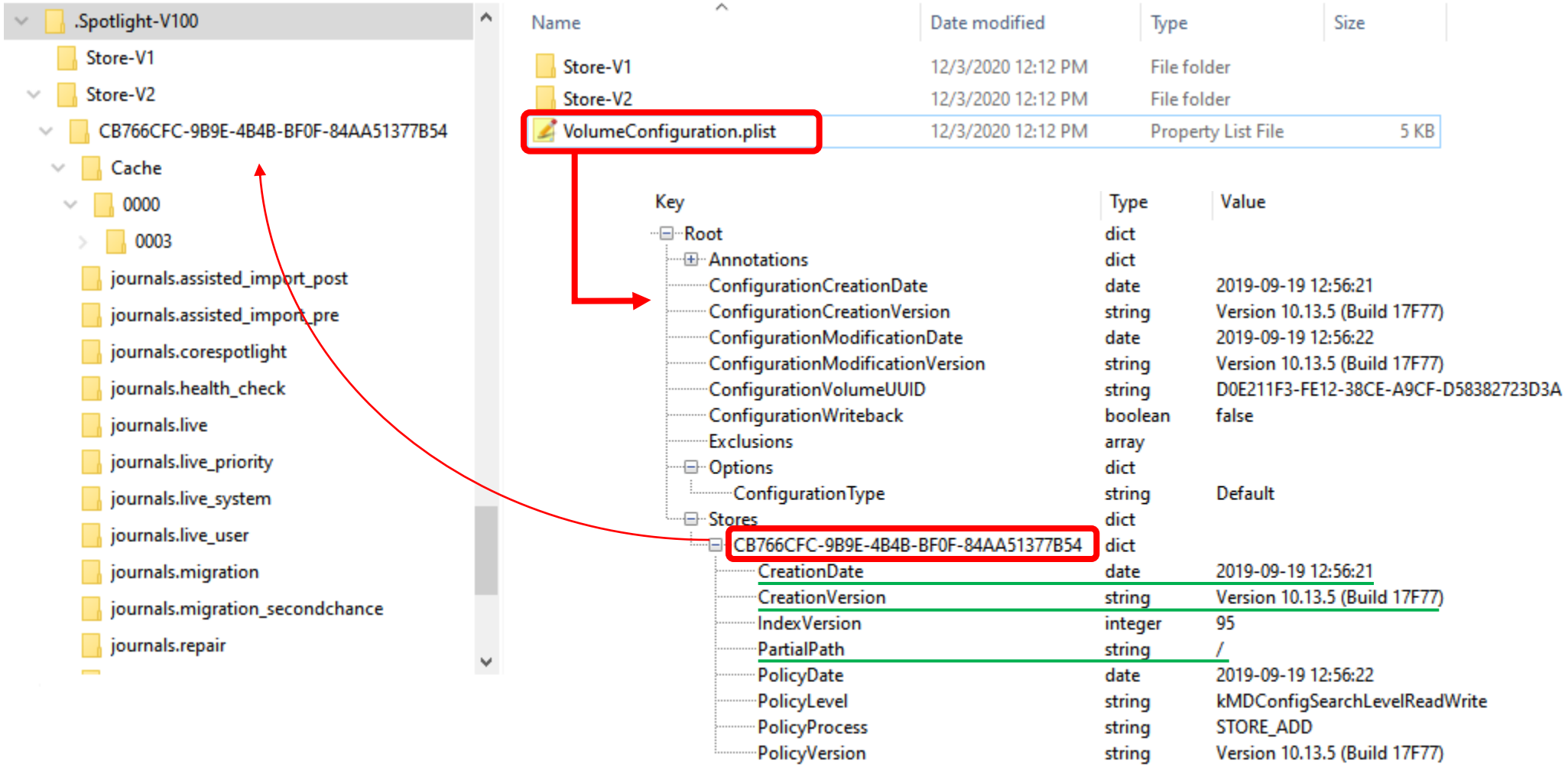
Artifact Location on macOS – One per volume

- At volume's root at /.Spotlight-V100/
- On Catalina (10.15) and above (11.0), this folder is located elsewhere
  - DATA volume, same location
    - On live system, this can be accessed via /System/Volumes/Data
  - SYSTEM volume
    - /private/var/db/Spotlight-V100/BootVolume

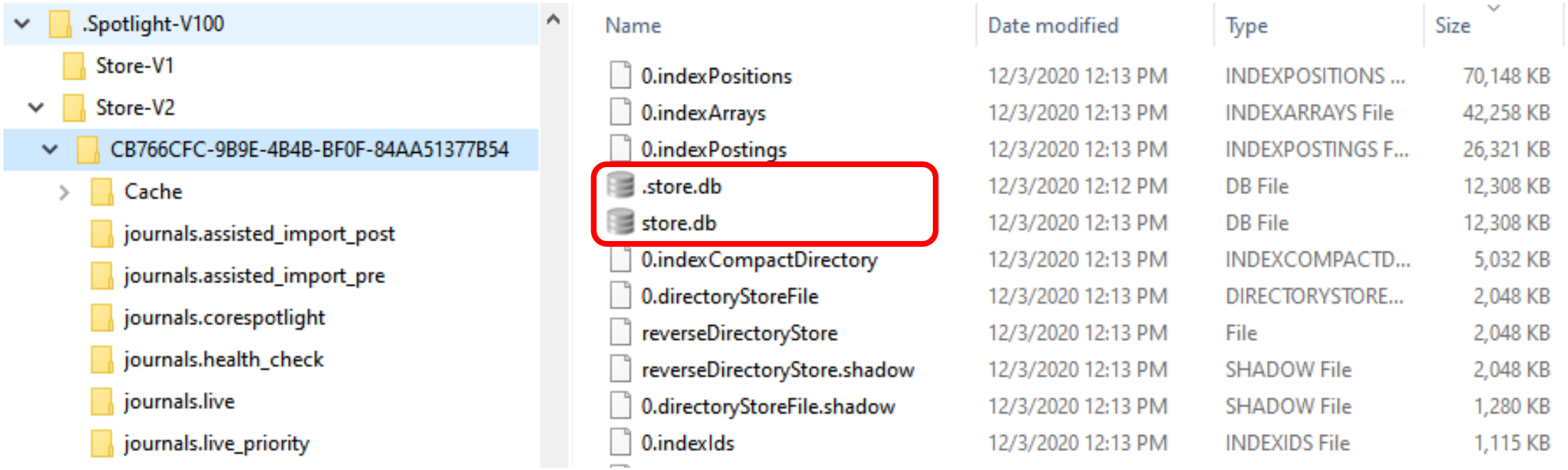
```
Yogesh-Khatri:~ yogesh$ ls -al /System/Volumes/Data
total 3418
drwxr-xr-x@  30 root    wheel    960 Nov 19 13:55 .
drwxr-xr-x   14 root    wheel    448 Jan  1  2020 ..
-rw-rw-r--    1 root    admin   6148 Sep 10  2019 .DS_Store
d--x--x--x    9 root    wheel    288 Nov 23 20:47 .DocumentRevisions-
...
drwx------    5 root    wheel    160 May 17  2019 .Spotlight-V100
...
```



The per volume database

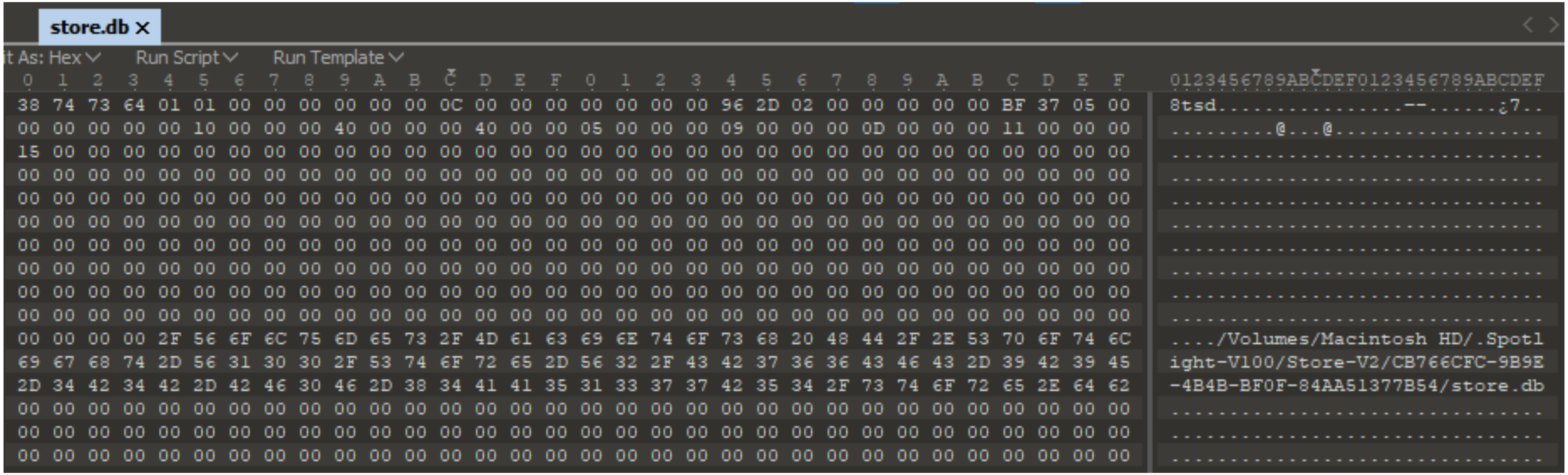


The per volume database..



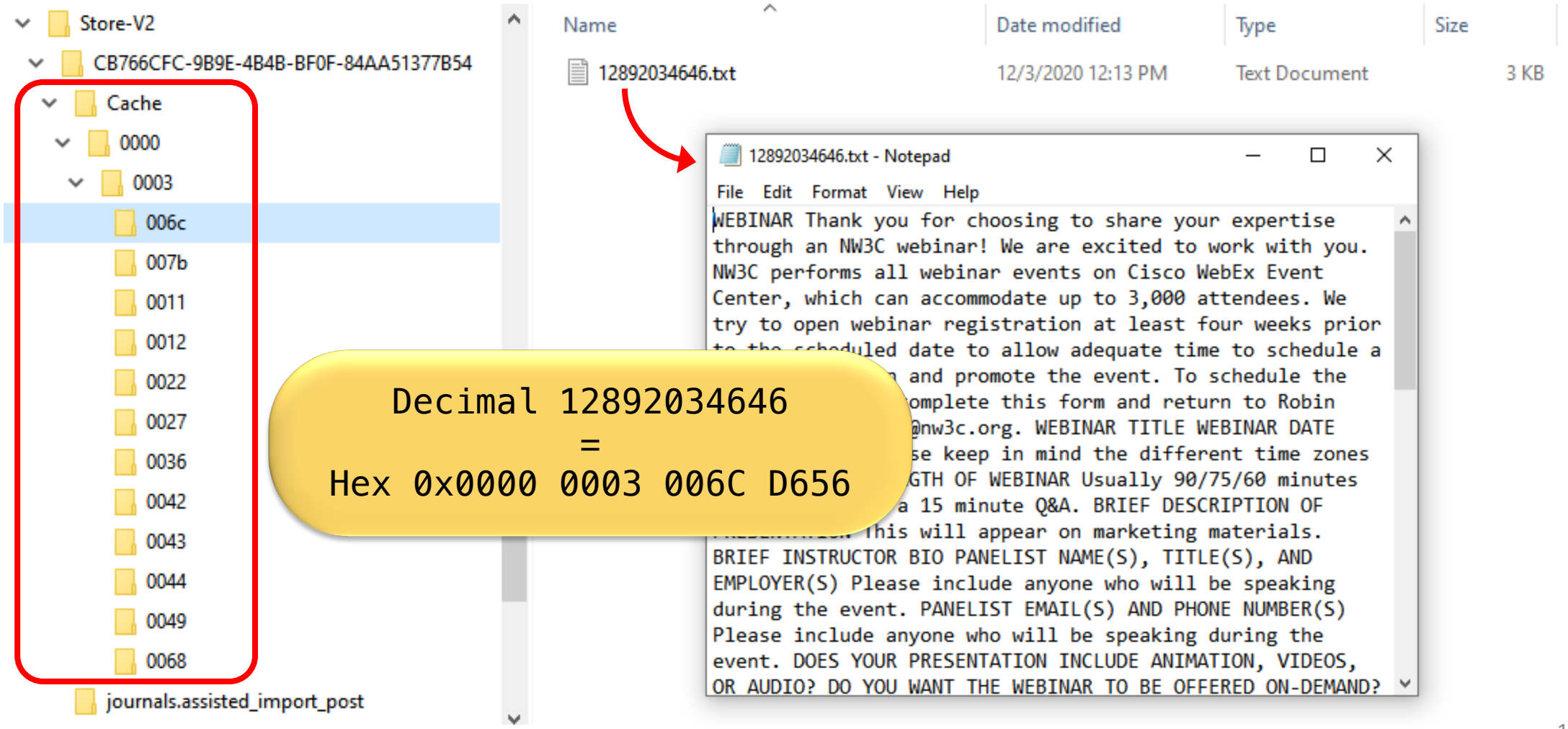
store.db has a proprietary format

- Not discussing internals / details here



(c) Yogesh Khatri 2020

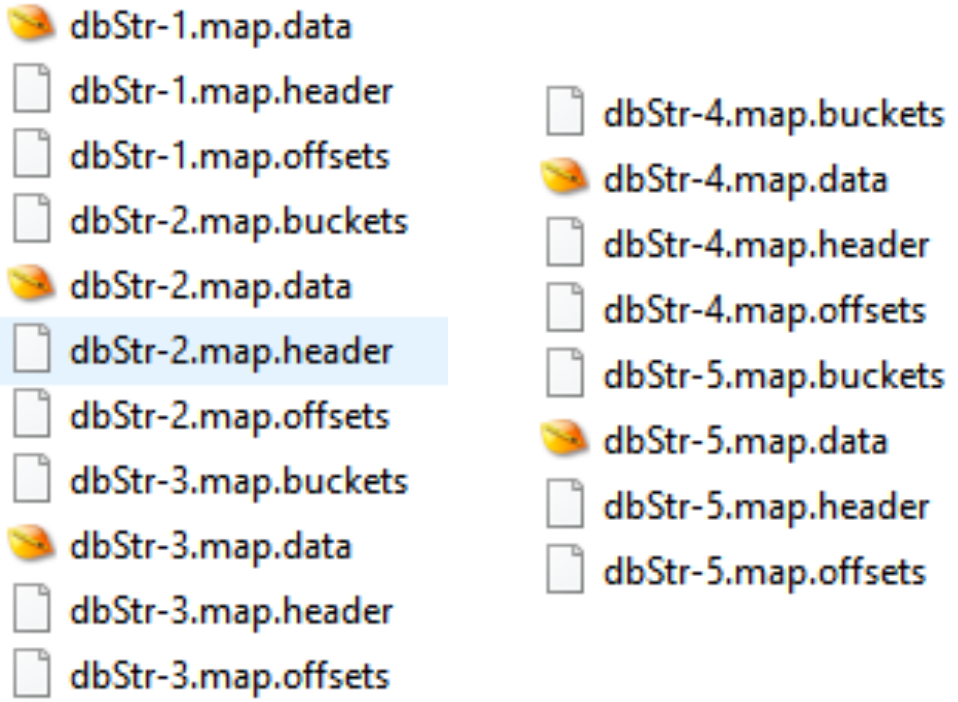
The per volume database..



Artifact Location on macOS – Per user db

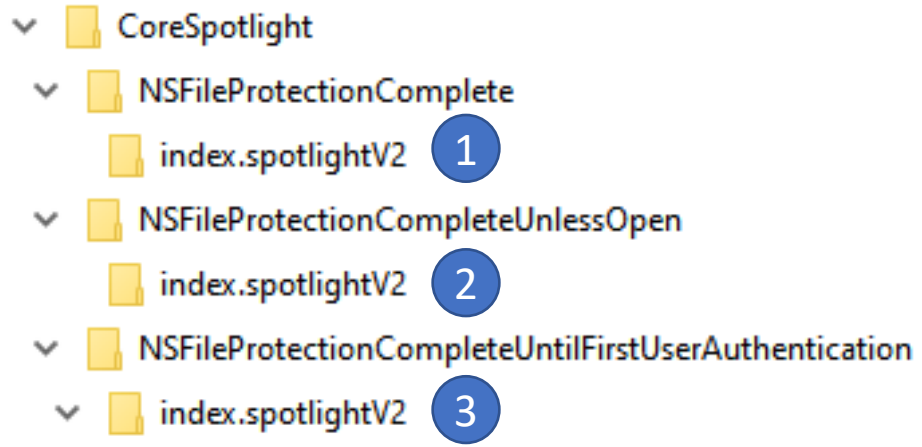
- In user's profile folder ~/Library/Metadata/CoreSpotlight/index.spotlightV3/
  - store.db
  - .store.db

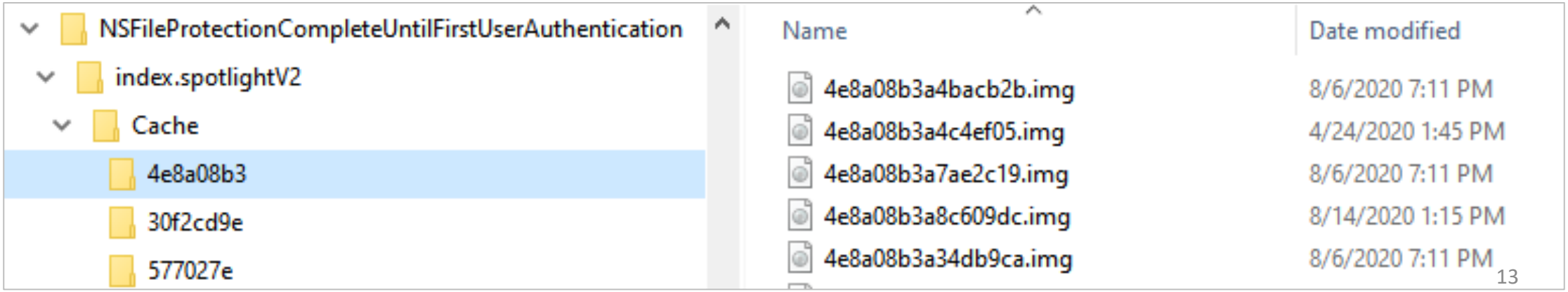
- Database dependencies
  - dbStr-x.map.xxxxx files



Artifact location on iOS

- /private/var/mobile/Library/Spotlight/CoreSpotlight/*/index.spotlightV2/
  - store.db
  - .store.db





Information from per volume database

- Info about Files / Folders
  - Date – Created, Modified, Added
  - Other Dates
    - Last usage
    - Last viewed
    - Downloaded date
  - Item Kind
  - UID & GID
  - Logical & Physical size
  - Other attributes
  - Item Description
- Download url
- Doc & Media metadata (EXIF, ID3, ..)
  - Height/Width
  - Lat/Long
  - Codec
  - Author(s)

Inode_Num --> 12886072633
Store_ID --> 76856
Parent_Inode_Num --> 12885640371
Last_Updated --> 2020-12-02 20:06:05.792257
_kMDItemContentChangeDate --> 2019-10-17 04:36:37.020195
_kMDItemCreationDate --> 2019-10-17 04:36:36.730605
_kMDItemFileName --> summit_archive_1528404628.pdf
_kMDItemOwnerGroupID --> 20
_kMDItemOwnerUserID --> 501
kMDItemAuthors --> Yogesh Khatri
kMDItemContentCreationDate --> 2019-10-17 04:36:36.730605
kMDItemContentModificationDate --> 2019-10-17 04:36:37.020195
kMDItemContentType --> com.adobe.pdf
kMDItemCreator --> Microsoft® PowerPoint® 2016
kMDItemDateAdded --> 2019-10-17 04:36:36.730605
kMDItemKind --> PDF document
kMDItemLastUsedDate --> 2019-10-17 17:00:16.939266
kMDItemLogicalSize --> 3542769
kMDItemNumberOfPages --> 28
kMDItemPageHeight --> 450.0
kMDItemPageWidth --> 800.0399780273438
kMDItemPhysicalSize --> 3543040
kMDItemSecurityMethod --> None
kMDItemTitle --> mac_apt
kMDItemUseCount --> 7
kMDItemUsedDates --> 2019-10-17 04:00:00
kMDItemWhereFroms --> https://www.sans.org/cyber-security-summit/archives/file/summit-archive-1528404628.pdf

Data from spotlight parser *(some fields have been removed to fit data here)*

Inode_Num --> 12889266235
Store_ID --> 128692
Parent_Inode_Num --> 12889266234
Last_Updated --> 2020-12-02 20:06:06.154310
_kMDItemFileName --> IMG_0002.PNG
kMDItemBitsPerSample --> 32
kMDItemColorSpace --> RGB
kMDItemComment --> Screenshot
kMDItemContentCreationDate --> 2020-05-08 16:55:08
kMDItemContentModificationDate --> 2020-05-08 16:55:25.782376
kMDItemContentType --> public.png
kMDItemContentTypeTree --> public.png, public.image, public.data, public.item, public.content
kMDItemDateAdded --> 2020-05-08 16:55:26.071326
kMDItemDisplayName --> IMG_0002.PNG
kMDItemDownloadedDate --> 2020-05-08 16:55:26.097162
kMDItemKind --> PNG image
kMDItemLogicalSize --> 213480
kMDItemOrientation --> 1
kMDItemOriginApplicationIdentifier --> com.apple.messages
kMDItemOriginSenderHandle --> hazelhill010@icloud.com
kMDItemPhysicalSize --> 217088
kMDItemPixelCount --> 3145728
kMDItemPixelHeight --> 2048
kMDItemPixelWidth --> 1536
kMDItemProfileName --> sRGB IEC61966-2.1
kMDItemTransportAccount --> E:janesmithmacfor@icloud.com
kMDItemTransportService --> iMessage
kMDItemUserSharedReceivedDate --> 2020-05-08 16:55:26.099445
kMDItemUserSharedReceivedRecipient --> janesmithmacfor@icloud.com
kMDUserSharedReceivedRecipientHandle --> janesmithmacfor@icloud.com
kMDItemUserSharedReceivedSender --> hazelhill010@icloud.com
kMDItemUserSharedReceivedSenderHandle --> hazelhill010@icloud.com
kMDItemUserSharedReceivedTransport --> com.apple.messages
kMDItemWhereFroms --> hazelhill010@icloud.com, Received via Messages file transfer

Attachment from iMessage

-

Data from spotlight parser *(some fields have been removed to fit data here)*

Inode_Num --> 12889266299
Flags --> 0
Store_ID --> 141374
Parent_Inode_Num --> 12889266082
Last_Updated --> 2020-12-02 20:06:06.354879
_kMDItemFileName --> hazelhill010@icloud.com on 2020-05-08 at 12.36.46.ichat
_kMDItemIsExtensionHidden --> 1
_kMDItemLocked --> 1
_kMDItemOwnerGroupID --> 20
_kMDItemOwnerUserID --> 501
com_apple_metadata_modtime --> 610650577.177143
kMDItemAuthorAddresses --> e:janesmithmacfor@icloud.com
kMDItemContentCreationDate --> 2020-05-08 16:36:46.134475
kMDItemContentModificationDate --> 2020-05-08 17:09:37.177143
kMDItemContentType --> com.apple.ichat.transcript
kMDItemDateAdded --> 2020-05-08 17:09:52.282463
kMDItemDeliveryType --> iMessage
kMDItemDisplayName --> hazelhill010@icloud.com on 2020-05-08 at 12.36.46
kMDItemKind --> Chat transcript
kMDItemLastUsedDate --> 2020-05-08 16:36:44.388566
kMDItemLogicalSize --> 226689
kMDItemPhysicalSize --> 229376
kMDItemRecipientAddresses --> hazelhill010@icloud.com
kMDItemUseCount --> 2
kMDItemUsedDates --> 2020-05-08 04:00:00

iMessage parsed out

-

Data from spotlight parser *(some fields have been removed to fit data here)*

Safari history hacked into Spotlight.. earlier

- Prior to macOS 10.13, files could be seen under *~/Library/Caches/Metadata/Safari/*
- These .webhistory files represent urls visited

```
-rw-r--r--  1 yogesh  staff  162 Dec 11  2017 https:%2F%2Fwww.bhphotovideo.com%2Ffind%2FthankYouSurvey.jsp.webhistory
-rw-r--r--  1 yogesh  staff  156 Jan 11  2018 https:%2F%2Fwww.binaryhexconverter.com%2Fdecimal-to-hex-converter.webhistory
-rw-r--r--  1 yogesh  staff  105 Jun 10 16:16 https:%2F%2Fwww.bing.com%2F.webhistory
-rw-r--r--  1 yogesh  staff   92 Apr 11  2018 https:%2F%2Fwww.blogger.com%2F?tab=mj.webhistory
-rw-r--r--  1 yogesh  staff  131 Apr 11  2018 https:%2F%2Fwww.blogger.com%2Fblogger.g?tab=mj%23welcome.webhistory
-rw-r--r--  1 yogesh  staff  121 Apr 11  2018 https:%2F%2Fwww.blogger.com%2Fblogger.g?tab=mj.webhistory
-rw-r--r--  1 yogesh  staff  113 Nov 30  2017 https:%2F%2Fwww.blogger.com%2Fprofile%2F08966595734678290320.webhistory
-rw-r--r--  1 yogesh  staff  241 Feb 16  2018 https:%2F%2Fwww.bloomberg.com%2Fnews%2Farticles%2F2018-02-16%2Fgoogle-firing-of-d
-rw-r--r--  1 yogesh  staff  244 Feb 16  2018 https:%2F%2Fwww.bloomberg.com%2Fnews%2Farticles%2F2018-02-16%2Fu-s-charges-13-rus
-rw-r--r--  1 yogesh  staff  231 Aug 13 08:52 https:%2F%2Fwww.bloomberg.com%2Fnews%2Farticles%2F2018-08-09%2Fcryptokidnapping-o
-rw-r--r--  1 yogesh  staff  250 Aug 13 08:59 https:%2F%2Fwww.bloomberg.com%2Fnews%2Farticles%2F2018-08-12%2Flira-extends-retre
-rw-r--r--  1 yogesh  staff  203 Apr 23 20:44 https:%2F%2Fwww.booking.com%2Fdirections.en-us.html?hotel_id=56473&aid=389181.web
-rw-r--r--  1 yogesh  staff  122 May 13 16:24 https:%2F%2Fwww.burlingtonfreepress.com%2F.webhistory
-rw-r--r--  1 yogesh  staff  126 May 13 16:26 https:%2F%2Fwww.burlingtonfreepress.com%2Fbiz%2F.webhistory
-rw-r--r--  1 yogesh  staff  134 May 13 16:26 https:%2F%2Fwww.burlingtonfreepress.com%2Fnews%2F.webhistory
-rw-r--r--  1 yogesh  staff  148 Jan  3  2018 https:%2F%2Fwww.burlingtonfreepress.com%2Fsection%2Fglobal%2Fnation-now%2F.webhis
-rw-r--r--  1 yogesh  staff  138 May 13 16:26 https:%2F%2Fwww.burlingtonfreepress.com%2Fsports%2F.webhistory
```

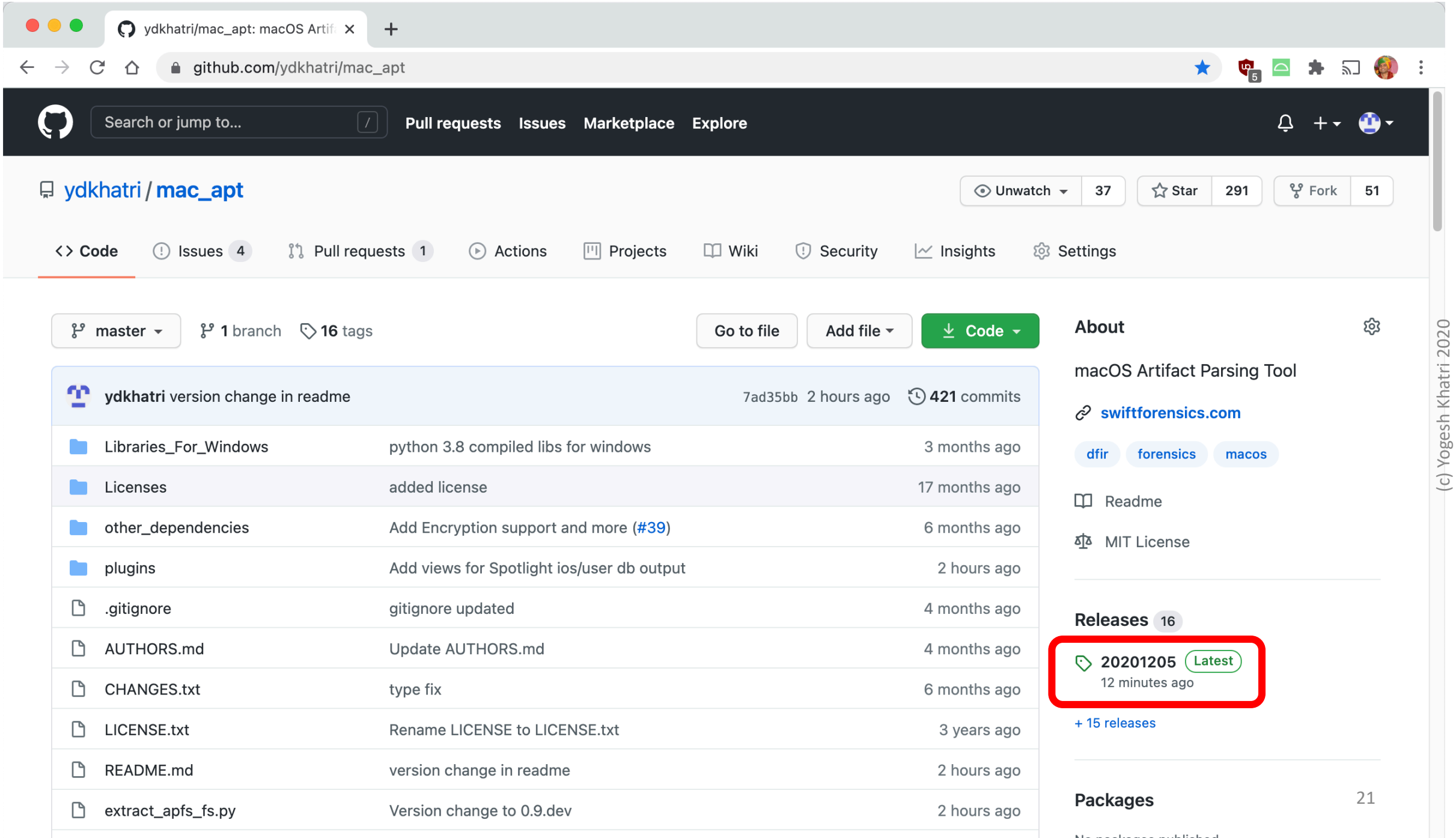
Solution – a db not linked to the filesystem

- Per-user or iOS spotlight db
  - 3rd party apps can add their own fields (metadata types)
  - Developers can implement in-app searches for any kind of data now
  - Used by
    - Notes app
    - Maps app
    - Apple Mail
    - iMessage (on iOS)
    - Safari
    - Chrome (on iOS)
    - Voice Memos app
    - ..
  - Internal format of store.db is similar to per-volume spotlight db

Tools please..

- Spotlight parser
  - https://github.com/ydkhatri/spotlight-parser
  - Not updated (yet!) to write to an sqlite database!

- mac_apt_artifact_only script to work on individual spotlight dbs
  - Part of mac_apt suite
    - https://github.com/ydkhatri/mac_apt
    - Lots of functionality but we only need the SPOTLIGHT plugin
  - Recent functionality includes creating views for easy review


ydkhatri/mac_apt: macOS Artif
github.com/ydkhatri/mac_apt
Search or jump to...
Pull requests
Issues
Marketplace
Explore
ydkhatri / mac_apt
Unwatch 37
Star 291
Fork 51
Code
Issues 4
Pull requests 1
Actions
Projects
Wiki
Security
Insights
Settings
master
1 branch
16 tags
Go to file
Add file
Code
ydkhatri version change in readme
7ad35bb 2 hours ago
421 commits
Libraries_For_Windows python 3.8 compiled libs for windows 3 months ago
Licenses added license 17 months ago
other_dependencies Add Encryption support and more (#39) 6 months ago
plugins Add views for Spotlight ios/user db output 2 hours ago
.gitignore gitignore updated 4 months ago
AUTHORS.md Update AUTHORS.md 4 months ago
CHANGES.txt type fix 6 months ago
LICENSE.txt Rename LICENSE to LICENSE.txt 3 years ago
README.md version change in readme 2 hours ago
extract_apfs_fs.py Version change to 0.9.dev 2 hours ago
About
macOS Artifact Parsing Tool
swiftforensics.com
dfir
forensics
macos
Readme
MIT License
Releases 16
20201205 Latest
12 minutes ago
+ 15 releases
Packages
21
(c) Yogesh Khatri 2020

Running mac_apt_artifact_only

C:\> mac_apt_artifact_only.exe -i P:\ios_spotlight1\store.db -o W:\output SPOTLIGHT

Plugin to run

```
Output path was : W:\output
MAIN-INFO-Started macOS Artifact Parsing Tool - Artifact Only mode, version 0.9.dev
MAIN-INFO-Dates and times are in UTC unless the specific artifact being parsed saves it as local time!
MAIN-INFO-------------------------------------------------
MAIN-INFO-Running plugin SPOTLIGHT
MAIN-INFO-------------------------------------------------
MAIN.SPOTLIGHT-INFO-Module Started as standalone
MAIN.SPOTLIGHT-INFO-Now processing file P:\ios_spotlight1\store.db
MAIN.SPOTLIGHT-INFO-Processing P:\ios_spotlight1\store.db
MAIN.SPOTLIGHT-INFO-Creating output folder for spotlight at W:\output\SPOTLIGHT_DATA
MAIN.HELPERS.SPOTLIGHT_FILTER-INFO-24 views added for table Spotlight-store.db
MAIN-INFO-------------------------------------------------
MAIN-INFO-Finished in time = 00:00:01
MAIN-INFO-Review the Log file and report any ERRORs or EXCEPTIONS to the developers
```

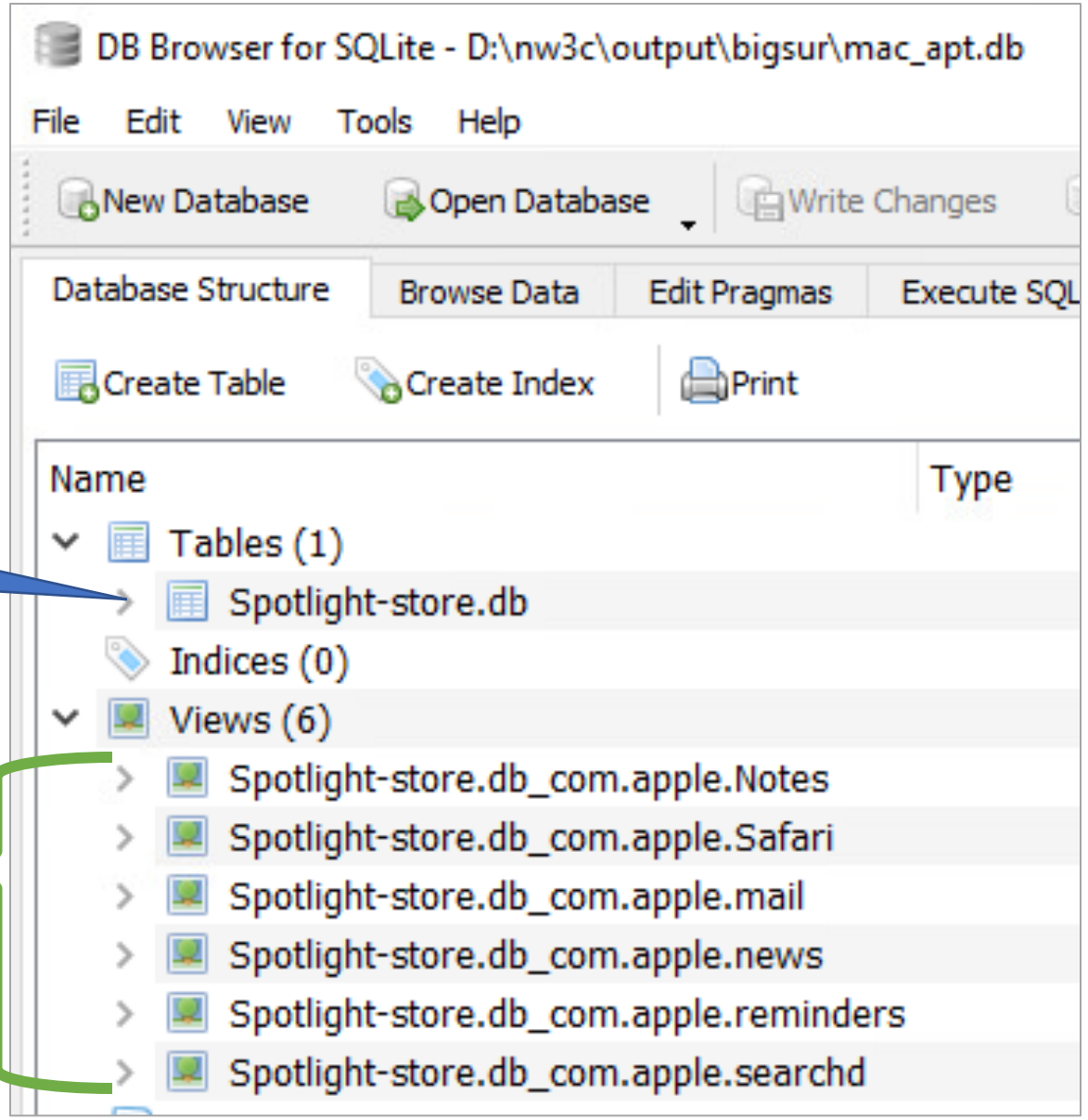
Script options

-i <PATH_TO_STORE.DB>
-o <OUTPUT_FOLDER>

Output database

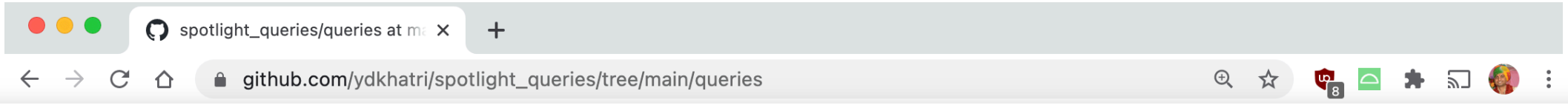
Table representing parsed data from store.db

Views created from table
One view per App (BundleID)



App-based views are only on User/iOS databases. Volume databases can't be split like this

Demo



main

spotlight_queries / queries / com.apple.mail.md

Go to file

ydkhatri Create com.apple.mail.md

Latest commit 61bf9af 11 hours ago History

1 contributor

8 lines (7 sloc) | 350 Bytes

Raw Blame


```
SELECT _kMDItemExternalID, kMDItemContentCreationDate, kMDItemSubject, com_apple_mail_dateLastViewed,
com_apple_mail_read, kMDItemUseCount,
_kMDItemSnippet, kMDItemAuthorEmailAddresses, kMDItemAuthors, kMDItemPrimaryRecipientEmailAddresses
FROM "Spotlight-store.db" -- Change db name here to yours
WHERE kMDItemKind LIKE "email message"
```

com.apple.mobilesafari.md Create com.apple.mobilesafari.md 10 hours ago

Email searched and launched from Spotlight Search

SQL 1

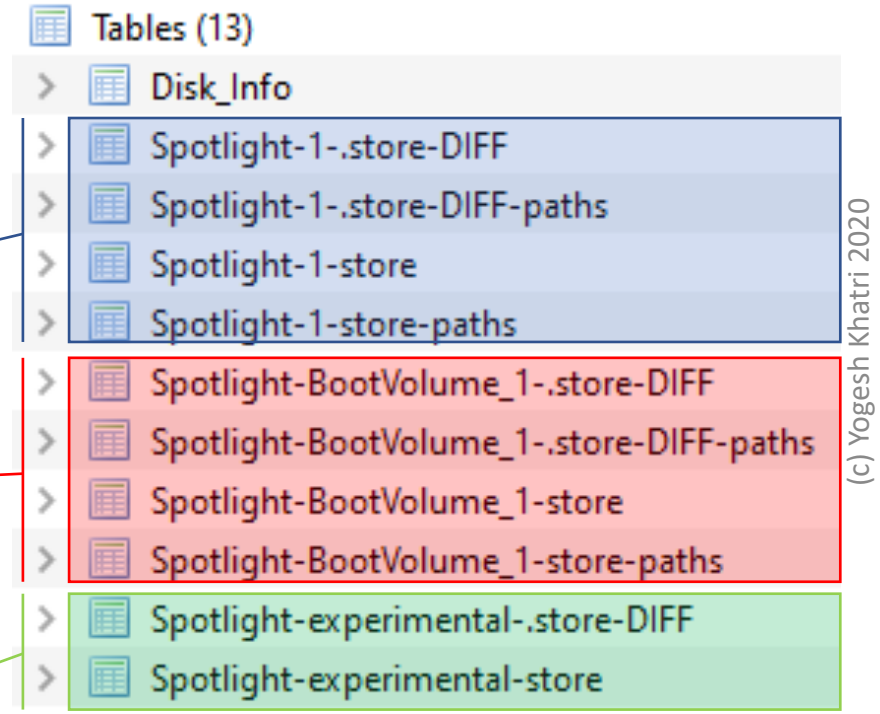
```
1   SELECT _kMDItemExternalID, kMDItemContentCreationDate, kMDItemSubject, com_apple_mail_dateLastViewed,
2   com_apple_mail_read, kMDItemUseCount,
3   _kMDItemSnippet, kMDItemAuthorEmailAddresses, kMDItemAuthors, kMDItemPrimaryRecipientEmailAddresses,
4   _kMDItemLaunchString, _kMDItemShortcutLastUsedDate
5   FROM "Spotlight-store.db" -- Change db name here to yours
6   WHERE kMDItemKind LIKE "email message"
```

		kMDItemAuthors	ItemPrimaryRecipientEmailAddre	_kMDItemLaunchString	_kMDItemShortcutLastUsedDate
2		Google	goashleymcdonald@gmail.com		
3		The Blogs at The Times of Israel	goashleymcdonald@gmail.com		
4		VegasInsider.com	goAshleymcdonald@gmail.com	vegas	2020-12-03 17:35:28.834117
5		People News	goashleymcdonald@gmail.com		

Searched Term

Understanding mac_apt's SPOTLIGHT output (for Catalina – 10.15 or above)

- Multiple spotlight databases exist on macOS Catalina (and above)
  - Volume databases
    - One for DATA volume
    - One for SYSTEM volume (under BootVolume folder)
  - Per-user databases
    - One per user (stores records from Apps that user interacts with). Here user name was *experimental*



mac_apt.db Tables

NOTE: -.store-DIFF tables only contain data not saved in the -store tables to avoid duplication

Thanks for watching!

Any Questions?

https://github.com/ydkhatri/mac_apt
https://github.com/ydkhatri/spotlight_queries

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