September 2018

Apple Health

Vladimir Katalov, ElcomSoft

Heartrate Sleeping habits Workouts Steps and walking routines

Apple Health

What Is Apple Health?

- Introduced in Sep 2014 with iOS 8
- Health app pre-installed on all iPhones
- Makes use of low-energy sensors
- Always active, always collecting information
- Supported by Apple Watch, additional data collected

Apple Health

Main Data Categories

- **Activity** – how much you move
- **Nutrition** – breakdown of your diet
- **Sleep** –your sleep habits
- **Mindfulness** – native support limited to Mindful Minutes, Activity and Sleep; third-party apps help build out your mindfulness data. Pretty meaningless in its current state, may improve in iOS 12

Apple Health

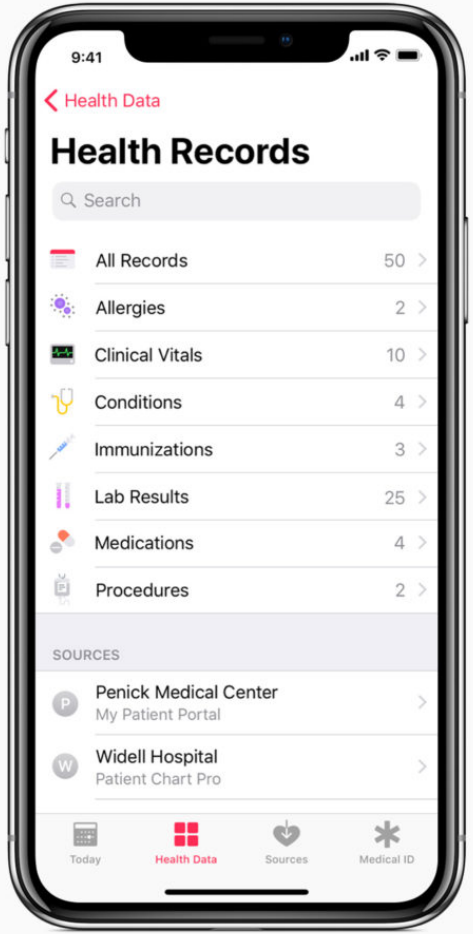
Additional Data Categories

- **Body Measurements** – height and weight
- **Health Records** - CDA + Health Records
- **Heart** – blood pressure, heart rate
- **Reproductive Health** – sexual activity and menstruation cycles
- **Results** – various medical test results (e.g. sugar level)
- **Vitals** – blood pressure, body temperature, heart rate, breathing rate
- **Medical ID** – essential medical data:

Apple Health

Clinical Document Architecture (CDA)

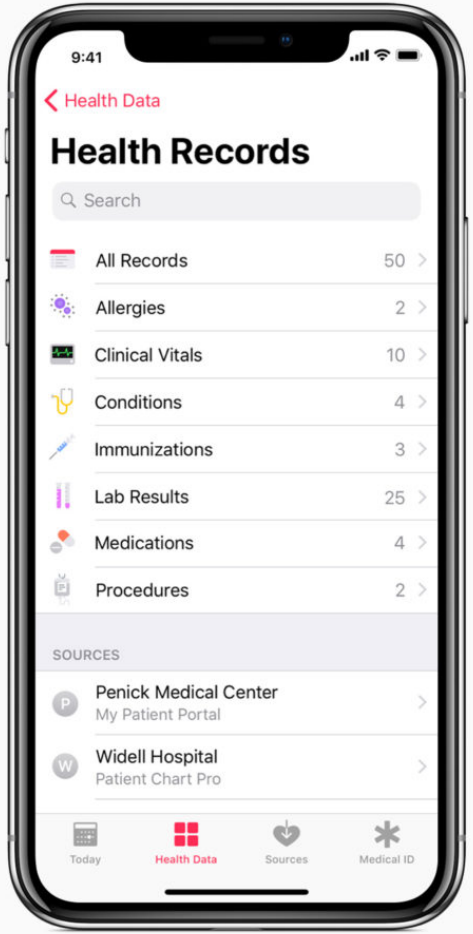
- Standard architecture for transferring health information across medical facilities
- Widespread in USA, UK, Australia
- XML format
- CDA documents are stored in Health Records
- Prior to iOS 11 Health Records only contained CDA documents



Apple Health

Clinical Document Architecture (CDA)

- Registering a CDA document in Apple Health
  - Must receive complete file (e.g. from the hospital)
  - Open with Apple Health app
  - Data will be synced with other devices via iCloud
- Contains highly sensitive medical information



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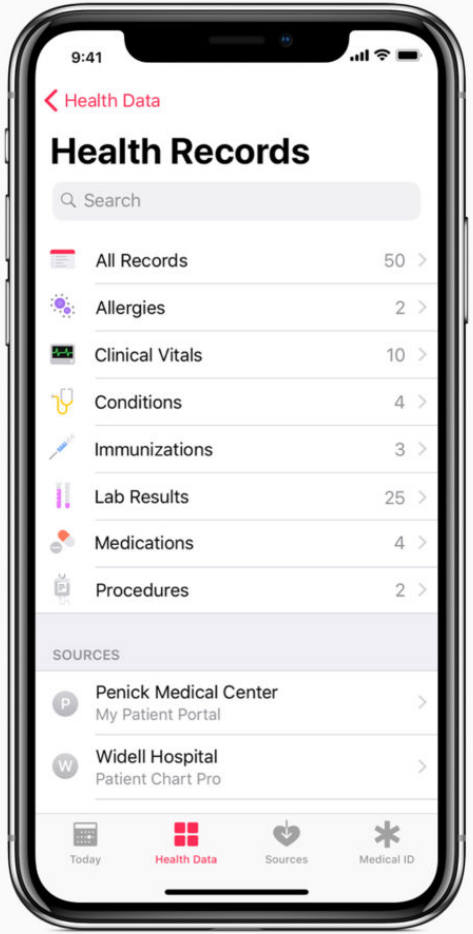
Health Records

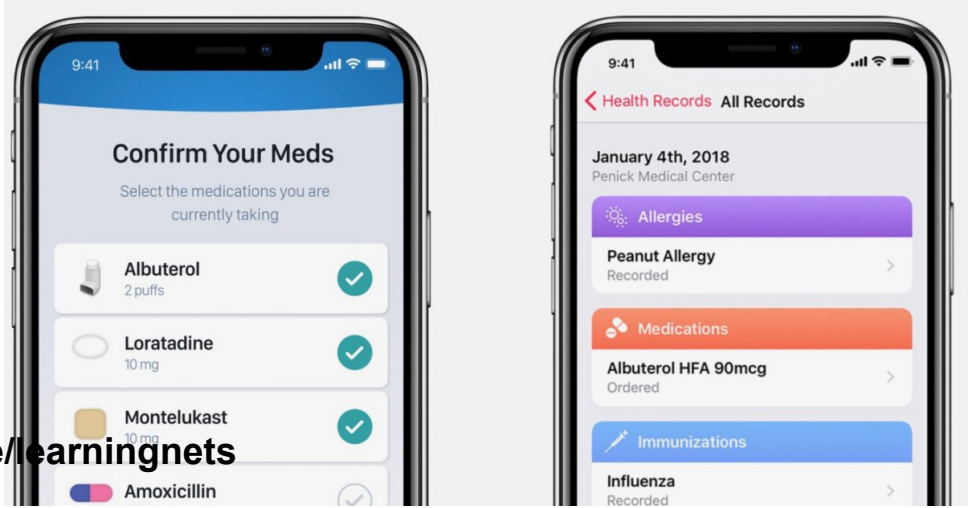
- March 2018: **Apple Health Records**
- 39 US hospitals joined at the time of introduction
- The number of participating facilities quickly growing
- FHIR (Fast Healthcare Interoperability Resources) interoperability via HealthKit



Apple Health

Apple Health Records

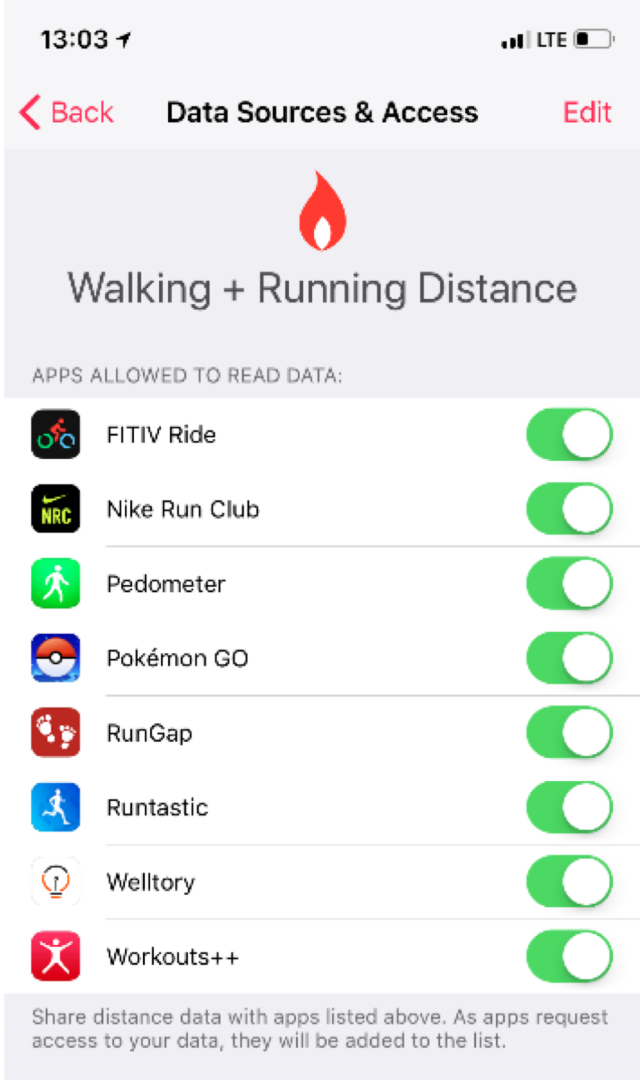
- **What's inside:**
  - Information about allergies, chronic diseases, immunizations
  - Lab tests, prescriptions, studies
  - Basic health data



Apple Health

Third Party Access

- **Third-party apps have access to Health data**
- User permission required
  - Do you trust all of them?
- Other types of data leaked before (Celebgate, location leaks etc.)
- **Can Health data leak?**
- Leaked Health data may be used for targeted advertising



Apple Health

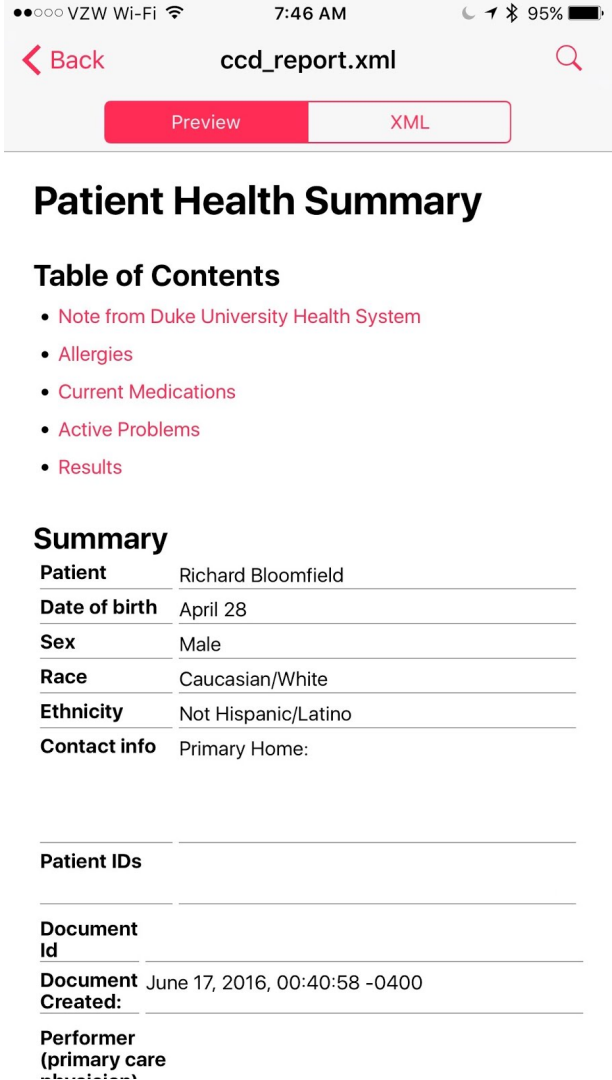
Where Apple Health Gets Data From

- Manual entry in the Health app
- Data received from HealthKit devices (iPhone, Apple Watch, compatible fitness trackers etc.)
- Third-party apps (Nike+, MyFitnessPal, Pillow)

Apple Health

Where Apple Health Gets Data From

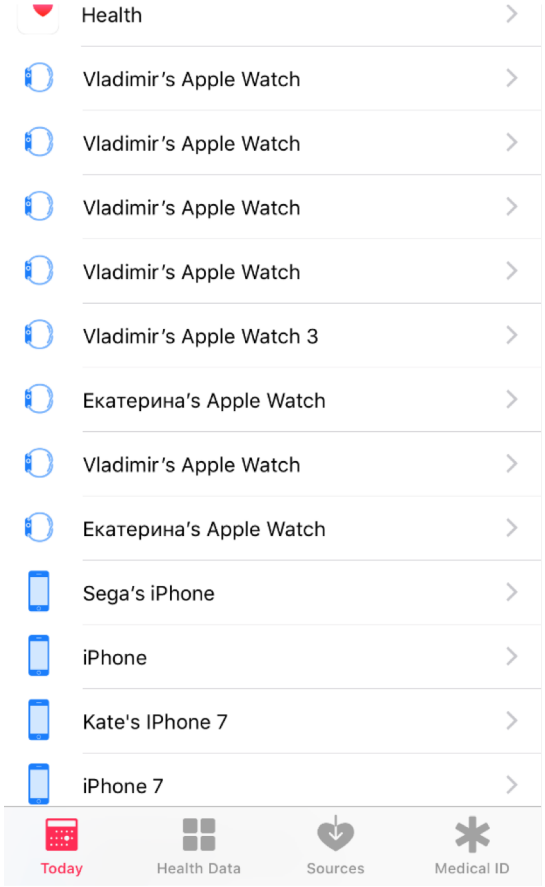
- Manual entry in the Health app
  - CDA documents
  - Electronic medical card data
  - **No Health Records**



Apple Health

Where Apple Health Gets Data From

- Data received from HealthKit devices (iPhone, Apple Watch, compatible fitness trackers etc.)
  - Automatic data submission
  - Pulse, blood pressure
  - Data for Mindfulness, Heart and Activity
  - Apple Whatch collects Sleep data; **no automatic mode** (third-party apps can be used)



Apple Health

Apple Watch

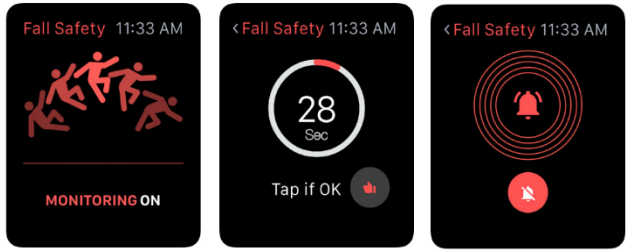
- Apple Watch contributes greatly to Health data
- Compatible with third-party apps (e.g. Pedometer++, Runkeeper)
- Steps (Health app calculates distance travelled)
- Heart rate
- Basic activity info: how long you stand, how much you exercise, calories burned
- New: Apple Watch 4 supports ECG (Electrocardiogram) (US only)

Apple Health

Apple Watch

- New: Fall detection
- Three fall patterns
- Automatic call to emergency number
- Logs and syncs fall events
- Essential bit of evidence: exact timestamp (down to the second) of the crime
  - Synced with the cloud, data may be available even if phone and watch are taken from the victim

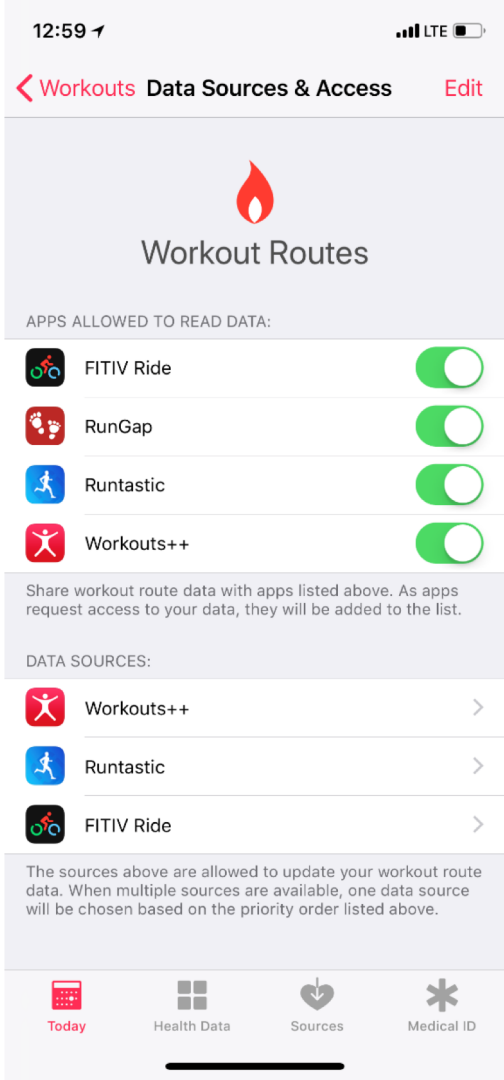
Apple Watch



Apple Health

Where Apple Health Gets Data From

- Third-party apps (Nike+, MyFitnessPal, Pillow)
  - All data categories supported…
  - Except Health Records and Medical ID
  - Each data category has a list of “Recommended” third-party apps for collecting that type of data
  - Third-party apps must be activated in categories tracked in Health > Sources



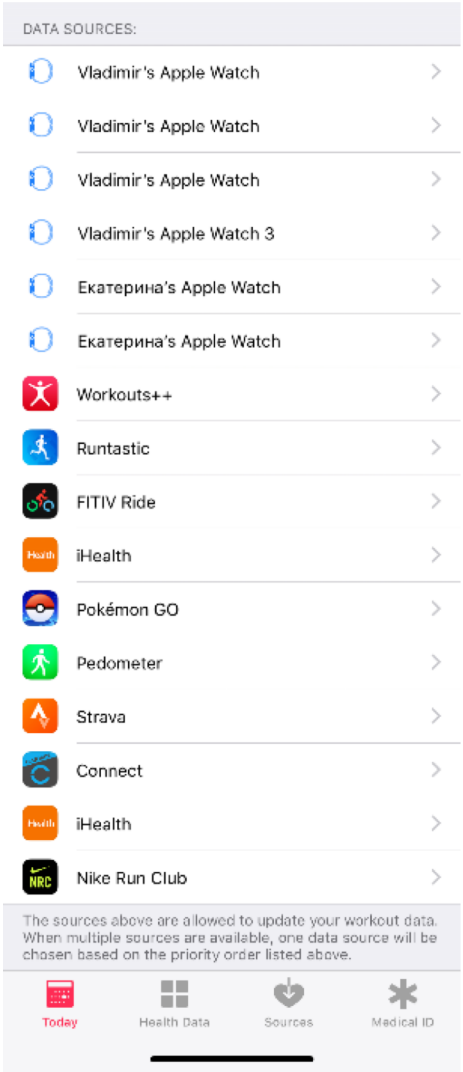
Apple Health

Apple Watch and Health security

Apple Health

How Apple Health Data Is Stored

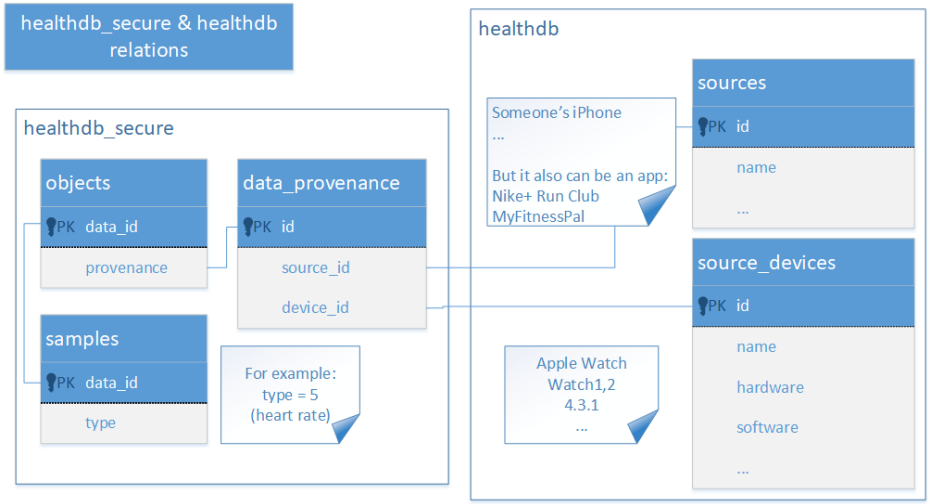
- Main data stored at **/private/var/mobile/Library/Health/**
- Two linked SQLite databases: **healthdb.sqlite** and **healthdb_secure.sqlite**
- Training geodata: **healthdb_secure.hfd**
- Encrypted database: healthdb_secure.hfd

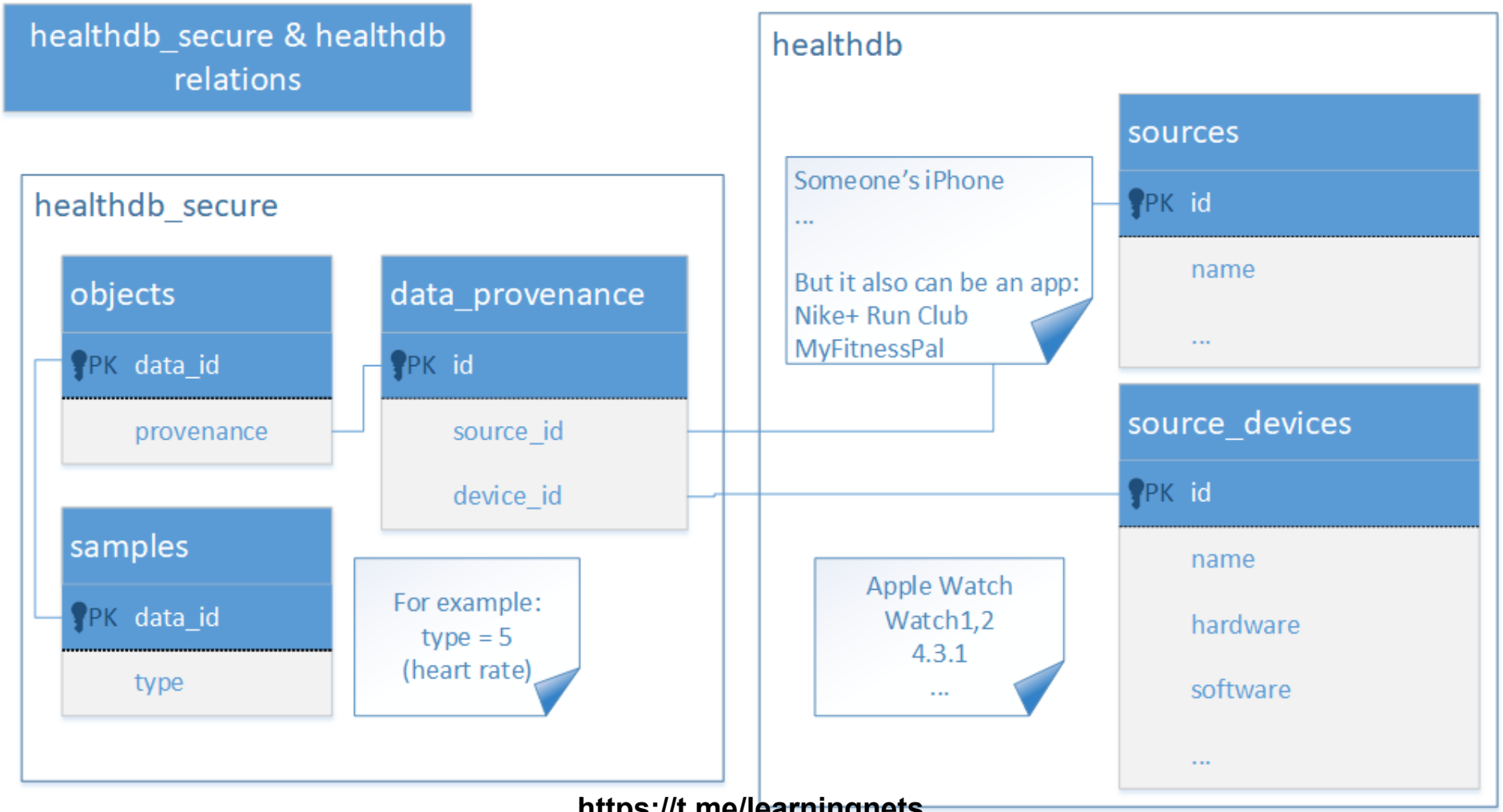


Apple Health

Database Structures

- healthdb.sqlite mainly contains information about data sources
- healthdb_secure.sqlite stores basic health information with frequent links to the first DB

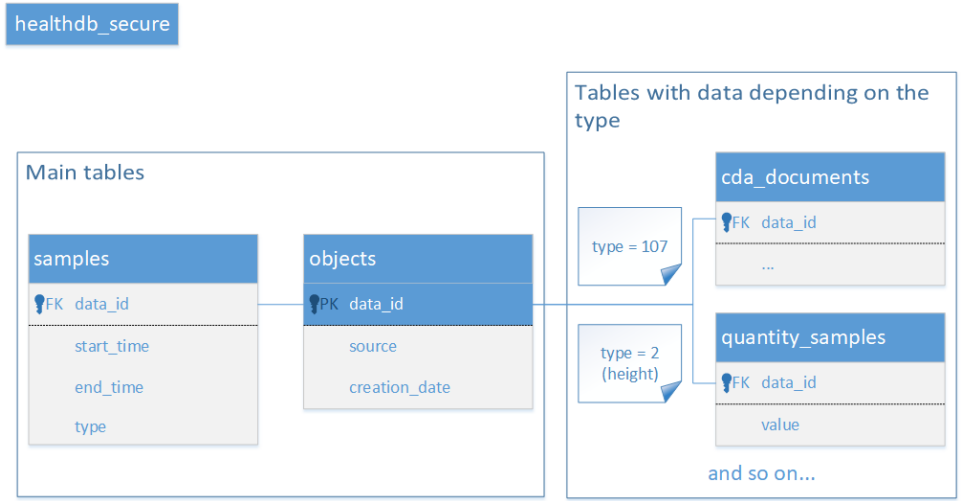




Apple Health

healthdb_secure

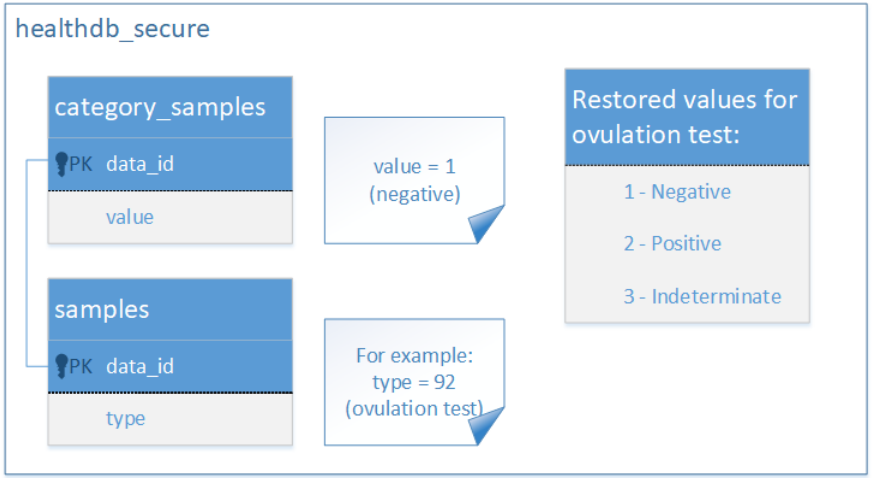
- **objects**: information on “samples” including ID and source
- Samples contain information including timestamp, type, numerical data (e.g. “10 steps”) or category data (“test result positive”), and ID
- Samples are linked with “samples” table via ID
- Data values may be stored in various tables, e.g. **quantity_samples** or **cda_documents**



Apple Health

Category Samples

- Category samples contain non-numerical data
- Corresponds to list view selection in the app
- category_samples table stores these values
- Restoring category_samples values to meaningful data is essential for understanding Apple Health data



Researching healthdb_secure

Table	Description
objects	Sample's uuid and source
samples	id, event type and time
quantity_samples	Source of numeric values
category_samples	Non-numerical category samples (e.g. "positive" or "negative" test result)
correlations	Keeps references to data instances, allowing to corellate quantitative data with activities
key_value_secure	Information about the user
metadata_values, metadata_keys	Sample metadata. Could be a note, time zone etc.
workouts,workout_events	Cumulative information about the workout: length, calories burned, distance walked, workout type etc.
fitness_friend_activity_snapshots	Data received via "share with friends & family". The contact is linked via an extra file ActivitySharing/contacts.dat. This file contains information about the contact (name, phone number and e-mail)
cda_documents	Binary data of a corresponding CDA document
data_provenance	Allows linking data sample with data source (device, app etc.)
unit_strings	Metric type (lb/kg etc.) from quantity_samples

Known healthdb tables

Таблица	Описание
authorization	Authentication and sync data
cloud_sync_stores	Last sync data
key_value	App-specific values (e.g. if emergency sos mode is active)
source_devices	Information about devices the data was synced from
sources	Information on received data (source, modification date)
subscription_data_anchors	Data about synchronization
sync_stores	List of synchronization sources

Apple Health

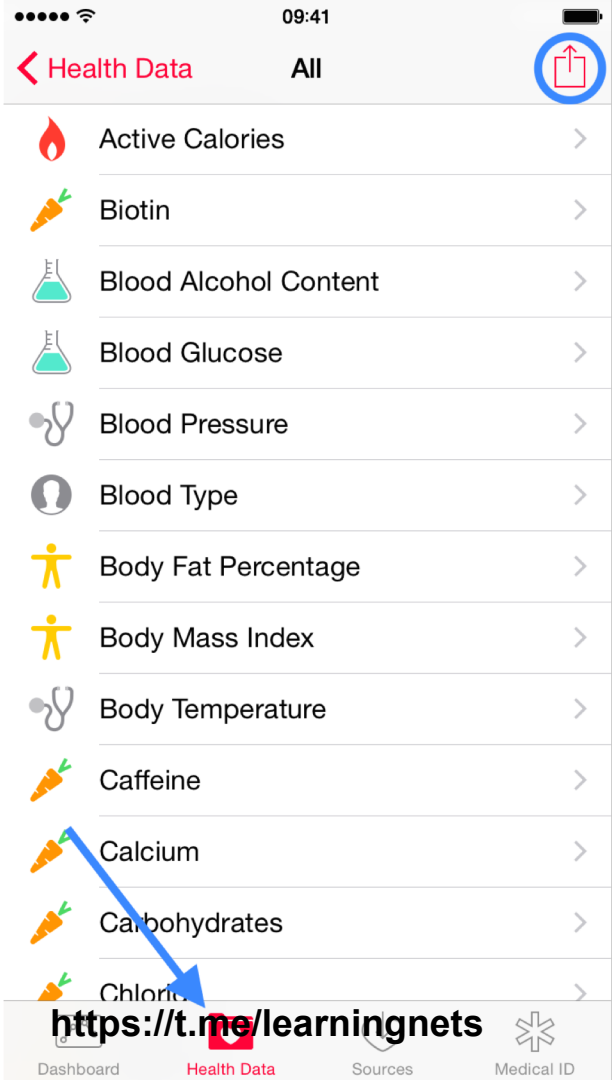
Accessing Apple Health Data

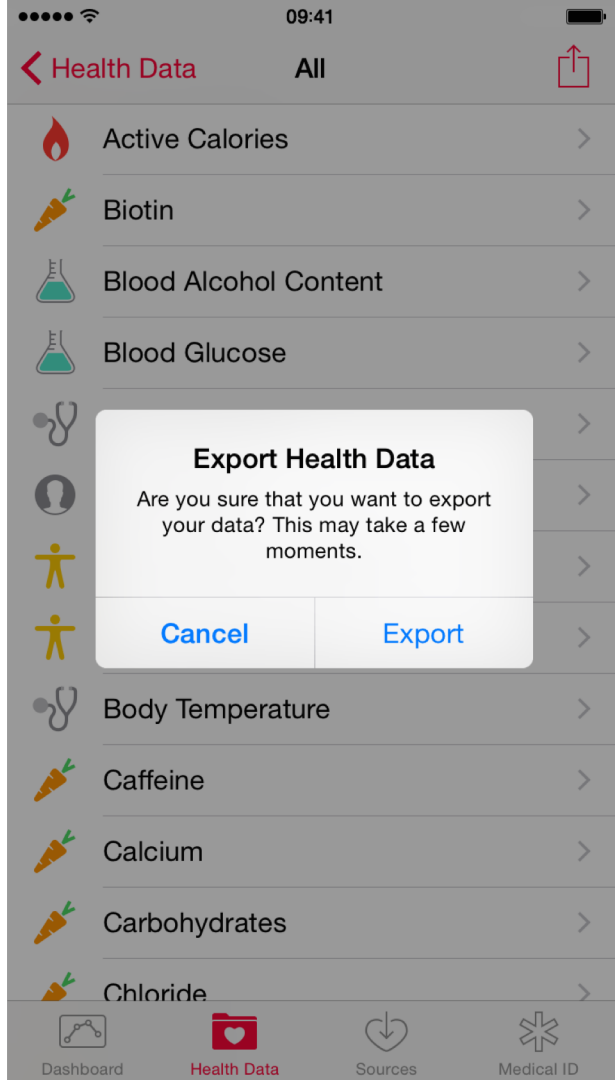
- Export from Apple Health app
- Local backup
- GDPR request
- Physical acquisition
- Cloud extraction

Apple Health

Exporting Data

- Apple Health has export option
- Data can be exported to a ZIP file
- Analysis?





Apple Health

Extracting Apple Health Data: The Easy Way

- Apple Health is available via logical acquisition
- **No Apple Health data in unencrypted backups!**
  - Unlike keychain, which is still present in unencrypted backups, protected with a hardware key
- Set a known password before making a backup
- Make local backup (iOS Forensic Toolkit or iTunes)
- Decrypt backup, access Apple Health data
- View with Elcomsoft Phone Viewer

Apple Health

Extracting Apple Health Data: The Complex Way

- Apple Health is available via file system acquisition
- **Jailbreak required**
  - At this time, jailbreak is available for all versions of iOS 8..10, iOS 11.0-11.3.1
- Jailbreak, use Elcomsoft iOS Forensic Toolkit
- Obtain TAR image
- Open TAR with Elcomsoft Phone Viewer

Apple Health

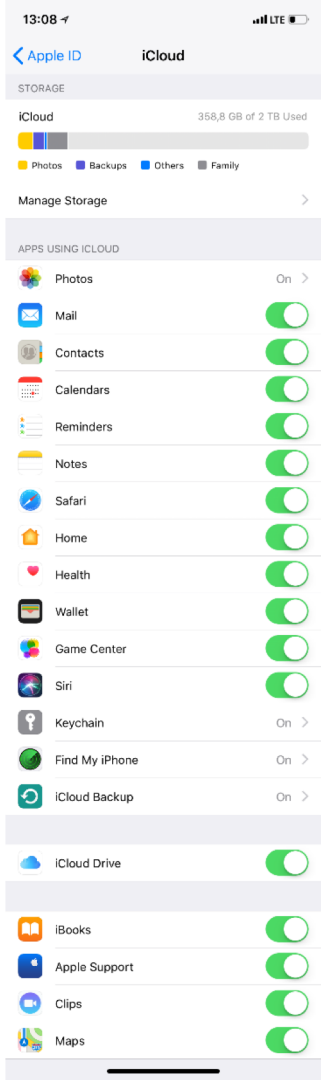
Extracting Apple Health Data: GDPR

- EU users can access their Health data by pulling a GDPR request
- Registering GDPR request: **privacy.apple.com**
- **Apple ID, password, 2FA required**
- Takes up to 7 days to receive the data
- Multiple binary formats

Apple Health

Apple Health and Cloud

- Native Apple Health data is synced with iCloud to all registered devices
- Third-party apps operate through HealthKit
- Some third-party app data is not shared with Apple Health
- Certain apps use proprietary cloud sync (Strava, Endomondo)
- **Medical ID** data is unique per device and **does not sync**



Apple Health

Apple Health and iCloud

- Apple Health data can be obtained from iCloud
- May contain significantly more information compared to what is available on device
- Technically, Apple Health belongs to “synced data” as opposed to “cloud backups”
    - This results in significantly more reliable extraction
    - Loose expiration rules of iCloud tokens compared to backups

Apple Health

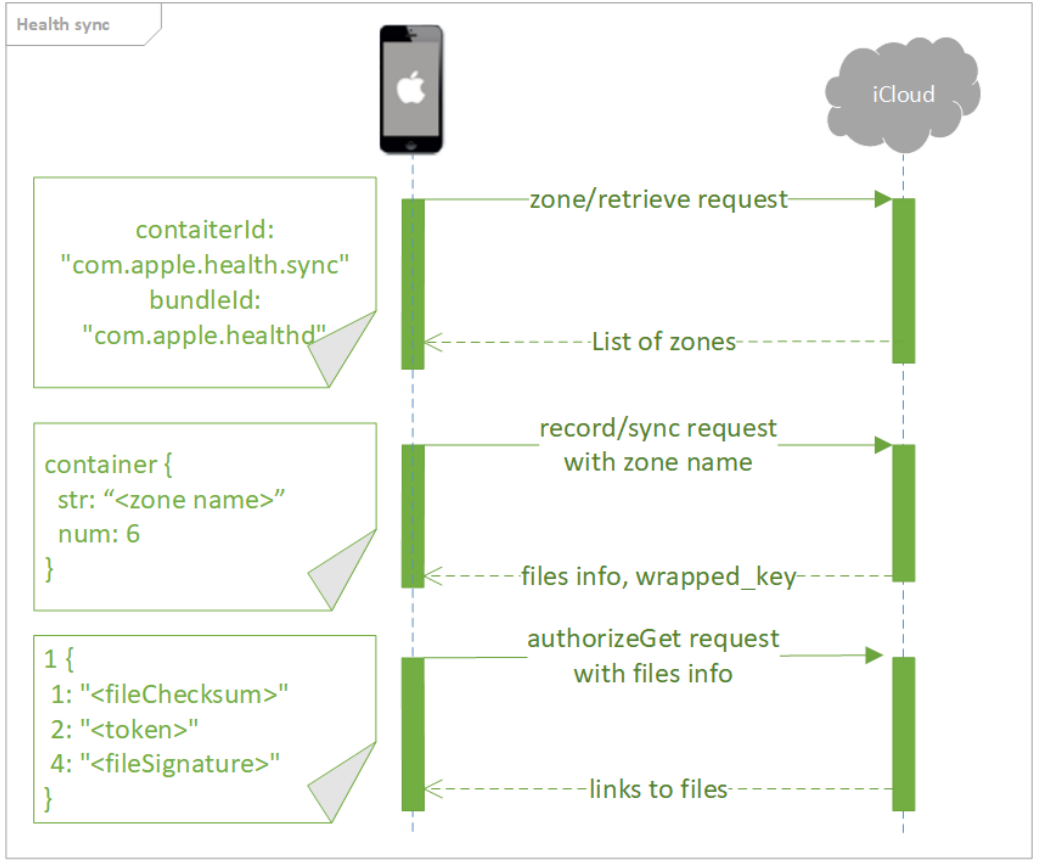
How Apple Health Data Is Synced

- Regular syncing: scheduled, after device reboot, on account change
- Data is stored in iCloud Drive (in chunks)
- Unlike iCloud Keychain or Messages, iCloud Health data has no additional protection
    - No need to enter device passcode, no additional encryption

Apple Health

Accessing Health Data

- Receive encrypted file chunks
- Request zone list
- Request zone sync
- Request file links
- Download files



Apple Health

```
containerId: "com.apple.health.sync"
bundleId: "com.apple.healthd"
```

Request Zone List

- All zones start with PrimarySyncCircle
- Followed by zone UUID, e.g. 1AA8B4D0-9B73-4D88-A740-BFE04DD8A5AC
- New zones created with logging in or on subsequent logins
- Zones are periodically merged

Apple Health

Request Zone Sync

- Request / Result:

```
container {
 str: "PrimarySyncCircle:AF64D6
29-3688-4062-9503-BE97B45D5BC2"
 num: 6
}
```

```
propertyName {
 name: "ChangeSet"
}
propertyValue {
 valueType: 6
 authInfo {
  owner1Dsid: "8888888888"
  fileChecksum: "\001\233\254\2671GQ\316\324mM\243\031\254\322|\017\364\233N\
f"
  structSize: 13465
  token: "B3B9SvMwRNXBK6fGaX6vOuVLwfbWA1H5QwEAAAMR7kM"
  url: "https://p29-content.icloud.com:443"
  owner2Dsid: "8888888888"
  wrapped_key {
   name: "\003_\242\000\335\266\255\312\0304\226e\344\333\235\227\226a\266\32
3H\364\021DM3\341\020~B\337O\346\016\017\357\375C[\346\301\311\356\261"
  }
  fileSignature: "\001\310\273\331\332\326a\337\202Xd\035e`p\277\321\226\211\
222\312"
  downloadTokenExpiration: 1529588220
 }
}
```

Apple Health

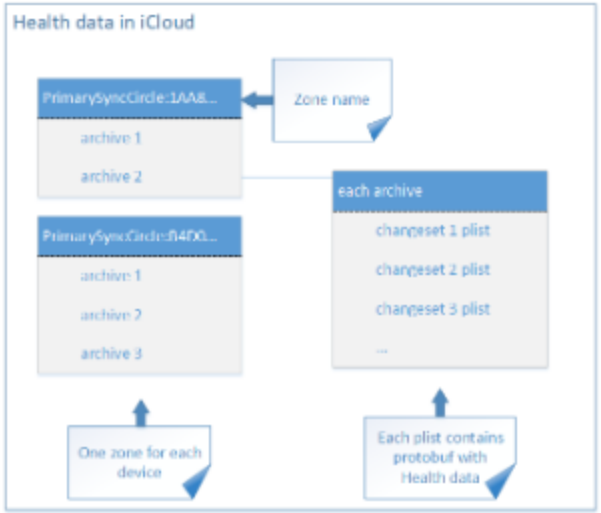
Request File Links


```
1 {
 1: "\001\233\254\2671GQ\316\324mM\243\031\254\322|\017\364\233N\f"
 2: "B3B9SvMwRNXBK6fGaX6vOuVLwfbWA1H5QwEAAAMR7kM"
 4: "\001\310\273\331\332\326a\337\202Xd\035e`p\277\321\226\211\222\312"
}
```

Apple Health

Download Files

- Files from the list are downloaded by chunks
- Downloaded chunks must be decrypted
- record/sync request returns encrypted key (wrapped_key)
- Key is decrypted
- We’ve got a key for unwrapping encryption keys that accompany each chunk
- These keys are unsrapped with wrapped_key and are used to decrypt the chunks
- Decrypted chunks are merged into files
- Files can be saved into a ZIP archive



Apple Health

Sounds too simple?

- Synced data is received in protobuf structures
- Received structures are serialized objects described in HealthDaemon header files
- There are several types of Protobuf structures (see next slide)

```
@interface HDCodableObject : PBCodable <HDDecoding, NSCopying> {
        double _creationDate; //proto index 4
        long long _externalSyncObjectCode; //proto index 5
        HDCodableMetadataDictionary* _metadataDictionary; //proto index 2
        NSString* _sourceBundleIdentifier;
        NSData* _uuid; //proto index 1
        SCD_Struct_HD20 _has;
}
@interface HDCodableSample : PBCodable <HDDecoding, NSCopying> {
        long long _dataType; //proto index 2
        double _endDate; //proto index 4
        double _startDate; //proto index 3
        HDCodableObject* _object; //proto index 1
        SCD_Struct_HD48 _has;
}
@interface HDCodableCategorySample : PBCodable <HDDecoding, NSCopying> {
        long long _value; //proto index 2
        HDCodableSample* _sample; //proto index 1
        SCD_Struct_HD16 _has;
}
```

Apple Health

Accessing Health Data in iCloud

We can download **synced data**, which includes Apple Health

What can go wrong:

- Two-factor authentication may be an issue
- Access to secondary authentication factor is required (unless using authentication token)

Apple Health

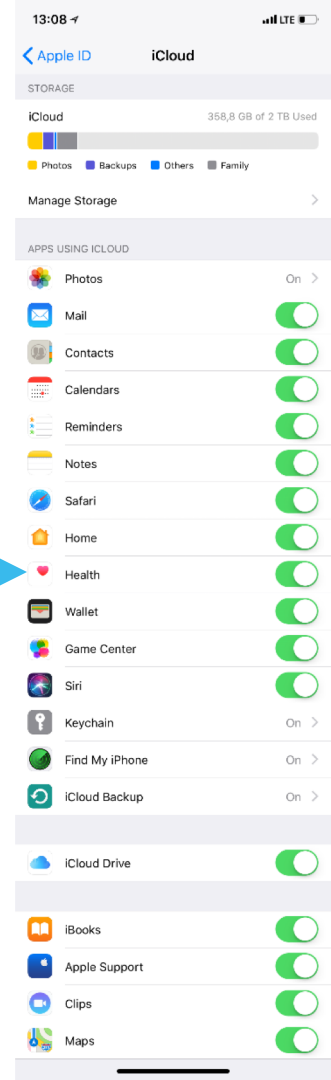
Accessing Health Data in iCloud

- If iCloud for Windows is installed, binary authentication token may exist
- Use Elcomsoft Phone Breaker to locate and extract the token
- Use Elcomsoft Phone Breaker to download **synced data,** which includes Apple Health, using the authentication token

Apple Health

iCloud Data Sync

- Health data
- If Settings | iCloud | Safari is enabled, it syncs:
  - Bookmarks
  - Open tabs
  - Reading list
  - Browsing history
  - **Call logs** (not in the Settings; syncs if iCloud Drive is enabled)
- Contacts, Notes, Calendars, Wallet (including boarding passes), Maps (searches and bookmarks)
- Keychain
  - With luck, password to Google Account (device passcode required)
- Messages (iMessages, SMS): since iOS 11.4 (device passcode required)



Apple Health

Authenticate into iCloud

- Using Apple ID and password:
  - Sign in
  - Respond to 2FA request
- Using iCloud token:
  - Sign in (synced data only)
  - Note: iCloud tokens do not appear to expire for synced data

Apple Health

That Looked Simple?

- Using a login and password is pretty straightforward
- Two-Factor Authentication can complicate things
- If the device is locked, you can pull a SIM card out and receive 2FA code

Apple Health

Vladimir Katalov, ElcomSoft

Questions?