The OS X App Sandbox

Session 700/713

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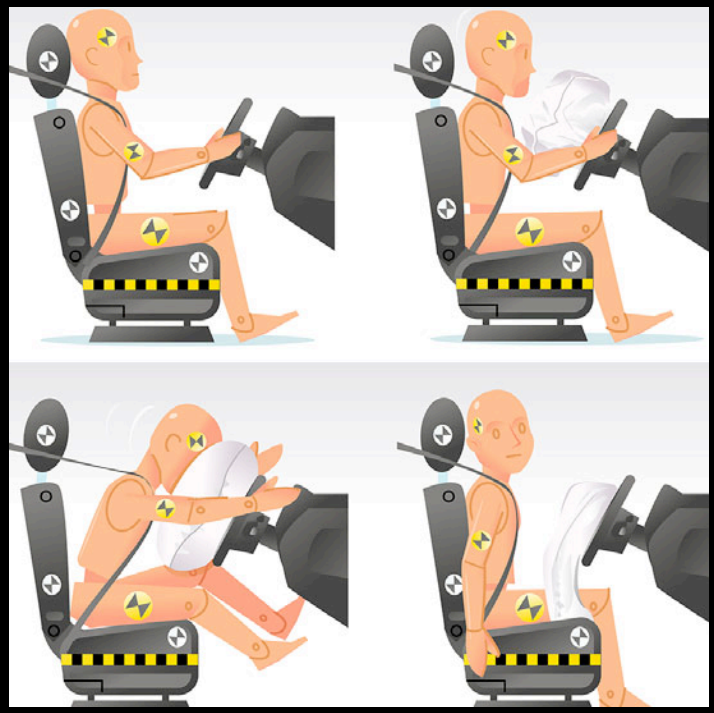
Core OS Disaster Monkey

Modern Car Safety

- Mandatory standardized crash testing performed by the government
- Traction control, blind spot warnings, lane drift alerts
- But: Damage containment
- When all else fails, there are seatbelts and airbags



Traditional Desktop Security

- Defender must protect everything at all times, attacker must breach one protection at any time
- Emphasis on damage prevention (ASLR, NX, antivirus), not containment
- One thing goes wrong, game over
- No seatbelt and airbag for the computer

The Unfortunate Assumption

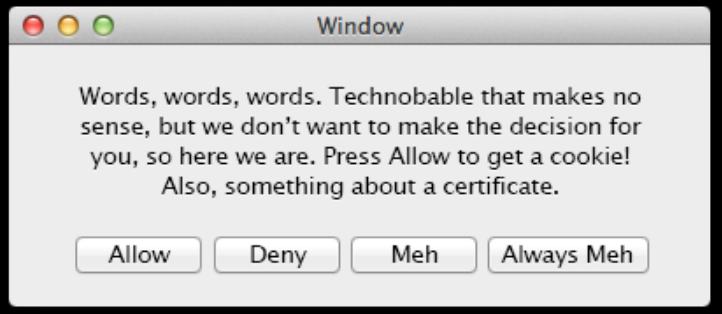
- All programs should execute with the full privileges of the executing user
  - Or: Security is a barrier between different users, not different programs
- But most modern computer devices are single-user systems
- Not every app should have access to the most sensitive data
  - Apps should only have access to the resources they need

An Unfortunate Example

- The unfortunate assumption does not work
- Compromising any app must not grant access to all user data

Security UI Does Not Work

- Security dialogs are mysterious and opaque; riddles wrapped inside enigmas
- Clicking “Permit” or “Allow” maximizes the likelihood of getting work done
- “If you’re explaining, you’re losing”
- Pavlovian conditioning to ignore security



Landscape Changes

- Many apps, many developers
- Computers are always on a network
- Easier than ever to find and run new software
- Security challenge: Isolate data between programs

Software Reality

- Complex systems will always have vulnerabilities
  - Complexity is never decreasing
- Single buffer overflow can ruin your user's day
- Frameworks and libraries you don't control
  - Every `WebView` instance: Millions of lines of code and a full-featured JavaScript engine
- No limit on exploit damage

App Sandbox

App Sandbox

- Introduced in OS X Lion
- More secure applications
- Drive security policy by user intent
- Contain exploit damage
- Reduce ability for a compromised or misbehaving application to steal, corrupt, or destroy user data

Key Concepts

- Developer expresses what an app is supposed to be able to do
- Each app runs in its own container
- User controls access to documents
  - Special cases (e.g., recent items, drag and drop) work automatically

Key Components

1. Entitlements
2. Containers
3. Powerbox
4. XPC Services

Entitlements

- What apps can do is determined by the developer-specified entitlements in the code signature
- Just a property list, editable in Xcode
- Simple, easy to understand
- About 20 total entitlements in Mountain Lion

Entitlements

- User-selected files, Downloads folder, secure bookmarks
- Personal information
  - Address book, calendars, location
- Assets: Music, movies, pictures
- Network client, server
- Devices
  - Camera, microphone, printing, USB, FireWire, Bluetooth, serial
- Application groups and scripting/automation targets

Key Components

1. Entitlements
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4. XPC Services

```
HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/
```

HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/

HOME=~/Library/Containers/App/
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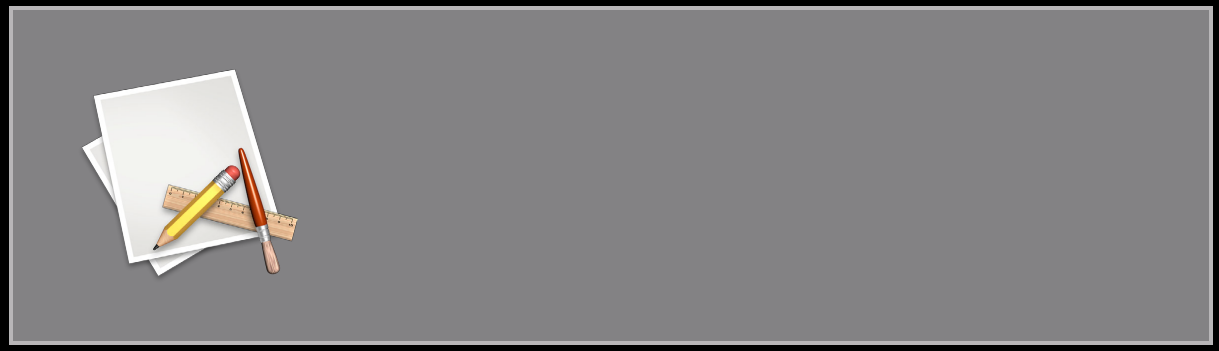
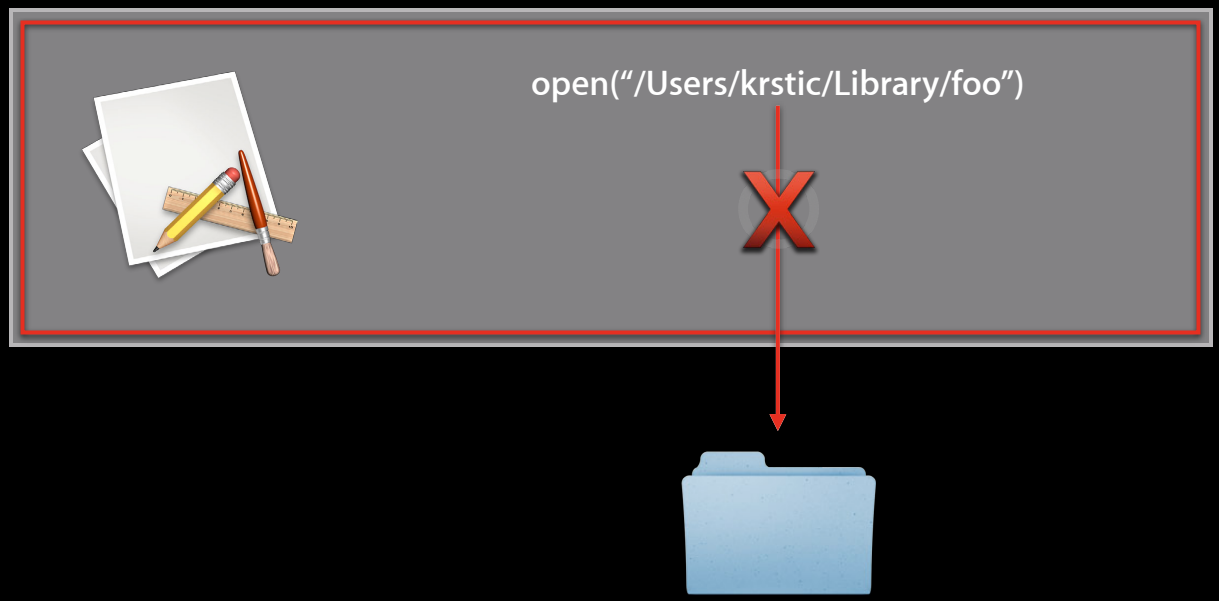


```
HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/
```

open(“/Users/krstic/Library/foo”)

```
HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/
```



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CFFIXED_USER_HOME=~/Library/Containers/App/

HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/

NSHomeDirectory()

HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/

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HOME=~/Library/Containers/App/
CFFIXED_USER_HOME=~/Library/Containers/App/
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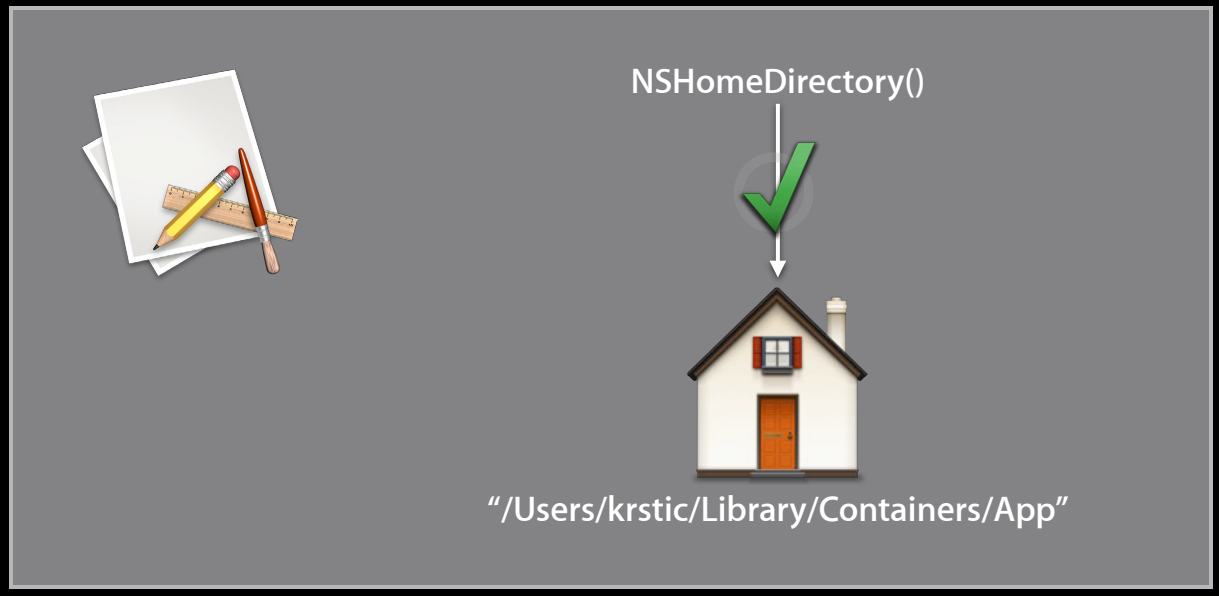
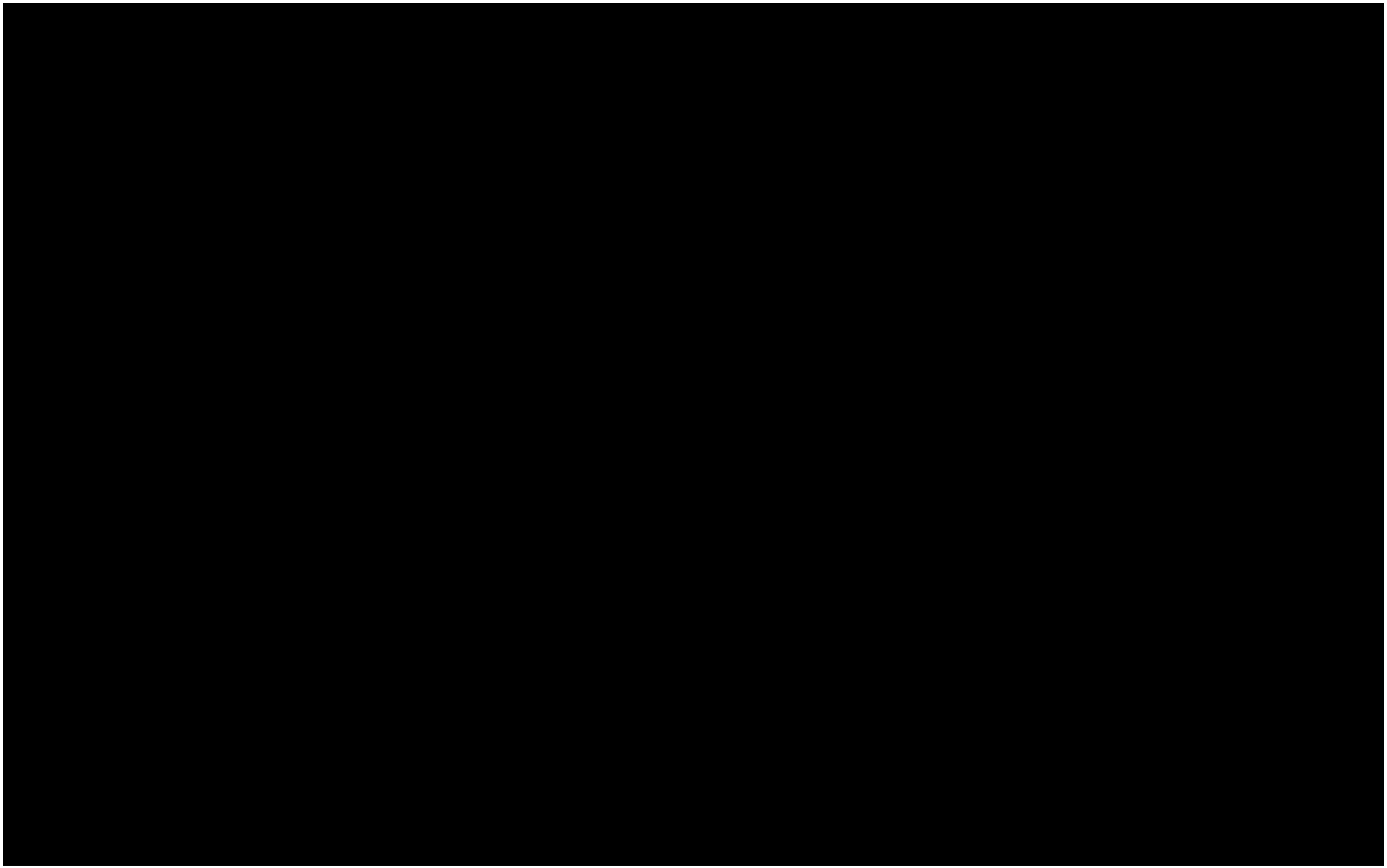


Key Components

1. Entitlements
2. Containers
3. Powerbox
4. XPC Services

Powerbox

- Cocoa NSOpenPanel/NSSavePanel
- Trusted mediator process
- Clear declaration of user intent
  - Drives security policy
  - Sandboxed apps cannot synthesize user input events

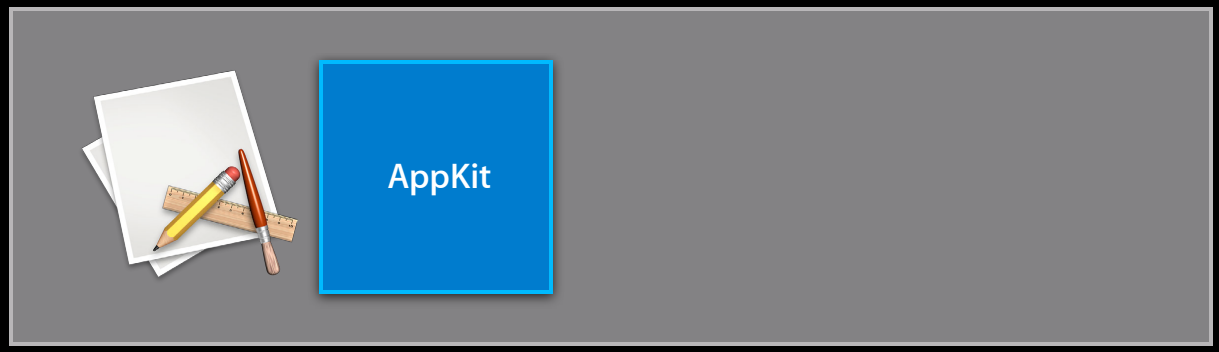


AppKit

~/Documents

Powerbox

AppKit



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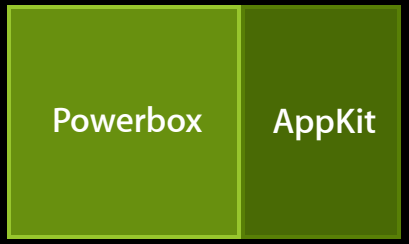

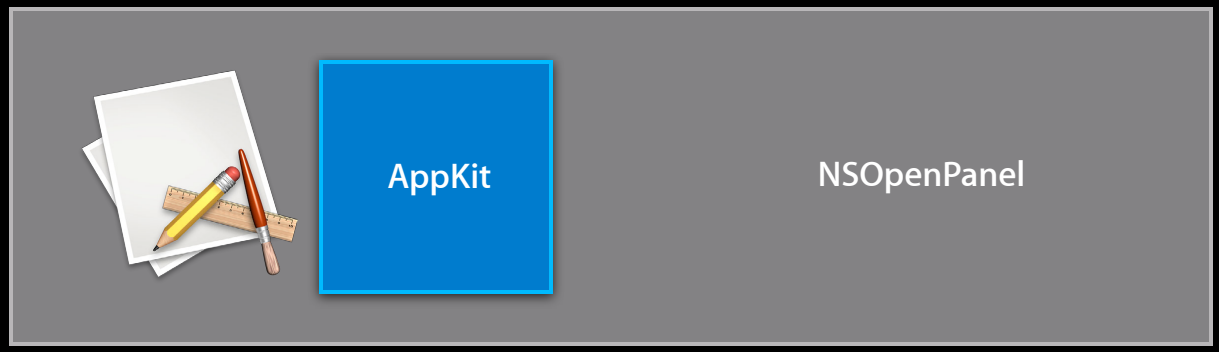

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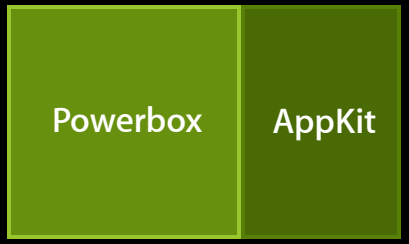

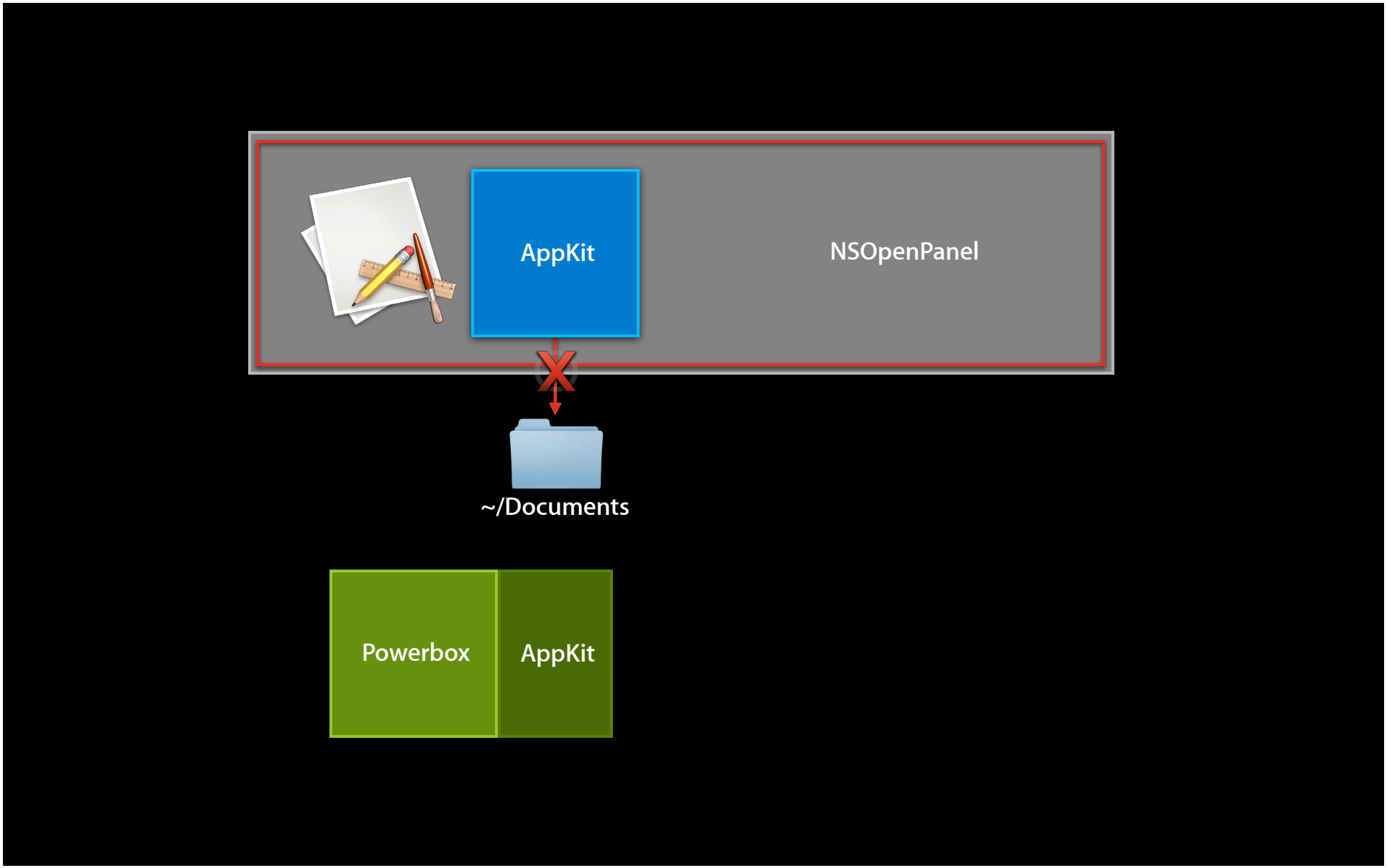
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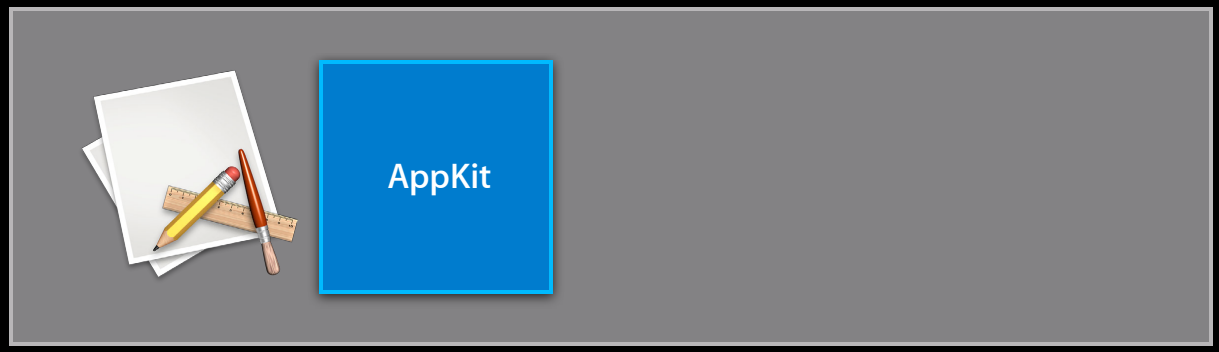

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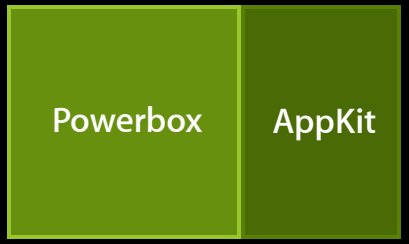

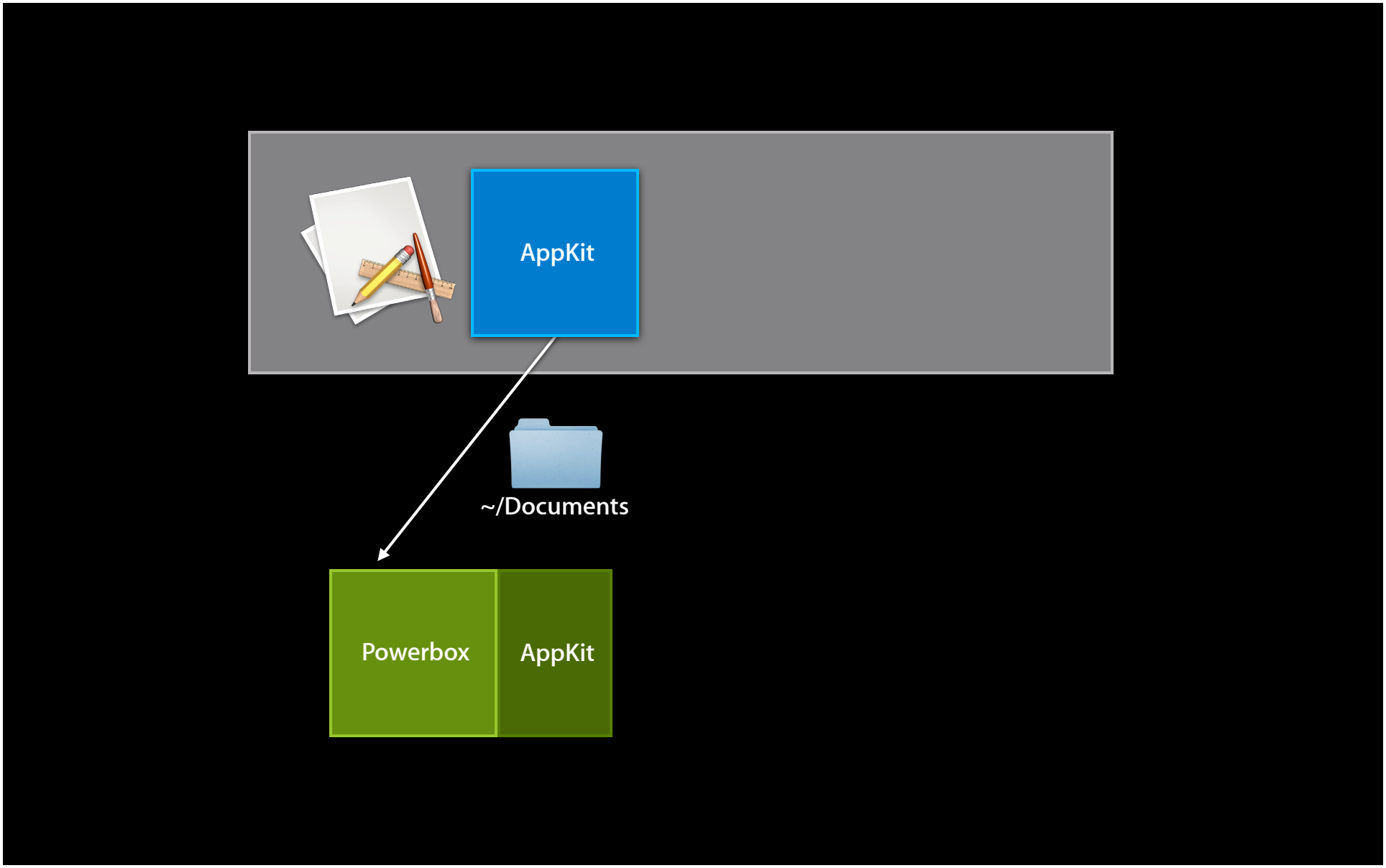
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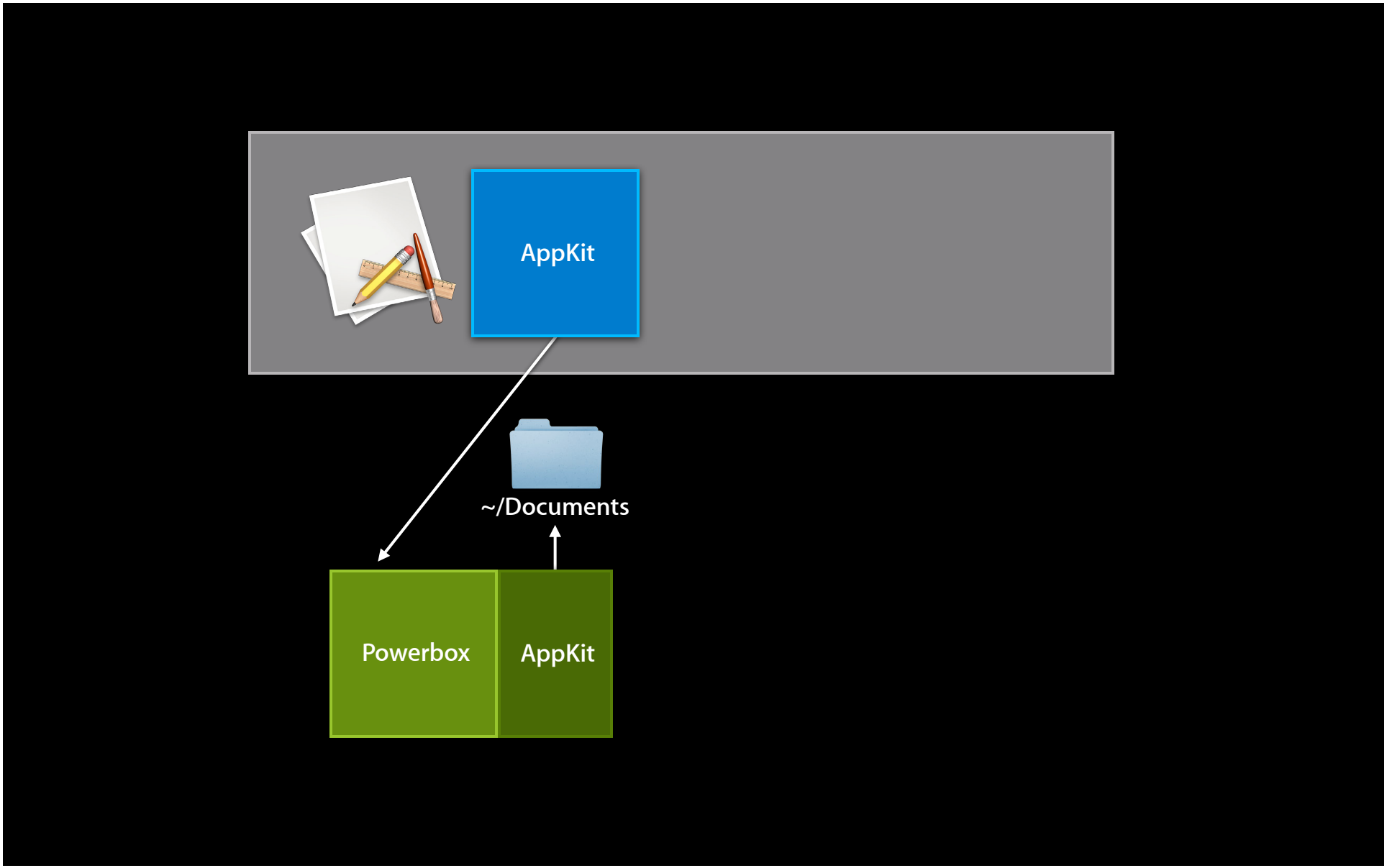
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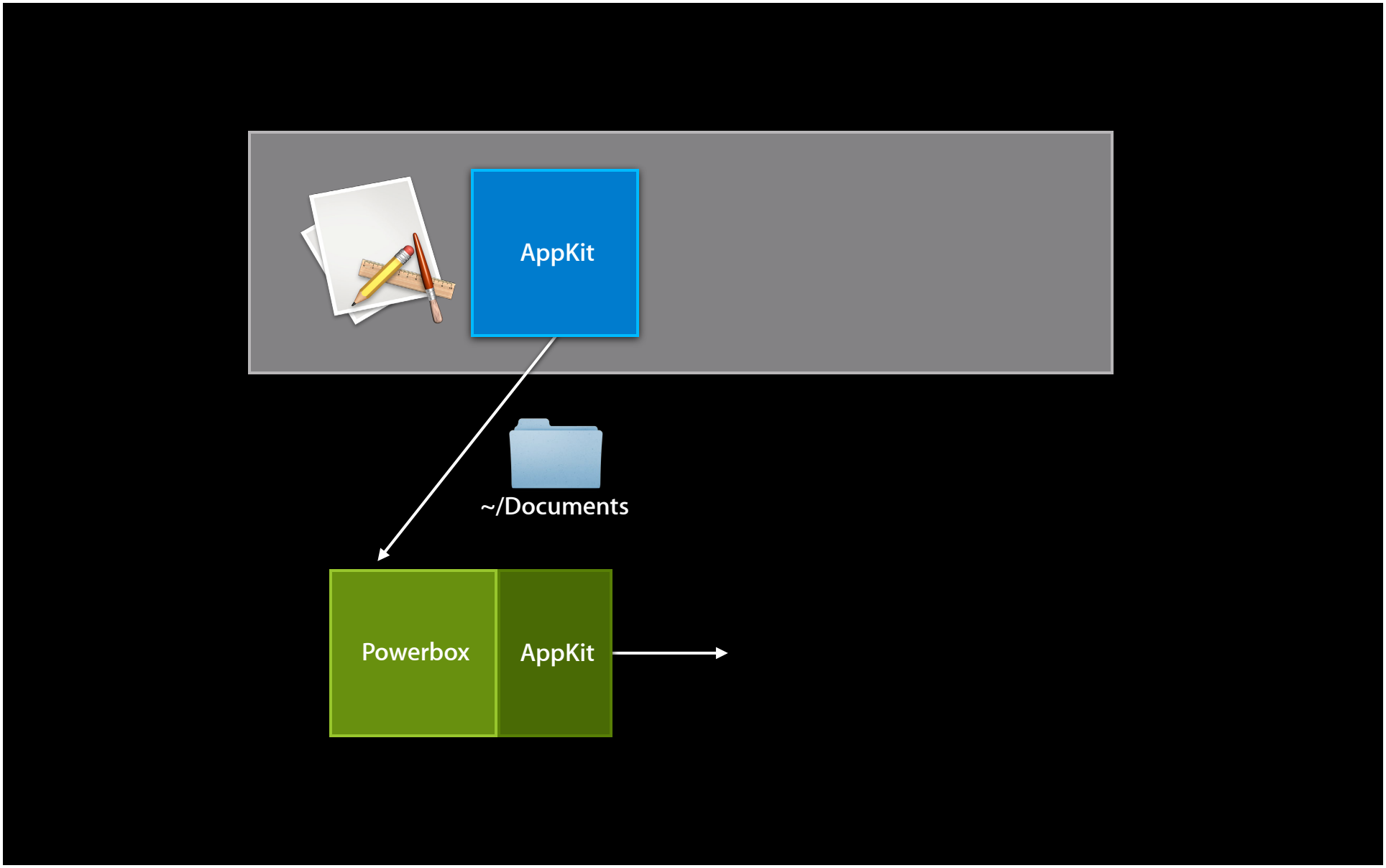
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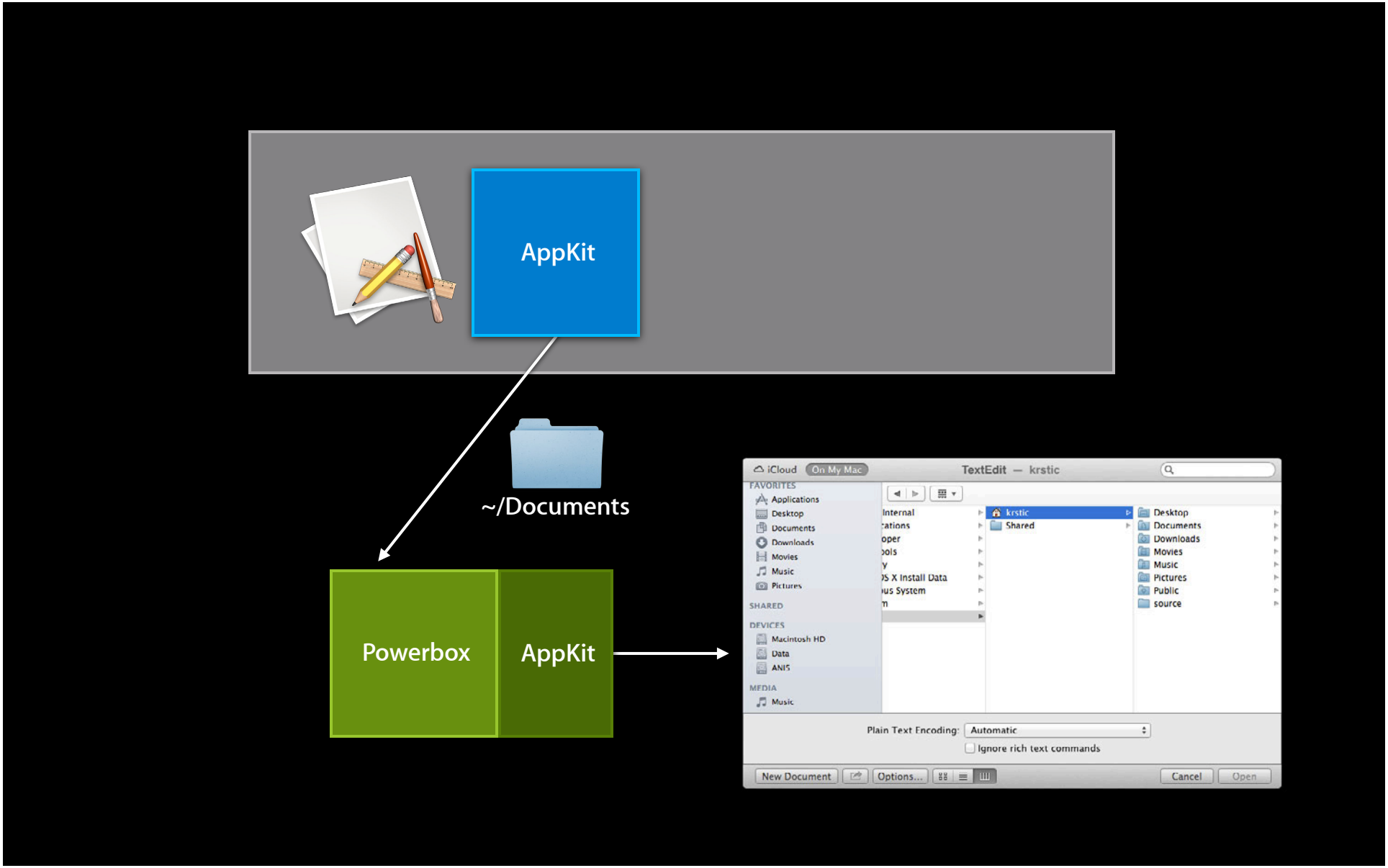
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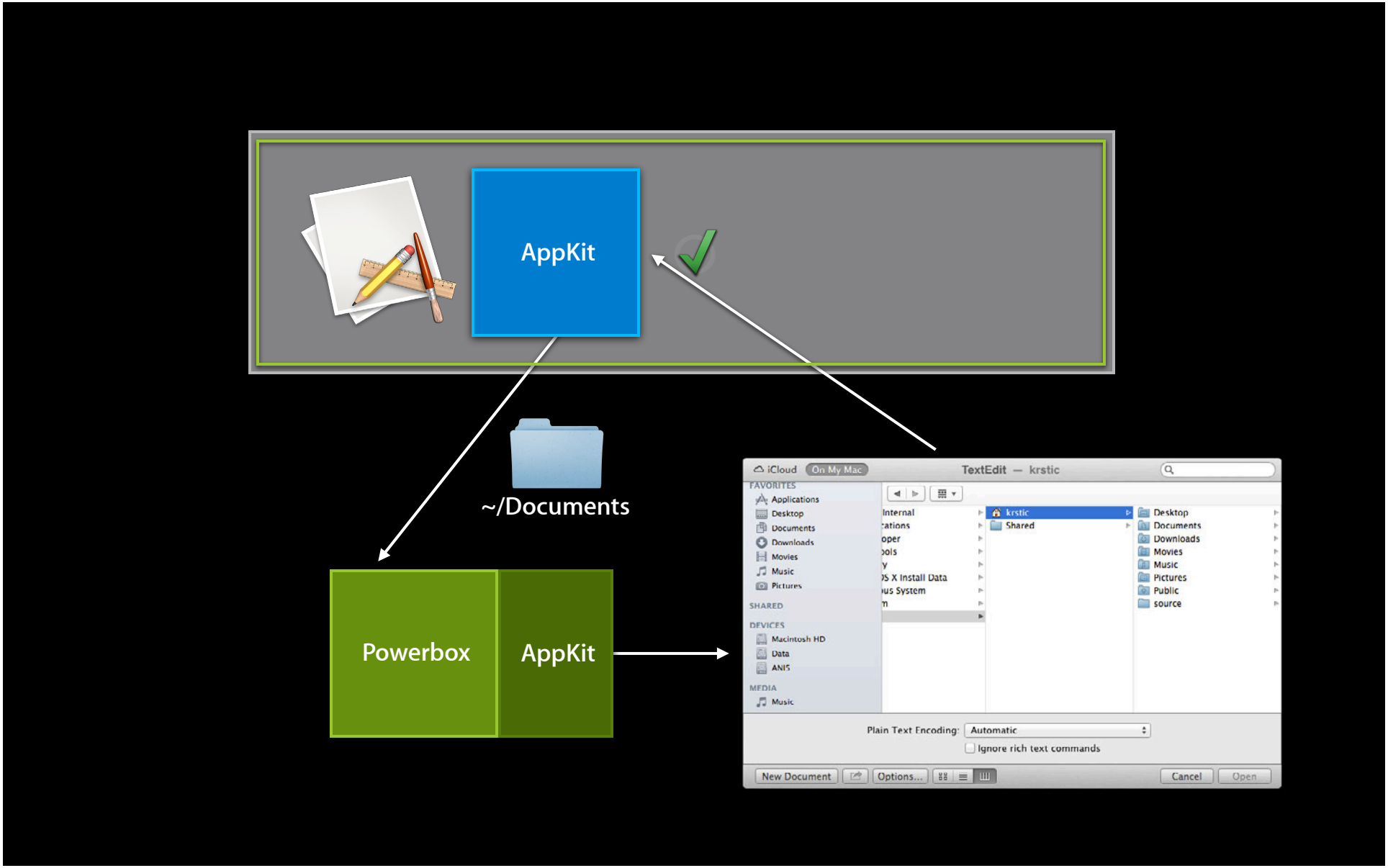
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Movies
Music
Pictures
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source
Plain Text Encoding:
Automatic
Ignore rich text commands
New Document
Options...
Cancel
Open

Key Components

1. Entitlements
2. Containers
3. Powerbox
4. XPC Services

XPC Services

- Very easy app and framework privilege separation
- Services have their own entitlements
- No fork/exec, process lifecycle managed by XPC
- Only available to the containing app

Putting It All Together

Adium

Adium

- Popular open source IM client
- Full featured
- 250 source files
- 75,000 lines of code for the main app
- 65,000 lines in app's own frameworks

Adium

Process

- Prepare entitlements
- Code sign program
- Run and verify App Sandbox status
- Look for violations

Demo

Adium

Exploitation

- The attacker only has access to documents that the user exchanged with buddies during this Adium run
- No ability to access or modify other apps or documents
- Need multiple vulnerabilities for a successful exploit

New Since Lion

New Since Lion

- Security-scoped bookmarks (10.7.3 and later)
- Application groups (10.7.3 and later)
- Related items
- Automation

New Since Lion

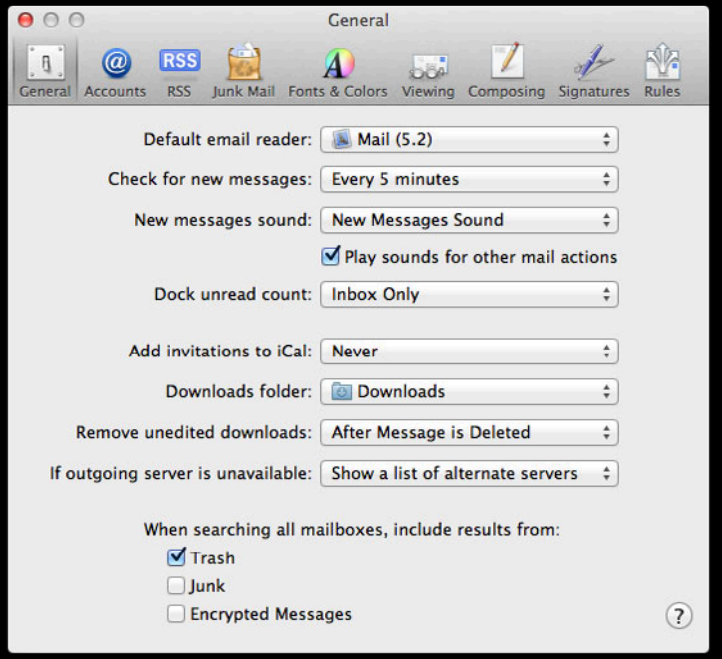
Security-scoped bookmarks

Security-Scoped Bookmarks

- Preserve access to user-chosen files and folders across system reboot
- Per-user app configuration: Input and output folders, commonly accessed files
- Document formats that contain references to files

Security-Scoped Bookmarks

- App scope
  - `com.apple.security.files.user-selected.read-{write,only}`
  - Locked to the app and user that created them



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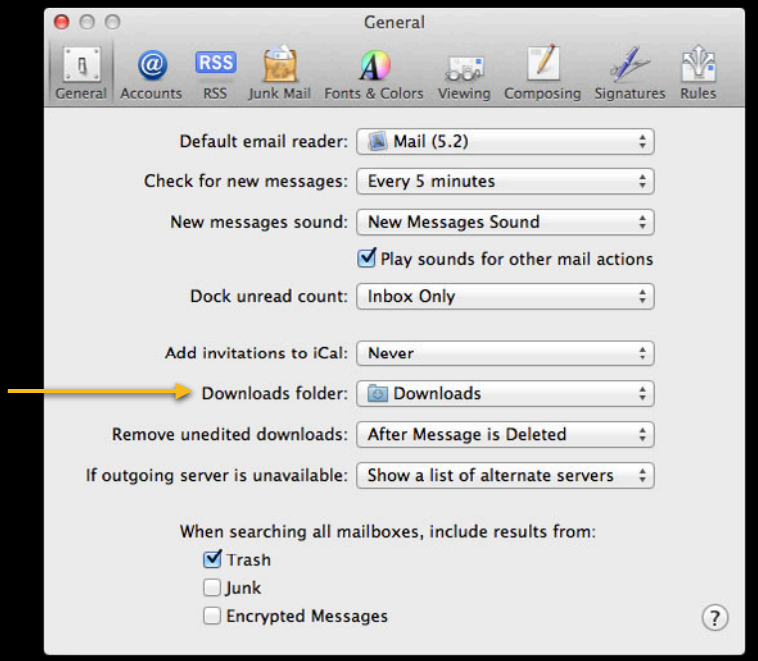

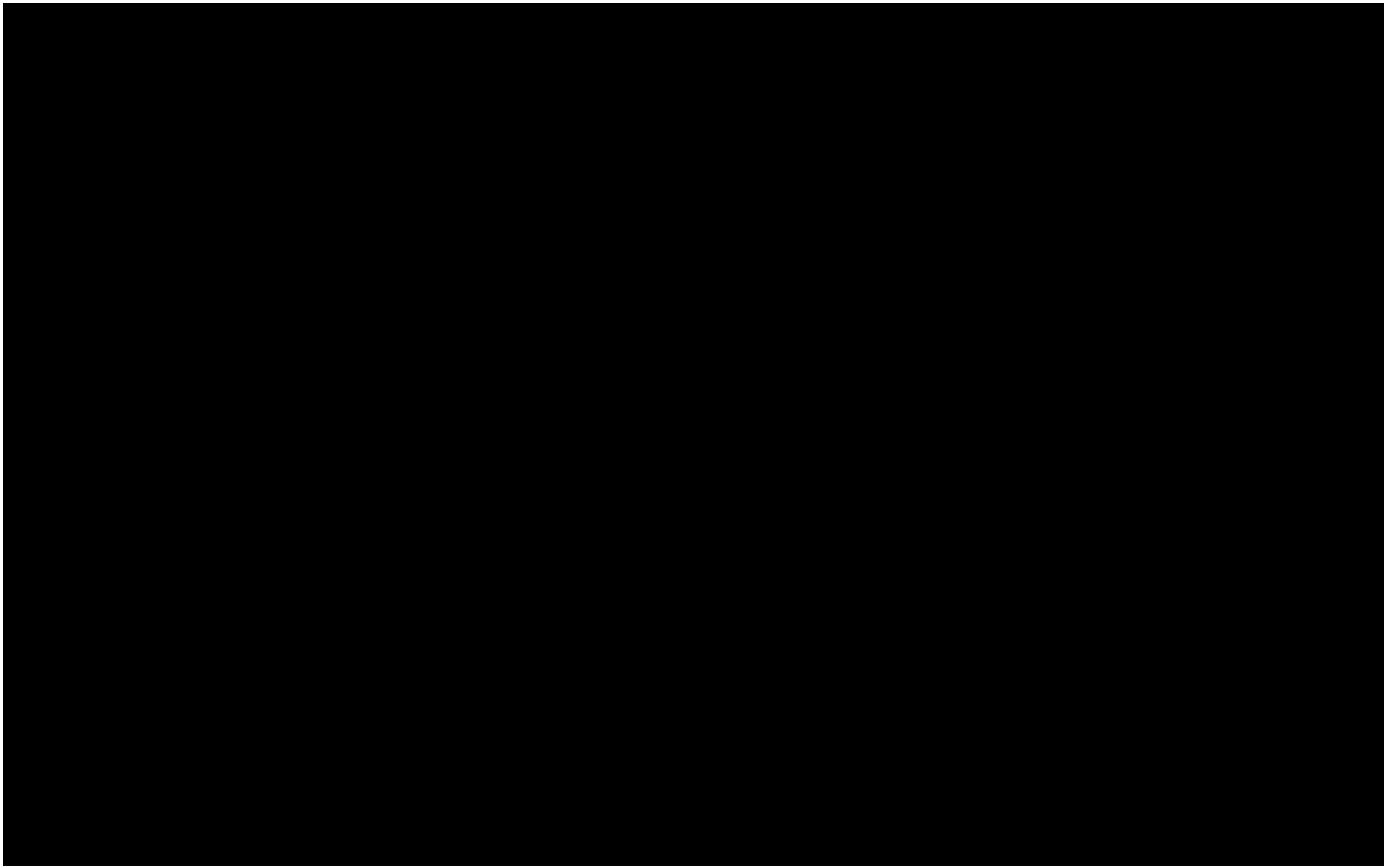

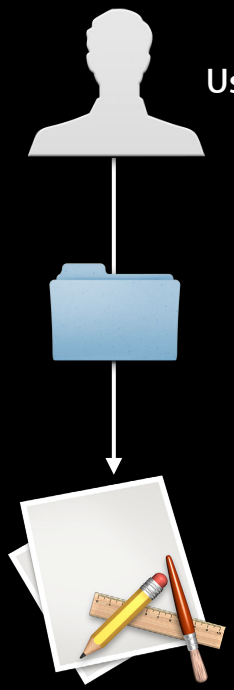
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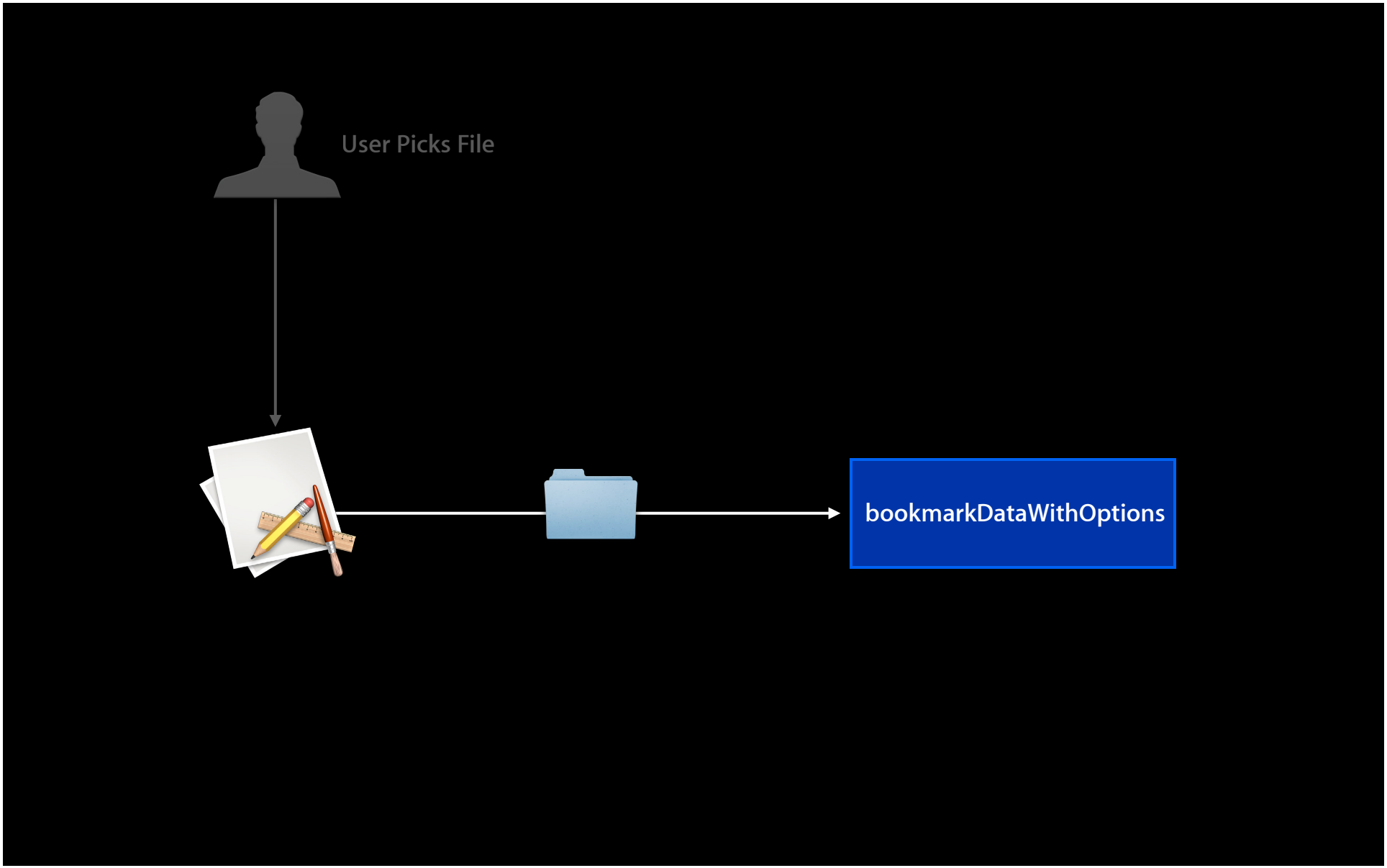
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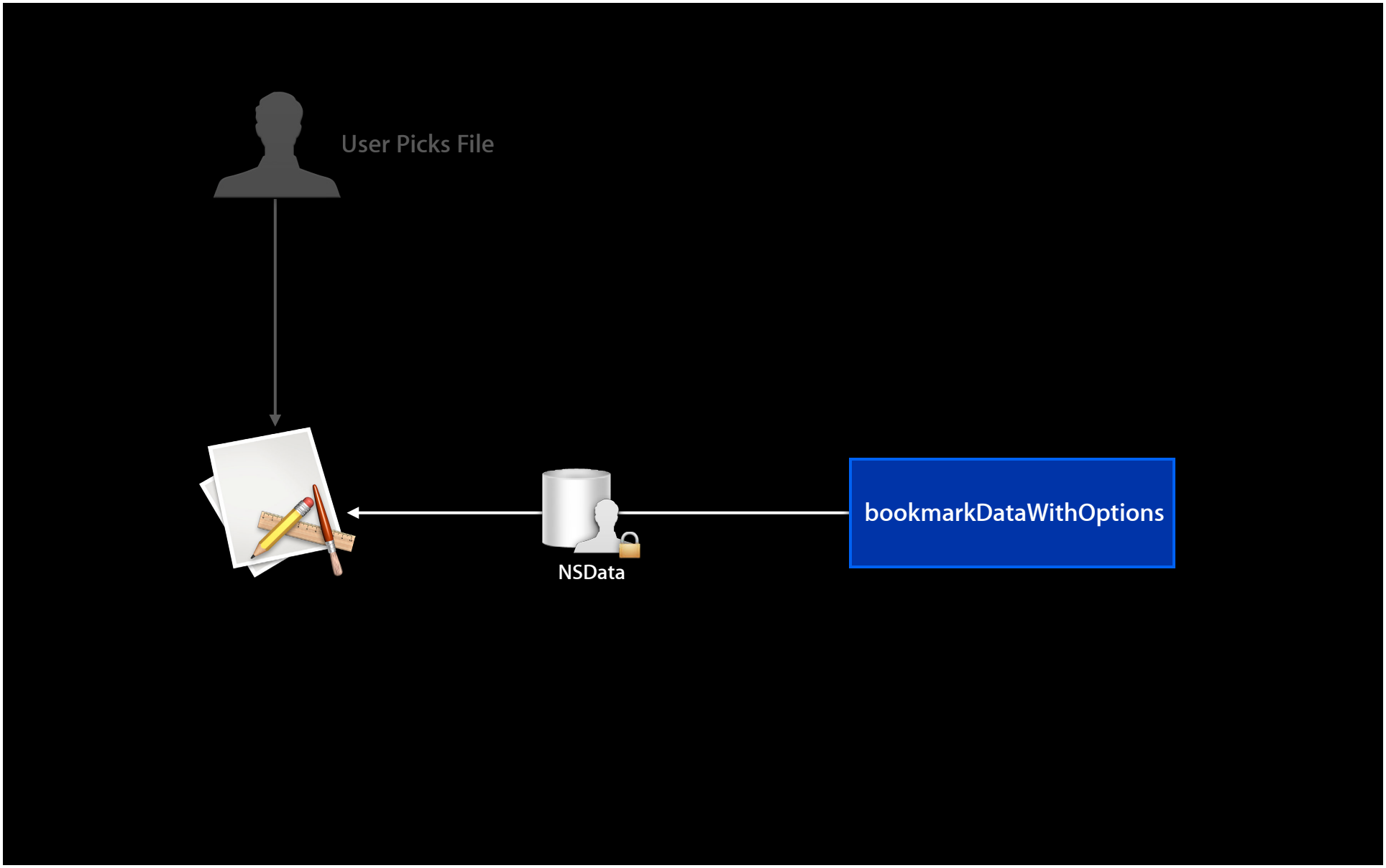
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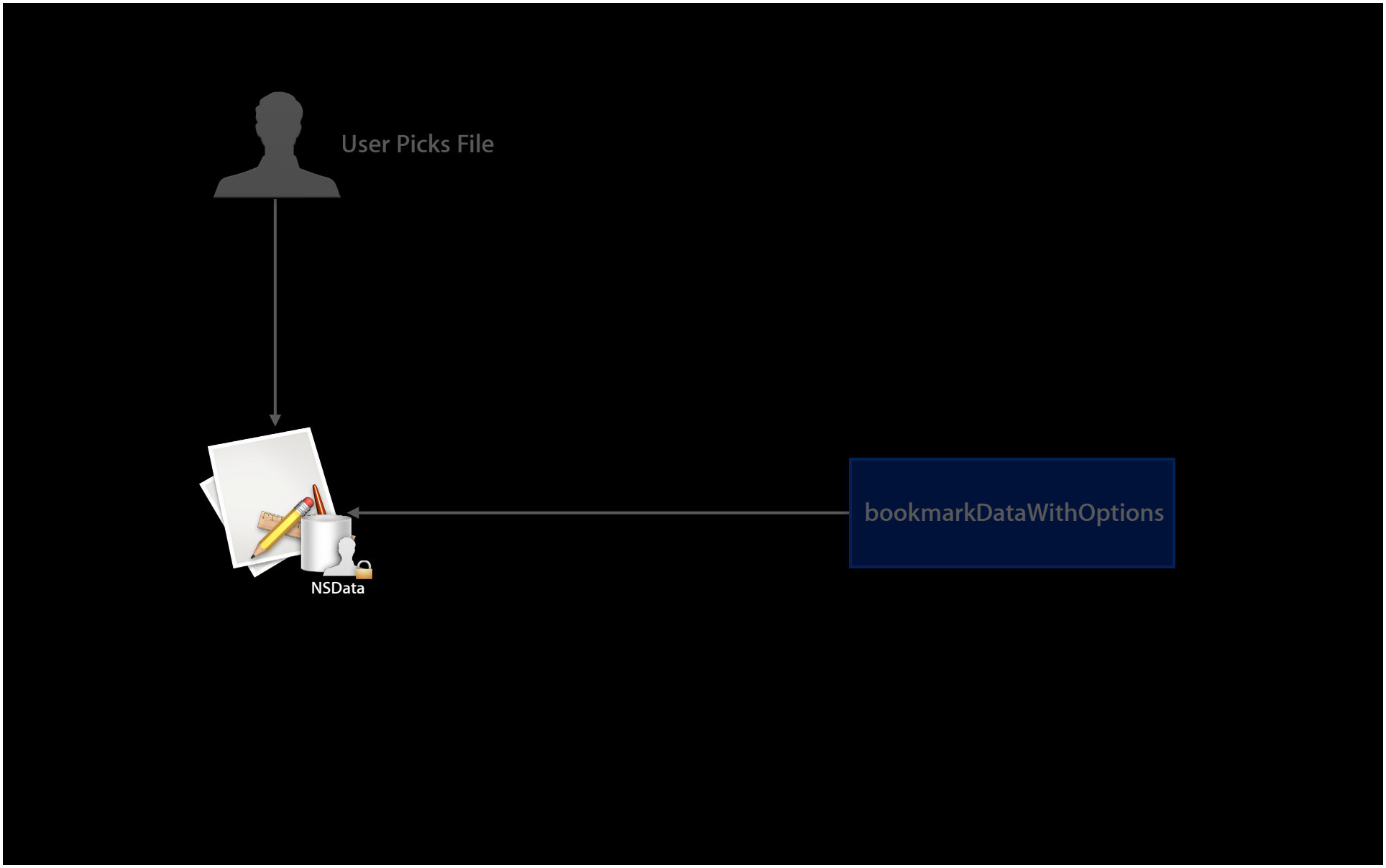
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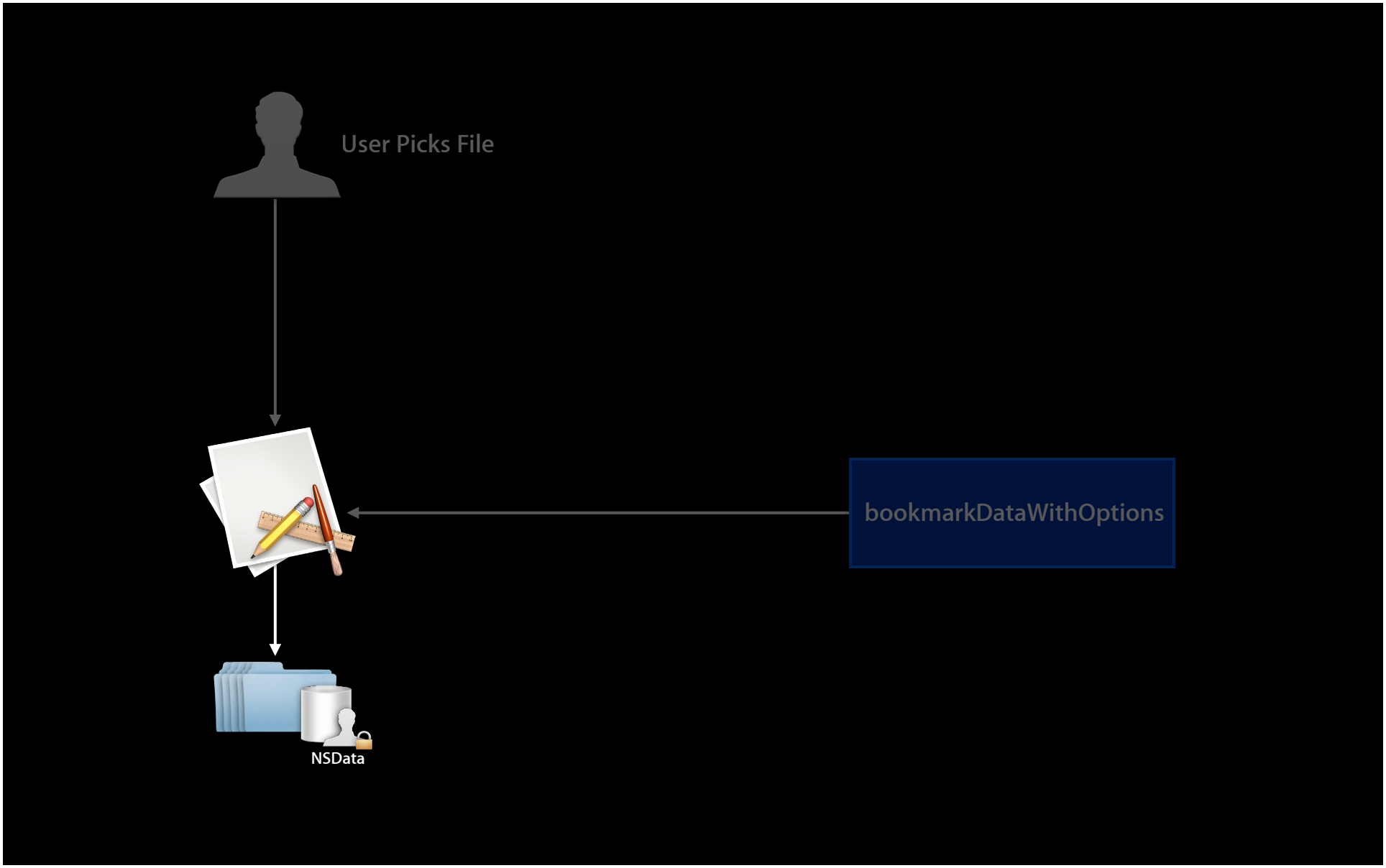
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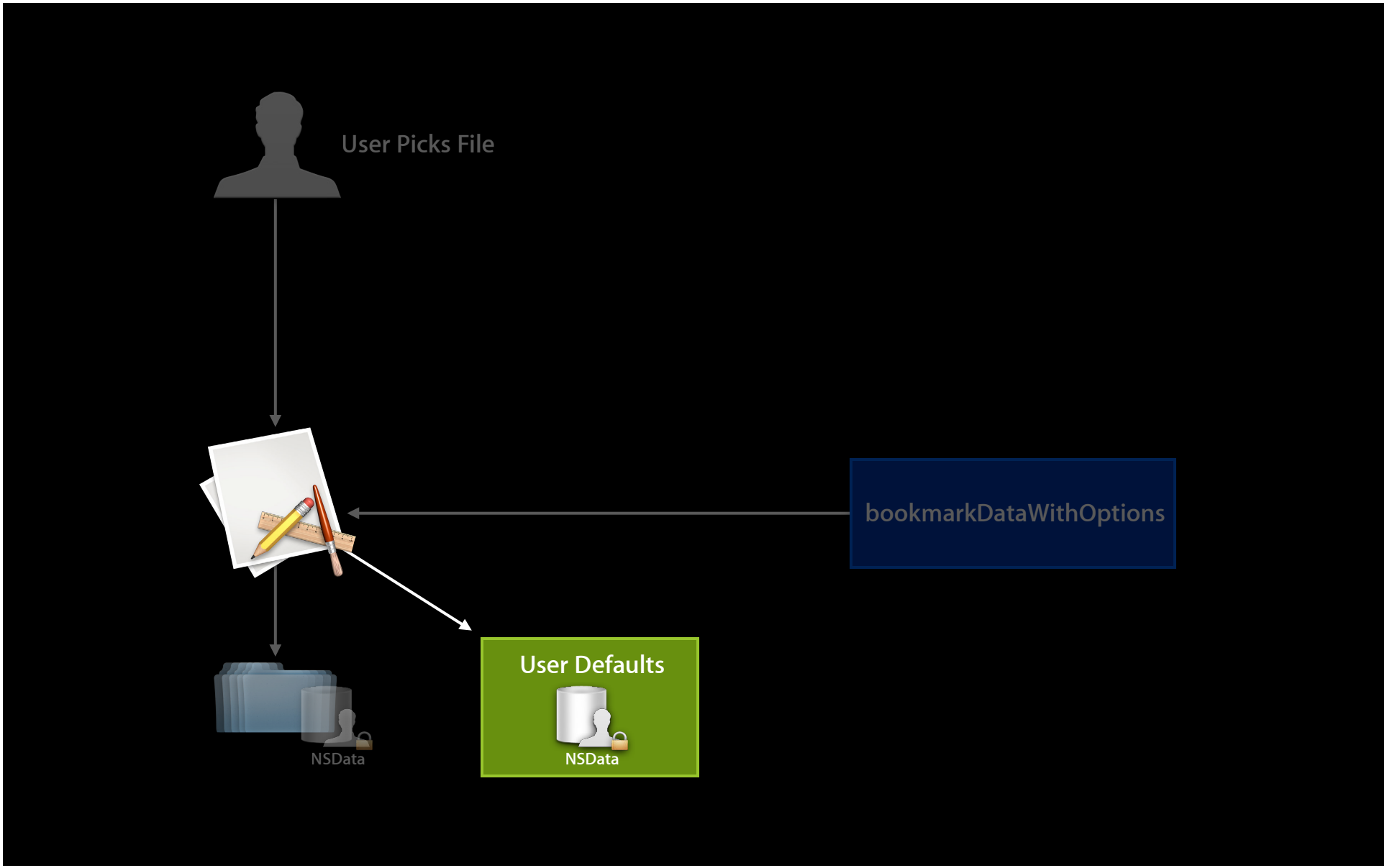
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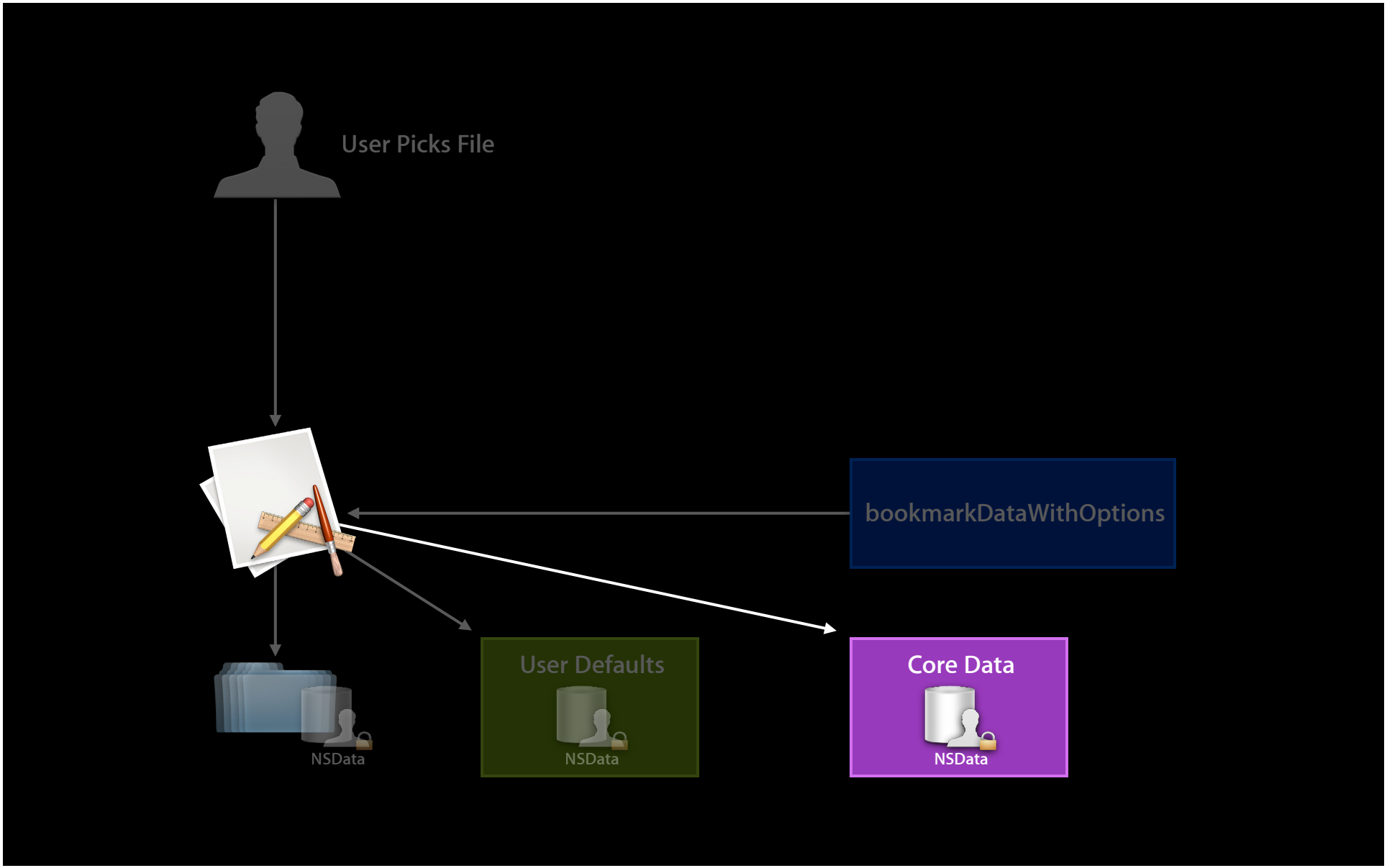
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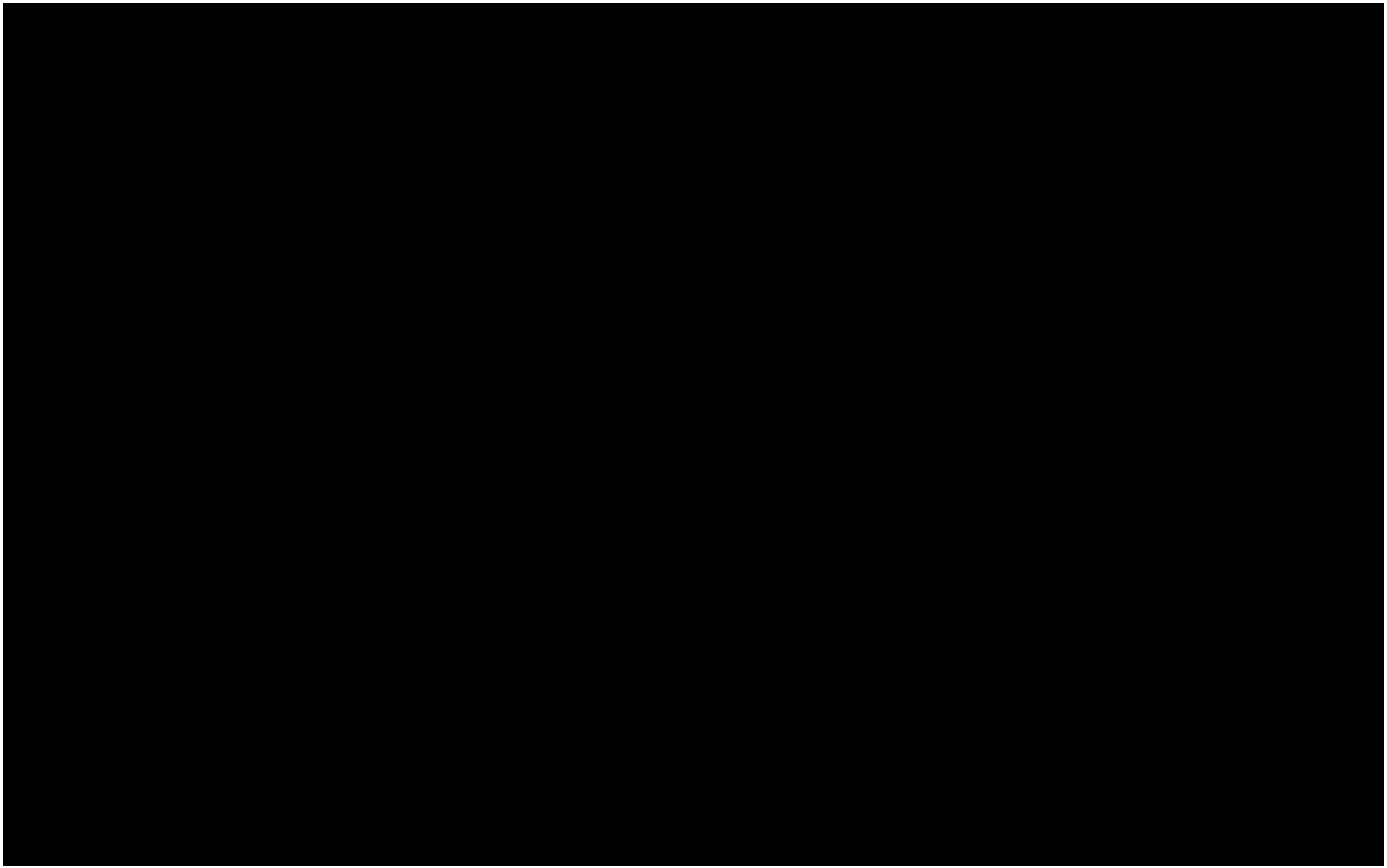

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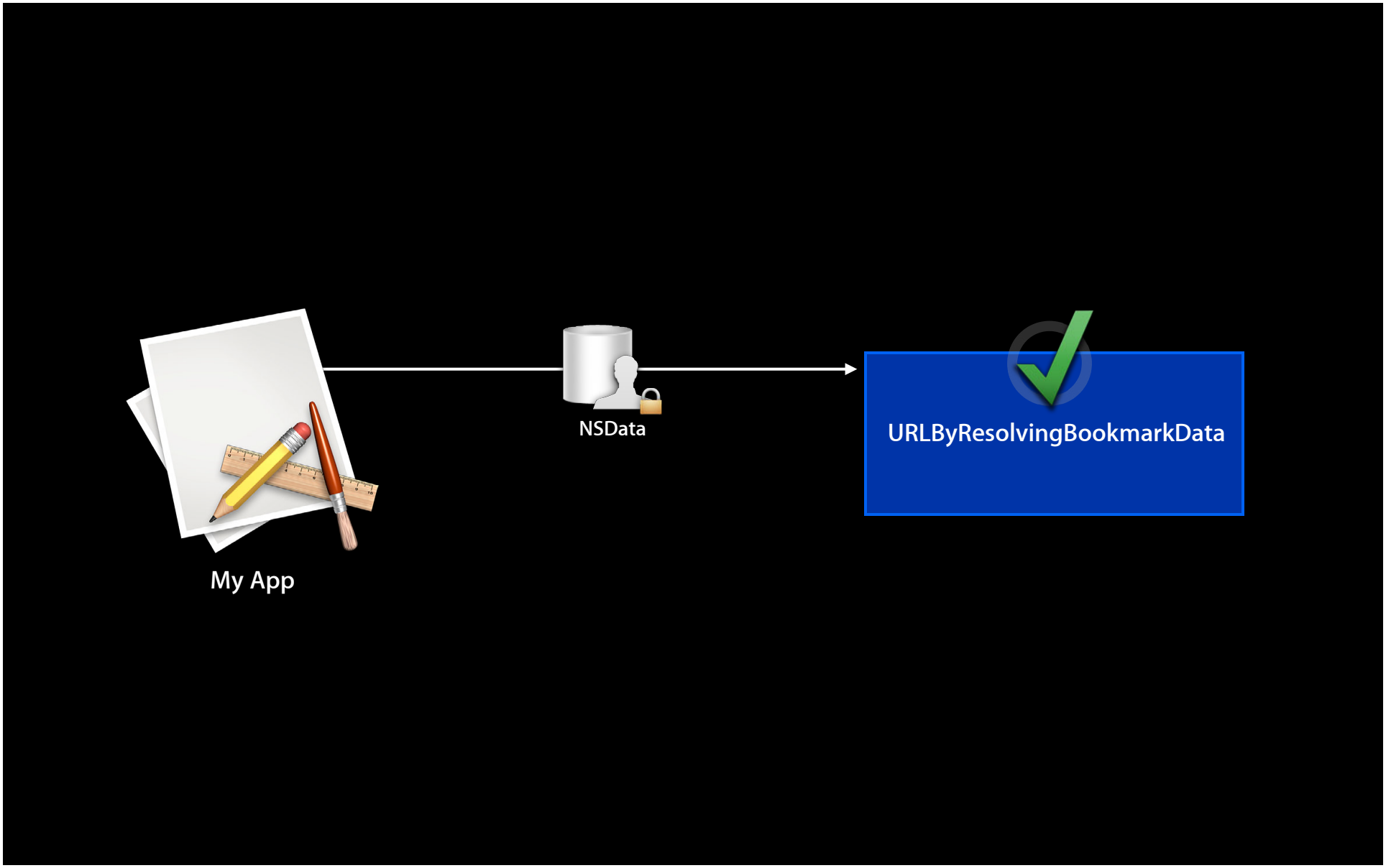
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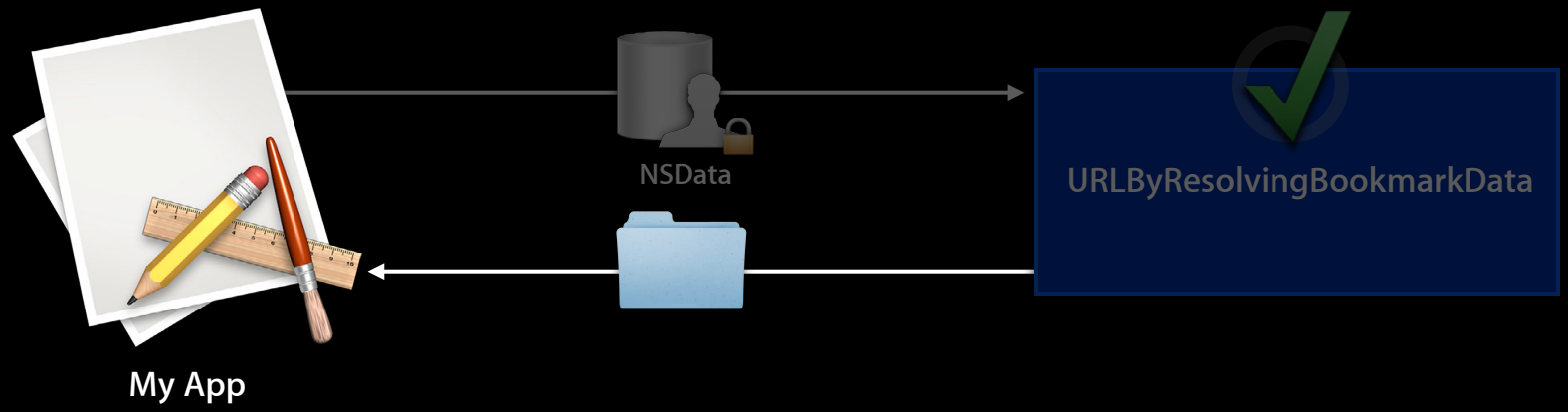
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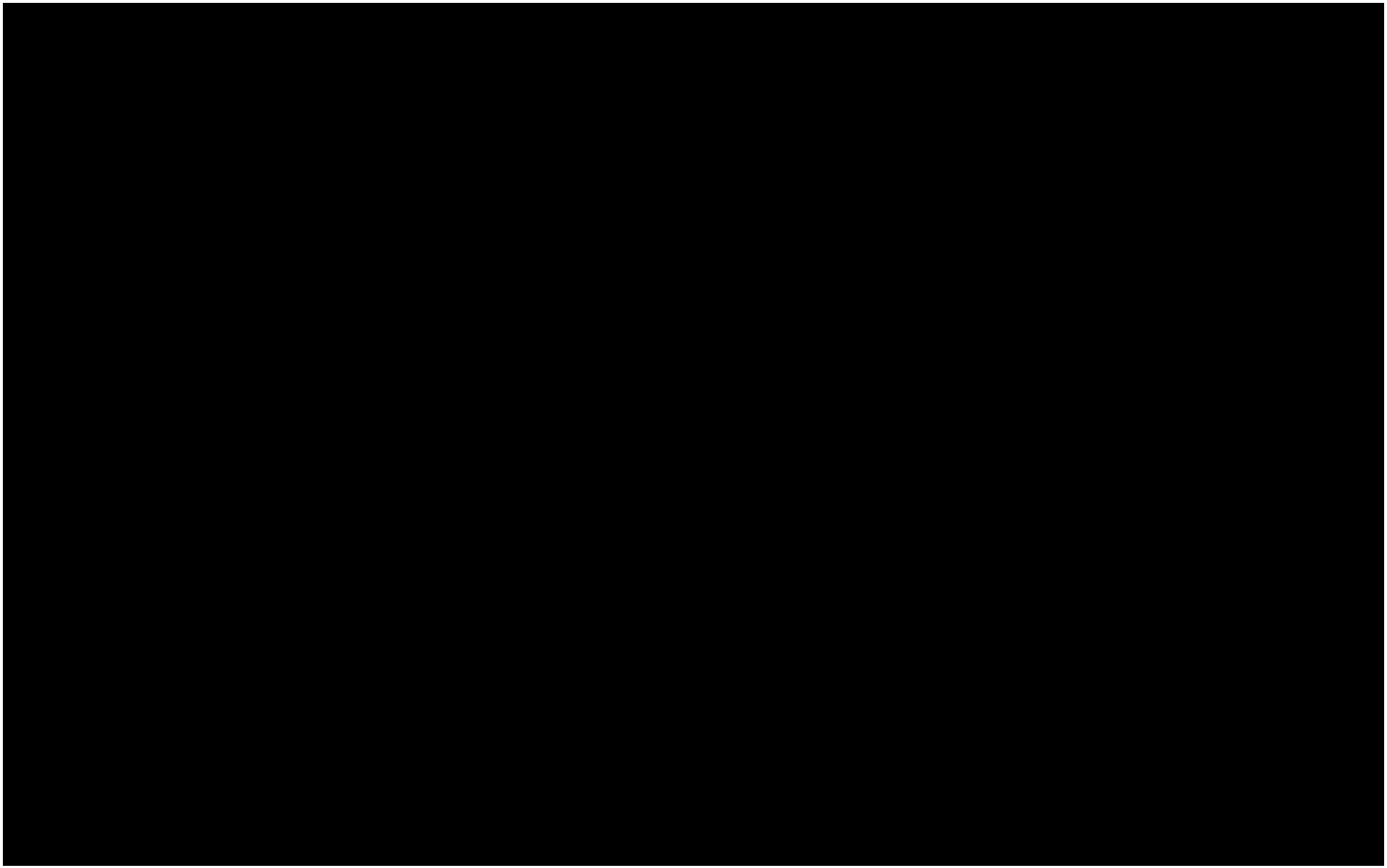

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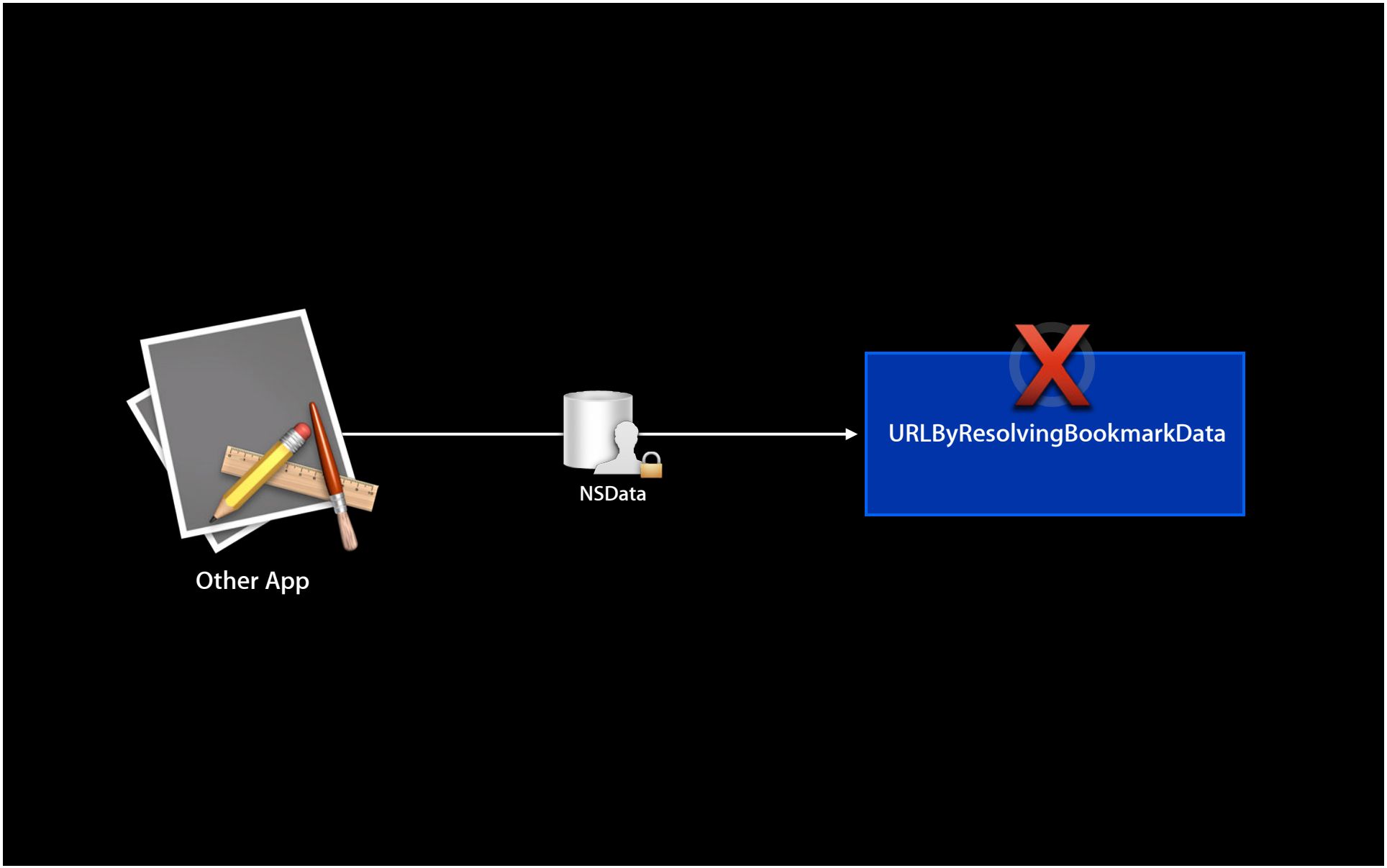
Other App
NSData
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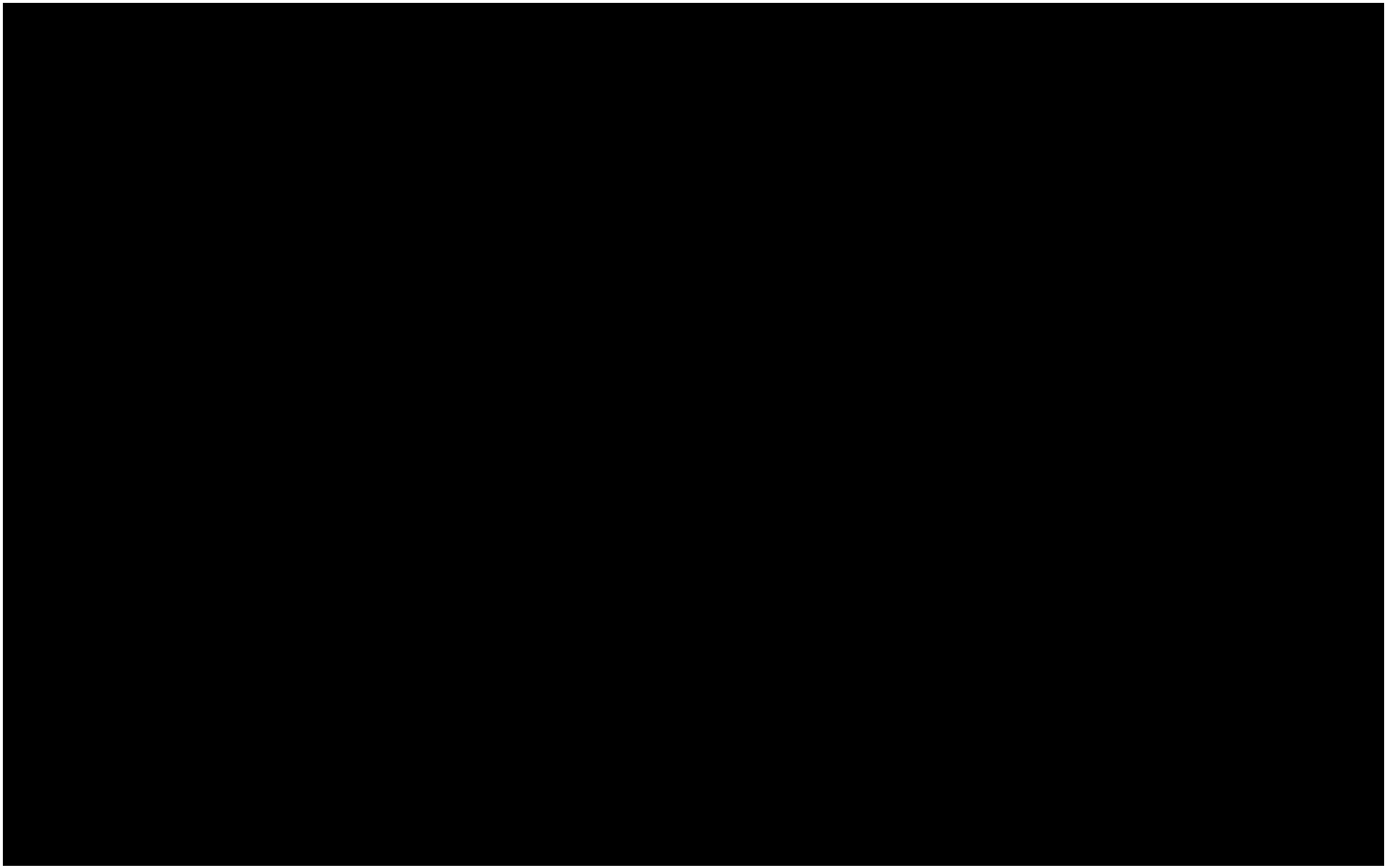
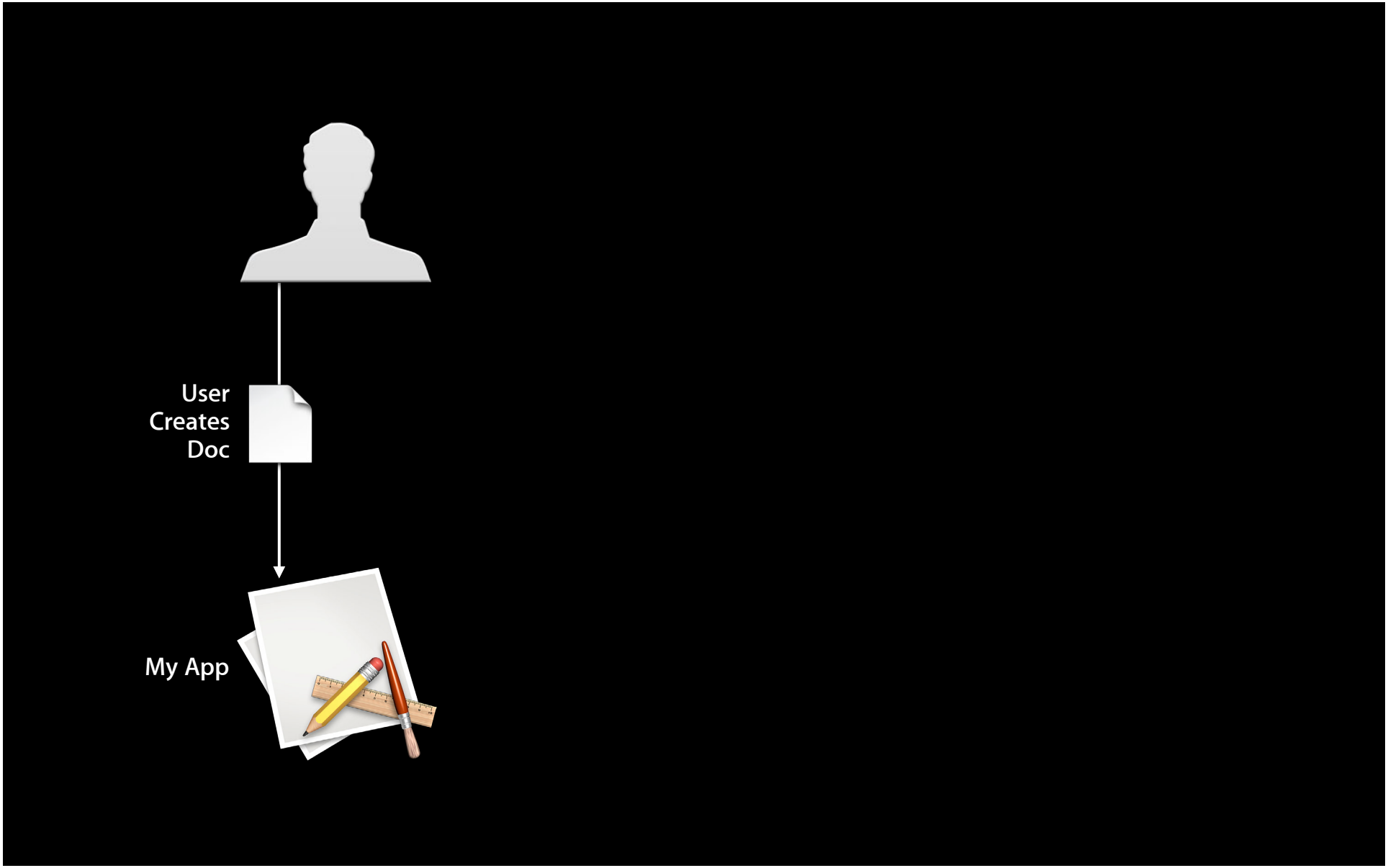
Security-Scoped Bookmarks

- Document scope
  - `com.apple.security.files.bookmarks.document-scope`
  - Allows a document format to contain references to files (but not folders) that travel with it
  - Bookmark must be stored in the document file/bundle itself
  - Cannot point to system or hidden locations (~/Library)

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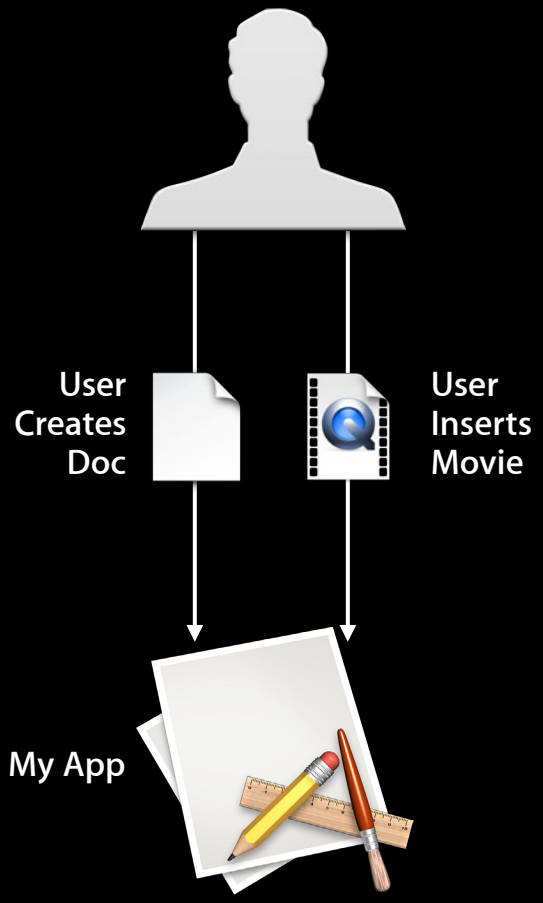
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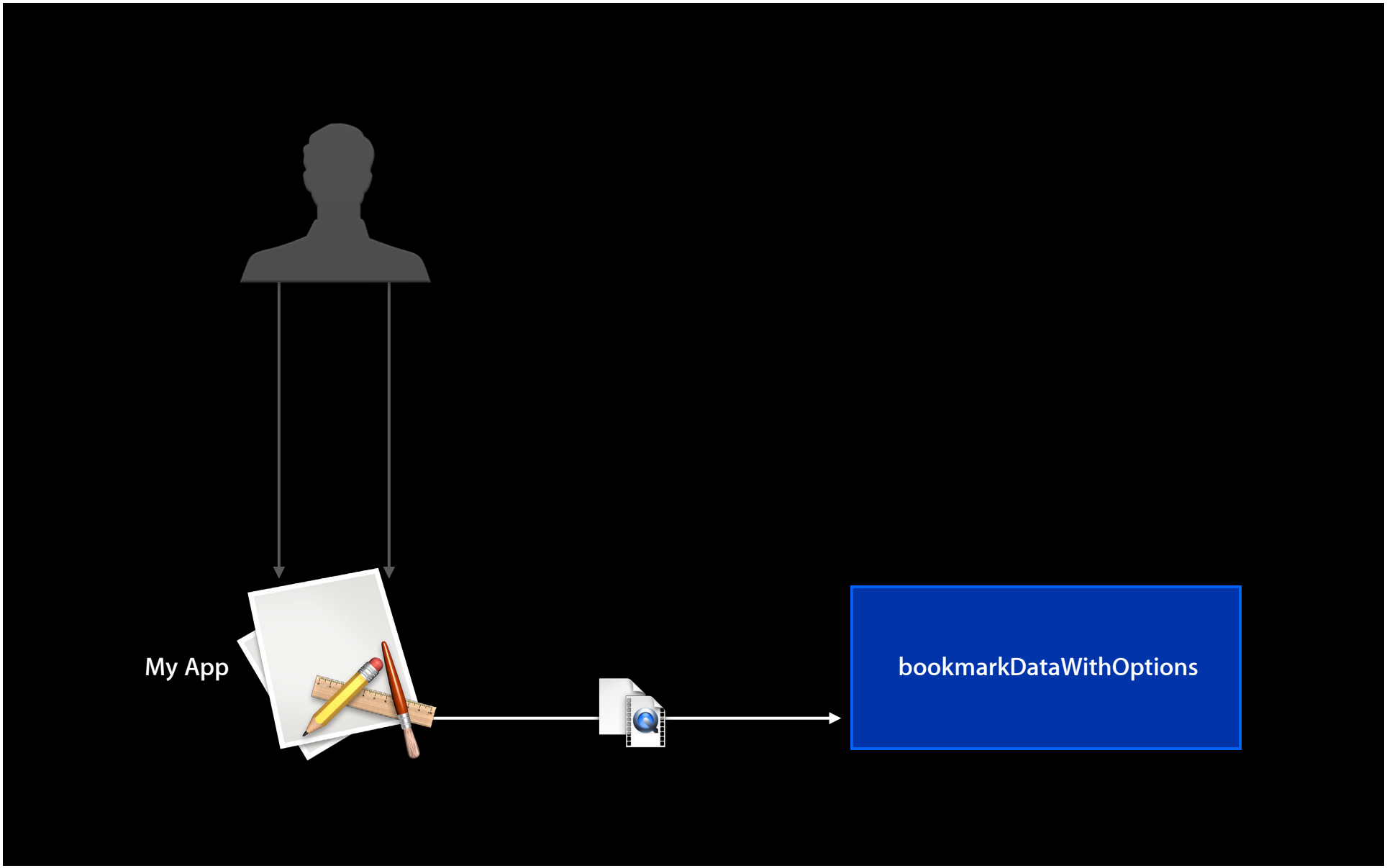
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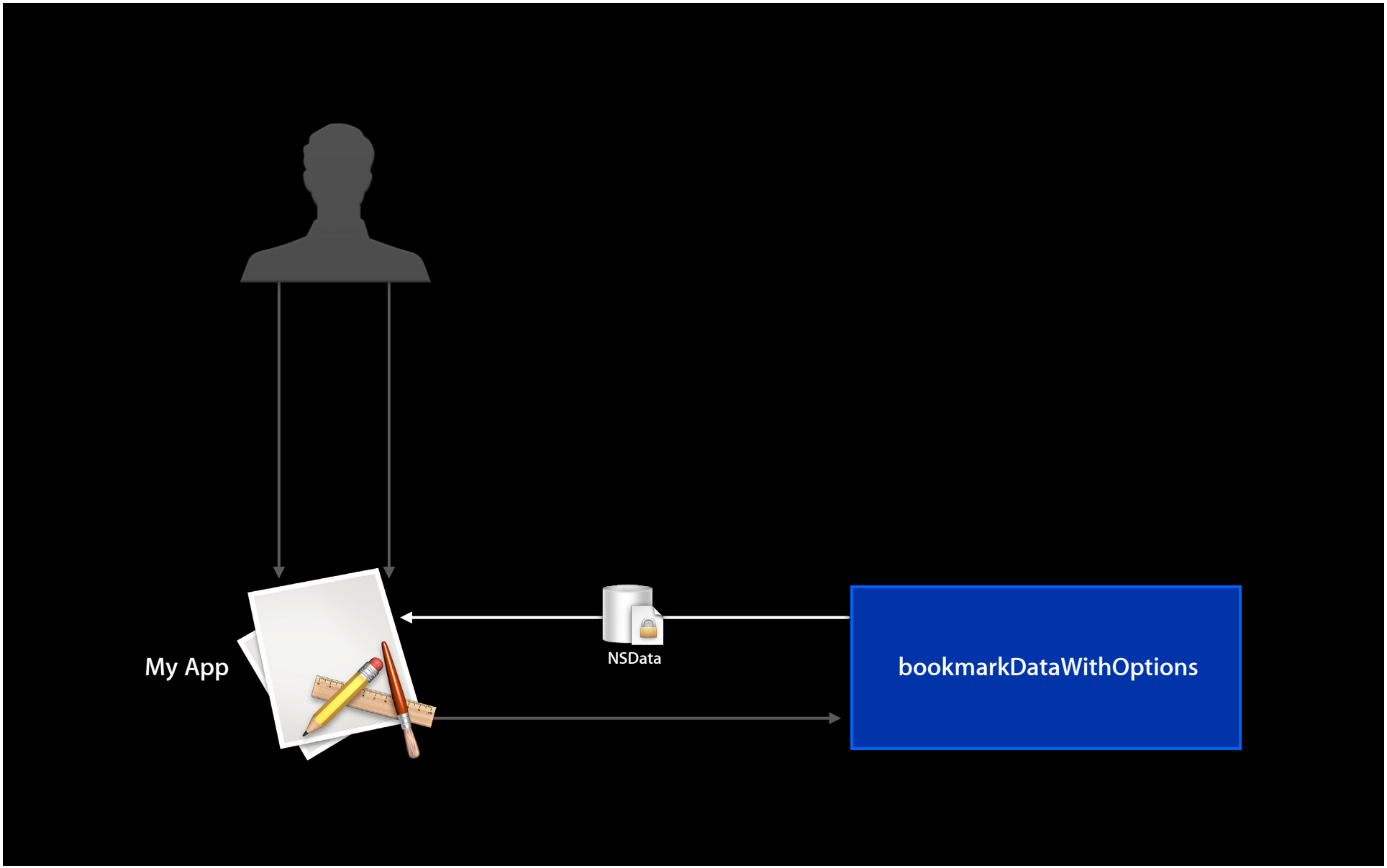
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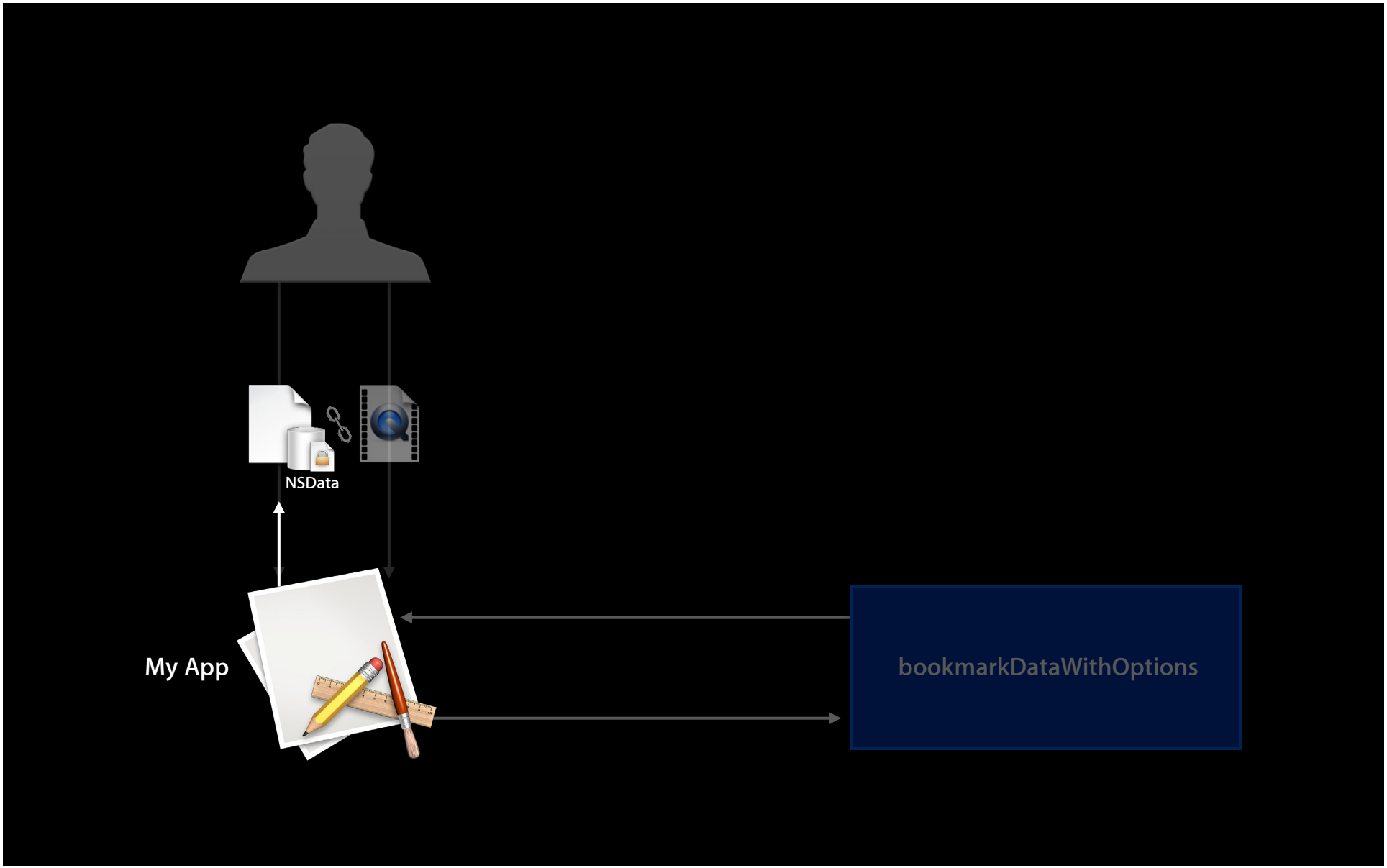
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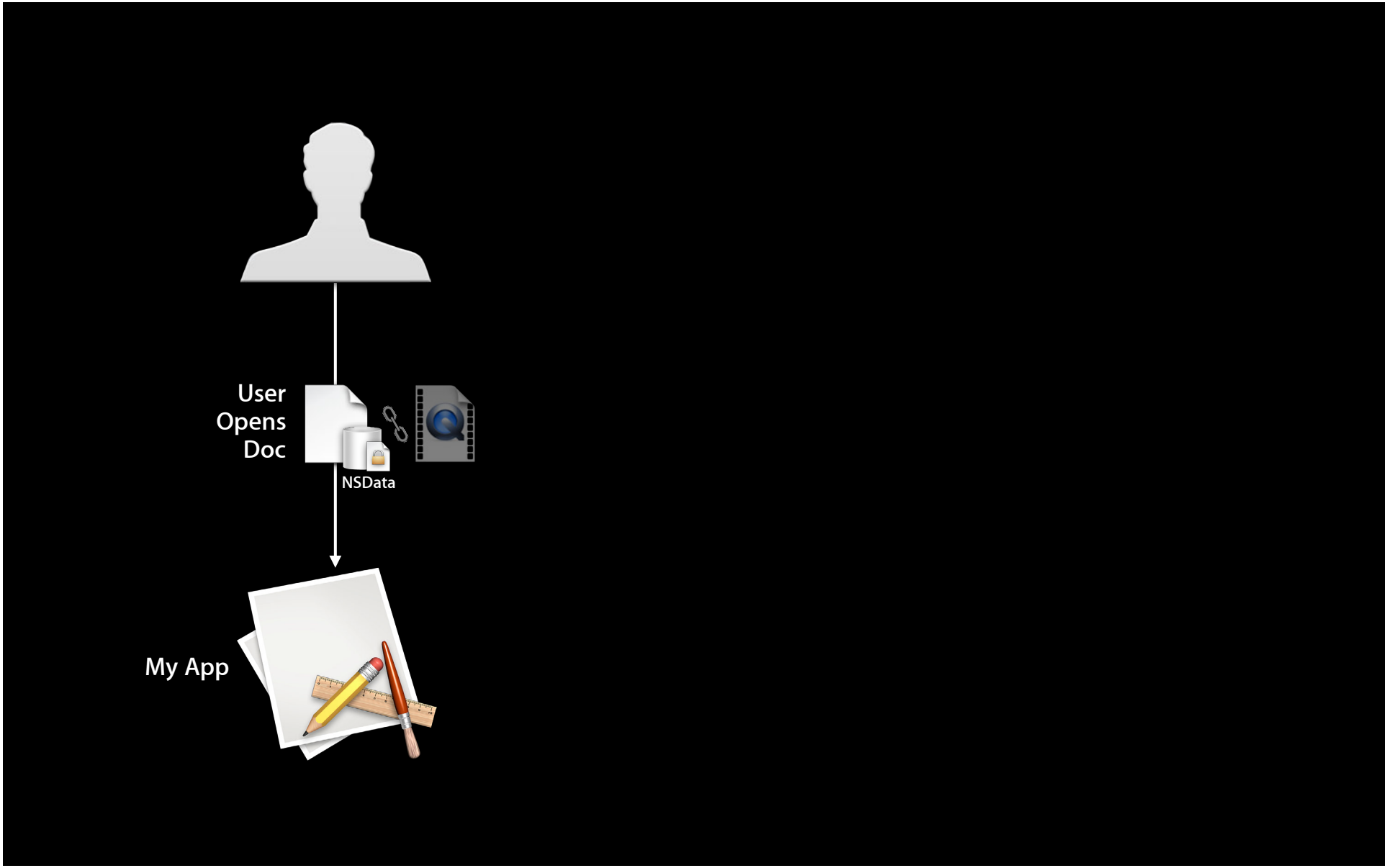
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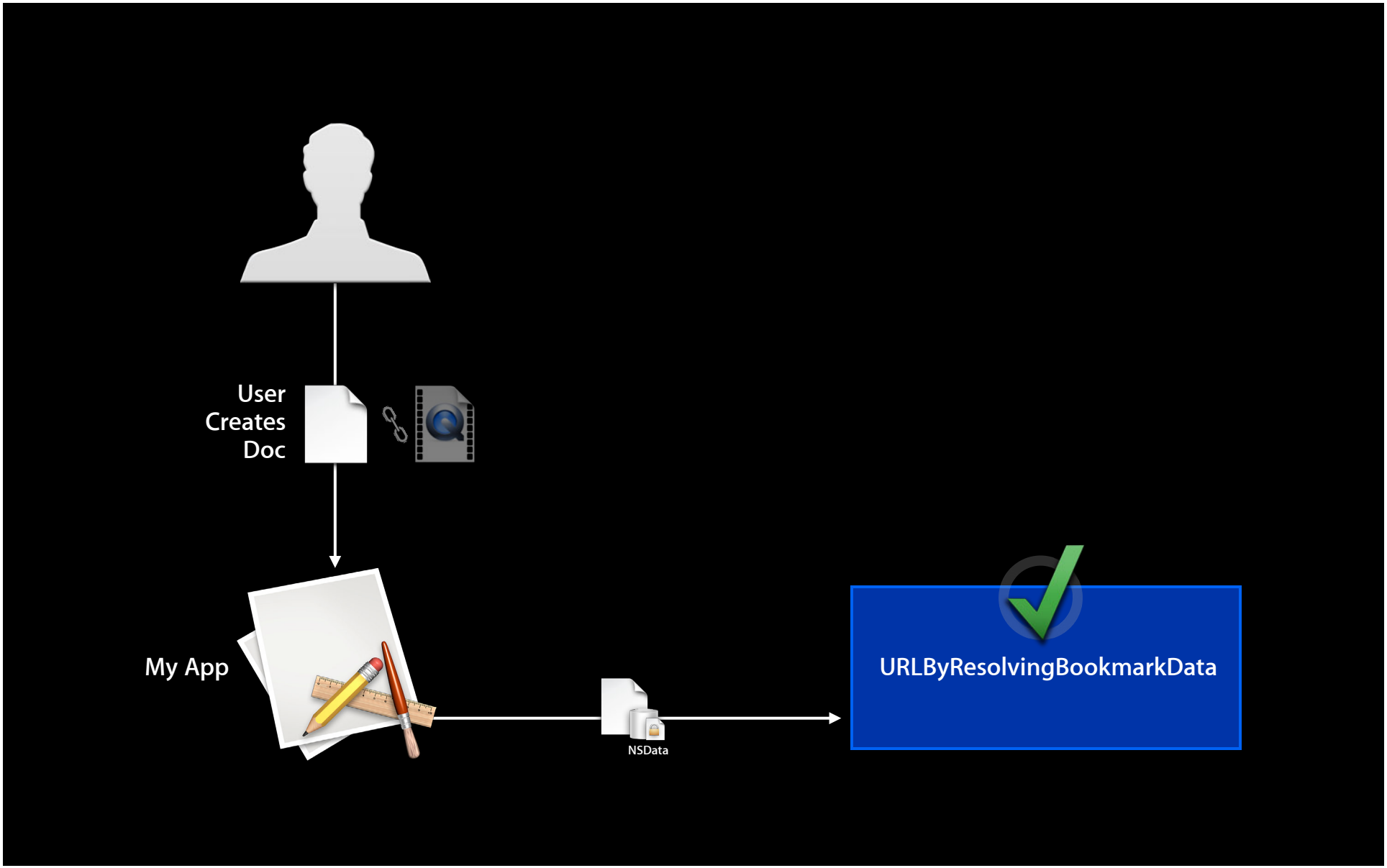
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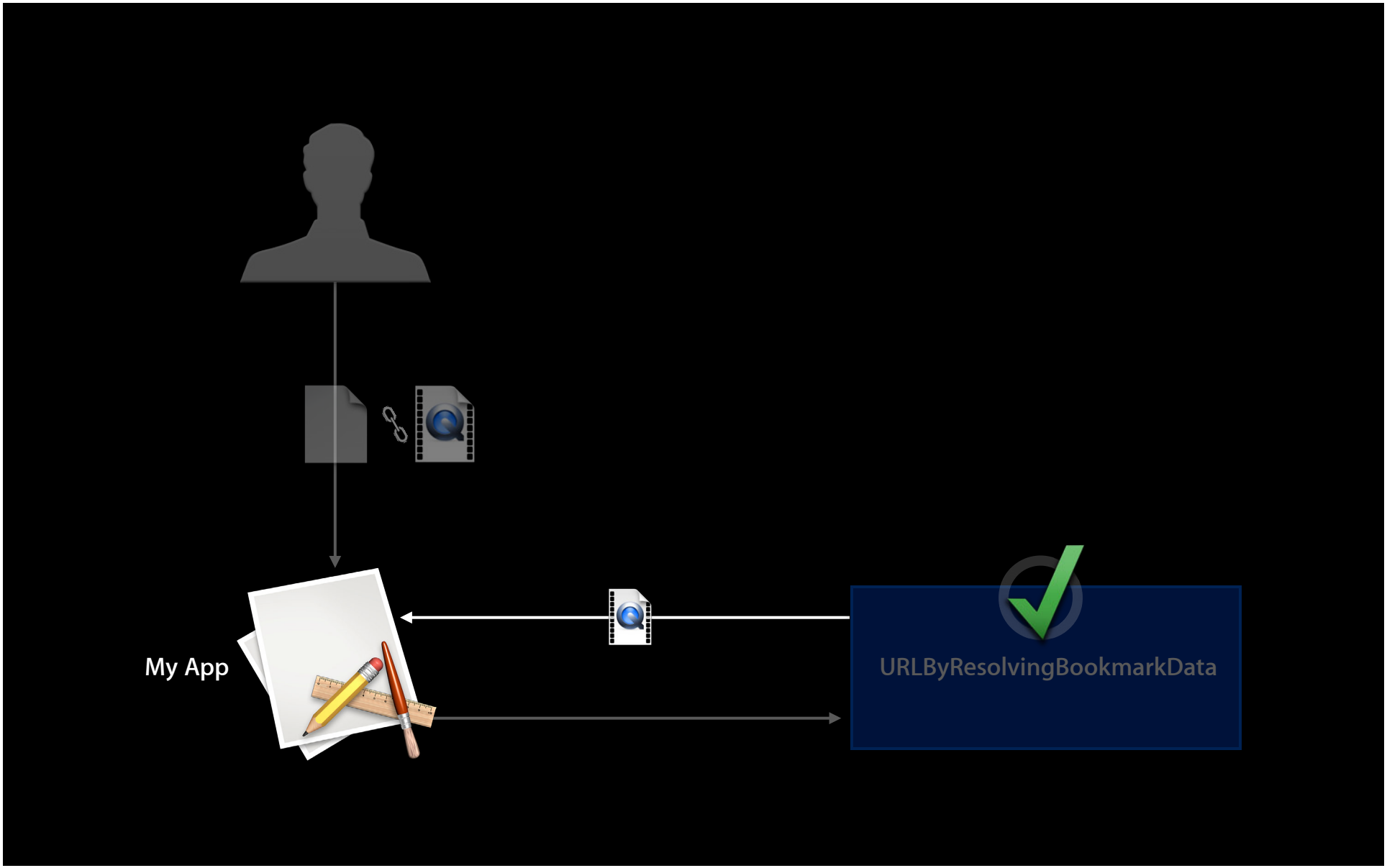
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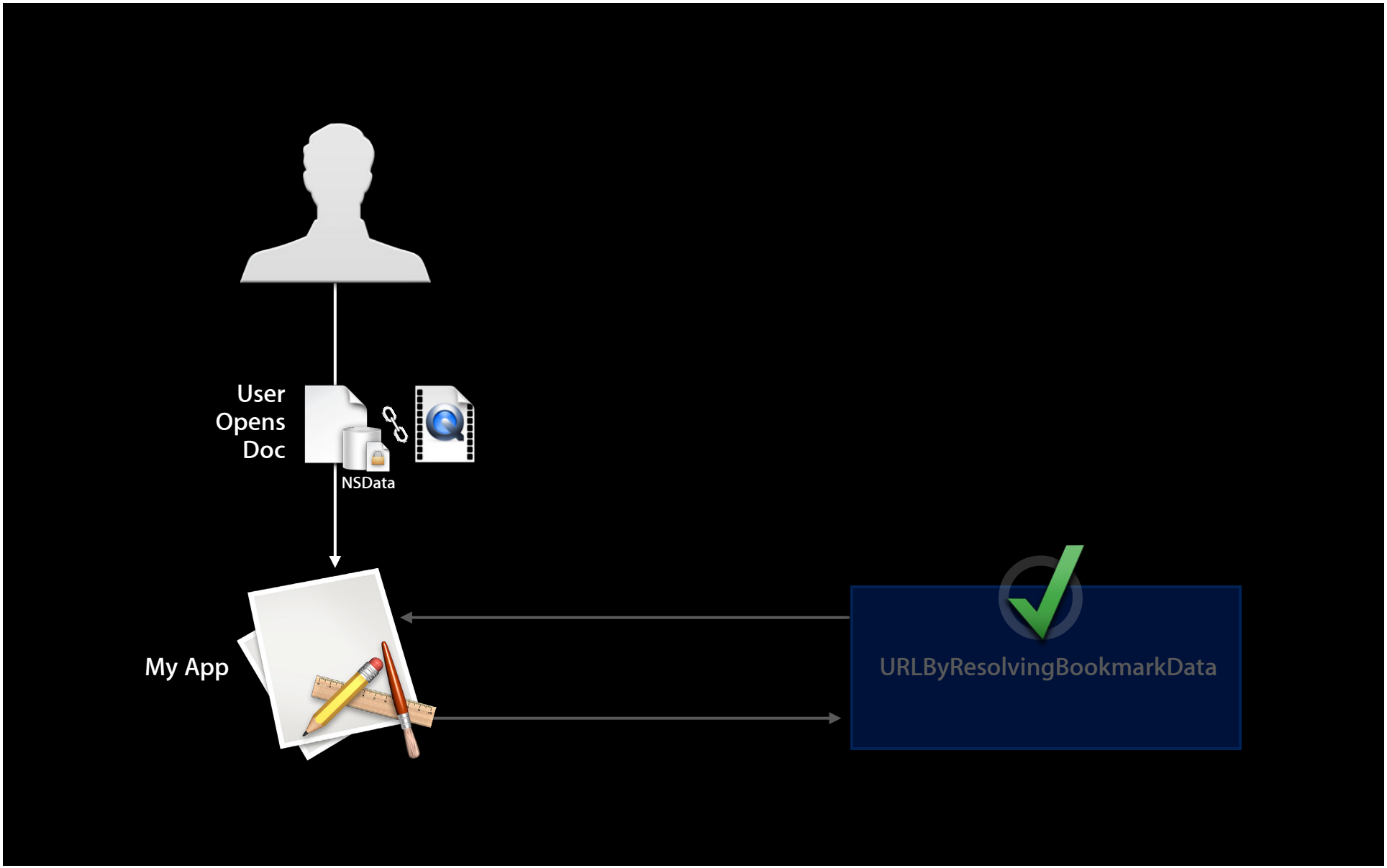
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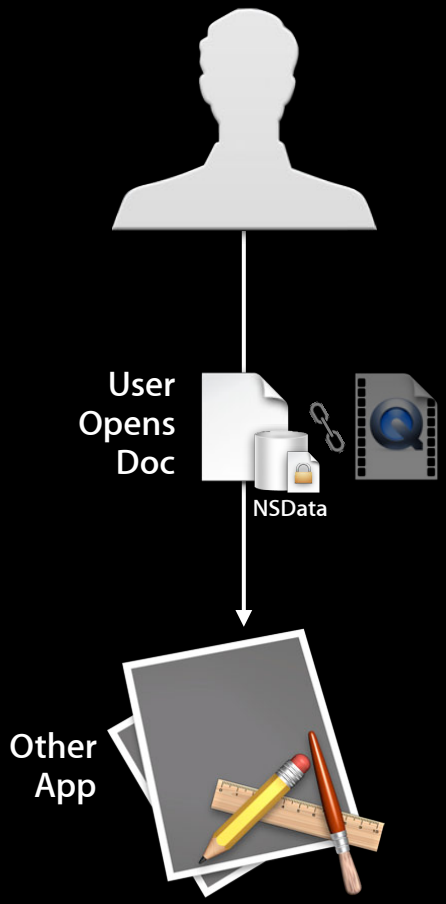
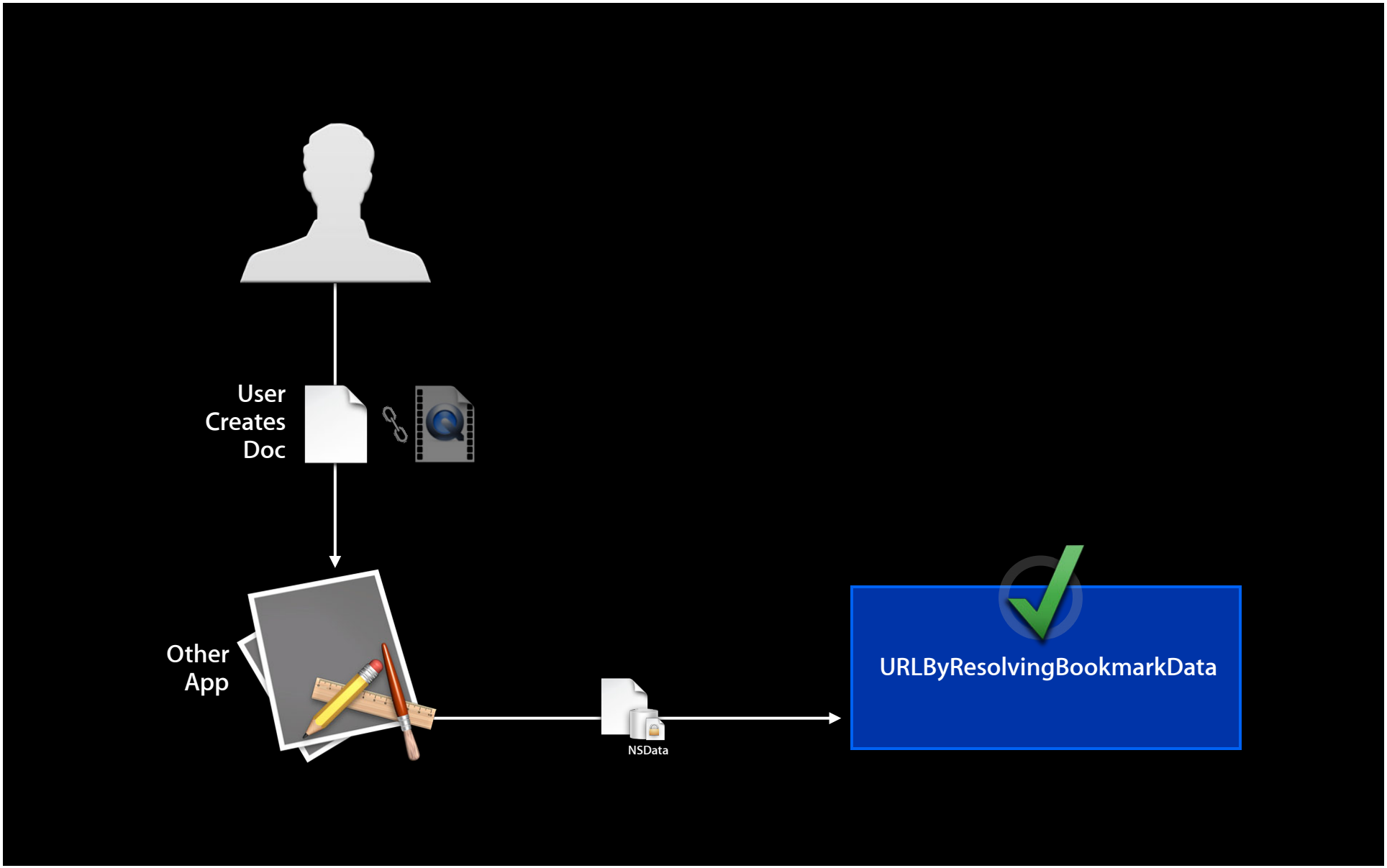
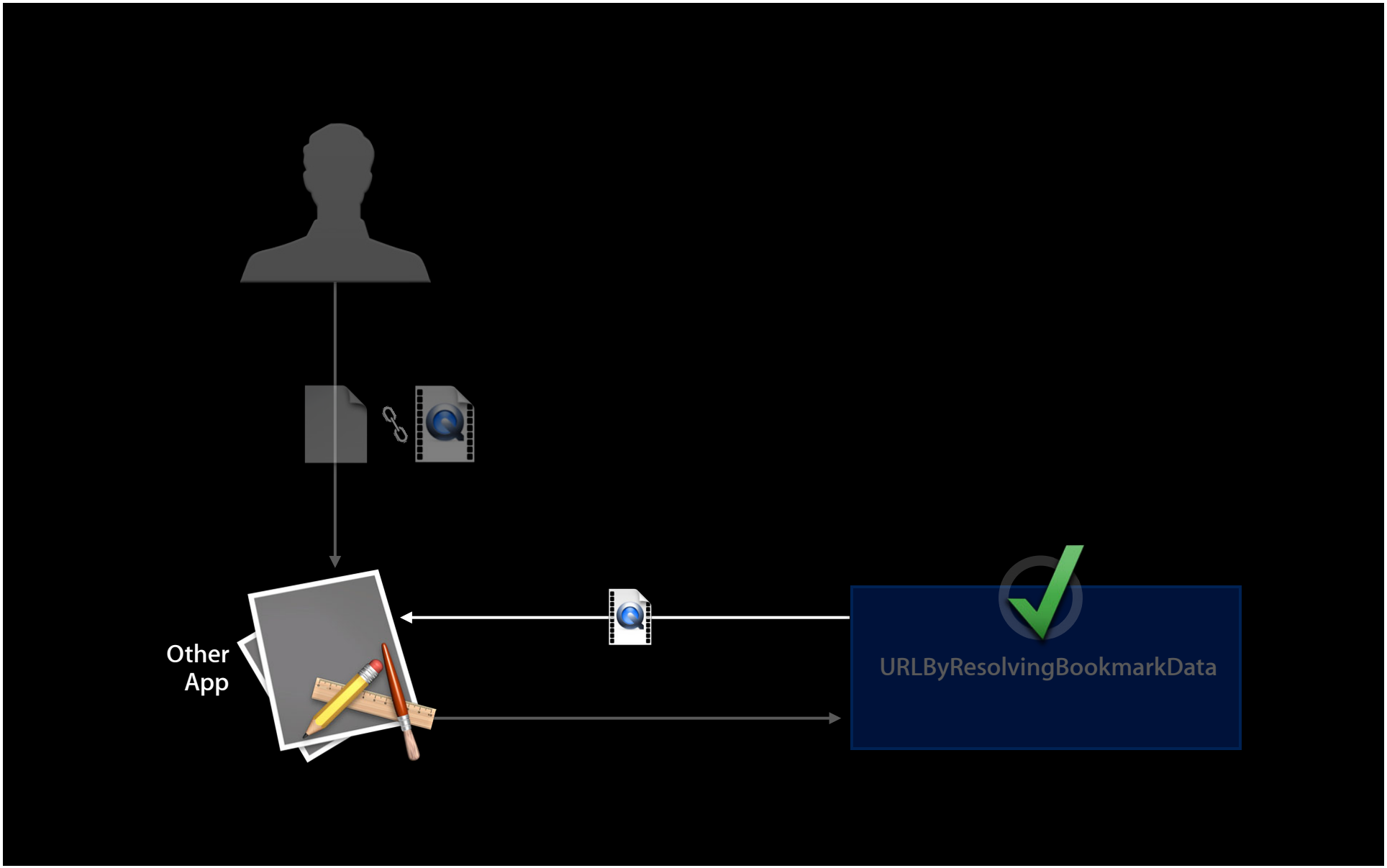
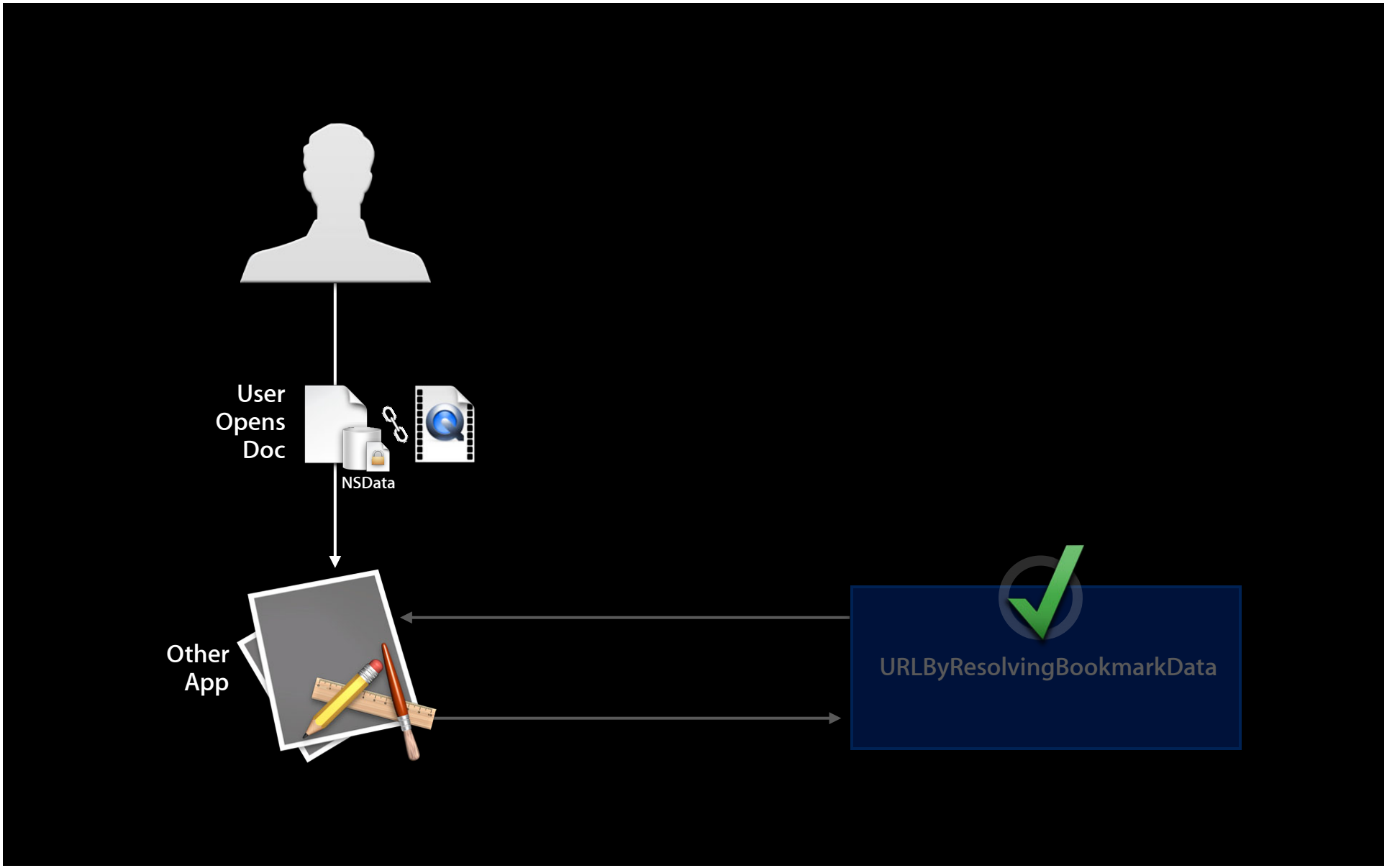
My App
URLByResolvingBookmarkData


User
Opens
Doc
NSData
Other
App


User
Creates
Doc
Other
App
NSData
URLByResolvingBookmarkData


Other
App
URLByResolvingBookmarkData


User
Opens
Doc
NSData
Other
App
URLByResolvingBookmarkData

Security-Scoped Bookmarks

- No new API, just a flag on existing NSURL methods
  - `+ URLByResolvingBookmarkData:options:relativeToURL:bookmarkDataIsStale:error:`
  - `– bookmarkDataWithOptions:includingResourceValuesForKeys:relativeToURL:error:`
- Big difference: Resolution returns a *security-scoped NSURL*
  - Must call `{start,stop}AccessingSecurityScopedResource` to gain and discontinue access to resource
  - Failure to do so will leak kernel resources and will eventually suspend app's ability to use user-selected files until relaunch

New Since Lion

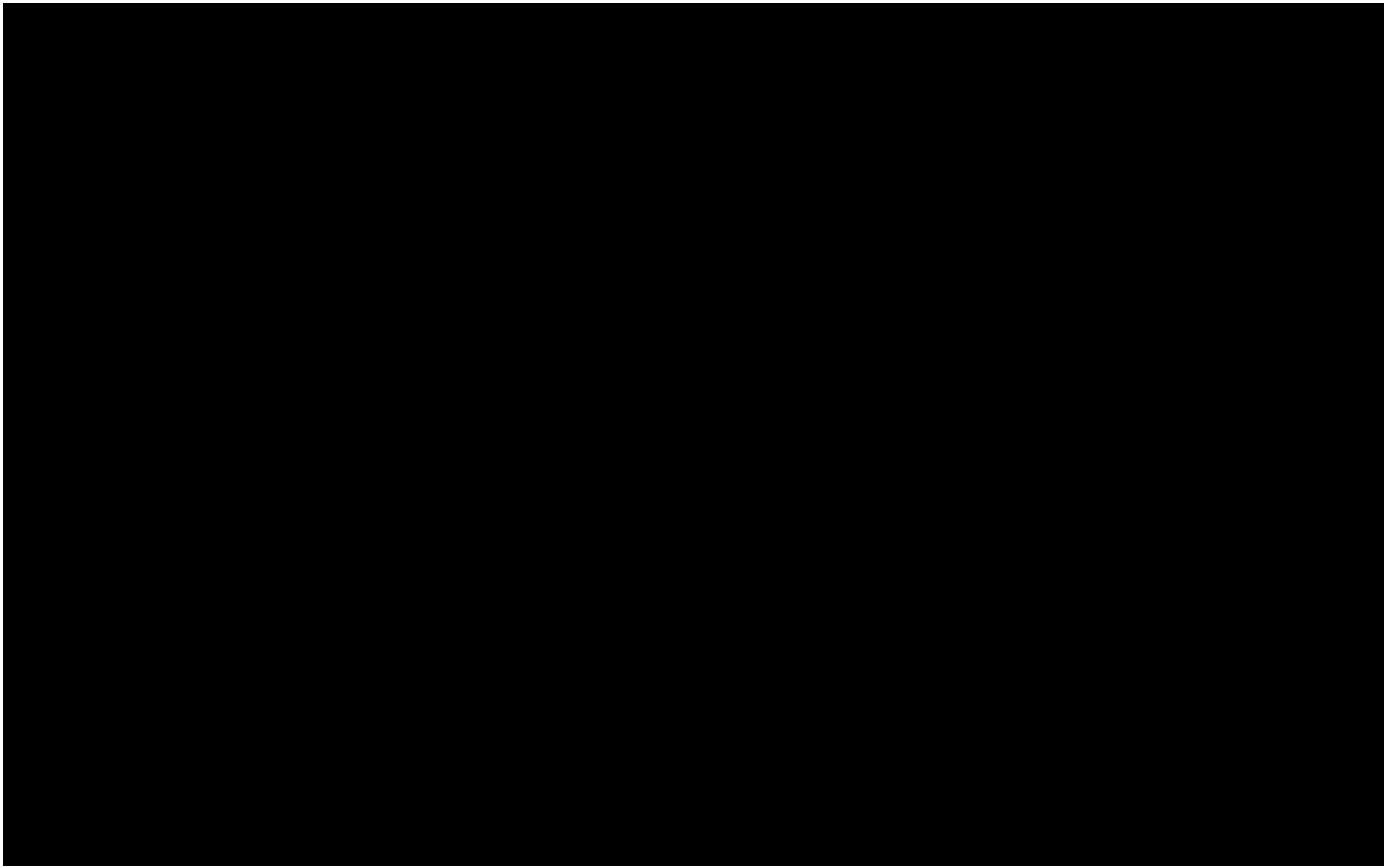
Application groups

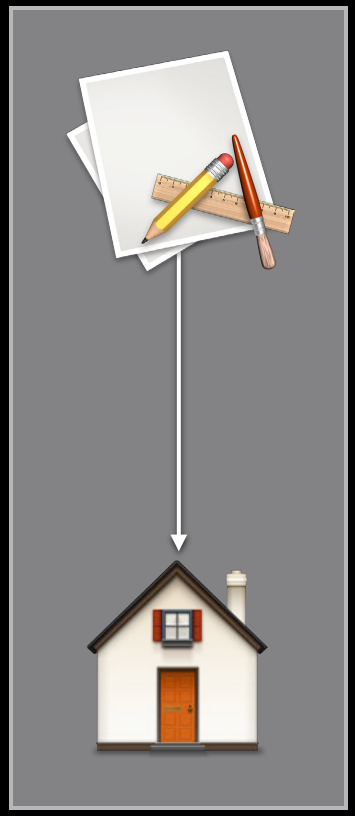
Application Groups

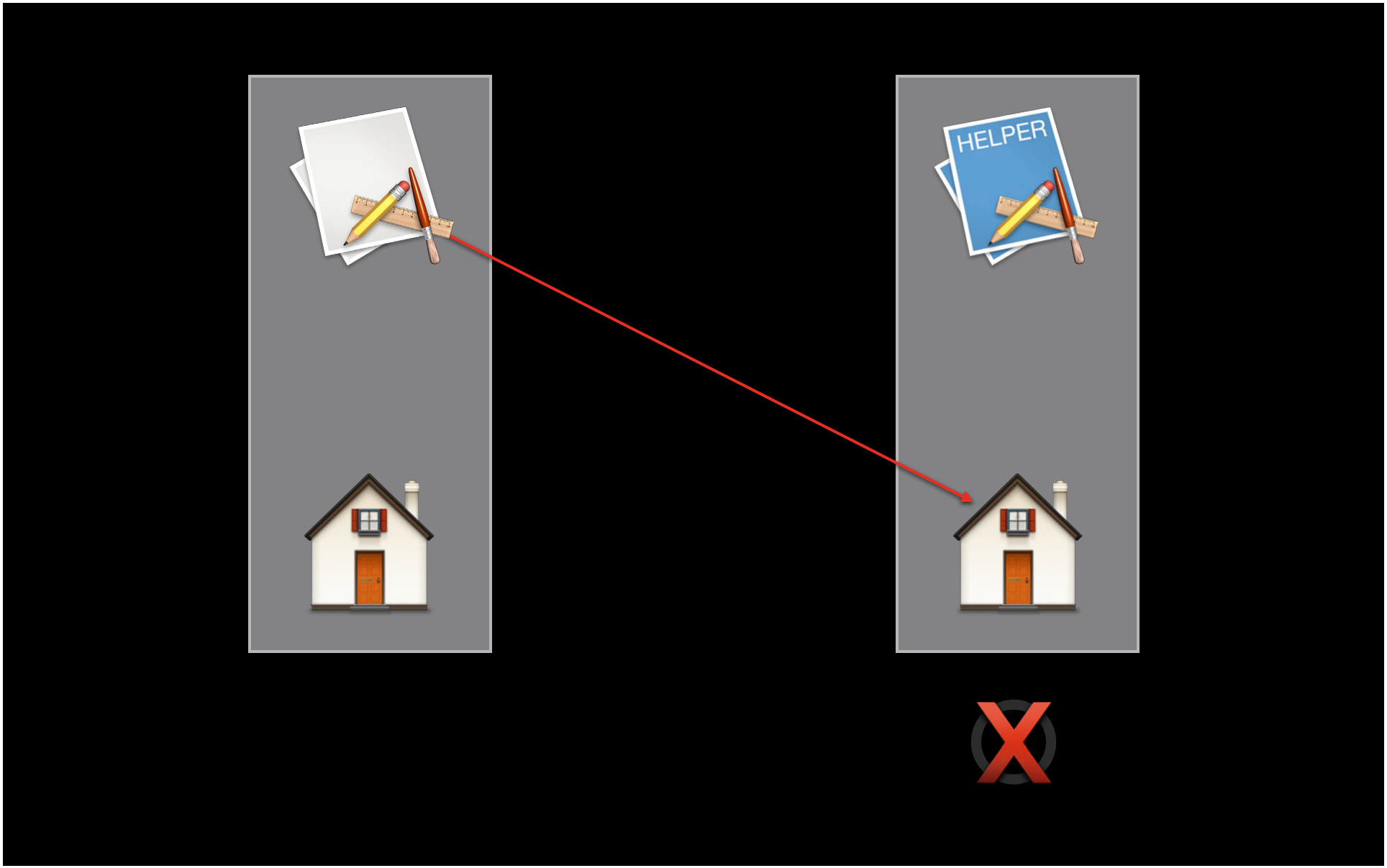
- Groups of apps from the same developer sometimes need more direct communication
- IPC, file sharing
- App Sandbox now offers a special affordance for this scenario

Application Groups

- `com.apple.security.application-groups`
- Each group name must begin with Apple-assigned Team ID
- Useful for suites of different apps, or a single app and its helper(s)
- Direct IPC permitted: XPC, POSIX
- Each group is assigned a shared file system location






HELPER


HELPER


Certificate
Entitlement
HELPER
com.apple.security.application-groups
8314ABCD.myapp


Certificate
Entitlement
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Certificate


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Certificate


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Certificate


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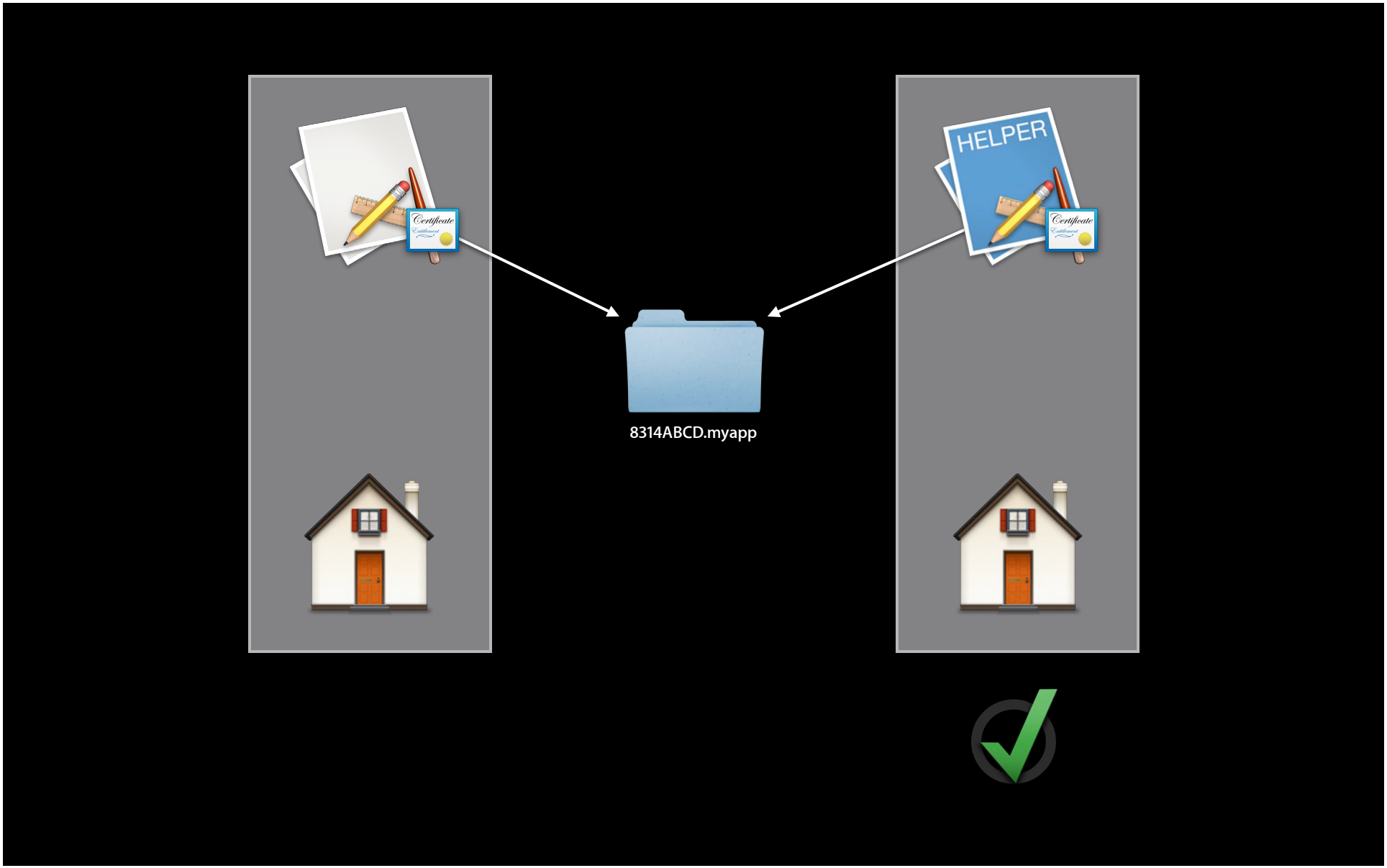
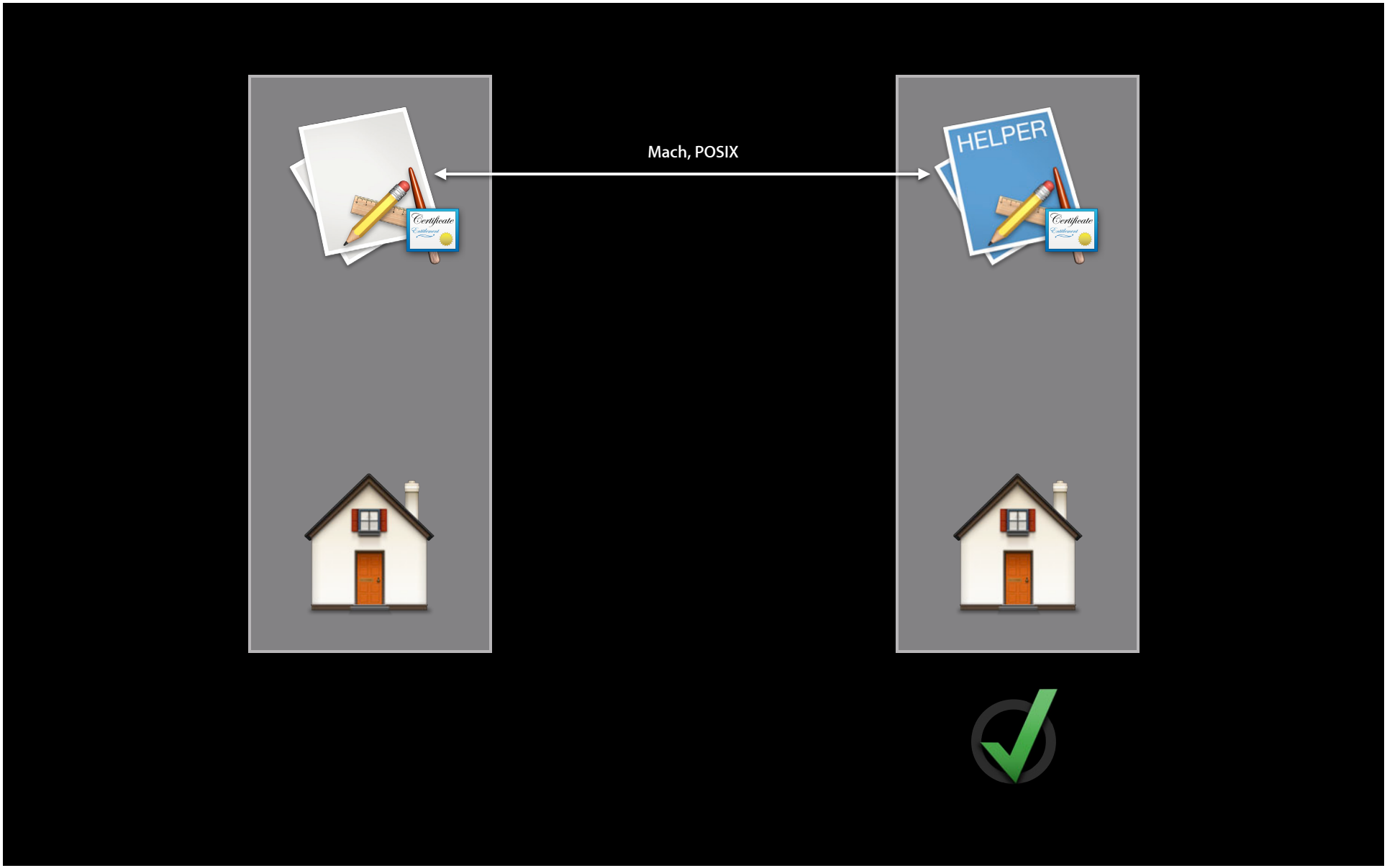
HELPER
Certificate
8314ABCD.myapp

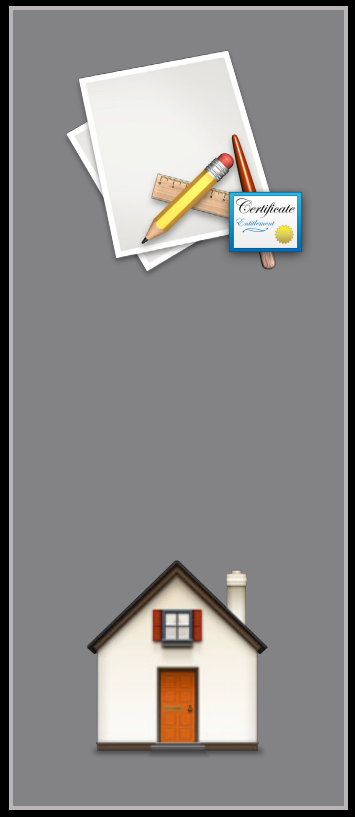

HELPER
Certificate
8314ABCD.myapp

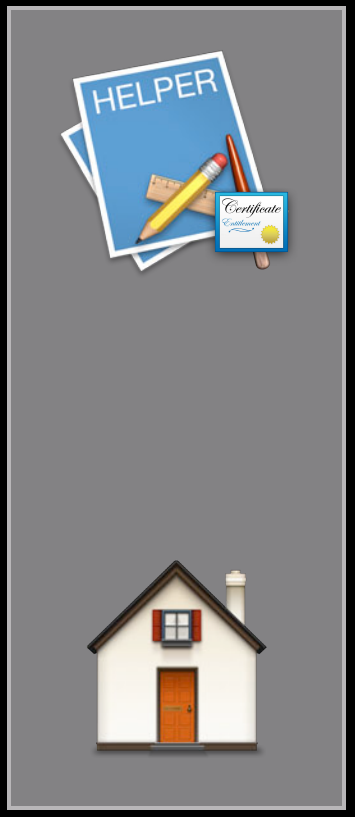

Certificate

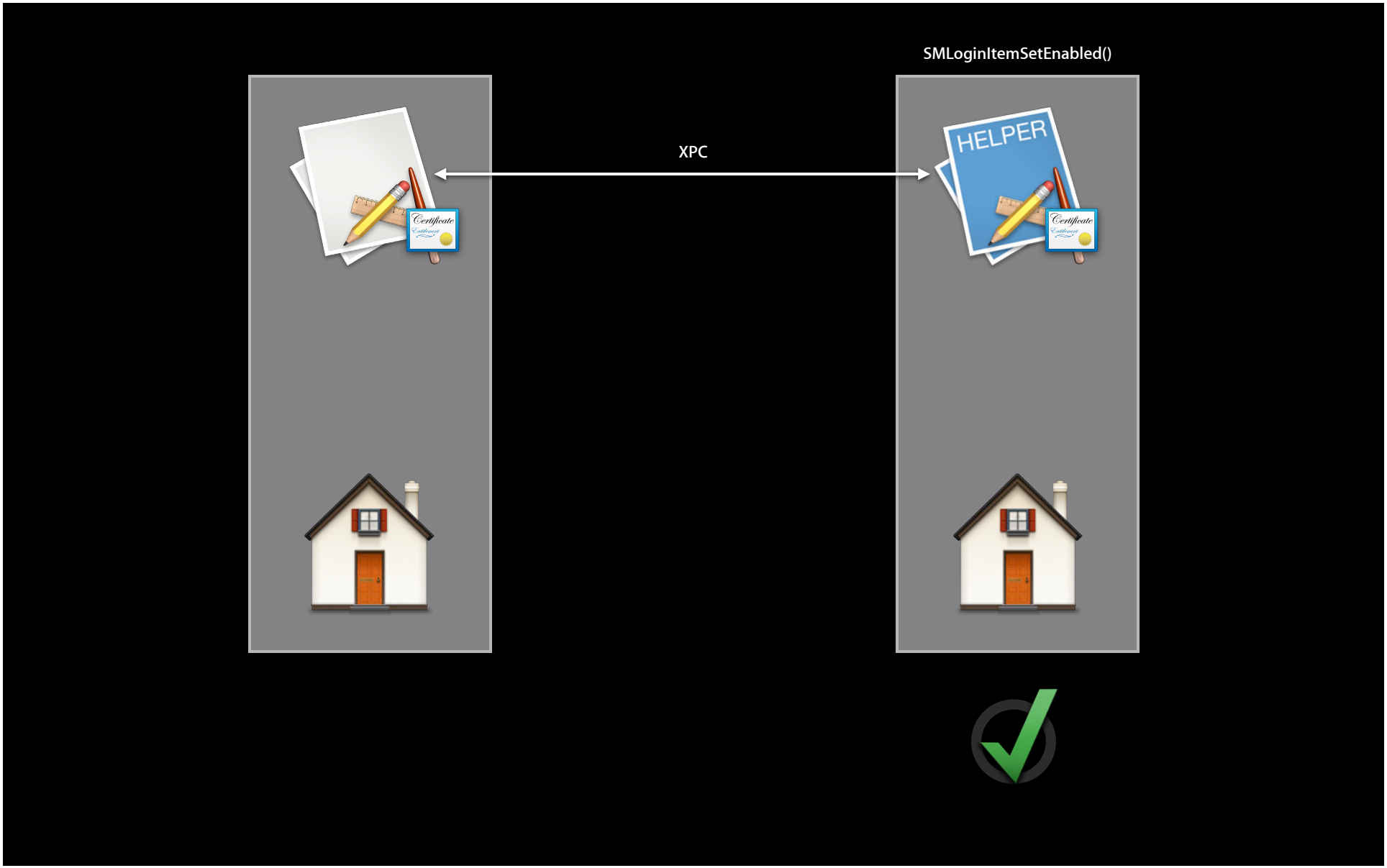

HELPER
Certificate


Mach, POSIX
HELPER
Certificate
Certificate

SMLoginItemSetEnabled()






SMLoginItemSetEnabled()
XPC
HELPER

New Since Lion

Related items

Related Items

- Access to files/folders with same name, but different file extension
  - Movie player opening a subtitle file for a movie
  - TextEdit upgrading a .rtf document to a .rtfd for attachments
- NSFilePresenter's `primaryPresentedItemURL` for the former, `itemAtURL:willMoveToURL:` for the latter
- Requires a declaration of allowed patterns in the app's Info.plist

New Since Lion

Automation

Automation

- Rich history of automation on OS X
- App Sandbox does not impose restrictions on how your apps can be scripted
- But your apps were very limited in how they can script other apps
- Two new mechanisms in Mountain Lion aim to safely support most common scripting scenarios

Background

- Apple events can escape App Sandbox
  - Use Finder to escape file system restrictions
  - Use Safari to escape network restrictions
  - Use Terminal to escape everything!
- Therefore, no Apple event sending by default
- Had to use a temporary exception entitlement

Apple Events Entitlement

Lion: Sending events to Mail

```
<key>com.apple.security.temporary-exception.apple-events<key>
<array>
    <string>com.apple.mail<string>
</array>
```

Apple Events Entitlement

Lion: Sending events to Mail

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Apple Events Entitlement

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</array>
```

Apple Event Access Groups

New in Mountain Lion

- *Access groups* define groups of scriptable operations
  - Commands, classes, properties
  - Part of the application's scripting interface (sdef)
  - man 5 sdef
- Already in Mountain Lion applications
  - Mail: com.apple.Mail.compose
  - iTunes: com.apple.iTunes.playback, com.apple.iTunes.library.read, com.apple.iTunes.library.read-write

Defining an Access Group

Compose Mail message

```
<class-extension name="application">
    <element name="outgoing message"/>
</class>



<class name="outgoing message">
    ...
<class>


<command name="send">
    <direct-parameter type="outgoing message"/>
</command>
```

Defining an Access Group

Compose Mail message

```
<class-extension name="application">
    <element name="outgoing message"/>
        <access-group identifier="com.apple.Mail.compose" access="rw"/>
    </element>
</class>

<class name="outgoing message">
    ...
<class>


<command name="send">
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</command>
```

Defining an Access Group

Compose Mail message

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<class-extension name="application">
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</class>

<class name="outgoing message">
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    ...
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<command name="send">
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</command>
```

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Compose Mail message

```
<class-extension name="application">
    <element name="outgoing message"/>
        <access-group identifier="com.apple.Mail.compose" access="rw"/>
    </element>
</class>

<class name="outgoing message">
    <access-group identifier="com.apple.Mail.compose" access="rw"/>
    ...
<class>

<command name="send">
    <!-- Not part of any access group.  No sending for you! -->
    <direct-parameter type="outgoing message"/>
</command>
```

Using an Access Group

- New entitlement
  - com.apple.security.scripting-targets
- Value is a dictionary
  - Keys are application code signing identifiers
  - Values are access group identifiers

Using an Access Group

Compose Mail message

```
<key>com.apple.security.scripting-targets<key>
<dict>
    <key>com.apple.Mail</key>
    <array>
        <string>com.apple.Mail.compose<string>
    </array>
</dict>
```

Using an Access Group

Compose Mail message

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<dict>
    <key>com.apple.Mail</key>
    <array>
        <string>com.apple.Mail.compose<string>
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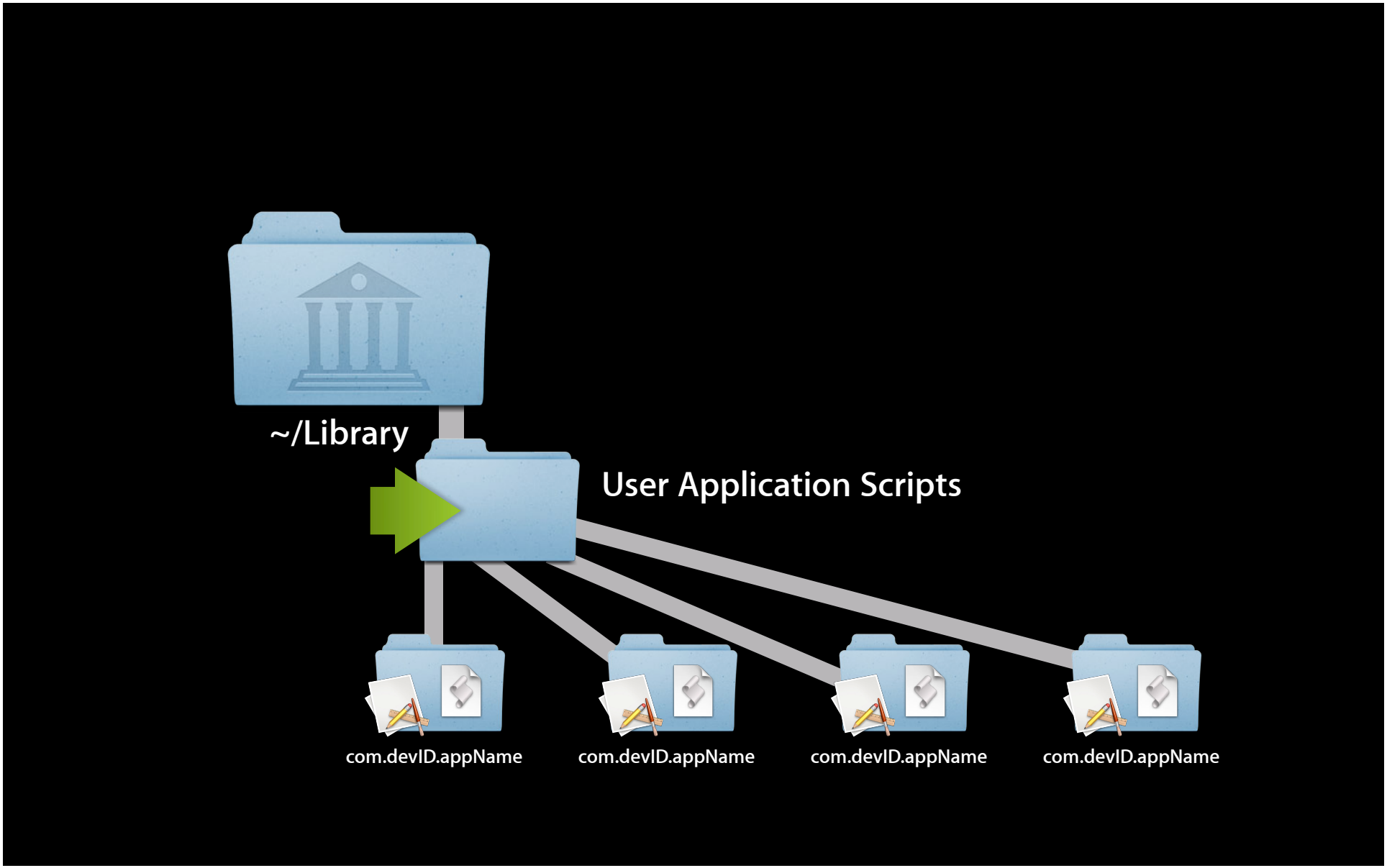
    <key>com.apple.Mail</key>
    <array>
        <string>com.apple.Mail.compose<string>
    </array>
</dict>
```

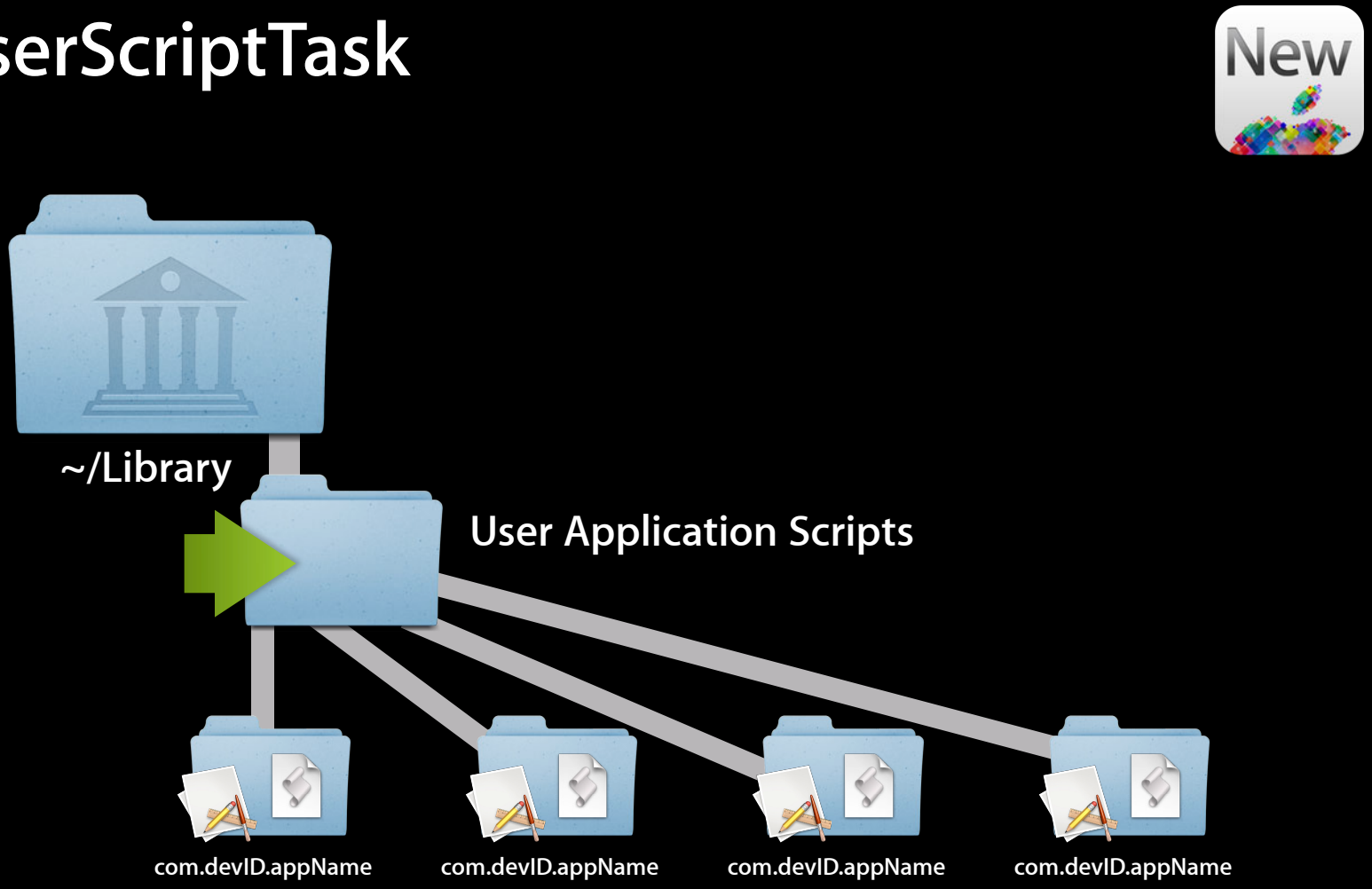
Application-Run User Scripts

New in Mountain Lion

- Application Script Menu
- Event Handlers
  - Mail Rule
  - Aperture Import Action
  - Messages Events
- Scripts executed by the application
- Inherit application's permissions


~/Library
User Application Scripts
com.devID.appName
com.devID.appName
com.devID.appName
com.devID.appName

NSUserScriptTask



NSUserScriptTask

Running attached user scripts

- Part of Foundation.framework
- NSUserScriptTask for generic scripts
  - Supports AppleScript, Automator, and UNIX scripts
- Subclasses for specific control
  - NSUserAppleScriptTask, NSUserAutomatorTask, NSUserUnixTask
- Script runs outside the sandbox
- No entitlement required

Summary

App Sandbox

- Strong barrier against exploitation and coding errors
- Drives policy by user intent
- Complementary to Gatekeeper
- See the *App Sandbox Design Guide*
- Sample code available

Summary

- iOS Sandbox: 30 billion app downloads with confidence
- Delight users with carefree apps on OS X

Related Sessions

Gatekeeper and Developer ID	Nob Hill Tuesday 11:30AM
Secure Automation Techniques in OS X	Russian Hill Tuesday 3:15PM
Asynchronous Design Patterns with Blocks, GCD, and XPC	Pacific Heights Friday 9:00AM

Related Labs

Security Lab	Core OS Lab B Tuesday 3:15PM
Sandboxing Audio Lab	Graphics, Media & Games Lab D Wednesday 2:00PM
Open and Save Panels Within an App Sandbox Q&A Lab	Essentials Lab B Wednesday 4:30PM
Security Lab	Core OS Lab B Thursday 9:00AM
Cocoa and XPC Lab	Essentials Lab A Friday 10:15AM
Core OS Open Hours	Core OS Lab A, B Friday 2:00PM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