CLICKONCE AND YOU'RE IN:

When .appref-ms abuse is operating as intended

CISA
CYBER+INFRASTRUCTURE

William Joseph Burke IV 07 August 2019

ClickOnce and you're in

- Speaker Introduction
- The End of the Golden Age
- Compendium of ClickOnce
- Aquaman, King of the Phish
- Sleeper Cells: C2 Management
- A Little Help for my Friends
- Closing Questions

SPEAKER INTRODUCTION

Speaker Introduction – @0xF4B0

- William Joseph Burke IV
- CISA Red Team Lead
  - Provide red team ops for whole federal sector
- 15 Years across intelligence & cyber fields
  - Military, Private, and Public sectors
- Linguistics, NetAdmin, SysAdmin, Operations
- Adjunct Graduate Professor, Marymount University
- OSCP, GXPN, GPEN, GCIH, GWAPT, eCPPT, CORIII, CNDA, CEH, Sec+, CISSP

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THE END OF THE GOLDEN AGE

The End of the Golden Age

- Initial access via phishing used to be simple
  - Batch script Object Linking & Embedding (OLE) in Word documents
  - Basic scripts delivered via HTTP Application (HTA)
  - …Pretty much everything Windows 7
- As time ticked through the hourglass, difficulty increased
  - Windows Defender / Antimalware Scan Interface (AMSI)
  - Permitted filetypes for execution via OLE's are increasingly limited
  - Additional layers of barriers preventing entry
  - …Pretty much everything Windows 10

The End of the Golden Age

- The resulting operational need:
  - Additional methods of code execution
  - Delivery as either an attachment, hyperlink, or OLE
- Capabilities needed to work in the following environments:
  - Native, fully patched Windows 10 with Defender enabled
  - Native, fully patched Windows 7 with third party anti-virus enabled
  - Cooperate with the Cobalt Strike Command & Control (C2) platform
- Focus of research was on **delivery and execution** of code

The End of the Golden Age

- So, where to begin? Let's take a journey…
- OLE delivery was the first item of interest
  - Inspired by .SettingContent-ms research by Matt Nelson (@enigma0x3)
  - Cross-referenced native Win 10 executable formats to the OLE blacklist
  - Research available executable formats for delivery potential
  - This resulted in a preliminary list which was narrowed down to:

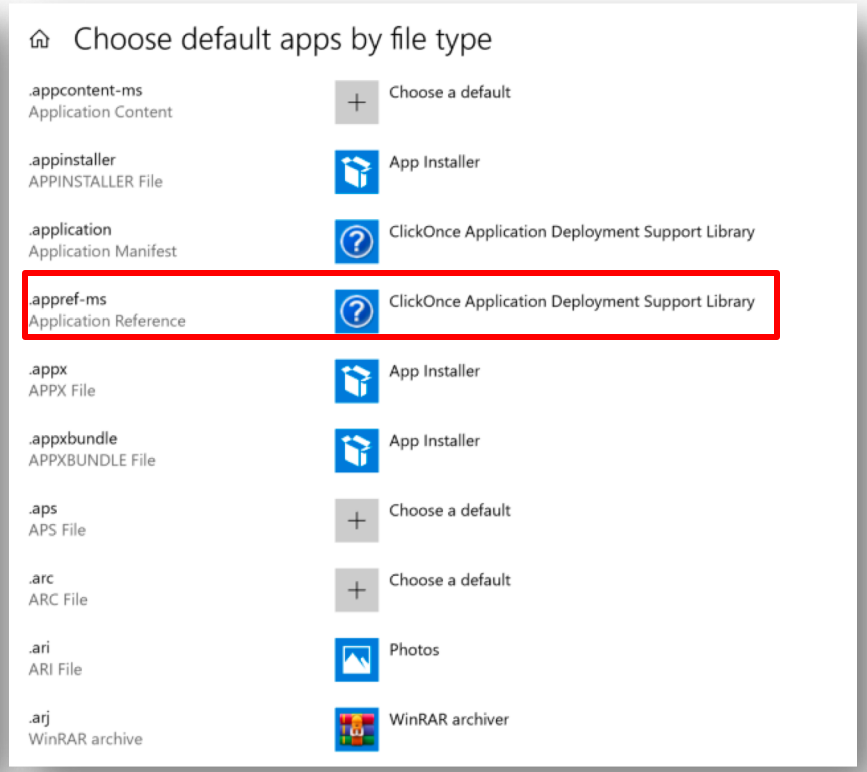
.appref-ms	.appx	.cat	.webpnp	.wcx

  - These filetypes were individually researched for potential manipulation

The End of the Golden Age

File extensions blocked in OLE package

File name extension	File type
.ade	Access Project Extension (Microsoft)
.adp	Access Project (Microsoft)
.app	Executable Application
.appcontent-ms	Application Content
.application	Application Manifest
.asp	Active Server Page
.bas	BASIC Source Code
.bat	Batch Processing script
.cer	Internet Security Certificate File



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.appref-ms	.appx	.cat	.webpnp	.wcx

  - These filetypes were further researched for potential manipulation

A New Light Arises

- While researching the extension formats, this caught my eye

What is an APPREF-MS file?

Application reference file used by ClickOnce, a Microsoft platform used to deploy and run remote Web applications; contains a local or remote link to an application; commonly used to enable links from the Windows Start Menu.

More Information

APPREF-MS file and their corresponding .APPLICATION files are enabled by the Microsoft .NET framework. When an APPREF-MS file is activated from a Web hyperlink, ClickOnce can check for updates, make installations, and run a program.

You had my curiosity, but now you have my attention

A New Light Arises

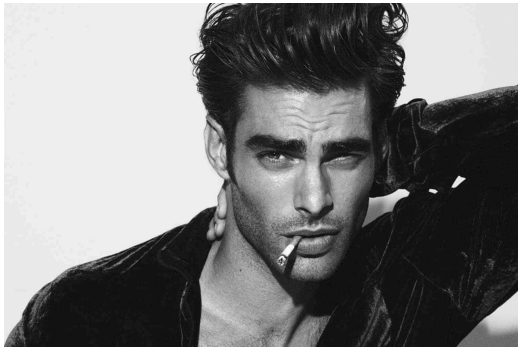
- No prior research on .appref-ms abuse was discovered
- ClickOnce is the application that runs the .appref-ms filetype
- Now, some great prior research on ClickOnce was discovered
  - Ryan Gandrud, NETSPI 2015
  - Justin Warner (@sixdub), 2015
  - @Bohops, 2018

- However, their research focused on a very different aspect
- Ultimately obtained execution while “operating as intended”

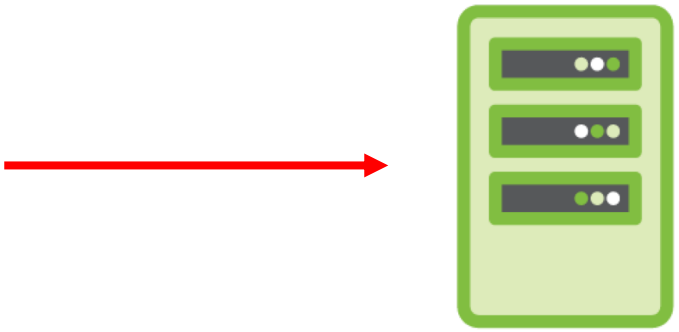
COMPENDIUM OF CLICKONCE

A ClickOnce Summary

- Intended use of ClickOnce follows this type of path:
  - An application is developed in C# within Visual Studio
  - The application is published either to a share or remote server



(Your average developer)



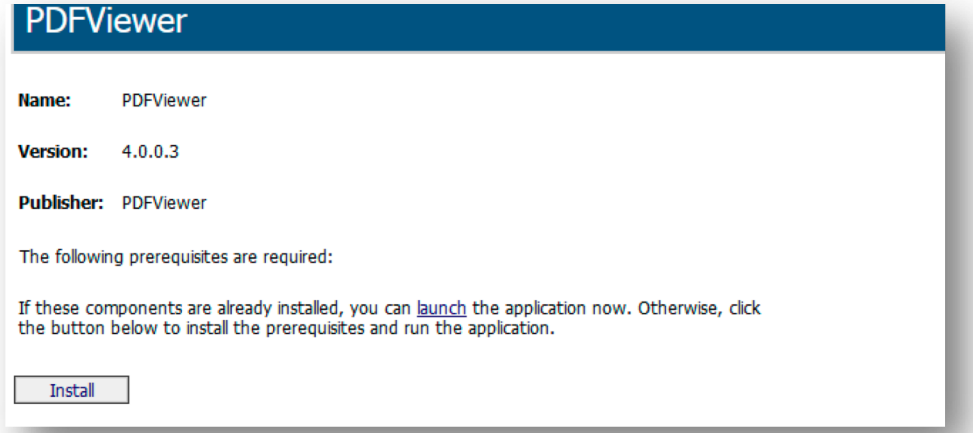
(Your average share)

Published as “Online only” or “Online or Offline” access

(This becomes important later)

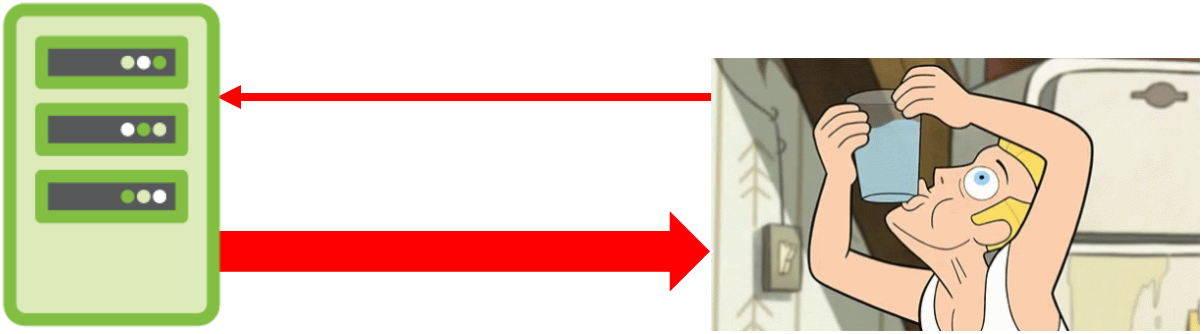
A ClickOnce Summary

- The root folder of the published directory could contain:
  - publish.htm - landing page for the application
  - .application file – Initiates web installation for the application
  - setup.exe, raw installer for the program
  - ”Application Files” folder – Stores the app version, manifest, & deploy files



A ClickOnce Summary

- It’s incredibly simple for the end user to install the program:
  - Launch the .application link through a web browser, execution is automated
  - Launch or install the application from the publish.htm page and run it



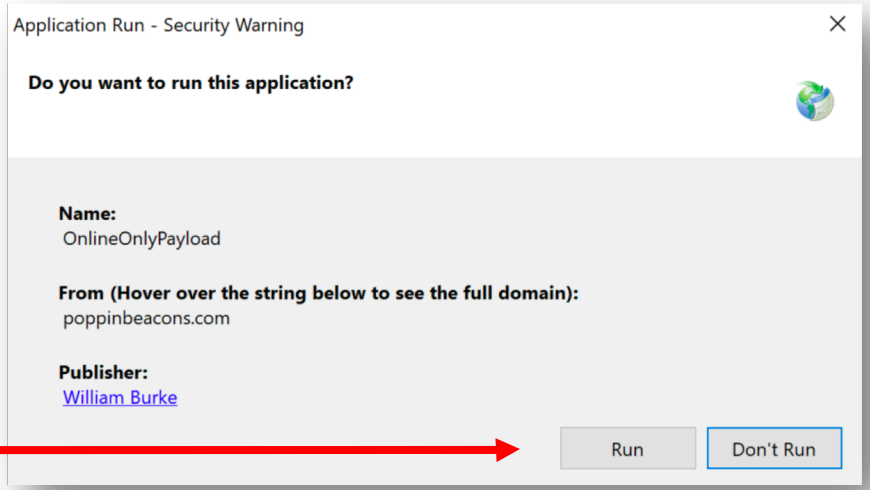
(Your average share)

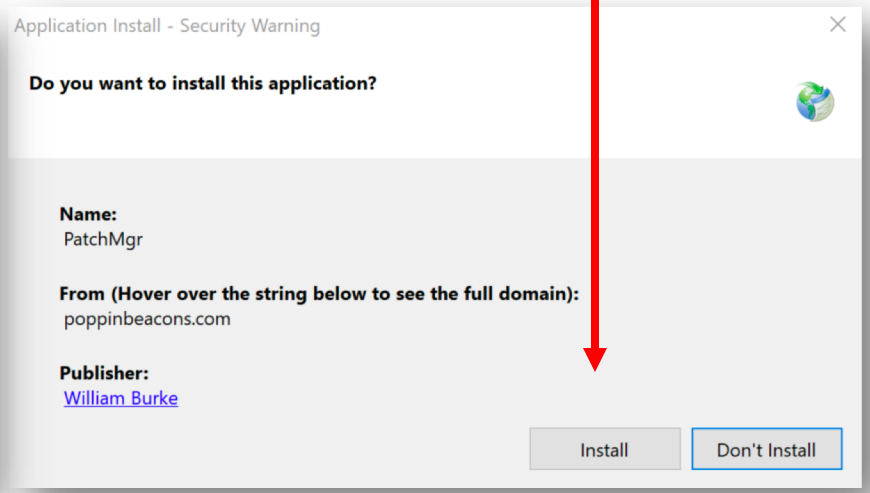
(Your average end user)

These methods will always install the latest version of the app

A ClickOnce Summary

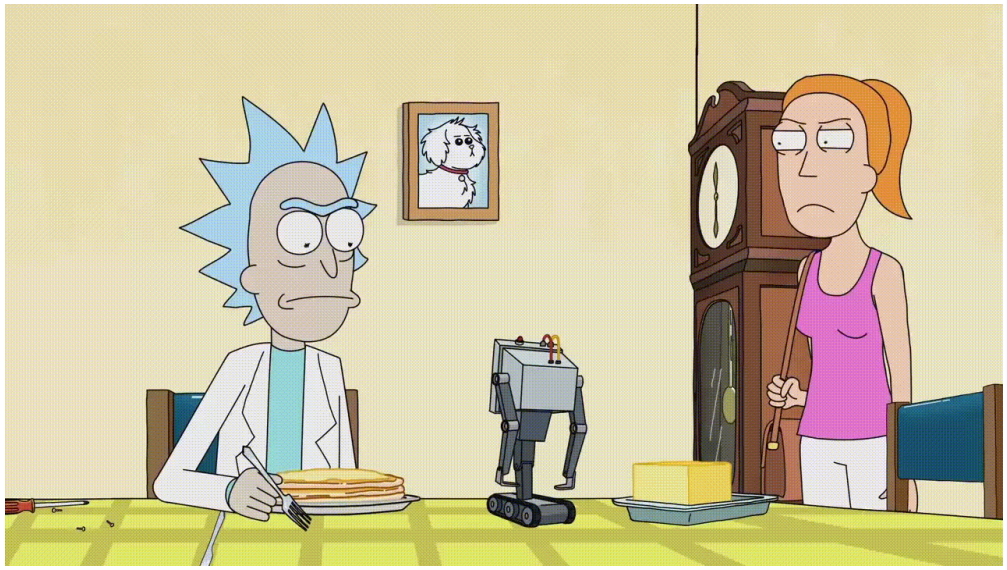
- Installation differs between ”Online only” and “Online & Offline”
  - Established when the application is deployed
- Online Only: Drops files to temp directory and runs
- Online or Offline: “Installs” the program and runs





A ClickOnce Summary

- And that's it! Simple way for a dev to get their app deployed



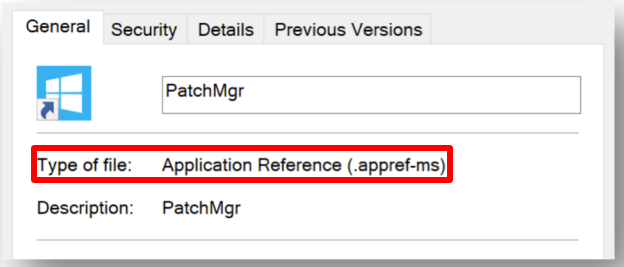
(So simple Google uses ClickOnce to install chrome via IE)

But what about .appref-ms?

- In both “Online only” and “Online or Offline” availability:
  - Files are dropped to the following directory - C:\Users\<username>\AppData\Local\Apps\2.0\<Random String>
- In Online Only deployment the application is ran a single time
- In ”Online or Offline” availability some additional work is done
  - Two major actions are performed as the “installation”
  - A registry key is added under HKCU\Software\Microsoft\Windows\CurrentVersion\Uninstall
  - An application reference file (!) is installed under the user’s start menu

But what about .appref-ms?

- The application reference (.appref-ms) file runs the application



- If the .appref-ms file is executed, it will:
  - Check the deployment site to see if there is an update
  - Will download any required or missing files and run the application
  - If the developer mandates the latest version, it will force an update
  - So if we send an .appref-ms file in an e-mail…

AQUAMAN, KING OF THE PHISH

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“Application” Deployment

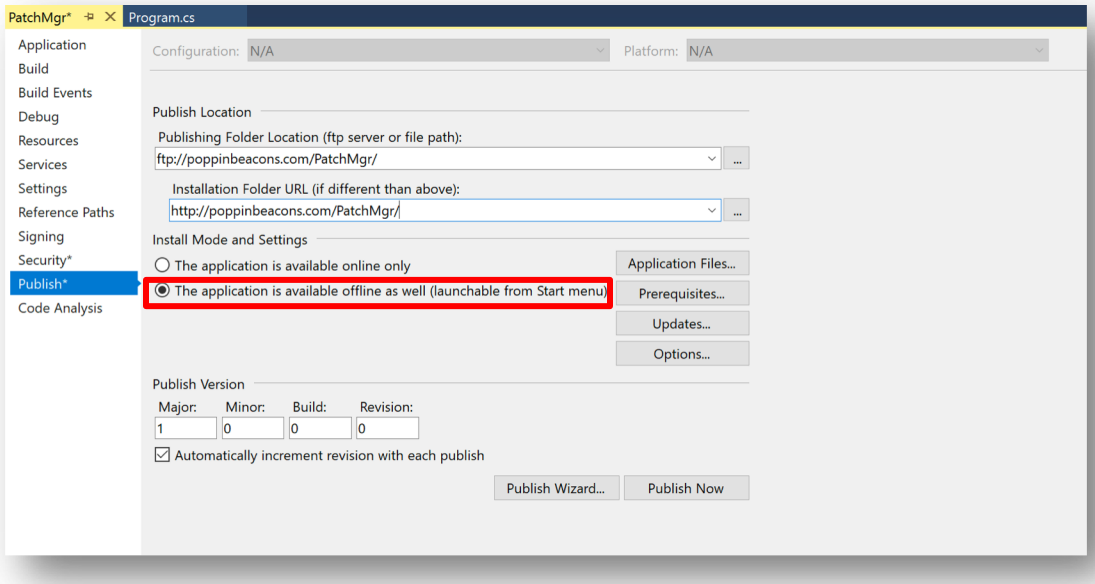
- Pre-Deployment requirements
  - C# code that bypasses your defensive mechanism of choice upon execution
  - Code signing certificate (if deploying externally)
  - A method to clean up files / stop the IOC’s below:
- Methods for removing the following should be in your C# code:
  - Reg Key:

  HKCU\Software\Microsoft\Windows\CurrentVersion\Uninstall\<key>
  - Directory & Files:

  C:\Users\<username>\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\<Application name>\<Application Files>
  - **Example code is provided in the white paper**

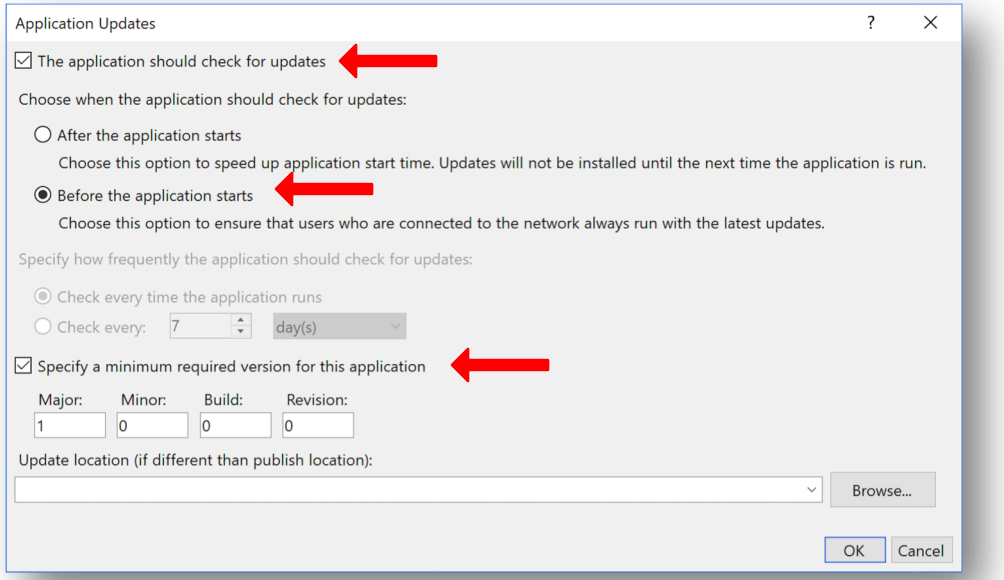
“Application” Deployment

- With the code in place, it’s time to deploy
- Publishing options sets your deployment configurations
  - For .appref-ms use, “available offline as well” must be selected
  - Any version number can be arbitrarily set



“Application” Deployment

- The options section opens up some additional configurations
  - Here you can mandate when and how the application checks for updates
  - You can also specify a minimum required version
  - If the current version does not match the required minimum, it will force install



“Application” Deployment

- Two ways to generate your own .appref-ms file:
  - Test on a host you own and copy the .appref-ms from the startup folder
  - A better option would be to create your own!
    - Saves time on continuous testing
      (Especially if using self-cleaning deployment)

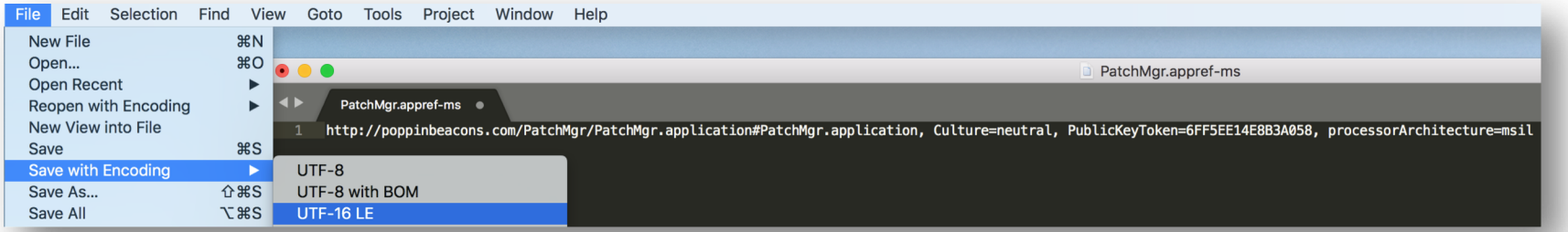
- An .appref-ms file consists of the following in a single line
  - URL_to_App#<name>, Culture, Public Key Token, Processor Architecture
  - This information is in the “Assembly Identity” section of the .application file

```
name="PatchMgr.application" version="1.0.0.0" publicKeyToken="6ff5ee14e8b3a058" language="neutral" processorArchitecture="msil"
```

Name Token Culture Arch

“Application” Deployment

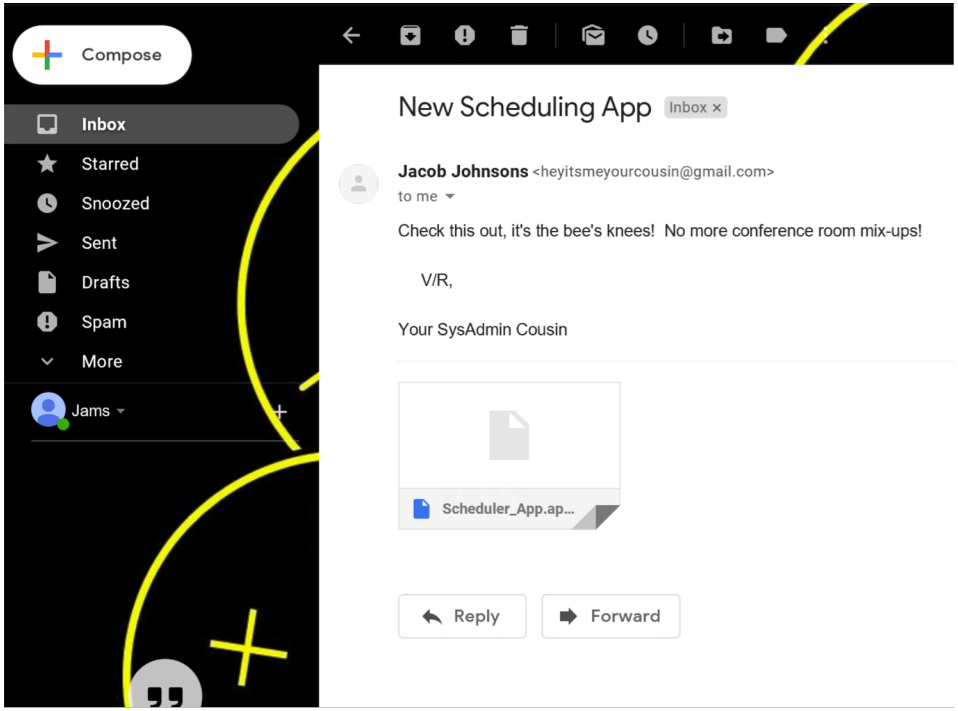
- You can put the information into a text file as a single line
- The file must be saved with UTF-16 LE encoding
  - Shout out to Alex Feinberg’s blog post from 2014
- Save as an .appref-ms file and it is ready to go!



- At this point we are ready to move to delivery

You're .appref-ms'ing with me

- Lazy mode: It could be attached directly to an e-mail
  - the .appref-ms file isn't flagged as malicious once attached or on download

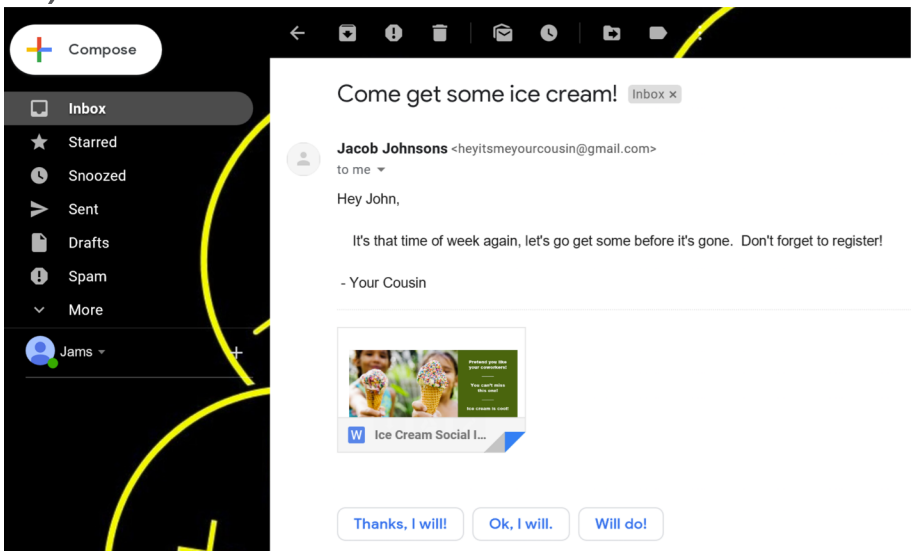


You're .appref-ms'ing with me

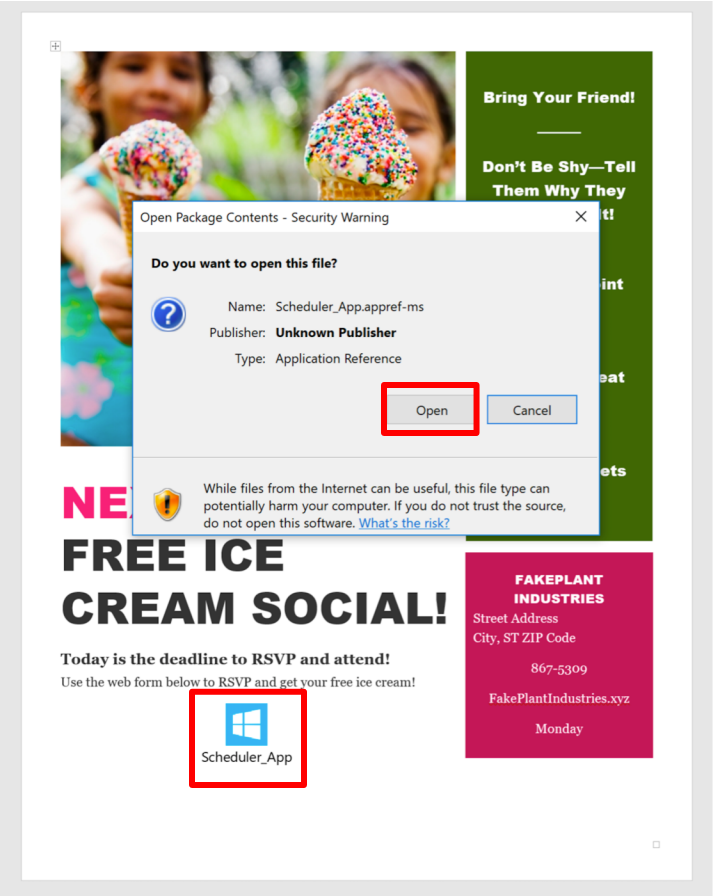
Totally innocuous OLE

You're .appref-ms'ing with me

1) Word document delivered



2) .appref-ms opened



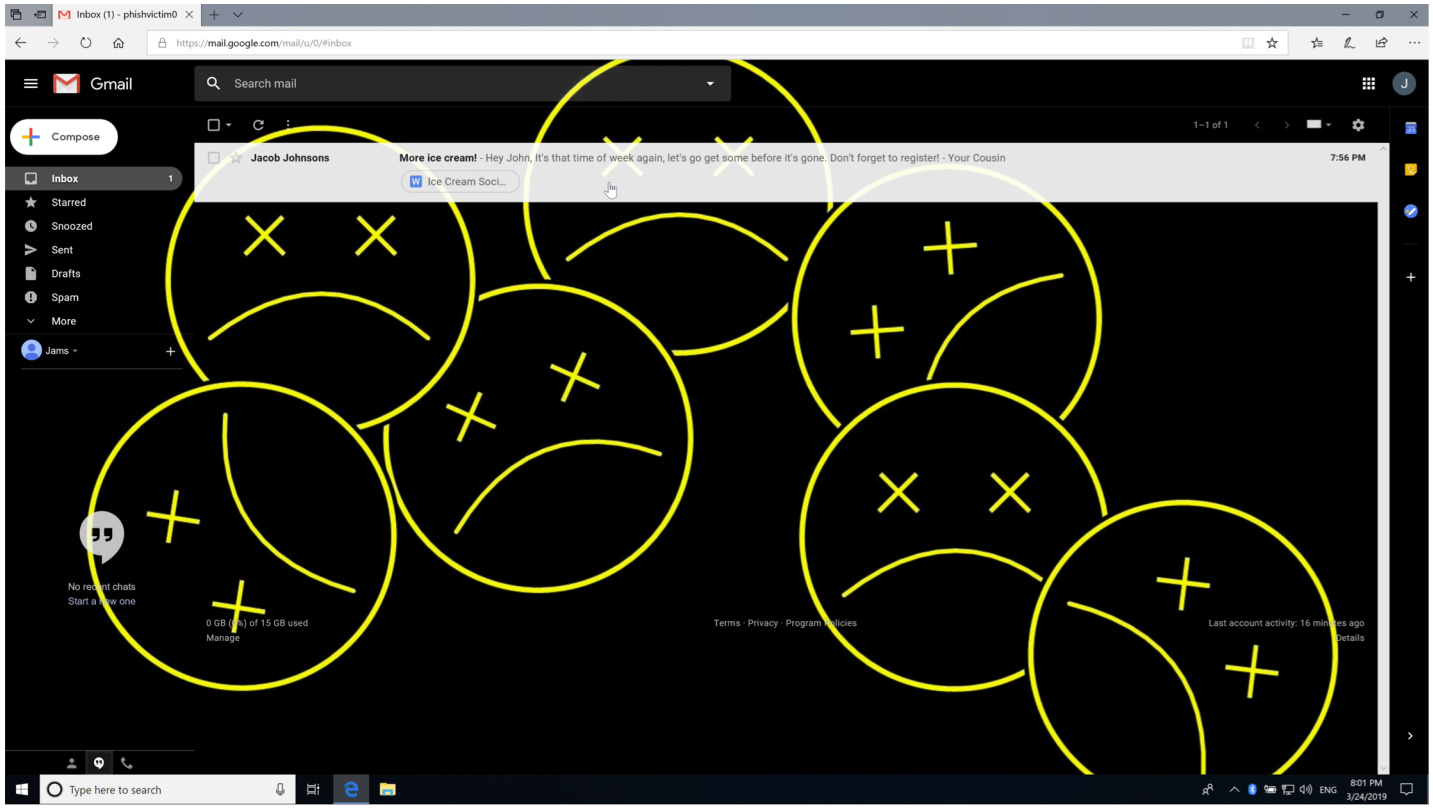
You're .appref-ms'ing with me

3) Once install is clicked…

4) Gondor calls for aid! We've got beacons

external	internal	user	computer	note	pid	last
173.54.167.128	172.16.202.183	devtest	DESKTOP-9RCLIP6	DevTest2_Host	2384	9s

You're .appref-ms'ing with me



Lateral Movement Rundown

- Lateral movement could be obtained by combining .appref-ms deployment with other capabilities
- Example 1: If you can move files remotely you could push the .appref-ms file to the remote user's startup folder
- Example 2: Run the application with psexec
  - Call the .application deployment link by invoking dfshim.dll with rundll32
  - Not appref-ms specific - can also be used in online only deployments
- The user will still need to approve the initial installation
  - Social engineering still at play – name your application accordingly
  - Once installed the user will no longer be prompted for execution or updates

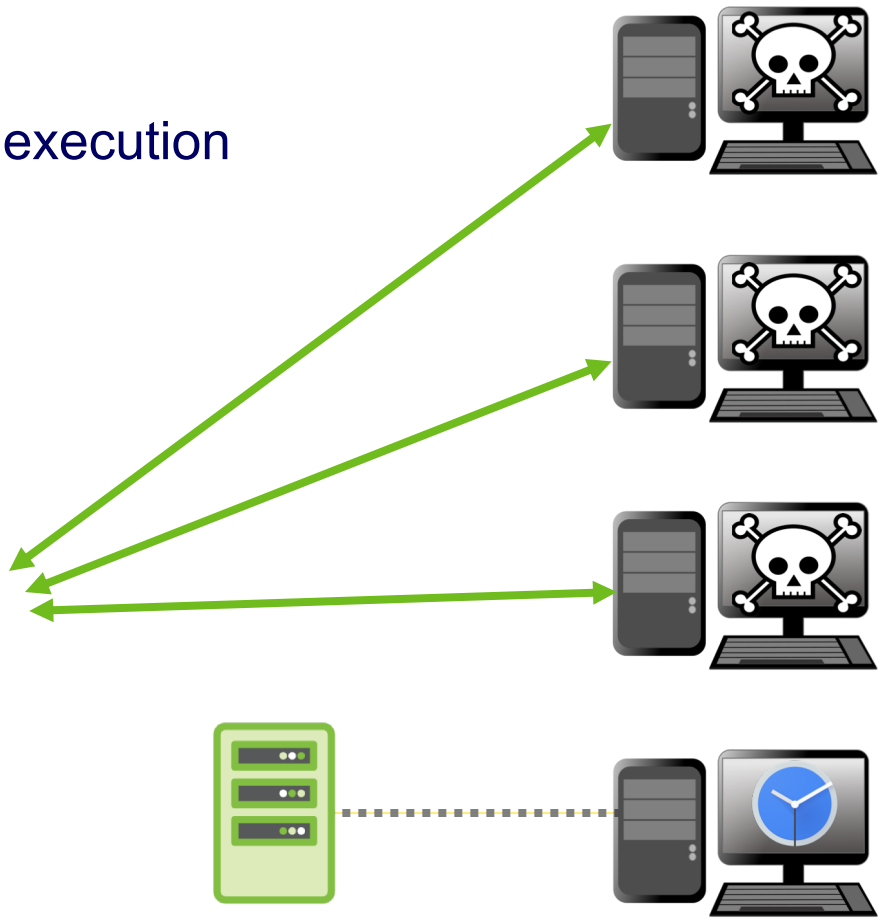
SLEEPER CELLS: C2 MGMT

C2 Management

= C2 Communication

= Periodic .appref-ms execution

(Your average operator)

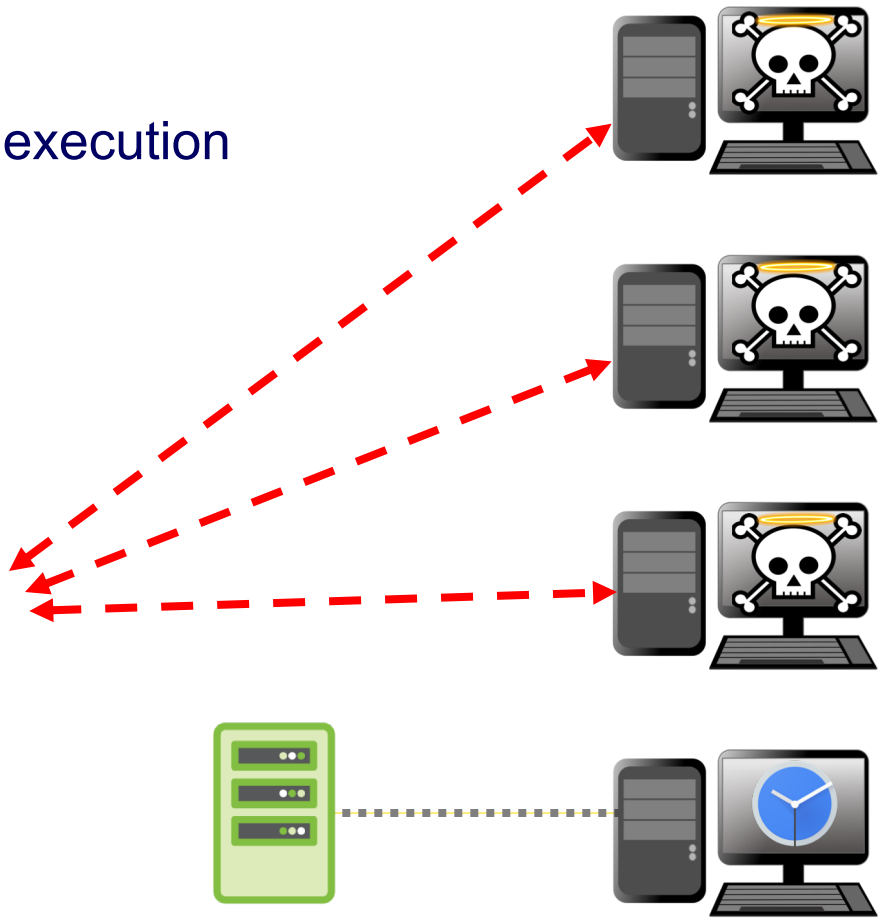


C2 Management

= C2 Denied

= Periodic .appref-ms execution

(Your average operator)



C2 Management

= C2 has ceased to be, it is no more

= Periodic .appref-ms execution

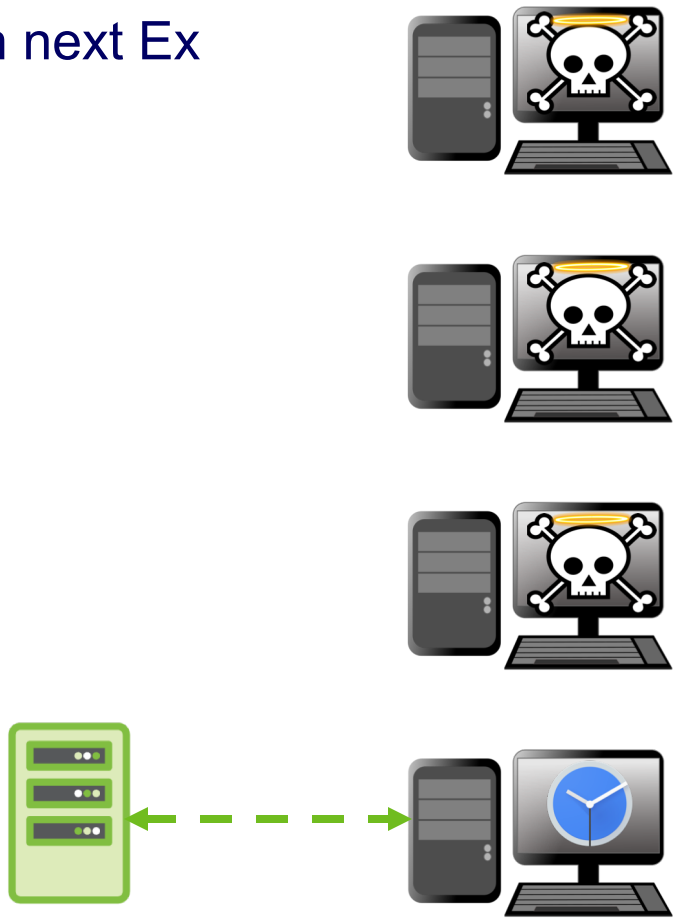
= Update pushed to server

(Your average operator)

C2 Management

← - - → = Update pulled from server on next Ex

(Your average operator)



C2 Management

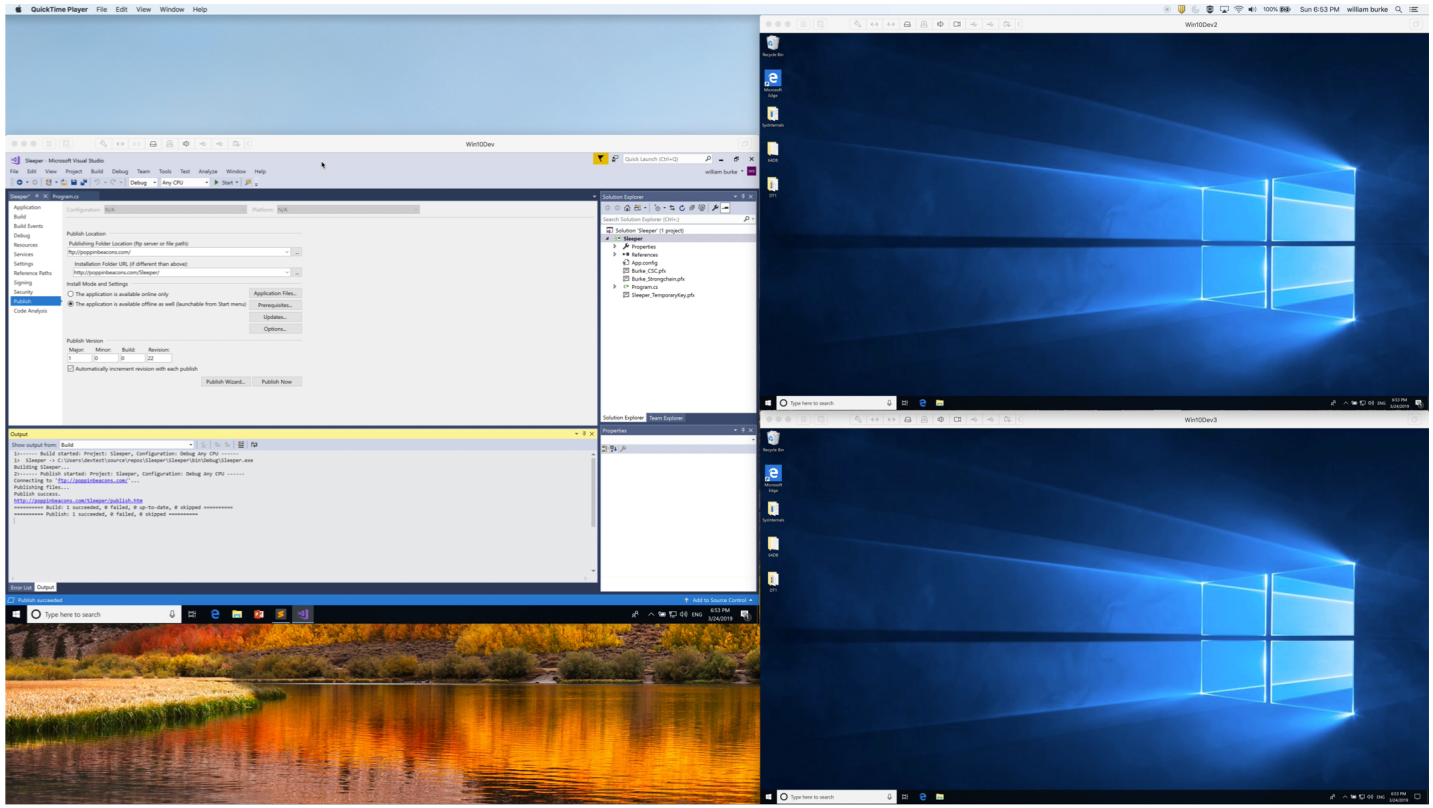
= C2 communication reestablished!

(Your average operator)

C2 Management

- Operational requirements may necessitate “lifelines”
  - Compromised hosts in an environment that can be utilized as backdoors
- By using ClickOnce’s update management capability, you can:
  - Have non-malicious code running on a remote host
  - Use an .appref-ms file to run on a schedule, startup, etc.
  - When it runs it will check for an update
  - If you lose access to your environment - push a malicious update!
  - The next time it checks in, if updates are forced it will run your malicious code
  - Can also be used to create logic bombs – Maybe a future talk?

C2 Management - Demo



A LITTLE HELP
(FOR MY FRIENDS)

IOCs & Defensive actions

- Can be difficult to detect .appref-ms as it is “Living off the Land”
  - Blocking .appref-ms execution may or may not be an option
  - Activity within the AppData folder is not atypical
- Monitor registry key modification
  - Addition and potential deletion of keys in the Uninstall tree
- Train end users to report odd activity
  - Odd installation prompts
  - ClickOnce execution sequence
- Continued efforts on post-execution detection

BLACKHAT TAKEAWAYS

3 Takeaways:

- *.appref-ms is a versatile addition to any offensive toolbelt*
- *Tinker - Be curious about “outside the box” applicability*
- *Defender awareness of .appref-ms malicious activity*

CLOSING QUESTIONS?

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