EMET 4.0 PKI MITIGATION

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ABOUT ME

- Security Engineer on MSRC (Microsoft Security Response Center)
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  - EMET Developer
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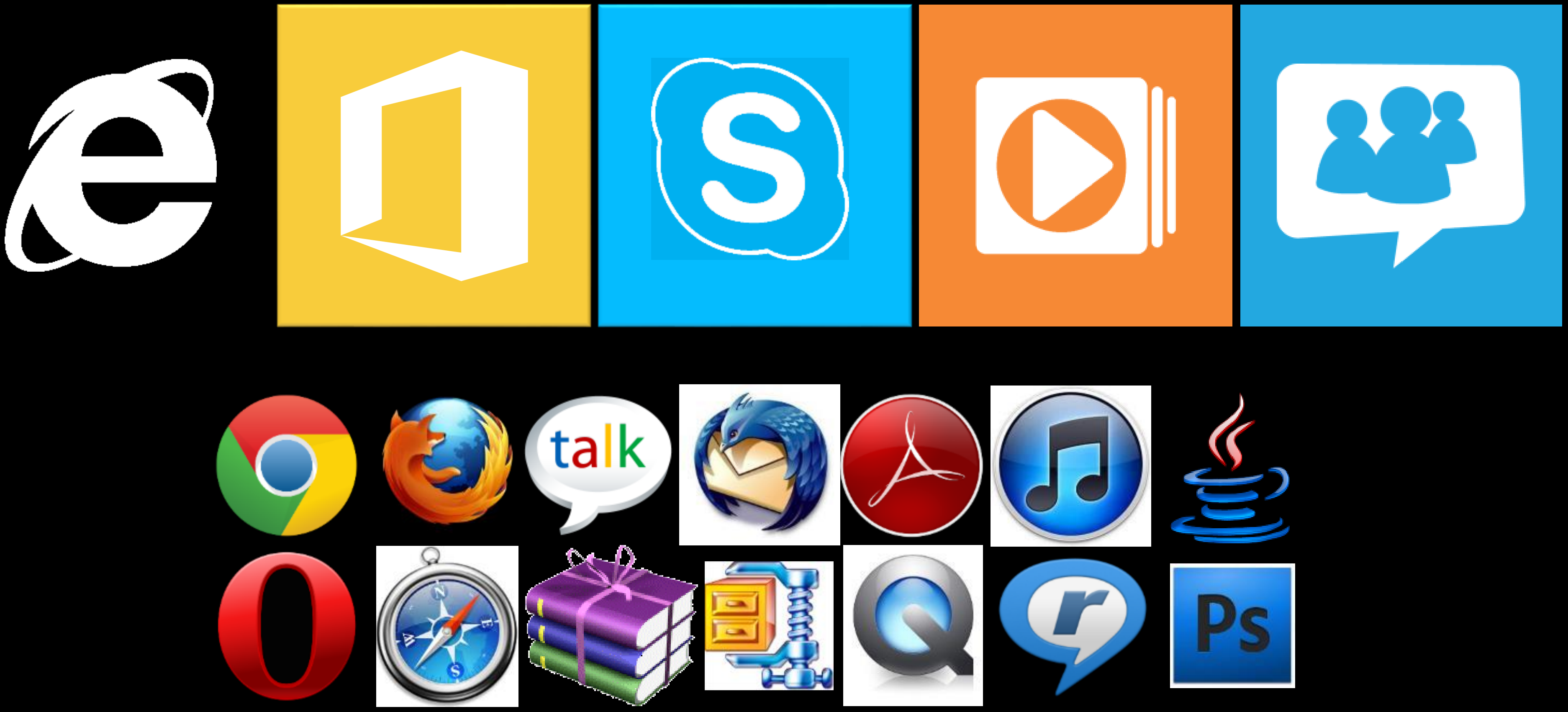
OVERVIEW

1. What Is EMET?
2. New Features in EMET 4.0
3. EMET Architecture
4. PKI Feature In Depth
5. PKI Demo

WHAT IS EMET?

- Mitigates various exploitation techniques
- Not signature based—behavior based
  - Things like stopping shellcode from reading Export Address Table etc
- DLLs dynamically loaded at runtime
- No application recompiling/redeploying necessary
- Can help mitigate 0Days
- Works as far back as Windows XP
- Giving back to the security community
- Its Free

COMPATIBLE APPLICATIONS



CHANGES BETWEEN EMET 3.0/4.0

- We added **Certificate Trust (PKI) Mitigations** ☺
  - Our first non memory corruption mitigation
- Some ROP Hardening (Deep Hooks, Antidetours, Banned Functions)
- ROP Mitigations
- New GUI

SHELLCODE MITIGATIONS

- DEP
  - Call SetProcessDEPPolicy
- HeapSpray
  - Reserve locations used by heap sprays
- Mandatory ASLR
  - Reserve module preferred base address, causing loader to load module somewhere else
- NullPage
  - Reserve first memory page in process, defense in depth
- EAF
  - Filter shellcode access to Export Address Table (kernel32 and ntdll)
- BottomUp Randomization
  - Randomize data structure bases

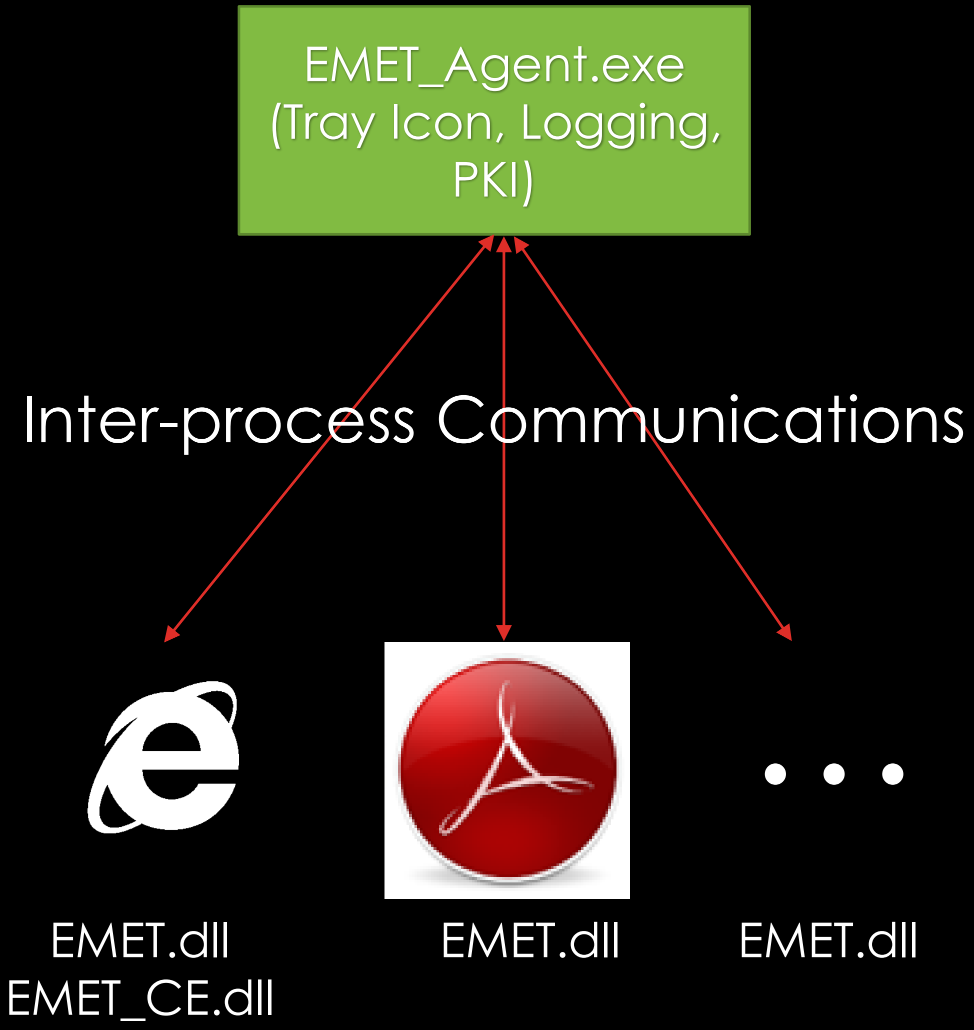
MORE SHELLCODE MITIGATIONS

- SEHOP-validate SEH chain looking for _EXCEPTION_REGISTRATION structure whose prev pointer is -1
- ROP Hardening
  - Deep Hooks-protect critical APIs and the APIs they call
  - AntiDetours-protect against jumping over detoured part of a function
  - Banned Functions-disallow calling ntdll!LdrHotpatchRoutine

ROP MITIGATIONS

- ROP (Detour functions that are commonly ROP’ed to)
  - LoadLib
    - Make sure we are not trying to call LoadLibrary() on a network location
  - MemProt
    - Make sure we aren’t making stack pages executable
  - Caller
    - Make sure return address on stack was proceeded by a call
    - Make sure we didn’t ret to this function
  - SimExecFlow
    - Make sure we don’t ret to ROP gadgets
  - StackPivot
    - Make sure Stack Pointer (ESP) is between stack limits defined by TIB

EMET ARCHITECTURE



EMET_Agent.exe
(Tray Icon, Logging,
PKI)

Inter-process Communications

EMET.dll
EMET_CE.dll

EMET.dll

• • •

EMET.dll

WHAT IS PKI?

- A **public-key infrastructure** (**PKI**) is a set of hardware, software, people, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates.

  --Wikipedia

- Used to ensure confidentiality, integrity and attribution online
- Communication with bank websites and other secure communications online depend on PKI
- PKI is the basis of HTTPS

RECENT SSL/TLS INCIDENTS

- December 2008- MD5 proven harmful (Sotirov/Stevens)
- March 2011- Comodo CA signs 9 fraudulent certificates
- August 2011- Diginotar signs at least 1 fraudulent certificate
- November 2011- DigiCert issues 22 certs with 512 bit keys
- January 2013- TURKTRUST creates 2 issues fraudulent CAs and a certificate

PKI is under ATTACK

PKI CERTIFICATE PINNING

Pinning is when we enforce certain assumptions or expectations about certificates that we get from the internet

EXISTING PINNING WORK

- TACK (Marlinspike, Perrin): requires TLS changes, pins to TACK signing key
- DANE/TLS (RFC 6698) : requires DNS changes
- HSTS (RFC 6797) + Draft ietf websec key pinning (Evans, Palmer, Sleevi): pins to SubjectPublicKeyInfo hash, requires HTTP changes, used in Chrome

EMET'S DESIGN GOALS

- Our goals in EMET PKI design were the following:
  1. Give control to users
     - Users specify the certificates
     - Users specify the domain names
     - Users specify the heuristic checks
  2. Don't require changes to pre-existing protocols
     - This could break something
     - This would require adoption by the rest of the internet
  3. Keep EMET as a standalone tool on the client and not depend on remote services
- In order to achieve these goals, we had to make tradeoffs that existing designs didn't have to make

EMET'S APPROACH

- Requires no protocol changes
- Pins to Root Certificates, not Intermediate Certificates
- Pins to certificates in the Current User's "Trusted Root Certification Authorities" store
- Identifies certificates by either:
    - <Issuer, Serial #> Tuple

    OR

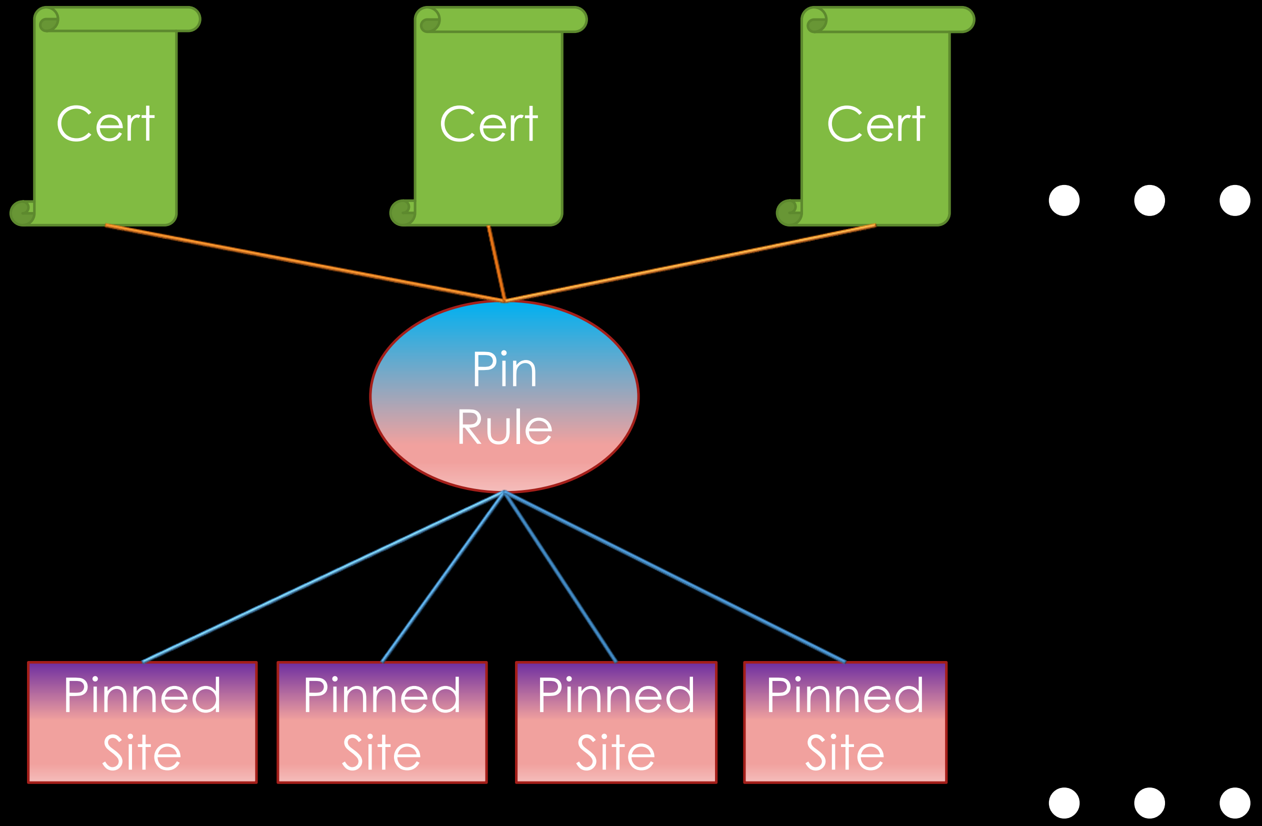
    - Subject Key Identifier (SHA-1 of subjectPublicKey)

CERTIFICATE IDENTIFICATION

- Certificates can be identified by <issuer, serial #> tuples
  - According to RFC5280:

    “`the issuer name and serial number identify a unique certificate`”
  - Identifying a specific certificate is more rigid (restrictive)
- Certificates can be identified by Public Key
  - Some certificates chain to roots which share the same public key
  - EMET optionally allows certificate identification by only Subject Key Identifier (SHA-1 of hash of Public Key)

EMET PKI PINNING ARCHITECTURE



Default Configuration Example

Baltimore CyberTrust Root
Verisign
GlobalSign
GTE CyberTrust Global Root

MSSkypeCA

login.skype.com
secure.skype.com

WINDOWS CAPI EXTENSION

- Implemented in EMET_CE[64].dll
- EMET_CE.dll loaded inside the process
- Communicates with EMET_Agent.exe, and passes it the entire certificate chain including the Root and End certificates hex encoded in XML
- EMET_Agent.exe decides whether the cert is OK or not

```
CryptRegisterOIDFunction() is called with following parameters:
CRYPT_OID_VERIFY_CERTIFICATE_CHAIN_POLICY_FUNC,
CERT_CHAIN_POLICY_SSL,
EXPORT_FUNC_NAME
```

CERTIFICATE CHECKS 1

- If none of the following matches a Pinned Site’s Domain Name, pass because this domain is not configured
  - Server Name of HTTPS connection
  - End certificate’s Subject Name
  - End certificate’s Subject Simple Name
  - End certificate’s Subject DNS Name
  - End certificate’s Subject URL Name
  - Any Subject Alternative Name on End certificate
- Is Pin Rule Expired?
  - If yes, fail

CERTIFICATE CHECKS 2

- Either (Depending on Configuration)
  - Is Subject Name of root **AND** Serial Number of root equal to that in a pinned Root Store certificate?
    - If yes, pass

OR

  - Is root Subject Key Identifier equal to that in a pinned Root Store certificate?
    - If yes, pass

CERTIFICATE CHECKS 3 (EXCEPTIONS)

- Is root Public Modulus Bit length < Pin Rule’s allowed length?
  - If yes, fail
- Is root Digest Algorithm disallowed by the Pin Rule?
  - If yes, fail
- Is root country equal to the Pin Rule’s Allowed Country?
  - If no, fail

DEFAULT PROTECTED DOMAINS

- Shipped in CertTrust.xml
- Enabled by “Recommended Settings” in wizard
- Protected Domains:
  - login.microsoftonline.com
  - secure.skype.com
  - www.facebook.com
  - login.yahoo.com
  - login.live.com
  - login.skype.com
  - twitter.com

LIMITATIONS

- Mitigation is specifically for SSL
- Since we just check End and Root Certificates, we don’t run heuristics on intermediate certificates
- Pin configuration is statically shipped with EMET, so they could get outdated
- EMET’s mitigations are not 100% “bullet proof”
  - They just try to raise the bar for attackers

DEMO TIME!

REFERENCES

- ntdll!LdrHotpatchRoutine
  - http://cansecwest.com/slides/2013/DEP-ASLR%20bypass%20without%20ROP-JIT.pdf
- MD5 Harmful (Sotirov/Stevens)
  - http://www.win.tue.nl/hashclash/rogue-ca/
- TACK (Marlinspike, Perrin)
  - http://tack.io/draft.html
- DANE/TLS RFC 6698
  - http://tools.ietf.org/html/rfc6698
- HSTS RFC 6797
  - http://tools.ietf.org/html/rfc6797
- Chrome's Public Key Pinning Extension (Evans, Palmer, Sleevi)
  - http://tools.ietf.org/html/draft-ietf-websec-key-pinning-07
- X509 RFC 5280
  - http://tools.ietf.org/html/rfc5280
- Download EMET 4
  - http://www.microsoft.com/en-us/download/details.aspx?id=39273
- More Information about Memory Corruption Mitigations in EMET 4.0:
  - http://www.recon.cx/2013/slides/Recon2013-Elias%20Bachaalany-Inside%20EMET%204.pdf

QUESTIONS

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