Statistically effective protection against APT attacks

- Study on effectiveness of popular defense measures

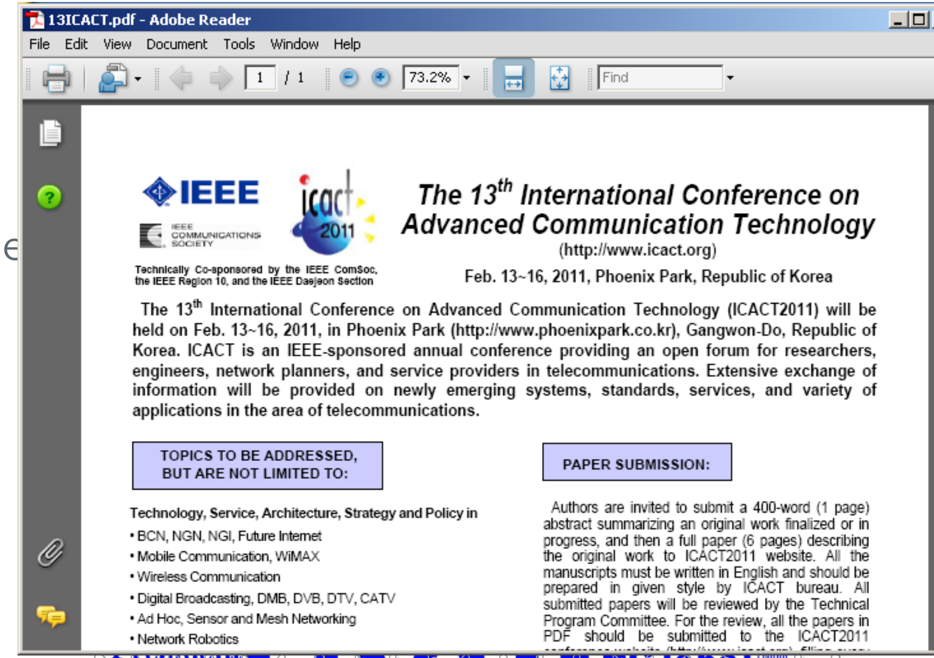
Jarno Niemelä. Virus Bulletin 2013
Twitter: @jarnomn

Why This Research Was Made?

- Applying hardening in corporate environment is expensive
- Thus I wanted to give decision making support tools for corporate security
- In this research we evaluated popular hardening approaches against a set of exploits
- Attacks and defenses evolve constantly so we focused more on different styles of approach rather than exact settings or tools
- For tests we obviously used publicly available tools

Exploits Used In Tests

- The used exploit set consisted of ~930 confirmed exploit document samples
- Samples in the wild 2010-2013
- CVE identification was done by scan results
- Most exploits have short lifespan in active use
- APT nature verified by context identification
    - Press events, conference proceedings
    - Diplomatic/political reports, analysis
    - Human rights/activism reports, articles
    - Military reports, events, analysis
    - Business related mail



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TOPICS TO BE ADDRESSED, BUT ARE NOT LIMITED TO:

Technology, Service, Architecture, Strategy and Policy in

- BCN, NGN, NGI, Future Internet
- Mobile Communication, WiMAX
- Wireless Communication
- Digital Broadcasting, DMB, DVB, DTV, CATV
- Ad Hoc, Sensor and Mesh Networking
- Network Robotics

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Authors are invited to submit a 400-word (1 page) abstract summarizing an original work finalized or in progress, and then a full paper (6 pages) describing the original work to ICACT2011 website. All the manuscripts must be written in English and should be prepared in given style by ICACT bureau. All submitted papers will be reviewed by the Technical Program Committee. For the review, all the papers in PDF should be submitted to the ICACT2011

Analysis Method

- We tested samples with Windows XP SP3
  - Adobe Acrobat 8.0.0
  - Adobe Flashplayer 6.0
  - Office 2003
- We intentionally used obsolete software versions to enable as many exploits as possible
- We used automatic forensics to check for exploit success indicators
  - Network communication
  - Process creation
  - File creation
- Each exploit was verified to work consistently in base system

Protection Methods

- Application memory handling mitigations
- Application Sandboxing
- Hardening application settings
- Hardening operating system

Application Sanboxing

- Chrome, Acrobat, etc popular apps have built in sandboxing
- The problem with them is that attacker has to circumvent them in order to exploit
- Thus we wanted to test exploits against unexpected sandboxing
- We used Sandboxie 3.76 Pro with custom configuration
  - Own sandbox for each document type
  - File execution denied for any files created by sandboxed application
  - No file access outside the sandbox for Acrobat
  - Access to %documents% %recent% and network drives for Office applications

Hardened Security Settings For Client Apps

- Advisories often have mitigation instructions what to do before patch is available
- We wanted to find out how effective those measures are in general
- Who on earth needs a flash content in PDF file in the first place?

Changes to Office

- Installed Office file validation
- Installed MOICE isolation
- Set Macro security level to high
- Disabled trust on add-ons and templates

Changes to Acrobat

- Disabled opening non-PDF attachments
- Disabled trust in multimedia components
- Disabled multimedia player
- Disabled Javascript

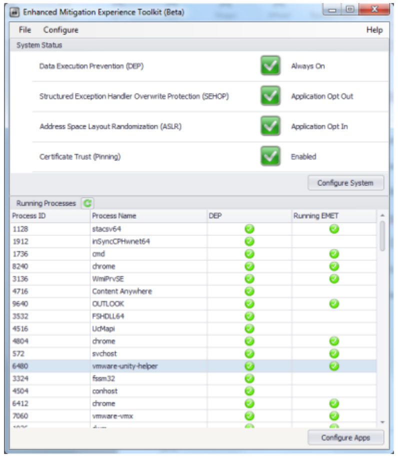
After VB paper submission NSA came out with their Acrobat guidelines ☺
http://www.nsa.gov/ia/_files/app/Recommendations_for_Configuring_Adobe_Acrobat_Reader_XI_in_a_Windows_Environment.pdf

Hardened System Access Policies

- In T2 2011 we announced research pointing to that hardening breaks malware
- However APTs are quite a different beast compared to plain old malware
- We tested the samples against following hardened system settings
- Blocked file writing to roots of
  - C:\, D:\, etc, %localsettings%, %appdata%
- Blocked file writing recursively to
  - C:\windows, %program files%
- Prevented file execution from
  - C:\,%documents%, c:\RECYCLER,%temp%,%APPDATA%,%localsettings%

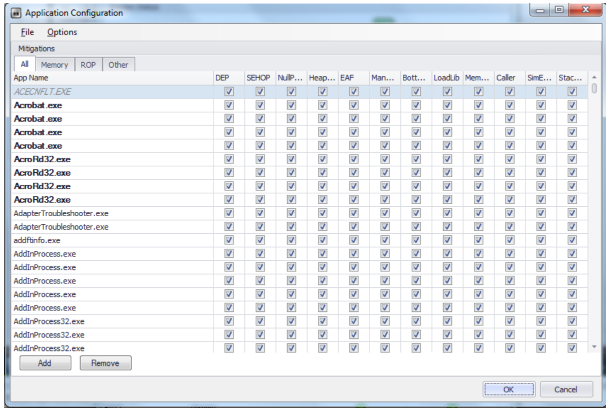
Application Memory Handling Mitigations

- Memory handling mitigations prevent types of memory operations needed by exploits
- Thus normal apps are mostly unhindered while exploits fail to work
- Currently only tool providing such capabilities is Microsoft EMET
    - Allocation mitigations (SEHOP, Heapspray ,ASLR , Null page)
    - Code execution or loading mitigations (DEP, ROP, Bottom up rnd,EAF)
    - Hooking preventions (Deep hooks, Anti detours, Banned functions)
- For this research we used Emet 4.0b which was the latest available



Data Execution Prevention (DEP)	✓	Always On
Structured Exception Handler Overwrite Protection (SEHOP)	✓	Application Opt Out
Address Space Layout Randomization (ASLR)	✓	Application Opt In
Certificate Trust (Pinning)	✓	Enabled

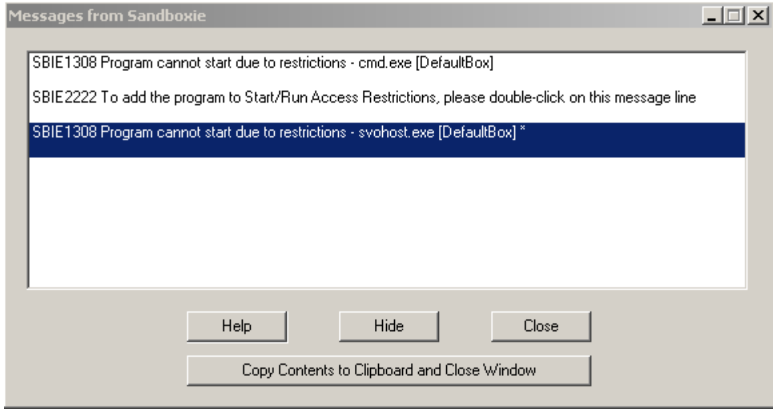
Process ID	Process Name	DEP	Running EMET
1128	stacsv64	✓	✓
1912	inSyncCPHwnet64	✓	
1736	cmd	✓	✓
8240	chrome	✓	✓
3136	WmiPrvSE	✓	✓
4716	Content Anywhere	✓	
9640	OUTLOOK	✓	✓
3532	FSHDLL64	✓	
4516	UcMapi	✓	
4804	chrome	✓	✓
572	svchost	✓	✓
6480	vmware-unity-helper	✓	✓
3324	fssm32	✓	
4504	conhost	✓	
6412	chrome	✓	✓
7060	vmware-vmx	✓	✓



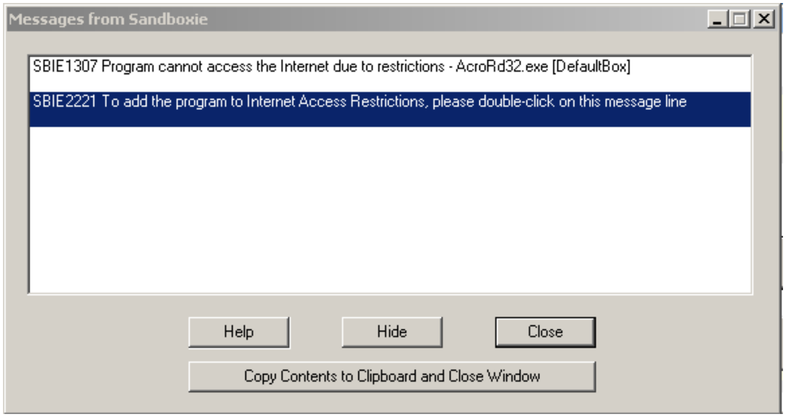
App Name	DEP	SEHOP	NullP...	Heap...	EAF	Man...	Bott...	LoadLib	Mem...	Caller	SimE...	Stac...
ACECNFLT.EXE	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Acrobat.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Acrobat.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Acrobat.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Acrobat.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AcroRd32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AcroRd32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AcroRd32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AcroRd32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AdapterTroubleshooter.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AdapterTroubleshooter.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
addftinfo.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
AddInProcess32.exe	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Application Sandboxing Results

- Unfortunately Sandboxie interfered with our automatic forensics
- We were able to get results for 452 samples with 100% protection
- Of the remaining samples we tested 60 random samples which had 100% protection
- So we cant say with full certainty, but third party sandboxing seems to be effective
- Built in payloads were dropped but not executed
- Samples which tried to download were blocked



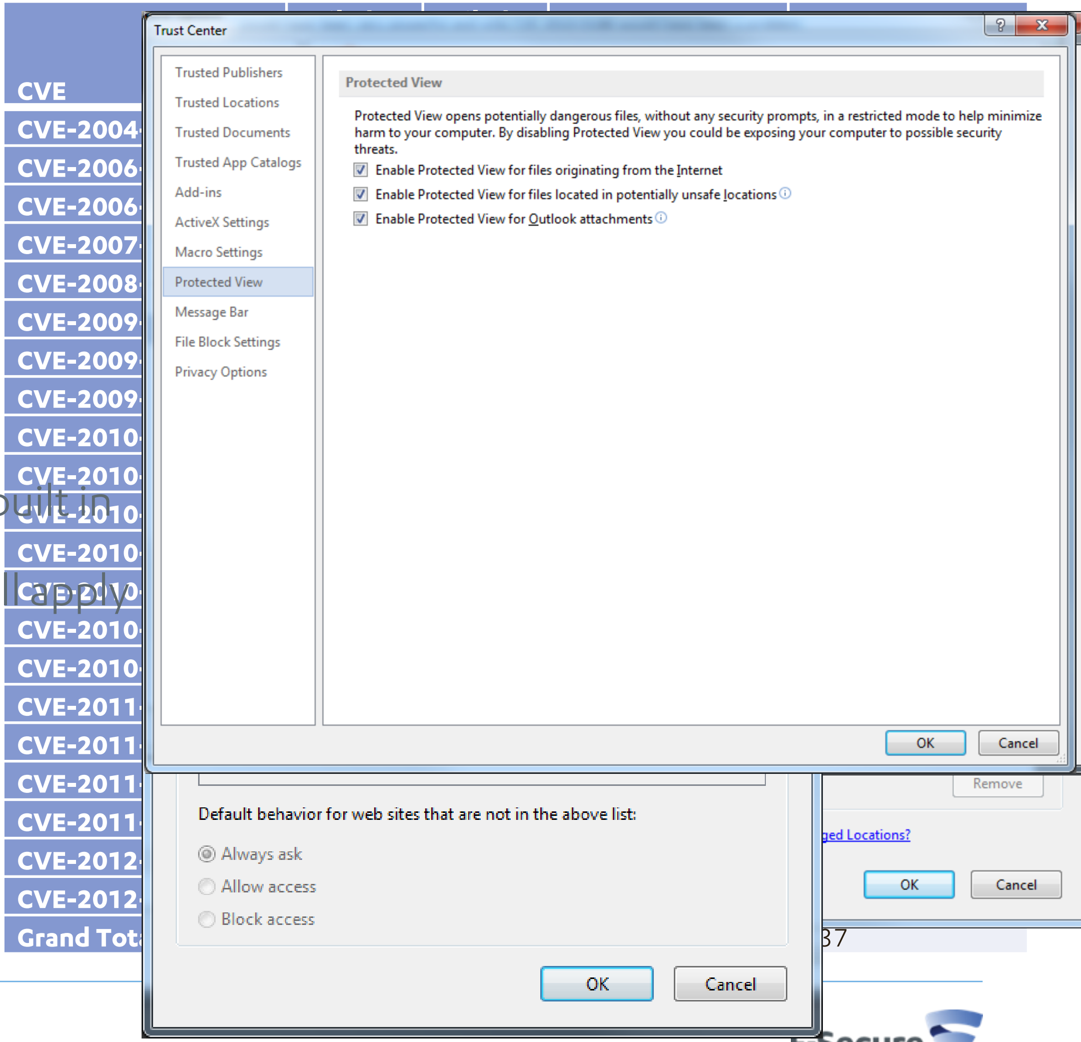
```
SBIE1308 Program cannot start due to restrictions - cmd.exe [DefaultBox]
SBIE2222 To add the program to Start/Run Access Restrictions, please double-click on this message line
SBIE1308 Program cannot start due to restrictions - svohost.exe [DefaultBox] *
```



```
SBIE1307 Program cannot access the Internet due to restrictions - AcroRd32.exe [DefaultBox]
SBIE2221 To add the program to Internet Access Restrictions, please double-click on this message line
```

Hardened Client Apps results

- Hardening applications gave 80% total protection against exploits
- CVE-2010-0188 failed as not all samples were using JavaScript
- CVE-2010-0188 failed as we did not think if isolating RTF files
- CVE-2012-0158 also failed due not isolating RTF files
- In Office 2013 OFV and MOICE are built in
- In Acrobat the recommendations still apply



CVE
CVE-2004
CVE-2006
CVE-2006
CVE-2007
CVE-2008
CVE-2009
CVE-2009
CVE-2009
CVE-2010
CVE-2010
CVE-2010
CVE-2010
CVE-2010
CVE-2010
CVE-2010
CVE-2011
CVE-2011
CVE-2011
CVE-2011
CVE-2012
CVE-2012
Grand Tot

37

Trust Center

Protected View

Protected View opens potentially dangerous files, without any security prompts, in a restricted mode to help minimize harm to your computer. By disabling Protected View you could be exposing your computer to possible security threats.

☑ Enable Protected View for files originating from the Internet

☑ Enable Protected View for files located in potentially unsafe locations

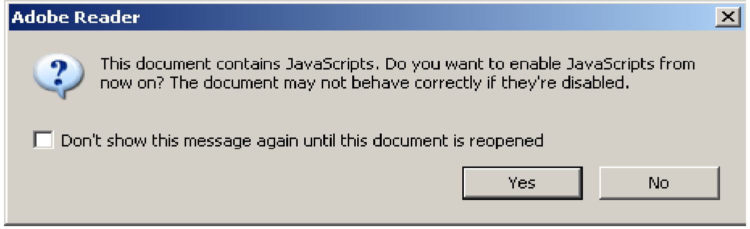
☑ Enable Protected View for Outlook attachments

Default behavior for web sites that are not in the above list:

● Always ask

○ Allow access

○ Block access



Adobe Reader

This document contains JavaScripts. Do you want to enable JavaScripts from now on? The document may not behave correctly if they're disabled.

☐ Don't show this message again until this document is reopened

Hardened System Access Policies results

- Hardened system access policies gave very small total protection of ~10%
- ~7% were partially mitigated
  - Network was blocked in 40 samples
  - Process creation blocked in 28 samples
- So in total system hardening is ineffective

CVE	Failed: network event	Failed: file event	Failed: process event	Success
CVE-2004-0210		1		
CVE-2006-2492			1	
CVE-2006-3590		3		
CVE-2007-5659	20		1	
CVE-2008-4841		1		
CVE-2009-0927	1			
CVE-2009-3129		159	52	8
CVE-2009-4324	3	2		4
CVE-2010-0188	294	2		
CVE-2010-0806	7	1		
CVE-2010-1297		5		
CVE-2010-2572		2	8	7
CVE-2010-2883	3	27	2	50
CVE-2010-3333	1	82	14	1
CVE-2010-3654		11	12	6
CVE-2011-0097			1	
CVE-2011-0101		4	51	13
CVE-2011-0611		19	2	
CVE-2011-1269		1		
CVE-2012-0158	15	21	7	
CVE-2012-0779	2			
Grand Total	346	341	151	89

Memory Handling Mitigations Results

- EMET was able to stop every single exploit!
- However 4.0b is newer than samples, so results can be skewed
- There are claims that EMET can be circumvented
- But in our tests we could not find a sample that actually does so
- Memory handling mitigations are not effective against all exploit types
  - If exploit is based on other than code execution, EMET will not help
- But such exploits are very rare and we could not find in the wild sample

CVE	failed	success
cve-2004-0210	0	1
cve-2006-2492	0	1
cve-2006-3590	0	3
cve-2007-5659	0	21
cve-2008-4841	0	1
cve-2009-0927	0	1
cve-2009-3129	0	219
cve-2009-4324	0	9
cve-2010-0188	0	296
cve-2010-0806	0	8
cve-2010-1297	0	5
cve-2010-2572	0	17
cve-2010-2883	0	82
cve-2010-3333	0	98
cve-2010-3654	0	29
cve-2011-0097	0	1
cve-2011-0101	0	68
cve-2011-0611	0	21
cve-2011-1269	0	1
cve-2012-0158	0	43
cve-2012-0779	0	2
Grand Total	**0**	927

Defence In Depth, Harden Your Network

Prevent lateral movement within your network

- Isolate everything in network, no inbound to clients no outbound from server
- Block remote execution and RDP from other than admin network segment
- Allow user to login only to his workstations

Isolate email to approved business use only

- Allow email only over company mail server
- Don’t allow mail sending without user authentication

Control DNS resolution, do not allow unknown domains to resolve

  - Most APT C&C infra rely on being able to resolve domain names

Make data difficult to steal

Use DRM to make stolen documents worthless

- Use rights management server to provide transparent crypto for documents
- Valid users can read documents, stolen docs are worthless outside company

Watermark company browsers and check watermark in server

- Have own browser that can access only intra. Check against that in the server
- Water mark can be faked, but hard to get 100% right on the first go -> alarm

Use token based email certificates and crypto for all internal mail

- Direct stealing of mail files becomes useless
- Attacker needs to decrypt messages before stealing, which slows down attack and gives you time to react

Conclusions

- With the exception of OS hardening all other methods were very effective
  - Very few attackers aim at anything but default configuration
- Which methods to use depends on what your corporate IT finds easiest to deploy
- As rule of thumb all applications that deal with external data should be hardened
- Personally I would recommend a combination of hardened application settings and EMET
- Sandboxing is also very effective but can require effort to make it transparent to users
- Most important thing to do is not to rely on a single security layer
- Our corporate security product is very good at catching exploits
  but no single layer is going to be enough