Designing and Attacking DRM

Nate Lawson | Root Labs | 2008/4/11 | Session Code: HT1-402

RSA CONFERENCE 2008

If you pay attention, you'll learn…

- Why software protection matters
- Attack methods
  - Tools & techniques
- Design principles
  - Model: mesh vs. chain
  - Anti-debugging is no panacea
- Update: who's cracked or not

My background

- Root Labs founder
  - Design and analyze security schemes
  - Emphasis on embedded, kernel, software protection, and crypto
- IBM/ISS
  - Original developer of RealSecure IDS
- Cryptography Research
  - Co-designed Blu-ray disc content protection layer, aka BD+

In the past, DRM was simple

- Copy protection (1980's)
  - Simple goal: only run from the original floppy media
  - No privacy problems
  - Relatively harmless
    - Some games did format themselves if not properly cracked
  - Legal restrictions only via copyright, not on analyzing schemes or releasing tools

Today, bad DRM is too common

- Goals overly complex
  - Can share among a few devices but not too many
  - Expiration dates, limited number of plays
- Privacy problems
  - Network access
  - Cookies
- Collateral damage when it goes bad
- Dangerous and unclear legal environment

- If there's going to be DRM, make it simpler!

Definition: software protection

- Software protection is the technical enforcement mechanism
  - DRM is the policy, a different talk
- Composed from:
  - Integrity protection
  - Obfuscation/anti-debugging
  - Encryption/key management
  - Renewability

Why you will care

Laptop disk encryption

- Common myth: software protection only matters for DRM
- Nope!
  - "Cold Boot Attacks on Encryption Keys", Halderman et al
    - Extract FileVault key from RAM after a reboot
    - Or, freeze RAM with cold spray and move to another computer
- If you use software encryption, you need effective obfuscation
  - Since the key is somewhere in RAM, key hiding vital
  - Exactly same problem as DRM

Exploit protection

- If you want to make exploits difficult, obfuscate
  - Address layout randomization
  - Initial stack configuration
  - Future: compilers will randomize code generation
- Integrity checking
  - Stack canaries
  - Vista PatchGuard (aka Kernel Patch Protection)
- Same measures as DRM

Malware analysis

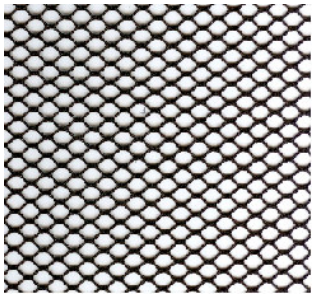
- Malware hides with same techniques as DRM
  - But worse!
- DRM designers have the harder problem
  - "Do no harm"
    - Debuggers must be allowed for legitimate work
    - No persistent modifications
    - Avoid interfering with Vista PatchGuard

- All these areas require knowledge of the same techniques as designing or analyzing DRM

Designing software protection

Software protection design principles

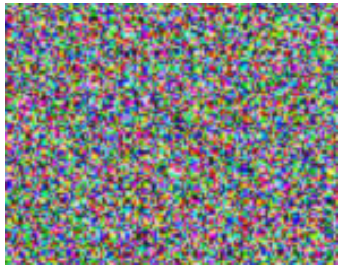
- Mesh vs. chain
  - Protection measures should be mutually enforcing
    - Example: two threads hashing each other
  - A chain is a long series of links
    - Failure of any one link and it falls apart
- Full integration with application functions
  - Protection must be intertwined with main functionality
- Renewability
  - Provide yourself a way to repair hacks



Integrity protection

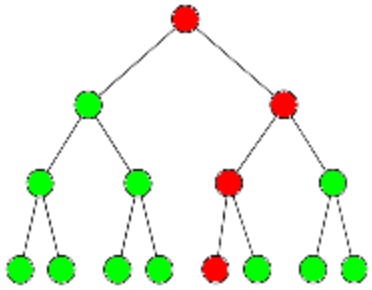
- Goal: respond to modifications
  - Explicit: detect and perform some action
  - Implicit: modifications directly cause change
- Many things can perturb the environment
  - Patching
  - INT3 breakpoints
  - Attaching debugger
- Implicit integrity protection better than explicit
  - Check/response are not separable logic
  - Prevent “divide-and-conquer”

Obfuscation/anti-debugging



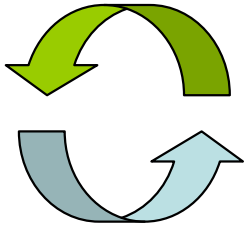
- Goal: make inspection more difficult
  - Obfuscation: logic becomes harder to understand or patch coherently
  - Anti-debugging: respond to the act of inspecting the program
- Better if mixed with integrity protection
  - Example: hash the results of various anti-debugging checks and use as key to decrypt next function
- Most anti-debugging is poorly-implemented
  - Single point checks with if/then logic

Encryption/key management



- Encryption in software protection is a type of obfuscation
  - Cipher+key in some form present in memory
- Key management
  - Broadcast encryption
    - Encrypt content key with lots of keys
    - Stop doing this for known-hacked keys
  - Software protection can make this more versatile
    - “You must be at least this unhacked to decrypt the video”

Renewability



- Every scheme needs a survival plan
- Online updates
  - Common in a PC environment
  - Caveats: version roll-back, privacy
- Piggy-backing on content
  - Better in embedded/cross-platform environments
  - Caveat: heterogeneity complicates testing
  - Examples
    - DTV/Dish send updates in channel stream (“ECMs”)
    - BD+ puts protection logic on each Blu-ray disc

Tools & techniques

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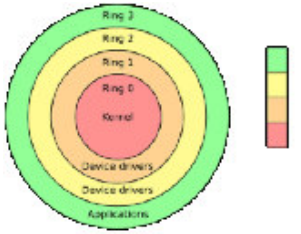
Historical reverser's toolbag

- In the past
  - debug.exe
  - SoftICE with iceext
  - IDA Pro doing static disassembly
  - Hex editor

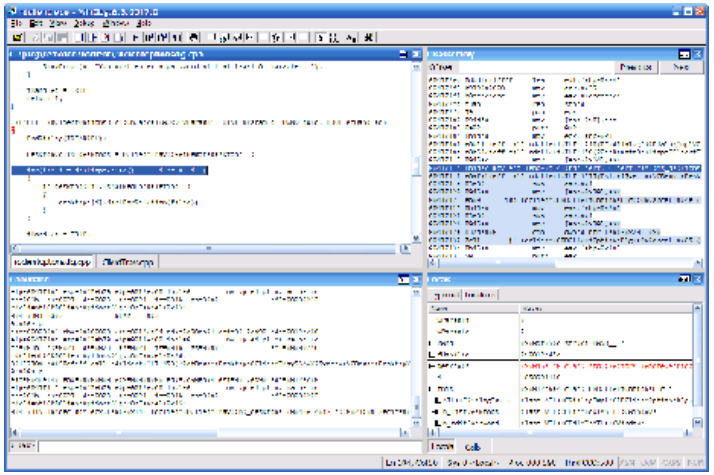
- Today
  - IDA, Ollydbg
  - Bindiff, binnavi
  - Paimei
  - Custom tools

Tip: go to ring 0



- Even if you're attacking a user-mode app, kernel access gives a powerful viewpoint
  - Full access to thread state
  - No modification of process memory (i.e., int3 instruction)
  - Access to page protection, MSRs, etc. allow stealth schemes
- More advanced
  - Patch bochs/qemu
  - Write your own hypervisor debug stub

WinDbg is awesome



- Powerful tool for reversing
  - Kernel and usermode access
  - Automatic symbol server
  - x86 32 and 64-bit support
  - Extensions for common tasks (“!peb”)
  - Open plug-in interface
  - Free
- Downsides
  - No third-party CPU extensions (sorry ARM)
- Let’s make it the next SoftICE

Tip: use debug registers creatively

- Intel processors have hardware breakpoints
  - DR0-3: addresses to be monitored
  - DR6: status bits that describe which event occurred
  - DR7: configures the type of event to monitor for each address
- Interesting side effects
  - DR4-5 are aliases for DR6-7 if the CR4.DE bit is clear
  - DR7.GD bit causes reads or writes to any of the debug registers to generate an INT1
    - Legacy behavior from ICE days

Update on recent hacks

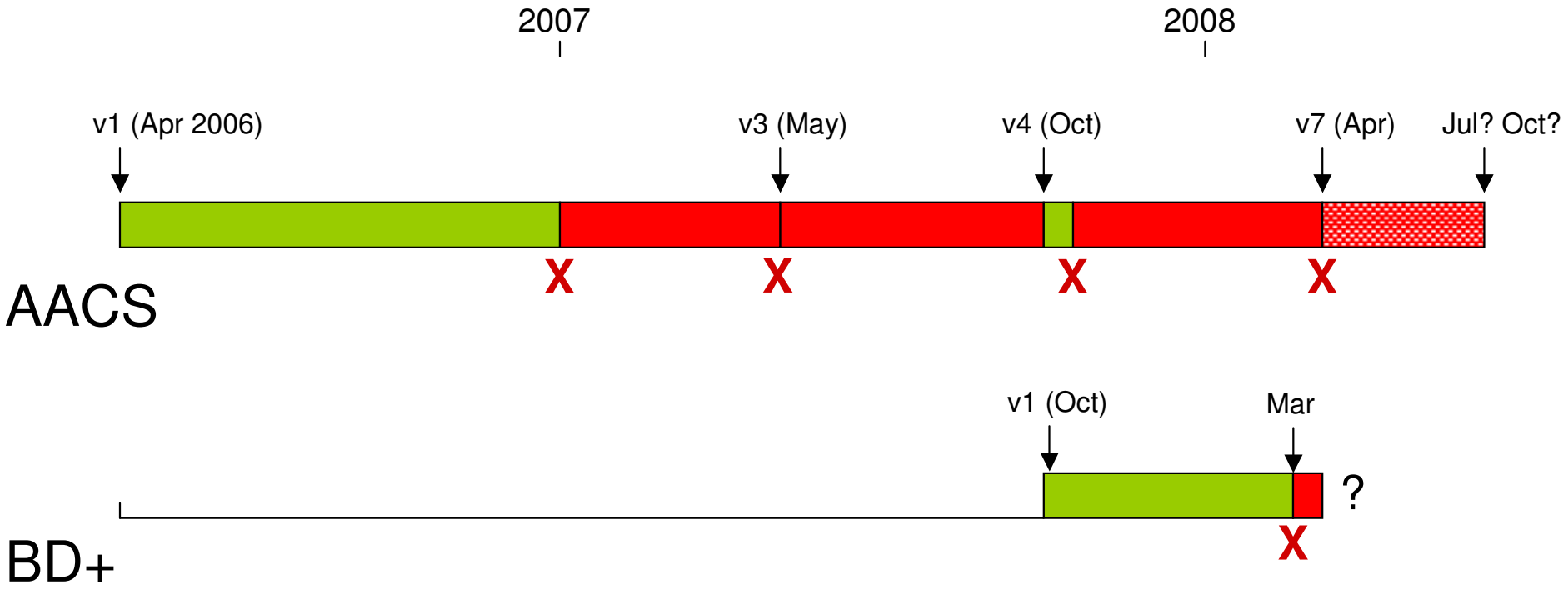
Recent hacks this year

- Nintendo Wii
  - Loader compromised (tmbinc; Dec)
  - Software save game hack (bushing, segher, tmbinc; Feb)
- Windows Media DRM
  - drmdbg decrypts keys and is staying current with updates (Jan)
- iTunes
  - requiem decrypter released, removed via C&D (Feb)
  - Tools that rip audio samples from memory still exist (QTFairUse6, myFairTunes7)
- iPhone
  - Bootloader software compromise (iPhone Dev Team; March)

AACS vs. BD+

- Both allow updates to security
  - AACS: new MKBs and player keys
  - BD+: new software on discs
- Effectiveness metrics
  - How long each update survives before being hacked (L)
  - How frequently the updates appear (T)
    - If L < T, you are releasing new discs into an already-hacked environment!
- Goal: increase L, decrease T

Timeline of hacks



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AACS analysis

- Not doing so hot
  - Very low L (length of time update is unbroken)
    - -2 … +2 weeks if you throw out the initial period
  - Long T (time between updates)
    - < 3 months not allowed by business agreements
    - Up to 18 months if hacked player not identified
    - Appears to be steady now at every 6 months
- Game over or …?
  - Unmasking the Slysoft oracle
  - Sequence keys

BD+ analysis

- Too early to tell
- Flexible L
  - Software protection can be a small or large barrier, depending on effort invested
- Potentially lower T
  - Update schedule in hands of disc authors
    - Potentially less parties to coordinate with for updates
    - Just test and ship a disc
- 2008 will be an exciting year!

Questions?

For more on software protection, check out my blog “rdist” at:

rootlabs.com

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