Operating Systems
Security

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Introductions
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Used to hack stuff—now build things and security research
Security
Our Definition of Security

• Engineer and build systems to prevent attackers from doing things we don’t want them to do
Why should anyone care?

The weapon's target was Ukraine. But its blast radius was the entire world. “It was the equivalent of using a nuclear bomb to achieve a small tactical victory,” Bossert says.

The release of NotPetya was an act of cyberwar by almost any definition—one that was likely more explosive than even its creators intended. Within hours of its first appearance, the worm raced beyond Ukraine and out to countless machines around the world, from hospitals in Pennsylvania to a chocolate factory in Tasmania. It crippled multinational companies including Maersk, pharmaceutical construction company Reckitt Benckis costs. It even spread back to Rosneft.

“The result was more than $10 billion in total damages…

Google uncovers 2-year iPhone hack that was ‘sustained’ and ‘indiscriminate’

The attack may be one of the largest ever on iPhone users, exposing messages, address books, GPS data and more.
Attacker Lifecycle
Attacker Lifecycle

Initial Access
- Delivery
- Exploitation
- Code Execution

Persistence

Access to Data or Systems
- Application Access
- IT Asset Access
- Malware
- Command and Control

Lateral Movement
- Exploitation
- Credential Theft and Reuse

Actions on Target
- Local Enumeration
- Privilege Escalation
- Environment Enumeration
- Data Theft
What can we do to disrupt the attacker lifecycle?

- Prevent attackers from exploiting systems
- Prevent malicious code from executing
- Ensuring that attackers do not have full (administrative / root) access to compromised assets
- Prevent attackers from moving from one asset to another
What does this mean for OS Security?

• Can we prevent software vulnerabilities?
  • We can try, but ultimately, no
• Can we prevent users from clicking on things
  • We can try, but ultimately, no
• Can we design systems that are resilient to exploitation?
  • Yes, absolutely
• Can we try to keep users and admins separate?
  • Yes, absolutely
Operating Systems Security
Core OS Security Goals

1. Build and enforce security boundaries
2. Keep secrets secret (passwords, cryptographic keys, etc.)

• “CIA Triad”
  • Confidentiality
  • Integrity
  • Accessibility
Security Boundaries
What’s a Security Boundary?

• A Security Boundary is a by-design feature that will be serviced by the OS maintainer / vendor to protect the C/I/A of the Operating System

• Not all things that sound like security boundaries are security boundaries
  • “Secure Boot”
  • “AppLocker”
  • “User Account Control (UAC)”

User Mode vs. Kernel Mode

Let’s look at Windows
What does this look like in the real world?
Root vs. User

- Who watches the watcher?
- Kernel enforces permissions and access
- Kernel controls direct hardware access
- Boundary between root / kernel / admin
- Elevation of Privilege attacks
Impact of Security Boundaries in Modern Environments

Provide Security:
• Operating System Protections
  • Admin Access
• Virtual Machines
  • Resource Isolation

Do NOT Provide Security:
• Containers
  • Do not isolate resources
• Docker, Kubernetes, etc.
• Admin vs. Kernel
  • Not a security boundary in the real world
Challenges in OS Security
Core Challenges in OS Security

- Performance tradeoffs
- Sandboxing (how do we share system resources / control access to system APIs)
- Secrecy vs. Simplicity
- Wrangling users to make good choices
Performance Tradeoffs

How bad design decisions created the least secure driver on Windows

Thomas Garnier  Follow  Aug 21, 2016 · 5 min read

This driver is called win32k, it manages the user interface of Windows. This post will discuss the multiple bad ideas that are part of this driver.

How bad is it?

It is hard to get a bug count estimate. Each page unique and it can be hard to infer affected modi patch and look at the files, when the links still v

Designed with trust in mind

In Windows NT 3.5, the UI was managed by a user-mode module in the CSRSS system process. The original design was overhauled in Windows NT 4 due to bad performance. The win32k driver was created almost as an extension of its user-mode counterpart with an obvious trust between the two of them. This new design was much faster and flexible though hard to make reliable and secure.
Sandboxing

• Maybe we can just have a gatekeeper for all of the resources?
• Can be effective as a mitigation but not as a true prevention measure (Google Chrome)
• Isolation-based approaches like a VM are generally more secure
Secrecy vs. Simplicity

- In general security is good
- Some security can add unnecessary complexity
User Wrangling

• We can make things secure by default...
• ... up to a point

What is Protected View?

Files from the Internet and from other potentially unsafe locations can contain viruses, worms, or other kinds of malware that can harm your computer. To help protect your computer, files from these potentially unsafe locations are opened as read only or in Protected View. By using Protected View, you can read a file and see its contents and enable editing while reducing the risks.

NEWS
Email attacks exploit unpatched Microsoft Word vulnerability
Attackers have been exploiting a zero-day vulnerability in Microsoft Word since January to infect computers with malware
Quick Primer on Exploitation
Smashing the stack for fun and profit

- Life was great in 1996
- Phrack magazine issue 49

"smash the stack" [C programming] n. On many C implementations it is possible to corrupt the execution stack by writing past the end of an array declared auto in a routine. Code that does this is said to smash the stack, and can cause return from the routine to jump to a random address. This can produce some of the most insidious data-dependent bugs known to mankind. Variants include trash the stack, scribble the stack, mangle the stack; the term mung the stack is not used, as this is never done intentionally. See spam; see also alias bug, fandango on core, memory leak, precedence lossage, overrun screw.

Introduction
Smashing the stack for fun and profit

void vulnerable() {
    char buffer[100]; // read string from stdin
    scanf("%s", buffer);
    do_something_with(buffer);
}
Memory Corruption

- Things are fun when you overwrite the buffer
- Real fun starts when the function returns

**Stack-Based Buffer Overflows**

EXHIBIT 10.2 A normal stack and a stack with a buffer overflow.
Case Study 1
OS Mitigations
OS Mitigations

- [link](https://msrc-blog.microsoft.com/2010/12/08/onth-effectiveness-of-dep-and-aslr/)
- DEP and ASLR
  - Prevent any code in memory from being executable
  - Prevent attackers from knowing where things are in memory
LDRHotPatchRoutine

- **MS13-063**
  - SharedUserData ... exist(ed) at a fixed location in every user process
  - LDRHotPatchRoutine... loads a DLL that’s passed as a parameter
  - Enabled VUPEN to easily weaponized exploits

```c
0:000 > dde 7ffe0340 Lc
00000000 7ffe0340 77029ce9 ntdll!LdrInitializeThunk
00000000 7ffe0344 77800100 ntdll!KiUserExceptionDispatcher
00000000 7ffe0348 77800028 ntdll!KiUserApcDispatcher
00000000 7ffe034c 778000b8 ntdll!KiUserCallbackDispatcher
00000000 7ffe0350 7781f8d4 ntdll!LdrHotPatchRoutine
00000000 7ffe0354 77822551 ntdll!ExpInterlockedPopEntrySListFault
00000000 7ffe0358 7782251b ntdll!ExpInterlockedPopEntrySListResume
00000000 7ffe035c 77822553 ntdll!ExpInterlockedPopEntrySListEnd
00000000 7ffe0360 77800190 ntdll!RtlUserThreadStart
00000000 7ffe0364 77892cfd ntdll!RtlQueryProcessDebugInformationRemote
00000000 7ffe0368 778517d9 ntdll!KvpNotificationThread
00000000 7ffe036c 777f0000 ntdll!CsrServerApcRoutine
```
Case Study 2

Extreme iOS 0days
iOS Vulnerabilities

• What’s the impact?
• What was the root cause?
• Were mitigations successful? Why Not?
iOS Vulnerabilities

• What's the impact?
  • Nation-state surveillance of an entire population
• What was the root cause?
  • Lots of sandbox issues
  • Graphics parsing
  • Heap allocation
  • Unused code (task_swap_mach_voucher)
  • JIT / JSC bypass
• Were mitigations successful? Why Not?
  • Kind of?
  • We see from this that some exploits didn’t need byasses but some did so ¯\_(ツ)_/¯
Q and A
Where to learn / do more with security

- Reverse Engineering
  - CrackMes
- Finding Vulnerabilities
  - Bug Bounties
- Competing / having fun with CTFs
  - “Intro to CTFs”

- My contact info
  - @weplV
Thank You