VMRAY

The beast within – Evading dynamic malware analysis using Microsoft COM

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Outline

- Introduction
  - Dynamic Malware Analysis
  - Microsoft COM & Malware
- Case Studies
  - Self-crafted COM tests
  - Analyzed with various sandboxes
- Dynamic Analysis of COM Malware
  - How do sandboxes work and why is there a problem
- Alternative Approach

Dynamic Malware Analysis

The Problem

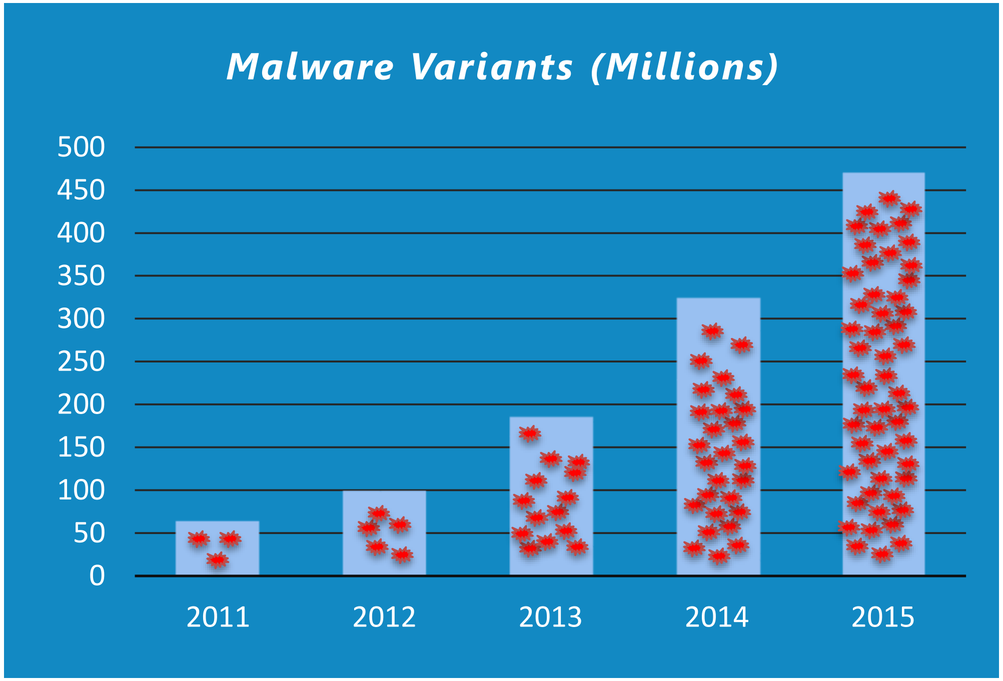
Cyber Threat Trends

Exponential Volume Growth

- 2015: >450K new variants / day
- 2015: >150M total

Increasing Complexity

- More evasive malware
- Targeted attacks
- Advanced persistent threats (APT)

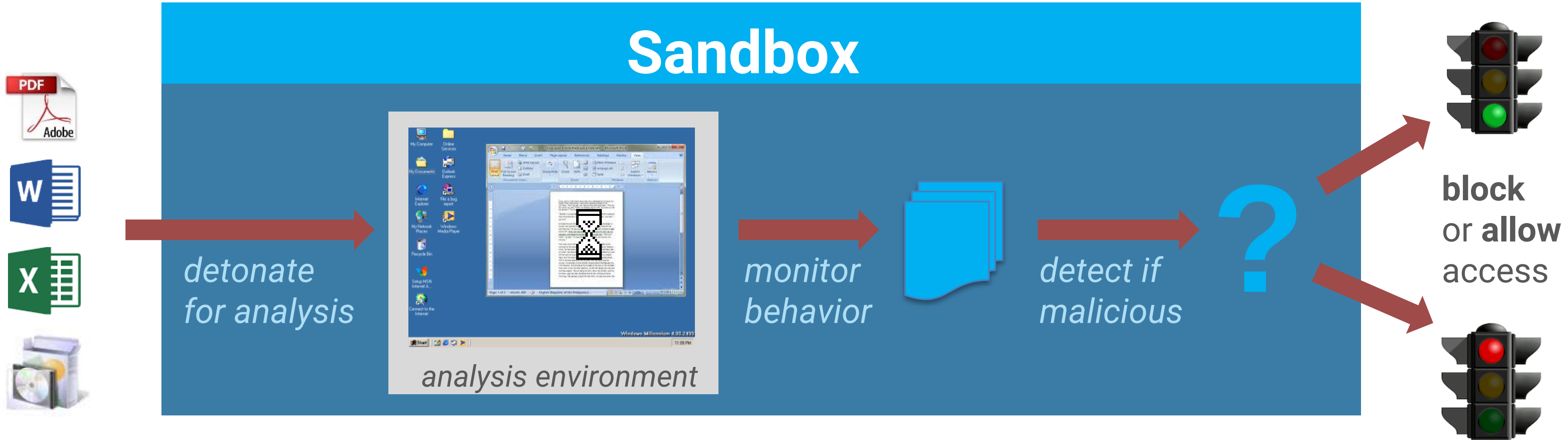


https://www.av-test.org/de/statistiken/malware

Signature based approaches have shortcomings given quantity and quality of today's malware.

Dynamic malware analysis is widely accepted solution to cope with this problem.

Comprehensive Threat Detection with Sandboxing



Sandbox

detonate for analysis

analysis environment

monitor behavior

detect if malicious

?

block or **allow** access

Unknown files and URLs (e.g. Word, PDF, Installer)
from arbitrary sources (e.g. Webbrowsing, Email, Download, USB device)

Microsoft COM

Microsoft Component Object Model (COM)

- Binary interface standard for software components
- Standard Win32 API provides procedural „C“ interface
  - Maybe use C++?
  - C++ poses many problems with binary interface
- COM is the solution
  - Provides binary standard C++ lacks
  - Language neutral: Can be used in C++, VB, C#, etc.
- COM objects provide interfaces and methods
  - Example: IWebBrowser2::Navigate

COM Today

- Still used in many current technologies
  - DirectX
  - Windows Scripting Host (VBScript, JScript, VBA)
  - Microsoft Office
  - PowerShell
  - .NET / WinRT

- Popular interfaces for malware are:
  - Internet Explorer: Download files in background
  - Shell Link: Create, delete, modify, etc. files
  - WBEM (WMI): Query for installed AV products, etc.
  - Firewall Manager: Create firewall exceptions
  - Task Scheduler: Create new Windows tasks

COM Malware Statistics

- Some statistics from internal sharing programs:
  - ~20 % of all samples use COM interface
  - Mix of executables, MS Office files, etc.
    - Executables ~10 %
    - MS Office files ~90 %

- Tons of COM interfaces exist in Windows
  - Create files
  - Access the registry
  - Download data from remote server
  - …

Case Studies

Case Studies Motivation

- Let‘s see how well sandboxes *perform* with COM samples…

- *5* different self-crafted test programs

- Inspired by *typical* malware behavior
  - Persistence
  - C&C communication
  - Evasion
  - …

COM Test Programs

1. *Autostart*
   - Create autostart entry using *CLSID_ShellLink* interface

2. *Browser*
   - Receives C&C commands using *CLSID_InternetExplorer* interface

3. *Firewall*
   - Disables Windows Firewall using *CLSID_NetFwPolicy2* interface

4. *Filesystem*
   - Copy file to Windows folder using *CLSID_FileOperation* interface

5. *New Process*
   - Create new process using *CLSID_WbemLocator* interface (WMI)

Case Study Results

- Submitted all of these tests to four different sandboxes
  - Open source sandbox
  - Public version of a commercial sandbox
  - Two non-public commercial sandboxes

Detection results

worst case

	#1 Autostart	#2 Browser	#3 Firewall	#4 Filesystem	#5 New Process
SB #1	✗	✗	✗	✗	✗
SB #2	✓	!	✗	✗	✗
SB #3	✓	!	✗	!	✗
SB #4	✓	!	✓	✓	✓

Observation: Noise

- Sandboxes that detect *something* also log a *noise*

- SB #2
  - Wrong IOCs (host names, files, etc.)

- SB #3
  - False alerts: Anti-reverse engineering, suspicious imports, …

- SB #4
  - Report contains 136 events (files, process, hosts, etc.)
  - 32 are *actually* test behavior ➔ almost *80%* is noise
  - „Opens TCP port“, „code injection“, „tampers with explorer“, …

Dynamic Analysis of COM Malware

Excursion: Classic Sandbox Classification

- Approach #1: **Hooking** based
  - Install hooks at various memory locations
  - Quite fast, close to native performance
  - Can be detected/evaded

- Approach #2: **Emulation** based
  - Executes malware in full system emulator
  - Can theoretically see every machine instruction executed
  - Very slow (a lot of overhead only for CPU emulation)

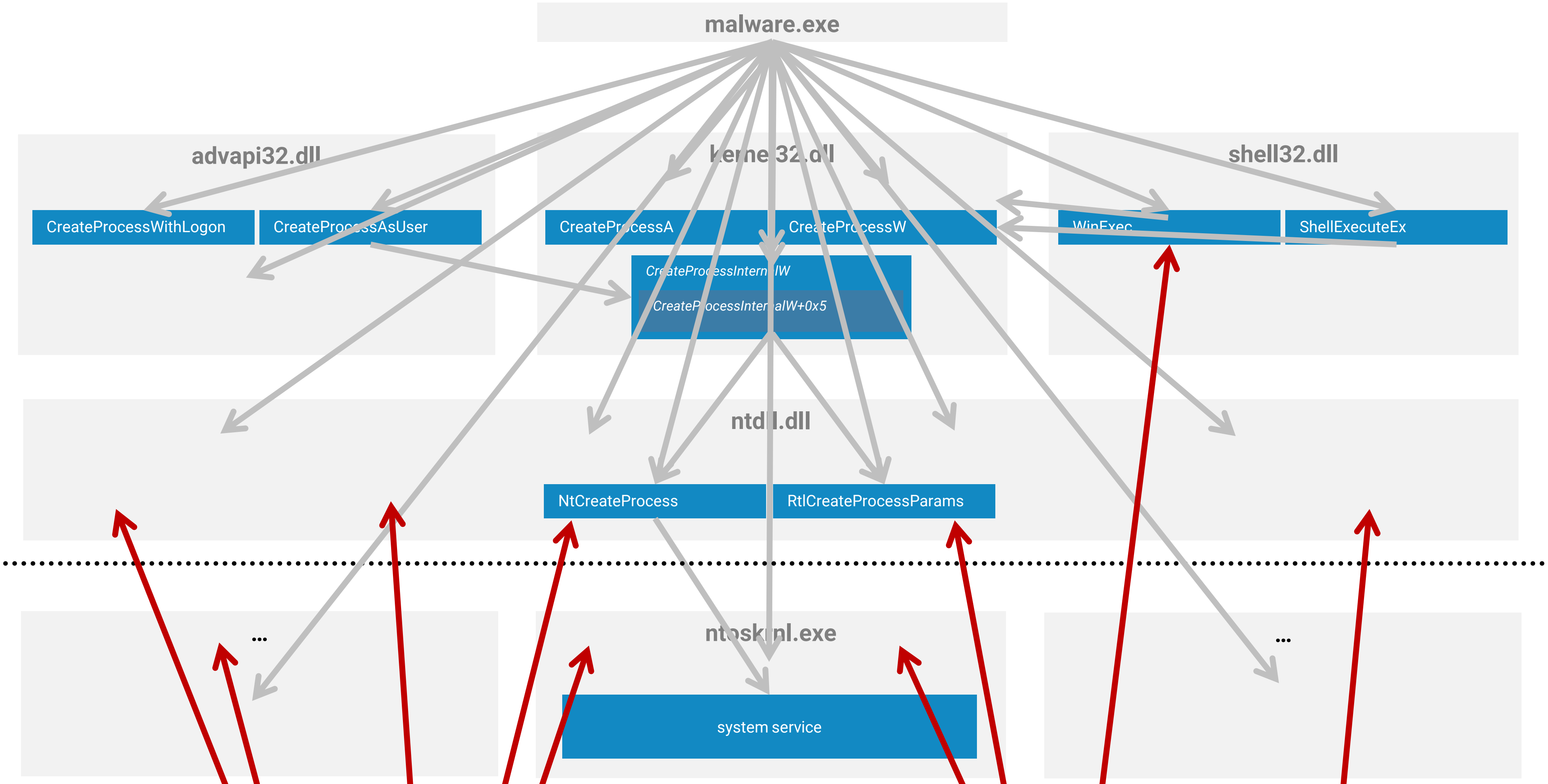
- Approach #3: **Transition** based
  - See later …

Design Goals

1. ***No evasion***: All behavior must be reported
2. ***No noise***: Reports must not be inflated with noise
3. ***Stealthiness***: Do not leave (a big) footprint in the system
4. ***Stability***: Do not crash due to buggy hooks
5. ***Performance***: Do not slow down the system too much

Goals 3, 4 & 5 can only be achieved by *limiting* the amount of hooks

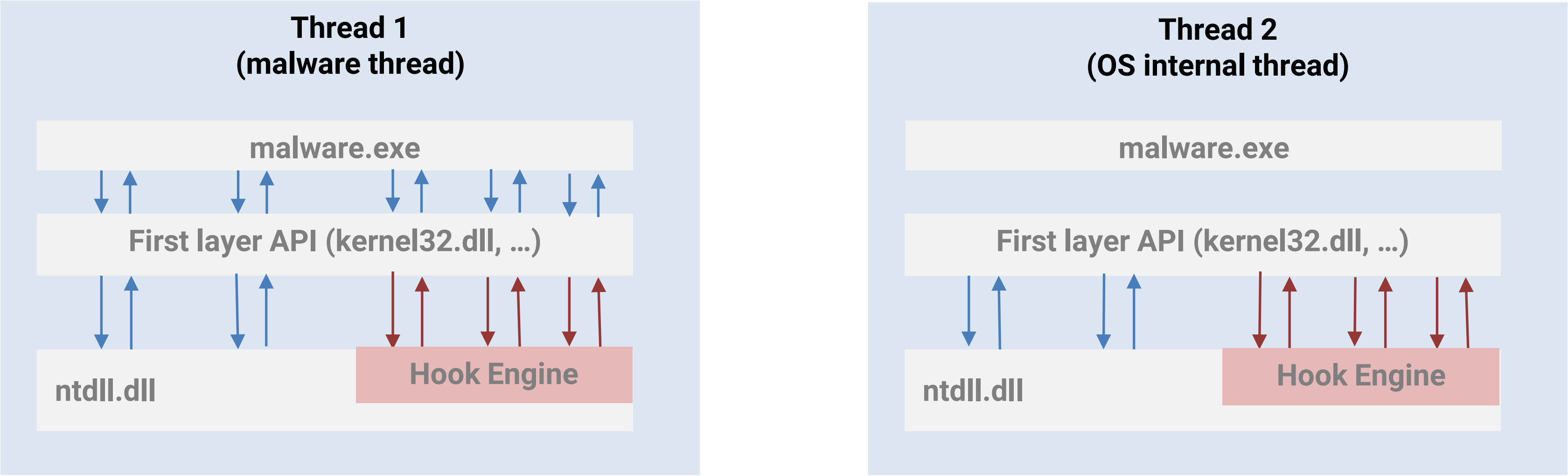
Challenge #1: Where to Place Hooks?



Hooks are implemented here

Challenge #2: Handling Noise

- Must *filter* out irrelevant hooked calls
- OS and apps generate *unrelated* calls as *side-effect*



Thread 1
(malware thread)

malware.exe

First layer API (kernel32.dll, …)

ntdll.dll

Hook Engine

Thread 2
(OS internal thread)

malware.exe

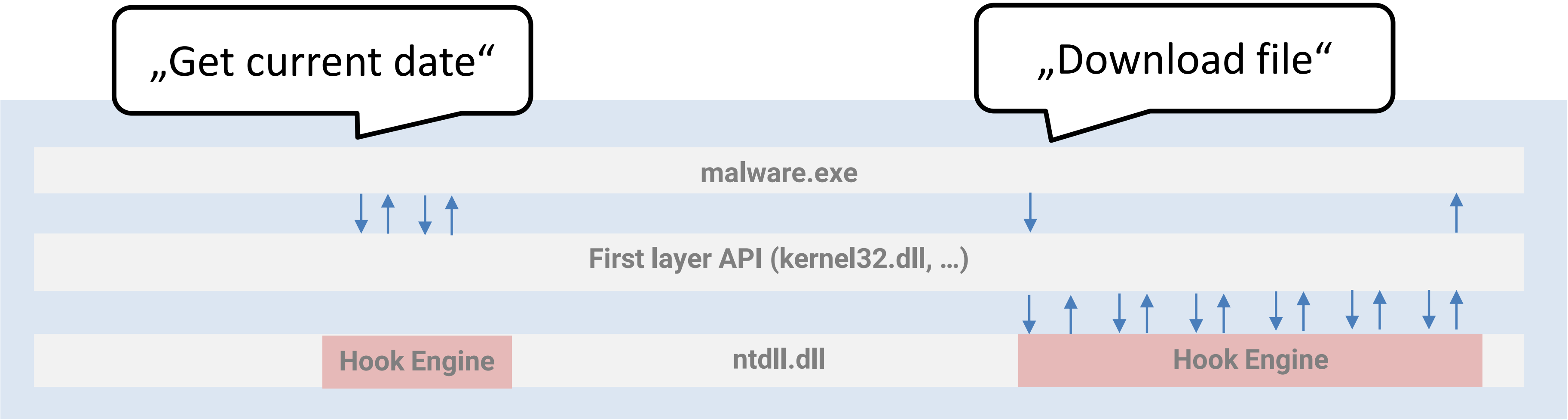
First layer API (kernel32.dll, …)

ntdll.dll

Hook Engine

- Is hooked call *relevant* or not?
- Image you hook inside Internet Explorer, MS Word, ...
- Not easy to solve …

Challenge #3: Limited Visibility

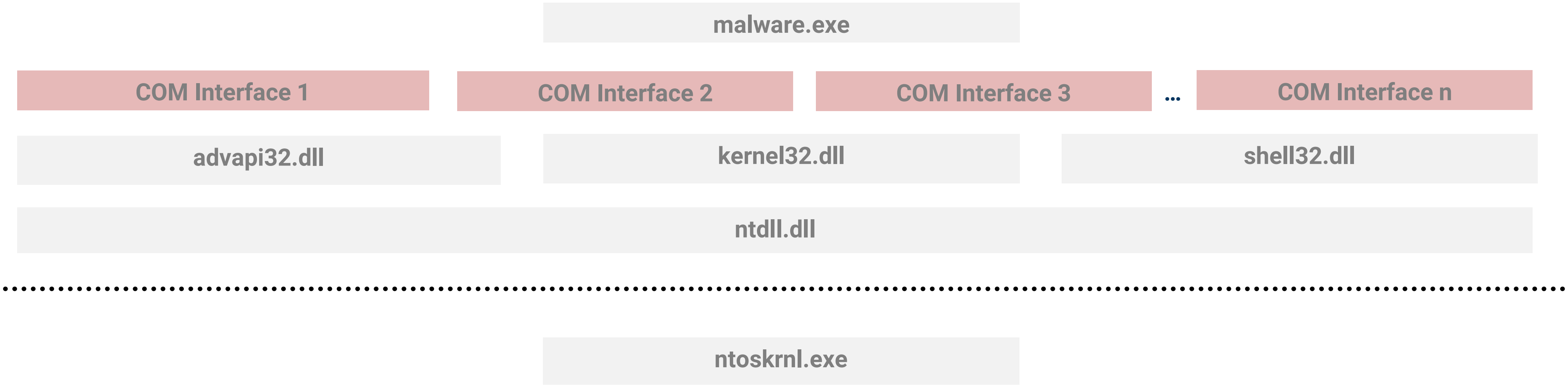


**See too little:
Calls do not end in NTDLL**

**See too much
(avalanche effect)**

COM Issue #1: Additional API Layer

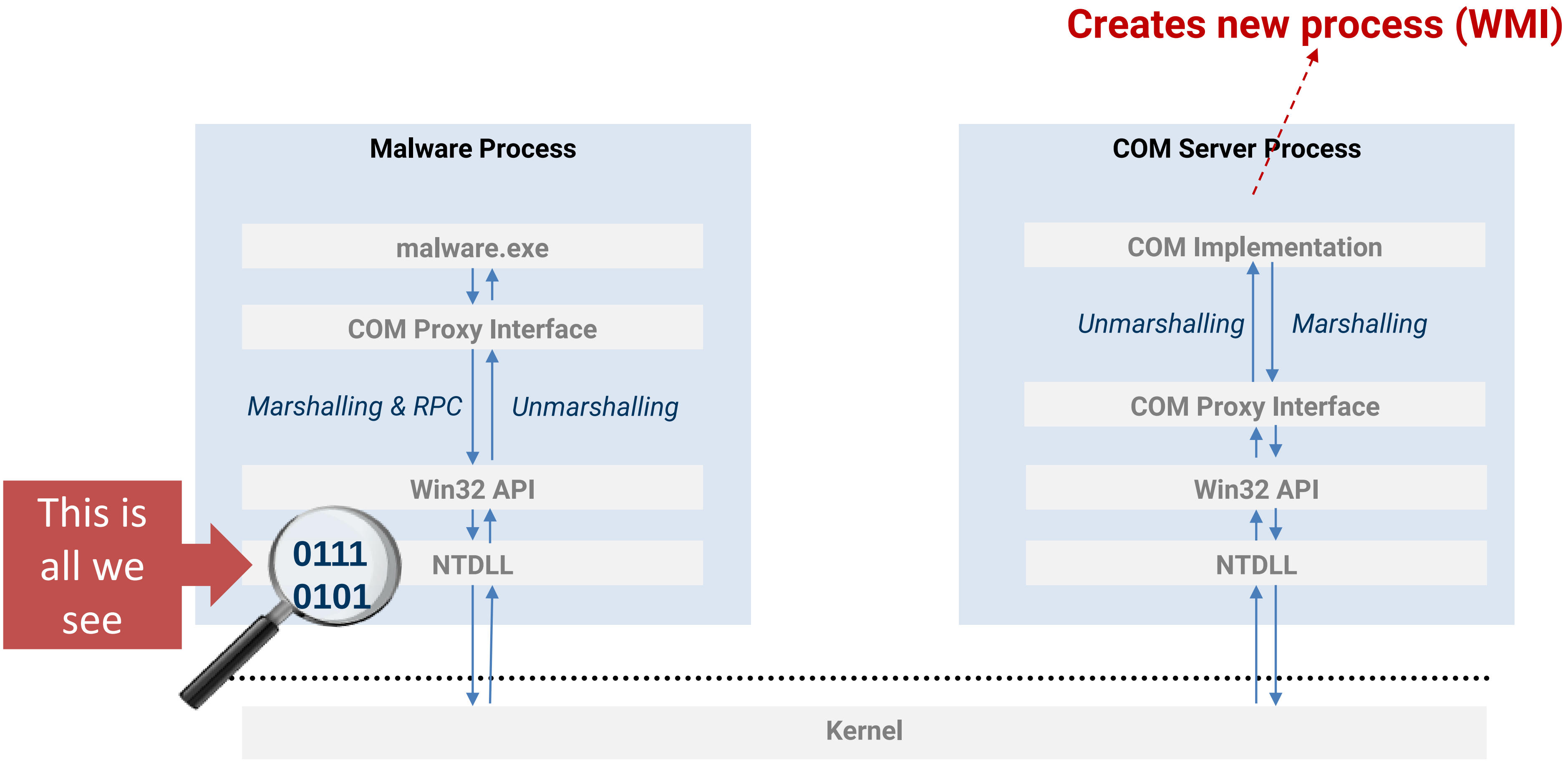
COM provides yet another (inflated) API layer



1. Must filter out even *more* noise
2. Even *more* calls go unnoticed
3. Avalanche effect even *worse*

COM Issue #2: RPC

- COM supports *remote procedure calls* (RPC)
- Method calls are executed in another process



RPC Madness

- Only *marshalled* data seen at NTDLL layer
  - Which *method* is executed?
  - What are the *parameters*?

- Interpretation needs *internal* knowledge of COM runtime
  - Mostly *non-documented* information
  - Lots of *reversing* necessary
  - Microsoft is free to adjust and/or change runtime at any time

- Let‘s just monitor *COM server processes* then
  - How to *filter* out COM server process noise?
  - How to *filter* out COM calls from irrelevant processes?

Summary

- Don‘t want sandbox to be *evaded* with one COM call

- Don‘t want sandbox which cannot be evaded but contains tons of *noise*

- Remember noise in SB #4?
  - „Opens TCP port“ ➔ This is the Internet Explorer COM process
  - „Code injection“➔ This is COM runtime doing RPC
  - „Tampers explorer“➔ This is the *CLSID_FileOperation* interface

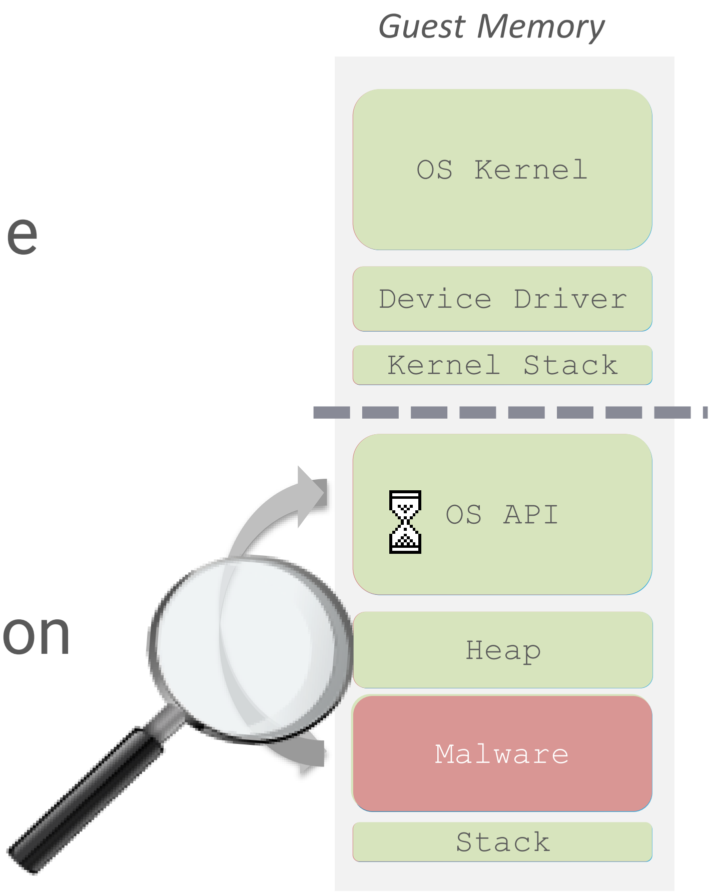
Alternative Approach

Intermodular Transition Monitoring (ITM)

1. Use VT MMU to partition memory
   - Current module: X executable
   - Remaining memory: NX non-executable

2. Run malware in VM
   - With bare metal performance
   - Interrupts only on intermodular transition

3. Monitor is automatically invoked
   - Read guest memory
   - Readjust partitioning
   - Continue execution
   - Until return to calling malware



IWebBrowser2:Navigate (
url=„https://www.vmray.com“,
Flags=0x123,
TargetFrameName=„_blank“,
PostData=NULL,
Headers=„…“)

Challenges

- Need to parse a lot of information
  - Interface and method names
  - Parameters: Integers, strings, variants, byref, byvalue, …

- „Dynamic“ binding of COM interfaces
  - Many different variations exist (*QueryInterface*, *Invoke*, …)

- Need to understand what each COM method does

- Lots of work but at least it‘s public and documented!

Summary

ITM fixes all disadvantages mentioned previously:

1. No noise filtering necessary
2. No missing first layer calls
3. No avalanche effect
4. No need for special handling of RPCs

Thank you for your attention!

Happy to answer any questions!