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**The beast within –  
Evading dynamic malware analysis using  
Microsoft COM**

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- 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



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# Dynamic Malware Analysis



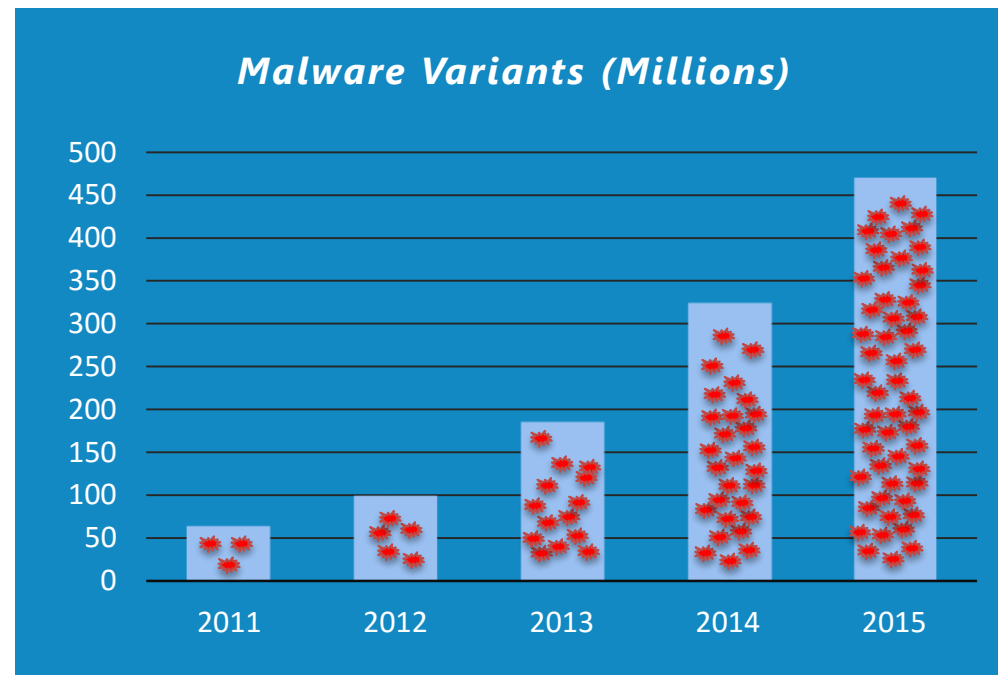
## Cyber Threat Trends

### Exponential Volume Growth

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

### Increasing Complexity

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



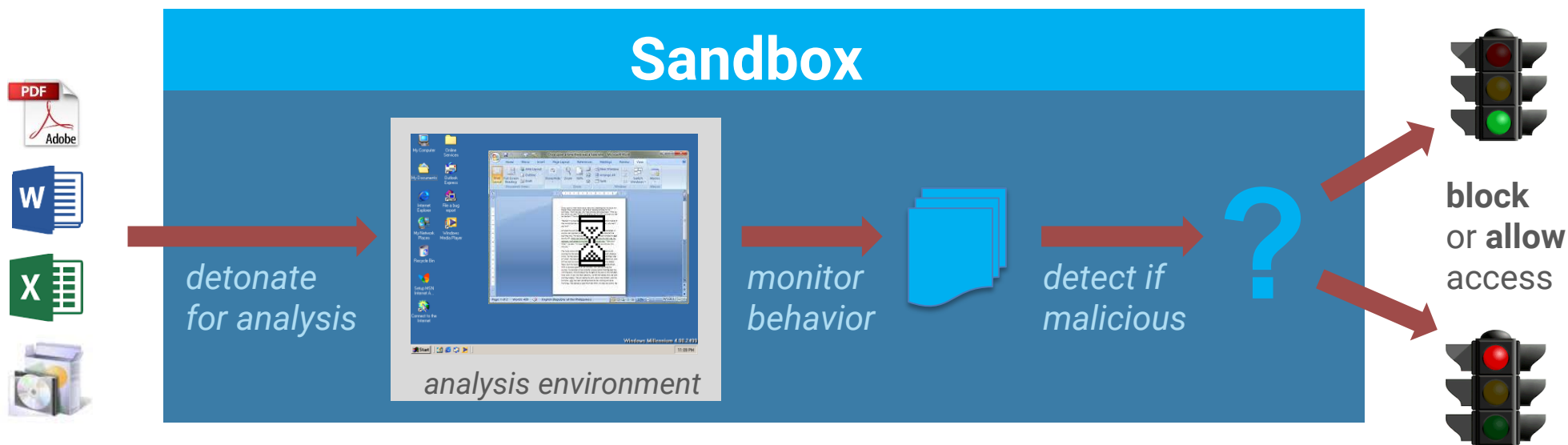
<https://www.av-test.org/de/statistiken/malware>

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



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



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# Microsoft 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

- 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





- 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
  - ...



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# Case Studies

- 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
  - ...

## 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)

- 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	x	x	x	x	x
SB #2	✓	!	x	x	x
SB #3	✓	!	x	!	x
SB #4	✓	!	✓	✓	✓

- 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“, ...



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# Dynamic Analysis of COM Malware

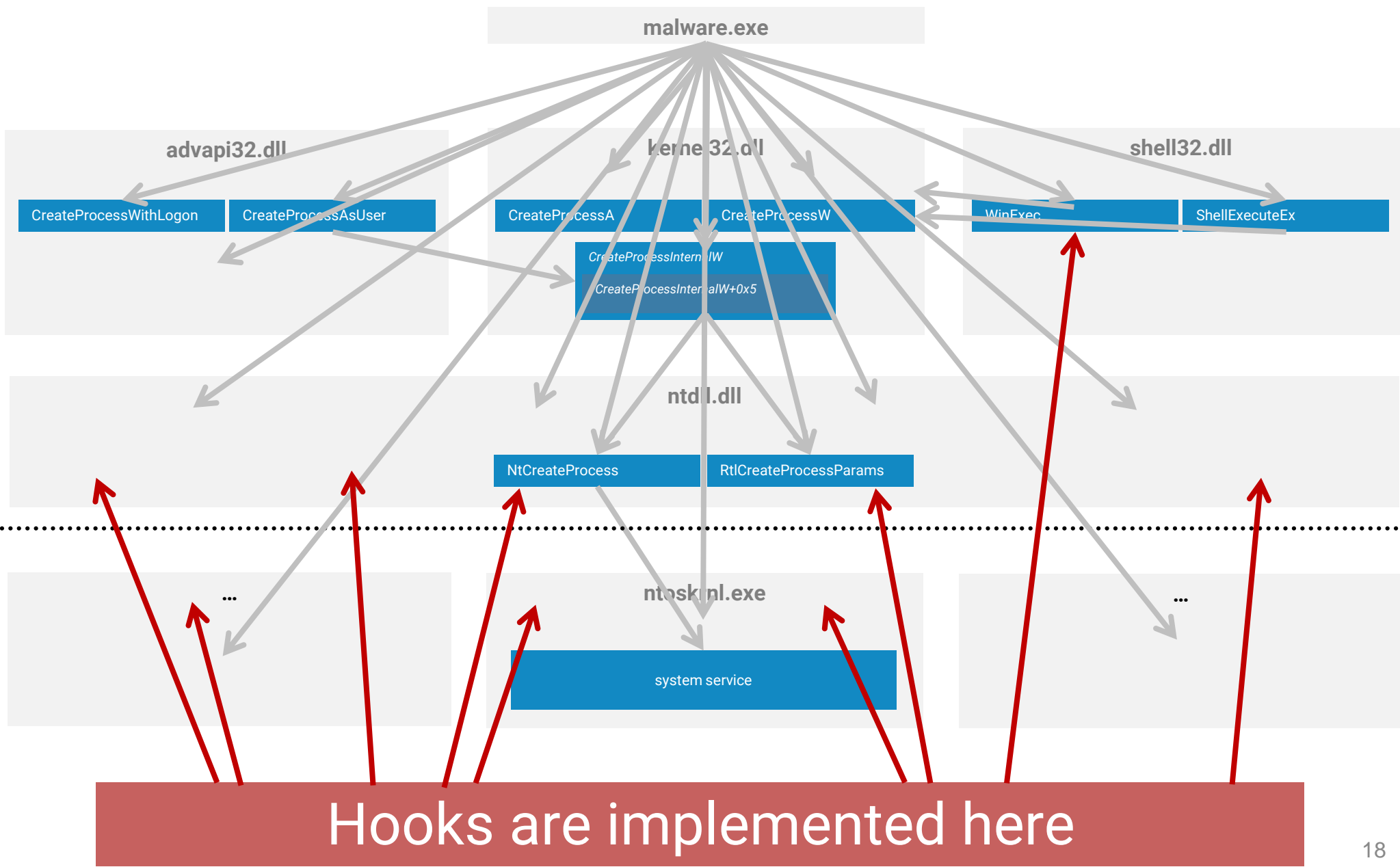
- Approach #1: **Hooking** based
  - Install hooks at various memory locations
  - Quite fast, close to native performance
  - Can be detected/evaded
- Approach #2: **Emulation** based
  - Executes malware in full system emulator
  - Can theoretically see every machine instruction executed
  - Very slow (a lot of overhead only for CPU emulation)
- Approach #3: **Transition** based
  - See later ...



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

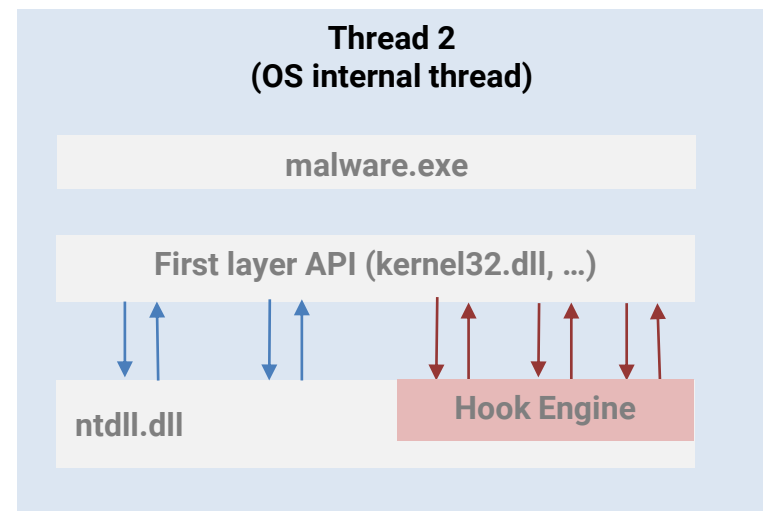
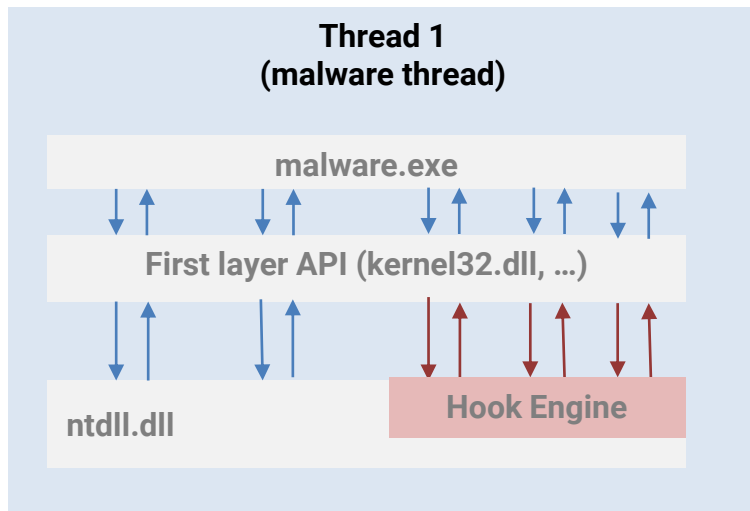
Goals 3, 4 & 5 can only be achieved by *limiting* the amount of hooks

# Challenge #1: Where to Place Hooks?

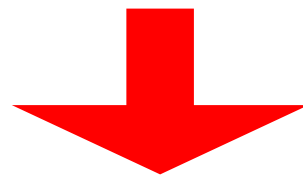
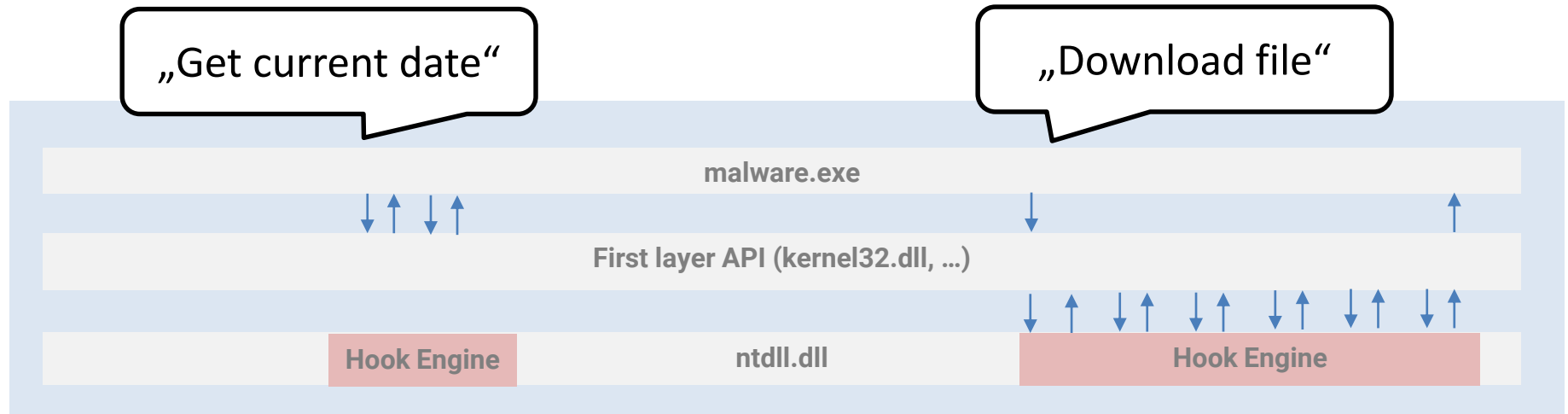


# Challenge #2: Handling Noise

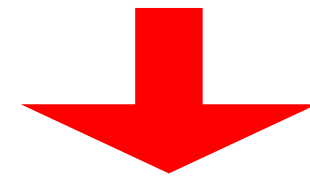
- Must *filter* out irrelevant hooked calls
- OS and apps generate *unrelated* calls as *side-effect*



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

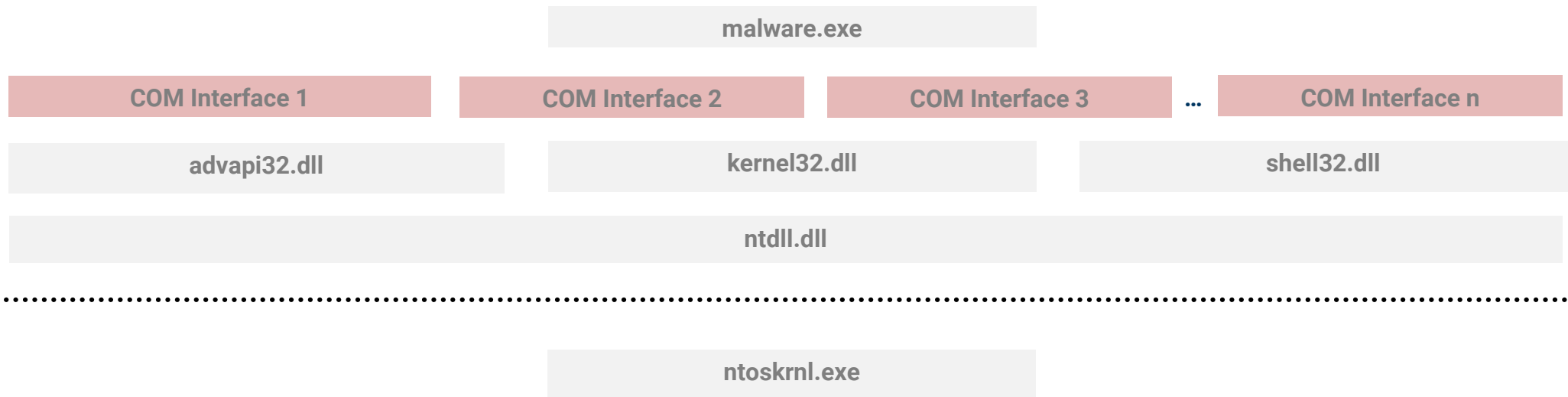


**See too little:  
Calls do not end in  
NTDLL**



**See too much  
(avalanche effect)**

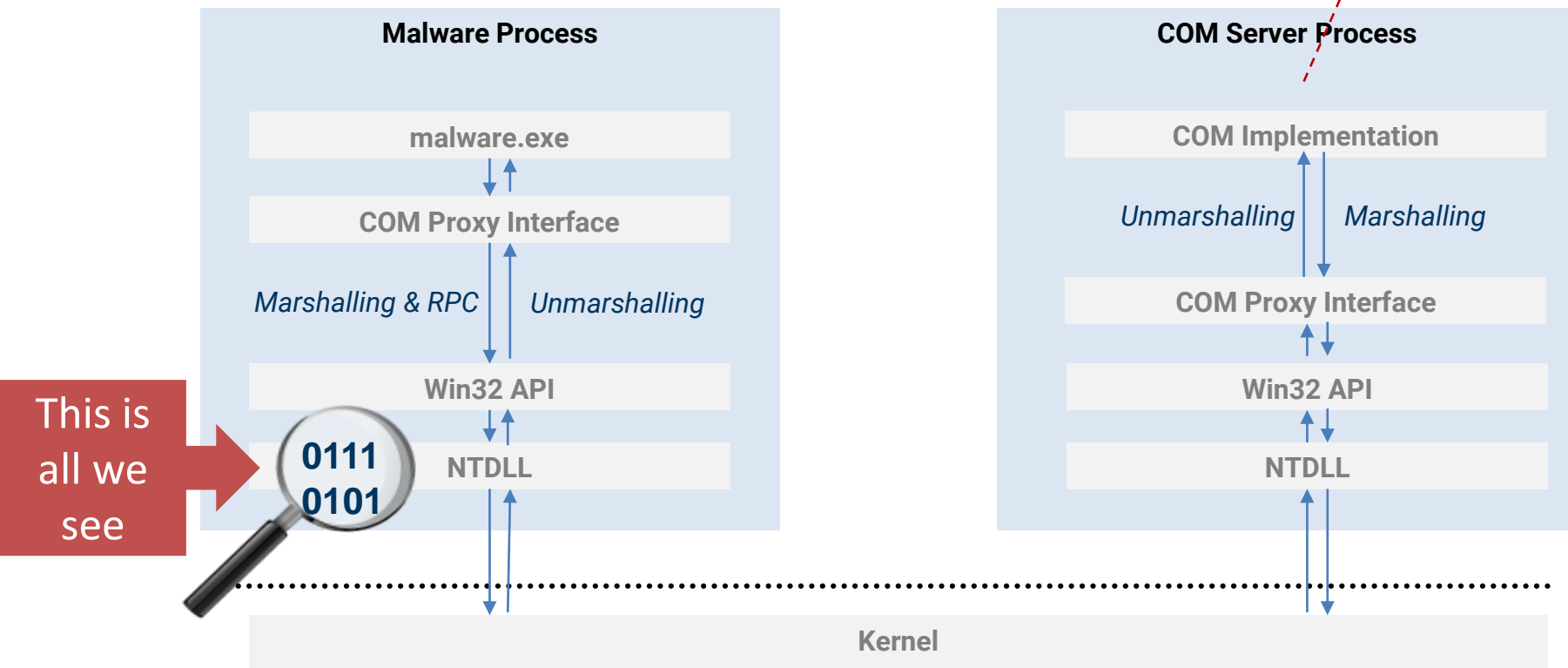
COM provides yet another (inflated) API layer



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

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

**Creates new process (WMI)**



- 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?

- 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

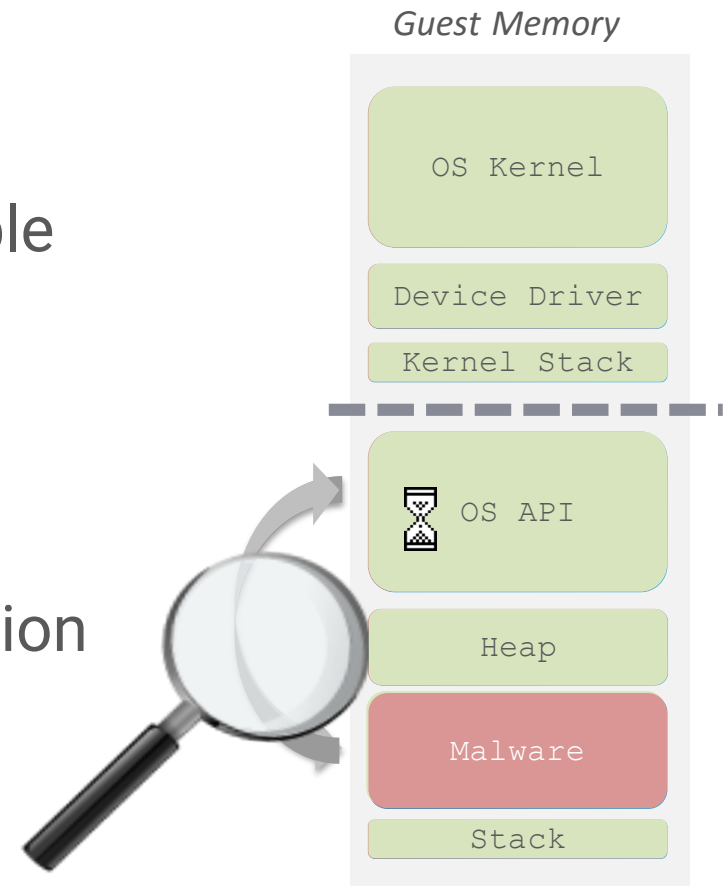




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# Alternative Approach

1. Use VT MMU to partition memory
  - Current module: X executable
  - Remaining memory: N  
X 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.vmrays.com“,
  Flags=0x123,
  TargetFrameName=„_blank“,
  PostData=NULL,
  Headers=„...“)
```

- 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!

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



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**Thank you for your attention!**

**Happy to answer any questions!**