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An Introduction to Virtual Machine Introspection

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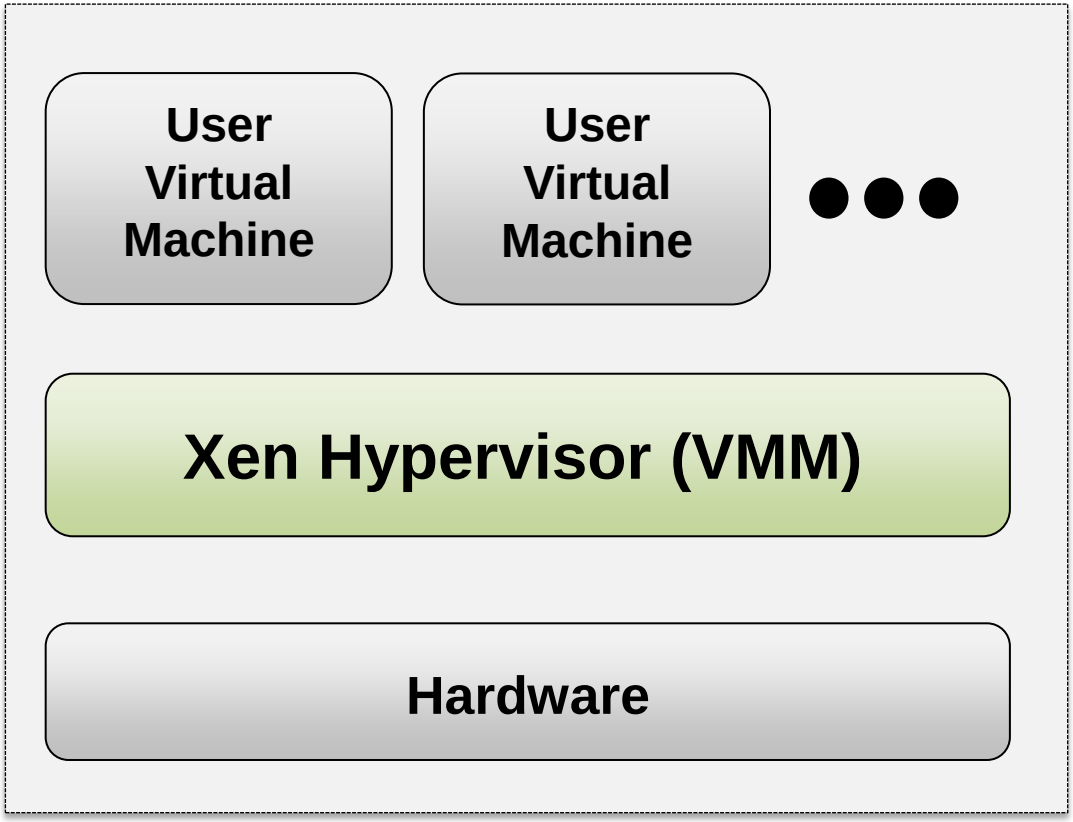
Introduction

- Introduction to virtualization and Xen
- Motivation for agentless VM introspection with an emphasis on security
- Uses of agentless VM introspection in the context of security
- Challenges to agentless VM introspection
- Examples of existing agentless VM introspection technology

Virtualization Background

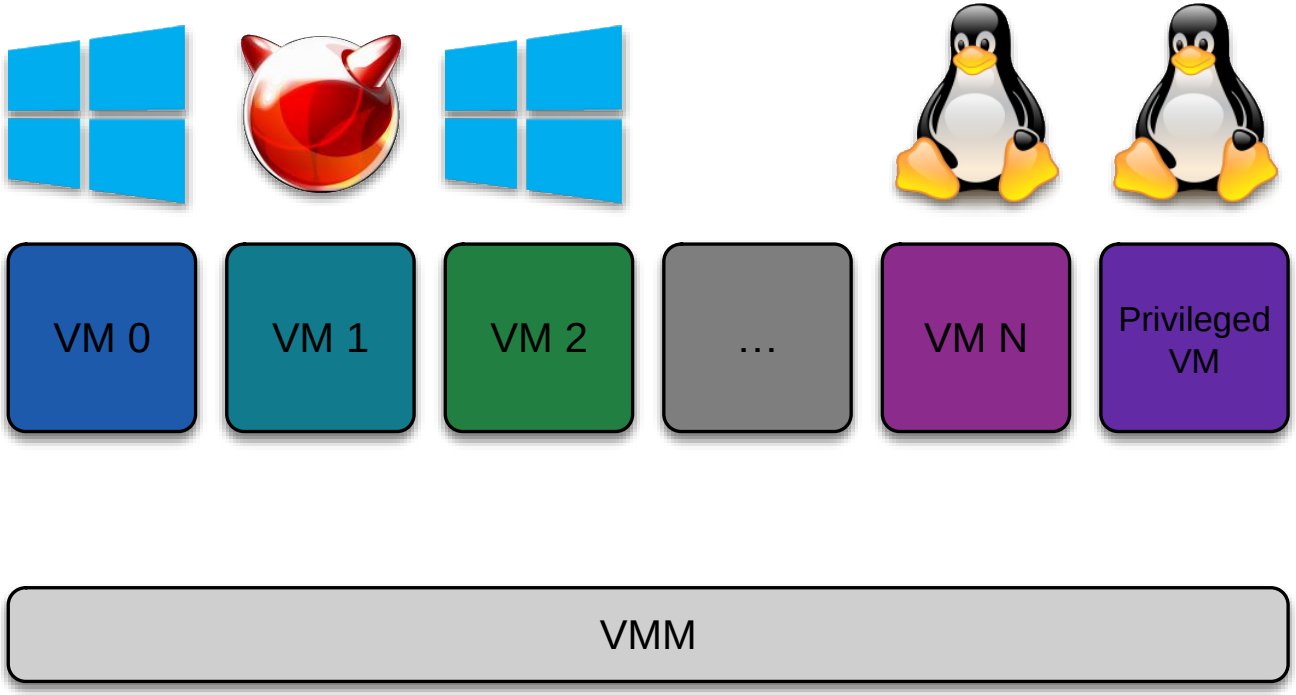
- Virtualization allows running many virtual machines (VMs) on a single host.
- A virtual Machine Monitor (VMM) creates and manages VMs. A VMM is also called a "hypervisor".
- Examples of VMMs:
  - KVM
  - Microsoft Hyper-V
  - VMware ESXi
  - Xen

Xen Overview



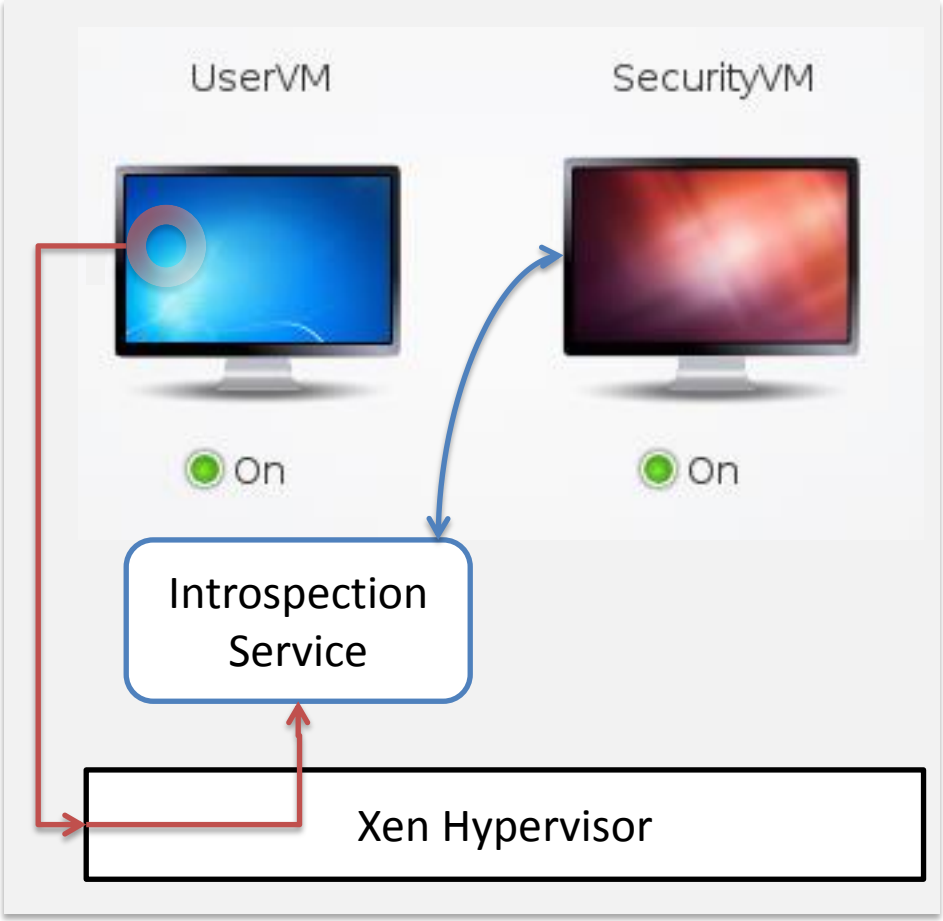
Virtual Machine Introspection

- Virtual machine introspection provides access to low-level details of a running virtual machine to agents running outside the guest.



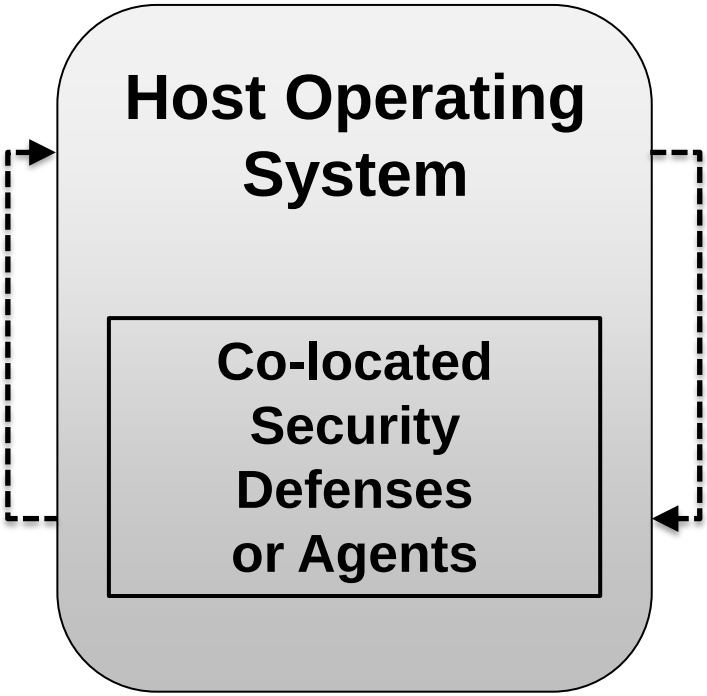
Applications of VM Introspection

- Applications
  - Provide system administrators with deeper visibility into running systems' state.
  - Enhance system security via agentless defenses.



Security as a Motivation for Agentless VM Introspection

- Host-based defenses: who defends the defender?



Analysis, Detection, and Prevention

- Malware Analysis
  - Drop malware into a monitored guest and study its behavior.
- Malware Detection
  - Monitor a guest for indicators of malware.
- Malware Prevention
  - Intervene when malware is detected.

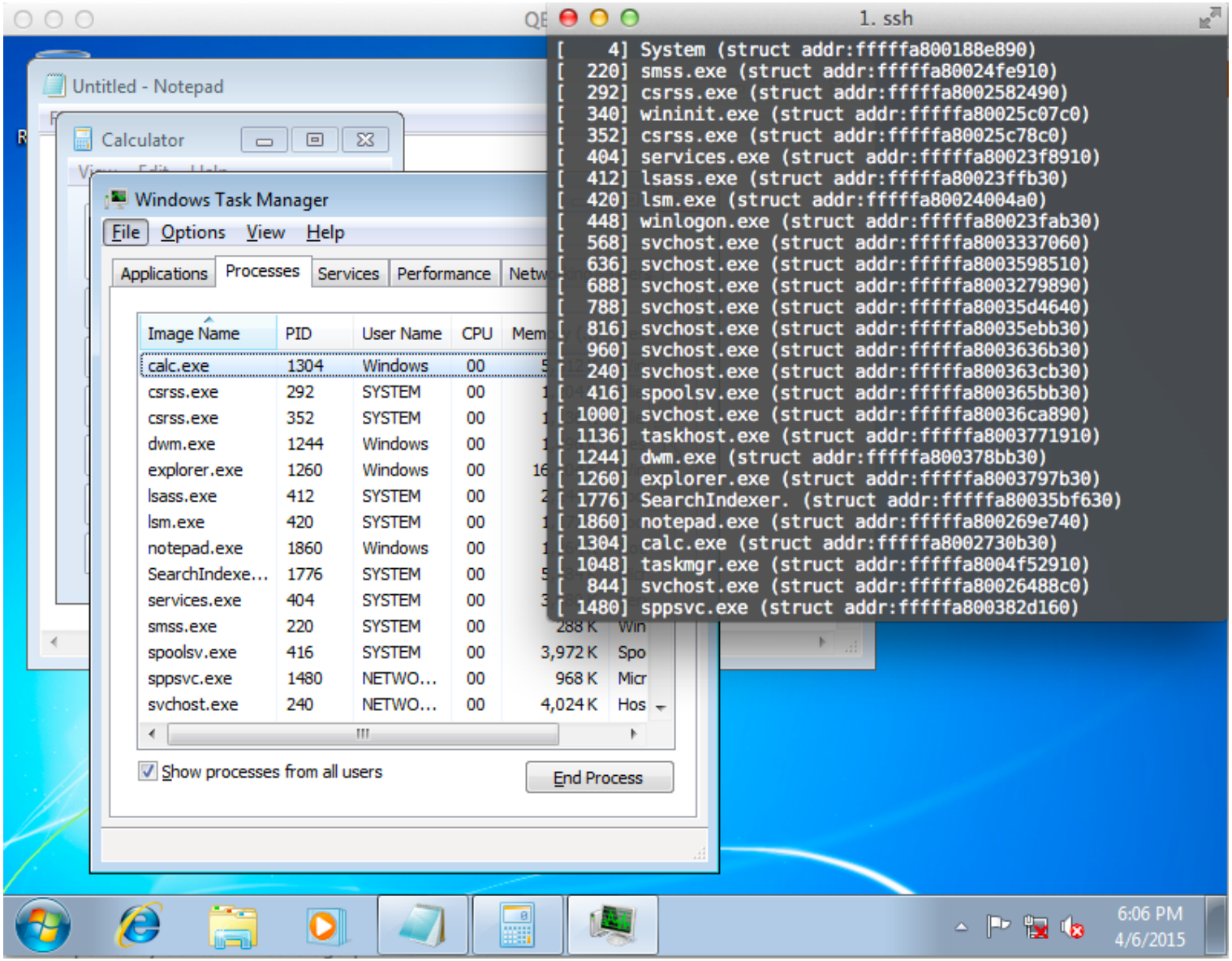
Three Challenges to Introspection

- Semantic Gap
  - Data as the guest OS sees it versus data as the hypervisor sees it.
- Performance
  - Introspection cycles should not detract from guest OS users' experience.
- Precision
  - Introspection cycles should have coherence over time.

Technologies: LibVMI

- LibVMI (http://libvmi.com/)
- C library with Python bindings
- View contents of memory and registers
- Event-based introspection
- Integration with Volatility

LibVMI: “process-list”



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Technologies: DRAKVUF

- DRAKVUF (http://drakvuf.com/)
- Agentless malware analysis system
- Uses LibVMI, Rekall, Volatility
- Detailed tracing and logging
- Process injection

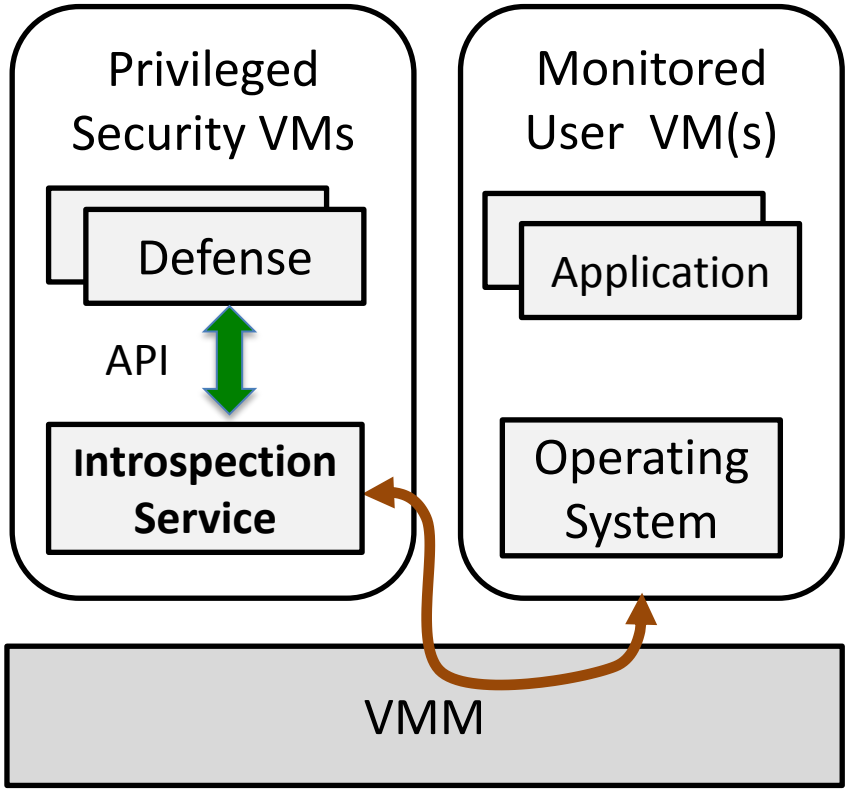
DRAKVUF: Process Injection

```
File  Edit  View  Search  Terminal  Help
Starting event loop
Ready to hijack thread of PID 2364 on vCPU 0!
CPA @ 0x77408840
GS: 0x7fffffde000 RSP: 0x11eda8. RIP: 0x77381930. RCX: 0x357960
Stack base: 0x120000. Limit: 0x11b000
cmd.exe /K echo Hello World @ 0x11ed80.
pip @ 0x11ed68
sip @ 0x11ed00
Return address @ 0x11eca8 -> 0x77381930. Setting RSP: 0x11eca8.
Done with hijack routine
INT3 @ 0x26bb4930
RAX: 0x1
Restoring RSP to 0x11eda8
Restoring RAX to 0x0
Restoring RCX to 0x357960
Restoring RDX to 0x3579a0
Restoring R8 to 0x0
Restoring R9 to 0x0
-- CreateProcessA SUCCESS --
        Process handle: 0x1c4. Thread handle: 0x1d0
        PID: 2452. TID: 2336
Finished with test.
root@t0:/demo# ./injector 23 2364 "C:\\Program Files\\Internet Explorer\\iexplore.exe http://www.darp
Target PID 2364 to start C:\Program Files\Internet Explorer\iexplore.exe http://www.darpa.mil
LibVMI Suggestion: set win_ntoskrnl=0x265e000 in libvmi.conf for faster startup.
LibVMI Suggestion: set win_kdbg=0x1f10a0 in libvmi.conf for faster startup.
LibVMI Suggestion: set win_kdvb=0xfffff8000284f0a0 in libvmi.conf for faster startup.
```


```
root@t0:/demo# ./injector 23 2364 "C:\\Program Files\\Internet Explorer\\iexplore.exe http://www.da
Target PID 2364 to start C:\Program Files\Internet Explorer\iexplore.exe http://www.darpa.mil
Stack base: 0x120000. Limit: 0x11b000
C:\Program Files\Internet Explorer\iexplore.exe http://www.darpa.mil @ 0x11ed58.
pip @ 0x11ed40
sip @ 0x11ecd8
Return address @ 0x11ec80 -> 0x77381930. Setting RSP: 0x11ec80.
Done with hijack routine
INT3 @ 0x26bb4930
RAX: 0x1
Restoring RSP to 0x11eda8
Restoring RAX to 0x0
Restoring RCX to 0x3579a0
Restoring RDX to 0x374b80
Restoring R8 to 0x0
Restoring R9 to 0x0
-- CreateProcessA SUCCESS --
        Process handle: 0x1cc. Thread handle: 0x1d4
        PID: 2480. TID: 2688
```

Technologies: Adventium

- XIP (Adventium)
- Architecture for monitoring running guests from trusted vantage point
- Provides an OS-level interface (API) for introspection



XIP	`get_process_info(filter = {name, id})`
LibVMI	`vmi_read_va(pid=0, buf, 0xfffffa80`80348ac3, 0x100)`
Xen	`xc_map_foreign_range(id=3, buf, 0x400, 0x100, …)`

Adventium: XipWire and XipTop

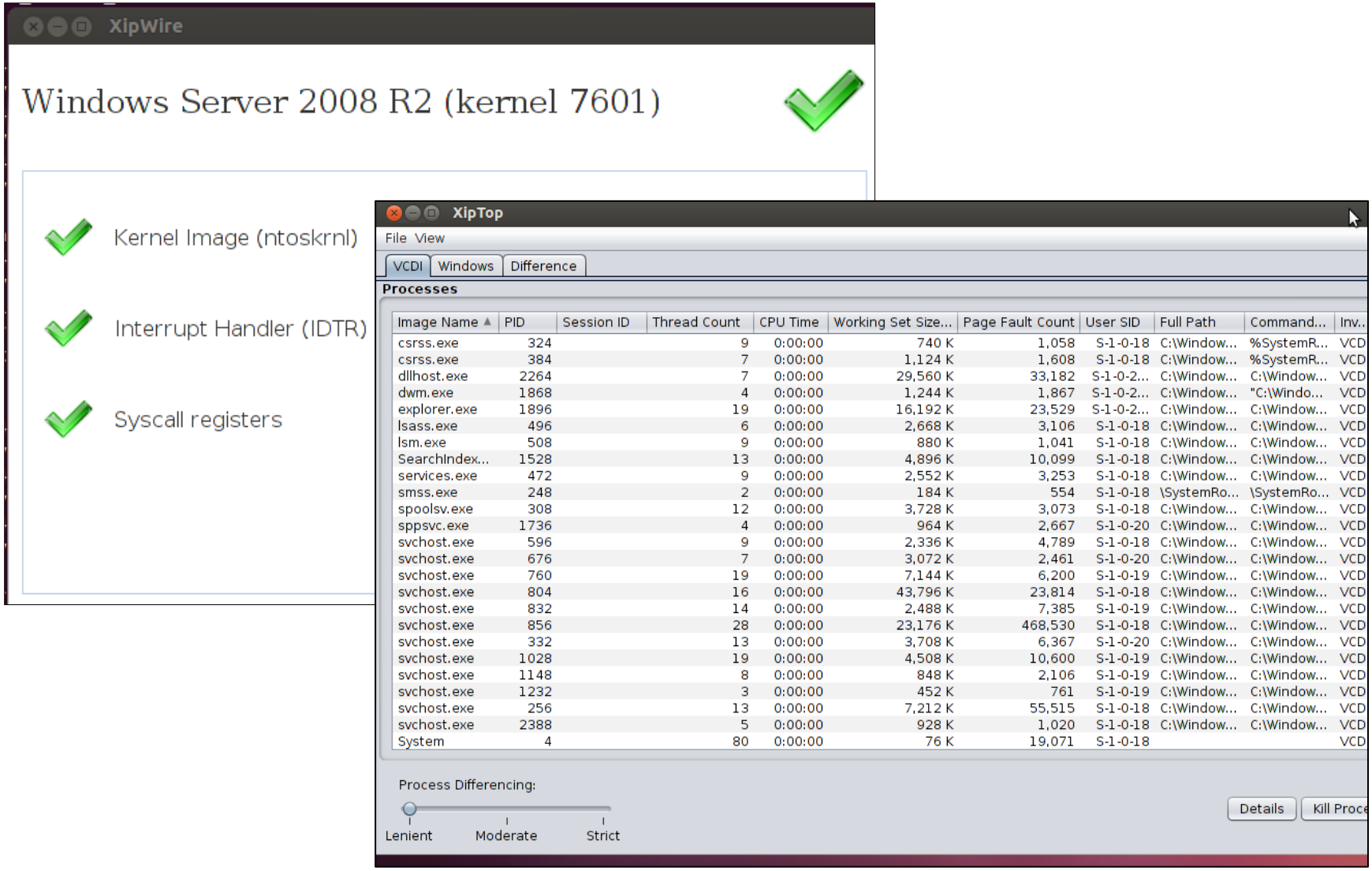


Image Name	PID	Session ID	Thread Count	CPU Time	Working Set Size...	Page Fault Count	User SID	Full Path	Command...	Inv..
csrss.exe	324		9	0:00:00	740 K	1,058	S-1-0-18	C:\Window...	%SystemR...	VCD
csrss.exe	384		7	0:00:00	1,124 K	1,608	S-1-0-18	C:\Window...	%SystemR...	VCD
dllhost.exe	2264		7	0:00:00	29,560 K	33,182	S-1-0-2...	C:\Window...	C:\Window...	VCD
dwm.exe	1868		4	0:00:00	1,244 K	1,867	S-1-0-2...	C:\Window...	"C:\Windo...	VCD
explorer.exe	1896		19	0:00:00	16,192 K	23,529	S-1-0-2...	C:\Window...	C:\Window...	VCD
lsass.exe	496		6	0:00:00	2,668 K	3,106	S-1-0-18	C:\Window...	C:\Window...	VCD
lsm.exe	508		9	0:00:00	880 K	1,041	S-1-0-18	C:\Window...	C:\Window...	VCD
SearchIndex...	1528		13	0:00:00	4,896 K	10,099	S-1-0-18	C:\Window...	C:\Window...	VCD
services.exe	472		9	0:00:00	2,552 K	3,253	S-1-0-18	C:\Window...	C:\Window...	VCD
smss.exe	248		2	0:00:00	184 K	554	S-1-0-18	\SystemRo...	\SystemRo...	VCD
spoolsv.exe	308		12	0:00:00	3,728 K	3,073	S-1-0-18	C:\Window...	C:\Window...	VCD
sppsvc.exe	1736		4	0:00:00	964 K	2,667	S-1-0-20	C:\Window...	C:\Window...	VCD
svchost.exe	596		9	0:00:00	2,336 K	4,789	S-1-0-18	C:\Window...	C:\Window...	VCD
svchost.exe	676		7	0:00:00	3,072 K	2,461	S-1-0-20	C:\Window...	C:\Window...	VCD
svchost.exe	760		19	0:00:00	7,144 K	6,200	S-1-0-19	C:\Window...	C:\Window...	VCD
svchost.exe	804		16	0:00:00	43,796 K	23,814	S-1-0-18	C:\Window...	C:\Window...	VCD
svchost.exe	832		14	0:00:00	2,488 K	7,385	S-1-0-19	C:\Window...	C:\Window...	VCD
svchost.exe	856		28	0:00:00	23,176 K	468,530	S-1-0-18	C:\Window...	C:\Window...	VCD
svchost.exe	332		13	0:00:00	3,708 K	6,367	S-1-0-20	C:\Window...	C:\Window...	VCD
svchost.exe	1028		19	0:00:00	4,508 K	10,600	S-1-0-19	C:\Window...	C:\Window...	VCD
svchost.exe	1148		8	0:00:00	848 K	2,106	S-1-0-19	C:\Window...	C:\Window...	VCD
svchost.exe	1232		3	0:00:00	452 K	761	S-1-0-19	C:\Window...	C:\Window...	VCD
svchost.exe	256		13	0:00:00	7,212 K	55,515	S-1-0-18	C:\Window...	C:\Window...	VCD
svchost.exe	2388		5	0:00:00	928 K	1,020	S-1-0-18	C:\Window...	C:\Window...	VCD
System	4		80	0:00:00	76 K	19,071	S-1-0-18			VCD

Conclusion and Final Remarks

- Virtualization, introspection, host-based defenses, challenges, and technologies.
- Agentless VM introspection provides a unique vantage point into a system's security.
- Adventium develops introspection-based security solutions for customers with high security requirements.