What if

software had no bugs?

Herbert Bos

Vrije Universiteit Amsterdam

2010

Security problems are caused by

- –**Software bugs**, and
- –**Configuration bugs**

Impossible

to write software without bugs

2016

Even if the software is perfect

–and well-configured

it is **still vulnerable!**

What does that mean for

formally verified systems?

Credits

Erik Bosman
Ben Gras
Kaveh Razavi
Victor van der Veen
Cristiano Giuffrida

VUSec

https://vusec.net

BinArmor	(USENIX ATC '12)
ASLR3	(USENIX Sec '12)
ShrinkWrap	(ACSAC '15)
StackArmor	(NDSS '15)
PathArmor	(CCS '15)
TypeArmor	(S&P '16)
MvArmor	(DSN '16)
CodeArmor	(EuroS&P'16)
APM	(USENIX Sec '16)
VTPin	(ACSAC '16)
TypeSan	(CCS '16)

Out of Control	(S&P '14)
SROP	(S&P '14)
Size Does Matter	(USENIX Sec '14)
Allocation Oracles	(USENIX Sec '16)
Thread Spraying	(USENIX Sec '16)
Dedup est machina	(S&P'16)
Flip Feng Shui	(USENIX Sec '16)
Drammer	(CCS'16)

Defenses

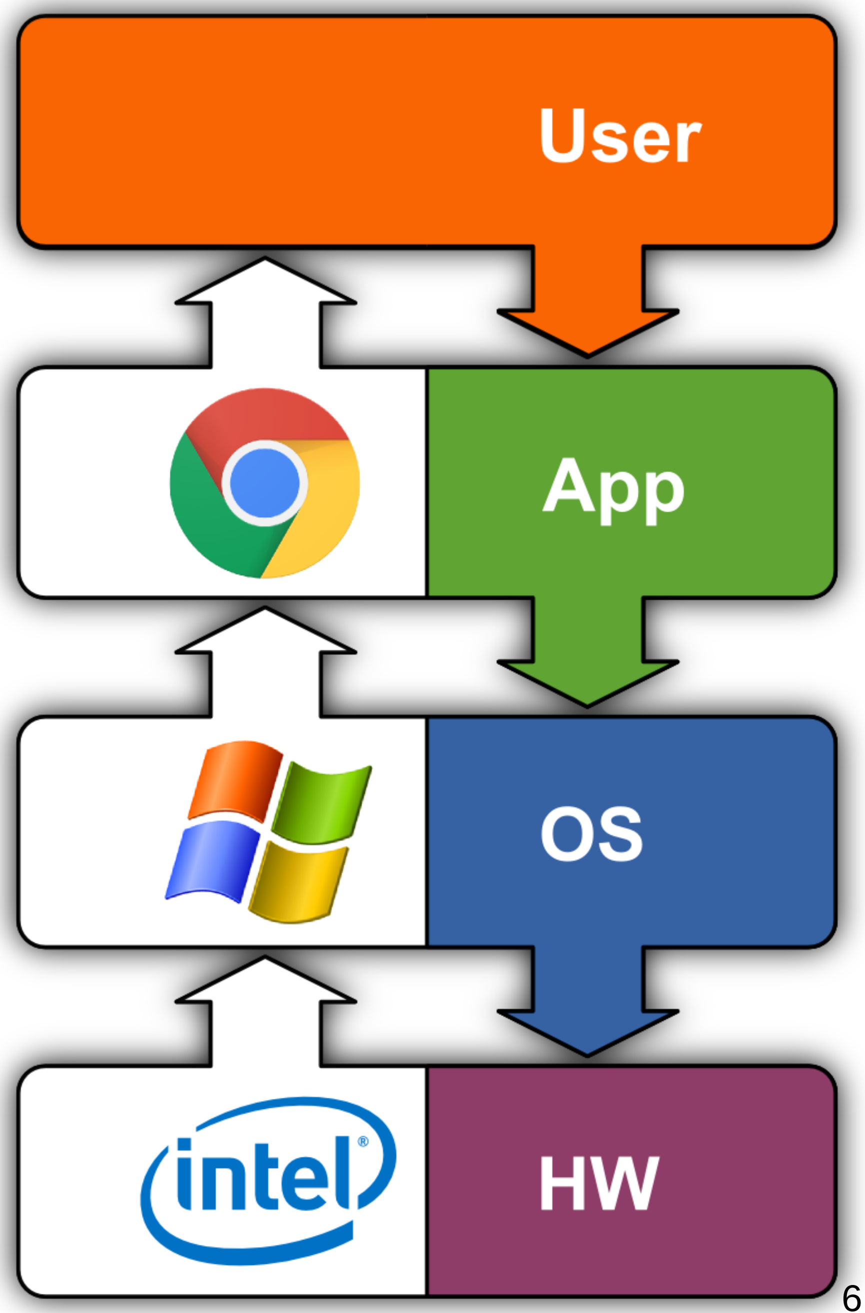
VUSec

Attacks

https://vusec.net

Software Exploitation:

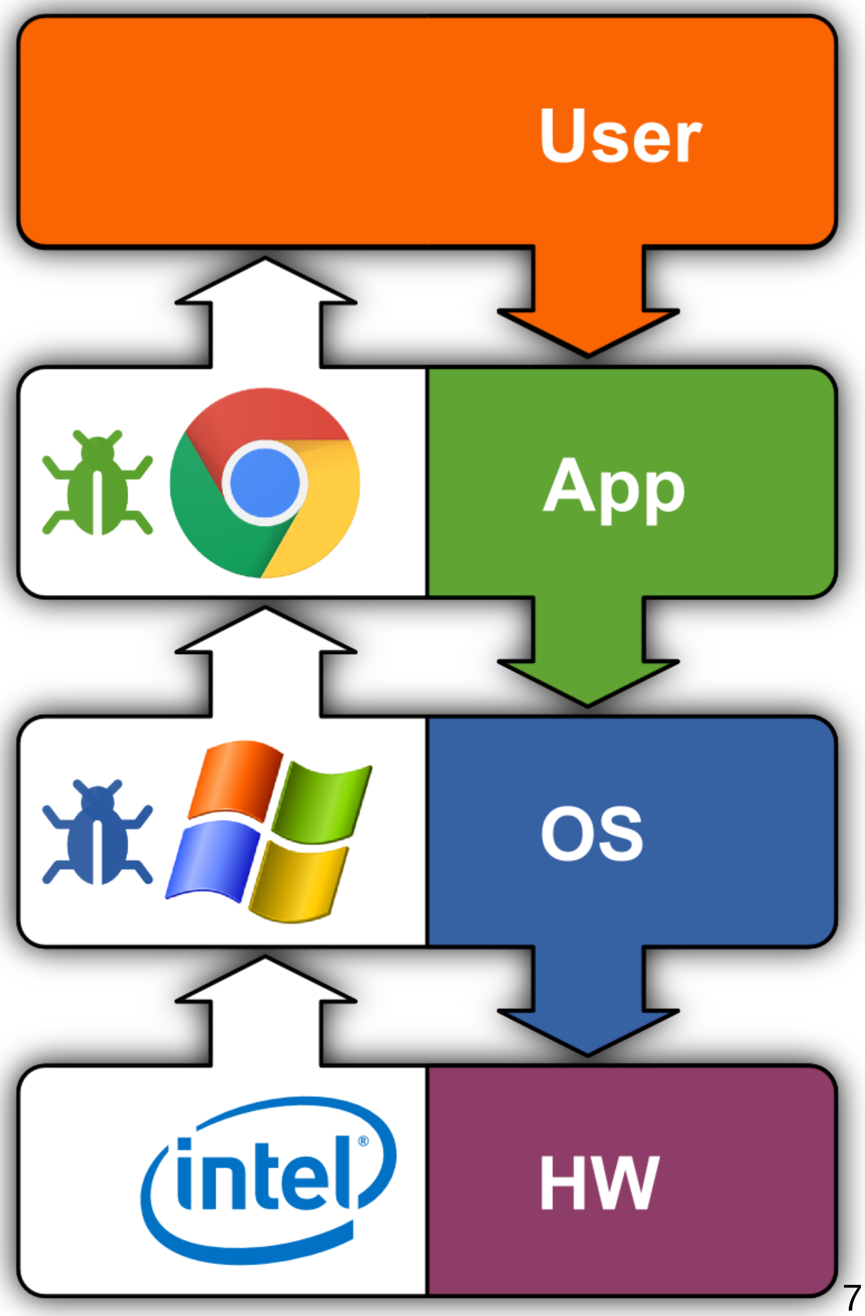
2010



Software Exploitation:

2010

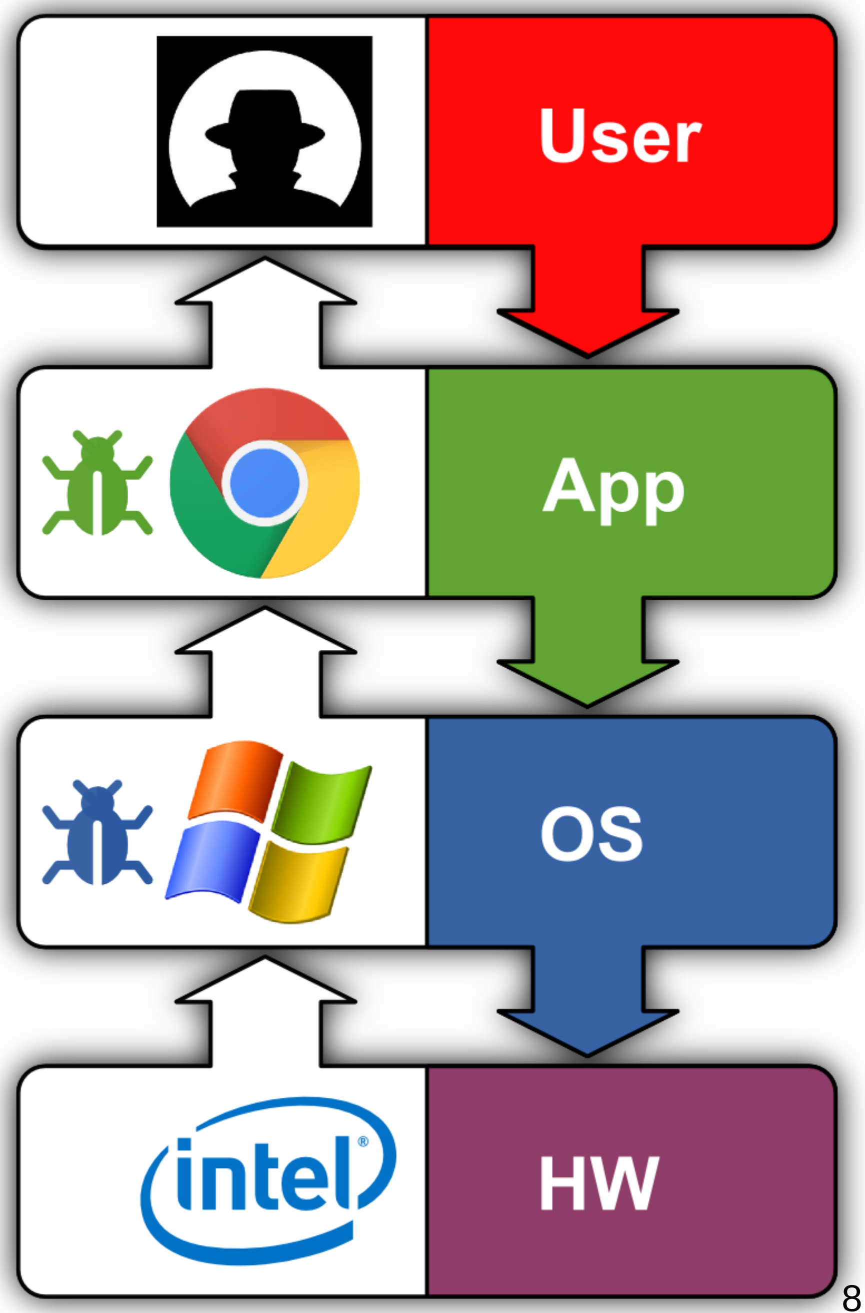
Bugs, Bugs Everywhere!



Software Exploitation:

2010

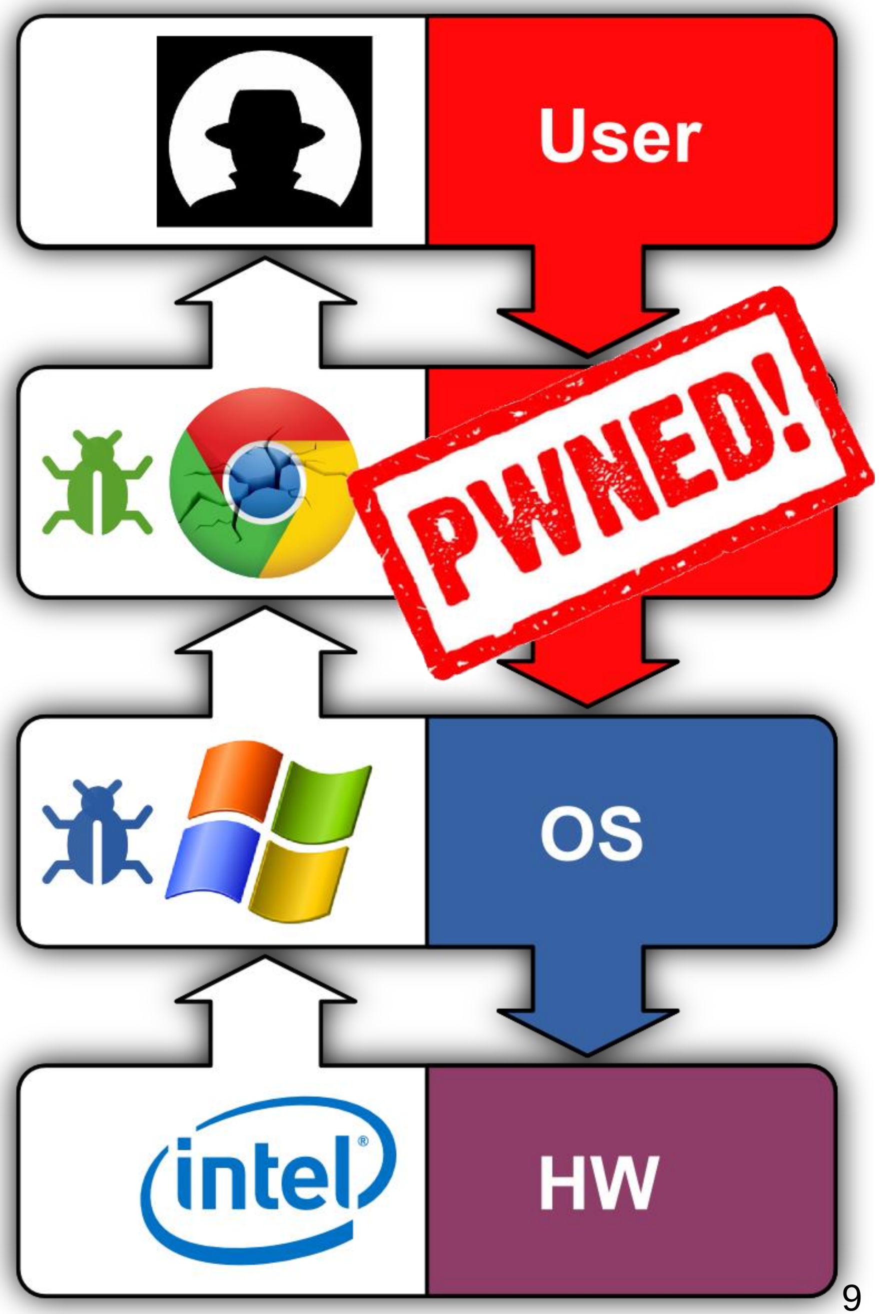
Attacker Exploits Vulnerable Software



Software Exploitation:

2010

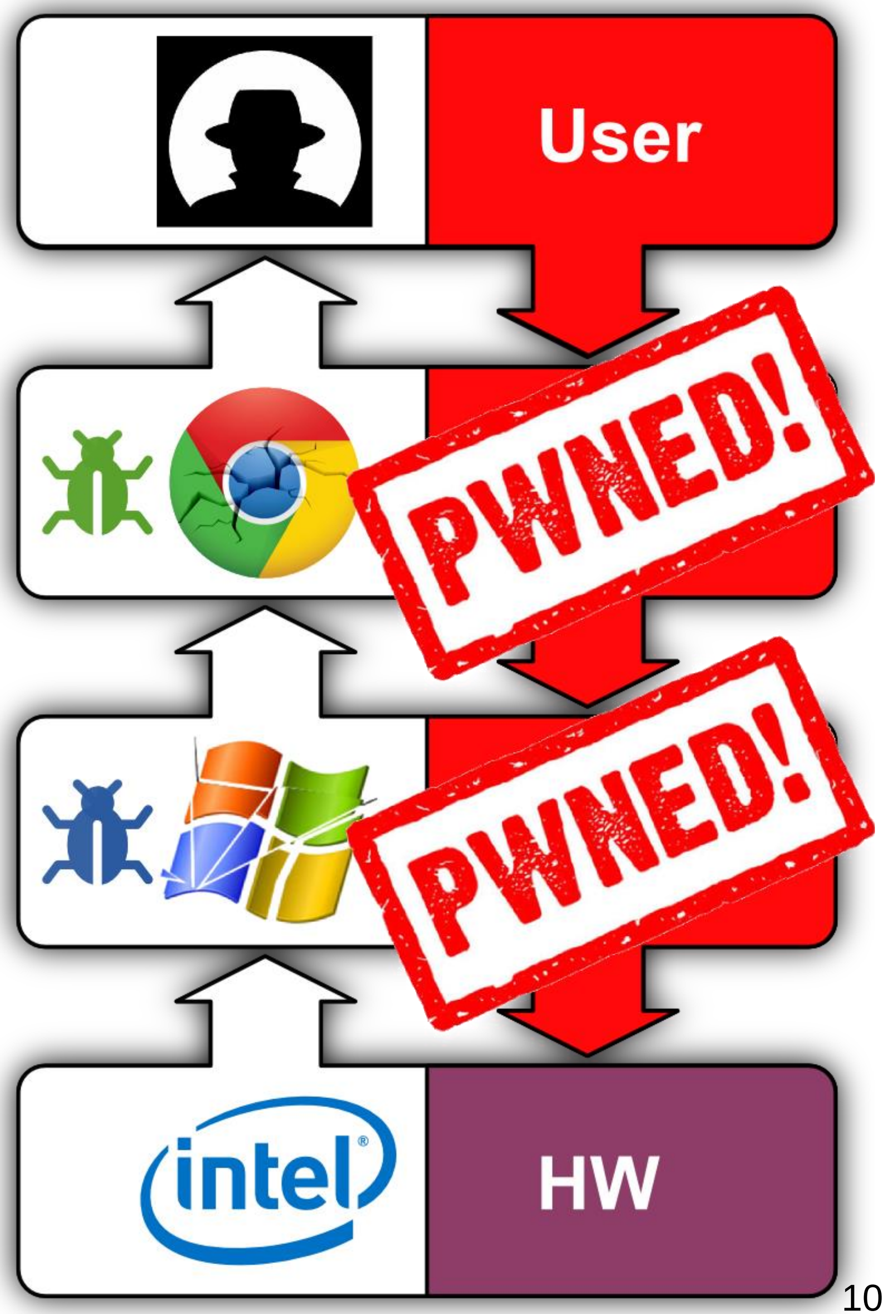
Attacker Owns Application



Software Exploitation:

2010

Attacker Owns System



Software Exploitation: 2010

Systems security problems caused by **bugs**

- Software and configuration bugs
- Weak security implementations

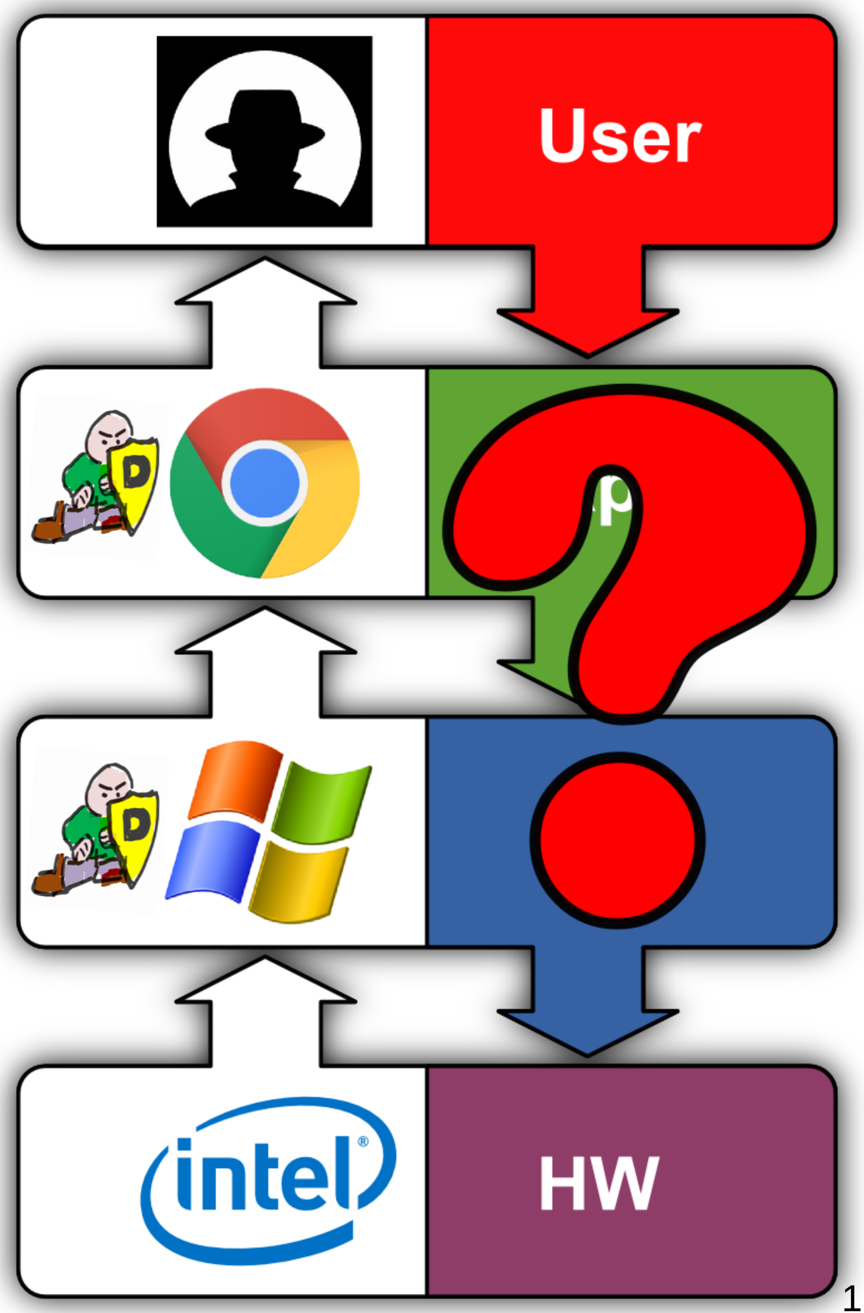
Impossible to write software without bugs

- However, we can mitigate their impact
- Many defenses proposed by industry and academia

Software Exploitation:

2016

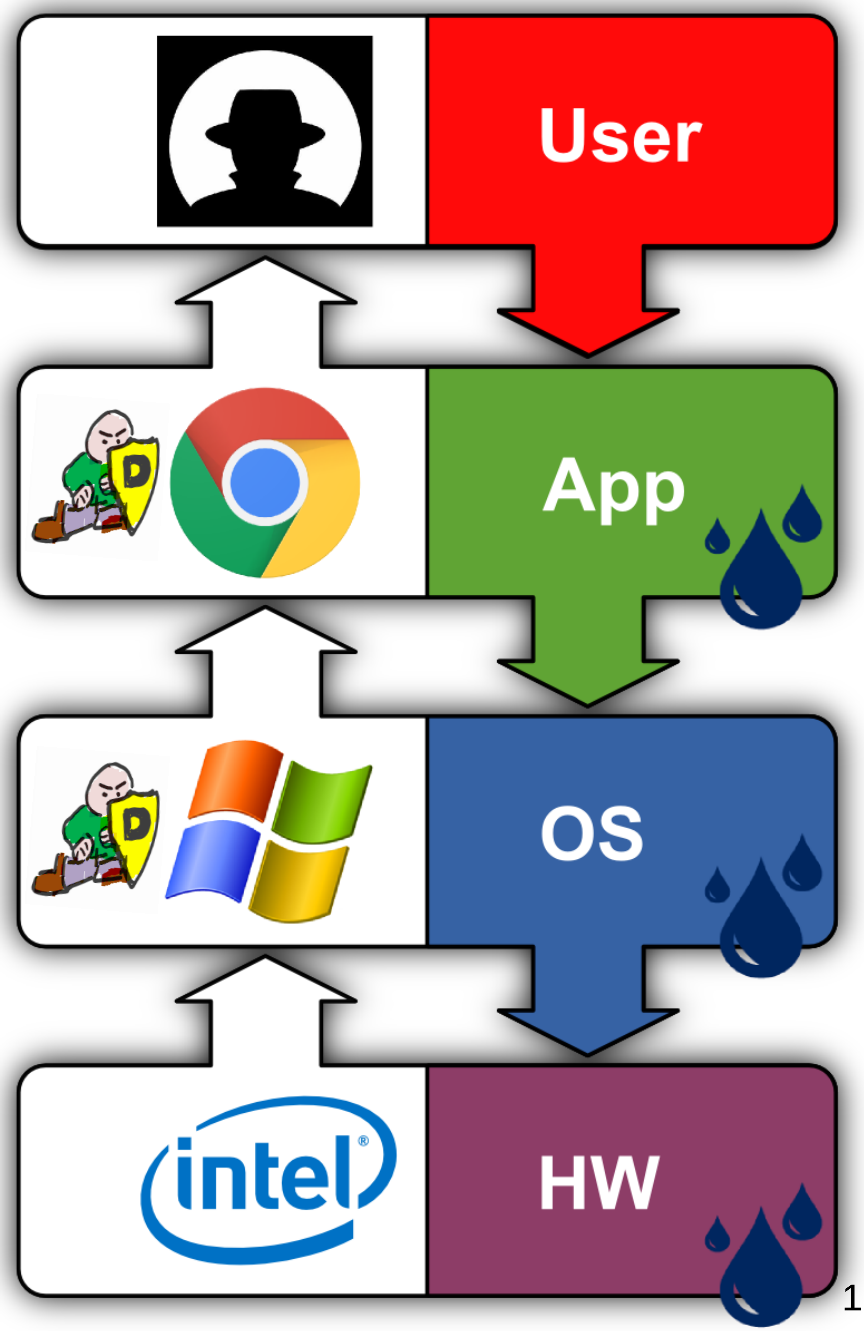
How to Find Memory R/W Primitives?



Software Exploitation:

2016

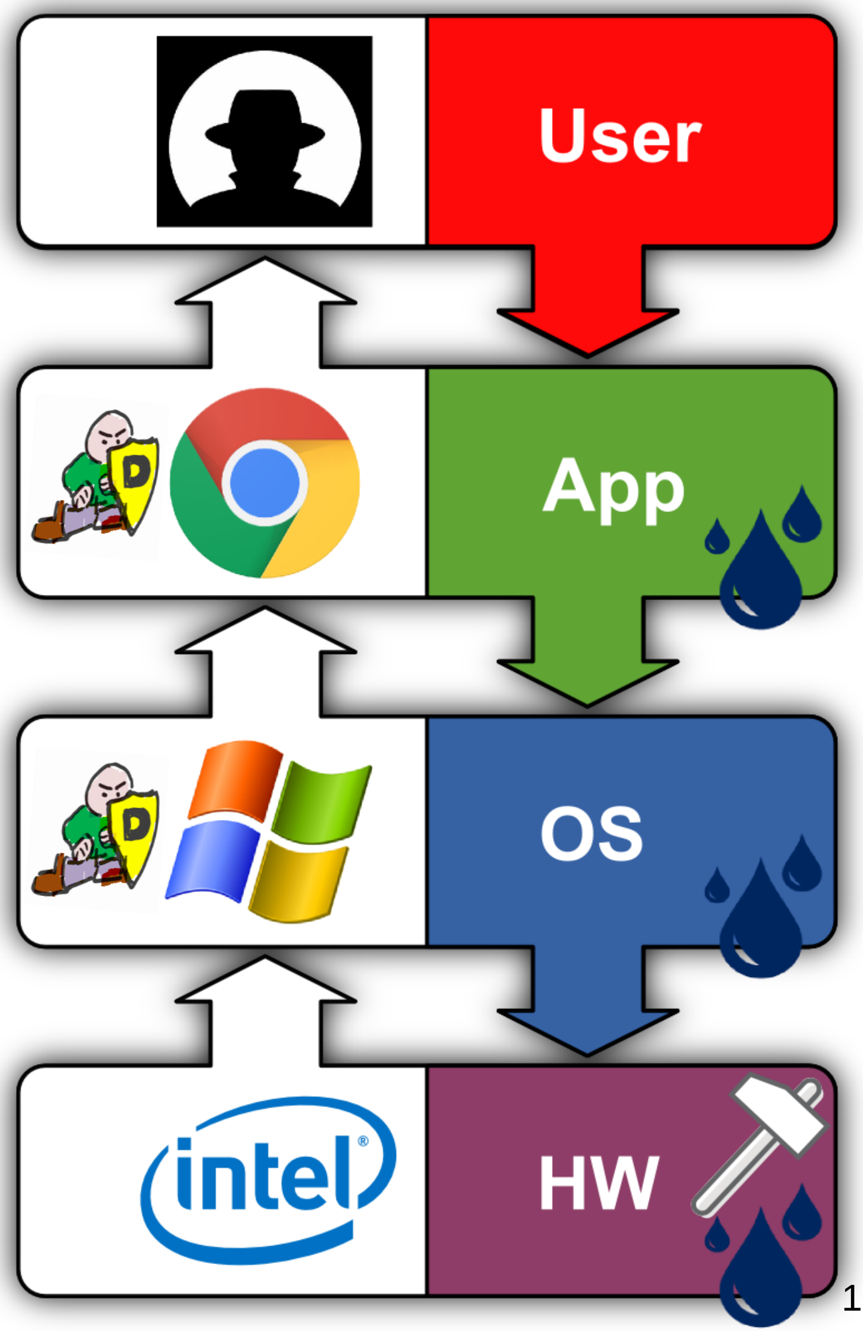
Memory R: Hw/Sw Side Channels



Software Exploitation:

2016

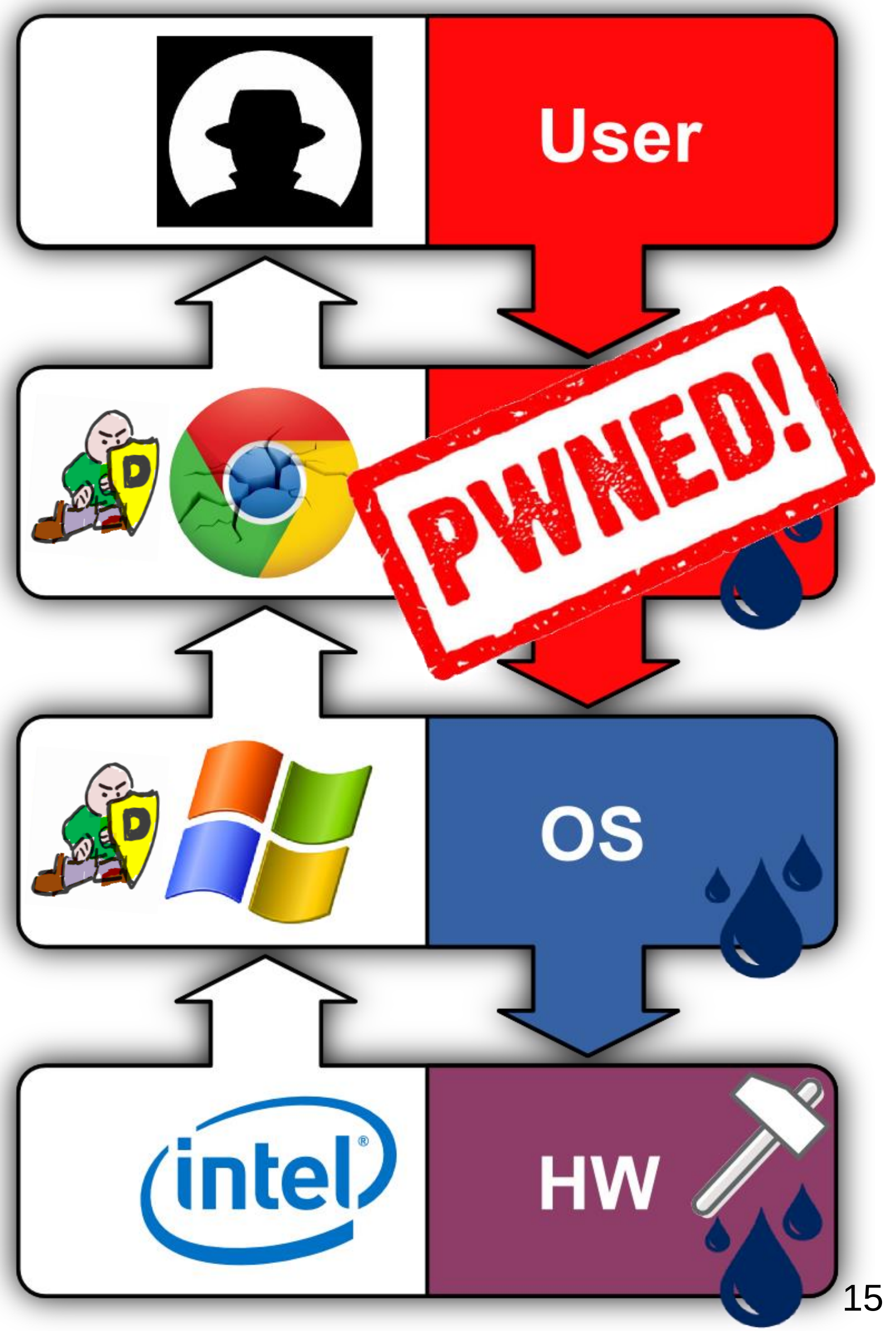
Memory W: Hardware Glitches



Software Exploitation:

2016

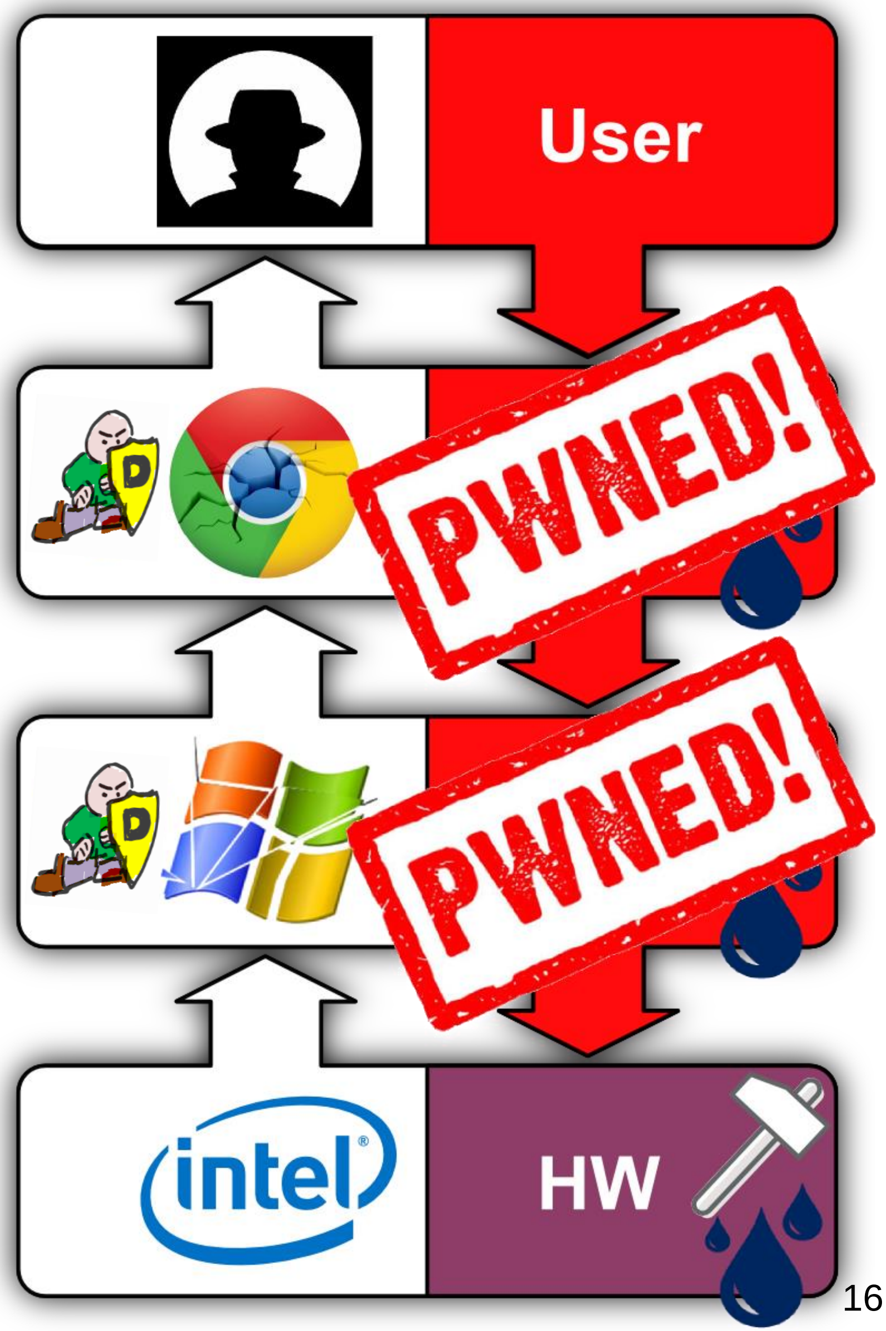
Memory R/W: Back to Reliable Exploits



Software Exploitation:

2016

Memory R/W: Back to Reliable Exploits



Software Exploitation: 2016

Even if the software is **perfect**...

...with no bugs, well-configured, and latest defenses

...it is still **vulnerable**!

Attackers abuse **properties** of modern hw and sw for reliable exploitation

We’ll look at **2 examples** (browsers, clouds) with **2 properties** (dedup, Rowhammer)

EXAMPLE 1

Bug-free Exploitation in Browsers

Dedup Est Machina

Published at IEEE S&P 2016

with Erik, Kaveh, Cristiano

Won **Pwnie Award** at Black HAT 2016

black hat®
USA 2016

"Most Innovative Research"

Exploit of Microsoft Edge browser on Windows 10 from malicious JavaScript

...without relying on a single software bug

Dedup Est Machina

**Memory deduplication
(software side channel)**

Dedup Est Machina

Memory deduplication
(software side channel)
+
Rowhammer
(hardware glitch)

Dedup Est Machina

Memory deduplication
(software side channel)
+
Rowhammer
(hardware glitch)

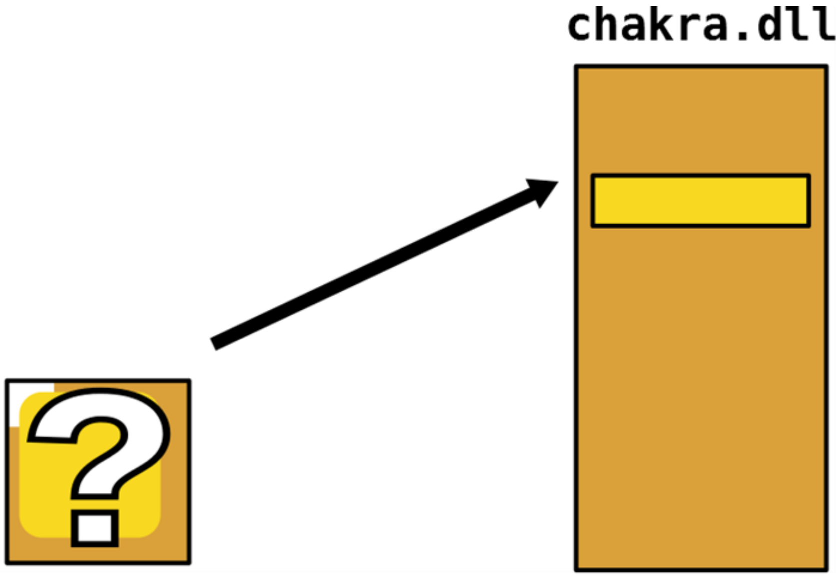
↓

Exploit MS Edge without software bugs
(from JavaScript)

Dedup Est Machina: Overview

Memory deduplication

Leak randomized heap and code pointers



Dedup Est Machina: Overview

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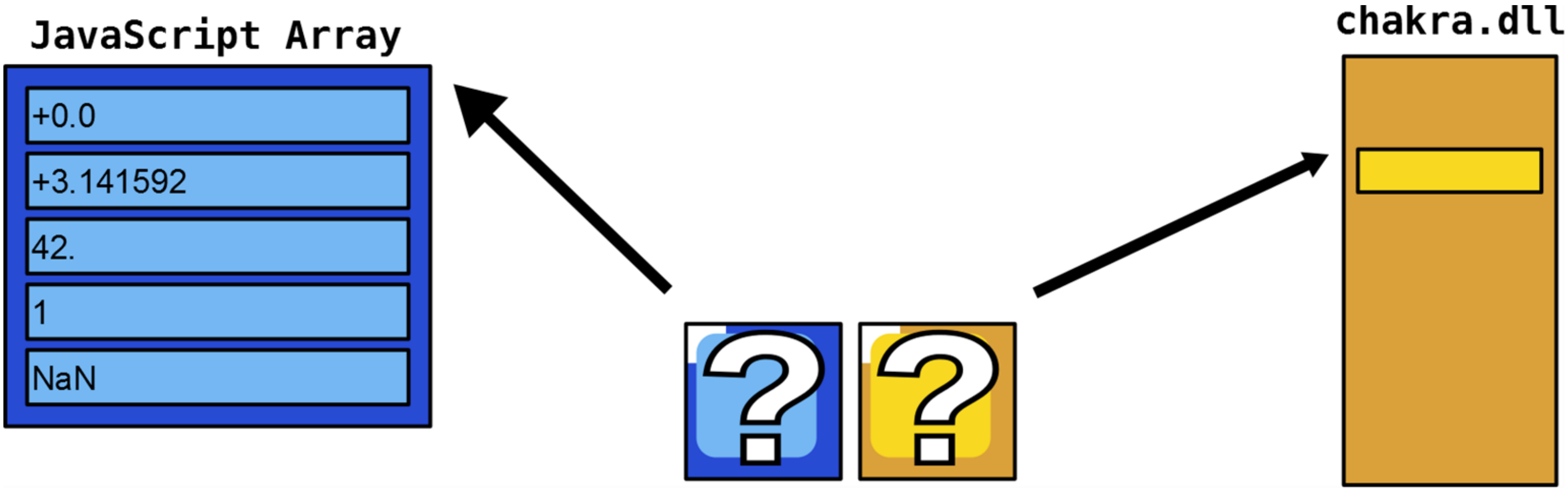
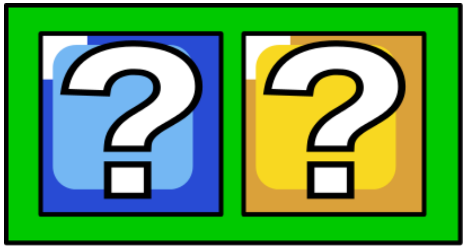


Dedup Est Machina: Overview

Memory deduplication

Leak randomized heap and code pointers

Create a fake JavaScript object



Dedup Est Machina: Overview

Memory deduplication

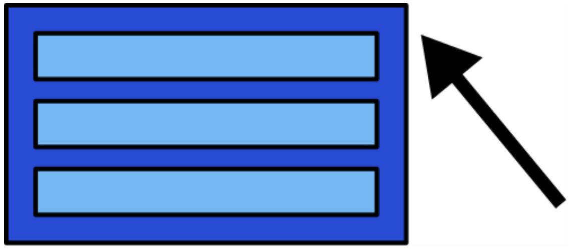
Leak randomized heap and code pointers

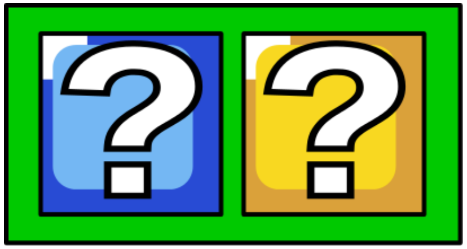
Create a fake JavaScript object

+

Rowhammer

Create a reference to our fake object





Dedup Est Machina: Overview

Memory deduplication

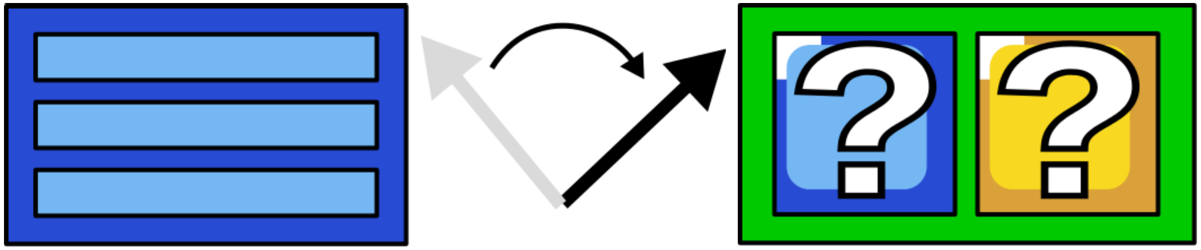
Leak randomized heap and code pointers

Create a fake JavaScript object

+

Rowhammer

Create a reference to our fake object



Memory Deduplication

A strategy to reduce physical memory usage

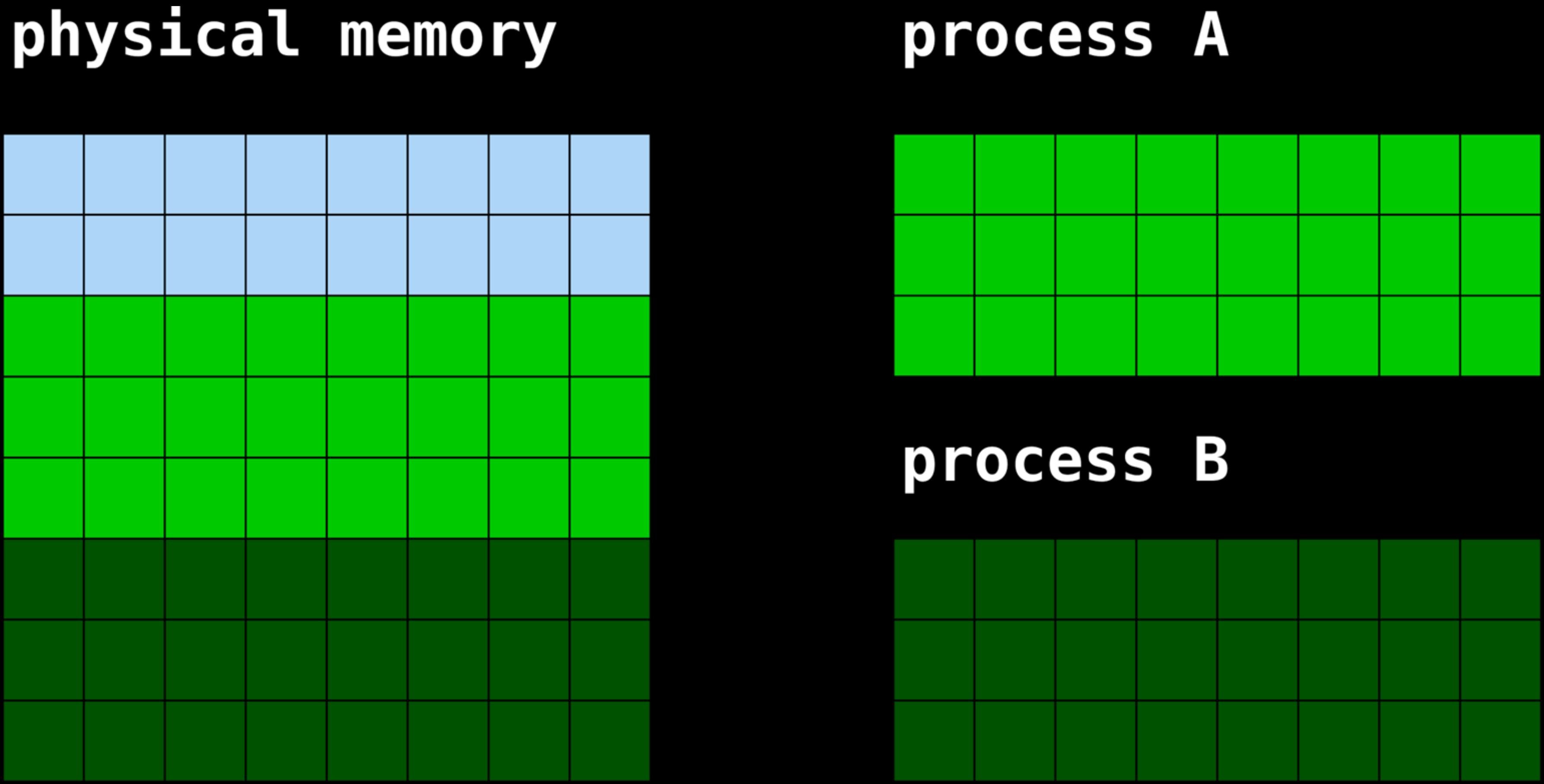
Removes duplication in physical memory

Common in virtualization environments

Now also enabled by **default on Windows**

- Windows 8.1
- Windows 10

Memory Deduplication: Mechanics

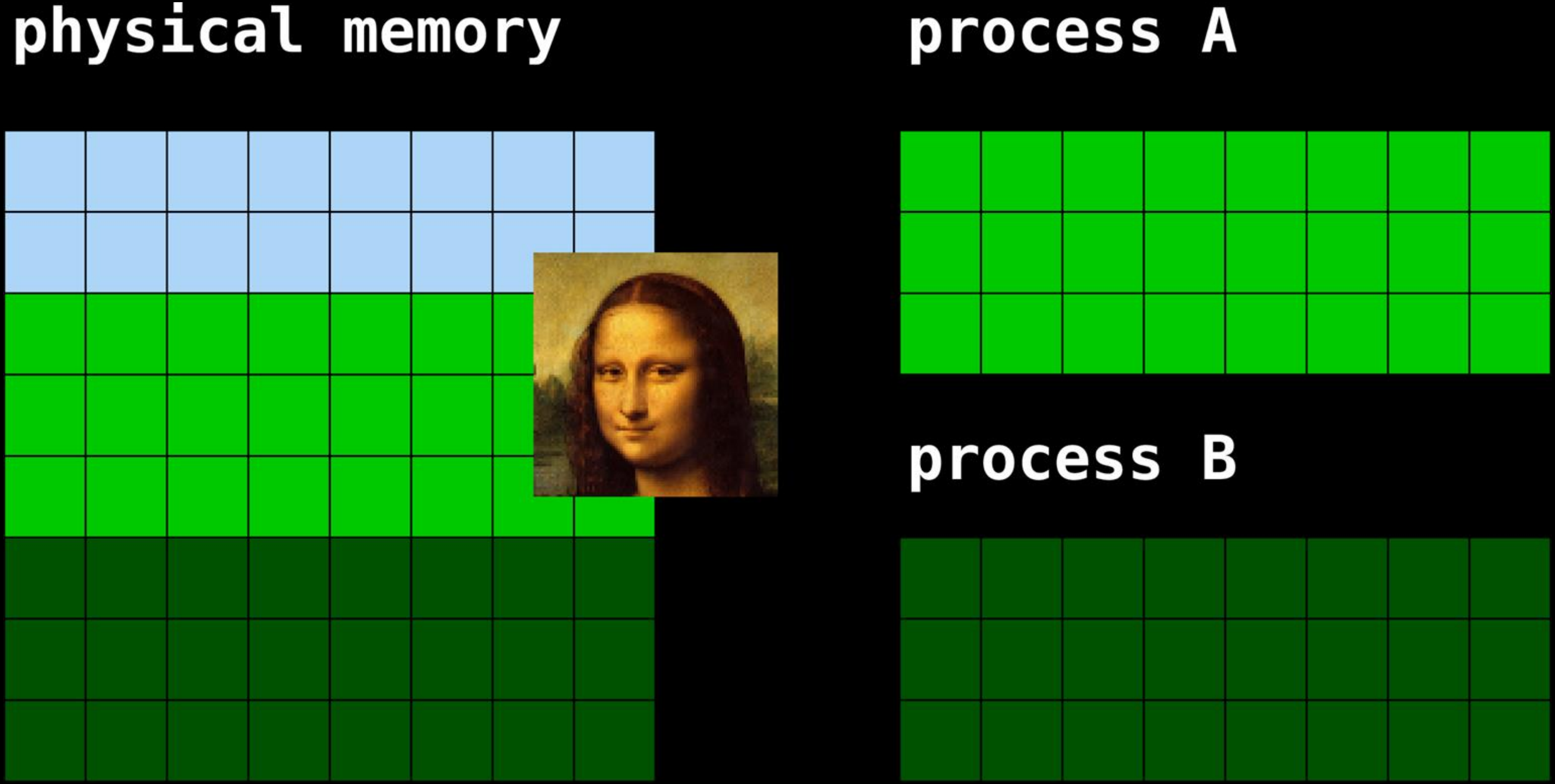


physical memory

process A

process B

Memory Deduplication: Mechanics

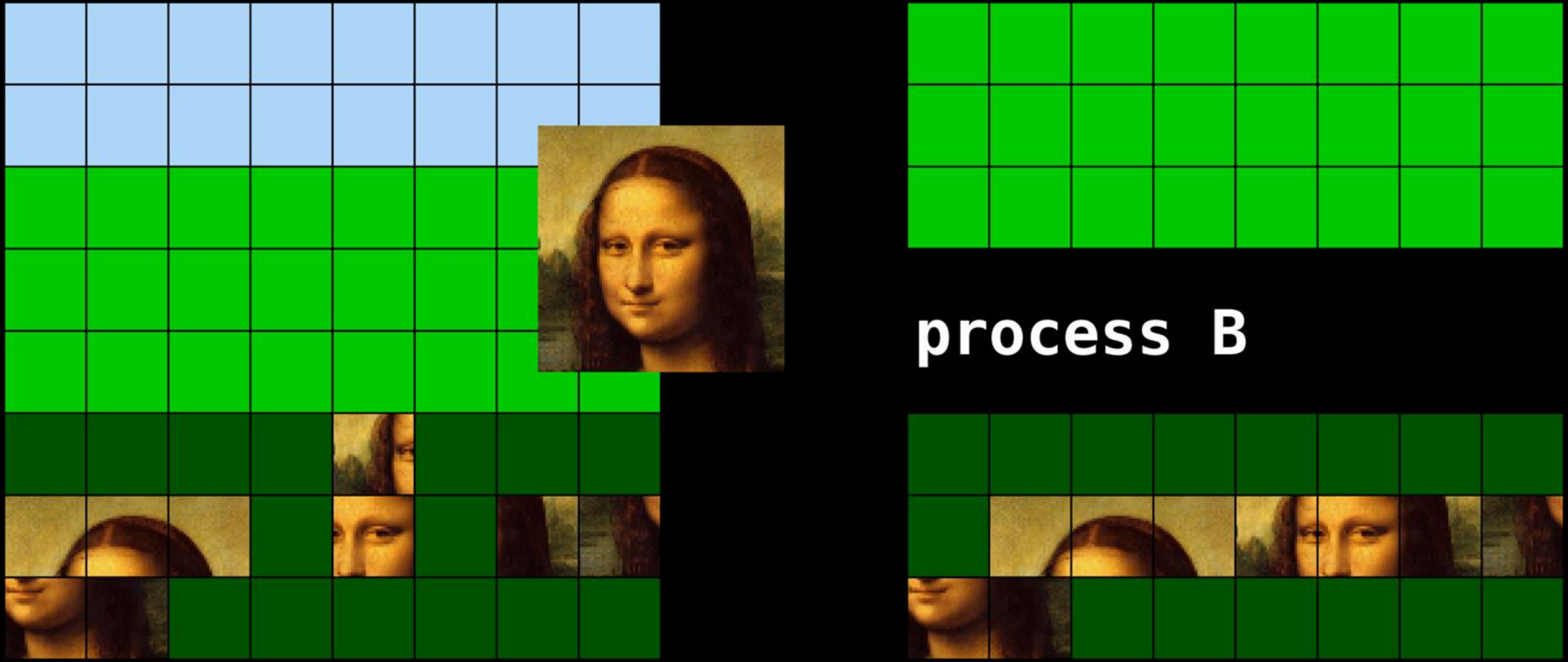


physical memory

process A

process B

Memory Deduplication: Mechanics

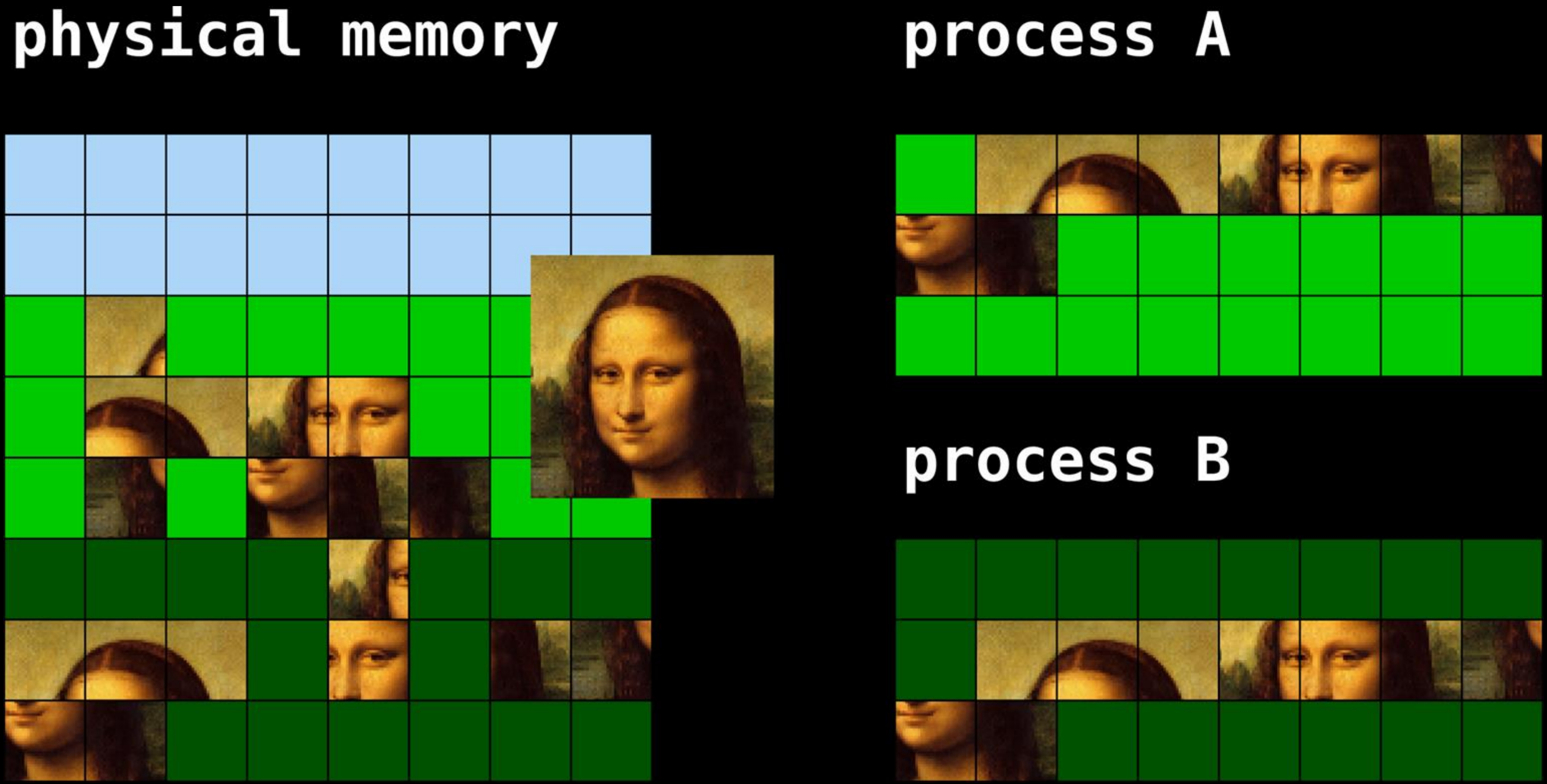


physical memory

process A

process B

Memory Deduplication: Mechanics

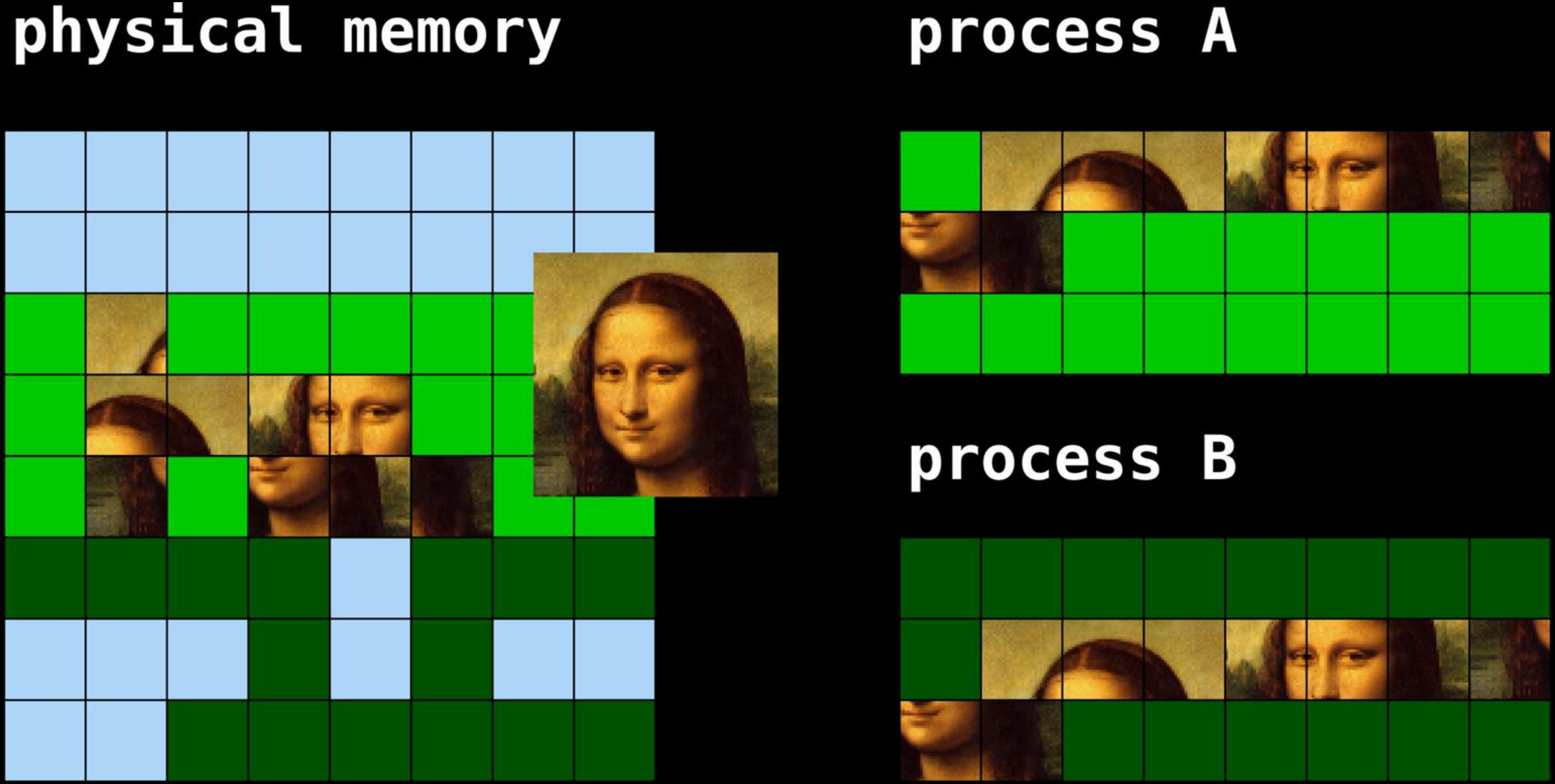


physical memory

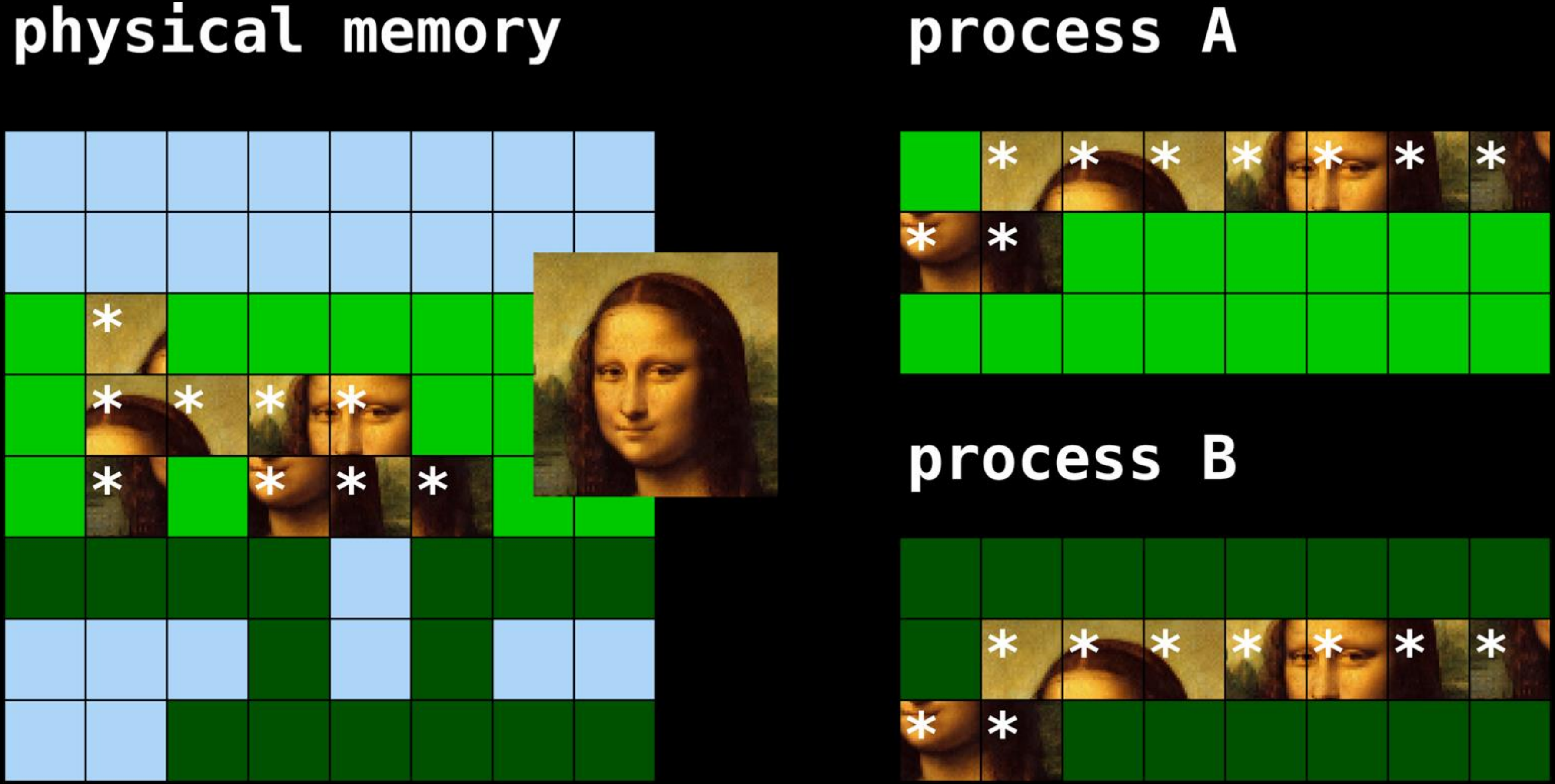
process A

process B

Memory Deduplication: Mechanics



Memory Deduplication: Mechanics



Memory Deduplication: The Problem

Deduplicated memory is origin-agnostic

Merges pages across security boundaries

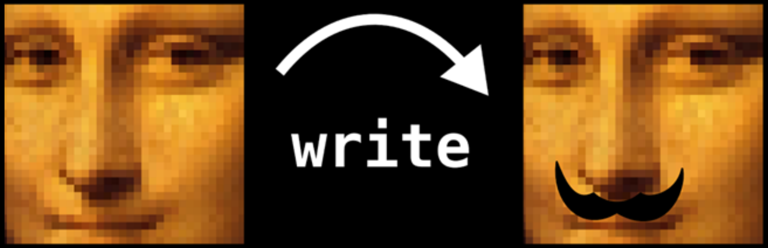
Attackers can use this as a **side channel**!

Memory Deduplication: Timing Side Channel

normal write

Memory Deduplication: Timing Side Channel

normal write



Memory Deduplication: Timing Side Channel

normal write

copy on write (due to deduplication)

Memory Deduplication: Timing Side Channel

normal write

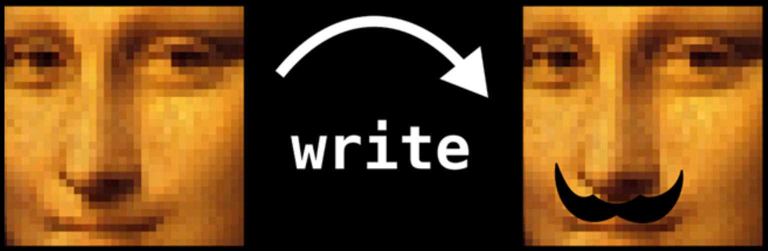
write

copy on write (due to deduplication)

trap to kernel

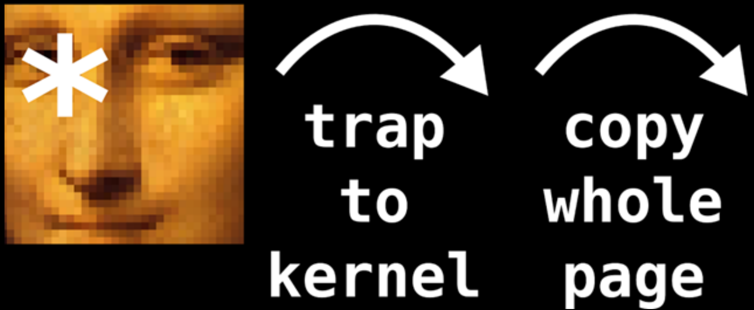
Memory Deduplication: Timing Side Channel

normal write



write

copy on write (due to deduplication)

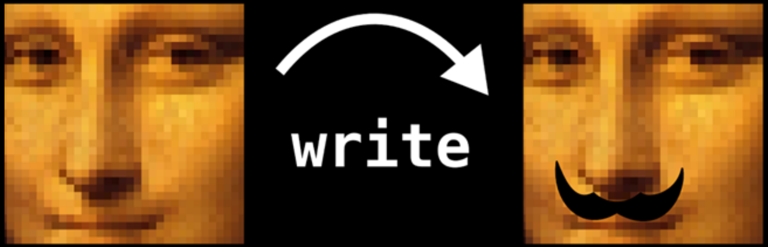


trap to kernel

copy whole page

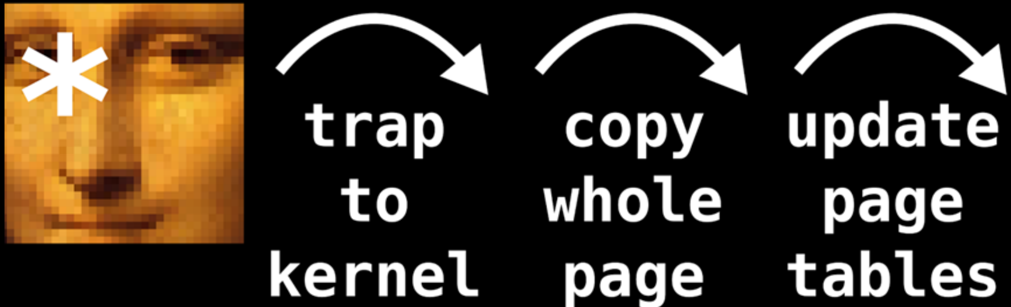
Memory Deduplication: Timing Side Channel

normal write



write

copy on write (due to deduplication)



trap to kernel

copy whole page

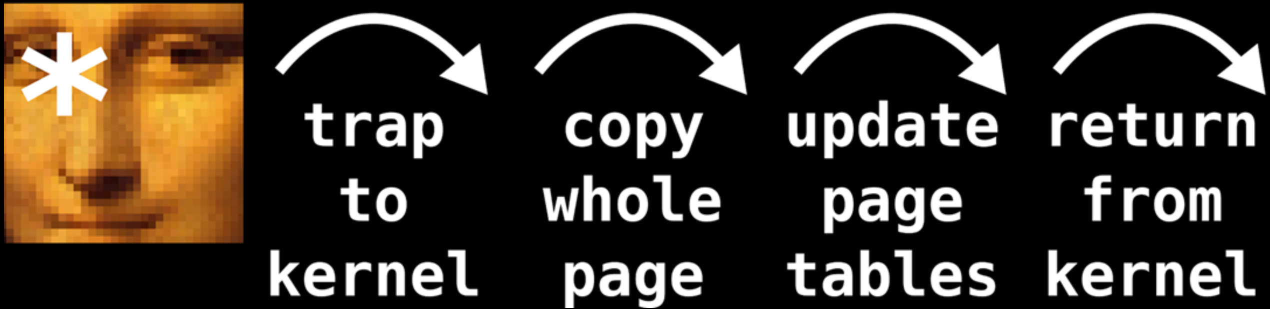
update page tables

Memory Deduplication: Timing Side Channel

normal write

write

copy on write (due to deduplication)


trap to kernel

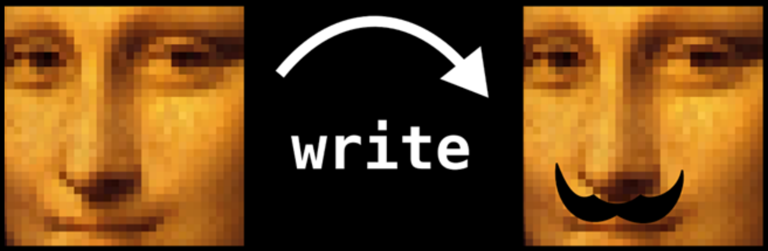
copy whole page

update page tables

return from kernel

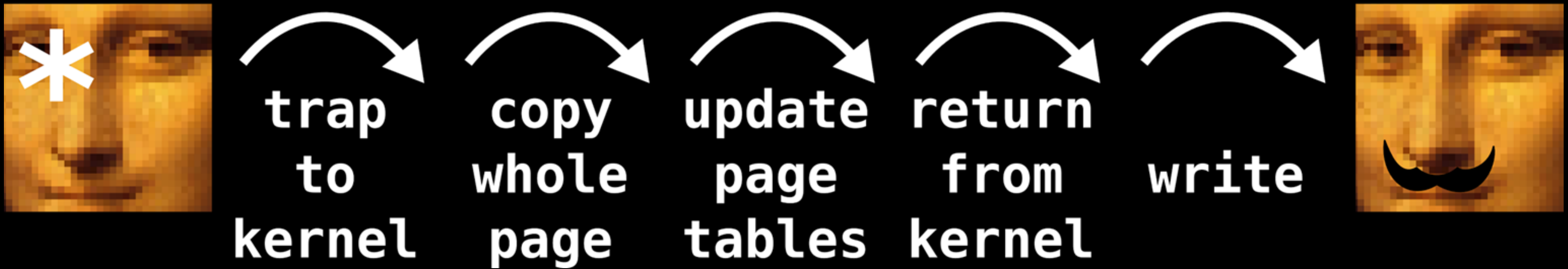
Memory Deduplication: Timing Side Channel

normal write



write

copy on write (due to deduplication)



trap to kernel

copy whole page

update page tables

return from kernel

write

Memory Deduplication: Side-channel Leaks

Attacker can now leak **1 bit** of information
(directly from JavaScript and system-wide)

“Does the victim
*process have **this***
page in memory?”

Memory Deduplication: Side-channel Leaks

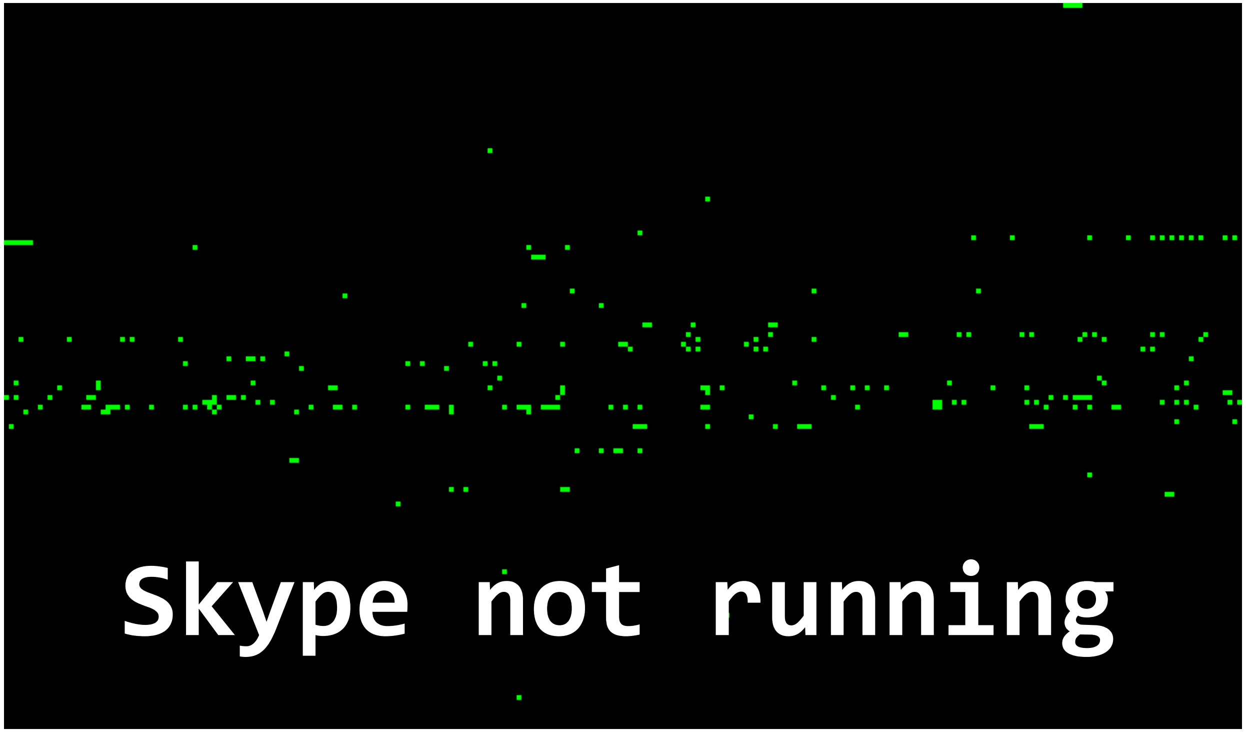
Very **coarse-grained**. Still interesting?

Is user logged into bank website X?

Memory Deduplication: Side-channel Leaks

Very **coarse-grained**. Still interesting?

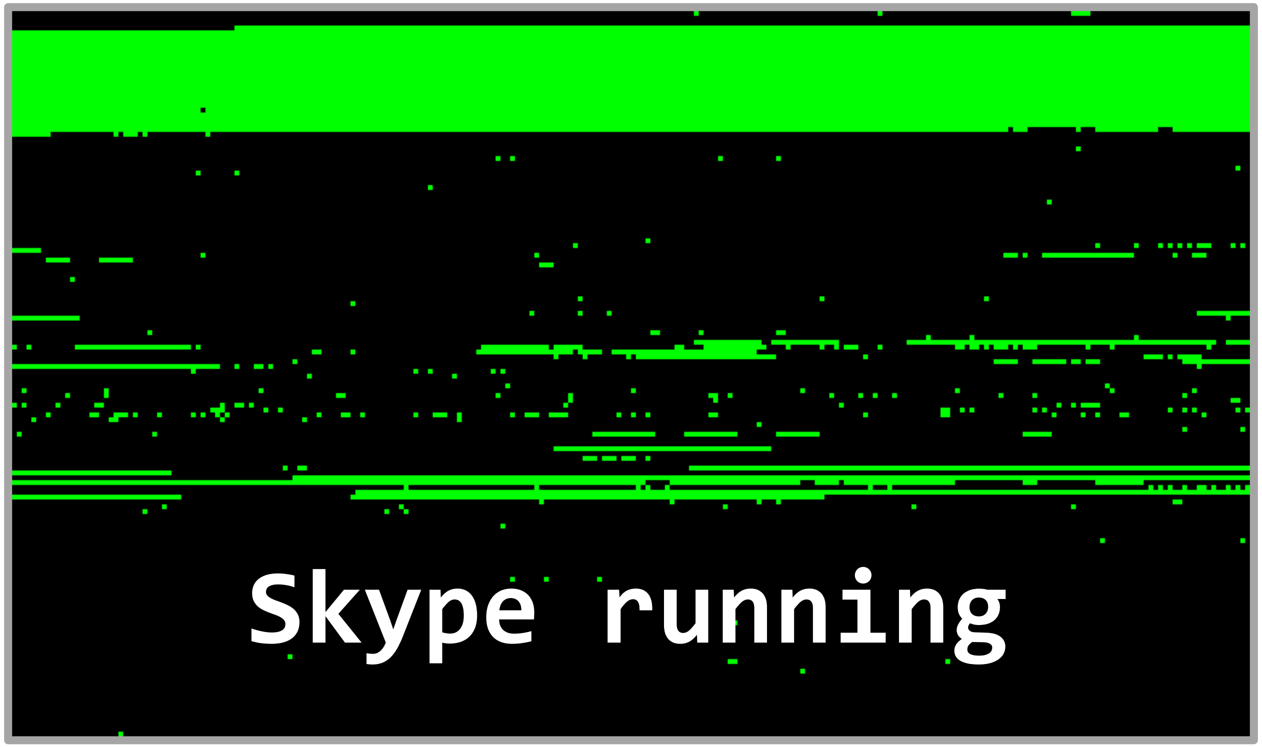
Is user running software X?



Memory Deduplication: Side-channel Leaks

Very **coarse-grained**. Still interesting?

Is user running software X?



Memory Deduplication: Software Exploitation

For software exploitation, 1 bit won’t really cut it (e.g., need to leak 64-bit pointers for MS Edge)

“Can we generalize this to leaking ***arbitrary data*** *like randomized pointers or passwords?”*

Dedup Est Machina: Challenges

Challenge 1:

The secret we want to leak does not span an entire memory page

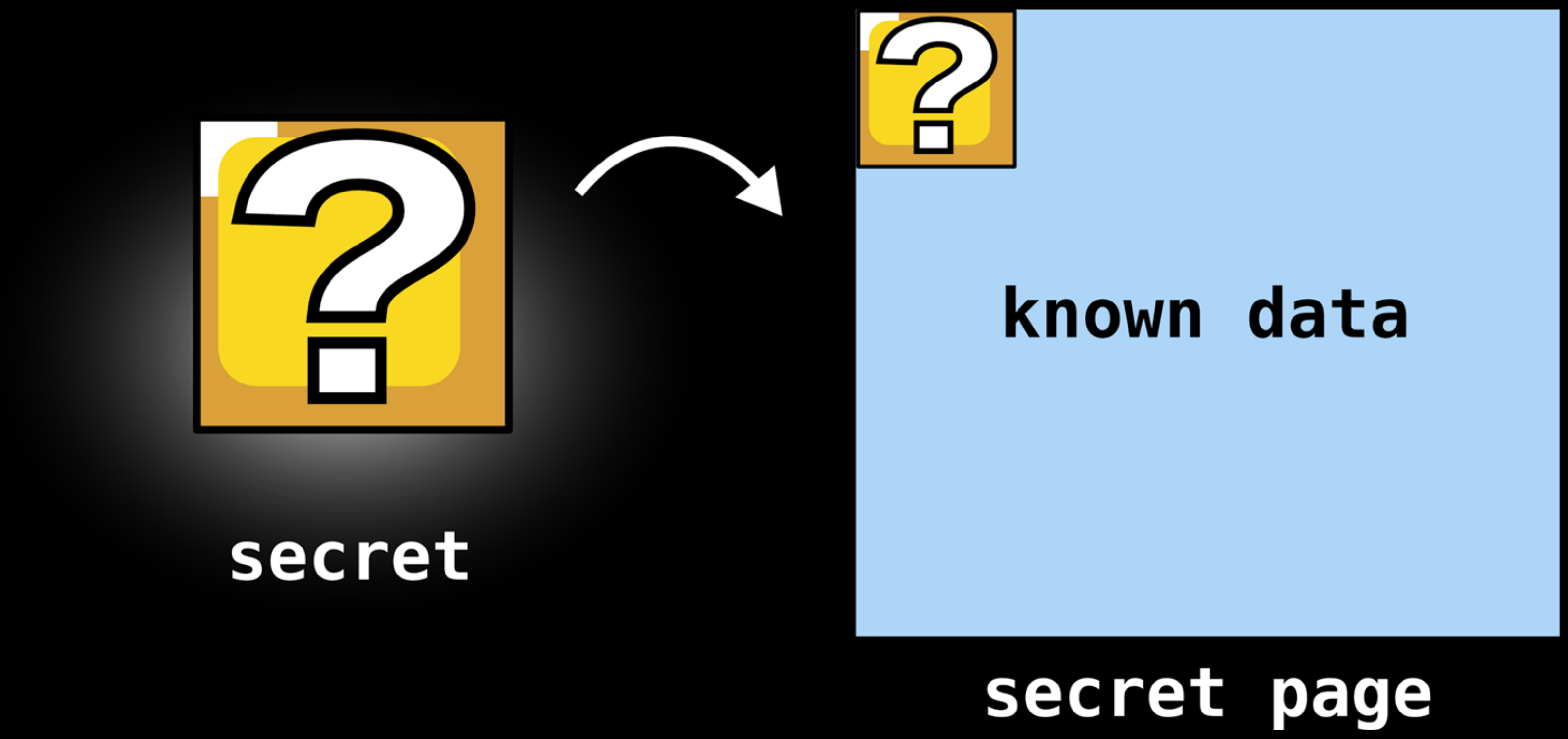
Dedup Est Machina: Challenges

Turning a secret into a page

secret

Dedup Est Machina: Challenges

Turning a secret into a page



Dedup Est Machina: Challenges

Challenge 2:

The secret to leak has too much entropy to leak it all at once

Dedup Est Machina: Challenges

Challenge 2:

The secret to leak has too much entropy to leak it all at once

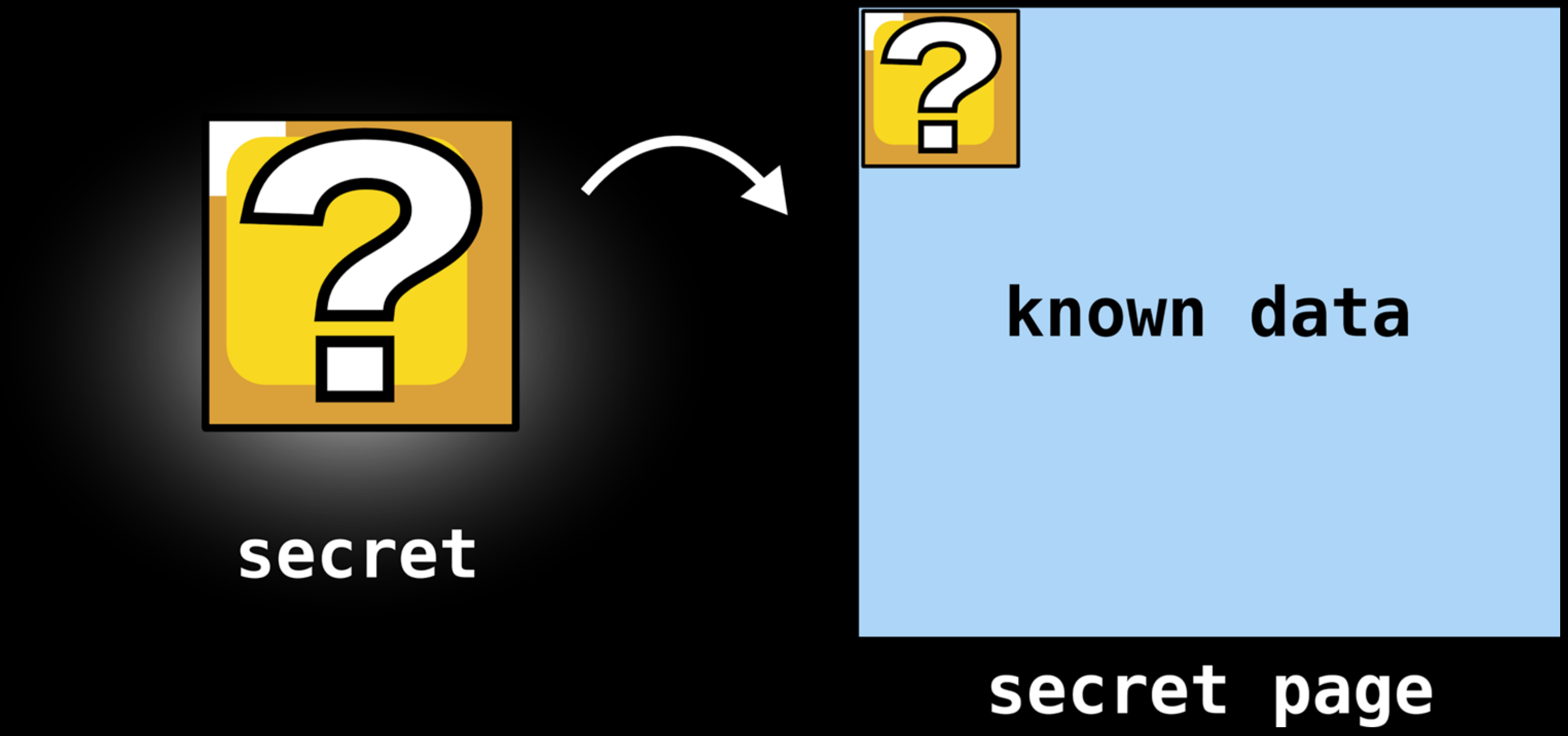
Primitive #1

Primitive #2

Primitive #3

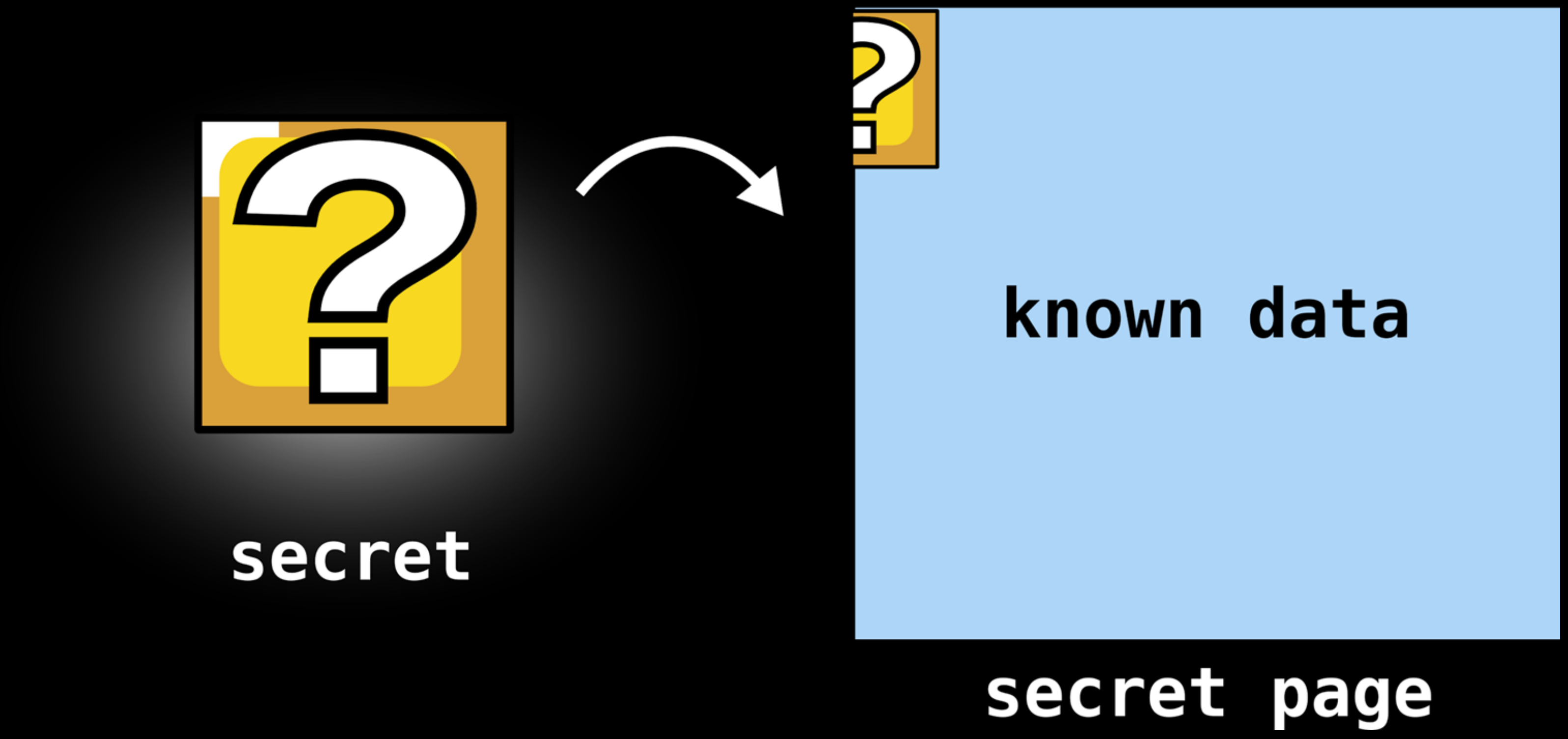
Dedup Est Machina: Primitives

Primitive #1: Alignment Probing



Dedup Est Machina: Primitives

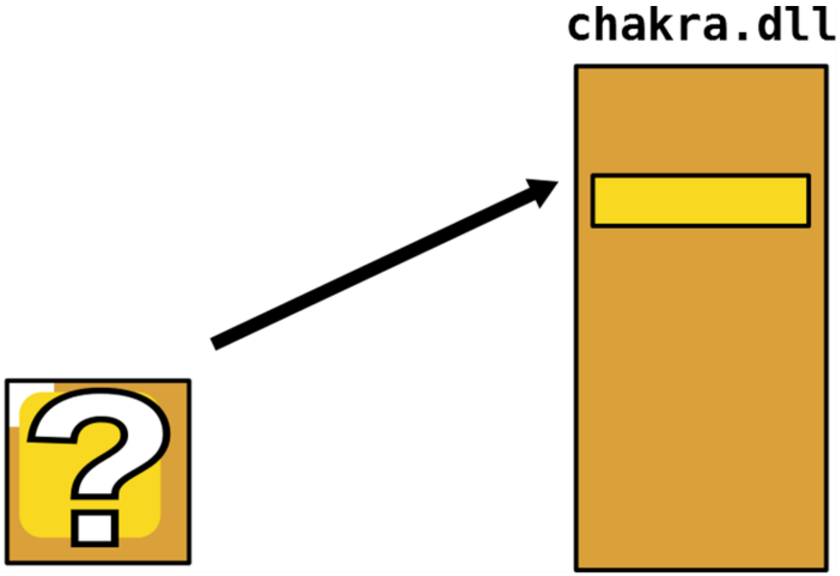
Primitive #1: Alignment Probing



Dedup Est Machina: Overview

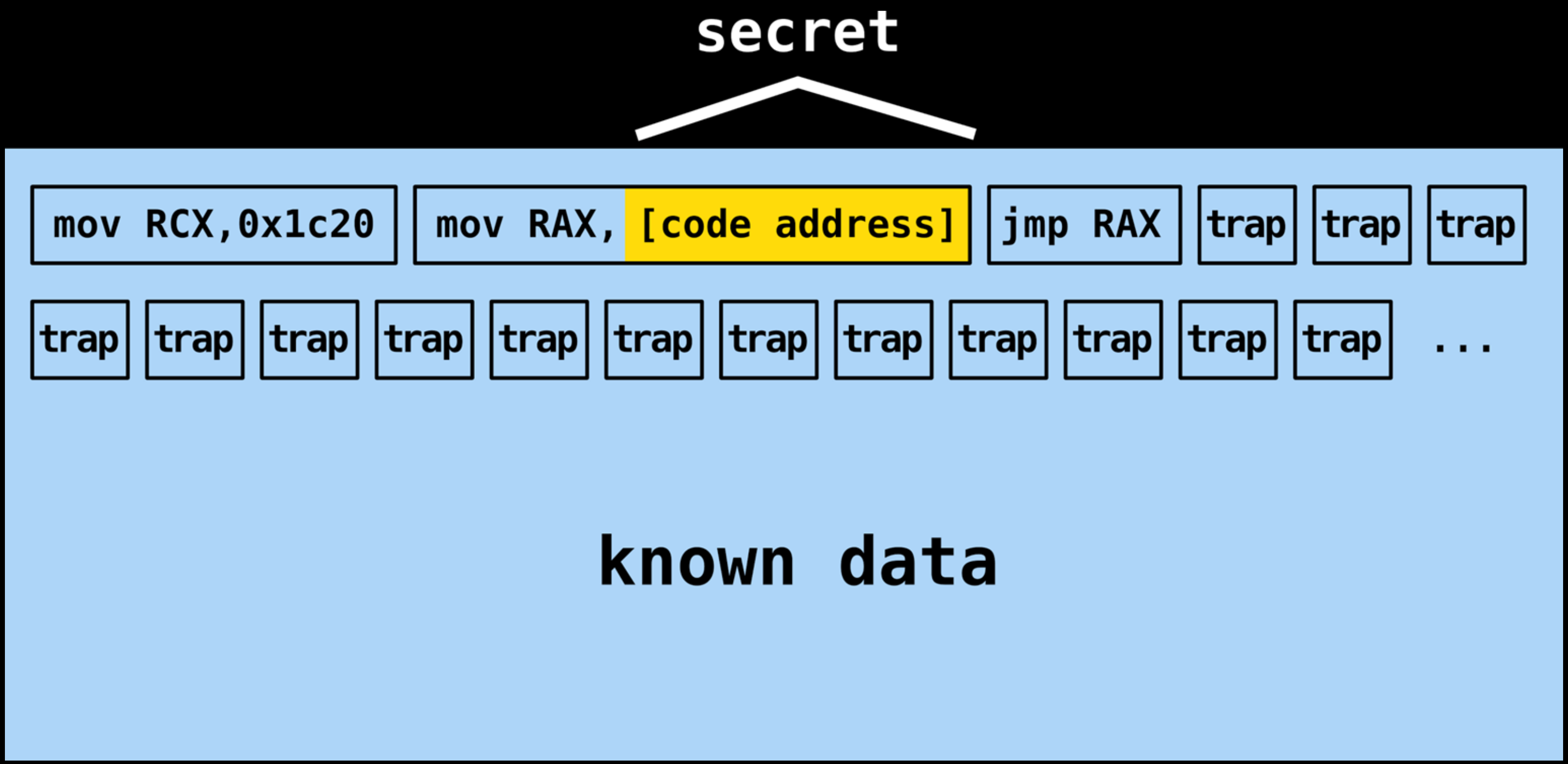
Memory deduplication

Leak randomized heap and code pointers



Dedup Est Machina: Leaking Code Pointer (#1)

JIT Function Epilogue in MS Edge



secret

mov RCX,0x1c20

mov RAX, [code address]

jmp RAX

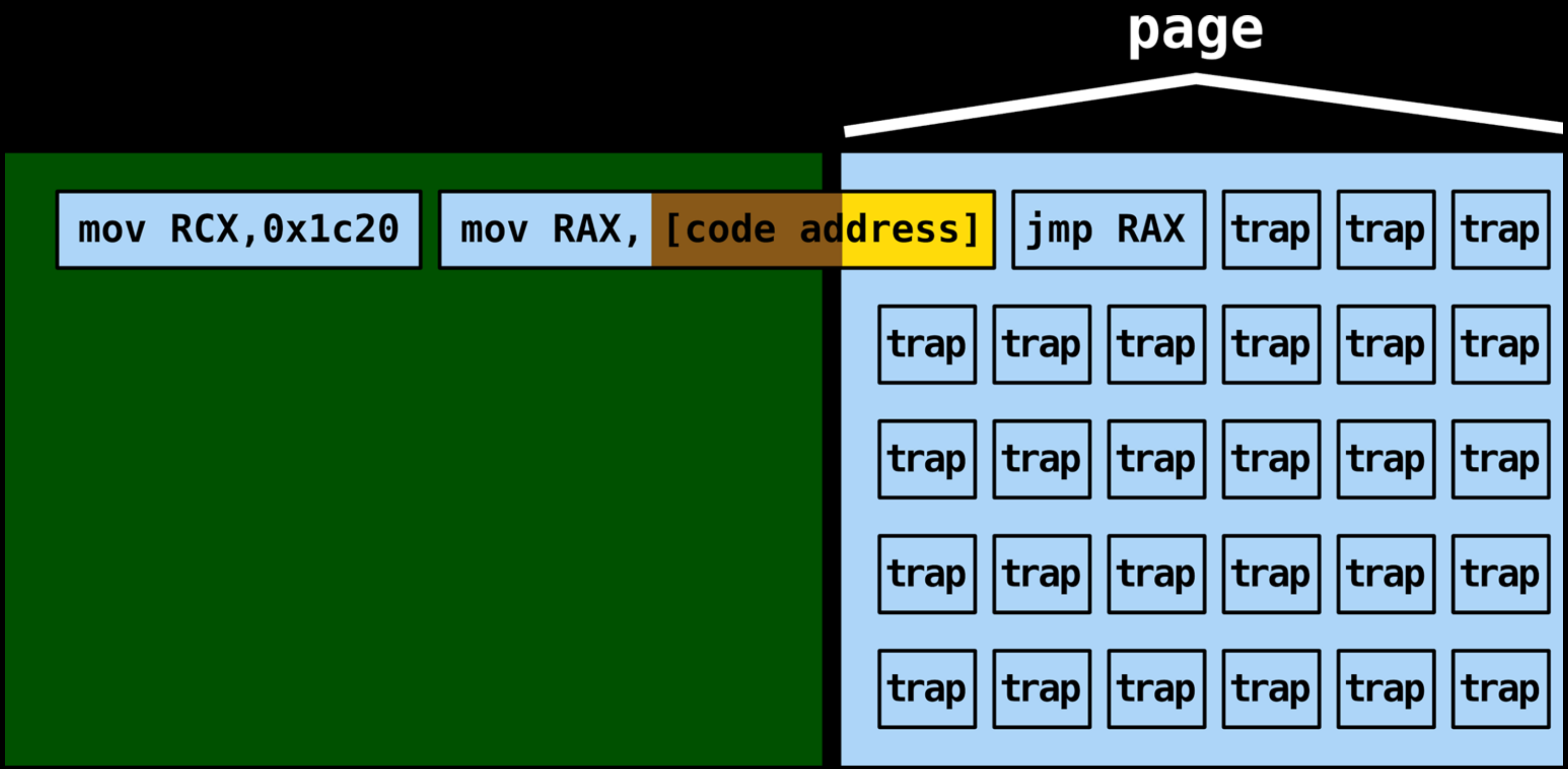
trap trap trap

trap trap trap trap trap trap trap trap trap trap trap trap ...

known data

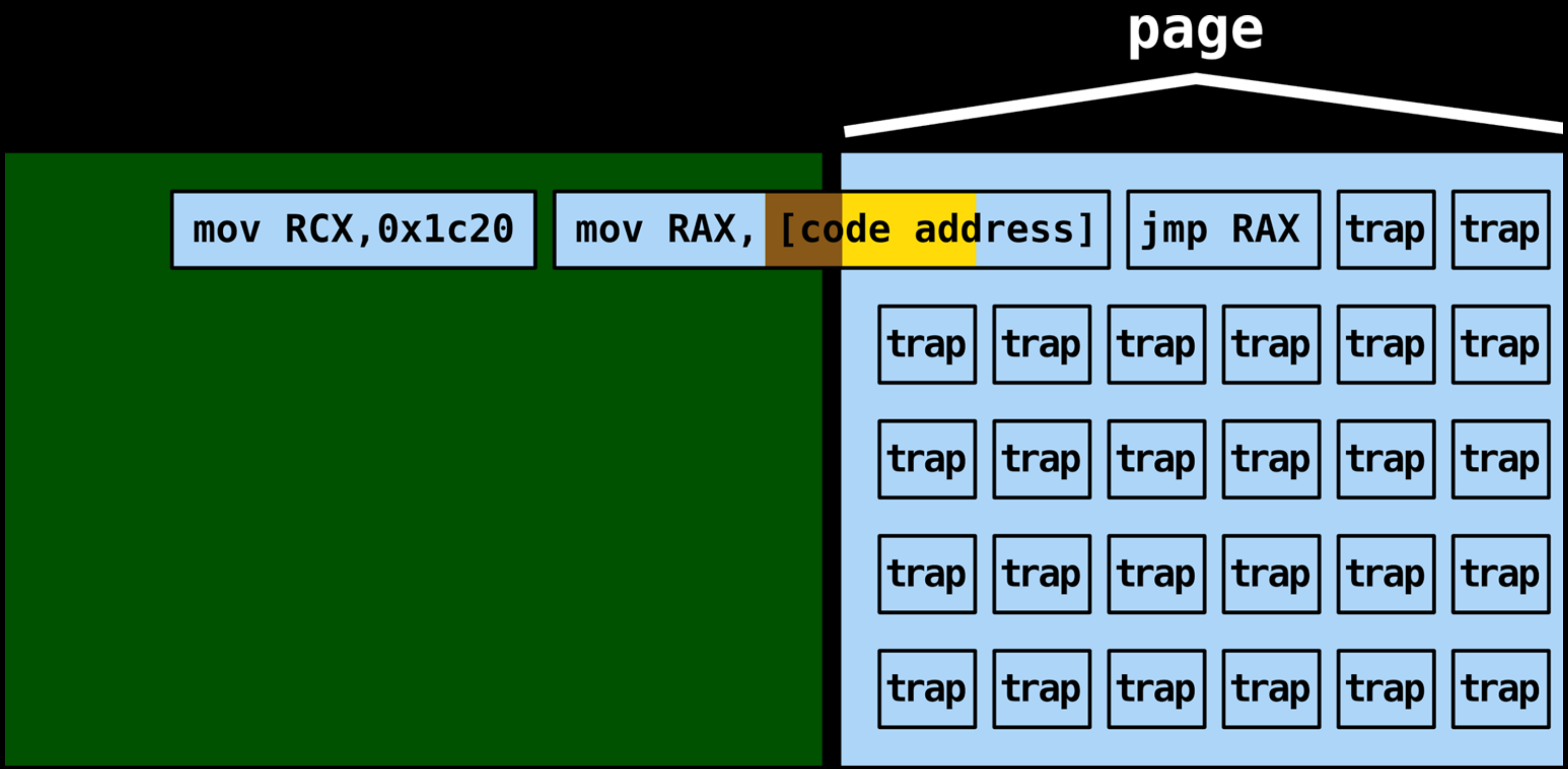
Dedup Est Machina: Leaking Code Pointer (#1)

JIT Function Epilogue in MS Edge



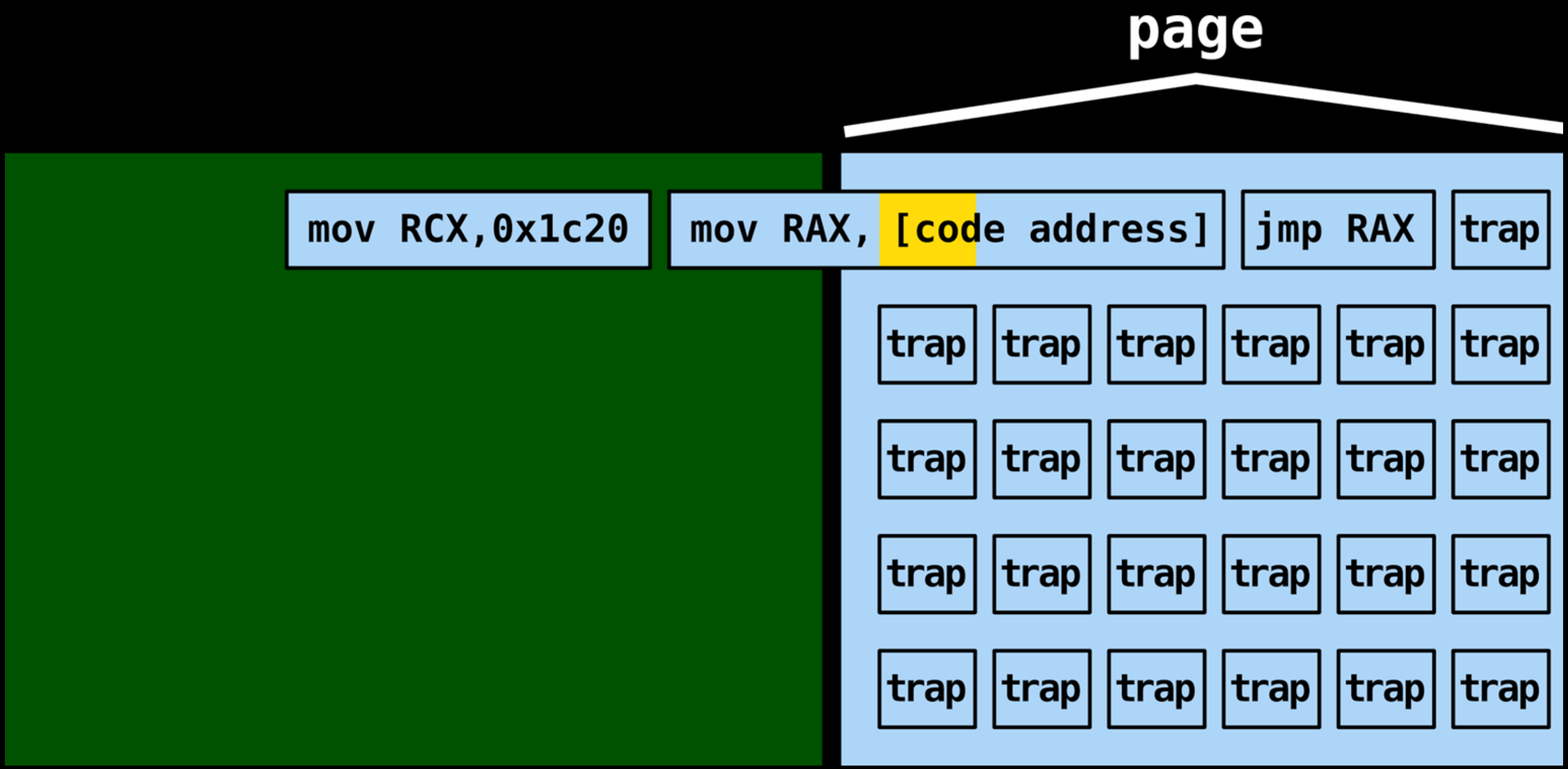
Dedup Est Machina: Leaking Code Pointer (#1)

JIT Function Epilogue in MS Edge



Dedup Est Machina: Leaking Code Pointer (#1)

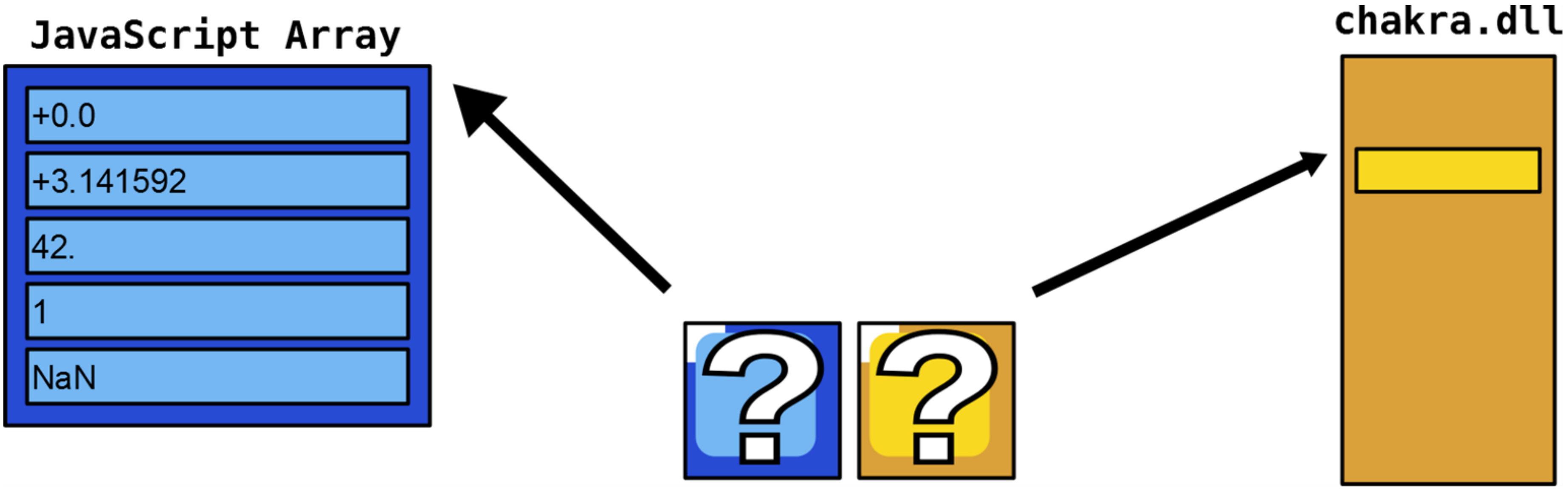
JIT Function Epilogue in MS Edge



Dedup Est Machina: Overview

Memory deduplication

Leak randomized heap and code pointers



Dedup Est Machina: Leaking Heap Pointer

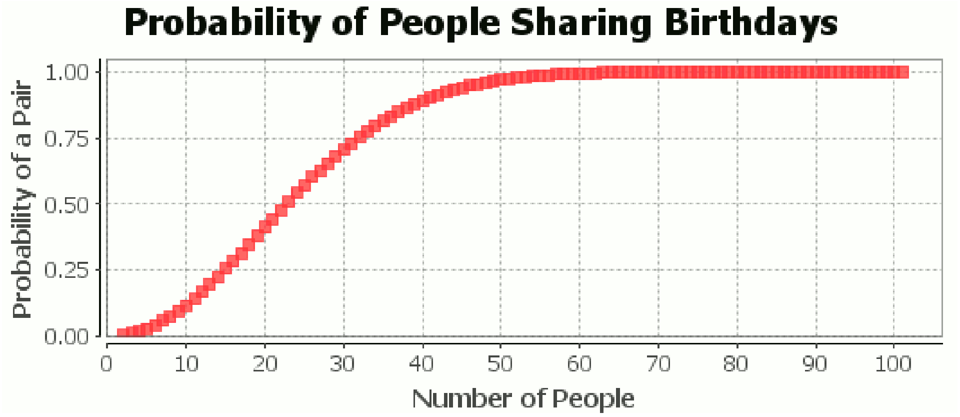
- Heap pointers are word aligned
  - Alignment probing won’t cut it, same for primitive #2

- Time for primitive #3!

“How do we leak a heap pointer if we can only leak the secret ***all at once****?”*

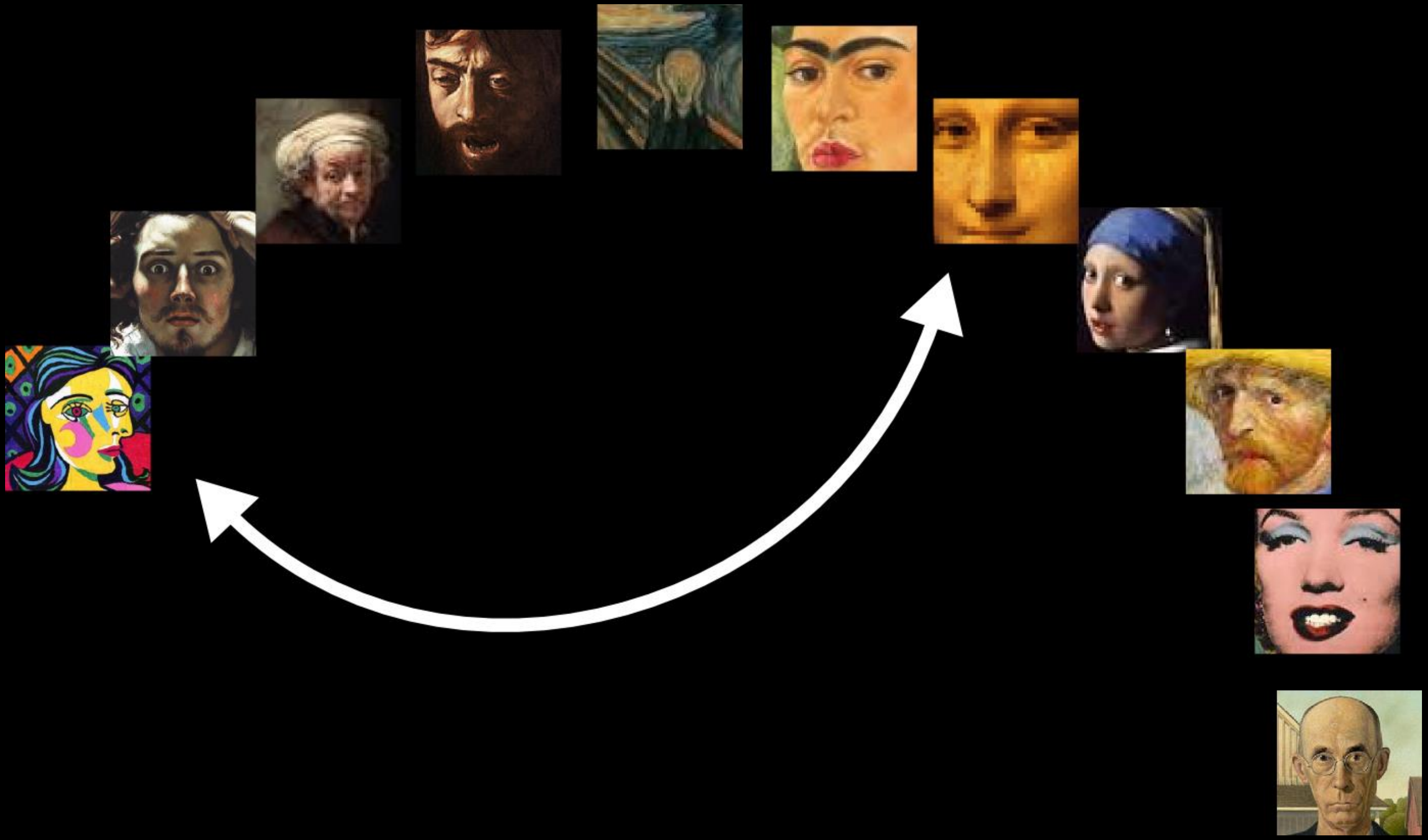
Dedup Est Machina: Birthday Paradox

Only 23 people for a 50% same-birthday chance

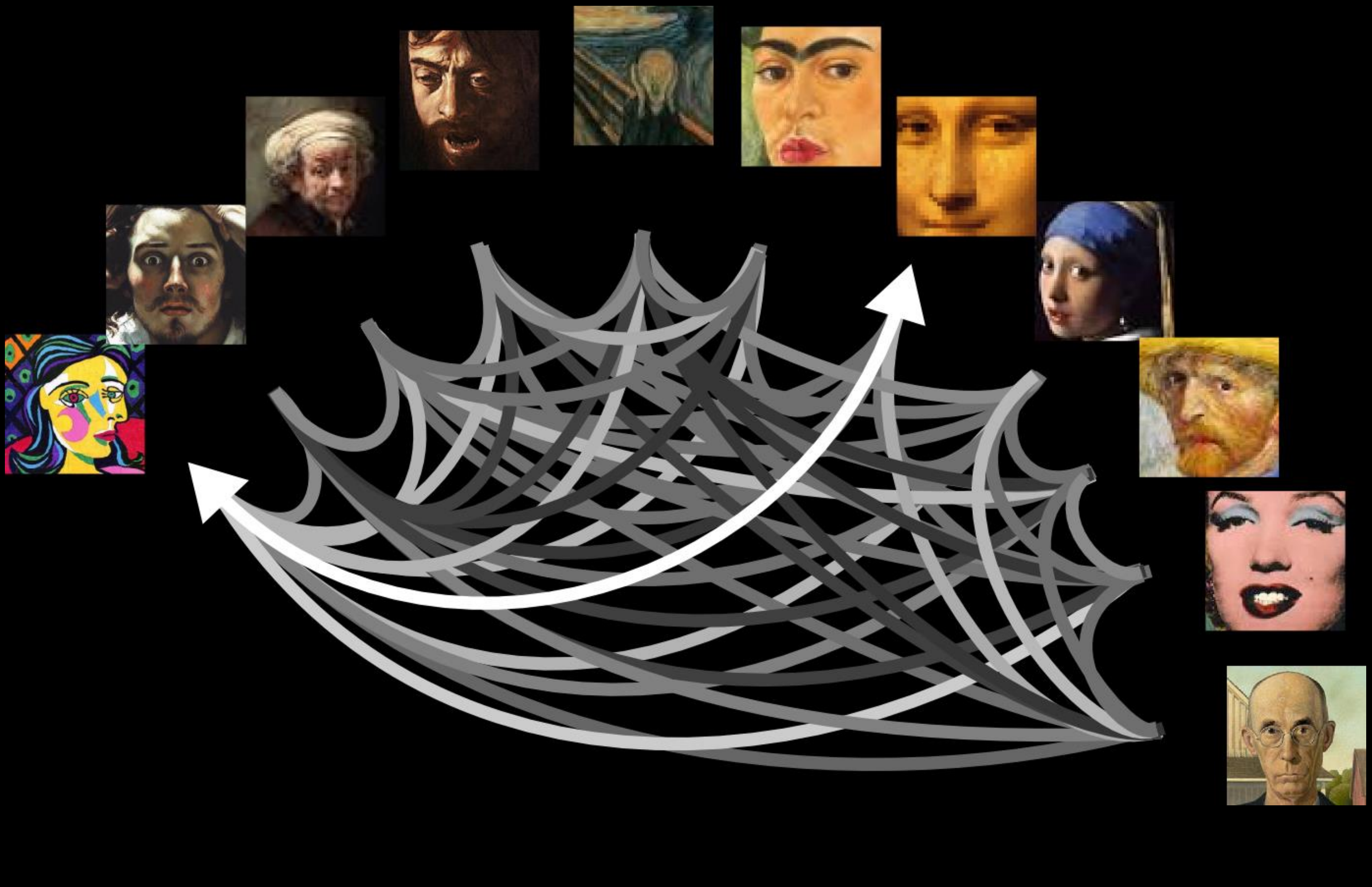


You compare everyone with everyone else → **Any match suffices!**

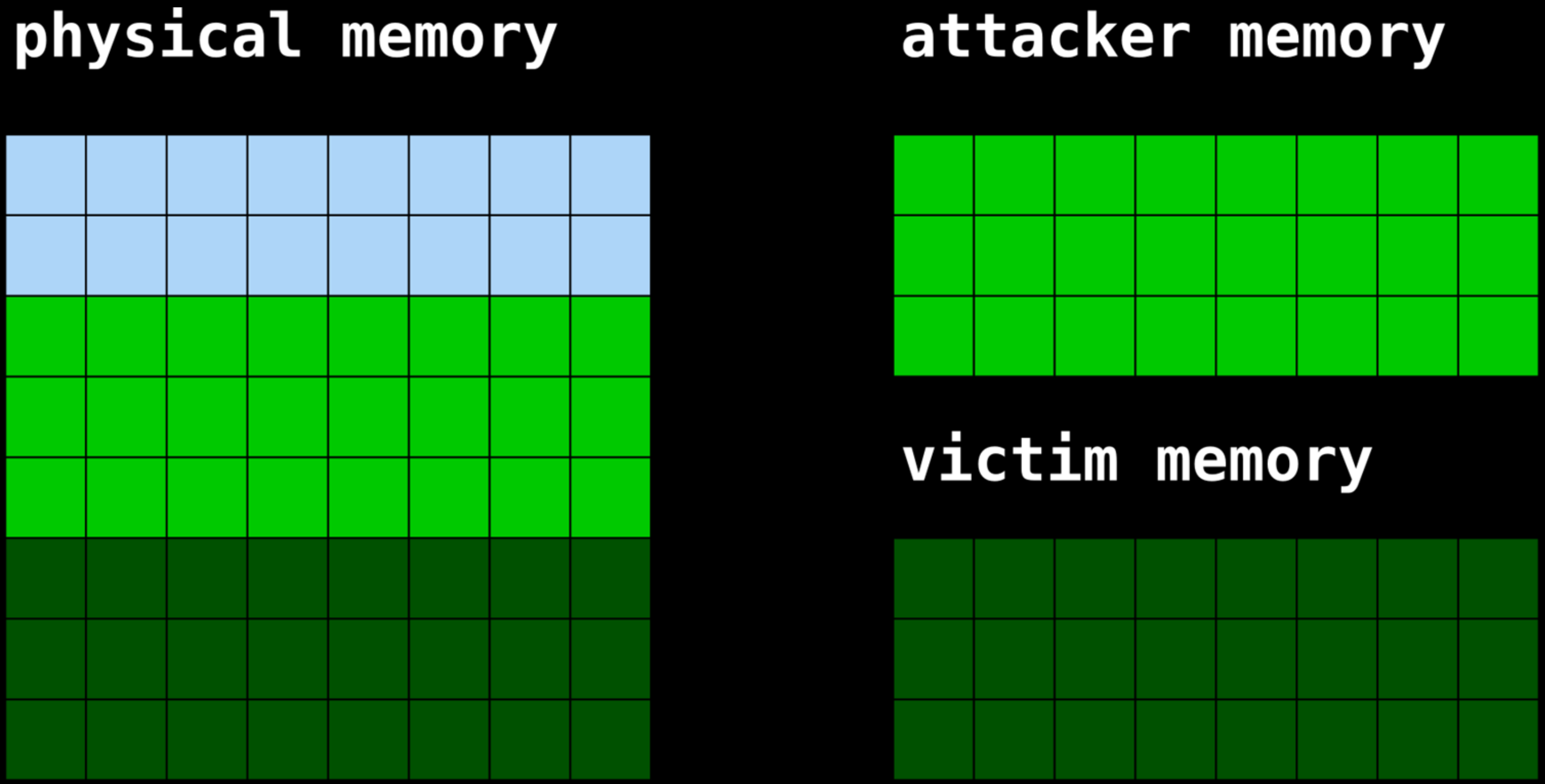
Dedup Est Machina: Birthday Paradox



Dedup Est Machina: Birthday Paradox



Primitive #3: Birthday Heapspray

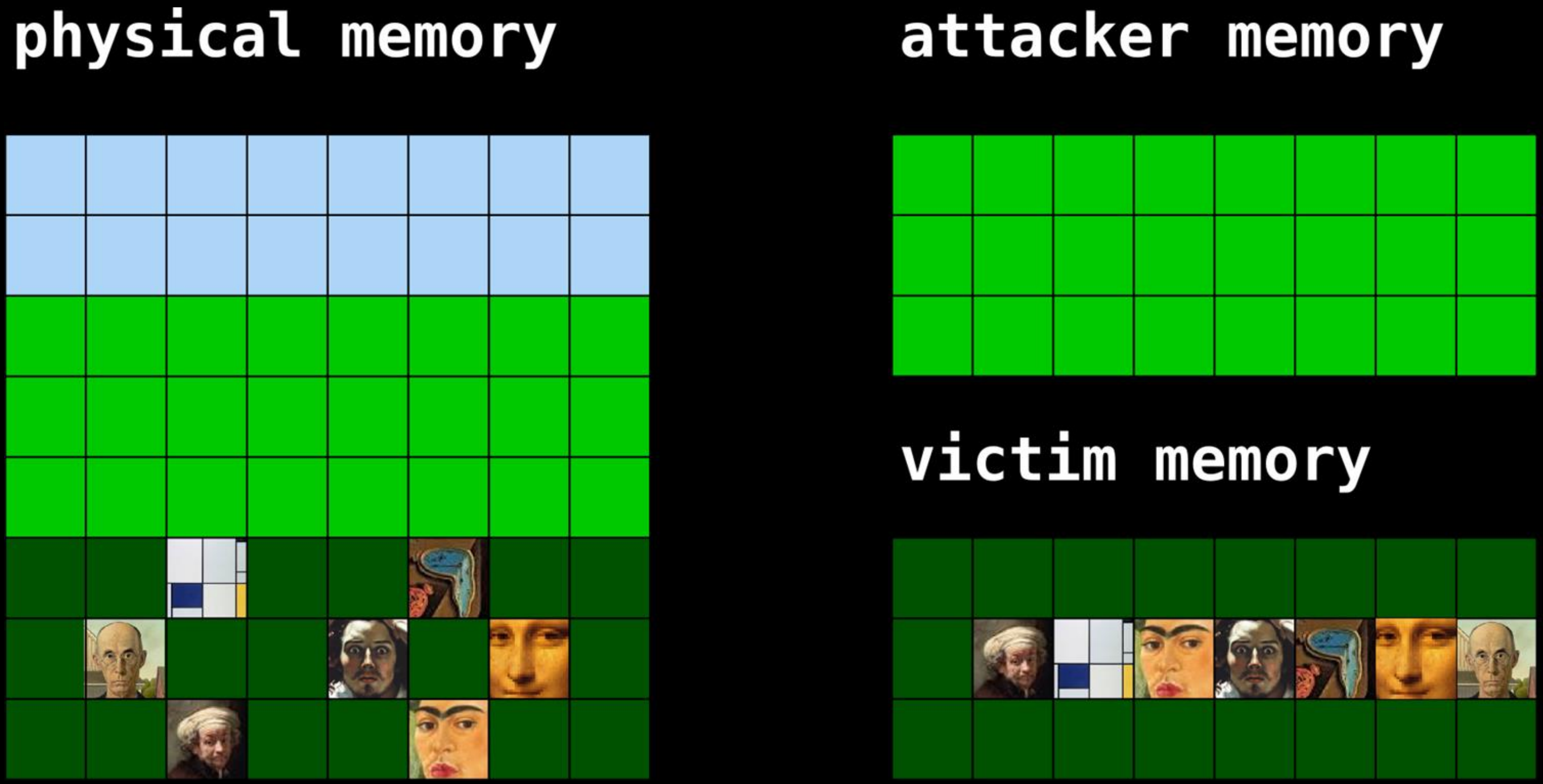


physical memory

attacker memory

victim memory

Primitive #3: Birthday Heapspray

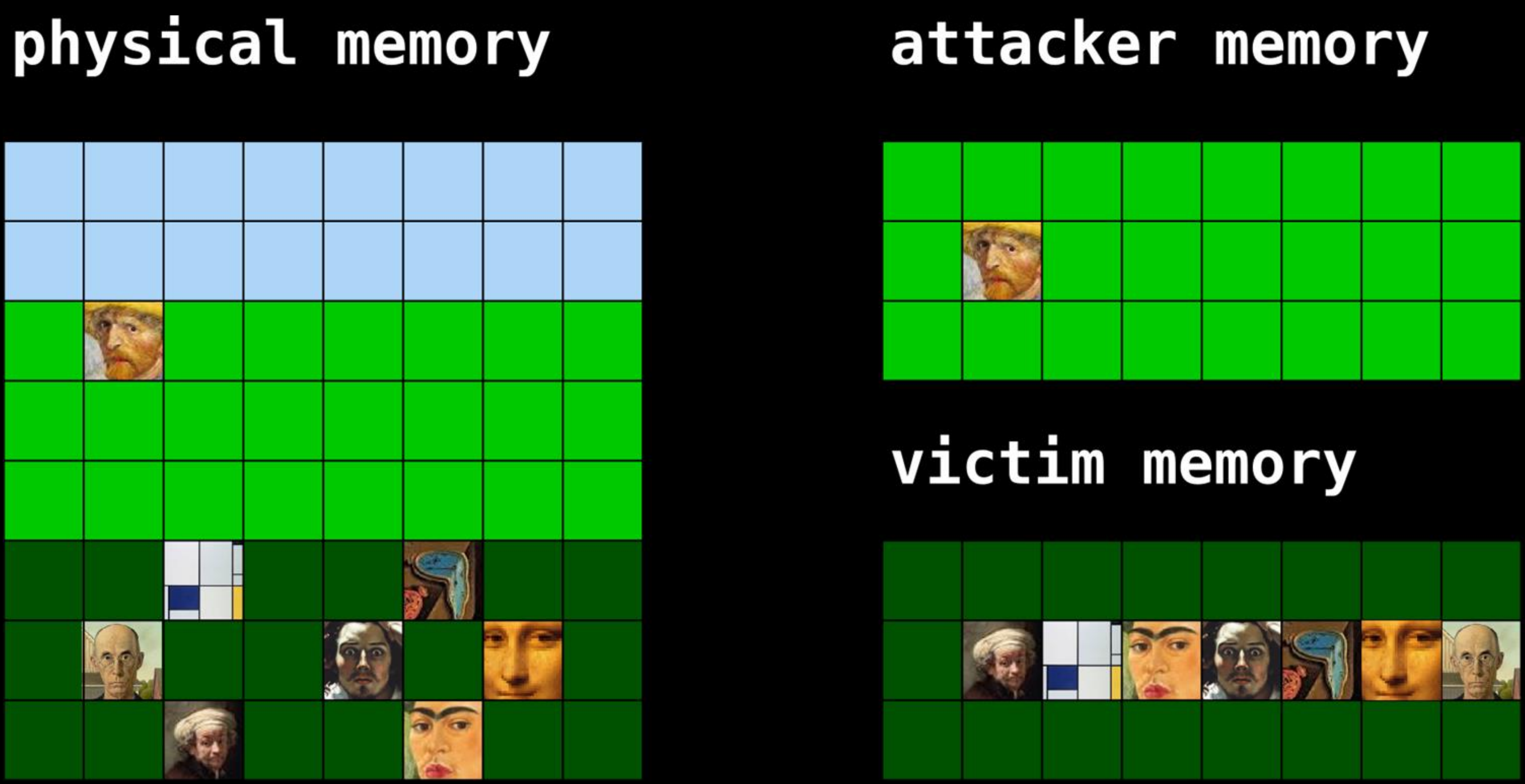


physical memory

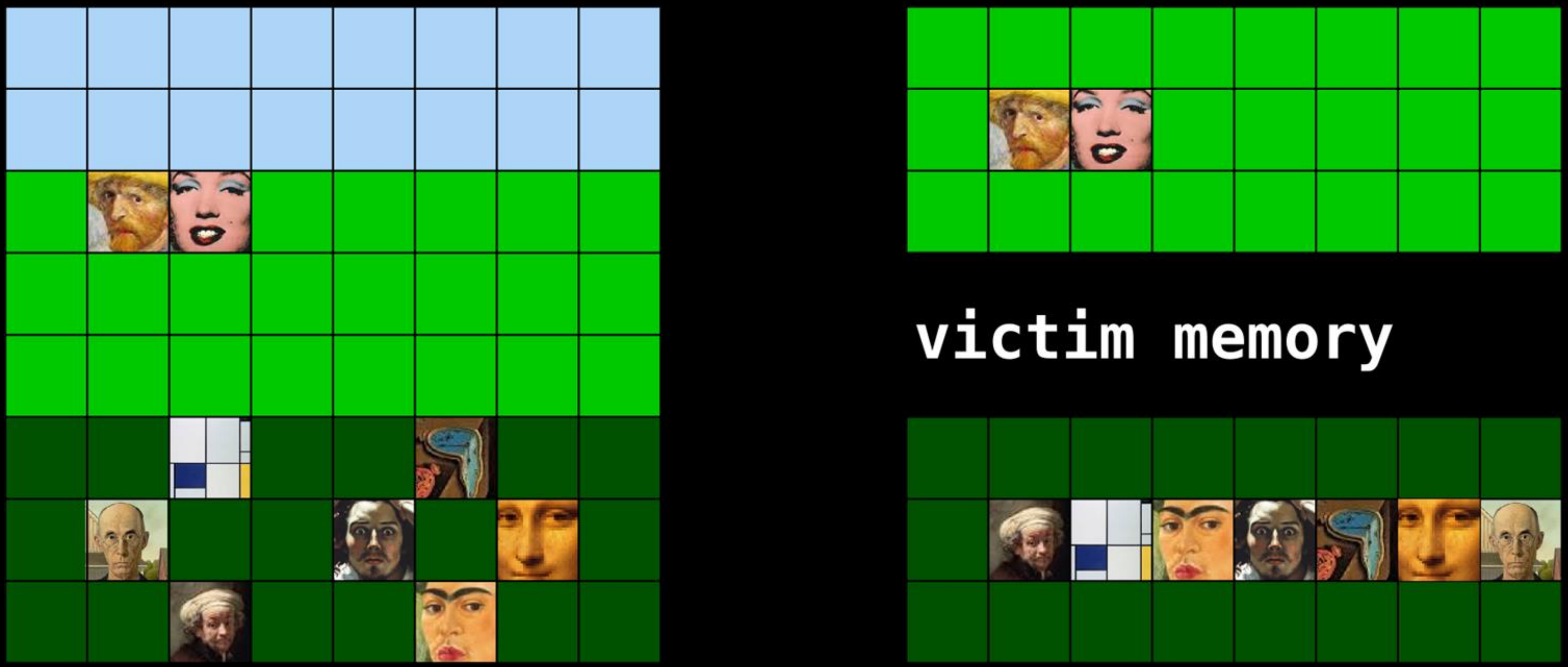
attacker memory

victim memory

Primitive #3:
Birthday Heapspray



Primitive #3: Birthday Heapspray



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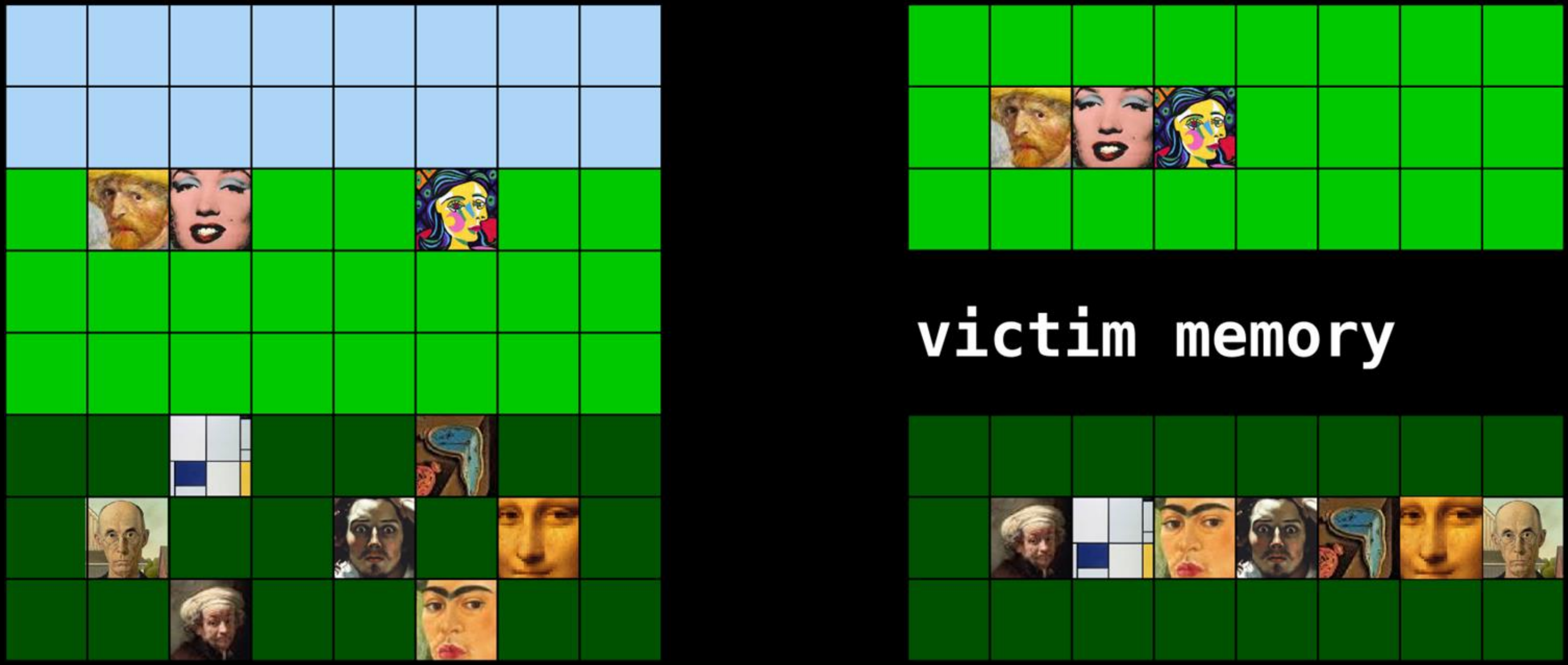
attacker memory

victim memory

Primitive #3:
Birthday Heapspray

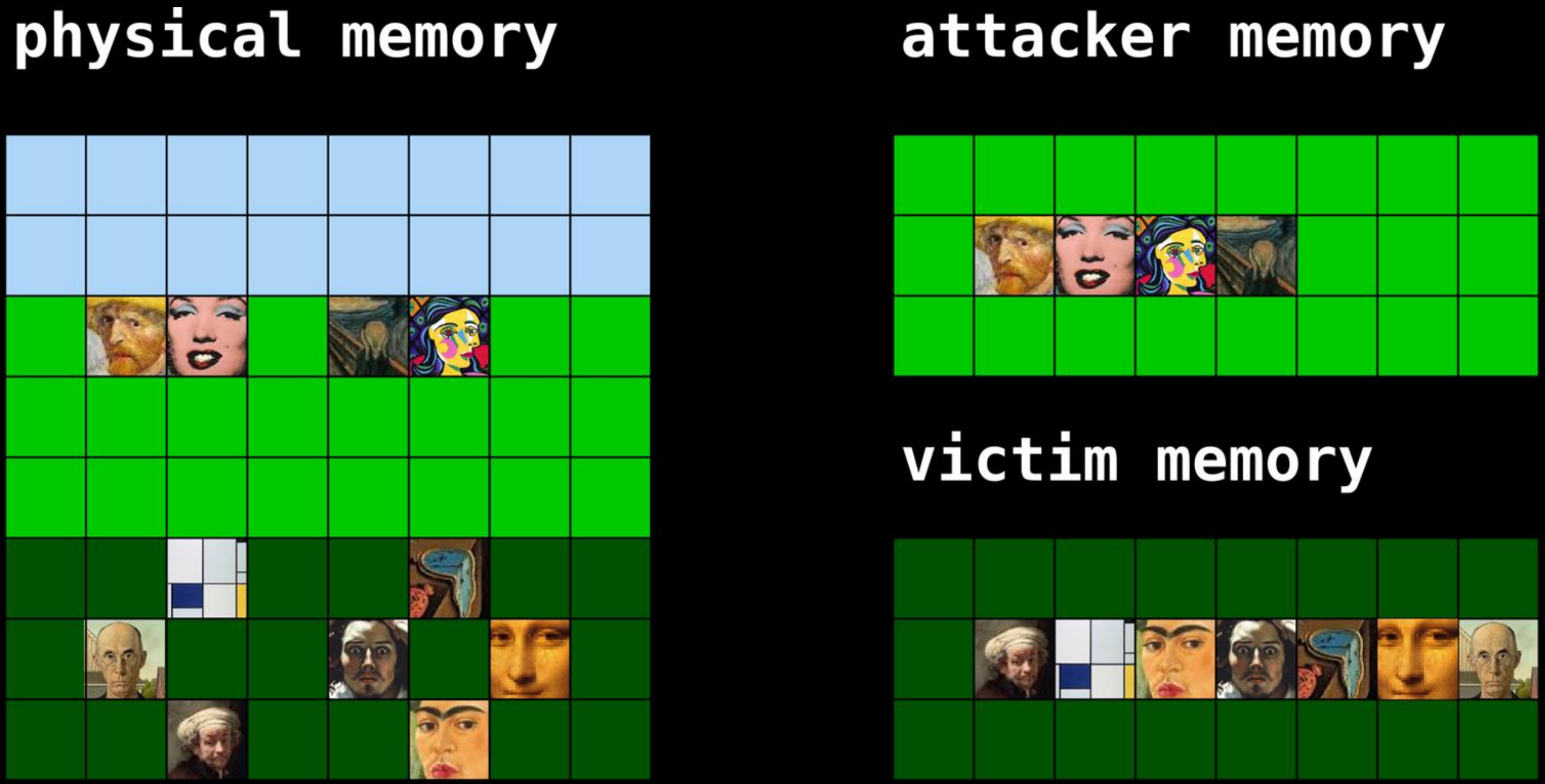


physical memory

attacker memory

victim memory

Primitive #3: Birthday Heapspray



Primitive #3:
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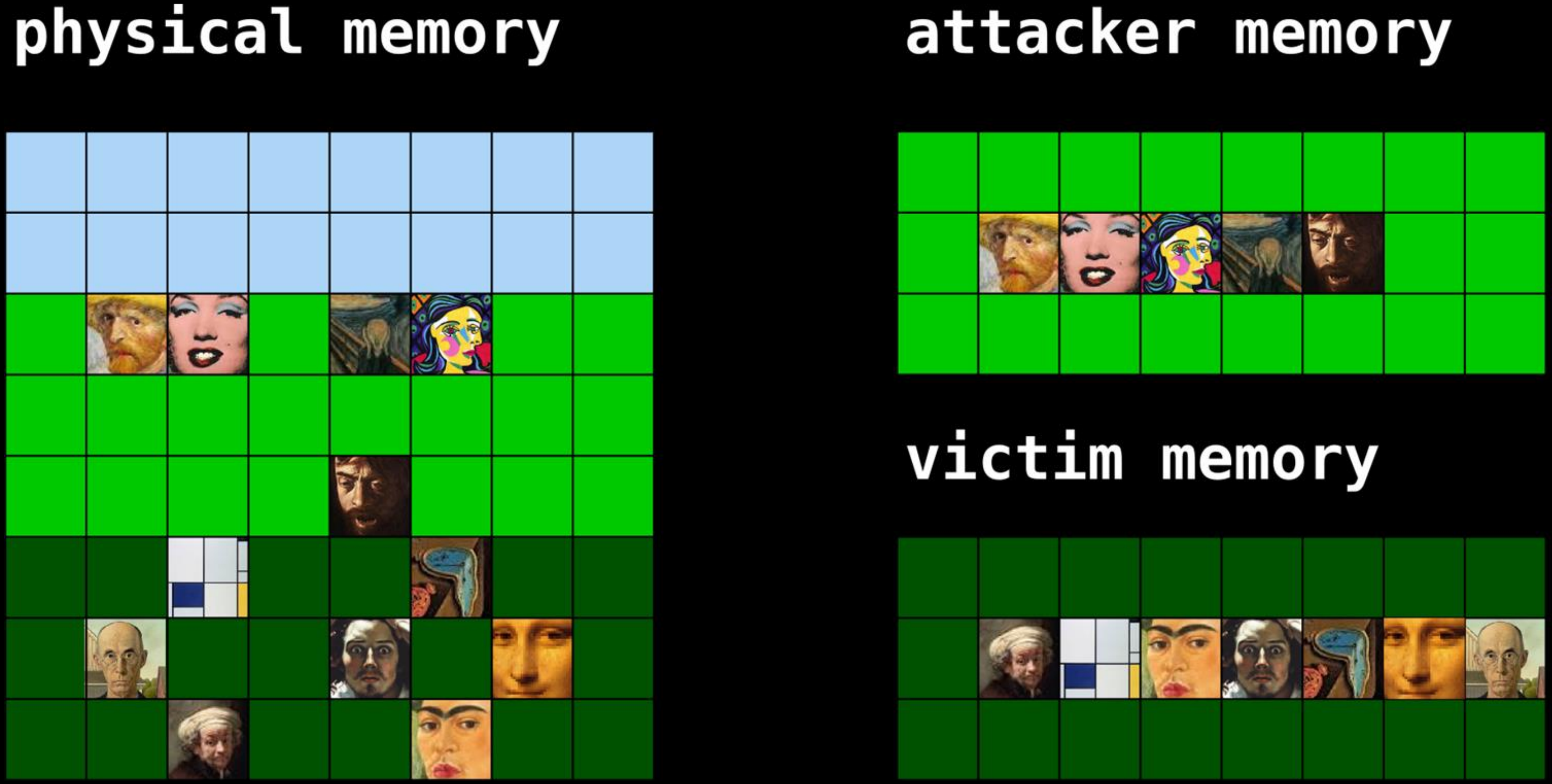

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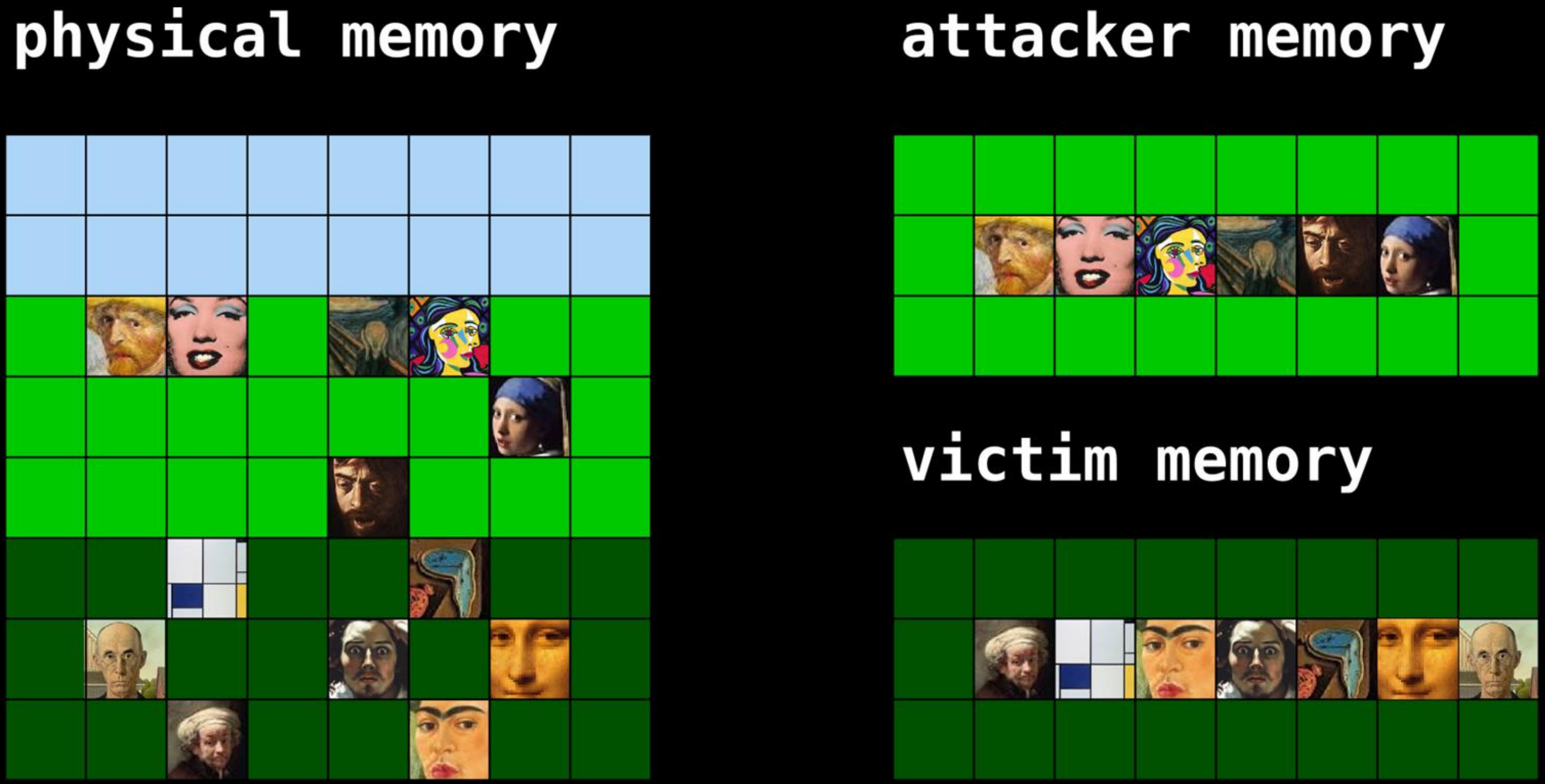

physical memory

attacker memory

victim memory

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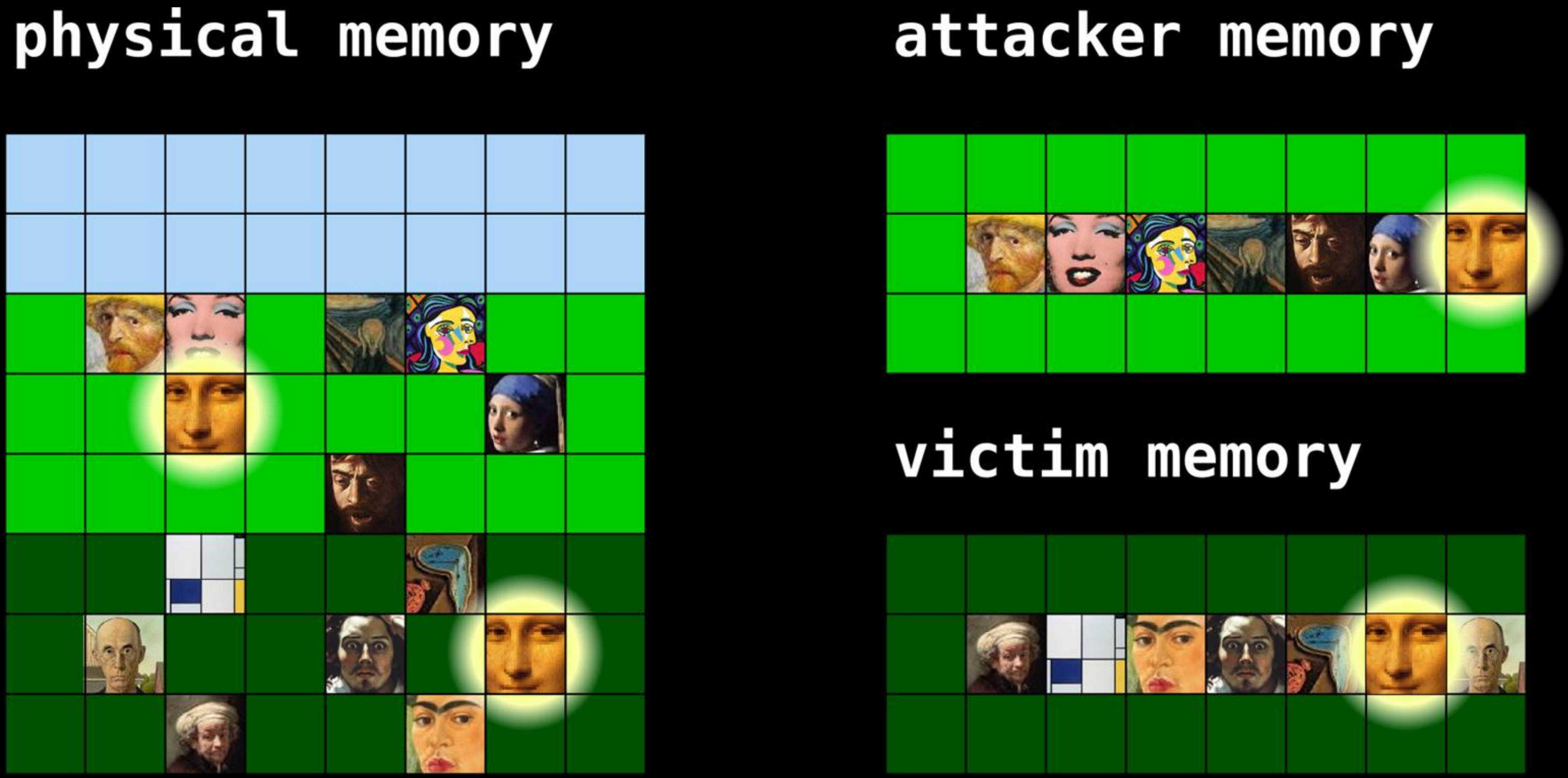
Birthday Heapspray

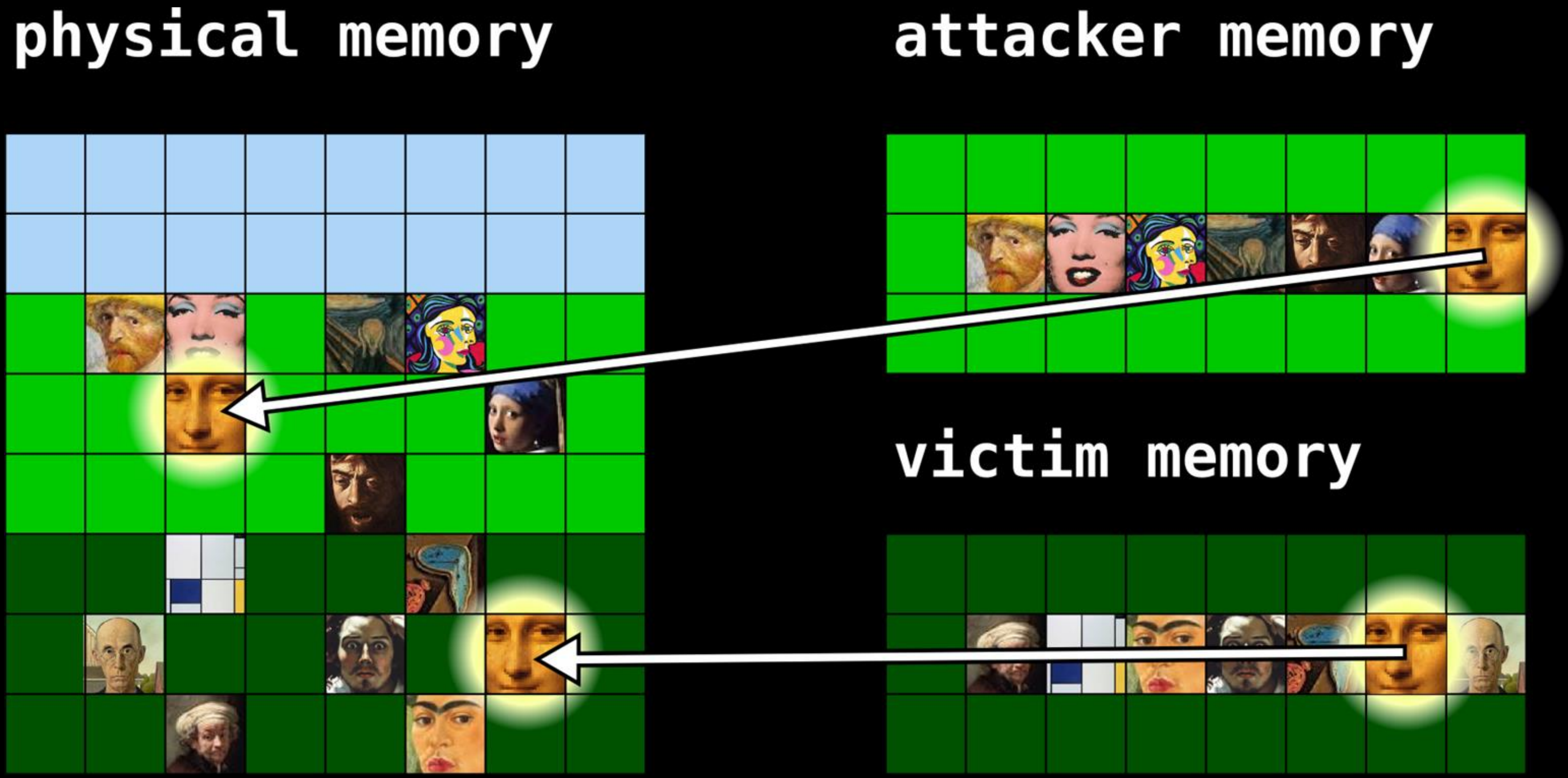


physical memory

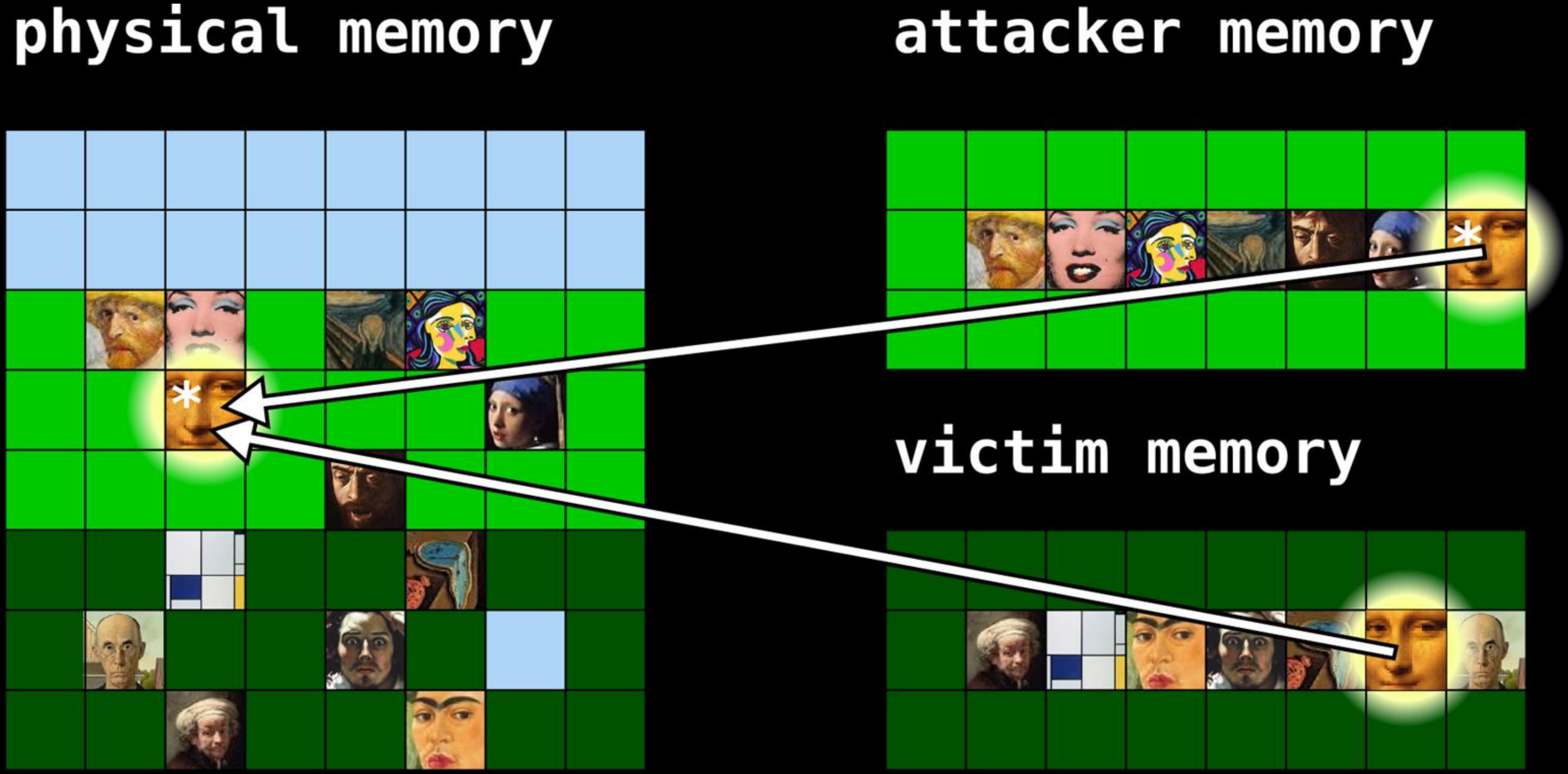
attacker memory

victim memory

Primitive #3: Birthday Heapspray

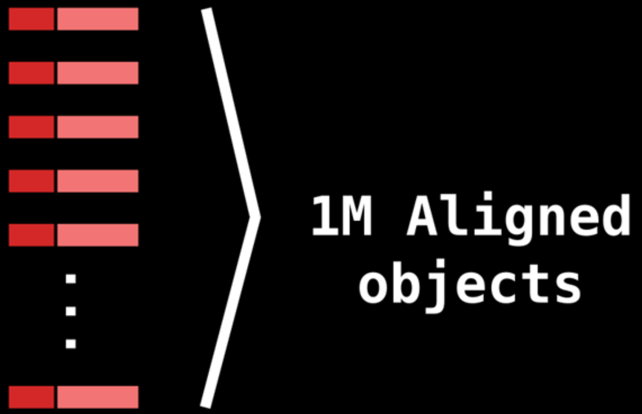


Primitive #3: Birthday Heapspray



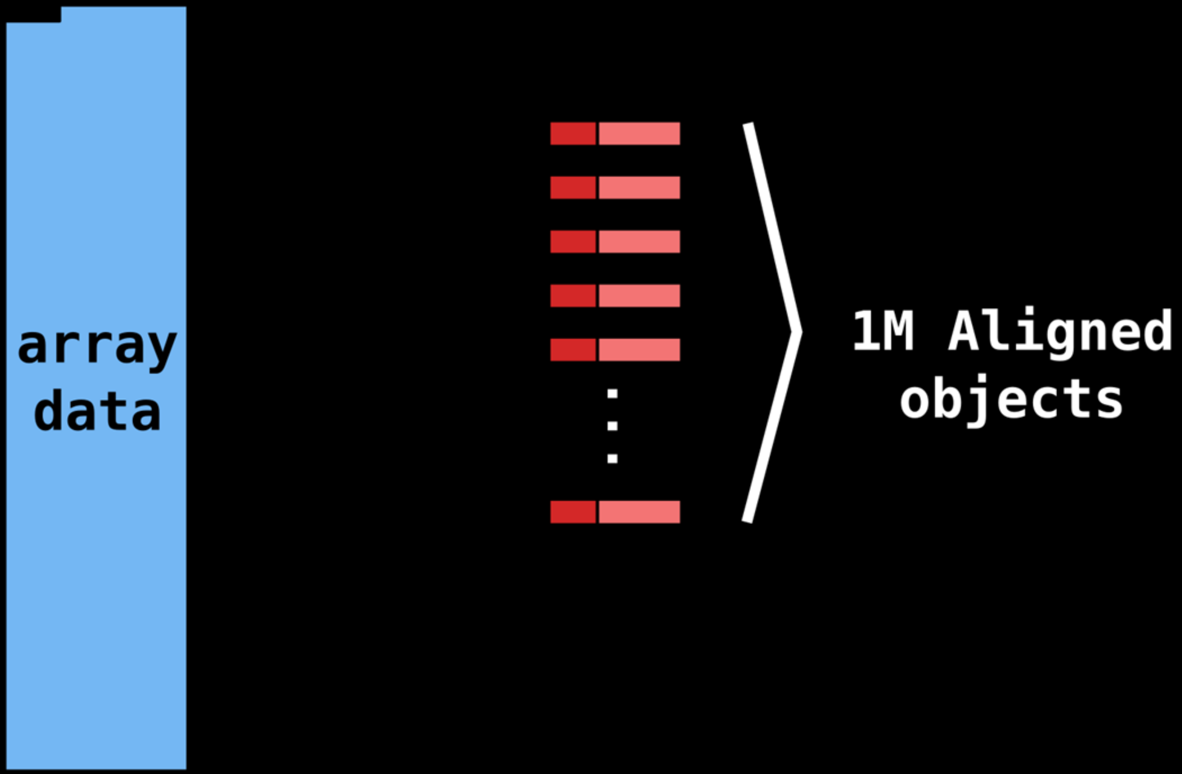
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Secret Pages



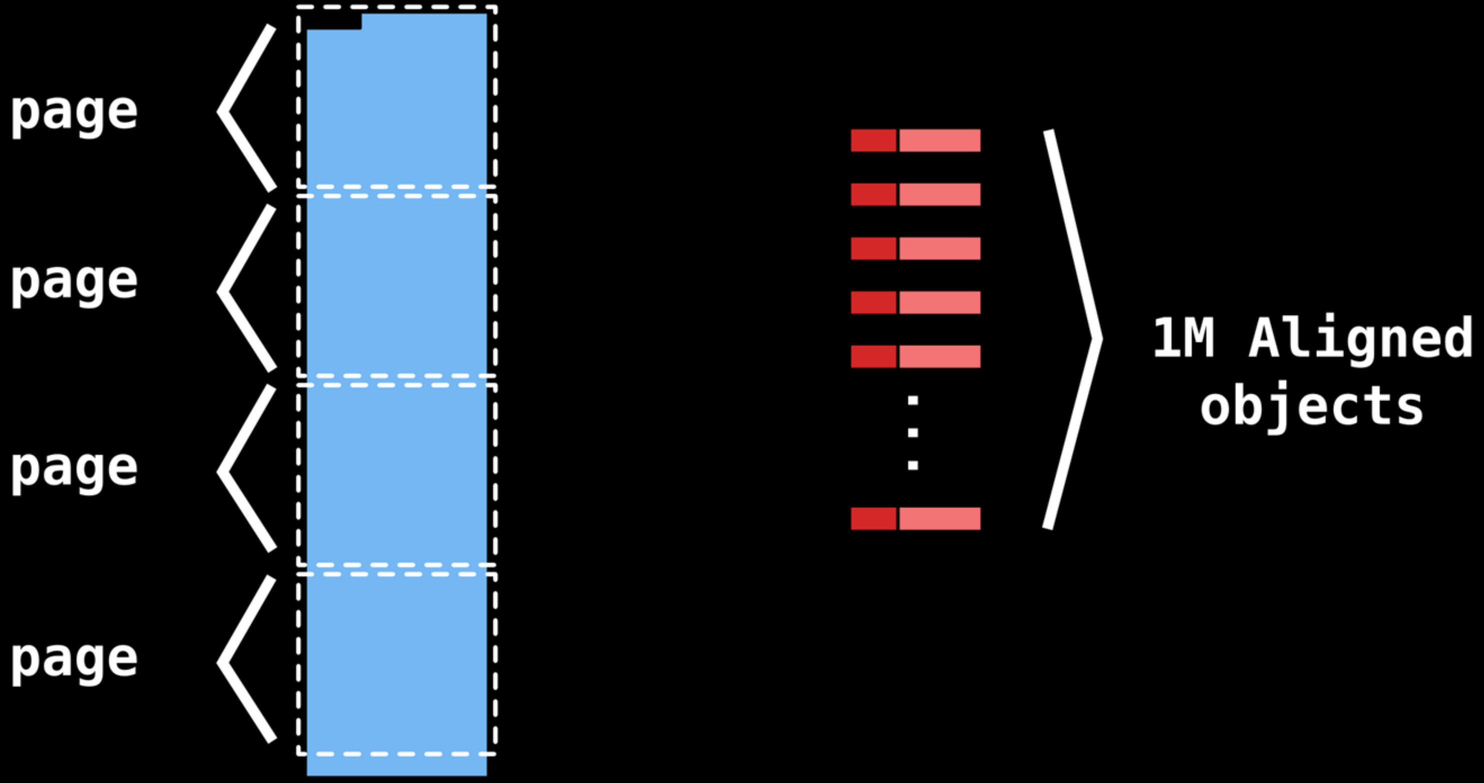
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Secret Pages



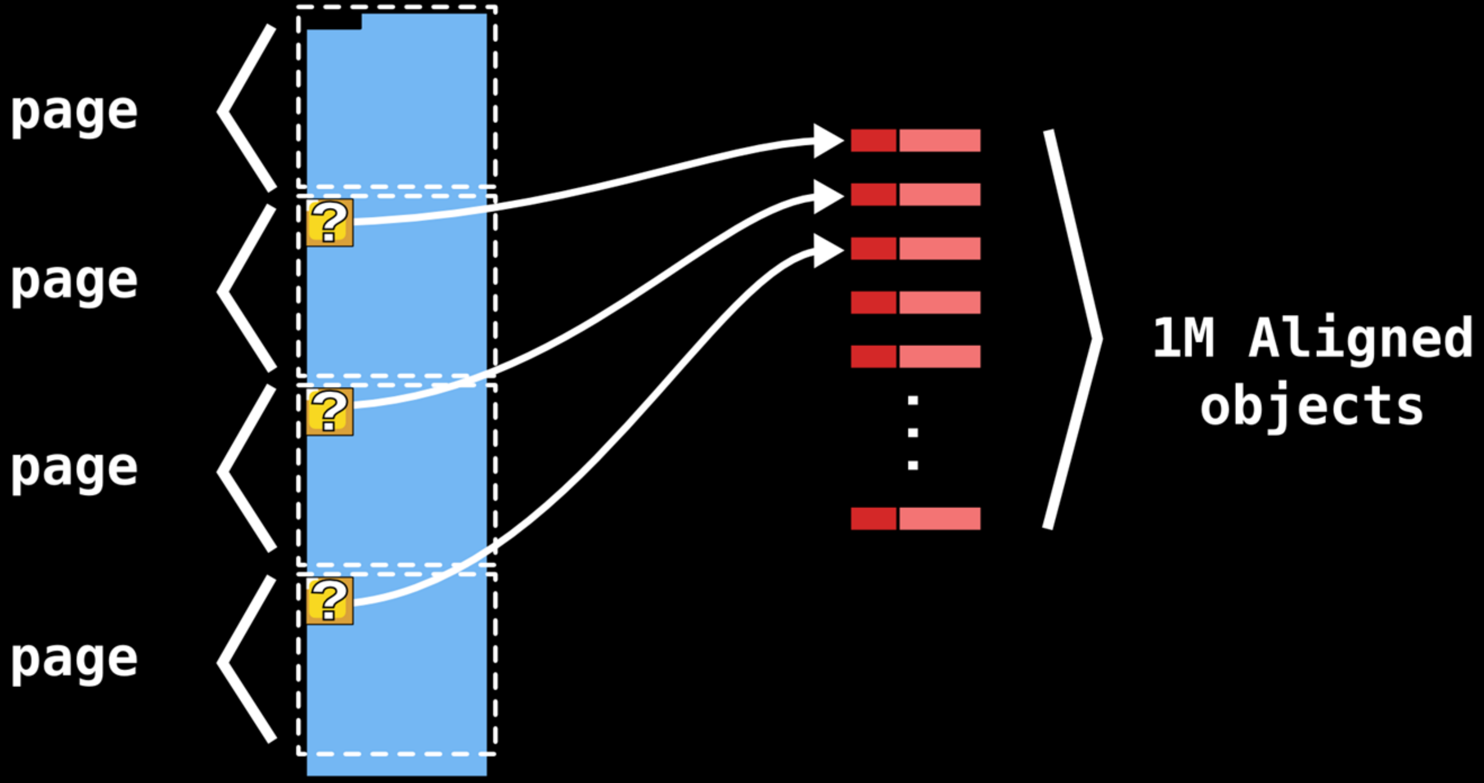
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Secret Pages



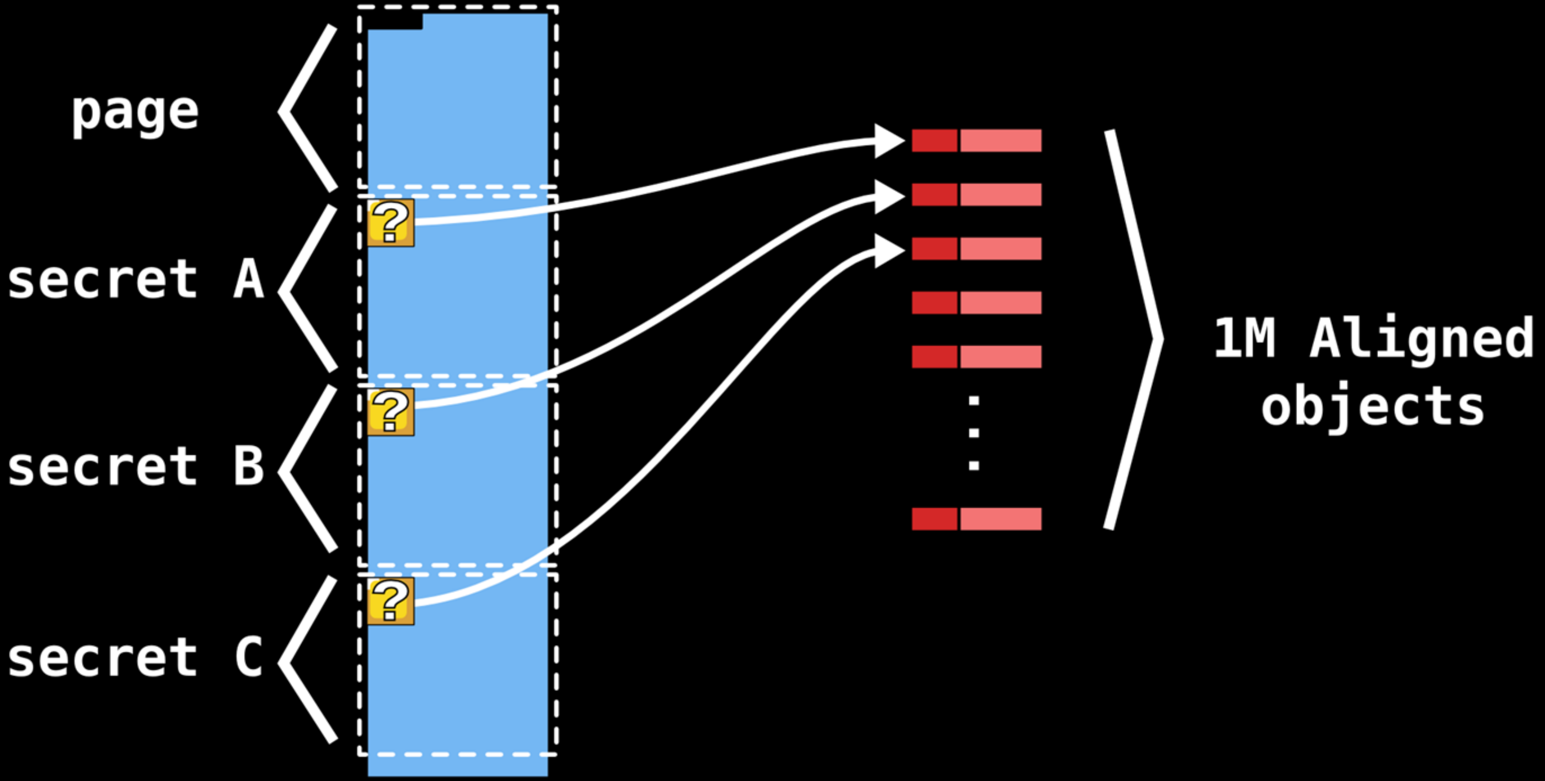
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Secret Pages



Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Secret Pages



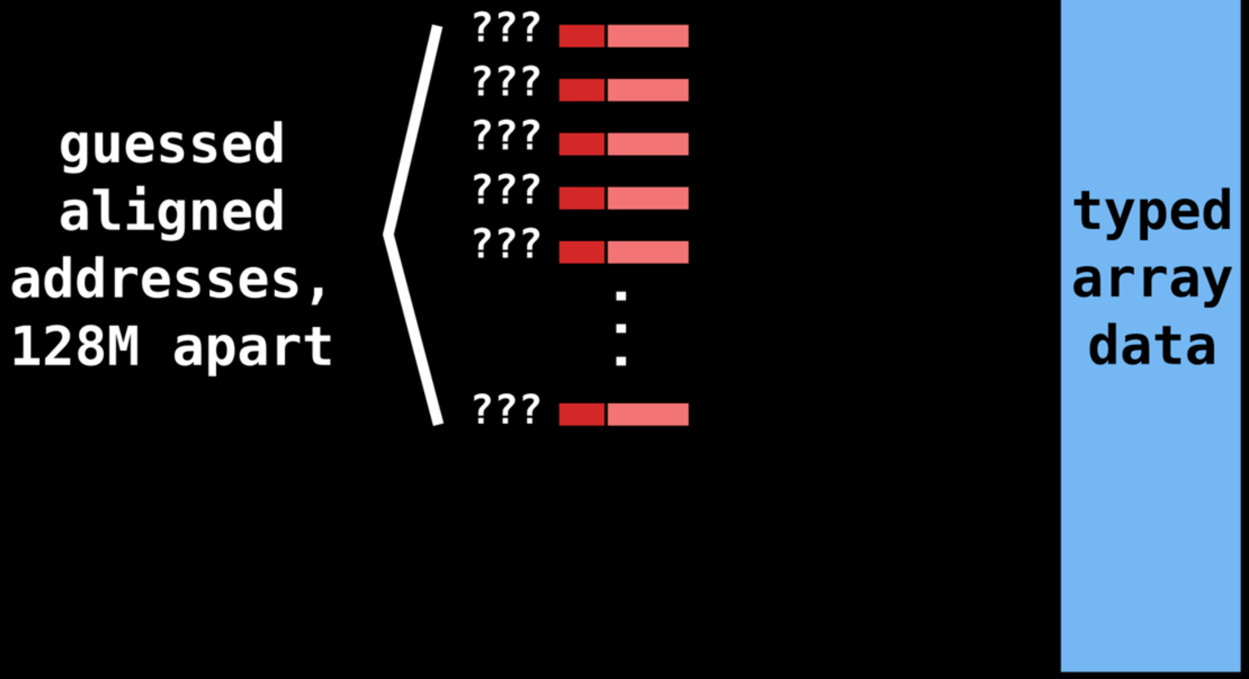
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Probe Pages

typed
array
data

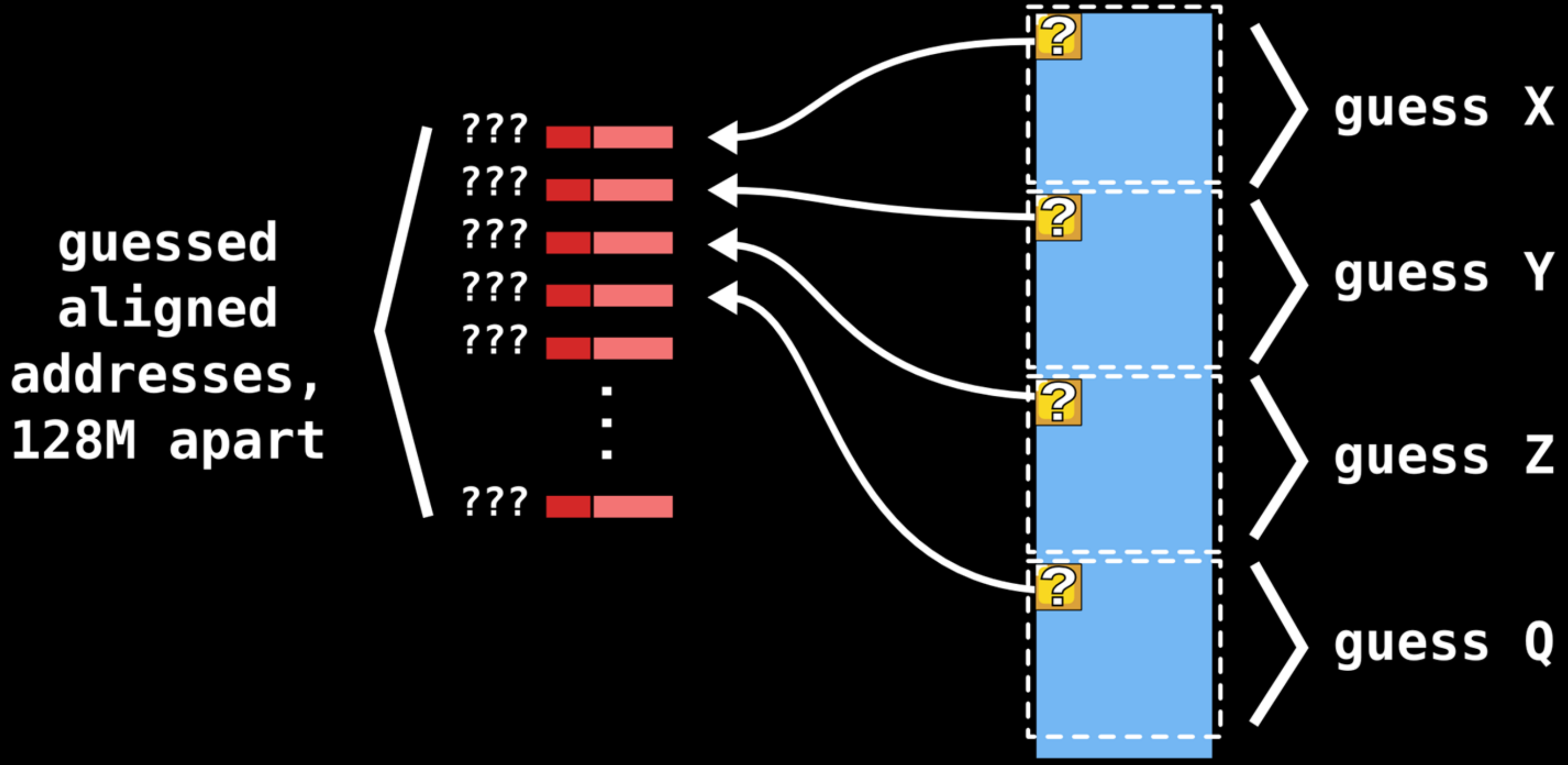
Dedup Est Machina:
Leaking Heap Pointer (#3)

Creating Probe Pages



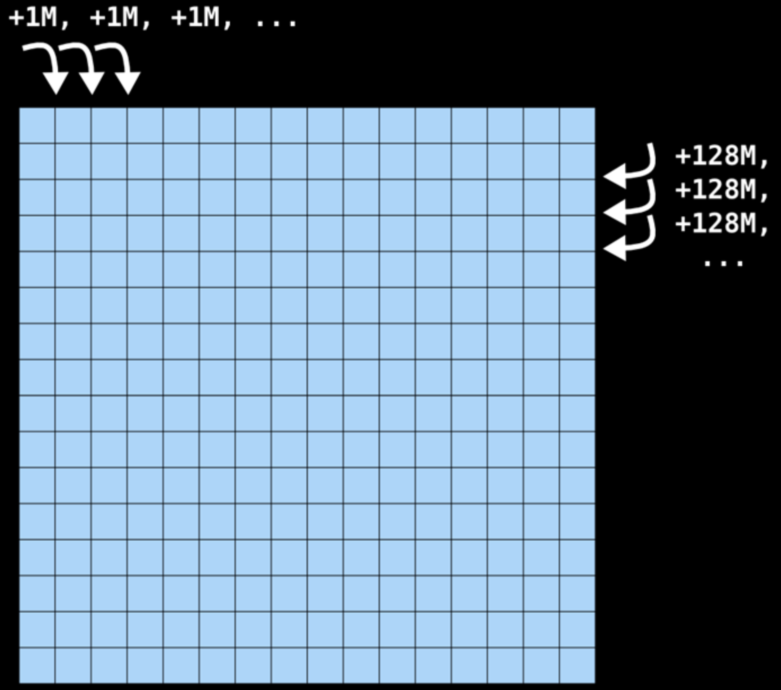
Dedup Est Machina: Leaking Heap Pointer (#3)

Creating Probe Pages



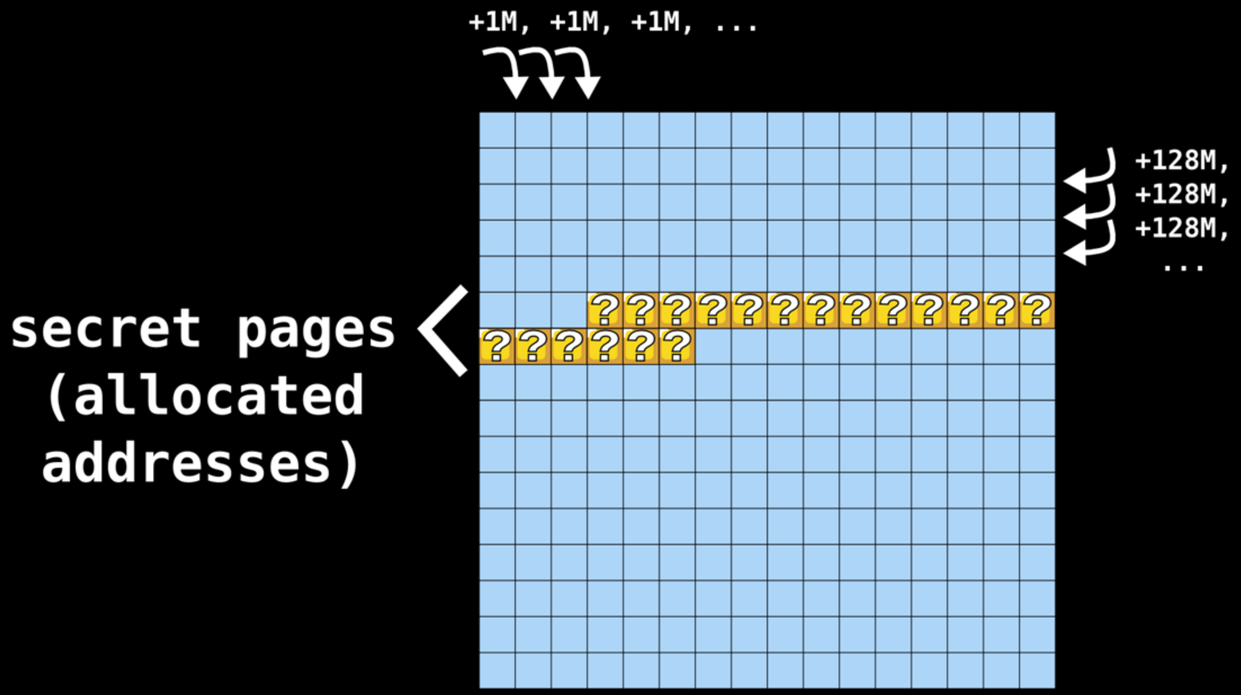
Dedup Est Machina: Leaking Heap Pointer (#3)

Birthday Heapspray



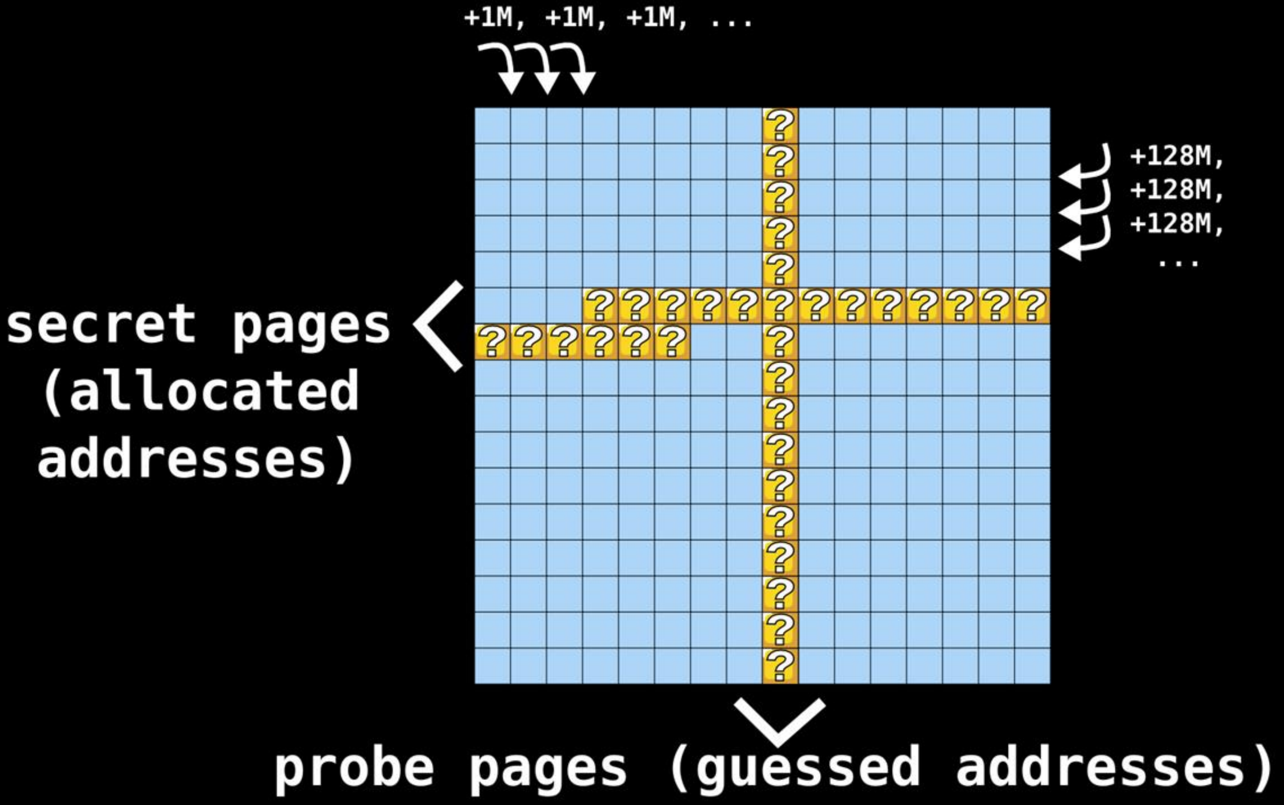
Dedup Est Machina: Leaking Heap Pointer (#3)

Birthday Heapspray



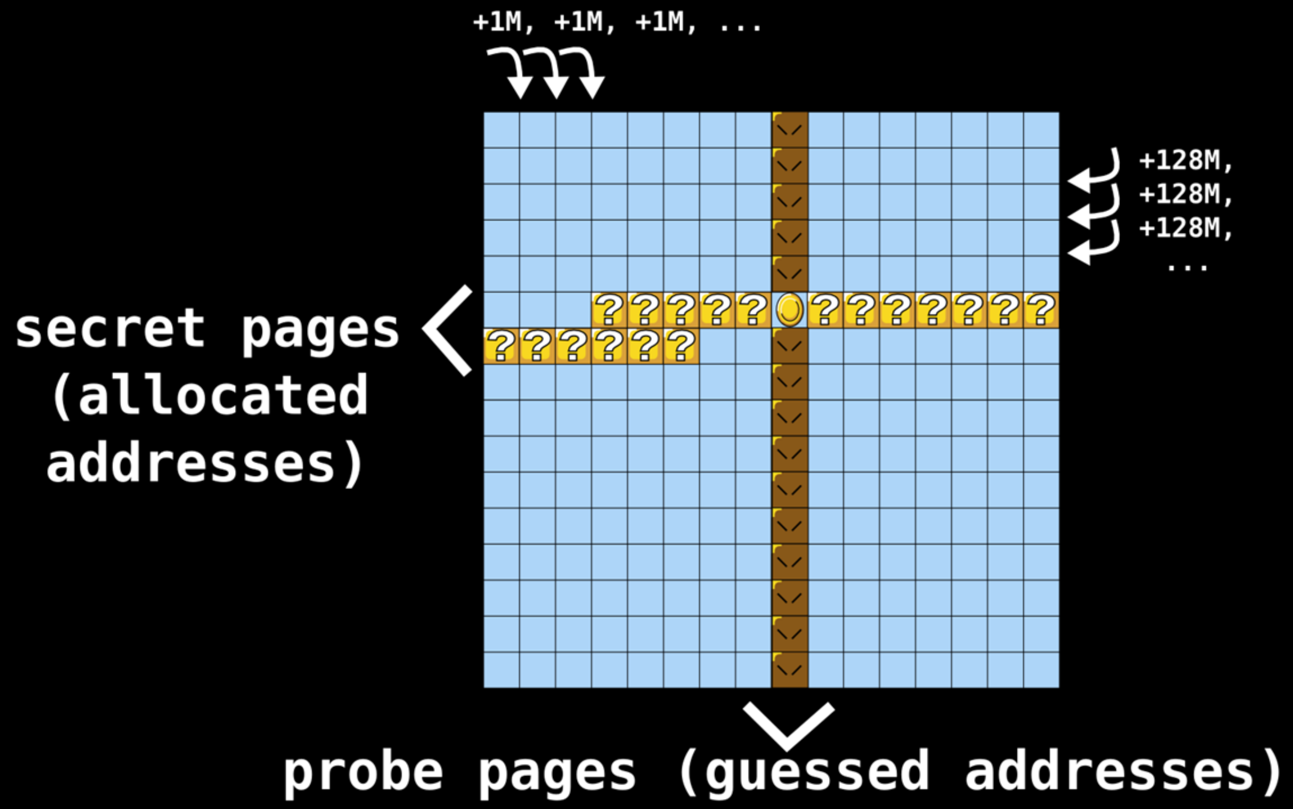
Dedup Est Machina: Leaking Heap Pointer (#3)

Birthday Heapspray


+1M, +1M, +1M, ...
+128M,
+128M,
+128M,
...
secret pages (allocated addresses)
probe pages (guessed addresses)
?

Dedup Est Machina:
Leaking Heap Pointer (#3)

Birthday Heapspray

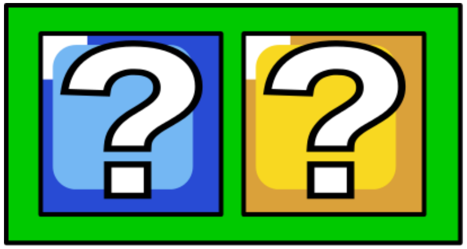


Dedup Est Machina: Overview

Memory deduplication

Leak randomized heap and code pointers

Create a fake JavaScript object

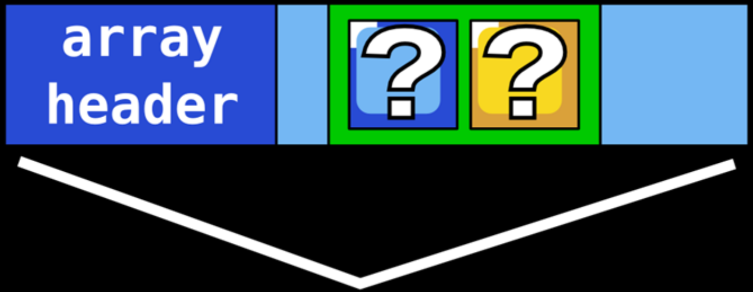


Dedup Est Machina: Creating a Fake Object

Fake JavaScript Uint8Array

Dedup Est Machina: Creating a Fake Object

Fake JavaScript Uint8Array



JavaScript Array

Dedup Est Machina: Overview

Memory deduplication

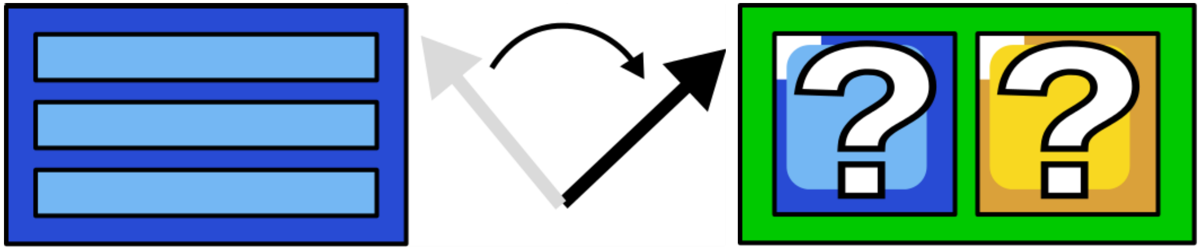
Leak randomized heap and code pointers

Create a fake JavaScript object

+

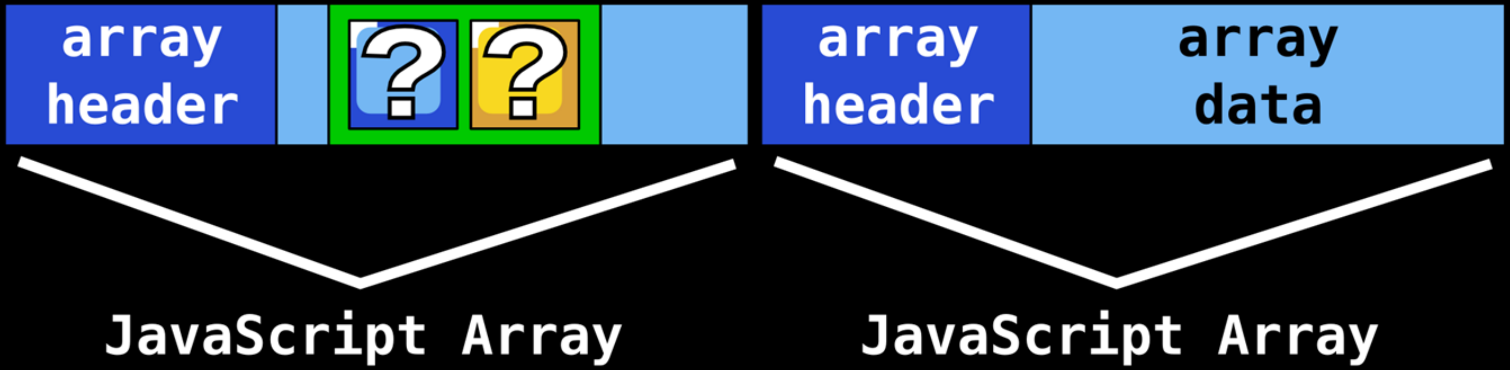
Rowhammer

Create a reference to our fake object



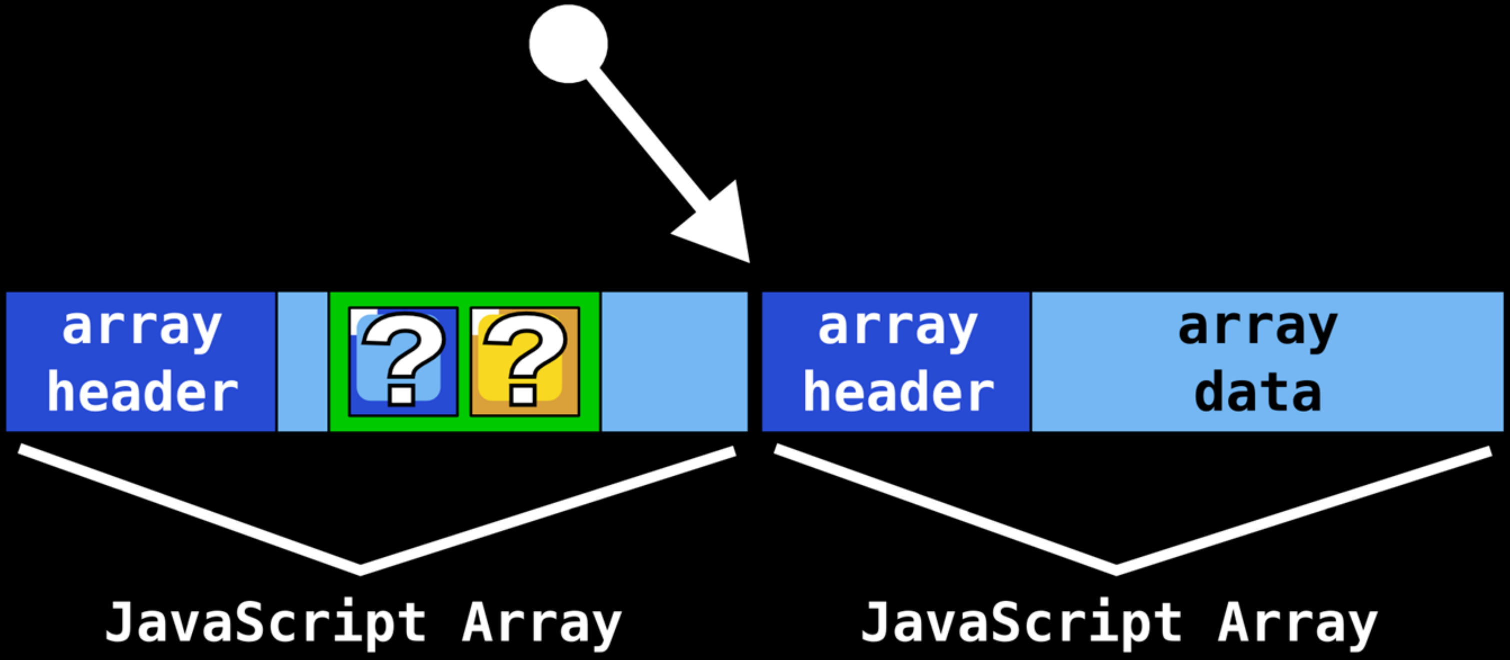
Dedup Est Machina: Creating a Fake Object

Fake JavaScript Uint8Array



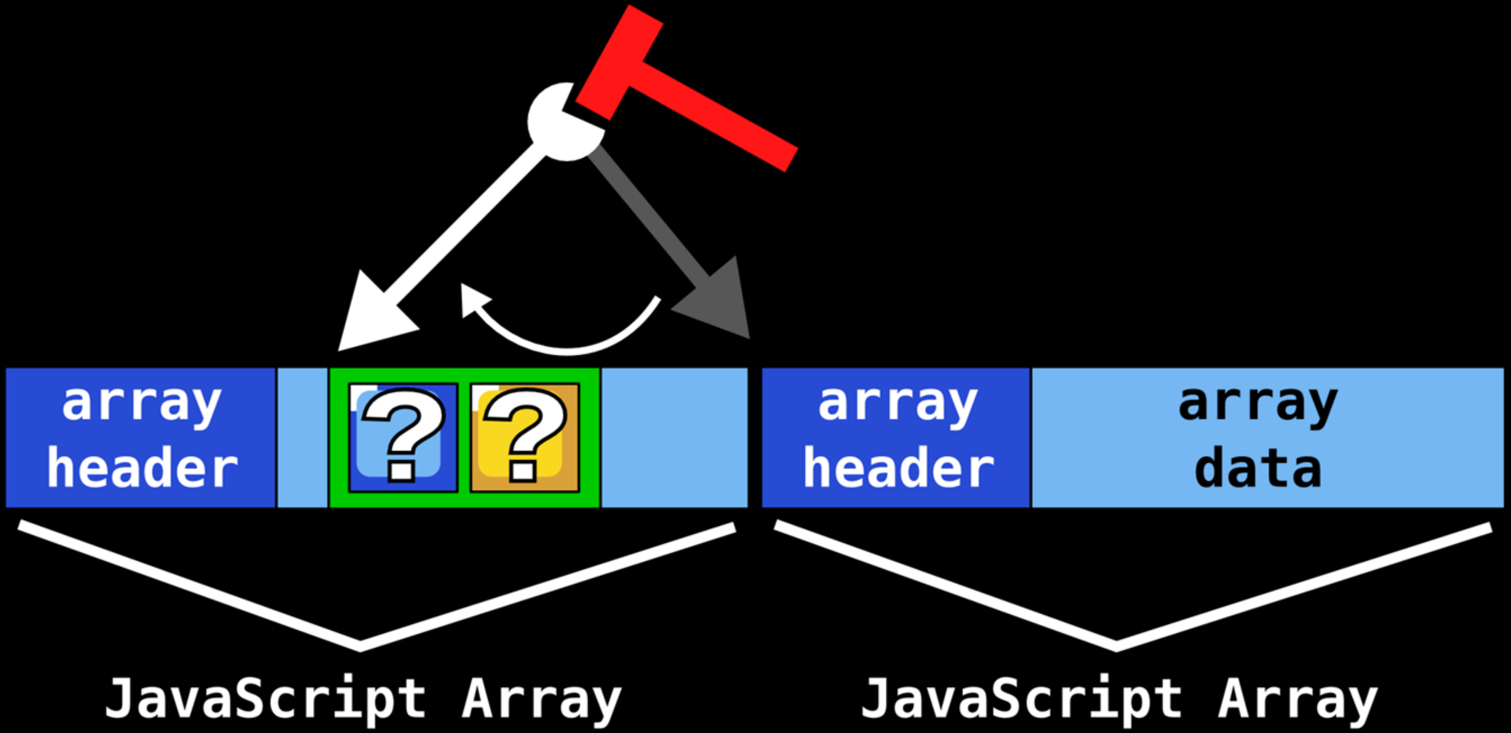
Dedup Est Machina: Creating a Fake Object

Fake JavaScript Uint8Array



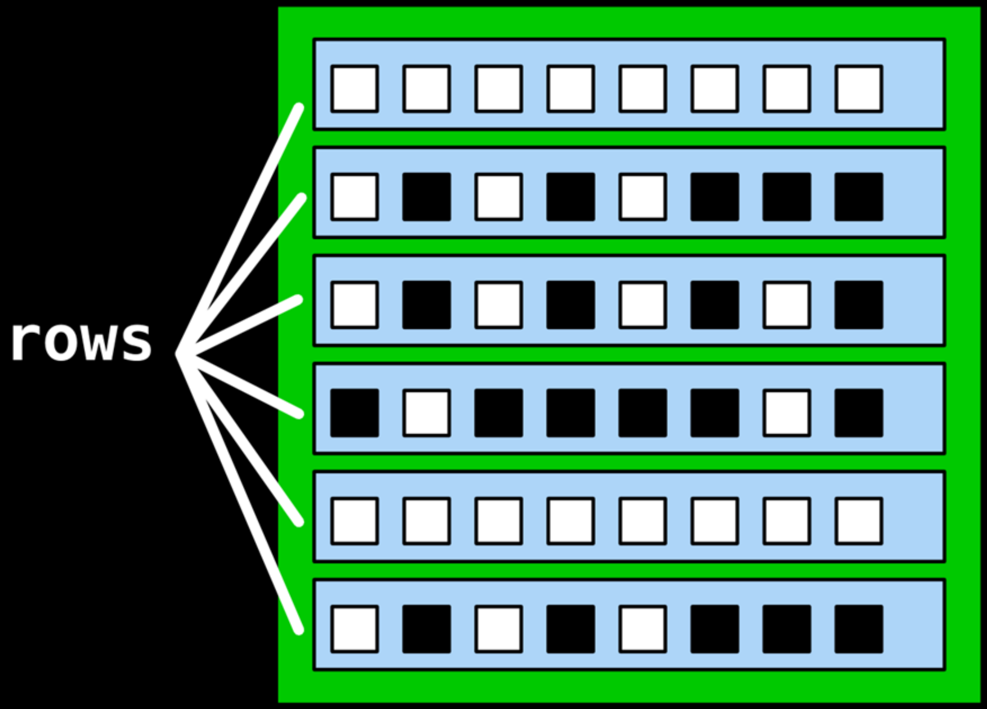
Dedup Est Machina: Creating a Fake Object

Pointer Pivoting



Dedup Est Machina: Referencing the Fake Object

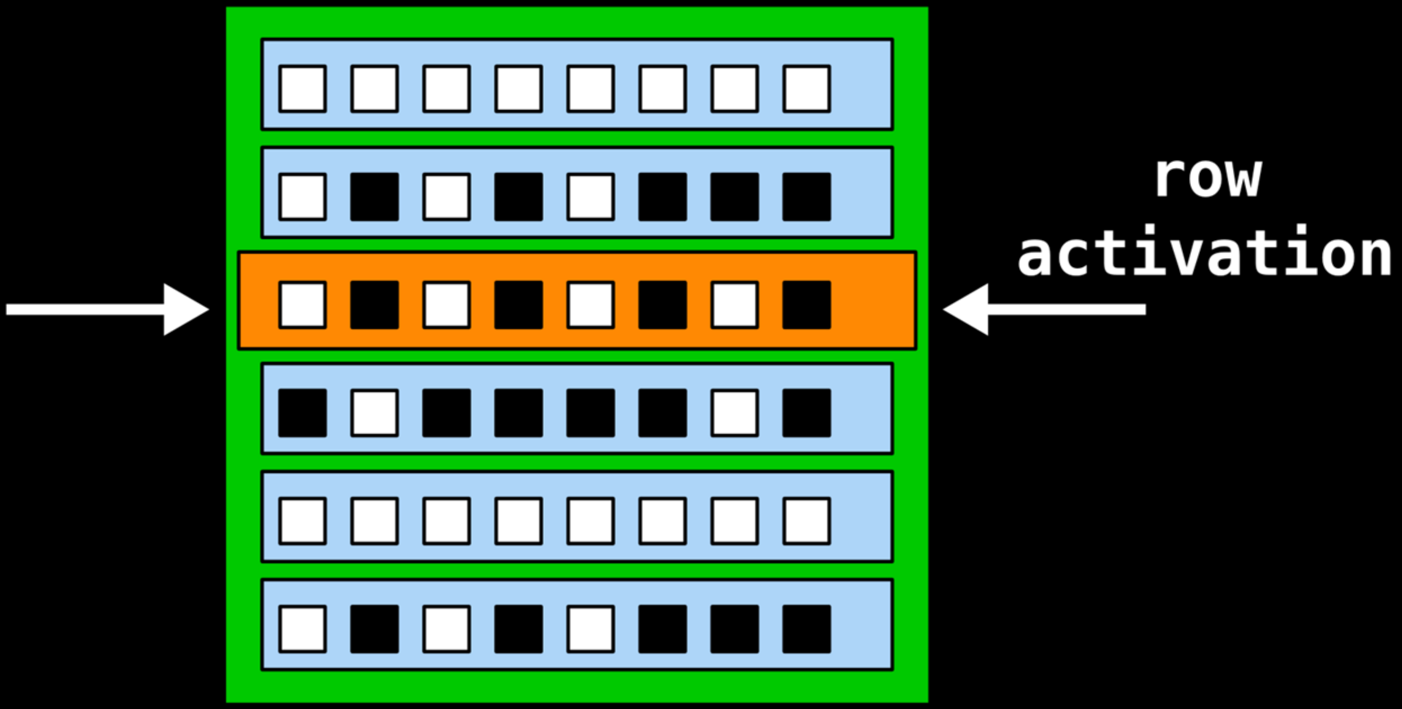
Rowhammer



DDR memory

Dedup Est Machina: Referencing the Fake Object

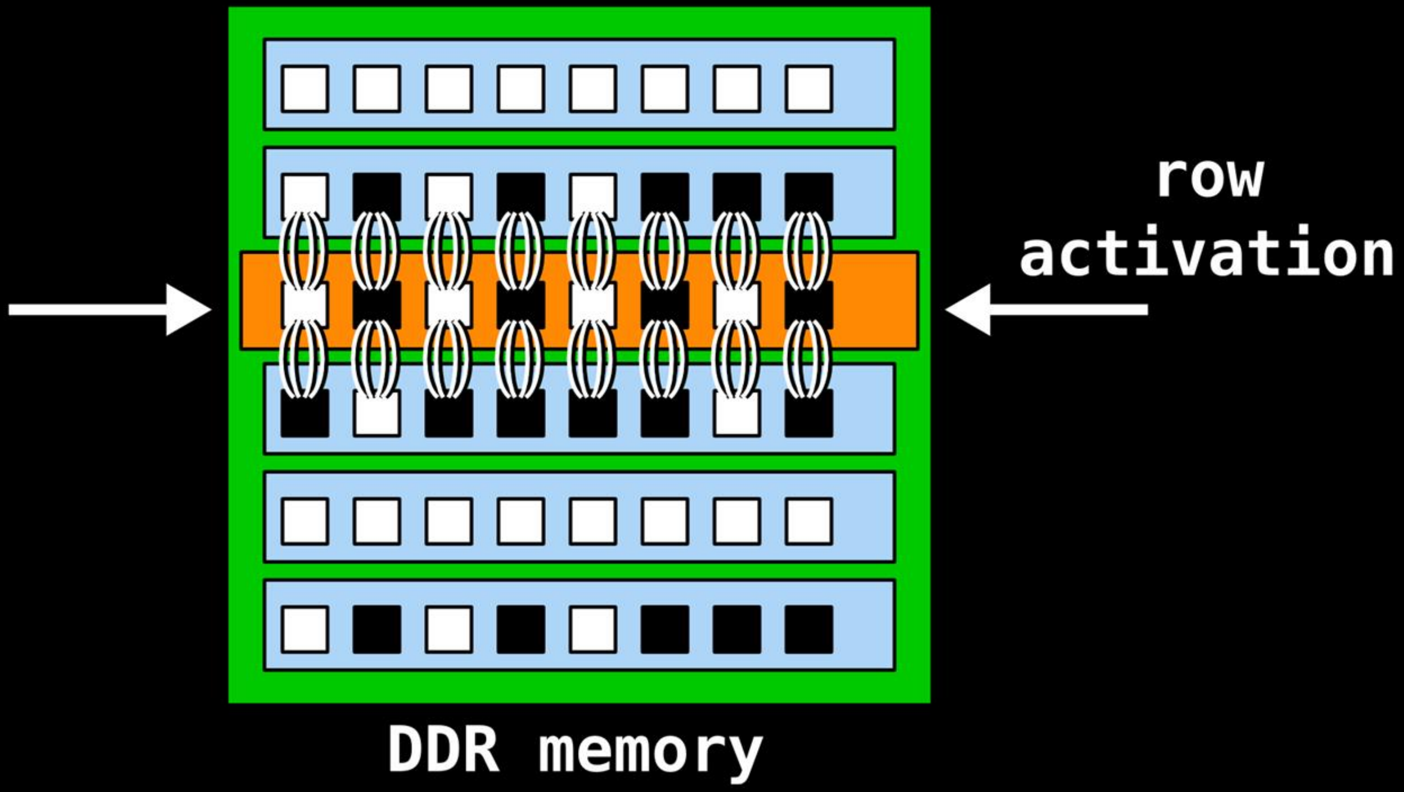
Rowhammer



DDR memory

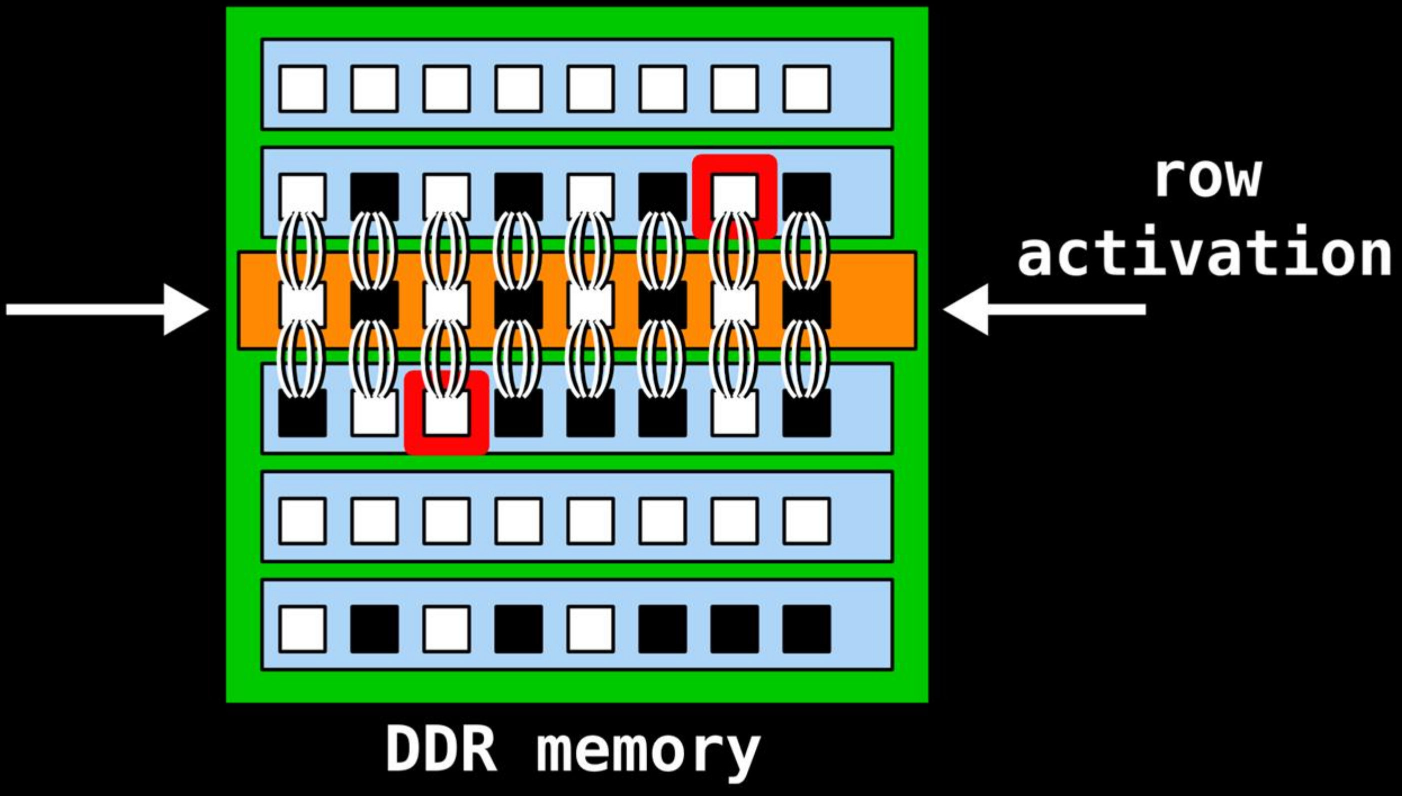
Dedup Est Machina: Referencing the Fake Object

Rowhammer



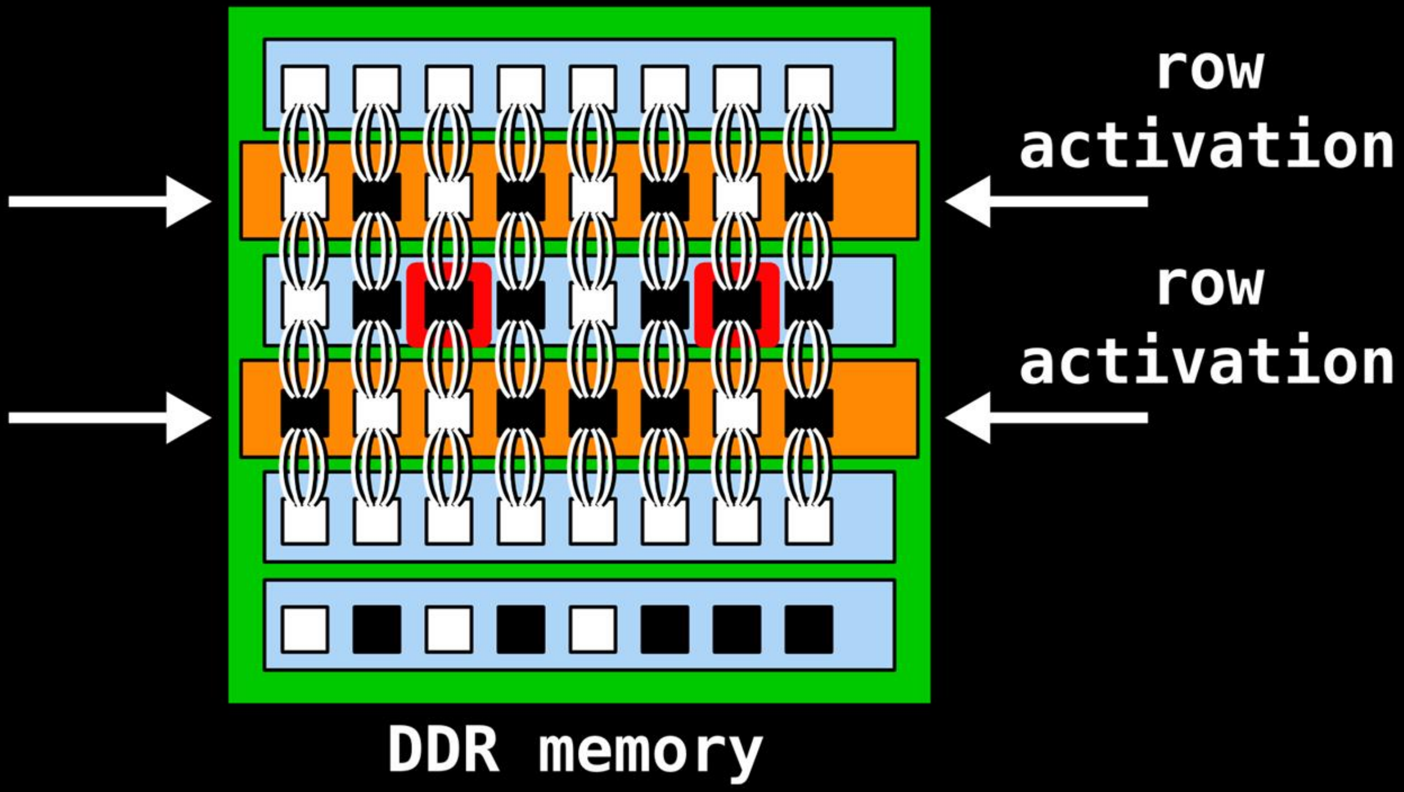
Dedup Est Machina: Referencing the Fake Object

Rowhammer



Dedup Est Machina: Referencing the Fake Object

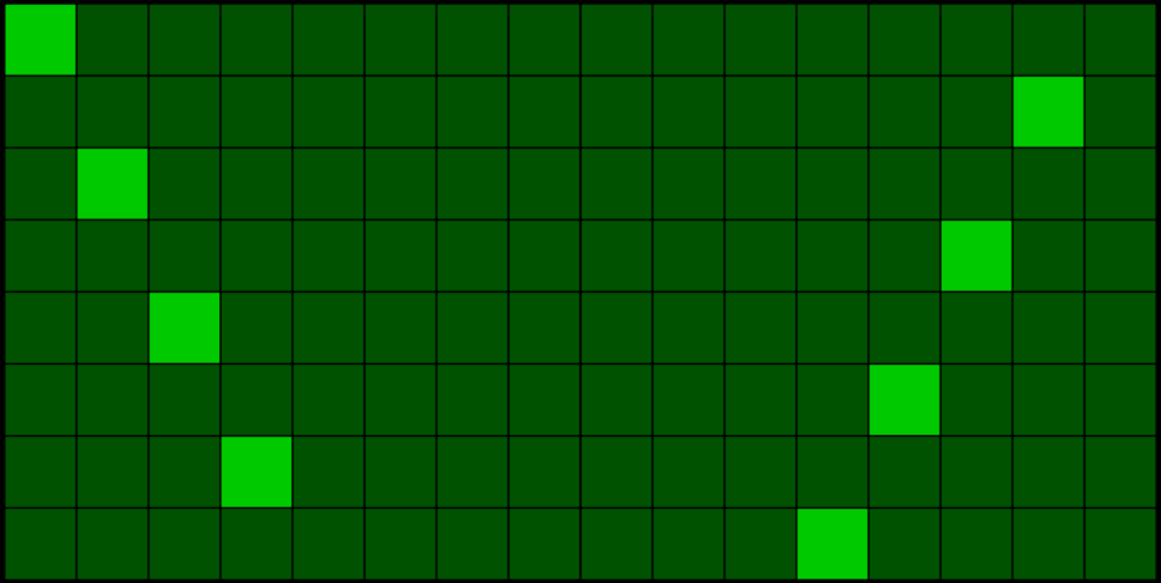
Double-sided Rowhammer



Dedup Est Machina: Referencing the Fake Object

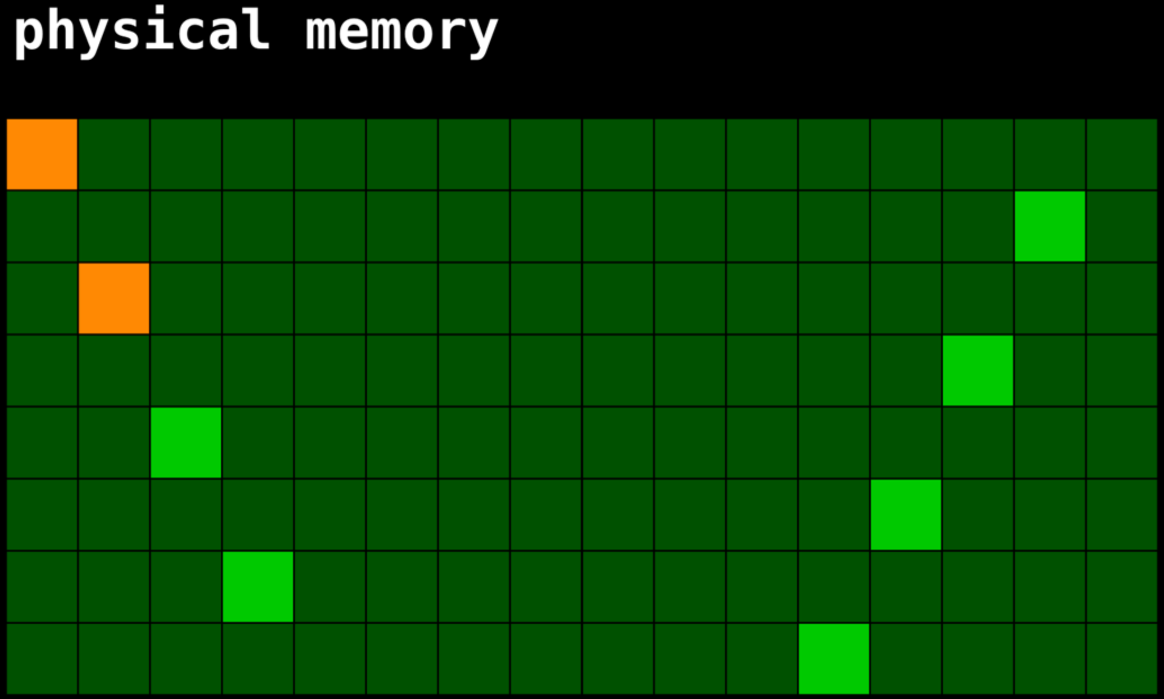
Double-sided Rowhammer

physical memory



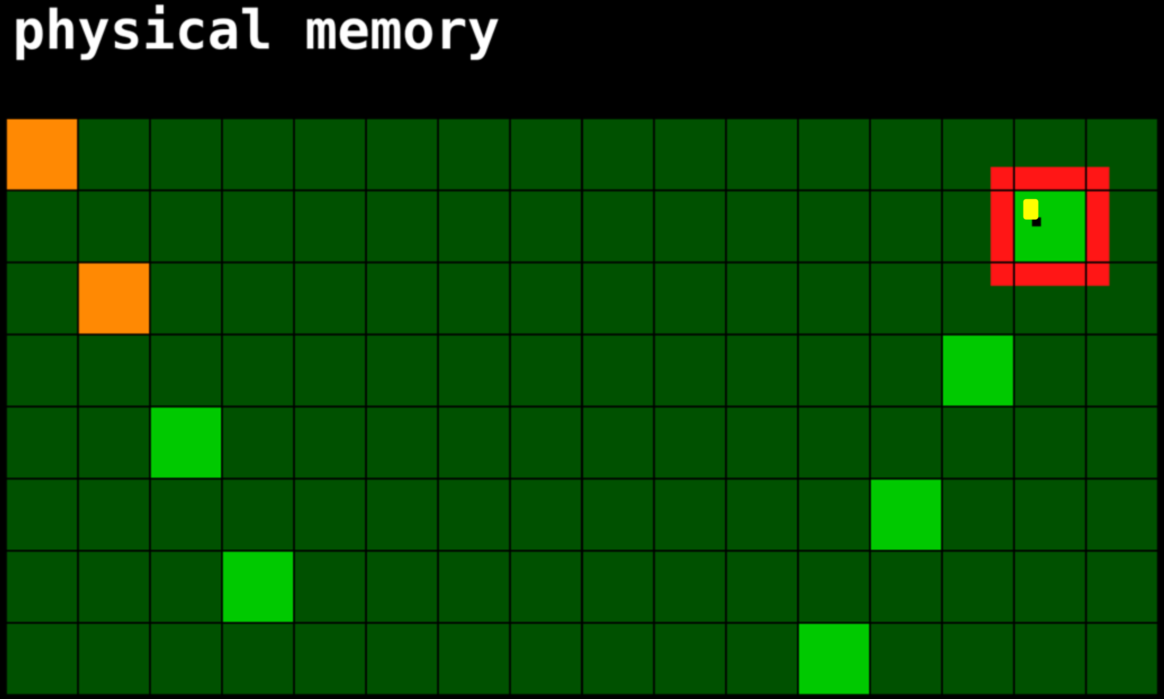
Dedup Est Machina: Referencing the Fake Object

Double-sided Rowhammer



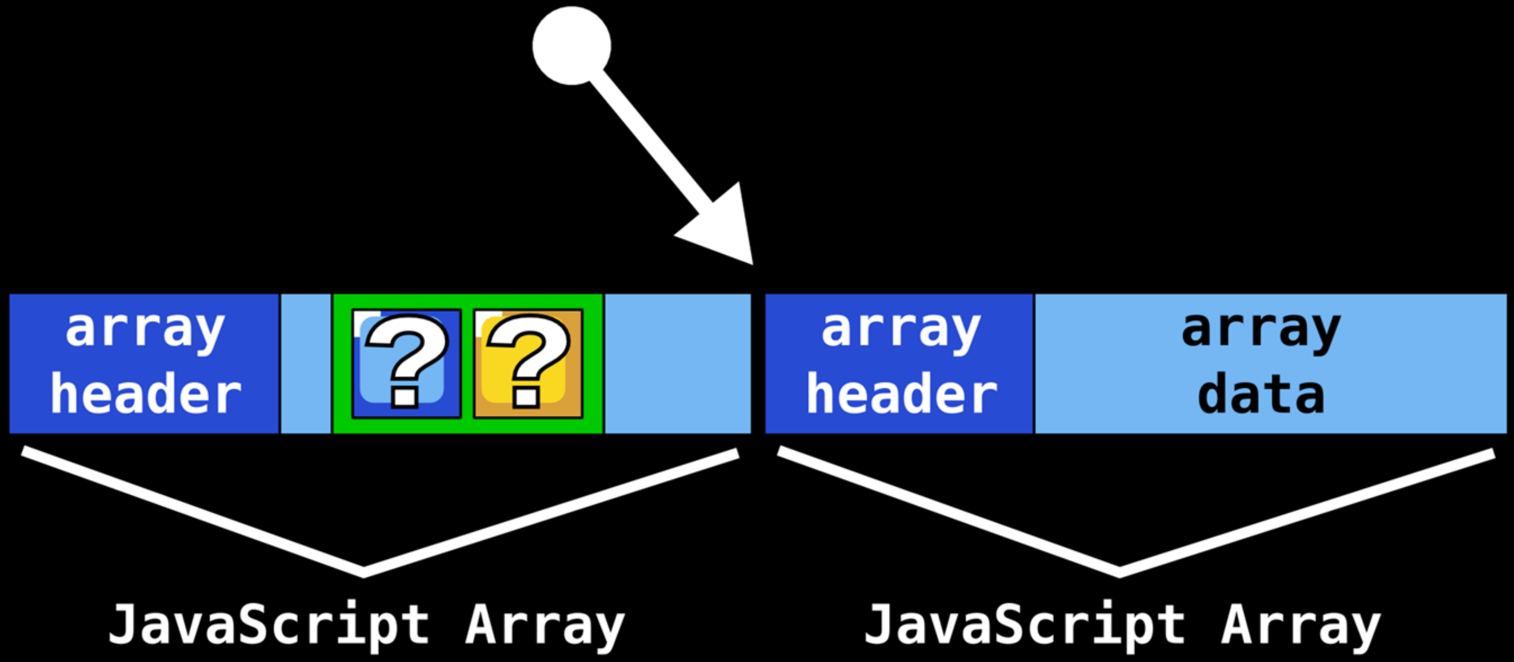
Dedup Est Machina: Referencing the Fake Object

Double-sided Rowhammer



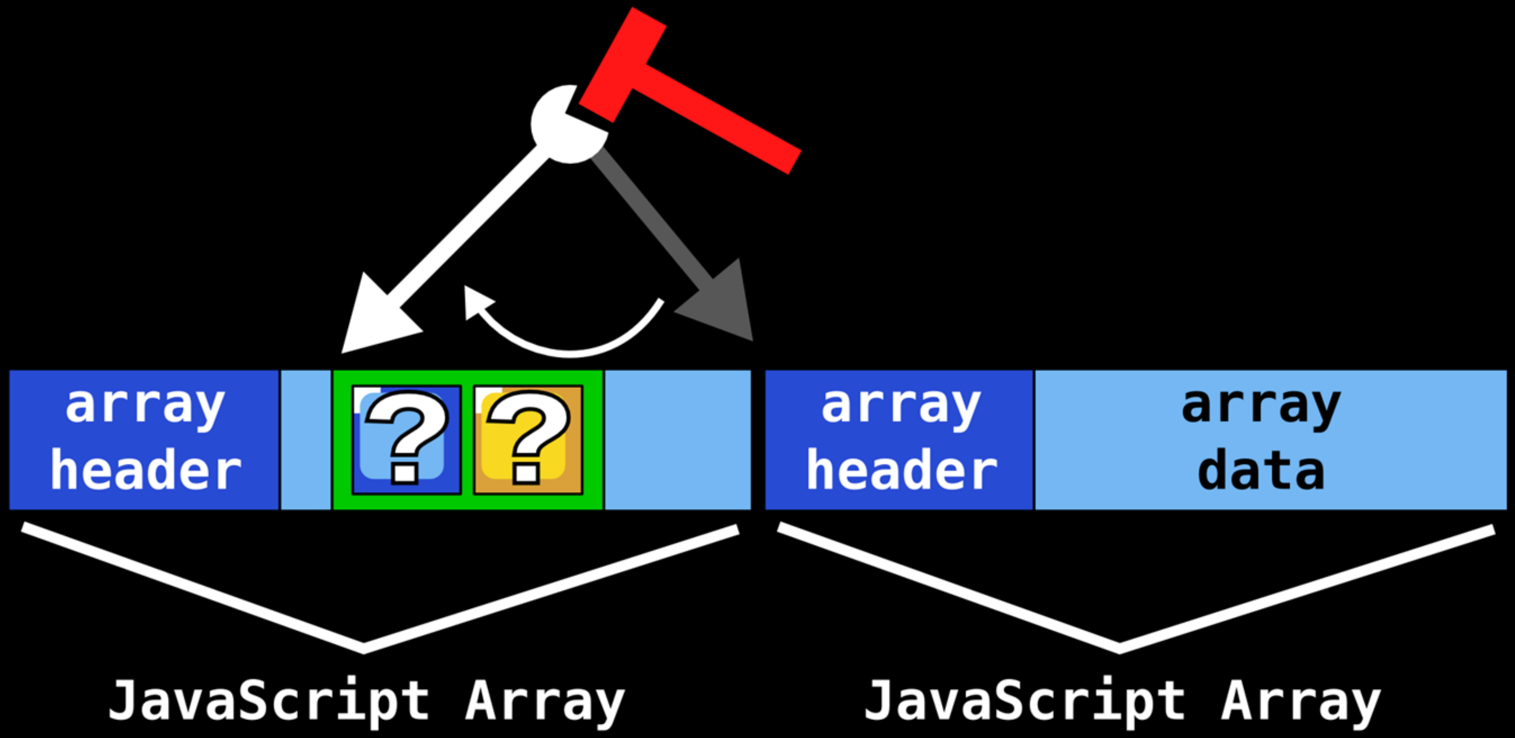
Dedup Est Machina: Referencing the Fake Object

Pointer Pivoting



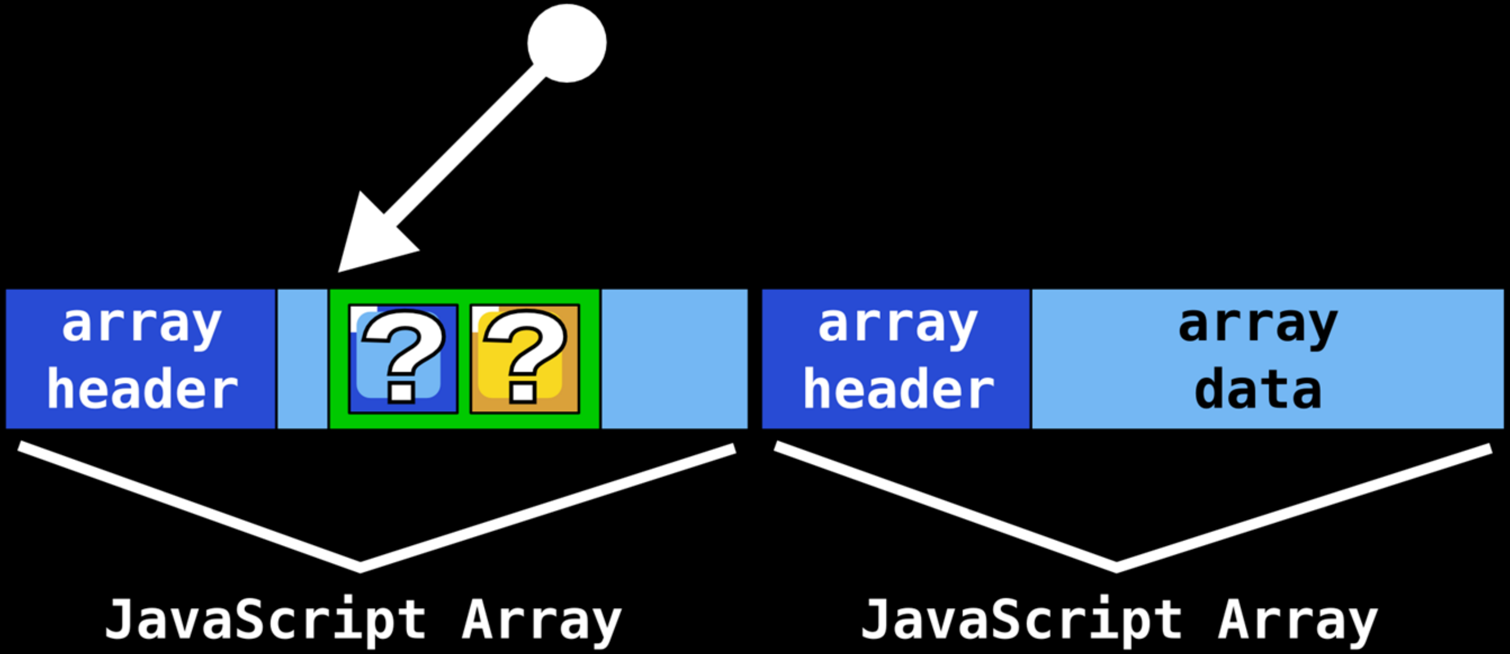
Dedup Est Machina: Referencing the Fake Object

Pointer Pivoting



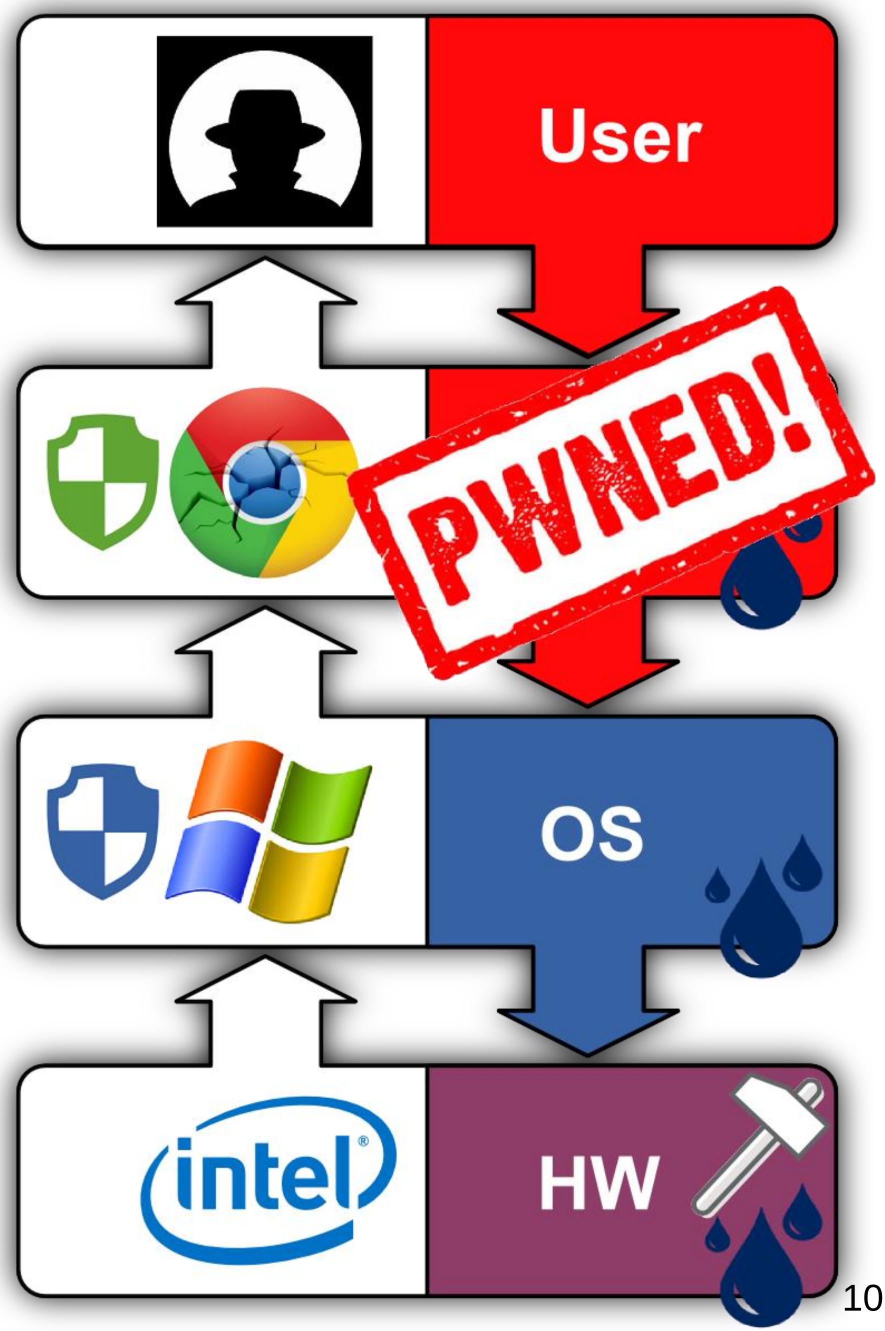
Dedup Est Machina: Referencing the Fake Object

Pointer Pivoting



Dedup Est Machina:

Can One Attack the Full System?



Dedup Est Machina: System-wide Exploitation

Deduplication is enabled system-wide

We can leak secrets from other processes

Say arbitrarily long passwords

- E.g., 30-byte password hashes in nginx

System-wide Rowhammer is more involved

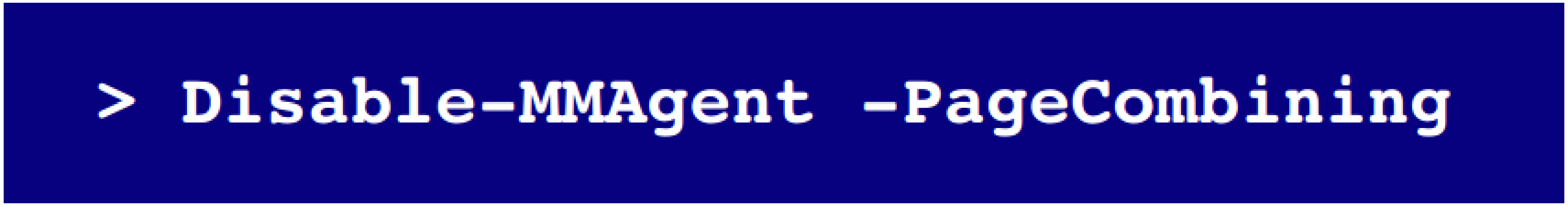
- We don’t “own” other processes’ physical memory

We’ll look at this in our **next example**

Dedup Est Machina: Impact

We shared our MS Edge exploit with Microsoft and they addressed it in MS-16-093, July 18th (CVE-2016-3272) by temporarily disabling memory deduplication on Windows 10

Disable it on legacy systems (Powershell):



```
> Disable-MMAgent -PageCombining
```

EXAMPLE 2

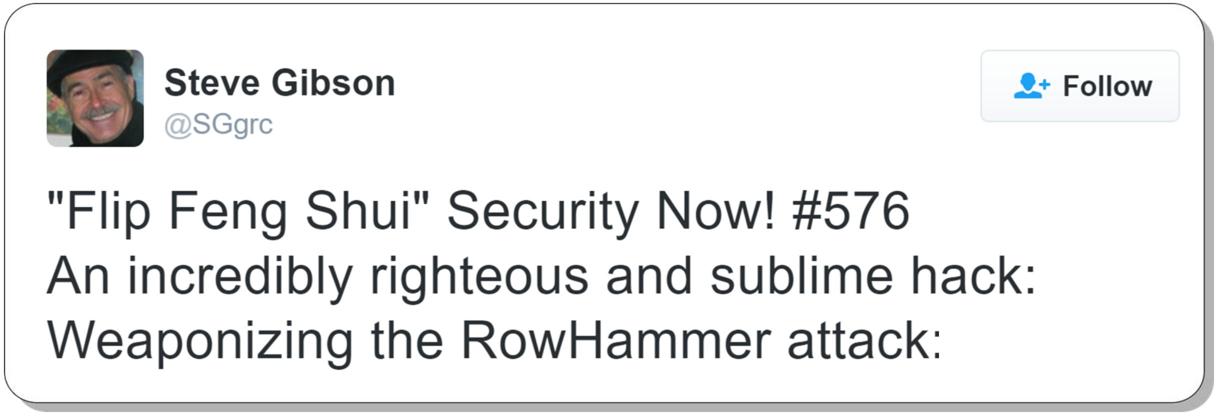
Bug-free Exploitation in Clouds

Flip Feng Shui

Published at USENIX Security 2016

with Ben, Kaveh, Erik, Herbert, and Bart (KU Leuven)

Much media attention



Steve Gibson
@SGgrc

"Flip Feng Shui" Security Now! #576
An incredibly righteous and sublime hack:
Weaponizing the RowHammer attack:

System-wide exploits in public KVM clouds

...without relying on a single software bug

Flip Feng Shui: Overview

Rowhammer
(hardware glitch)

Flip Feng Shui: Overview

Rowhammer
(hardware glitch)
+
Memory deduplication
(physical memory massaging primitive)

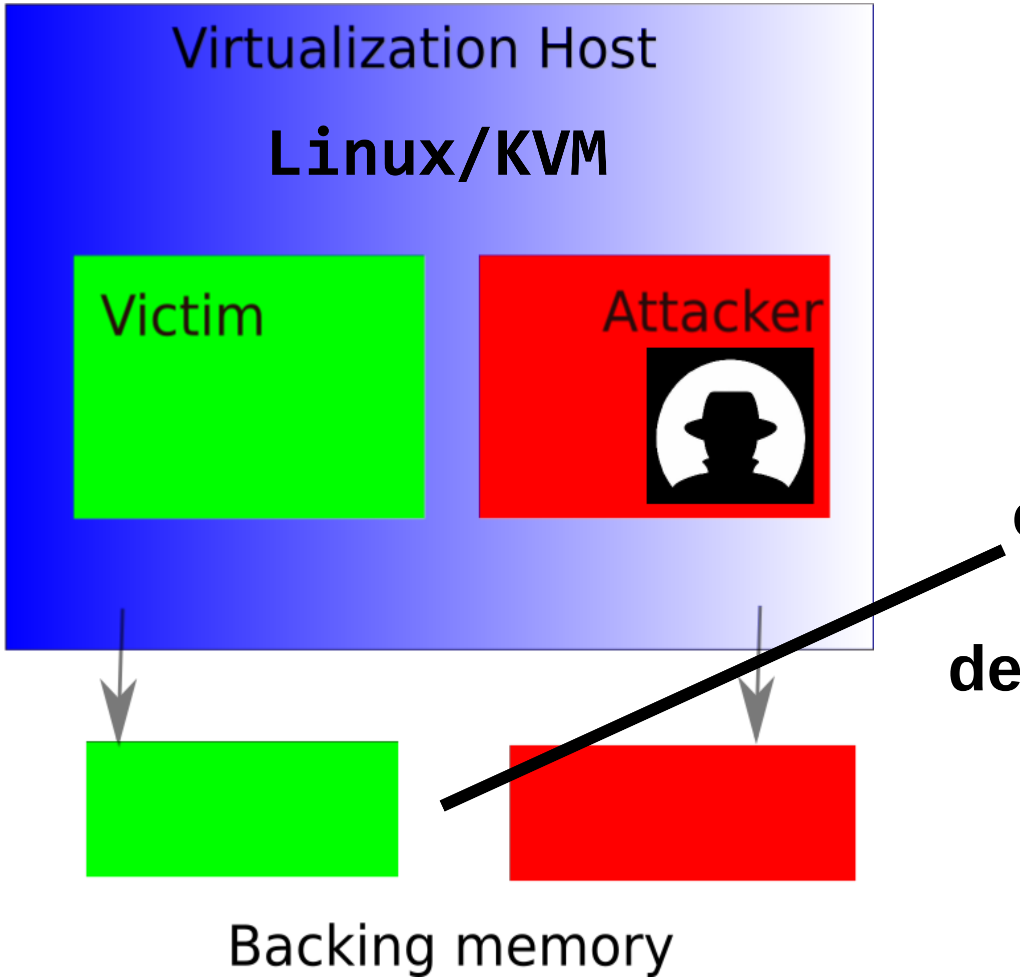
Flip Feng Shui: Overview

Rowhammer
(hardware glitch)
+
Memory deduplication
(physical memory massaging primitive)

↓

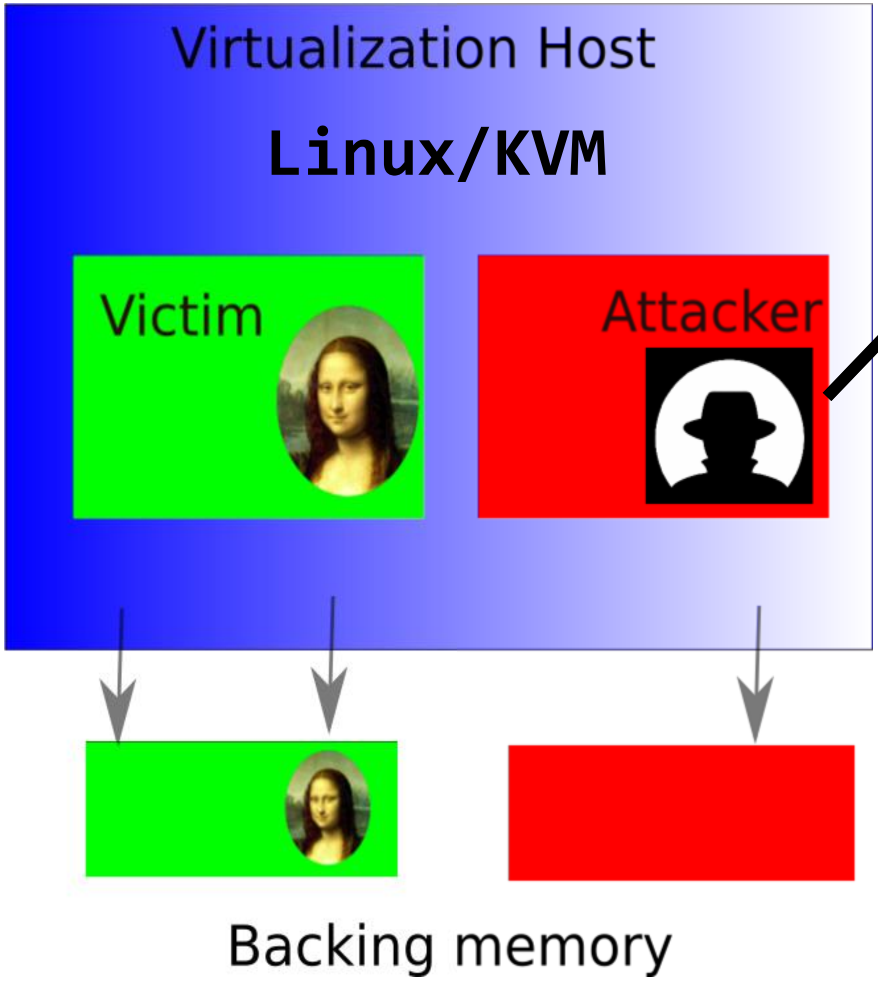
Cross-VM compromise in public Linux/KVM clouds without software bugs

Flip Feng Shui: Attacker's Goals



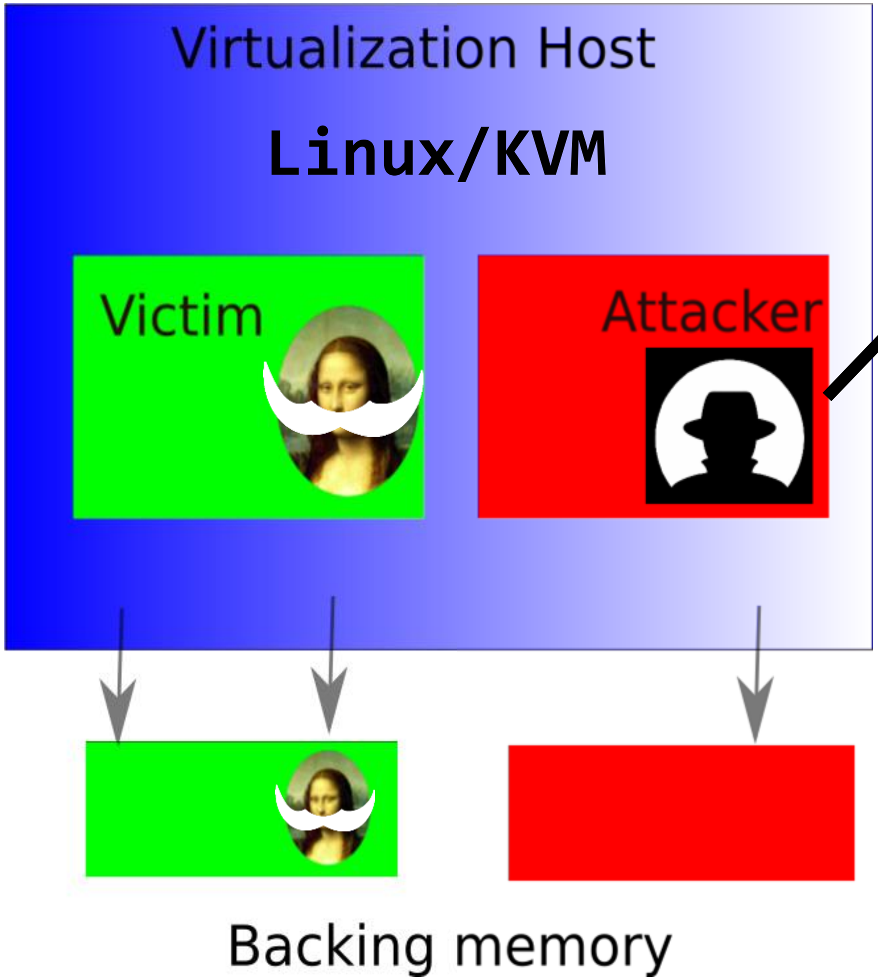
KSM: cross-VM memory deduplication

Flip Feng Shui: Attacker’s Goals



Target sensitive memory page in victim VM’s memory

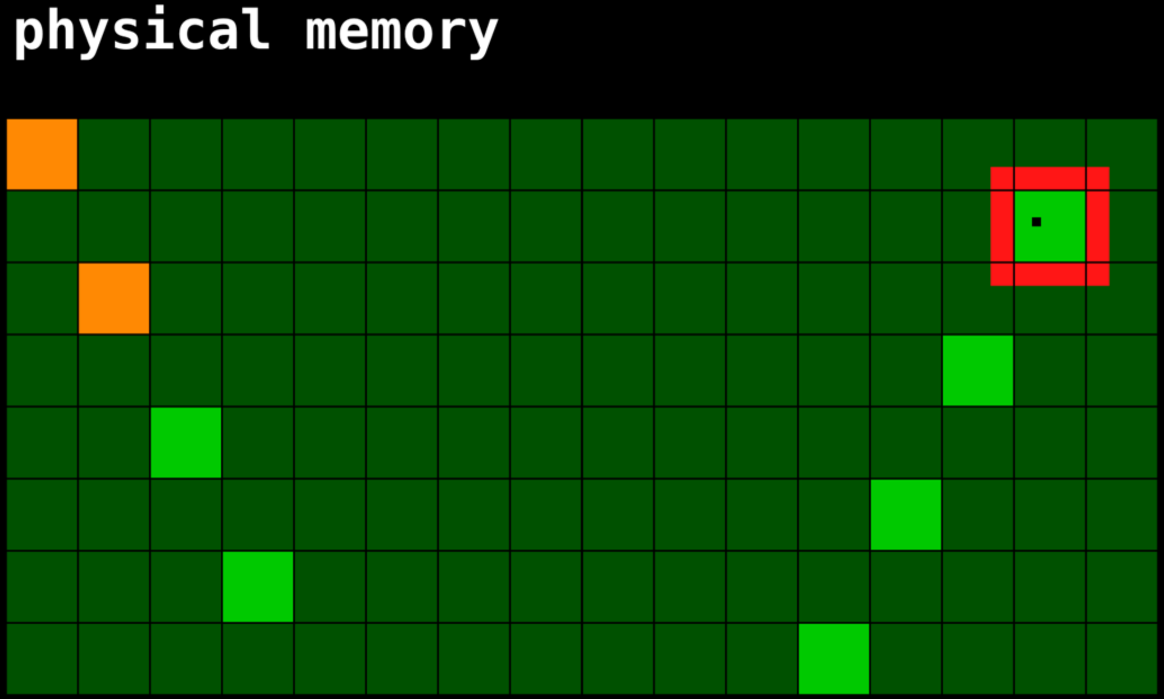
Flip Feng Shui: Attacker's Goals



Corrupt sensitive page to subvert victim VM

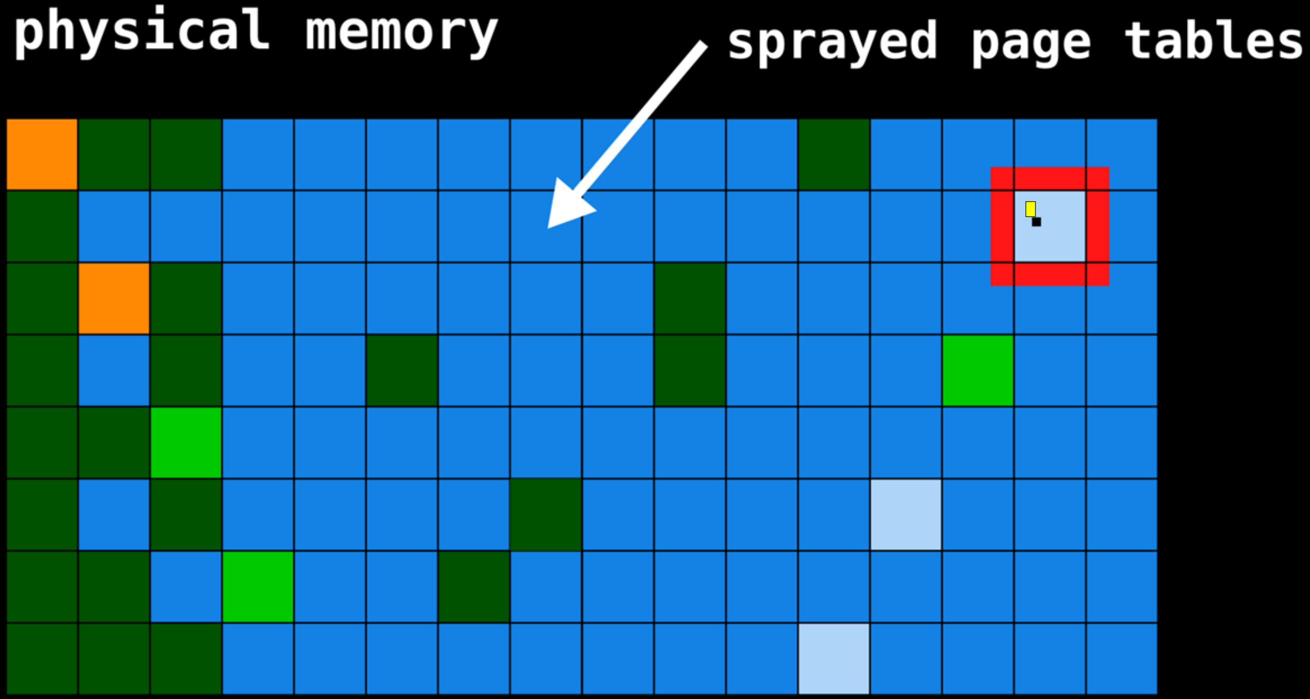
Flip Feng Shui: Probabilistic Rowhammering

Double-sided Rowhammer



Flip Feng Shui: Probabilistic Rowhammering

Seaborn’s Attack

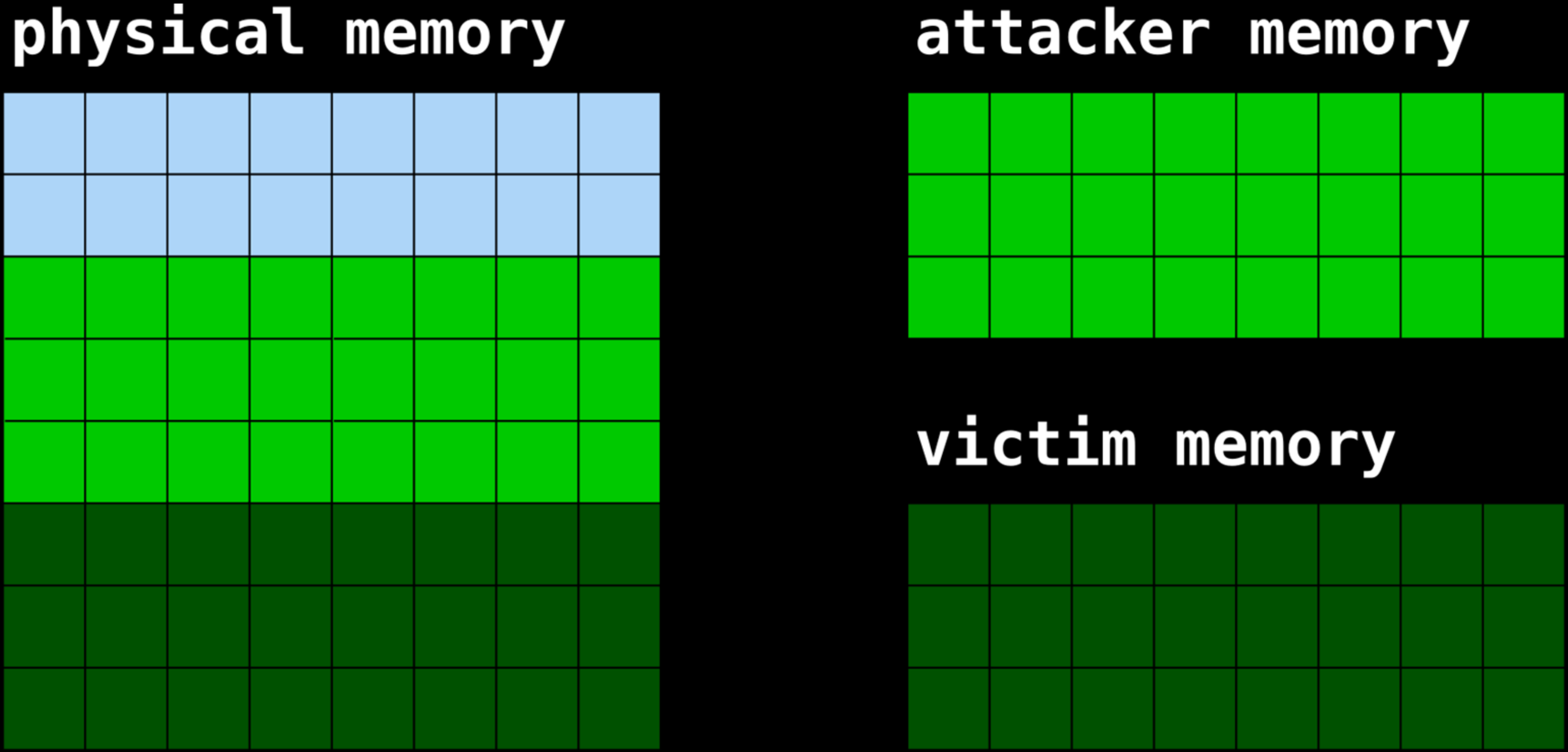


Flip Feng Shui: Mechanics

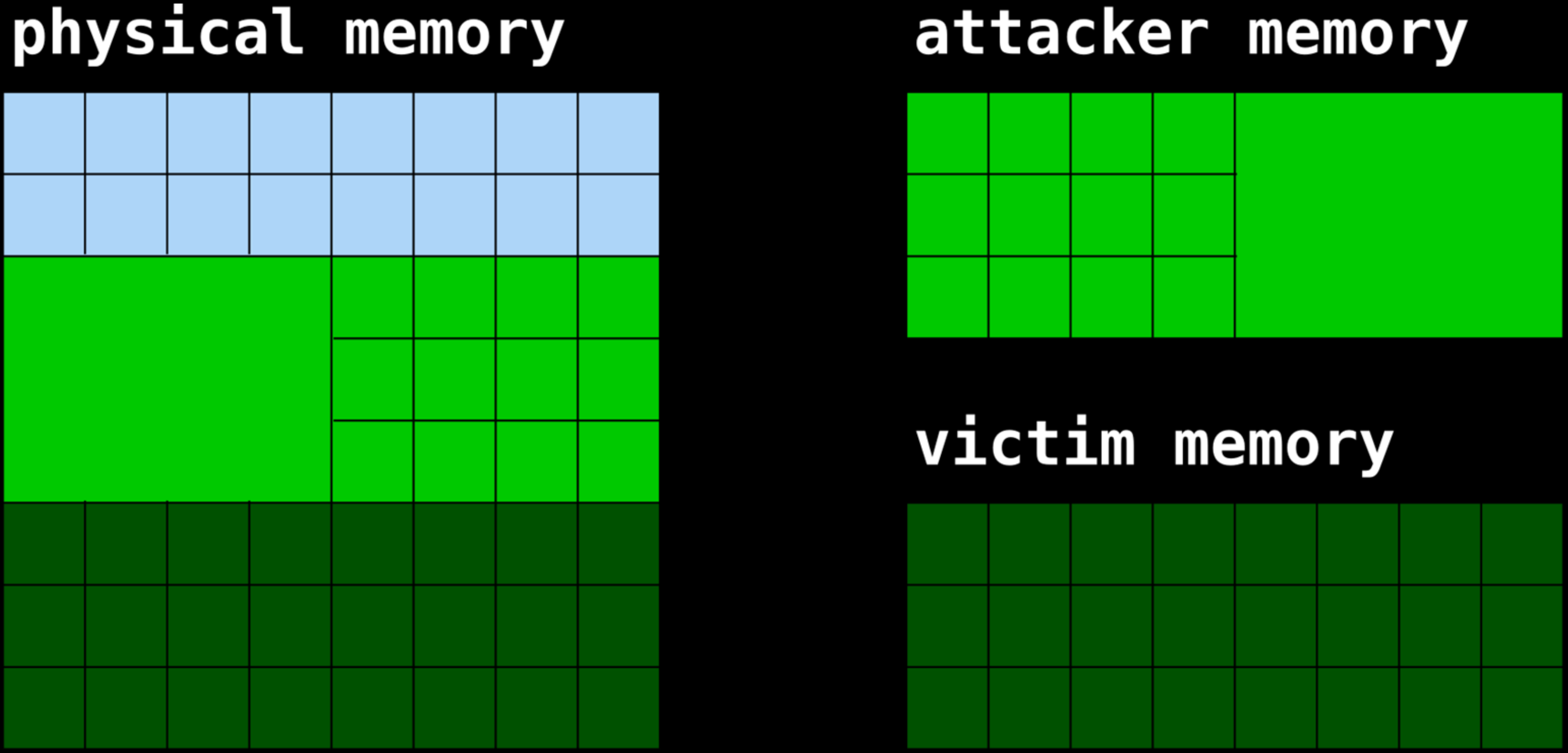
Step 1:

The attacker needs to find a vulnerable physical page to flip bits at a given sensitive offset

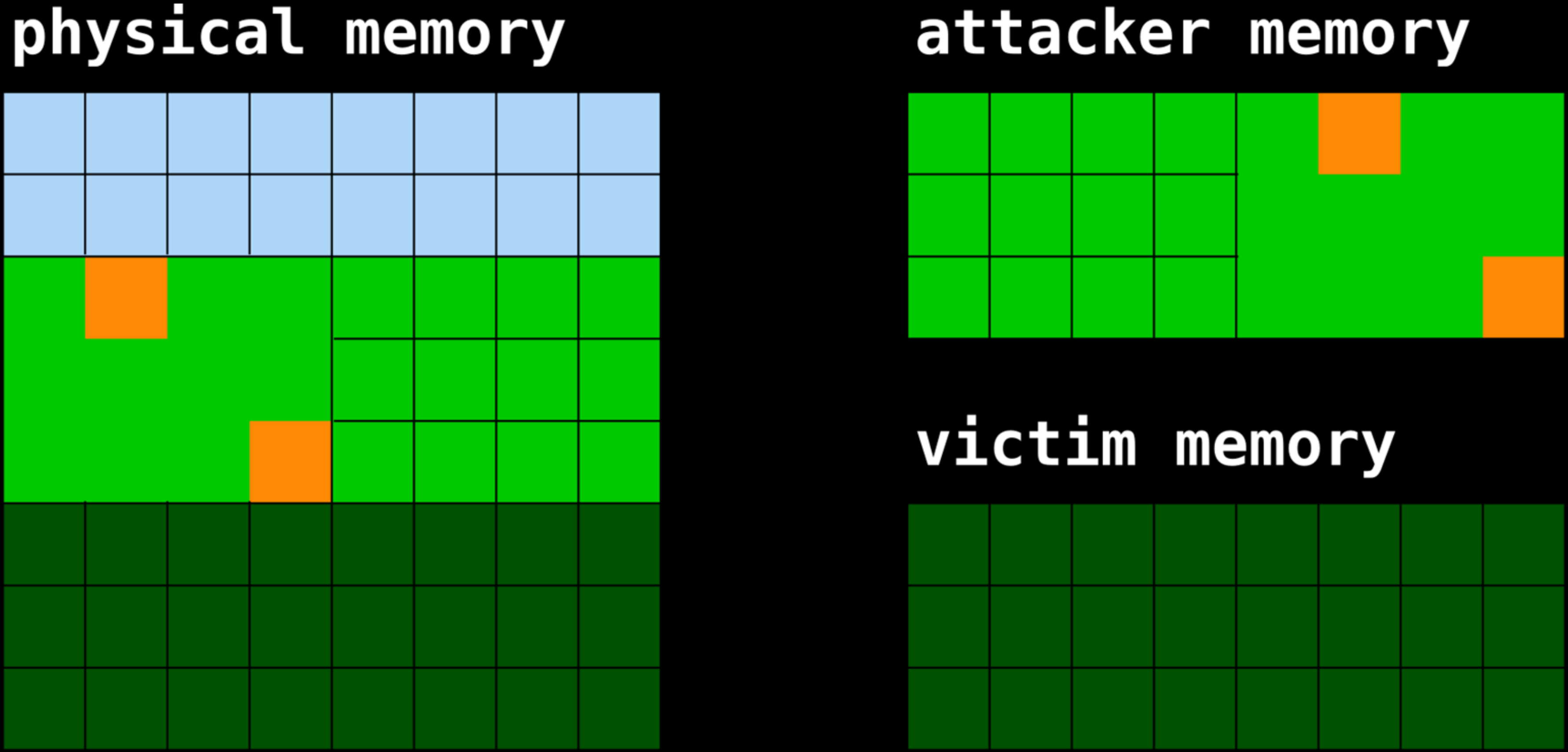
Flip Feng Shui: Templating



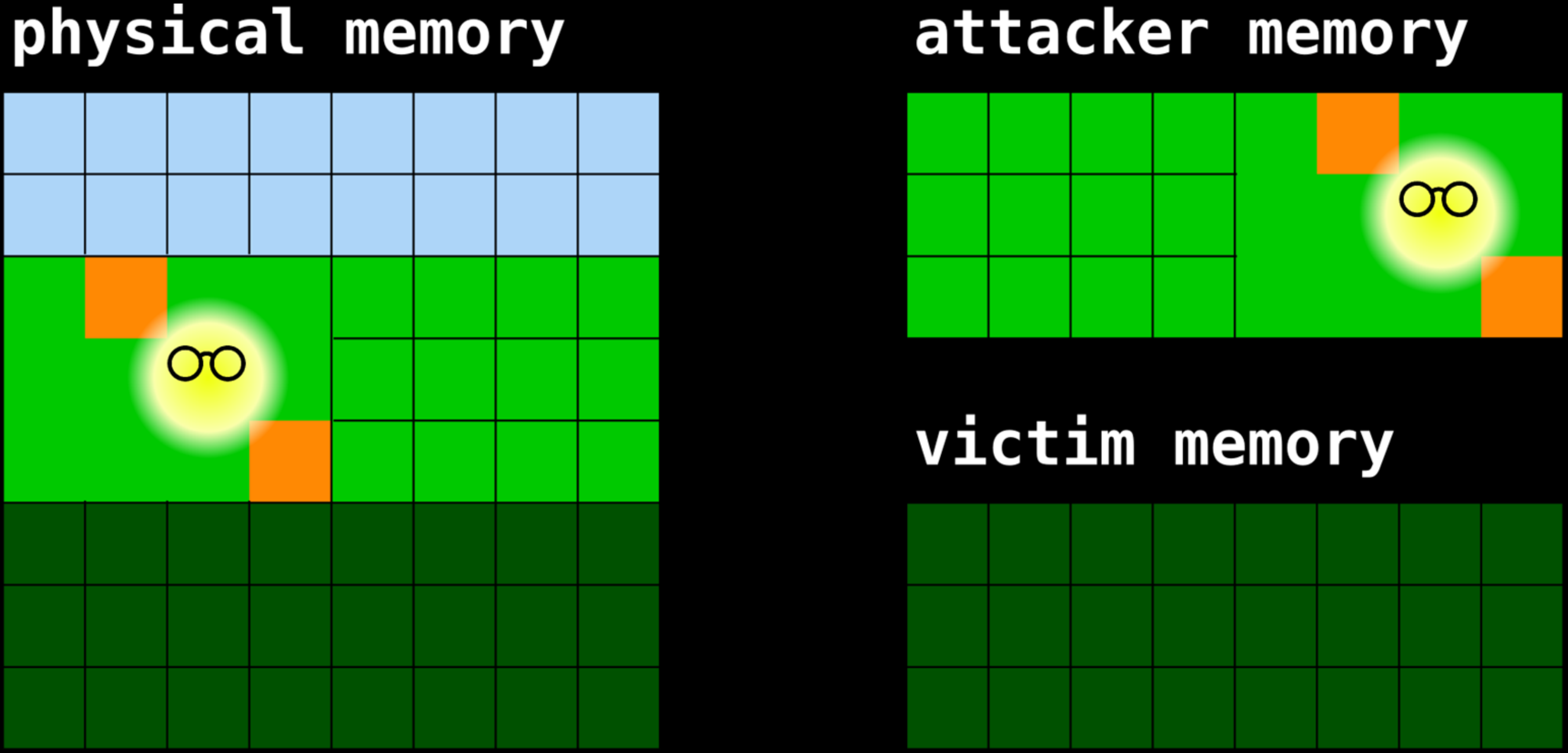
Flip Feng Shui: Templating



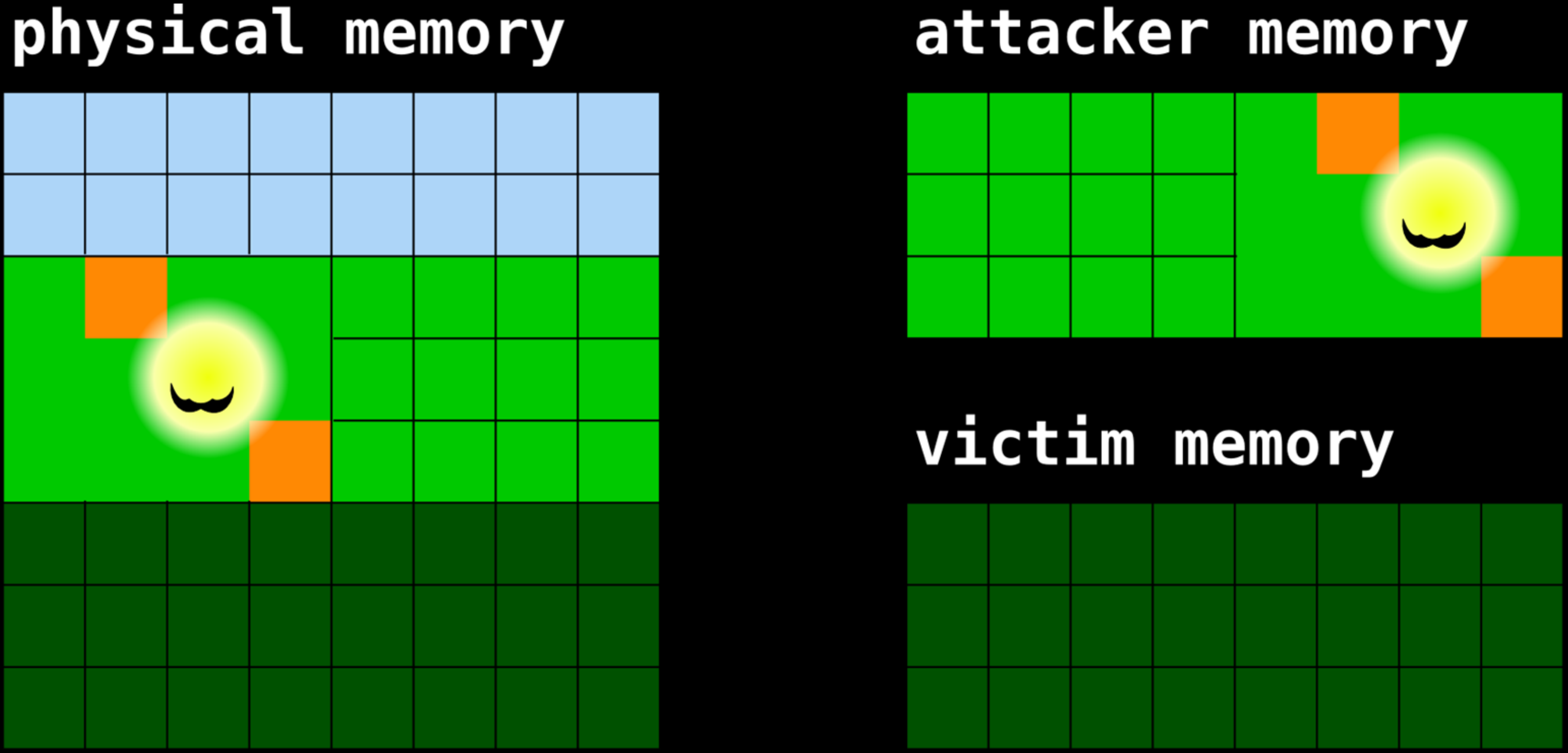
Flip Feng Shui: Templating



Flip Feng Shui: Templating



Flip Feng Shui: Templating

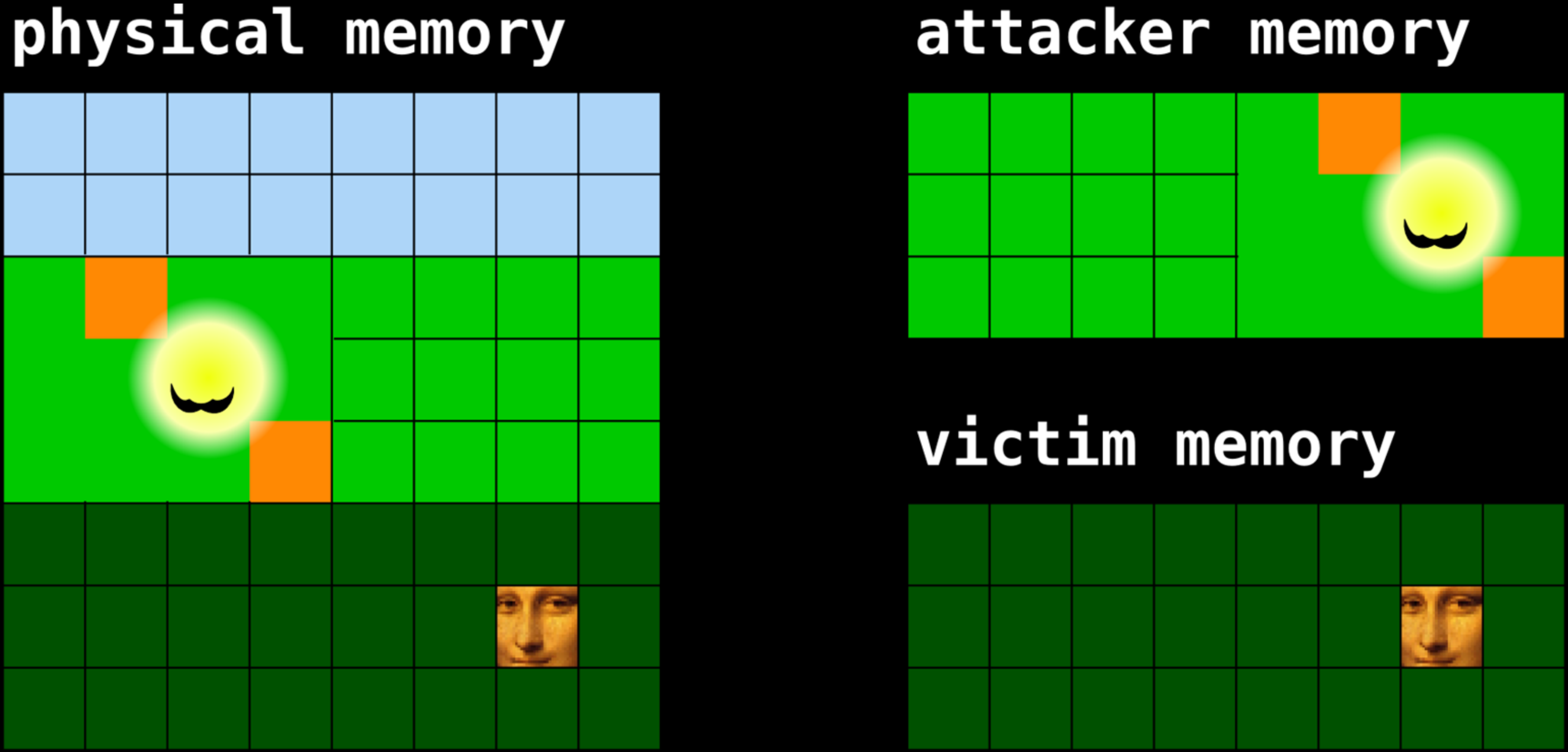


Flip Feng Shui: Mechanics

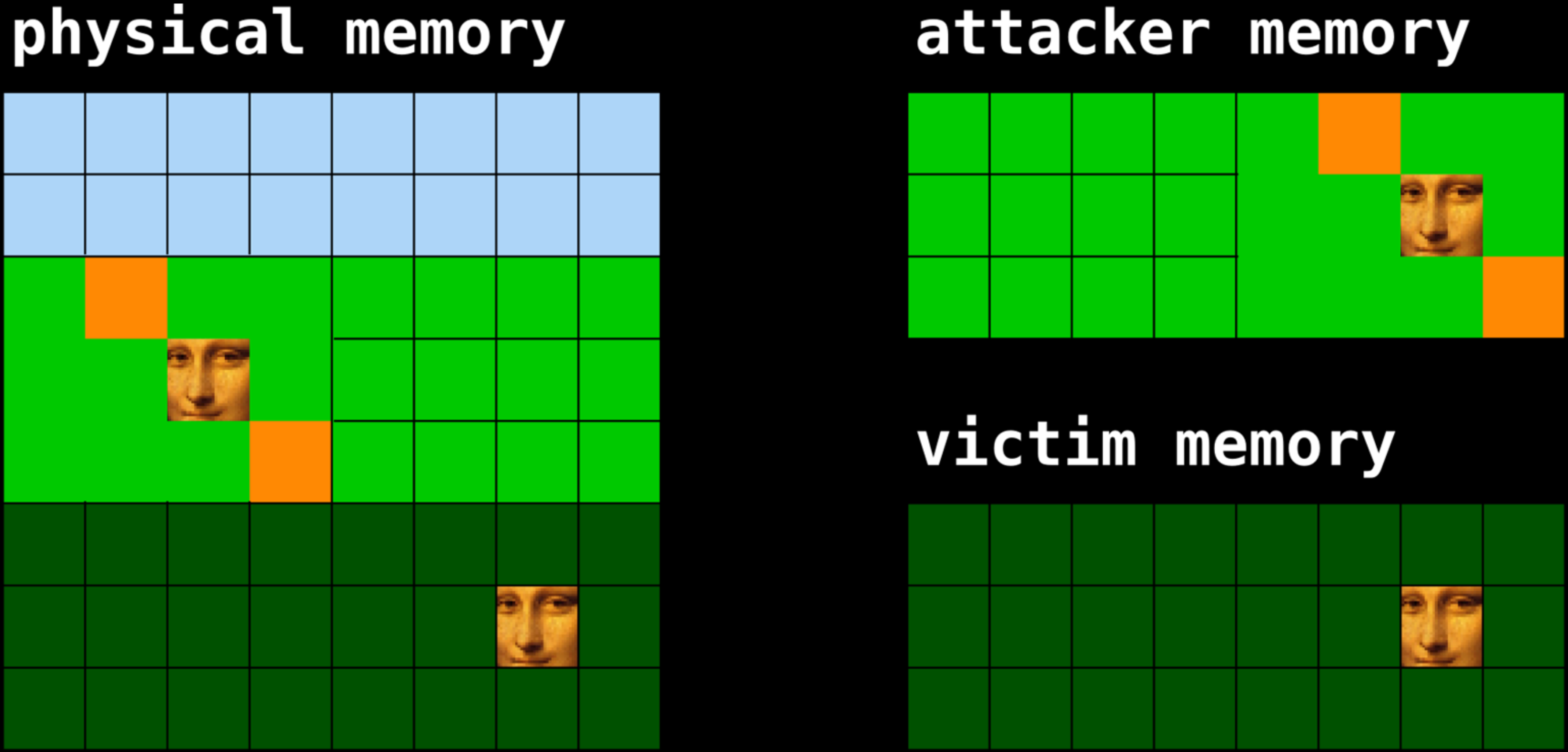
Step 2:

The attacker needs to force the system to map the victim page into the vulnerable template

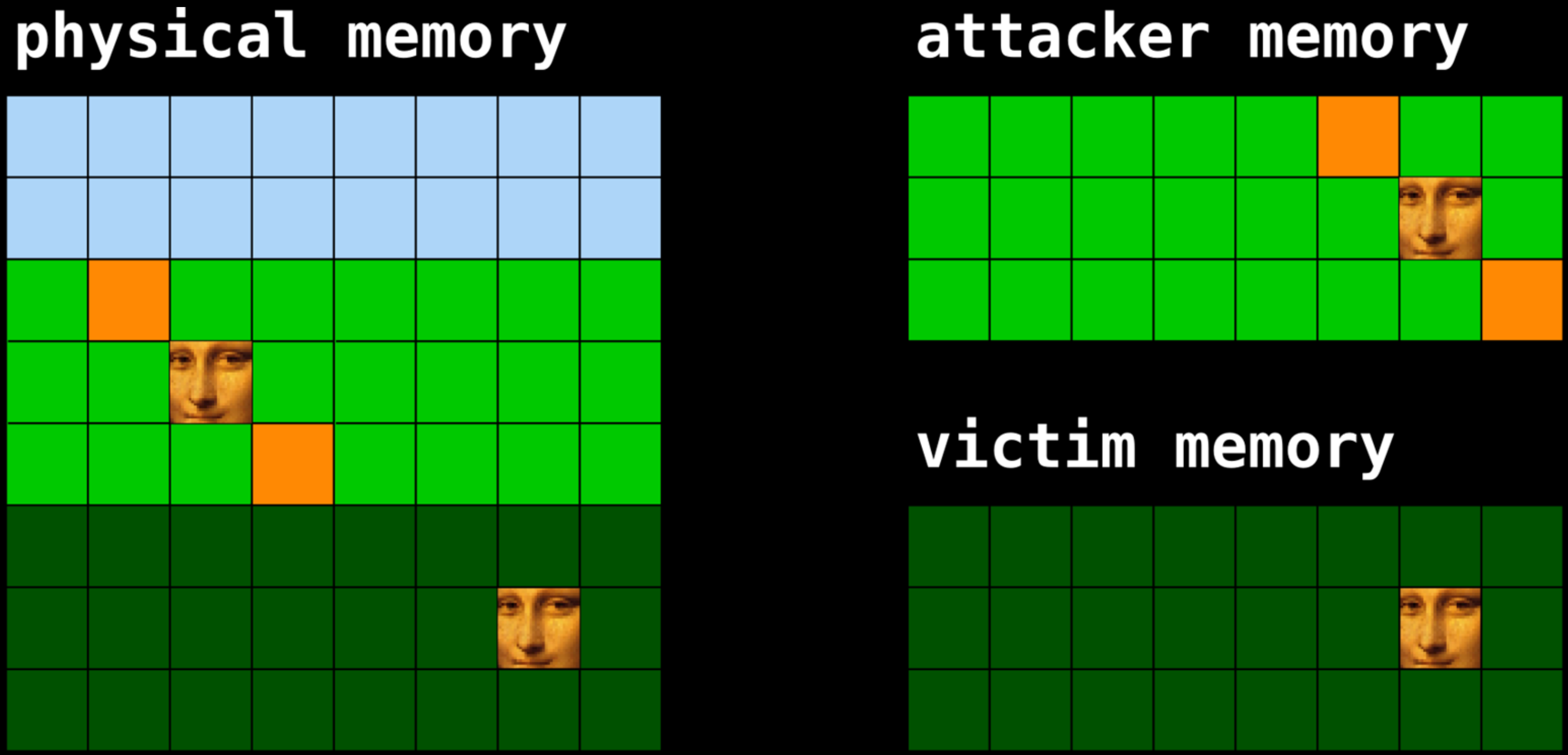
Flip Feng Shui: Physical Memory Massaging



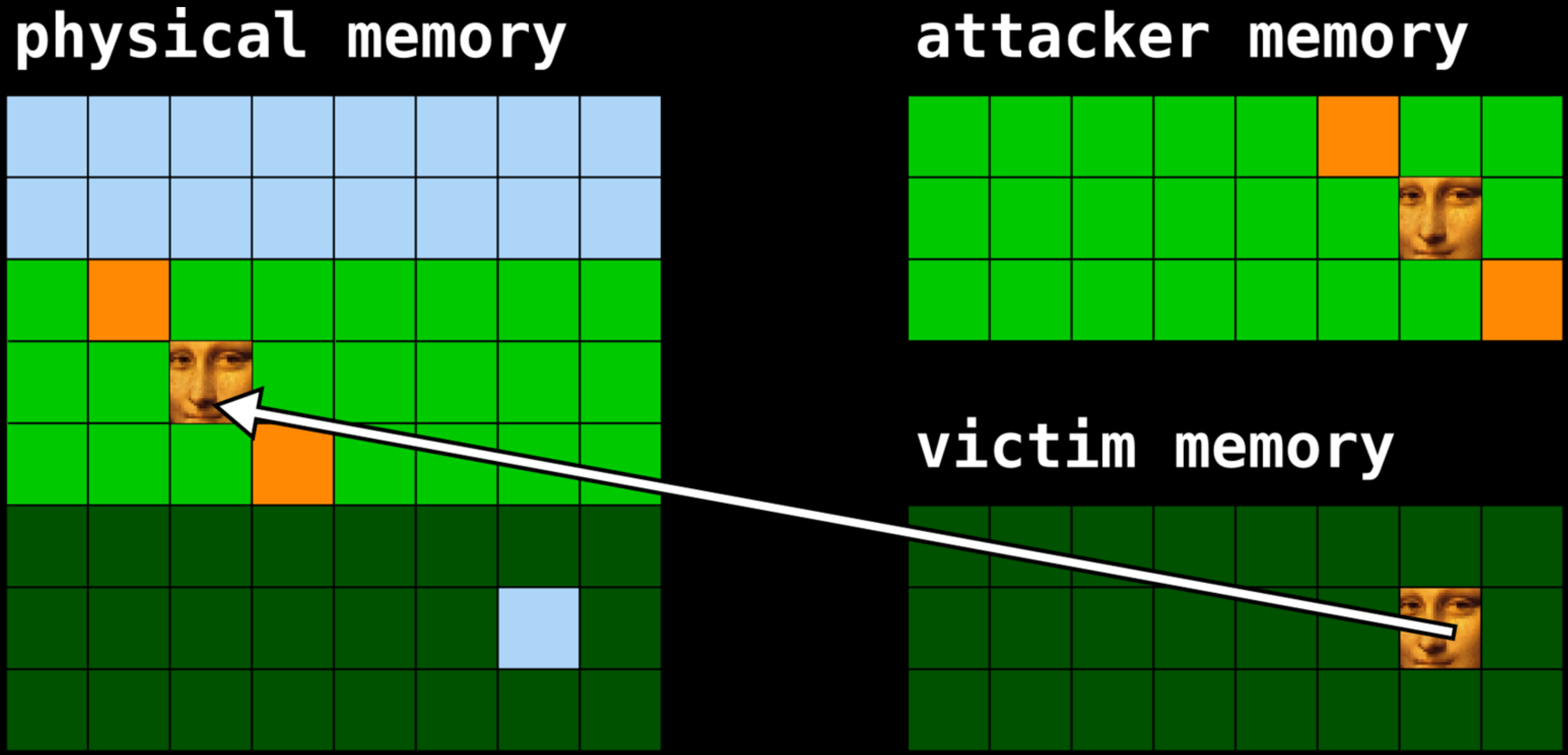
Flip Feng Shui: Physical Memory Massaging



Flip Feng Shui: Physical Memory Massaging



Flip Feng Shui:
Physical Memory Massaging

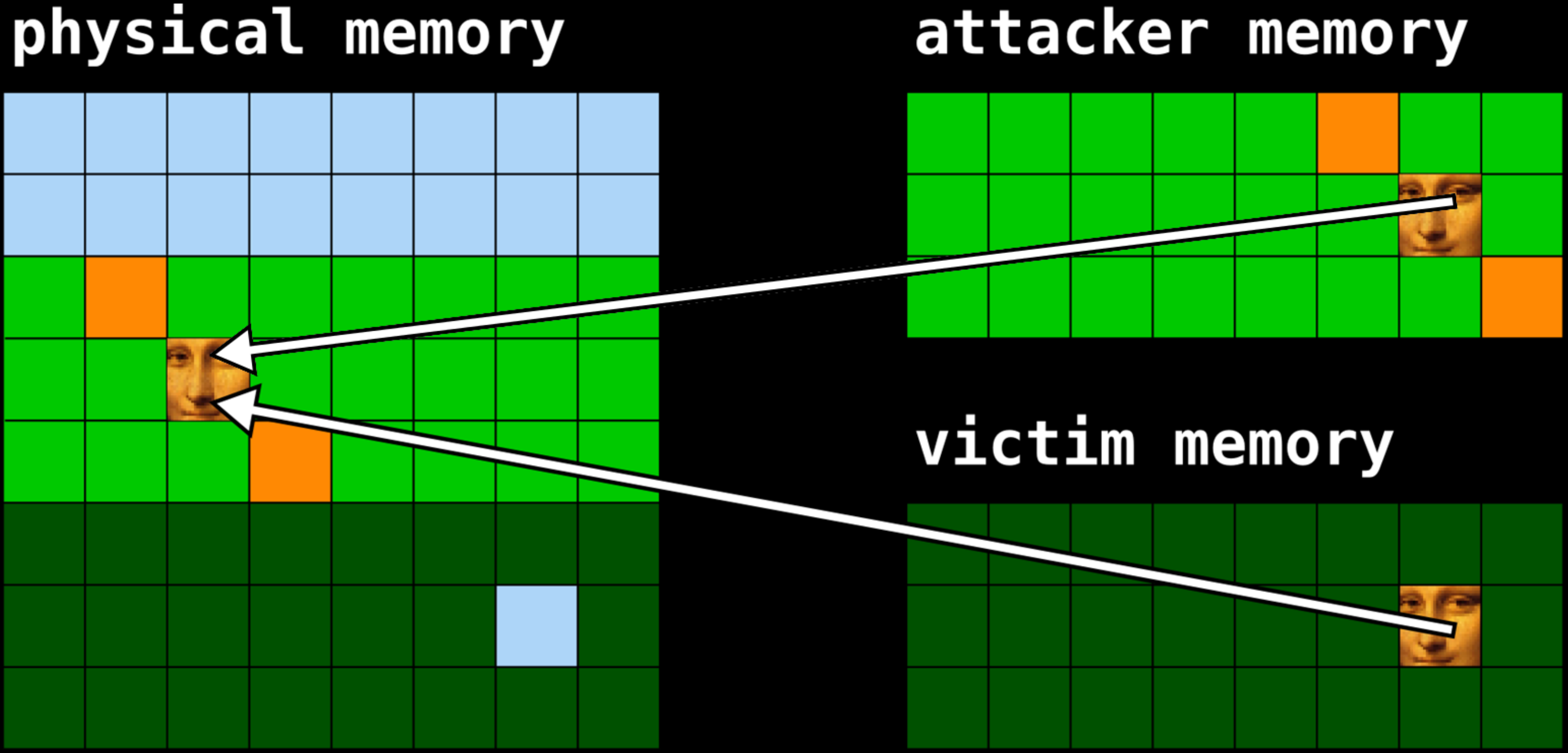


Flip Feng Shui: Mechanics

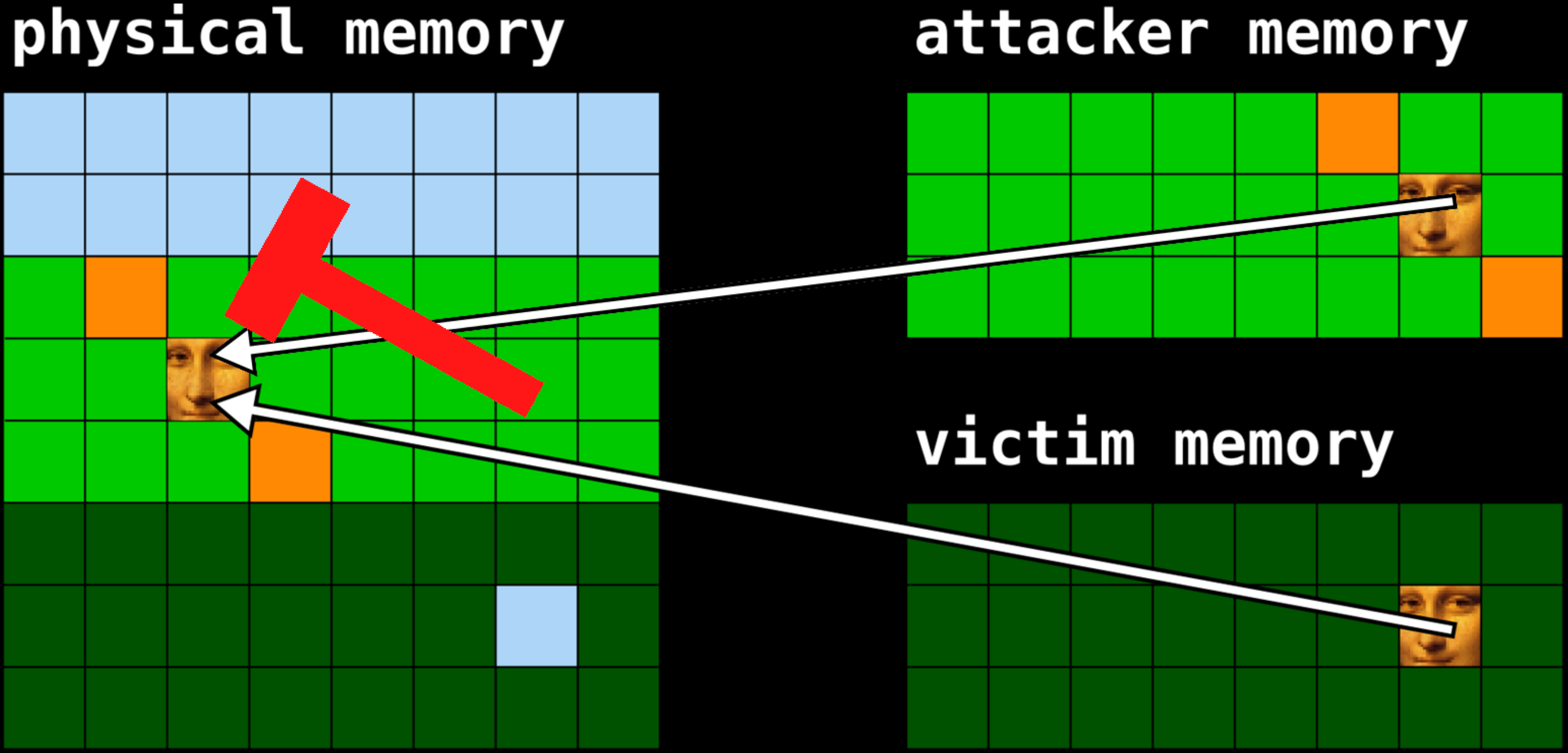
Step 3:

The attacker needs to flip the bit at the sensitive offset in the vulnerable template

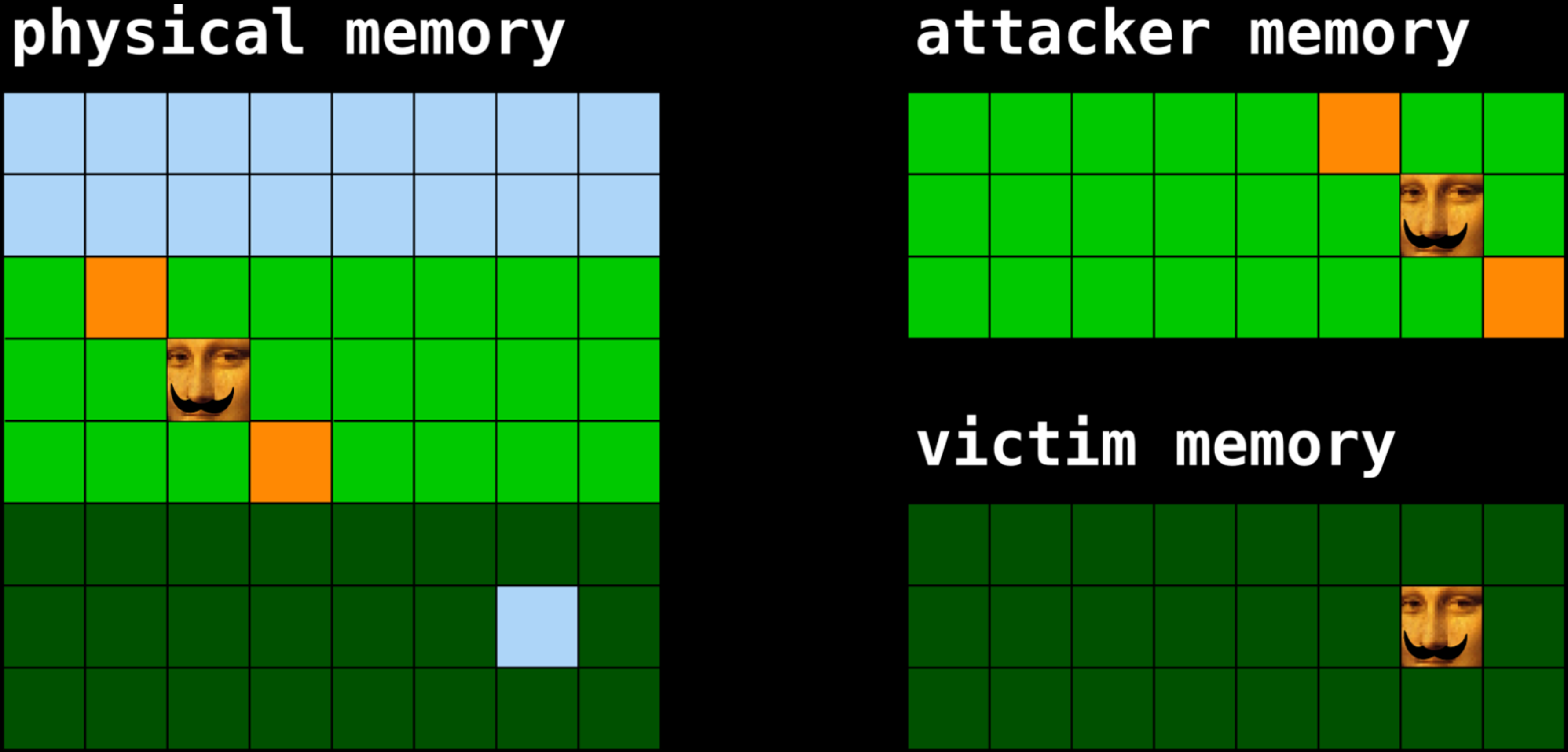
Flip Feng Shui: Exploitation



Flip Feng Shui: Exploitation



Flip Feng Shui: Exploitation



Flip Feng Shui:
Finding a Victim Page

The attacker wants a **victim page**:

- containing security-sensitive data
  - Corruption should result in cross-VM compromise
- with predictable content
  - For memory deduplication to map it into attacker VM
- with ideally many sensitive offsets
  - Easier to find useful templates

Flip Feng Shui: Finding a Victim Page

How about **public cryptographic keys**?

- Public keys are not secret, thus predictable
  - Arbitrary corruption weakens their security

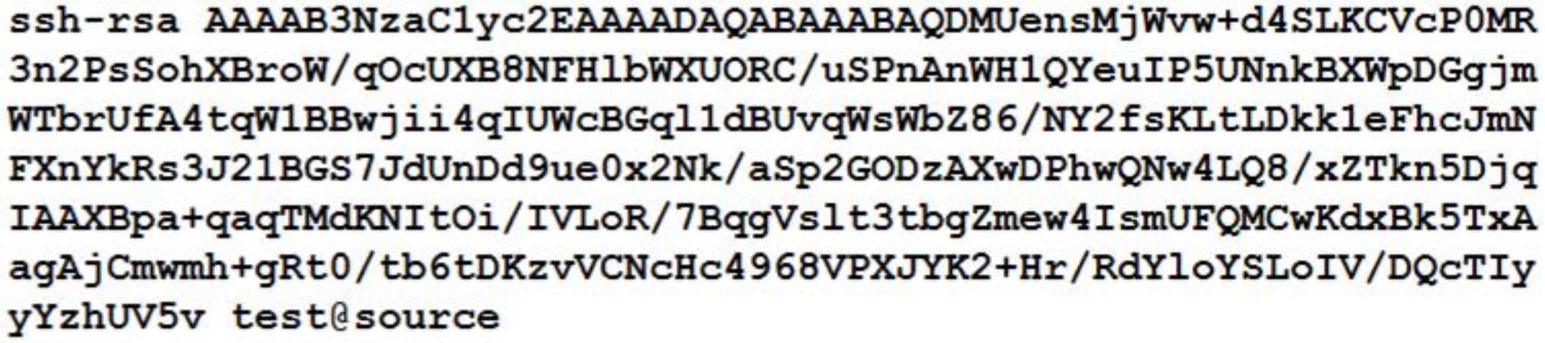
Flip Feng Shui: OpenSSH Attack

How about **public cryptographic keys**?

Public keys are not secret, thus predictable

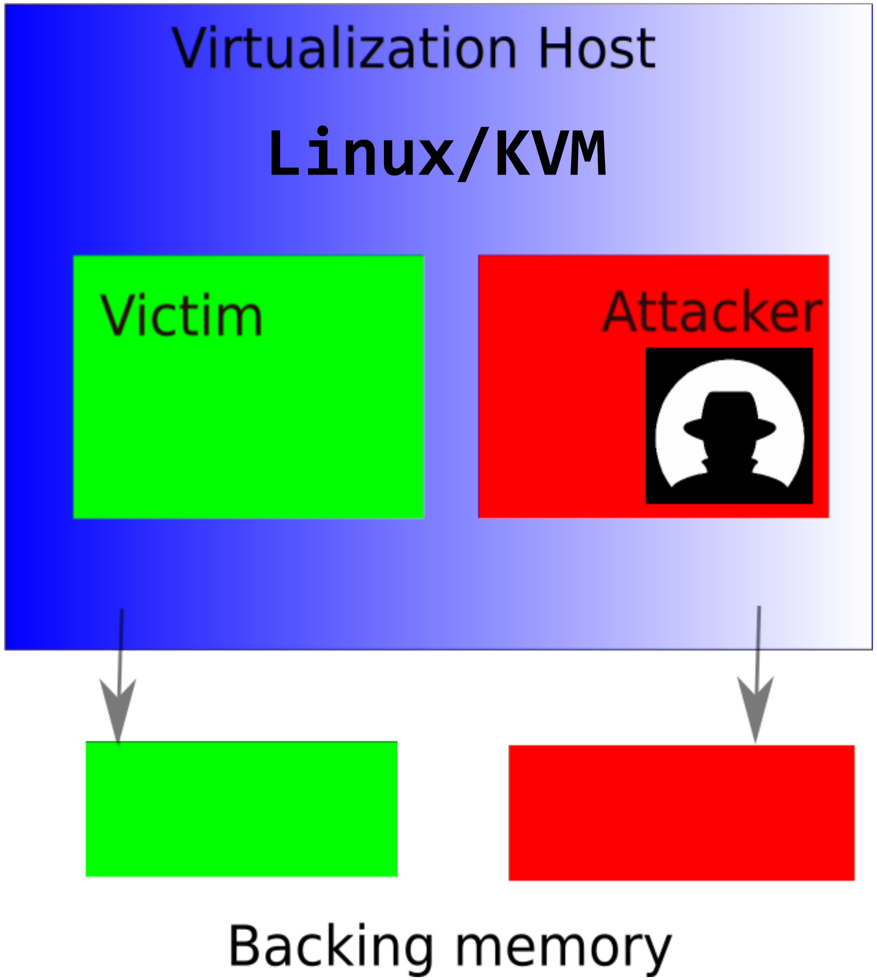
Arbitrary corruption weakens their security

Target OpenSSH's `~/.ssh/authorized_keys` to SSH to victim VM and login as administrator

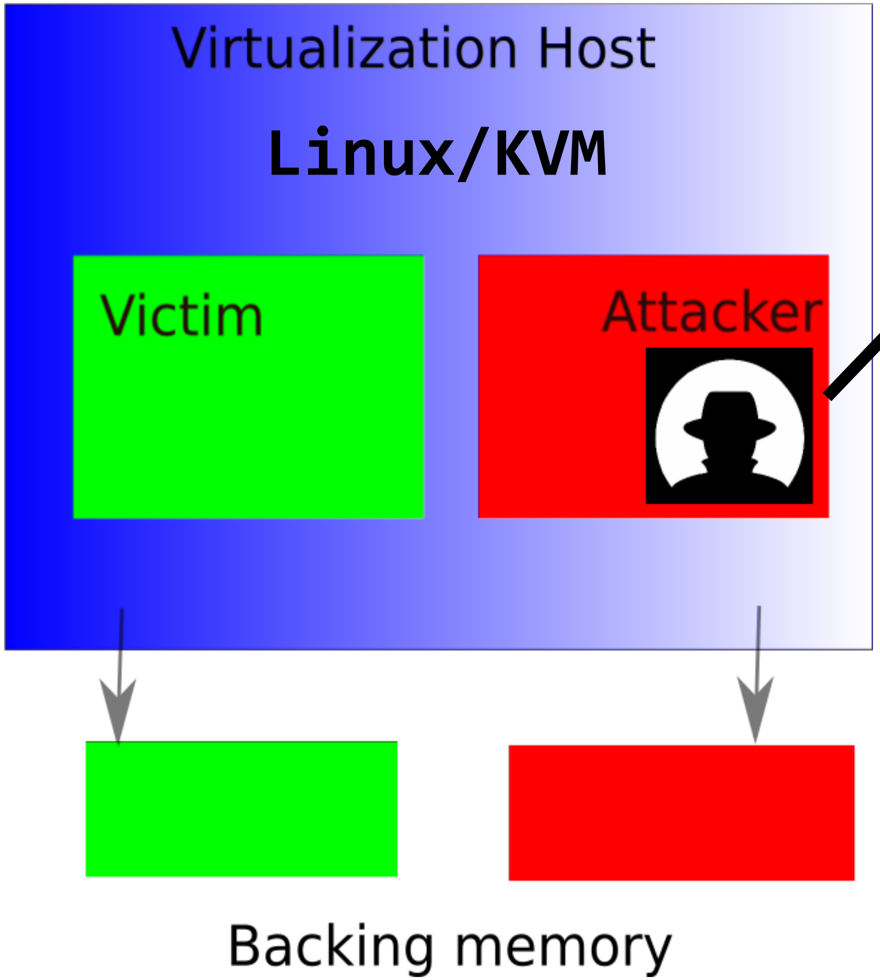


```
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQDMUensMjWvw+d4SLKCVcP0MR
3n2PsSohXBroW/qOcUXB8NFH1bWXUORC/uSPnAnWH1QYeuIP5UNnkBXWpDGgjm
WTbrUfA4tqW1BBwjii4qIUWcBGql1dBUvqWsWbZ86/NY2fsKLtLDkk1eFhcJmN
FXnYkRs3J21BGS7JdUnDd9ue0x2Nk/aSp2GODzAXwDPhwQNw4LQ8/xZTkn5Djq
IAAXBpa+qaqTMdKNItOi/IVLoR/7BqgVslt3tbgZmew4IsmUFQMCwKdxBk5TxA
agAjCmwmh+gRt0/tb6tDKzvVCNcHc4968VPXJYK2+Hr/RdYloYSLoIV/DQcTIy
yYzhUV5v test@source
```

Flip Feng Shui: OpenSSH Attack

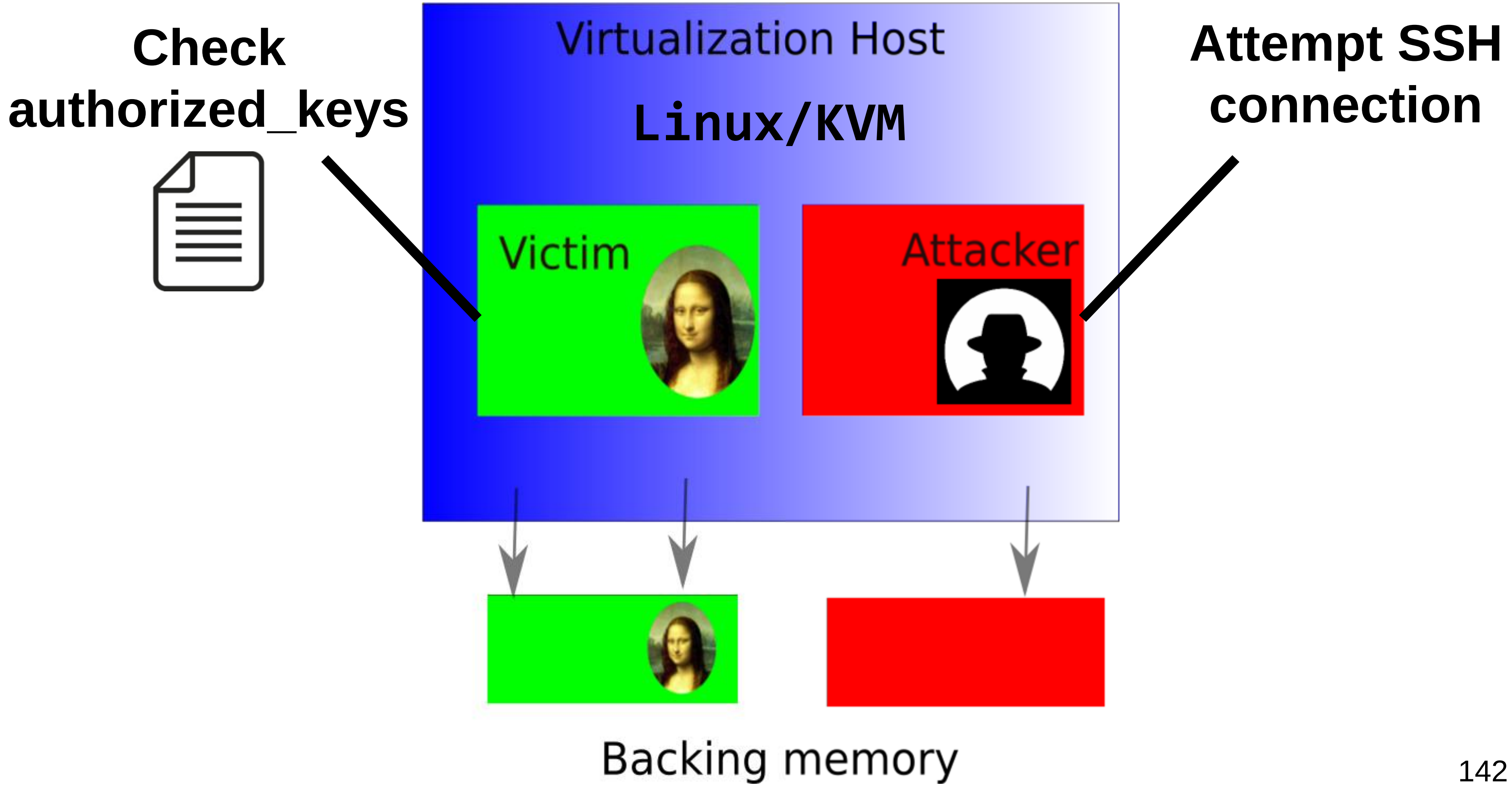


Flip Feng Shui: OpenSSH Attack

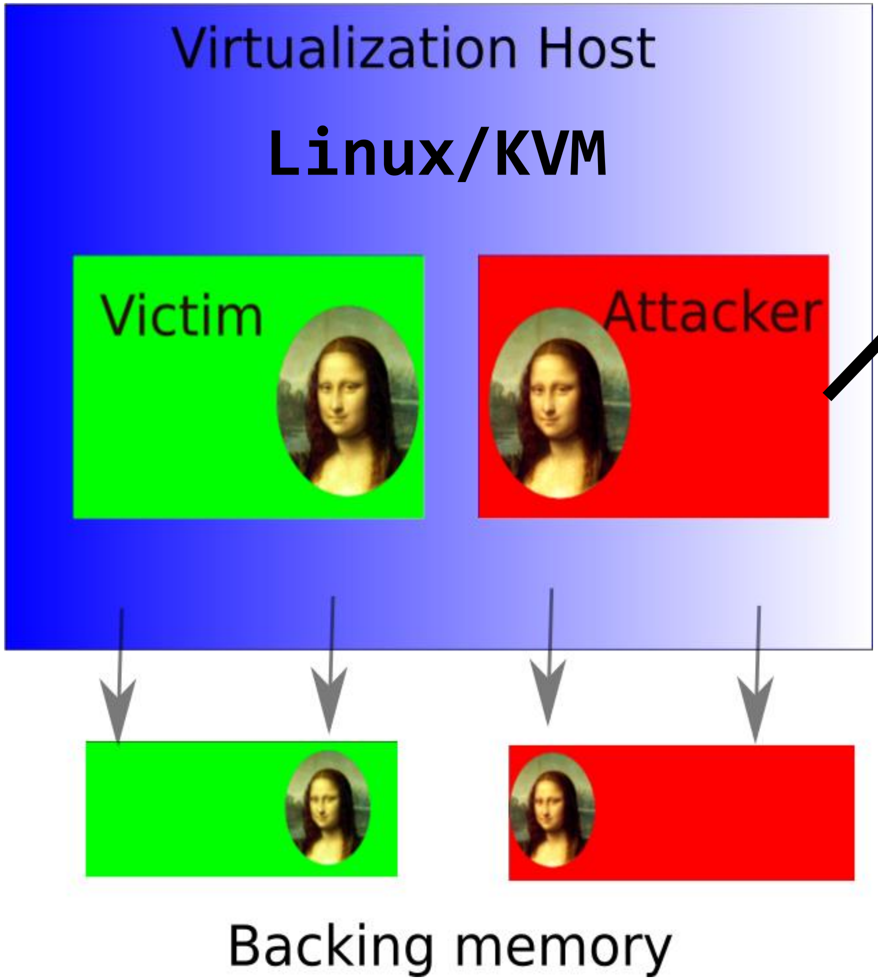


Attempt SSH connection

Flip Feng Shui: OpenSSH Attack

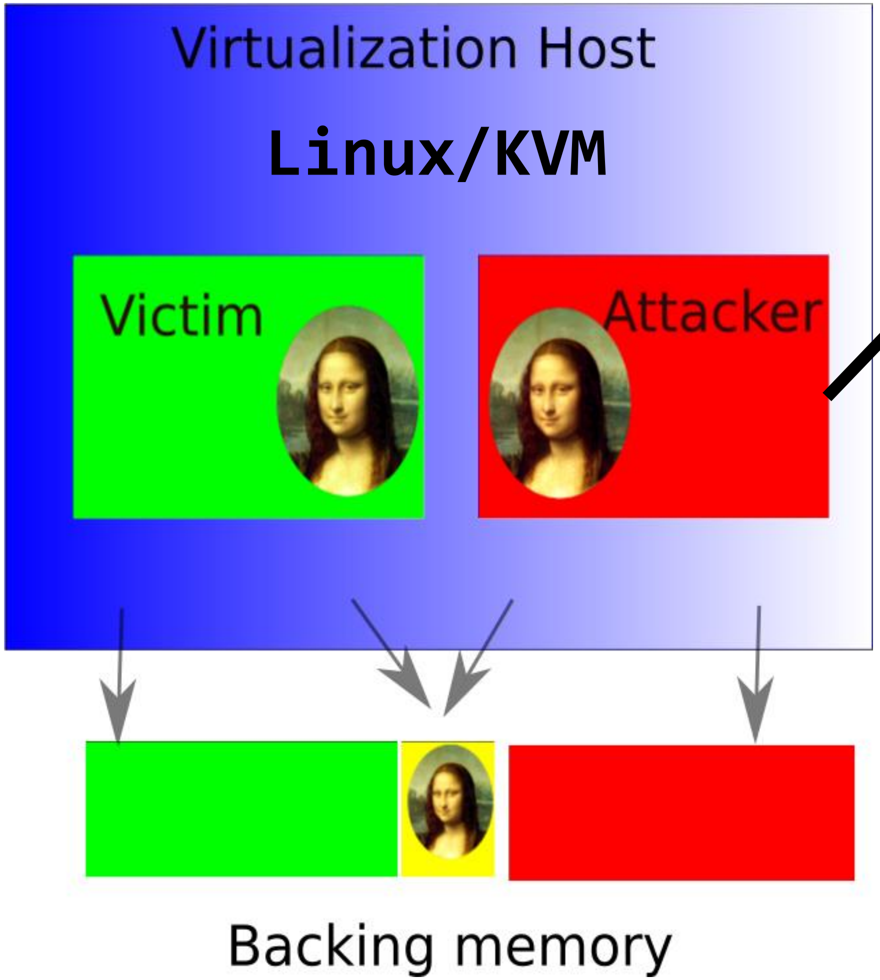


Flip Feng Shui: OpenSSH Attack



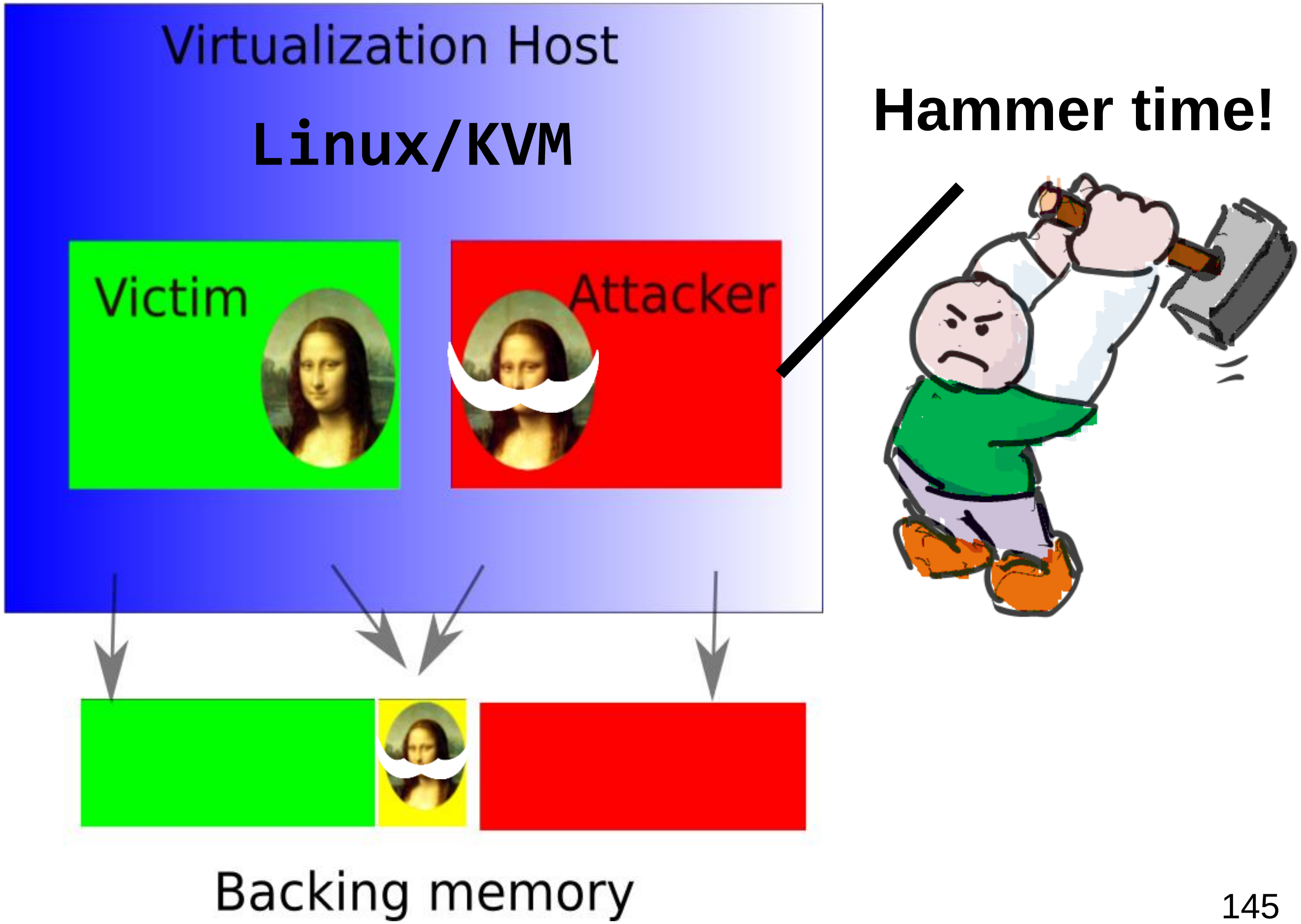
Craft victim page content in vulnerable template

Flip Feng Shui: OpenSSH Attack



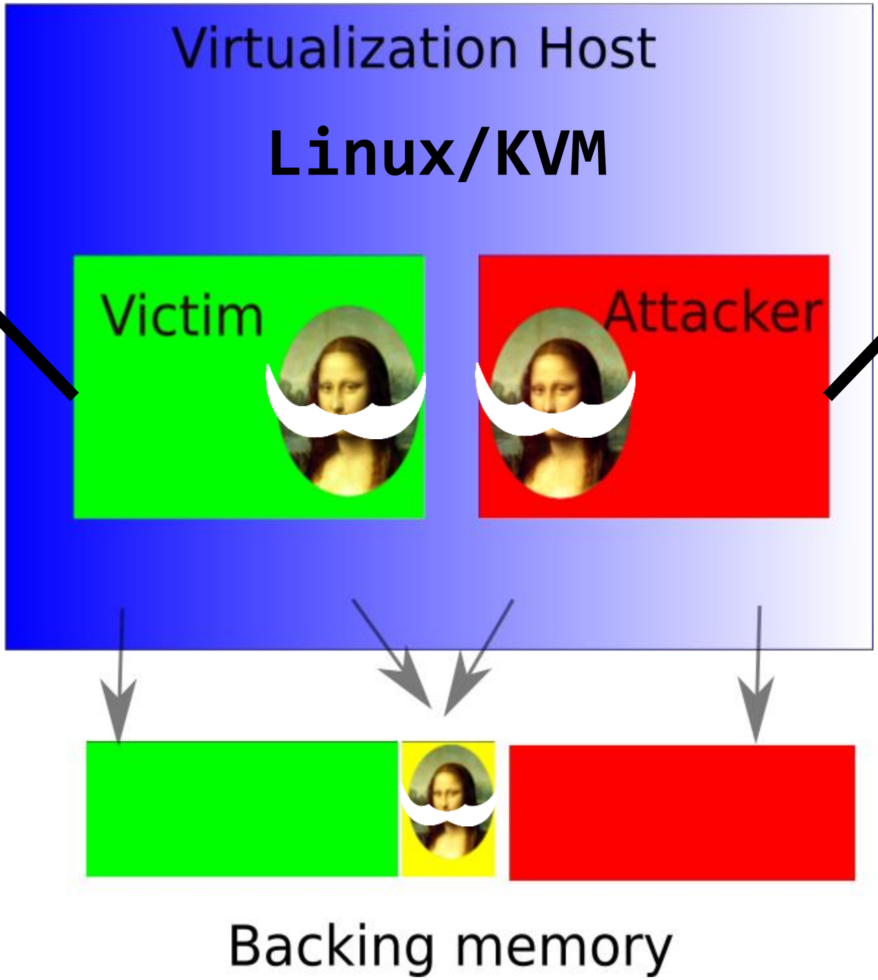
Dedup moves the victim page to the vulnerable template

Flip Feng Shui: OpenSSH Attack



Flip Feng Shui: OpenSSH Attack

Changes are reflected in the victim page



Virtualization Host

Linux/KVM

Victim

Attacker

Backing memory

Hammer time!

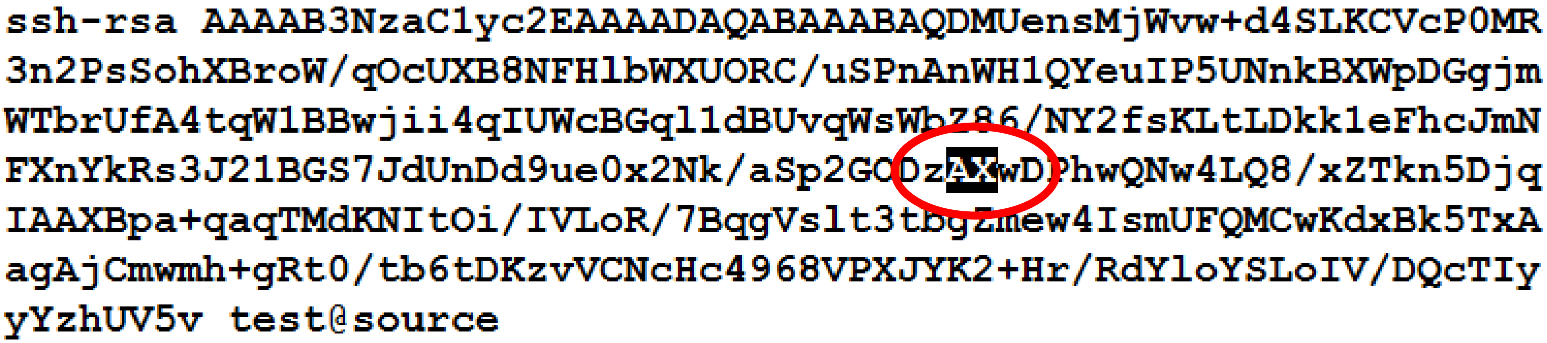
Flip Feng Shui: OpenSSH Attack

A bit flip in a **public RSA key**...

Results in a weak key one can factorize

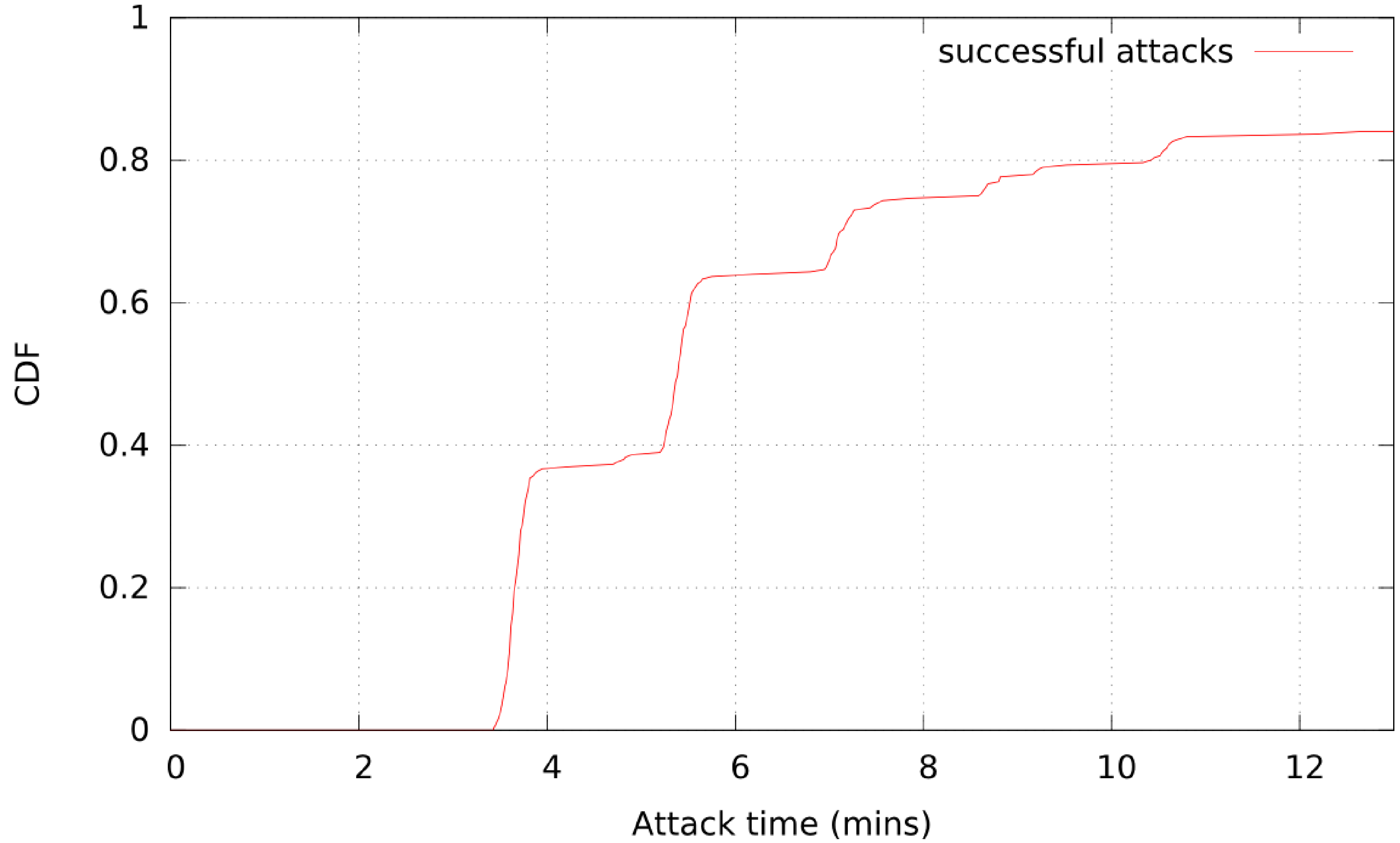
Easy to reconstruct the new private key

We do this in minutes and login to the VM!



```
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQDMUensMjWvw+d4SLKCVcP0MR
3n2PsSohXBroW/qOcUXB8NFHlbWXUORC/uSPnAnWH1QYeuIP5UNnkBXWpDGgjm
WTbrUfA4tqW1BBwjii4qIUWcBGql1dBUvqWsWbZ86/NY2fsKLtLDkk1eFhcJmN
FXnYkRs3J21BGS7JdUnDd9ue0x2Nk/aSp2GODzAXwDPhwQNw4LQ8/xZTkn5Djq
IAAXBpa+qaqTMdKNItOi/IVLoR/7BqgVslt3tbgZmew4IsmUFQMCwKdxBk5TxA
agAjCmwmh+gRt0/tb6tDKzvVCNcHc4968VPXJYK2+Hr/RdYloYSLoIV/DQcTIy
yYzhUV5v test@source
```

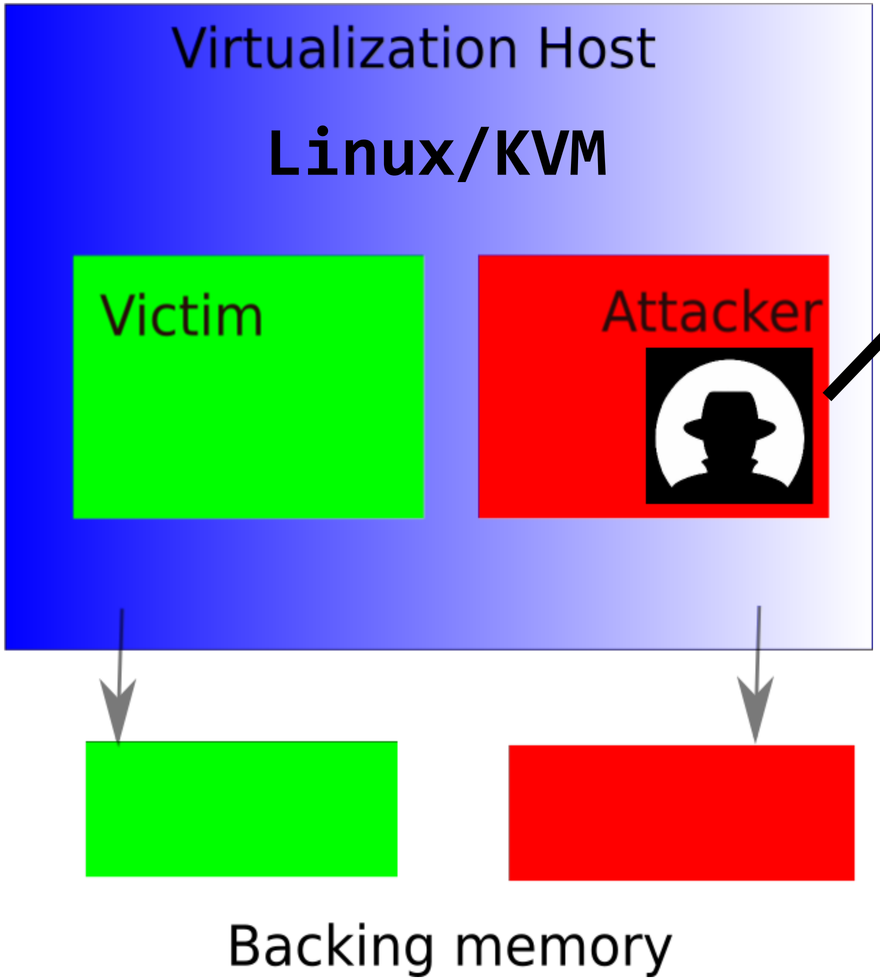
Flip Feng Shui: OpenSSH Attack



Flip Feng Shui: OpenSSH Attack

“What if we don’t know
the public key(s) of the
administrator?”

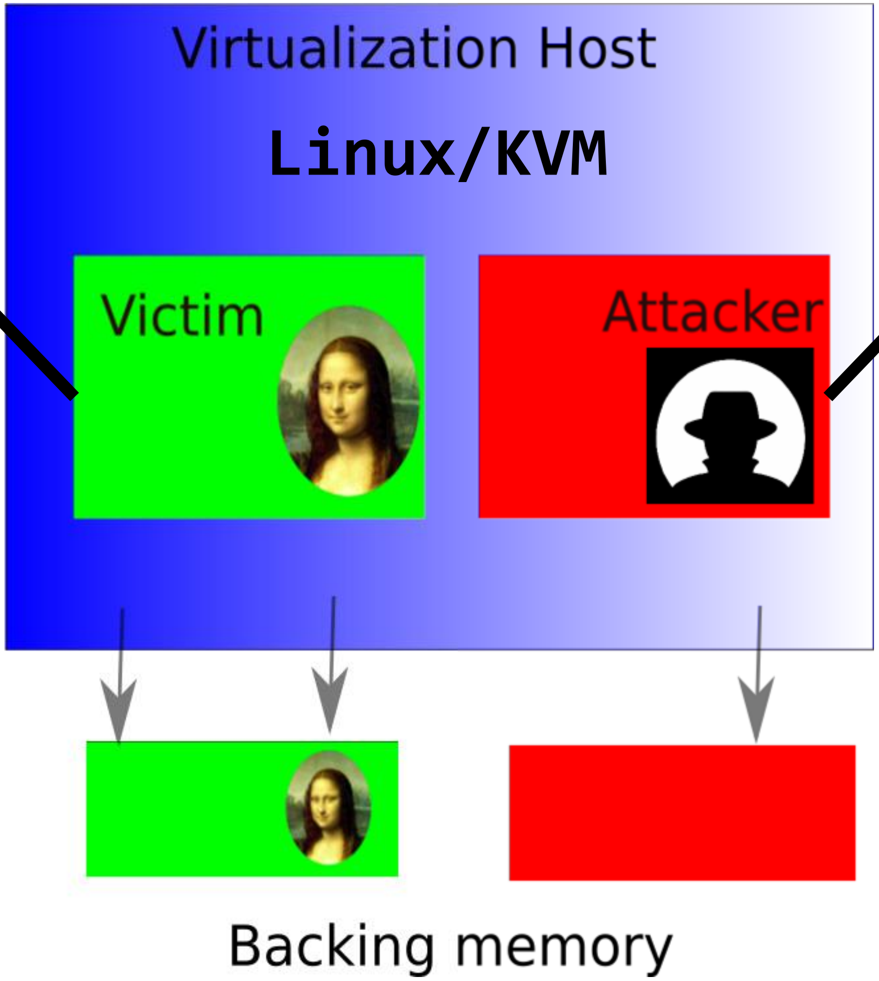
Flip Feng Shui: apt-get Attack



Wait for apt-get update on Ubuntu or Debian victim VM

Flip Feng Shui: apt-get Attack

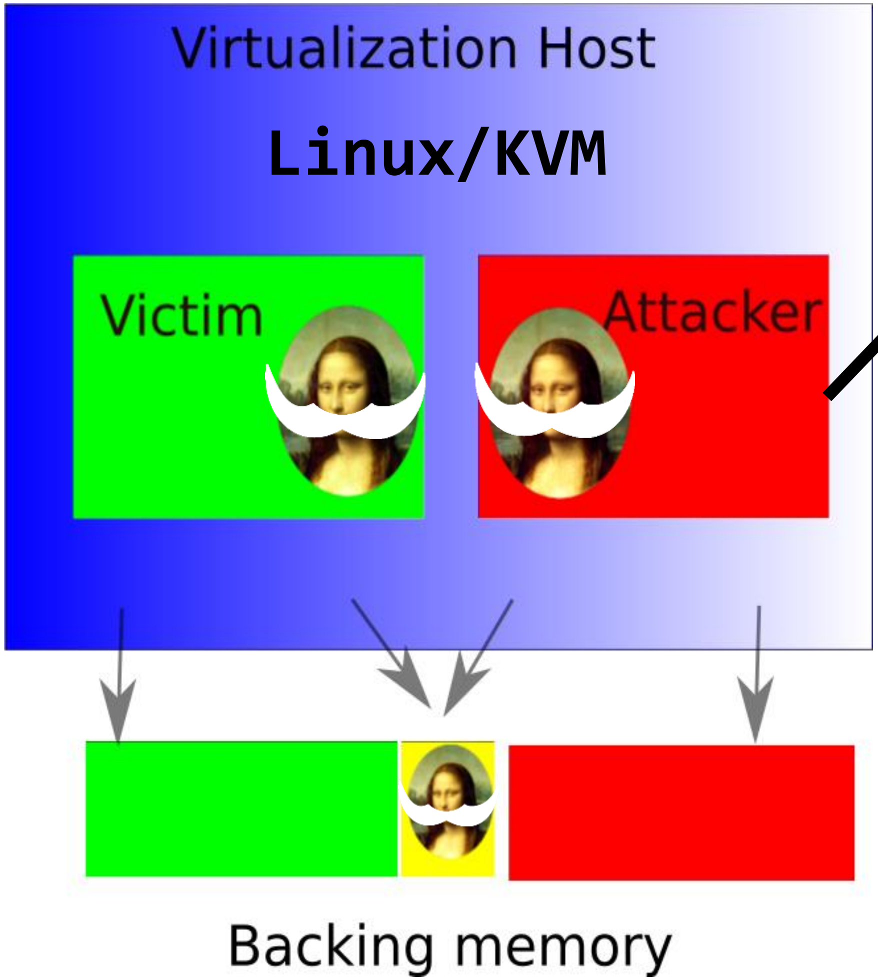
Check `sources.list`



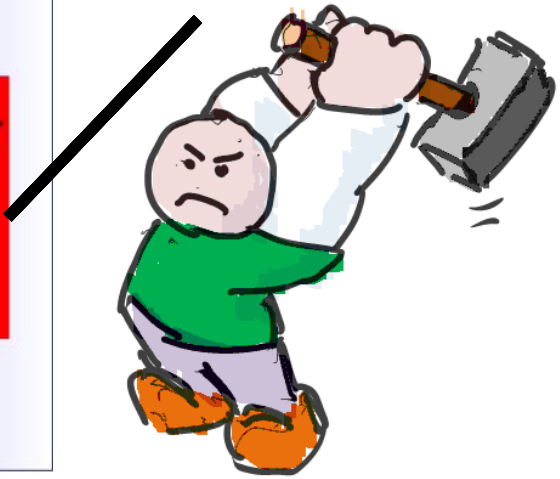
`debian.org`
`ubuntu.com`
`...`

Wait for apt-get update on Ubuntu or Debian victim VM

Flip Feng Shui: apt-get Attack



Corrupt URLs in sources.list



Flip Feng Shui:
apt-get Attack

With a bit flip in a **mirror domain name**...

The victim VM installs our own packages from:

```
ubunvu.com
 ucuntu.com
 ...
```

(which we own)

But fortunately, the packages are signed!

Wait…

Flip Feng Shui: `apt-get` Attack

We can:

- Flip a bit in `trusted.gpg`
  - where apt-get’s trusted package public keys are stored
- Generate the new corresponding private key
  - Again, we can do this in minutes
- Sign our own packages
  - Say from `ubunvu.com`
- Install & run anything we want in the victim VM

Flip Feng Shui: Impact

Notified:

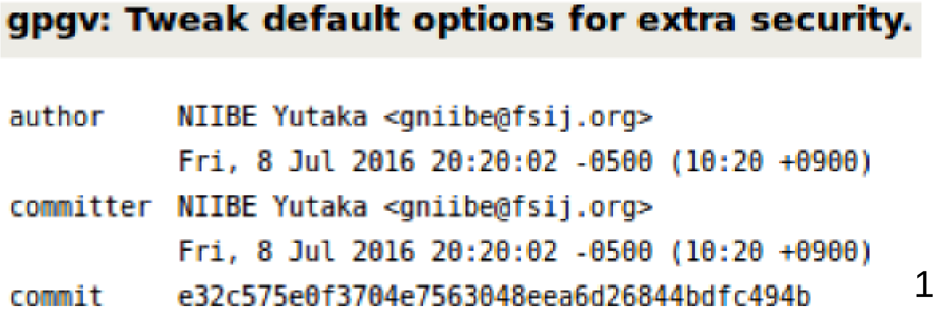
- Red Hat, Oracle, Xen, VMware, Debian, Ubuntu, OpenSSH, GnuPG, hosting companies

NCSC did all the hard work, thanks!

Nationaal Cyber Security Centrum
Ministerie van Veiligheid en Justitie

Virtuele servers kunnen hun buren aanvallen

GnuPG "*included hw bit flips in their threat model*"



gpgv: Tweak default options for extra security.

```
author     NIIBE Yutaka <gniibe@fsij.org>
           Fri, 8 Jul 2016 20:20:02 -0500 (10:20 +0900)
committer  NIIBE Yutaka <gniibe@fsij.org>
           Fri, 8 Jul 2016 20:20:02 -0500 (10:20 +0900)
commit     e32c575e0f3704e7563048eea6d26844bdfc494b
```

Mitigations

“Can we just disable memory deduplication and buy better DRAM?”

Yes, you really should, but...

Mitigations

No dedup?

- Need another memory massaging primitive
- E.g., just exploit predictable memory reuse patterns in common page allocators
- Basic approach:
  - Fill physical memory with attacker-allocated pages
  - Find a vulnerable template
  - Release corresponding physical page to allocator
  - Trigger allocation of victim page
  - The allocator has only 1 option to fulfill the allocation

Mitigations

Better DRAM?

Not so fast

- Rowhammer exploits fundamental DRAM properties

Discovered on DDR3, still there on DDR4

- Despite targeted countermeasures

Originally on x86, we found flips on ARM

- See our upcoming *Drammer* CCS'16 paper

ECC memory is not a panacea

- Not cheap/widespread, can't fix all bit flips

Mitigations

No dedup and no Rowhammer?

Other primitives will come along

Expect:

More hw/sw properties you didn’t know about

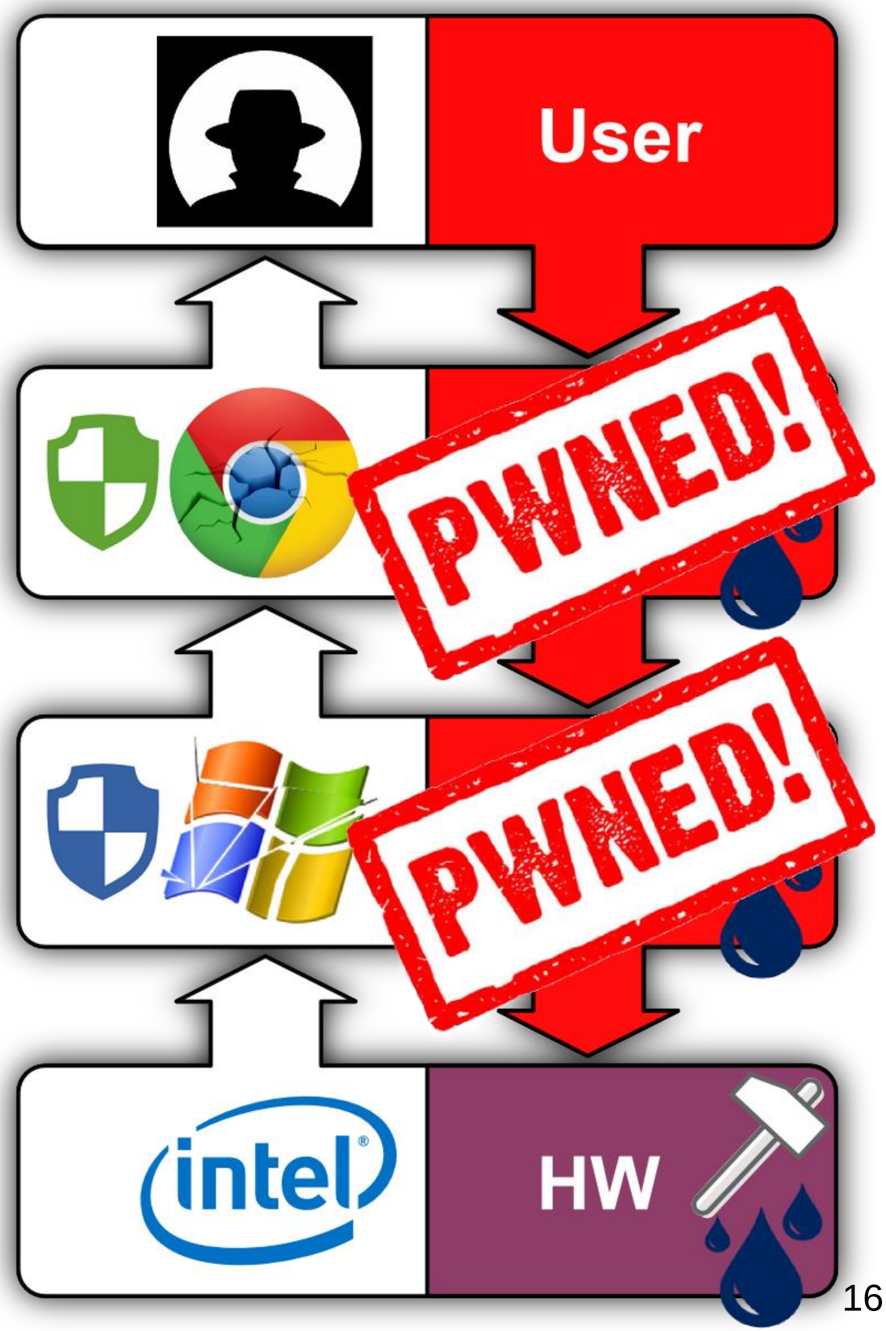
More **side channels**

More **hardware glitches**

A **radical change** in the way we think about sys security and “reasonable” threat models

Flip Feng Shui:

Is Physics Part of Your Threat Model Yet?



Rethinking Systems Security

Software security defenses

black hat®
USA 2016

[Aug 4, 12:00] **Microsoft**: “*Thanks to our mitigation improvements, since releasing Edge one year ago, there have been no zero day exploits targeting Edge*”

Rethinking Systems Security

Software security defenses

black hat

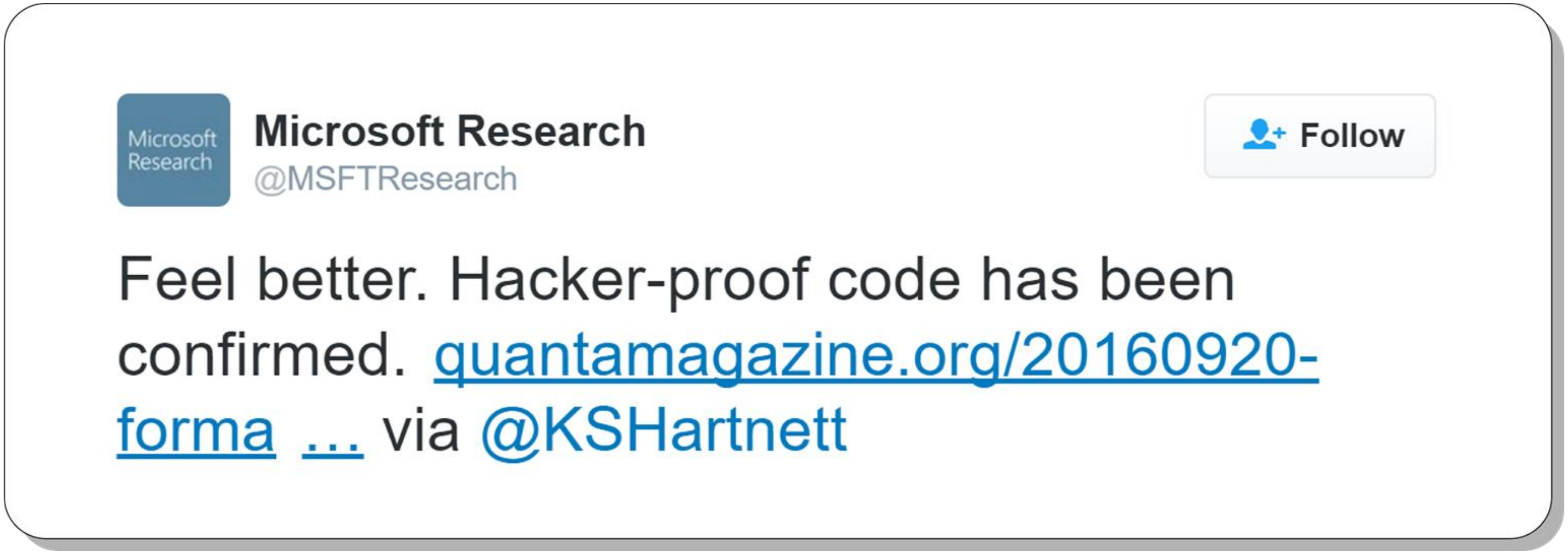
USA 2016

[Aug 4, 12:00] **Microsoft**: “*Thanks to our mitigation improvements, since releasing Edge one year ago, there have been no zero day exploits targeting Edge*”

[Aug 4, 17:00] **VUSec**: “*Dedup Est Machina: One can exploit the latest Microsoft Edge with all the defenses up, even in absence of software/configuration bugs*”

Rethinking Systems Security

Formally verified systems

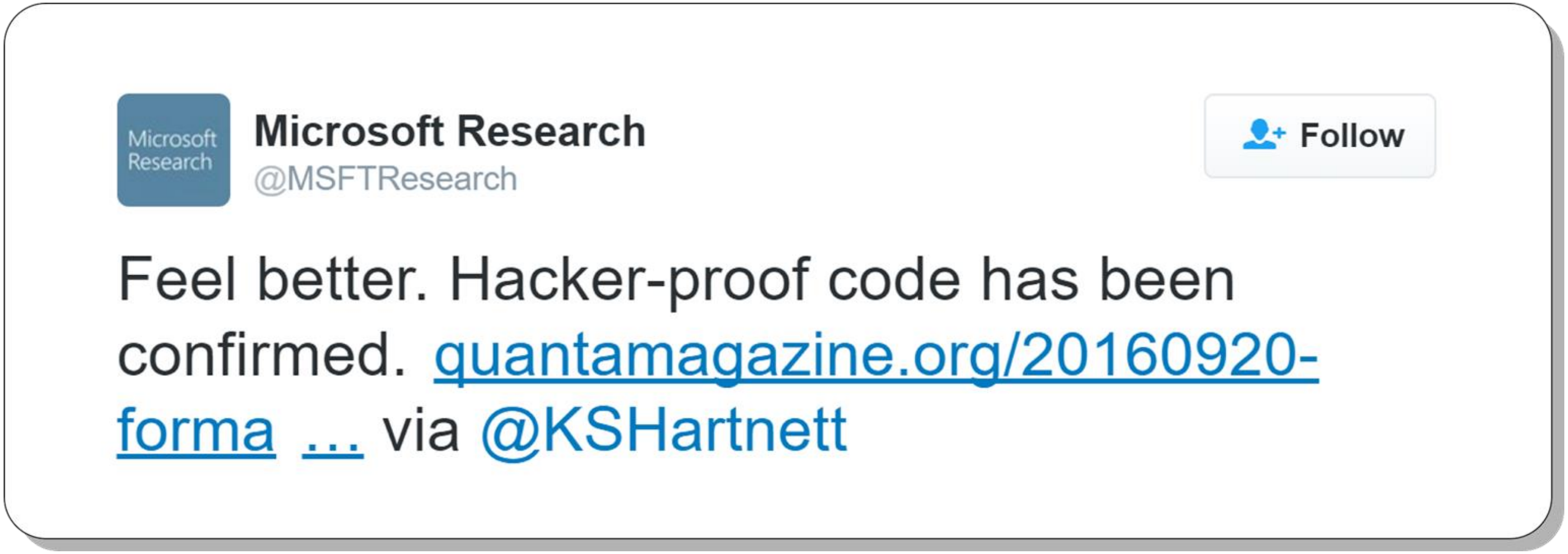


Microsoft Research
@MSFTResearch

Feel better. Hacker-proof code has been confirmed. quantamagazine.org/20160920-forma ... via @KSHartnett

Rethinking Systems Security

Formally verified systems



Microsoft Research
@MSFTResearch

Feel better. Hacker-proof code has been confirmed. quantamagazine.org/20160920-forma ... via @KSHartnett

[Aug 10] **VUSec**: “*Flip Feng Shui: Reliable exploitation of bug-free software systems*”

Rethinking Systems Security

What's Next?

- Start worrying about emerging new threats
  - Think about new security defenses
  - Don't forget the past
    - E.g., Anomaly detection for Rowhammer attacks
  - But also:
    - Randomization
    - Isolation
    - ...

(now applied to physical memory)

Conclusion

Software security defenses are getting better

- But hw and sw are getting extremely complex
- Potentially huge unexplored attack surface
- Attackers can subvert even “perfect” software
- Beyond side channels (but they play a role)

VUSec

https://vusec.net