Flip Feng Shui: Hammering a Needle in the Software Stack

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August 10, 2016

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Teaser

- OpenSSH compromise
- apt-get compromise by GPG signature forgery
- No software bug
- Weak assumptions
- Demo!

Contribution

Flip Feng Shui is a novel exploitation structure

- Hardware glitch
- Memory massaging primitive

Makes the glitch

- Easy to target precisely
- Reliable

We demonstrate FFS = Rowhammer + Memory Deduplication

Outline

Flip Feng Shui At Work

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Flip Feng Shui Mechanics

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OpenSSH Attack

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GPG/APT Updates Attack Demo

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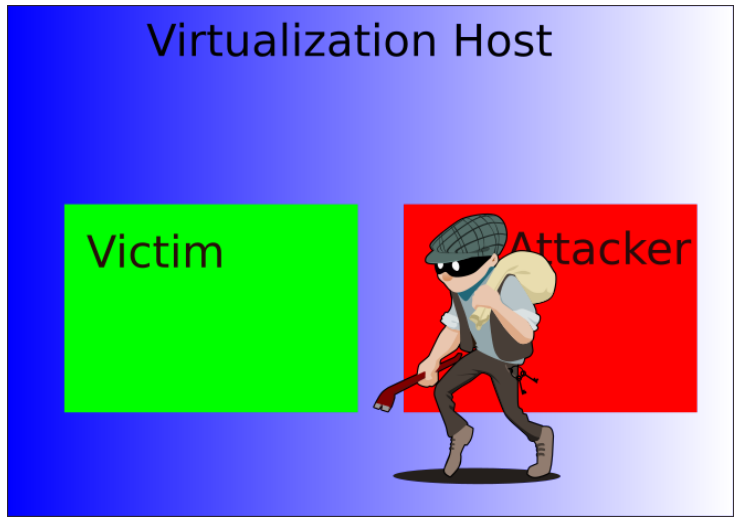
Notification, Conclusion & Further Resources

Section 1

Flip Feng Shui At Work

Flip Feng Shui

- Flip one bit per page in a co-hosted victim VM



- Whenever you know its contents
- Organised bitflip
- DRAM glitch
- Breaks CPU virtualization isolation

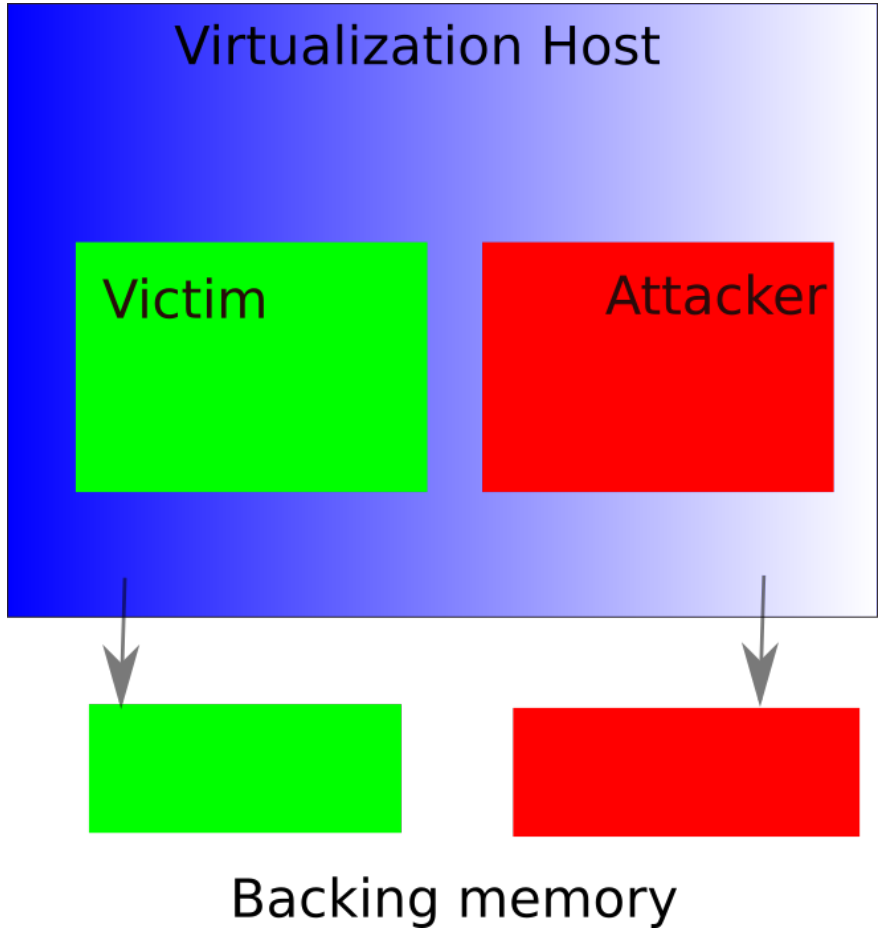
Section 2

Flip Feng Shui Mechanics

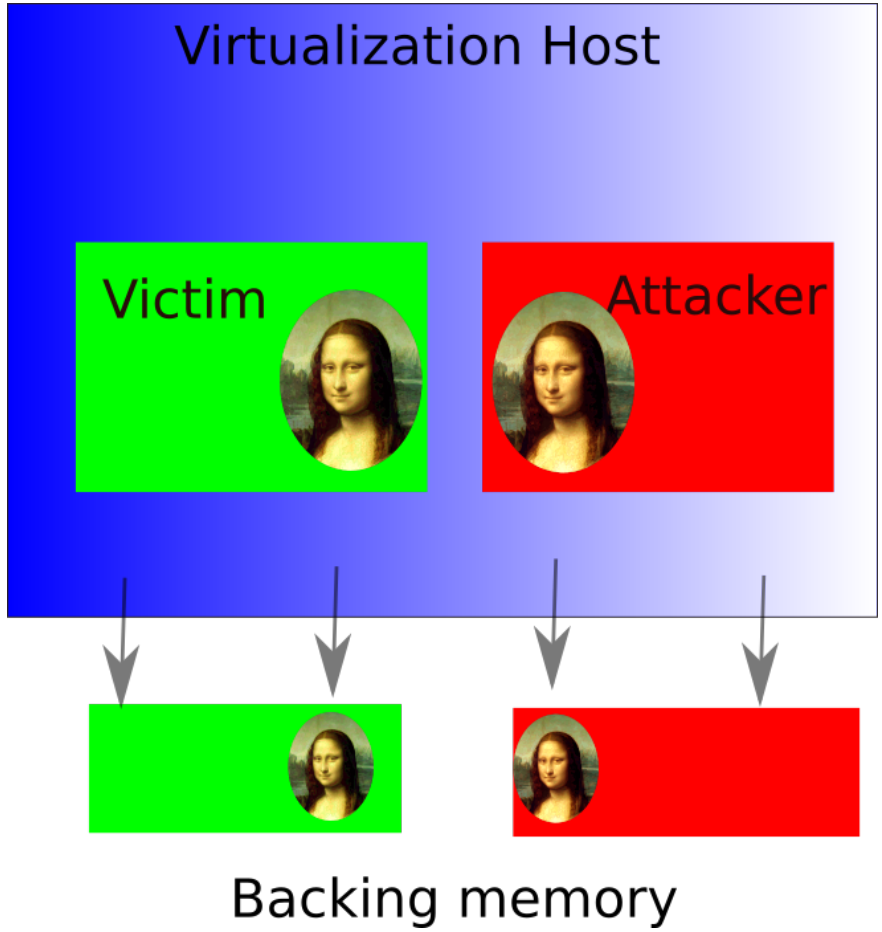
Flip Feng Shui Mechanics

- Co-hosted VMs
- Memory deduplication
- Rowhammer
- RSA

Memory deduplication



Memory deduplication



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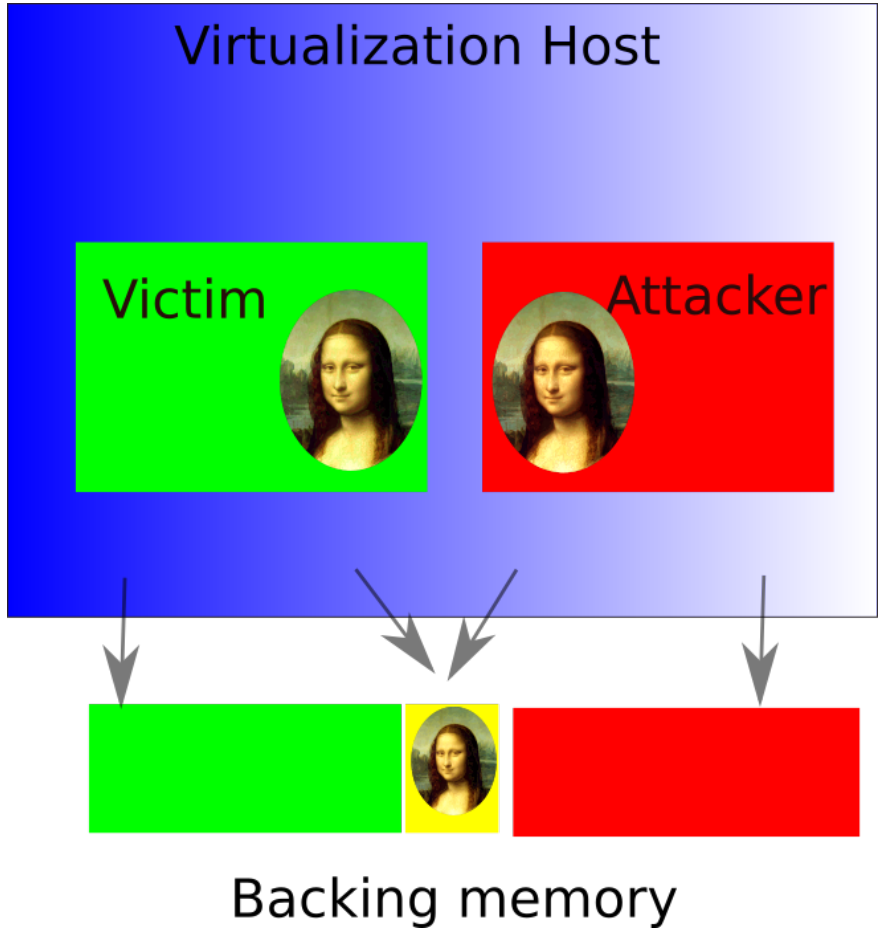

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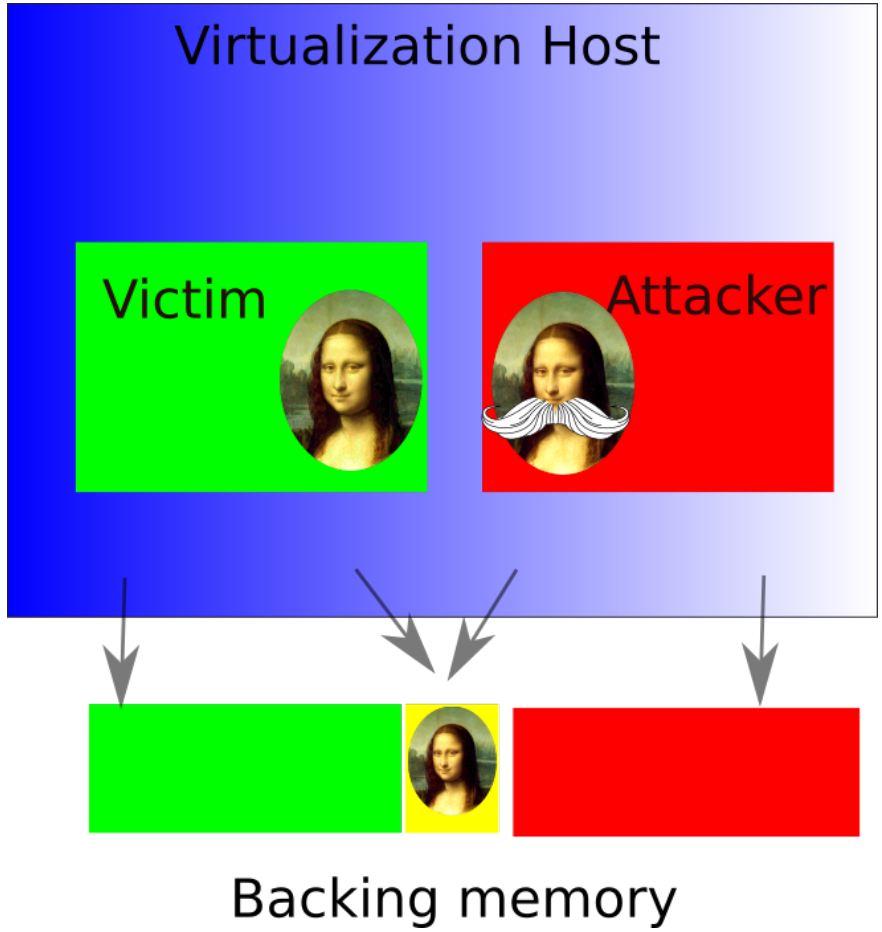

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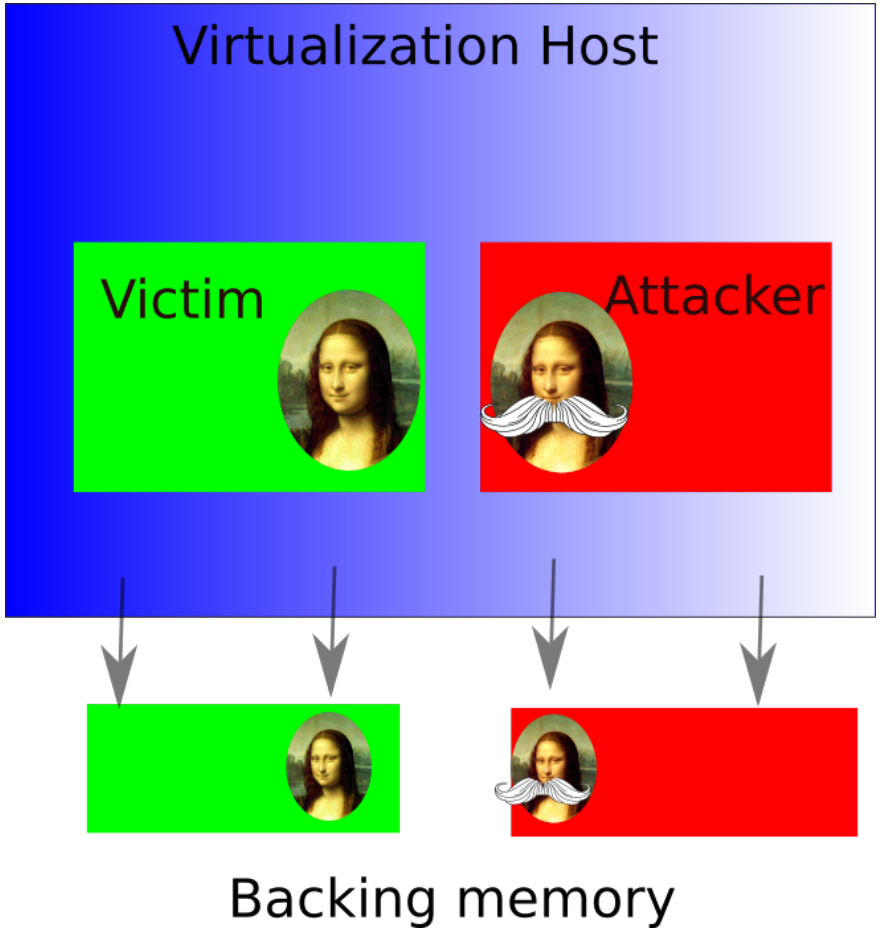
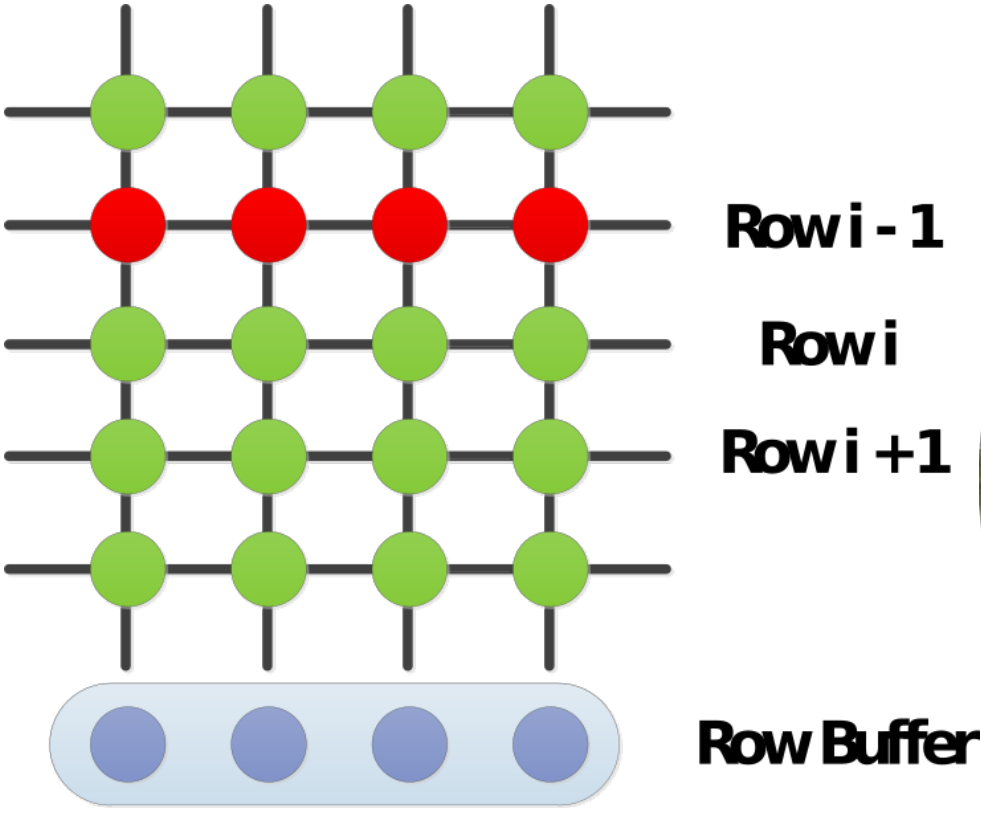


Rowhammer

- Causes charge to leak in DRAM
- DRAM row activations cause flips



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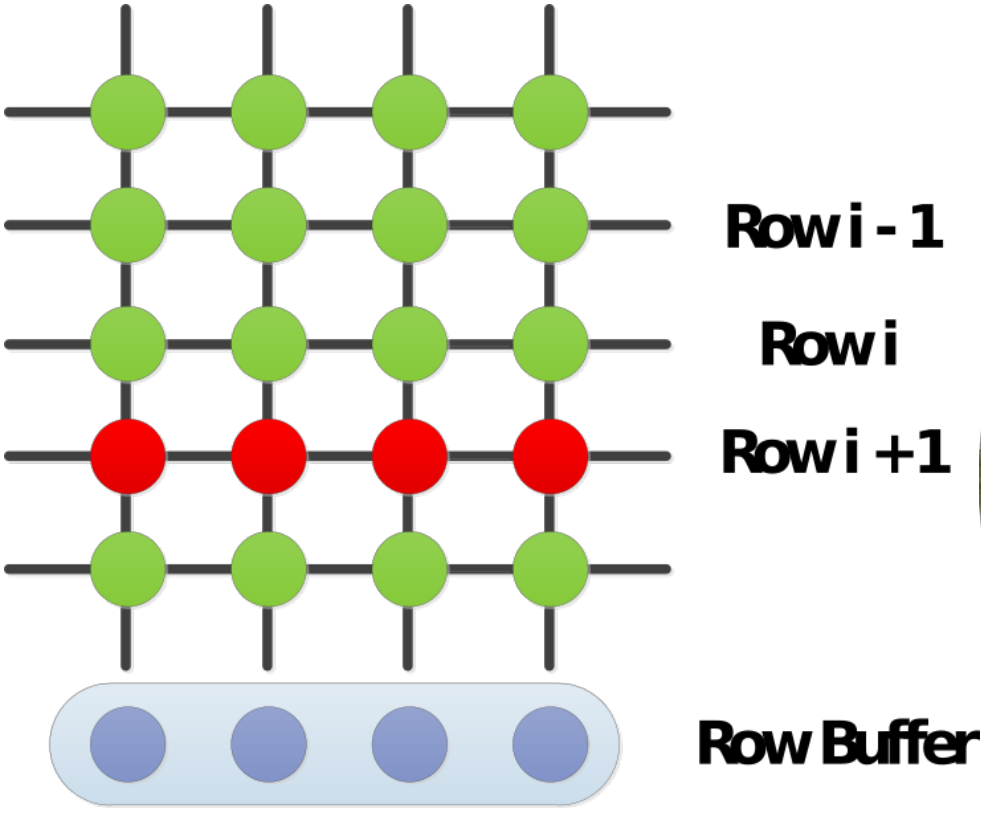

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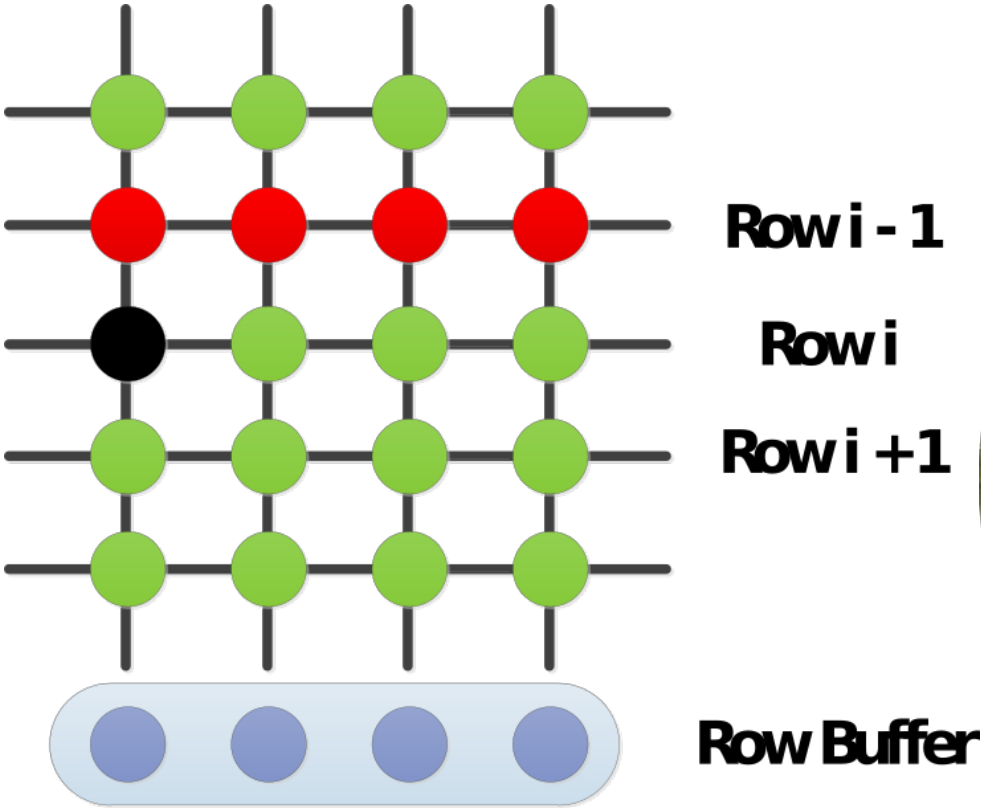

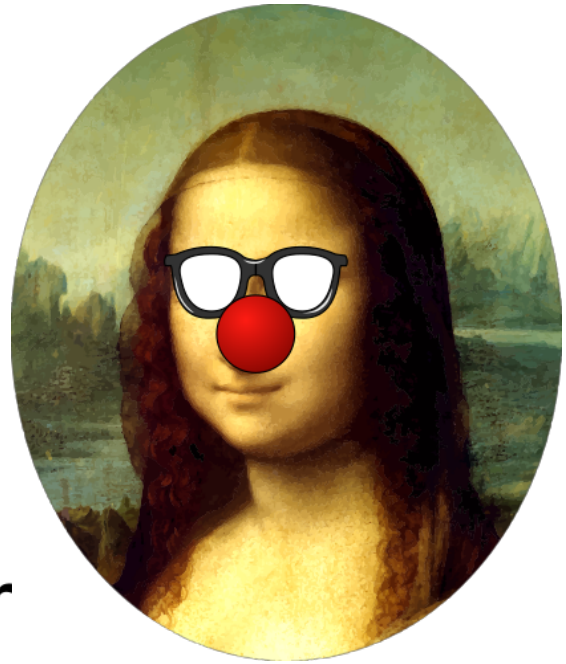

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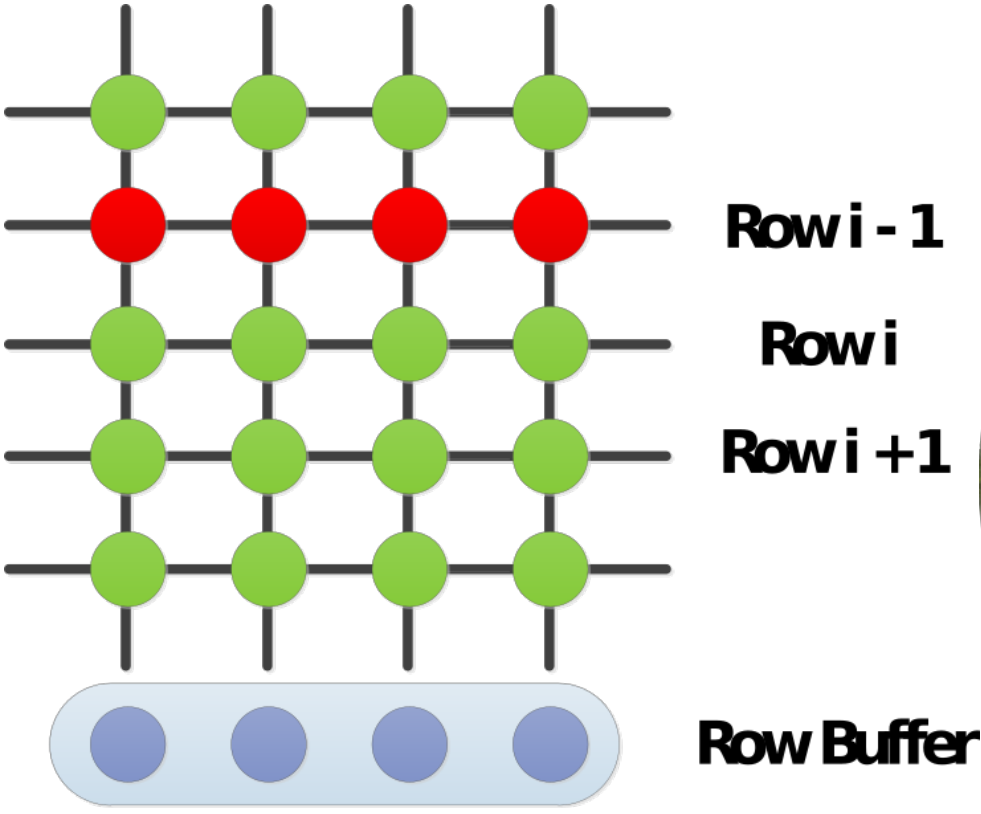

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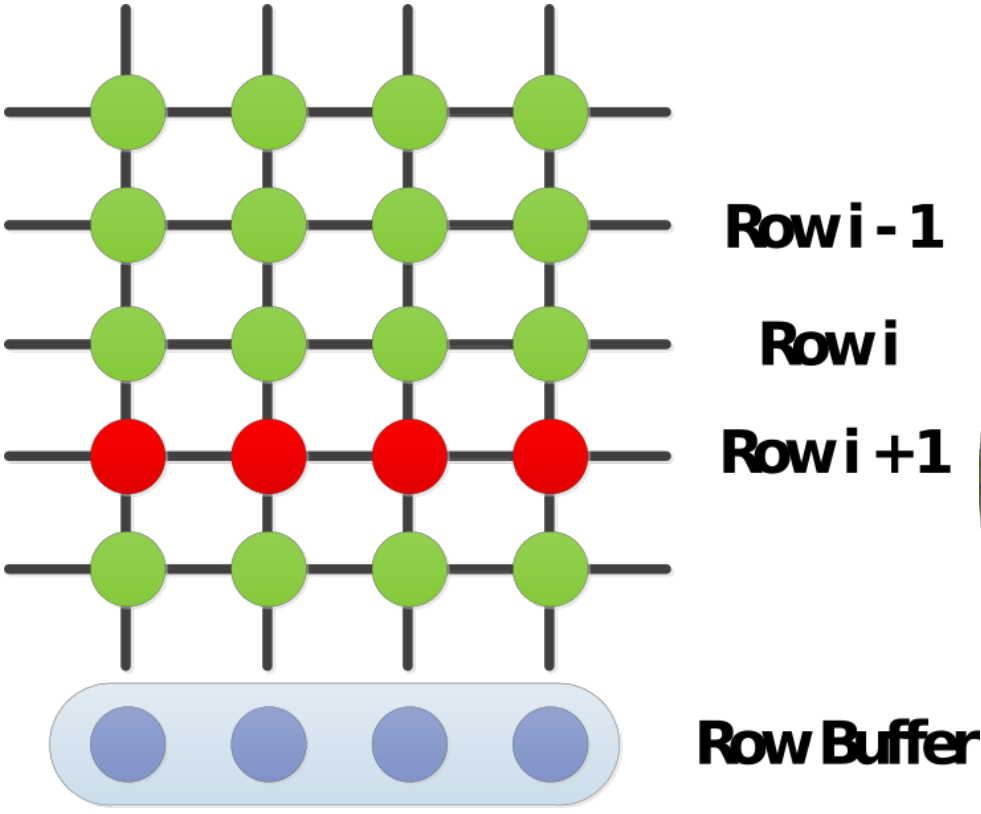

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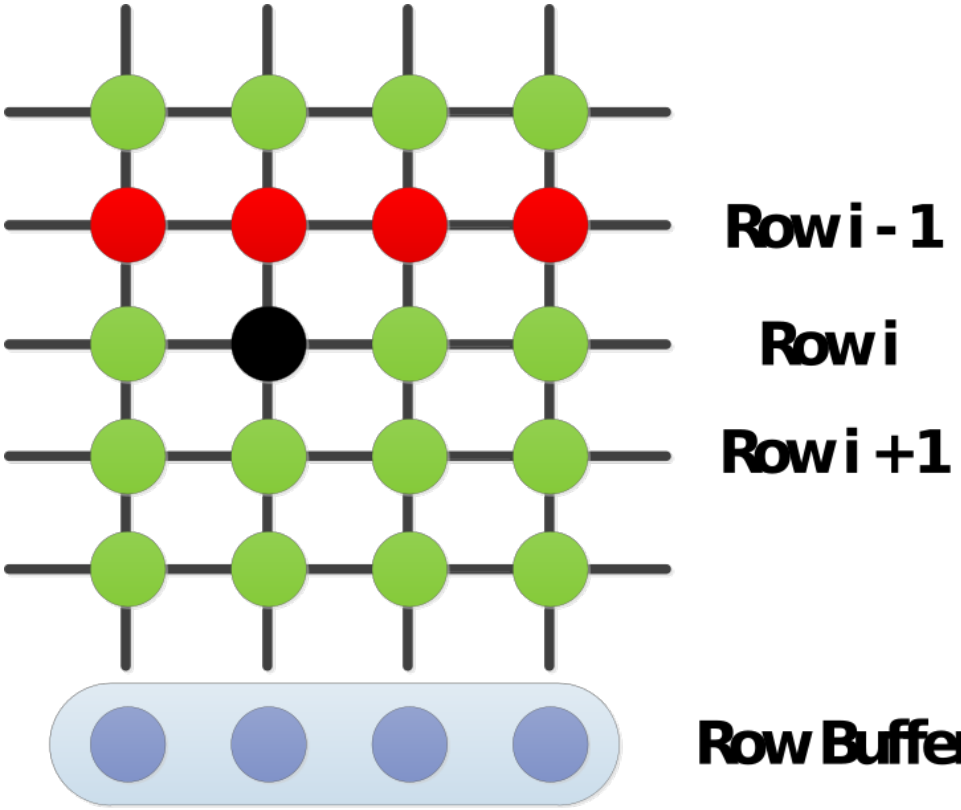

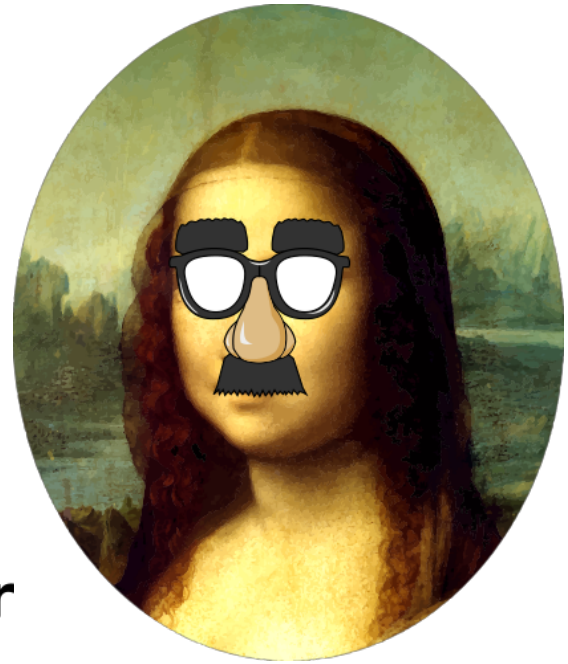

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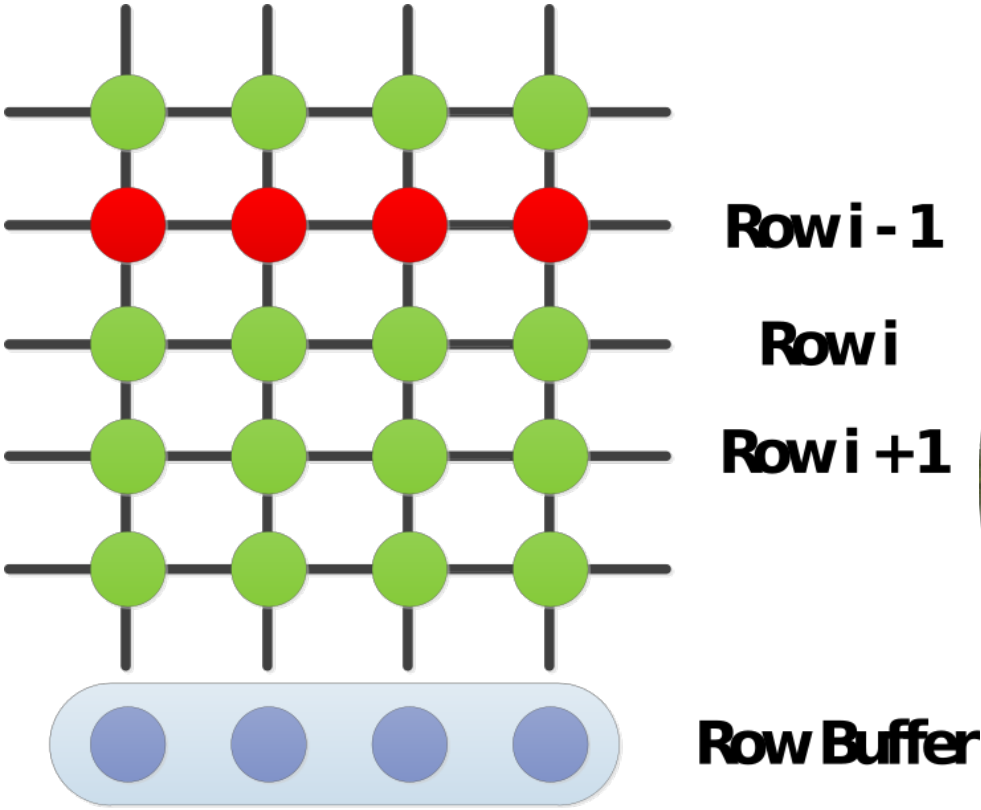

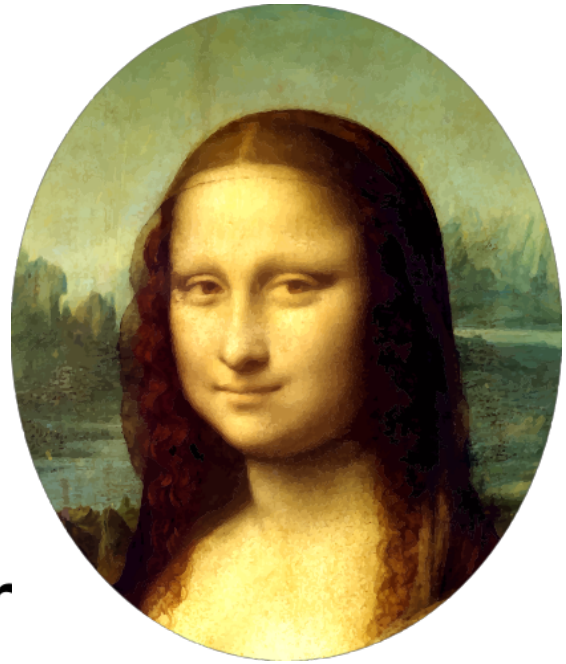

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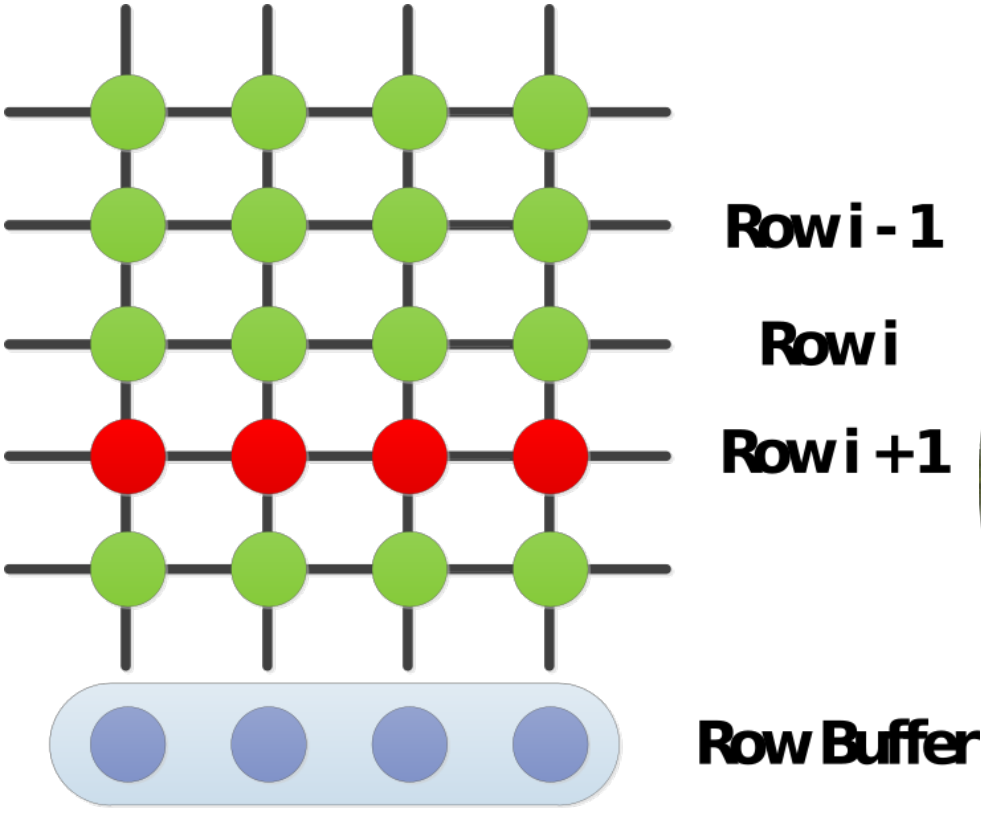

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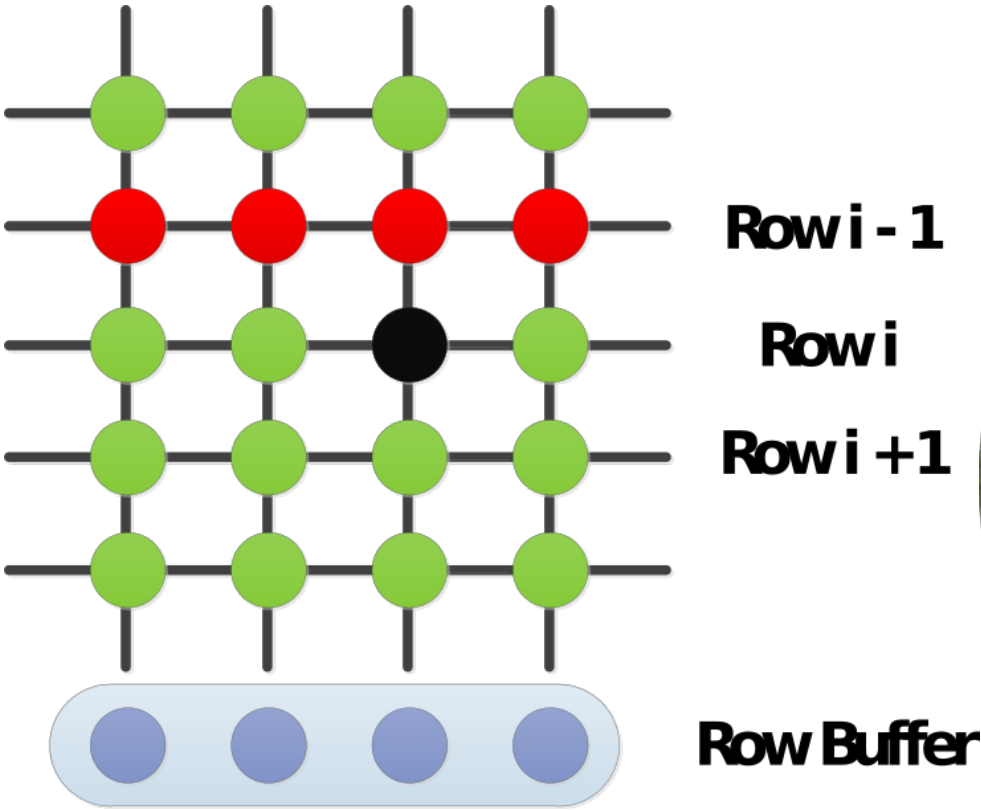
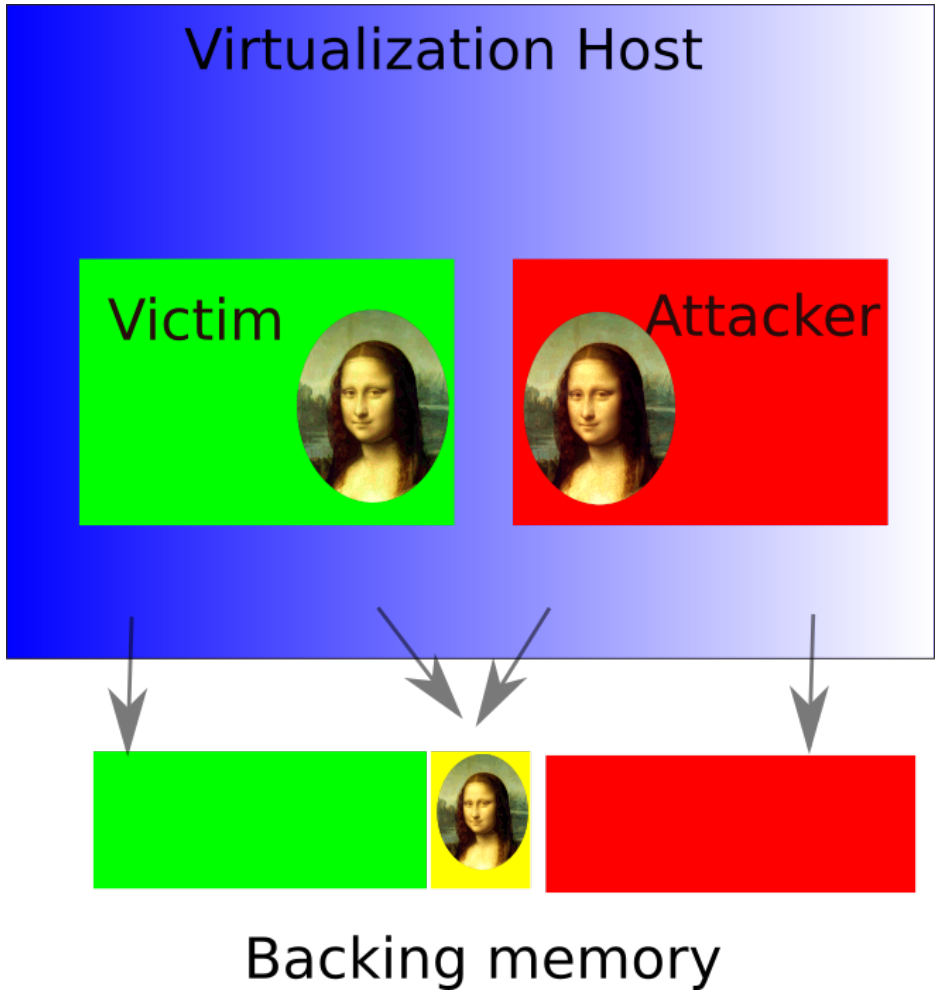


Memory deduplication + Rowhammer = FFS



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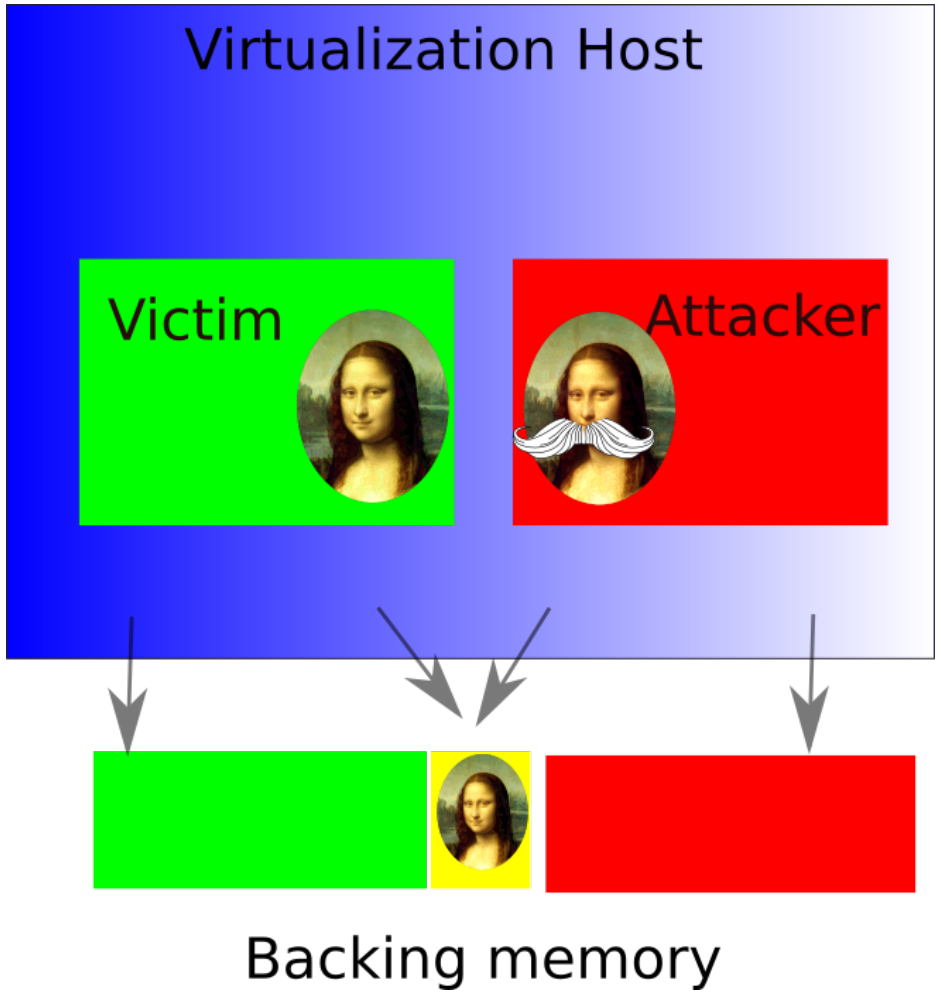

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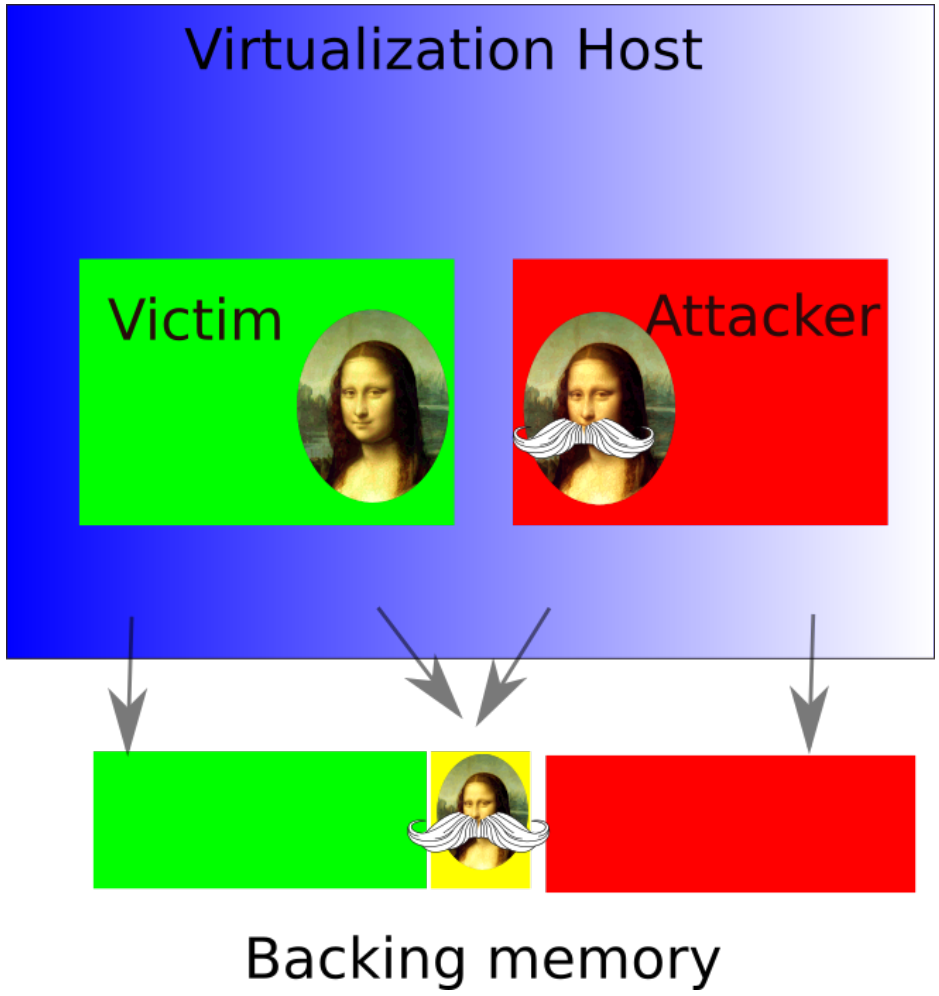
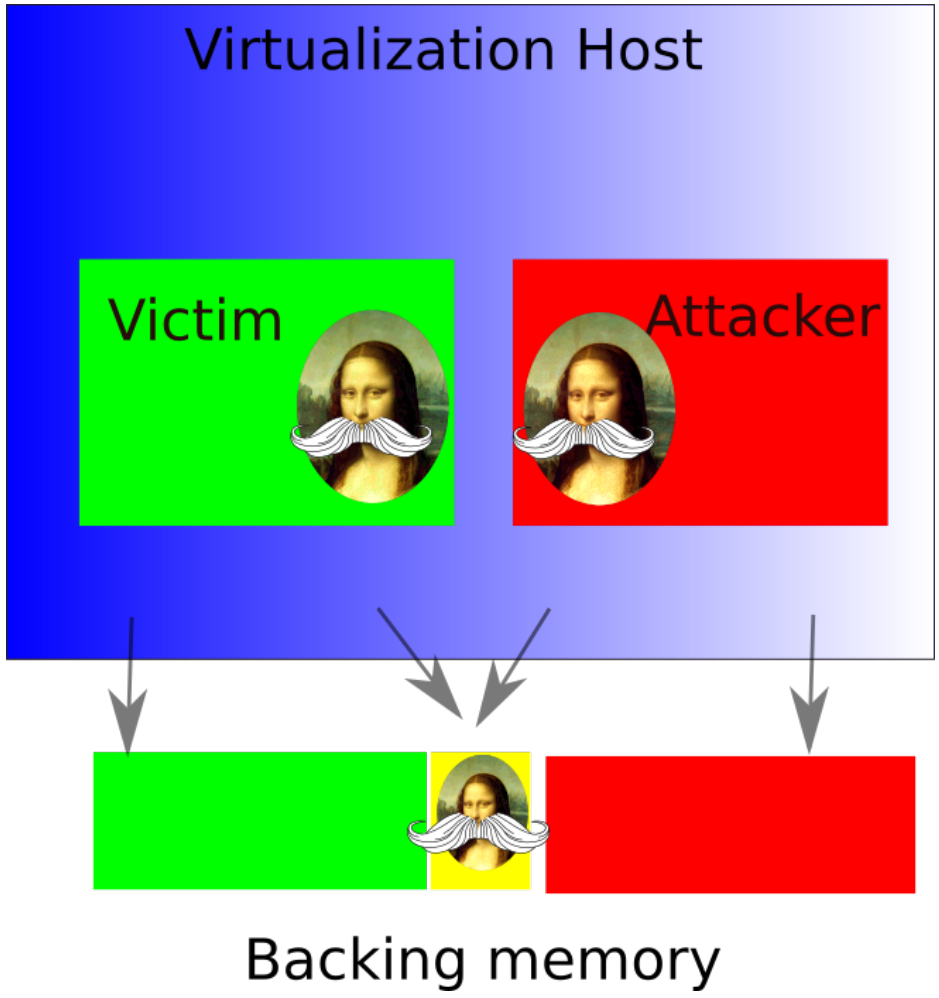


Memory deduplication + Rowhammer = FFS



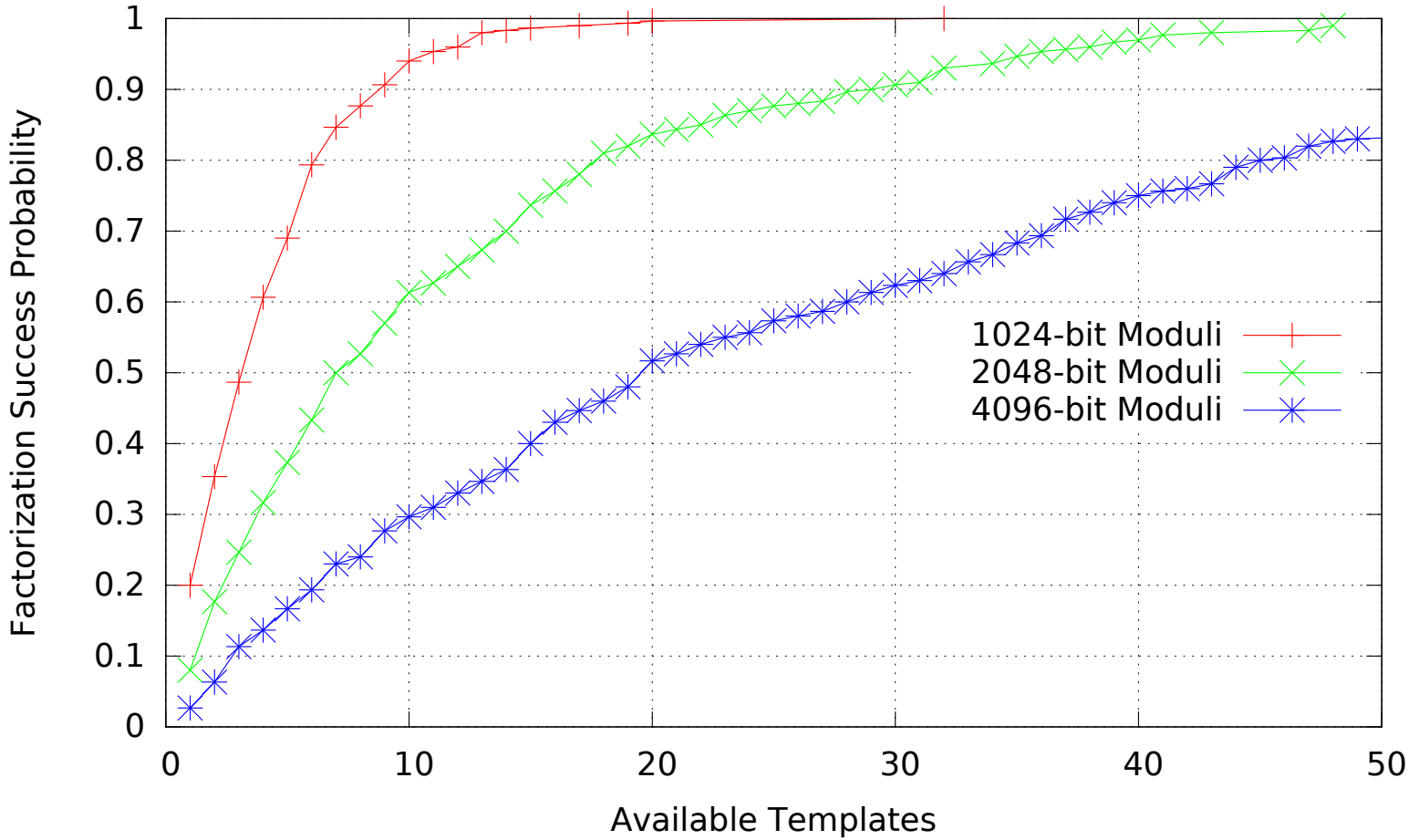
- FFS breaks COW

RSA

- Public key cryptosystem
- Two keys: public and private
- Compute secret private from factorization

FFS - What now?

Break weakened RSA.



Section 3

OpenSSH Attack

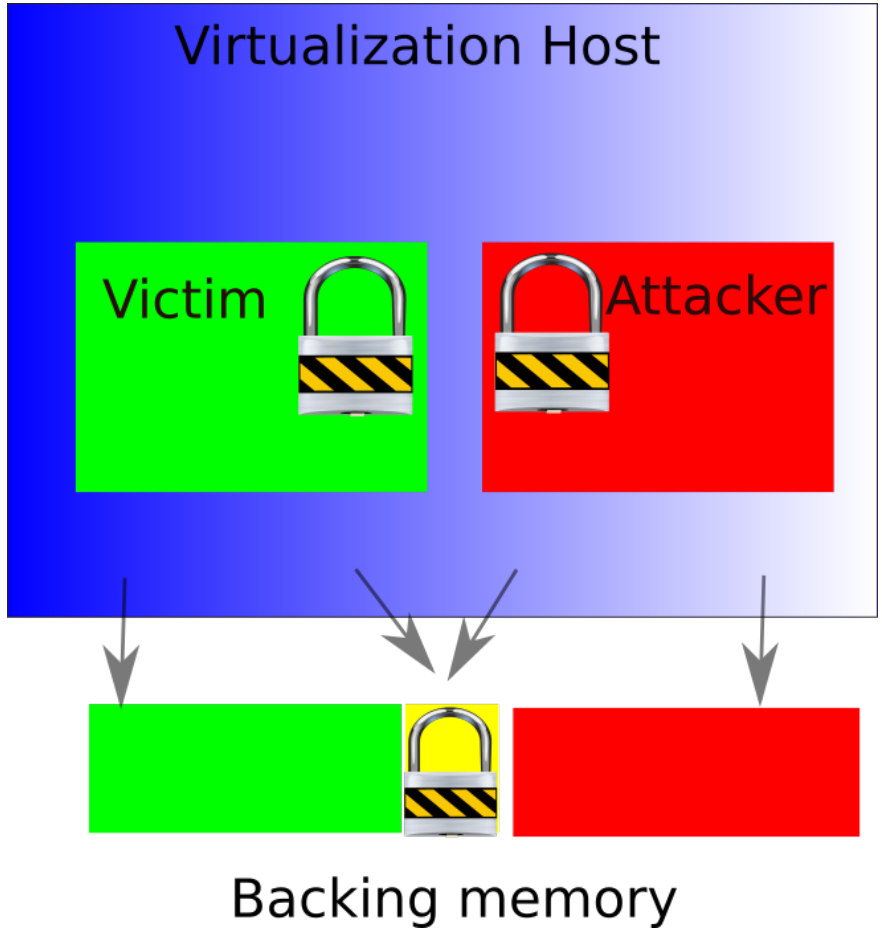
authorized_keys file

Looks like this:

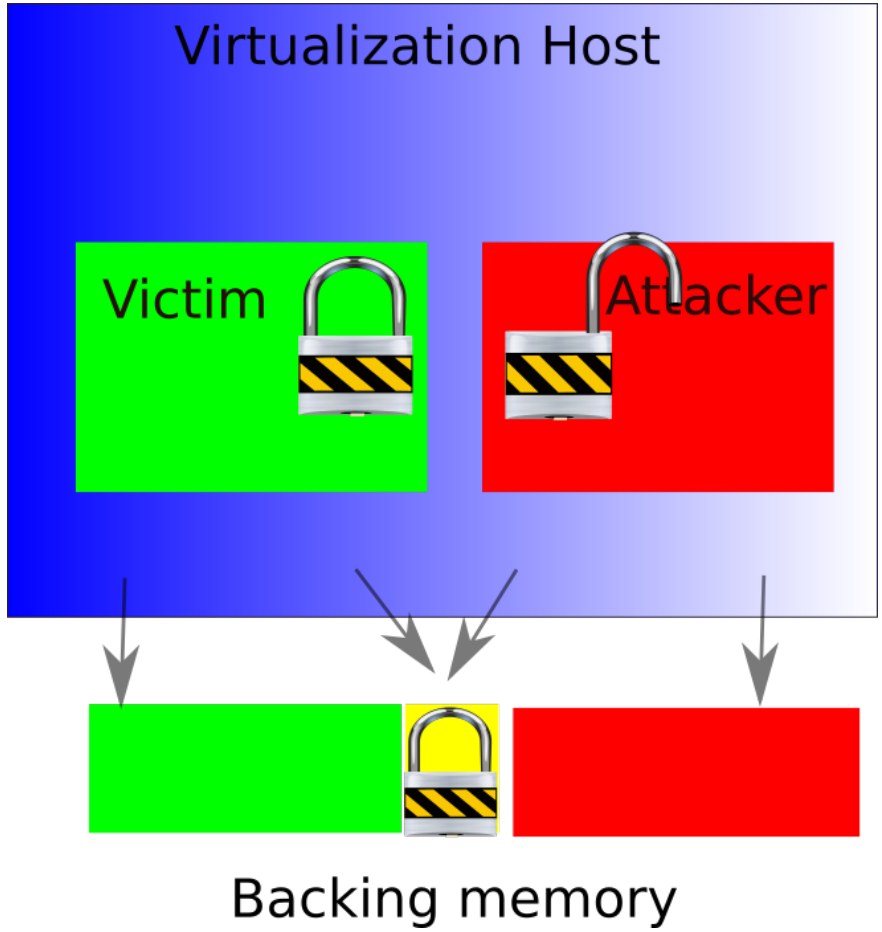
```
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQDX
y7MdVToVAvKB0/Xven/kqBzfRZm+GITl6sB0u+Aa
3/UTC3x+eKjB2jf+48kTP7AvsdbSwg9Q5upN77xX
3mNGwwj1RUQpOPPc99XH09M84iCydE+9smYseySf
bJQnrov5Ricz2Z18Neuy5ZUH/Ldrf1NSwWoo5NZL
6tj0E9JvZurMPPk2EqEyHltEFC6OetJwEfaPq9kO
glmzFtBWLHR4dF1796JeVkFiWcmMaykAoN+JRF2n
MlayPlUxdWR0JwxZ2cJ9la/QLXvv8x0tsORGP9ZG
5BWqOcD781evuSS3i91BNg6Osl7mlxo6Mc3oUbew
/7ddV08WjdRBn7iQF9WN beng@mymachine
```

- RSA public key
- Attacker writes this to memory
- We need the private key

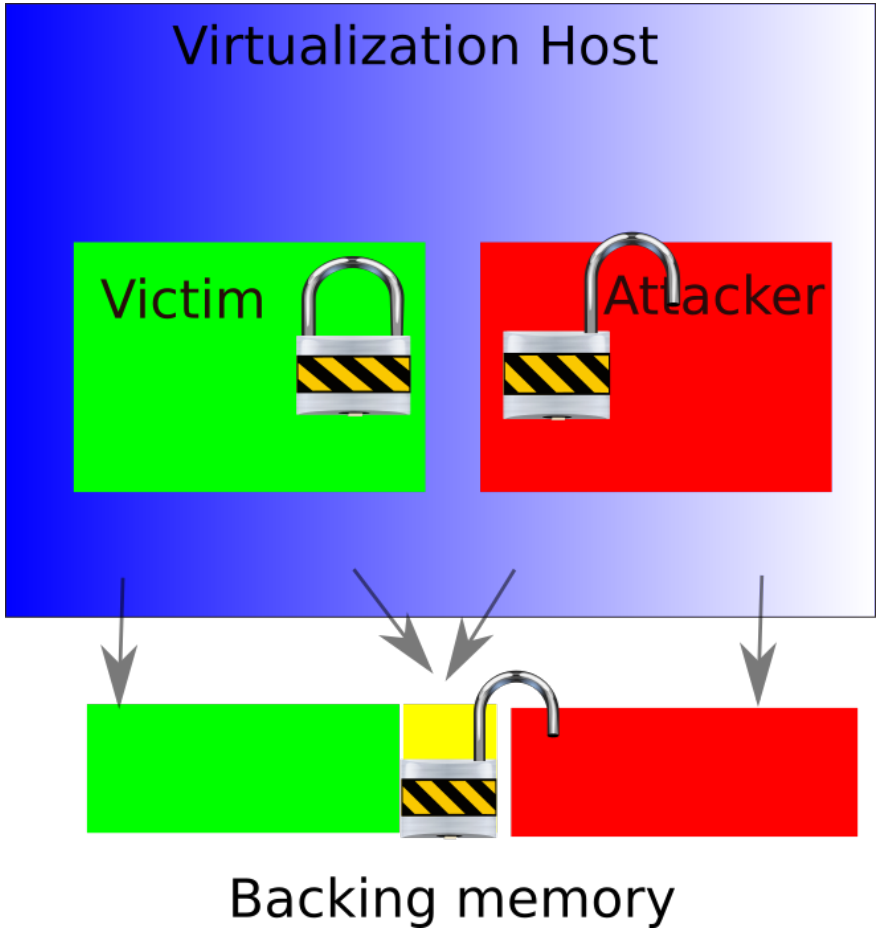
OpenSSH FFS attack



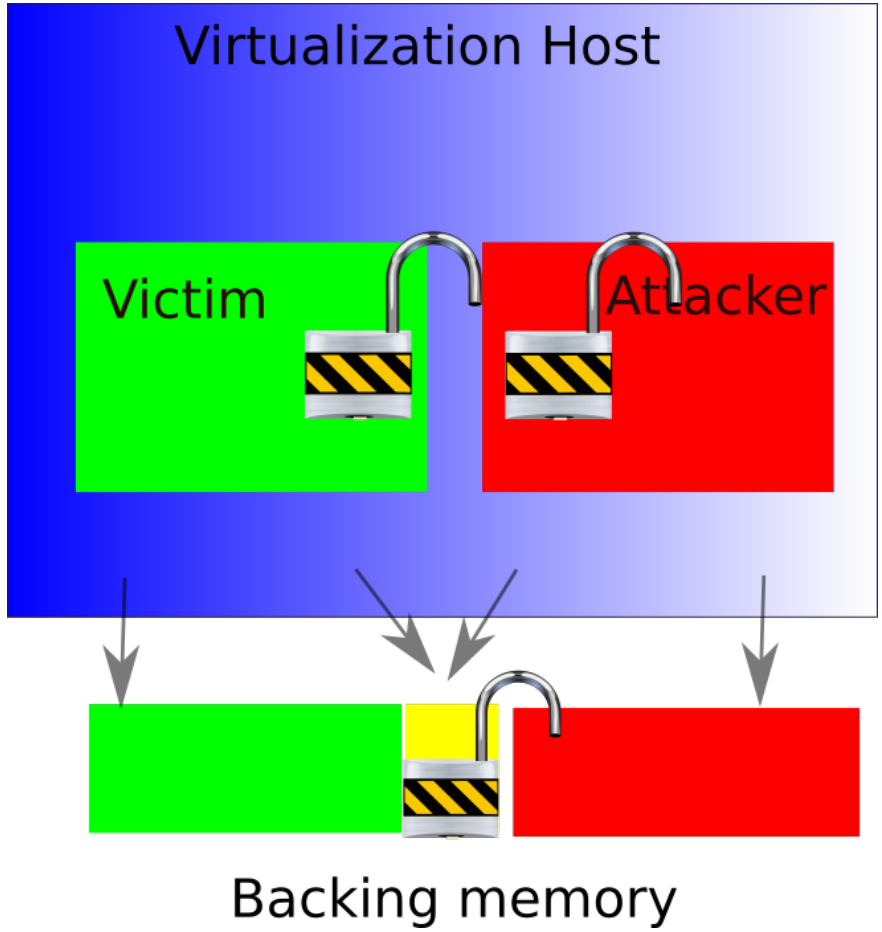
OpenSSH FFS attack



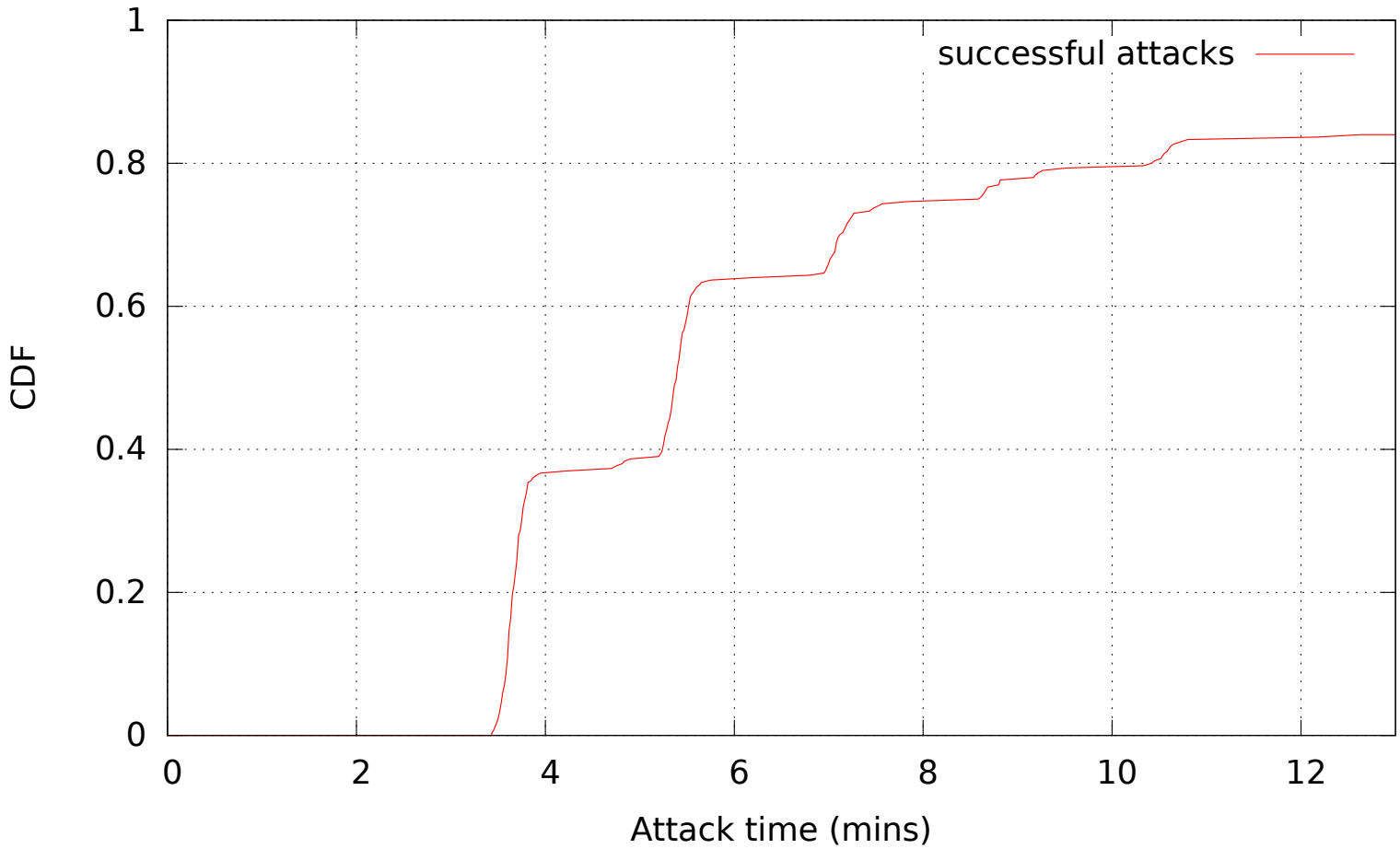
OpenSSH FFS attack



OpenSSH FFS attack



OpenSSH Attack



- Could retry

Section 4

GPG/APT Updates Attack Demo

GPG/APT Updates

- With FFS we flip `/etc/apt/sources.list`
- With FFS we flip `/etc/apt/trusted.gpg`
- Use computed private key
- Long term RSA Ubuntu signing keys

Section 5

Notification, Conclusion & Further Resources

Notification

- Notified: Red Hat, Oracle, Xen, VMware, Debian, Ubuntu, OpenSSH, GnuPG, some hosting companies
- Thank you NCSC

- GnuPG commit

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
```

Conclusion

- Flip Feng Shui breaks isolation
- Co-hosting VMs is risky
- Disable memory dedup

`https://www.vusec.net/projects/flip-feng-shui`