Security: Xbox

Emmett Witchel

CS380L

Xbox faux quiz

- How many security mistakes did the Xbox designers make?
- What links are in the Xbox chain of trust that ensures a valid OS boots and only MS-approved applications can run?
- What is attestation?
- Why is the Xbox initial OS in ROM, and not in flash? Why are there two bootloaders?
- What is control flow integrity? How can it be violated? How can it be enforced?
- Why can’t Xbox store the 2bl and OS in plaintext?
- Why is memory “unstable” during early boot of Xbox? What impact does this have on crypto?
- Linux hackers recovered RC4 key, could encrypt Linux bootloader as 2bl: why didn’t they?
- Why is the special purpose VM + xcode purported to be secure?

Security

What does it mean for a computer system to be secure?

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All of these properties are security properties

- P – Privacy
- C – Confidentiality
- A – Authentication
- A – Authorization
- A – Availability
- I – integrity
- N – non-repudiation

Two security ideas

- Privacy – Sensitive data is not read
  - My health and financial records should remain private
  - Do I want Facebook to have my family photos?
  - Data breaches are privacy/confidentiality problems
- Integrity – Sensitive data is not written
  - Taking over computer system is an integrity attack
  - Then steal data, or steal money, or send email as you
  - What devices/software do you trust? with what data?

- Privacy gets more press, but distinguish privacy from integrity

Discretionary & Mandatory Access Control

- Discretionary access control (DAC)
  - Access control policy controlled by user
  - E.g., Linux
  - Usability a plus, but always getting broken
- Mandatory access control (MAC)
  - Access control policy controlled by administrator
  - E.g., SELinux, AppArmor
  - Difficult to configure, brittle, but more secure

- Trend toward usable MAC

Why is computer security hard?

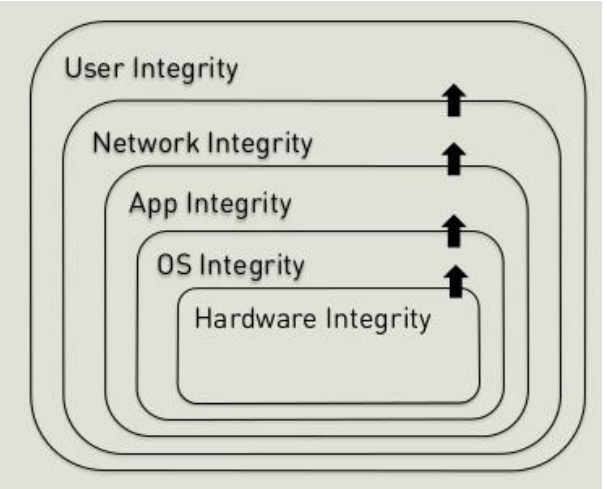
- Because managing secrets and trust is hard
  - Who keeps your secrets?
  - Who do you trust for your health care decisions?
  - Who can debit from your bank account?
- Trust benefits from societal and legal support
  - Can't testify against your spouse
- Computers make it easier to exploit
  - Millions of users' privacy from one event

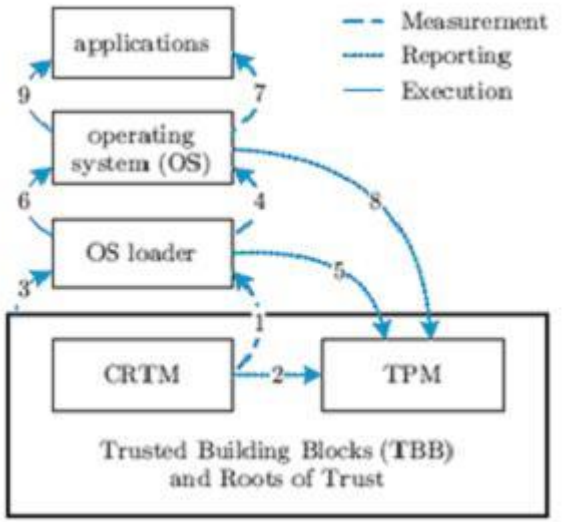
- Authentication story

Chain of Trust

Use hardware and cryptography to ensure:

- system starts in a known, good state
- proceeds to load uncompromised software
- ***Attests*** to the start state of software
  - often not enough to ensure security during operation, but it is a start.





Microsoft obviously made a lot of mistakes. But it would be too easy to just attribute all these to stupid engineers. There have been good (and different) reasons for most of these mistakes, and one can learn a lot from them.

--Michael Steil

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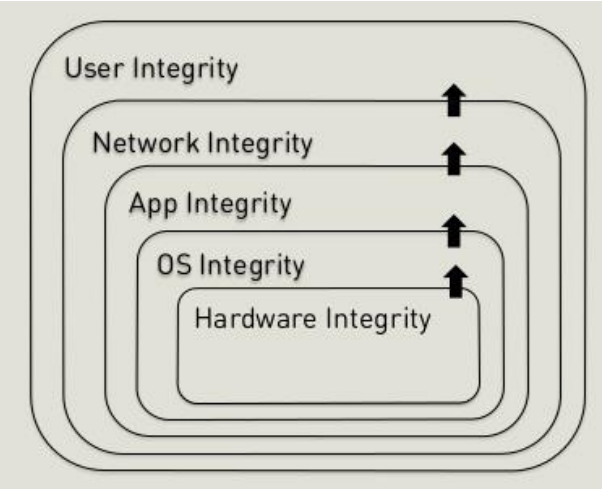

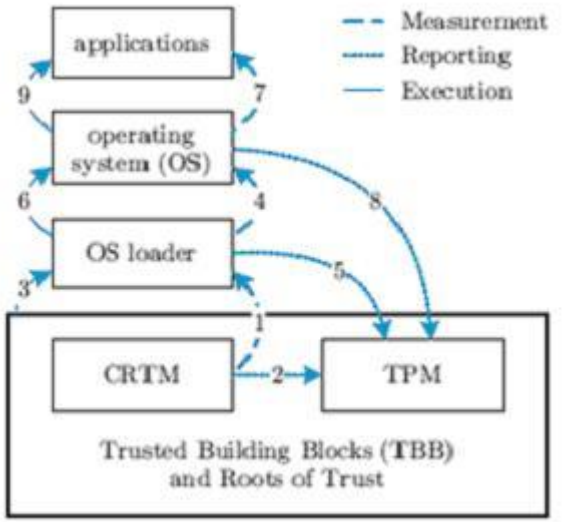

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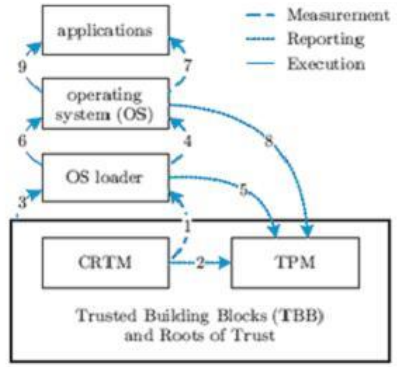

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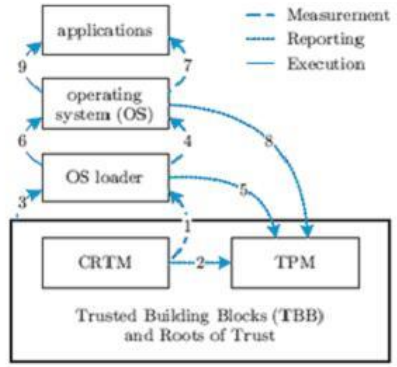

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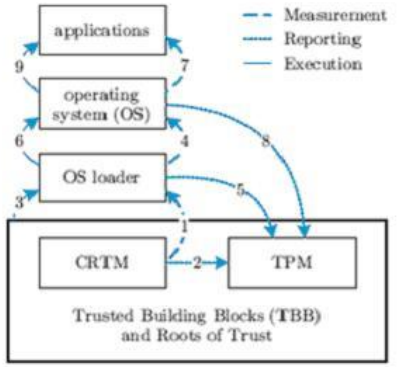

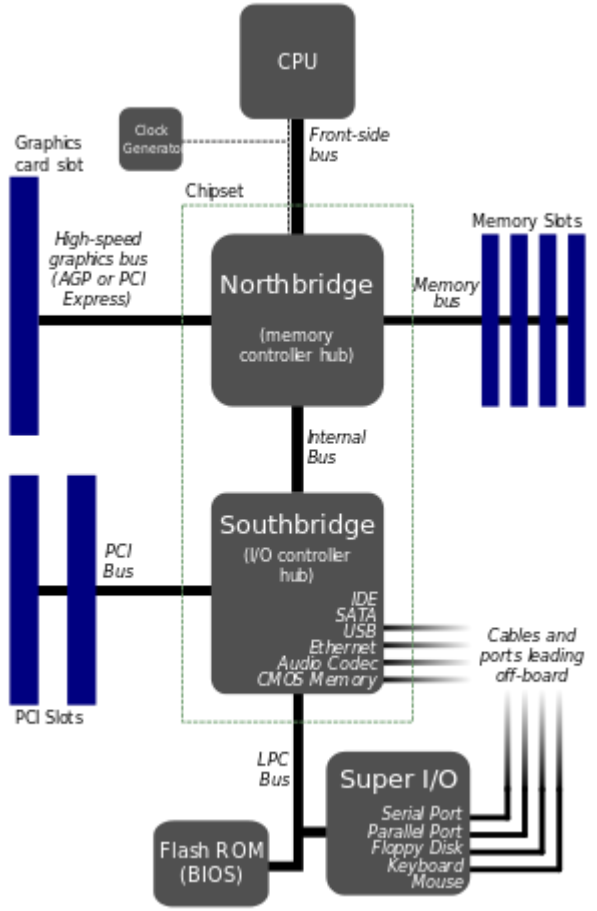

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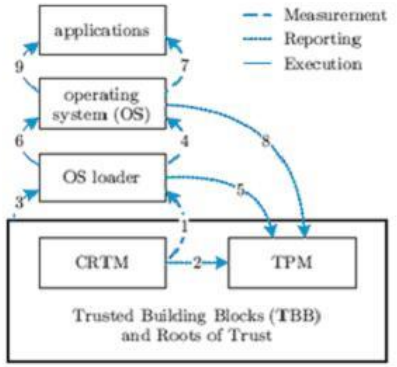

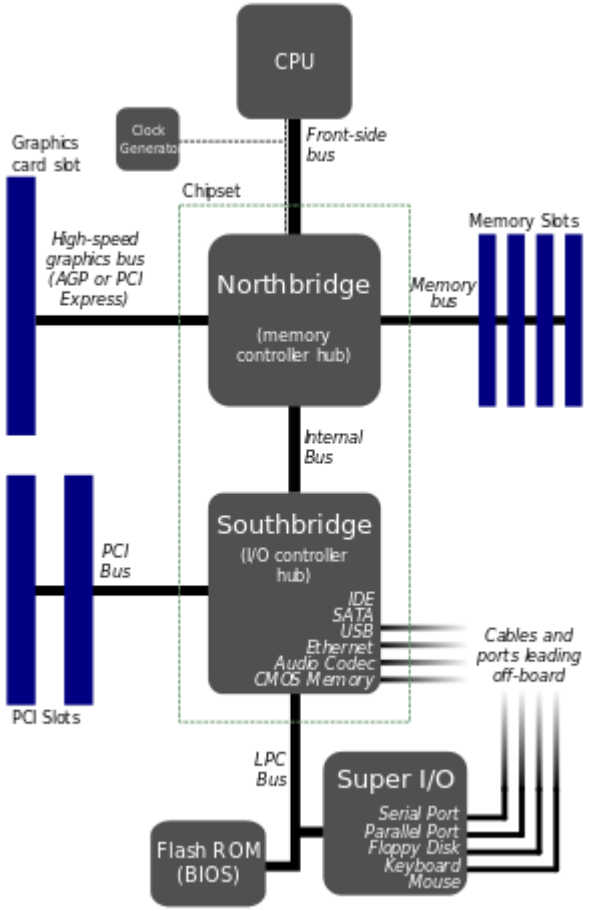

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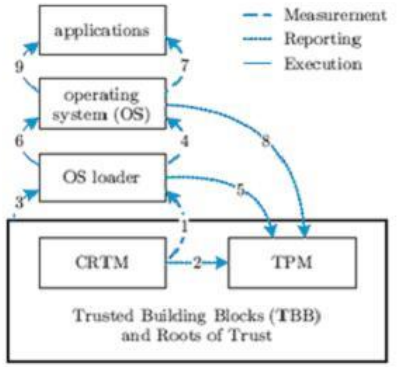

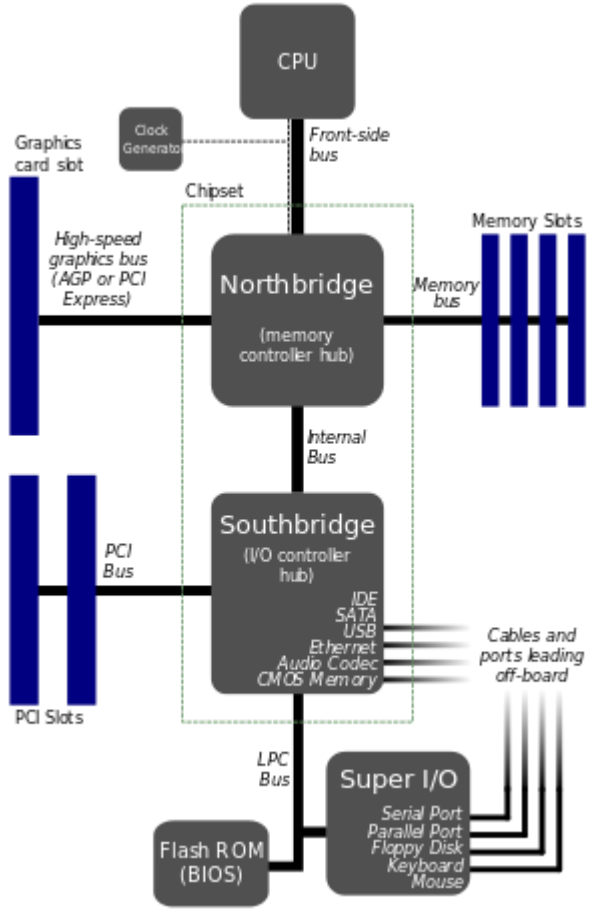

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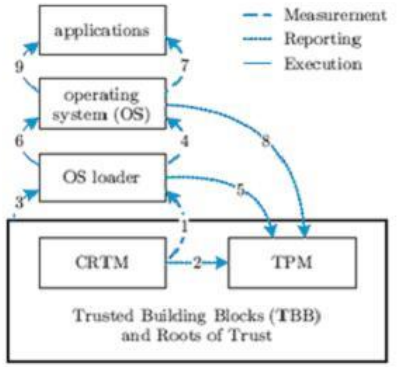

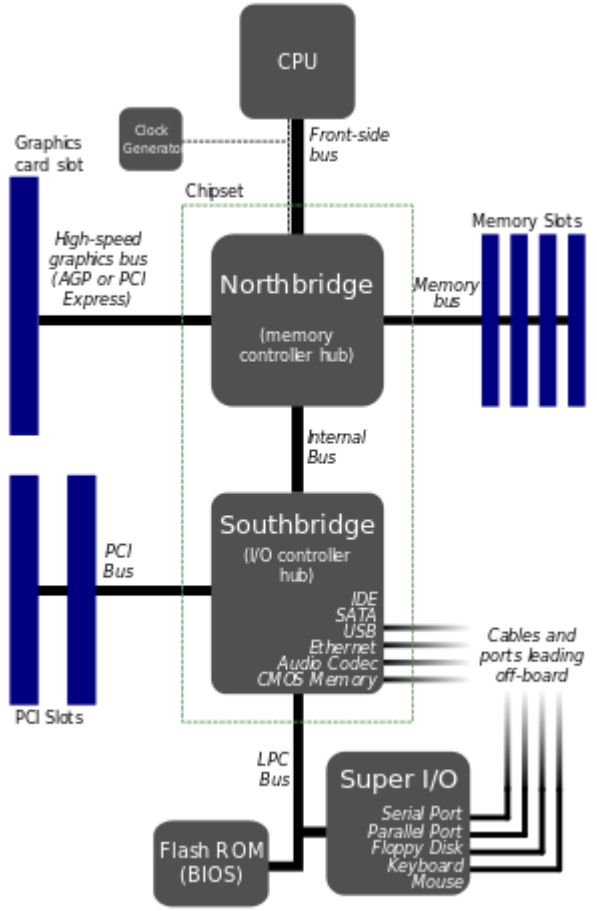

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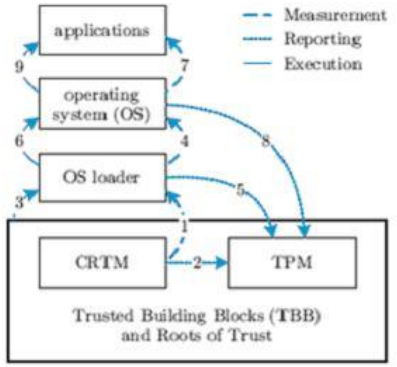

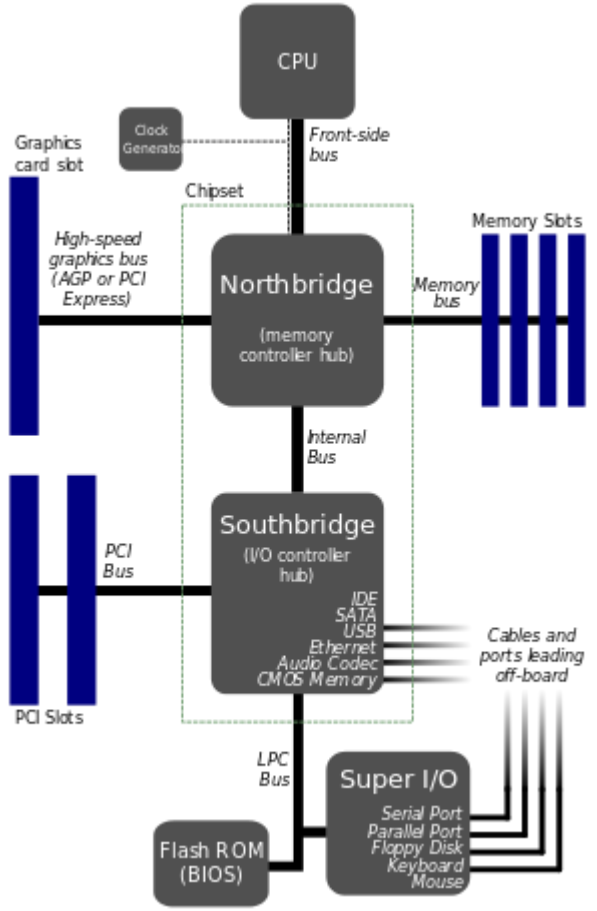

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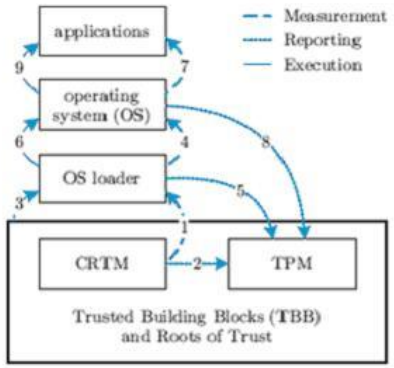

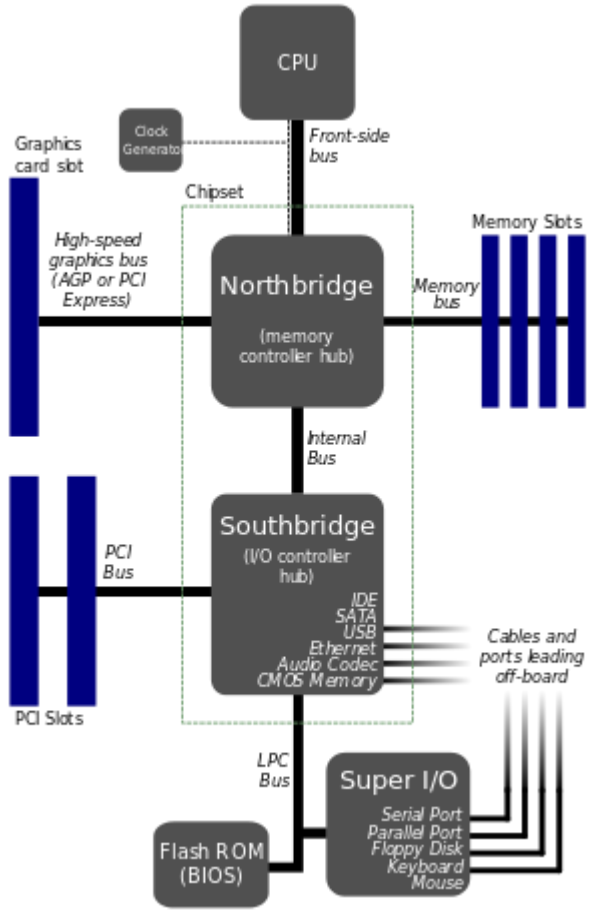

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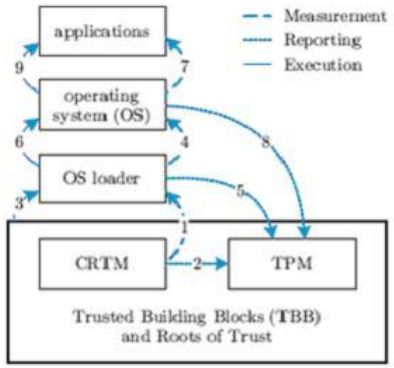

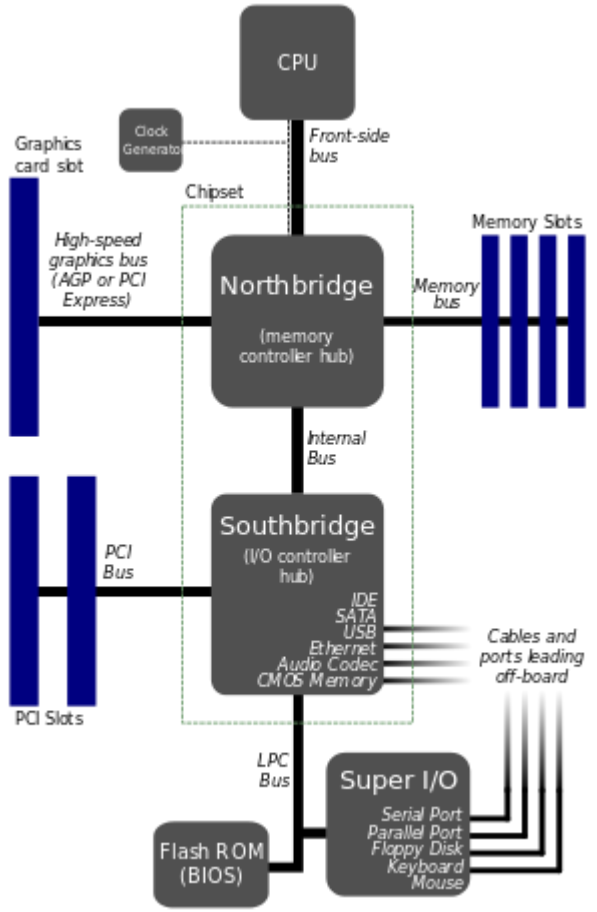

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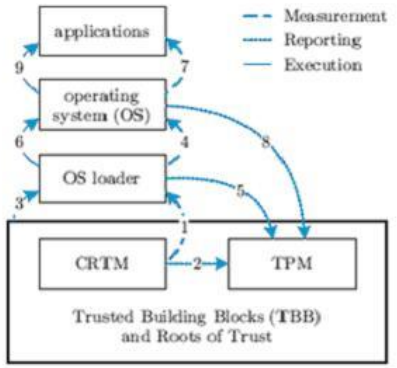

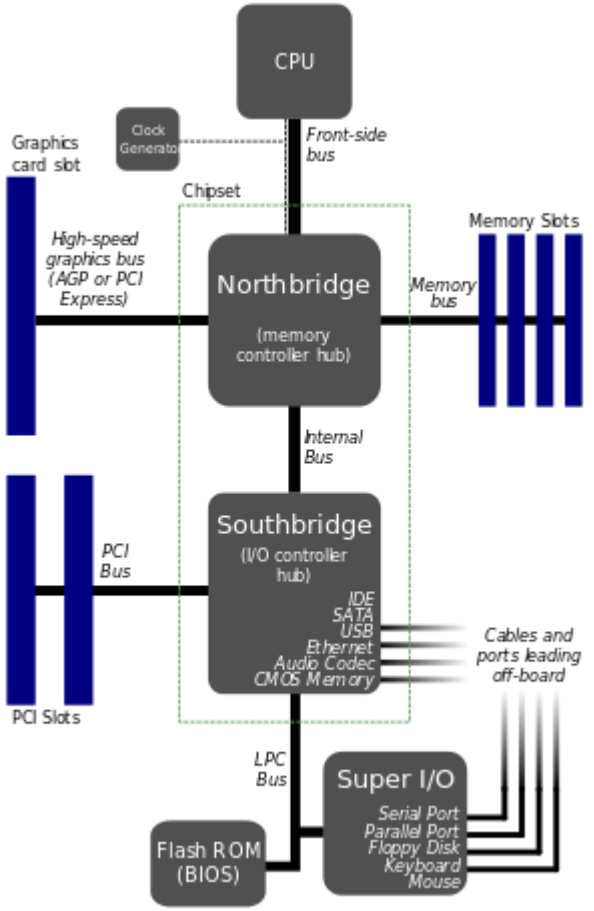

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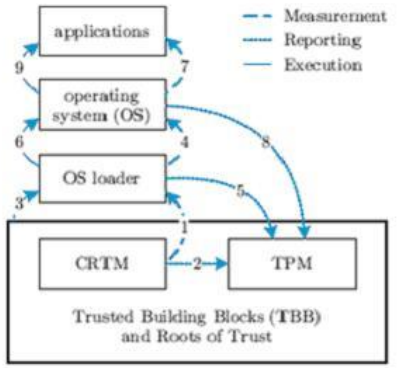

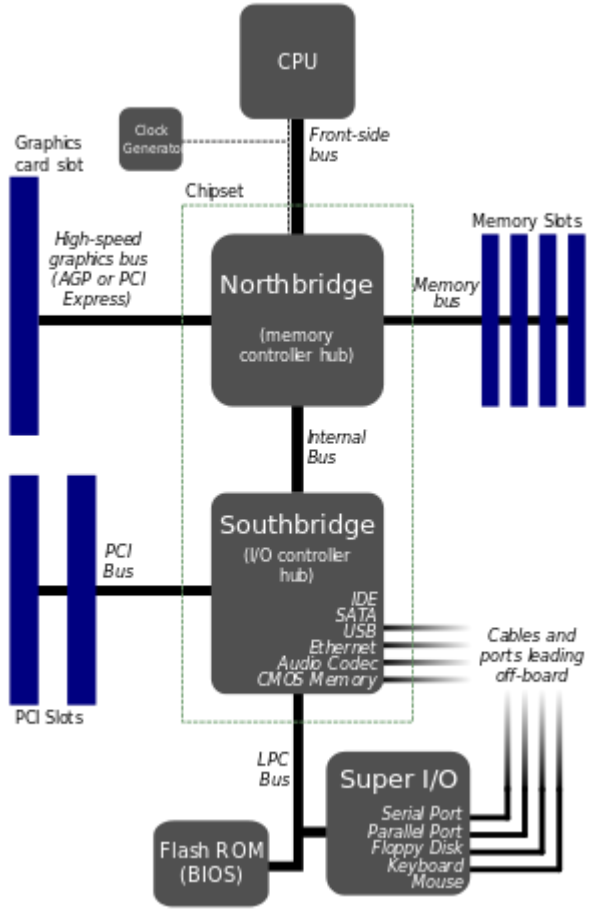

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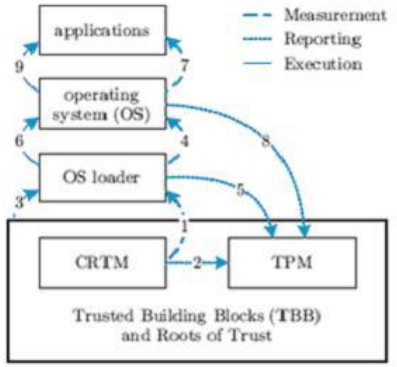

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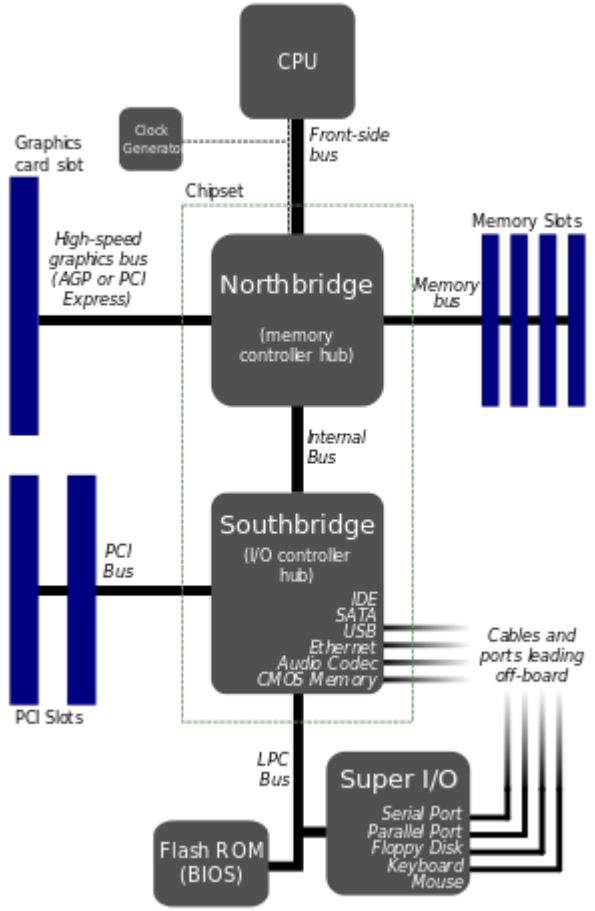

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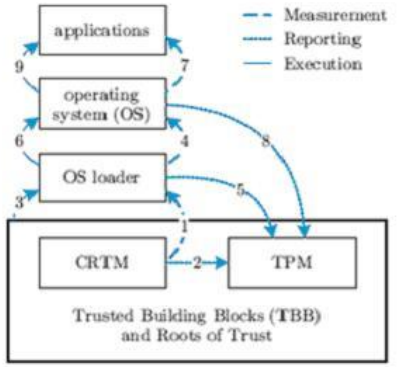

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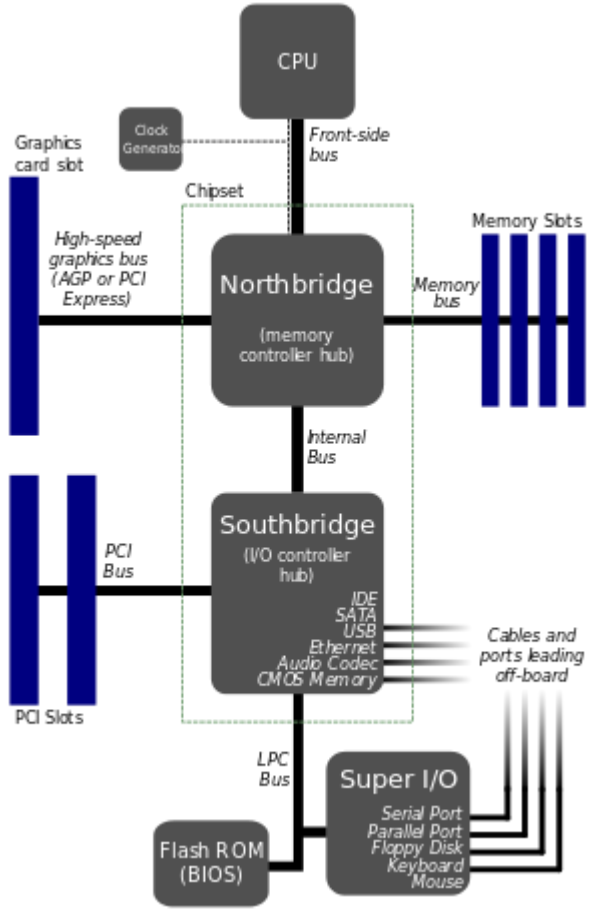

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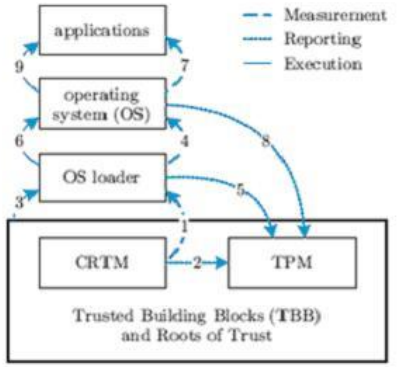

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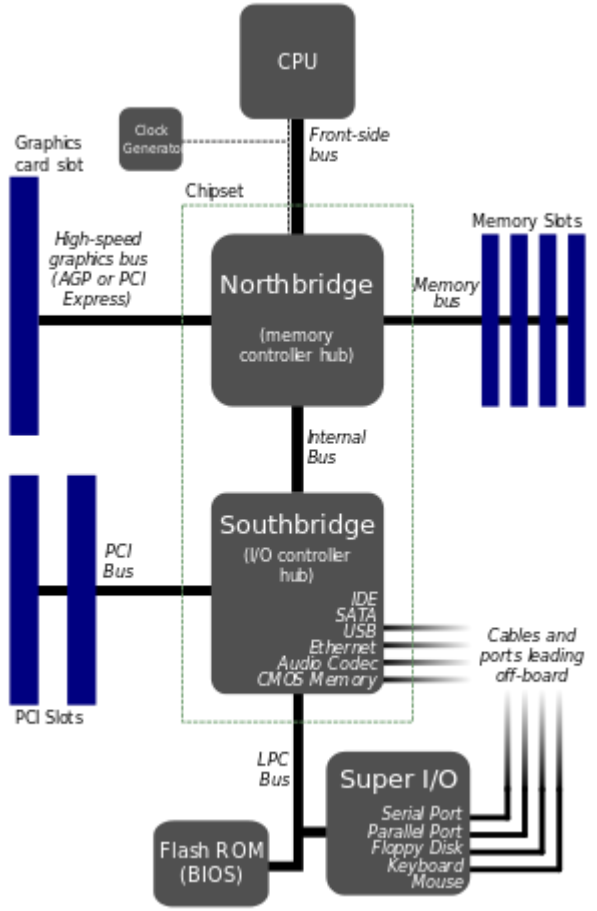

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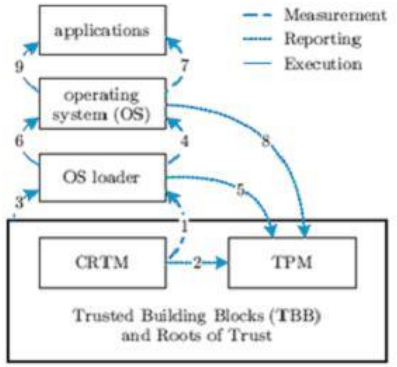

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  - …therefore (ostensibly) incapable of malicious operations

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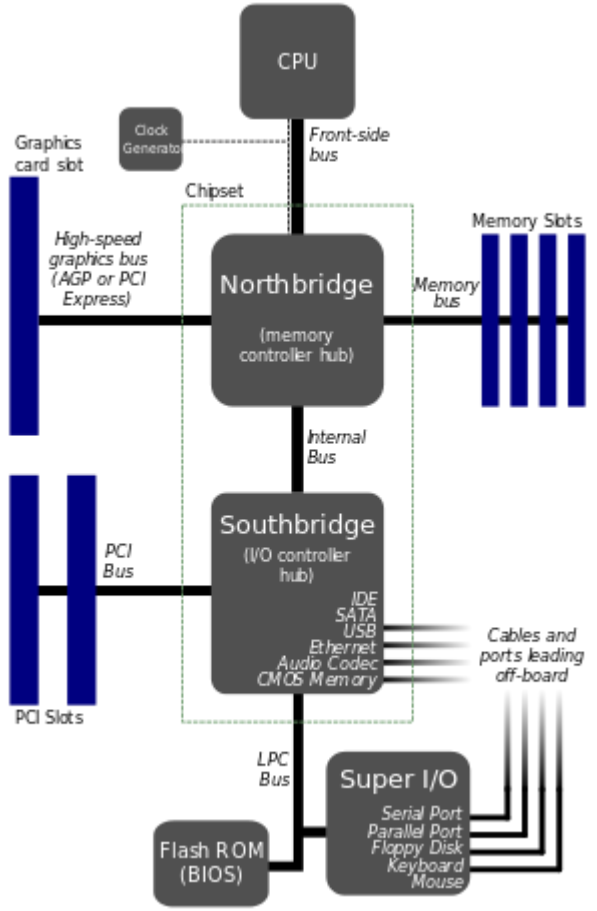
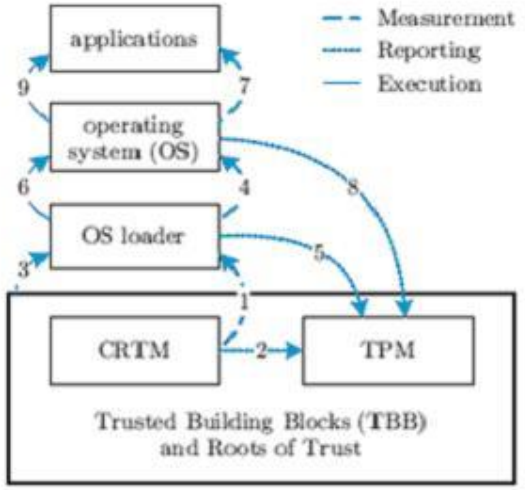


Confining Xcodes, Hide secret ROM



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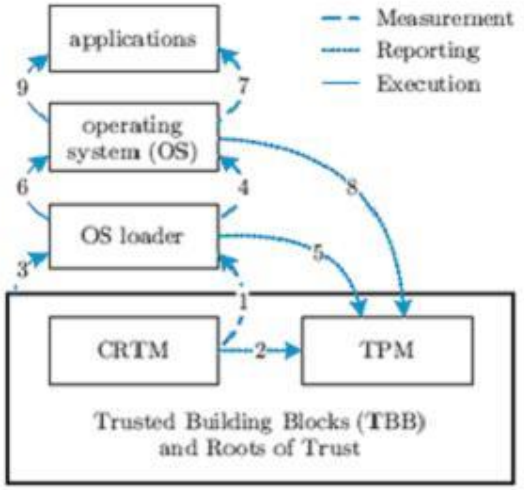

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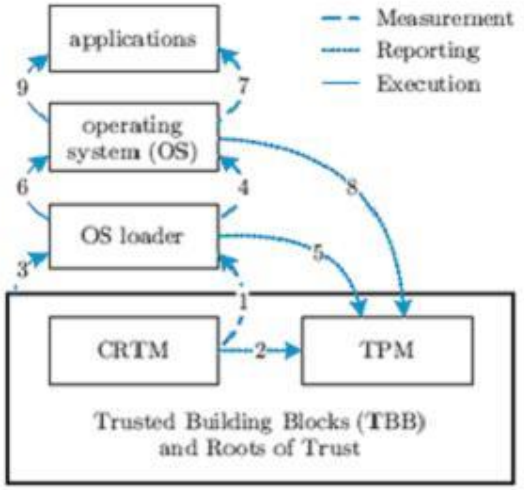

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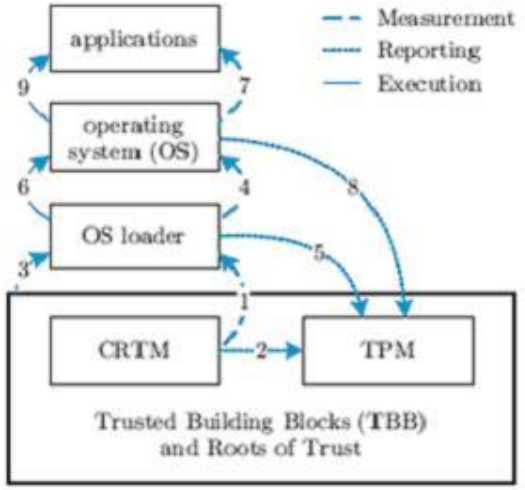

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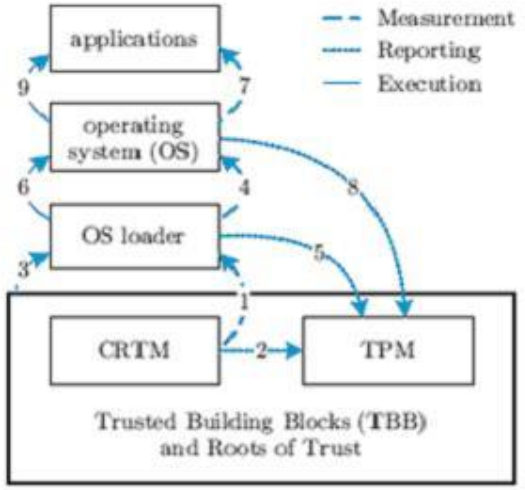
- Resulting design:
  - Execute secret ROM, set up segment descriptors.
  - Interpret untrusted xcodes (set up RAM)
  - Decrypt and hash 2bl, store it in RAM
  - If H(2bl) == 0x7854794A, execute 2bl, otherwise panic.
  - 2bl decrypts and verifies Windows kernel.
  - Windows kernel verifies media and checks RSA signature of games.



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Why doesn't this version work?

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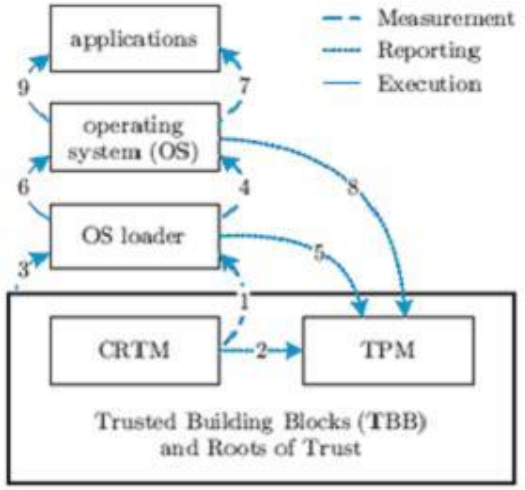

Block Cipher Crypto Background

Electronic Codebook Mode

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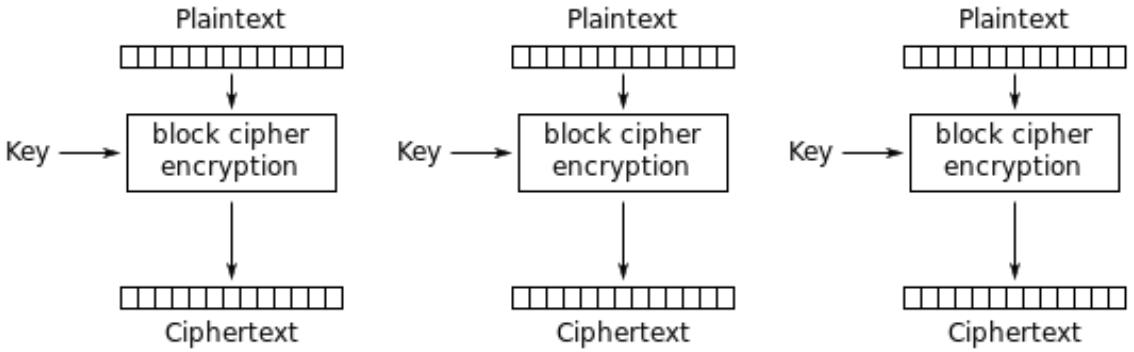
- insecure (Why)?



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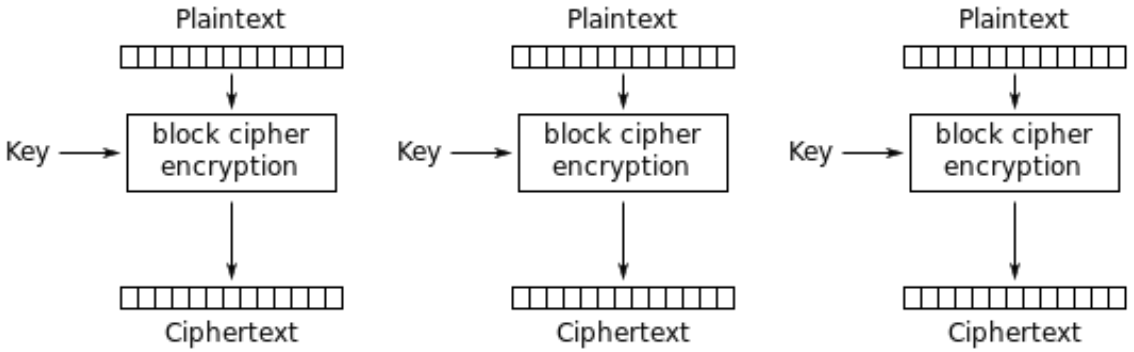
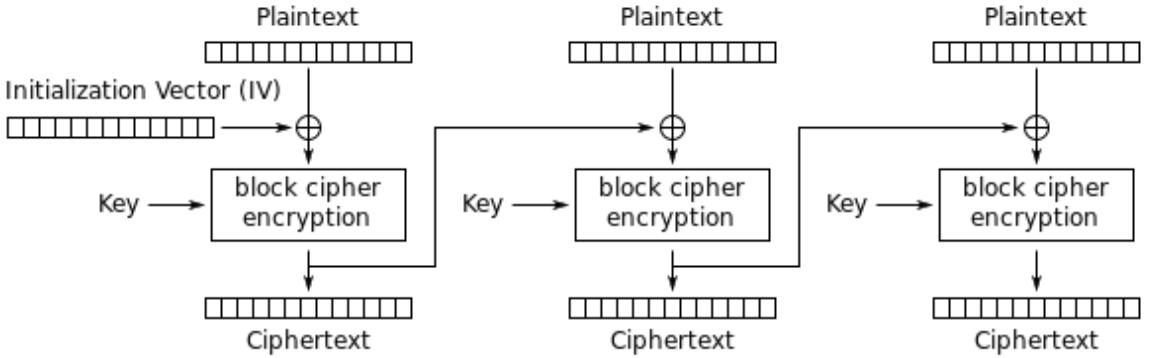


Electronic Codebook (ECB) mode encryption

Cipher Block Chaining

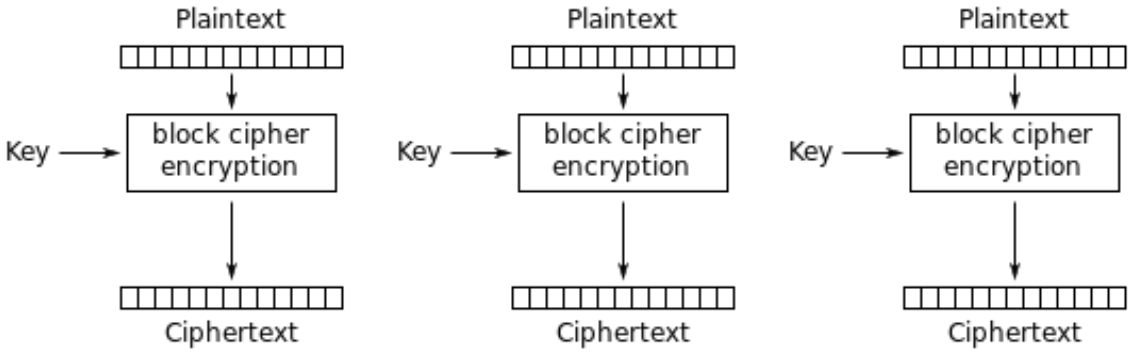


Cipher Block Chaining (CBC) mode encryption

Block Cipher Crypto Background

Electronic Codebook Mode

- Fast, parallelizable
- insecure (Why)?



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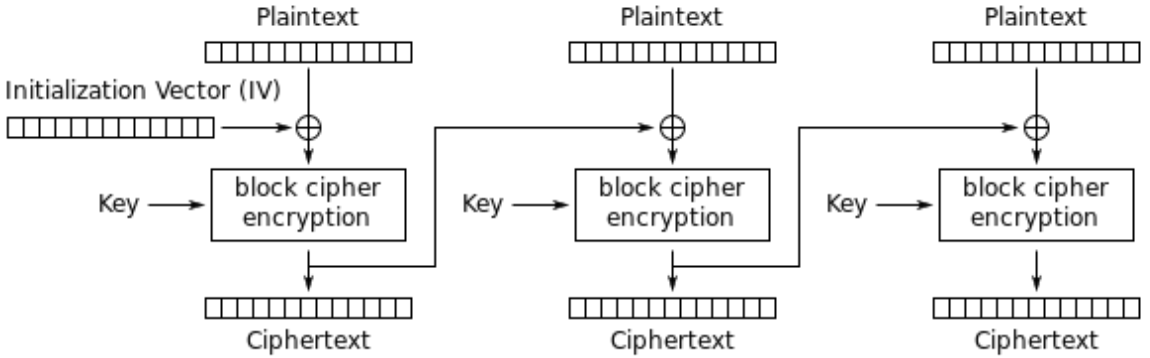

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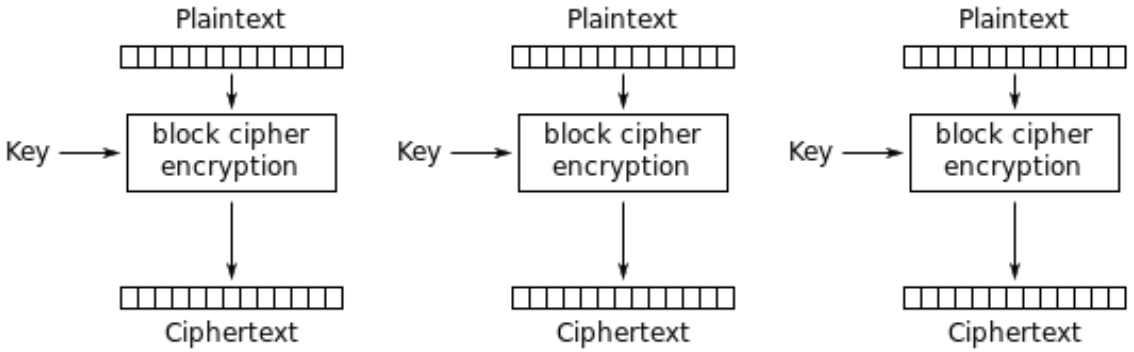

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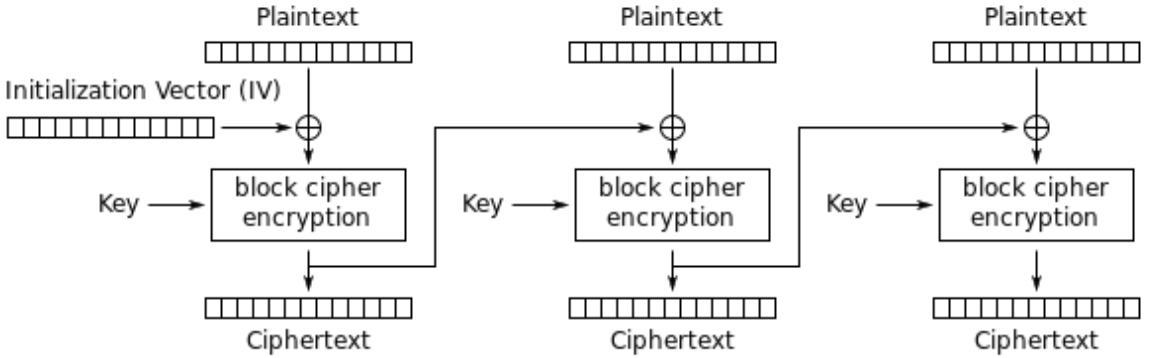

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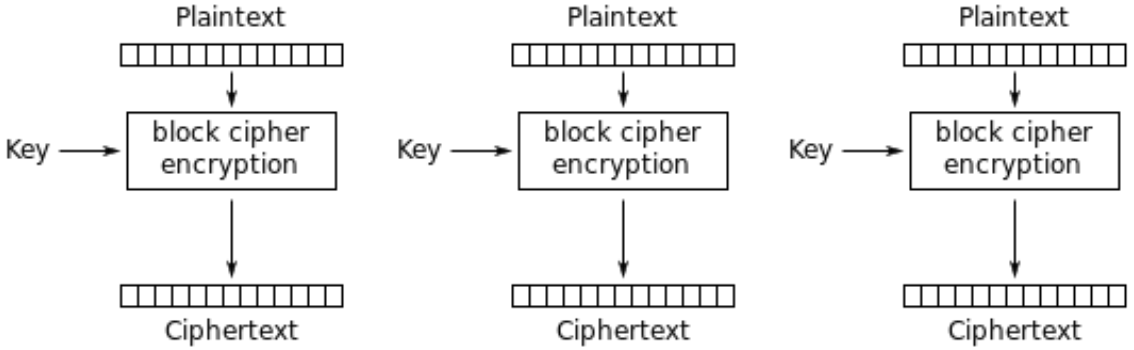

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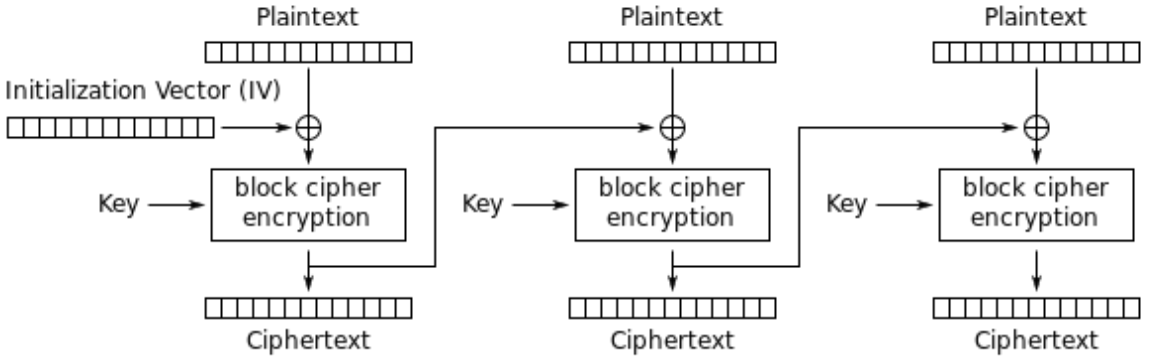
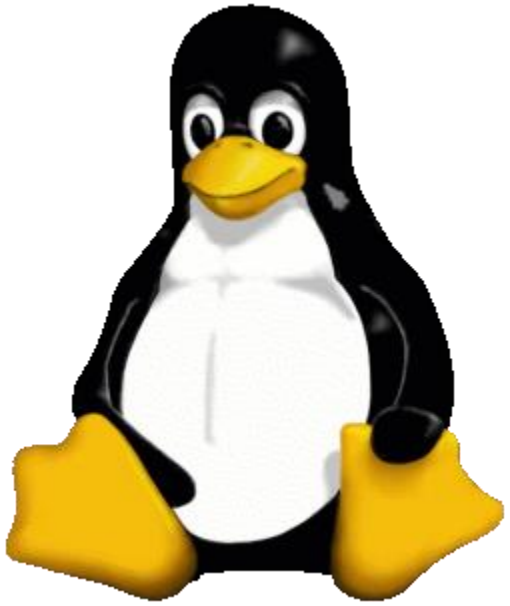
- Enc(bit) is changed → propagates



Cipher Block Chaining (CBC) mode encryption

ECB Penguin

Original image



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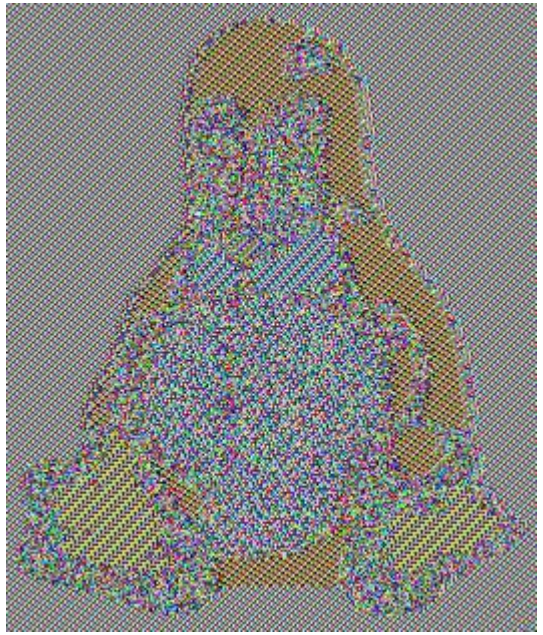

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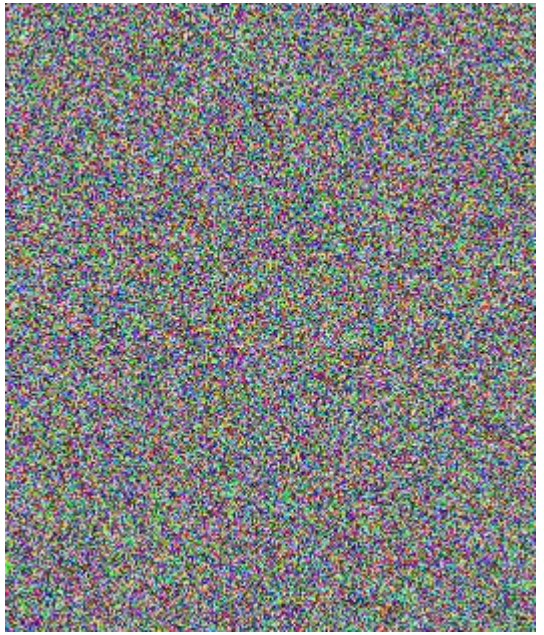

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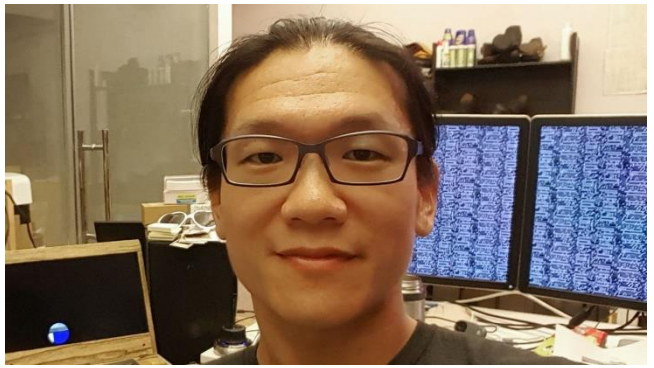
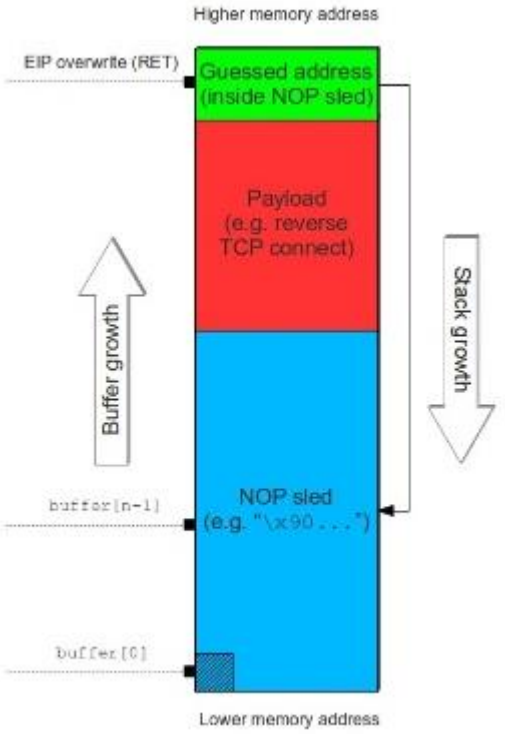
- Solution
  - turn off ROM as last instruction in the address space,
  - PC rolls over to 0, causing exception, double fault → halts the machine

Exploit: Job 1 == read secret ROM





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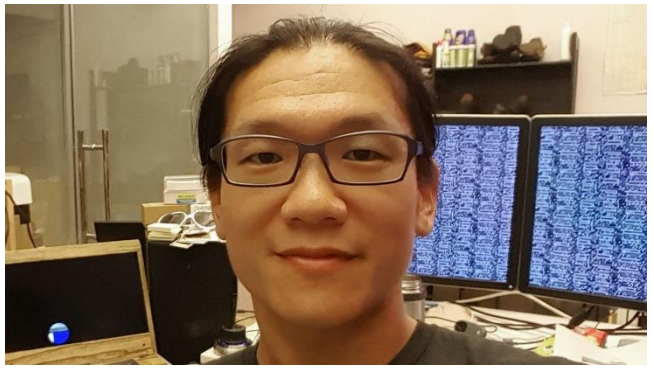

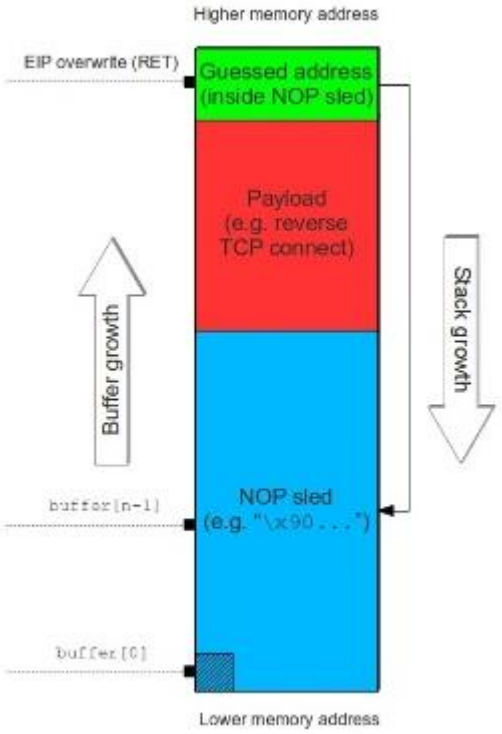

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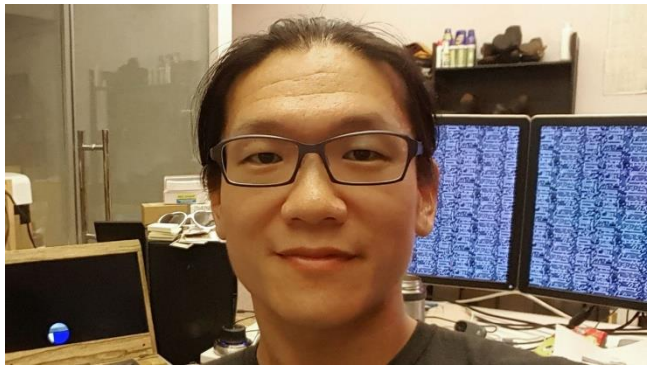

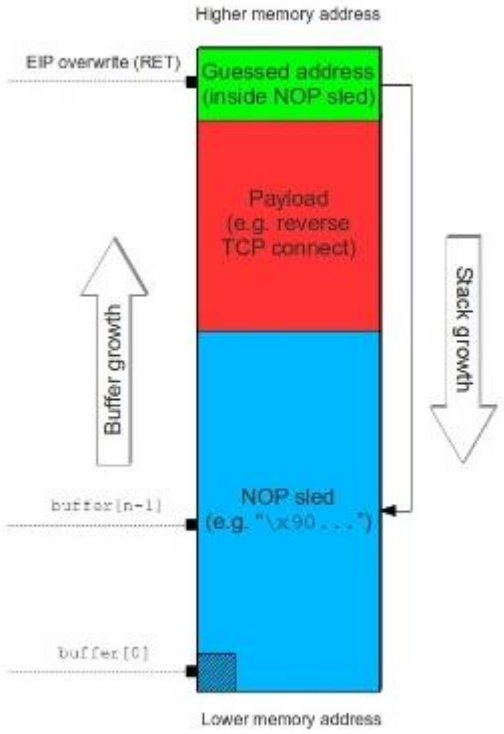

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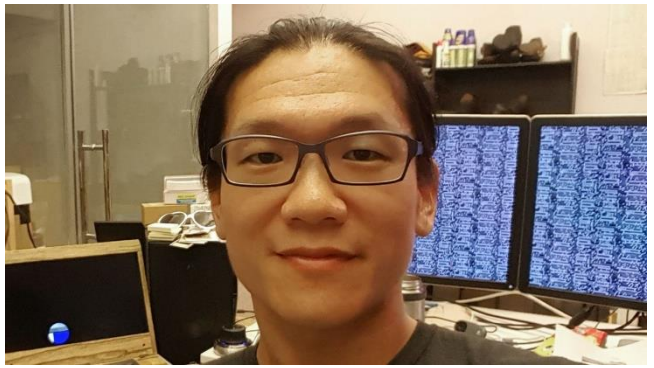

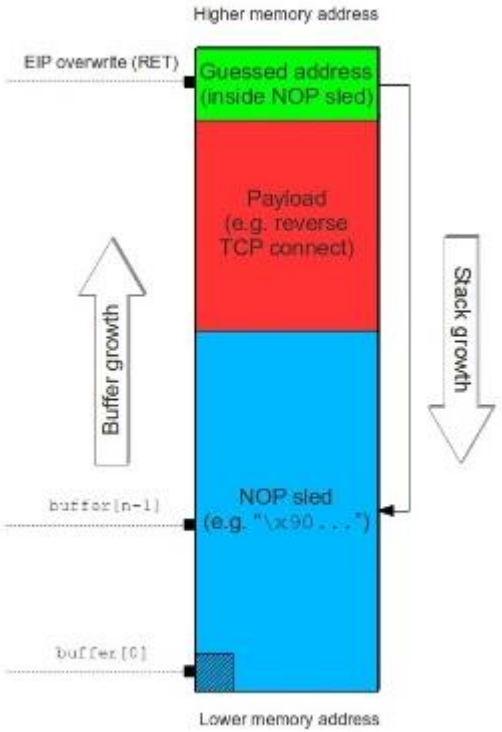

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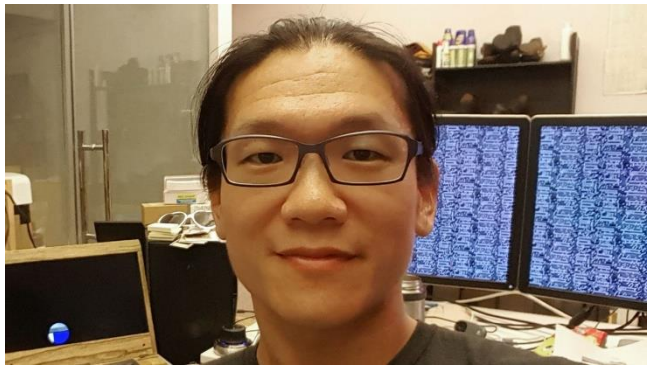

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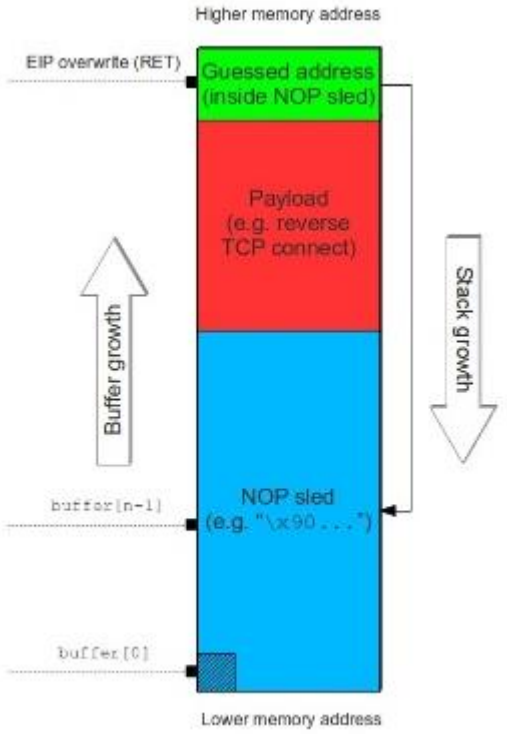

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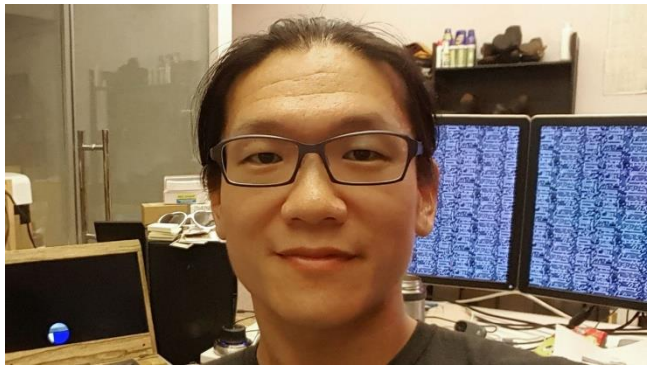

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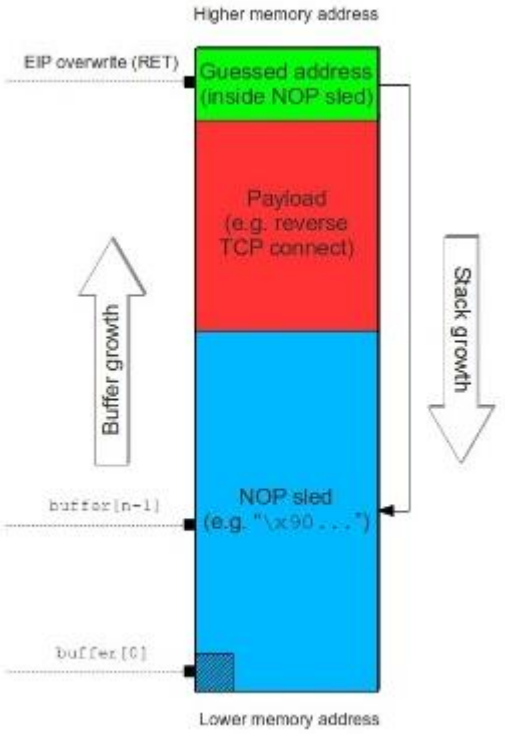
- xcode restriction on disabling secret ROM via PCI register write: flawed.
  - checks against a single constant. put a nop sled at the top of flash,
  - disable secret ROM with xcodes, slide down sled to jump to beginning of (modified) flash.
  - Defense code made attack easier.



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- Key-schedule identical for each cycle
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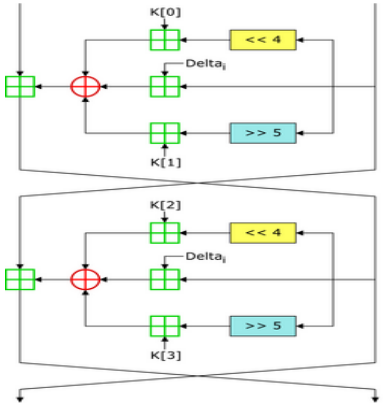

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- The A20 I/O pin grounds address line 20, making address 1MB == 0.
  - remaps secret ROM addresses into flash memory.
  - secret ROM is still on, so it can be dumped by a slow bus.

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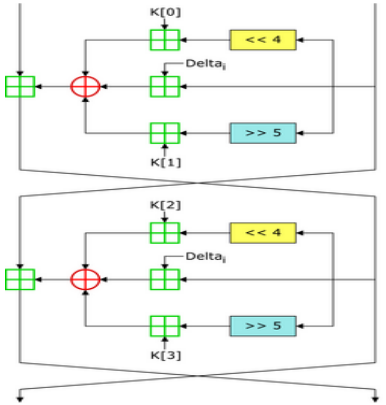

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- modify savegames → buffer overflows in savegame loaders.
  - buffer overflows only compromise user-level programs.
  - all games execute in kernel mode on the xbox.
  - then overwrite flash,
  - but need to solder a bridge make flash writable
  - or just run savegame every time you need unsigned code.

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Ostensible Lessons

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- Security v Money
- Security v Performance
- Combined Weaknesses
- “Harder for Hackers” meaningless
- single security → different purposes
- security by obscurity
- quick fixes

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- Defense in depth.
- Don’t run in kernel mode!
- Know your attacker’s motivations.
- Security by obscurity does not work.