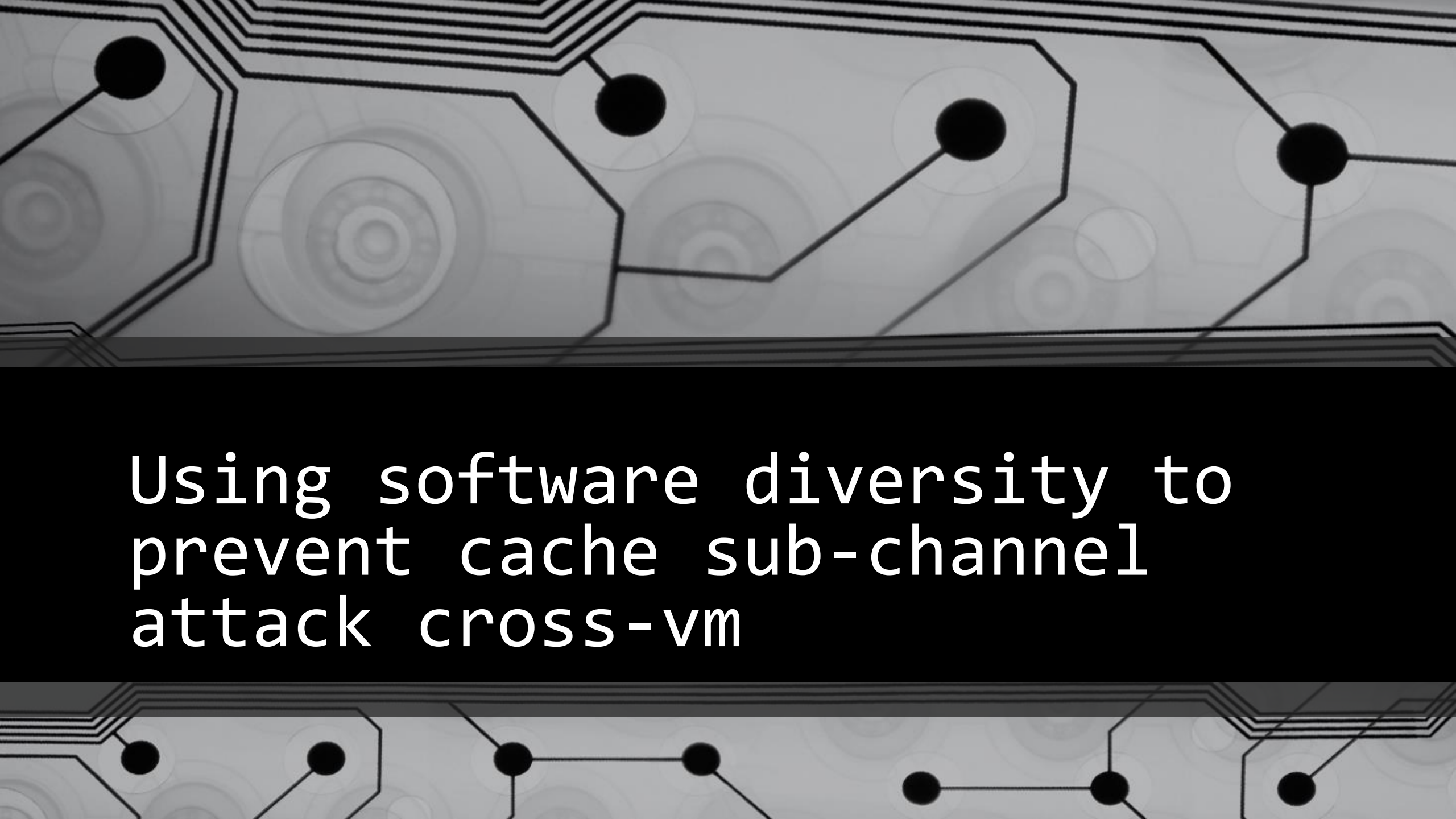


Using software diversity to prevent cache sub-channel attack cross-vm

Outline

- Diversity
- Side channel attack
- Side channel attack cross-vm
- Current countermeasures

- Diversity  Side channel attack cross-vm

Diversity

- Biodiversity
- Culture Diversity
- Similarly to natural systems, software systems including diverse functions and elements are able to cope with many kinds of anticipatable problems and failure

Common ways to implement software diversity

- Manual (timeline of software production)
  - Requirements
  - Different design versions of program
  - Development diversity(example)
- Automatic
  - Randomization
  - Domain-specific Diversity
  - Integrated Diversity

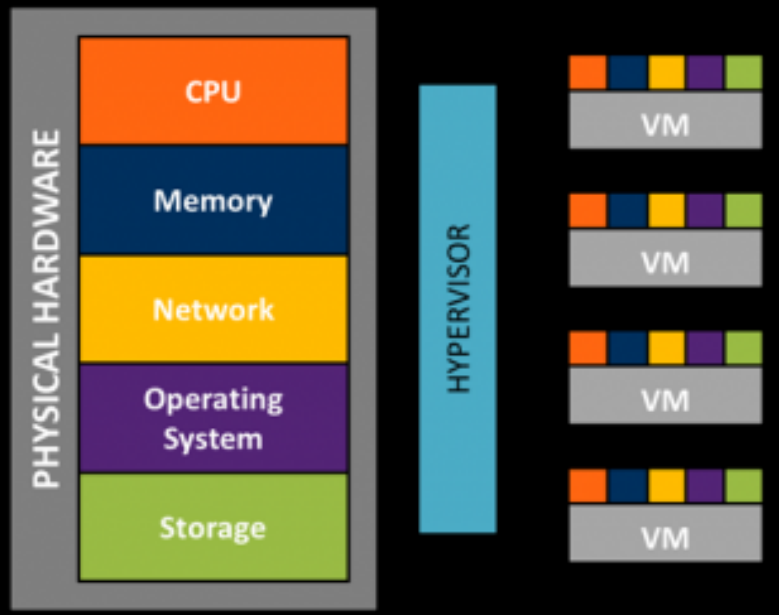
```
program Adhoc;

function Add( x, y : Integer ) : Integer;
begin
    Add := x + y
end;

function Add( s, t : String ) : String;
begin
    Add := Concat( s, t )
end;

begin
    Writeln(Add(1, 2));                    (* Prints "3" *)
    Writeln(Add('Hello, ', 'World!'));     (* Prints "Hello, World!" *)
end.
```

Different types of side-channel attacks cross-vm in the cloud

- In the cloud,
  Several different virtual machines can be in the same host.
- Networking side channel attack.

  e.g co-resident watermarking.
  Try to insert malicious code into other co-resident virtual machines.

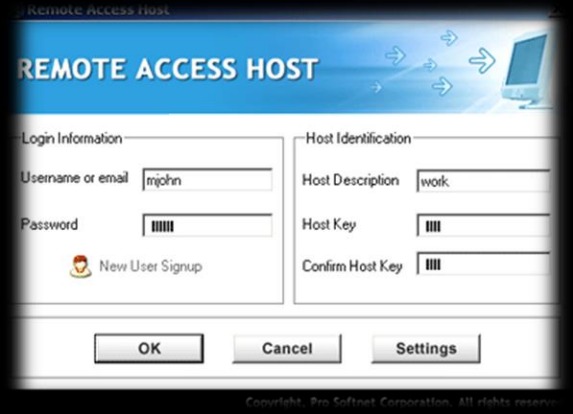
- Cache-based side channel attacks.

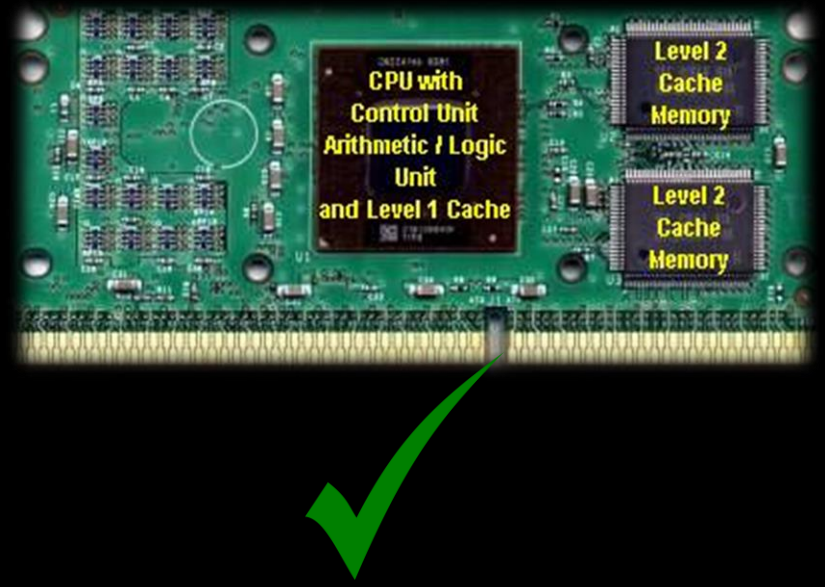


Timing attack and Cache timing attack

"Timing attack based on the leakage of information of secret parameters through variations in the running times of a cryptographic device."

Cache timing, timing attack on cache☺





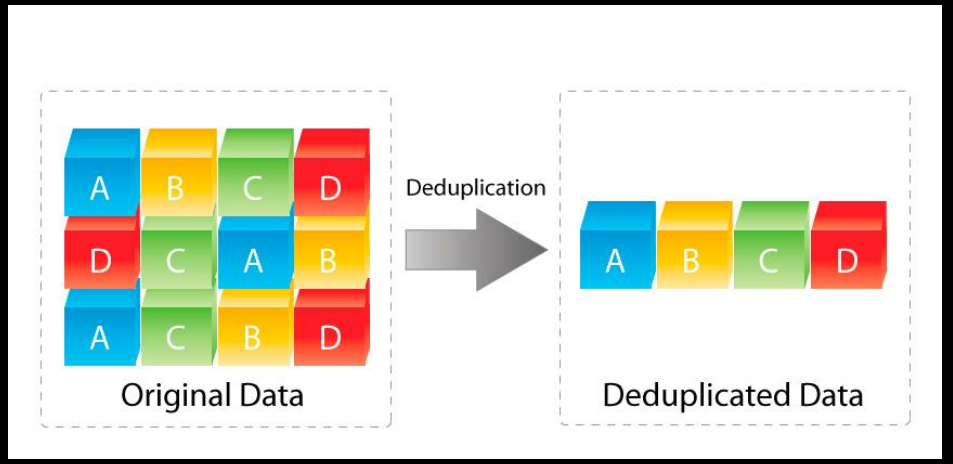
Why preventing cache timing attack from different virtual machines matters?

Cloud

VM Isolation

Vulnerabilities of encryption libraries

Deduplication



Types of cache timing side channel attacks

- According to procedures:

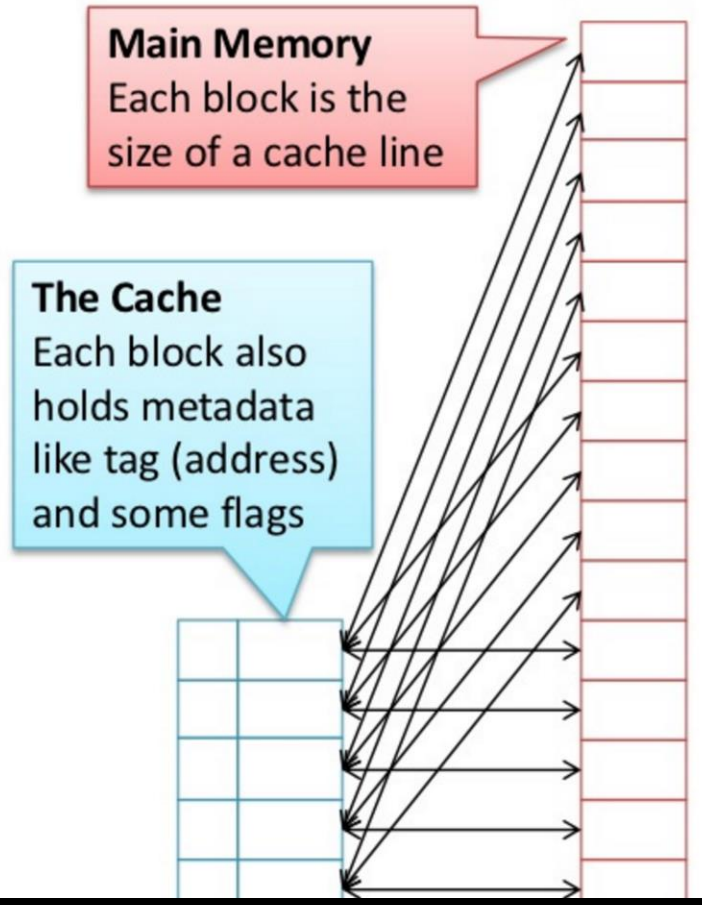
1) PRIME + PROBE
2) EVICT + TIME
3) FLUSH + RELOAD(cloud)

- According to which round of encryption:

1) First round + second round attack
2) Final round

Cache Architecture

- When any memory byte is needed, its place in cache is calculated;
- CPU asks the cache;
- If there, the cache returns the data;
- If not, the data is pulled in from memory;
- If the calculated cache line is occupied by data with a different tag, that data is *evicted*.
- If the line is *dirty* (modified) it is written back to memory first.



Cache miss

Cache hit

PRIME + PROBE

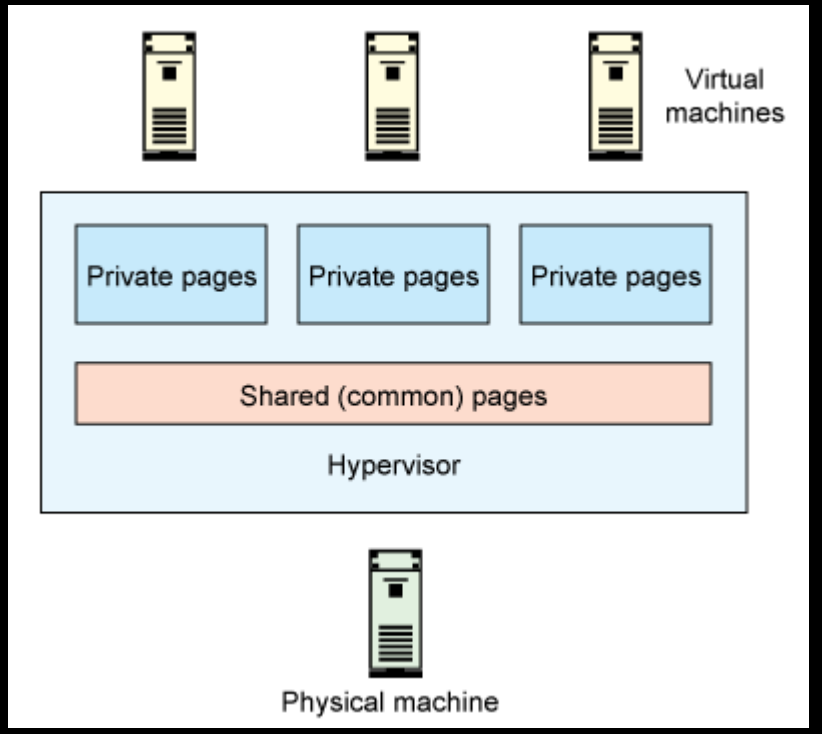
- Step 1 Fill cache with attacker's own data(will be change for sure)
- Step 2 Trigger encryption
- Step 3 Load the target information want to check and timing(e.g AES will load T-table, check which entries in the T-table is accessed during encryption.)

Evict + Time

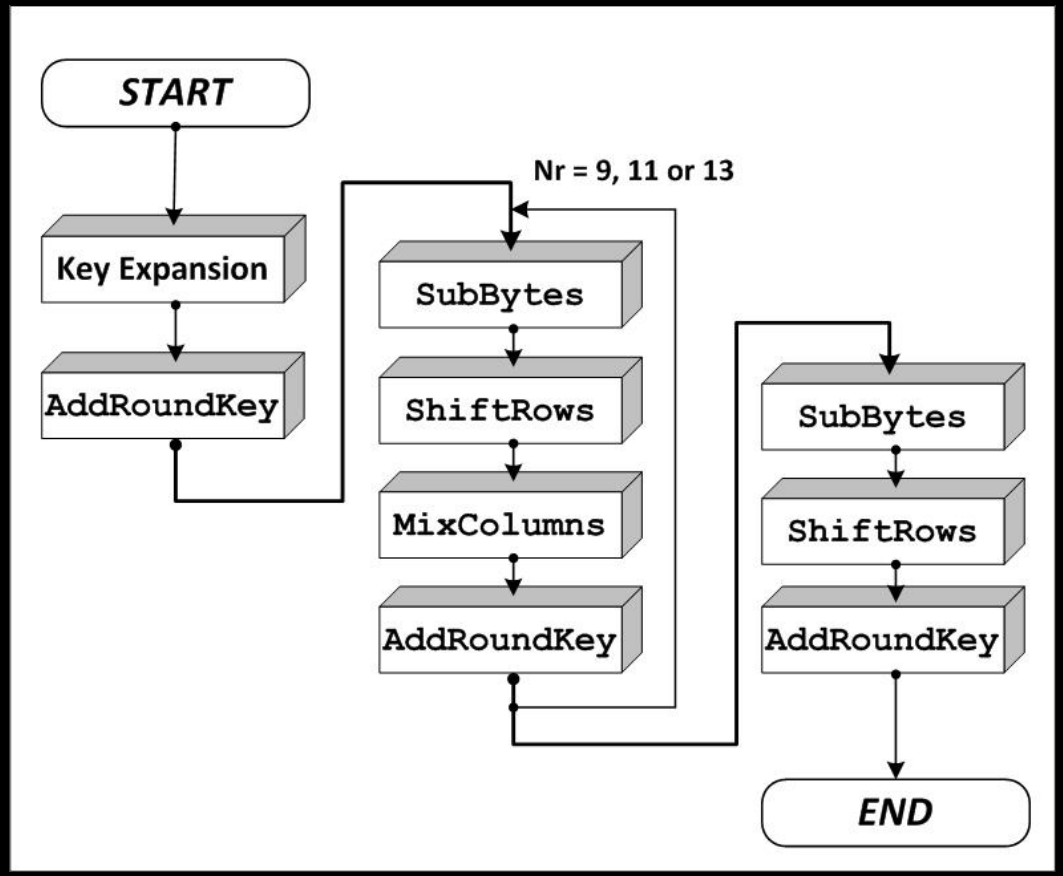
- Step 1 Triger encrypt, calculate average encryption time t1
- Step 2 Evict specific cache set
- Step 3 Encrypt again, timing the encryption time t2, if t2 > t1, means that cache set is used during encryption.
- In cloud: require targeting VM and attacker VM are using the same core, so they are sharing L1 , L2 cache, since it requires attack can modify the cache content

Memory Deduplication

- Improve the memory utilization by recognizing processes(or VMs) that place the same data in memory
  e.g. Two virtual machine share libraries
- Implemented: VMware (Transparent Page Sharing- TPS)
  KVM(Kenel same-page KSM)

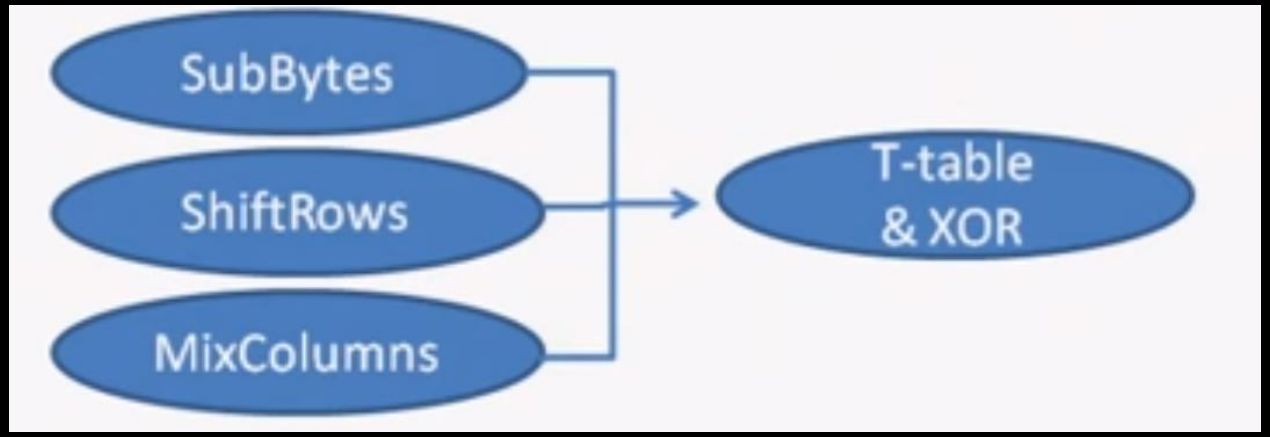


AES Encryption Processes



- https://www.youtube.com/watch?v=mlzxpkdXP58

T-table



FLUSH + RELOAD

- Premise: attacker can monitor of a single memory line

Step 1 Attack uses the clflush command to flush desired memory lines from the cache to make sure that they have to be retrieved from the main memory next time

Step 2 Encryption

Step 3 Timing and tell whether had access that monitored memory line by reloading the cache line again.

$$c_i = k_i \oplus T\left[s_{[i]}\right]$$

Countermeasures for what?Reason? Tell the problem and explain the solution

- Pre-fetching
- Disable memory duplication
- Software diversity: diversify
- Hardware mechanism: separation cache used in L3

Asking a question you already know just to see if the person will lie.