ARTIFACT EVALUATED
usenix ASSOCIATION
PASSED

D-TIME
Distributed Threadless Independent Malware Execution for Runtime Obfuscation

13th USENIX Workshop on Offensive Technologies

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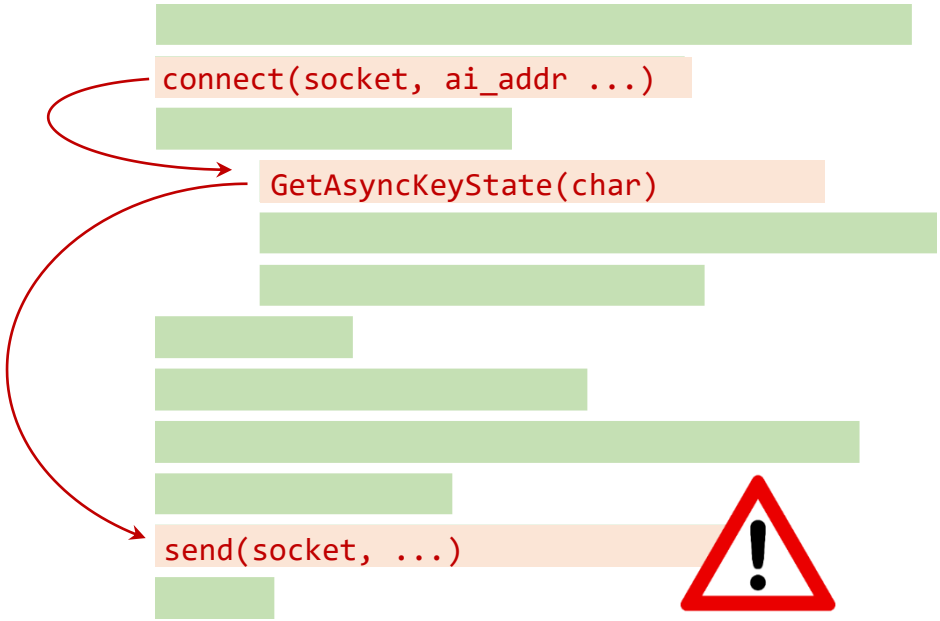
Advanced Malware Detection Techniques

Behavioral Detection → **Run time behavior**



D-TIME
Distributed Threadless Independent Malware Execution

D-TIME

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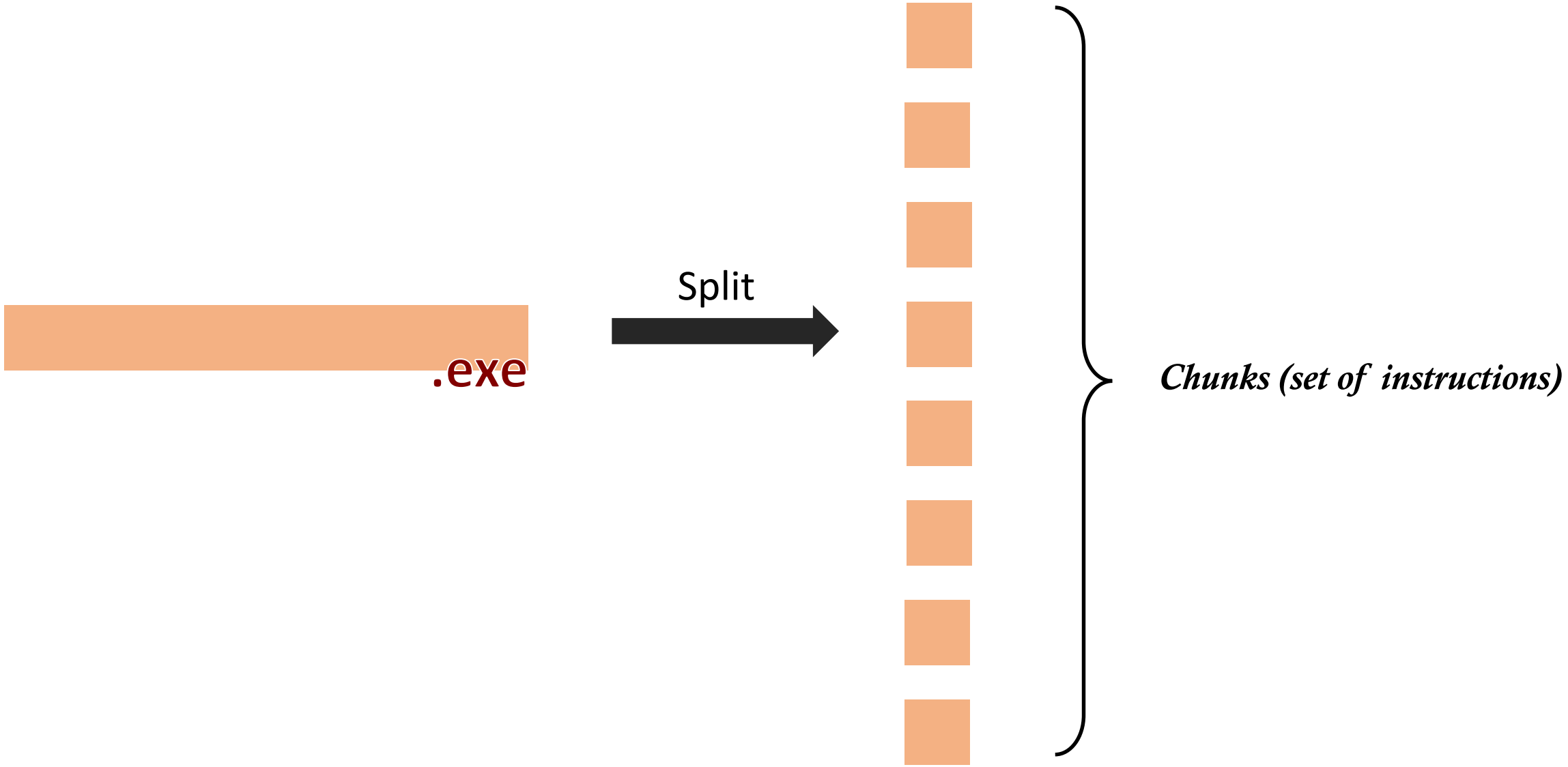
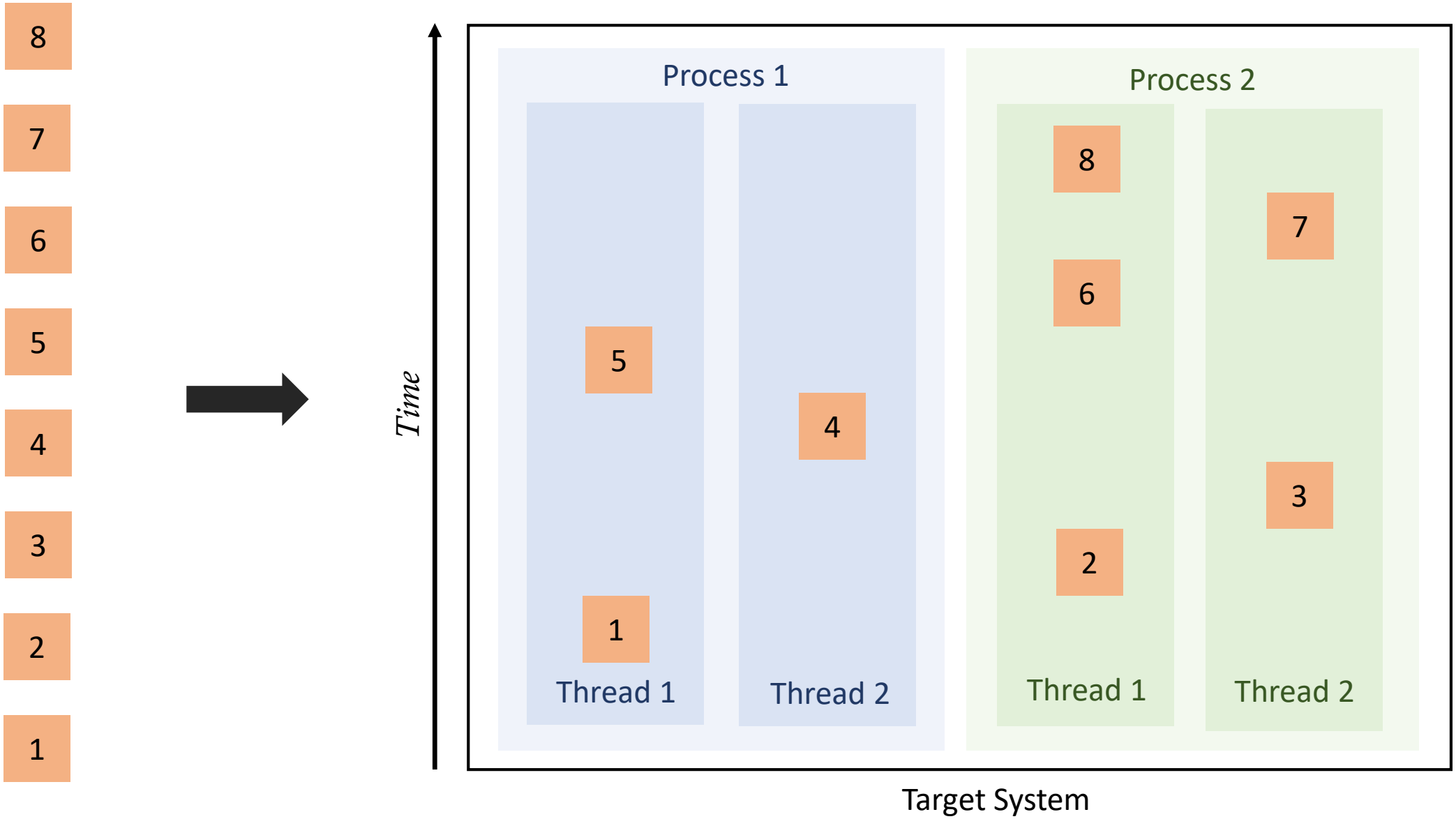


D-TIME

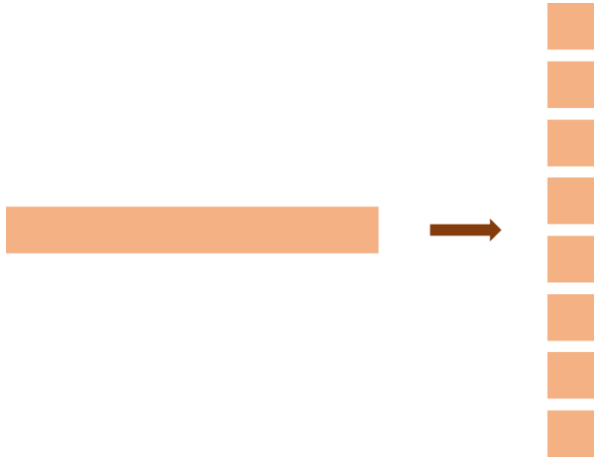

8
7
6
5
4
3
2
1
Time
Process 1
5
1
Thread 1
4
Thread 2
Process 2
8
6
2
Thread 1
7
3
Thread 2
Target System

Difficulties of Distribution

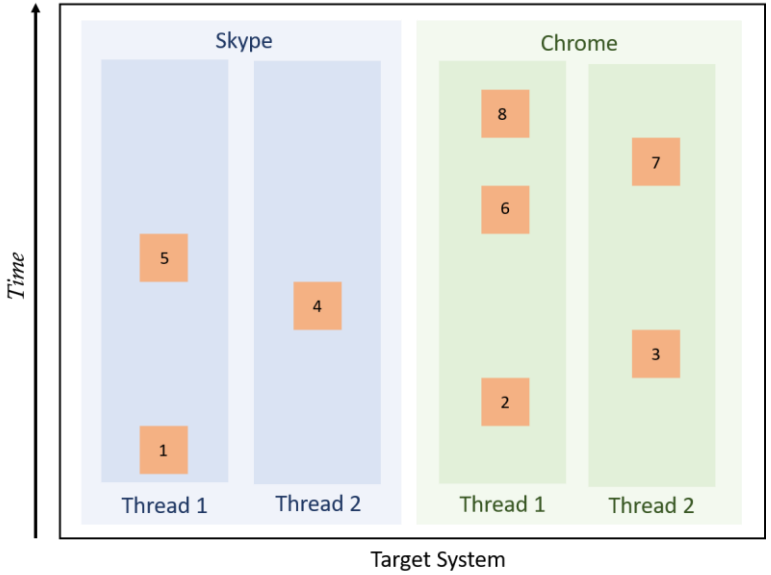
- Sequence of Chunks
- Context

D-TIME

Offline Phase



Online Phase



D-TIME – Offline Phase

```
      ...                  ;
    cmp [a], [b]           ; if(a==b){
    jne a_unequal_b        ;
    mov [a], 0             ;     a = 0
a_unequal_b:               ; }
    mov [c], [d]           ; c = d
      ...                  ;
```

Splitting technique adopted from MalWASH (WOOT'16)

D-TIME – Offline Phase

Chunk 1

```
  ...                    ;
cmp [a], [b]             ; if(a==b){
jne  a_unequal_b         ;
```

Chunk 2

```
mov [a], 0               ;     a = 0
```

Chunk 3

```
mov [c], [d]             ; c = d
  ...                    ;
```


Splitting technique adopted from MalWASH (WOOT'16)

D-TIME – Offline Phase

Chunk 1

```
...                     ;
cmp [a], [b]            ; if(a==b){
jne a_unequal_b         ;
mov ebx, 2
jmp END
jmp a_unequal_b:
mov ebx, 3
```

Chunk 2

```
mov [a], 0              ;     a = 0
mov ebx, 3
```

Chunk 3

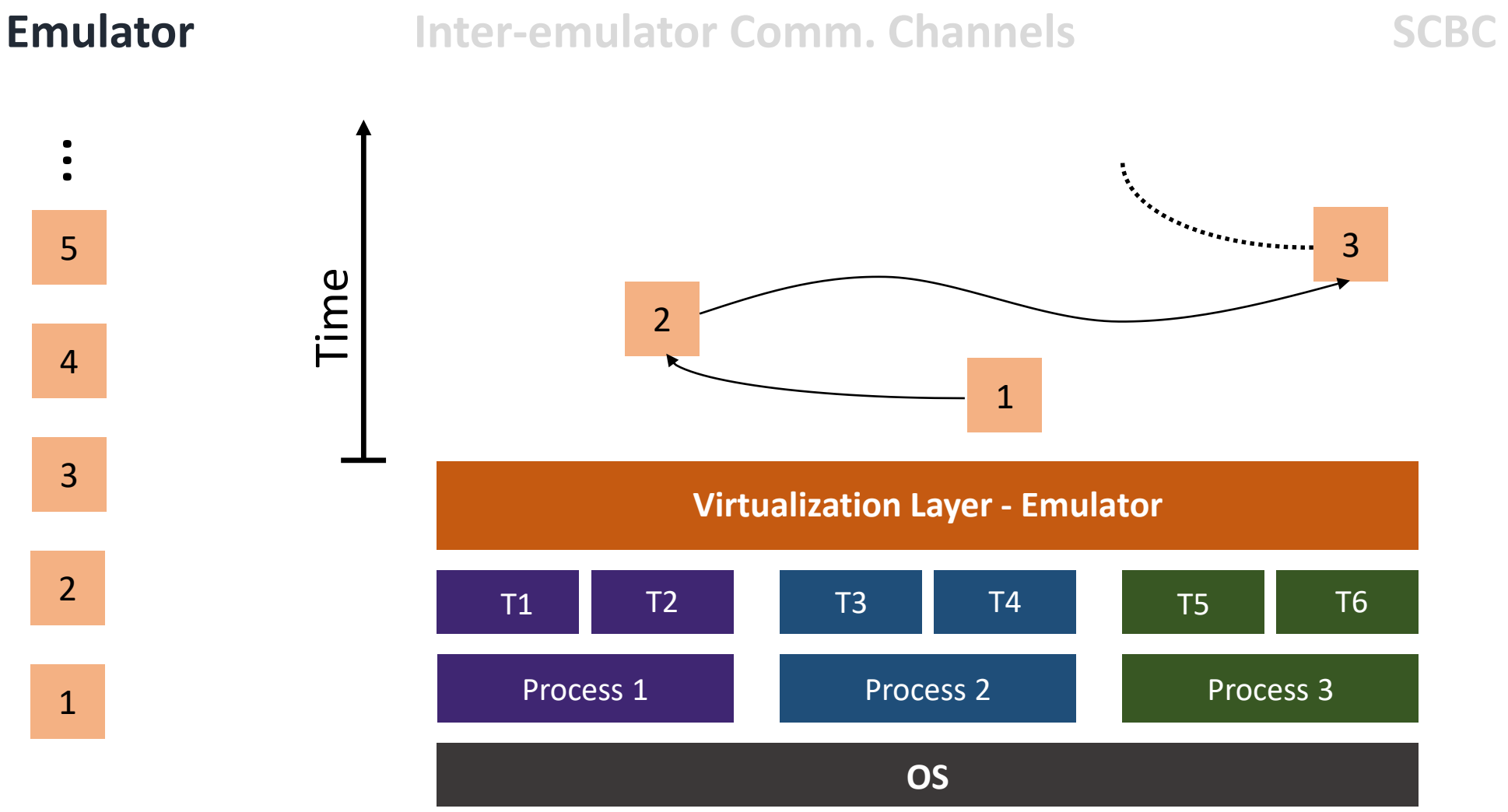
```
mov [c], [d]            ; c = d
...                     ;
```

Splitting technique adopted from MalWASH (WOOT'16)

D-TIME – Online Phase

Emulator **Inter-emulator Comm. Channels** **SCBC**

D-TIME – Online Phase

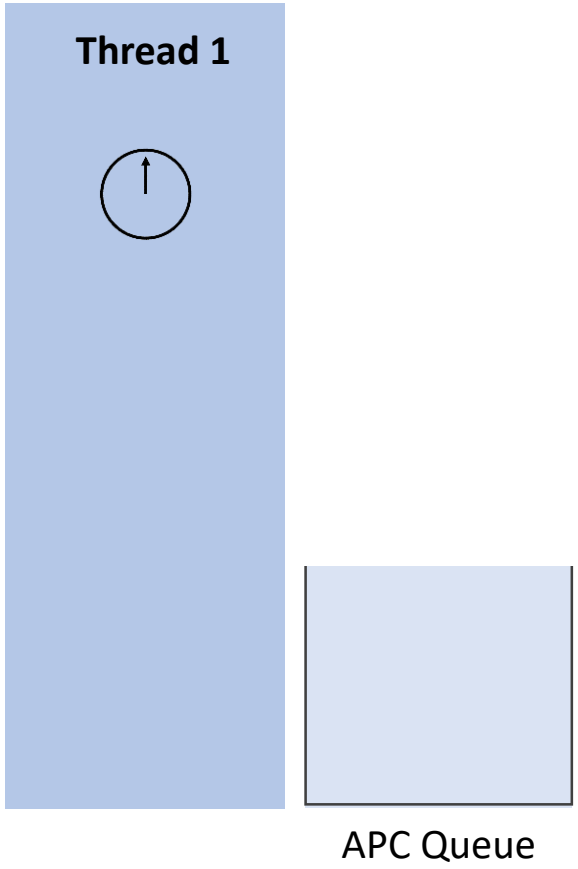


D-TIME – Online Phase

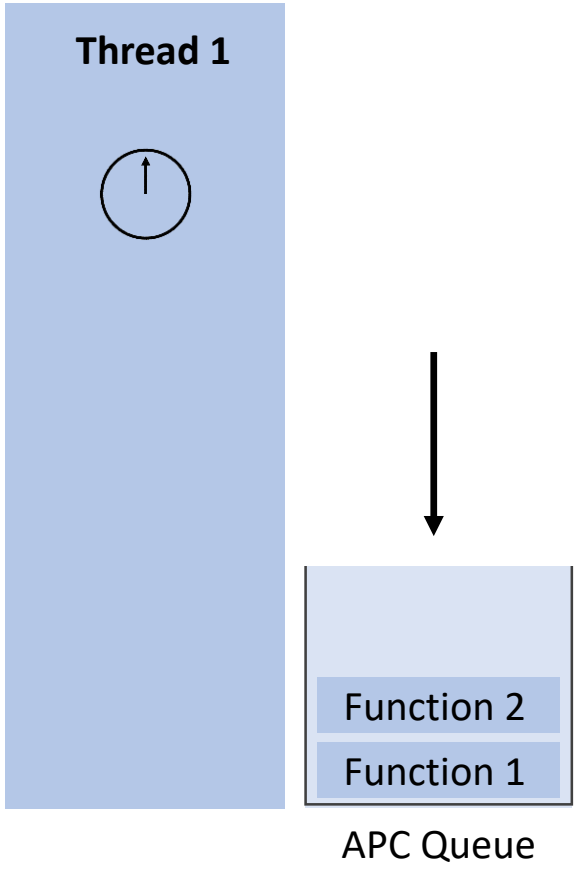
Emulator Inter-emulator Comm. Channels SCBC

- A Function
- Gets executed in benign thread's context
- Creates the virtualization layer
- Execute a chunk
- Maintaining
  - ✓ Sequence of chunks
  - ✓ Continuity of state (stack, registers, heap)
- Ensures completeness of malware

APC
(Asynchronous Procedural Call)



APC
(Asynchronous Procedural Call)



APC
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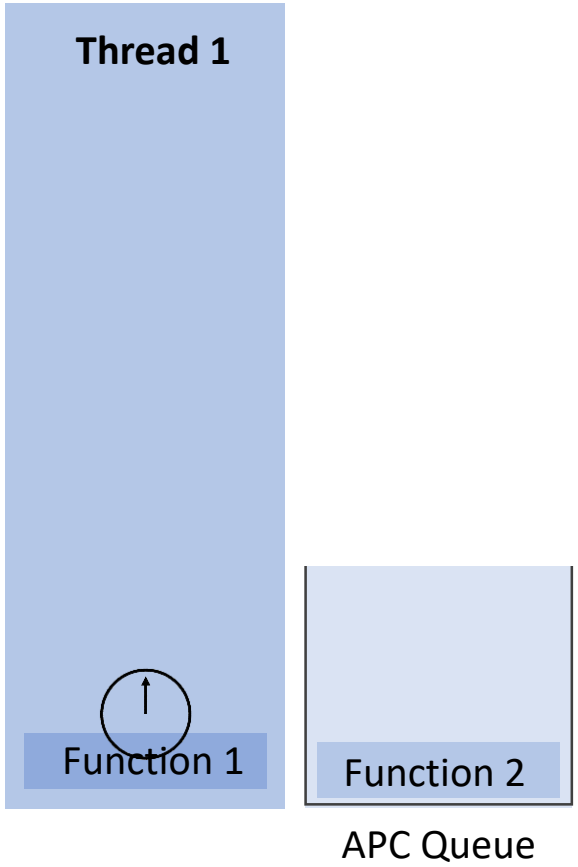


Alertable Wait State

```
SleepEx
SignalObjectAndWait
MsgWaitForMultipleObjectsEx
WaitForMultipleObjectsEx
WaitForSingleObjectEx
```

D-TIME

Emulator Inter-emulator Comm. Channels SCBC

Steps:

1. Connect to Comm. Channel
2. Retrieve
3. Statefing

Online Phase: A series of emulator executions,

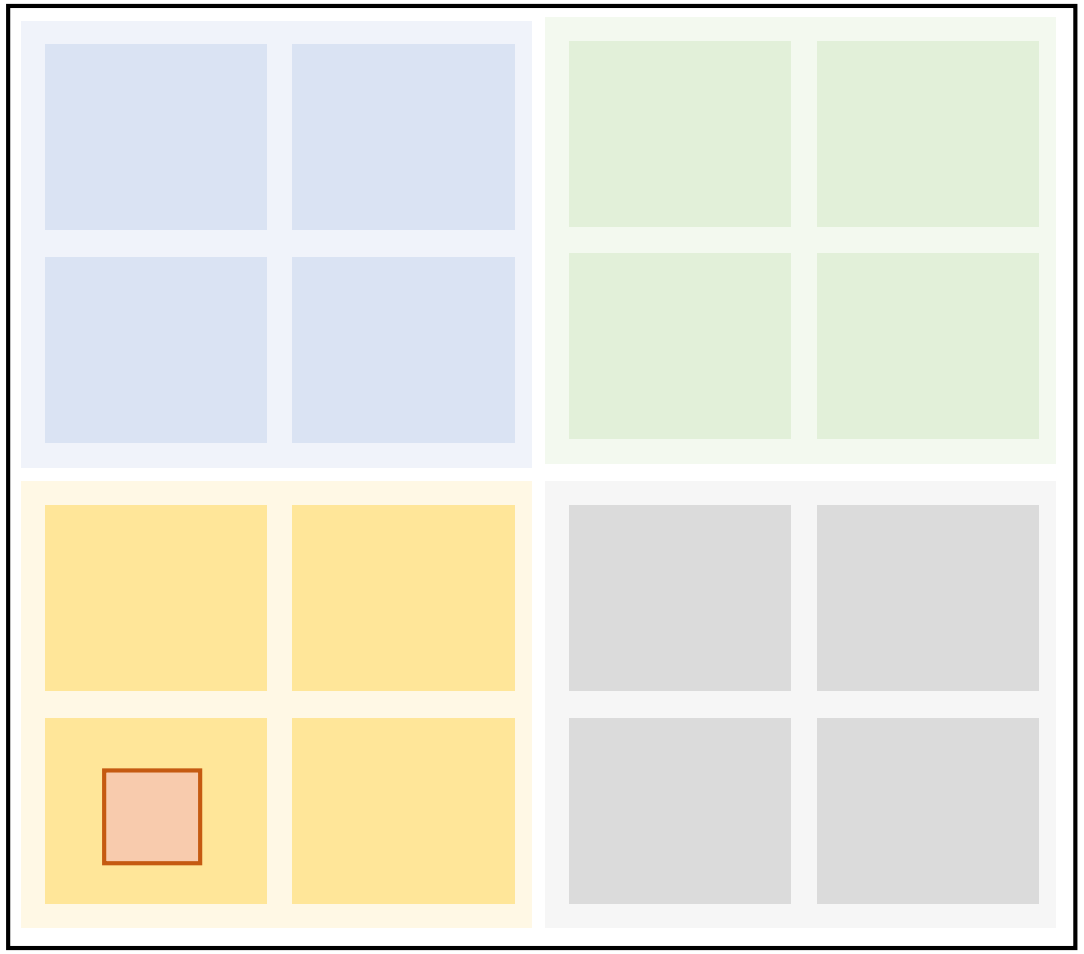
Emulators

- Spawn in different threads
- Executing one chunk each
- Collectively completing the sequence.

5. Regenerate itself

D-TIME

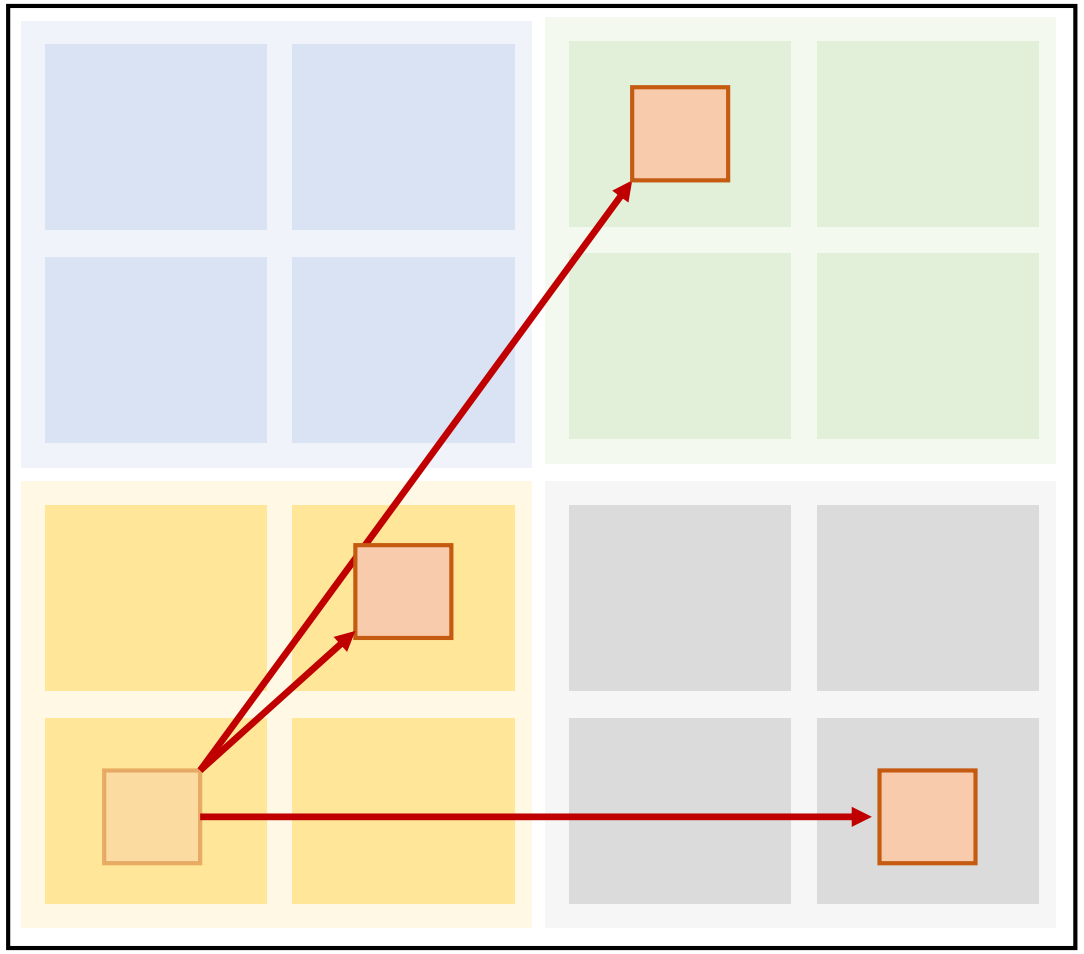
Emulator Regeneration



Target System

D-TIME

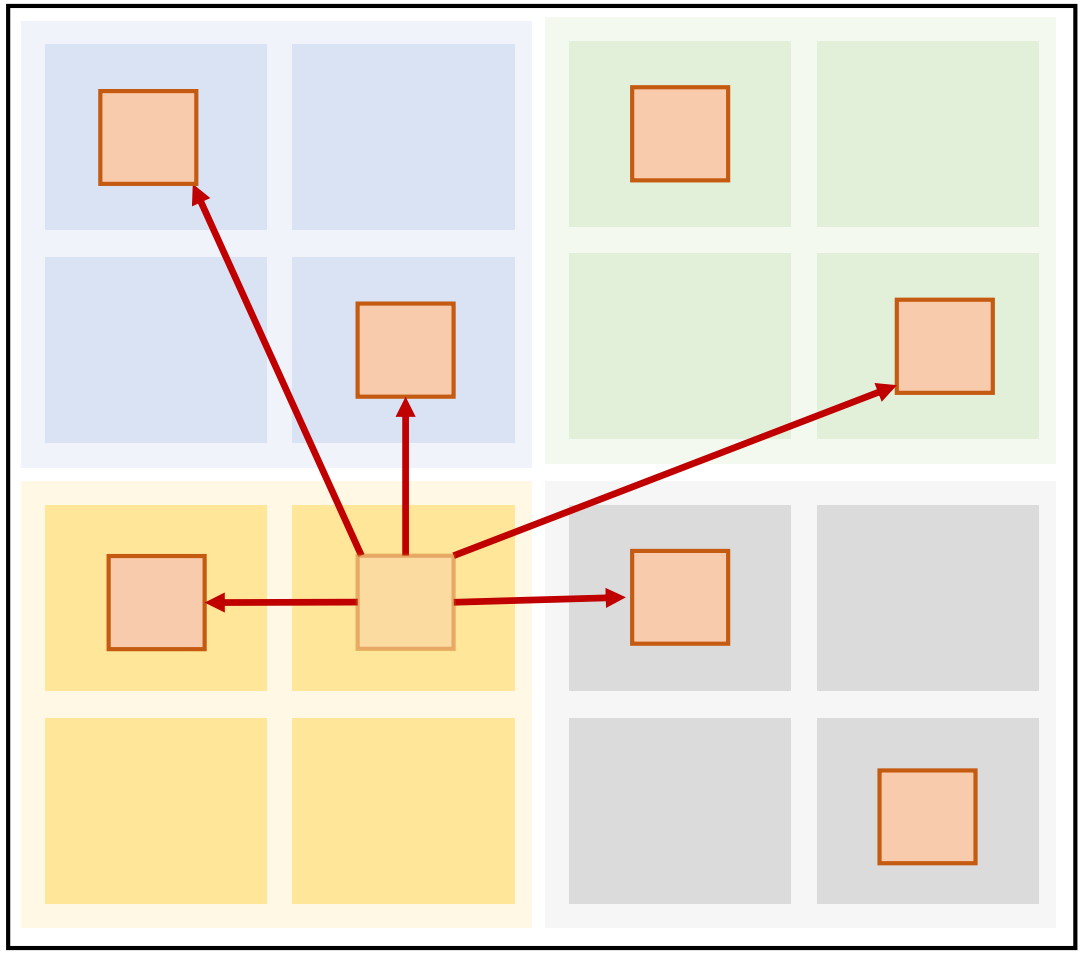
Emulator Regeneration



Target System

D-TIME

Emulator Regeneration



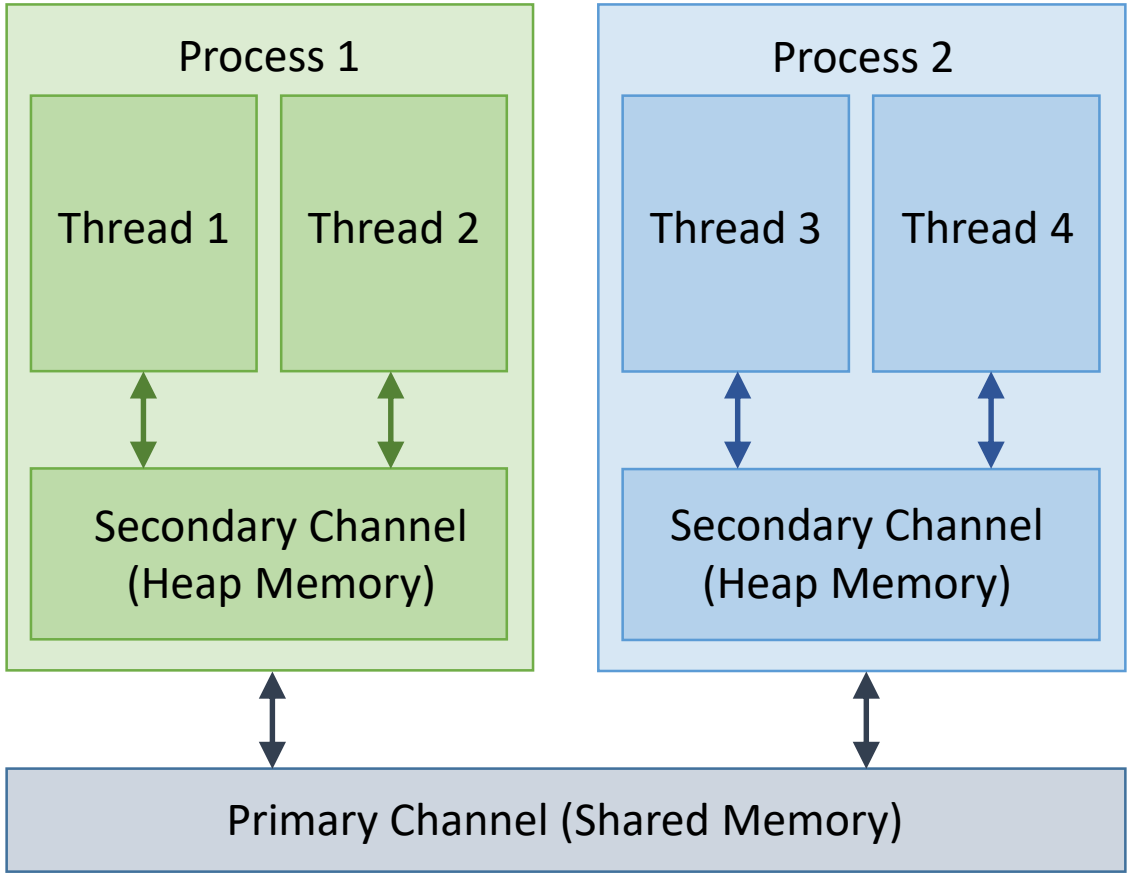
Target System

D-TIME

Emulator

Inter-emulator Comm. Channels

SCBC

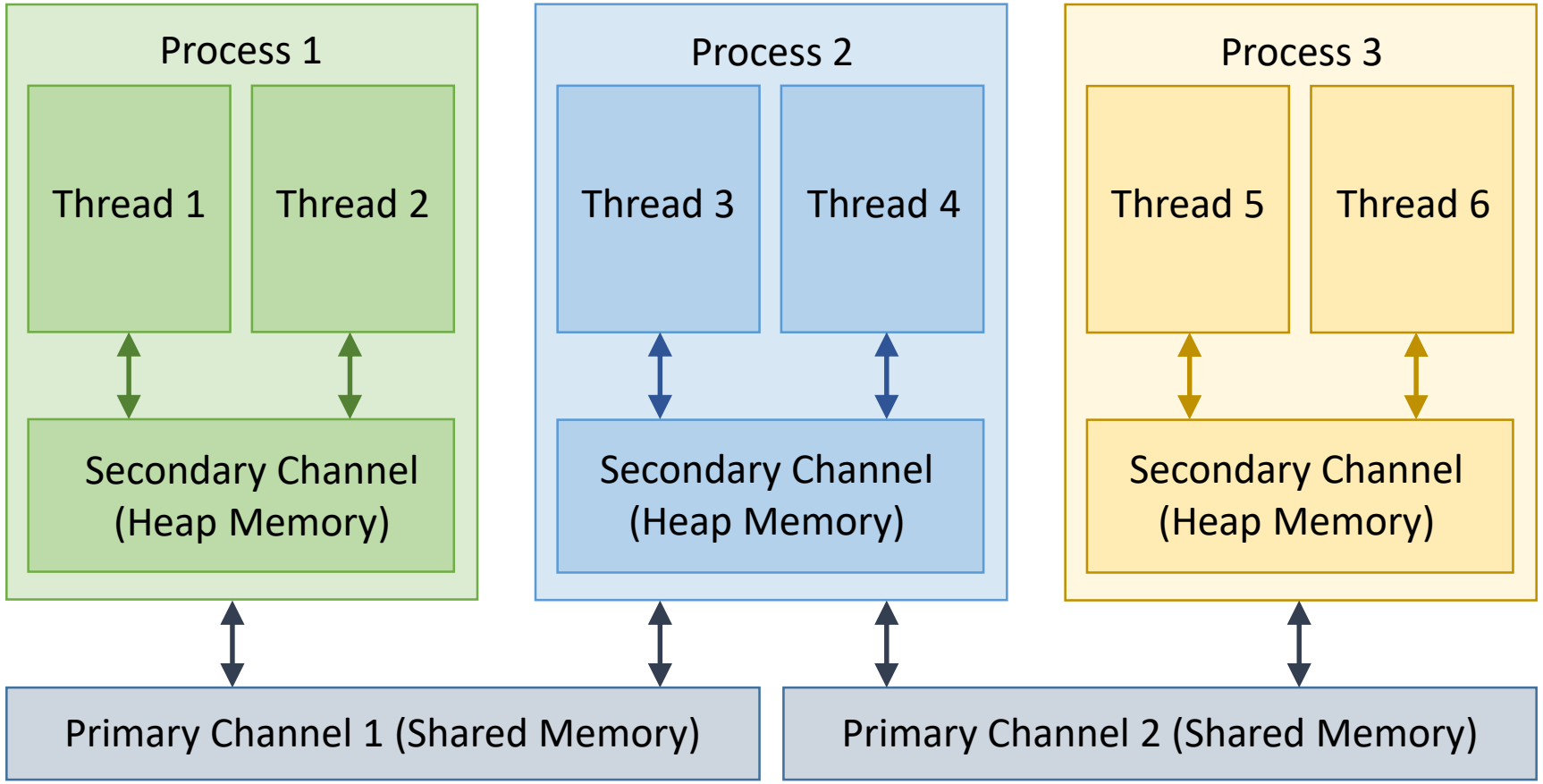


D-TIME

Emulator

Inter-emulator Comm. Channels

SCBC



Partially adopted from MalWASH (WOOT'16)

D-TIME

Emulator **Inter-emulator Comm. Channels** SCBC

Heap and Shared Memory

1. Commonly used ⟶ Hard to classify as malign
2. Once allocated/attached, lives until
   a) De-allocated by application or
   b) Process exit

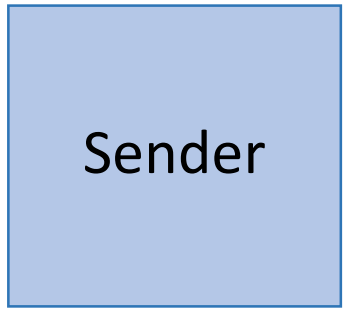
D-TIME

Emulator **Inter-emulator Comm. Channels** SCBC

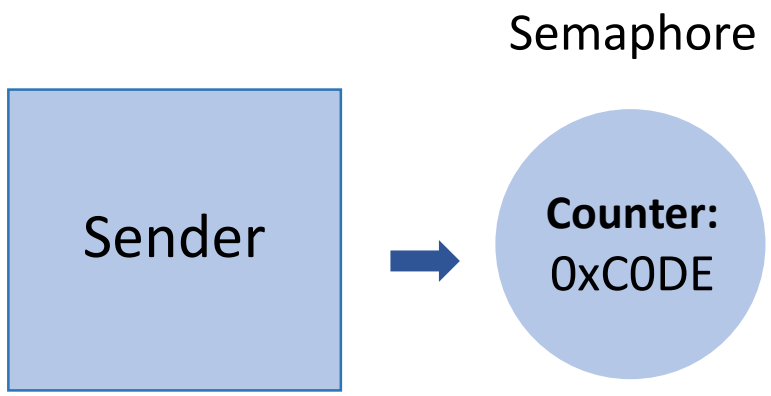
Unknown location!

1. First emulator comes up
   a) Attaches the shared memory
   b) Executes a chunk
   c) Exit
2. The second emulator comes up
   ✓ Has access rights to shared memory
   ? Doesn't know the starting address

SCBC
(Semaphore based Covert Broadcasting Channel)



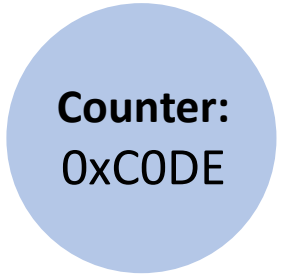
SCBC
(Semaphore based Covert Broadcasting Channel)



Creates a semaphore and set
semaphore-counter = data

SCBC
(Semaphore based Covert Broadcasting Channel)

Semaphore



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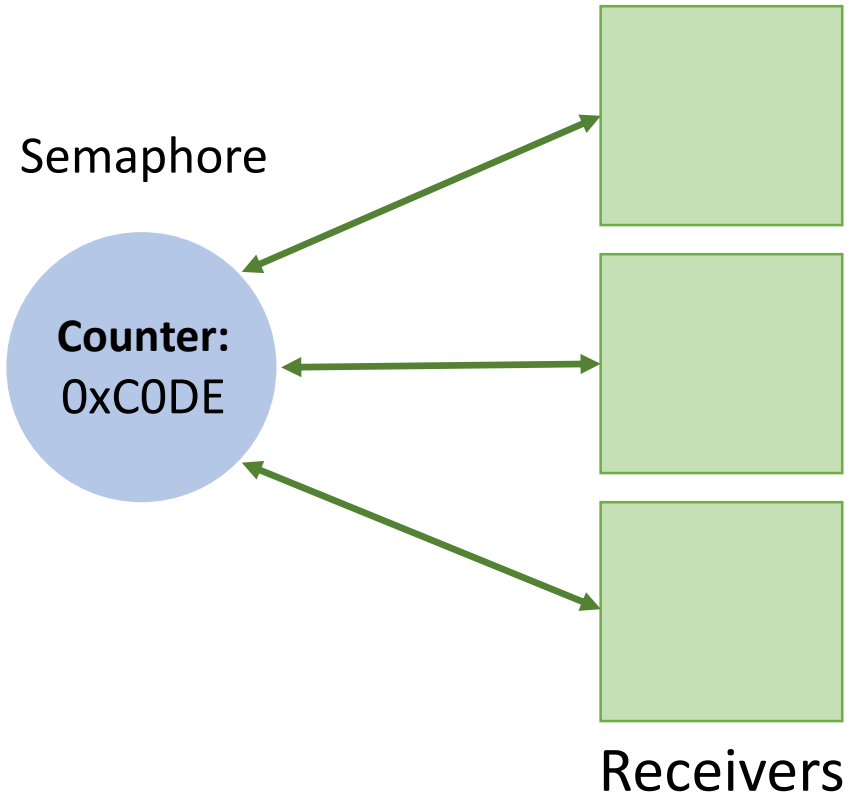

SCBC
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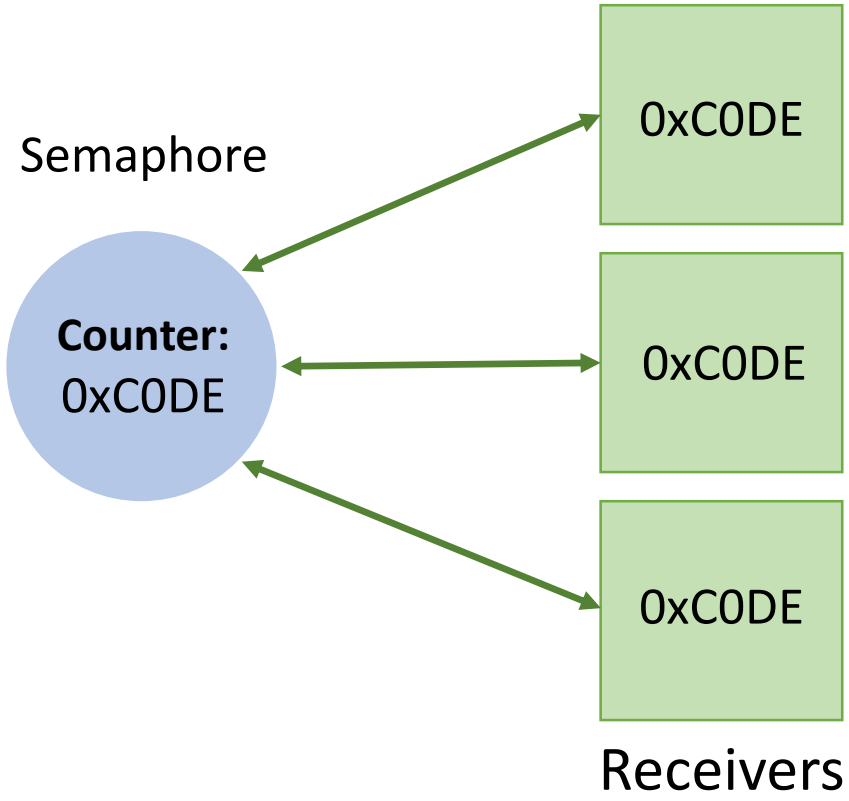


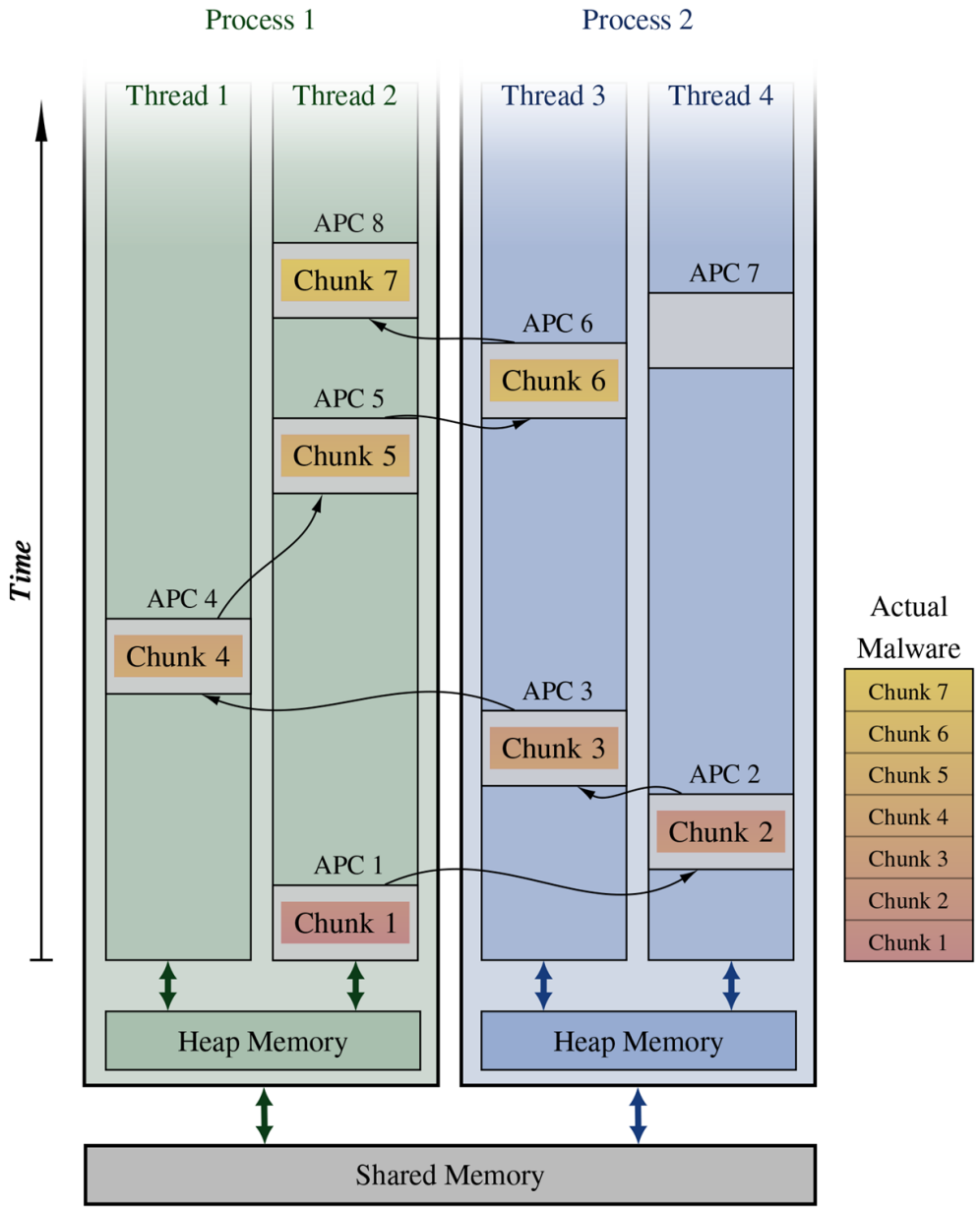
Works in Linux as well as Windows

SCBC
(Semaphore based Covert Broadcasting Channel)

- High Integrity
- Broadcasting
- Persistent
- As Convenient as a shared integer

Converts semaphore to a shared integer

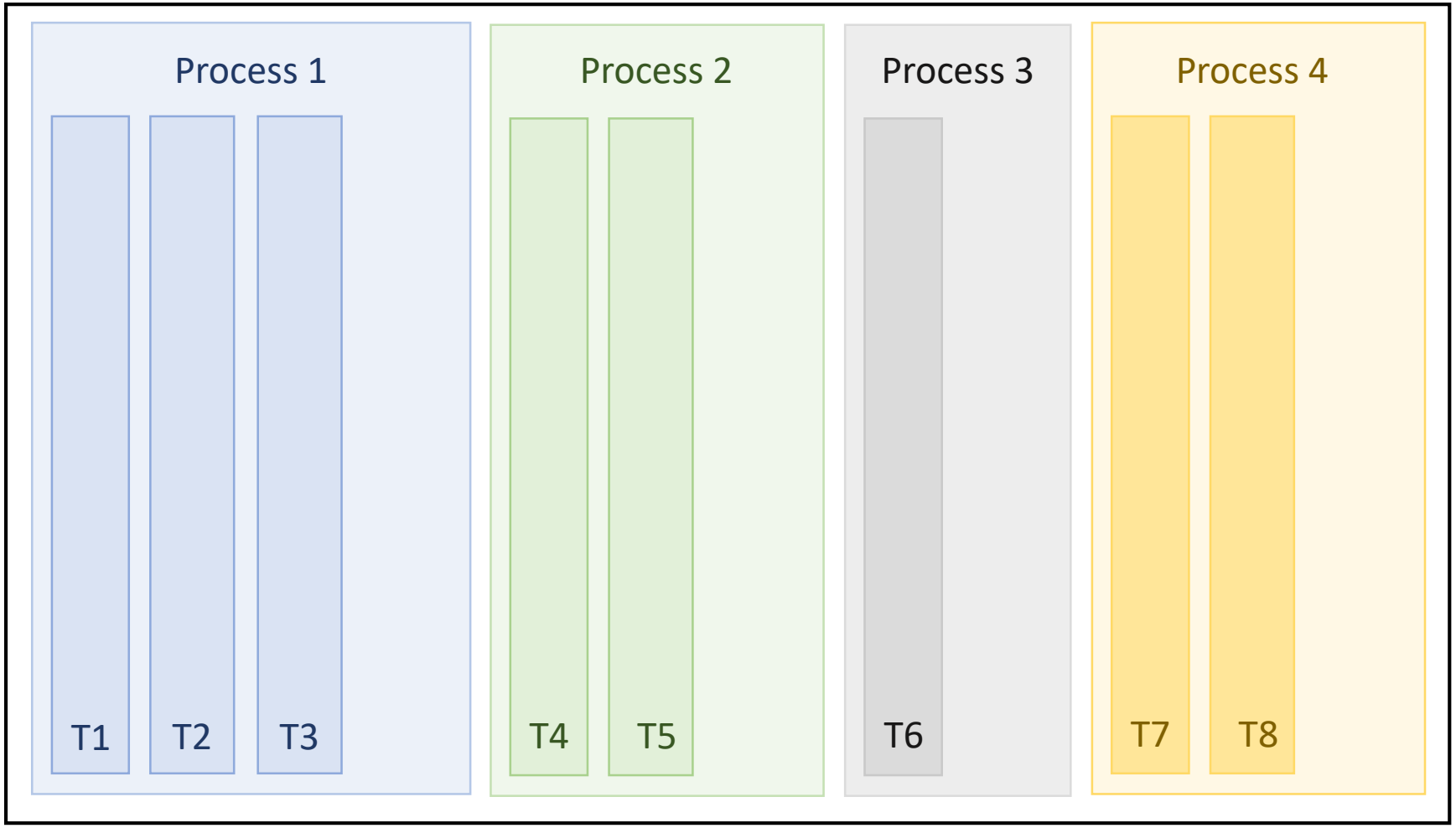
D-TIME Execution



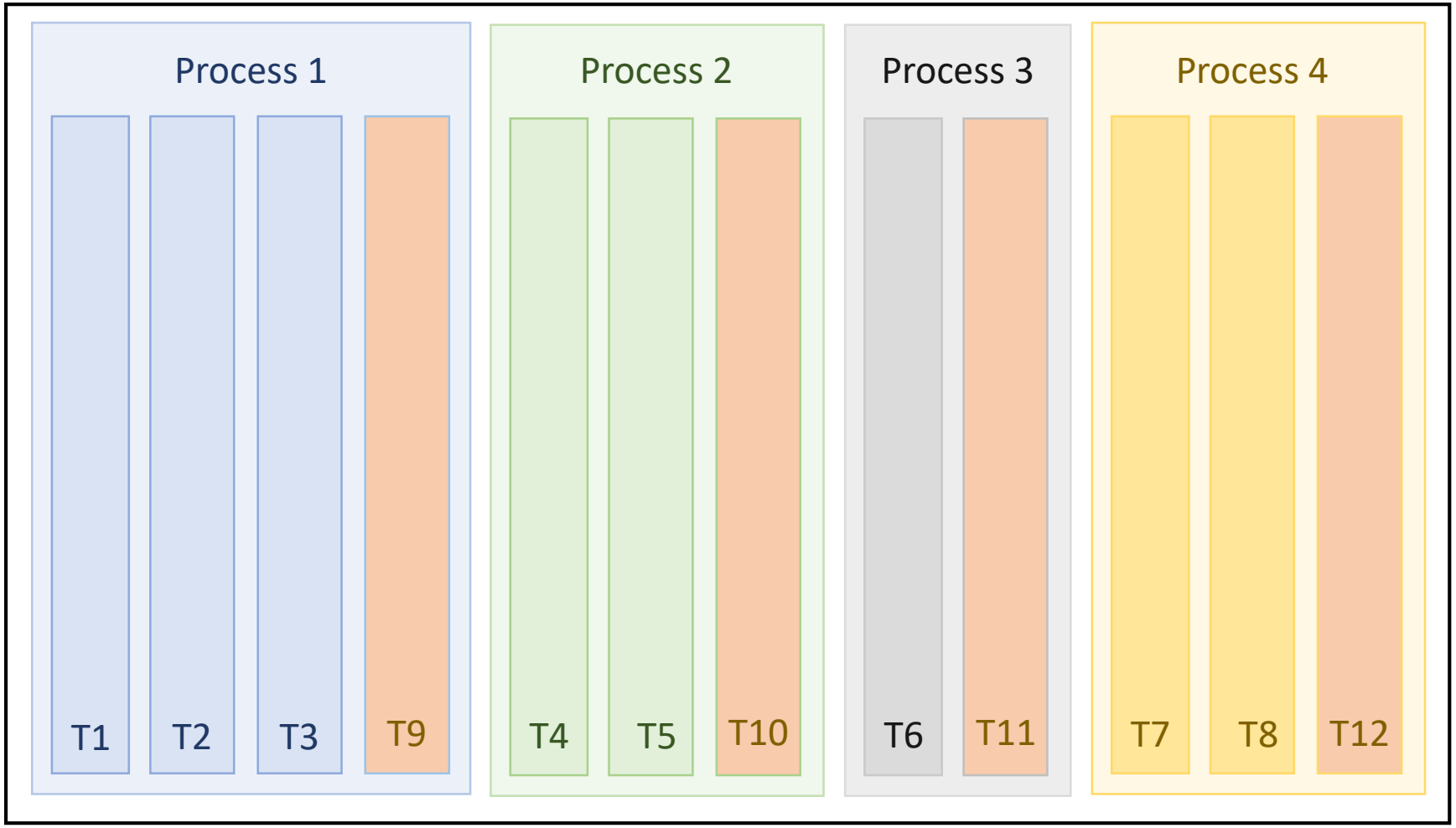
D-TIME - Summary

- Evades Detection by Distribution
- Performs Threadless execution
- Independent of Victim Process
- Completely Decentralized System
- High resilience

MalWASH – Phase 2

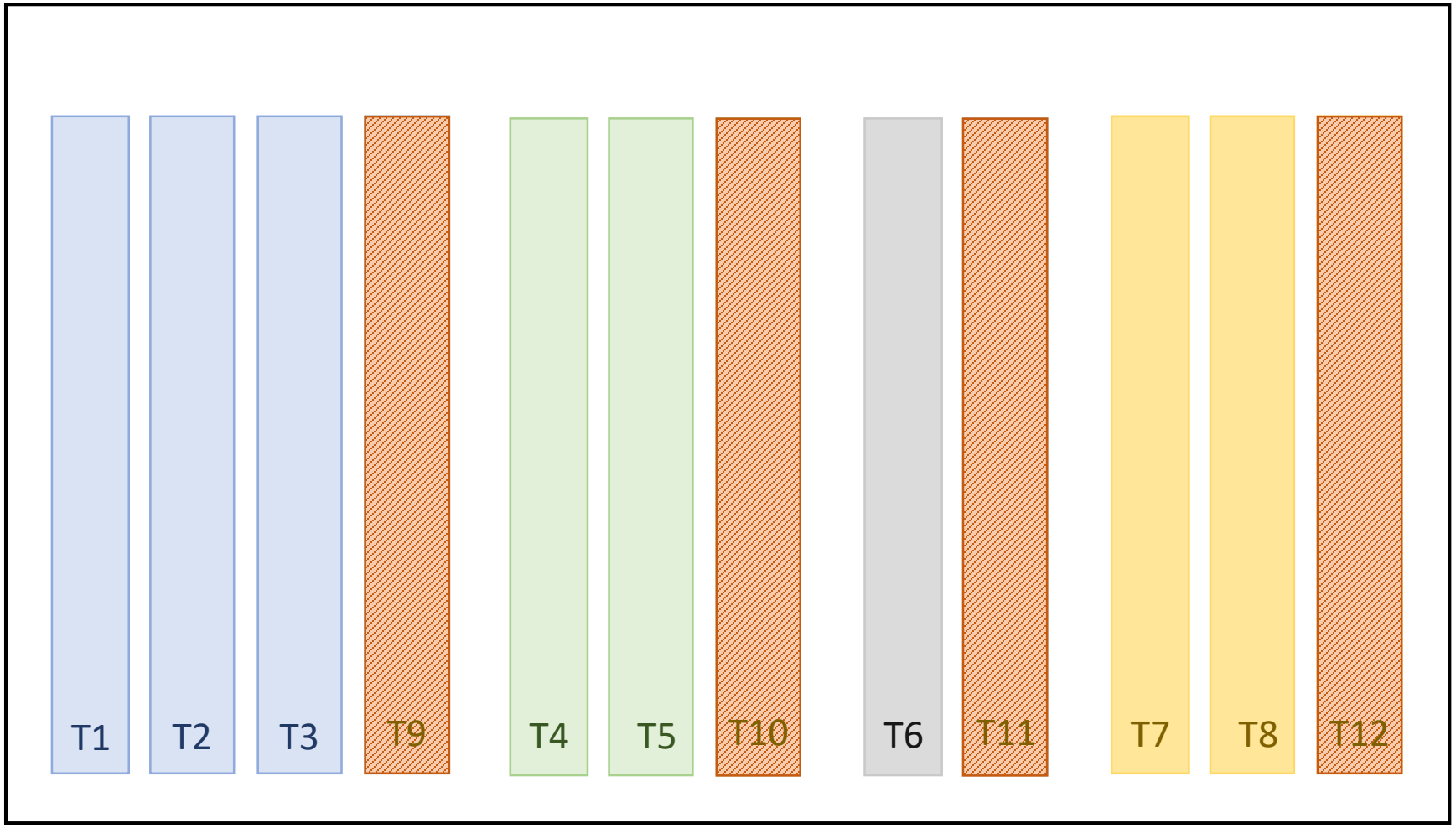


MalWASH – Phase 2



Creates threads in benign processes

MalWASH – Phase 2



Created threads are well exposed!

MalWASH vs D-TIME

	MalWASH	D-TIME
Needs to Create Threads	YES	NO
Has Dedicated Threads	YES	NO
Needs Administrative Privilege	YES	NO
Resilience	-	IMPROVED
Communication mechanism	-	IMPROVED

Evaluation & Results

Key-logger Offline

Key-logger Online

Backdoor

Ransomware

Screenshot malware

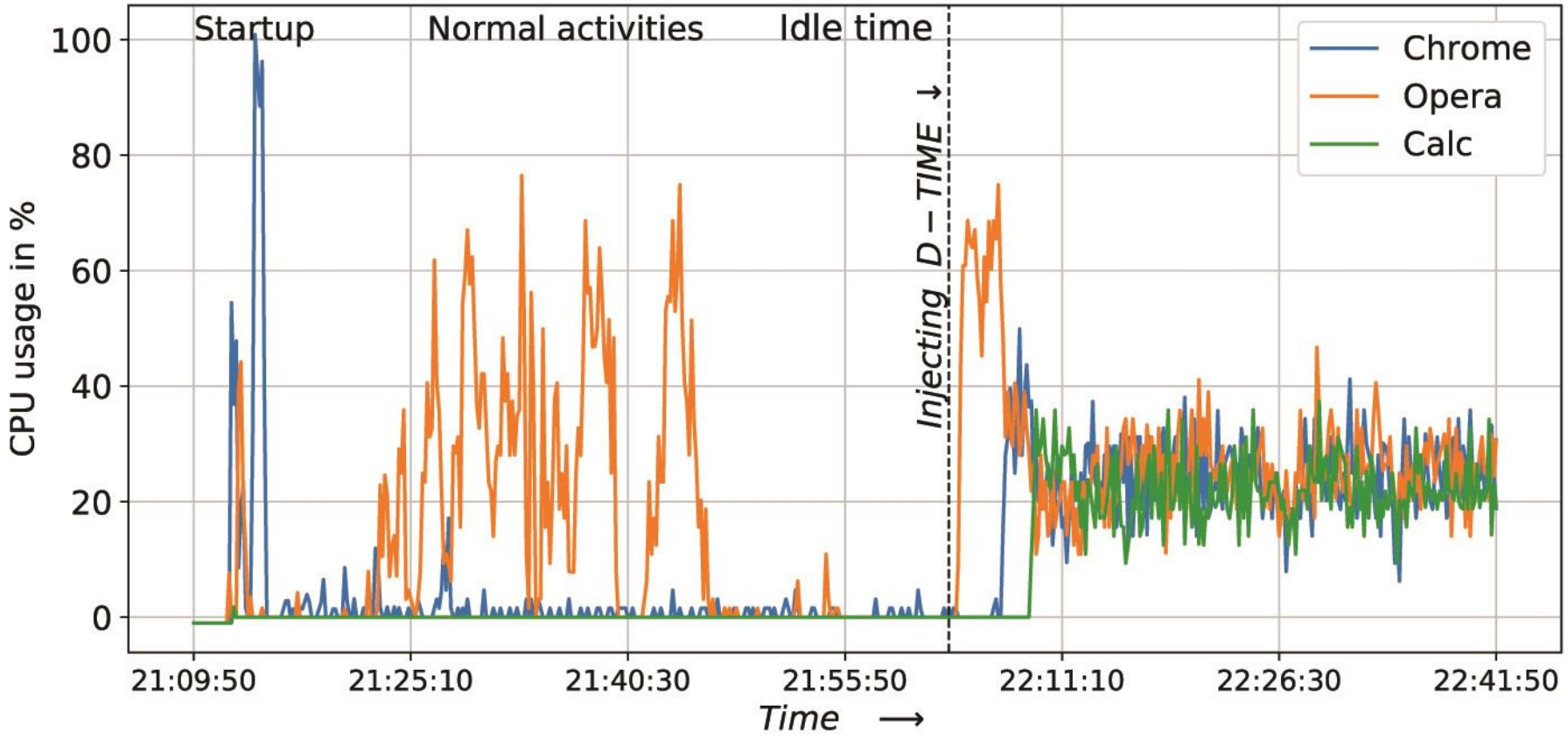
Window Monitor

Evaluation & Results

1. BitDefender
2. Norton
3. Kaspersky
4. WEBROOT
5. McAfee
6. ESET
7. Avast
8. AVG
9. Windows Defender
10. Avira

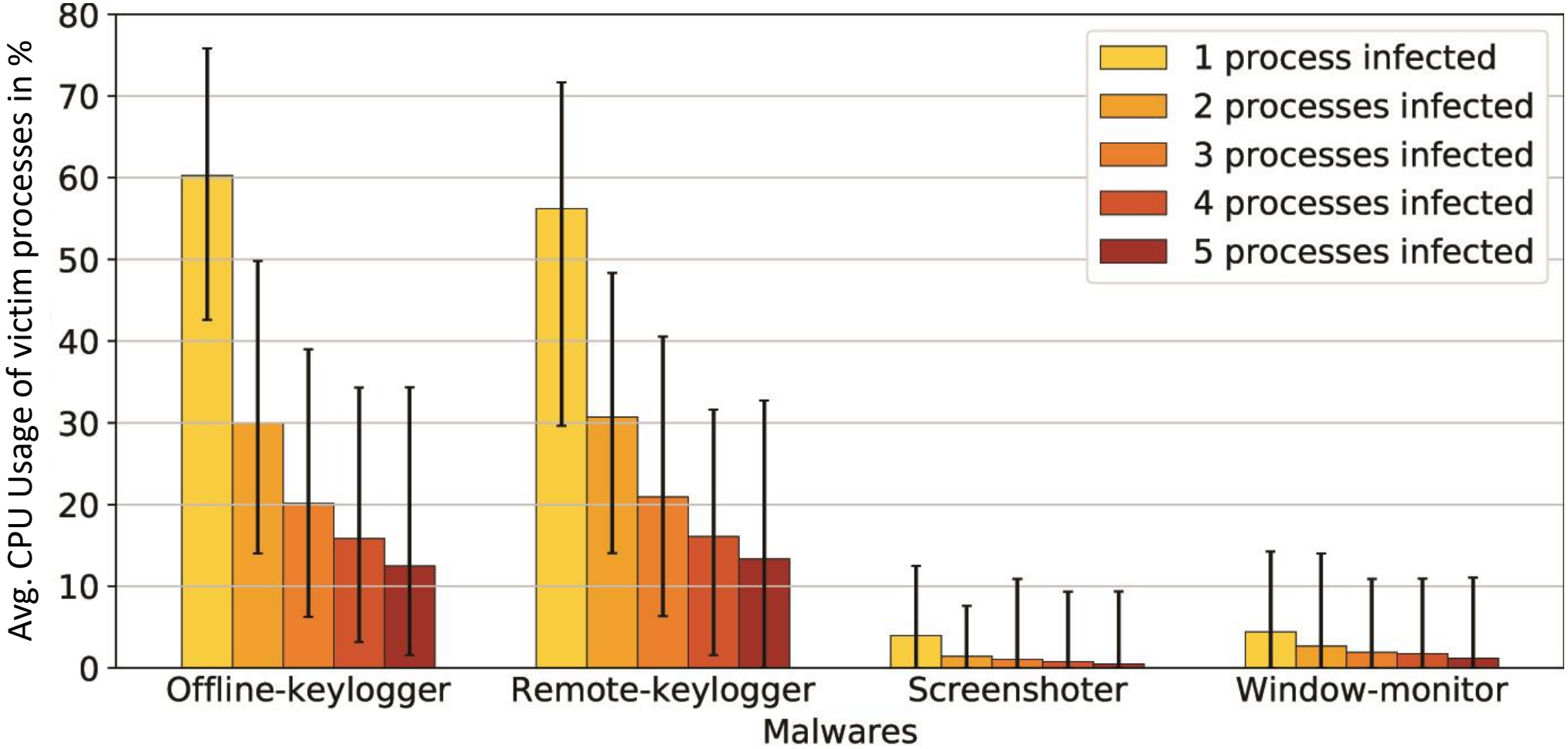
Evaluation & Results

CPU usage vs Time



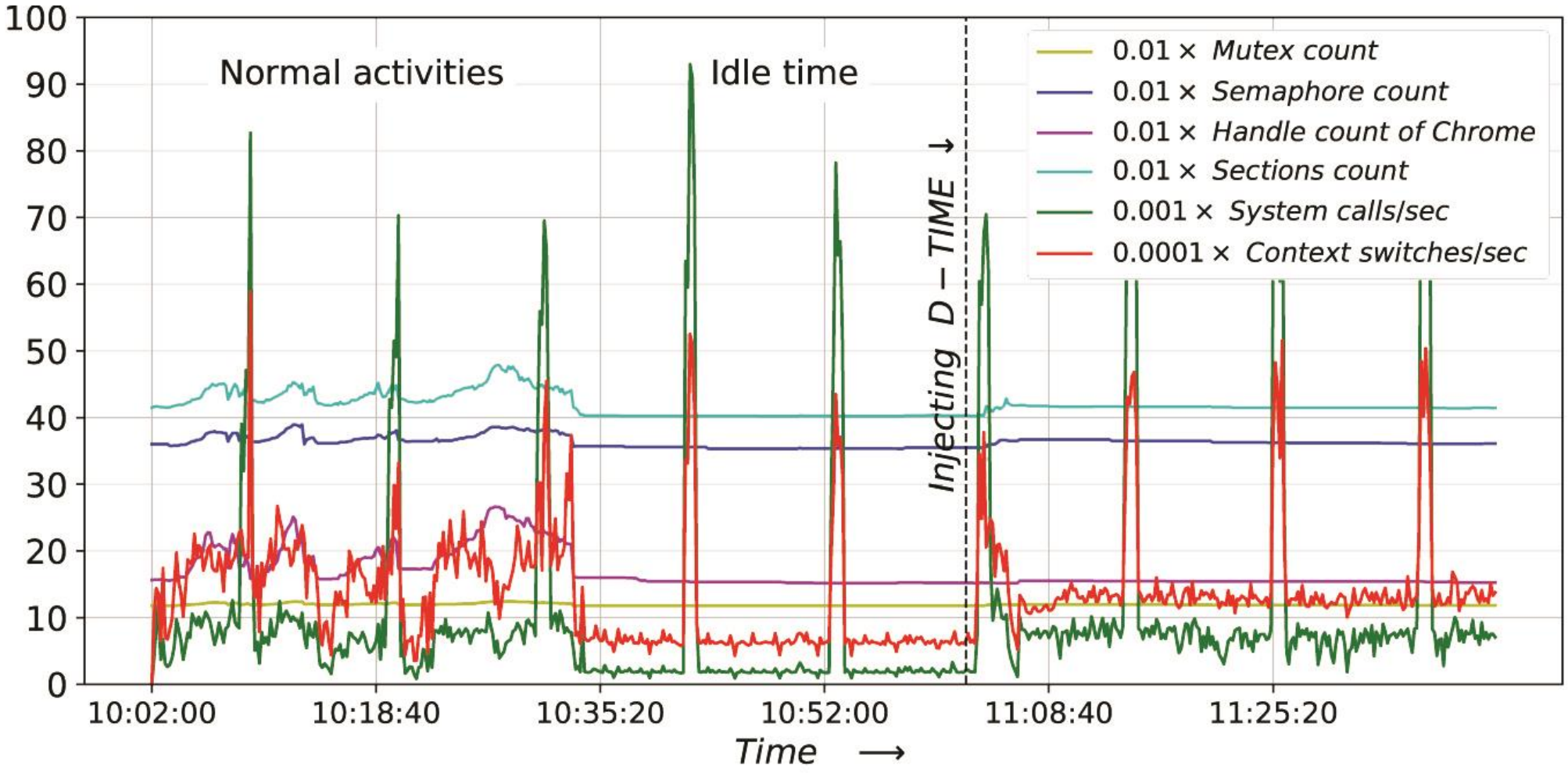
Evaluation & Results

CPU usage for different number of infected processes



Evaluation & Results

Performance Counters



Countermeasures

Prevention

- Redesign APC
- Create QPC (Queue Privilege Class)
- Limit Recursive Queuing
- Principle of minimum disclosure

Detection

- Detecting Comm. Channels
- Analyzing
  - CPU Usage
  - Context switches

Removal

- Removing all Emulators
- Destroying all Comm. Channels

Contributions

- D-TIME:
  Distributed, Decentralized, threadless malware execution framework
- SCBC (Semaphore based Covert Broadcasting Channel)
- Tested D-TIME using 6 Malware against 10 anti-virus
- Suggested counter measures

Artifact

Paper

Thank you