OpenIoT Summit Europe 2018

Compartmentalization in IoT

Trusted Firmware M Secure Partitioning

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Arm

Agenda

The right level of security

Hardware support

Compartmentalization scenarios

Interaction between isolated components

Challenges in IoT

High volume, low cost, low power

- Microcontrollers
  - Small die
  - No MMU (single, physical address space)
  - XIP Flash code
  - Small SRAM

Wide spectrum of use-cases

- Different threat models
- Scalable solutions

Holistic approach to IoT security needed

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Establishing the “right” level of security

Secure domain

Basic isolation – create a Secure Processing Environment

Protected TCB

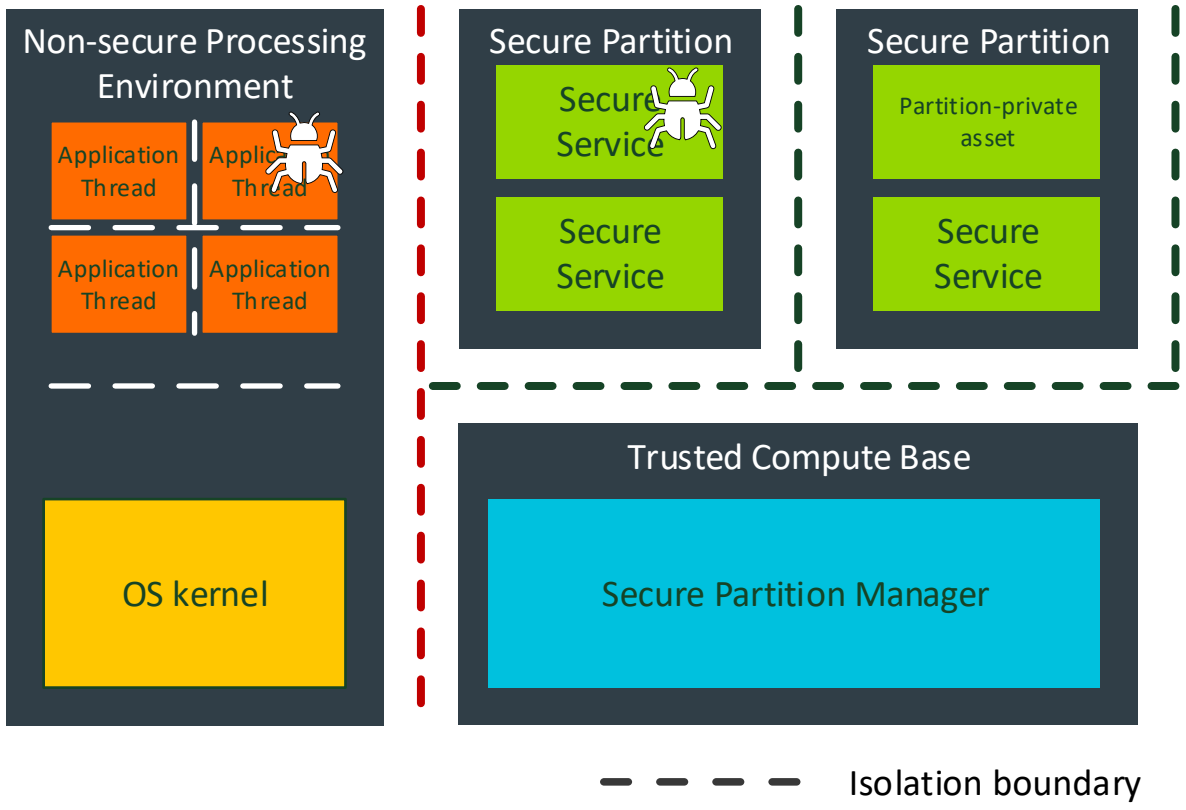
Separate Root of Trust from Secure Partitions within SPE

Multiple tenancy in secure PE

More robustness – isolate all partitions from each other

Non-Secure isolation

Access policies for NS threads



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Hardware isolation

… the foundation for software security

Physical isolation (e.g. dual-core system):

Dedicate cores/resources

Shared memory system or Mailbox

Concurrent execution

Temporal isolation (e.g. Arm-v8M):

Privilege control – using MPU

Secure/Non-secure states (Secure Attribution)

Shared Processing Element, resources

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Interaction scenarios

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Execution flows

Crossing boundaries in single processing element

Crossing from Non-secure to secure state

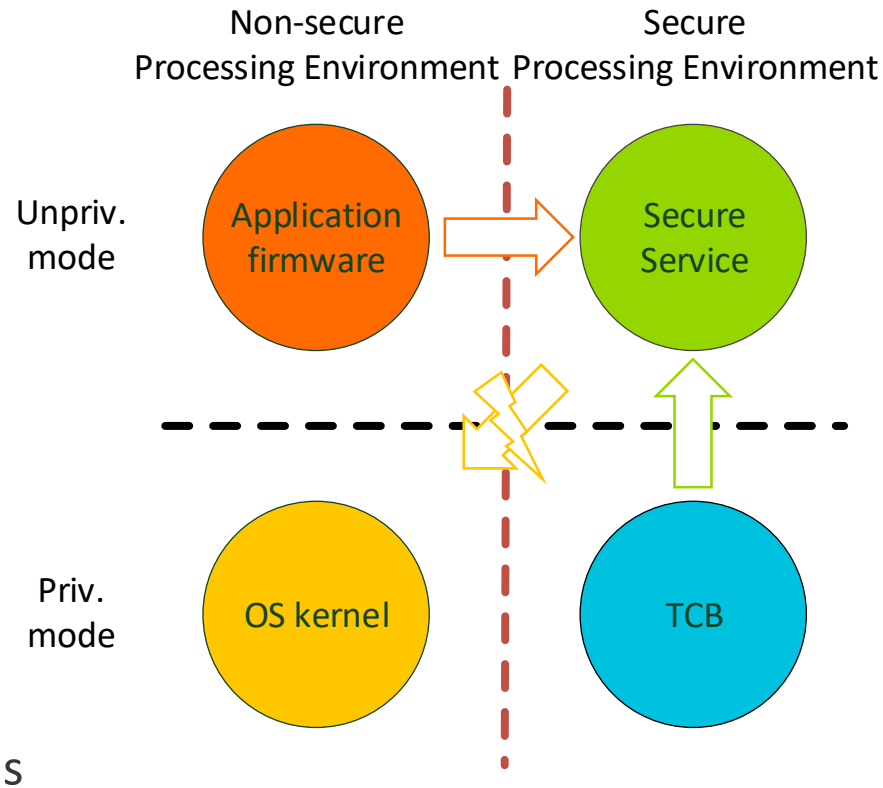
- Non-secure thread requests secure service

Isolated driver code

- ISR execution in unprivileged partition

Asynchronous events in non-secure PE

- Non-secure interrupt pre-empts secure operation
- Non-secure context awareness
- Concurrent secure service requests from non-secure threads



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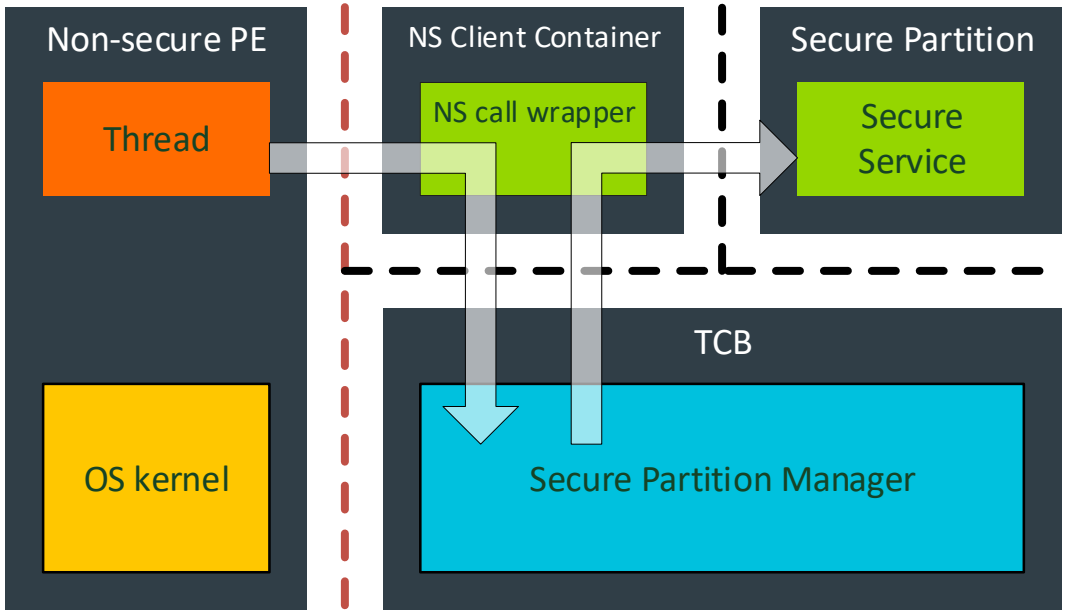
Non-secure call to secure service

Security state change only permitted using dedicated entry points

Wrapper function triggers privileged management code

Secure Partition Management code

- Performs parameter sanitization
- Sets up Secure Partition (container)



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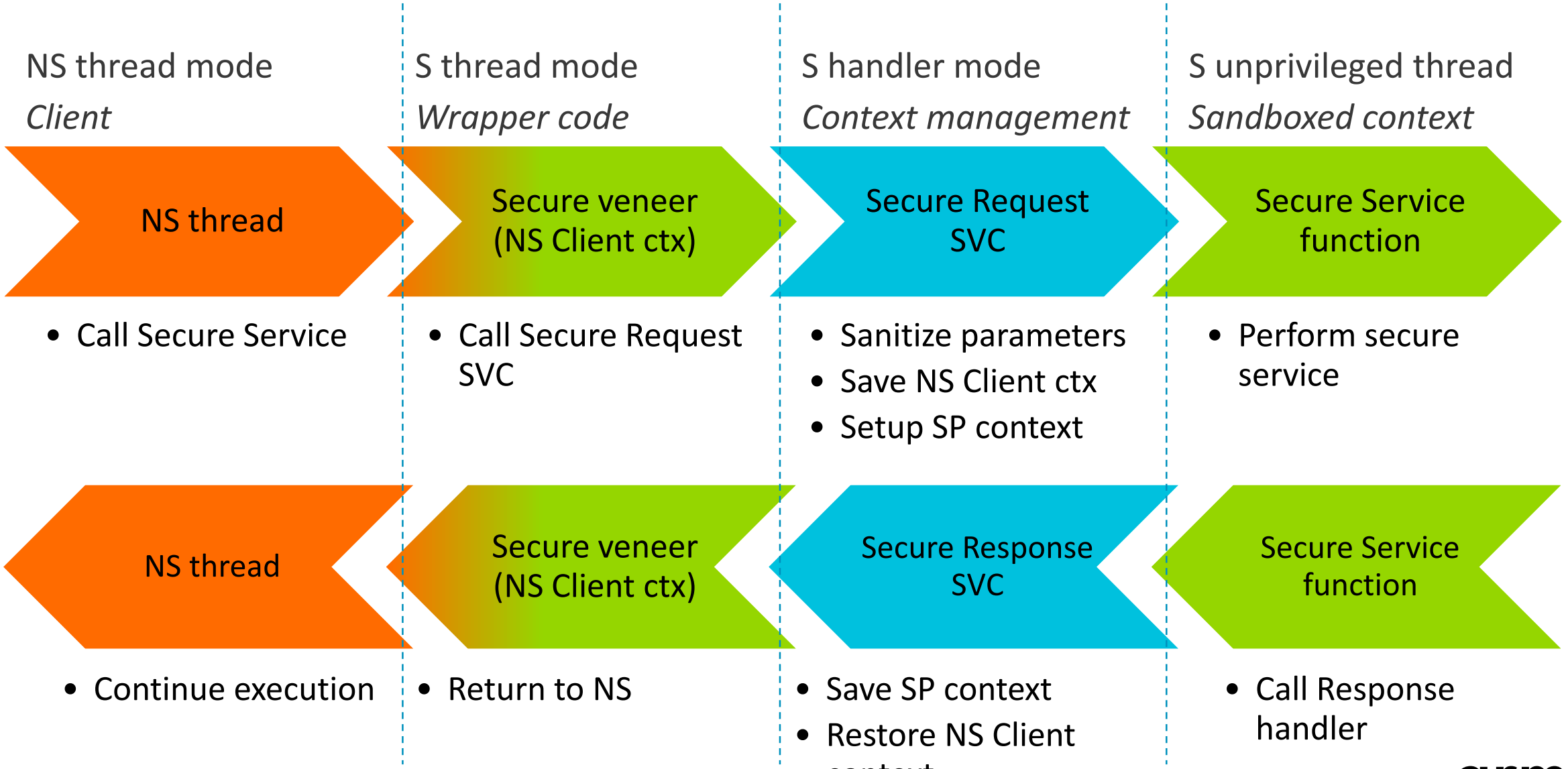
Non-secure call to secure service



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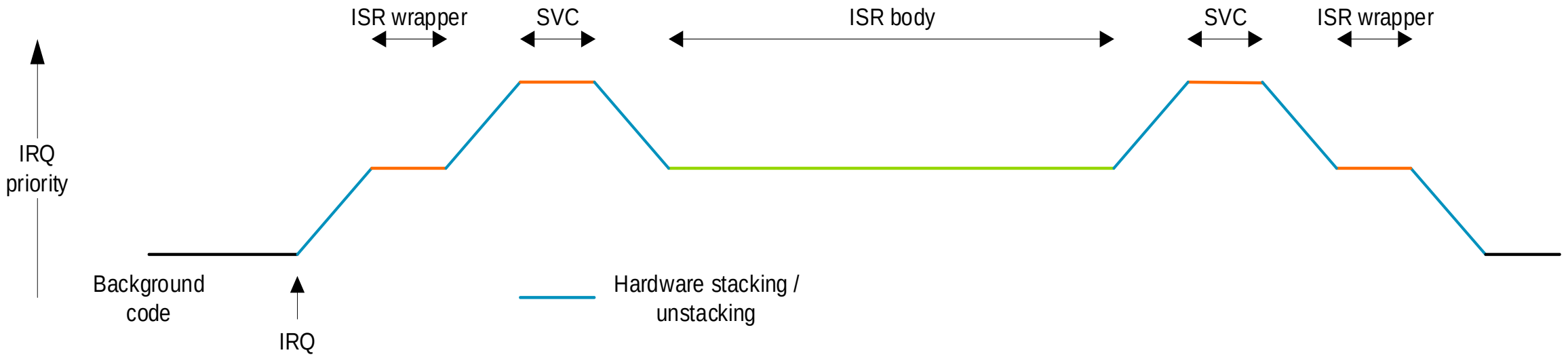
Secure interrupt deprivileging

- Privileged ISR is wrapper
  - Triggers Partition Manager
- Sandbox created
  - Returns to thread mode
- Secure Partition code
  - Executes deprivileged ISR



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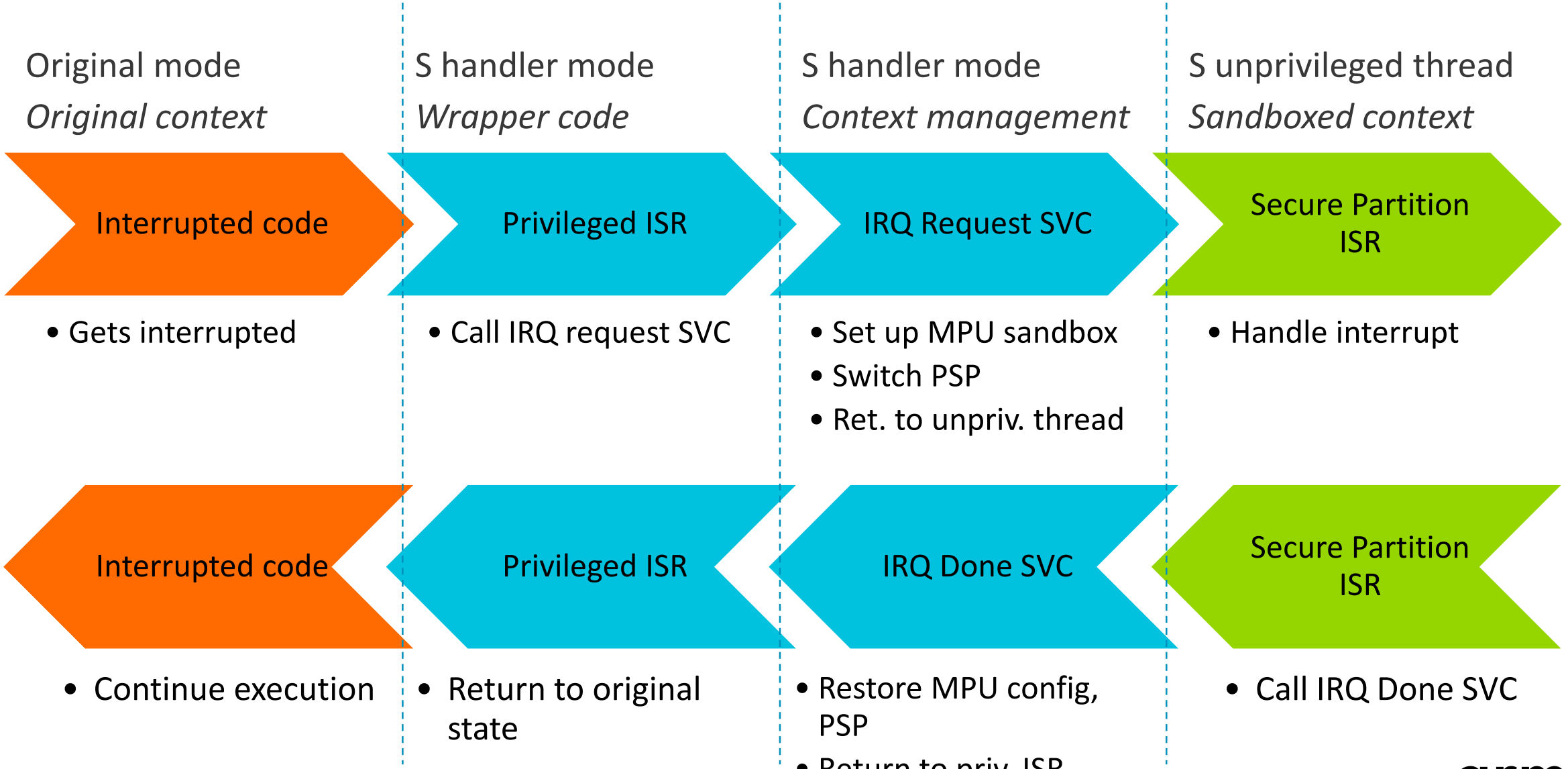
Secure interrupt deprivileging



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Non-Secure interrupts

Pre-emption of secure execution

Non-secure thread is executing

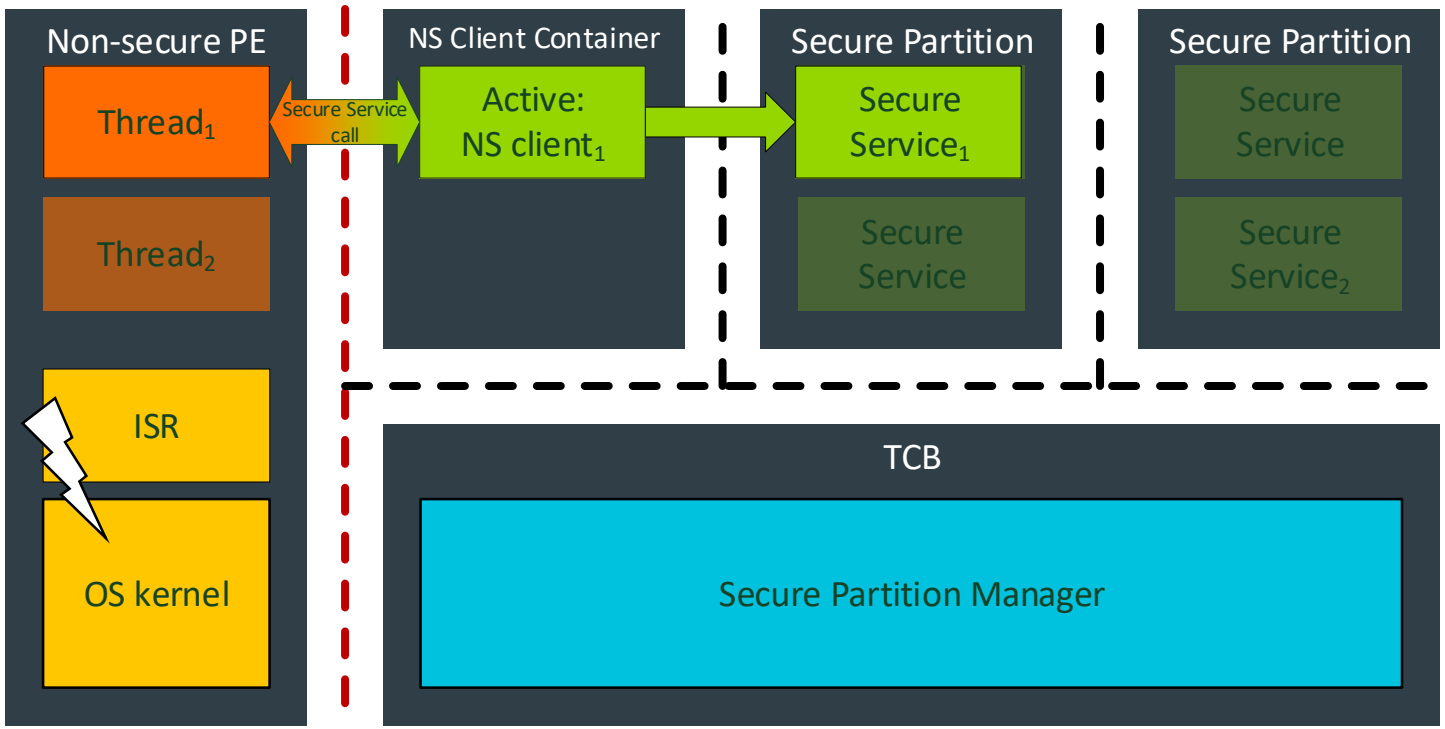
Thread calls Secure Service

Non-secure IRQ pre-empts operation

Secure context is stacked

Non-secure ISR is executed

Return from ISR resumes secure execution



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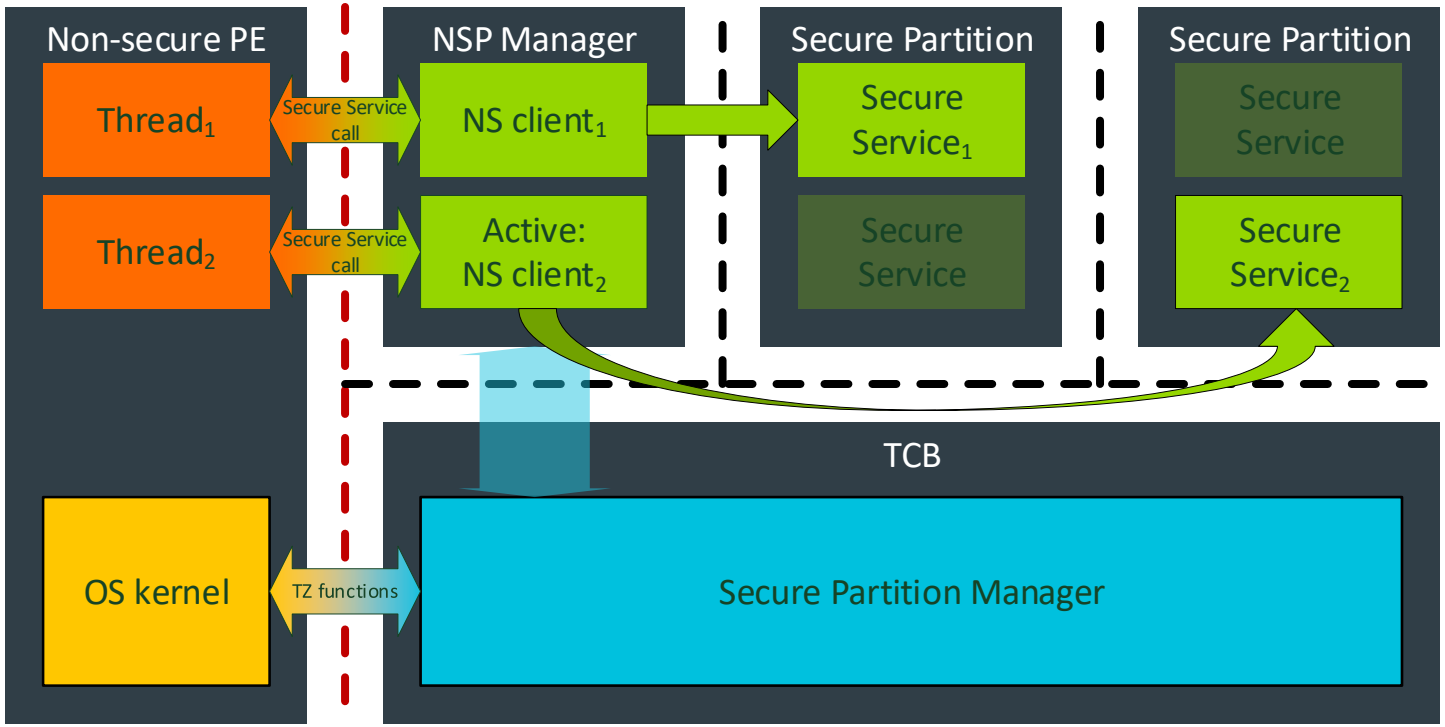
Context Management Functions

Non-secure context awareness in Arm-v8M

1. **Non-secure threads created**
2. **Thread$_1$ calls Secure Service$_1$**
3. **Non-secure IRQ pre-empts operation -> context change**
4. **Thread$_2$ calls secure service$_2$**
5. **Secure service$_2$ returns**
6. **Thread$_2$ yields**
7. **Secure Service$_1$ returns**

NS RTOS provides notification to SPM about context creation, deletion, load or store operation, enabling NS context-dependent access to secure assets/services.



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Implementations

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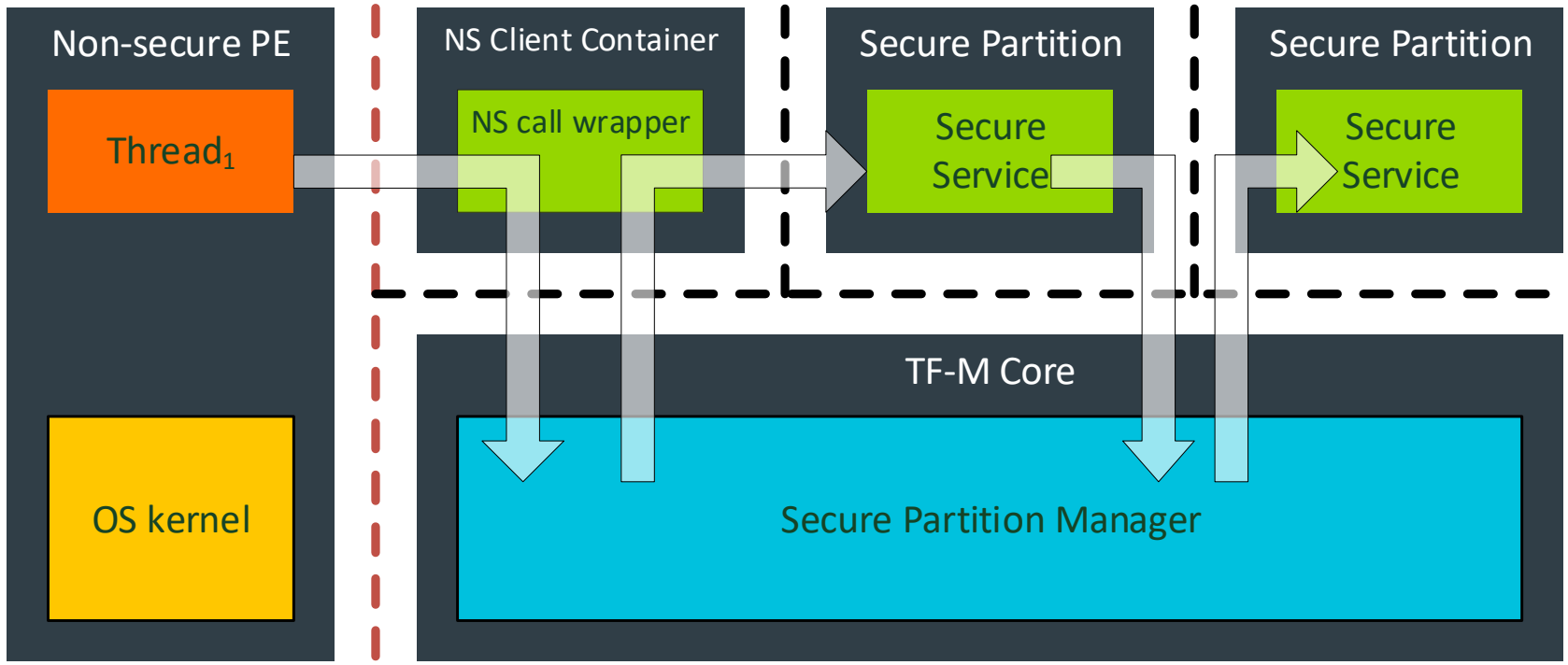
Trusted Firmware M library model

Secure Services implemented as functions

- Arm-v8M architecture support
- Secure Partition is a library of secure services
- Synchronous execution of secure services
- Programming model closely follows embedded/MCU concepts
- Low footprint – on demand allocation of resources



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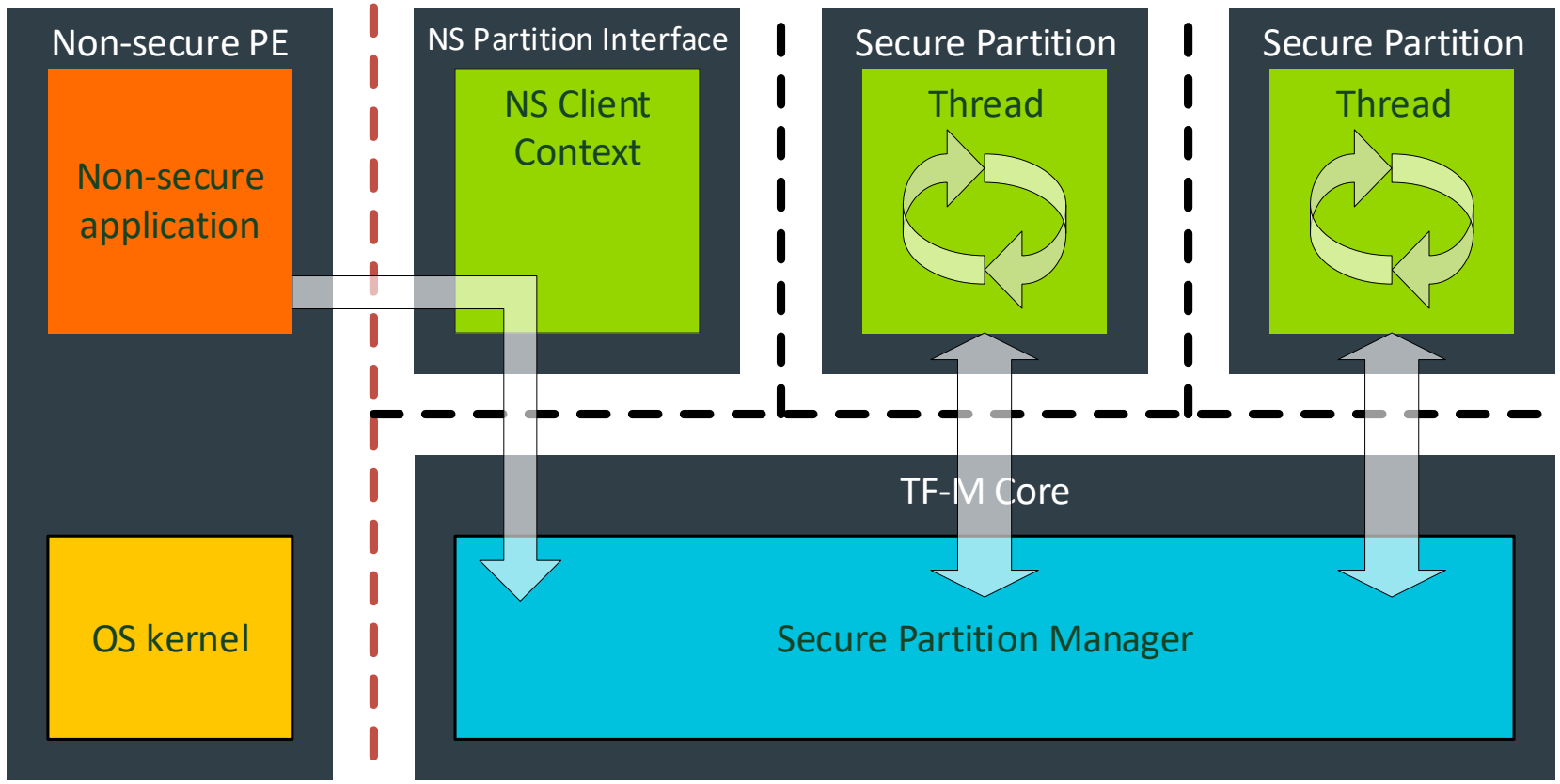
Trusted Firmware M thread model

Secure Partitions implemented as threads

- Connection/message based interaction
- Robust, more prescriptive framework
- Static allocation of secure resources
- Asynchronous processing of service requests
- Less architecture dependent -> well suited for physical separation



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Interaction with secure threads

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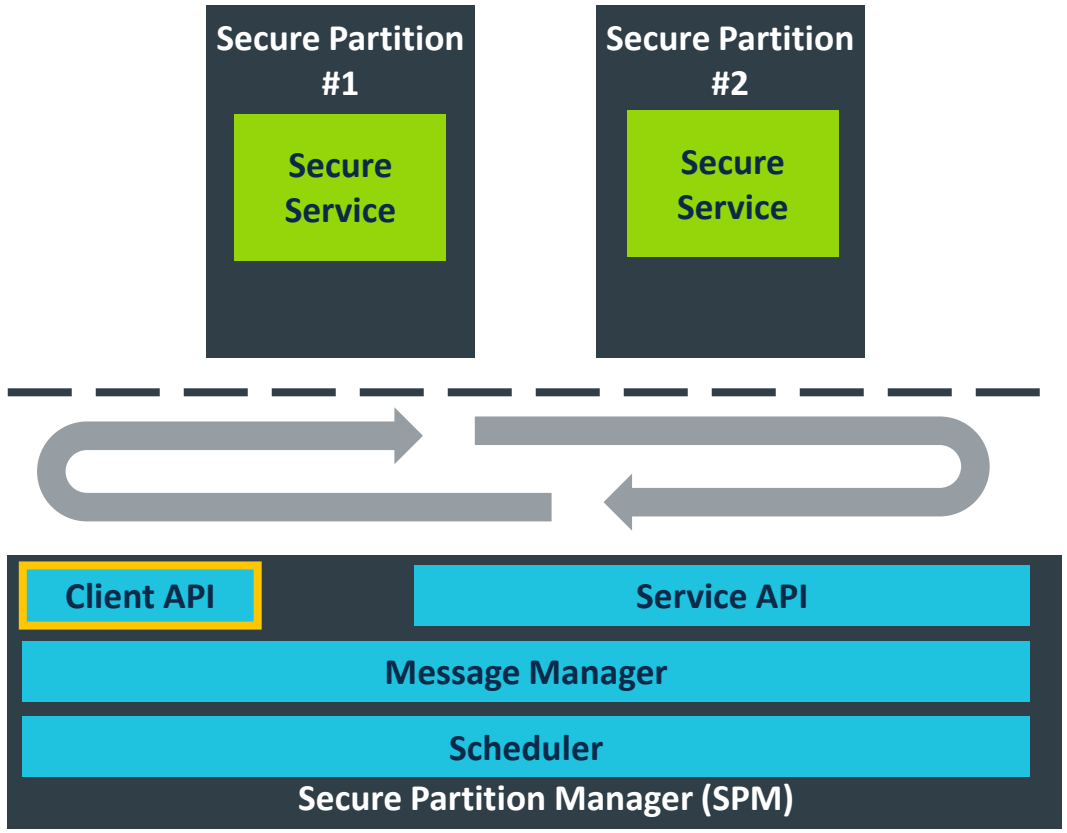
TF-M Inter-Process Communication (IPC)

- **For TF-M Thread model**
- **Secure Partitions provide secure services**
  - NSPE is reflected as one Non-Secure Partition
- **One thread in one Secure Partition**
- **While loop in thread waiting for messages**
- **Client call sent as messages**
  - Non-Secure Partition is a client
  - Secure Partition could be a client
- **Service Interrupt is handled asynchronously**



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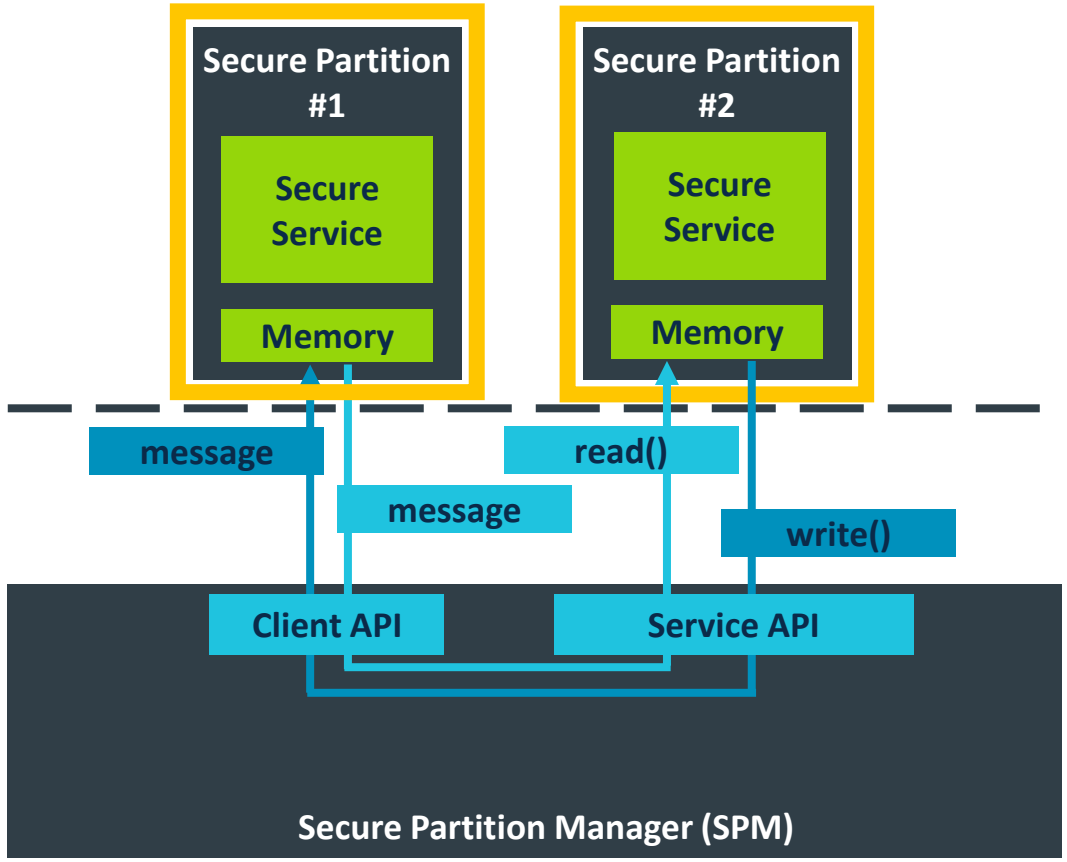
Security Consideration on Compartmentalization

- No shared memory
- Streamed read/write APIs for copying memory
- Memory integrity checking based on isolation level
- Peripheral usage is also isolated
- Runtime protection rule change to isolate



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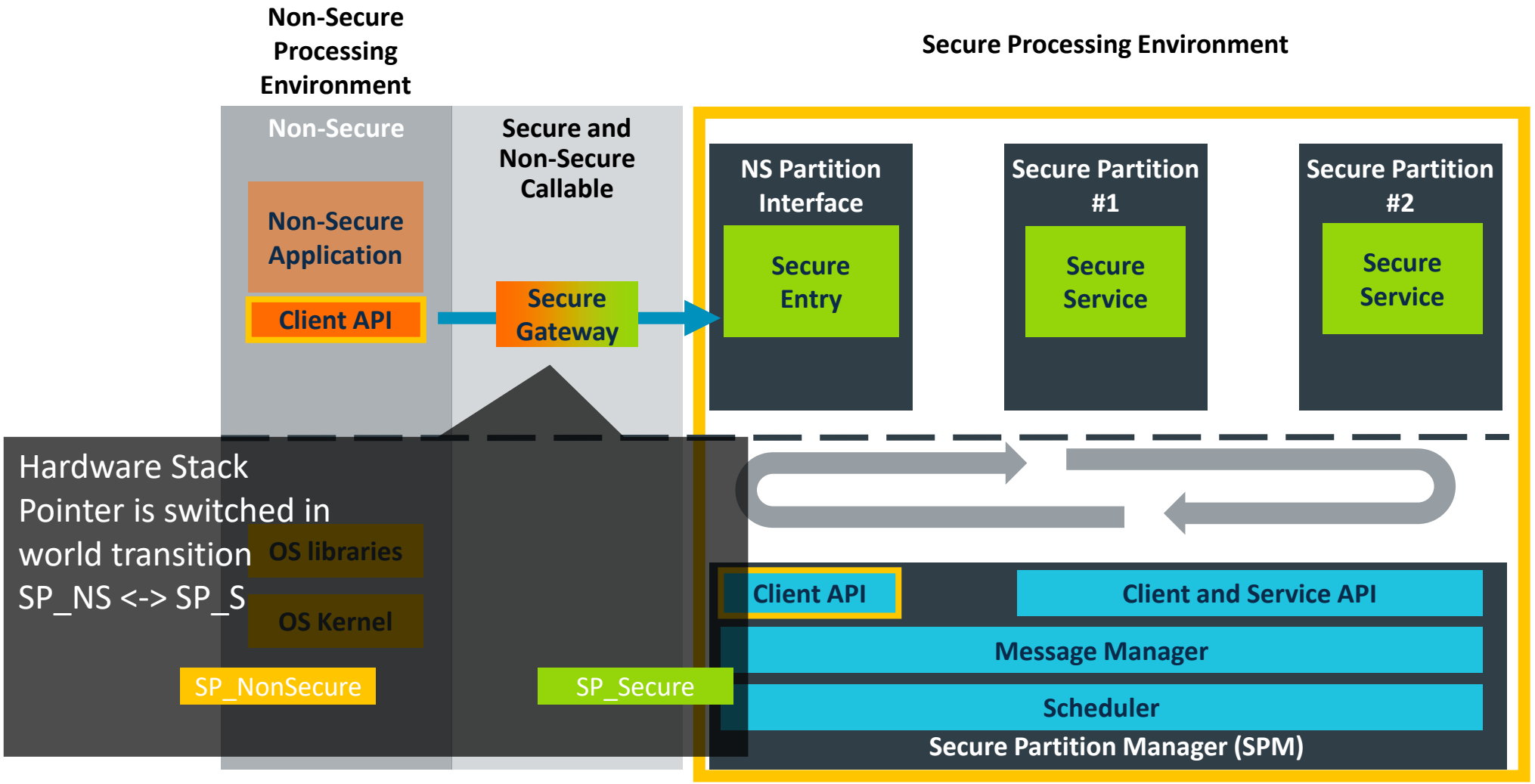
Expand NSP with Arm-v8M TrustZone



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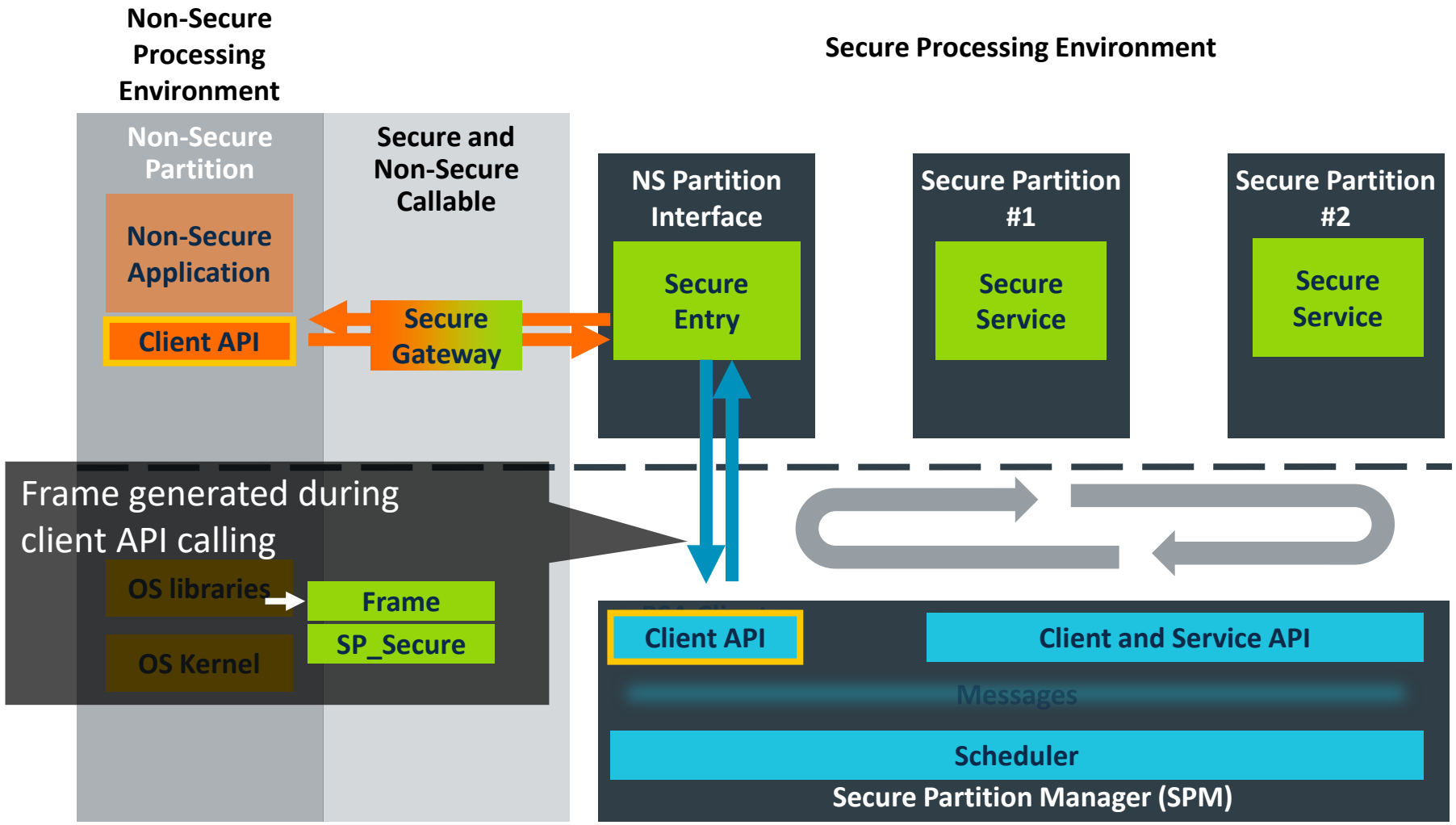
Single NS Thread requests Secure Service



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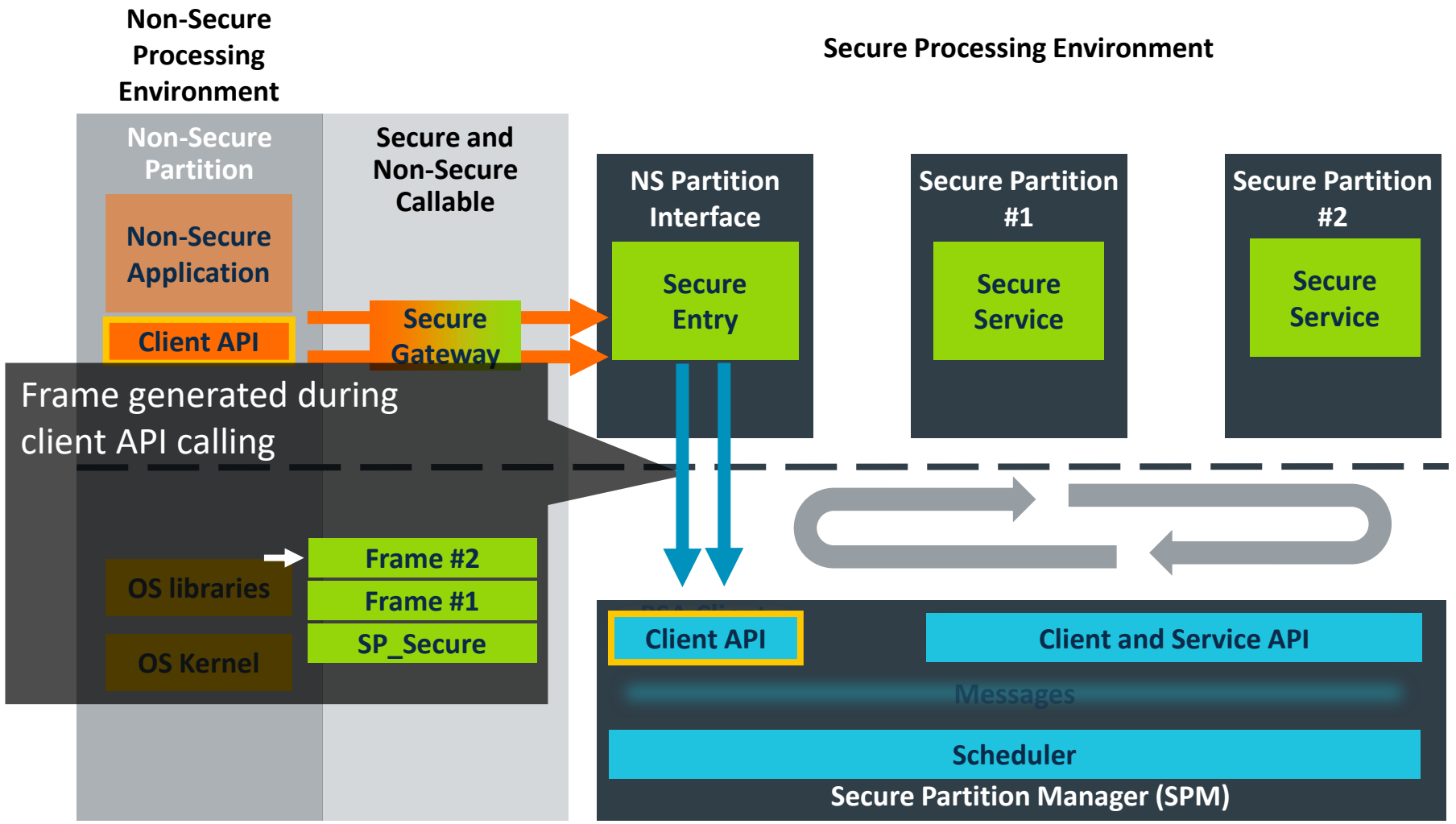
Multiple NS Thread request Secure Service



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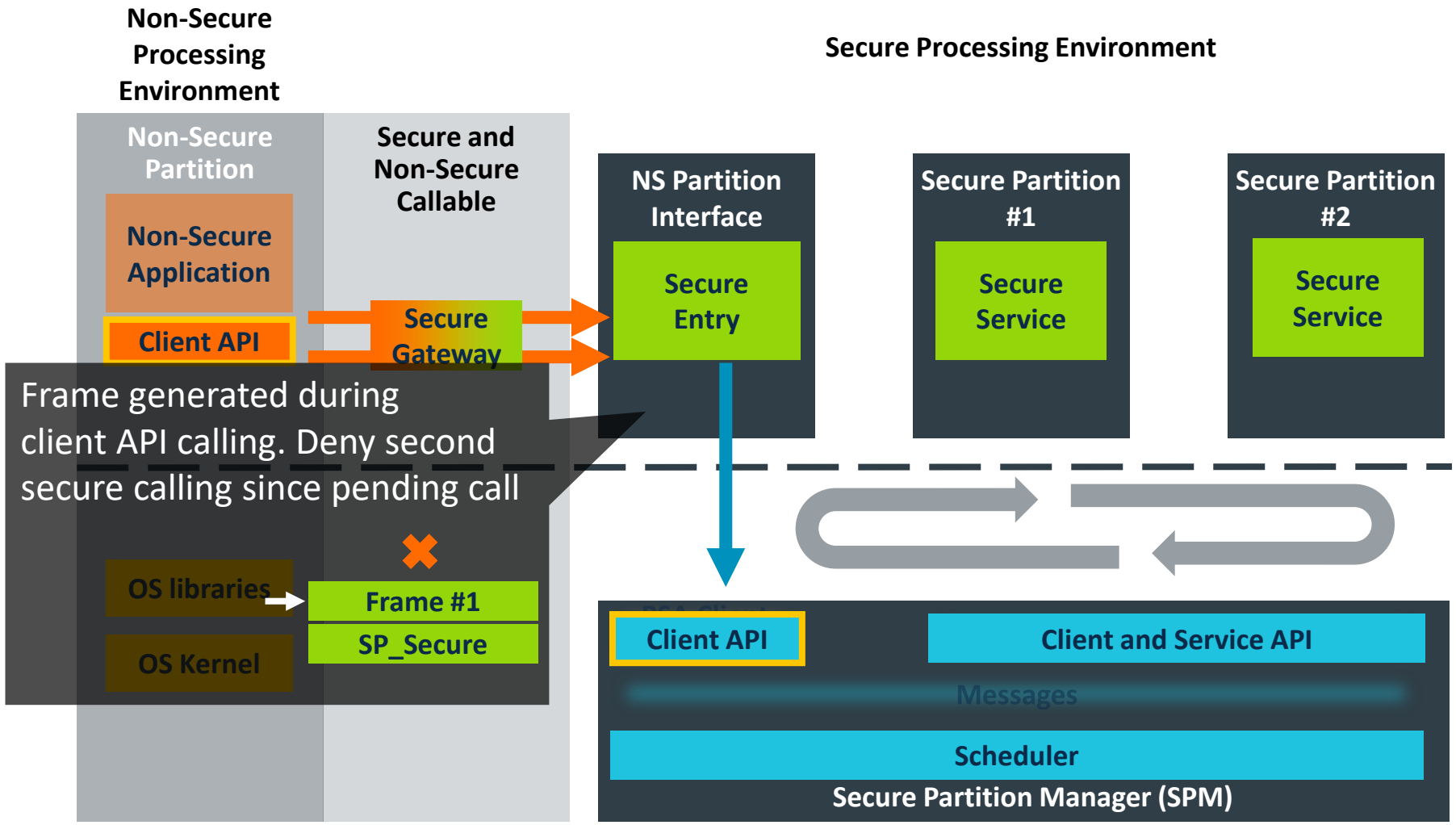
Multi-Thread NSPE Secure Call Solution 1



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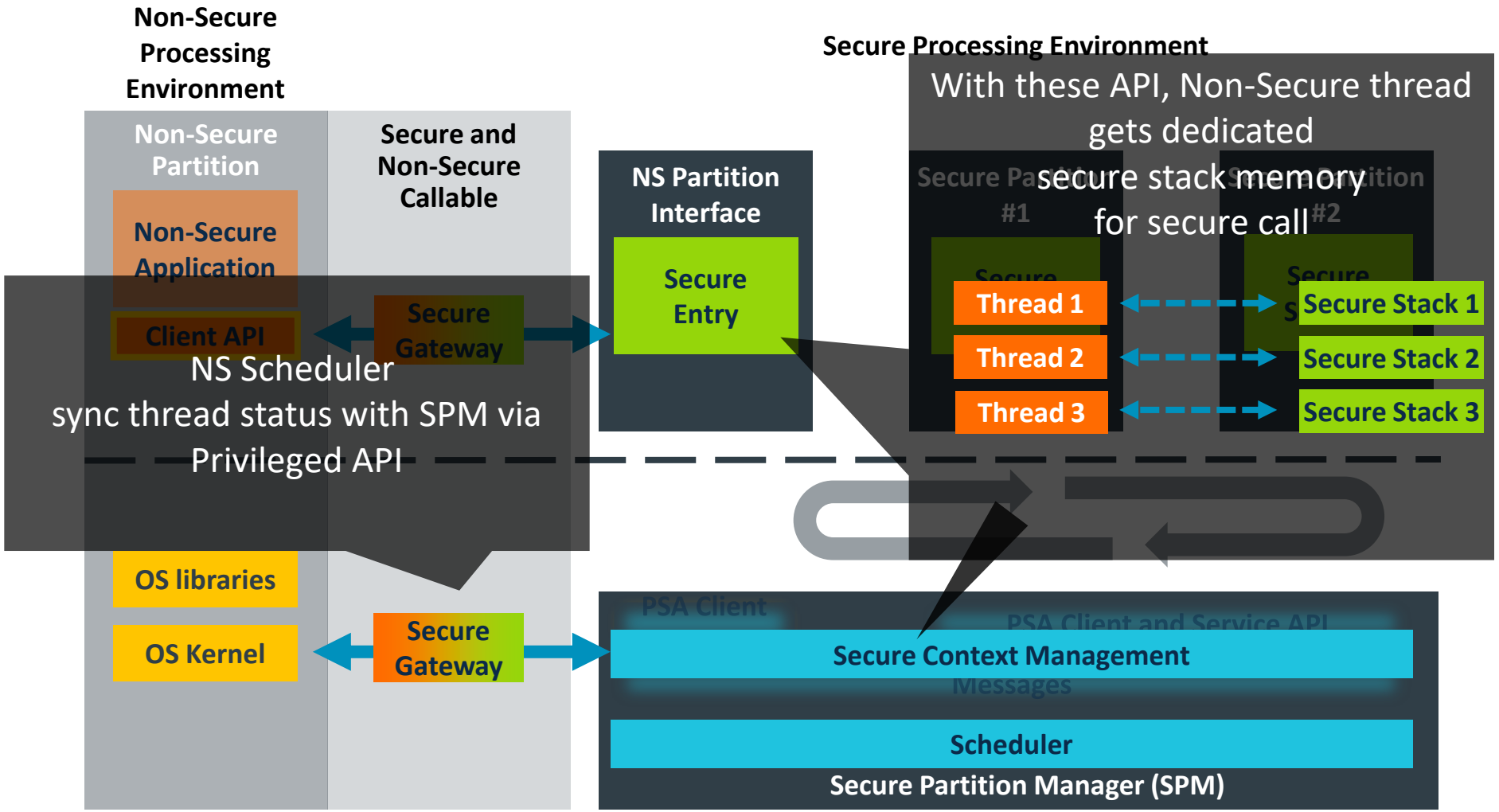
Multi-Thread NSPE Secure Call Solution 2



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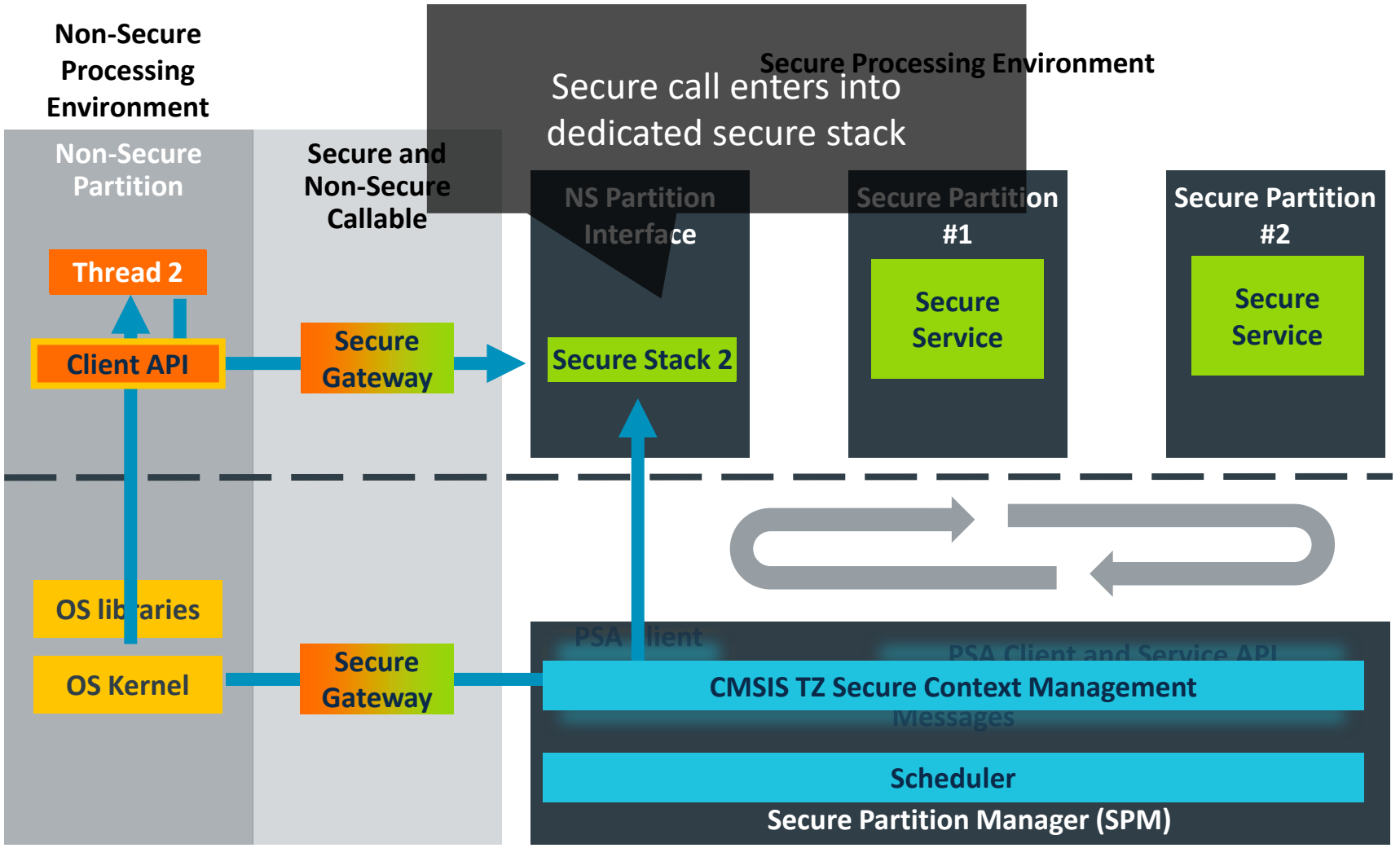
Solution 2 Calling Process



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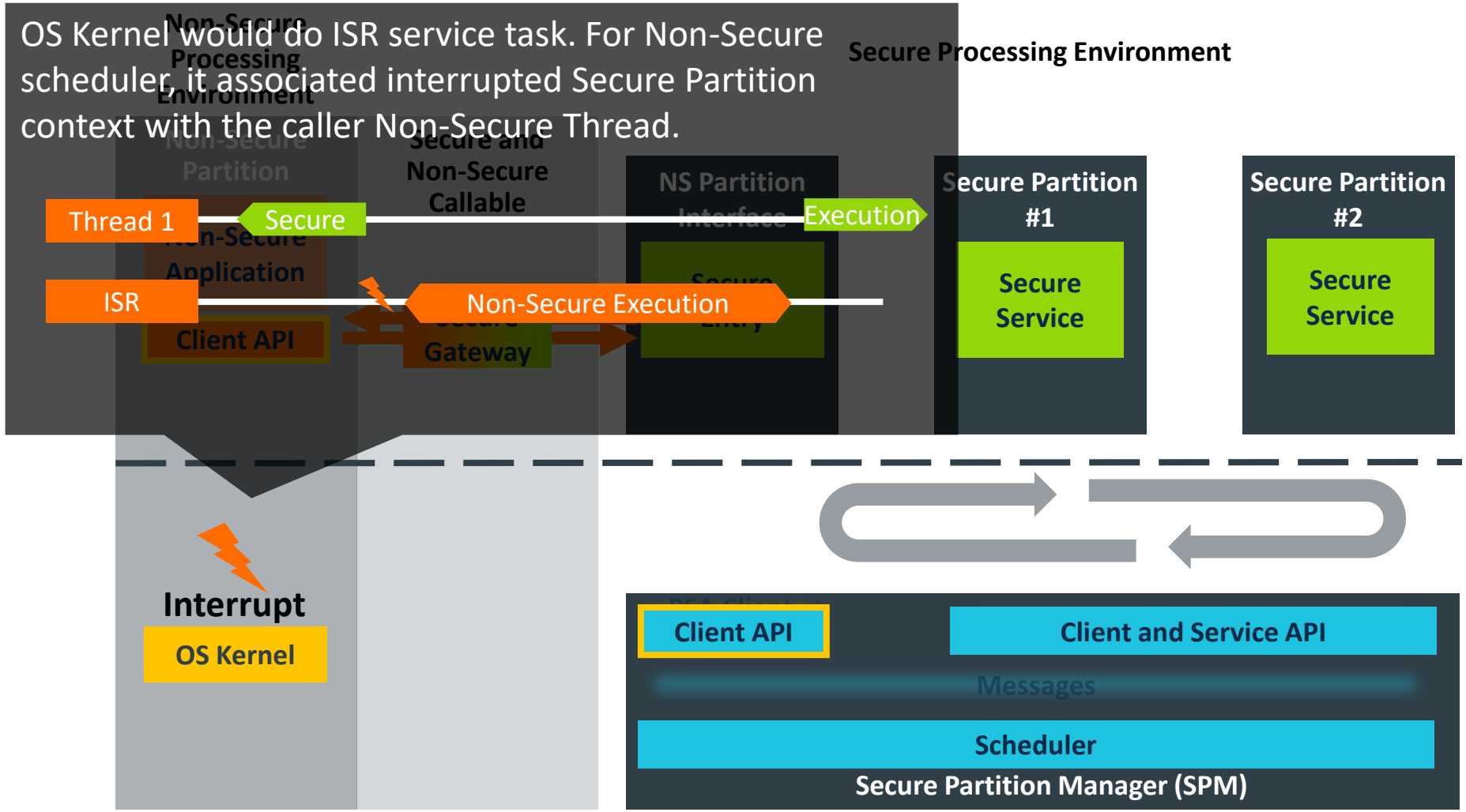
Non-Secure Interrupt Preempts Secure Service



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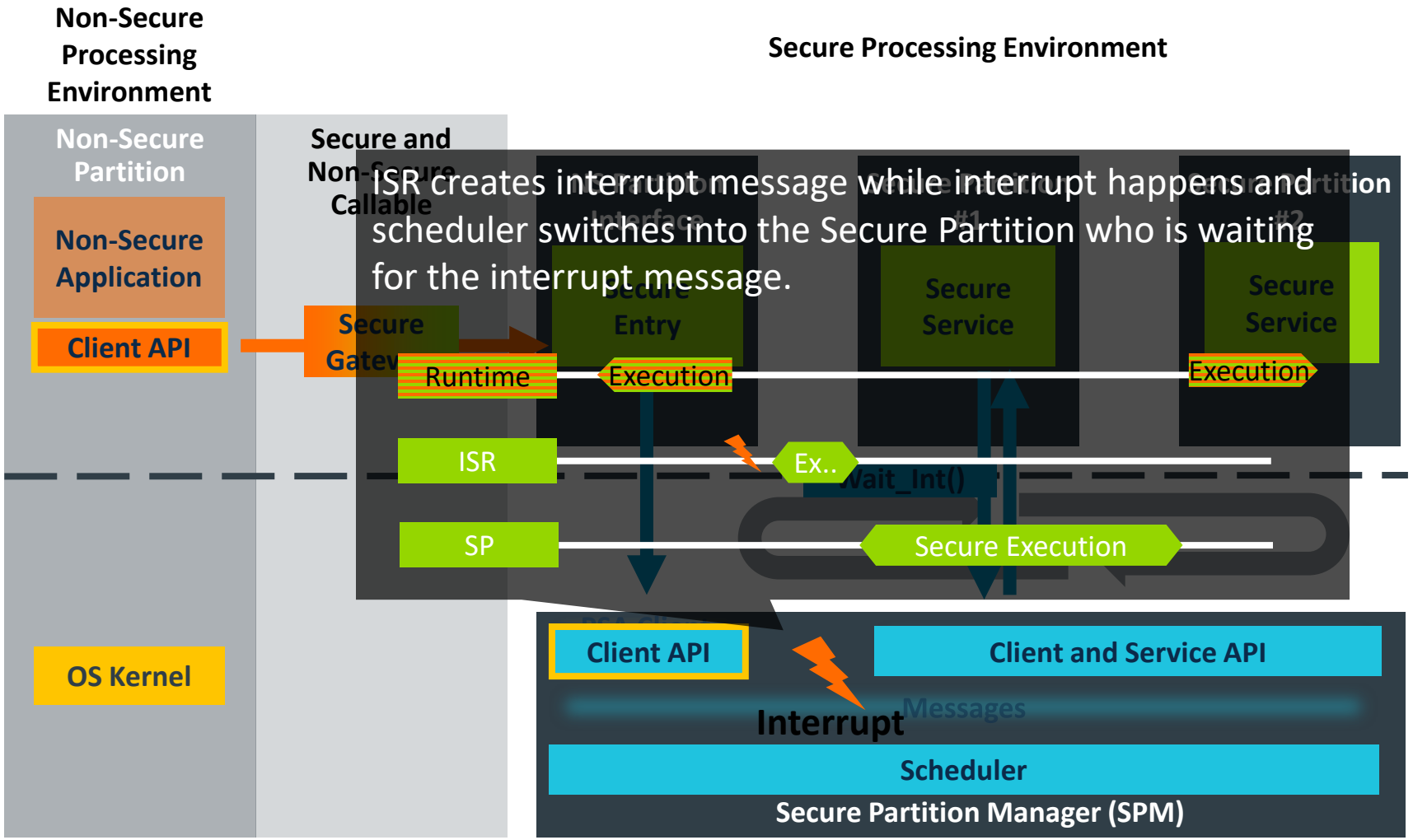
Secure Interrupt Preempts Execution



ISR creates interrupt message while interrupt happens and scheduler switches into the Secure Partition who is waiting for the interrupt message.

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Summary

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Compartmentalization in IoT – No one-size-fits-all

Secure/non-secure isolation:
- physical
- temporal

Privilege control:
- none
- within secure domain
- within non-secure domain

Interaction:
- function calls
- IPC
- hardware mailbox

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How to get involved

TF-M is part of the Open Source/Open Governance trustedfirmware.org project

- Code base: https://git.trustedfirmware.org/

TF-M Team @ OpenIoT Summit Europe 2018

- Shebu Kuriakose
- Ashutosh Singh
- Ken Liu
- Miklos Balint

Get in touch

- Come round to the Arm booth during the summit
- Contact TF-M team at support-trustedfirmware@arm.com

More info on developer.arm.com and trustedfirmware.org

Thank You!
Danke!
Merci!
谢谢!
ありがとう!
Gracias!
Kiitos!
감사합니다
धन्यवाद