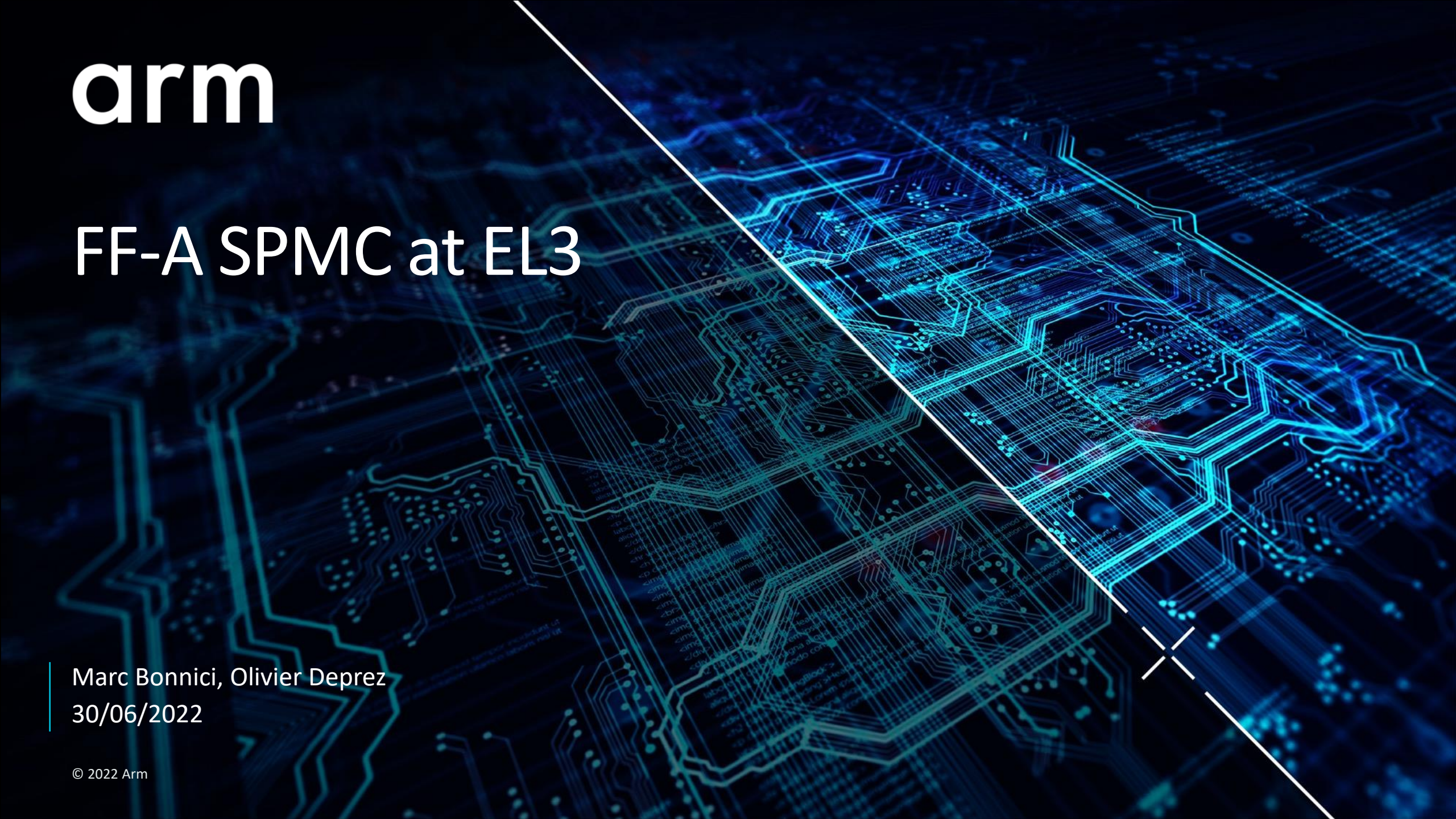


FF-A SPMC at EL3

Marc Bonnici, Olivier Deprez

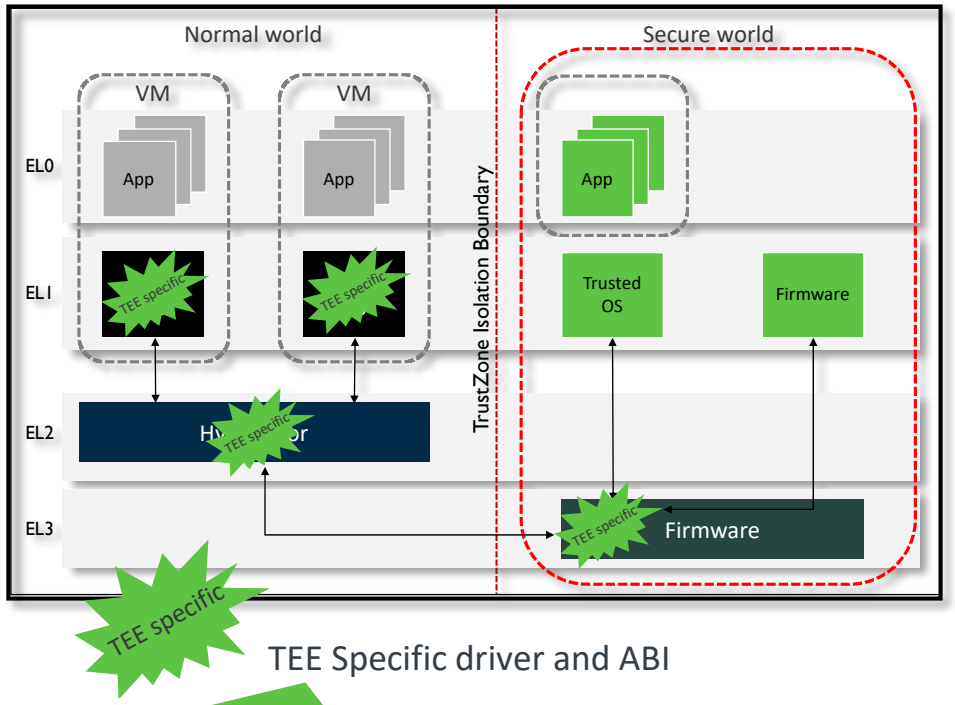
30/06/2022

Introduction

- The FF-A (Arm Firmware Framework for Arm A-profile) specification [1] provides a standardised interface between two sandboxes (VMs, SPs etc.)
- Key focus areas:
  - Discovery
  - Communication
  - Memory Management

- [1] https://developer.arm.com/documentation/den0077/latest

Why Do We Need FF-A?



- TEE driver and ABI in OS
- TEE driver and ABI in Hypervisor
- TEE driver and ABI in EL3 firmware

Pain Points

- Fragmentation and multiple implementations across components
- Duplicated Code

Need for Standardization

- Provide a standard interface to partitions for common tasks
- Single implementation of the programming model across components
- Reduced integration cost
- Support for configurations both with and without S-EL2
  - Provides a migration path for pre 8.4 platforms
  - Changes to secure world configuration can be transparent to the normal world
- Improved portability for a TEE SP

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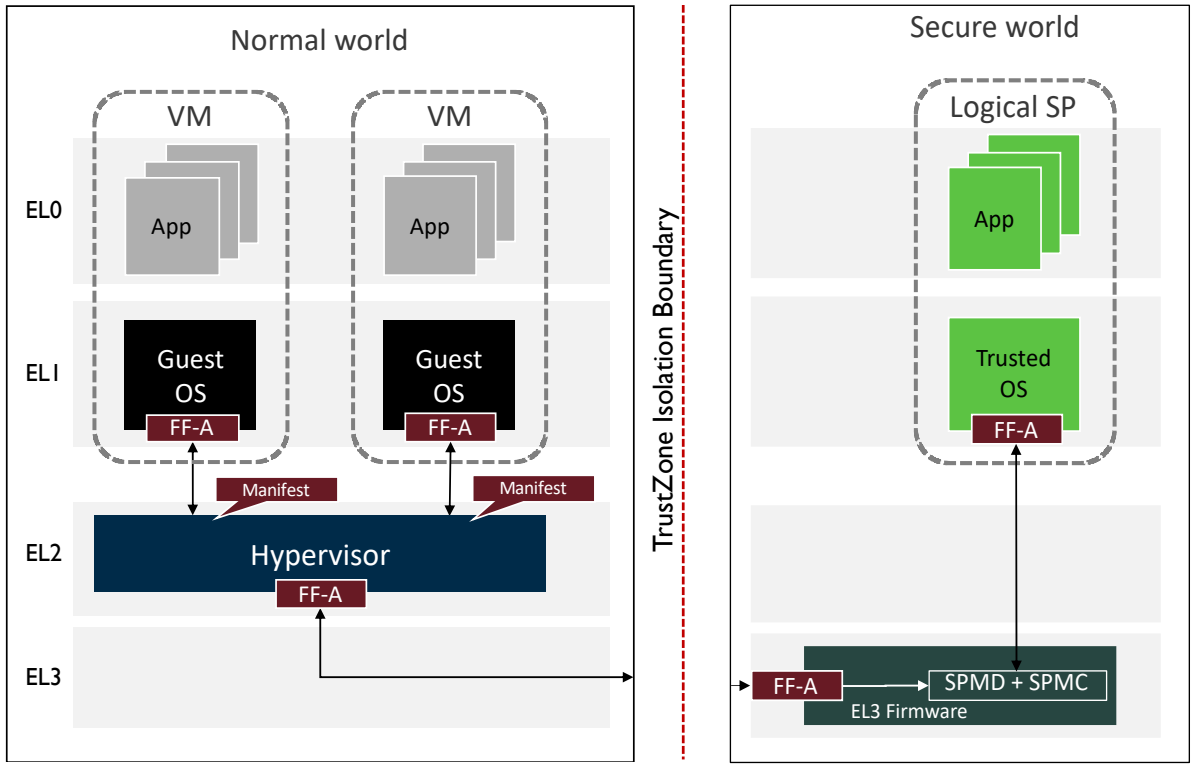
Firmware Framework for Armv8-A

How does it all fit together on a < Armv8.4 system



Single TOS migrates to FF-A

- **VMs implement a generic FF-A driver**
  - Implements the S/NS FF-A programming model
  - Provides a transport for service specific protocols
- **SPs implement a generic FF-A driver**
  - Implements the SP/SPMC FF-A programming model
  - Provides a transport for service specific protocols
- **Hypervisor implements a generic FF-A driver**
  - Dispatches messages between the two worlds
  - Implements the S/NS FF-A programming model
- **SPMD is a generic component in EL3**
  - Dispatches messages between the two worlds
  - Agnostic of SP and SPMC implementation
- **SPMC is a firmware component in EL3**
  - Implements the FF-A programming model
  - Provides a logical isolation for an SP

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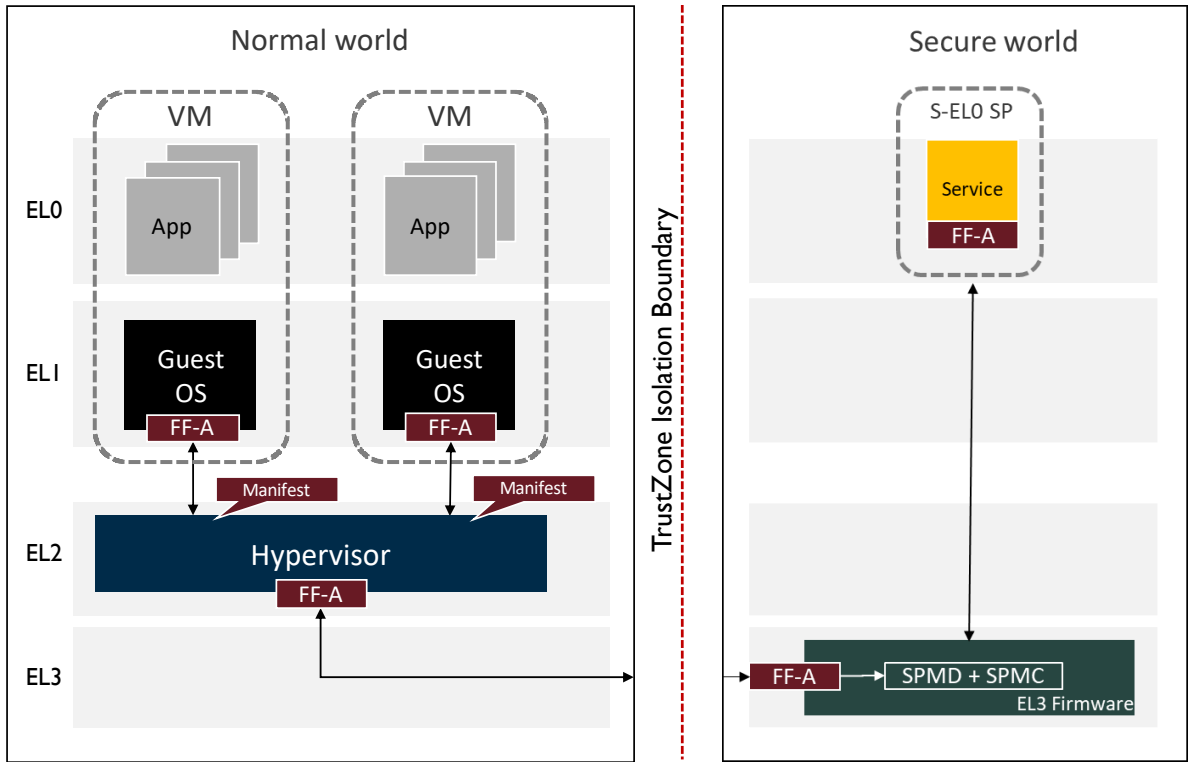
Firmware Framework for Armv8-A

How does it all fit together on a < Armv8.4 system



EL3 firmware manages S-EL0 SP

- **SP could also be deployed as S-EL0 Partition**
  - Implements the S/NS FF-A programming model
  - Provides a transport for service specific protocols
- **Currently available with SPM MM dispatcher**
  - Functionality replaced with the FF-A EL3 SPMC

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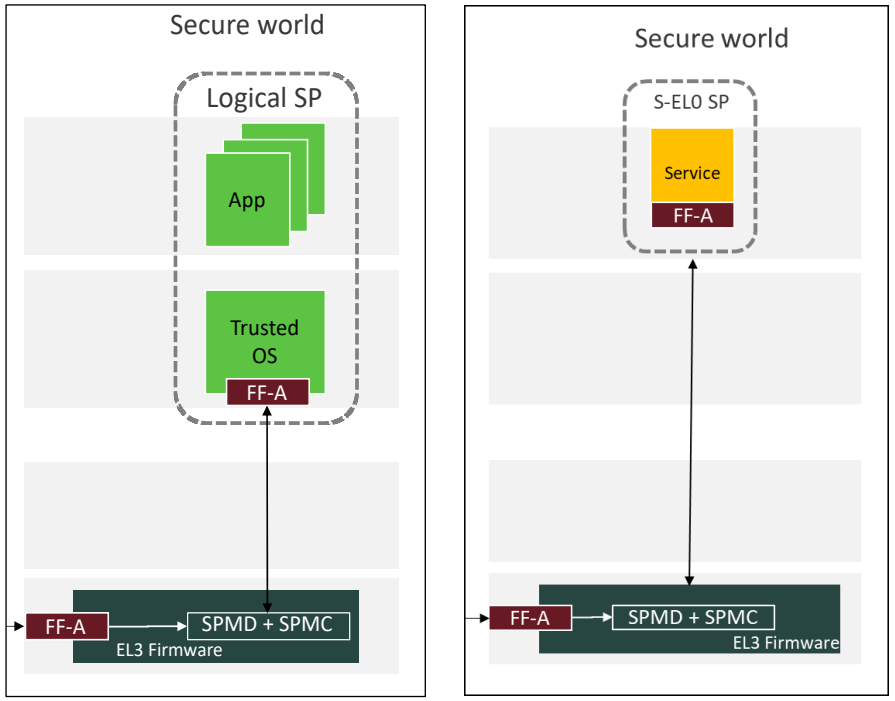
EL3 SPMC: What and Why?

- The EL3 SPMC is the implementation of the FF-A SPMC directly in EL3
  - Experimental support added to TF-A v2.7
- Supports systems without S-EL2 e.g. pre v8.4 platforms
- Serves as a migration path to help transition to running under S-EL2
  - Alignment between Hafnium (S-EL2 SPMC) and EL3 SPMC for SP manifest and major features
- Working closely with open source TOS and other partners during the review process to help ensure target use cases can be met
  - OP-TEE
  - Trusty



EL3 SPMC: Supported Features

- **Single Multi-Core S-EL1 SP Support**
  - SP Entry Point Registration
  - Pinned CPU contexts
  - Ongoing work for supporting S-EL0 partitions
- **Direct Messaging**
  - Register based message passing
- **Logical EL3 Partitions**
  - A simple entity in EL3 that can be communicated with via direct messaging
- **Partition Discovery**
  - Including EL3 and S-EL1 Partitions
  - Partition IDs & partition information.

- **Memory Management**
  - Lend memory
    - Lender loses access
    - Borrower(s) share access
  - Share memory
    - Lender and borrower(s) both have access
  - Implemented ABIs:
    - MEM_LEND/MEM_SHARE
    - MEM_RETRIEVE_REQ/RESP
    - MEM_RELINQUISH/ MEM_RECLAIM
  - Inc. Fragmented Descriptor Transmission
    - FFA_FRAG_TX
    - FFA_FRAG_RX
  - Support for multiple borrowers
    - From the normal world
  - Inc. Platform hooks for IMPDEF behavior
    - E.g. MPU programming

- **Power Management**
  - Supports Hot-plugging CPUs from Linux
  - SP Subscription to power events:
    - CPU_OFF
    - CPU_SUSPEND
    - CPU_SUSPEND_RESUME
- **Interrupt Support**
  - Signaling and completion mechanisms
- **State Tracking**
  - ABIs invocations / interrupts provoke state transitions
- **FF-A Boot Protocol v1.1**
  - Provides access to an SP's DT to the SP itself.

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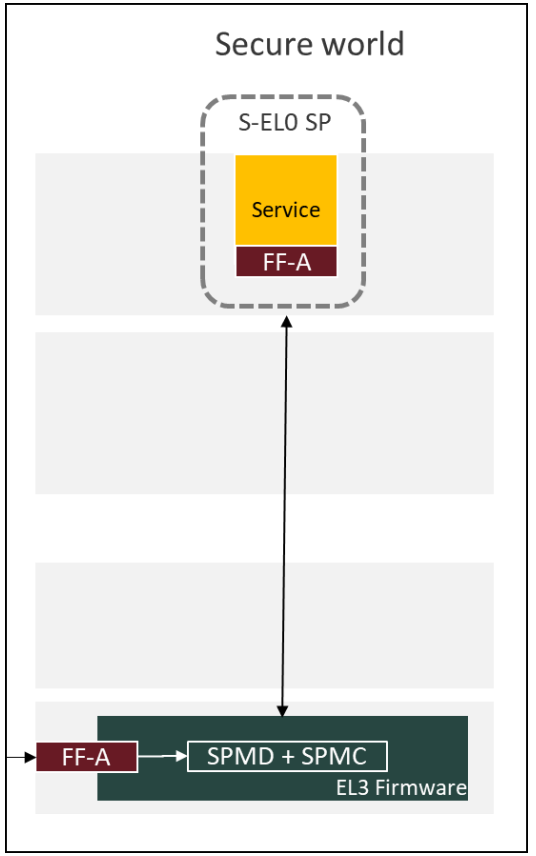
EL3 SPMC: S-EL0 Support

- Upstream EL3 SPMC patches currently only support an S-EL1 partition.
- Support to enable a single S-EL0 partition is under development and almost ready to post for review
- Currently validated use cases:
  - Secure boot
  - RAS



EL3 SPMC: Build Options

```
make                                \
CROSS_COMPILE=aarch64-none-elf-     \
SPD=spmd                            \   # Using FF-A SPMD Component
SPMD_SPM_AT_SEL2=0                  \   # Running on a system without S-EL2
SPMC_AT_EL3=1                       \   # Enable the FF-A EL3 SPMC
BL32=<path-to-tee-binary>           \   # S-EL1 SP image
BL33=<path-to-bl33-binary>          \
PLAT=fvp                            \
all fip
```

- https://trustedfirmware-a.readthedocs.io/en/latest/components/secure-partition-manager.html#tf-a-build-options

Example Boot Logs

```
INFO:    BL31: Initializing runtime services
INFO:    EL3 Logical Secure Partition init start.
INFO:    LSP: Init function called.
INFO:    EL3 Logical Secure Partition init completed.
INFO:    Secure Partition context setup start.
INFO:    Manifest size = 465 bytes.
INFO:    SP boot info @ 0x4021000, size: 529 bytes.
INFO:    SP manifest @ 0x4021040, size: 465 bytes.
INFO:    Entry point address = 0xff200000
INFO:    SPSR = 0x3c5
INFO:    Secure Partition setup done.
INFO:    BL31: Initializing BL32
INFO:    Secure Partition (0x8001) init start.
INFO:    Secure Partition initialized.
INFO:    BL31: Preparing for EL3 exit to normal world
INFO:    Entry point address = 0x88000000
INFO:    SPSR = 0x3c9
```

EL3 Logical Partition Setup

SPMC Partition Setup

S-EL1 Partition Initialisation

Normal World Handoff

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TF-A Details and Next Steps

TF-A EL3 SPMC (Jun'22)

- EL3 SPMC core changes TF-A v2.7 May'22
  - Released as experimental feature.
  - 45 patches developed (Arm arch team), reviewed (TF-A + partners) and merged.
  - Single S-EL1 partition (TEE) configuration. Complies with FF-A v1.1 EAC0 specification.
  - Partner contributions welcome for new feature development onwards.
- Test and CI changes (10) under development/review.
  - TSP adopting FF-A. NS side linux based test driver.
  - Review & merge TSP+CI changes (Jul'22).
- FF-A Architecture Compliance Suite
  - Runs against the EL3 SPMC
  - Few fixes planned in coming weeks
  - Plan to document test results and waived findings.
- Hikey960 platform changes (7) under review.
- Documentation updates (Aug'22)
  - EL3 SPMC threat model and design doc.

EL3 SPMC to SEL2 SPMC features catch up

- FF-A v1.1 features picked early in the EL3 SPMC
- Goal to maintain a smooth migration from EL3 SPMC to SEL2 SPMC
- Catch up the SEL2 SPMC:
  - Memory sharing to multiple borrowers.
  - Memory sharing structures forward compatible.
  - NS bit passed in memory retrieve response.
  - Power management run-time.
  - FF-A ACS results "match".

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Thank You
Danke
Gracias
Grazie
谢谢
ありがとう
Asante
Merci
감사합니다
धन्यवाद
Kiitos
شكرًا
ধন্যবাদ
תודה