RMM-EL3 Interface

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Agenda

- Requirements
- Boot process
- Error handling and return values
- Versioning
- Boot Manifest details
- RMM <-> EL3 Runtime calls
- Shared buffer management during EL3 <-> RMM calls
- RMM <-> EL3 World switch register convention
- Runtime Services
- Implementation details

Requirements

- RMM needs to be as platform independent as possible
  - Support for PIE
  - Needs to be able to receive configuration parameters at boot time.
    - RMM has minimal platform specific differentiation at build time
  - RMM does not depend on stages prior to BL31 and its configuration is dependent of the configuration mechanism used for the EL3 firmware
    - This would allow partners to use their own BL2/BL1 image and any configuration mechanism (DT, FCONF, hardcoded parameters). BL31 would parse and extract the relevant info for RMM.
  - RMM should be EL3 firmware agnostic
    - When possible, we should make no assumption about the underlying EL3 software.
    - A contract between EL3 and RMM is needed to allow the former to pass platform information to the latter, such as
      - Number of CPUs
      - Address range for peripherals (e.g UART)
      - Shared memory buffer (more on this later)

Requirements

- The information will be passed from EL3 to RMM via a register contract between both parties or via a Boot Manifest (or both).
- RMM may require services from EL3 FW (e.g, to get attestation keys or to delegate or undelegate memory granules)
  - A formal spec of the services is required.
- The spec defines the switch register convention between RMM and EL3, part of the SMCCC contract, when NS world is the client.
- Manage compatibility and migration between EL3 and RMM as the interface evolves to cater for future requirements.

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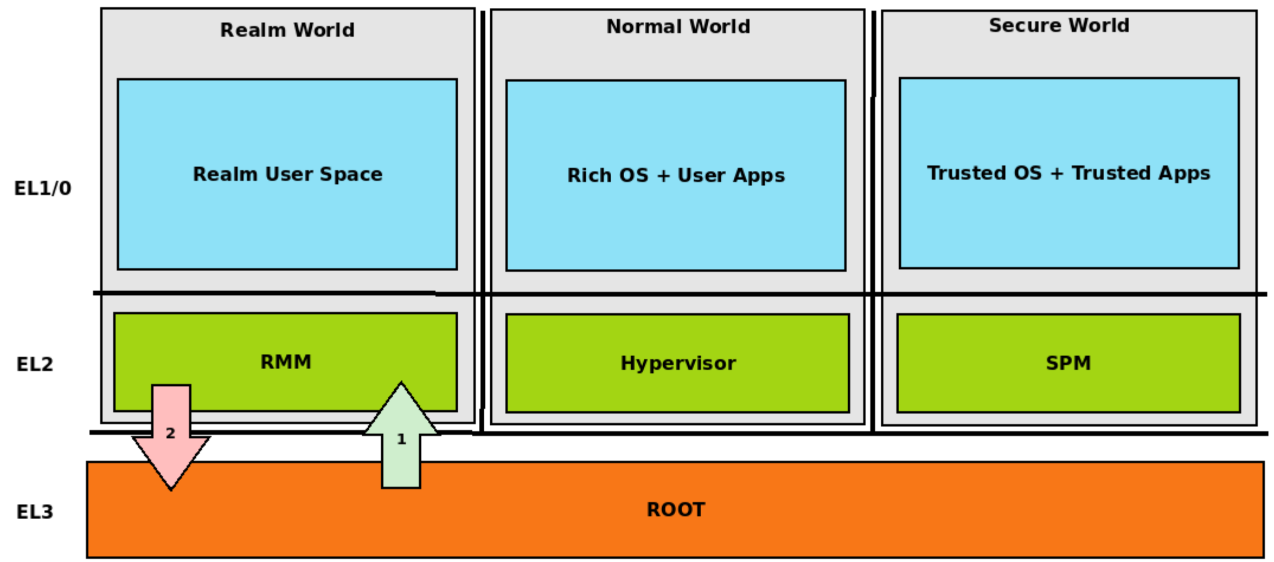
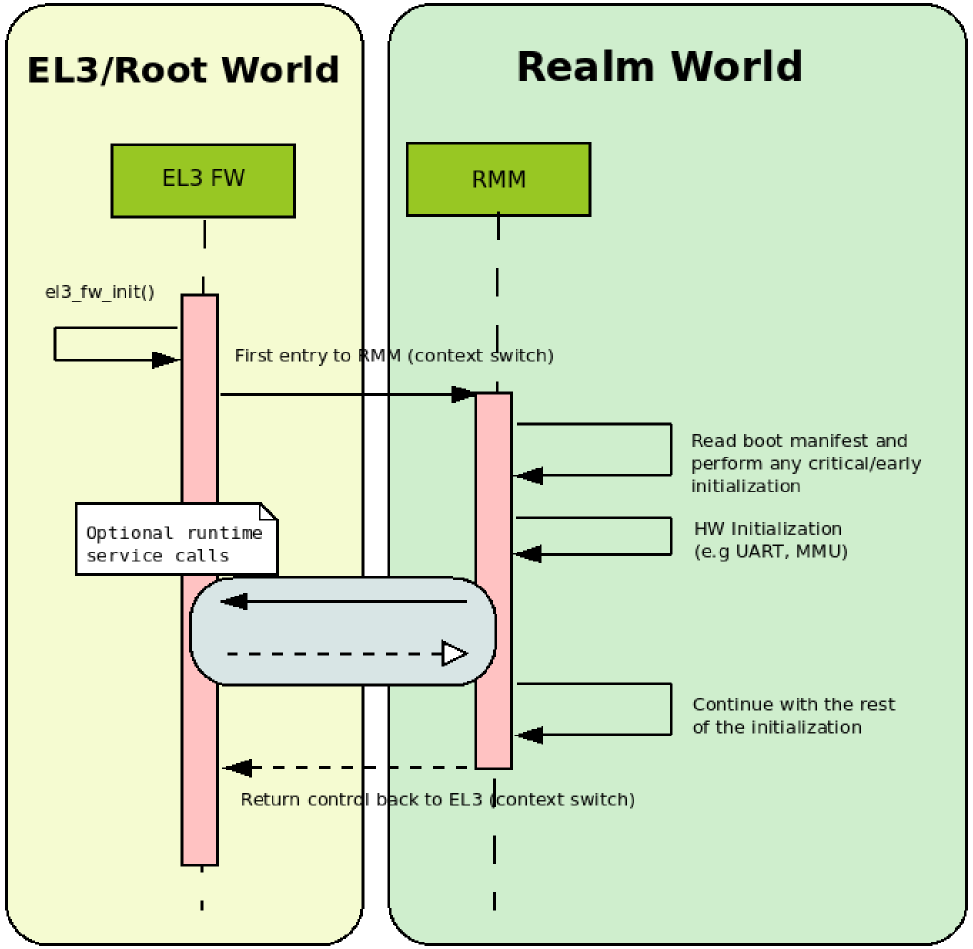
Boot process

The boot process is initiated by the Root world (EL3 Firmware)





Boot process

RMM accepts up to four arguments, stored in registers x0 to x3. A proposal for the v0.1 Boot Interface (argument usage) is:

COLD BOOT

Register	Value
x0	Linear index for this PE. This index starts from 0 and must be less than `PLATFORM_CORE_COUNT`
x1	RMM - EL3 Interface Version (0.1 for this spec)
x2	`PLATFORM_CORE_COUNT`
x3	Base PA for the shared buffer used for communication between EL3 and RMM.
x4 - x7	RES0

WARM BOOT

Register	Value
x0	Linear index for this PE. This index starts from 0 and must be less than `PLATFORM_CORE_COUNT`
x1 - x7	RES0

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Error handling and return values

- After cold/warm boot up and initialization, RMM returns control back to RMMD through *SMC_RMM_BOOT_COMPLETE SMC* call
  - This call only accepts one argument, an error code in x1
- Upon error, whether it happens during cold or warm boot, RMM will abort the boot process and it will be made unavailable to all the CPUs as to present a symmetric view to the entire system.

Error handling and return values

Error Code	Description	ID
E_RMM_BOOT_SUCCESS	Boot successful	0
E_RMM_BOOT_ERR_UNKNOWN	Unknown error	-1
E_RMM_IFC_VERSION_INVALID	Boot interface version reported by RMMD is not supported by RMM	-2
E_RMM_BOOT_CPUS_OUT_OF_RANGE	RMMD reported a maximum number of CPUs larger than the maximum supported by RMM	-3
E_RMM_BOOT_CPU_ID_OUT_OF_RANGE	Current CPU ID is higher than the maximum reported by RMMD	-4
E_RMM_BOOT_INVALID_SHARED_BUFFER	Invalid pointer to shared buffer area	-5
E_RMM_BOOT_MANIFEST_VERSION_NOT_SUPPORTED	Version reported by the boot manifest not supported by RMM	-6
E_RMM_BOOT_MANIFEST_DATA_ERROR	Error parsing the core boot manifest	-7

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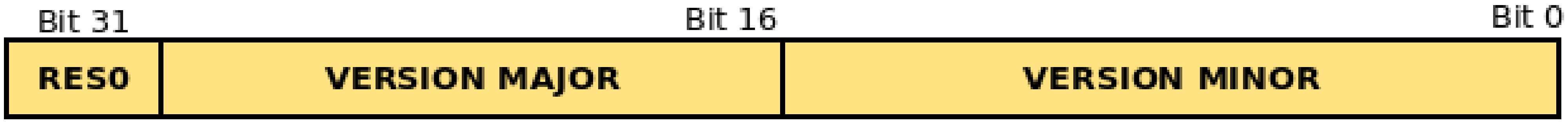
Interface (and manifest) versioning

- The EL3 – RMM interface is versioned to ease compatibility between versions.
- Version number (passed through x1) is 32 bits-wide with bit 31 set as RES0
  - `VERSION_MAJOR` (Bits [16:30])
    - This value is increased iff the changes to the Boot Interface ABI break compatibility with previous versions.
  - `VERSION_MINOR` (Bits [0:15])
    - This value is increased iff the changes to the Boot Interface ABI do not break backwards compatibility with previous versions or
    - It is reset to 0 upon `VERSION_MAJOR` update.
  - `RES0` field
    - For consistency with other modules' versioning on RMM.



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Boot Manifest details

```
/* Boot manifest core structure as per v0.1 */
You, last month | 1 author (You)
typedef struct rmm_manifest {
	uint32_t version;	/* Manifest version */
	uintptr_t plat_data;	/* Manifest platform data */
} rmm_manifest_t;

CASSERT(offsetof(rmm_manifest_t, version) == 0,
				rmm_manifest_t_version_unaligned);
CASSERT(offsetof(rmm_manifest_t, plat_data) == 8,
				rmm_manifest_t_plat_data_unaligned);
```

- Common to all platforms.
- First field corresponds to the version number (mandatory).
- Can grow up to 1 page size.
- Must be allocated inside the RMM – EL3 Shared buffer.

- It caters for per-platform data.
  - The platform part of the manifest must fall inside the shared area and not overlap with the core manifest.
    - Macros will be provided on TF-A to get a valid pointer for the platform manifest data.
- The offset of each component on the manifest is enforced by the spec.

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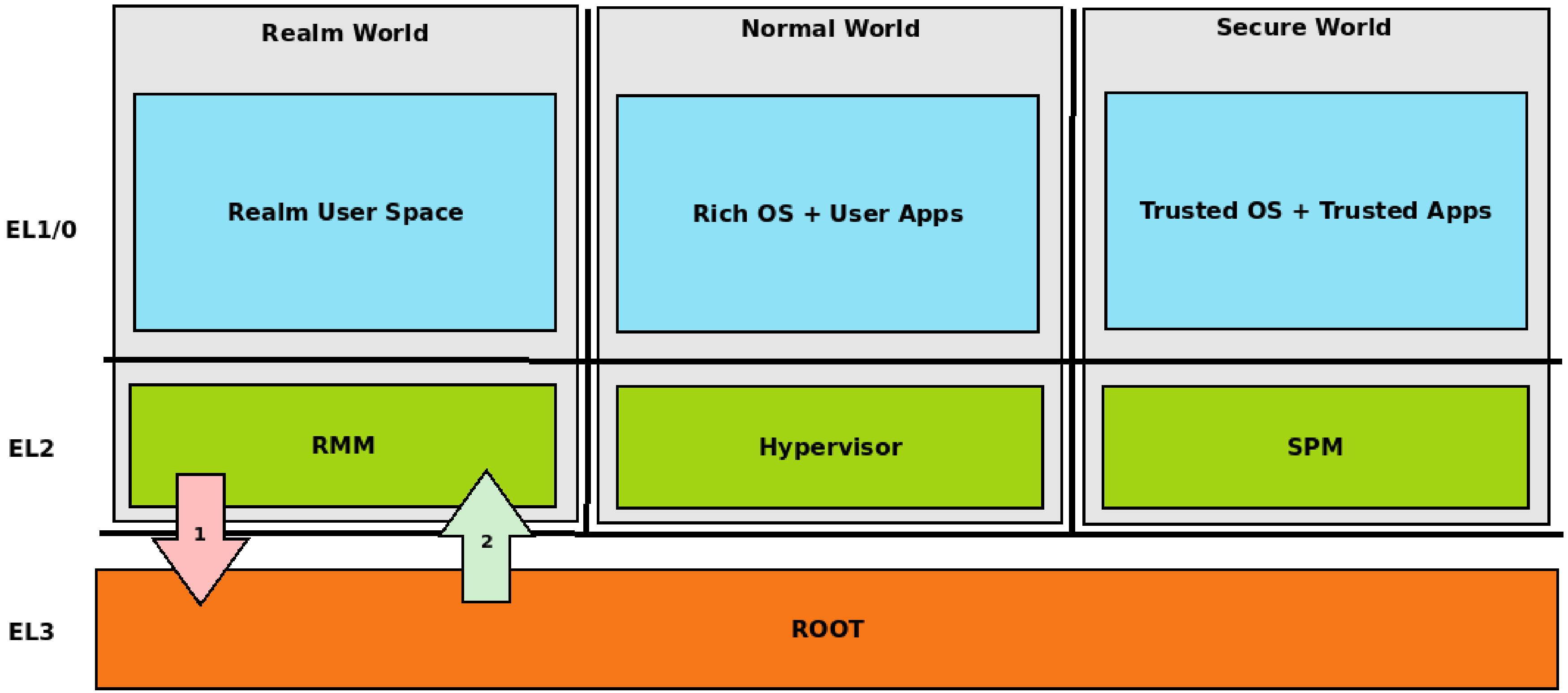
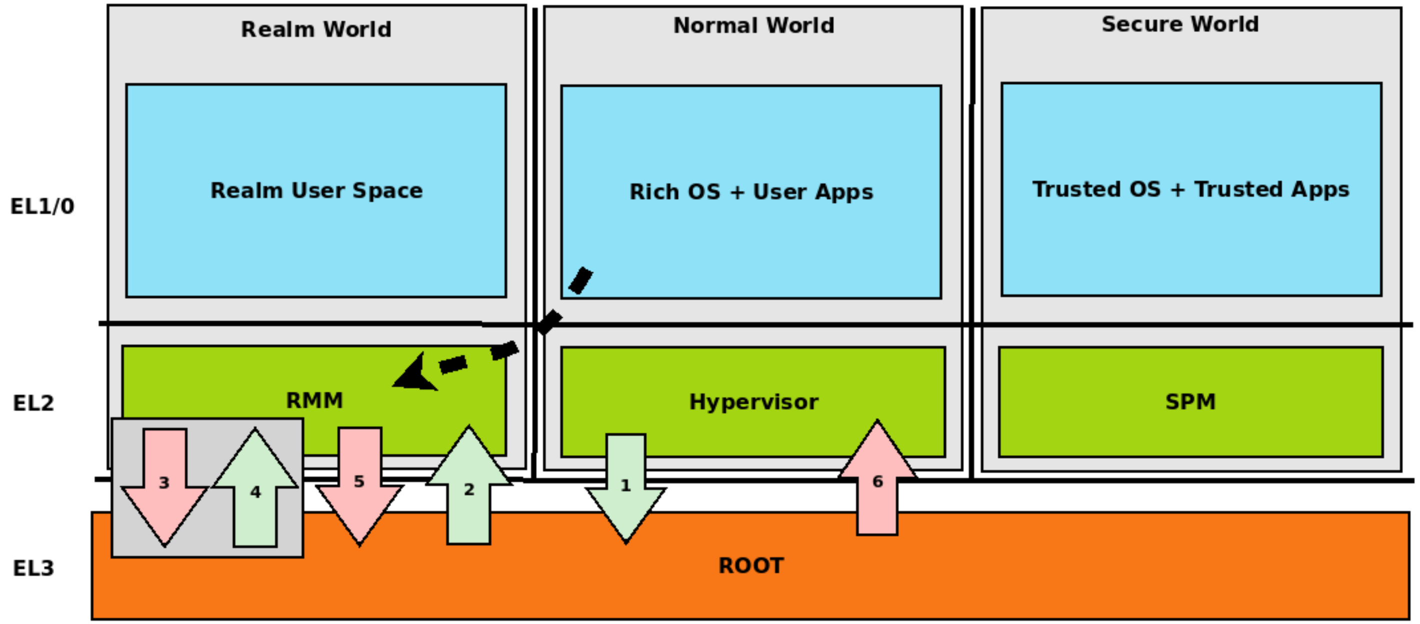
RMM <-> EL3 Runtime calls – RMM initiated



RMM <-> EL3 Runtime calls – NS Initiated

- The specification defines the implementation defined register switch convention between RMM and EL3 when NS world is the client.
- EL3 FW is seen as a service provider.
- Steps 3 & 4 are optional.



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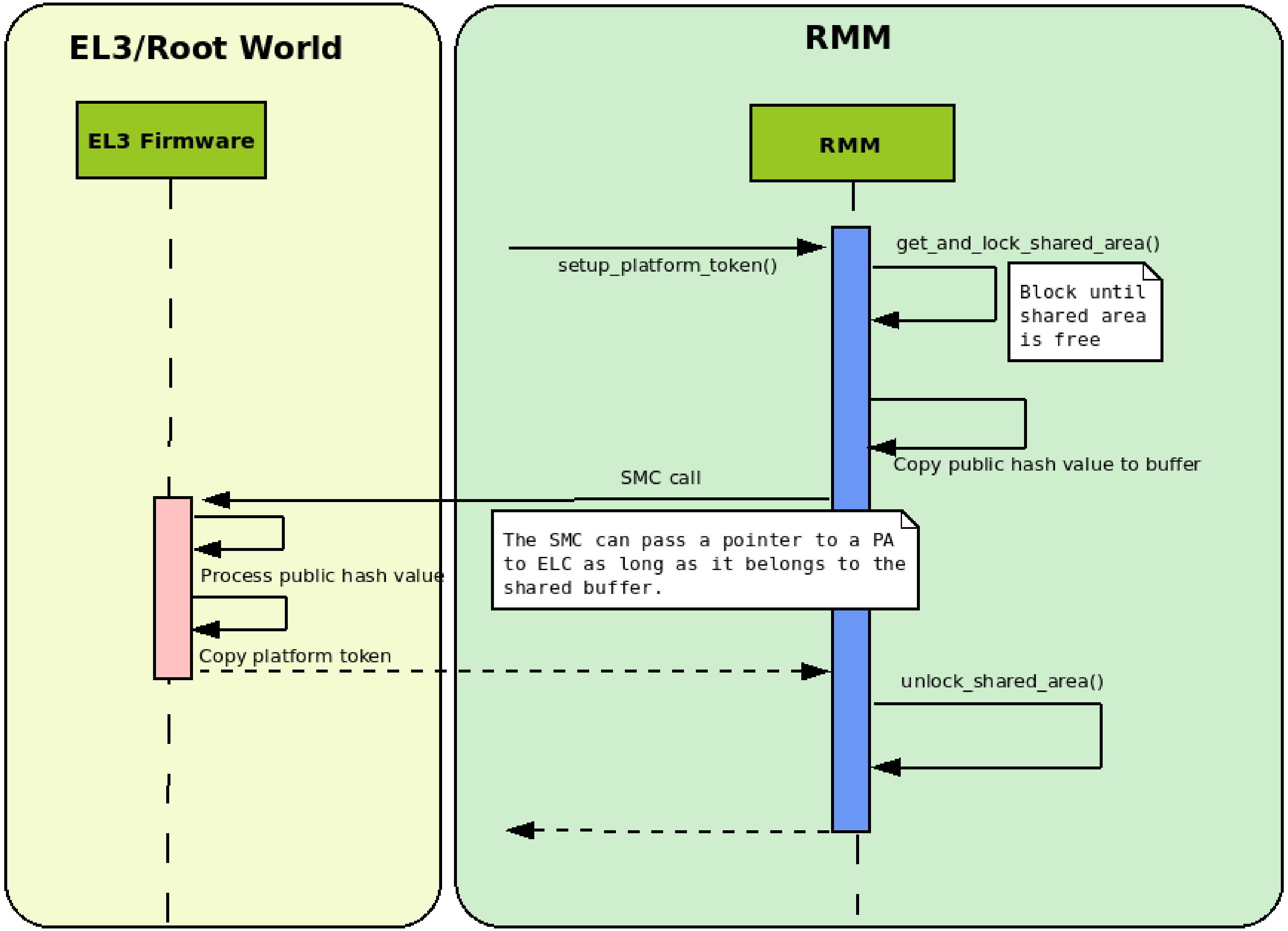
Shared buffer management during EL3 <-> RMM interaction

- The shared buffer is meant to be used during EL3 <-> RMM communications, to pass large data structures.
  - Platform tokens or keys
- RMM sees EL3 as a service provider. Only RMM can initiate communications via SMC.
- When the shared buffer is needed in a communication (regardless of the data direction), RMM is responsible of locking and own the buffer to avoid concurrent accesses or other race conditions.
- EL3 assumes that the PE making the service call has exclusive access to the shared buffer.
- It is RMM responsibility to unlock and free the shared buffer upon request termination.

Shared buffer management during EL3 <-> RMM comms.



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RMM <-> EL3 world switch register convention

- EL3 is expected to maintain a register context specific to each world and it will save and restore the register appropriately.
- EL3 must maintain a separate register context for
  - GPRs (x0 – x30) as well as *sp_el0* and *sp_el2* stack pointers.
  - EL2 system register context for all enabled features by EL3, including registers with *_EL2* prefix.
  - EL2 physical and virtual timer registers must not be included in the register context.
- EL3 will not save some registers as mentioned below. It is responsibility of RMM to save them if the Realm World makes use of them.
  - FP/SIMD registers
  - SVE registers
  - SME registers
  - EL1/0 registers

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Runtime services – SMC_RMMD_GTSI_DELEGATE

0xC4001B0

- Request EL3 to delegate a memory granule

Input Values:

Name	Register	Field	Type	Description
FID	x0	[63:0]	Uint64	Command FID
PA	x1	[63:0]	Address	Physical Base Address of the granule to delegate

Output Values:

Name	Register	Field	Type	Description
Error	x0	[63:0]	Error Code	Command return status

Runtime services – SMC_RMMD_GTSI_UNDELEGATE

0xC4001B1

- Request EL3 to undelegate a memory granule

Input Values:

Name	Register	Field	Type	Description
FID	x0	[63:0]	Uint64	Command FID
PA	x1	[63:0]	Address	Physical Base Address of the granule to undelegate

Output Values:

Name	Register	Field	Type	Description
Error	x0	[63:0]	Error Code	Command return status

Runtime services – SMC_RMM_GET_REALM_ATTEST_KEY

0xC4001B2

- Retrieve the Realm Attestation Key from EL3

Input Values:

Name	Register	Field	Type	Description
FID	x0	[63:0]	Uint64	Command FID
PA	x1	[63:0]	Address	PA where to store the Realm Attestation Key. The PA must belong to the shared buffer
BSize	x2	[63:0]	Size	Size in bytes of the Realm Attestation Key Buffer
Curve	x3	[63:0]	Enum	Type of the elliptic curve to which the requested attestation key belongs to

Output Values:

Name	Register	Field	Type	Description
Error	x0	[63:0]	Error Code	Command return status
PTSize	x1	[63:0]	Size	Size of the Realm Attestation Key

Runtime services – SMC_RMM_GET_REALM_TOKEN

0xC4001B3

- Retrieve the platform token from EL3

Input Values:

Name	Register	Field	Type	Description
FID	x0	[63:0]	Uint64	Command FID
PA	x1	[63:0]	Address	PA of the platform attestation token. The challenge object is passed in this buffer. The PA must belong to the shared buffer
BSize	x2	[63:0]	Size	Size in bytes of the platform attestation token buffer
CSize	x3	[63:0]	Size	Size in bytes of the challenge object. It corresponds to the size of one of the defined SHA algorithms

Output Values:

Name	Register	Field	Type	Description
Error	x0	[63:0]	Error Code	Command return status
PTSize	x1	[63:0]	Size	Size of the platform token

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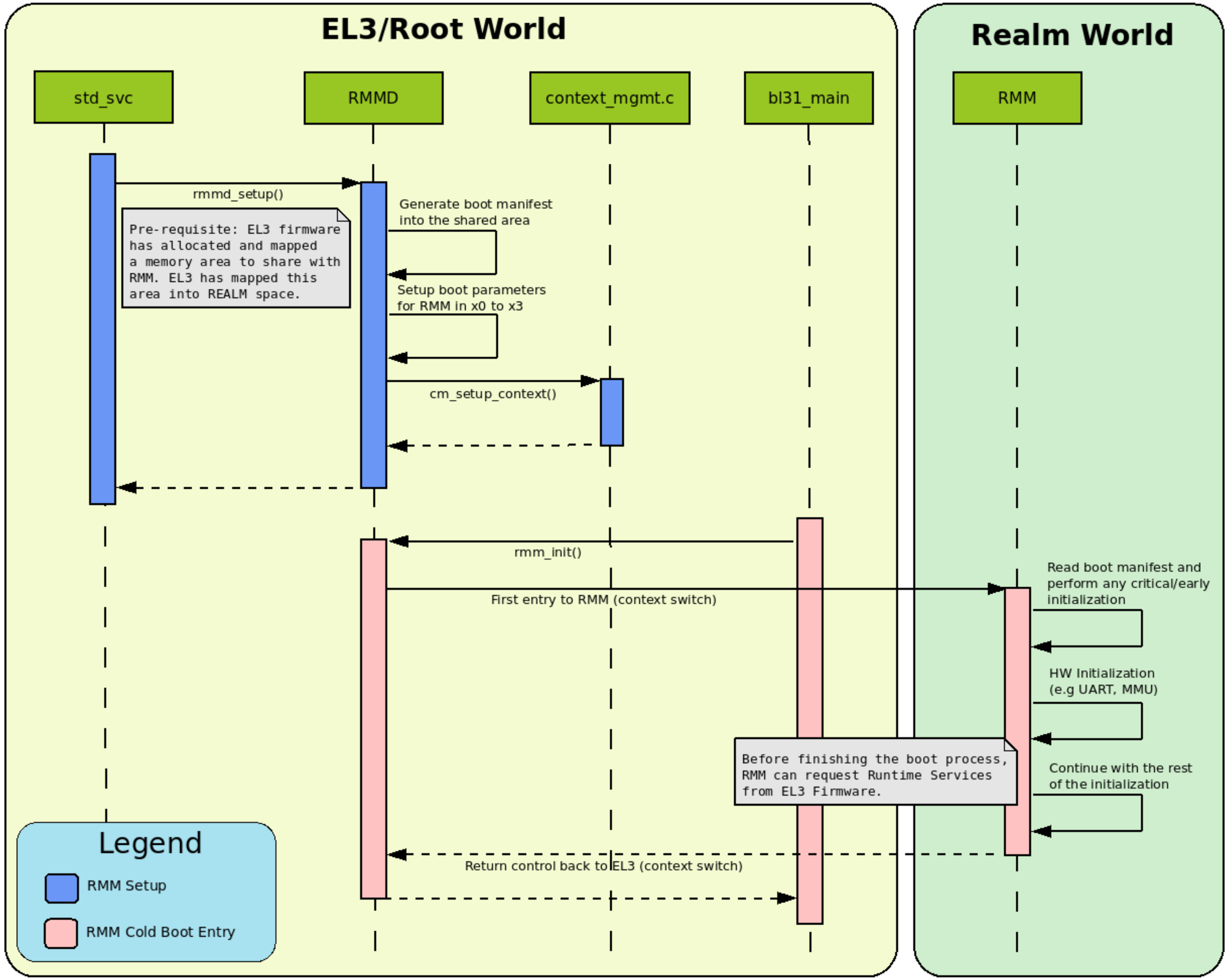
Implementation details – TF-A Boot process



Implementation details

```
/*
 * The top 16MB (or 64MB if RME is enabled) of DRAM1 is configured as
 * follows:
 *   - SCP TZC DRAM: If present, DRAM reserved for SCP use
 *   - L1 GPT DRAM: Reserved for L1 GPT if RME is enabled
 *   - REALM DRAM: Reserved for Realm world if RME is enabled
 *   - TF-A <-> RMM SHARED: Area shared for communication between TF-A and RMM
 *   - AP TZC DRAM: The remaining TZC secured DRAM reserved for AP use
 *
 *              RME enabled(64MB)                RME not enabled(16MB)
 *              --------------------             -------------------
 *              |                  |             |                 |
 *              |  AP TZC (~28MB)  |             |  AP TZC (~14MB) |
 *              --------------------             -------------------
 *              |                  |             |                 |
 *              |      REALM       |             |  EL3 TZC (2MB)  |
 *              |   (32MB - 4KB)   |             -------------------
 *              --------------------             |                 |
 *              |                  |             |    SCP TZC      |
 *              |   TF-A <-> RMM   |  0xFFFF_FFFF-------------------
 *              |   SHARED (4KB)   |
 *              --------------------
 *              |                  |
 *              |  EL3 TZC (3MB)   |
 *              --------------------
 *              | L1 GPT + SCP TZC |
 *              |      (~1MB)      |
 *  0xFFFF_FFFF --------------------
 */
```

- The shared buffer area is a single page of statically allocated memory. It can be used by any CPU.
- BL2 maps the REALM area to load the RMM image.
- BL31 (Root) maps the shared buffer area with the Realm PAS attributes.
- The Realm and shared buffer areas are mapped as a single GPT block with same attributes (PAS_REALM) as both areas can only be accessed by the Realm world (and from Root)
- The shared buffer area is available for the whole lifecycle of the system.

Boot Manifest details

```
int plat_rmmd_load_manifest(rmm_manifest_t *manifest)
{
        assert(manifest != NULL);

        manifest->version = RMMD_MANIFEST_VERSION;
        manifest->plat_data = (uintptr_t)NULL;

        return 0;
}
```

- `plat_rmmd_load_manifest()` must be implemented by the platform provider.
- It receives a pointer to a manifest, which it can populate the boot parameters.
- The platform is responsible for defining a platform manifest data structure and populate it if necessary.

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