Qualcomm

Protected DMAbufs and its dynamic memory assignment woes

Sumit Garg

Senior Staff Engineer, QUALCOMM India Private Limited

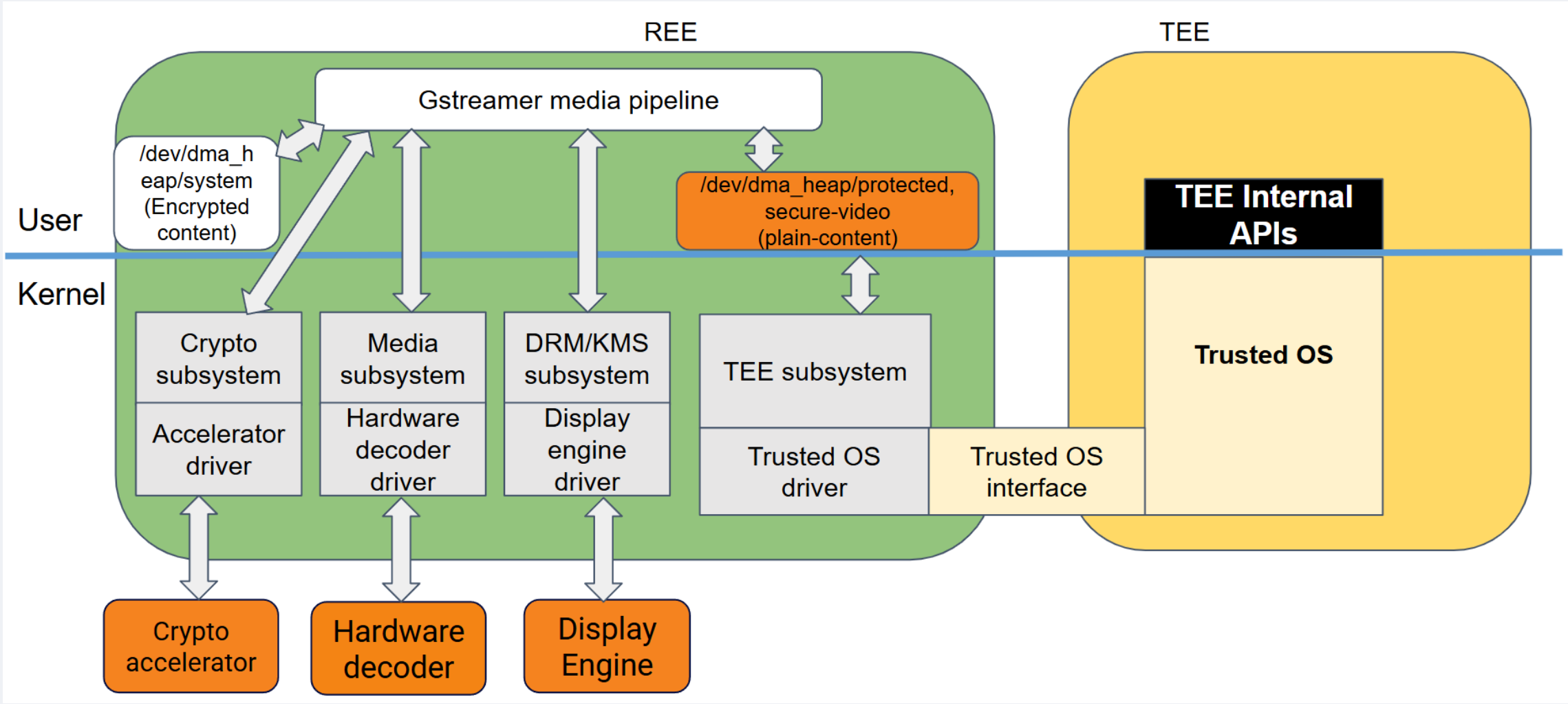
Who am I?

- A member of the Qualcomm open-source team

- Have a keen interest in open-source boot & security
  - Linux kernel: TEE subsystem reviewer, author for TEE bus driver framework
  - edk2, TF-A and OP-TEE: Qualcomm platform maintainer
  - TF-A and OP-TEE: Firmware encryption framework maintainer
  - OP-TEE: Author for Rust no-std Trusted Applications support

- Other areas of interest
  - U-Boot: OF_UPSTREAM devicetree maintainer
  - ftrace for OP-TEE
  - meta-arm-toolchain

Protected DMAbufs use-case - Secure media pipeline



Protected DMAbufs use-case

Secure DMA heaps have been discussed upstream for many years but haven’t found it’s way into the mainline kernel, the major reasons being:

- A missing end-to-end open-source use-case
- The difficulty to encode vendor specific metadata leading to vendor specific secure heaps being exposed to user-space

The Digital Rights Management (DRM) secure media pipeline use-case is the major driver here but with binding that the complete user-space and TEE stack not being fully open.

Kernel TEE subsystem came to the rescue here:

- Abstract out the vendor specific metadata to the backend TEE implementation
- Provide a common infrastructure to enable wider use-cases like protected DMAbufs based key/crypto operations etc.

Protected DMAbufs: Static memory carveouts

Static memory carveouts for protected DMAbufs are based on reserved memory regions which are marked as “no-map” in devicetree.

The kernel trusted OS (OP-TEE) driver creates a protected memory pool based on the carveout configuration probed from OP-TEE.

Shortcomings:

- Lack of efficient memory reuse especially when buffer allocations reaches 100s of MBs
- Lack of support for scatter gather buffer allocations

Protected DMAbufs: Dynamic memory assignment

The dynamic assignment of protected DMAbufs are based on regular DMAbufs allocated from the kernel CMA or system heap region.

The kernel trusted OS (OP-TEE) driver lends the regular DMAbuf region to the devices requiring exclusive access as per the use-case. Firmware Framework – A (FF-A) memory management protocol specifies how memory lending framework works.

Shortcomings:

- Missing framework in the kernel to enable exclusive device access once the memory lend happens

Protected DMAbufs: Dynamic memory assignment - **woes**

drivers/tee/optee/protmem.c +35

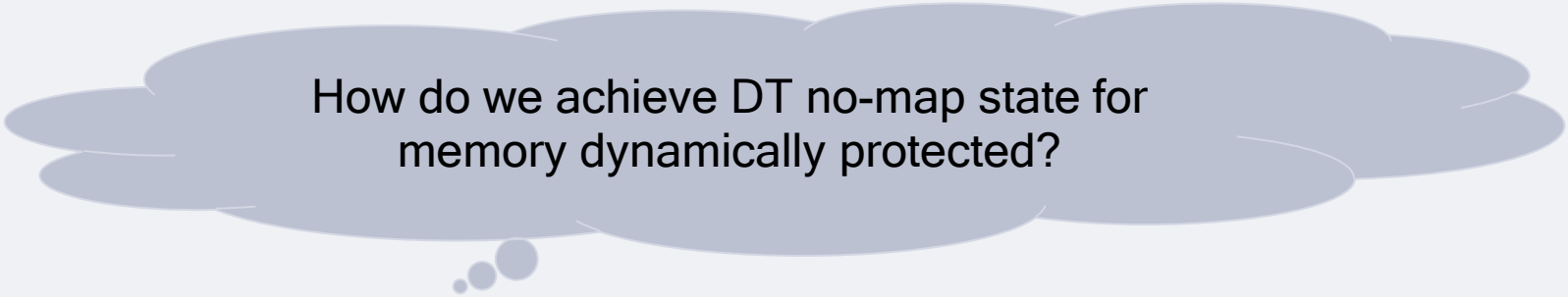
```
static int init_dyn_protmem(struct optee_protmem_dyn_pool *rp)
{
    int rc;

    rp->protmem = tee_shm_alloc_dma_mem(rp->optee->ctx, rp->page_count);
    if (IS_ERR(rp->protmem)) {
        rc = PTR_ERR(rp->protmem);
        goto err_null_protmem;
    }

    /*
     * TODO unmap the memory range since the physical memory will
     * become inaccessible after the lend_protmem() call.
     *
     * If the platform supports a hypervisor at EL2, it will unmap the
     * intermediate physical memory for us and stop cache pre-fetch of
     * the memory.
     */
    rc = rp->optee->ops->lend_protmem(rp->optee, rp->protmem,
                      rp->mem_attrs,
                      rp->mem_attr_count, rp->use_case);
    if (rc)
        goto err_put_shm;
    rp->protmem->flags |= TEE_SHM_DYNAMIC;
...
}
```

```
tee_shm_alloc_dma_mem()
  -> dma_alloc_pages()
```

Protected DMAbufs: Dynamic memory assignment – **solution?**



- Heterogeneous Memory Management (HMM) subsystem can enable this use-case
  - Exclusive access memory: enable support for CMA and system heap memory regions?

- Pages un-map call chain of interest

```
memunmap_pages()
 -> pageunmap_range()
  -> arch_remove_memory()
```

- Open to ideas?

Thank you

Follow us on:

For more information, visit us at qualcomm.com & qualcomm.com/blog