Agenda

- What is shared memory between TAs?
- Shared memory without pager
- Paged memory
- Paged shared memory
- Data structures used by pager
- Example - releasing a physical page
- Sharing read-only pages of TAs
- Lifecycle of struct fobj
What is shared memory between TAs?

A TA is a Trusted Application with its own context in secure world.

Wikipedia defines shared memory as:

> Shared memory is memory that may be simultaneously accessed by multiple programs with an intent to provide communication among them or avoid redundant copies.

In OP-TEE shared memory is used for both purposes where saving memory is a priority.
Shared memory without pager

- Without pager shared memory is achieved by mapping the same physical memory in the different TA contexts
Paged memory

- Paged memory has a backing store
- Remapped on demand to maintain an illusion that the entire memory region is mapped
Paged shared memory

- Paged shared memory has a backing store
- Remapped on demand to maintain an illusion that the entire memory region is mapped
- Only referenced pages are mapped in each TA
- To ensure a coherent view of the memory, a backing store index can only be represented by one physical page at a time
- Shared memory is achieved by sharing physical pages representing the backing store
Data structures used by pager

- **area_head**: Represents the combined VM space for one TA
- **area**: Virtual memory range of a partial or a complete fobj
- **fobj**: Backing store for one secure shared memory object
- **pmem**: Physical page
Example - releasing a physical page

- A physical page may be mapped at several places
- Pager must find owners of shared page when releasing a page
- Areas are present in two different linked lists:
  - By virtual memory context as in the previous slide
  - By `fobj` to be able to find users of the same physical page
- To the right area 0 and 2 belongs to the same VM context while area 1 belongs to a different VM context
- pmem 0 might be mapped by area 0 and area 1
Sharing read-only pages of TAs

- Read-only sections (slices) of a Trusted application are registered with file_new()
- Read-write sections are not saved since it costs memory
- The tag is a hash of the entire file from which the TA is loaded from

```c
struct file_slice {
    struct fobj *fobj;
    unsigned int page_offset;
};

struct file *
file_new(uint8_t *tag,
        unsigned int taglen,
        struct file_slice *slices,
        unsigned int num_slices);
```
Sharing read-only pages of TAs, continued

- `file_get_by_tag()` is used while a TA is loaded to find out if there are any sharable sections available.
- `file_find_slice()` is used to find a specific section which can be shared.
- The `fobj` in struct `file_slice` is a pointer to a `fobj` which backs a read-only section of a TA.

```c
struct file_slice {
    struct fobj *fobj;
    unsigned int page_offset;
};

struct file *
file_get_by_tag(uint8_t *tag,
                unsigned int len);

struct file_slice *
file_find_slice(struct file *f,
                unsigned int offs);
```
Lifecycle of struct fobj

- struct fobj is reference counted
- fobj_put() is called each time a reference to a fobj is released
- When the reference count reaches 0 the fobj is freed
- The same principle applies for struct file

```c
struct fobj {
    ...  
    struct refcount refc; 
    ... 
};

Void fobj_put(struct fobj *fobj);
```
Thank you

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