An Exploration of the seL4 Kernel from Genode's Perspective

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Outline

1. Background (Genode)
2. The seL4 project
3. Capabilities and kernel objects
4. Virtual memory
5. What's next?

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Motivations behind Genode

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Key technologies

- Microkernels
- Componentization, kernelization
- Capability-based security
- Virtualization

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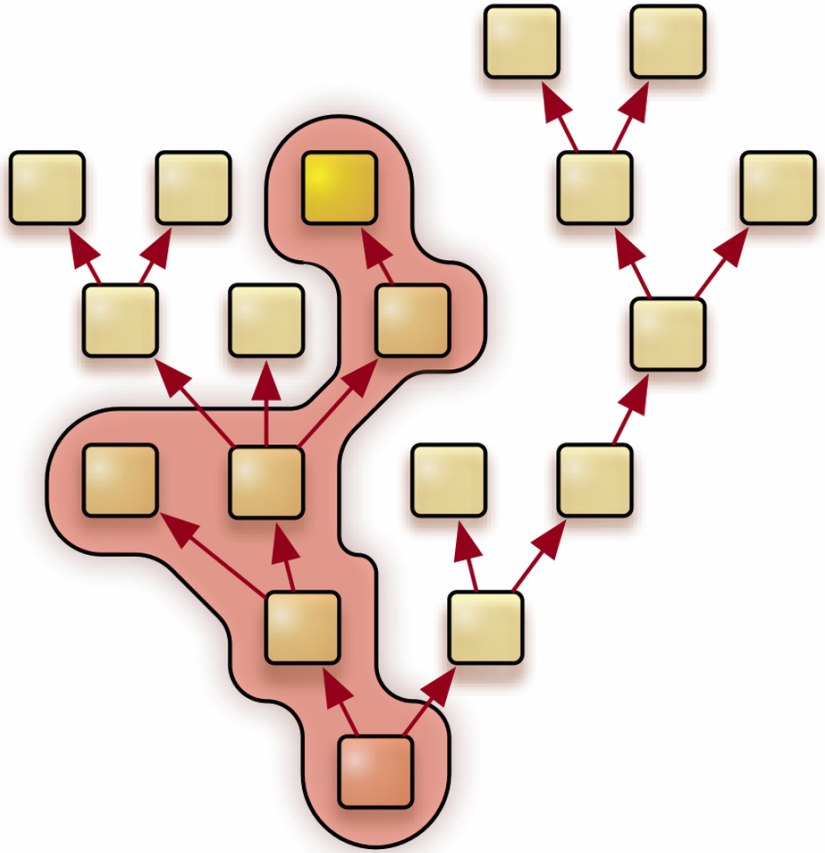
...but how to compose those?

Genode architecture



→ Application-specific TCB

Combined with virtualization

Genode operating-system framework

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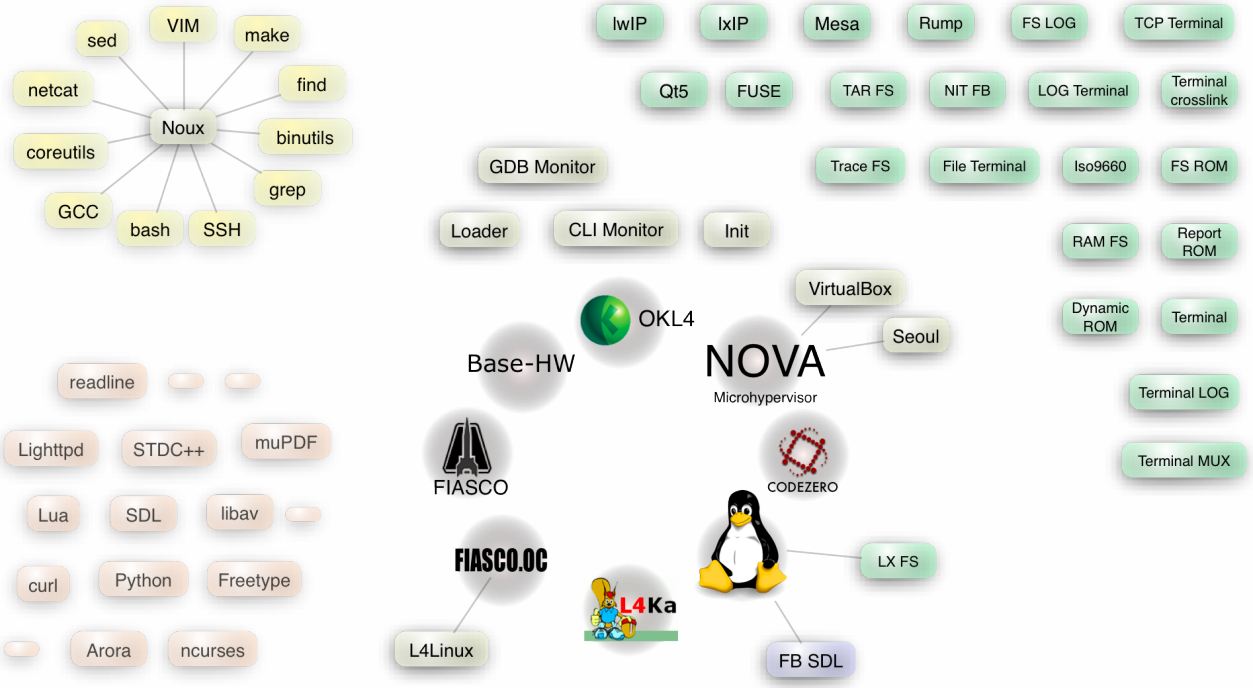
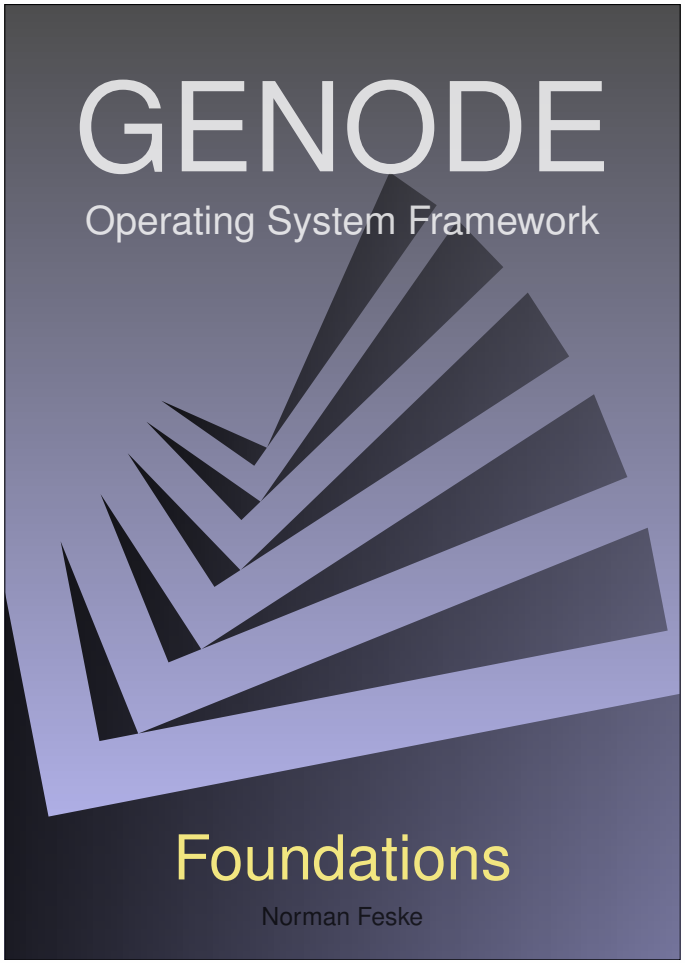


The Book “Genode Foundations”



http://genode.org/documentation/genode-foundations-15-05.pdf

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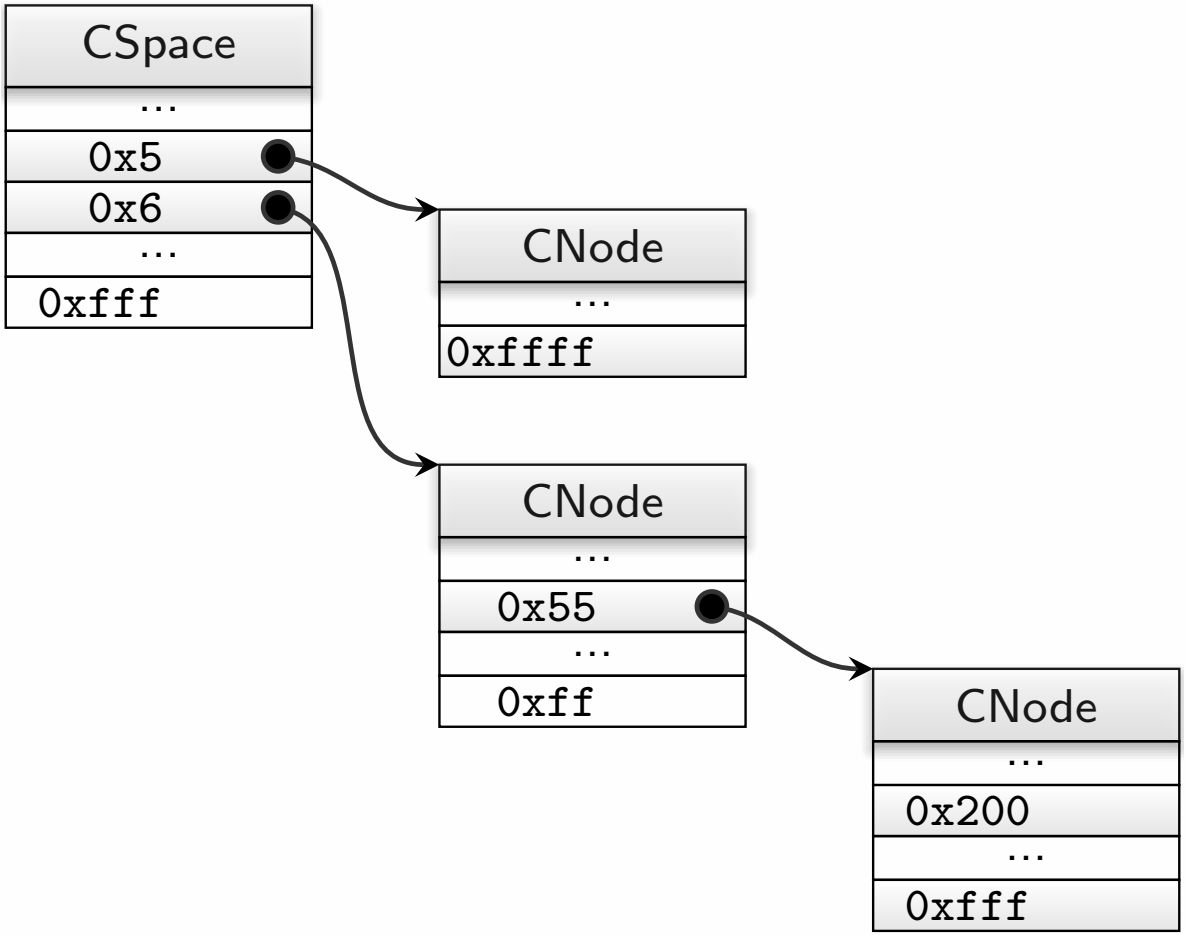
- GPLv2 since August 2014
- Active and dedicated community

Outline

seL4 kernel-object inventory

seL4 kernel object	Analogy
`UntypedObject`	Range of physical memory
`TCBObject`	Thread
`EndpointObject`	Destination of IPC calls
`AsyncEndpointObject`	Recipient of signals
`CapTableObject` (“CNode”)	Array of capabilities
`IA32_4K`	4 KiB page frame
`IA32_4M`	4 MiB page frame
`IA32_PageTableObject`	Page table
`IA32_PageDirectoryObject`	Protection domain

seL4 capabilities (“selectors”)

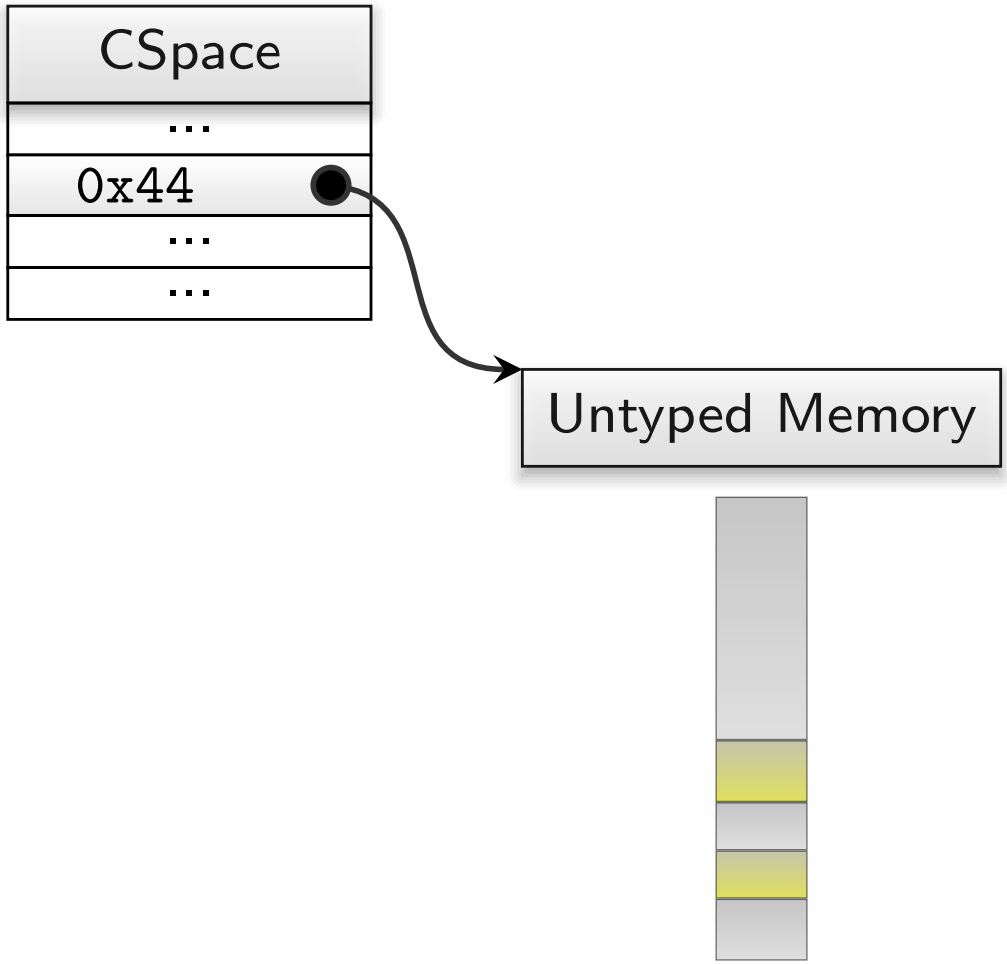


Startup

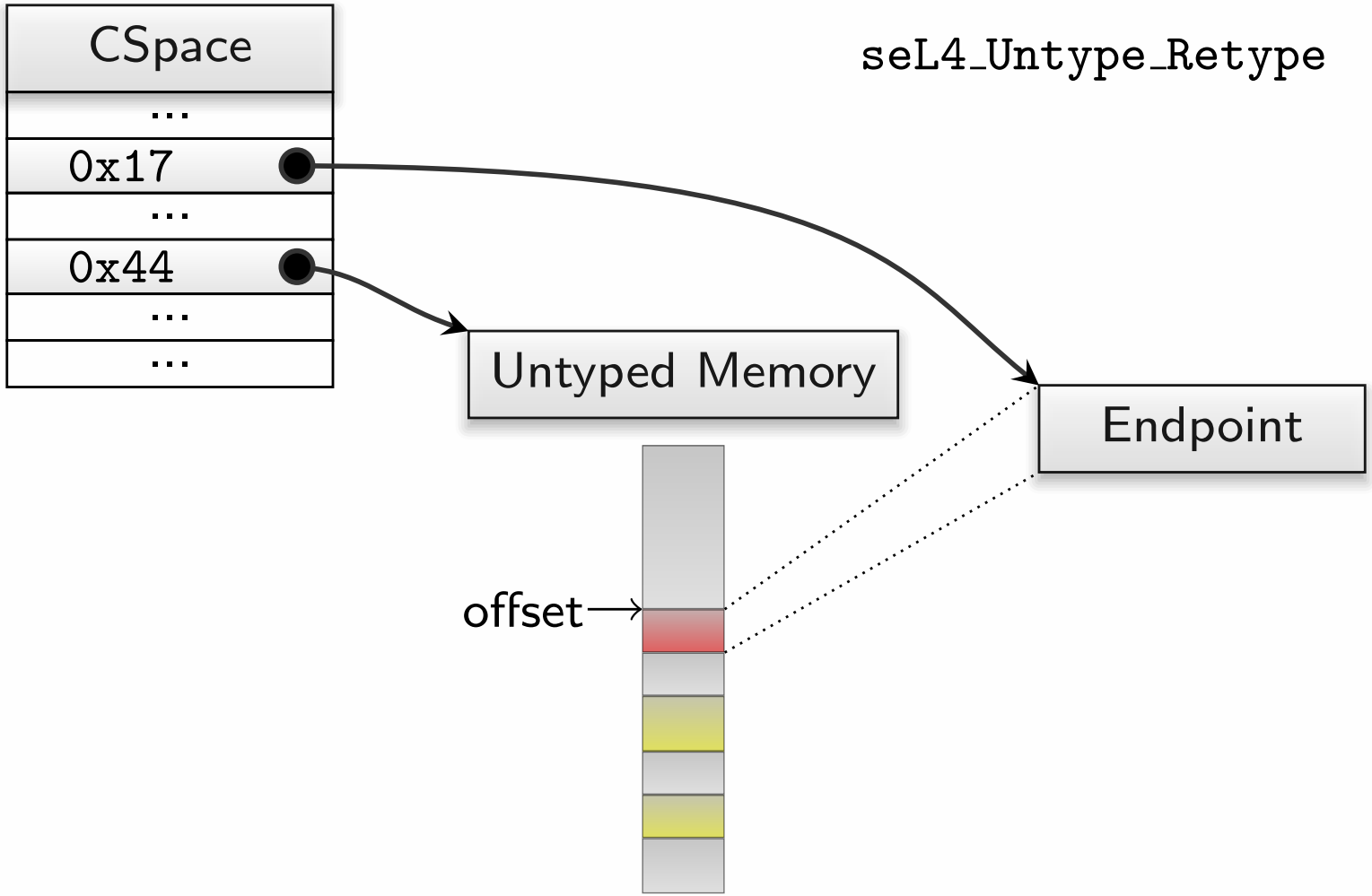
Once upon a time, there was untyped memory...

```
--- boot info ---
 initThreadCNodeSizeBits: 12
 untyped:                 [38,4d)
                          [38] [00100000,00107fff]
                          [39] [00108000,00109fff]
                          [3a] [001a0000,001bffff]
                          [3b] [001c0000,001fffff]
                          [3c] [00200000,003fffff]
                          [3d] [00400000,007fffff]
                          [3e] [00800000,00ffffff]
                          [3f] [01000000,01ffffff]
                          [40] [02000000,02ffffff]
                          [41] [03000000,037fffff]
                          [42] [03800000,03bfffff]
                          [43] [03c00000,03dfffff]
                          [44] [03e00000,03efffff]
                          [45] [03f00000,03f7ffff]
                          [46] [03f80000,03fbffff]
                          [47] [03fc0000,03fdffff]
                          [48] [03fe0000,03feffff]
                          [49] [03ff0000,03ff7fff]
                          [4a] [03ff8000,03ffbfff]
                          [4b] [03ffc000,03ffdfff]
                          [4c] [00189000,001897ff]
```

Kernel-object creation



Kernel-object creation (2)



Managing untyped memory

- Book keeping
  - Tracking of free physical memory
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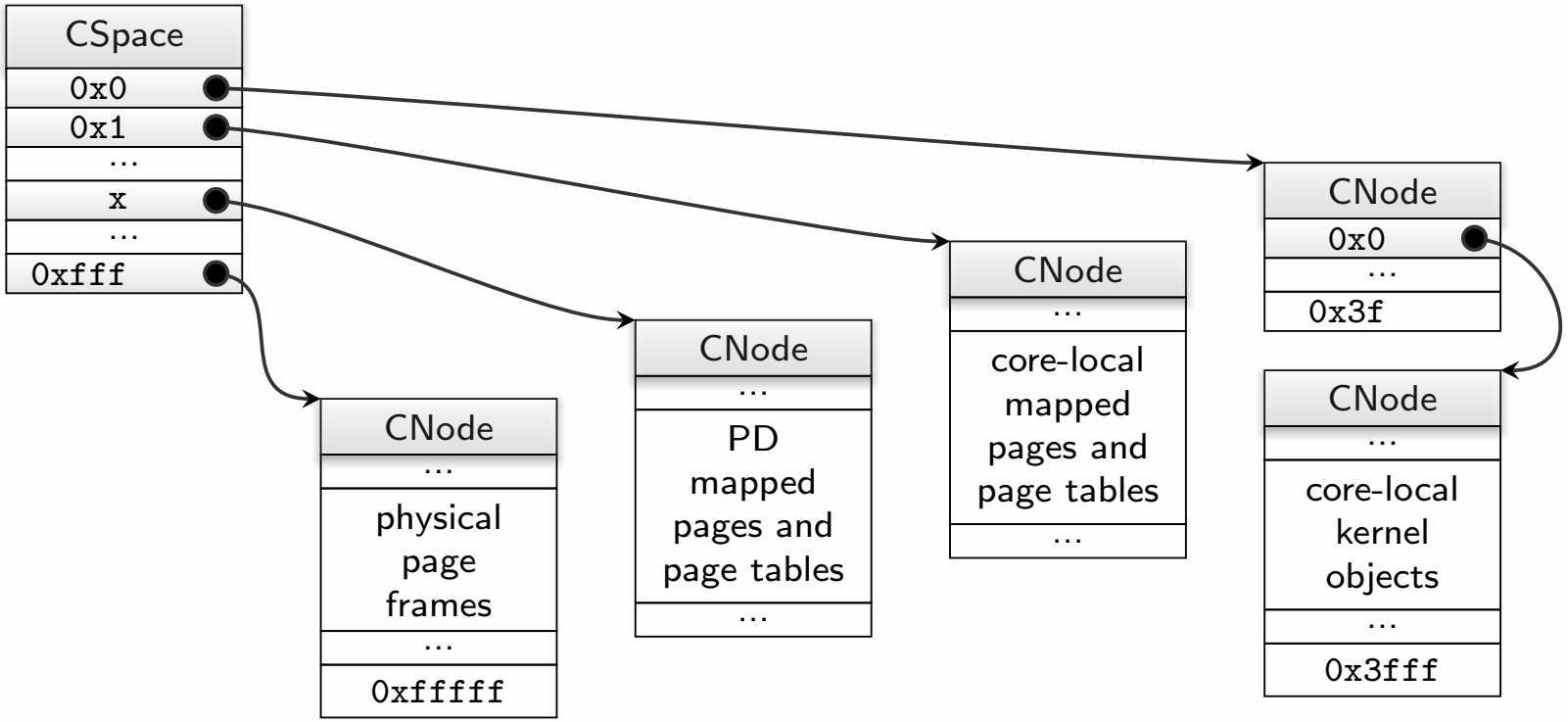
$\rightarrow$ *Trick: natural alignment of all allocations*

Core's CSpace organization



Capability delegation and invocation

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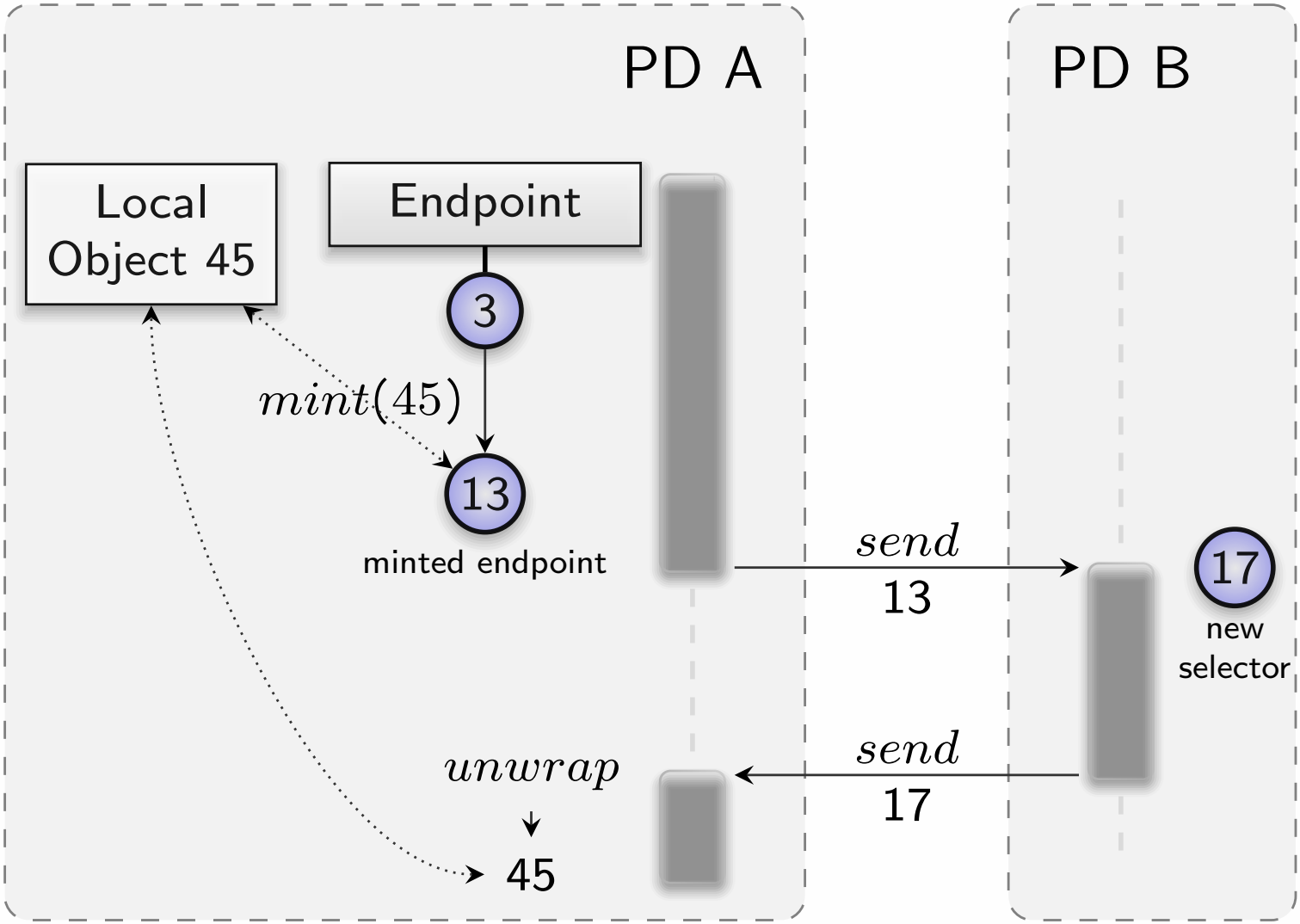

Capability re-identification problem

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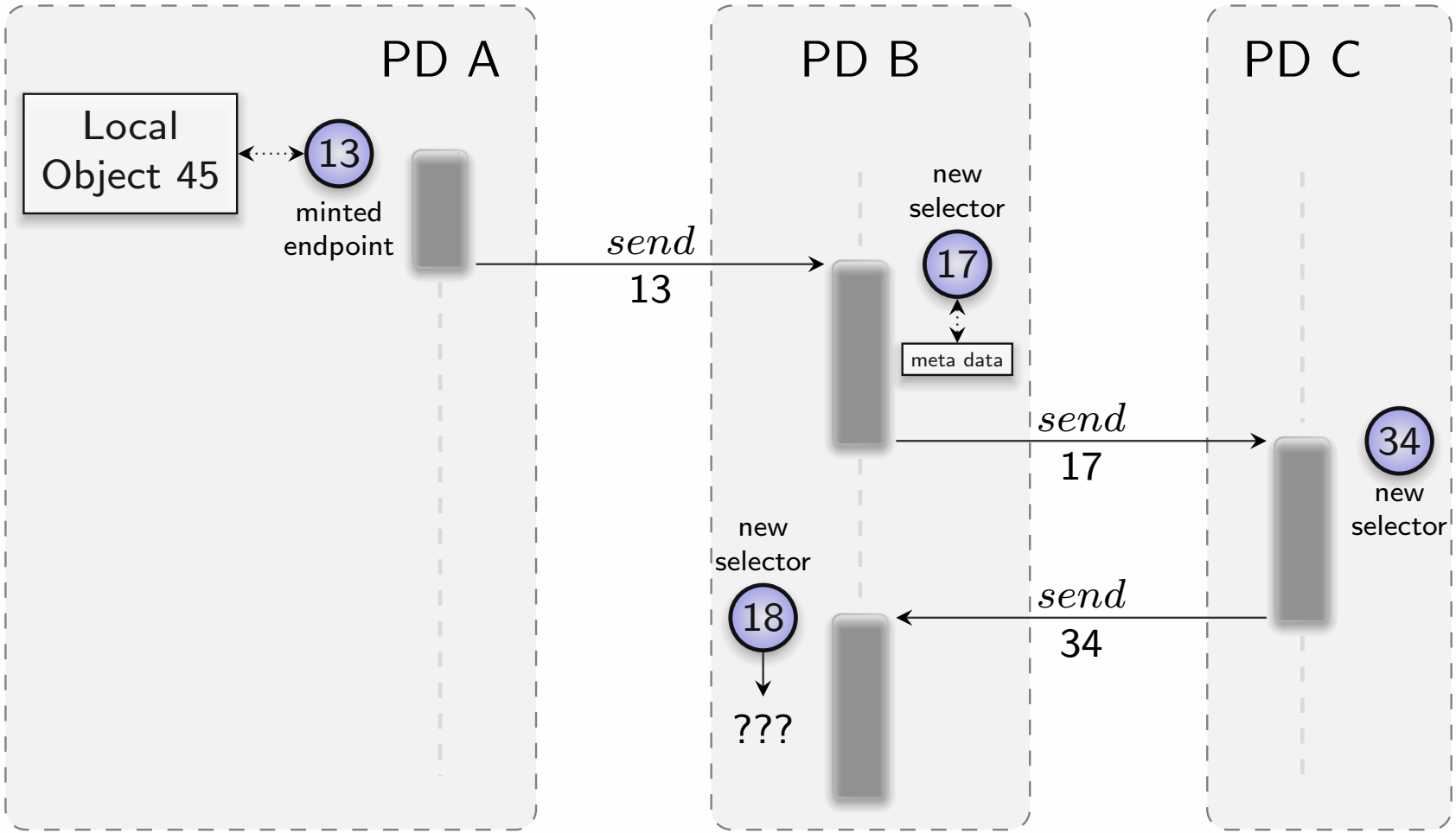
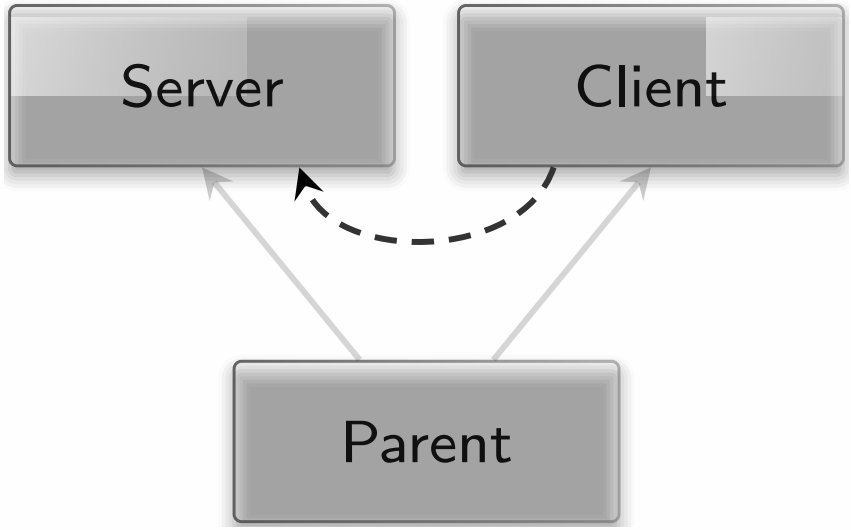


Problem in Genode



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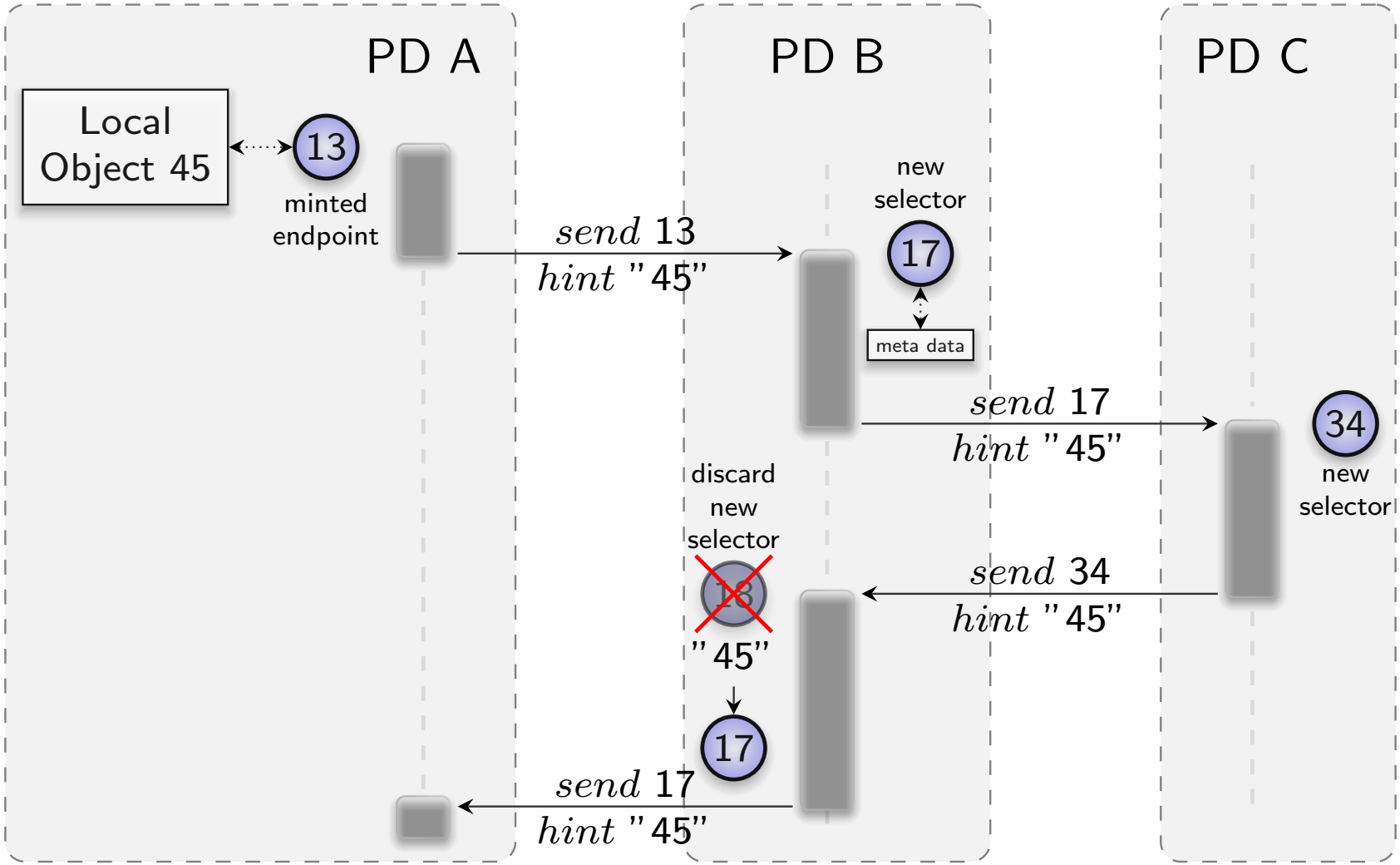

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- Who provokes kernel memory consumption?

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- Where to take the memory from?
  → *Traditional approach: kernel-local memory pool*
- What happens when the memory get exhausted?
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- Who provokes kernel memory consumption?
  → *Untrusted application code!*

The seL4 way of virtual memory management

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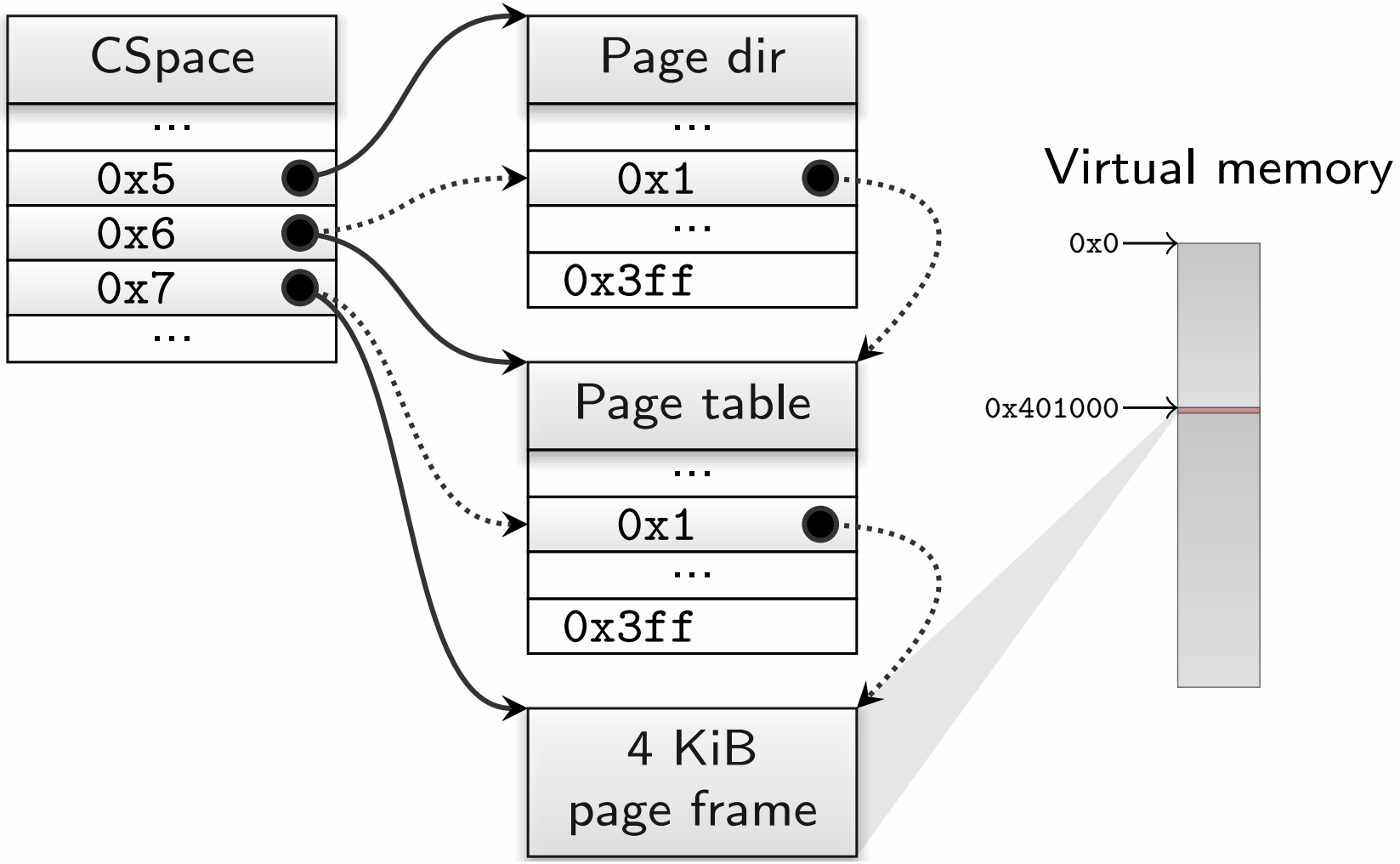

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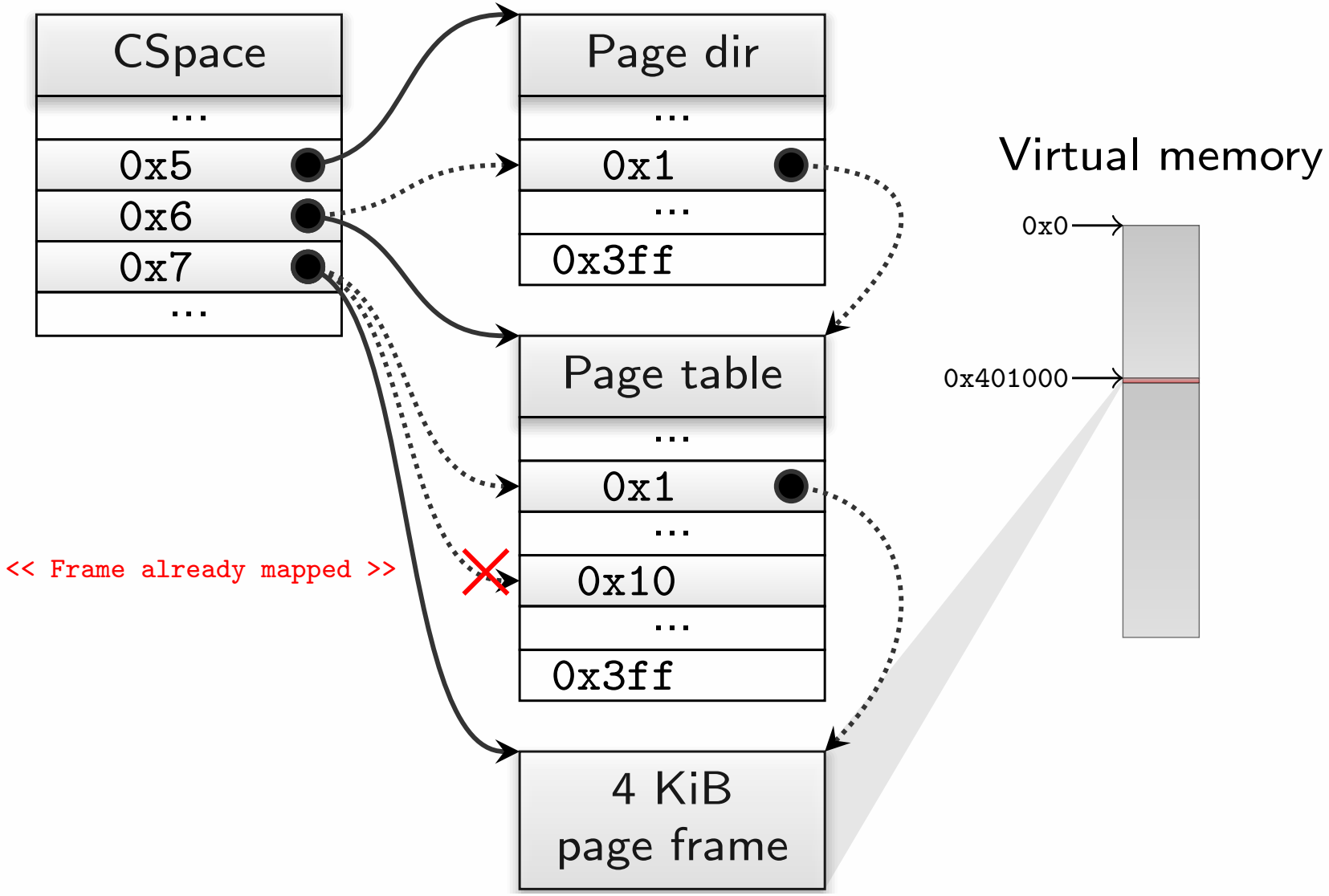
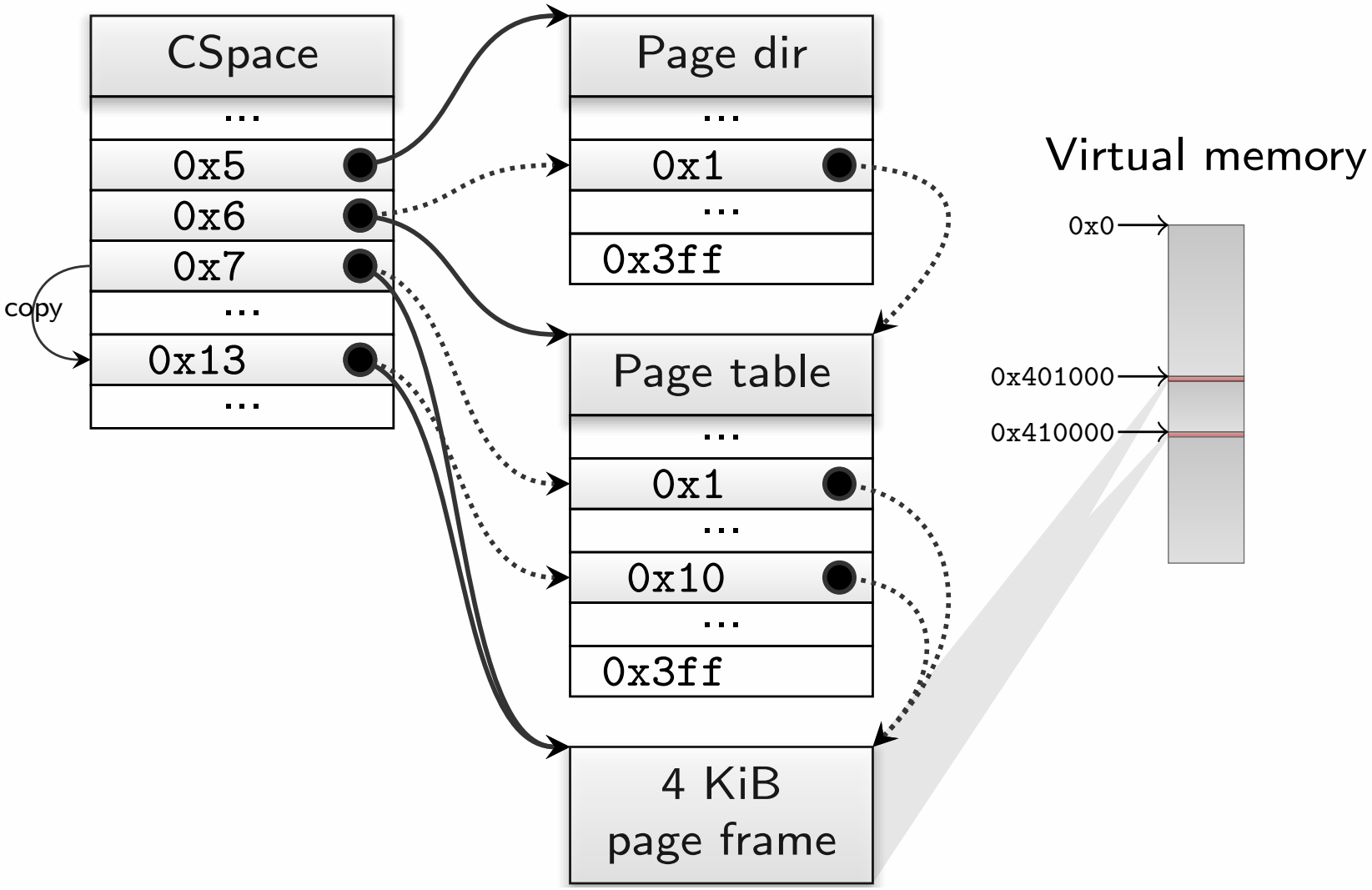


Mapping a page twice, the seL4 way



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- Fixed pool of page tables per PD, used in LRU fashion
- Leveraging Genode's resource trading mechanism:
  → Page-table pool size is a PD-specific

Outline

What's next?

- seL4 2.0
- Signal API backend, interrupts
- Memory-mapped I/O
- Real lock implementation
- Shared library support

→ *Interactive scenarios by mid 2016*

Open issues

- Asynchronous notifications

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- Capability integrity protection

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- Capability integrity protection
- Superpages

Thank you

Articles about Genode on seL4

http://genode.org/documentation/articles

Genode OS Framework

http://genode.org

Genode Labs GmbH

http://www.genode-labs.com

Source code at GitHub

http://github.com/genodelabs/genode