A Binary Compatible Unikernel

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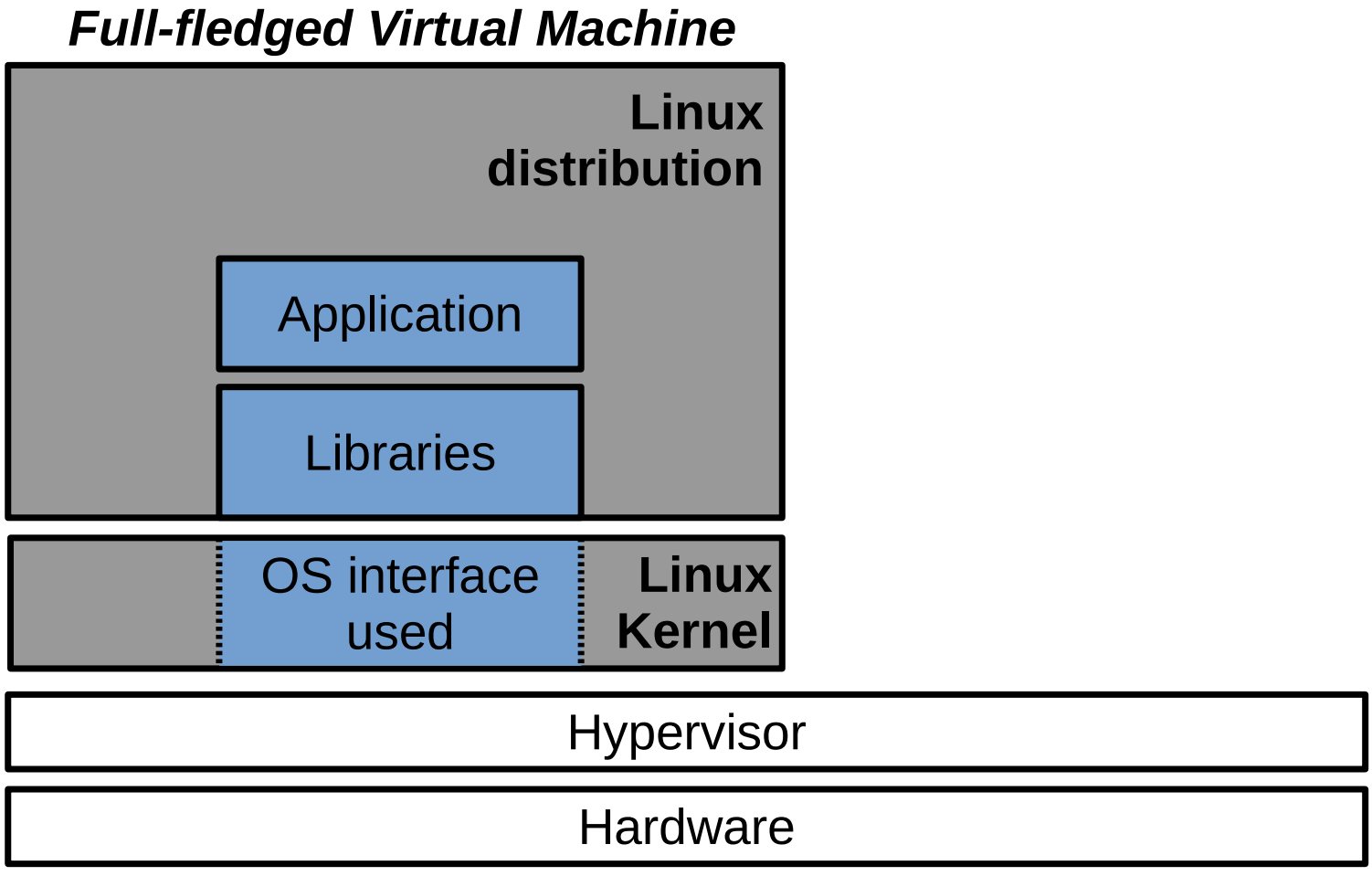
Unikernels
Presentation



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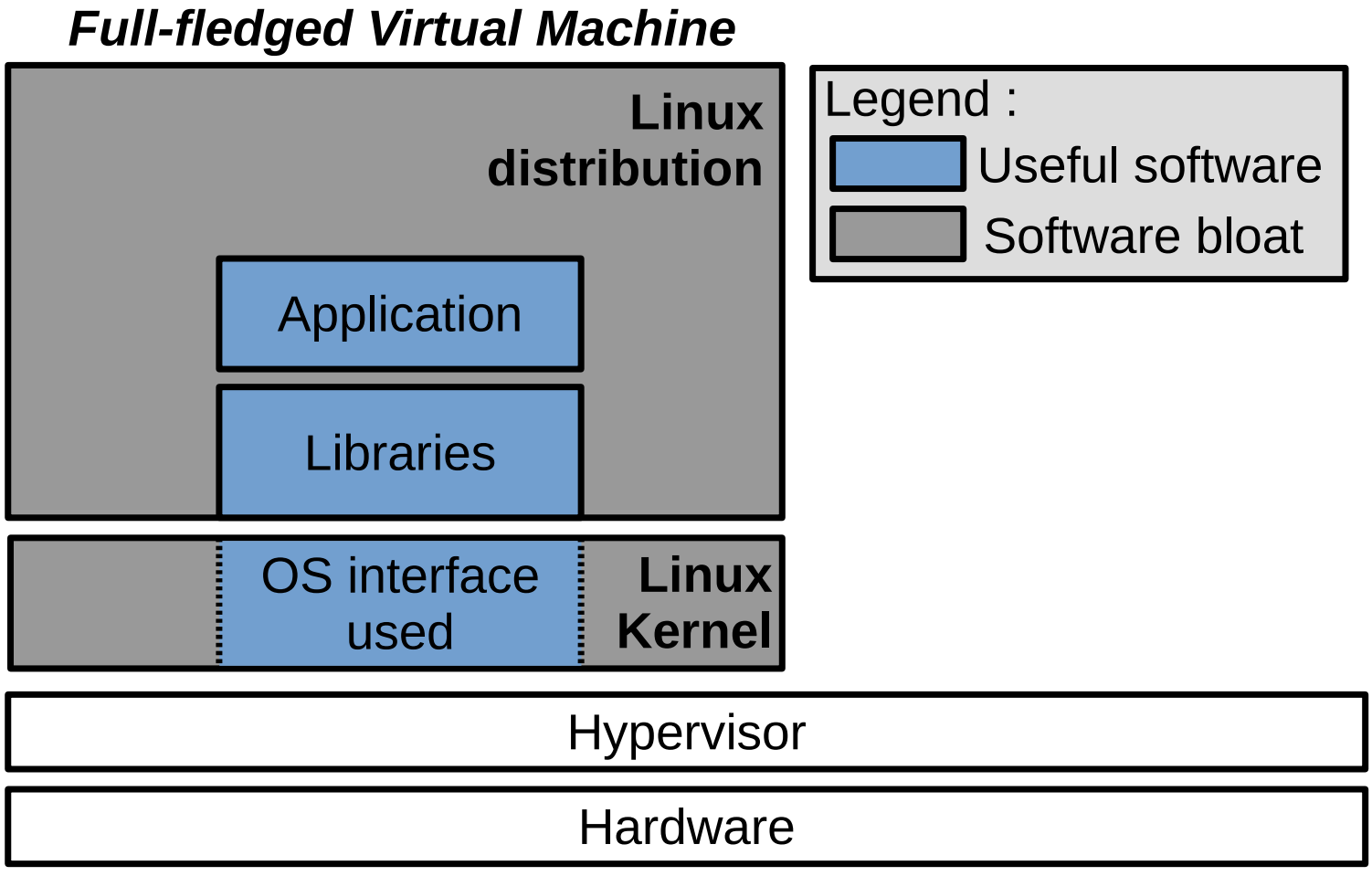

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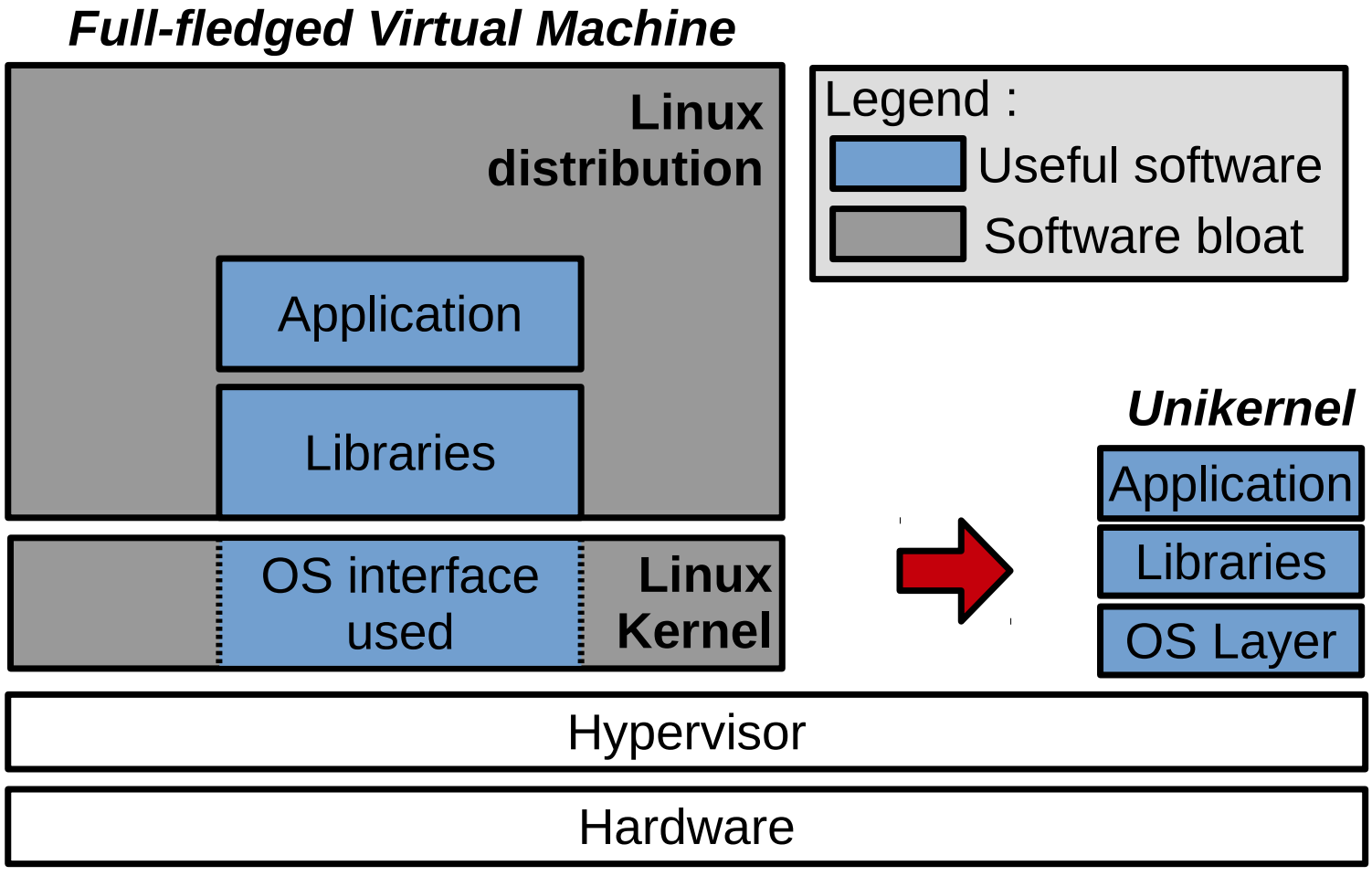

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Presentation (2)

Unikernel: application + dependencies + thin OS compiled as a static binary running on top of a hypervisor

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- **Reduced OS noise, increased performance**
  - Low system call latency
    - App + kernel in ring 0, system calls are function calls

Unikernels
The Issue

- Unikernels have plenty of benefits to bring
- Unikernels have plenty of application domains
- They are very popular in academia ...
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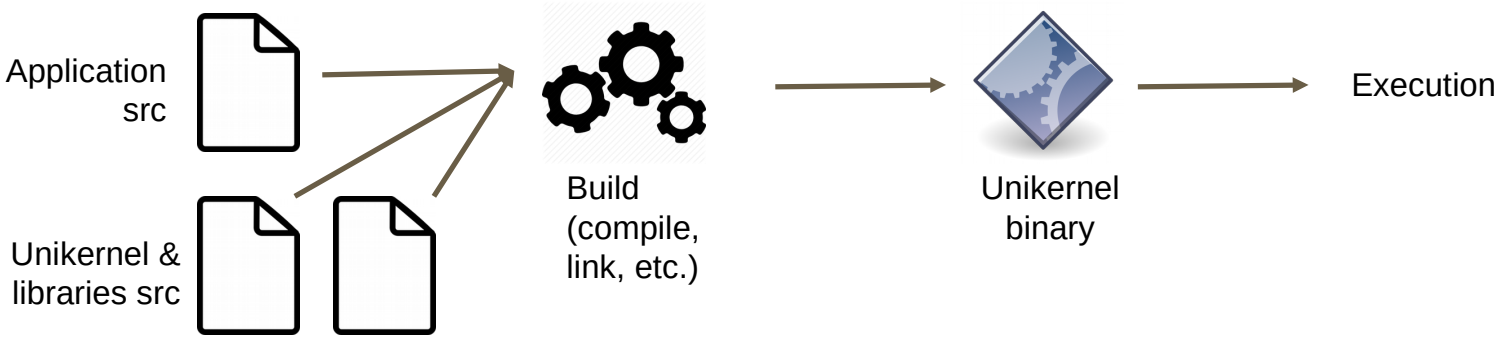
Because it is hard to port existing applications!

Unikernels

The Issue: Porting to Unikernels



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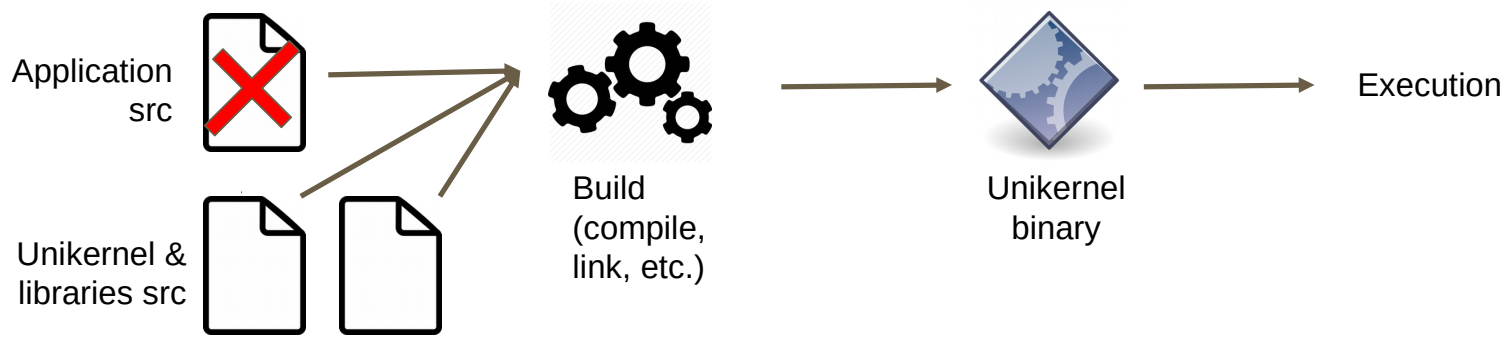

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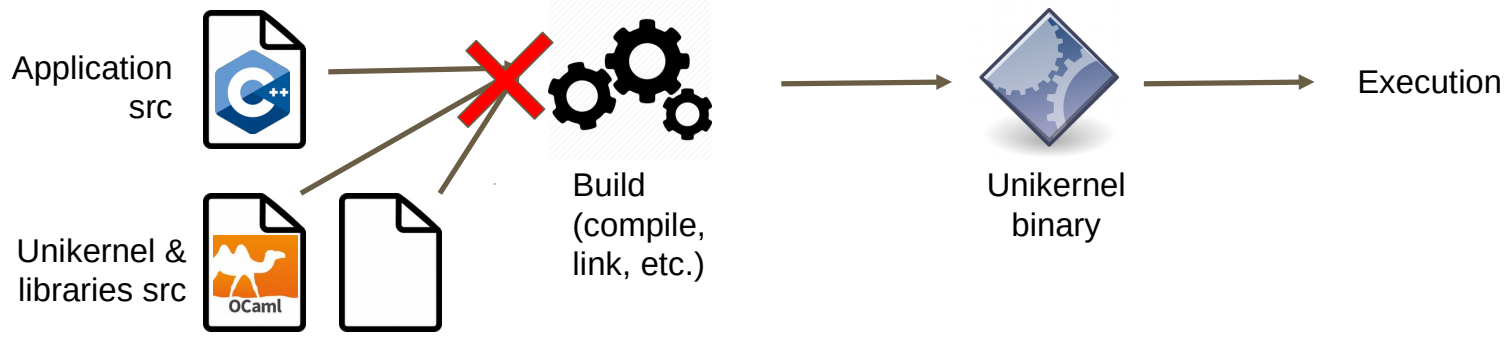

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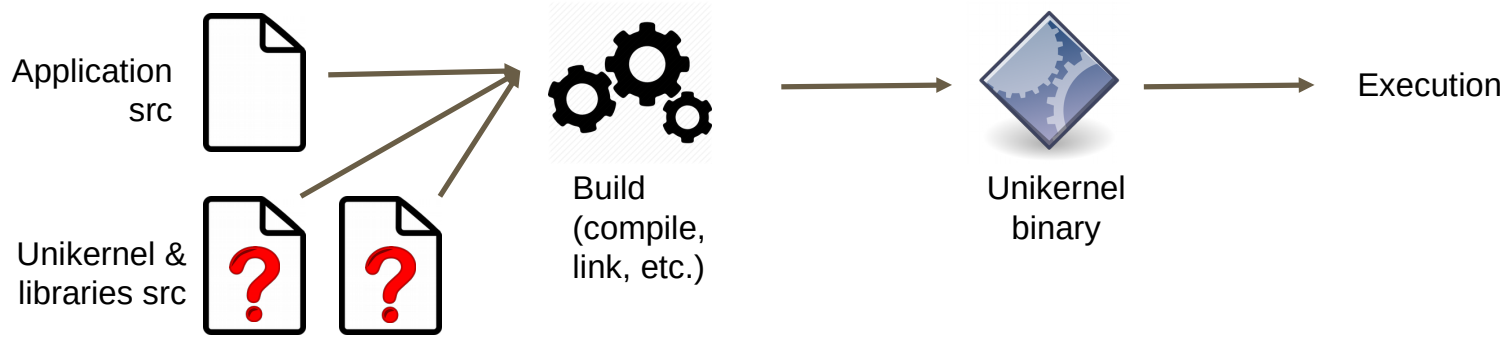

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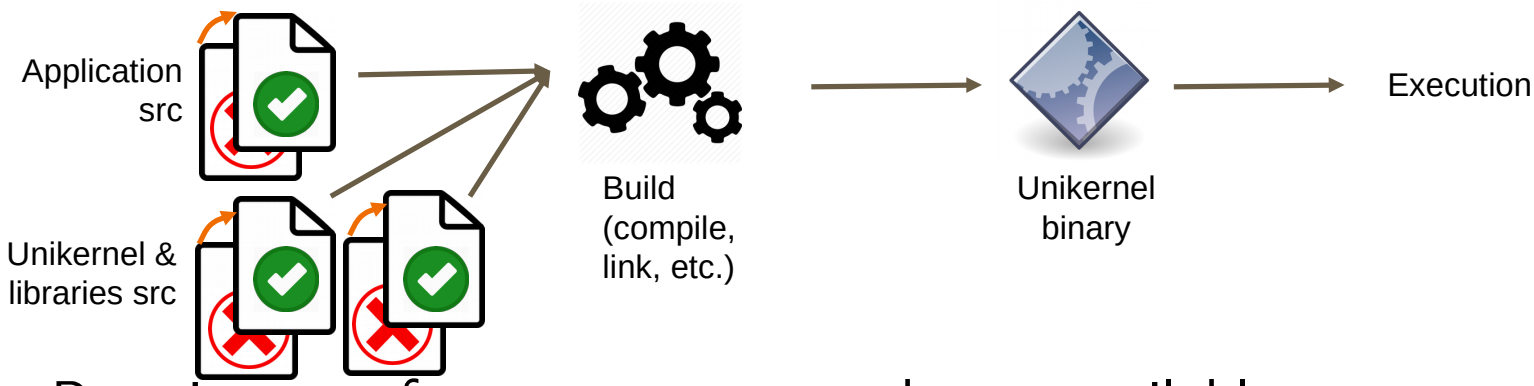

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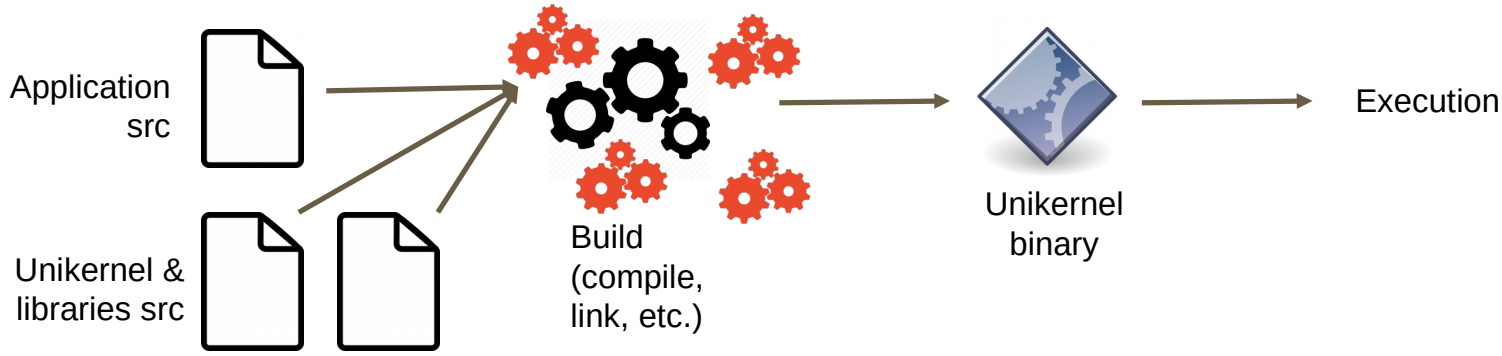

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HermiTux Solution

- **A unikernel binary-compatible with Linux**
  - For x86-64 for now

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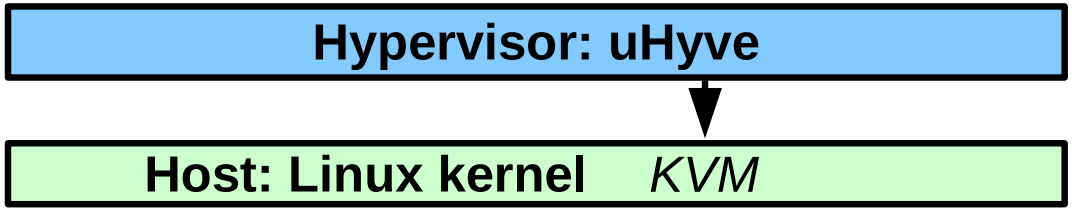

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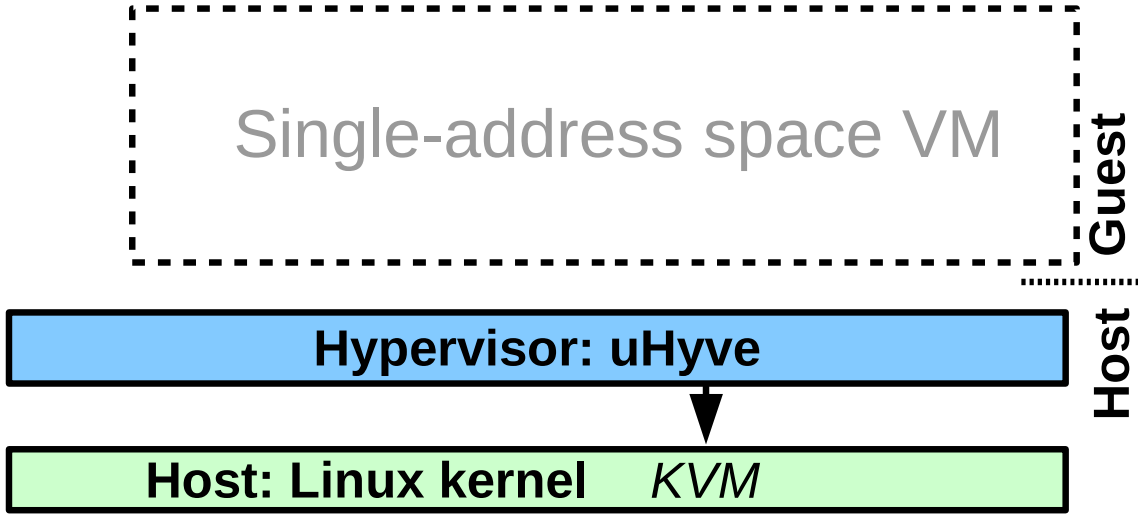

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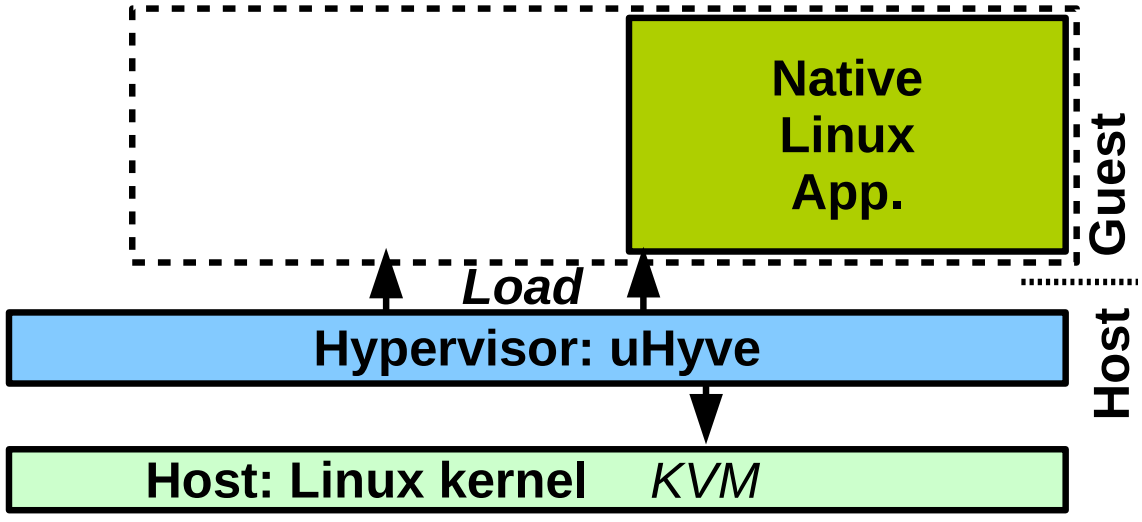

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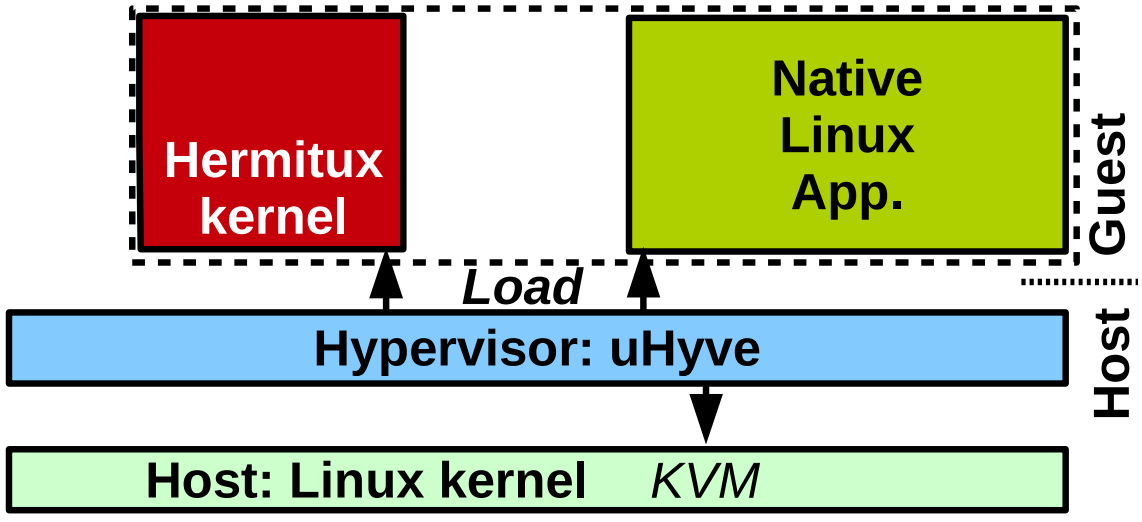

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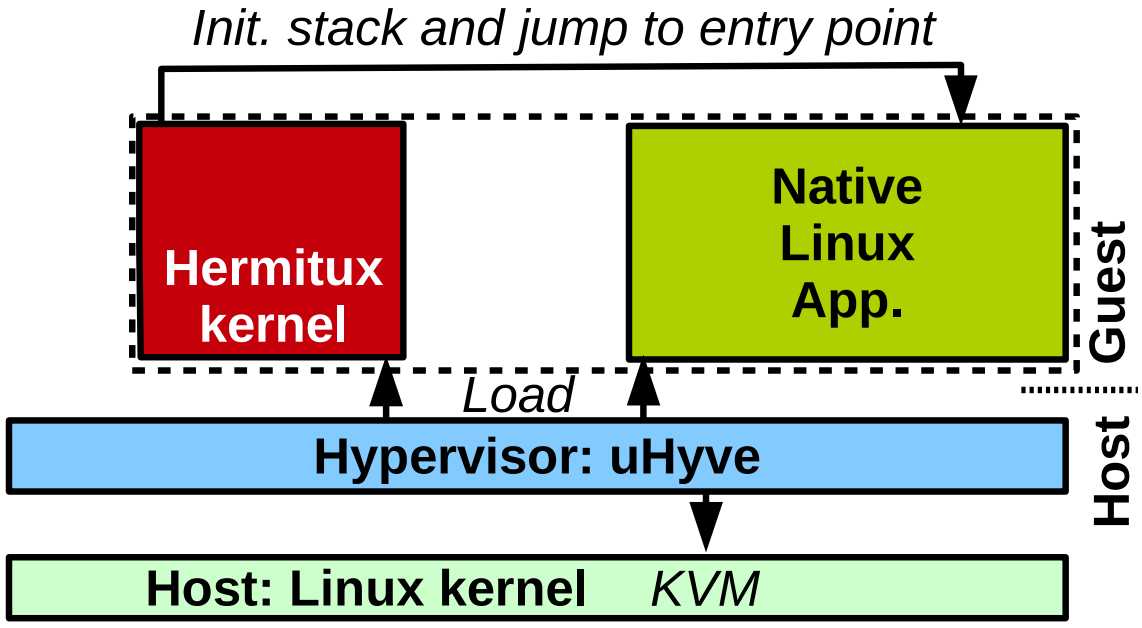

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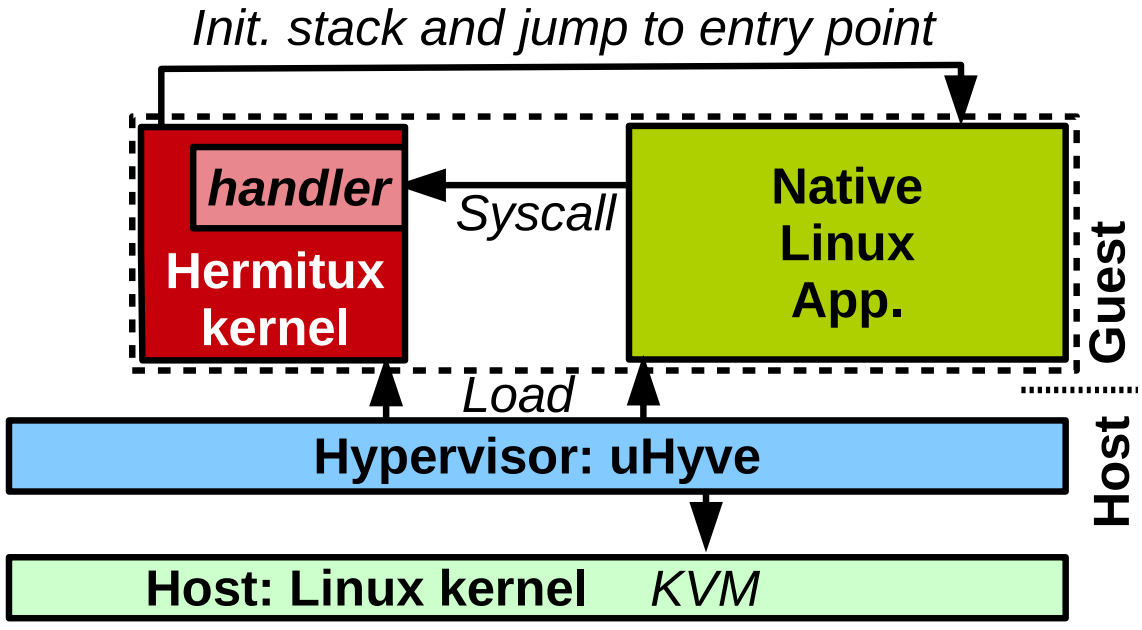

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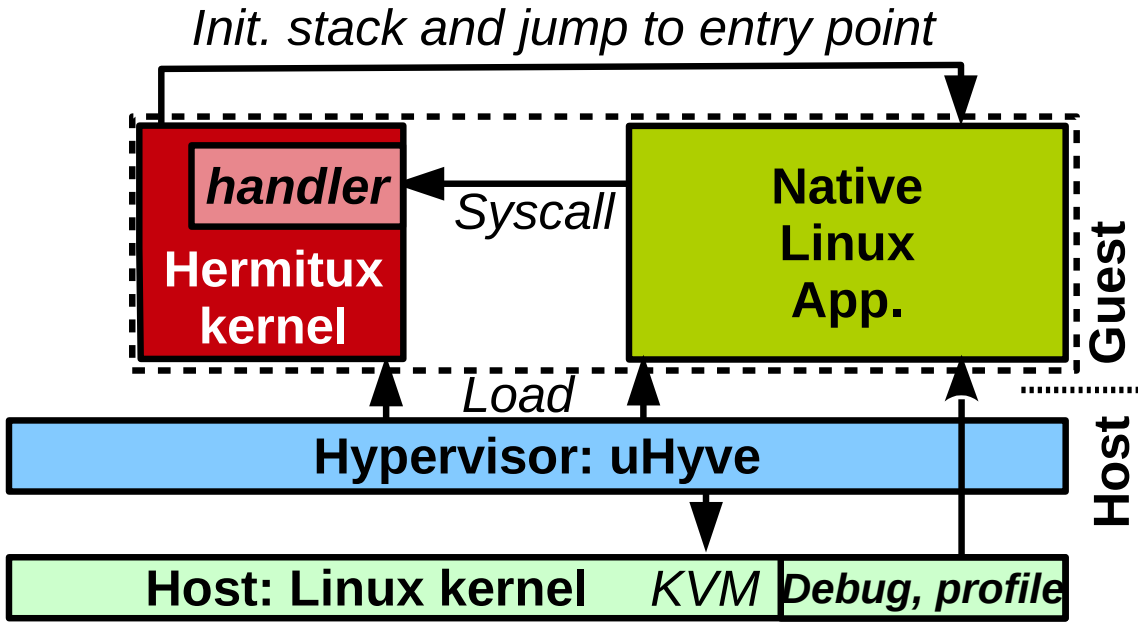

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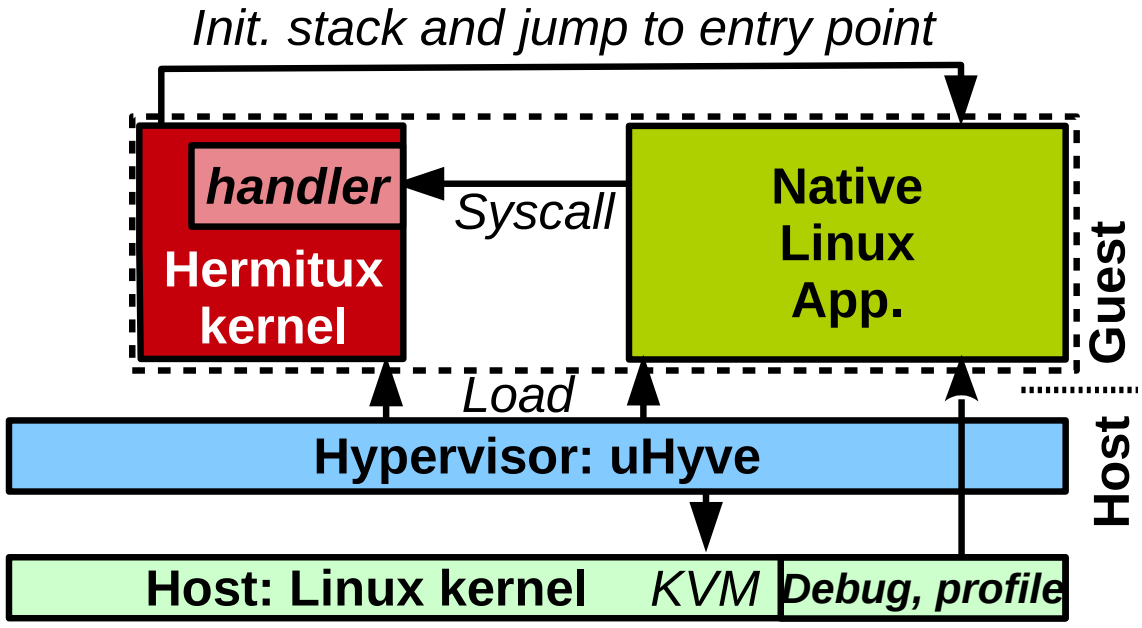

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- **How to maintain unikernel benefits without access to the application sources?**
  - *Fast system calls* and *modularity*

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Fast Syscalls with Libc Substitution

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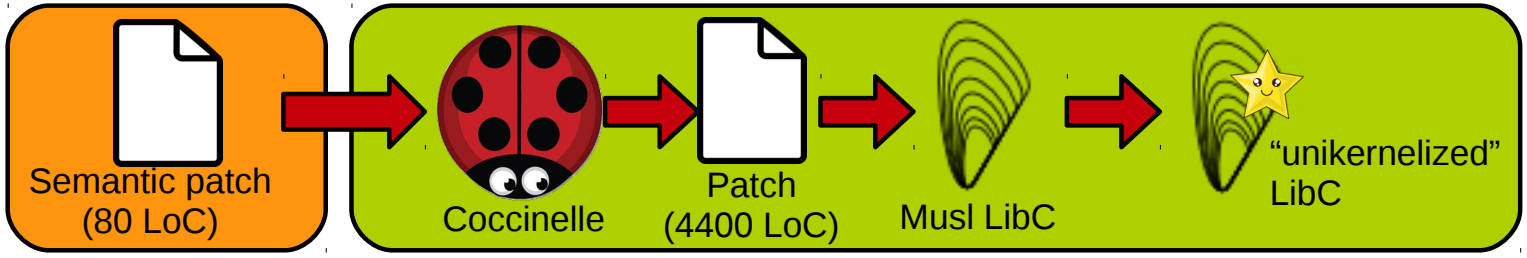
Fast Syscalls with Libc Substitution

- HermiTux's syscall handler is invoked by the `syscall` instruction
  - Reintroduce high latency for system calls due to the world switch
- For **dynamically compiled programs:**
  - At runtime **load a unikernel-aware Libc**
    - Making for system calls (fast) function calls directly into the kernel
  - Automatically transformed version of Musl Libc with Coccinelle



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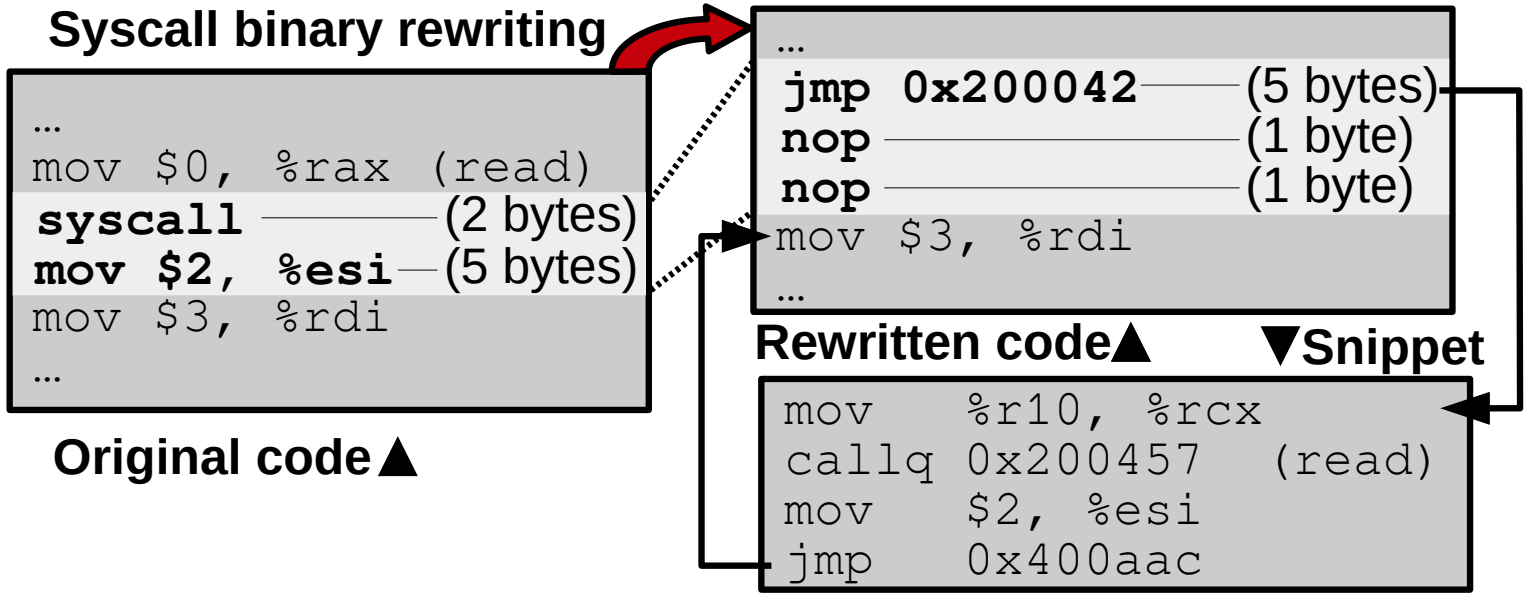
Fast Syscalls with Binary Rewriting

- What about **static binaries?**
- (Statically) **binary-rewrite `syscall` instructions to direct jumps to the syscall implementation**
  - Problem: `syscall` is 2 bytes long and any `call`/`jmp` instruction will be larger



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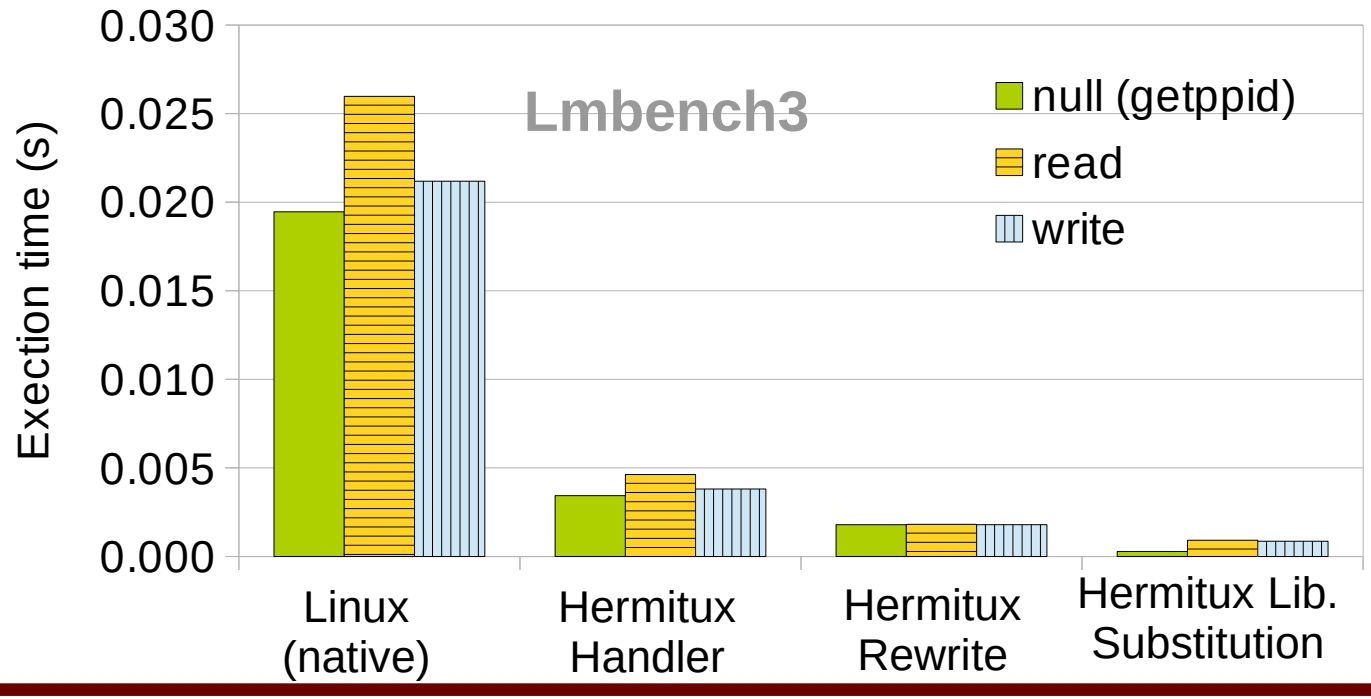

Unikernels
System-call-based Modularity

- System-call based modularity
  - Compile a kernel with support for only the necessary system calls
  - How to identify syscall needed without access to the sources?
    - **Use binary analysis** to find out what is the value in `%rax` for each `syscall` invocation

Program	Number of system calls	Kernel `.text` size reduction
Minimal	5	21.87 %
Hello world	10	19.84 %
PARSEC Blackscholes	15	17.05 %
Postmark	26	14.36 %
Sqlite	31	11.34 %
Full syscalls support	64	00.00 %

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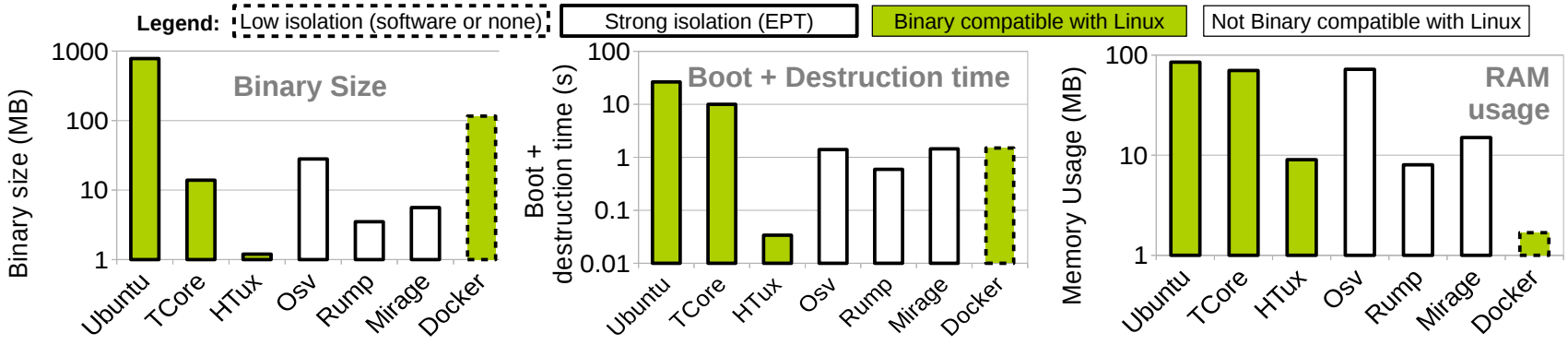
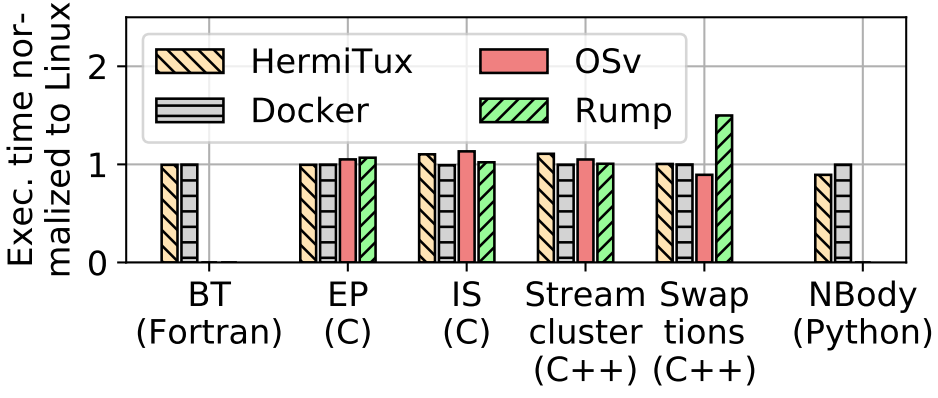
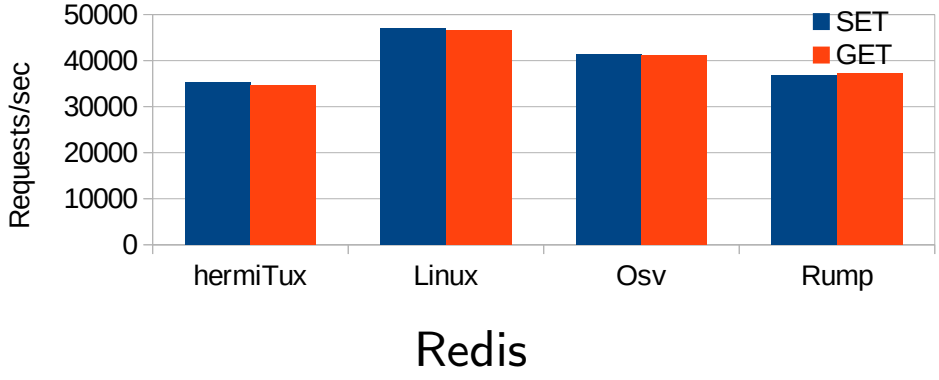
Evaluation



- Image 650x smaller, boot time 780x faster, RAM usage 9x lower than a Linux VM!





Conclusion

- Porting to unikernels is hard
  - Hinders their adoption in the industry
- **HermiTux provides binary-compatibility with Linux applications**
- HermiTux **maintains unikernel benefits:**
  - Fast boot times, small footprints
  - Various techniques to get fast system calls and modularity

It's open source, try it out!

`https://ssrg-vt.github.io/hermitux/`