A Rust-based Alternative for BPF

Bachelor Thesis Colloquium

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RUB - ITS

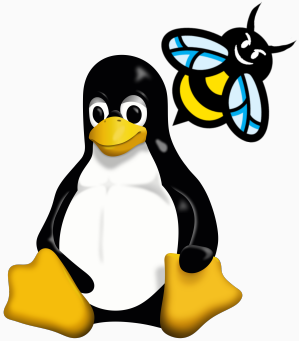
Motivation

What Makes eBPF so Important?

- Fast and safe kernel extensions
- Important for very time sensitive tasks
  - Profiling
  - Network packet rerouting
  - Security
  - ...

[?]

Why Might an Alternative to eBPF be Necessary?

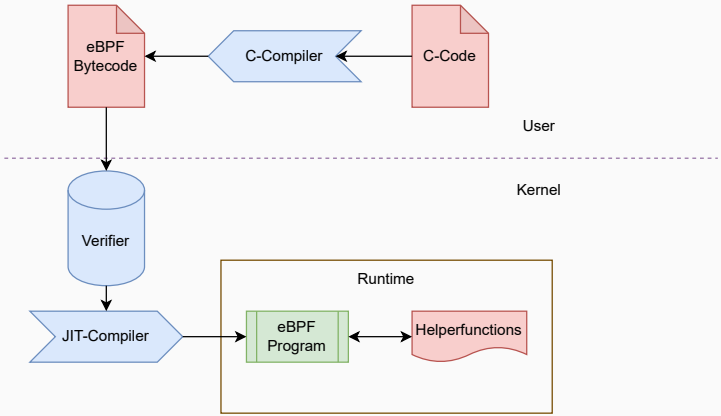


- Very complex
- Restrictive
- Safety and security concerns

Structure

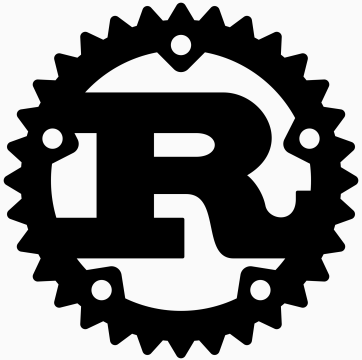
Necessary Background on Important Technologies

High-Level View of eBPF



Rust

- Growing kernel support
- Only other language besides C and ASM used for Linux kernel
- Memory and type safe [?, ?, ?]
  - Resource Acquisition Is Initialization (RAII)
  - Ownership and borrowing
- Similar performance to C [?, ?, ?, ?]



[?]

Parallels Betweeen eBPF and Rust

Feature	eBPF	Rust
Calling other programs	✓	✗
Dead code elimination	(✓) only privileged programs	✓
Bounded loops	(✓) limited in complexity	✗
No deadlock	✓	✗
Memory Safety	✓	✓
Stack Safety	✓	(✓) with compiler pass
Stack Security	✓	✓

In-depth View of the Proposed Alternative

How Safety is Achieved

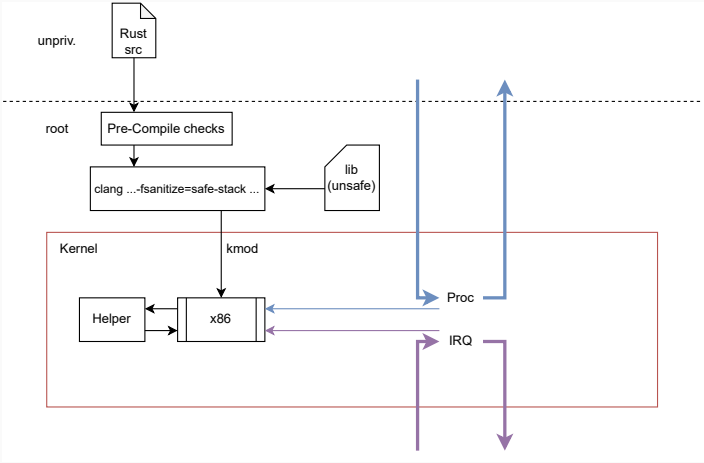
- Memory/type safety $\rightarrow$ Rust language features
- Stack security (e.g. Stack buffer overflow)$\rightarrow$ compiler passes [**?**, **?**]
- Bounded stack size $\rightarrow$ compiler [**?**], 3rd party [**?**], guard page
- Termination $\rightarrow$ pre-emption timer
- Kernel locks $\rightarrow$ exclude from provided library
- Less helper functions $\rightarrow$ more expressive

Checks Differ for IRQ-Context

- No pre-emption possible
- Termination
  - Bounded execution time needs to be assured
    - → Check loops and recursion [**?**, **?**]
- Blocking calls
  - Analyze call graph [**?**]
  - Exclude functions with blocking calls from provided library

Implementation of Important Structural Parts

High-Level View of the Proposed Structure



Tool for Compiling and Loading of a Module

- Conceptual implementation
- Provides basic pipeline for
  - Checking
  - Compiling
  - Loading

Rust Macro for Loop Checking

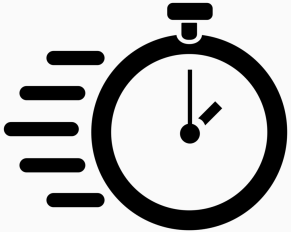
- Checks for *for*- and *while*-loops
- Can recognize *for*-loops with a constant range
  - for <variable> in <number>..<number> {...}
  - Constant range might not be constant runtime
- Can distinguish between *for*-loops and trait implementation
- missing checks for *loop*-loops (infinite loops)
- Easily extensible
- Takes 0,18s for around 500 lines of Code

Example for Rejected Code

```
fn it_works() {
    ...
    for i in 0..1 { \\static range
        for n in 0..j { \\variable range
            println!("{}",n);
        }
    }
}
```

Estimating the Alternatives Capabilities

Expected Computation Speed



[?]

- WAT or AOT compilation results in a faster program than JIT-compilation
- More efficient code due to less restrictions
- Might be possible to use hardware acceleration [?]

Expected Safety and Security

- Memory, type and stack safety are guaranteed by compiler/language features
- Pre-emption timer have been shown to work
- Memory acquisition and release with Drop trait might cause problems
- Checking for termination through AST analyzing might leave loopholes

Conclusion

Conclusion

- eBPF promises safe kernel extensions
- Does not deliver on these promises
- Rust has memory safety build in
- Most other safety concerns can be adressed easily
- Might be easier to work with and result in better programs

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