Rusty Linux: Advances in Rust for Linux Kernel Development

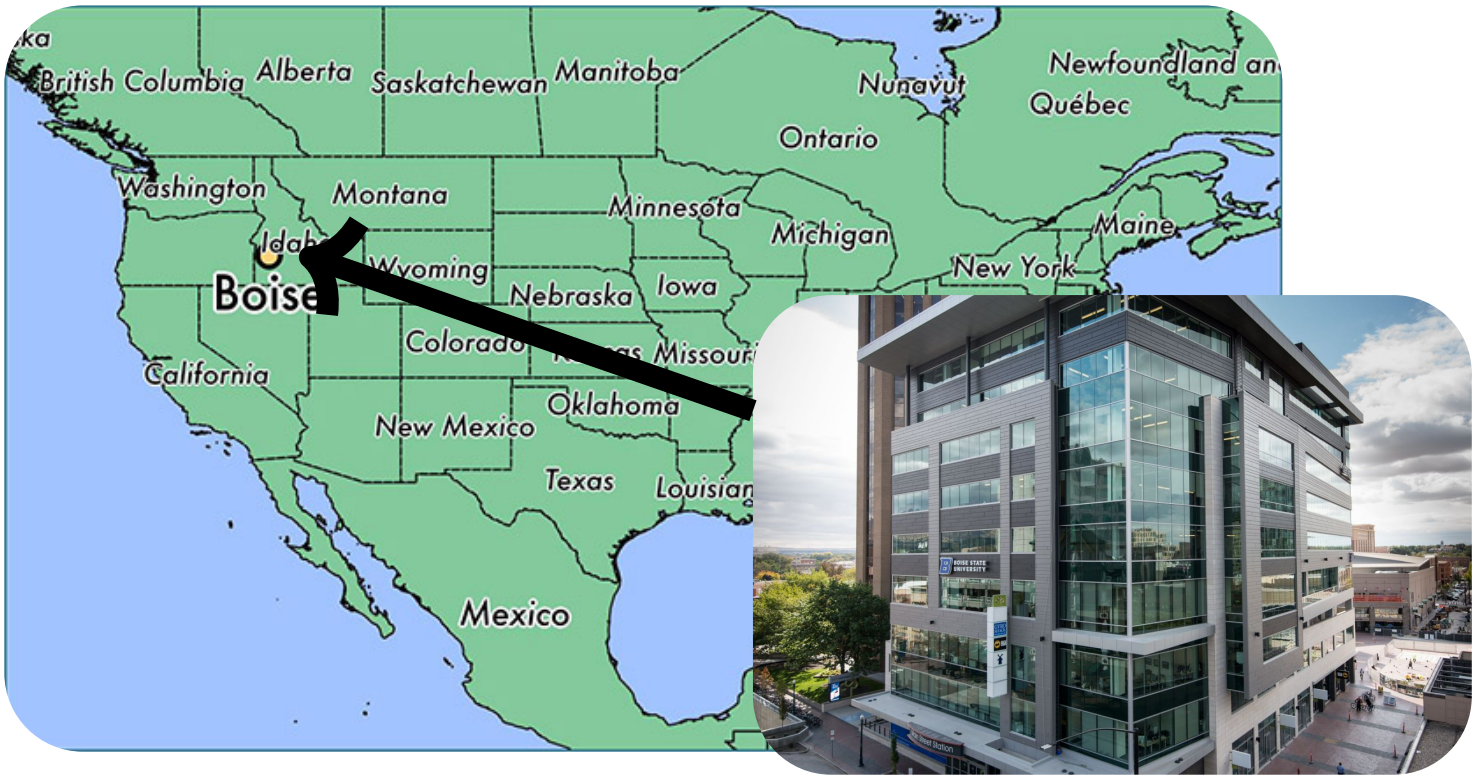
Shane K. Panter[1] Nasir Eisty[2]

[1]Clinical Assistant Professor
Boise State University

[2]Assistant Professor
Boise State University

International Symposium on Empirical Software Engineering and Measurement, October 2024

Introduction



Boise State University

The Computer Science Department is located in Beautiful downtown Boise Idaho, United States!

Our Research

We aim to find the current advances in using Rust in Kernel development to reduce the number of memory safety vulnerabilities in one of the most critical pieces of software that underpins all modern applications (SLR).

▸ Paper Link

Figure: A rusty computer[1]

[1]AI Prompt: A rusty computer with a penguin next to it

Why Rust

- Low-level **control** like C and C++

Why Rust

- Low-level **control** like C and C++
- Strong **safety** guarantees

Why Rust

- Low-level **control** like C and C++
- Strong **safety** guarantees
- **Modern**, functional paradigms

Why Rust

- Low-level **control** like C and C++
- Strong **safety** guarantees
- **Modern**, functional paradigms
- Industrial development and backing

Why Rust

- Low-level **control** like C and C++
- Strong **safety** guarantees
- **Modern**, functional paradigms
- Industrial development and backing
- No garbage collector needed! All checks are performed at compile time

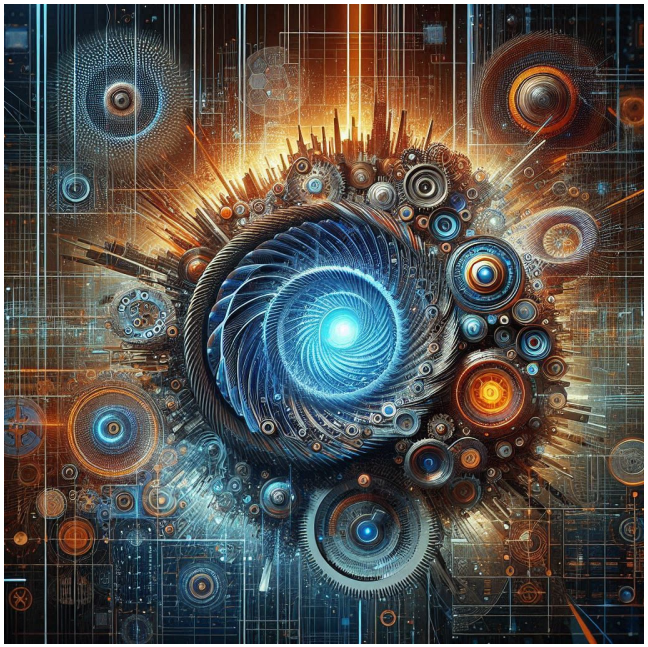
RQ1

RQ1: What are the existing approaches for implementing operating system kernels in Rust?[2]

[2] Fun side note: What happens if we put our research questions into an AI image generator?

RQ2

RQ2: What are the performance implications of using Rust for operating system kernel development?



RQ3

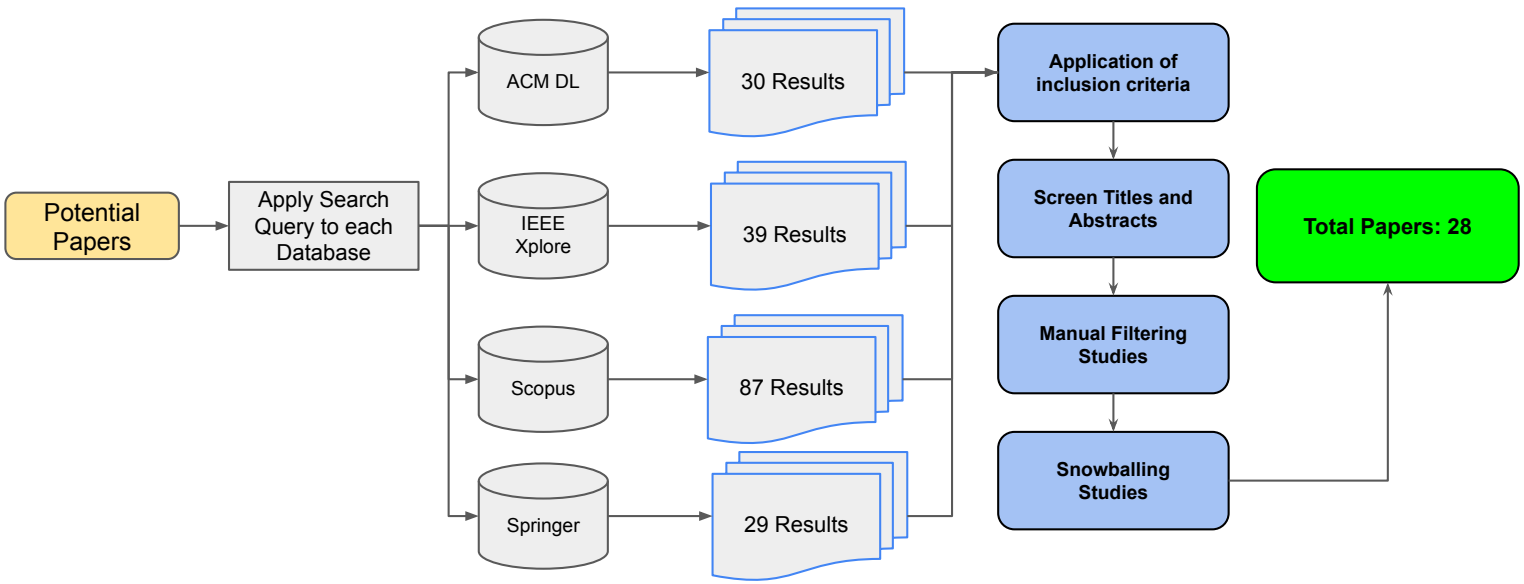
RQ3: What are the major challenges and limitations when developing operating system kernels in Rust?

RQ4

RQ4: What are the lessons learned when developing operating systems kernels in Rust?

Process Diagram

Rusty Linux



Results

Our findings!

Figure: Super happy researcher![1]

[1]AI Prompt: scientist getting research results and is super happy in a cyberpunk universe with lots of computers showing matrix code on them

RQ1

Table: Approaches and Methodologies for Rust in the Kernel

Approach	Papers	Operating System in Rust
Monolithic	4	Linux Kernel v6.1+
Micro-kernel	5	Atmosphere, Redox, Redleaf
Embedded	2	Tock, Hubris, Drone, Bern, HarSaRK
Unikernel	4	RustyHermit, Theseus

RQ2

Table: Performance Implications of Rust in the Kernel

No.	Implication	Studies that Reported the challenge
1	Performance	3
2	Throughput	1
3	Latency	1

- Performance issues - Caused by the safe $->$ unsafe transition layer
- Throughput issues - Caused by immature and or missing bindings within the FFI layer
- Latency issues - Caused by the interrupt layer written in Rust

RQ3: Challenges and Limitations

- Binary Size
  - Rust can produce larger binaries
  - The same issue that C++ templates have!

RQ3: Challenges and Limitations

- Binary Size
  - Rust can produce larger binaries
  - The same issue that C++ templates have!
- Missing Features
  - Rust still evolving and adding features
  - Makes it difficult to integrate into the classroom due to the rapid evolution

RQ3: Challenges and Limitations

- Binary Size
  - Rust can produce larger binaries
  - The same issue that C++ templates have!
- Missing Features
  - Rust still evolving and adding features
  - Makes it difficult to integrate into the classroom due to the rapid evolution
- Soundness - How to deal with raw memory without sacrificing safety?

RQ3: Challenges and Limitations

- Binary Size
  - Rust can produce larger binaries
  - The same issue that C++ templates have!
- Missing Features
  - Rust still evolving and adding features
  - Makes it difficult to integrate into the classroom due to the rapid evolution
- Soundness - How to deal with raw memory without sacrificing safety?
- Panics - What happens when things go wrong?

RQ3: Challenges and Limitations

- Binary Size
  - Rust can produce larger binaries
  - The same issue that C++ templates have!
- Missing Features
  - Rust still evolving and adding features
  - Makes it difficult to integrate into the classroom due to the rapid evolution
- Soundness - How to deal with raw memory without sacrificing safety?
- Panics - What happens when things go wrong?
- C Interop - Specific to mixed language kernels

RQ4: Lessons Learned

- Impossible to use 100% rust - Same with C, some low level asm is needed to setup initial stack pointer, etc.

RQ4: Lessons Learned

- Impossible to use 100% rust - Same with C, some low level asm is needed to setup initial stack pointer, etc.
- Rust is not as expressive as other formal verification techniques

RQ4: Lessons Learned

- Impossible to use 100% rust - Same with C, some low level asm is needed to setup initial stack pointer, etc.
- Rust is not as expressive as other formal verification techniques
- Ownership root - An OS provides memory to rust so if the OS is itself written in rust who is the root owner?
  - Open research question if this can even be done in software
  - Researchers looking at hardware support (CHERI)

Conclusion

- We are still in the early stages of figuring out who to do kernel dev in Rust

Conclusion

- We are still in the early stages of figuring out who to do kernel dev in Rust
- High potential for enhanced security and stability

Conclusion

- We are still in the early stages of figuring out who to do kernel dev in Rust
- High potential for enhanced security and stability
- Need to address integration issues (FFI)

Conclusion

- We are still in the early stages of figuring out who to do kernel dev in Rust
- High potential for enhanced security and stability
- Need to address integration issues (FFI)
- Need to expand the body of empirical evidence on Rust's impact! (Or more generally low level memory safe languages)

Questions?

Questions?

Figure: Happy People[1]

[1]AI Prompt: People attending a conference who all want to ask a question and are really excited!