

Rusty Linux

Introduction Our Research

Why Rust

Methodology

Research Questions

RQ1

RQ2

RQ3

r.Q4

Results

Approaches

RQ2: Performance
Implications

RQ3: Challeng Limitations

RQ4: Lessons Learned

Conclusior

Questions?

Rusty Linux: Advances in Rust for Linux Kernel Development

Shane K. Panter¹ Nasir Eisty²

¹Clinical Assistant Professor Boise State University

²Assistant Professor Boise State University

International Symposium on Empirical Software Engineering and Measurement, October 2024



Introduction

Rusty Linux

Introduction

Why Rus

vviiy itus

Research Questions

RQ1 RQ2 RQ3

Process Diagr

_ .

RQ1: Existing Approaches RQ2: Performance Implications

Implications

RQ3: Challenges a
Limitations

RQ4: Lessons

Conclusio

Questions?



Boise State University

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



Our Research

Rusty Linux

Introduction Our Research

Why Rust

Methodology Research Questions RQ1

RQ3 RQ4

Process Diagran

RQ1: Exist Approaches

Approaches
RQ2: Performance
Implications
RQ3: Challenges and
Limitations
RQ4: Lessons

Conclusion

Questio

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).

Figure: A rusty computer¹



▶ Paper Link

¹Al Prompt: A rusty computer with a penguin next to it



Why Rust

Rusty Linux

Introduction Our Research

Why Rust

Methodolog

Research Questions

RQ1

RQ3

RQ4 Process Diagra

D. . . I .

RQ1: Existing Approaches RQ2: Performance Implications RQ3: Challenges a

C

- 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

Rusty Linux

RQ1

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



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

RQ2

Rusty Linux

Our Research

Why Rus

Methodology Research Questions

Research Questions

RQ3

Process Diagra

Poculto

RQ1: Existing Approaches

RQ2: Performanc Implications RQ3: Challenges

RQ4: Lessons Learned

Conclusion

Questions 7

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



RQ3

Rusty Linux

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





 ${\sf Rusty\ Linux}$

Introduction Our Research

Why Rus

Methodology Research Questions

Research Question RQ1 RQ2

RQ3

RQ4

Process Diagr

RQ1: Existing Approaches RQ2: Performance

RQ3: Challeng Limitations

RQ4: Lessons Learned

Conclusion

Questions

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





Process Diagram

Rusty Linux

Our Possarch

Why Rust

Mathadalam

Research Questions RQ1

RQ2

RO4

Process Diagram

Results

Approaches

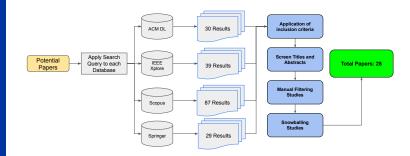
Implications

Limitations

RQ4: Lesson Learned

Conclusion

Questions'





Results

Rusty Linux

Introducti Our Research

Why Rus

Methodology

Research Questions RQ1

RQ2

Process Diam

Results

Approaches

RQ2: Performance
Implications

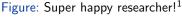
RQ3: Challenges:

Limitations RQ4: Lessons

Conclusion

Questic

Our findings!





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



 ${\sf Rusty\ Linux}$

Introductio
Our Research

Why Rus

Methodology
Research Questions
RQ1

RQ4 Process Diagra

Reculte

RQ1: Existing Approaches RQ2: Performance Implications

RQ3: Challenge Limitations RQ4: Lessons Learned

Conclusion

Ouestiens?

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



Rusty Linux

Our Research

vviiy Rus

Methodology Research Questions RQ1 RQ2

Process Diagra

RQ1: Existing Approaches RQ2: Performance Implications RQ3: Challenges at Limitations RQ4: Lessons

Conclusior

Questions?

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

Rusty Linux

Introductio Our Research

Why Rus

Methodology Research Questions RQ1

RQ4 Process Diagrar

Results

Approaches

RQ2: Performance
Implications

Limitations RQ4: Lessons

Conclusion

Questions?

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

Rusty Linux

Introductio

Why Rus

Methodology
Research Questions
RQ1
RQ2
RO3

RQ4 Process Diagrar

RQ1: Existing
Approaches
RQ2: Performance
Implications
RQ3: Challenges an
Limitations
RQ4: Lessons

Learned Conclusion

- 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

Rusty Linux

Introductio

Why Rus

Methodology Research Questions

RQ1 RQ2 RQ3

ocess Diagra

Results

RQ1: Existing Approaches RQ2: Performance Implications RQ3: Challenges at Limitations RQ4: Lessons

Conclusion

Questions?

- 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?

Rusty Linux

Questions?

Questions?

Figure: Happy People¹



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