Bridging the gap between Typestates and Rust in production code

José Duarte
António Ravara (Advisor)
March 2021
NOVA School of Science and Technology

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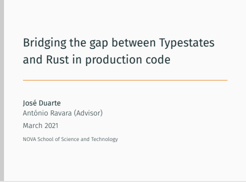

Bridging the gap between Typestates and Rust in production code

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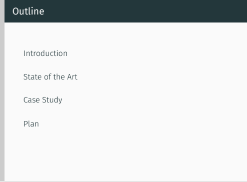
Hello everyone! My name is José Duarte and today I will be talking about using typestates in Rust. I'll present:

- A brief definition of typestates.
- Why they are useful.
- And finally I'll discuss their relationship with Rust and my proposal to integrate them in the ecosystem.

Outline


Outline

Introduction

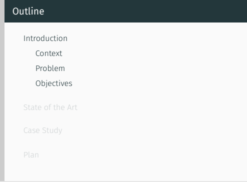
State of the Art

Case Study

Plan

Durante a apresentação irei introduzir o tema, rever sumáriamente o estado da arte, apresentar a proposta de trabalho e por fim rever o plano de trabalho da mesma.

Outline



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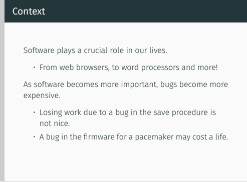
Context

Software plays a crucial role in our lives.

- From web browsers, to word processors and more!

As software becomes more important, bugs become more expensive.

- Losing work due to a bug in the save procedure is not nice.
- A bug in the firmware for a pacemaker may cost a life.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Problem

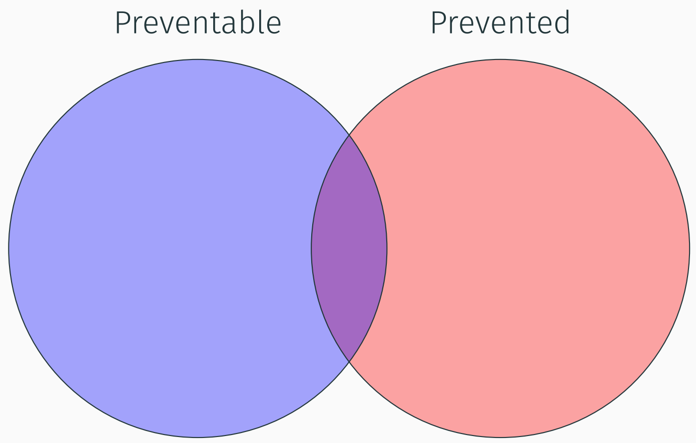
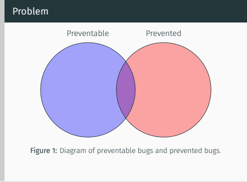


Figure 1: Diagram of preventable bugs and prevented bugs.


Problem

Preventable Prevented

Figure 1: Diagram of preventable bugs and prevented bugs.

Problem - with Rust

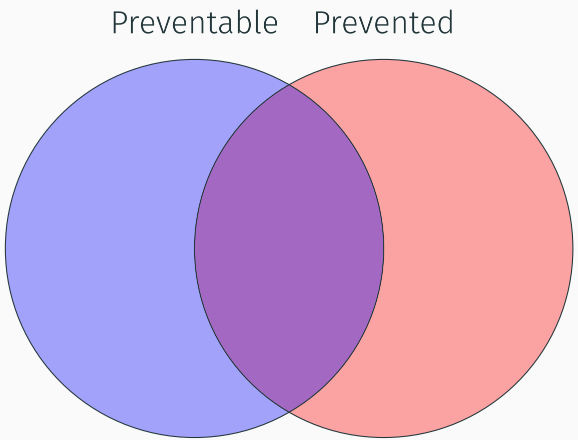
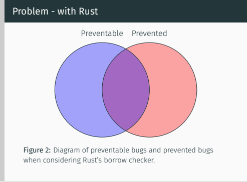


Figure 2: Diagram of preventable bugs and prevented bugs when considering Rust's borrow checker.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Problem - Ideal

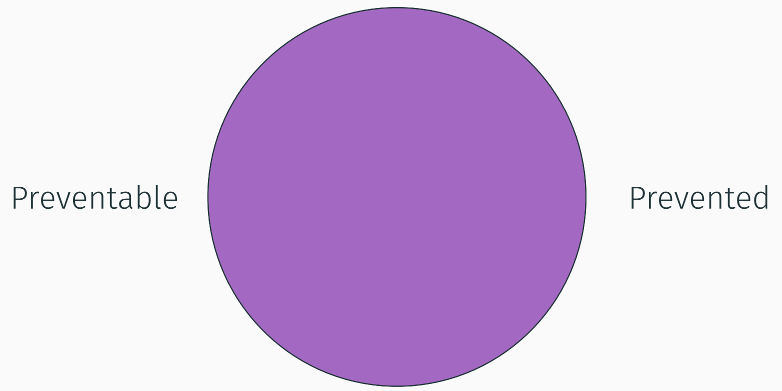


Figure 3: The ideal diagram of preventable bugs and prevented bugs, where all bugs are prevented.

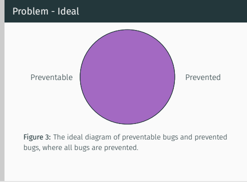
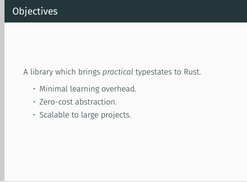

Problem - Ideal

Figure 3: The ideal diagram of preventable bugs and prevented bugs, where all bugs are prevented.

Objectives

A library which brings *practical* typestates to Rust.

- Minimal learning overhead.
- Zero-cost abstraction.
- Scalable to large projects.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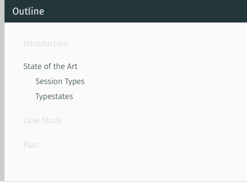

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Typestates

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Session Types

Bridging the gap between Typestates and Rust in production code
└─State of the Art
  └─Session Types

Typestates

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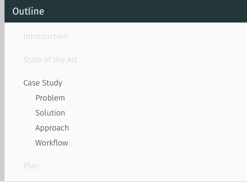
Bridging the gap between Typestates and Rust in production code
└─State of the Art
  └─Typestates

Outline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Solution

Approach

Workflow

Plan

└─Outline

Problem

Error happens at runtime, possibly crashing the program.

```rust
fn main() {
    let protocol = Protocol::new();
    protocol.step1();
    protocol.step3(); // runtime error
    protocol.step2();
}
```

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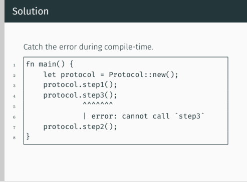
Solution

Catch the error during compile-time.

```
fn main() {
    let protocol = Protocol::new();
    protocol.step1();
    protocol.step3();
            ^^^^^^^
            | error: cannot call `step3`
    protocol.step2();
}
```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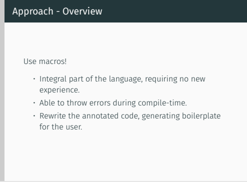
Approach - Overview

Use macros!

- Integral part of the language, requiring no new experience.
- Able to throw errors during compile-time.
- Rewrite the annotated code, generating boilerplate for the user.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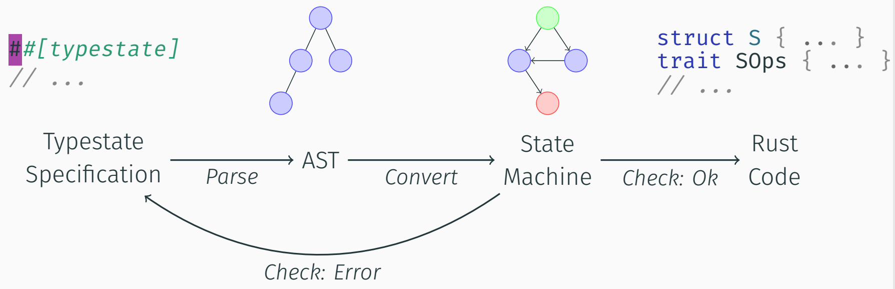
Approach - Going deeper



```
##[typestate]
// ...
```

```
struct S { ... }
trait SOps { ... }
// ...
```

$$\begin{tikzcd}
\text{Typestate Specification} \arrow[r, "Parse"'] & \text{AST} \arrow[r, "Convert"'] & \text{State Machine} \arrow[r, "Check: Ok"'] \arrow[ll, bend left, "Check: Error"] & \text{Rust Code}
\end{tikzcd}$$

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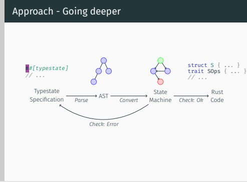
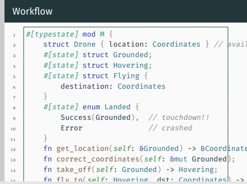
└Case Study

└Approach



Workflow

```
#[typestate] mod M {
    struct Drone { location: Coordinates } // avail
    #[state] struct Grounded;
    #[state] struct Hovering;
    #[state] struct Flying {
        destination: Coordinates
    }
    #[state] enum Landed {
        Success(Grounded),  // touchdown!!
        Error               // crashed
    }
    fn get_location(self: &Grounded) -> &Coordinate
    fn correct_coordinates(self: &mut Grounded);
    fn take_off(self: Grounded) -> Hovering;
    fn fly_to(self: Hovering, dst: Coordinates) ->
```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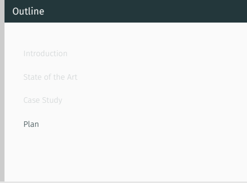
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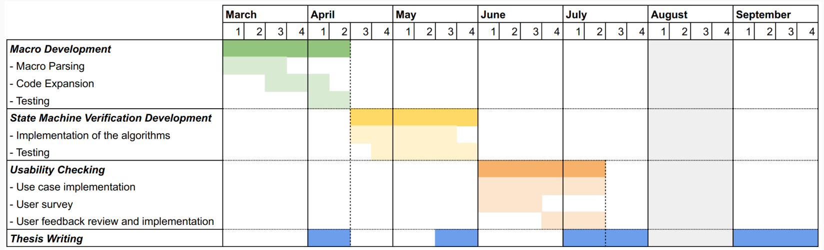

Figure 4: Work plan Gantt chart

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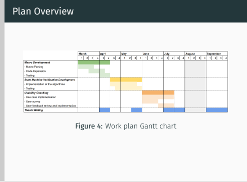
└Plan



Plan Overview

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