

Fast and safe web services with
axum

About me

- Tim Eggert
- Working at a Startup called drant as a Staff Engineer & Security Officer
- Recently moved to Baldenhain
- **Looking for a cozy place to talk about tech frequently!**

Me trying to make friends



Goal

- Broad overview about Rust and it's current usage/applications
- Detailed example to illustrate some features
- Encourage audience to try it out
- Provide resources for continued research

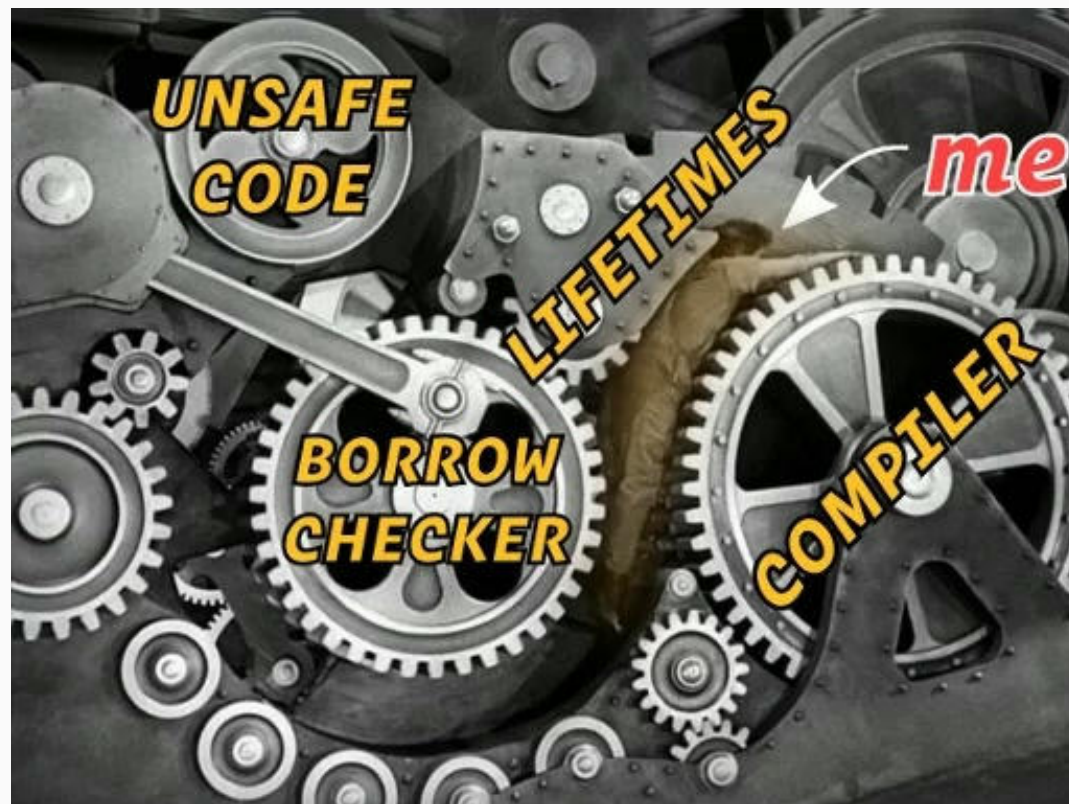


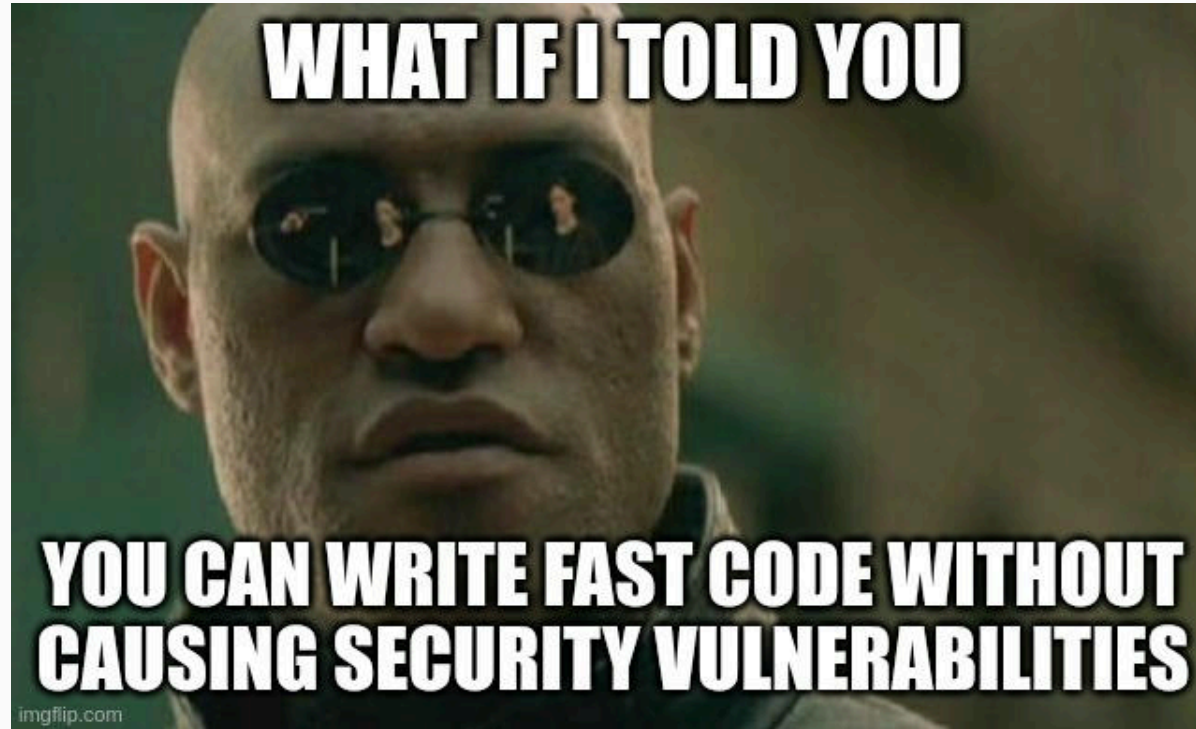
My way to Rust

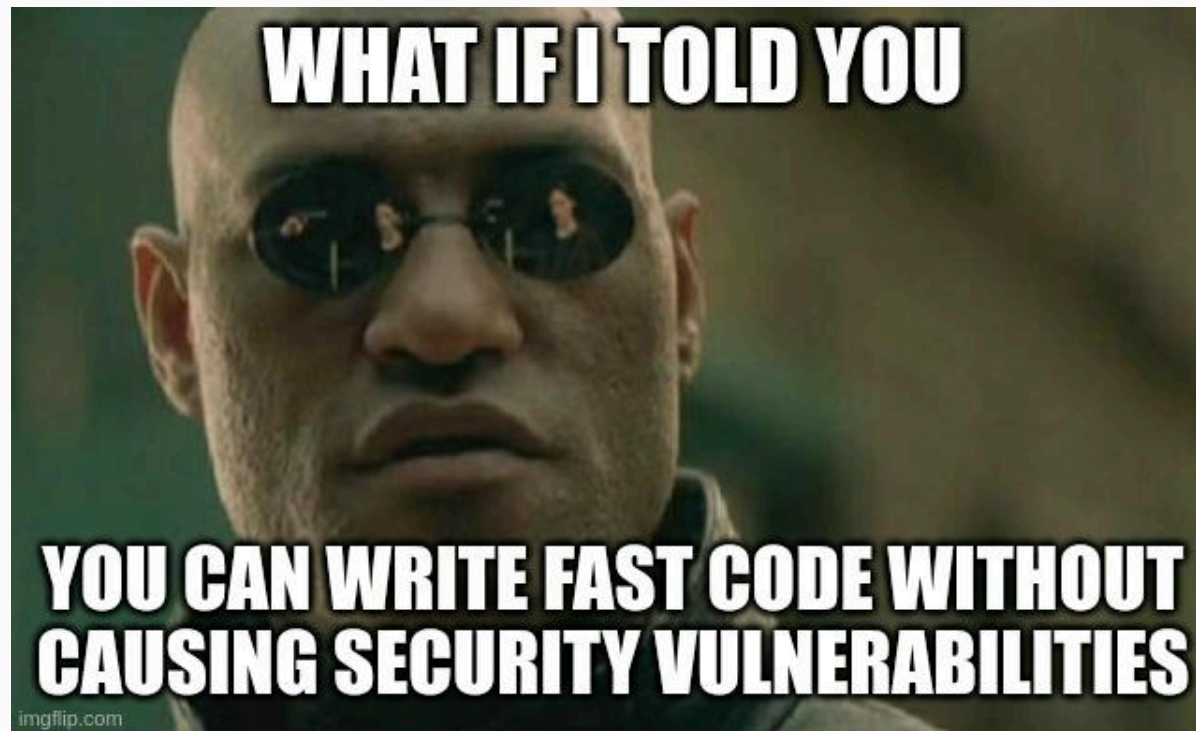
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- Sometimes Java, but too verbose...
- Some C++ 11 with type inference

My way to Rust

- Started programming with dynamic languages (PHP, later Python)
- Sometimes Java, but too verbose...
- Some C++ 11 with type inference
- Started my Rust journey in 2018 (freetime only)
 - Steep learning curve
 - Lot's of headaches with the Memory model







“A language empowering everyone to build reliable and efficient software.”

— <https://www.rust-lang.org>

Disclaimer!!!

**I am a fan of Rust, there might be a bias towards it,
which I cannot justify rationally...**

Rust Intro: Typical language features

- Compiled, statically typed language
- Generics
- Async
- Macros
- Multi-Threading
- Zero Cost Abstractions
- Minimal Runtime
- Inline Assembly Code

Rust Intro: Novel / exotic language features

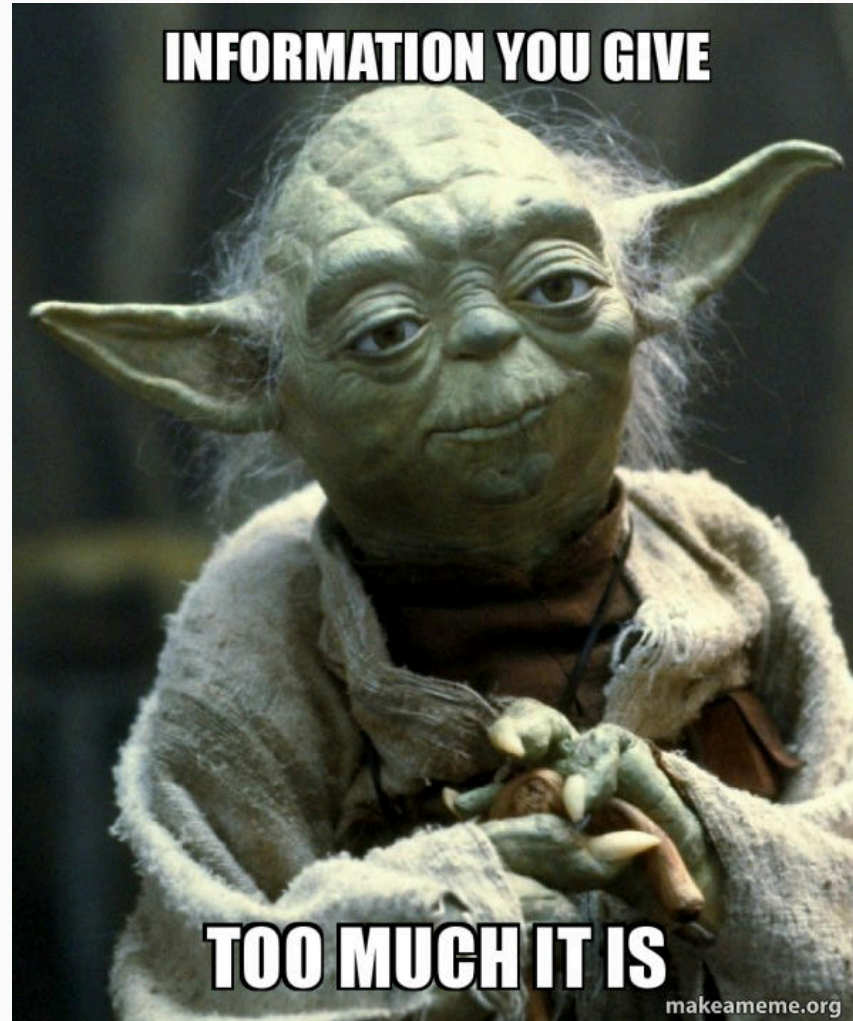
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- Memory Safety without Garbage Collection
- Pattern Matching + Advanced Enums
- Traits + Trait Objects (Structs, but no Classes; Composition over Inheritance)
- Option (no nulls pointers!) and Result Types
- Immutable by Default

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- Ecosystem at hand with cargo: Build, test, release, format, lint, manage dependencies (so-called crates)
- [Many different build targets](#)
 - Embedded devices like ESP32
 - Major CPU architectures: x86, ARM,
 - Multiple platforms: Linux, Mac, Windows, Android, Web Assembly, ...

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 - Multiple platforms: Linux, Mac, Windows, Android, Web Assembly, ...
- Widely adopted own documentation standard
- Enterprise features for stability and maintainability (Editions)



Rust Intro: Origins

- Brainchild of Graydon Hoare started in 2006
- Sponsored (2009) + officially adopted (2010) by Mozilla
- Decision at Mozilla: Build new Browser Engine (Servo) from scratch based on Rust
- Rust 1.0 was released (2015)
- Adoption by bigger companies in 2020 (Amazon, Google, Microsoft)
 - Rust Foundation was created in 2021
 - Big Corps hired core engineers (Ex-Mozillians) and also long standing community members

- [Android](#)
- AWS Lambda (via [Firecracker](#))
- Discord, Dropbox, Cloudflare backend systems
- Mozilla Servo (browser engine)

Rust Intro: Usage / Applications

- [Android](#)
 - AWS Lambda (via [Firecracker](#))
 - Discord, Dropbox, Cloudflare backend systems
 - Mozilla Servo (browser engine)
 - Databases (Meilisearch, Qdrant, ...)
 - CLI Tools, Editors, Terminal Emulators, Shells, Language tooling (ruff, uv, ...)
 - Deno (nodejs runtime competitor)
 - Operating Systems (Redox OS, Linux Kernel)
 - Cryptocurrency projects
- ... and [many many more](#)



Demo Time: Setup / Installation

- Install Rust toolchain via rustup.rs:

```
curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh
```



- Initiate a new project

```
cargo init hello_world
```

```
cd hello_world
```

```
cargo run
```



Demo Time: Hello World

```
1 fn main() {  
2     println!("Hello World!");  
3 }
```

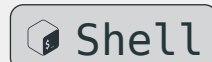


- Famous choices: Actix Web, Rocket, Warp, Axum, Rouille, Tide, ...
- [Framework Comparison](#)
- For benchmark results, see the [Tech Empower Web Framework Benchmarks](#)

ToDo Example

Initialize project

```
cargo init todos  
cd todos
```



Install dependencies

```
cargo add axum  
cargo add tokio --features full  
cargo add serde --features derive  
cargo add uuid --features v4 --features serde
```



ToDo Example: Structure

- Simple static axum server
- Static JSON response
- Dynamic JSON response
- Create Todos
- Delete Todos

ToDo Example: Static axum server

Static Axum Server



```
1 use axum::{response::IntoResponse, routing::get, Router};
2
3 #[tokio::main]
4 async fn main() {
5     let app = Router::new().route("/todos", get(list_todos));
6     println!("Server running on http://0.0.0.0:3000");
7     let listener = tokio::net::TcpListener::bind("0.0.0.0:3000").await.unwrap();
8     axum::serve(listener, app).await.unwrap();
9 }
```

ToDo Example: Static axum server

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ToDo Example: Static axum server

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9 }
```

ToDo Example: static list_todos function

handler function to list Todos



```
1 async fn list_todos() -> impl IntoResponse {  
2     // Just return a static string for now  
3     return "Todos";  
4 }
```

ToDo Example: Running the static server

```
cargo run --example 01_static
```



```
Finished `dev` profile [unoptimized + debuginfo] target(s) in 0.03s
```

```
Running `target/debug/examples/01_static`
```

```
Server running on http://0.0.0.0:3000
```

ToDo Example: Static JSON response

Add a TodoItem type / struct



```
1 use serde::{Deserialize, Serialize};
2 use uuid::Uuid;
3
4 #[derive(Serialize, Deserialize, Clone)]
5 struct TodoItem {
6     id: Uuid,
7     title: String,
8     completed: bool,
9 }
```

ToDo Example: Static JSON response

Return static TodoItem as JSON



```
1  use axum::Json;
2
3  async fn list_todos() -> Json<Vec<TodoItem>> {
4      let todo = TodoItem {
5          id: Uuid::new_v4(),
6          title: "First Todo".into(),
7          completed: false,
8      };
9      return Json(vec![todo]);
10 }
```

ToDo Example: Dynamic JSON response

Add shared state



```
1 use tokio::sync::RwLock;  
2  
3 #[derive(Default)]  
4 struct AppState {  
5     todos: RwLock<Vec<TodoItem>>,  
6 }
```

ToDo Example: Dynamic JSON response

Add shared state



```
1  use std::sync::Arc;
2
3  #[tokio::main]
4  async fn main() {
5      let state = Arc::new(AppState::default());
6      let app = Router::new()
7          .route("/todos", get(list_todos))
8          .with_state(state);
9      ...
10     axum::serve(listener, app).await.unwrap();
11 }
```


ToDo Example: Dynamic JSON response

Use AppState in list handler



```
1 use axum::extract::State;  
2  
3 async fn list_todos(State(state): State<Arc<AppState>>) -> Json<Vec<TodoItem>> {  
4     let todos = state.todos.read().await.clone();  
5     return Json(todos);  
6 }
```

ToDo Example: Create Todo feature

Add POST /todos



```
1  use std::sync::Arc;
2
3  #[tokio::main]
4  async fn main() {
5      let state = Arc::new(AppState::default());
6      let app = Router::new()
7          .route("/todos", get(list_todos).post(create_todo))
8          .with_state(state);
9      ...
10     axum::serve(listener, app).await.unwrap();
11 }
```

ToDo Example: Create Todo feature

Add a request type for TodoItem



```
1 #[derive(Serialize, Deserialize, Clone)]
2 struct TodoItemCreateRequest {
3     title: String,
4     completed: bool,
5 }
```

ToDo Example: Create Todo feature

Add create_todo handler function



```
1  async fn create_todo(  
2      State(state): State<Arc<AppState>>,  
3      Json(payload): Json<TodoItemCreateRequest>,  
4  ) -> Json<TodoItem> {  
5      let mut todos = state.todos.write().await;  
6      let todo = TodoItem {  
7          id: Uuid::new_v4(),  
8          title: payload.title,  
9          completed: payload.completed,  
10     };  
11     todos.push(todo.clone());  
12     return Json(todo);  
13 }
```

ToDo Example: Delete Todo feature

Add DELETE /todo/{id}

 Rust

```
1  use axum::routing::delete;
2
3  #[tokio::main]
4  async fn main() {
5      let state = Arc::new(AppState::default());
6      let app = Router::new()
7          .route("/todos", get(list_todos).post(create_todo))
8          .route("/todos/{id}", delete(delete_todo))
9          .with_state(state);
10     ...
11     axum::serve(listener, app).await.unwrap();
12 }
```

ToDo Example: Delete Todo feature

Add DELETE /todo/{id}


 Rust

```
1 use axum::{extract::Path, http::StatusCode};
2
3 async fn delete_todo(
4     Path(id): Path<Uuid>,
5     State(state): State<Arc<AppState>>
6 ) -> StatusCode {
7     let mut todos = state.todos.write().await;
8     if let Some(pos) = todos.iter().position(|todo| todo.id == id) {
9         todos.remove(pos);
10        return StatusCode::NO_CONTENT;
11    } else {
12        return StatusCode::NOT_FOUND;
13    }
14 }
```

ToDo Example

Building a release version

```
$> cargo build --release
```

 Shell

```
$> ls -lah ./target/release/todos
```

```
-rwxr-xr-x@ 1 tim  staff   1.8M Jan 11 00:33 ./target/release/todos*
```

Questions now or later while socializing :)

Additional Notes

- Weekly newsletter: “This week in Rust”
- Books / Reads:
 - “The Rust Programming Language”
 - rustbyexample.io
 - “Programming Rust: Fast, Safe Systems Development”
 - “Rust for Rustaceans”
 - “Zero To Production In Rust”
- Youtube channels:
 - Crust of Rust (Jon Gjengset)
 - Ryan Levick (old but nice)
 - Chris Biscardi

Fun fact: Those slides were created with typst (a Latex successor written in Rust)

Thanks

Thank you for listening
and a big Thanks to our
organizers!

