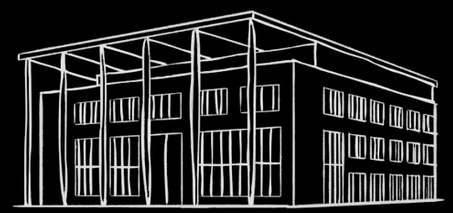
Learning Rust

Emphasizing Security and Performance

NEAL MAGEE
SCHOOL OF DATA SCIENCE
UNIVERSITY OF VIRGINIA



UVA Data Science

Agenda

- Why Rust?
- What is Rust?
- Compare to other languages
    - OO vs. Procedural vs. Functional
- Basics
- Examples

Software Memory Safety

Executive summary

Modern society relies heavily on software-based automation, implicitly trusting developers to write software that operates in the expected way and cannot be compromised for malicious purposes. While developers often perform rigorous testing to prepare the logic in software for surprising conditions, exploitable software vulnerabilities are still frequently based on memory issues. Examples include overflowing a memory buffer and leveraging issues with how software allocates and de-allocates memory. Microsoft® revealed at a conference in 2019 that from 2006 to 2018 70 percent of their vulnerabilities were due to memory safety issues. [1] Google® also found a similar percentage of memory safety vulnerabilities over several years in Chrome®. [2] Malicious cyber actors can exploit these vulnerabilities for remote code execution or other adverse effects, which can often compromise a device and be the first step in large-scale network intrusions.

Commonly used languages, such as C and C++, provide a lot of freedom and flexibility in memory management while relying heavily on the programmer to perform the needed checks on memory references. Simple mistakes can lead to exploitable memory-based vulnerabilities. Software analysis tools can detect many instances of memory management issues and operating environment options can also provide some protection, but inherent protections offered by memory safe software languages can prevent or mitigate most memory management issues. NSA recommends using a memory safe language when possible. While the use of added protections to non-memory safe languages and the use of memory safe languages do not provide absolute protection against exploitable memory issues, they do provide considerable protection.

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What is Rust?

A memory-safe, compiled, statically typed, programming language that emphasizes performance and security.

Rust is a (mostly) *functional* language.

Functional vs. Procedural vs. OO

Rust is functional in that it focuses on *what* to compute; it prioritizes functions; its data is immutable; and it behaves more like an equation.

Concepts

Compiled vs. JIT Compiled

- Completely portable
- Bundled dependencies

Static Types

- Specified or Inferred
- CANNOT be changed

Garbage Cleanup

- Performs no GC like others
- Allows dev to manage memory
- No background processes

Memory Safe

- Ownership & Borrowing
- No Shared State
- Compile-time checks

Python

- Priority: Ease of Use
- Interpreted
- Dynamic typing
- Uses GC to reclaim memory

Rust

- Priority: Performance
- Compiled
- Static typing
- Ownership+Borrowing to limit memory access

Data Types

- Scalar types (single values)
  - Integers (whole, signed/unsigned)
  - Floating-point (fractional)
  - Booleans
  - Characters
- Compound types (multiple values)
  - Tuples
  - Arrays
- Strings
- Enums - define a type by enumerating its variants
- Structs - custom data types

Statically Typed Variables

Immutable

```
let my_name = "Neal";
let word = String::from("blueberries");
let x = 5;
let z: i32 = 10;
```

Mutable

```
let mut my_name = "Neal";
let mut x = 5;
let mut pi: f64 = 3.1415927
```

Statically Typed Variables

Inferred

```
let m = 15;                  // i32 default integer
let y = 3.14;                // f64 default flt-pt
let z = z.to_uppercase;      // str inferred from usage
let bool2 = false;           // bool inferred
```

Explicitly Declared

```
let pi: f64 = 3.1415927
let x: i64 = 14;
let my_bool: bool = true;
let name = String::from("Phil");
```

Variables

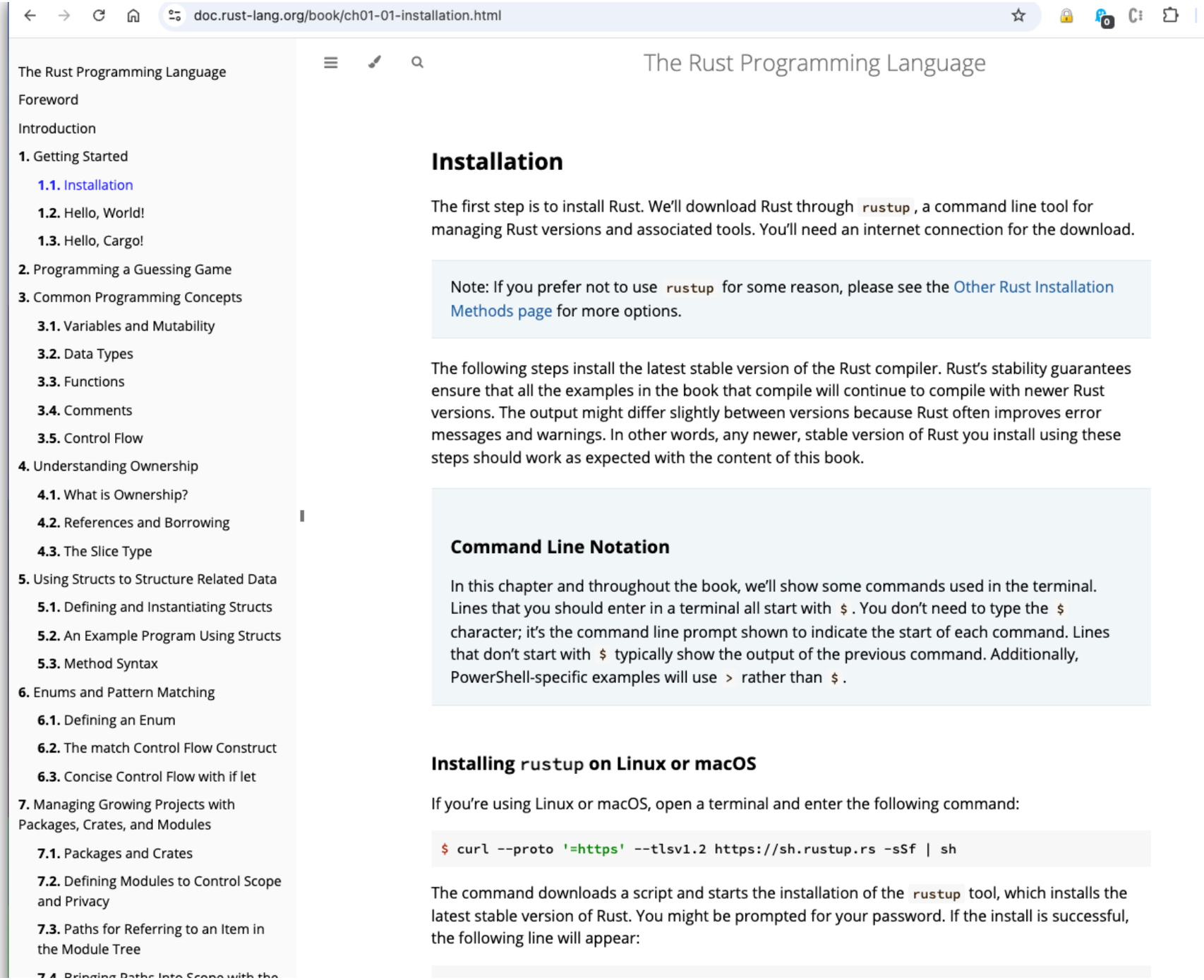
```
fn main() {
    // string using String::from()
    let word = String::from("My favorite number is");
    let num: i64 = 11;


    // use the var in a print statement
    println!("{} {}", word, num);
}
```

Getting Started: `cargo`

Software

Start w/ Rustup



https://github.com/uvads/learn-rust

Cargo basics

```
cargo new my-new-project

cargo run

cargo build / cargo build --release
```