Sri Lanka Institute of Information Technology

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Implementing

an

Operating System

using Rust

**Assignment Report**

IE2032- Secure Operating Systems

B.Sc. (Hons)in Information Technology Specializing in Cyber Security

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Terms Of Reference

The report was produced and submitted to fulfill the specifications for the IE2032 module at the Sri Lanka Institute of Information Technology.

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Abstract

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# Introduction

# What is Rust and Why Rust ?

## What is Rust

Rust is a low-level multi-paradigm programming language focused on safety and efficiency that overcomes problems that C/C++ has continued to struggle with for a long period of time, such as memory errors and developing concurrent applications [1].

Rust has three major advantages,

* The compiler provides improved memory safety.
* Concurrency is made easier because of the data ownership paradigm, which prevents data races.
* Abstractions at no expense.

## What does rust do?

Rust, although being a low-level language, is beneficial when you need to get more out of your resources. Because it is statically typed, the type system aids in the elimination of certain types of problems during compilation. As a result, you will most likely utilize it when resources are restricted, and it is necessary that your application does not fail. High-level dynamically typed languages, such as Python and JavaScript, on the other hand, are excellent for things like fast prototypes.

Rust is not an object-oriented programming language. However, it includes certain object-oriented capabilities, such as the ability to build structs, which may have both data and related functions on that data, comparable to classes but without inheritance. In comparison to languages such as Java, Rust does not employ inheritance and instead relies on characteristics to create polymorphism [1].

## Rust vs C++

When attempting to prevent undefined behavior in C++, developers face greater challenges. The borrow checker in Rust enables you to prevent unsafe practices by designing. This eliminates an entire class of bugs, which is crucial. Furthermore, Rust is a far more current and, in some ways, better-designed language. The sophisticated type system, in particular, will assist you even if its primary goal is not to detect memory issues, and since it is new, it can design its tooling with guiding principles in mind not having to worry about old codebases [1].

The slogan for Rust is "A language that empowers everyone to write dependable and efficient software."

While Rust began as a C++ alternative, it is evident that they are aiming higher, attempting to enable lower-level programming approachable to an increasing number of individuals who may not be capable of mastering C++ . Rust is not a replacement, but rather a language that offers up new avenues of potential, one of which we shall describe in the next chapter.

# How to implement an OS using Rust

This chapter contains the steps to create an operating system in the Rust programming language.

## A Freestanding Rust Binary

We need code that is independent of any operating system features in order to develop an operating system kernel. This implies that we won't be able to utilize heap memory, threads, files, the network, standard output, random numbers, , or any other capabilities that require OS abstractions or particular hardware.

So, the first step in building an own operating system kernel is to write a Rust executable that does not reference the standard libraries. This allows Rust programs to execute on bare metal without the need for an underlying OS. This sort of executable is sometimes referred to as "freestanding" or "bare-metal."

### Disabling the Standard Library

All Rust crates, by default, connect towards the standard library, which itself is dependent on the operating system for capabilities like threads, files, and networking. It also relies upon C standard library libc, which interacts closely with operating system services.

As a result, we should disable the standard library's automatic inclusion using the no\_std attribute. After adding no\_std attribute, we can’t include println since it a part of the standard library. Without the standard library, compiler is missing a #[panic\_handler] function and the eh\_personality language item [2].

#### Panic Implementation

The panic handler attribute specifies the function that should be called by the compiler when a panic occurs. The standard library contains its own panic handler method, but we must create it ourselves in a no std environment [2].

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hpanN0dXZ3eHl6g4SFhoeIiYqSk5SVlpeYmZqio6Slpqeoqaqys7S1tre4ubrCw8TFxsfIycrS09TV1tfY2drh4uPk5ebn6Onq8fLz9PX29/j5+v/EAB8BAAMBAQEBAQEBAQEAAAAAAAABAgMEBQYHCAkKC//EALURAAIBAgQEAwQHBQQEAAECdwABAgMRBAUhMQYSQVEHYXETIjKBCBRCkaGxwQkjM1LwFWJy0QoWJDThJfEXGBkaJicoKSo1Njc4OTpDREVGR0hJSlNUVVZXWFlaY2RlZmdoaWpzdHV2d3h5eoKDhIWGh4iJipKTlJWWl5iZmqKjpKWmp6ipqrKztLW2t7i5usLDxMXGx8jJytLT1NXW19jZ2uLj5OXm5+jp6vLz9PX29/j5+v/aAAwDAQACEQMRAD8A8QooorvPGCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAop8MTzzJFGMu7BQPera2UUurG2gkJhU/NIewA+Y/zoAo0U6TZ5jeXnZk7d3XFWrG0NyszeV5gSNjhZVUg4znB5I+lLpcLa2KdFWbfT7m6j8yCMFN2zcXCjPpyagkRopGjkUqynDA9jTAbRVuDTLu5h82CHcnPO4Dp17+9Kml3jzPEsQ8yM7WUuoOfbJ5/CkOzKdFXbOyebz90Jfy0bKiRVZSB1weSB7VHb6fc3UfmQRgpu2bi4UZ9OTQFmVqKdIjRSNHIpVlOGB7GprewuLqNnt496qQG+YDH4Z6e9MRXoq2ul3jSSIIgDE21yXUAH0yTg1VZSjlWGGU4IpBZiUUUUwCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAvWLra2893uHmgeXEueQT1b8B/OhHW10lyrAzXR2nB5VB1/M/wAqo0Uh3CtHSHt4ZpJLi5SH92yAFWJOVIzwDWdRTEtHc0o7iCHTxB5wZluw+QpwVAxnpVbUJUn1K4liO5HkZlOMZBNVqKVh30satteQR6akTyYcJMCNp/iAx/Krf2/TzcvOJEEglVizwlyyBRwuRwcg+lc/RRYL6WNi1mtBqt3cSXaRo/mBMoxLbgcHge9Qx3EEOniDzgzLdh8hTgqBjPSs2ii1gbuaErWV1ql5LPOyRMXeJlXO454FLYSwx6depJcrFJMoVQVY5wc9hWdRRbSwX1uamnXaBXF5dJsdw0kU0Rk3+4I6H8qz7gxG5kNuCsRY7AeoGeKjoo6hfSwUUUUxBRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFSQwS3BYQxs5RS7bR0A6mgCOiiigAooooAKKKKACipre0nu2cW0TymNDI4UZ2qOp+lQ0AFFFFABRUlvbz3UwhtYZJpW6JGpZj+ApJoZbeZoriN4pFOGR1KkfUGgBlFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAatrZwSaIs7x5lN8kRbJ+6VyRV9LHS11TUbUxwmZLkpbxXErohXJGAw/i6dTWNaand2UbR20u1GYMQUDYYdCMjg+4qWPW9QimllScb5pDI5aNW+b1GRwfpXm1KGIk5cstOmrXVeX5fgaRlFJf13NK00uzhtbm51GOGNkuzb+VPI4CYGTygJJ+vHFYt8lvHfTJZSGW3Dny3I6r2qW31e+tXlaKc5mbdJvUOGPqQwPPvVSSR5pWkkO53JZj6k1tRpVYVJSnK6fnp91tPv1CUotWSNKzgtYdIlv7q3+0nzhEsZcqF4yScc1LawWS2H2ya0MwmuvJWPzCPLXGeo6nmqFnqN1Ybxay7A/3lKhgfwIIp0GrXts8jQz4Mrb2yobLeuCOD7ivSU4Jq6/D+v+ATdWNNbCxtW1ZLiEzCycGNt5BOWxtODjH60ttaaXJbTX7JGkDXHlxxzySAIuM/w5OfrxWVDql3BFPGkilbg5l3xqxb8SCaS01K6sVdbaXar4LKyhgSO+CDzRGcVa6/Ad1cf5dgusNG0kslkHIDxD5ivbGaYq2f2W4LGfzgw8nAG3Ged3vTYL24tr4XcUmJwxbeQDyetKL+5W2ngEn7u4YNINo+Yg5rO6sK6uX7CGzXSVubm0+0OboRY8xl+UrntVyHSLaDUZ47iKF7b7V5Ecksrq30AXqeRyeKzrTWJLHSTb2pKTGfzNxRWGNuO/fNQw6vfQK6xXBG9/MJKgnd6gkZB9xWynTTV1/Wn/AAQTVv68zRjsbK3hkM1t9oZb/wCzgs7D5fwI5pLW1to9X1CyaDeqLNskLsGUKDgcEA9O9Zj6jdSAh5chpvPPyj7/AK9Kkh1i9t5ppopE8yYlnZoUYnPXqOPoKlSjp/XRfqPmV/68yazgtYdIlv7q3+0nzhEsZcqF4yScc1Ut/ssmoL9pWWO2ZjlYjlgOwGetPg1W8tpJXglCeacuvlrtJ/3cY/So4b64t74XkUmJwxbeQDyevFTzRuv6/wCHJ0tYcq2f2W4LGfzgw8nAG3Ged3vXTeHp5bfwhO8OqJpn+npulcMdw2H5cKDn6dOK5gX9yttPAJP3dwwaQbR8xBzTRe3A09rISf6O0glKbR94DGc9ehrOWqsvIaaTv6nWRW2maprFxfNZ2w066uxDC80skbE4Gdip35zyMc1Wi0zTbO2na4s/tbJqv2RS8rL8mP8AZI54rEstb1HTrZoLO5McbPvxsU7WxjcpIyp9xikk1i+lVhJPkPcfaW+ReZP73T9OlQo2fl/w3/BG5Jrz/wCH/wCAbdjY2UXiLV9Ma1EiRLceVKZXVkCK2BwQD0HUGqWm21jb+H59VvrT7awuFt0hMjIq5UsWJXn2FV7fxFqdrdXFzDNF51yxaV2t42LE9eqnAOeg4plrruo2U08lrOsZuDmRBEhRj/uEbR+Aos/wQXjf5s2PCmp3EFzqiWMsltB9jnmSJXJCsF+U57ketR6dFZz6T/aOpWv225m1FYWaSV1yGXJJ2kZNZ1n4i1Owed7aeMPcMWlZ4I3LZ68sp4Pp0qudVvGjMfmgIZ/tO1Y1A8z14HH06U7a39PzFfS3r+R02mQ2GmX3iWAx3R+zxSIrRzBT5YkUYGVPPv8ApVCyt9PXS/7SvLSS++0Xv2dEkmYGNcZySuMtz9OOlZB1W9M95MZv3l6CLg7B84Jye3HI7Yp2n6zf6WjrYz+WrkMVKKwyOhAYHB9xzSSfXyG5Lp5mhJp9pp/iDVLKWzuL+O3WRY/KJBjI6O2Ow79qwa09N1qXT5b6fLyT3cDxby3diMsfXv8AjWZTV1uKTT27hRRRVEhRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAPhieeZIoxl3YKB71bWyil1Y20EhMKn5pD2AHzH+dFi62tvPd7h5oHlxLnkE9W/AfzoR1tdJcqwM10dpweVQdfzP8qQ0U5NnmN5edmTt3dcVdsLC2vI38y7eKREZ2UQ7htHvkVQq7ptxHbvcGZtoe3dF4JySOBR0BbkyaULmzeWxZ5mEwjBbCAjGe54OfeorSweRrgSQlzErAqJFVlYDrg8kDHanW91EmlpEz4cXSyEYP3cdaswXFodYvLp7pI0kMgTKMS24EA8D3pO+o1Z2M63sbi7VmgQFVOCzMFGfTJPWoGUo5VhhlOCK1NPmgg8yKa7iaAuC0ckLMrgdxxkH8qzrgxG5kNuCsRY7AeoGeKfUVtC3pmnG982R45niiQkiJclj/dBx15qGS0clnhidYvN8oCQjcG9D0qSwuUghvFdypkhKoOeTkVNZXFv/AGeIZ5vKZbhZeVJ3DGDjHf60dQ0sQJpV47OFiHySeW2XUAN6ZJpkOnXU8kiRxHMRw+4hQp9CTxV+5v7aRZdkmd1/5w+U/c9aWa6tLsXkD3HkrJcmZJChIYcjBA5pXf8AXyHZf18yrbaTPcx3DbkQwcFWdRk5AxyeOvWm2dk0/nkxeYI0bhZVUggdeTyPpT7GW3j+2W8k+yOZNqSlDjhgeQOe1P0w2tvdTPLdoi7HjUlG+bIIB4FGoK2hUtrC5vAxt49wU4JLADPpz39qdFpt3OrGOLhX8s7mC4b05NWreW1Nl9kmuhH5Vx5qyBGIcYxxxnPHepLjUoLhJGBKl70ShSDwuOtPqKysZMiNFI0cilWU4YHsatWNoblZm8rzAkbHCyqpBxnODyR9KZqEqT6lcSxHcjyMynGMgmrGkPbwzSSXFykP7tkAKsScqRngGjWw9OaxWt7G4u1ZoEBVTgszBRn0yT1qBlKOVYYZTgitTT5oIPMimu4mgLgtHJCzK4HccZB/Ks64MRuZDbgrEWOwHqBnijqK2hJbWVxebvs8e4J94lgoH4ninQ6ddTyOkUYLI20qXUHPoMnn8KmtZbeXTJLO4m+znzRIrlCwPGMHFT6fPY20eTIglSbdveHcXQf3R0B/zmgLIr2trBNa3QlWVbiBC/3ht4IGCMZ7+tJZ29vcWdyXEomhjMgIYbTyBjGM9/Wp4rm2Ooahvm2RXKuqSbSQMtkZHWobCWCGS6hlm2pNEY1l2kjqCDjr2pa2Hpf5kFtY3F2GMEe4KcElgoz6ZPf2qS10y5uZSBEwVHCSEkLg+nPf2q3ZXdvFYyWrTxIyzb0kkg8xWGMdCCQaVb2C5hK3Nzsdbrzt5jP7wYx0HQ8U+oWVjOvYFtr+eBCSschUE9cA0ttYXN4GNvHuCnBJYAZ9Oe/tS6hKk+pXEsR3I8jMpxjIJqzaT2z6cttcT+QY5/NDbC24YxjjvxQtgduYrxabdzqxji4V/LO5guG9OTVeRGikaORSrKcMD2Na1xqUFwkjAlS96JQpB4XHWqGoSpPqVxLEdyPIzKcYyCaSbBpC22nXV3Hvt4ty7tuSwHPpyaIdOup5HSOMb0bays4U59ME81eskhfQ/wDSJ/IVbsHdtLfw+1TJqFi9zLdEpHKbnzMyQ7yydgvYH/OafUEla/8AXUy4dNu7hS0cXCv5ZLMFw3pyaktLB5GuBJCXMSsCokVWVgOuDyQMdqszXtu0cgSTJa+84fKfu+tOguLQ6xeXT3SRpIZAmUYltwIB4HvSu7DsrmdbWVxebvs8e4J94lgoH4nioXRo5GRxhlOCPQ1oQPatYTWM1yI/3wkWUIxV+MYx1qvbx2bTTLcTusaqfLZU+8e3HamTYq0UUUxBRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFADvMfy/L3NsznbnjPrim0UUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFT21nc3jMtpBJMVGSEUnArU8P2QuYL13spbkBAi7DjBLDPY845zWjqNsILXWGSwntlIVRI5+RwHH3RtGPzNbKl7vMyoxurnKEFSQRgjqKStiwhs10lbm6tPtDm6EWPMZeCue1XIdItoNRnjuIoXtvtXkRySyurfQBep5HJ4pKlJ2/rt/mFtL/1/WhzdSQwS3BYQxs5RS7bR0A6mtqOxsreGQzW32hlv/s4LOw+X8COaS1tbaPV9Qsmg3qizbJC7BlCg4HBAPTvS9n/AF8rhyu5hUVqWcFrDpEt/dW/2k+cIljLlQvGSTjms2RlaRjGmxCcquc4HpmplGwraXF8qTyfN2N5e7bvxxn0z60yt7TjANAVbq389XvlXaXKgZXrxzUlvpVtHfzpcwwm2+1mCN5ZXVuvRQvU9OTxWnsm2rf1t/mO2l/66/5HO0qqWYKoJJOAB3rdjsbK3hkM1t9oZb/7OCzsPl/AjmpVsbPT5WkaAzn7eYIwXI8sKevHU896I0m7a/1p/mDi1/Xr/kYhsLwRPKbWcRxkh38s4UjqCe1V66Jif7Q8QjJx5cnH/AxVfTLGyOlm8vTCcz+UBM7qAMZONgJz9eKlU72t2v8AjYbjrZGLVzTtPOozeSlxDFJ/Csm75/pgGr9vb6YItTcxfaYrZlaGQMylgWwAfb8M0zSngfxTC1pGY4TIdiE5IGD7mnGGqv1Faxjng0UrfeP1pKyJCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigCe3vJrVWWFgoZlY8A5KnIqe11IwfafPhW4W5H7wMxXvnPHvV3w7aQTfbLiaS23QQMyJcKzAHI+YgAggZ/8ArU1NOhvo5L24u44FNyIAIIMqSRwQMjA/L+lcrxsYTcXtHTZvfyt2LUXa6IrXWXstLaC1zHMZ/MyVDKBjHfPOagh1e+gV1iuCN7+YSVBO71BIyD7iob21ayvp7V2DNDIyEjvg4rS03RLa70v7deah9kj+0i3AEJckkZB6iutVXJKSYtU7FB9RupAQ8uQ03nn5R9/16VJDrF7bzTTRSJ5kxLOzQoxOevUcfQVpWfhYz6tc6dPPOk0E3lZgtGlXr95iCNoptv4ciMMkl/f/AGfy737GVSHzMt69RxSVR9H/AF/VgtJf1/XmZsGq3ltJK8EoTzTl18tdpP8Au4x+lOhnsXDvqEVzLO7Fi0cqqD+BU1q6XpSwapqli12q3UEU0YBthIjhQcnJYbTxwcGqGnaRDc6fLf3959jtY5BEGERkZ3IzgDI7DrmhVP69R2kVmvHH7mz3pbiUSojYZg2MZzjmnprWoRmQpcYMshkY7F+8e444P0xWlpippuj6rqVq4kmjdba3m242785cA9DgYHpmufpqcr6P+v6sLVK/9f1uWn1G6kBDy5DTeeflH3/XpUkesX0byuk/MsnmNlFPzf3hkcH6Vd8OW0dy94ouRFP9mk2o9sJVZQpJ5LDaeODg03TdEt7zTVvLq+a2RroWwVYd5JIyD1FHPJPf+tg1tcoR6ldxXkl1HLiaXO8lQQ2euRjFOg1W8tmlMMoXzW3OpRSpPrgjArf0TRYLa+1gXk9k0uno6otyjMoYMBvK7SCOT689qpRaVDqCy6hf3sNnA9z9njNvbkq746hRjauMHPv0pKo+j/pjs1uZsWqXcMc6JIu24OZd0Stu/EijTr8adP5wto5pB9xnLDZ+RH61YGjpDql7Zajex2j2qvhipYSMvRR9ay6am9GmJ3W4pOTSV0eg6VBd6PNcfYkvLgXCxBJrjyFCkfwtkAtnsSfpVvTfD/laXc+fon9o3sV6sLRpMx8tSuTzG2Ovc9Km9nYFFvU5GiuoPhizuvEV5Y2V1ceXFKEjMVsZwM/3mBGADxn2qrb+HIjDJJf3/wBn8u9+xlUh8zLevUcUlJMHFowaK6PS9KWDVNUsWu1W6gimjANsJEcKDk5LDaeODg1Q07SIbnT5b+/vPsdrHIIgwiMjO5GcAZHYdc0cyDlZl0V0Xh6DTZZ9QgurKO/WCCWeOZnkjJ2DgYDDg/nUNno9rqFmb+a6+wxSXYt0hjiMm0sMjBLDge5/OnfUVtLmHRXV6JosFtfawLyeyaXT0dUW5RmUMGA3ldpBHJ9ee1UotKh1BZdQv72Gzge5+zxm3tyVd8dQoxtXGDn36UuZMfK1uYWCQSBwOvtSVv6RFJpXis6TeASRTS/ZLmPqrgnGR9Dgg1jXkH2W+nt858qRkz64OKd7itYhoq1aaZf36s1jZXFyqnDGGJnAPvgVq2HhHU72O4WSyvLe4VN0Ky2zKkmOq7iOD6etDaQJN7GBRSsrI5VwVZTggjkGtPQrS3u5b0XUe8R2UsqfMRh1GQeKL6XBK7sZdFFdB4ViliN/qEZVRbWkmHBBdHK/KQvXr36Ch6JsErtI5+ilZi7FmOSTkk96SmIKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKALdlffY47pfL3/aIDFndjbkg59+lPh1HydNFp5WcXKz793oMYxj9ao0VjKjTle631/Qd2WL+6+3ajcXWzZ50jPtznbk5xmtvTNRsLTwqUvYFu3F+JFgE3ltgJ97oeM8VzlFaKKjHlX9WC7vdnRp4tLCU3tkJpGvDeIUmKAP6MAPmAwO4qtP4hE0cqC12iTUPtv+szjj7vT9f0rFopqKX9f12G5N7/ANf1c6C18RWkWtX2pXGnSyyXbSYVbkIEVwQR9w5PPXj6VXtNZtILW4sbjT2uLGWYTRxGfa8bAY++BzxweKx6KXKg5mbGn6haGHULC6U29peYZCuX8l1JK+5HJB781XstMgu4DJLqtnaNux5c3mbvr8qkVn0U7Cubel6hZaDfXHmQHUGKNEssFx5aFWXB4KEnr7VCusRw2AtILVljW9F0u6XcQAMbTwM/X9KyqKLa3C+ljYbXt19q9x9mx/aSOu3zP9XucN6c9MdqTTdahtdP+xX1j9shWcXEYEpjKvjBycHIPHH61kUUJJBzNu5qDWEm1S9vtRso7t7pXwpYqI2bow+lZdFFCSQNt7mzpuuQWtjFa3tj9qWCf7RCyzGMq3Gc8HI4Hp9aZca7JcabdWzRbXubz7Uzo+AMggrj8fWsmiiyYczRt6Z4gSw01bSaz8/yrn7TEwmKDfgD5gB8w49qSfxCJo5UFrtEmofbf9ZnHH3en6/pWLRRZXv/AF/WgXdrf1/Wp0Fr4itItavtSuNOllku2kwq3IQIrggj7hyeevH0qvaazaQWtxY3GntcWMswmjiM+142Ax98Dnjg8Vj0UuVD5mbek61YabLdu+mSS/aEeIKl1sCRsMEcqST71CmsRxWH2SG1Kxrei6XdLkgAYC9Ofr+lZVFO2txXdrGw2vbr7V7j7Nj+0kddvmf6vc4b056Y7Umm61Da6f8AYr6x+2QrOLiMCUxlXxg5ODkHjj9ayKKEkg5m3c27HVoW8QT61qZzMjGeKFVOJJM/KM9gOv4VjyyNNM8khy7sWY+pNMooskDbZJHPLECIpXQHrtYitCw1660+OcxMzXEibI5mkJMQ7lR6npntWXRRuJOwE5OTyatWF3HaPMZoDMJIWjUCQptJH3uOuPToaq0UwCtbw9dW9te3Au5hAs1rLCsrKSFZlwCcAnH4Vk0Ut1YFo7isNrEAhgDjI70lFFMAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKK0NM01NRju/wDSPKlghaZUKZDhRkjOeD+BrPo62DpcKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooA3PCjLHf3buvmIllMzQnpKAv3Sew+nPFYsjK8rsiCNWYkICSFHpzVi11C5soZ4rZ1QXCbJG2AsV7gEjIB7461VpdbjvpYKKKKYgooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAP//Z)

Figure .

The eh\_personality Language Item

Language items are particular functions and types which the compiler need internally. The eh\_personality language item denotes a function which used to implement stack unwinding. Rust offers the ability to abort on panic. This prevents the creation of unwinding symbol information, significantly reducing binary size. There are several areas in which we could disable unwinding. The simplest method is to include the following code in Cargo.toml [2].

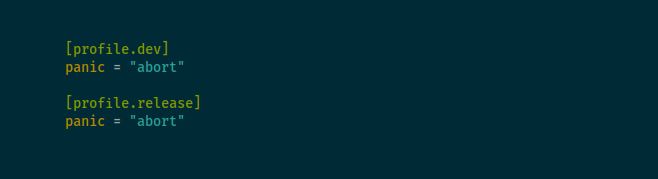


Figure .

This causes the panic strategy for both the dev and release profiles to terminate. The language item eh personality will not be needed anymore.

Defining our entry-point

In a rust program, the main function isn't the initial function that is called. The execution process begins with a runtime library. Crt0 is used by Rust. This, in turn, invokes the Rust runtime, which is a method denoted by the start language item. This, in turn, invokes the main function.  we do not use the crt0 and start language items. As a result, we must specify our own entrance point [3].

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hpanN0dXZ3eHl6g4SFhoeIiYqSk5SVlpeYmZqio6Slpqeoqaqys7S1tre4ubrCw8TFxsfIycrS09TV1tfY2drh4uPk5ebn6Onq8fLz9PX29/j5+v/EAB8BAAMBAQEBAQEBAQEAAAAAAAABAgMEBQYHCAkKC//EALURAAIBAgQEAwQHBQQEAAECdwABAgMRBAUhMQYSQVEHYXETIjKBCBRCkaGxwQkjM1LwFWJy0QoWJDThJfEXGBkaJicoKSo1Njc4OTpDREVGR0hJSlNUVVZXWFlaY2RlZmdoaWpzdHV2d3h5eoKDhIWGh4iJipKTlJWWl5iZmqKjpKWmp6ipqrKztLW2t7i5usLDxMXGx8jJytLT1NXW19jZ2uLj5OXm5+jp6vLz9PX29/j5+v/aAAwDAQACEQMRAD8A8Tl/1hplPl/1hpld54wUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAD5f9YaZT5f9YaZQAUUUUAFFFFABRRRQAUVPZ2st7dx28ClnkbAwM4961rbwxd/brZbqCUwSOQ5RCNoBxkkjjNXGnKWyGk3sYVFXBaG/vJE0y3cKqlijyAkAdTnAoOk3oultvJzI6b12upBX13A4x75pcr6ILMp0VNdWk9lN5VzHsbAYcggj1BHBp9np9zfsy2kfmFAC3zAYycdzSUW3ZIRWoq8+j30c8cMkIR5ASoaRQOOvOcD8aT+yL43bWwgPmqnmFdw+76g5wRT5Zdh2ZSoq4dJvRdCDycuyeYMOpXb/AHt2cY981attJSLU7e11QN/pBAXyJlJXJ4J4IIpqnJuwWZk0VZFlLNfvbWqGRlZgOR0HcnoKVorjS7xPOiQOBuUOFkVge/cEVKWl+gWaKtFaOvIiaxKI0SNdqHaihQMqD0FZ1DVnYHowooopCCiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAHy/6w0yny/6w0ygAooooAKKKKACiiigC/o09vbatDNd58uMlgQcYIGR2Peti1vtNk1bTVjilBjQAO04CoSSSDlRnk9ciuYorWNRxSXmNOxq2jDTrm9jvGCNJbOi7TuyT0GRmrUWpWhSGGSUqr2Bt3kCE+W24n8R9PWsizspL1pREVHlRNK249Qo5/Gq9RGsvhXT/g/5ju1qv62Na8U6h9ltdMSW8+yw7WeOM/Nlic4645xzTrIPpUdwmoxSWzTKnliSNhuw4J7egrJV2Q5Rip9jihnZ/vsW+pzVKpaXN1Fe50R1DTJ3HnSISDOY2kiZlRmfKkjHPGfWmz6pZtcOyzgj+z2gysRQF/QADgGsG3gkuriOCBd8kjBVXOMmmMpVircEHBo9tpyf11RXM73OisruGWS3UEvFHYNFOPLZlU5PDY5xkjkVFdu9nq+nXc7RNbKFMQgVgAit0w3Pr1rFhnmt5PMt5XicdGRip/MUTTzXEnmXEryv/edix/M1Tq7Pre4r+7b+uhsWl3Z2Or3JFyksNzE6+b5JIQk5GVYc9KrXzvqF5DBDcQzhE2oVjECL1JHOP1xWZViytHvrtbeJlVmBILnA4BP9Kjn0UeiE52TbLWvsrazLsZXAVBlWBHCjuKzauyaVdJqAso1E0zKrAR8jBUN39jTl0a7+3R2sgjjeVSysXDKQASeVz6VMndtkOpHe5Qoqxe2b2NyYJWVm2q2UORggEfzqOCF7i4jhhG6SRgqj1JOBUtpK7Gmmrojoq1fWP2GURm5gnbJDCFidpHY5AqrSjJTXMimmnZhRRRVCCiprW1mvbqO2tU8yaVtqKCBk/jUTKVYq3BBwaAEooqa1tZr26jtrVPMmlbaiggZP40AQ0VZsrCe/1GKygXM0j7ACeB6k+wqR7ayTWPs4vGa0EgQ3Ij7d2C56f0pBYpUVa1Kwl0zUJbSfBaM8MpyGB5DD2I5qrRuDVtAopVUscKCT6AUlMAop8MTzzJFENzyMFUZxkngU64t5bS6lt7hdksTlHXIOCDgjIoAioqS3hNxdRQqQpkcICegycVY1Szj0/U5rSGdpxCxRnMez5hweMnjNAFOiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAHy/wCsNMp8v+sNMoAKKKKACiiigAooooA2vDAkN9deQAZfscuwEDrgY68VrkSyXMcNz82pSaXKkq8bmbnaD/tY/GuWtLySyaUxBT5sTRNuHZuv41XrzauDlVqyne3bTX/hvI1jPlVv66f5HZW0U8E1rGq7bhdIkAU44bc2BzxWR4iMm2w+2/8AH8IP9Izjd947d3visSinRwXs6qqOV/l+t9vIHU9239dP8jZ8MeV/aknmDMvkP5ADBSZO2CQQDjOK0zJO3iC3MttJb+Xbt9ra4cO0kXOS+AOccevSuToqquDVSpKd91b0/H9N9RRnZWOq+0va+LdOmhmMVhIsawEHA8nj5T+Oc+9JZR3S+JJv7YErXTQP9m8xwGLfw7ScgHGcVy1FQ8CrWT+zbbXT5/f38h+0OwtnuZfF2nqbS4hmWPExkkDvInPL7QPpyPSq1nqF7Jf3SXaCKS0spwi7MbO4GPbtXPW9pcXjlLS3lnYDJWJCxA9eKiZSjFWBVgcEEcip+o022rrZLbbV+b3uP2j38zX16RpodMmlYvLJaAu56sd7DJPfgVkxyPE4eJ2Rh0ZTg02iu+jT9lBQ7GUnzGxokrTyXsLS/wCkXFqY4mdup4+XJ9QMVSuLS80uVPPVreRgSuGwwHTsciqlORGkkVI1LOxAUDqTWpko2bfQHkeVt0js7YAyxycDgVoeH5TD4gsiqo26ZFO9A2MsOmeh96jbR71dUGnNGgujx5ZlTrjpnOM+2c1Umhkt5nhmQpJGxVlPUEdRWVWCq03DujXVHQ2V3JJrmpy7YkaO1nC+XEqjjoSAME+9U9ekaaHTJpWLyyWgLuerHewyT34FY9Fc8MJGFVVF08vKxbqNprv/AMD/ACCtnwrLNDrYe2tDduI2GxHCuMjG5Cf4h24NULC/k0+VpIY7eQsu0ieFZB+TA0t/qMuoujTRW8ZQYHkQLED9doGa7CF3Os86fS/H2mvJqMxMyxibz2CyRqT/AKuQjgnp+lQWdlq8nii4k1Ke8jvI7d5IlVwZpgDgKpOcd/XpXH0UuUrm/Q9DRJ28faTJBHJumtAbkbgzNjcG3lQATwAeKydN13UV8Y6fFqEn2T7PL5DqB5eELZ2kenQY9AK5KihRsDldHX2C6jH412a00oubiGWKFp2yfmVlXn68CuSaN1lMbKQ4baVI5B9KRWKMGUlWByCD0q0dTu21Mag0uboMH8wqPvDvjGM0JWFKVzR8WHbqVtbt/rbeyhim9nC8j8M4rLszaLcA6gkzw4ORA4Vs/Ugj9KhkkeWRpJWLuxJZmOST602mthN3Z0+iyaN/bFv/AGdDqcVzuyrtdxBVGOScp0xnPtWX4hk06XXbl9HQpalvlB6E9yPQZ6VmUUra3HzaWLOnFhqlqY13MJk2rkDJyOOal1su2v37SoY3Nw5ZCQdp3HjI4qjRT6i6F/Q5Y4datWmtkuVMigRuxAyTweKNdBHiHUAXMhFzIC5ABb5jzxVJHaORXjYq6kFSOxqa9vZtQu2uboq0r/eZUVNx9SAAM+9D3TBPRor0UUUxBRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAPl/1hplPl/wBYaZQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAX9DYrr1jgkZuEBx/vCrVrawXOsajJdIZI7ZJZvLDY3kHpkduayI5GikWSNirqQysOoI71cbWL5r4XhmAnC7dyxqMg9cgDB696461GpKblB7q3bZ/r36FxkktTWXS7GTy73yCsJsnuWtRIeWVtuM9cHrSxabp8jR3RtiIZbCS48gSH5WQkcHrg475rHOr3xvVu/tB85V2KQoAC/3duMY9sVas9dmivprq6dnka2aGMqoAQkcccACuOeHxSjdSv8AN/d/9tuWpQvt/Wn/AASPV7a3jgsbm1h8hbqEs0W4sFIYjIJ5wcVHoi2761ai7meCMSKd6JuOc8cfXvUF5e3F/MJLqTeyqFX5QAoHYAcCo7eY211FOoDGNw4B6HBzXp0IyhBKb1+//h7GU7PY1bzzP+E2mzEnmfbz+73/AC539M46e+Kj8TLAviO9+zTPMGmYuWTbtfccgeoHrx9KSXU7SXxEdSNpMIml85oROM7+vDbemfbpVK+umvtQuLt1CNPI0hUdBk5xVRTsvL/gFSabl5/8EgoooqyAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAHy/wCsNMp8v+sNMoAKKKKACiiigAooooAu6RcvaaxazRSPGVlUFkGTgnB478Z4qx4ls3svEV4jrGgeVpEWNgQFJOBgdD7HkVW0oxrq1s806W6RyB2kcEgYOegBPak1W4iutYvLi3z5Us7umRg4LEik918/0Gtn8v1KlFFFMQUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQA+X/WGmU+X/AFhplABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAPl/1hplPl/1hplABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/9k=)We use the #! [no main] attribute to notify the Rust compiler that we don't utilize the standard entry point chain. We no longer execute the main function. Instead, we've replaced the operating system's point of entry with our \_start function [2].

Figure .

The ! will change the function into a diverging function that should never return. (In the future, we alter it to a command to shut down the system.)

Solving linker errors by building a bare metal

![Graphical user interface, text

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linker is a program which converts the compiler's objects into executable code. The linker believes we are executing the C runtime(which used by an underlying OS) by default. To avoid linker error from occurring, we can create a bare-metal target. We can do it by building freestanding executable for this target using following code [3].

Figure .

![Text

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generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAERpbnVyYQAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzY5AACSkgACAAAAAzY5AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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RRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAH//Z)This is how a minimal freestanding rust binary looks.

Figure .

## A Minimal Rust Kernel

The next section will go through how to turn a freestanding binary into a minimal operating system kernel. Creating a custom target, merging our executable with a bootloader, and understanding how to print things to the screen are all part of this.

## VGA Text Mode

## Testing

## CPU Exceptions

## Double Faults

## Hardware Interrupts

## Introduction to Paging

## Paging Implementation

## Heap Allocation

## Allocator Designs

## Async/Await

# Conclusion

# References

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