Party Parrot

Solana Smart Contract Security Audit

Prepared by: **Halborn**

Date of Engagement: **August 2nd, 2021 - August 24th, 2021**

Visit: **Halborn.com**

DOCUMENT REVISION HISTORY 4
CONTACTS 4
1 EXECUTIVE OVERVIEW 5
1.1 INTRODUCTION 6
1.2 AUDIT SUMMARY 6
1.3 TEST APPROACH & METHODOLOGY 7
RISK METHODOLOGY 7
1.4 SCOPE 9
2 ASSESSMENT SUMMARY & FINDINGS OVERVIEW 10
3 FINDINGS & TECH DETAILS 11
3.1 (HAL-01) OUTDATED DEPENDENCY - LOW 13
Description 13
Code Location 13
Risk Level 13
Recommendation 13
Remediation Plan 14
3.2 (HAL-02) ARITHMETIC ERRORS - LOW 15
Description 15
Code Location 15
Recommendation 16
Reference 16
Remediation Plan 16
3.3 (HAL-03) UNSAFE RUST CODE USAGE - INFORMATIONAL 17
Description 17

Result 18
Risk Level 19
Recommendation 19
Remediation Plan 19
3.4 (HAL-04) LOW TEST COVERAGE - INFORMATIONAL 20
Description 20
Result 20
Risk Level 20
Recommendation 21
Remediation Plan 21
4 MANUAL TESTING 22
Description 23
4.1 WITHDRAW AMOUNT ON BEHALF OF OTHER USER 23
Description 23
Code Location 23
Results 24
4.2 BORROW AMOUNT ON BEHALF OF OTHER USER 25
Description 25
Code Location 25
Results 26
5 FUZZING 26
5.1 FUZZING UNSAFE RUST DEPENDENCIES 28
Description 28
Results 28
6 AUTOMATED TESTING 29
6.1 VULNERABILITIES AUTOMATIC DETECTION 31
Description 31

Results 32
6.2 UNSAFE RUST CODE DETECTION 33
Description 33
Results 34
6.3 RUST UNDEFINED BEHAVIOUR TESTING 35
Description 35
Results 35
References 36

DOCUMENT REVISION HISTORY

VERSION	MODIFICATION	DATE	AUTHOR
0.1	Document Creation	08/19/2021	Nishit Majithia
0.5	Document Edit	08/22/2021	Nishit Majithia
0.9	Document Edit	08/23/2021	Timur Guvenkaya
1.0	Final Version	08/25/2021	Gabi Urrutia
1.1	Remediation Plan	08/27/2021	Gabi Urrutia

CONTACTS

CONTACT	COMPANY	EMAIL
Rob Behnke	Halborn	Rob.Behnke@halborn.com
Steven Walbroehl	Halborn	Steven.Walbroehl@halborn.com
Gabi Urrutia	Halborn	Gabi.Urrutia@halborn.com
Nishit Majithia	Halborn	Nishit.Majithia@halborn.com
Timur Guvenkaya	Halborn	Timur.Guvenkaya@halborn.com

EXECUTIVE OVERVIEW

1.1 INTRODUCTION

The Parrot Protocol is a DeFi network built on Solana that will include the stablecoin PAI, a non-custodial lending market, and a margin trading vAMM. These are all use cases designed to solve one single problem: making value locked in DeFi systems accessible.

PartyParrot engaged Halborn to conduct a security assessment on their Smart contracts beginning on August 2, 2021. The security assessment was scoped to the smart contract provided in the Github repository gopartyparrot/parrot-program and an audit of the security risk and implications regarding the changes introduced by the development team at Apricot prior to its production release shortly following the assessments deadline.

1.2 AUDIT SUMMARY

The team at Halborn was provided several weeks for the engagement and assigned two full time security engineers to audit the security of the smart contract. The security engineers are blockchain and smart-contract security experts with advanced penetration testing, smart-contract hacking, and deep knowledge of multiple blockchain protocols.

The purpose of this audit to achieve the following:

- Ensure that smart contract functions are intended.
- Identify potential security issues with the smart contracts.

Though this security audit's outcome is satisfactory, only the most essential aspects were tested and verified to achieve objectives and deliverables set in the scope due to time and resource constraints. It is essential to note the use of the best practices for secure smart-contract development.

1.3 TEST APPROACH & METHODOLOGY

Halborn performed a combination of manual view of the code and automated security testing to balance efficiency, timeliness, practicality, and accuracy in regard to the scope of the smart contract audit. While manual testing is recommended to uncover flaws in logic, process, and implementation; automated testing techniques help enhance coverage of smart contracts and can quickly identify items that do not follow security best practices. The following phases and associated tools were used throughout the term of the audit:

- Research into architecture, purpose, and use of the platform.
- Manual code review and walkthrough.
- Manual assessment of use and safety for the critical Rust variables and functions in scope to identify any arithmetic related vulnerability classes.
- Manual assessment to determine access control issues such as missing ownership checks, missing signer checks, and solana account confusions.
- Fuzz testing. (Halborn custom fuzzing tool)
- Checking the test coverage. (cargo tarpaulin)
- Scanning of Rust files for vulnerabilities. (cargo audit)
- Detecting usage of unsafe Rust code. (cargo-geiger)
- Detecting Rust undefined behaviour. (Miri)

RISK METHODOLOGY:

Vulnerabilities or issues observed by Halborn are ranked based on the risk assessment methodology by measuring the **LIKELIHOOD** of a security incident, and the **IMPACT** should an incident occur. This framework works for communicating the characteristics and impacts of technology vulnerabilities. It's quantitative model ensures repeatable and accurate measurement while enabling users to see the underlying vulnerability characteristics that was used to generate the Risk scores. For every vulnerability, a risk level will be calculated on a scale of 5 to 1 with 5 being the highest likelihood or impact.

RISK SCALE - LIKELIHOOD

5 - Almost certain an incident will occur.
4 - High probability of an incident occurring.
3 - Potential of a security incident in the long term.
2 - Low probability of an incident occurring.
1 - Very unlikely issue will cause an incident.

RISK SCALE - IMPACT

5 - May cause devastating and unrecoverable impact or loss.
4 - May cause a significant level of impact or loss.
3 - May cause a partial impact or loss to many.
2 - May cause temporary impact or loss.
1 - May cause minimal or un-noticeable impact.

The risk level is then calculated using a sum of these two values, creating a value of 10 to 1 with 10 being the highest level of security risk.

10 - CRITICAL
9 - 8 - HIGH
7 - 6 - MEDIUM
5 - 4 - LOW
3 - 1 - VERY LOW AND INFORMATIONAL

1.4 SCOPE

Code into https://github.com/gopartyparrot/parrot-program/tree/4afe638e60c4fe72d2393cfa4c9f24d14b8376f1/programs/parrot/src folder.

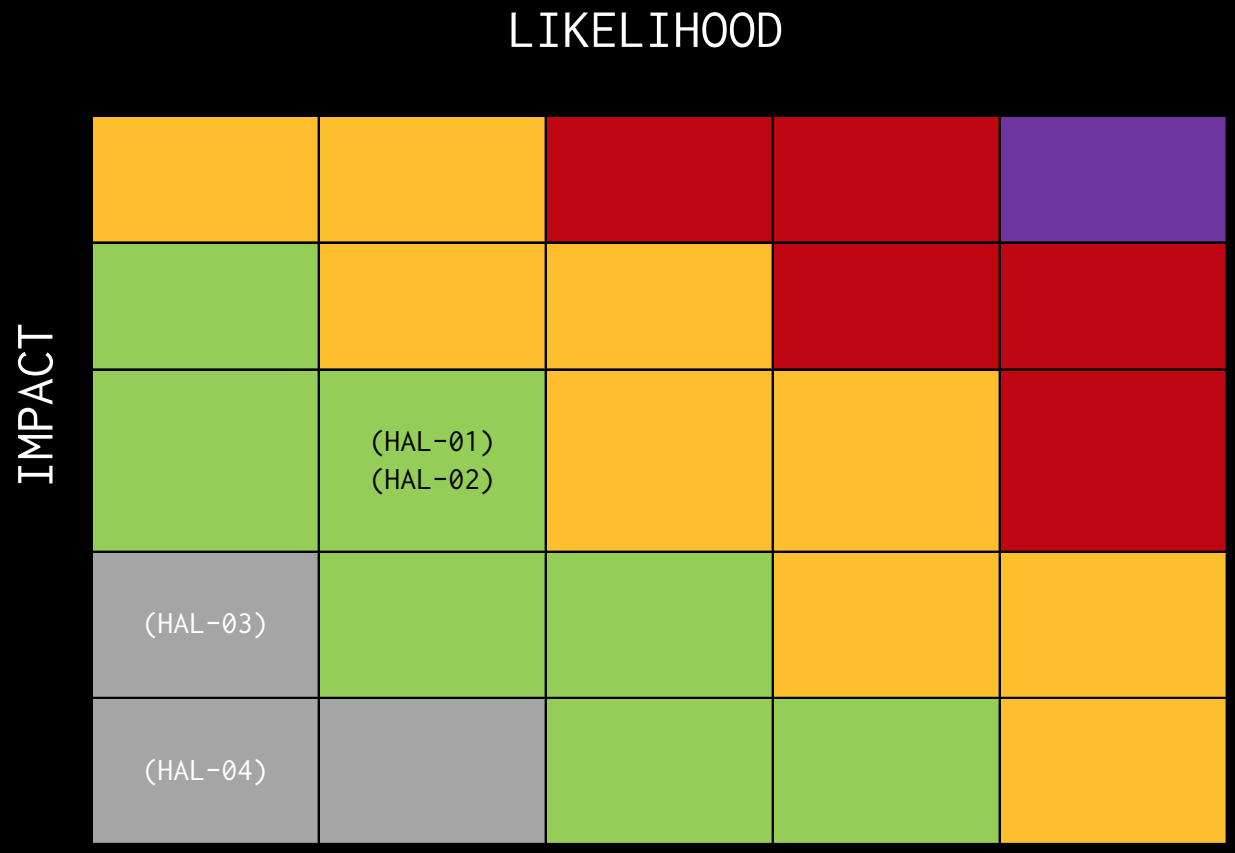
Specific commit of platform: commit 4afe638e60c4fe72d2393cfa4c9f24d14b8376f1

OUT-OF-SCOPE:

Other smart contracts in the repository and economics attacks.
Third party connections/connectivity.

2. ASSESSMENT SUMMARY & FINDINGS OVERVIEW

CRITICAL	HIGH	MEDIUM	LOW	INFORMATIONAL
0	0	0	2	2



SECURITY ANALYSIS	RISK LEVEL	REMEDIATION DATE
OUTDATED DEPENDENCY	Low	RISK ACCEPTED
ARITHMETIC ISSUES	Low	RISK ACCEPTED
UNSAFE RUST CODE USAGE	Informational	ACKNOWLEDGED
LOW TEST COVERAGE	Informational	ACKNOWLEDGED

FINDINGS & TECH DETAILS

3.1 (HAL-01) OUTDATED DEPENDENCY - LOW

Description:

Partyparrot is using solana dependency version 1.6.3 which is not the last solana version. Also anchor version is too old compare to the latest one 0.13.x. Crate for fixed point number which is fixed is also old. It is always recommended to use the latest solana program version to avoid already fixed issues.

Code Location:

Listing 1: Cargo.toml (Lines 22,23,24,25)

```
21 [dependencies]
22 fixed = "1.7.0"
23 anchor-lang = "0.5.0"
24 anchor-spl = "0.5.0"
25 solana-program = "1.6.3"
```

Risk Level:

Likelihood - 2
Impact - 3

Recommendation:

Halborn recommends to use the latest possible version of solana dependency (0.7.4 at the moment of this audit) unless rust programs are bounded to specific versions. Also use the latest version for fixed and anchor crates.

Remediation Plan:

RISK ACCEPTED: Party Parrot team is not considering to upgrade the anchor crate at the moment.

3.2 (HAL-02) ARITHMETIC ERRORS - LOW

Description:

The most serious arithmetic errors include integer overflow/underflow . In computer programming, integer overflow/underflow occurs when an arithmetic operation attempts to create a numeric value that is outside of the range that can be represented with a given number of bits -- either larger than the maximum or lower than the minimum representable value. Although integer overflows and underflows do not cause Rust to panic in the release mode, the consequences could be dire if the result of those operations is used in financial calculations.

Code Location:

Integer Overflow/Underflow

Listing 2: math.rs

```
27     let delta_decimal =
28         price.price_decimal as i16 + price.token_decimal as i16 -
               price.bid_token_decimal as i16;
```

Listing 3: math.rs

```
63     let delta_decimal =
64         price.price_decimal as i16 + price.token_decimal as i16 -
               price.bid_token_decimal as i16;
```

Division

Listing 4: math.rs

```
34     if delta_decimal > 0 {
35         collateral_amount_in_debt_token =
               collateral_amount_in_debt_token.div(ten_exponent)
```

```
36      } else {
```

Listing 5: math.rs

```
75      } else {
76          fp_repay_collateral_amount = fp_repay_collateral_amount.
               div(ten_exponent);
77      }
78      fp_repay_collateral_amount = fp_repay_collateral_amount.div(
           Fix::from_num(price.price));
```

Recommendation:

It is recommended to use vetted safe math libraries(like checked_add , checked_div) for arithmetic operations consistently throughout the smart contract system. Consider using Rust safe arithmetic functions for primitives rather than standard arithmetic operators.

Reference:

Safe arithmetic operations for primitives: u8, u32, u64

Remediation Plan:

RISK ACCEPTED: Party Parrot team considers acceptable the arithmetic in this context, because the debt type owners chooses the asset types, so decimals will not overflow.

3.3 (HAL-03) UNSAFE RUST CODE USAGE - INFORMATIONAL

Description:

Rust code that uses the unsafe keyword is considered unsafe since all of the memory safety guarantees of Rust are not enforced there.It means that the code might be prone to vulnerabilities that would’ve been prevented by the compiler such as Buffer overflow, Double free, Use After free, and more.

FINDINGS & TECH DETAILS

Result:

```
Metric output format: x/y
    x = unsafe code used by the build
    y = total unsafe code found in the crate

Symbols:
    🔒 = No `unsafe` usage found, declares #![forbid(unsafe_code)]
    ❓ = No `unsafe` usage found, missing #![forbid(unsafe_code)]
    ☢️ = `unsafe` usage found

Functions  Expressions  Impls  Traits  Methods  Dependency

0/1        0/7          0/0    0/0     0/0      ❓ parrot 0.1.0
0/0        0/0          0/0    0/0     0/0      ❓ ├── anchor-lang 0.5.0
0/0        0/0          0/0    0/0     0/0      ❓ │   ├── anchor-attribute-access-control 0.5.0
0/0        8/8          0/0    0/0     0/0      ☢️ │   │   ├── anchor-syn 0.5.0
15/18      432/439      3/3    0/0     11/11    ☢️ │   │   │   ├── anyhow 1.0.40
0/0        1/1          0/0    0/0     0/0      ☢️ │   │   │   ├── bs58 0.3.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── heck 0.3.2
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── unicode-segmentation 1.7.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   └── unicode-xid 0.2.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── quote 1.0.9
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── proc-macro2 1.0.24
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   ├── serde 1.0.125
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── serde_derive 1.0.125
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │       ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │       ├── quote 1.0.9
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │   │       └── syn 1.0.67
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │           ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │           ├── quote 1.0.9
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │           └── unicode-xid 0.2.1
0/0        4/6          0/0    0/0     0/0      ☢️ │   │   │   ├── serde_json 1.0.64
0/0        1/1          0/0    0/0     0/0      ☢️ │   │   │   │   ├── itoa 0.4.7
8/12       674/921      0/0    0/0     2/2      ☢️ │   │   │   │   ├── ryu 1.0.5
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   │   └── serde 1.0.125
2/2        73/74        0/0    0/0     0/0      ☢️ │   │   │   ├── sha2 0.9.3
0/0        6/6          0/0    0/0     0/0      ☢️ │   │   │   │   ├── block-buffer 0.9.0
0/0        3/3          0/0    0/0     0/0      ☢️ │   │   │   │   │   ├── block-padding 0.2.1
1/1        295/295      20/20  8/8     5/5      ☢️ │   │   │   │   │   └── generic-array 0.14.4
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   │   │       ├── serde 1.0.125
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   │       └── typenum 1.13.0
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   ├── cfg-if 1.0.0
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   ├── cpuid-bool 0.1.2
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   ├── digest 0.9.0
1/1        295/295      20/20  8/8     5/5      ☢️ │   │   │   │   │   └── generic-array 0.14.4
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── opaque-debug 0.3.0
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │   ├── syn 1.0.67
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   └── thiserror 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │       └── thiserror-impl 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │           ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │           ├── quote 1.0.9
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │           └── syn 1.0.67
15/18      432/439      3/3    0/0     11/11    ☢️ │   │   ├── anyhow 1.0.40
0/0        0/0          0/0    0/0     0/0      ❓ │   │   ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   ├── quote 1.0.9
0/0        34/34        1/2    0/0     2/2      ☢️ │   │   ├── regex 1.4.5
19/19      678/678      0/0    0/0     22/22    ☢️ │   │   │   ├── aho-corasick 0.7.15
26/27      1823/1896    0/0    0/0     0/0      ☢️ │   │   │   │   └── memchr 2.3.4
0/19       10/311       0/0    0/0     5/27     ☢️ │   │   │   │       └── libc 0.2.91
26/27      1823/1896    0/0    0/0     0/0      ☢️ │   │   │   ├── memchr 2.3.4
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   └── regex-syntax 0.6.23
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   └── syn 1.0.67
```

After cloning the repository, Halborn installed and executed cargo geiger on the in scope program. The results show that many core components contain unsafe Rust code.

Risk Level:

Likelihood - 1
Impact - 2

Recommendation:

It is recommended to always double check unsafe Rust code in your own codebase and monitor any core dependencies that contain unsafe Rust in case of any found vulnerabilities.

Remediation Plan:

ACKNOWLEDGED: Party Parrot team claims that the use of certain dependencies is out of their control.

3.4 (HAL-04) LOW TEST COVERAGE - INFORMATIONAL

Description:

Checking the code by automated testing (unit testing or functional testing) is a good practice to be sure all lines of the code work correctly. Halborn used an automatic tool to discover the test coverage. This is also known as “code coverage”. The tool used by the auditors is a rust utility called cargo tarpaulin.

Result:

```
running 9 tests
test math::tests::example_inaccurate_float_calculation ... ok
test math::tests::test_calculate_collateral_ratio_precision_lost ... ok
test math::tests::test_calculate_collateral_repay_amount ... ok
test math::tests::test_calculate_collateral_ratio ... ok
test math::tests::test_rpy ... ok
test stables_oracle::test_id ... ok
test math::tests::tool_calculate_interest_rate ... ok
test tests::test_vault_decrease_collateral ... ok
test tests::test_vault_type_update_interest_accum ... ok

test result: ok. 9 passed; 0 failed; 0 ignored; 0 measured; 0 filtered out; finished in 0.04s

Aug 19 03:10:24.694  INFO cargo_tarpaulin::report: Coverage Results:
|| Tested/Total Lines:
|| node_modules/@solana/web3.js/examples/bpf-rust-noop/src/lib.rs: 0/1
|| programs/parrot/src/lib.rs: 115/476
|| programs/parrot/src/math.rs: 135/136
||
40.78% coverage, 250/613 lines covered
```

After cloning the repository, Halborn installed and executed cargo tarpaulin on the libraries on the in scope components. The coverage results ended up determining that 40.78% of the lines of rust code were covered with unit/function tests. Details on which components/libraries have coverage are provided in the output on the next page.

Risk Level:

Likelihood - 1
Impact - 1

Recommendation:

It is recommended to have the developers enhance the code coverage to have as much possible tests to check all the functionalities of the ledger platform. This will ensure the production release functions as intended.

Remediation Plan:

ACKNOWLEDGED: Party Parrot team claims that most of the tests are integration tests, and not captured by rust tests. So they consider that the test coverage is acceptable.

MANUAL TESTING

Description:

Custom tests are useful for developers to check if functions and permissions work correctly. Furthermore, they are also useful for security auditors to perform security tests behaving like a malicious user. Then, auditors manually manipulated inputs to check the security in the smart contracts.

4.1 WITHDRAW AMOUNT ON BEHALF OF OTHER USER

Description:

`unstake()` method requires just amount as an argument. Since `unstake()` is public function, one can pass `Unstake` object and amount value to withdraw the amount on behalf of other users. But it is not possible due to derived macro `account` for `anchor_lang` makes sure correct value for vault owner, debt token, collateral token holder etc in passed `Unstake` object.

Code Location:

Listing 6

```
#[derive(Accounts)]
pub struct Unstake<'info> {
    debt_type: ProgramAccount<'info, DebtType>,

    #[account(mut, has_one = debt_type)]
    vault_type: ProgramAccount<'info, VaultType>,

    #[account(mut, "&debt_type.debt_token == debt_token.
        to_account_info().key")]
    debt_token: CpiAccount<'info, Mint>, //to get token decimal

    #[account(mut, has_one = vault_type)]
    vault: ProgramAccount<'info, Vault>,

    #[account("&vault_type.price_oracle == oracle.key")]
```

```
15      oracle: AccountInfo<'info>,
16
17      #[account(mut, signer, "&vault.owner == vault_owner.key")]
18      vault_owner: AccountInfo<'info>,
19
20      #[account("token_program.key == &token::ID")]
21      token_program: AccountInfo<'info>,
22
23      #[account(
24          mut,
25          "&vault_type.collateral_token == collateral_token.
                to_account_info().key"
26      )]
27      collateral_token: CpiAccount<'info, Mint>,
28
29      #[account(
30          mut,
31          "&vault_type.collateral_token_holder ==
                collateral_token_holder.key"
32      )]
33      collateral_token_holder: AccountInfo<'info>,
34
35      // PDA of vault_type
36      collateral_token_holder_authority: AccountInfo<'info>,
37
38      #[account(mut)]
39      receiver: AccountInfo<'info>,
40
41      clock: Sysvar<'info, Clock>,
42  }
```

Results:

Struct Unstake checks vault owner, debt token, collateral tokens, collateral token holder account etc, so it is not possible to perform unstake on behalf of other user.

4.2 BORROW AMOUNT ON BEHALF OF OTHER USER

Description:

borrow() method requires just amount as an argument. Since borrow() is public function, one can pass Borrow object and amount value to borrow the amount on behalf of other users. But it is not possible due to implemented checked for vault owner, vault token, debt originator etc in passed Borrow object.

Code Location:

Listing 7

```
pub struct Borrow<'info> {
    debt_type: ProgramAccount<'info, DebtType>,

    #[account(mut, has_one = debt_type)]
    vault_type: ProgramAccount<'info, VaultType>,

    #[account("&vault_type.collateral_token ==
       collateral_token_mint.to_account_info().key")]
    collateral_token_mint: CpiAccount<'info, Mint>, //to get token
        decimal

    #[account(mut, has_one = vault_type)]
    vault: ProgramAccount<'info, Vault>,

    #[account(signer, "&vault.owner == vault_owner.key")]
    vault_owner: AccountInfo<'info>,

    #[account("token_program.key == &token::ID")]
    token_program: AccountInfo<'info>,

    #[account("&debt_type.debt_token ==  debt_token.
       to_account_info().key")]
    debt_token: CpiAccount<'info, Mint>, //use Mint to get token
       decimal

```

```
22      #[account(mut, "&debt_type.debt_originator == debt_originator.
            key")]
23      debt_originator: AccountInfo<'info>,
24
```

Results:

Struct Borrow checks vault owner, vault token, debt originator etc, so it is not possible to perform borrow on behalf of other user.

Also method increase_debt() checks the debt_ceiling to prevent unlimited borrow.

FUZZING

5.1 FUZZING UNSAFE RUST DEPENDENCIES

Description:

Since the program uses some core dependencies that contain unsafe Rust code, Halborn used some custom fuzzing tools and industry standard tools like libfuzzer, honggfuzz and fzero_fuzzer to fuzz some of those dependencies for a certain period.

Results:

Due to the time constraints, only two handpicked dependencies were fuzzed for a certain amount of time. All fuzzing tests were positive ie. no issues were detected at this time.

- serde-json: Fuzz Code

```
#![no_main]

use libfuzzer_sys::fuzz_target;
use serde_json::*;

fn json_fuzz(data:&str) -> serde_json::Result<()> {
    // Some JSON input data as a &str. Maybe this comes from the user.

    // Parse the string of data into serde_json::Value.
    let v: serde_json::Value = serde_json::from_str(data)?;


    Ok(())
}

fuzz_target!(|data: &[u8]| {

    if let Ok(data) = std::str::from_utf8(data) {
        json_fuzz(data);
    }

});
```

- anyhow: Fuzz Code

FUZZING

```rust
#[macro_use]
extern crate honggfuzz;
extern crate anyhow;

use anyhow::{ Result, anyhow};

fn err (data: &str) -> Result<()> {
    anyhow::ensure!(data.len() > 0, "only user {} is allowed", data);

    return Err(anyhow!("some error {:?}", data));

}

▶ Run | Debug
fn main() -> Result<()>{
    println!("Starting fuzzer");

    loop {

        fuzz!(|data: &str| {

            err(data);

        });

    }
}
```

AUTOMATED TESTING

6.1 VULNERABILITIES AUTOMATIC DETECTION

Description:

Halborn used automated security scanners to assist with detection of well known security issues and vulnerabilities. Among the tools used was cargo audit, a security scanner for vulnerabilities reported to the RustSec Advisory Database. All vulnerabilities published in https://crates.io are stored in a repository named The RustSec Advisory Database. cargo audit is a human-readable version of the advisory database which performs a scanning on Cargo.lock. Security Detections are only in scope. All vulnerabilities shown here were already disclosed in above report. However, to better assist the developers maintaining this code, the auditors are including the output with the dependencies tree, and this is included in the cargo audit output to better know the dependencies affected by unmaintained and vulnerable crates.

Results:

```
    Fetching advisory database from `https://github.com/RustSec/advisory-db.git`
      Loaded 323 security advisories (from /home/ethsec/.cargo/advisory-db)
    Updating crates.io index
    Scanning Cargo.lock for vulnerabilities (131 crate dependencies)
Crate:         cpuid-bool
Version:       0.1.2
Warning:       unmaintained
Title:         `cpuid-bool` has been renamed to `cpufeatures`
Date:          2021-05-06
ID:            RUSTSEC-2021-0064
URL:           https://rustsec.org/advisories/RUSTSEC-2021-0064
Dependency tree:
cpuid-bool 0.1.2
└── sha2 0.9.3
    ├── solana-program 1.6.10
    │   ├── spl-token 3.1.0
    │   │   ├── serum_dex 0.3.0
    │   │   │   └── anchor-spl 0.5.0
    │   │   │       └── parrot 0.1.0
    │   │   ├── flux-aggregator 0.1.0
    │   │   │   └── parrot 0.1.0
    │   │   └── anchor-spl 0.5.0
    │   ├── serum_dex 0.3.0
    │   ├── parrot 0.1.0
    │   ├── flux-aggregator 0.1.0
    │   ├── anchor-spl 0.5.0
    │   └── anchor-lang 0.5.0
    │       ├── parrot 0.1.0
    │       └── anchor-spl 0.5.0
    ├── solana-frozen-abi 1.6.10
    │   └── solana-program 1.6.10
    └── anchor-syn 0.5.0
        ├── anchor-derive-accounts 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-state 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-program 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-interface 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-event 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-error 0.5.0
        │   └── anchor-lang 0.5.0
        ├── anchor-attribute-account 0.5.0
        │   └── anchor-lang 0.5.0
        └── anchor-attribute-access-control 0.5.0
            └── anchor-lang 0.5.0

warning: 1 allowed warning found
```

6.2 UNSAFE RUST CODE DETECTION

Description:

Halborn used automated security scanners to assist with the detection of well-known security issues and vulnerabilities. Among the tools used was cargo-geiger, a security tool that lists statistics related to the usage of unsafe Rust code in a core Rust codebase and all its dependencies.

Results:

```
Metric output format: x/y
    x = unsafe code used by the build
    y = total unsafe code found in the crate

Symbols:
    🔒 = No `unsafe` usage found, declares #![forbid(unsafe_code)]
    ❓ = No `unsafe` usage found, missing #![forbid(unsafe_code)]
    ☢️ = `unsafe` usage found

Functions  Expressions  Impls  Traits  Methods  Dependency

0/1        0/7          0/0    0/0     0/0      ❓ parrot 0.1.0
0/0        0/0          0/0    0/0     0/0      ❓ ├── anchor-lang 0.5.0
0/0        0/0          0/0    0/0     0/0      ❓ │   ├── anchor-attribute-access-control 0.5.0
0/0        8/8          0/0    0/0     0/0      ☢️ │   │   ├── anchor-syn 0.5.0
15/18      432/439      3/3    0/0     11/11    ☢️ │   │   │   ├── anyhow 1.0.40
0/0        1/1          0/0    0/0     0/0      ☢️ │   │   │   ├── bs58 0.3.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── heck 0.3.2
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── unicode-segmentation 1.7.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   └── unicode-xid 0.2.1
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   ├── quote 1.0.9
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── proc-macro2 1.0.24
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   ├── serde 1.0.125
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── serde_derive 1.0.125
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │       ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │       ├── quote 1.0.9
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │   │       └── syn 1.0.67
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │           ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │           ├── quote 1.0.9
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │           └── unicode-xid 0.2.1
0/0        4/6          0/0    0/0     0/0      ☢️ │   │   │   ├── serde_json 1.0.64
0/0        1/1          0/0    0/0     0/0      ☢️ │   │   │   │   ├── itoa 0.4.7
8/12       674/921      0/0    0/0     2/2      ☢️ │   │   │   │   ├── ryu 1.0.5
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   │   └── serde 1.0.125
2/2        73/74        0/0    0/0     0/0      ☢️ │   │   │   ├── sha2 0.9.3
0/0        6/6          0/0    0/0     0/0      ☢️ │   │   │   │   ├── block-buffer 0.9.0
0/0        3/3          0/0    0/0     0/0      ☢️ │   │   │   │   │   ├── block-padding 0.2.1
1/1        295/295      20/20  8/8     5/5      ☢️ │   │   │   │   │   └── generic-array 0.14.4
0/0        4/4          0/0    0/0     0/0      ☢️ │   │   │   │   │       ├── serde 1.0.125
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   │       └── typenum 1.13.0
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   ├── cfg-if 1.0.0
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   ├── cpuid-bool 0.1.2
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   │   ├── digest 0.9.0
1/1        295/295      20/20  8/8     5/5      ☢️ │   │   │   │   │   └── generic-array 0.14.4
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   │   └── opaque-debug 0.3.0
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │   ├── syn 1.0.67
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │   └── thiserror 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │       └── thiserror-impl 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │           ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   │           ├── quote 1.0.9
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   │           └── syn 1.0.67
15/18      432/439      3/3    0/0     11/11    ☢️ │   │   ├── anyhow 1.0.40
0/0        0/0          0/0    0/0     0/0      ❓ │   │   ├── proc-macro2 1.0.24
0/0        0/0          0/0    0/0     0/0      ❓ │   │   ├── quote 1.0.9
0/0        34/34        1/2    0/0     2/2      ☢️ │   │   ├── regex 1.4.5
19/19      678/678      0/0    0/0     22/22    ☢️ │   │   │   ├── aho-corasick 0.7.15
26/27      1823/1896    0/0    0/0     0/0      ☢️ │   │   │   │   └── memchr 2.3.4
0/19       10/311       0/0    0/0     5/27     ☢️ │   │   │   │       └── libc 0.2.91
26/27      1823/1896    0/0    0/0     0/0      ☢️ │   │   │   ├── memchr 2.3.4
0/0        0/0          0/0    0/0     0/0      🔒 │   │   │   └── regex-syntax 0.6.23
0/0        45/45        3/3    0/0     2/2      ☢️ │   │   └── syn 1.0.67
```

6.3 RUST UNDEFINED BEHAVIOUR TESTING

Description:

Halborn used automated security scanners to assist with detection of different classes of undefined behaviour in Rust. Among the tools used was Miri, an experimental interpreter for Rust's mid-level intermediate representation (MIR). It can run binaries and test suites of cargo projects and detect certain classes of undefined behavior, for example:

- Out-of-bounds memory accesses and use-after-free
- Invalid use of uninitialized data
- Violation of intrinsic preconditions (an unreachable_unchecked being reached, calling copy_nonoverlapping with overlapping ranges, . . .)
- Not sufficiently aligned memory accesses and references
- Violation of some basic type invariants (a bool that is not 0 or 1, for example, or an invalid enum discriminant)
- Experimental: Violations of the Stacked Borrows rules governing aliasing for reference types
- Experimental: Data races (but no weak memory effects)

On top of that, Miri will also tell you about memory leaks: when there is memory still allocated at the end of the execution, and that memory is not reachable from a global static, Miri will raise an error.

Halborn ran predefined tests that exist in the program through Miri to catch any undefined behaviour.

Results:

All tests are passing without any issues raised by Miri

```
running 9 tests
test math::tests::example_inaccurate_float_calculation ... ok
test math::tests::test_calculate_collateral_ratio ... ok
test math::tests::test_calculate_collateral_ratio_precision_lost ... ok
test math::tests::test_calculate_collateral_repay_amount ... ok
test math::tests::test_rpy ... ok
test math::tests::tool_calculate_interest_rate ... ok
test stables_oracle::test_id ... ok
test tests::test_vault_decrease_collateral ... ok
test tests::test_vault_type_update_interest_accum ... ok

test result: ok. 9 passed; 0 failed; 0 ignored; 0 measured; 0 filtered out
```

References:

Rust Undefined Behavior

THANK YOU FOR CHOOSING

// HALBORN