Polkaswap

Security Assessment

August 2, 2021

Prepared For:
Iurii Vinogradov | Soramitsu
vinogradov@soramitsu.co.jp

Pavel Golovkin | Soramitsu
golovkin@soramitsu.co.jp

Prepared By:
Dominik Czarnota | *Trail of Bits*
dominik.czarnota@trailofbits.com

Artur Cygan | *Trail of Bits*
artur.cygan@trailofbits.com

Executive Summary

From July 12 to July 30, 2021, Soramitsu engaged Trail of Bits to review the security of the Polkaswap system. Trail of Bits conducted this assessment over six person-weeks, with two engineers working from the `sora2-substrate` (`9d72e6c`), `sora2-eth` (`f3cf040`), and `sora2-frame-pallets` (`021b1e5`) repositories.

During the first week of the assessment, we focused on gaining an understanding of the codebase, documentation, and Polkaswap system. We reviewed the Ethereum bridge smart contract, the off-chain components, and the `permissions` and `assets` pallets, among others. In the second week, we started reviewing the DEX components: the bonding curve, `XYKPool`, `liquidity-proxy`, `MCBP`, `price-tools`, `pswap-distribution`, `trading-pair`, `xor-fee`, `vested-rewards`, and `rewards` pallets. In the last week, we also analyzed certain Substrate-related concerns, such as the definition of extrinsic weights and the atomicity of the extrinsics. In addition to manually reviewing the code, we leveraged the Polkaswap.io wallet interface, the Sorascan explorer, and custom Python scripts to conduct dynamic testing of various scenarios. We also tested certain parsing code using the `test-fuzz` fuzzing framework, which did not find any bugs.

Our review resulted in 24 findings ranging from high to informational severity. Several high-severity issues result from the incorrect handling of certain operations in the Ethereum bridge contract, such as token transfers; specifically, a user could execute a transfer and a subsequent withdrawal without actually transferring any funds, draining value from the Polkaswap system. Since the system is live, we reported those issues to Soramitsu immediately upon discovering them, and the Soramitsu team disabled the problematic tokens in the off-chain workers, all of which are currently controlled by the team.

Other high-severity issues involve bridge contract peer signatures, which in certain cases can be reused or replayed across contract instances. In addition, the off-chain bridge component has no mechanism for handling Ethereum blockchain reorganizations and depends on a single source of truth for Ethereum event data; as a result, an Ethereum reorganization involving numerous blocks or an attack against that source of data could lead to an incorrect chain state or a loss or theft of funds.

As part of the audit, we identified non-security-related issues, which are detailed in Appendix C, and compiled a list of ERC20 token transfer semantics, provided in Appendix D, which helped us evaluate the risks stemming from the transfer-related findings. Appendix E provides guidance on interactions with arbitrary tokens, and Appendix G details the process of fuzzing the Polkaswap codebase and includes a patch that adds a fuzzing harness.

The Polkaswap system is complex, and its security is heavily dependent on the actions of trusted peers and the external API it uses as an Ethereum data source. Additionally, many aspects of the Polkaswap system lack proper documentation, which makes it harder to reason about the system.

Trail of Bits recommends that Soramitsu take the following steps:

- Fix the issues detailed in this report.
- Expand the test suite.
- Expand and centralize the documentation, ensuring that it details the system's algorithms and formulas.
- Implement a process for ensuring that new supported ERC20 tokens have the expected semantics before they are used in the system.
- Develop an automated mechanism for tracking upgradeable ERC20 tokens to ensure that their expected semantics do not change as new versions are introduced.

After implementing the recommendations provided in this report, Soramitsu should perform additional security assessments to ensure that the expected security properties of the system hold.

Project Dashboard

Application Summary

Name	Polkaswap
Versions	`sora2-substrate` (9d72e6c) `sora2-eth` (f3cf040) `sora2-frame-pallets` (021b1e5)
Type	Rust
Platform	Linux

Engagement Summary

Dates	July 12–July 30, 2021
Method	Full knowledge
Consultants Engaged	2
Level of Effort	6 person-weeks

Vulnerability Summary

Total High-Severity Issues	7	■ ■ ■ ■ ■ ■ ■
Total Medium-Severity Issues	5	■ ■ ■ ■ ■
Total Low-Severity Issues	4	■ ■ ■ ■
Total Informational-Severity Issues	5	■ ■ ■ ■ ■
Total Undetermined-Severity Issues	3	■ ■ ■
Total	24	

Category Breakdown

Auditing and Logging	3	■ ■ ■
Data Exposure	1	■
Data Validation	16	■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■
Denial of Service	1	■
Patching	1	■
Undefined Behavior	2	■ ■

Total	24	

Code Maturity Evaluation

Category Name	Description
Access Controls	**Weak.** We found several issues involving the peer signature hashing schemes, which could enable the reuse of signatures or allow an attacker to add the bridge contract itself as a trusted peer. The system also lacks documentation on its use of validators and peers and its permission system, which enforce its access controls.
Arithmetic	**Moderate.** We did not find any arithmetic-related issues. However, there are many places in the code that use saturating arithmetic rather than checked. The arithmetic will require further investigation, as additional issues (such as rounding or economic issues) might be present.
Assembly Use	**Not applicable.** The project does not use assembly.
Centralization	**Weak.** In principle, the SORA Network ensures decentralization by using Substrate's built-in nominated proof-of-stake consensus algorithm. However, the Ethereum bridge contract is managed by trusted peers that are fully controlled by the Soramitsu team, which also controls all SORA Network validators. Additionally, the system depends on a single Ethereum data source and would therefore be significantly affected by a hack of that source.
Code Stability	**Moderate.** The code was undergoing changes during the audit and might continue to evolve before reaching its final version.
Upgradeability	**Satisfactory.** We did not find any issues directly related to upgradeability.
Function Composition	**Satisfactory.** The codebase's functions are narrow and have clear purposes. However, the number of Rust modules and the lack of architecture-related documentation make it difficult to track the components' interactions.
Front-Running	**Satisfactory.** We did not find any front-running issues.
Monitoring	**Not considered.**
Specification	**Moderate.** The system is very complex. While it has some documentation in the form of Medium posts, certain aspects of the system, such as the complex swap process, the peer system,

	and the `eth-bridge` and `technical` pallets, are not well documented. The documentation should also be aggregated into one source.
Testing & Verification	**Moderate.** The unit tests are not exhaustive, and many check only happy paths. The unit tests should ensure that expected states are triggered when errors occur.

Engagement Goals

The engagement was scoped to provide a security assessment of the Polkaswap system.

Specifically, we sought to answer the following questions:

- Could malicious users steal funds or manipulate asset prices in unexpected ways?
- Does the Ethereum bridge contract handle supported tokens appropriately?
- Can peer signatures be bypassed or manipulated?
- Does the Ethereum bridge handle blockchain reorganizations properly?
- Is it possible for users to perform swaps in unintended ways?
- Are the arithmetic operations correct and prevented from overflowing?
- Are storage changes applied appropriately and reverted in case of a failure?
- Is it possible to spam or abuse the network?
- Can third-party integrators rely on the system to emit events where appropriate?

Coverage

General use of Substrate. We performed a manual code review to check whether the Polkaswap system uses the Substrate features properly. We analyzed the runtime parameters it uses, the emitted events, the configuration of extrinsics such as weights and dispatches (including the means of verifying their origins), and its validation of unsigned transactions. We also examined the use of cryptographic primitives and looked for transaction atomicity issues.

Ethereum bridge. We performed a manual code review of the Ethereum bridge smart contract and the off-chain components and ran the static analysis tool Slither on the Solidity code. We also analyzed the transfer and upgradeability semantics of the tokens supported by the bridge, which helped us assess the risks to the system and identify issues that required an immediate fix from the Soramitsu team.

DEX system. We performed a manual review of the liquidity sources in the `bonding-curve-pool`, `multicollateral-bonding-curve-pool`, and `XYKPool` pallets and analyzed most of the pallets used by the pools, namely the `dex-api`, `dex-manager`, `assets`, `liquidity-proxy`, `price-tools`, `pswap-distribution`, `technical`, `rewards`, and `xor-fees` pallets. We also used the Polkaswap.io wallet interface to execute dynamic testing of various swap processes; we then used the Sorascan explorer to check the results of that testing. Because of the time constraints of the audit, we reviewed the complex swap functionality only briefly; it will therefore be necessary to conduct additional reviews to ensure that all swap implications work as expected.

Permissions system. We did not find any issues in the permissions system. However, we identified an unused enum case, the `Mode::Forbid`, which the Soramitsu team indicated will be deleted. We recommend ensuring that related changes do not enable bypassing of the system's permission checks.

Key management. We performed a manual review of the peer key management code.

Recommendations Summary

This section aggregates all the recommendations made during the engagement. Short-term recommendations address the immediate causes of issues. Long-term recommendations pertain to the development process and long-term design goals.

Short Term

❑ **In the SORA Network, disable the four ERC20 tokens (BAT, HT, CHSB, and cUSDC) with `transfer` or `transferFrom` functions that return `false` upon a failure but still cause the Ethereum bridge to emit a `Deposit` or a `Withdrawal` event.** Re-enable those tokens after the issue has been fixed on the Ethereum bridge's side. TOB-PSWAP-001, TOB-PSWAP-009

❑ **Prevent the Ethereum bridge contract from using invalid signatures in signature counts.** Additionally, ensure that it properly validates the signatures of new peers to prevent the `0x0` address from being added as a peer. TOB-PSWAP-002

❑ **Add an empty-string check to the `is_symbol_valid` and `is_name_valid` functions to prevent the creation of assets with an empty ticker symbol or name field.** TOB-PSWAP-003

❑ **Clearly document the bridge semantics to inform users that the bridge is not designed to use inflationary or deflationary ERC20 tokens.** TOB-PSWAP-004

❑ **Disable support for upgradeable (proxy) tokens in the Polkaswap system.** (See Appendix D for a list of these tokens.) Then implement an automated upgrade-tracking mechanism and have the system pause interactions with upgraded tokens until they have received approval by consensus. TOB-PSWAP-005

❑ **Add a mechanism (such as slashing) for punishing peers who submit invalid signatures when approving requests in the Ethereum bridge component.** TOB-PSWAP-006

❑ **Update the vulnerable and unmaintained dependencies in the `sora2-substrate` codebase.** This will prevent the exploitation of a known vulnerability against the SORA Network. TOB-PSWAP-007

❑ **Add code to `eth-bridge` to detect Ethereum reorganizations by comparing block hashes.** Ensure that the code fetches blocks starting from the last processed block and compares that block's hash to the hash of the corresponding block (the block at the same height) returned by the API. If the hashes differ, a reorganization has occurred. Finally, design and document a reorganization-handling strategy. TOB-PSWAP-008

❑ **Upgrade the Ethereum bridge smart contract and fix the signature replay issue stemming from the `prepareForMigration` function.** Add `used` mapping checks to `prepareForMigration` and `shutDownAndMigrate`, as well as all other Ethereum bridge functions, to protect them from signature reuse/replay. Additionally, until the signature hashing issues have been fixed, ensure that calls to the `prepareForMigration` function pass in a `salt` of a `txHash` value already present in the contract's `used` mapping. This will prevent users of the system, which is already live, from reusing signatures and adding the bridge contract as a peer, which could render the contract inoperable. TOB-PSWAP-010

❑ **Use the contract's address and the `chainID` of the current transaction in all signature schemes to ensure that signatures cannot be reused across contract instances or after a chain fork.** TOB-PSWAP-011

❑ **Use `abi.encode` instead of `abi.encodePacked` to encode data for signature checking, especially in the `addNewSidechainToken` and `addEthNativeToken` functions.** This will prevent hash collisions caused by the hashing of multiple dynamic types. While this issue is currently mitigated by the `used[txHash]` check, we still recommend fixing it in case the code is reused. TOB-PSWAP-012

❑ **Update the description of the `technical` pallet's `SwapSuccess` event to indicate that it takes only one argument.** TOB-PSWAP-013

❑ **Enable the off-chain worker to fetch Ethereum events from multiple sources, and cross-validate the values it returns.** Then require validators to use at least two Ethereum sources, including one self-hosted Ethereum node. Finally, document the process of adding additional sources. These steps will mitigate the risk of system outages or theft in the event that the Ethereum source to which the off-chain worker connects becomes malicious or unavailable. TOB-PSWAP-014

❑ **Fix the Sorascan blockchain explorer so that it displays unknown asset IDs, includes their hex values, and marks them as nonexistent.** TOB-PSWAP-015

❑ **Avoid storing peers' secret key material in plaintext on the drive.** Store private keys (encrypted via symmetric encryption) with a password, and decrypt each key in memory when the corresponding peer is initialized. Ensure that these passwords are delivered in a safe way, such as through standard input. To automate the deployment process, store passwords on another server in the internal network and configure a deployment bot to use the secure shell (SSH) protocol to start or restart peers. TOB-PSWAP-016

❑ **Change the `LiquiditySourceType` so that mock pools are compiled only in a test environment.** Use the `#[cfg(test)]` Rust annotation to make that change. TOB-PSWAP-017

❑ **Implement appropriate data validation for the `selected_source_types` vector in the `liquidity-proxy` pallet's `swap` extrinsic.** Ensure that the network rejects calls if the vector is too long or if it contains duplicates. Additionally, consider accounting for the vector's length in calculations of the extrinsic's base weight. TOB-PSWAP-018

❑ **Benchmark the extrinsics that have a base weight set to zero.** Then, based on the results of that benchmarking, change the weights so that they cannot be used to spam the network. TOB-PSWAP-019

❑ **Remove the `technical` pallet's `create_swap` extrinsic, which is unused and redundant.** This will decrease the attack surface of the pallet. TOB-PSWAP-020

❑ **Use an arbitrary-precision decimal library to handle `amount` types.** This will ensure that the Sorascan explorer displays the correct initial supply value even when the value is very large. TOB-PSWAP-021

❑ **Either remove the `Decoder.next_u8` method from the `eth-bridge` pallet or change it so that it uses the `u8::try_from` method for decoding, as shown in figure 22.3.** That change will prevent the method from panicking (and possibly causing a denial of service) if it is called with untrusted input. TOB-PSWAP-022

❑ **Add a minimum initial supply requirement to the `assets` pallet's `register` extrinsic.** Additionally, consider adding a garbage collection method to handle assets that have no trading pairs and have not been used for a long time. TOB-PSWAP-023

❑ **Change the off-chain worker so that it no longer expects `block_number` values returned by the Ethereum API to be non-null.** Additionally, ensure that the system always checks the values returned by external APIs. TOB-PSWAP-024

Long Term

❑ **Migrate the Ethereum bridge smart contract to a new version and add a check for the return values of `token.transferFrom` to its `sendERC20ToSidechain` function.** Ensure that the bridge emits a `Deposit` event only when the transfer succeeds (when its return value is `true`). TOB-PSWAP-001

❑ **Use Echidna or Manticore to ensure that invalid signatures cannot be used in the Ethereum bridge smart contract.** TOB-PSWAP-002

❑ **Perform extensive negative testing of all data validation code.** TOB-PSWAP-003

❑ **Review the Token Integration Checklist and implement its recommendations to make sure that ERC20 tokens used by the bridge behave as expected.** TOB-PSWAP-004

❑ **To disincentivize trusted actors from destabilizing the network, ensure that there are always mechanisms in place for punishing trusted actors who misbehave.** TOB-PSWAP-006

❑ **Use the `cargo-audit` tool to ensure that the dependency versions used by the `sora2-substrate` project are free of known vulnerabilities, and integrate the tool into the CI/CD pipeline.** TOB-PSWAP-007

❑ **Implement a strategy for automated reorganization handling.** After detecting a reorganization, the algorithm should calculate which events need to be unapplied and which new events are missing from the blockchain. Additionally, design a strategy for handling negative balances, which can occur when events are unapplied. TOB-PSWAP-008

❑ **Migrate the Ethereum bridge smart contract to a new version and add a check for the return value of `transfer` calls to its `receiveByEthereumAssetAddress` and `shutDownAndMigrate` functions.** TOB-PSWAP-009

❑ **Thoroughly document and test the signature hashing schemes.** Consider using EIP-712: Ethereum typed structured data hashing and signing as a hashing structure. TOB-PSWAP-010, TOB-PSWAP-011

❑ **Use the static analyzer Slither to find code in which `abi.encodePacked` is used with more than one dynamic type.** TOB-PSWAP-012

❑ **Avoid relying on a single third-party source when fetching data that influences the chain state.** TOB-PSWAP-014

❑ **Use a secret management solution such as HashiCorp Vault or AWS' Key Management Service.** Note that currently, HashiCorp Vault does not support `secp256k1` signatures; however, there are ongoing efforts to add that support, tracked in issue `hashicorp/vault#4594` and pull request `hashicorp/vault#11469`. We recommend tracking those efforts and using the service once `secp256k1` support has been implemented. TOB-PSWAP-016

❑ **Ensure that the staging and production environments do not use any code that should live only in tests.** TOB-PSWAP-017

❑ **Add tests to the `liquidity-proxy` pallet's `swap` extrinsic to ensure that it properly validates the `selected_source_types` vector and disallows duplicate sources and excessive vector lengths.** TOB-PSWAP-018

❑ **Deploy only those extrinsics that will be used.** TOB-PSWAP-020

❑ **Test the Sorascan explorer against edge-case values such as very small and very large values.** The Sorascan explorer likely uses the `Number` type, which would explain why it displays rounded values. Testing the explorer against edge cases will help determine whether the values it displays are accurate. TOB-PSWAP-021

❑ **Use a technique such as fuzzing to test all encoding and decoding functions against edge-case inputs.** TOB-PSWAP-022

❑ **Add unit tests to the off-chain worker codebase to ensure that it correctly handles all invalid and edge-case values fetched from the Ethereum API.** TOB-PSWAP-024

Findings Summary

#	Title	Type	Severity
1	Ethereum bridge's failure to check transferFrom return values could facilitate illicit transfers	Data Validation	High
2	Improper use of ecrecover weakens the bridge's security	Data Validation	High
3	Users can register assets with empty name and ticker symbol fields	Data Validation	Informational
4	Use of ERC20 tokens that could become inflationary or deflationary	Data Validation	Medium
5	Polkaswap blindly trusts upgradeable ERC20 proxy tokens	Data Validation	Medium
6	Peers are not punished for submitting invalid signatures in approve_request	Data Validation	Undetermined
7	Outdated Rust dependencies	Patching	Undetermined
8	Ethereum bridge cannot handle chain reorganizations	Data Validation	High
9	Ethereum bridge does not check transfer results	Data Validation	High
10	Potential reuse of peer signatures from, and in calls to, the prepareForMigration function	Data Validation	High
11	Risk of replay attacks across contract instances	Data Validation	High
12	ABI encodePacked collision	Data Validation	Informational
13	Inaccurate description of SwapSuccess event	Auditing and Logging	Informational
14	Off-chain worker depends on a single Ethereum data source	Data Validation	High
15	Sorascan does not show asset IDs that are not present in the system	Auditing and Logging	Informational

16	Peers' secret keys are stored as plaintext in off-chain storage	Data Exposure	Medium
17	LiquiditySourceType contains mock pools	Undefined Behavior	Low
18	A vector in the liquidity-proxy's swap extrinsic can be used for network spamming	Data Validation	Medium
19	Zero-weight extrinsics can be used to spam the network	Denial of Service	Medium
20	Unused create_swap extrinsic in technical pallet	Undefined Behavior	Undetermined
21	Sorascan does not accurately display large initial supply values	Auditing and Logging	Low
22	eth-bridge Decoder.next_u8 method could panic if used	Data Validation	Low
23	Non-mintable assets can be created with no initial supply	Data Validation	Informational
24	Off-chain worker can panic if the Ethereum API returns a null block_number	Data Validation	Low

1. Ethereum bridge's failure to check transferFrom return values could facilitate illicit transfers

Severity: High
Type: Data Validation
Target: `sora2-eth/contracts/Bridge.sol`

Difficulty: Low
Finding ID: TOB-PSWAP-001

Description

The Ethereum bridge's `sendERC20ToSidechain` function (figure 1.1) does not check the values returned by certain ERC20 tokens' `token.transferFrom` function, which may return `false` (rather than reverting) when transfers of those tokens fail. In such cases, the bridge would still emit a `Deposit` event, which would then be processed by the SORA Network off-chain worker and logged by the Polkaswap system. As such, an attacker could execute the `sendERC20ToSidechain` function by calling `token.transferFrom` with an ERC20 token that does not revert upon a failure; the attacker, without having sent any funds, could then use the funds deposited into the SORA Network.

As part of the audit, we analyzed 55 ERC20 tokens owned by the Ethereum bridge and found 4 that could be used to exploit this issue: BAT, HT, CHSB, and cUSDC. However, it is also possible that tokens implemented through a proxy contract could be migrated to a version with different semantics. Appendix D includes a list of these 55 tokens and details their `transfer` return value semantics.

```
/**
 * Send ERC-20 token to sidechain.
 *
 * @param to destination address on the sidechain
 * @param amount amount to sendERC20ToSidechain
 * @param tokenAddress contract address of token to send
 */
function sendERC20ToSidechain(
    bytes32 to,
    uint amount,
    address tokenAddress)
external
shouldBeInitialized shouldNotBePreparedForMigration {
    IERC20 token = IERC20(tokenAddress);

    require(token.allowance(msg.sender, address(this)) >= amount, "NOT ENOUGH DELEGATED
TOKENS ON SENDER BALANCE");

    bytes32 sidechainAssetId = _sidechainTokensByAddress[tokenAddress];
    if (sidechainAssetId != "" || _addressVAL == tokenAddress || _addressXOR ==
tokenAddress) {
        ERC20Burnable mtoken = ERC20Burnable(tokenAddress);
        mtoken.burnFrom(msg.sender, amount);
    } else {
        require(acceptedEthTokens[tokenAddress], "The Token is not accepted for transfer to
sidechain");
        token.transferFrom(msg.sender, address(this), amount);
    }
    emit Deposit(to, amount, tokenAddress, sidechainAssetId);
}
```

Figure 1.1: The `sendERC20ToSidechain` *function (sora2-eth/contracts/Bridge.sol#L265-L291)*

Exploit Scenario

An attacker approves a transfer of BAT, an ERC20 token, from his Ethereum account to the SORA Network Ethereum bridge, deliberately setting a transfer allowance that exceeds the balance of his account. The attacker then sends a transaction to the bridge, calling the `sendERC20ToSidechain` function to transfer BAT tokens to an account in the SORA Network; the amount of the transfer exceeds his balance but not the allowance amount. The bridge calls the BAT token's `transferFrom` function; the execution fails, but the bridge emits a `Deposit` event, which is processed by the SORA Network's off-chain worker. The attacker can then use the funds on the SORA Network without having actually made a transfer.

Recommendations

Short term, in the SORA Network, disable the four ERC20 tokens (BAT, HT, CHSB, and cUSDC) with `transfer` functions that return `false` upon a failure but still cause the Ethereum bridge to emit a `Deposit` event. Re-enable those tokens after the issue has been fixed on the Ethereum bridge's side.

Long term, migrate the Ethereum bridge smart contract to a new version and add a check for the return value of `token.transferFrom` to its `sendERC20ToSidechain` function. Ensure that the bridge emits a `Deposit` event only when the transfer succeeds (when its return value is `true`).

2. Improper use of ecrecover weakens the bridge’s security

Severity: High
Difficulty: High
Type: Data Validation
Finding ID: TOB-PSWAP-002
Target: `sora2-eth/contracts/Bridge.sol`

Description

The bridge contract fails to check whether the address returned by the `ecrecover` function is the null address. An attacker could leverage this deficiency to reduce the number of valid signatures required to execute administrative operations.

The Ethereum bridge contract allows a set of peers to perform administrative operations by submitting ECDSA signatures. These operations include adding new peers or ERC20 tokens to (or removing them from) the bridge. Signatures are validated by the `recoverAddress` function:

```
function recoverAddress(
    bytes32 hash,
    uint8 v,
    bytes32 r,
    bytes32 s)
private pure returns (address) {
    bytes32 simple_hash = keccak256(abi.encodePacked("\x19Ethereum Signed Message:\n32",
hash));
    address res = ecrecover(simple_hash, v, r, s);
    return res;
}
```

Figure 2.1: The `recoverAddress` *function (sora2-eth/contracts/Bridge.sol#L265-L291)*

However, the code does not properly check the return value of `ecrecover`, which can be `0x0` if the signature provided to the function is invalid. As stated in the Solidity documentation, `ecrecover` “recover[s] the address associated with the public key from [an] elliptic curve signature or return[s] zero on [an] error.”

The `addPeerByPeer` function allows peers to add a new address, even the `0x0` address, as a peer:

```
function addPeerByPeer(
    address newPeerAddress,
    bytes32 txHash,
    uint8[] memory v,
    bytes32[] memory r,
    bytes32[] memory s
) public shouldBeInitialized returns (bool) {
    require(used[txHash] == false);
    require(checkSignatures(keccak256(abi.encodePacked(newPeerAddress, txHash, _networkId)),
        v,
        r,
        s), "Peer signatures are invalid"
    );

    addPeer(newPeerAddress);
    used[txHash] = true;
    emit ChangePeers(newPeerAddress, false);
    return true;
}
```

Figure 2.2: The `addPeerByPeer` *function (sora2-eth/contracts/Bridge.sol#L302-L324)*

If the `0x0` address is added as a peer, an invalid signature can be used to execute any administrative operation, weakening the security of the bridge.

Exploit Scenario

The `0x0` address is accidentally added as a peer. Eve, a malicious peer, exploits this mistake to include one invalid signature that will be accepted as valid, making it easier for her to reach the number of signatures required to execute administrative functions.

Recommendations

Short term, prevent the Ethereum bridge contract from using invalid signatures in signature counts. Additionally, ensure that it properly validates the signatures of new peers to prevent the `0x0` address from being added as a peer.

Long term, use Echidna or Manticore to ensure that invalid signatures cannot be used in the Ethereum bridge smart contract.

3. Users can register assets with empty name and ticker symbol fields

Severity: Informational
Type: Data Validation
Target: `pallets/assets/src/lib.rs`

Difficulty: Low
Finding ID: TOB-PSWAP-003

Description

The SORA Network allows any user to register an asset by providing a name and ticker symbol for it. The code validates name and ticker symbol values (figure 3.1) but permits the use of empty strings.

```
/// According to UTF-8 encoding, graphemes that start with byte 0b0XXXXXXX belong
/// to ASCII range and are of single byte, therefore passing check in range 'A' to 'Z'
/// and '0' to '9' guarantees that all graphemes are of length 1, therefore length check is
valid.
pub fn is_symbol_valid(symbol: &AssetSymbol) -> bool {
    symbol.0.len() <= ASSET_SYMBOL_MAX_LENGTH
        && symbol
            .0
            .iter()
            .all(|byte| (b'A'..=b'Z').contains(&byte) || (b'0'..=b'9').contains(&byte))
}

/// According to UTF-8 encoding, graphemes that start with byte 0b0XXXXXXX belong
/// to ASCII range and are of single byte, therefore passing check in range 'A' to 'z'
/// guarantees that all graphemes are of length 1, therefore length check is valid.
pub fn is_name_valid(name: &AssetName) -> bool {
    name.0.len() <= ASSET_NAME_MAX_LENGTH
        && name.0.iter().all(|byte| {
            (b'A'..=b'Z').contains(&byte)
                || (b'a'..=b'z').contains(&byte)
                || (b'0'..=b'9').contains(&byte)
                || byte == &b' '
        })
}
```

Figure 3.1: The `is_symbol_valid` and `is_name_valid` functions (pallets/assets/src/lib.rs#L744-L766)

Recommendations

Short term, add an empty-string check to the `is_symbol_valid` and `is_name_valid` functions to prevent the creation of assets with an empty ticker symbol or name field.

Long term, perform extensive negative testing of all data validation code.

4. Use of ERC20 tokens that could become inflationary or deflationary

Severity: Medium	Difficulty: Low
Type: Data Validation	Finding ID: TOB-PSWAP-004
Target: `sora2-eth/contracts/Bridge.sol`	

Description

If the bridge uses an ERC20 token that is inflationary, is deflationary, or has any kind of dynamic supply or balance, its bookkeeping may be severely affected.

The bridge contract was not designed for tokens that can suddenly change the value returned by `balanceOf` or can transfer an unexpected number of tokens. When a user makes a deposit, the balance of the contract and the number of tokens deposited are used in several operations:

```
/**
 * Send ERC-20 token to sidechain.
 *
 * @param to destination address on the sidechain
 * @param amount amount to sendERC20ToSidechain
 * @param tokenAddress contract address of token to send
 */
function sendERC20ToSidechain(
    bytes32 to,
    uint amount,
    address tokenAddress)
external
shouldBeInitialized shouldNotBePreparedForMigration {
    IERC20 token = IERC20(tokenAddress);

    require(token.allowance(msg.sender, address(this)) >= amount, "NOT ENOUGH DELEGATED
TOKENS ON SENDER BALANCE");

    bytes32 sidechainAssetId = _sidechainTokensByAddress[tokenAddress];
    if (sidechainAssetId != "" || _addressVAL == tokenAddress || _addressXOR ==
tokenAddress) {
        ERC20Burnable mtoken = ERC20Burnable(tokenAddress);
        mtoken.burnFrom(msg.sender, amount);
    } else {
        require(acceptedEthTokens[tokenAddress], "The Token is not accepted for transfer to
sidechain");
        token.transferFrom(msg.sender, address(this), amount);
    }
    emit Deposit(to, amount, tokenAddress, sidechainAssetId);
}
```

Figure 4.1: The `sendERC20ToSidechain` *function (sora2-eth/contracts/Bridge.sol#L265-L291)*

The bridge emits a `Deposit` event with the expected `amount` value; if inflationary tokens were being used, though, the value might not be correct.

The following widely used ERC20 tokens can cause issues:

- Tether (as well as other tokens) can charge a fee for each transfer, meaning that users will receive fewer tokens than expected. Currently, this fee is set to zero, but if it is increased, Tether will become a deflationary token.
- Ampleforth executes daily rebases on contracts or increases the total supply (and therefore the balance of each user) so that its expected price will be pegged to USD 1.

Currently, it does not appear that any of the tokens supported by the Polkaswap system are deflationary or inflationary or could be used to exploit this finding. However, certain of the tokens use a proxy contract and could therefore be upgraded, as detailed in TOB-PSWAP-005.

Exploit Scenario
Alice deploys a bridge and initializes it to use a token that has a dynamic supply. Users perform deposits and withdrawals. At some point, there is an error in the bookkeeping, so users do not receive the expected number of tokens when executing withdrawals.

Recommendations
Short term, clearly document this behavior to inform users that the bridge is not designed to use inflationary or deflationary ERC20 tokens.

Long term, review the Token Integration Checklist and implement its recommendations to make sure that ERC20 tokens used by the bridge behave as expected.

5. Polkaswap blindly trusts upgradeable ERC20 proxy tokens

Severity: Medium
Type: Data Validation
Target: `off-chain worker`

Difficulty: High
Finding ID: TOB-PSWAP-005

Description

The Polkaswap system does not have an automated mechanism for tracking supported tokens implemented via a proxy contract, which can be upgraded; nor can it pause interactions with a token that has been upgraded pending the token's approval.

As part of an upgrade, a token's semantics may change such that the token violates the Polkaswap system's assumptions. This can lead to problems such as incorrect accounting or could leave the Polkaswap system vulnerable to theft or a loss of funds.

Exploit Scenario

A proxy token supported by the Polkaswap system performs an upgrade and changes its semantics, becoming deflationary. As a result, in each transfer of this token, a fraction of the transferred amount is burned. An attacker finds that Polkaswap cannot handle deflationary tokens and transfers his tokens to the SORA Network. The ERC20 balance of the attacker's SORA Network account is then higher than the amount of his deposit, allowing the attacker to spend more tokens than he transferred.

Recommendations

Short term, disable support for upgradeable (proxy) tokens in the Polkaswap system. (See Appendix D for a list of these tokens.) Then implement an automated upgrade-tracking mechanism and have the system pause interactions with upgraded tokens until they have received approval by consensus.

6. Peers are not punished for submitting invalid signatures in approve_request

Severity: Undetermined
Type: Data Validation
Target: `eth-bridge`

Difficulty: High
Finding ID: TOB-PSWAP-006

Description

The `approve_request` extrinsic checks the validity of signatures submitted by peers; however, there is no punishment imposed on peers who submit invalid signatures (figure 6.1).

```
if !Self::verify_message(
    request_encoded.as_raw(),
    &signature_params,
    &ocw_public,
    &author,
) {
    // TODO: punish the peer.
    return Err(Error::<T>::InvalidSignature.into());
}
```

Figure 6.1: [pallets/eth-bridge/src/lib.rs#L1640-L1648]

Recommendations

Short term, add a mechanism (such as slashing) for punishing peers who submit invalid signatures when approving requests in the Ethereum bridge component.

Long term, to disincentivize trusted actors from destabilizing the network, ensure that there are always mechanisms in place for punishing trusted actors who misbehave.

7. Outdated Rust dependencies

Severity: Undetermined
Type: Patching
Target: `sora2-substrate dependencies`

Difficulty: High
Finding ID: TOB-PSWAP-007

Description
The `sora2-substrate` project depends on six outdated package versions that contain known vulnerabilities. These vulnerabilities, which we identified using the `cargo-audit` tool, are listed below with their RUSTSEC advisory numbers.

Dependency	Version	Advisory	Description
Libsecp256k1	0.3.5	RUSTSEC-2021-0076 ("libsecp256k1 allows overflowing signatures")	This issue allows signature overflows in the `Signature::parse` and `Signature::parse_slice` functions, which are used in the off-chain worker and the `rewards` pallet.
Nalgebra	0.19.0	RUSTSEC-2021-0070 ("VecStorage Deserialize Allows Violation of Length Invariant")	This is a memory safety issue involving the deserialization of `VecStorage` from untrusted input. The `sora2-substrate` code does not directly use the crate or its `VecStorage` type. Nalgebra is a dependency of linregress, which is used by the `frame-benchmarking` crate. Since the crate should be used only for benchmarking, it does not appear that this issue affects the Polkaswap system.
Prost-types	0.7.0	RUSTSEC-2021-0073 ("Conversion from `prost_types::Timestamp` to `SystemTime` can cause an overflow and panic")	The current `sora2-substrate` code does not appear to use this conversion.

raw-cpuid	8.1.2	RUSTSEC-2021-0013 (“Soundness issues in `raw-cpuid`”)	There are soundness issues in this crate’s `cpuid_count` function and `as_string` method. These issues are present in `cranelift-native`, an indirect dependency of Substrate. We notified the Substrate developers (through this thread) that the issues should be fixed, so they will hopefully be addressed in a newer release.
Cranelift-codegen	0.69.0	RUSTSEC-2021-0067 (CVE-2021-32629) (“Memory access due to code generation flaw in Cranelift module”)	This bug may allow a sandbox escape from a WebAssembly module in an x64 Cranelift back end. We have not investigated this issue thoroughly enough to definitively state whether it affects the Polkaswap system; however, we notified Substrate about it in the aforementioned thread.

Additionally, nine of the packages used in the project have “allowed warnings,” which means they were either pulled from Cargo packages (for reasons such as vulnerabilities) or are unmaintained.

Recommendations
Short term, update the vulnerable and unmaintained dependencies in the `sora2-substrate` codebase. This will prevent the exploitation of a known vulnerability against the SORA Network.

Long term, use the `cargo-audit` tool to ensure that the dependency versions used by the `sora2-substrate` project are free of known vulnerabilities, and integrate the tool into the CI/CD pipeline.

8. Ethereum bridge cannot handle chain reorganizations

Severity: High
Difficulty: High
Type: Data Validation
Finding ID: TOB-PSWAP-008
Target: `eth-bridge`

Description
The SORA Network integrates with Ethereum through the `eth-bridge` pallet, which monitors events emitted by the bridge contract. The `eth-bridge` code does not detect Ethereum chain reorganizations or include any strategy for handling them.

The code processes all blocks through the highest block except for the newest blocks (specifically the 30 newest blocks, since the `CONFIRMATION_INTERVAL` constant is set to 30). This reduces the likelihood that the SORA Network will observe a reorganization.

Exploit Scenario
An attacker deposits ETH by calling the `sendEthToSidechain` function, and `eth-bridge` registers the event and adds funds to the attacker's account on the SORA Network. An Ethereum chain reorganization occurs, and the `Deposit` event does not exist in the reorganized chain. The funds added to the attacker's account are not reclaimed by the chain.

Recommendations
Short term, add code to `eth-bridge` to detect Ethereum reorganizations by comparing block hashes. Ensure that the code fetches blocks starting from the last processed block and compares that block's hash to the hash of the corresponding block (the block at the same height) returned by the API. If the hashes differ, a reorganization has occurred. Finally, design and document a reorganization-handling strategy.

Long term, implement a strategy for automated reorganization handling. After detecting a reorganization, the algorithm should calculate which events need to be unapplied and which new events are missing from the blockchain. Additionally, design a strategy for handling negative balances, which can occur when events are unapplied.

References
- Ethereum Classic Suffers Reorganization That Resembles 51% Attack Amid Miner Complications

9. Ethereum bridge does not check transfer results

Severity: High	Difficulty: High
Type: Data Validation	Finding ID: TOB-PSWAP-009
Target: `eth-bridge`	

Description

The `shutDownAndMigrate` and `receiveByEthereumAssetAddress` functions (figures 9.1–2) use the ERC20 standard `transfer` function to transfer tokens when migrating a contract or performing a token withdrawal. However, the functions do not check the value returned by the `transfer` function, which may be `false` if a transfer fails. Without this check, funds may become locked in the bridge contract, which could result in a contract shutdown; alternatively, the contract could emit a `Withdrawal` event despite the lockup.

As part of the audit, we analyzed 55 ERC20 tokens owned by the Ethereum bridge and found 4 that could be used to exploit this issue: BAT, HT, CHSB, and cUSDC. However, it is also possible that tokens implemented through a proxy contract could be migrated to a version with different semantics. Appendix D includes a list of these 55 tokens and details their `transfer` return value semantics.

```
function shutDownAndMigrate(/* (...) */)
public shouldBeInitialized shouldBePreparedForMigration {
    // (...)
    for (uint i = 0; i < erc20nativeTokens.length; i++) {
        IERC20 token = IERC20(erc20nativeTokens[i]);
        token.transfer(newContractAddress, token.balanceOf(address(this)));
    }
    Bridge(newContractAddress).receivePayment{value: address(this).balance}();
    initialized_ = false;
    emit Migrated(newContractAddress);
}
```

Figure 9.1: The `shutDownAndMigrate` function (sora2-eth/contracts/Bridge.sol#L175-L203)

```
function receiveByEthereumAssetAddress(/* (...) */) public shouldBeInitialized {
    // (...)
    if (tokenAddress == address(0)) {
        used[txHash] = true;
        // untrusted transfer, relies on provided cryptographic proof
        to.transfer(amount);
    } else {
        IERC20 coin = IERC20(tokenAddress);
        used[txHash] = true;
        // untrusted call, relies on provided cryptographic proof
        coin.transfer(to, amount);
    }
    emit Withdrawal(txHash);
}
```

Figure 9.2: The `receiveByEthereumAssetAddress` function (sora2-eth/contracts/Bridge.sol#L371-L402)

Exploit Scenario

A user calls `receiveByEthereumAssetAddress` to request his funds. Because the transfer semantics of the requested ERC20 token violate the bridge contract's assumptions, the transfer fails. The bridge does not send the funds to the user's Ethereum account but still emits a `Withdrawal` event, which is incorrectly accounted for in the SORA Network.

Recommendations

Short term, in the SORA Network, disable the four ERC20 tokens (BAT, HT, CHSB, and cUSDC) with `transferFrom` functions that return false upon a failure but still cause the Ethereum bridge to emit a `Withdrawal` event. Re-enable those tokens after the issue has been fixed on the Ethereum bridge's side.

Long term, migrate the Ethereum bridge smart contract to a new version and add a check for the return value of `transfer` calls to its `receiveByEthereumAssetAddress` and `shutDownAndMigrate` functions.

10. Potential reuse of peer signatures from, and in calls to, the prepareForMigration function

Severity: High
Type: Data Validation
Target: eth-bridge

Difficulty: High
Finding ID: TOB-PSWAP-010

Description

The prepareForMigration function (figure 10.1) does not ensure that a salt has not been used before. It also uses the same data layout for signatures as the addPeerByPeer and removePeerByPeer functions (figure 10.2). This data layout is detailed in the table below. (Note, though, that the salt argument used by the prepareForMigration function corresponds to the txHash field used by addPeerByPeer and removePeerByPeer.)

An attacker could therefore replay a valid signature from the prepareForMigration function to call the other functions; for example, an attacker could add the bridge contract address as a peer through the addPeerByPeer function. Because the bridge cannot sign any data, that would make it more difficult to perform peer-approved operations.

It would also be possible for an attacker to replay a signature from addPeerByPeer or removePeerByPeer in prepareForMigration; however, because of a check in the prepareForMigration function for the bridge contract's address, the attacker would need to call those functions with the bridge address as the newPeerAddress or peerAddress (depending on the function).

Function	prepareForMigration	addPeerByPeer	removePeerByPeer
First argument	address thisContractAddress (must be the bridge address)	address newPeerAddress	address peerAddress
Second argument	bytes32 salt	bytes32 txHash (verified as unique through the used[txHash] == false check)	
Third argument	bytes32 _networkId (set when the contract is initialized)		

```
function prepareForMigration(/* (...) */) public shouldBeInitialized
shouldNotBePreparedForMigration {
    require(preparedForMigration_ == false);
    require(address(this) == thisContractAddress);
    require(
        checkSignatures(keccak256(abi.encodePacked(thisContractAddress, salt, _networkId)),
        v,
        r,
        s), "Peer signatures are invalid"
    );
    preparedForMigration_ = true;
    emit PreparedForMigration();
}
```

Figure 10.1: The `prepareForMigration` *function (sora2-eth/contracts/Bridge.sol#L144-L162)*

```
function addPeerByPeer(/* (...) */) public shouldBeInitialized returns (bool) {
    require(used[txHash] == false);
    require(checkSignatures(keccak256(abi.encodePacked(newPeerAddress, txHash, _networkId)),
        v,
        r,
        s), "Peer signatures are invalid"
    );
    addPeer(newPeerAddress);
    used[txHash] = true;
    emit ChangePeers(newPeerAddress, false);
    return true;
}

function removePeerByPeer(/* (...) */) public shouldBeInitialized returns (bool) {
    require(used[txHash] == false);
    require(checkSignatures(
            keccak256(abi.encodePacked(peerAddress, txHash, _networkId)),
            v,
            r,
            s), "Peer signatures are invalid"
    );
    removePeer(peerAddress);
    used[txHash] = true;
    emit ChangePeers(peerAddress, true);
    return true;
}
```

Figure 10.2: The `addPeerByPeer` and `removePeerByPeer` *functions (sora2-eth/contracts/Bridge.sol#L302-L358)*

Exploit Scenario

The Ethereum bridge is operating with 10 trusted peers, but 3 of them lose access to their accounts. Instead of adding new peers, the remaining peers prepare a bridge migration, calling the `prepareForMigration` function with 7 valid peer signatures. An attacker reuses those signatures and calls the `addPeerByPeer` function to add the bridge contract as a peer. After these operations, there are 11 peers, so the system requires 8 valid peer signatures for every action. However, because there are not enough valid peer signatures to finish the migration (through the `shutDownAndMigrate` function), the system will remain permanently inoperable.

Recommendations

Short term, upgrade the Ethereum bridge smart contract and fix the signature replay issue stemming from the `prepareForMigration` function. Add `used` mapping checks to `prepareForMigration` and `shutDownAndMigrate`, as well as all other Ethereum bridge functions, to protect them from signature reuse/replay. Additionally, until the signature hashing issues have been fixed, ensure that calls to the `prepareForMigration` function pass in a `salt` of a `txHash` value already present in the contract's `used` mapping. This will prevent users of the system, which is already live, from reusing signatures and adding the bridge contract as a peer, which could render the contract inoperable.

Long term, thoroughly document and test the signature hashing schemes. Consider using EIP-712: Ethereum typed structured data hashing and signing as a hashing structure.

11. Risk of replay attacks across contract instances

Severity: High
Type: Data Validation
Target: `eth-bridge`

Difficulty: High
Finding ID: TOB-PSWAP-011

Description

All of the Ethereum bridge's signature schemes lack mechanisms for preventing signature replay attacks across contract deployments or chain forks.

None of the signature hashing schemes include any information about the contract's instances (figure 11.1). As a result, signatures can be reused across multiple contract deployments.

```
keccak256(abi.encodePacked(newToken, ticker, name, decimals, txHash, _networkId))
keccak256(abi.encodePacked(thisContractAddress, salt, _networkId))
keccak256(abi.encodePacked(thisContractAddress, newContractAddress, salt, erc20nativeTokens,
_networkId))
keccak256(abi.encodePacked(name, symbol, decimals, sidechainAssetId, txHash, _networkId))
keccak256(abi.encodePacked(newPeerAddress, txHash, _networkId))
keccak256(abi.encodePacked(peerAddress, txHash, _networkId))
keccak256(abi.encodePacked(tokenAddress, amount, to, from, txHash, _networkId))
keccak256(abi.encodePacked(sidechainAssetId, amount, to, from, txHash, _networkId))
keccak256(abi.encodePacked("\x19Ethereum Signed Message:\n32", hash))
```

Figure 11.1: The signature schemes used in the Ethereum bridge contract

Moreover, while the signature hashing schemes use a `_networkId` variable meant to reflect the current ID of the network, this variable is set only once, by the constructor, and will not change in the event of a fork after the contract deployment (figure 11.2).

```
/** EVM netowrk ID */
bytes32 public _networkId;
// (...)
constructor(
    address[] memory initialPeers,
    address addressVAL,
    address addressXOR,
    bytes32 networkId)  {
    // (...)
    _networkId = networkId;
}
```

Figure 11.2: The bridge contract constructor sets the `networkId` once (sora2-eth/contracts/Bridge.sol#L44-L70).

Exploit Scenario

- Alice and Bob are the signers when a peer wants to add a new peer.

- Eve deploys a second version of the Ethereum bridge contract.
- Eve convinces Bob and Alice to sign a transaction adding Eve as a trusted peer in the contract instance.
- Eve reuses the signature in the original bridge contract and becomes a trusted peer in that contract as well.

Recommendations
Short term, use the contract's address and the `chainID` of the current transaction in all signature schemes to ensure that signatures cannot be reused across contract instances or after a chain fork.

Long term, thoroughly document and test the signature hashing schemes. Consider using EIP-712: Ethereum typed structured data hashing and signing as a hashing structure.

12. ABI encodePacked collision

Severity: Informational
Type: Data Validation
Target: `eth-bridge`

Difficulty: High
Finding ID: TOB-PSWAP-012

Description

The `addEthNativeToken` and `addNewSidechainToken` functions use the `abi.encodePacked` Solidity function and pass in two consecutive strings, which could lead to a hash collision.

We set the severity of this finding to informational because the `used[txHash]` check currently prevents exploitation of this issue.

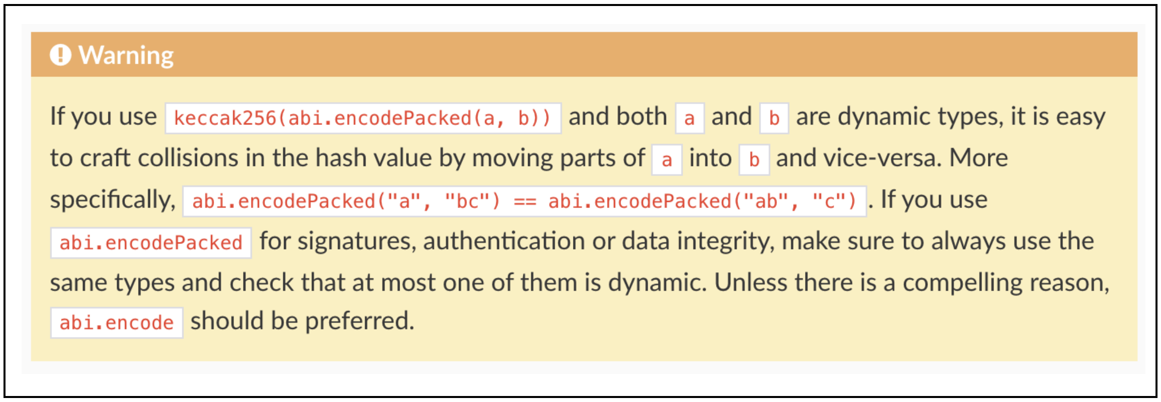
The `addEthNativeToken` function passes in `ticker` and `name` strings, and the `addNewSidechainToken` function passes in `name` and `symbol` strings (figure 12.1).

```
function addEthNativeToken(
    address newToken,
    string memory ticker,
    string memory name,
    uint8 decimals,
    bytes32 txHash,
    uint8[] memory v,
    bytes32[] memory r,
    bytes32[] memory s
)
public shouldBeInitialized {
    require(used[txHash] == false);
    // (...)
    require(checkSignatures(keccak256(
        abi.encodePacked(newToken, ticker, name, decimals, txHash, _networkId)),
    // (...)
}

function addNewSidechainToken(
    string memory name,
    string memory symbol,
    uint8 decimals,
    bytes32 sidechainAssetId,
    bytes32 txHash,
    uint8[] memory v,
    bytes32[] memory r,
    bytes32[] memory s)
public shouldBeInitialized {
    require(used[txHash] == false);
    require(checkSignatures(keccak256(abi.encodePacked(
            name,
            symbol,
            decimals,
            sidechainAssetId,
            txHash,
            _networkId
        )),
```

Figure 12.1: The problematic `abi.encodePacked` *calls (sora2-eth/contracts/Bridge.sol#L113-L133 and L217-L239)*

This scheme leaves the code vulnerable to a hash collision, in which two calls to these two functions, each with different `ticker` and `name` (or `name` and `symbol`) strings, would result in the same hash. The Solidity documentation also includes a warning about this issue:



Warning

If you use `keccak256(abi.encodePacked(a, b))` and both `a` and `b` are dynamic types, it is easy to craft collisions in the hash value by moving parts of `a` into `b` and vice-versa. More specifically, `abi.encodePacked("a", "bc") == abi.encodePacked("ab", "c")`. If you use `abi.encodePacked` for signatures, authentication or data integrity, make sure to always use the same types and check that at most one of them is dynamic. Unless there is a compelling reason, `abi.encode` should be preferred.

Figure 12.2: A warning from the Solidity documentation

Recommendations

Short term, use `abi.encode` instead of `abi.encodePacked` to encode data for signature checking, especially in the `addNewSidechainToken` and `addEthNativeToken` functions. This will prevent hash collisions caused by the hashing of multiple dynamic types. While this issue is currently mitigated by the `used[txHash]` check, we still recommend fixing it in case the code is reused.

Long term, use the static analyzer Slither to find code in which `abi.encodePacked` is used with more than one dynamic type.

13. Inaccurate description of SwapSuccess event

Severity: Informational
Type: Auditing and Logging
Target: `sora2-substrate/pallets/technical/src/lib.rs`

Difficulty: High
Finding ID: TOB-PSWAP-013

Description

The description of the `SwapSuccess` event in the `technical` pallet suggests that the event should have two arguments, an `initiator` and a `finaliser`, but the event takes only a single argument (figure 13.1).

This event is currently triggered only by a `perform_create_swap_unchecked` function, which passes in a `source` argument (figure 13.2). This function is called by two other functions:

- The exchange function in the `XYKPool` pallet, which passes in a `sender` argument
- A `perform_create_swap` function in the `technical` pallet, which passes in a `source` argument

We set the severity of this issue to informational because it does not have a direct security impact on the Polkaswap system. However, it may pose problems for third-party developers who would like to track swap-related events.

```
/// Swap operaction is finalised [initiator, finaliser].
/// TechAccountId is only pure TechAccountId.
SwapSuccess(AccountIdOf<T>),
```

Figure 13.1: The `SwapSuccess` *event (sora2-substrate/pallets/technical/src/lib.rs#L364-L366)*

```
/// Perform creation of swap, version without validation
pub fn perform_create_swap_unchecked(
    source: AccountIdOf<T>,
    action: &T::SwapAction,
) -> DispatchResult {
    common::with_transaction(|| {
        action.reserve(&source)?;
        if action.is_able_to_claim() {                              // always true
            if action.instant_auto_claim_used() {                   // always true
                if action.claim(&source) {                          // always true
                    Self::deposit_event(Event::SwapSuccess(source));
```

Figure 13.2: The `perform_create_swap_unchecked` *function (sora2-substrate/pallets/technical/src/lib.rs#L92-L102)*

Recommendations

Short term, update the description of the `technical` pallet's `SwapSuccess` event to indicate that it takes only one argument.

14. Off-chain worker depends on a single Ethereum data source

Severity: High
Difficulty: High
Type: Data Validation
Finding ID: TOB-PSWAP-014
Target: `sora2-substrate/pallets/technical/src/lib.rs`

Description
The Polkaswap system uses a single source of truth to fetch Ethereum events from the Ethereum bridge contract. There is no mechanism for including additional Ethereum data sources.

If this Ethereum data source experienced an outage, the Polkaswap system would also be at risk of an outage; if an attacker hacked the API, the attacker could manipulate the events provided to the system in an attempt to steal funds from it.

Exploit Scenario
An attacker finds a way to hack the Ethereum data source used by the Polkaswap system. The attacker then modifies the API to serve bogus events to the Polkaswap off-chain worker, changing the chain state to his benefit.

Recommendations
Short term, enable the off-chain worker to fetch Ethereum events from multiple sources, and cross-validate the values it returns. Then require validators to use at least two Ethereum sources, including one self-hosted Ethereum node. Finally, document the process of adding additional sources. These steps will mitigate the risk of system outages or theft in the event that the Ethereum source to which the off-chain worker connects becomes malicious or unavailable.

Long term, avoid relying on a single third-party source when fetching data that influences the chain state.

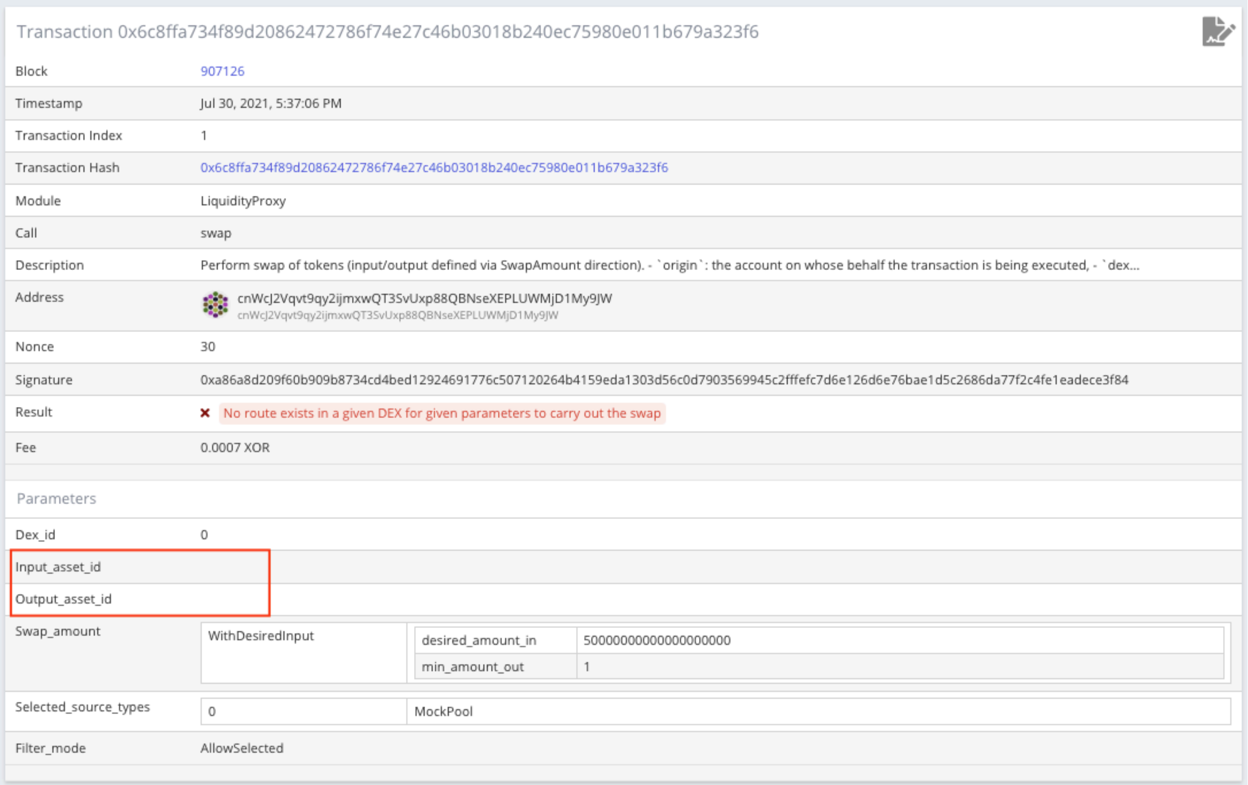
15. Sorascan does not show asset IDs that are not present in the system

Severity: Informational
Type: Auditing and Logging
Target: Sorascan

Difficulty: High
Finding ID: TOB-PSWAP-015

Description

When a transaction is sent with an asset ID that is not present in the system, the Sorascan blockchain explorer will not display the asset ID (figure 15.1).



Transaction 0x6c8ffa734f89d20862472786f74e27c46b03018b240ec75980e011b679a323f6

Block	907126
Timestamp	Jul 30, 2021, 5:37:06 PM
Transaction Index	1
Transaction Hash	0x6c8ffa734f89d20862472786f74e27c46b03018b240ec75980e011b679a323f6
Module	LiquidityProxy
Call	swap
Description	Perform swap of tokens (input/output defined via SwapAmount direction). - `origin`: the account on whose behalf the transaction is being executed, - `dex...
Address	cnWcJ2Vqvt9qy2ijmxwQT3SvUxp88QBNseXEPLUWMjD1My9JW cnWcJ2Vqvt9qy2ijmxwQT3SvUxp88QBNseXEPLUWMjD1My9JW
Nonce	30
Signature	0xa86a8d209f60b909b8734cd4bed12924691776c507120264b4159eda1303d56c0d7903569945c2fffefc7d6e126d6e76bae1d5c2686da77f2c4fe1eadece3f84
Result	✕ No route exists in a given DEX for given parameters to carry out the swap
Fee	0.0007 XOR

Parameters

Dex_id	0
Input_asset_id	
Output_asset_id	
Swap_amount	WithDesiredInput desired_amount_in: 50000000000000000000 min_amount_out: 1
Selected_source_types	0 MockPool
Filter_mode	AllowSelected

Figure 15.1: Sorascan does not show unknown asset IDs (https://test.sorascan.com/sora-staging/transaction/0x6c8ffa734f89d20862472786f74e27c46b03018b240ec75980e011b679a323f6).

Recommendations

Short term, fix the Sorascan blockchain explorer so that it displays unknown asset IDs, includes their hex values, and marks them as nonexistent.

16. Peers' secret keys are stored as plaintext in off-chain storage

Severity: Medium
Difficulty: High
Type: Data Exposure
Finding ID: TOB-PSWAP-016
Target: `Off-chain storage`

Description

When a peer is initialized, its secret key is loaded as plaintext into Substrate's off-chain storage (figure 16.1), from which it is fetched when the peer signs outgoing requests (figure 16.2). Because the off-chain storage is not encrypted, the key is effectively stored in a file as plaintext. As a result, an attacker who is able to read arbitrary files from the disk or has access to unencrypted backups could steal the key.

```
if let Some(first_pk_raw) =
    SyncCryptoStore::keys(&*keystore_container.sync_keystore(), eth_bridge::KEY_TYPE)
        .unwrap()
        .first()
        .map(|x| x.1.clone())
{
    let pk = eth_bridge::offchain::crypto::Public::from_slice(&first_pk_raw[..]);
    if let Some(keystore) = keystore_container.local_keystore() {
        if let Ok(Some(kep)) = keystore.key_pair::<eth_bridge::offchain::crypto::Pair>(&pk)
{
            let seed = kep.to_raw_vec();
            bridge_peer_secret_key = Some(seed);
        }
    }
} else {
    log::debug!("Ethereum bridge peer key not found.")
}

if let Some(sk) = bridge_peer_secret_key {
    let mut storage = backend.offchain_storage().unwrap();
    storage.set(STORAGE_PREFIX, STORAGE_PEER_SECRET_KEY, &sk.encode());
```

Figure 16.1: The key material is loaded into the off-chain storage
(node/src/service.rs#L102-L121)

```
let secret_s = StorageValueRef::persistent(STORAGE_PEER_SECRET_KEY);
let sk = secp256k1::SecretKey::parse_slice(
    &secret_s
        .get::<Vec<u8>>()
        .flatten()
        .expect("Off-chain worker secret key is not specified."),
)
.expect("Invalid off-chain worker secret key.");
// Signs `abi.encodePacked(tokenAddress, amount, to, txHash, from)`.
let (signature, public) = Self::sign_message(encoded_request.as_raw(), &sk);
```

Figure 16.2: The key is used to sign outgoing requests
(pallets/eth-bridge/src/offchain/handle.rs#L70-L79)

Exploit Scenario
An attacker gains access to the filesystem in which a peer is running and steals the peer’s private key.

Recommendations
Short term, avoid storing peers’ secret key material in plaintext on the drive. Store private keys (encrypted via symmetric encryption) with a password, and decrypt each key in memory when the corresponding peer is initialized. Ensure that these passwords are delivered in a safe way, such as through standard input. To automate the deployment process, store passwords on another server in the internal network and configure a deployment bot to use the secure shell (SSH) protocol to start or restart peers.

Long term, use a secret management solution such as HashiCorp Vault or AWS’ Key Management Service. Note that currently, HashiCorp Vault does not support `secp256k1` signatures; however, there are ongoing efforts to add that support, tracked in issue `hashicorp/vault#4594` and pull request `hashicorp/vault#11469`. We recommend tracking those efforts and using the service once `secp256k1` support has been implemented.

17. LiquiditySourceType contains mock pools

Severity: Low	Difficulty: High
Type: Undefined Behavior	Finding ID: TOB-PSWAP-017
Target: `sora2-substrate/common/src/primitives.rs`	

Description

The `LiquiditySourceType` enum contains mock pools (figure 17.1), which should not be present outside of tests but are present on the sora-staging network.

We set the severity of this finding to low because we did not find a way to leverage the mock pools in an exploit. However, mock code left in production builds may enable unexpected behavior when the code changes in the future.

We tested the pools by trying to execute various swap operations on the sora-staging network; each attempt resulted in an error of "No route exists in a given DEX for given parameters to carry out the swap." Additionally, we confirmed that the DEXAPI's `EnabledSourceTypes` storage value contains the `XYKPool` and `MulticollateralBondingCurvePool` pools, but not the mock pools.

```
/// Enumaration of all available liquidity sources.
#[derive(Encode, Decode, RuntimeDebug, PartialEq, Eq, Copy, Clone, PartialOrd, Ord)]
#[cfg_attr(feature = "std", derive(Serialize, Deserialize))]
#[repr(u8)]
pub enum LiquiditySourceType {
    XYKPool,
    BondingCurvePool,
    MulticollateralBondingCurvePool,
    MockPool,
    MockPool2,
    MockPool3,
    MockPool4,
}
```

Figure 17.1: The `LiquiditySourceType` *enum*
(sora2-substrate/common/src/primitives.rs#L449-L461)

Exploit Scenario

A network upgrade results in code changes that make it possible to use mock pools as a liquidity source. An attacker uses these pools to his benefit, which would not be possible if the mock pools had not been compiled in a production build.

Recommendations

Short term, change the `LiquiditySourceType` so that mock pools are compiled only in a test environment. Use the `#[cfg(test)]` Rust annotation to make that change.

Long term, ensure that the staging and production environments do not use any code that should live only in tests.

18. A vector in the liquidity-proxy's swap extrinsic can be used for network spamming

Severity: Medium | Difficulty: High
Type: Data Validation | Finding ID: TOB-PSWAP-018
Target: `sora2-substrate/pallets/liquidity-proxy/src/lib.rs`

Description

There are insufficient limits on `selected_source_types`, which is a vector in the `liquidity-proxy` pallet's `swap` extrinsic. Specifically, the vector can contain duplicate entries, and there is no check preventing it from becoming too long. Additionally, the vector's length is not factored into calculations of the extrinsic's base weight (figure 18.1). These deficiencies leave the system vulnerable to the following scenarios:

1. An attacker could provide a very long `selected_source_types` vector to spam the network with swap transactions at a relatively low cost, which could lead to a denial of service.
2. An attacker could perform swaps via calls to the `generic_split` method, passing in the same source multiple times. This method is called in the `quote_single` function (figure 18.2), which is called by the `swap` extrinsic's `Self::exchange` function.

This transaction on the sora-staging test network shows a relatively limited instance of spamming.

```
#[pallet::weight(<T as Config>::WeightInfo::swap((*swap_amount).into()))]
pub fn swap(
    origin: OriginFor<T>,
    dex_id: T::DEXId,
    input_asset_id: T::AssetId,
    output_asset_id: T::AssetId,
    swap_amount: SwapAmount<Balance>,
    selected_source_types: Vec<LiquiditySourceType>,
    filter_mode: FilterMode,
) -> DispatchResultWithPostInfo {
    let who = ensure_signed(origin)?;

    if Self::is_forbidden_filter(
        &input_asset_id,
        &output_asset_id,
        &selected_source_types,
        &filter_mode,
    ) {
        fail!(Error::<T>::ForbiddenFilter);
    }

    let outcome = Self::exchange(
        &who,
        &who,
        &input_asset_id,
        &output_asset_id,
        swap_amount,
        LiquiditySourceFilter::with_mode(dex_id, filter_mode, selected_source_types),
    )?;
    // (...)
```
Figure 18.1: The `swap` *extrinsic (sora2-substrate/pallets/liquidity-proxy/src/lib.rs#L1575-L1625)*

```
fn quote_single(/* (...) */) -> /* (...) */ {
    let sources =
        T::LiquidityRegistry::list_liquidity_sources(input_asset_id, output_asset_id,
filter)?;
    ensure!(!sources.is_empty(), Error::<T>::UnavailableExchangePath);

    // Check if we have exactly one source => no split required
    if sources.len() == 1 { /* (...) */ }

    // Check if we have exactly two sources: the primary market and the secondary market
    // Do the "smart" swap split (with fallback)
    if sources.len() == 2 { /* (...) */ }

    // Otherwise, fall back to the general source-agnostic procedure based on sampling
    Self::generic_split(sources, input_asset_id, output_asset_id, amount, skip_info)
}
```
Figure 18.2: The `quote_single` *function, called through the* `Self::exchange` *call in the* `swap` *extrinsic (sora2-substrate/pallets/liquidity-proxy/src/lib.rs#L544-L598)*

Exploit Scenario

An attacker sends numerous batch transactions that make many calls to the `liquidity-proxy` pallet's `swap` extrinsic, each with a very long `selected_source_types` vector. In this way, the attacker forces the SORA Network to spend a very long time processing swap transactions, causing a denial of service.

Recommendations

Short term, implement appropriate data validation for the `selected_source_types` vector in the `liquidity-proxy` pallet's `swap` extrinsic. Ensure that the network rejects calls if the vector is too long or if it contains duplicates. Additionally, consider accounting for the vector's length in calculations of the extrinsic's base weight.

Long term, add tests to the `liquidity-proxy` pallet's `swap` extrinsic to ensure that it properly validates the `selected_source_types` vector and disallows duplicate sources and excessive vector lengths.

19. Zero-weight extrinsics can be used to spam the network

Severity: Medium	Difficulty: High
Type: Denial of Service	Finding ID: TOB-PSWAP-019

Target: `sora2-substrate/pallets/liquidity-proxy/src/lib.rs`

Description

The following extrinsics have a base weight set to zero and can therefore be used to spam the network, causing a denial of service:

- `PswapDistribution::claim_incentive`
- `BridgeMultisig::register_multisig`
- `BridgeMultisig::remove_signatory`
- `BridgeMultisig::add_signatory`
- `BridgeMultisig::as_multi_threshold_1`
- `BridgeMultisig::as_multi`
- `BridgeMultisig::approve_as_multi`
- `BridgeMultisig::cancel_as_multi`

Note, though, that `BridgeMultisig::as_multi` can be used for network spamming only if the account ID of the sender is not found in the `Accounts` storage map (specifically due to `unwrap_or(0)`).

Exploit Scenario

An attacker sends numerous batch transactions that make many calls to the `pswap-distribution` pallet's `claim_incentive` extrinsic, each for a very low fee. By spamming the network in this way, the attacker causes a denial of service of the SORA Network.

Recommendations

Short term, benchmark the extrinsics that have a base weight set to zero. Then, based on the results of that benchmarking, change the weights so that they cannot be used to spam the network.

20. Unused create_swap extrinsic in technical pallet

Severity: Undetermined
Type: Undefined Behavior
Target: `sora2-substrate/pallets/technical/src/lib.rs`

Difficulty: High
Finding ID: TOB-PSWAP-020

Description

The `technical` pallet contains an unused and redundant `create_swap` extrinsic. The extrinsic has never been called on the sora-staging test network, even though it exists there.

Trail of Bits did not perform an exhaustive analysis of this extrinsic, as it is not present on the sora-mainnet network, and the Soramitsu team indicated that it will be removed.

However, based on our investigation, the `create_swap` extrinsic (figure 20.1) appears to be overly complex and error-prone. It takes an `action` argument of the `SwapAction` type (figure 20.2); this type has three values—`PairSwapAction`, `DepositLiquidityAction`, and `WithdrawLiquidityAction`—each of which has multiple fields (figure 20.3). This `action` is passed to the `perform_create_swap` function, which then calls the `prepare_and_validate` and `perform_create_swap_unchecked` functions. The former mutates certain of the `action` object's fields, and the latter finalizes the swap operation. The functions are also implemented separately for each `action` type. This complex logic, along with the fact that the `action` object is fully controlled by extrinsic callers, makes the `create_swap` extrinsic error-prone and fragile; it would be even more problematic if the aforementioned aspects of the code were changed in the future.

By contrast, other functions that call the `prepare_and_validate` function pass in a pre-constructed `action` object in which only certain fields are controlled by the caller. These functions are as follows:

- The `XYKPool`'s exchange function, which uses the `PairSwapAction` action (and is the only function that calls `prepare_and_validate` directly, rather than through the `perform_create_swap` function)
- The `XYKPool`'s `deposit_liquidity_unchecked` function, which uses the `DepositLiquidityAction` action
- The `XYKPool`'s `withdraw_liquidity_unchecked` function, which uses the `WithdrawLiquidityAction` action

```
#[pallet::call]
impl<T: Config> Pallet<T> {
    #[pallet::weight(<T as Config>::WeightInfo::create_swap())]
    pub(crate) fn create_swap(
        origin: OriginFor<T>,
        action: T::SwapAction,
    ) -> DispatchResultWithPostInfo {
        let source = ensure_signed(origin)?;
        let mut action_mut = action;
        Module::<T>::perform_create_swap(source, &mut action_mut)?;
        Ok(().into())
    }
}
```

Figure 20.1: The `create_swap` *extrinsic (sora2-substrate/pallets/technical/src/lib.rs#L319-L331)*

```
impl technical::Config for Runtime {
    // (...)
    type SwapAction = pool_xyk::PolySwapAction<AssetId, AccountId, TechAccountId>;
```

Figure 20.2: The `SwapAction` *type (sora2-substrate/runtime/src/lib.rs#L642-L650)*

```
pub struct PairSwapAction<AssetId, AccountId, TechAccountId> { /* 8 fields */ }
pub struct DepositLiquidityAction<AssetId, AccountId, TechAccountId> { /* 6 fields */ }
pub struct WithdrawLiquidityAction<AssetId, AccountId, TechAccountId> { /* 6 fields */ }

pub enum PolySwapAction<AssetId, AccountId, TechAccountId> {
    PairSwap(PairSwapAction<AssetId, AccountId, TechAccountId>),
    DepositLiquidity(DepositLiquidityAction<AssetId, AccountId, TechAccountId>),
    WithdrawLiquidity(WithdrawLiquidityAction<AssetId, AccountId, TechAccountId>),
}
```

Figure 20.3: The complex `PolySwapAction` *enum (sora2-substrate/pallets/pool-xyk/src/operations.rs#L51-L88)*

Recommendations

Short term, remove the `technical` pallet's `create_swap` extrinsic, which is unused and redundant. This will decrease the attack surface of the pallet.

Long term, deploy only those extrinsics that will be used.

21. Sorascan does not accurately display large initial supply values

Severity: Low
Type: Auditing and Logging
Target: `Sorascan`

Difficulty: Medium
Finding ID: TOB-PSWAP-021

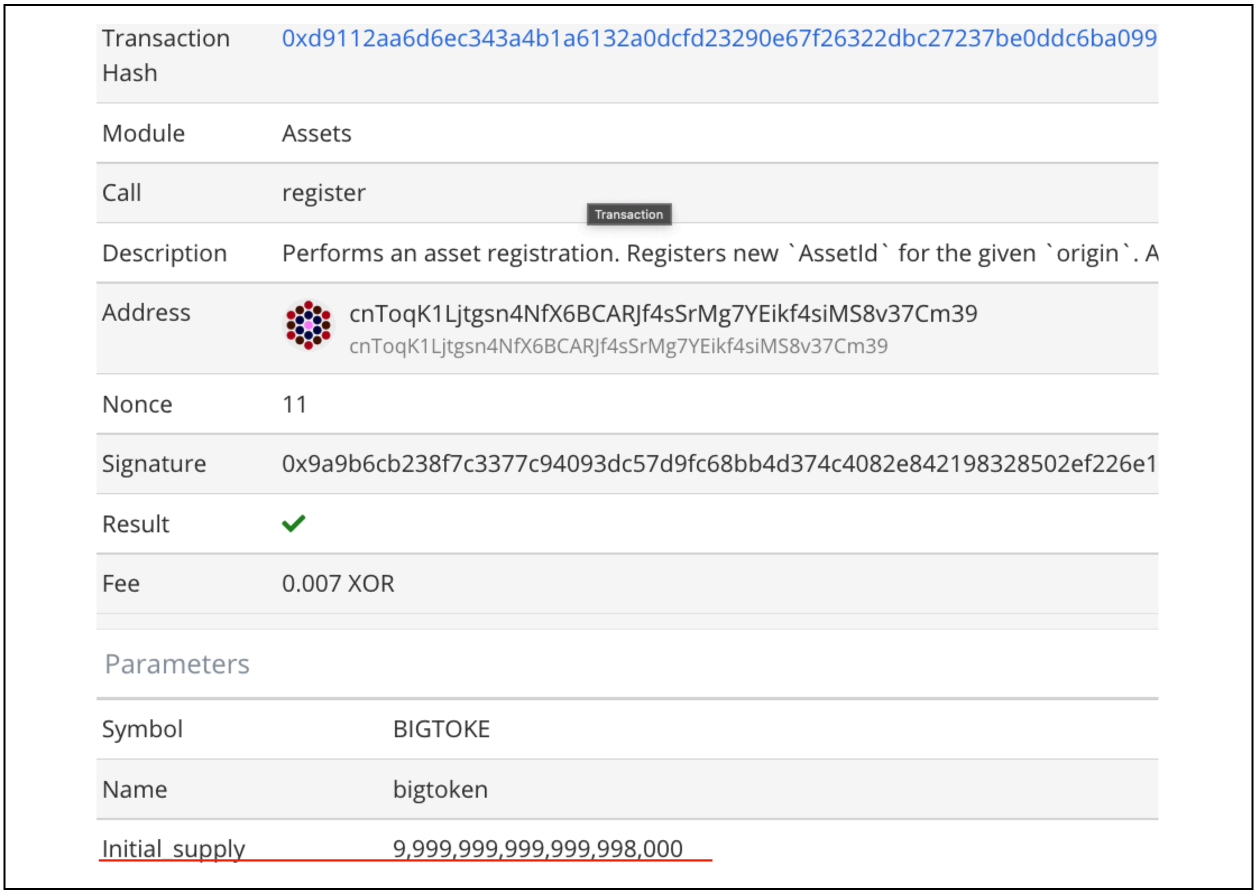
Description

If the initial supply of a token is too large a value, the Sorascan explorer will show an incorrect value.

For example, we created an asset with an initial supply of 10 quintillion tokens, for which the `Asset::register` extrinsic displays an incorrect initial supply value (figure 21.1). The sora-staging test network transaction shows the same incorrect value.

Because of time constraints and the low impact of this issue, Trail of Bits did not analyze the root cause of the issue.

It is also worth noting that the “SORA Network Account” tab on the Polkaswap.io wallet interface displays the correct token supply value after the token’s creation (figure 21.2).

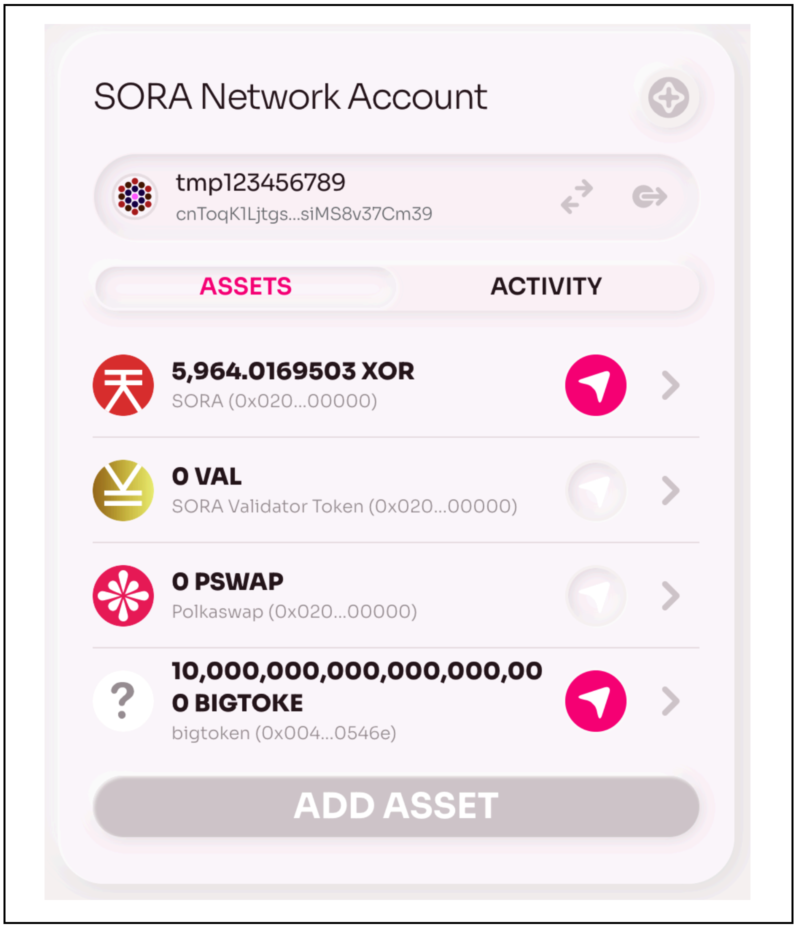


Transaction Hash	0xd9112aa6d6ec343a4b1a6132a0dcfd23290e67f26322dbc27237be0ddc6ba099
Module	Assets
Call	register
Description	Performs an asset registration. Registers new `AssetId` for the given `origin`. A
Address	cnToqK1Ljtgsn4NfX6BCARJf4sSrMg7YEikf4siMS8v37Cm39 cnToqK1Ljtgsn4NfX6BCARJf4sSrMg7YEikf4siMS8v37Cm39
Nonce	11
Signature	0x9a9b6cb238f7c3377c94093dc57d9fc68bb4d374c4082e842198328502ef226e1
Result	✓
Fee	0.007 XOR

Parameters

Symbol	BIGTOKE
Name	bigtoken
Initial_supply	9,999,999,999,999,998,000

Figure 21.1: The `Assets::register` extrinsic shows an incorrect initial supply value.



SORA Network Account

tmp123456789
cnToqK1Ljtgs...siMS8v37Cm39

5,964.0169503 XOR
SORA (0x020...00000)

0 VAL
SORA Validator Token (0x020...00000)

0 PSWAP
Polkaswap (0x020...00000)

10,000,000,000,000,000,000 BIGTOKE
bigtoken (0x004...0546e)

Figure 21.2: The "SORA Network Account" display on the Polkaswap.io wallet interface shows the correct BIGTOKE token amount.

Recommendations

Short term, use an arbitrary-precision decimal library to handle `amount` types. This will ensure that the Sorascan explorer displays the correct initial supply value even when the value is very large.

Long term, test the Sorascan explorer against edge-case values such as very small and very large values. The Sorascan explorer likely uses the `Number` type, which would explain why it displays rounded values. Testing the explorer against edge cases will help determine whether the values it displays are accurate.

22. eth-bridge Decoder.next_u8 method could panic if used

Severity: Low
Difficulty: High
Type: Data Validation
Finding ID: TOB-PSWAP-022
Target: `sora2-substrate/pallets/eth-bridge/src/util.rs`

Description

If the `eth-bridge` pallet's `Decoder.next_u8` method (figure 22.1) were used in the code, it could panic if provided untrusted input.

We set the severity of this finding to low because the code uses neither this method nor its caller, the `next_signature_params` method. However, if the code were changed and began using those methods, it would be at risk of a panic, as the methods could be called with untrusted input. An attacker could craft input that, once decoded to a `tokens` value, would result in a panic, causing a denial of service on the network.

For example, the code would panic if the value of a popped token (i.e., a token taken from the `tokens` vector) exceeded `u32::MAX`. This is because the `next_u8` method, through a call to `into_uint()`, would convert the popped token value to a [U256 type](), which can hold unsigned integers of up to 256 bits. Then the method would call the `x.as_u32()` function on the `U256` value. If that value exceeded the `u32::MAX` value, the `as_u32` method would panic when trying to convert it.

```
#[allow(unused)]
pub fn next_u8(&mut self) -> Result<u8, Error<T>> {
    self.tokens
        .pop()
        .and_then(|x| x.into_uint())
        .filter(|x| x.as_u32() <= u8::MAX as u32)
        .map(|x| x.as_u32() as u8)
        .ok_or_else(|| Error::<T>::InvalidByte.into())
}
```

Figure 22.1: The `Decoder.next_u8` method
([sora2-substrate/pallets/eth-bridge/src/util.rs#L91-L98]())

```
/// Conversion to u32 with overflow checking
///
/// # Panics
///
/// Panics if the number is larger than 2^32.
#[inline]
pub fn as_u32(&self) -> u32 {
       let &$name(ref arr) = self;
       if !self.fits_word() ||  arr[0] > u32::max_value() as u64 {
              panic!("Integer overflow when casting to u32")
       }
       self.as_u64() as u32
}
```

Figure 22.2: The `as_u32` method called on the `U256` type
([paritytech/parity-common/uint/src/uint.rs#L639-L651]())

Exploit Scenario

The code is changed such that it begins using the `Decoder.next_u8` method in the off-chain worker. An attacker takes advantage of this change and calls this method with a token value greater than `U32::MAX`. This causes the off-chain worker to panic, leading to a denial of service on the network.

Recommendations

Short term, either remove the `Decoder.next_u8` method from the `eth-bridge` pallet or change it so that it uses the `u8::try_from` method for decoding, as shown in figure 22.3. That change will prevent the method from panicking (and possibly causing a denial of service) if it is called with untrusted input.

```
#[allow(unused)]
pub fn next_u8(&mut self) -> Result<u8, Error<T>> {
    Ok(u8::try_from(
        self.tokens
            .pop()
            .and_then(|x| x.into_uint())
            .ok_or(Error::<T>::InvalidUint)?,
    )
    .map_err(|_| Error::<T>::InvalidByte)?)
}
```

Figure 22.3: A fixed version of the `Decoder.next_u8` *method*

Long term, use a technique such as fuzzing to test all encoding and decoding functions against edge-case inputs.

23. Non-mintable assets can be created with no initial supply

Severity: Informational
Type: Data Validation
Target: `sora2-substrate/pallets/eth-bridge/src/util.rs`

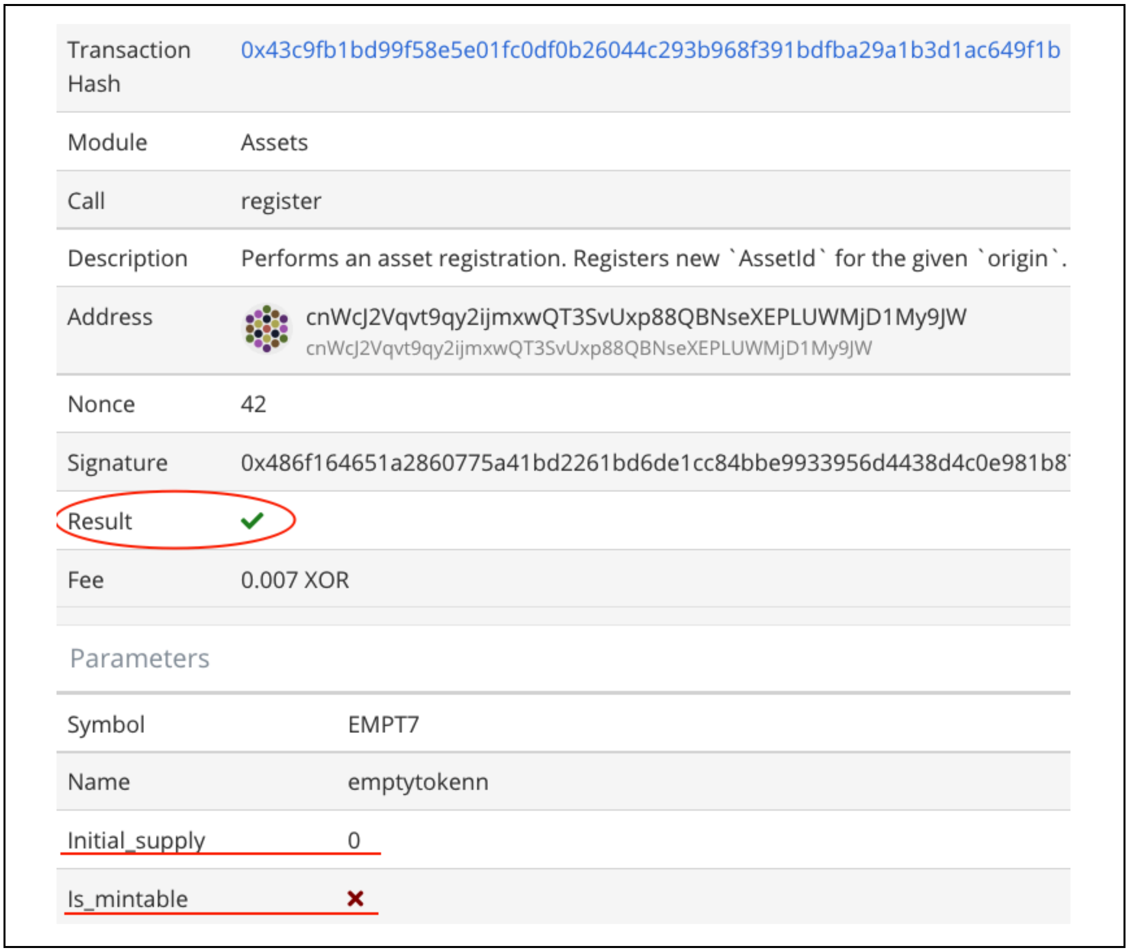
Difficulty: High
Finding ID: TOB-PSWAP-023

Description

The `assets` pallet's `register` extrinsic allows users to create assets that have an initial supply of zero—that is, non-mintable assets that cannot be used.

The Polkaswap.io wallet code includes a check that mitigates this issue; however, it is still possible to create such an asset by executing the extrinsic directly through the API. An example of a script that carries out this process is provided in Appendix F.

We also created an example of a non-mintable asset with an initial supply of zero in this sora-staging test network transaction.



Transaction Hash	0x43c9fb1bd99f58e5e01fc0df0b26044c293b968f391bdfba29a1b3d1ac649f1b
Module	Assets
Call	register
Description	Performs an asset registration. Registers new `AssetId` for the given `origin`.
Address	cnWcJ2Vqvt9qy2ijmxwQT3SvUxp88QBNseXEPLUWMjD1My9JW cnWcJ2Vqvt9qy2ijmxwQT3SvUxp88QBNseXEPLUWMjD1My9JW
Nonce	42
Signature	0x486f164651a2860775a41bd2261bd6de1cc84bbe9933956d4438d4c0e981b8
Result	✓
Fee	0.007 XOR

Parameters

Symbol	EMPT7
Name	emptytokenn
Initial_supply	0
Is_mintable	✗

Figure 23.1: A screenshot of the Sorascan explorer showing the successful registration of a non-mintable asset with an initial supply of zero.

Recommendations

Short term, add a minimum initial supply requirement to the `assets` pallet's `register` extrinsic. Additionally, consider adding a garbage collection method to handle assets that have no trading pairs and have not been used for a long time.

24. Off-chain worker can panic if the Ethereum API returns a null block_number

Severity: Low
Type: Data Validation
Target: eth-bridge

Difficulty: High
Finding ID: TOB-PSWAP-024

Description

The Ethereum bridge off-chain worker can panic if the Ethereum API to which it connects becomes malicious and returns a null block_number.

A panic is possible because the off-chain worker uses the .expect() function to retrieve block numbers. This occurs in the following code paths:

- The parse_incoming_request function, shown in figure 24.1
- The parse_cancel_incoming_request function
- The parse_old_incoming_request_method_call function

In the parse_incoming_request code path, external data is fetched by the handle_offchain_request function (figure 24.2), through the load_tx_receipt function (figure 24.3), which shows that the data is from the Ethereum API. If this API is hacked or operates incorrectly, it may return a null block_number, causing the off-chain worker to panic.

```
fn parse_incoming_request(
    tx_receipt: TransactionReceipt,
    incoming_pre_request: LoadIncomingTransactionRequest<T>,
) -> Result<IncomingRequest<T>, Error<T>> {
    // (...)
    let at_height = tx_receipt
        .block_number
        .expect("'block_number' is null only when the log/transaction is pending; qed")
        .as_u64();
```

Figure 24.1: The parse_incoming_request *function (sora2-substrate/pallets/eth-bridge/src/offchain/mod.rs#L408-L426)*

```
fn handle_offchain_request(request: OffchainRequest<T>) -> Result<(), Error<T>> {
    // (...)
          LoadIncomingRequest::Transaction(request) => {
              // (...)
              let tx = Self::load_tx_receipt(tx_hash, network_id)?;
              let mut incoming_request = Self::parse_incoming_request(tx, request)?;
```

Figure 24.2: The handle_offchain_request *function (sora2-substrate/pallets/eth-bridge/src/offchain/handle.rs#L244-L256)*

```
pub fn load_tx_receipt(
    hash: H256,
    network_id: T::NetworkId,
) -> Result<TransactionReceipt, Error<T>> {
    let hash = types::H256(hash.0);
    let tx_receipt = Self::eth_json_rpc_request::<_, TransactionReceipt>(
        "eth_getTransactionReceipt",
        &vec![hash],
        network_id,
    )?;
    let to = tx_receipt
        .to
        .map(|x| H160(x.0))
        .ok_or(Error::<T>::UnknownContractAddress)?;
    Self::ensure_known_contract(to, network_id)?;
    Ok(tx_receipt)
}
```

Figure 24.3: The `load_tx_receipt` function fetches data from the external API (sora2-substrate/pallets/eth-bridge/src/offchain/http.rs#L259-L275).

Recommendations

Short term, change the off-chain worker so that it no longer expects `block_number` values returned by the Ethereum API to be non-null. Additionally, ensure that the system always checks the values returned by external APIs.

Long term, add unit tests to the off-chain worker codebase to ensure that it correctly handles all invalid and edge-case values fetched from the Ethereum API.

A. Vulnerability Classifications

Vulnerability Classes	
Class	**Description**
Access Controls	Related to authorization of users and assessment of rights
Auditing and Logging	Related to auditing of actions or logging of problems
Authentication	Related to the identification of users
Configuration	Related to security configurations of servers, devices, or software
Cryptography	Related to protecting the privacy or integrity of data
Data Exposure	Related to unintended exposure of sensitive information
Data Validation	Related to improper reliance on the structure or values of data
Denial of Service	Related to causing a system failure
Documentation	Related to documentation errors, omissions, or inaccuracies
Error Reporting	Related to the reporting of error conditions in a secure fashion
Patching	Related to keeping software up to date
Session Management	Related to the identification of authenticated users
Testing	Related to test methodology or test coverage
Timing	Related to race conditions, locking, or the order of operations
Undefined Behavior	Related to undefined behavior triggered by the program

Severity Categories	
Severity	**Description**
Informational	The issue does not pose an immediate risk but is relevant to security best practices or Defense in Depth.
Undetermined	The extent of the risk was not determined during this engagement.
Low	The risk is relatively small or is not a risk the customer has indicated is important.

Medium	Individual users' information is at risk; exploitation could pose reputational, legal, or moderate financial risks to the client.
High	The issue could affect numerous users and have serious reputational, legal, or financial implications for the client.

Difficulty Levels	
Difficulty	**Description**
Undetermined	The difficulty of exploitation was not determined during this engagement.
Low	The flaw is commonly exploited; public tools for its exploitation exist or can be scripted.
Medium	An attacker must write an exploit or will need in-depth knowledge of a complex system.
High	An attacker must have privileged insider access to the system, may need to know extremely complex technical details, or must discover other weaknesses to exploit this issue.

B. Code Maturity Classifications

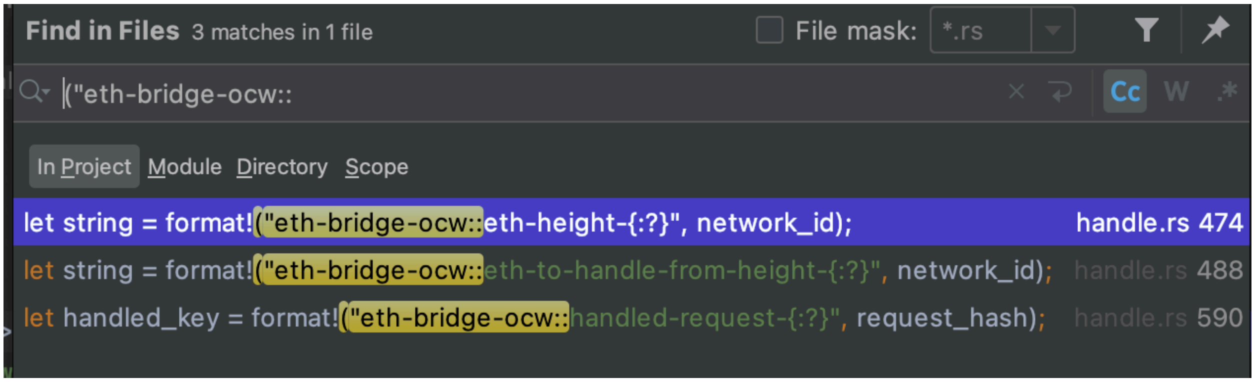
Code Maturity Classes	
Category Name	**Description**
Access Controls	Related to the authentication and authorization of components
Arithmetic	Related to the proper use of mathematical operations and semantics
Assembly Use	Related to the use of inline assembly
Centralization	Related to the existence of a single point of failure
Code Stability	Related to the recent frequency of code updates
Upgradeability	Related to contract upgradeability
Function Composition	Related to separation of the logic into functions with clear purposes
Front-Running	Related to resilience against front-running
Key Management	Related to the existence of proper procedures for key generation, distribution, and access
Monitoring	Related to the use of events and monitoring procedures
Specification	Related to the expected codebase documentation
Testing & Verification	Related to the use of testing techniques (unit tests, fuzzing, symbolic execution, etc.)

Rating Criteria	
Rating	**Description**
Strong	The component was reviewed, and no concerns were found.
Satisfactory	The component had only minor issues.
Moderate	The component had some issues.
Weak	The component led to multiple issues; more issues might be present.

Missing	The component was missing.
Not Applicable	The component is not applicable.
Not Considered	The component was not reviewed.
Further Investigation Required	The component requires further investigation.

C. Code Quality Recommendations

- The expression returned from the `list_enabled_sources_for_trading_pair` function does not need to be wrapped in `Ok(...)`.
- Remove the `permissions` pallet's `Mode` enum. Its `Mode::Forbid` kind is not used anywhere in the code, so the whole enum can be removed; the pallet should then be refactored accordingly.
- Remove the `check_permission_maybe_with_parameters` function from the `assets` pallet. It first checks for a scoped permission; if it does not find one, it checks for an unlimited-scope permission. This strategy of falling back to an unlimited-scope permission check is already implemented in the `check_permission_with_scope` function, which the `assets` pallet function calls.
- Add the missing comments about Ethereum events to the `parse_main_event` function. Currently, only the `ChangePeers(address,bool)` hash is commented; the two other hashes lack appropriate comments indicating which function signatures they are constructed from.
- In the off-chain worker, move the format string literals used for storage keys (shown in the screenshot below) to one place. That way, if two format strings have the same prefix, it will be easier to detect the collision during development. Additionally, consider adding an automated check for this issue during testing or compilation.



```
("eth-bridge-ocw::
```

```
let string = format!("eth-bridge-ocw::eth-height-{:?}", network_id);                    handle.rs 474
let string = format!("eth-bridge-ocw::eth-to-handle-from-height-{:?}", network_id);     handle.rs 488
let handled_key = format!("eth-bridge-ocw::handled-request-{:?}", request_hash);        handle.rs 590
```

- The `from` field in the `IncomingTransfer` structure is not used and should be removed.
- In the `assets` pallet's `burn_from` function, rename the "`to`" argument to "`from`," which better reflects its purpose.
- Fix the `StorageOverflow` error description, which contains a comment from a Substrate node-template example:

```
/// Errors should have helpful documentation associated with them.
StorageOverflow,
```

- Change the name of the `claim_incentive` function, which calculates weights, to `claim_rewards`. This will make the name of the function consistent with the name of the `claim_rewards` extrinsic, which will make the code more readable.

- The `IncentiveDistributionFailed` event is not used. There is a TODO comment regarding its future implementation.
- Fix the `into_balance` function's TODO in the `fixed_wrapper.rs`. This function is currently used only in tests but should be fixed if it will be used in production code.
- The case when an element is found in `RequestsQueue` map but missing in `Requests` map should be handled.
- Delete the unnecessary code described in the `handle_offchain_request` function.

D. ERC20 Token Transfer Semantics

This appendix lists the `transfer` and `transferFrom` return value semantics of the ERC20 tokens owned by the SORA Network's Ethereum bridge contract. We used this list to identify tokens that could be leveraged to exploit the issues described in TOB-PSWAP-001 and TOB-PSWAP-009 as well as upgradeable tokens that should be monitored, as described in TOB-PSWAP-005.

This list is also maintained on a Google Sheets spreadsheet, Trail of Bits: ERC20 Token Semantics [PUBLIC] , with a list of deflationary/inflationary tokens taken from etherscan.io on the second sheet of the document.

Token	Ticker Symbol	Contract	Is it a proxy?	Implementation	`transfer`	`transferFrom`
Dai Stablecoin	DAI	Code	No		True or revert	True or revert
USD Coin	USDC	Proxy code	Yes	Code	True or revert	True or revert
Phala	PHA	Code	No		True or revert	True or revert
RARE.Unique	RARE	Code	No		True or revert	True or revert
ChainLink	LINK	Code	No		True or revert	True or revert
Uniswap	UNI	Code	No		True or revert	True or revert
FOTO	FOTO	Code	No		True or revert	True or revert
unification.com/xfund	xFUND	Code	No		True or revert	True or revert
FANS.UNIQUE	FANS	Code	No		True or revert	True or revert
Compound	COMP	Code	No		True or revert	True or revert
RLC	RLC	Code	No		True or revert	True or revert
Ocean	OCEAN	Code	No		True or revert	True or revert
Robonomics	XRT	Code	No		True or revert	True or revert
Graph	GRT	Code	No		True or revert	True or revert
Binance USD	BUSD	Proxy code	Yes	code	True or revert	True or revert
Republic	REN	Code	Yo		True or revert	True or revert
Wrapped BTC	WBTC	Code	No		True or revert	True or revert
Litentry	LIT	Code	No		True or revert	True or revert
Aave	AAVE	Code	Yes	code	True or revert	True or revert
Matic	MATIC	Code	No		True or revert	True or revert
yearn.finance	YFI	Code	No		True or revert	True or revert
Akropolis	AKRO	Proxy code	Yes	code	True or revert	True or revert
STAKE	STAKE	Code	No		True or revert	True or revert

Reef.finance	REEF	Code	No		True or revert	True or revert
THORChain ETH.RUNE	RUNE	Code	No		True or revert	True or revert
TrueUSD	TUSD	Proxy code	Yes	code	True or revert	True or revert
Wrapped UST	UST	Code	No		True or revert	True or revert
DIAToken	DIA	Code	No		True or revert	True or revert
renBTC	renBTC	Code	No		True or revert	True or revert
HUSD	HUSD	Code	No		True or revert	True or revert
Crypto.com Coin	CRO	Code	No		True or revert	True or revert
Cream	CREAM	Code	No		True or revert	True or revert
Paxos Standard	PAX	Proxy code	Yes	code	True or revert	True or revert
StaFi	FIS	Code	No		True or revert	True or revert
SwissBorg	**CHSB**	**Proxy code**	**Yes**	**code**	**May return false**	**May return false**
HoloToken	HOT	Code	No		True or revert	True or revert
Nexo	NEXO	Code	No		True or revert	True or revert
BAT	**BAT**	**Code**	**No**		**May return false**	**May return false**
Curve DAO Token	CRV	Code	No		True or revert	True or revert
Bitfinex LEO Token	LEO	Code	No		True or revert	True or revert
SushiToken	SUSHI	Code	No		True or revert	True or revert
FTT	FTX Token	Code	No		True or revert	True or revert
Maker	MKR	Code	No		True or revert	True or revert
Decentraland	MANA	Code	No		True or revert	True or revert
KyberNetwork	KNC	Code	No		True or revert	True or revert
UMA Voting Token v1	UMA	Code	No		True or revert	True or revert
Telcoin	TEL	Code	No		True or revert	True or revert
Shabu Shabu	KOBE	Code	No		True or revert	True or revert
HuobiToken	**HT**	**Code**	**No**		**May return false**	**May return false**
OKB	OKB	Proxy code	Yes	code	True or revert	True or revert
IDEX Token	IDEX	Code	No		True or revert	True or revert
Compound USD Coin	**cUSDC**	**Code**	**No**		**May return false**	**May return false**
ChronoBase	TIK	Proxy code	Yes	code	True or revert	True or revert
Polkadex	PDEX	Code	No		True or revert	True or revert

SingularityNET	AGI	Code	no		True or revert	True or revert

E. Token Integration Checklist

The following checklist provides recommendations for interactions with arbitrary tokens. Every unchecked item should be justified, and its associated risks, understood. An up-to-date version of the checklist can be found in crytic/building-secure-contracts.

For convenience, all Slither utilities can be run directly on a token address, such as the following:

```
slither-check-erc 0xdac17f958d2ee523a2206206994597c13d831ec7 TetherToken
```

To follow this checklist, use the below output from Slither for the token:

```
- slither-check-erc [target] [contractName] [optional: --erc ERC_NUMBER]
- slither [target] --print human-summary
- slither [target] --print contract-summary
- slither-prop . --contract ContractName # requires configuration, and use of Echidna and
Manticore
```

General Security Considerations

- ❑ **The contract has a security review.** Avoid interacting with contracts that lack a security review. Check the length of the assessment (i.e., the level of effort), the reputation of the security firm, and the number and severity of the findings.
- ❑ **You have contacted the developers.** You may need to alert their team to an incident. Look for appropriate contacts on blockchain-security-contacts.
- ❑ **They have a security mailing list for critical announcements.** Their team should advise users (like you!) when critical issues are found or when upgrades occur.

ERC Conformity

Slither includes a utility, `slither-check-erc`, that reviews the conformance of a token to many related ERC standards. Use `slither-check-erc` to review the following:

- ❑ **`Transfer` and `transferFrom` return a boolean.** Several tokens do not return a boolean on these functions. As a result, their calls in the contract might fail.
- ❑ **The `name`, `decimals`, and `symbol` functions are present if used.** These functions are optional in the ERC20 standard and may not be present. If they are present, make sure that they cannot change over the lifetime of a token.
- ❑ **`Decimals` returns a `uint8`.** Several tokens incorrectly return a `uint256`. In such cases, ensure that the value returned is below 255.

- ❑ **The token mitigates the known ERC20 race condition.** The ERC20 standard has a known ERC20 race condition that must be mitigated to prevent attackers from stealing tokens.
- ❑ **The token is not an ERC777 token and has no external function call in `transfer` or `transferFrom`.** External calls in the transfer functions can lead to reentrancies.

Slither includes a utility, `slither-prop`, that generates unit tests and security properties that can discover many common ERC flaws. Use `slither-prop` to review the following:

- ❑ **The contract passes all unit tests and security properties from `slither-prop`.** Run the generated unit tests and then check the properties with Echidna and Manticore.

Finally, there are certain characteristics that are difficult to identify automatically. Conduct a manual review of the following conditions:

- ❑ **`Transfer` and `transferFrom` should not take a fee.** Deflationary tokens can lead to unexpected behavior.
- ❑ **Potential interest earned from the token is taken into account.** Some tokens distribute interest to token holders. This interest may be trapped in the contract if not taken into account.

Contract Composition

- ❑ **The contract avoids unnecessary complexity.** The token should be a simple contract; a token with complex code requires a higher standard of review. Use Slither's `human-summary` printer to identify complex code.
- ❑ **The contract uses `SafeMath`.** Contracts that do not use `SafeMath` require a higher standard of review. Inspect the contract by hand for `SafeMath` usage.
- ❑ **The contract has only a few non-token-related functions.** Non-token-related functions increase the likelihood of an issue in the contract. Use Slither's contract-summary printer to broadly review the code used in the contract.
- ❑ **The token has only one address.** Tokens with multiple entry points for balance updates can break internal bookkeeping based on the address (e.g., `balances[token_address][msg.sender]` may not reflect the actual balance).

Owner Privileges

- ❑ **The token is not upgradeable.** Upgradeable contracts may change their rules over time. Use Slither's `human-summary` printer to determine if the contract is upgradeable.
- ❑ **The owner has limited minting capabilities.** Malicious or compromised owners can abuse minting capabilities. Use Slither's `human-summary` printer to review minting capabilities, and consider manually reviewing the code.

- ❏ **The token is not pausable.** Malicious or compromised owners can trap contracts relying on pausable tokens. Identify pausable code by hand.
- ❏ **The owner cannot blacklist the contract.** Malicious or compromised owners can trap contracts relying on tokens with a blacklist. Identify blacklisting features by hand.
- ❏ **The team behind the token is known and can be held responsible for abuse.** Contracts with anonymous development teams or teams that reside in legal shelters require a higher standard of review.

Token Scarcity

Reviews of token scarcity issues must be executed manually. Check for the following conditions:

- ❏ **The supply is owned by more than a few users.** If a few users own most of the tokens, they can influence operations based on the tokens' repartition.
- ❏ **The total supply is sufficient.** Tokens with a low total supply can be easily manipulated.
- ❏ **The tokens are located in more than a few exchanges.** If all the tokens are in one exchange, a compromise of the exchange could compromise the contract relying on the token.
- ❏ **Users understand the risks associated with a large amount of funds or flash loans.** Contracts relying on the token balance must account for attackers with a large amount of funds or attacks executed through flash loans.
- ❏ **The token does not allow flash minting.** Flash minting can lead to substantial swings in the balance and the total supply, which necessitate strict and comprehensive overflow checks in the operation of the token.

F. Proof of Concept for Creating a Non-Mintable Asset with an Initial Supply of Zero

This appendix provides a proof-of-concept Python script (figure F.1) that we used to create the non-mintable asset EMPT7 on the sora-staging test network, as shown in TOB-PSWAP-023.

To run the script, it is necessary to install the `substrate-interface` and `scalecodec` Python packages and to download the `custom_types_polkaswap.json` file.

```
# Before running:
# 1) pip install scalecodec==0.11.13 substrate-interface==0.13.8
# 2) wget https://raw.githubusercontent.com/sora-xor/PythonBot/master/custom_types.json
# 3) fill in the 'KEYPAIR DETAILS' below
# 4) Set proper url
from substrateinterface import SubstrateInterface, Keypair
from substrateinterface.exceptions import SubstrateRequestException
from scalecodec.type_registry import load_type_registry_file

substrate = SubstrateInterface(
    #url='wss://ws.mof.sora.org',
    url='wss://ws.stage.sora2.soramitsu.co.jp/',
    ss58_format=69,
    type_registry_preset='default',
    # taken from
https://raw.githubusercontent.com/sora-xor/PythonBot/master/custom_types.json
    type_registry=load_type_registry_file('custom_types_polkaswap.json'),
)

# KEYPAIR DETAILS: This needs to be filled or better, changed to load keys from other source
keypair = Keypair.create_from_mnemonic('<KEY MNEMONICS HERE>')

call = substrate.compose_call(
    call_module='Assets',
    call_function='register',
    call_params={
        'symbol': 'EMPT7',          # May require changing
        'name': 'emptytokenn',      # May require changing
        'initial_supply': 0,
        'is_mintable': False
    }
)

try:
    extrinsic = substrate.create_signed_extrinsic(call=call, keypair=keypair)
    receipt = substrate.submit_extrinsic(extrinsic, wait_for_inclusion=False)
    print("Extrinsic '{}' sent".format(receipt.extrinsic_hash))
except Exception as e:
    print("Failed to send: {}".format(e))
```

Figure F.1: The script used to create a non-mintable asset with an initial supply of zero.

G. Fuzzing Polkaswap with test-fuzz

We used test-fuzz, a framework for convenient AFL fuzzing, to fuzz certain functions in the Polkaswap codebase. To use test-fuzz, one must mark a function for fuzzing; the framework will then generate a fuzzing harness for it, along with additional code that will serialize the marked function's arguments when it is called in tests.

To run test-fuzz, take the following steps:

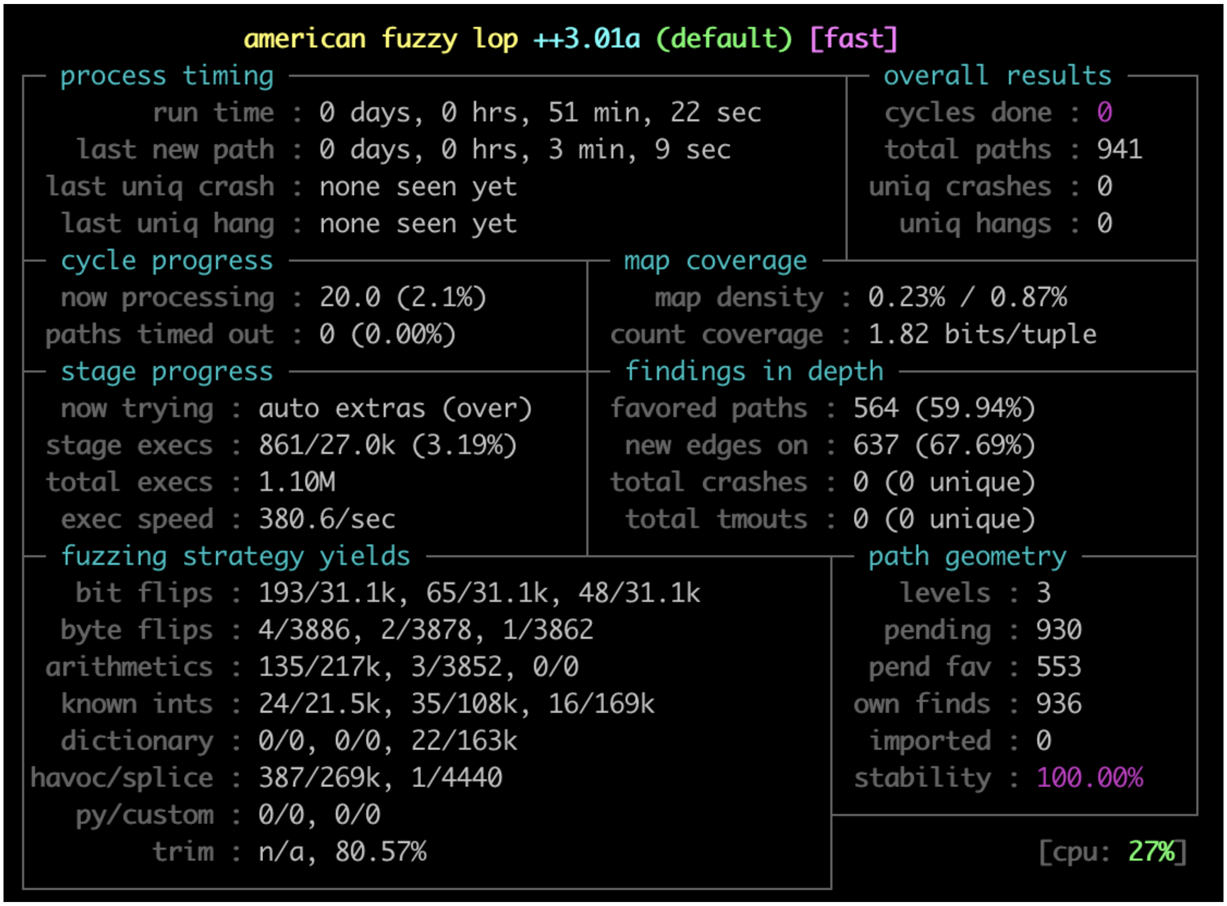
1. Add test-fuzz and serde as dependencies.
2. Force-install (or reinstall) AFL via the cargo install afl --force command. (Issue rust-fuzz/afl.rs#183 may necessitate reinstallation.)
3. Add the #[test_fuzz] macro to the function to be fuzzed. If the function is in a trait, add #[test_fuzz::test_fuzz_impl] before the "impl" block; it may also be necessary to perform argument concretization for the test_fuzz attribute. Additional information is provided in the example patch below and the test-fuzz documentation.
4. Execute cargo test so that the function to be fuzzed will be executed and its input will be serialized. The test-fuzz macro will work only if the target function is launched by tests, as it needs to save an initial corpus of the function arguments.
5. Run the fuzzing with the following command:
   ```
   cargo test-fuzz --target <function>
   ```
6. If the code cannot be compiled in its entirety (because of a dependency issue in another crate, for example), it may be necessary to run the tool against a given package by using the --package <package> argument.

The AFL fuzzer will run indefinitely. We recommend running it for as long as possible; however, if it runs for a long time without finding new paths, it may make sense to stop the fuzzing, investigate its code coverage, and generate inputs that reach the previously unreached paths.

Figure G.3 includes a patch that adds test-fuzz to the project as well as a fuzzing harness for the parse_deposit_event function. This patch can be applied to commit 9d72e6c of the project through the git apply <file> command. Then to run the fuzzing, invoke following commands:

```
- cargo test -p eth-bridge
- cargo test-fuzz -p eth-bridge --target=parse_deposit_event
```

Figure G.1 shows the AFL window that should appear to display the fuzzing progress.



```
              american fuzzy lop ++3.01a (default) [fast]
┌─ process timing ────────────────────────────────────┬─ overall results ────┐
│        run time : 0 days, 0 hrs, 51 min, 22 sec      │  cycles done : 0     │
│   last new path : 0 days, 0 hrs, 3 min, 9 sec        │  total paths : 941   │
│ last uniq crash : none seen yet                      │ uniq crashes : 0     │
│  last uniq hang : none seen yet                      │   uniq hangs : 0     │
├─ cycle progress ───────────────┬─ map coverage ─┴──────────────────────┤
│  now processing : 20.0 (2.1%)  │    map density : 0.23% / 0.87%        │
│ paths timed out : 0 (0.00%)    │ count coverage : 1.82 bits/tuple      │
├─ stage progress ───────────────┼─ findings in depth ───────────────────┤
│  now trying : auto extras (over) │ favored paths : 564 (59.94%)        │
│ stage execs : 861/27.0k (3.19%)  │  new edges on : 637 (67.69%)        │
│ total execs : 1.10M              │ total crashes : 0 (0 unique)        │
│  exec speed : 380.6/sec          │  total tmouts : 0 (0 unique)        │
├─ fuzzing strategy yields ─────────┴───────────────┬─ path geometry ────────┤
│   bit flips : 193/31.1k, 65/31.1k, 48/31.1k        │    levels : 3          │
│  byte flips : 4/3886, 2/3878, 1/3862               │   pending : 930        │
│ arithmetics : 135/217k, 3/3852, 0/0                │  pend fav : 553        │
│  known ints : 24/21.5k, 35/108k, 16/169k           │ own finds : 936        │
│  dictionary : 0/0, 0/0, 22/163k                    │  imported : 0          │
│havoc/splice : 387/269k, 1/4440                     │ stability : 100.00%    │
│   py/custom : 0/0, 0/0                             ├────────────────────────┘
│        trim : n/a, 80.57%                          │          [cpu: 27%]
└────────────────────────────────────────────────────┘
```

Figure G.1: The AFL window displaying the progress of the fuzzing.

If running `test-fuzz` results in an error of "`failed to download `parity-db v0.2.3``" (as shown in figure G.2), use the `cargo update -p parity-db` command to update the dependency.

```
Error: `cargo metadata` exited with an error: error: failed to download `parity-db v0.2.3`

Caused by:
  unable to get packages from source

Caused by:
  failed to parse manifest at
`/Users/dc/.cargo/registry/src/github.com-1ecc6299db9ec823/parity-db-0.2.3/Cargo.toml`

Caused by:
  failed to parse the version requirement `0.11    ` for dependency `parking_lot`

Caused by:
  expected comma after minor version number, found '\t'
```

Figure G.2: A potential `test-fuzz` dependency-related error, which can be resolved by updating the `parity-db` package.

```
diff --git a/src/sora2-substrate/pallets/eth-bridge/Cargo.toml b/src/sora2-substrate/pallets/eth-bridge/Cargo.toml
index 8a18512..d9dcbfc 100644
--- a/src/sora2-substrate/pallets/eth-bridge/Cargo.toml
+++ b/src/sora2-substrate/pallets/eth-bridge/Cargo.toml
@@ -19,7 +19,7 @@ rlp = { version = "0.4.6", default-features = false }
 rustc-hex = { version = "2.1.0", default-features = false }
 serde = { version = "1.0", features = ["alloc", "derive"], default-features = false }
 serde_json = { version = "1.0", default-features = false, features = ["alloc"] }
-sp-core = { version = "3", default-features = false }
+# sp-core = { version = "3", default-features = false }
 sp-std = { version = "3", default-features = false }
 tiny-keccak = { version = "2", default-features = false }
 pallet-scheduler = { version = "3", default-features = false }
@@ -32,11 +32,13 @@ ethabi-derive = { git = "https://github.com/vmarkushin/ethabi.git", branch = "no
 ethereum-types = { git = "https://github.com/vmarkushin/parity-common.git", branch = "no-std", package =
"ethereum-types", default-features = false, features = ['serialize', 'codec'] }
 jsonrpc-core = { git = "https://github.com/vmarkushin/jsonrpc.git", branch = "no-std", package = "jsonrpc-core",
default-features = false }

-assets = { path = "../assets", default-features = false }
-common = { path = "../../common", default-features = false }
-permissions = { path = "../permissions", default-features = false }
+# assets = { path = "../assets", default-features = false }
+# common = { path = "../../common", default-features = false }
+# permissions = { path = "../permissions", default-features = false }

-[dev-dependencies]
+test-fuzz = { version = "0.1.0-alpha.24", default-features = false, features = ["serde_cbor"] }
+
+# [dev-dependencies]
 async-std = { version = "1.5", features = ["attributes", "unstable"] }
 currencies = { version = "0.4", package = "orml-currencies", default-features = false }
 env_logger = "0.8.1"
diff --git a/src/sora2-substrate/pallets/eth-bridge/src/lib.rs b/src/sora2-substrate/pallets/eth-bridge/src/lib.rs
index df41c69..50bf953 100644
--- a/src/sora2-substrate/pallets/eth-bridge/src/lib.rs
+++ b/src/sora2-substrate/pallets/eth-bridge/src/lib.rs
@@ -142,7 +142,7 @@ mod migrations;
 pub mod offchain;
 pub mod requests;
 mod rpc;
-#[cfg(test)]
+// #[cfg(test)]
 mod tests;
 pub mod types;
 mod util;
@@ -364,7 +364,7 @@ pub mod pallet {
         type GetEthNetworkId: Get<Self::NetworkId>;
         /// Weight information for extrinsics in this pallet.
         type WeightInfo: WeightInfo;
-        #[cfg(test)]
+        // #[cfg(test)]
         type Mock: tests::mock::Mock;

         #[pallet::constant]
diff --git a/src/sora2-substrate/pallets/eth-bridge/src/offchain/mod.rs
b/src/sora2-substrate/pallets/eth-bridge/src/offchain/mod.rs
index 7324af5..f058ced 100644
--- a/src/sora2-substrate/pallets/eth-bridge/src/offchain/mod.rs
+++ b/src/sora2-substrate/pallets/eth-bridge/src/offchain/mod.rs
@@ -92,7 +92,9 @@ pub mod crypto {
     }
 }

+#[test_fuzz::test_fuzz_impl]
 impl<T: Config> Pallet<T> {
+    #[test_fuzz::test_fuzz(concretize_impl = "crate::tests::mock::Runtime")]
     fn parse_deposit_event(
         log: &Log,
     ) -> Result<DepositEvent<Address, T::AccountId, Balance>, Error<T>> {
diff --git a/src/sora2-substrate/pallets/eth-bridge/src/tests/mock.rs
b/src/sora2-substrate/pallets/eth-bridge/src/tests/mock.rs
index 8896dce..9b5e96e 100644
--- a/src/sora2-substrate/pallets/eth-bridge/src/tests/mock.rs
+++ b/src/sora2-substrate/pallets/eth-bridge/src/tests/mock.rs
```

```
@@ -435,6 +435,24 @@ construct_runtime!(
     }
 );

+impl<'de> serde::Deserialize<'de> for Runtime {
+    fn deserialize<D>(deserializer: D) -> Result<Self, D::Error>
+    where
+        D: serde::Deserializer<'de>,
+    {
+        <()>::deserialize(deserializer).map(|_| Runtime)
+    }
+}
+
+impl serde::Serialize for Runtime {
+    fn serialize<S>(&self, serializer: S) -> Result<S::Ok, S::Error>
+    where
+        S: serde::Serializer,
+    {
+        ().serialize(serializer)
+    }
+}
+
 pub type SubstrateAccountId = <<Signature as Verify>::Signer as IdentifyAccount>::AccountId;

 pub trait Mock {
diff --git a/src/sora2-substrate/pallets/eth-bridge/src/types/substrate.rs
b/src/sora2-substrate/pallets/eth-bridge/src/types/substrate.rs
index b65f380..430a719 100644
--- a/src/sora2-substrate/pallets/eth-bridge/src/types/substrate.rs
+++ b/src/sora2-substrate/pallets/eth-bridge/src/types/substrate.rs
@@ -32,7 +32,7 @@ use crate::types::{H256, U64};
 use alloc::string::String;
 use codec::{Decode, Encode};
 use serde::Deserialize;
-#[cfg(test)]
+// #[cfg(test)]
 use serde::Serialize;
 use sp_std::vec::Vec;

@@ -41,7 +41,7 @@ use sp_std::vec::Vec;
 #[derive(PartialEq, Eq, Clone, Default, Encode, Decode)]
 pub struct OpaqueExtrinsic(Vec<u8>);

-#[cfg(test)]
+// #[cfg(test)]
 impl ::serde::Serialize for OpaqueExtrinsic {
     fn serialize<S>(&self, seq: S) -> Result<S::Ok, S::Error>
     where
@@ -65,8 +65,7 @@ impl<'a> serde::Deserialize<'a> for OpaqueExtrinsic {
     }
 }

-#[derive(Deserialize)]
-#[cfg_attr(test, derive(Serialize))]
+#[derive(Deserialize, Serialize)]
 #[serde(rename_all = "camelCase")]
 pub struct SubstrateHeaderLimited {
     /// The parent hash.
@@ -85,8 +84,7 @@ pub struct SubstrateHeaderLimited {
     pub digest: (),
 }

-#[derive(Deserialize)]
-#[cfg_attr(test, derive(Serialize))]
+#[derive(Deserialize, Serialize)]
 #[serde(rename_all = "camelCase")]
 pub struct SubstrateBlockLimited {
     /// The block header.
@@ -95,8 +93,7 @@ pub struct SubstrateBlockLimited {
     pub extrinsics: Vec<OpaqueExtrinsic>,
 }

-#[derive(Deserialize)]
-#[cfg_attr(test, derive(Serialize))]
+#[derive(Deserialize, Serialize)]
 #[serde(rename_all = "camelCase")]
 pub struct SubstrateSignedBlockLimited {
     /// Full block.
diff --git a/src/sora2-substrate/pallets/iroha-migration/Cargo.toml
b/src/sora2-substrate/pallets/iroha-migration/Cargo.toml
index fc0305b..c2503e1 100644
--- a/src/sora2-substrate/pallets/iroha-migration/Cargo.toml
+++ b/src/sora2-substrate/pallets/iroha-migration/Cargo.toml
@@ -49,7 +49,7 @@ default = ["std"]

 std = [
     "codec/std",
-    "frame-benchmarking?/std",
+    "frame-benchmarking/std",
     "frame-support/std",
     "frame-system/std",
     "pallet-multisig/std",
diff --git a/src/sora2-substrate/runtime/Cargo.toml b/src/sora2-substrate/runtime/Cargo.toml
index 9c9553b..770bf57 100644
--- a/src/sora2-substrate/runtime/Cargo.toml
+++ b/src/sora2-substrate/runtime/Cargo.toml
@@ -160,7 +160,7 @@ std = [
     'eth-bridge/std',
     'eth-bridge-runtime-api/std',
     'farming/std',
-    'faucet?/std',
+    'faucet/std',
     'iroha-migration/std',
     'iroha-migration-runtime-api/std',
     'liquidity-proxy/std',
@@ -192,7 +192,7 @@ runtime-benchmarks = [
     "dex-api-benchmarking",
     "eth-bridge/runtime-benchmarks",
     "farming/runtime-benchmarks",
-    "faucet?/runtime-benchmarks",
+    "faucet/runtime-benchmarks",
     "frame-benchmarking",
     "frame-support/runtime-benchmarks",
     "frame-system-benchmarking",
```

Figure G.3: The patch is used to run `test-fuzz` over the Polkaswap codebase. The changes made to `cargo.lock` by the compiler are excluded from this listing; however, the file should regenerate itself after `Cargo.toml` has been changed.