PerlinXRewards.sol

This smart contract audit was prepared by Quantstamp, the protocol for securing smart contracts.

Executive Summary

Type                  | Audit
Auditors             | Poming Lee, Research Engineer
                      | Jan Gorzny, Blockchain Researcher
                      | Leonardo Passos, Senior Research Engineer
Timeline             | 2020-07-31 through 2020-08-07
EVM                  | Muir Glacier
Languages            | Solidity
Specification         | PerlinX Rewards Contract Spec - documentation
Source Code           | perlinx-contracts 9c62c6c
                      | perlinx-contracts 3c73f50
Total Issues          | 13 (7 Resolved)
High Risk Issues      | 2 (2 Resolved)
Medium Risk Issues    | 1 (0 Resolved)
Low Risk Issues       | 4 (3 Resolved)
Informational Risk Issues | 3 (1 Resolved)
Undetermined Risk Issues | 3 (1 Resolved)

- **High Risk**
The issue puts a large number of users’ sensitive information at risk, or is reasonably likely to lead to catastrophic impact for client’s reputation or serious financial implications for client and users.

- **Medium Risk**
The issue puts a subset of users’ sensitive information at risk, would be detrimental for the client’s reputation if exploited, or is reasonably likely to lead to moderate financial impact.

- **Low Risk**
The risk is relatively small and could not be exploited on a recurring basis, or is a risk that the client has indicated is low-impact in view of the client’s business circumstances.

- **Informational**
The issue does not post an immediate risk, but is relevant to security best practices or Defence in Depth.

- **Undetermined**
The impact of the issue is uncertain.

- **Unresolved**
Acknowledged the existence of the risk, and decided to accept it without engaging in special efforts to control it.

- **Acknowledged**
The issue remains in the code but is a result of an intentional business or design decision. As such, it is supposed to be addressed outside the programmatic means, such as: 1) comments, documentation, README, FAQ; 2) business processes; 3) analyses showing that the issue shall have no negative consequences in practice (e.g., gas analysis, deployment settings).

- **Resolved**
Adjusted program implementation, requirements or constraints to eliminate the risk.

- **Mitigated**
Implemented actions to minimize the impact or likelihood of the risk.
Summary of Findings

During auditing, we found 15 potential issues of various levels of severity: 2 high-severity, 1 medium-severity, 4 low-severity issues, 5 undetermined-severity issues, as well as 3 informational-level findings. The code looks well-structured and concise. We made 21 best practices recommendations.

We highly recommend addressing the findings before going live.

Disclaimer: Please be aware that Quantstamp was requested and had audited a single file: PerlinXRewards.sol; the whole system was not audited.

** 2020-08-07 update ** The Perlin team has received and taken care of all the findings and the best practice suggestions.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Severity</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSP-1</td>
<td>A user can increase their shares arbitrarily</td>
<td>High</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-2</td>
<td>Missing balance check after transfer of ERC20 token</td>
<td>High</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-3</td>
<td>No minimum quorum for privilege operations</td>
<td>Medium</td>
<td>Acknowledged</td>
</tr>
<tr>
<td>QSP-4</td>
<td>Contract allows incorrect combinations of pool/synth/emp addresses</td>
<td>Low</td>
<td>Acknowledged</td>
</tr>
<tr>
<td>QSP-5</td>
<td>Modifier flashSafe() cannot avoid flash loan and reentrancy</td>
<td>Low</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-6</td>
<td>Incorrect weight precision</td>
<td>Low</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-7</td>
<td>updateRewards may run out of gas</td>
<td>Low</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-8</td>
<td>Unlocked Pragma</td>
<td>Informational</td>
<td>Fixed</td>
</tr>
<tr>
<td>QSP-9</td>
<td>Clone-and-Own</td>
<td>Informational</td>
<td>Acknowledged</td>
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<tr>
<td>QSP-10</td>
<td>Missing input checks</td>
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<td>QSP-12</td>
<td>Potential division by zero</td>
<td>Undetermined</td>
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<td>snapshotPoolsInEra can be called on past eras</td>
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</table>

Quantstamp Audit Breakdown

Quantstamp’s objective was to evaluate the repository for security-related issues, code quality, and adherence to specification and best practices.

Methodology

The Quantstamp auditing process follows a routine series of steps:

1. Code review that includes the following:
   i. Review of the specifications, sources, and instructions provided to Quantstamp to make sure we understand the size, scope, and functionality of the smart contract.
   ii. Manual review of code, which is the process of reading source code line-by-line in an attempt to identify potential vulnerabilities.
   iii. Comparison to specification, which is the process of checking whether the code does what the specifications, sources, and instructions provided to Quantstamp describe.

2. Testing and automated analysis that includes the following:
   i. Test coverage analysis, which is the process of determining whether the test cases are actually covering the code and how much code is exercised when we run those test cases.
   ii. Symbolic execution, which is analyzing a program to determine what inputs cause each part of a program to execute.

3. Best practices review, which is a review of the smart contracts to improve efficiency, effectiveness, clarify, maintainability, security, and control based on the established industry and academic practices, recommendations, and research.

4. Specific, itemized, and actionable recommendations to help you take steps to secure your smart contracts.

Toolset

The notes below outline the setup and steps performed in the process of this audit.

Setup

Tool Setup:
- Mythril 0.22.8
- Slither v0.6.6

Steps taken to run the tools:
1. Installed the Mythril tool from Pypi: `pip3 install mythril`
2. Ran the Mythril tool on each contract: `myth analyze FlattenedContract.sol`
3. Installed the Slither tool: `pip install slither-analyzer`
4. Run Slither from the project directory: `slither`.

Findings

QSP-1 A user can increase their shares arbitrarily

Severity: High Risk

Status: Fixed

Description: L244 accumulates based on the input amount. In addition, the function `registerAllClaims` can be called by anyone at any time. So one can call the function...
QSP-2 Missing balance check after transfer of ERC20 token

Severity: High Risk
Status: Fixed
Description: The transfer of ERC20 will not always be successful. Hence, the success of transferFrom/transfer on L200, L225, L234, L265 should be checked.
Recommendation: It is recommended to check the balance before and after the transfer. Could also put the transfer/transferFrom into a require statement.

QSP-3 No minimum quorum for privilege operations

Severity: Medium Risk
Status: Acknowledged
Description: The contract has multiple admins. However, one admin can change the contract parameters without the consent of others. In this case, it is preferred to introduce a minimum quorum between admins instead of having a single admin doing a change.
**2020-08-07 update**: The Perlin team stated that they have added a `treasury` address for fund-sensitive actions.
Recommendation: Change admin settings such that any change to the contract requires a minimum quorum amongst registered admins.

QSP-4 Contract allows incorrect combinations of pool/synth/emp addresses

Severity: Low Risk
Status: Acknowledged
Description: Currently, `ListSynth` does not check if the input triple `<pool, synth, emp>` is valid; hence, it is possible to invoke `ListSynth` with a pool address that has no relation to the given `synth` address, which in turn, has no relation to the given `emp` address. A similar issue occurs for `ListPool`.
**2020-08-05 update**: The Perlin team stated that: "A balance of flexibility required, since these are just lookups and future AMMs might be used where it is unknown how to verify. It is not critical if they are listed wrong. The WEB-UI will show errors and alert admin if they incorrectly added. It is then possible to overwrite by just listing again."
Recommendation: If it is possible to assert whether all three addresses are related, please do so; if not (e.g., information is off-chain), perhaps rely on an oracle that automatically extracts this relationship somewhere and feed it to the contract.

QSP-5 Modifier `flashSafe()` cannot avoid flash loan and reentrancy

Severity: Low Risk
Status: Fixed
Description: An attacker’s TX could pass this modifier by using multiple contracts to change their `msg.sender`.
Recommendation: Use a single global flag to stop all the potential callees from re-entering these functions within a single TX instead of using user-based global flags to stop each one of them. For instance: `Remove mapping(address => uint) public memberLock and change it into a bool public has_entered.`

QSP-6 Incorrect weight precision

Severity: Low Risk
Status: Fixed
Description: On L124, the requirement statement checks that the weight is greater than or equal to 1 and less than or equal to 1000. The corresponding message says: "Must be greater than 0.1, less than or equal to 1000. Taking 1000 to be the baseline, the contract is representing the weight with two decimal precision; hence I shall denote 0.01, instead of 0.01, as the message suggests. An incorrect requirement statement message may inadvertently convey the incorrect precision, which could cause callees to incorrectly adjust the weight as a consequence.
Recommendation: Change the requirement statement message to "Weight must be greater than 0.01, less than 1.0". In `ListPool`, document the expected weight precision in the function.

QSP-7 `updateRewards` may run out of gas

Severity: Low Risk
Status: Fixed
Description: The loop in `updateRewards` expects the pool count to be less than 1000; however, the code does not bound `arraySynths` in any manner. If not controlled for, the function `updateRewards` may reach a point of never working again due to high gas costs. P.S. The Perlin team said that they’re aware of this and the loop count is planned to be less than 100, so it might not be a problem as long as this maximum loop count is being carefully maintained.
Recommendation: Either bound `arraySynths` to always be less than 100, or change `snapshotPoolsInEra` such as it receives a given offset (start & end positions) to take a snapshot of; such offset is then passed on to `updateRewards`, which uses it to bound the loop iterations.

QSP-8 Unlocked Pragma

Severity: Informational
Status: Fixed
Description: Every Solidity file specifies in the header a version number of the format `pragma solidity (^)0.4.*`. The caret (^) before the version number implies an unlocked pragma, meaning that the compiler will use the specified version and above, hence the term “unlocked.” For consistency and to prevent unexpected behavior in the future, it is recommended to remove the caret to lock the file onto a specific Solidity version.

QSP-9 Clone-and-Own

registerAllClams multiple times to increase its ratio of `memberClaimInEra/totalClaimsInEra`.
Recommendation: Assign the passed in `amount` to `mapMemberClaimInEra[member][currentEra][pool]` instead of accumulating it.

QSP-10 Incorrect requirement statement

Severity: Informational
Status: Fixed
Description: On L124, the requirement statement checks that the weight is greater than or equal to 1 and less than or equal to 1000. The corresponding message says: "Must be greater than 0.1, less than or equal to 1000. Taking 1000 to be the baseline, the contract is representing the weight with two decimal precision; hence I shall denote 0.01, instead of 0.01, as the message suggests. An incorrect requirement statement message may inadvertently convey the incorrect precision, which could cause callees to incorrectly adjust the weight as a consequence.
Recommendation: Change the requirement statement message to "Weight must be greater than 0.01, less than 1.0". In `ListPool`, document the expected weight precision in the function.

QSP-11 Low risk

Severity: Low Risk
Status: Fixed
Description: The loop in `updateRewards` expects the pool count to be less than 1000; however, the code does not bound `arraySynths` in any manner. If not controlled for, the function `updateRewards` may reach a point of never working again due to high gas costs. P.S. The Perlin team said that they’re aware of this and the loop count is planned to be less than 100, so it might not be a problem as long as this maximum loop count is being carefully maintained.
Recommendation: Either bound `arraySynths` to always be less than 100, or change `snapshotPoolsInEra` such as it receives a given offset (start & end positions) to take a snapshot of; such offset is then passed on to `updateRewards`, which uses it to bound the loop iterations.

QSP-12 Unlocked Pragma

Severity: Informational
Status: Fixed
Description: Every Solidity file specifies in the header a version number of the format `pragma solidity (^)0.4.*`. The caret (^) before the version number implies an unlocked pragma, meaning that the compiler will use the specified version and above, hence the term “unlocked.” For consistency and to prevent unexpected behavior in the future, it is recommended to remove the caret to lock the file onto a specific Solidity version.
Severity: Informational

Status: Acknowledged

Description: The clone-and-own approach involves copying and adjusting open source code at one’s own discretion. From the development perspective, it is initially beneficial as it reduces the amount of effort. However, from the security perspective, it involves some risks as the code may not follow the best practices, may contain a security vulnerability, or may include intentionally or unintentionally modified upstream libraries. Rather than the clone-and-own approach, a good industry practice is to use the Truffle framework for managing library dependencies. This eliminates the clone-and-own risks yet allows for following best practices, such as, using libraries.

** 2020-08-25 update **: The Perlin team considers that this is at low risk and all the problems related to it are reversible.

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QSP-10 Missing input checks

Severity: Informational

Status: Acknowledged

Description: Functions taking an input address (constructor, listSynth, ListPool, addAdmin, etc) do not check if the given input is different from 0x0, or if in the case of an expected contract address, that the input is indeed a contract. Passing in an incorrect input address may cause temporary downtime and/or unexpected behavior.

** 2020-08-25 update **: The Perlin team considers that this is at low risk and all the problems related to it are reversible.

Recommendation:
1) Add require statements to check if the input address is different from 0x0,
2) In the case where the address is expected to be a contract, add a require statement checking if the given address refers to a contract (see https://docs.openzeppelin.com/contracts/2.x/api/utils). For instance, could check if:
   - function listPool should check if pool is not 0x0
   - function snapshotPools should check if rewardAsset is not 0x0
   - function sweep should check if asset is not 0x0

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QSP-11 Should zero out a member’s rewards for an era after it is claimed

Severity: Undetermined

Status: Acknowledged

Description: The function `claim` does not zero out a member’s rewards for an era. The specification stated that this should happen, and while it decreases the rewards, there is nothing that decreases the rewards mapping to a specific member. Specifically, the `mapMemberEraPool_Claim` is not zeroed out.

** 2020-08-05 update ** The Perlin team stated that: “Multiple reward assets can be claimed, eg PERL, or BAL, or in future UNI (Uniswap token). These assets are likely to be airdropped to the rewards contract and need to be claimed. Thus, must not zero out claims, since these claims need to be re-used. Instead, a new mapping `mapMemberEraAsset_hasClaimed[msg.sender][era][rewardAsset] = true;` Tracks whether a member has claimed for a particular reward asset or not”.

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QSP-12 Potential division by zero

Severity: Undetermined

Status: Acknowledged

Description: On line 188, `total` could be zero; if so, the transaction will revert and taking the snapshot will fail for all pools.

** 2020-06-05 update **: The Perlin team stated that: “Multiple reward assets can be claimed, eg PERL, or BAL, or in future UNI (Uniswap token). These assets are likely to be airdropped to the rewards contract and need to be claimed. Thus, must not zero out claims, since these claims need to be re-used. Instead, a new mapping `mapMemberEraAsset_hasClaimed[msg.sender][era][rewardAsset] = true;` Tracks whether a member has claimed for a particular reward asset or not”.

Recommendation: Add an if-statement checking that `total` is not zero; if not zero, then proceed to the assignment `mapEraPool_Share[era][pool] = getShare(part, total, rewardForEra)`.

** 2020-08-25 update **: The Perlin team considers that this is at low risk and all the problems related to it are reversible.

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QSP-13 `snapshotPoolsInEra` can be called on past eras

Severity: Undetermined

Status: Fixed

Description: Currently, it is possible to call `snapshotPoolsInEra` on past eras, that is, on eras whose value is less than `currentEra`.

Recommendation: Change the function `snapshotPoolsInEra` to `internal`, or clarify if this behavior is indeed intended; if not, could also consider adding a requirement statement that `era == currentEra` if this fits the designed user scenario.

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Automated Analyses

Mythril

The analysis was completed successfully. No issues were detected.

Slither

Slither identified possible Reentrancys in functions `claim`, `lock`, and `unlock`. These issues, combined with our findings, were added to the finding section.

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Adherence to Specification

The functions `listPool` and `removeReward` have more arguments in the code than in the specification table. The functions `snapshotPoolsInEra` and `registerAllClaims` are not in the specification table.

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Code Documentation

Current specification does not clarify on the rationale of the system; rather, it seems to verbalize the code as written, which provides auditors with little insights into the
Adherence to Best Practices

- If the intent of updateRewards is to be called after snapshotPools, perhaps updateRewards should require eraIsOpen[era]=false.

- Function snapshotPoolInEra could be made internal, which is more in line with the specification.

- L188: mapEra_Total[era] could be passed in to the call, instead of total as that variable is not used elsewhere.

- The requires comments of the function in L280 should be enforced by the code.

- It is recommended to replace L225 and insert L223 to avoid reentrancy.

- The transferAdmin should check that the new admin is not the old admin. Also, separating the case where the new admin is 0x0 into a function renounceOwnership or similar would be helpful, unless that case is not desired (in which case the target address should be checked to be non-zero).

- Pool addresses are never checked to be non-zero; they should be.

- Document all public and external functions following a Natspec format.

- Don’t use uint; rather, specify which specific integer flavour to use. In this case, it seems uint256 is the desired one. If so, replace all uints to uint256.

- Variable names seem inconsistent. Most of the time developers use camelCase (e.g., poolIsListed), but on some occasions they mix it with _ (e.g., mapEraPool_Balance). Make sure all variable names are consistent.

- Index events to allow others to search logs efficiently.

- L93, typo: modify in method -> modify method.

- On L123, consider changing the require statement message to “Asset must not be PERL”.

- On L159, consider changing the requirement statement message to “Amount must be non-zero”.


- Add comments to the line immediately prior to what they are documenting. Currently, many comments are to the right of the code.

- Comments in lock & unlock are not properly indented. Indent them.

- Modifiers are generally used to check whether certain conditions hold. Updating state using modifiers is rather unusual. Hence, consider removing the flashProof modifier and adding its content right at the beginning of lock.

- On L259, consider changing the requirement statement message to “Reward asset must not have been claimed”.

- On L268, consider changing the requirement statement message to “Era must be opened”.

- Function claim only returns true or reverts. Hence, having a return value is useless and can be removed.

Test Results

Test Suite Results

All 32 tests were passed.
Appendix

File Signatures

The following are the SHA-256 hashes of the reviewed files. A file with a different SHA-256 hash has been modified, intentionally or otherwise, after the security review. You are cautioned that a different SHA-256 hash could be (but is not necessarily) an indication of a changed condition or potential vulnerability that was not within the scope of the review.

Contracts

82f0289fdeebf6c61dad9520b505d837422ebd9bad5538016eed5a85088bf4a ./contracts/PerlinXRewards.sol

Tests

6f51fd19856488a386a3b6a12433a3805342a4dbb66b1a9e819d76bb426e64 ./test/1_px.js

Changelog

• 2020-08-04 - Initial report
• 2020-08-07 - reaudit report
About Quantstamp

Quantstamp is a Y Combinator-backed company that helps to secure blockchain platforms at scale using computer-aided reasoning tools, with a mission to help boost the adoption of this exponentially growing technology.

With over 1000 Google scholar citations and numerous published papers, Quantstamp’s team has decades of combined experience in formal verification, static analysis, and software verification. Quantstamp has also developed a protocol to help smart contract developers and projects worldwide to perform cost-effective smart contract security scans.

To date, Quantstamp has protected $5B in digital asset risk from hackers and assisted dozens of blockchain projects globally through its white glove security assessment services. As an evangelist of the blockchain ecosystem, Quantstamp assists core infrastructure projects and leading community initiatives such as the Ethereum Community Fund to expedite the adoption of blockchain technology.

Quantstamp’s collaborations with leading academic institutions such as the National University of Singapore and MIT (Massachusetts Institute of Technology) reflect our commitment to research, development, and enabling world-class blockchain security.

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