Blockchain and Smart Contracts Using Ethereum

Contents

1 Introduction

An incompletely implemented Ethereum smart contract that implements a multi-signature wallet was provided.

1.1 Goals

- Add functionality to the smart contract to protect against replay attacks
- Change the wallet to support an arbitrary number of owners (m) with a minimum required number of signers (n)
- Include a check for sufficient contract balance before executing transfer of Ether
- Create a function that retrieves the addresses of owners that signed a transaction
- Discuss the contents of transaction receipt logs

2 Methodology

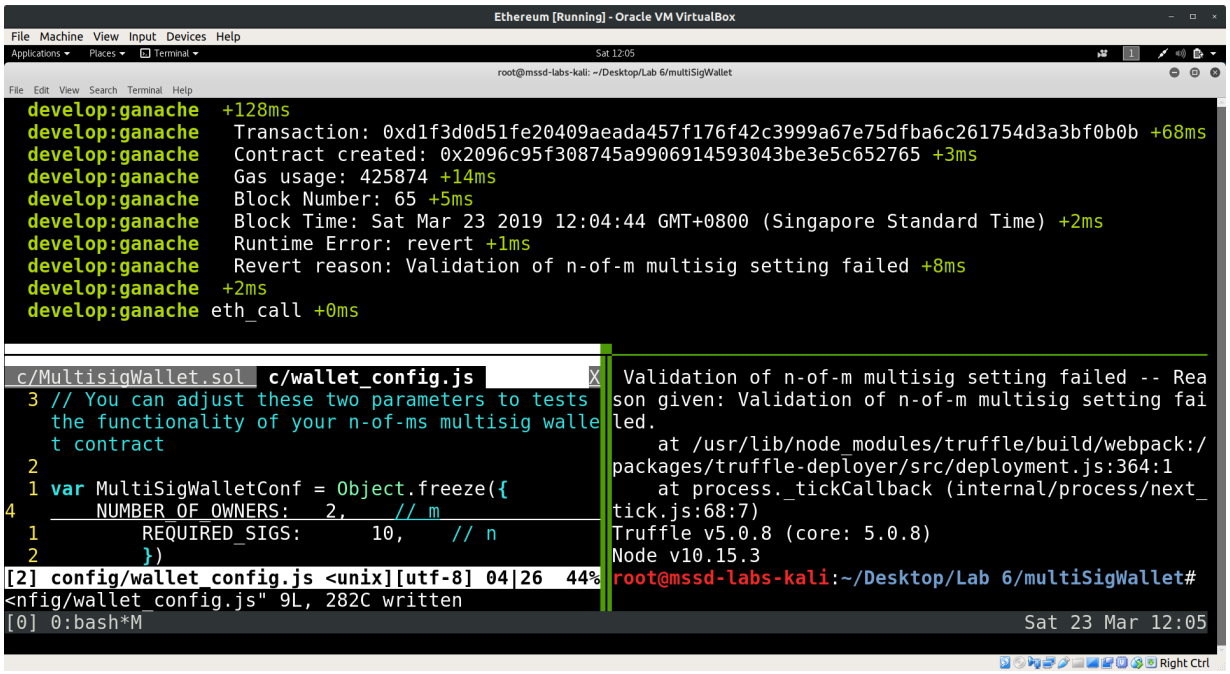
2.1 Protection Against Replay Attacks

An additional `executed` boolean field was added to `struct Transaction`. The initial value of this field is `false` when the transaction is first added, and is flipped to `true` after the transaction is executed. A `txnNotExecuted` modifier is created and placed at the start of the `executeTransaction()` function. The modifier will `revert` if the transaction has already been executed, preventing the replay from occuring.

2.2 n-of-m Multi-Signature Wallet

The wallet was changed from a 2-of-2 scheme to an n-of-m scheme. Loops were used to check that each owner of the contract was not a null address, and that no repeated owners were included. Once the checks pass, another loop was used to save the owners of the contract.

The `modifier checkValidSettings` was also changed to test for valid setting ranges. `ownerCount` should not be zero (0) or exceed `MAX_OWNER_COUNT`. `_requiredSigs` should not be zero (0) or exceed `ownerCount` (instead of `MAX_OWNER_COUNT` as stated in the task requirement, in order to catch invalid settings where the required number of signatures exceeds the numer of owners of the contract.)



Modified task requirement to catch _requiredSigs > ownerCount instead of _requiredSigs > MAX_OWNER_COUNT.

2.3 Checking Sufficiency of Contract Balance

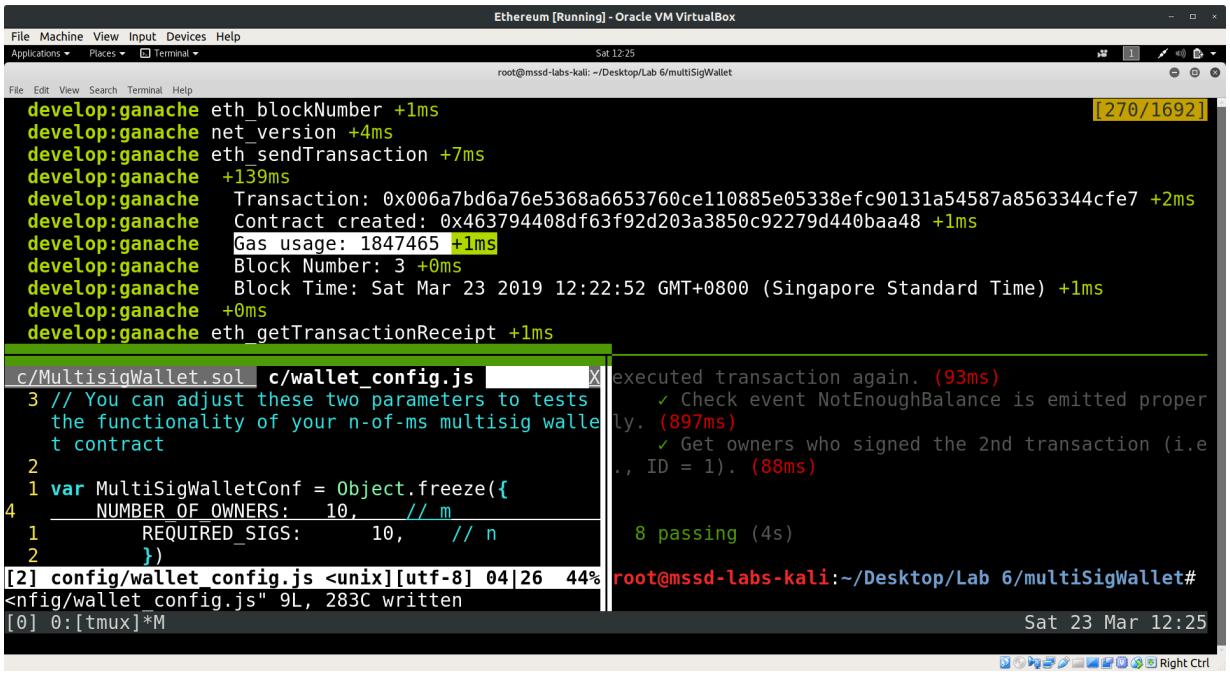
Additional checks for sufficient contract balance was added on transaction confirmation. A new event `NotEnoughBalance` was declared. If the requested balance (`txn.value`) exceeds the current contract balance (`address(this).balance`), the event was emitted, interrupting the execution of the transaction.

2.4 Retrieving Owners of Transaction Signatures

`function getOwnersWhoSignedTx()` was created to retrieve the addresses of the owners of transaction signatures. Initially, `push()` was attempted on a new `address[] memory` array to store the addresses. This triggered a `TypeError` as the `address[]` array is of fixed length when declared in `memory` instead of `storage`. Instead, the owner addresses had to be assigned individually to indexes of the array of length `getSignatureCount()`.

3 Discussion

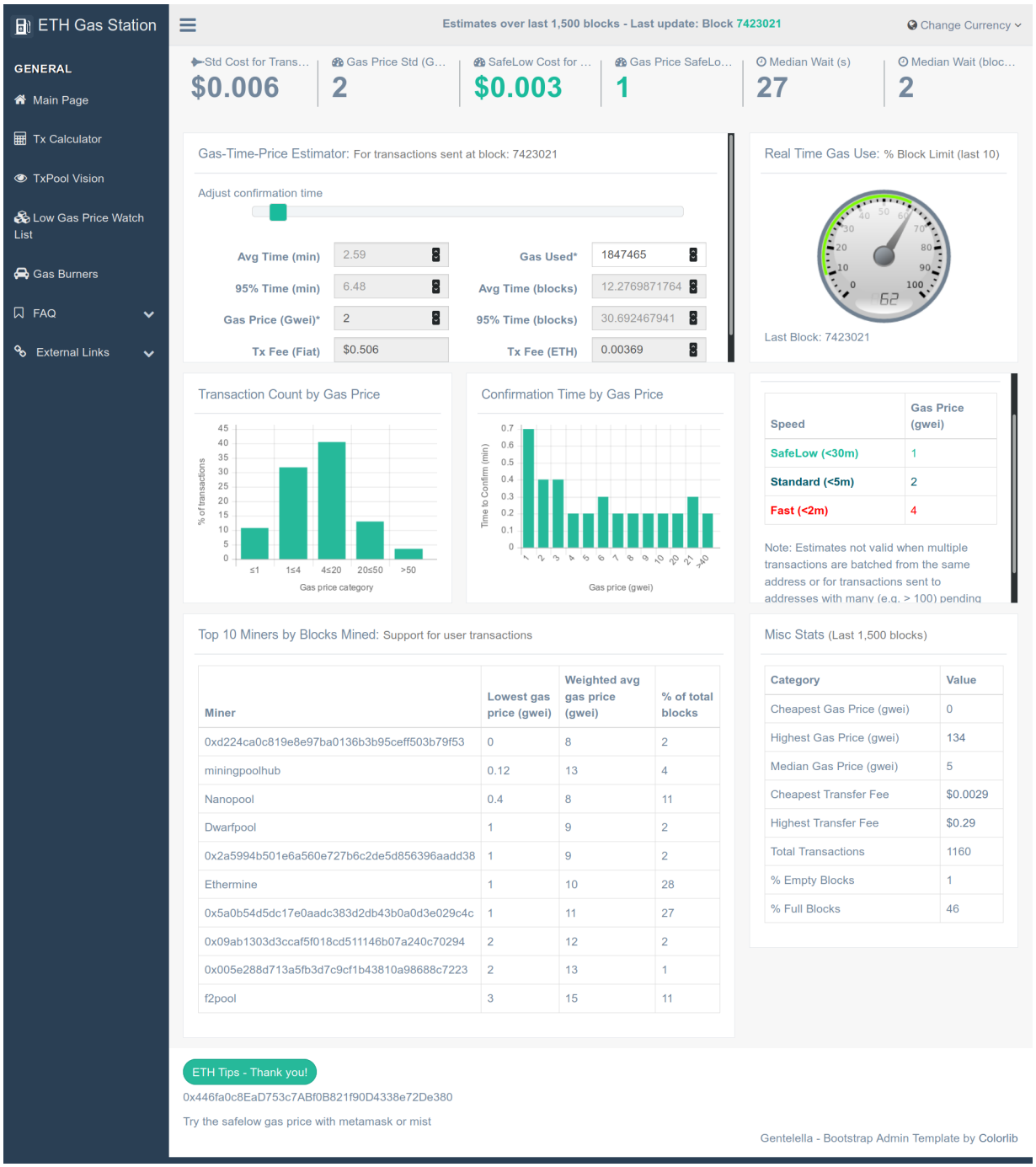
3.1 Resources Used in Deployment



The contract was created in block number 3 (assuming initial run of `truffle develop --log`).

The gas cost for contract deployment varies depending on the number of owners and required signatures. For a multi-signature smart contract with two owners, the gas cost is 1,498,037. For a smart contract with 10 owners, the gas cost rises to 1,847,465.

At the time of this report (2019 Mar 23 0510 UT), assuming a gas price of 2 Gwei (2e-9 ether) for a standard wait time of less than 5 minutes, 1,847,465 gas converted to USD$0.506. [1]



3.2 Full Receipts of Confirmation and Submission Calls

Since the output of `contract.submitTransaction` was stored in `var receipt`, `console.log` was called on `receipt`:

```
var receipt = await contract.submitTransaction(RECEPIENT, VALUE_SENT, {from: accounts[0]});
console.log(receipt);
```

This resulted in the output detailed within receipt.log.

The extracted log contains details on the *Submission* event, as well as the *Confirmation* event.

The fields on the full receipt log as follows:

tx:	Contains the hash string for the transaction.
receipt.transactionHash:	Contains the hash string for the transaction.
receipt.transactionIndex:	Indicates the position of the transaction in the block.
receipt.blockHash:	Hash string of the block containing the transaction.
receipt.blockNumber:	Block number containing the transaction.
receipt.from:	Address of the sender.
receipt.to:	Address of the receiver.
receipt.gasUsed:	Amount of gas used by this transaction.
receipt.cumulativeGasUsed:	Total amount of gas used when this transaction was executed in the block.
receipt.contractAddress:	Address of contract if the transaction is a contract creation.
receipt.logs:	Array of log objects generated by this transaction.
receipt.status:	Boolean to indicate transaction failure or success.
receipt.logsBloom:	Bloom filter for the logs of this block.
receipt.v:	Recovery ID (recid) for public key recovery. Used to speed up signature verification.
receipt.r:	Part of the Elliptic Curve Digital Signature Algorithm (ECDSA) signature pair, used in public key recovery.
receipt.s:	The other part of the ECDSA signature pair, used in public key recovery.
receipt.rawLogs:	Undecoded logs; stopgap measure until Application Binary Interface (ABI) for all events can be obtained
logs.logIndex:	Log position in the block.
logs.transactionIndex:	Indicates the position of the transaction in the block that this log was created from.
logs.transactionHash:	Contains the hash string for the transaction that this log was created from.
logs.blockHash:	Hash string of the block containing this log.
logs.blockNumber:	Block number containing this log.
logs.address:	Address where this log originated.
logs.type:	*'pending'* or *'mined'*.
logs.id:	Log identifier.
logs.event:	The name of the event that triggered this log.
logs.args:	The arguments from this event.

4 Conclusion

The 2-of-2 multi-signature smart contract wallet was convert to support n-of-m signatures. The functionality for protection against replay attacks was added, as well as a check for sufficient balance before transfer. A new function was added that retrieves addresses of owners who signed a transaction. The full transaction receipt logs was examined.

5 Source Code

MultisigWallet.sol

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1 https://ethgasstation.info/