

Welcome Neoxplorers!

Enterprise Distributed Application Development using the NEO Blockchain

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1. Introduction

Who is Michael Herman?

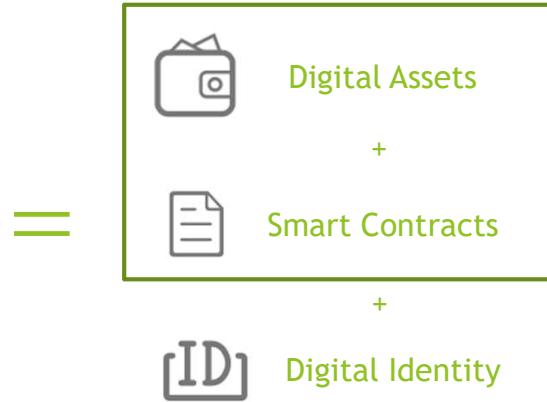
- ▶ Independent Blockchain Developer
 - ▶ I work 14 hours a day on the NEO Blockchain
 - ▶ Experienced Ethereum Developer
 - ▶ I work for myself (and on behalf of my clients)
- ▶ Decades of software development experience
 - ▶ Developer on every version of Microsoft Windows since the very first
 - ▶ Microsoft, IBM, medium-size companies, small businesses
- ▶ Curator of NEO C# Developers Center of Excellence community ([neo-csharp](#))
 - ▶ Contributes to several NEO community projects
 - ▶ NEO developer tool suite: [neo-debugger](#) and [neo-gui-developer](#) projects
 - ▶ NEO Persistable Class Framework (NPC) for efficient object-oriented smart contract development using C#.NEO: [mwherman2000/neo-persistentclasses](#) and [neo-npcc2s](#)
 - ▶ NEO Blockchain Quick Start Guide for .NET Developers: [mwherman2000/dotnetquickstart](#)
 - ▶ Founder of the first Canadian NEO Blockchain Meetup: NEO Blockchain Toronto



Who are you?

- ▶ Software Developer/Achitect?
 - ▶ NEO smart contract developers?
 - ▶ Ethereum smart contract developers?
 - ▶ Other blockchain developers?
 - ▶ Microsoft .NET developers? .NET/C#/Visual Studio
- ▶ Crytopinvestor/trader?
- ▶ Legal profession?
- ▶ Financial services (conventional)?
- ▶ Government?
- ▶ Banking?
- ▶ Other sectors?
- ▶ Students?

What is the NEO Smart Economy?



Future world where the boundary between real assets in the physical world and digital assets in the digital world has been removed.

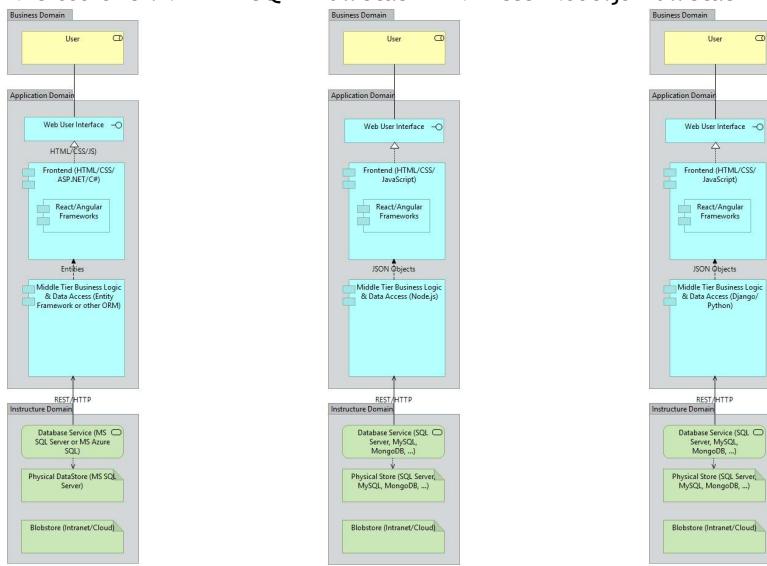
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Traditional Multi-Tier Enterprise Applications

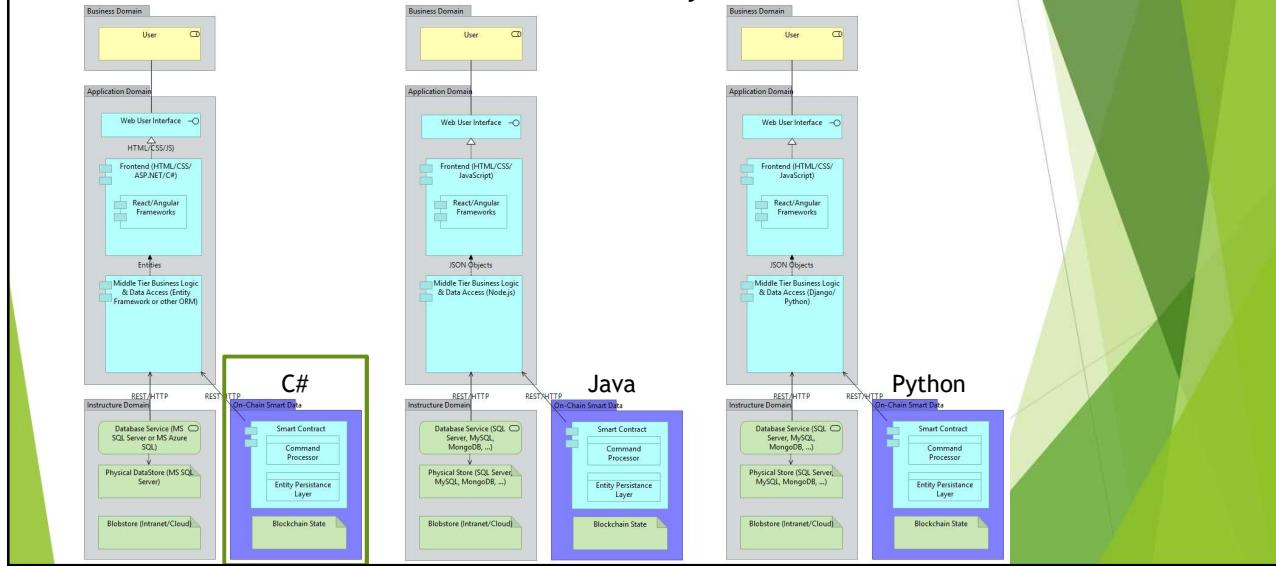
Microsoft ASP.NET/EF/SQL Full Stack HTML/CSS/Node.js Full Stack HTML/CSS/Python



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Enterprise Distributed Application Architecture

Microsoft ASP.NET/EF/SQL Full Stack HTML/CSS/Node.js Full Stack HTML/CSS/Python



When to use Blockchain Technology

“Blockchain: the force multiplier for the smart economy” [Microsoft whitepaper]

Questions to Ask

1. Is it a business process that crosses trust boundaries?
2. Do multiple parties manipulate the same data?
3. Are processes operating inefficiently or decisions delayed due to the number of intermediaries?
4. Does the business process involve low-value, manual verification steps?

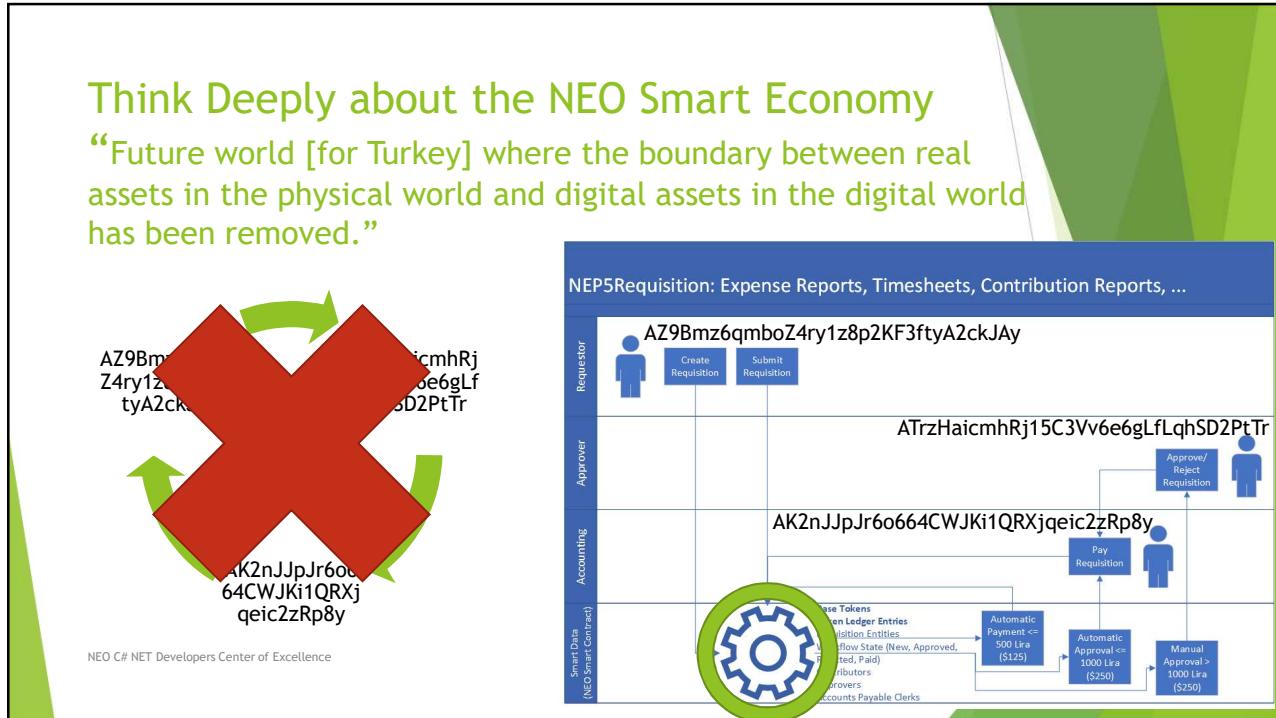
Use a Blockchain when there is a Need for

- Real-time transparency by connecting business processes across organizations
- Real-time, transparent access to a verifiable source of the truth across organization boundaries
- Introduce trust and increase efficiency amongst participants - reducing the need for intermediaries
- Improved efficiencies and increased confidence through automation and smart contracts that execute consistently.

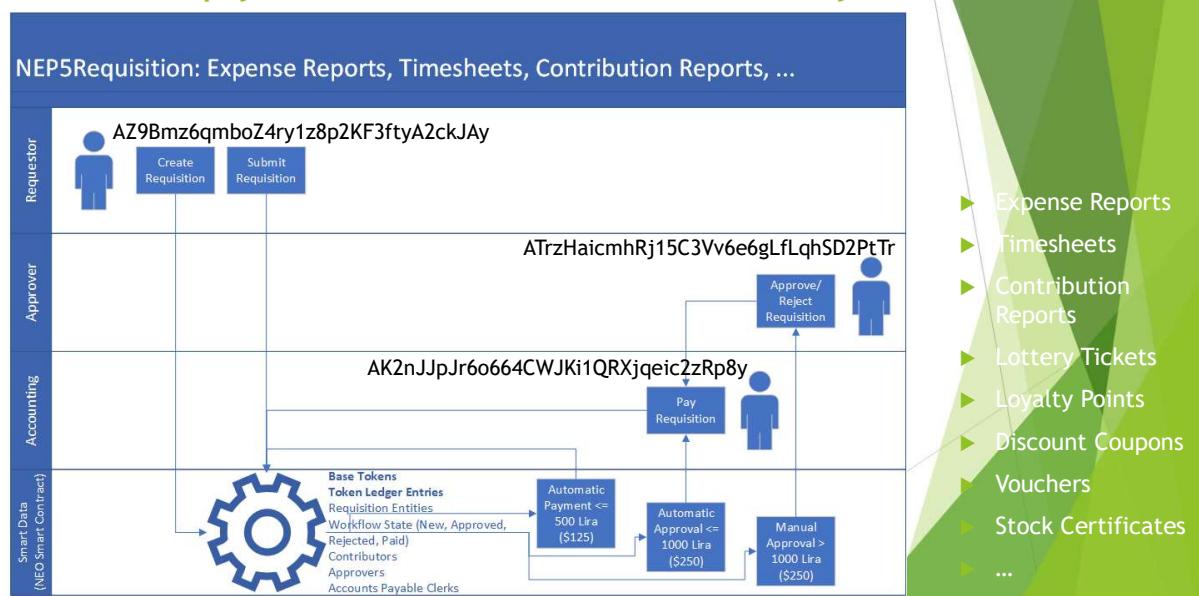
“Use blockchain technology when it matches the requirements of your application. Don’t automatically use blockchain technology simply because you’re re-platforming an existing application.” [Gartner 2018]

Think Deeply about the NEO Smart Economy

“Future world [for Turkey] where the boundary between real assets in the physical world and digital assets in the digital world has been removed.”



Think Deeply about the NEO Smart Economy



Purpose and Goals

- ▶ Purpose
 - ▶ Hands-on smart contract development workshop: .NET/C#/Visual Studio on the NEO Blockchain
- ▶ Goals, Non-goals and Assumptions
 - ▶ Target audience: Architects and Developers who are new to the NEO Blockchain platform
 - ▶ Background: Very little or no previous NEO or .NET/C#/Visual Studio Experience
 - ▶ Background: Understand basic 1st and 2nd generation blockchain technologies: hashing, blocks, mining, etc.
 - ▶ **Provide you with a basic level of awareness and understanding of NEO smart contract development**
 - ▶ Help create a strong NEO Blockchain community in Turkey - helping each other
- ▶ Principles
 - ▶ Provide reliable documentation: timely, accurate, visual, and complete
 - ▶ Save as much of a person's time as possible
 - ▶ Use open source software whenever possible
- ▶ Drivers
 - ▶ Need in the NEO .NET developer community to have concise and easy-to-follow documentation to enable people to get up to speed developing NEO smart contracts in as short a time as possible

Agenda

1. Introduction
2. Preparation for the Hands-on Labs
3. Module 1 Hands-on Labs (x3)
4. Why NEO?
BREAK - 15 minutes
5. NEO Architecture
6. Module 2 Hands-on Labs (x3)
7. Why NEO?
BREAK - 15 minutes
8. NEO as a 3rd Generation Distributed App (dApp) Platform
9. Smart Contract Development using Entities
10. NEO Evidence
11. NEO Resources
12. Next Steps

2. Preparation for the Hands-on Labs

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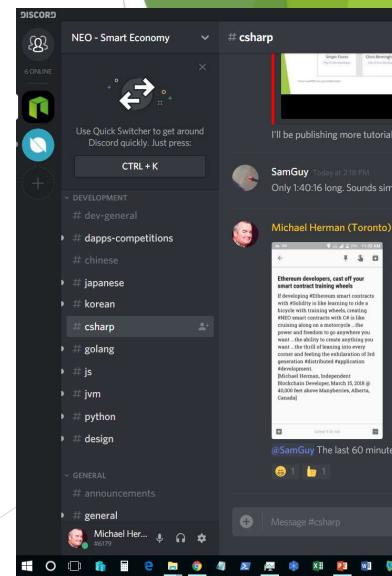
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Preparation: Twitter, Discord and Visual Studio

1. I will be sending links to additional downloads and information using [#BlockchainTURKIYE](#) on Twitter.
2. Join Discord NEO Developer Community on Discord by clicking on one of the following links:
<https://discord.gg/gqCYeup> or <https://discord.gg/4TQujHj>
3. Download and install Microsoft Visual Studio Community Edition 2017. This version is free to download and free to use. It is an excellent IDE for C# smart contract development.
<https://www.visualstudio.com/vs/community/>
4. Download and install the .NET 4.7.1 Dev Pack from here:
<https://www.microsoft.com/en-us/download/details.aspx?id=56119>

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Preparation: NEO Debugger Tools

- ▶ Download the NEO Debugger Tools source code.
<https://github.com/mwherman2000/neo-debugger-tools/archive/master.zip>
- ▶ Create a new folder on your hard drive - for example c:\repos
- ▶ Copy master.zip into c:\repos.
- ▶ Unzip master.zip and build the NEO Debugger Tools following the steps using diagram below.

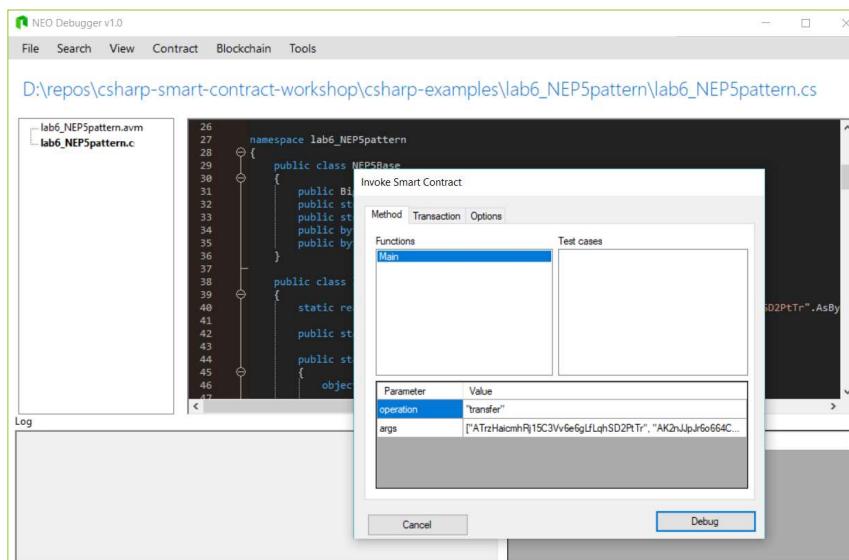
- ▶ **NOTE** Please download a new copy of the master.zip file. It was updated last night.

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NEO Debugger



Commands

F10 - Single Step

F5 - Run

F6 - Storage Viewer

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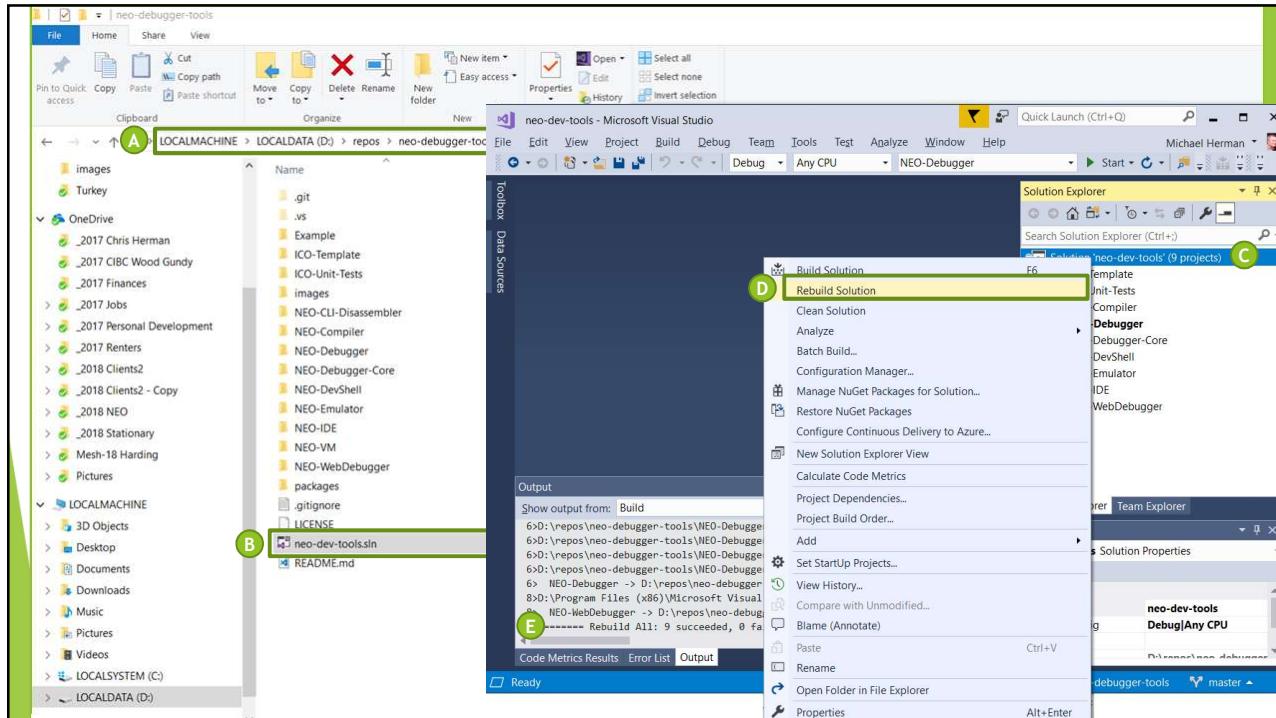
3. Module 1 Labs

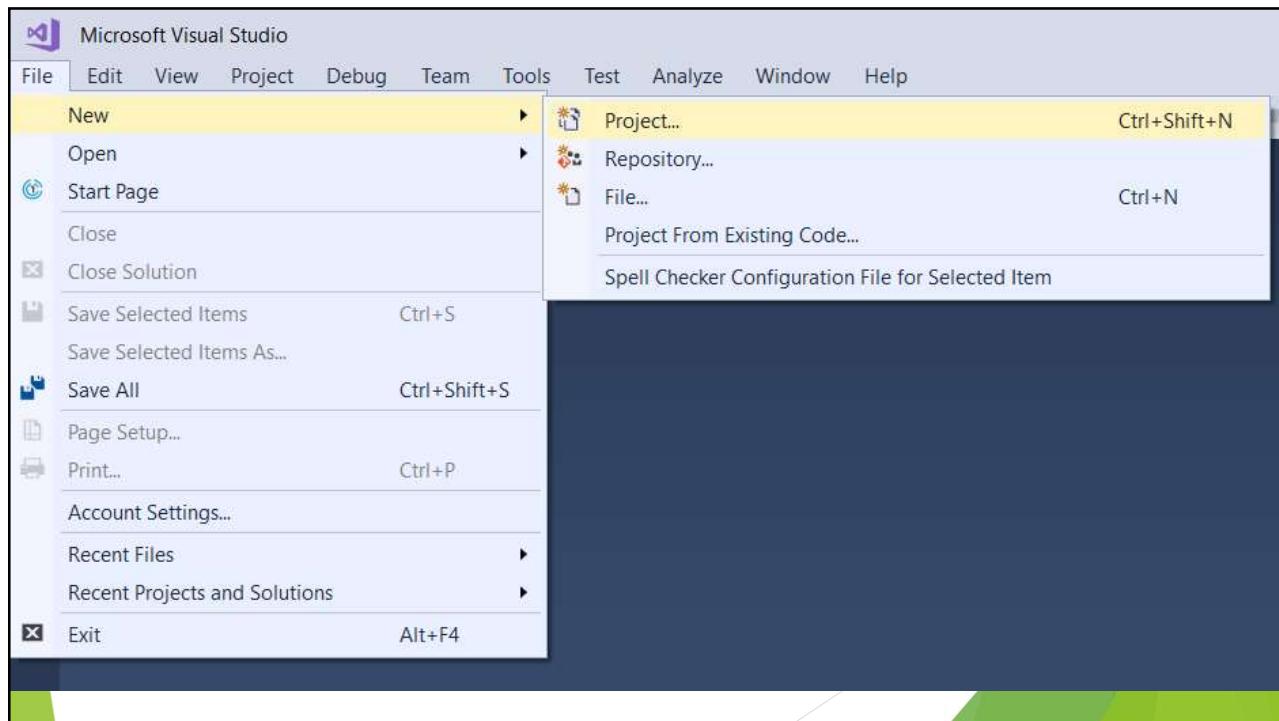
Runtime.Log(), Runtime.Notify(), and NEO Storage

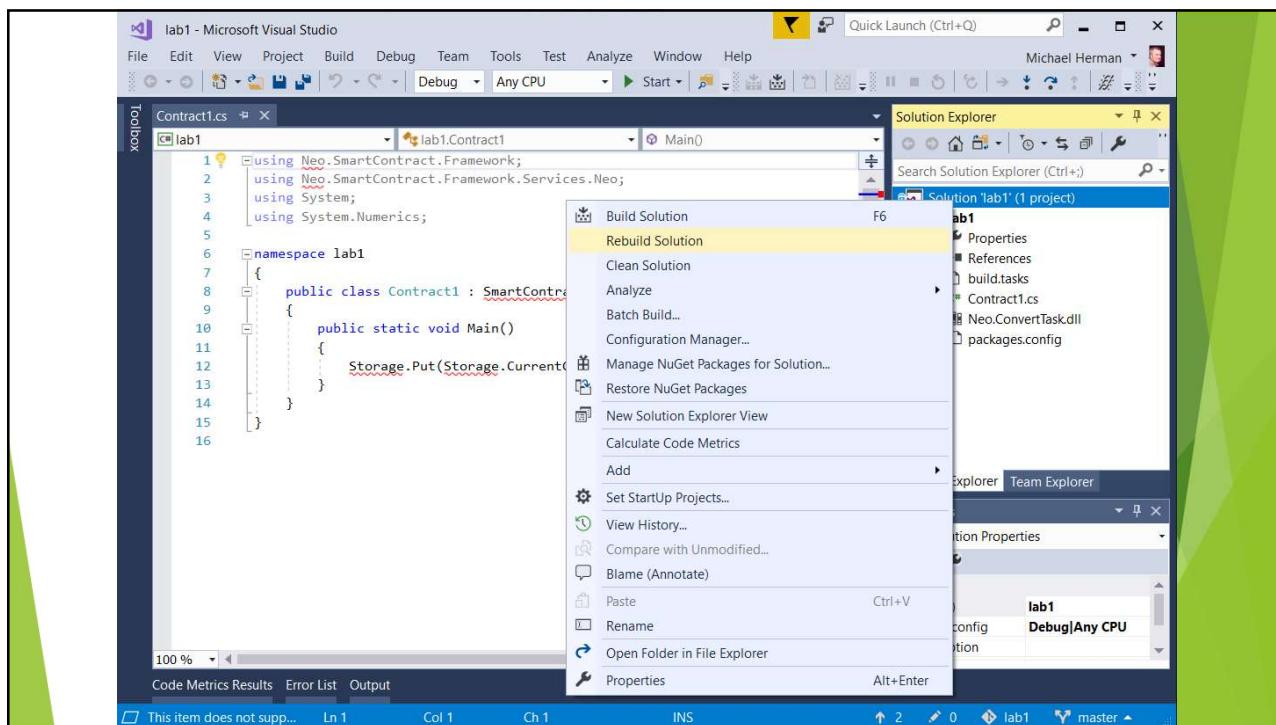
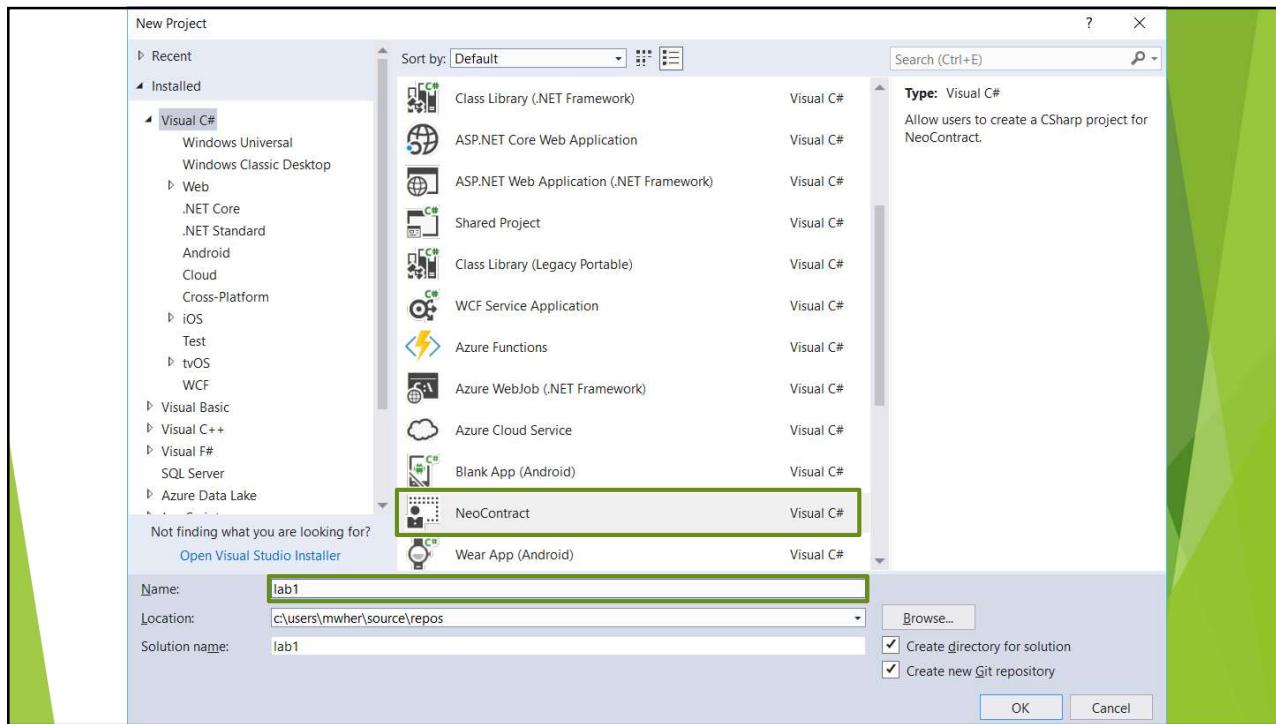
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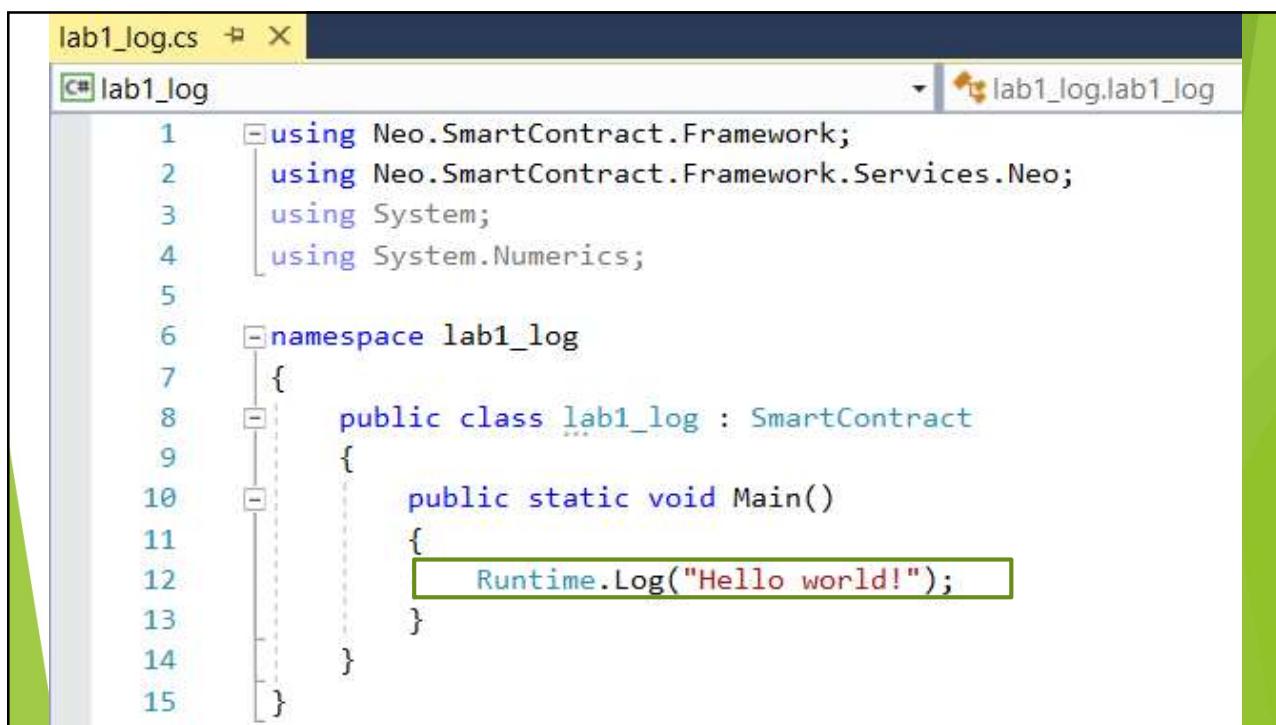
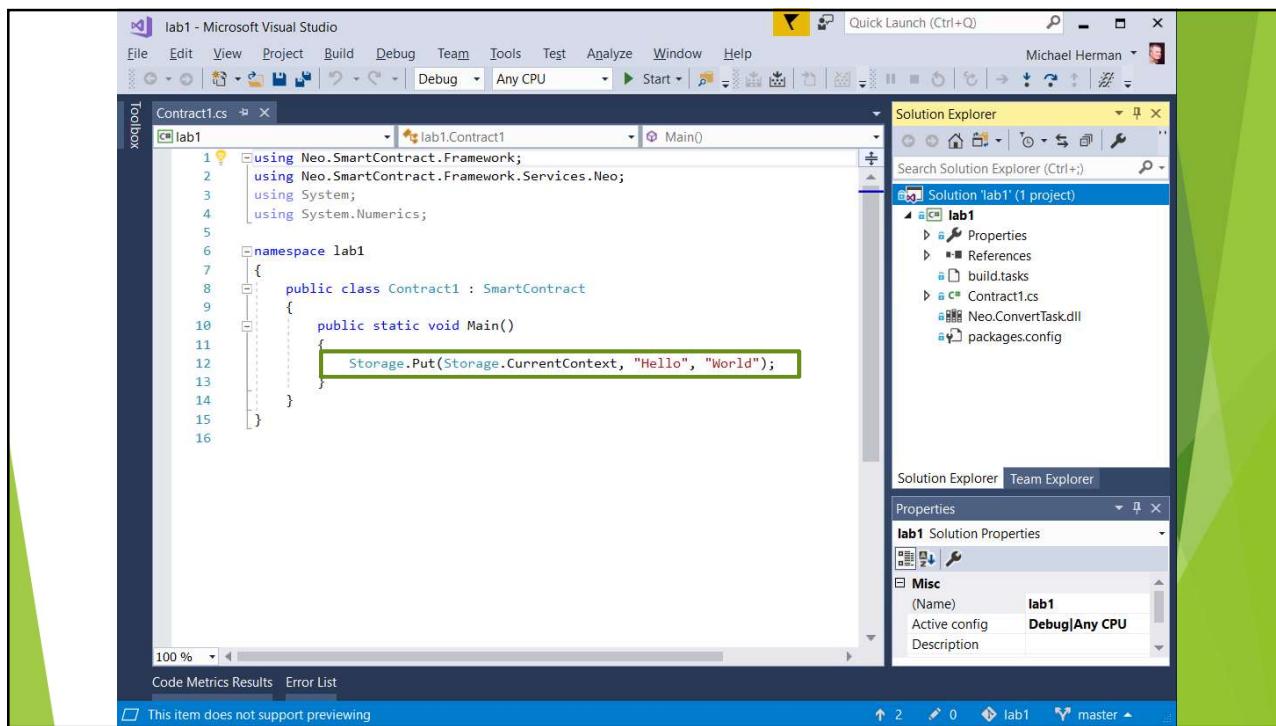
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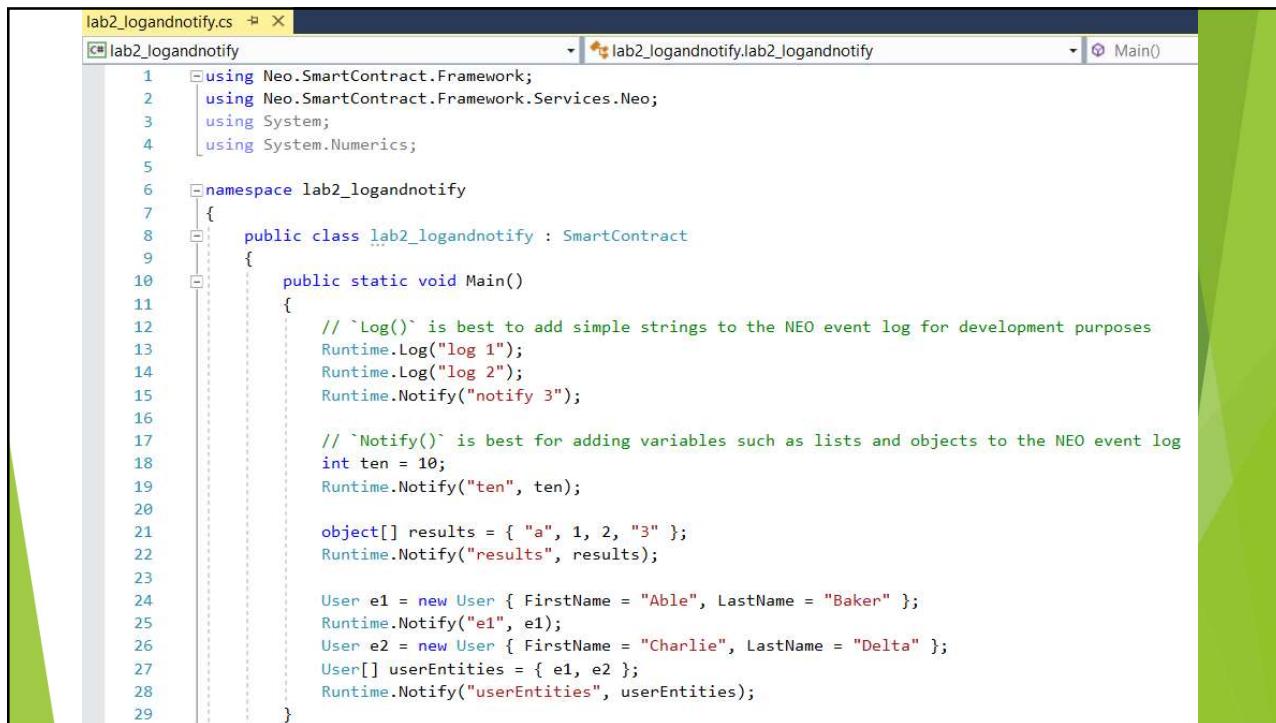
Lab 2 - lab2_logandnotify.cs

Runtime.Log() and Runtime.Notify()

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The screenshot shows a code editor window with the file "lab2_logandnotify.cs" open. The code implements a SmartContract named "lab2_logandnotify". It contains a Main() method that performs three operations: it logs three simple strings ("log 1", "log 2", and "notify 3") using the Runtime.Log() method. It then creates an integer variable "ten" with a value of 10 and notifies it using the Runtime.Notify("ten", ten) method. Finally, it creates an array of objects "results" containing three strings ("a", "1", "2") and notifies the array using the Runtime.Notify("results", results) method. The code also creates two User objects, e1 and e2, and an array of User objects, userEntities, which contains both e1 and e2, and notifies this array using the Runtime.Notify("userEntities", userEntities) method.

```
1  using Neo.SmartContract.Framework;
2  using Neo.SmartContract.Framework.Services.Neo;
3  using System;
4  using System.Numerics;
5
6  namespace lab2_logandnotify
7  {
8      public class lab2_logandnotify : SmartContract
9      {
10         public static void Main()
11         {
12             // `Log()` is best to add simple strings to the NEO event log for development purposes
13             Runtime.Log("log 1");
14             Runtime.Log("log 2");
15             Runtime.Notify("notify 3");
16
17             // `Notify()` is best for adding variables such as lists and objects to the NEO event log
18             int ten = 10;
19             Runtime.Notify("ten", ten);
20
21             object[] results = { "a", 1, 2, "3" };
22             Runtime.Notify("results", results);
23
24             User e1 = new User { FirstName = "Able", LastName = "Baker" };
25             Runtime.Notify("e1", e1);
26             User e2 = new User { FirstName = "Charlie", LastName = "Delta" };
27             User[] userEntities = { e1, e2 };
28             Runtime.Notify("userEntities", userEntities);
29         }
30     }
31 }
```

```
30  
31     public class User  
32     {  
33         public string FirstName;  
34         public string LastName;  
35     }  
36 }
```

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Lab 3 - lab3_storage.cs

NEO Storage

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NEO Storage

- ▶ Each smart contact deployed to the NEO Blockchain has its own key-value data store
- ▶ Keys = byte[] array
- ▶ Values = string, byte[] array or BigInteger

Key	Content
84-99-21-A9-19-A3-1F-42-54-3A-8D-C3-64-3F-CB-9E-02-5F-20-FF-2F-23-E5-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-5F-53-54-41	3
84-99-21-A9-19-A3-1F-42-54-3A-8D-C3-64-3F-CB-9E-02-5F-20-FF-2F-23-E5-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-4C-61-73...	0
84-99-21-A9-19-A3-1F-42-54-3A-8D-C3-64-3F-CB-9E-02-5F-20-FF-2F-23-E5-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-44-65-62...	-100
84-99-21-A9-19-A3-1F-42-54-3A-8D-C3-64-3F-CB-9E-02-5F-20-FF-2F-23-E5-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-42-61-6C...	999900
01-2F-23-4E-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-5F-53-54-41	3
01-2F-23-4E-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-4C-61-73-74-54-78-54-69-6D-65-73-74-61-6D-70	0
01-2F-23-4E-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-44-65-62-69-74-43-72-65-64-69-74-41-6D-6F-75-6E-74	100
01-2F-23-4E-50-43-4E-45-50-35-4C-65-64-67-65-72-45-6E-74-72-79-2E-42-61-6C-61-6E-63-65	100

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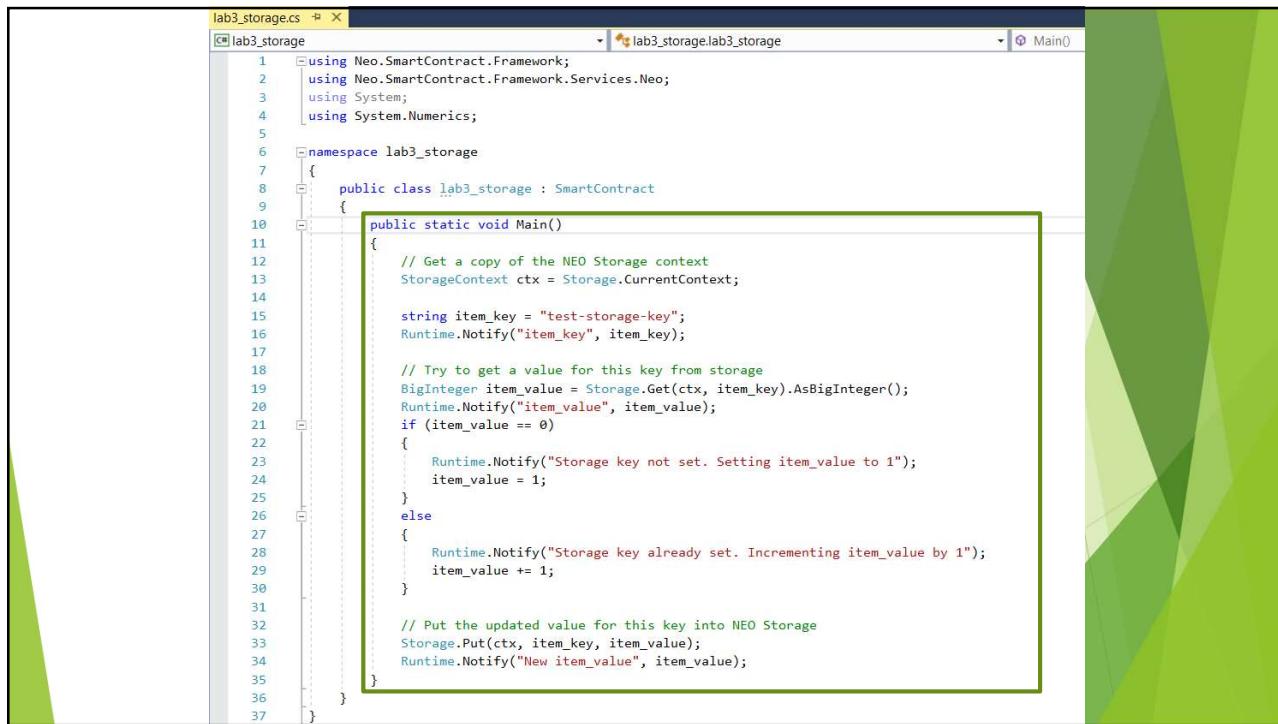
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NEO Storage API

```

Storage [from metadata] ⌂ ⌂ X
C# Neo.SmartContract.Framework Neo.SmartContract.Framework.Services.Neo
  7   - namespace Neo.SmartContract.Framework.Services.Neo
  8   {
  9     public static class Storage
 10    {
 11      public static StorageContext CurrentContext { get; }
 12
 13      ...
 14      public static void Delete(StorageContext context, byte[] key);
 15      ...
 16      public static void Delete(StorageContext context, string key);
 17      ...
 18      public static byte[] Get(StorageContext context, byte[] key);
 19      ...
 20      public static byte[] Get(StorageContext context, string key);
 21      ...
 22      public static void Put(StorageContext context, byte[] key, byte[] value);
 23      ...
 24      public static void Put(StorageContext context, byte[] key, BigInteger value);
 25      ...
 26      public static void Put(StorageContext context, byte[] key, string value);
 27      ...
 28      public static void Put(StorageContext context, string key, byte[] value);
 29      ...
 30      public static void Put(StorageContext context, string key, BigInteger value);
 31      ...
 32      public static void Put(StorageContext context, string key, string value);
 33    }
 34  }

```



```

lab3_storage.cs
lab3_storage
Main()

1  using Neo.SmartContract.Framework;
2  using Neo.SmartContract.Framework.Services.Neo;
3  using System;
4  using System.Numerics;
5
6  namespace lab3_storage
7  {
8      public class lab3_storage : SmartContract
9      {
10         public static void Main()
11         {
12             // Get a copy of the NEO Storage context
13             StorageContext ctx = Storage.CurrentContext;
14
15             string item_key = "test-storage-key";
16             Runtime.Notify("item_key", item_key);
17
18             // Try to get a value for this key from storage
19             BigInteger item_value = Storage.Get(ctx, item_key).AsBigInteger();
20             Runtime.Notify("item_value", item_value);
21             if (item_value == 0)
22             {
23                 Runtime.Notify("Storage key not set. Setting item_value to 1");
24                 item_value = 1;
25             }
26             else
27             {
28                 Runtime.Notify("Storage key already set. Incrementing item_value by 1");
29                 item_value += 1;
30             }
31
32             // Put the updated value for this key into NEO Storage
33             Storage.Put(ctx, item_key, item_value);
34             Runtime.Notify("New item_value", item_value);
35         }
36     }
37 }

```

```

10    public static void Main()
11    {
12        // Get a copy of the NEO Storage context
13        StorageContext ctx = Storage.CurrentContext;
14
15        string item_key = "test-storage-key";
16        Runtime.Notify("item_key", item_key);
17
18        // Try to get a value for this key from storage
19        BigInteger item_value = Storage.Get(ctx, item_key).AsBigInteger();
20        Runtime.Notify("item_value", item_value);
21        if (item_value == 0)
22        {
23            Runtime.Notify("Storage key not set. Setting item_value to 1");
24            item_value = 1;
25        }
26        else
27        {
28            Runtime.Notify("Storage key already set. Incrementing item_value by 1");
29            item_value += 1;
30        }
31
32        // Put the updated value for this key into NEO Storage
33        Storage.Put(ctx, item_key, item_value);
34        Runtime.Notify("New item_value", item_value);
35    }
36 }

```

End of Module 1

- ▶ Lab 1 - lab1_log.cs
- ▶ Lab 2 - lab2_logandnotify.cs
- ▶ Lab 3 - lab3_storage.cs

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4. What is NEO?

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What is NEO?

- ▶ PROJECT: NEO (<https://neo.org/>) is a non-profit, community-based blockchain project that utilizes blockchain technology and digital identity to digitize assets, to automate the management of digital assets using smart contracts, and to realize a "smart economy" with a distributed network.
- ▶ SOFTWARE PLATFORM: 3rd generation distributed applications (dApp) platform
 - ▶ Multiple languages: C# (reference implementation), Python, Java, Golang, JavaScript
 - ▶ First dApp platform suitable for enterprise application development, deployment, and operations
- ▶ DUAL CRYPTOCURRENCY: NEO and GAS
- ▶ NEO SMART ECONOMY
 - ▶ Key differentiator
- ▶ GLOBAL COMMUNITY
 - ▶ Discord: <https://discord.gg/gqCYeup> / <https://discord.gg/4TQujHj>
 - ▶ NEO C# Developers Center of Excellence (neo-csharpcoe)

<https://github.com/mwherman2000/neo-csharpcoe/blob/master/README.md>
 - ▶ NEL (NewEcoLab) "Chinese-speaking NEO Community"

<https://github.com/neweconolab>
 - ▶ City of Zion "Home of the Open-source Global NEO Developer Community"

<https://cityofzion.io/>

Dual Cryptocurrency Model: NEO and NeoGas

- ▶ NEO Smart Economy, there is a separation of concerns:
 - ▶ NEO represents Voting Power
 - ▶ NeoGas represents Ability to Fund Work (Systems Fees)
- ▶ NEO (NEO)
 - ▶ Intended use: acquire, hold, and retain NEO to maximize your voting power in the network
 - ▶ Receive distributions of GAS
- ▶ NeoGas (GAS)
 - ▶ Sometimes referred to as a "Utility Token" or the "Fuel Token"
 - ▶ Used to fund the deployment of smart contracts (applications) on the NEO Blockchain
 - ▶ Used to fund transactions executed on the NEO Blockchain
 - ▶ System Fees are recycled and re-distributed in ratio/proportion to the number of NEO you hold

<http://ndapp.org>

The NEO dApp List

These dApps come from the community. The information on this page is provided by the project owner. NEO Council and ndapp.org does not endorse these projects.

Add a NEO dApp

NEX By NEX NEX combined the NEO Blockchain with an off-chain matching engine to enable much faster and more complex trades than existing decentralized exchanges.	MOONLIGHT By Moonlight Moonlight is a distributed robotics and analytical project management platform, featuring a global public ledger of controller work experience and a new matching algorithm to identify useful project needs.	Red Pulse By Red Pulse Red Pulse Tokens are NEO tokens issued by Red Pulse, an event-driven research firm covering major events impacting Chinese companies, sectors and the overall economy.	AdEx By AdEx AdEx is a decentralized exchange built on the blockchain and smart contracts. The core feature of AdEx will be the so-called AdEx User Profile - a semantic profile that allows every user to understand and connect the ads delivered to them.	NeoAuth By NeoAuth NeoAuth enables authentication over the NEO blockchain, allowing you to log in with a NEO address instead of an email and password.	Zeepin By Zeepin Zeepin is a decentralized innovation community dedicated to promoting highly efficient circulation of innovative assets.	Qlink By Qlink Qlink is developed by Qlink Foundation in Singapore, across the blockchain technology and creates a decentralized mobile network for content distribution, enterprise telecom services and cloud-ground base stations (including	Neo Smart IoT By Neo Smart IoT Control IoT Internet of Things devices via Neo smart contracts (first dev kit is an ESP32).	imufisy. By imufisy imufisy is a free blockchain-based decentralized payment system for music-related digital content such as audio/video apps, images, and blogging where anyone can join, contribute and get paid.
Website Whitepaper Twitter LinkedIn Medium	Website	Website GitHub Reddit Contact	Website GitHub Reddit Contact	Website Domo GitHub Facebook Telegram Twitter Reddit	Website Domo GitHub Facebook Twitter Reddit	GitHub Medium Page AMA summary Contract	Website GitHub Contact	Website GitHub
CHAIN LINE By Chain Line Peer-to-peer lending platform. Courses range from 10% to 15% and have no counterfees.	PHANTASMA By Phantasma Phantasma is a platform that uses its own currency instead of using the NEO or other parties' servers. The platform supports any kind of transaction, including the transfer of real-life money transfers. NEO was used for the project due to its fast transactions and NEO's low fees.	Neo Trade By NeoTrade NeoTrade is a P2P trading platform developed by Ethereum (ERC20) tokens. It uses a swap smart contract that allows users to deposit NEO, GAS or any other NEO asset directly to the smart contract and trade amongst themselves.	Turing Complete Smart Contract By KRYPTONlive Krypton is a smart contract ecosystem to provide SGD registration and verification using a KRYPTON compatible SPV provider.	Krypton By Kryptone Kryptone is a smart contract ecosystem to provide SGD registration and verification using a KRYPTON compatible SPV provider.	Switcheo By Switcheo Switcheo is a decentralized exchange that provides SGD registration and verification using a KRYPTON compatible SPV provider.	Trip Shares By TripShares Trip sharing with deposits. Traveler can deposit NEO to a trip and receive a 10% interest rate. NEO is used as insurance when the passenger cancels the trip after a set date.	BlockSaver By BlockSaver Selling smart contracts with interests rates and fees. NEO is used as collateral and GAS tokens, the smart contract defines an interest rate and the system has a penalty for early withdrawal.	Lucky NEO By Lucky NEO Lucky NEO allows anyone to send their extra gas to a raffle contest. One winner will be chosen at random and will receive the gas paid out. Lucky NEO uses an admin account to automatically pay out the winner to the address that sent the funds or you don't have to follow
Website GitHub	Domo Website GitHub	Website GitHub	Youtube GitHub	Youtube Domo GitHub	Youtube Website GitHub	Website GitHub	Domo GitHub	Website GitHub
Neo Fund By Neo Fund Neo Fund is a decentralized crowdfunding platform, similar to Kickstarter. The basic function is to set a goal amount, and date limit. If goal is reached, all contributors' funds will be available to the project. Contributors can redeem their funds again.	Neo Raffle By Neo Raffle A smart contract that enables a raffle lottery on the Neo block chain. Send GAS with GAS as a protocol and smart contract for trading NEO & assets. This project also demonstrates a solid way to use smart contracts for lottery purposes.	Nep Swap By NepSwap Decentralized smart contract for trading NEO-based assets. NepSwap is a protocol and smart contract for trading NEO & assets. This project also demonstrates a solid way to use smart contracts for lottery purposes.	Smart Promise By Smart Promise Smart Promise is an external journal of smart promises developed through Blockchain. Use of such an environment requires a reward for the user who performs the promise. The idea behind the idea concerns the possibility to get a strong motivation to action that user posted in.	Sunny dApp By Sunny dApp This dApp allows to insure against bad weather conditions on a given day. If the relative sunshine duration on the day is lower than 80 percent, you get paid.	NEO Name Service By Neo Name Service Decentralized domain name ending with .neo based on NEO Blockchain.	THEKEY By THEKEY THEKEY is a Decentralized Ecosystem of Identity Verification Tool Using Fuzzy Bi-data and Blockchain.	THEKEY By THEKEY THEKEY is a Decentralized Ecosystem of Identity Verification Tool Using Fuzzy Bi-data and Blockchain.	TRINITY By Trinity Trinity is a platform to facilitate a peer-to-peer stable coin exchange.
GitHub	Website GitHub	GitHub	YouTube Website GitHub Whitepaper	Website GitHub	Website GitHub	Website GitHub Telegram Facebook Twitter	Website GitHub	Website GitHub

The New Vision - Da Hongfei | NEO DevCon 1

NEO Has All Ingredients

NEO DevCon

High TPS: 1,000 TPS

Finality: 1 Confirmation, dBFT

Interoperability: NeoX

Digital ID: Neold / Ontology

Stable Coin: Alchemint

By 2020, NEO Will Handle
100,000 TPS
Without Sharding!

NEO smart economy

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THE MOONSHOT

► ▶ ⏴ 29:22 / 45:34 CC HD

NEO Decentralized Applications (Use Cases)

- ▶ Smart fund
- ▶ AI-assisted legal smart contracts
- ▶ Social networking
- ▶ Automated token liquidity providers
- ▶ Decentralized exchanges
- ▶ Secure communications protocol
- ▶ Data exchange markets
- ▶ Intellectual property trading markets
- ▶ Prediction markets
- ▶ Advertising markets
- ▶ Hashpower (cryptohealth) markets
- ▶ NeoGas markets
- ▶ Supply chain (parts, food, wine, ...)
- ▶ Consortiums (business partnerships)
- ▶ Business process re-engineering
- ▶ Requisition processing

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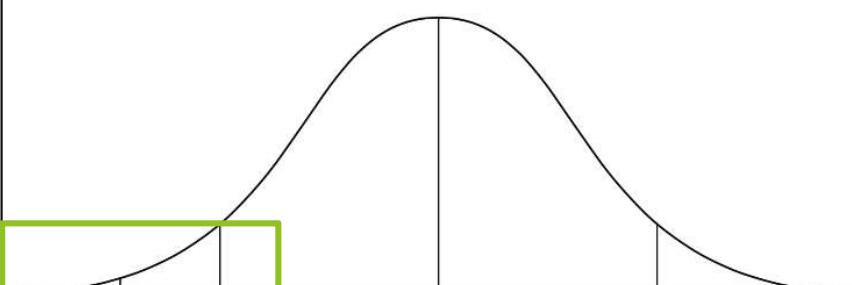
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Blockchain: Early Adopters Marketplace

The Technology Adoption Curve

*As captured by Everett Rogers in his book *Diffusion of Innovations*, people tend to adopt new technologies at varying rates. Their relative speed of adoption can be plotted as a normal distribution, with the primary differentiator being individuals' psychological disposition to new ideas.*



Innovators
(2.5%) are risk takers who have the resources and desire to try new things, even if they fail

Early Adopters
(13.5%) are selective about which technologies they start using. They are considered the “one to check in with” for new information and reduce others’ uncertainty about a new technology by adopting it.

Early Majority
(34%) take their time before adopting a new idea. They are willing to embrace a new technology as long as they understand how it fits with their lives.

Late Majority
(34%) adopt in reaction to peer pressure, emerging norms, or economic necessity. Most of the uncertainty around an idea must be resolved before they adopt.

Laggards
(16%) are traditional and make decisions based on past experience. They are often economically unable to take risks on new ideas.

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2. NEO Architecture

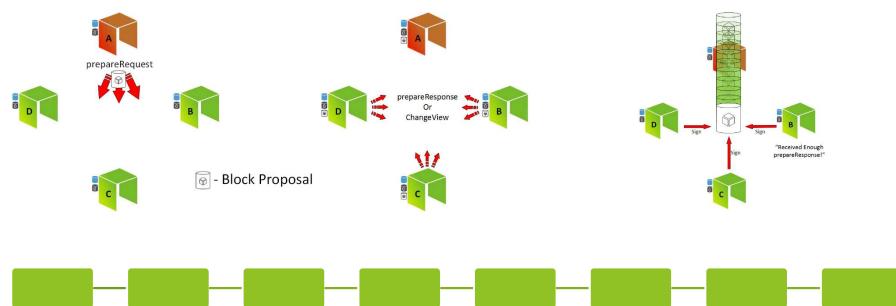
NEO Whitepaper

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Delegated Byzantine Fault Tolerance (dBFT) NEO Consensus Mechanism



- ▶ NEO: There is no competition to create the next block (e.g. no miners, no PoW)
- ▶ NEO: There is no betting or staking to choose the next block (e.g. no PoS)
- ▶ NEO: Consensus nodes are voted in as representatives to choose the next block
- ▶ NEO: No reward for your own node to be selected

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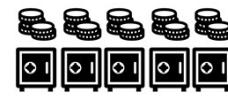
42

Problems with Proof of Work and Proof of Stake

1. Proof of Work (PoW)



2. Proof of Stake (PoS)



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PoW and PoS compared to dBFT

- ▶ Consensus algorithm: PoW and PoS



- ▶ Consensus algorithm: dBFT



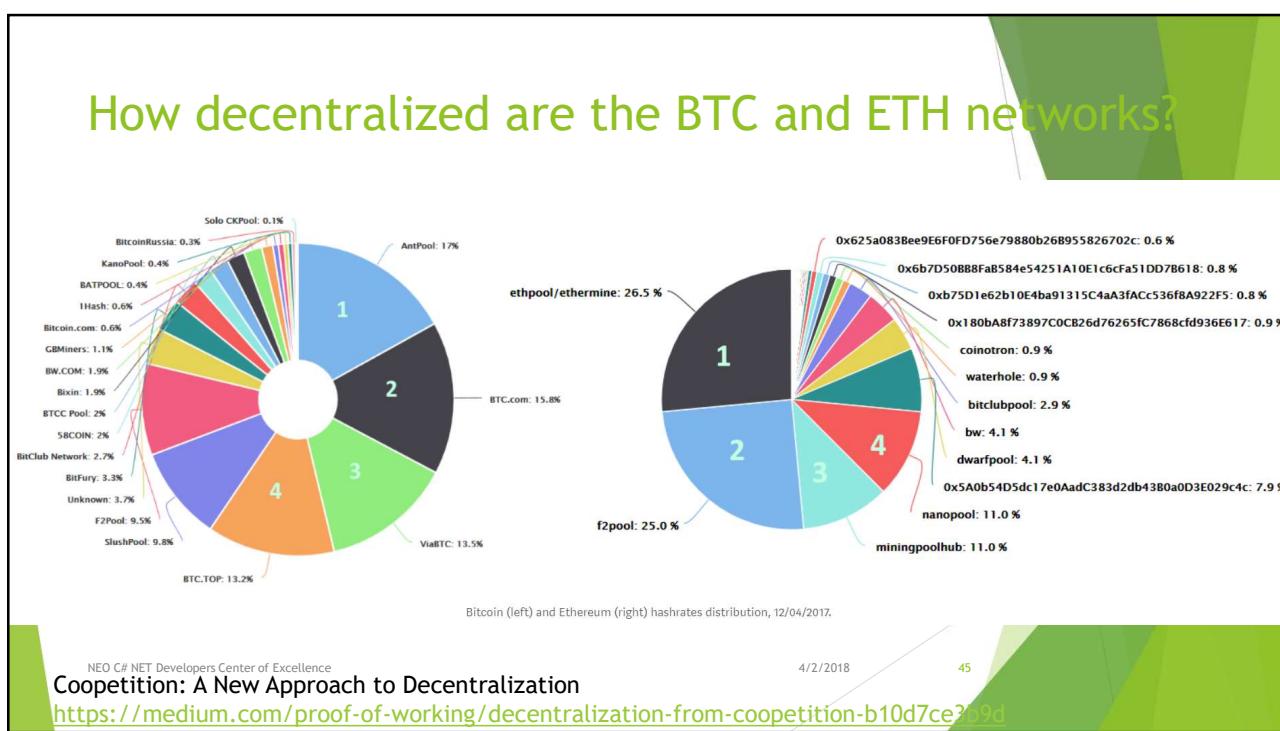
- ▶ One and only one branch

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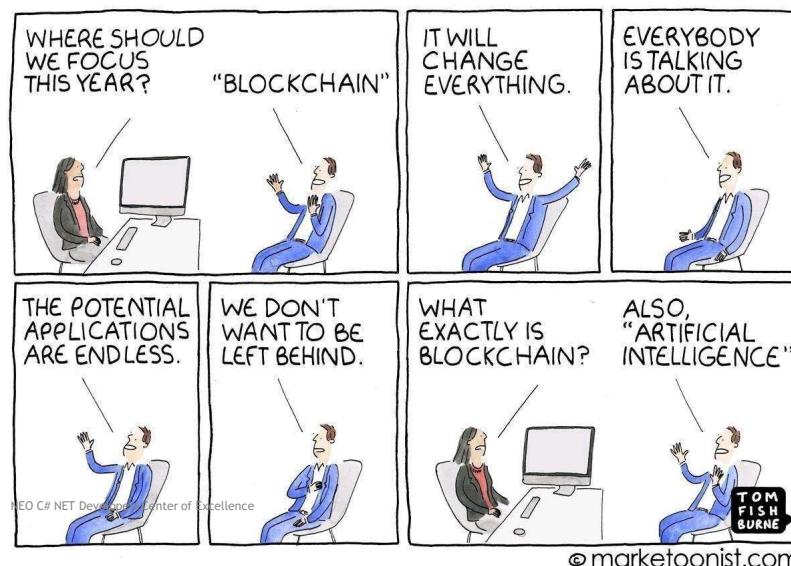
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How decentralized are the BTC and ETH networks?



BREAK - 15 MINUTES



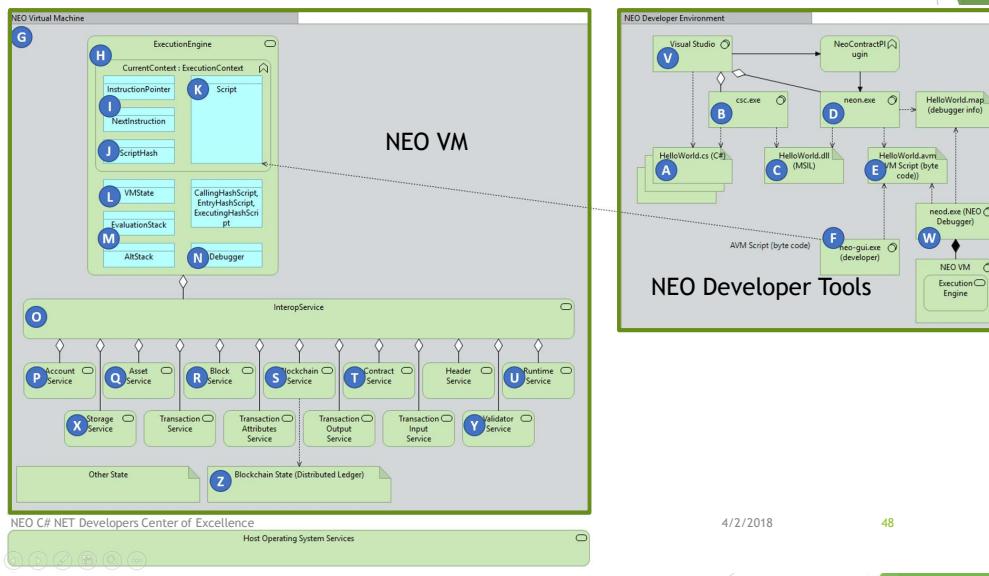
5. NEO Architecture

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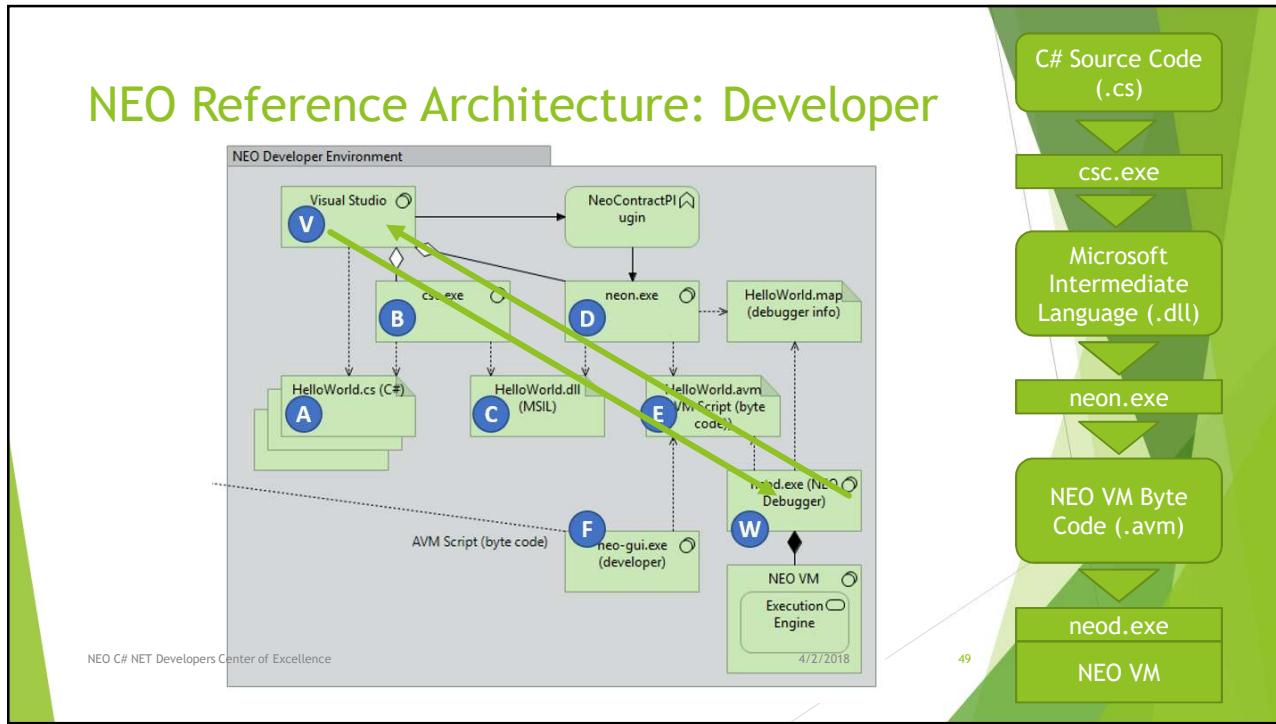
NEO Reference Architecture (neo-charm)



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NEO Reference Architecture: Developer

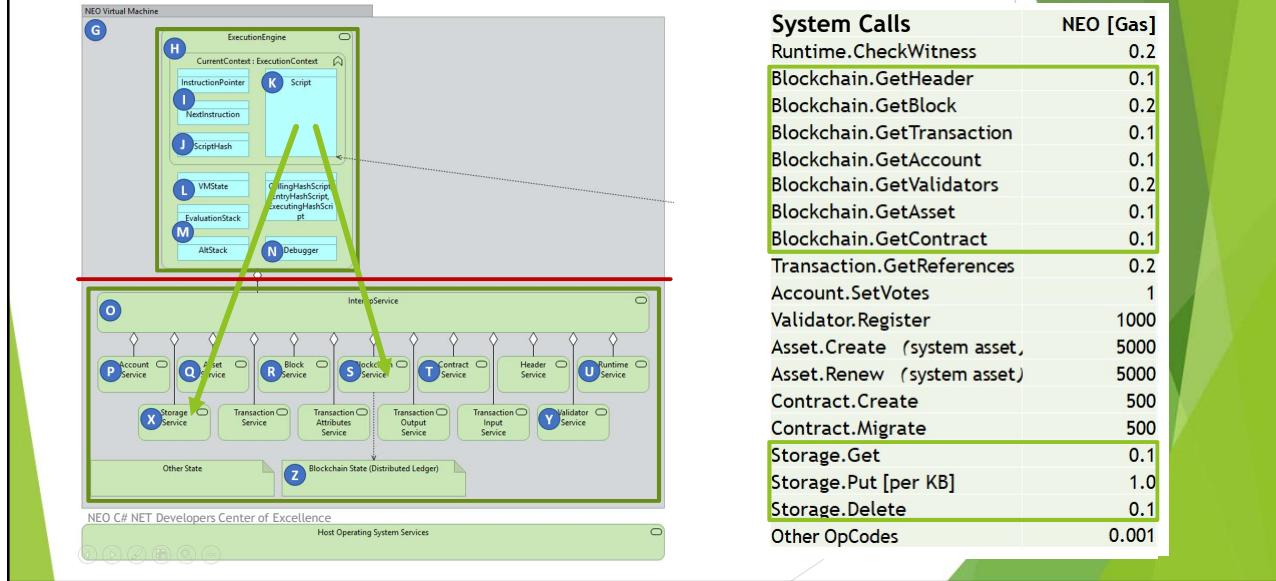


NEO System Fees

<http://docs.neo.org/en-us/sc/systemfees.html>

System Calls	NEO [Gas]	Instruction OpCodes	NEO [Gas]
Runtime.CheckWitness	0.2	OpCode.PUSH16 [or less]	0.00
Blockchain.GetHeader	0.1	OpCode.NOP	0.00
Blockchain.GetBlock	0.2	OpCode.APPCALL	0.01
Blockchain.GetTransaction	0.1	OpCode.TAILCALL	0.01
Blockchain.GetAccount	0.1	OpCode.SHA1	0.01
Blockchain.GetValidators	0.2	OpCode.SHA256	0.01
Blockchain.GetAsset	0.1	OpCode.HASH160	0.02
Blockchain.GetContract	0.1	OpCode.HASH256	0.02
Transaction.GetReferences	0.2	OpCode.CHECKSIG	0.10
Account.SetVotes	1	OpCode.CHECKMULTISIG [per signature]	0.10
Validator.Register	1000	Other OpCodes	0.001
Asset.Create (system asset)	5000	<ul style="list-style-type: none"> • Constants • Flow Control • Stack • String • Logical • Arithmetic • Cryptography • Structure • Exceptions 	4/2/2018
Asset.Renew (system asset)	5000		
Contract.Create	500		
Contract.Migrate	500		
Storage.Get	0.1		
Storage.Put [per KB]	1.0		
Storage.Delete	0.1		
Other OpCodes	0.001		

NEO Reference Architecture: NEO Virtual Machine



6. Module 2 Labs

NEO Smart Contract Patterns: Process Operation, Domain Name Server, NEP5 Token

Lab 4 - lab4_processoperationpattern.cs

NEO Smart Contract Patterns

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```
lab4_processoperationpattern.cs  ▾ X
lab4_processoperationpattern
  ↳ lab4_processoperationpattern.lab4_processoperationpattern
6   namespace lab4_processoperationpattern
7   {
8     public class lab4_processoperationpattern : SmartContract
9     {
10    public static object Main(string operation, params object[] args)
11    {
12      object result = false; // = 0 (zero)
13
14      if (args.Length == 0)
15      {
16        Runtime.Log("Missing parameters");
17        result = false;
18      }
19      else
20      {
21        if (operation == "query")
22        {
23          Runtime.Notify("query", args[0]);
24          result = args[0];
25        }
26        else if (operation == "delete")
27        {
28          Runtime.Notify("delete", args[0]);
29          result = true;
30        }
31        else if (operation == "register")
32        {
33          Runtime.Notify("register", args[0]);
34          result = true;
35        }
36        else if (operation == "transfer")
37        {
38          Runtime.Notify("transfer", args[0]);
39          result = true;
40        }
41        else
42        {
43          result = false;
44        }
45      }
46      return result;
47    }
48  }
```

Process Operation Pattern

```
public static object Main(string operation,
                         params object[] args)
```

Parameters

- ▶ **operation** task to be performed by the smart contract
- ▶ **args** parameters need for a specific task

Return Value

- ▶ **object** bool, simple value, entity, array of objects

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```
public static object Main(string operation, params object[] args)
{
    object result = false; // = 0 (zero)

    if (args.Length == 0)
    {
        Runtime.Log("Missing parameters");
        result = false;
    }
    else
    {
        if (operation == "query")
        {
            Runtime.Notify("query", args[0]);
            result = args[0];
        }
        else if (operation == "delete")
        {
            Runtime.Notify("delete", args[0]);
            result = true;
        }
        else if (operation == "register")
        {
            Runtime.Notify("register", args[0]);
            result = true;
        }
        else if (operation == "transfer")
        {
            Runtime.Notify("transfer", args[0]);
            result = true;
        }
        else
        {
            result = false;
        }
    }
    return result;
}
```

```
public static object Main(string operation, params object[] args)
{
    object result = false; // = 0 (zero)

    if (args.Length == 0)
    {
        Runtime.Log("Missing parameters");
        result = false;
    }
    else
    {
        if (operation == "query")
        {
            Runtime.Notify("query", args[0]);
            result = args[0];
        }
        else if (operation == "delete")
        {
            Runtime.Notify("delete", args[0]);
            result = true;
        }
        else if (operation == "register")
        {
            Runtime.Notify("register", args[0]);
            result = true;
        }
        else if (operation == "transfer")
        {
            Runtime.Notify("transfer", args[0]);
            result = true;
        }
        else
        {
            result = false;
        }
    }
    return result;
}
```

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Lab 5 - lab5_domain.cs

NEO Smart Contract Patterns

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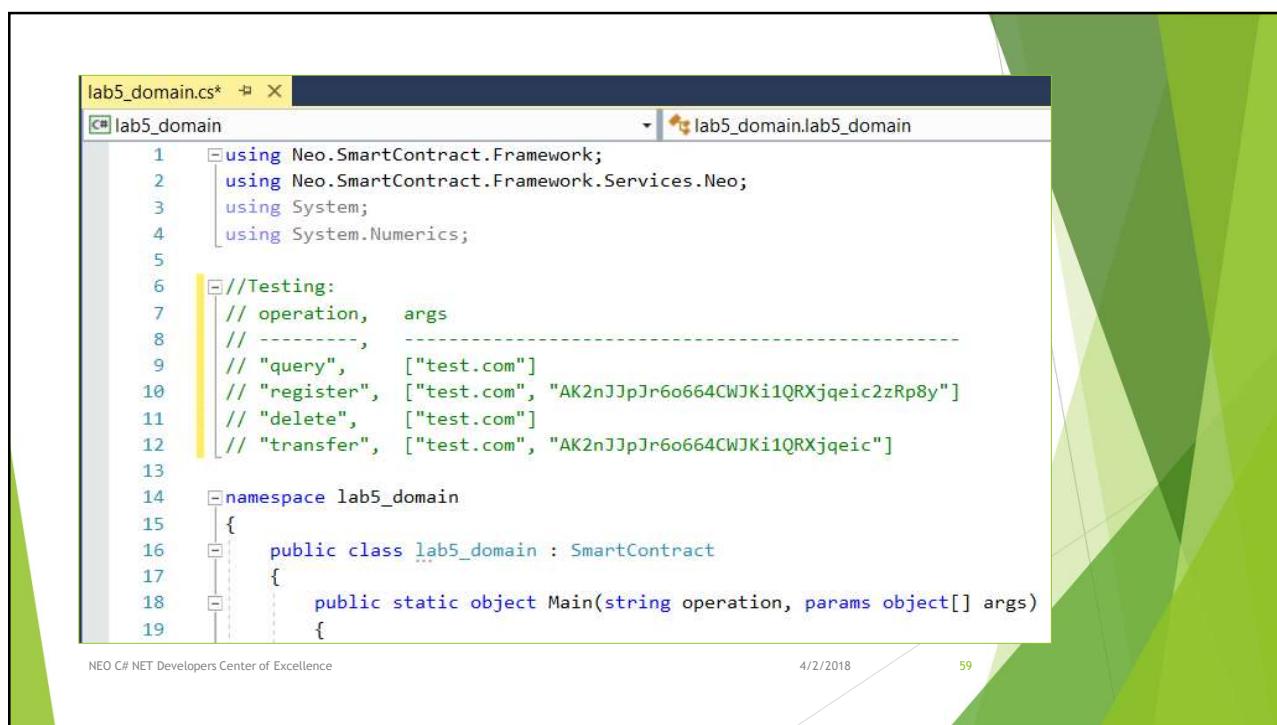
NEO Account Addresses, Keys and Key Lengths

Description	Length (byte[]/HexString)	Examples (Bold Lengths)
Address1	(34/68)	AcCHOikUq9cP6SMESHufCEMwADJNcTwnAv
Address1 WIF	(52/104)	L3f7C21q4Mu5FzZsDuCMeHqwJ1apHYCrwzU2821p1opaM43BAMKo
Address1 PublicKeyHex (33/ 66)		02c44534465c8b21f659eba5708e69edae1ddd6f8cd63004095f8e39493cf54e82
Address1 PrivateKeyHex(32/ 64)		c016e1c8a193cc1a28a15464106b91b52727547a3a36f40a8bfebd9933d1963c
Address1 ScriptHash	(20/ 40)	e000aa6a0ab08af8aa78b19d481e5b5c40d8be0e = Address1.AsScriptHash();
Address2	(34/68)	AK2nJJpJr6o664CWJKi1QRXjqeic2zRp8y
Address2 WIF	(52/104)	KxDgvEKzgSBPPfuVfw67oPQBSjidEiqTHURKSDL1R7yGaGYAeYnr
Address2 PublicKeyHex (33/ 66)		031a6c6fbfdf02ca351745fa86b9ba5a9452d785ac4f7fc2b7548ca2a46c4fcf4a
Address2 PrivateKeyHex (32/ 64)		1dd37fba80fec4e6a6f13fd708d8dc3b29def768017052f6c930fa1c5d90bbb
Address2 ScriptHash	(20/ 40)	23ba2703c53263e8d6e522dc32203339dcd8eee9 = Address2.AsScriptHash();
TxID, AssetID	(32/ 64)	687b68a1159429dc558e4fc7590e391d52f1ef79a12922f941daa37c00334ec5

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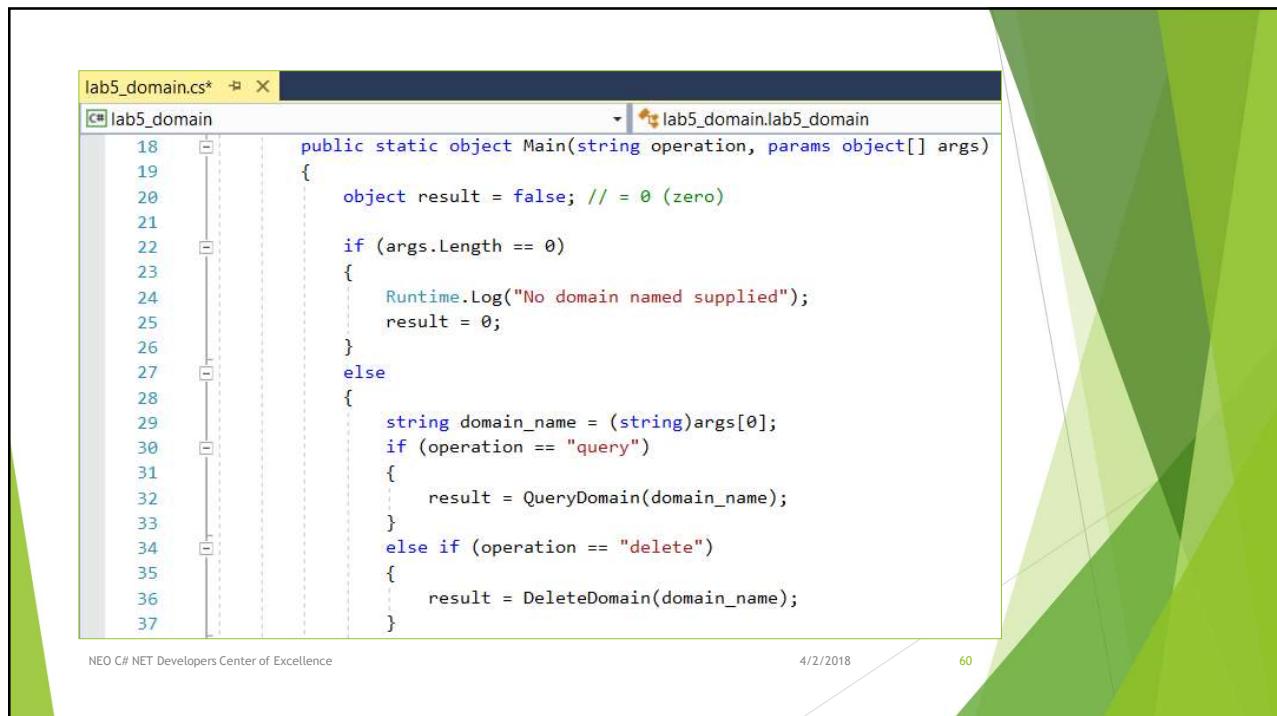


```

lab5_domain.cs*  X | lab5_domain.lab5_domain
lab5_domain
1  using Neo.SmartContract.Framework;
2  using Neo.SmartContract.Framework.Services.Neo;
3  using System;
4  using System.Numerics;
5
6  //Testing:
7  // operation,  args
8  // -----,
9  // "query",    ["test.com"]
10 // "register", ["test.com", "AK2nJJpJr6o664CWJKi1QRXjqeic2zRp8y"]
11 // "delete",   ["test.com"]
12 // "transfer", ["test.com", "AK2nJJpJr6o664CWJKi1QRXjqeic"]
13
14 namespace lab5_domain
15 {
16     public class lab5_domain : SmartContract
17     {
18         public static object Main(string operation, params object[] args)
19     }

```

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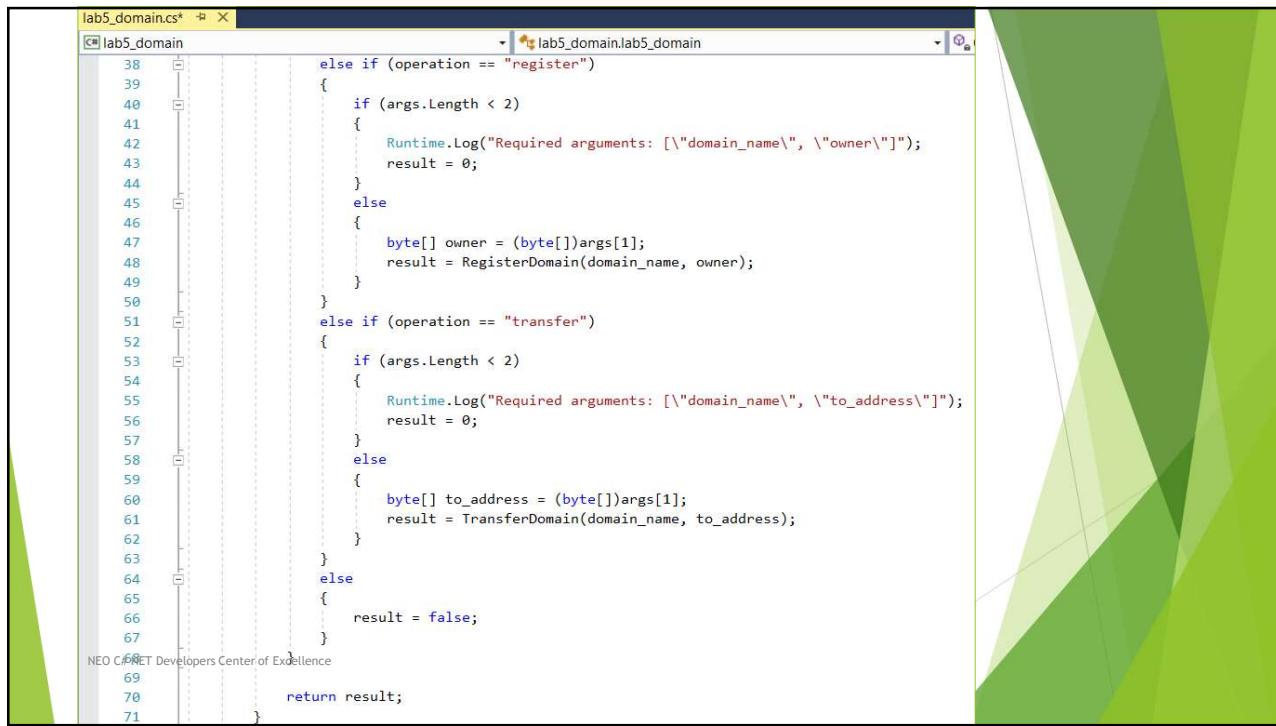


```

lab5_domain.cs*  X | lab5_domain.lab5_domain
lab5_domain
18     public static object Main(string operation, params object[] args)
19     {
20         object result = false; // = 0 (zero)
21
22         if (args.Length == 0)
23         {
24             Runtime.Log("No domain named supplied");
25             result = 0;
26         }
27         else
28         {
29             string domain_name = (string)args[0];
30             if (operation == "query")
31             {
32                 result = QueryDomain(domain_name);
33             }
34             else if (operation == "delete")
35             {
36                 result = DeleteDomain(domain_name);
37             }

```

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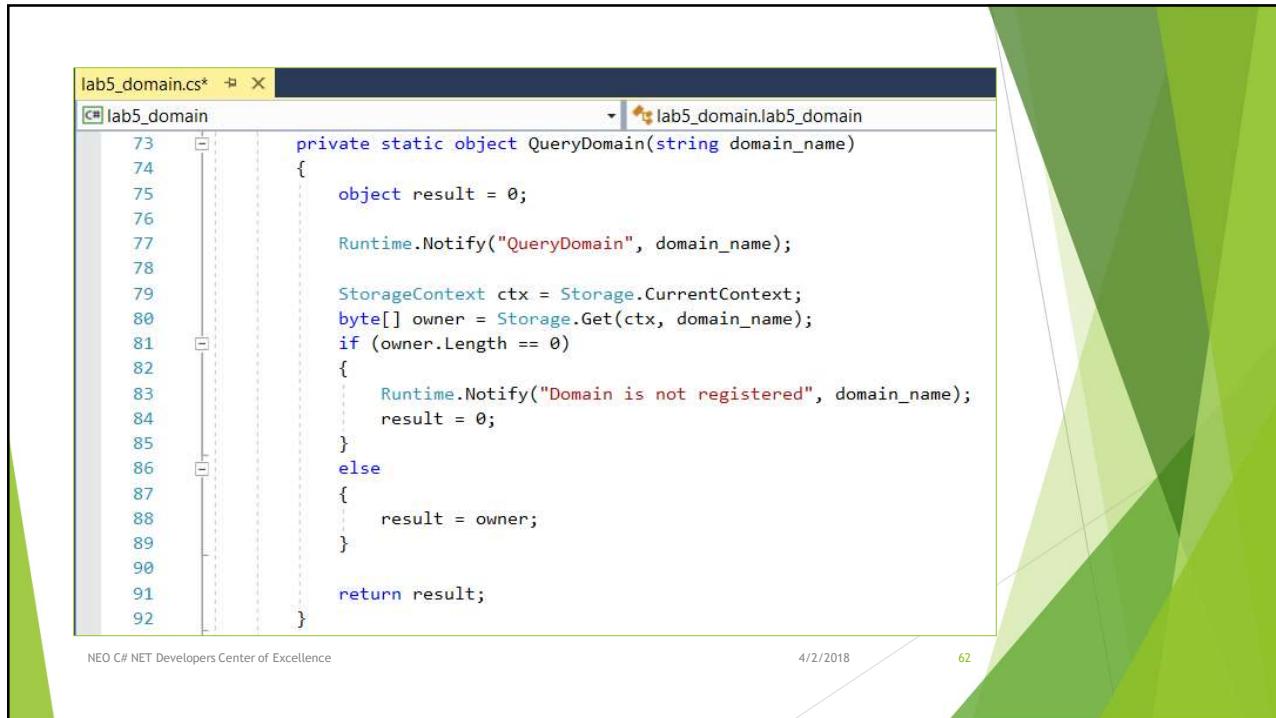


```

lab5_domain.cs*  ⌂ X
lab5_domain
    ↓ lab5_domain.lab5_domain
38     else if (operation == "register")
39     {
40         if (args.Length < 2)
41         {
42             Runtime.Log("Required arguments: [\"domain_name\", \"owner\"]");
43             result = 0;
44         }
45         else
46         {
47             byte[] owner = (byte[])args[1];
48             result = RegisterDomain(domain_name, owner);
49         }
50     }
51     else if (operation == "transfer")
52     {
53         if (args.Length < 2)
54         {
55             Runtime.Log("Required arguments: [\"domain_name\", \"to_address\"]");
56             result = 0;
57         }
58         else
59         {
60             byte[] to_address = (byte[])args[1];
61             result = TransferDomain(domain_name, to_address);
62         }
63     }
64     else
65     {
66         result = false;
67     }
68
69     return result;
70 }
71

```

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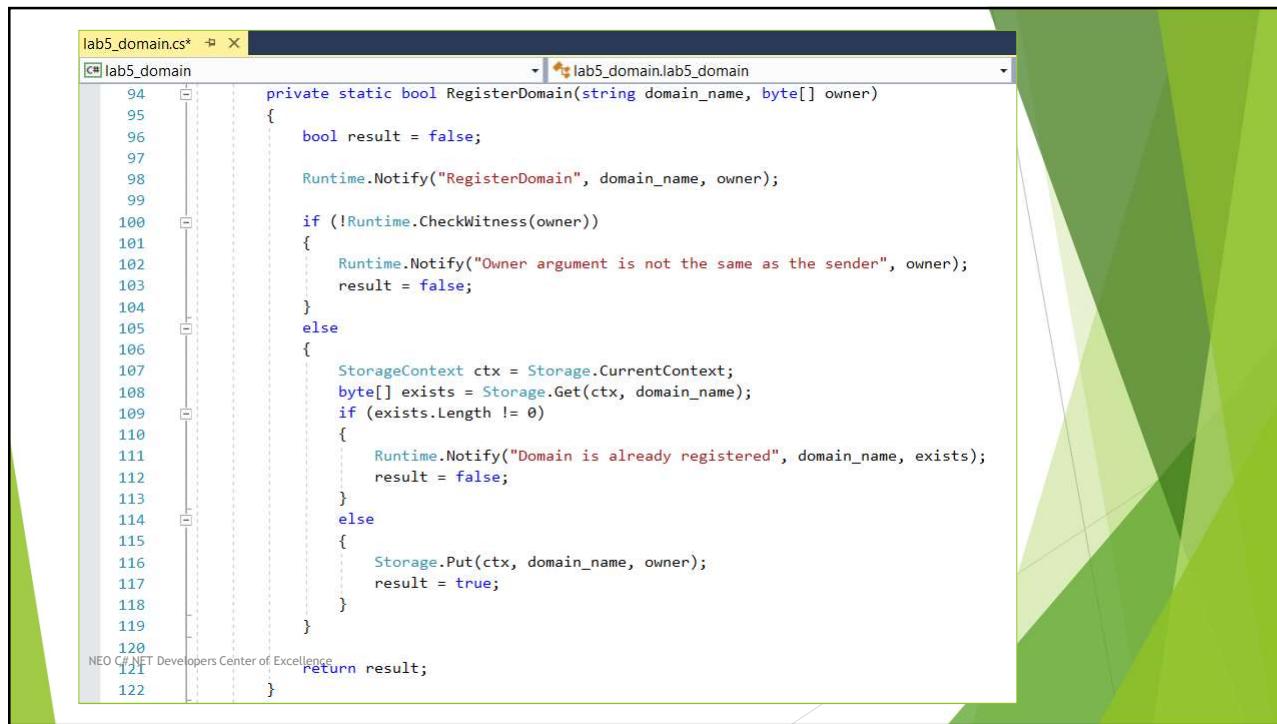
```

lab5_domain.cs*  ⌂ X
lab5_domain
    ↓ lab5_domain.lab5_domain
73     private static object QueryDomain(string domain_name)
74     {
75         object result = 0;
76
77         Runtime.Notify("QueryDomain", domain_name);
78
79         StorageContext ctx = Storage.CurrentContext;
80         byte[] owner = Storage.Get(ctx, domain_name);
81         if (owner.Length == 0)
82         {
83             Runtime.Notify("Domain is not registered", domain_name);
84             result = 0;
85         }
86         else
87         {
88             result = owner;
89         }
90
91         return result;
92     }

```

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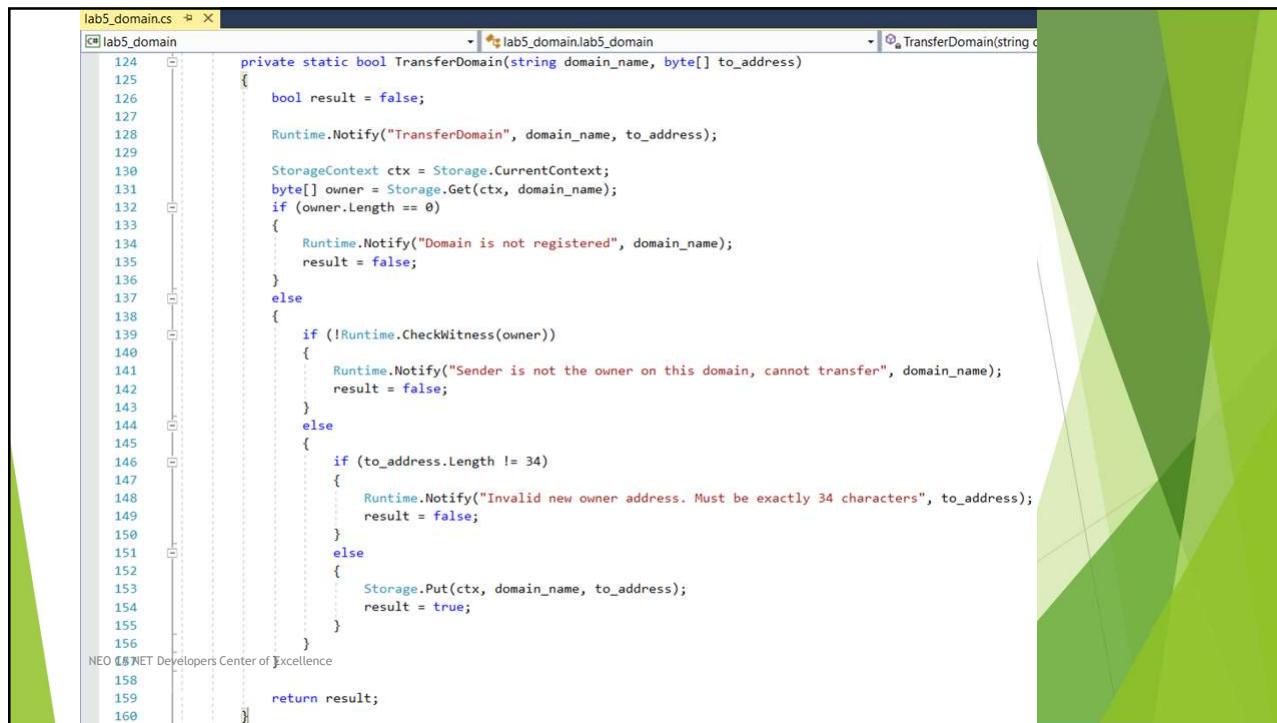
lab5_domain.cs* X lab5_domain.lab5_domain

```

94     private static bool RegisterDomain(string domain_name, byte[] owner)
95     {
96         bool result = false;
97
98         Runtime.Notify("RegisterDomain", domain_name, owner);
99
100        if (!Runtime.CheckWitness(owner))
101        {
102            Runtime.Notify("Owner argument is not the same as the sender", owner);
103            result = false;
104        }
105        else
106        {
107            StorageContext ctx = Storage.CurrentContext;
108            byte[] exists = Storage.Get(ctx, domain_name);
109            if (exists.Length != 0)
110            {
111                Runtime.Notify("Domain is already registered", domain_name, exists);
112                result = false;
113            }
114            else
115            {
116                Storage.Put(ctx, domain_name, owner);
117                result = true;
118            }
119        }
120
121        return result;
122    }

```

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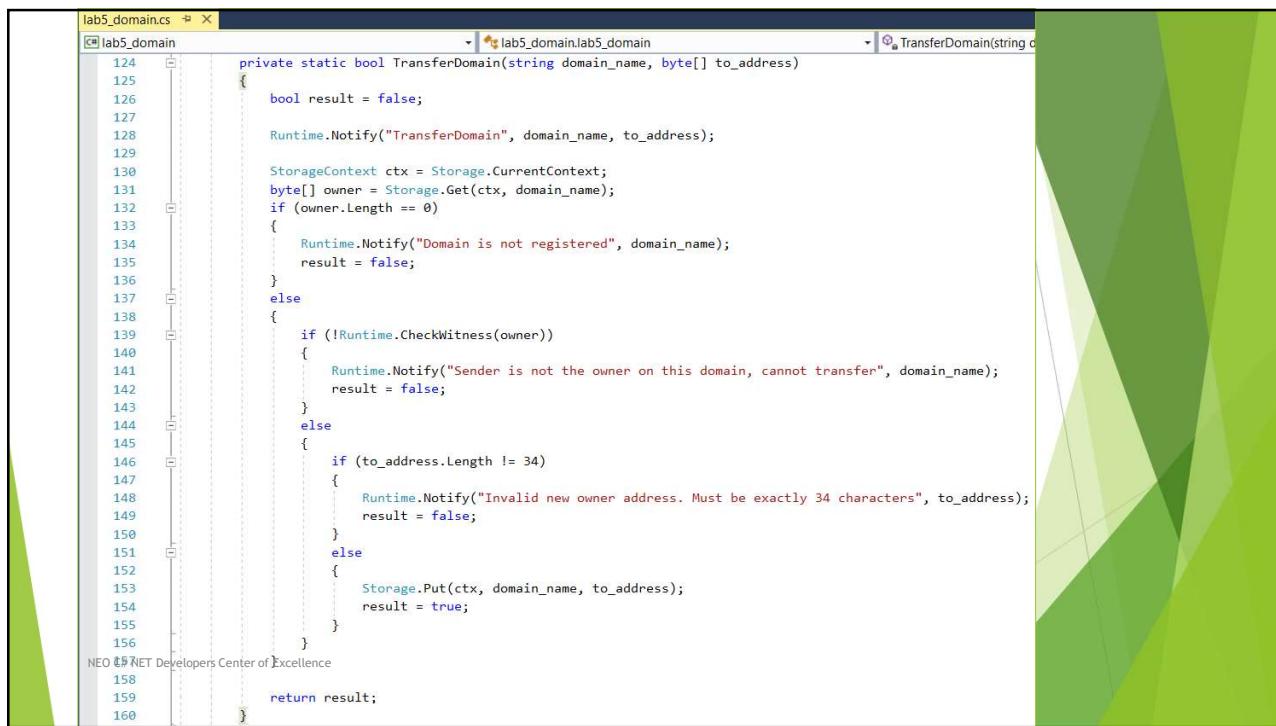
lab5_domain.cs* X lab5_domain.lab5_domain

```

124     private static bool TransferDomain(string domain_name, byte[] to_address)
125     {
126         bool result = false;
127
128         Runtime.Notify("TransferDomain", domain_name, to_address);
129
130         StorageContext ctx = Storage.CurrentContext;
131         byte[] owner = Storage.Get(ctx, domain_name);
132         if (owner.Length == 0)
133         {
134             Runtime.Notify("Domain is not registered", domain_name);
135             result = false;
136         }
137         else
138         {
139             if (!Runtime.CheckWitness(owner))
140             {
141                 Runtime.Notify("Sender is not the owner on this domain, cannot transfer", domain_name);
142                 result = false;
143             }
144             else
145             {
146                 if (to_address.Length != 34)
147                 {
148                     Runtime.Notify("Invalid new owner address. Must be exactly 34 characters", to_address);
149                     result = false;
150                 }
151                 else
152                 {
153                     Storage.Put(ctx, domain_name, to_address);
154                     result = true;
155                 }
156             }
157
158         }
159
160         return result;
161     }

```

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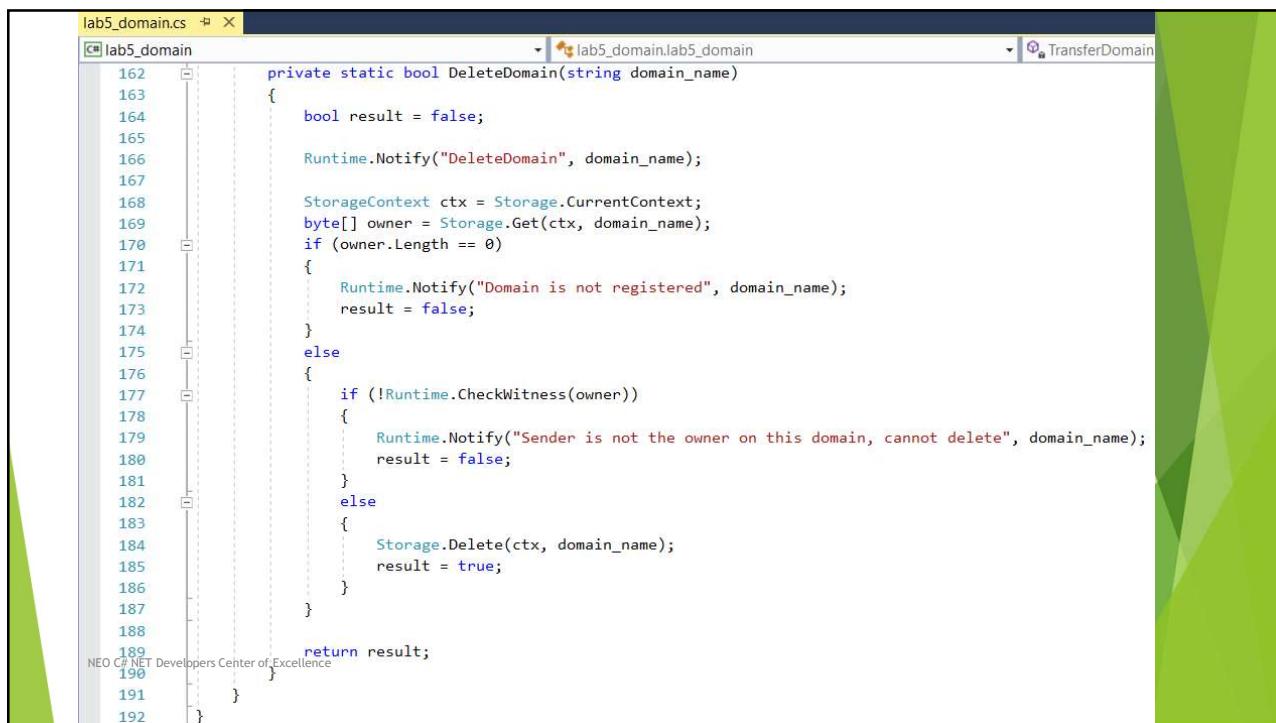
lab5.domain.cs

```

124     private static bool TransferDomain(string domain_name, byte[] to_address)
125     {
126         bool result = false;
127
128         Runtime.Notify("TransferDomain", domain_name, to_address);
129
130         StorageContext ctx = Storage.CurrentContext;
131         byte[] owner = Storage.Get(ctx, domain_name);
132         if (owner.Length == 0)
133         {
134             Runtime.Notify("Domain is not registered", domain_name);
135             result = false;
136         }
137         else
138         {
139             if (!Runtime.CheckWitness(owner))
140             {
141                 Runtime.Notify("Sender is not the owner on this domain, cannot transfer", domain_name);
142                 result = false;
143             }
144             else
145             {
146                 if (to_address.Length != 34)
147                 {
148                     Runtime.Notify("Invalid new owner address. Must be exactly 34 characters", to_address);
149                     result = false;
150                 }
151                 else
152                 {
153                     Storage.Put(ctx, domain_name, to_address);
154                     result = true;
155                 }
156             }
157         }
158     }
159
160     return result;
161 }

```

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lab5_domain.cs

```

162     private static bool DeleteDomain(string domain_name)
163     {
164         bool result = false;
165
166         Runtime.Notify("DeleteDomain", domain_name);
167
168         StorageContext ctx = Storage.CurrentContext;
169         byte[] owner = Storage.Get(ctx, domain_name);
170         if (owner.Length == 0)
171         {
172             Runtime.Notify("Domain is not registered", domain_name);
173             result = false;
174         }
175         else
176         {
177             if (!Runtime.CheckWitness(owner))
178             {
179                 Runtime.Notify("Sender is not the owner on this domain, cannot delete", domain_name);
180                 result = false;
181             }
182             else
183             {
184                 Storage.Delete(ctx, domain_name);
185                 result = true;
186             }
187         }
188
189     }
190
191     return result;
192 }

```

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Lab 6 - lab6_NEP5pattern.cs

NEO Smart Contract Patterns

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```
lab6_NEP5pattern.cs  X  lab6_NEP5pattern  TotalSupply
1  using Neo.SmartContract.Framework;
2  using Neo.SmartContract.Framework.Services.Neo;
3  using System;
4  using System.Numerics;
5
6  // NEP5 Token Proposal: https://github.com/neo-project/proposals/blob/master/nep-5.mediawiki
7
8  namespace lab6_NEP5pattern
9  {
10     public class NEP5Base
11     {
12         public BigInteger TotalSupply;
13         public string Name;
14         public string Symbol;
15         public byte Decimals;
16         public byte[] OwnerAccountScriptHash;
17     }
18
19     public class lab6_NEP5pattern : SmartContract
20     {
21         static readonly byte[] _OwnerAccountScriptHash = "ATrzHaicmhRj15C3Vv6e6gLfLqhSD2PtTr".ToScriptHash();
22
23         public static event Action<byte[], byte[], BigInteger> transfer;
24
25         public static object Main(string operation, params object[] args)
26         {
27             object result = false; // = 0 (zero)
28
29             NEP5Base TOKENBASE = new NEP5Base { TotalSupply = 10000,
30                                              Name = "My Test Token",
31                                              Symbol = "MTT",
32                                              Decimals = 8,
33                                              OwnerAccountScriptHash = _OwnerAccountScriptHash };
```

The screenshot shows a C# code editor with the file `lab6_NEPPattern.cs` open. The code is part of the `lab6_NEPPattern.NEPPattern` class. A `switch` statement is being edited, with the `case "balanceOf"` branch currently selected. The code handles various operations like `totalSupply`, `name`, `symbol`, `decimals`, and `balanceOf`.

```

35     if (operation == "totalSupply")
36     {
37         Runtime.Notify("totalSupply");
38         result = TotalSupply(TOKENBASE);
39     }
40     else if (operation == "name")
41     {
42         Runtime.Notify("name");
43         result = Name(TOKENBASE);
44     }
45     else if (operation == "symbol")
46     {
47         Runtime.Notify("symbol");
48         result = Symbol(TOKENBASE);
49     }
50     else if (operation == "decimals")
51     {
52         Runtime.Notify("decimals");
53         result = Decimals(TOKENBASE);
54     }
55     else if (operation == "balanceOf")

```

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The screenshot continues from the previous one, showing the completion of the `switch` statement. The `case "balanceOf"` branch is fully implemented, and the `case "transfer"` branch is partially implemented, showing the start of the logic for handling transfers.

```

55     else if (operation == "balanceOf")
56     {
57         if (args.Length < 1)
58         {
59             result = false;
60         }
61         else
62         {
63             byte[] account = (byte[])args[0];
64             Runtime.Notify("balanceOf");
65             result = BalanceOf(TOKENBASE, account);
66         }
67     }
68     else if (operation == "transfer")
69     {
70         if (args.Length < 3)
71         {
72             result = false;
73         }
74         else
75         {
76             byte[] from = (byte[])args[0];
77             byte[] to = (byte[])args[1];
78             BigInteger amount = (BigInteger)args[2];
79             Runtime.Notify("transfer", args[0], args[1], args[2]);
80             result = Transfer(TOKENBASE, from, to, amount);
81         }
82     }

```

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lab6_NEP5pattern.cs

```

83     else if (operation == "deploy")
84     {
85         Runtime.Notify("deploy");
86         result = Deploy(TOKENBASE);
87     }
88     else
89     {
90         result = false;
91     }
92
93     return result;
94 }
95
96 private static BigInteger TotalSupply(NEP5Base TOKENBASE)
97 {
98     return TOKENBASE.TotalSupply;
99 }
100
101 private static string Name(NEP5Base TOKENBASE)
102 {
103     return TOKENBASE.Name;
104 }
105
106 private static string Symbol(NEP5Base TOKENBASE)
107 {
108     return TOKENBASE.Symbol;
109 }
110
111 private static byte Decimals(NEP5Base TOKENBASE)
112 {
113     return TOKENBASE.Decimals;
114 }

```

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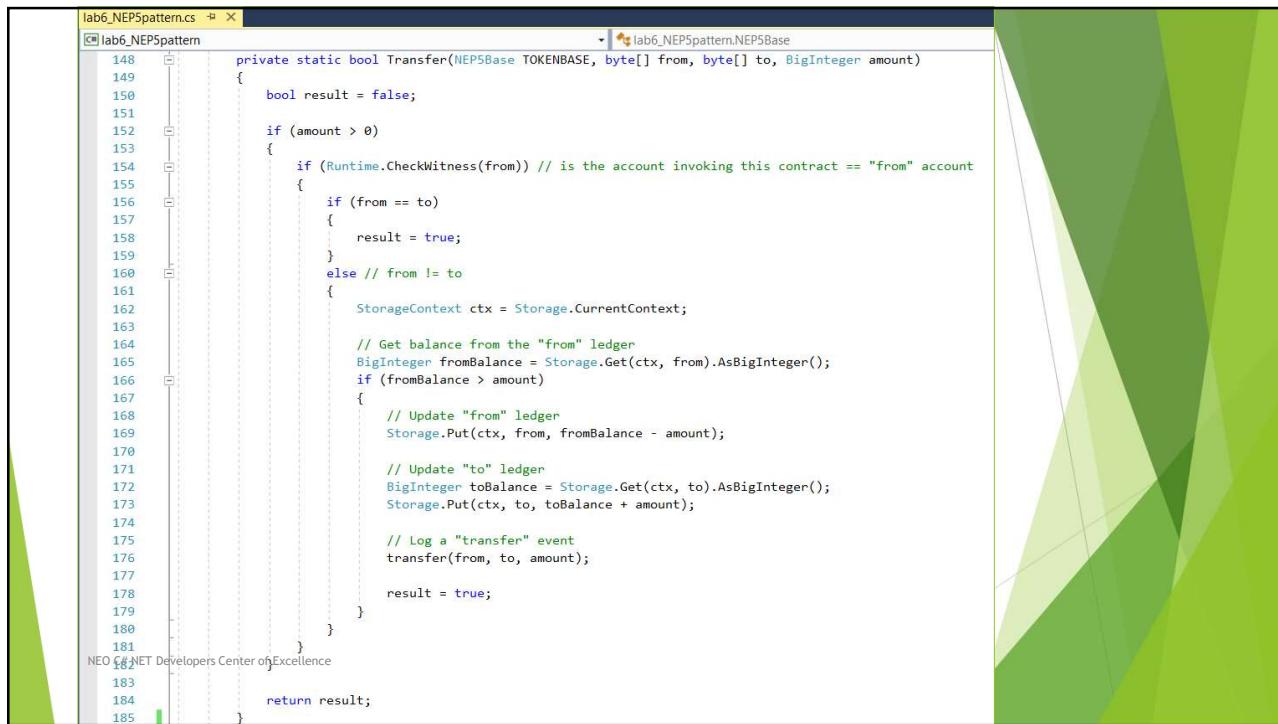
lab6_NEP5pattern.cs

```

116     private static BigInteger BalanceOf(NEP5Base TOKENBASE, byte[] account)
117     {
118         BigInteger result = 0;
119
120         StorageContext ctx = Storage.CurrentContext;
121         BigInteger currentBalance = Storage.Get(ctx, account).AsBigInteger();
122
123         result = currentBalance;
124
125         return result;
126     }
127
128     private static bool Deploy(NEP5Base TOKENBASE)
129     {
130         bool result = false;
131
132         if (Runtime.CheckWitness(TOKENBASE.OwnerAccountScriptHash))
133         {
134             StorageContext ctx = Storage.CurrentContext;
135
136             // Create on-chain ledger entry for the owner of this token. Check to see if the ledger already exists
137             byte[] currentBalance = Storage.Get(ctx, TOKENBASE.OwnerAccountScriptHash);
138             if (currentBalance.Length == 0)
139             {
140                 Storage.Put(ctx, TOKENBASE.OwnerAccountScriptHash, TOKENBASE.TotalSupply);
141                 result = true;
142             }
143         }
144
145         return result;
146     }

```

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```
lab6_NEP5pattern.cs # x
lab6_NEP5pattern
148     private static bool Transfer(NEP5Base TOKENBASE, byte[] from, byte[] to, BigInteger amount)
149     {
150         bool result = false;
151
152         if (amount > 0)
153         {
154             if (Runtime.CheckWitness(from)) // is the account invoking this contract == "from" account
155             {
156                 if (from == to)
157                 {
158                     result = true;
159                 }
160                 else // from != to
161                 {
162                     StorageContext ctx = Storage.CurrentContext;
163
164                     // Get balance from the "from" ledger
165                     BigInteger fromBalance = Storage.Get(ctx, from).AsBigInteger();
166                     if (fromBalance > amount)
167                     {
168                         // Update "from" ledger
169                         Storage.Put(ctx, from, fromBalance - amount);
170
171                         // Update "to" ledger
172                         BigInteger toBalance = Storage.Get(ctx, to).AsBigInteger();
173                         Storage.Put(ctx, to, toBalance + amount);
174
175                         // Log a "transfer" event
176                         transfer(from, to, amount);
177
178                         result = true;
179                     }
180                 }
181             }
182         }
183     }
184
185 }
```

End of Module 2

- ▶ Lab 4 - lab6_processoperationpattern.cs
- ▶ Lab 5 - lab5_domain.cs
- ▶ Lab 6 - lab6_NEP5pattern.cs

7. Why NEO?

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NEO was created for Large Scale dApps*

No transaction fees
Initial 10 GAS fee is
for free. Simple
Smart Contracts can
be run for free.

Mainchain speeds
NEO 1000 - 10,000 TPS (single core)
BTC 3 - 4 TPS
ETH 10 - 20 TPS

Confirmations needed
NEO 1 and only 1
BTC 6+
ETH 20+

More freedom for
application developers
to choose the business
model that most suits to
their business. Service
and usage fees can be
charged in any way off-
chain.

*dApps - Distributed Apps

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NEO Persistable Classes make Enterprise App Development real

8. 3rd Generation Distributed App (dApp) Platform

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NEO Smart Contracts: “Have it your Way”

- ▶ Develop, debug and test Smart Contracts in the language you prefer
 - ▶ C# (reference implementation)
 - ▶ Python, Java, Golang, JavaScript
- ▶ Develop, debug and test Client Apps using the frameworks you prefer
 - ▶ ASP.NET, WinForms, WPF, Console Applications, Window Services, ...
 - ▶ Node.JS
 - ▶ Python, Java, Golang, JavaScript



NEO C# Developer Tool Suite (March 2018)

- ▶ NEO Blockchain Quick Start Guide for .NET Developers (mwherman2000/neo-dotnetquickstart)
- ▶ NEO Persistable Classes (NPC) Compiler (mwherman/neo-npcc)
- ▶ NEO NEON Compiler (neo-project/neo-compiler)
- ▶ NEO Debugger (CityOfZion/neo-debugger-tools)
- ▶ NEO Node/Wallet (Developer Edition) (CityOfZion/neo-gui-developer)
- ▶ NEO PrivateNet Docker Container (metachris/neo-privnet-with-gas)
- ▶ NEO TestNet Network (<http://docs.neo.org/en-us/node/testnet.html>)
- ▶ NEO MainNet Network

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NEO Smart Contracts: “Have it your way”

- ▶ Java

```
import org.neo.smartcontract.framework.SmartContract;
public class ContractAuthentication extends SmartContract {
    static boolean Main(byte[] signature)
    {
        Header header = Blockchain.getHeader(Blockchain.height());
        if (header.timestamp() < 1506933900)
            return false;
        // Paste the public key byte array here
        byte[] b = { 2, -99, 6, 102, 4, -41, 48, -96, -116, 23, 9, 72, -89, -104, -107, 2, -8, -70, -2,
                    96, 60, -21, 105, 105, -93, 103, -80, -113, 17, -61, 7, 20, -85 };
        return verifySignature(b, signature);
    }
}
```

- ▶ Python

<https://github.com/CityOfZion/python-smart-contract-workshop>

- ▶ Next slide

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```

from boa.interop.Neo.Runtime import Log, Notify
from boa.interop.Neo.Storage import Get, Put, GetContext
def Main():
    context = GetContext()
    # This is the storage key we use in this example
    item_key = 'test-storage-key'
    # Try to get a value for this key from storage
    item_value = Get(context, item_key)
    msg = ["Value read from storage:", item_value]
    Notify(msg)
    if len(item_value) == 0:
        Notify("Storage key not yet set. Setting to 1")
        item_value = 1
    else:
        Notify("Storage key already set. Incrementing by 1")
        item_value += 1
    # Store the new value
    Put(context, item_key, item_value)
    msg = ["New value written into storage:", item_value]
    Notify(msg)
    return item_value

```

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Smart Contract Development: NEO or ETH?

Compare/contrast Ethereum and the NEO Blockchain

Ethereum

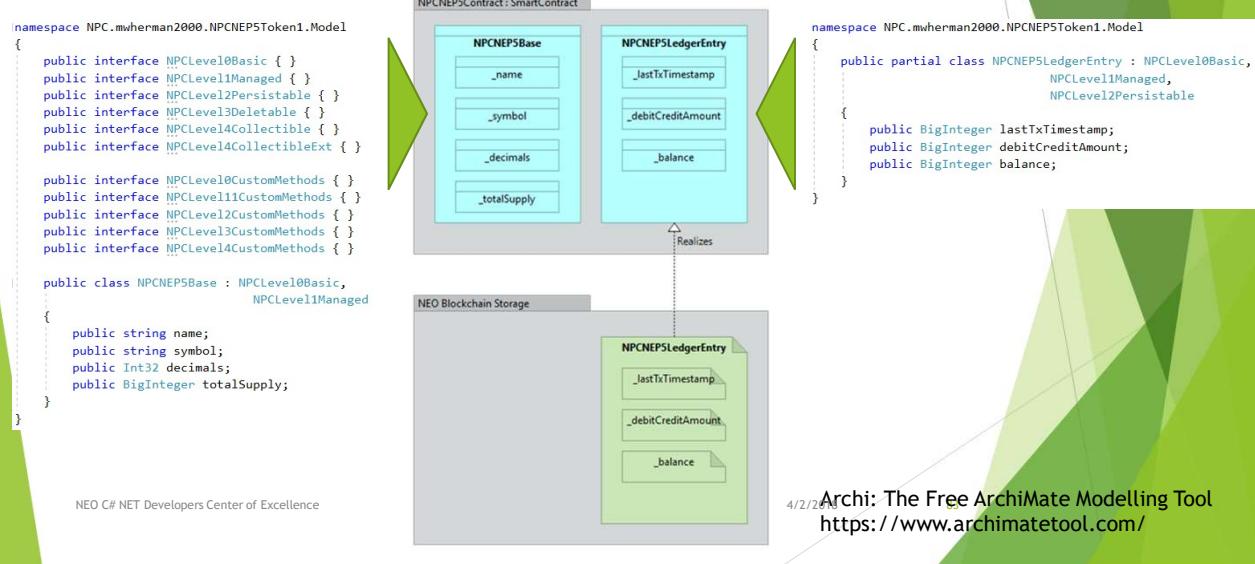
- ▶ ETH Smart contract == single object with a simple set of methods and simple types of data
- ▶ ETH is good for
 - ▶ Blockchain version 2.0 Alt tokens
 - ▶ Simple, single entity with only a few methods
- ▶ Beyond that?
 - ▶ Very little future for Ethereum as an Enterprise Application platform
 - ▶ “One trick pony” x 1500

NEO

- ▶ NEO Smart contract == a program capable of supporting business logic involving dozens of different types of entities
- ▶ Unlimited potential as an Enterprise Application Platform
- ▶ Will drive acquisition of NEO
- ▶ Automatic accumulation of GAS
- ▶ Increased ability to participate in the NEO Smart Economy

The NEO Blockchain is better (superior) for Enterprise Distributed Applications

NEO Persistable Classes (NPC) NEP5 Token Reference Implementation



9. Smart Contract Development using Entities

NEO is much more than a key-value data store: Smart Data

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NeoDraw - NEO Multi-Person Shared Whiteboard dApp

NEO Blockchain as an Enterprise Application Platform



- ▶ NeoDraw is advanced proof-of-concept distributed application (dApp) for the NEO Persistable Classes (NPC) Entity-based dApp (e-dApp) Platform running on the NEO Blockchain.
- ▶ Uses 3 entities
 - ▶ UserCredentials
 - ▶ User name and User Password
 - ▶ UserPoint
 - ▶ Array of (X,Y) coordinates/user
 - ▶ NeoCounter
 - ▶ Tracks number points/user

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NeoDraw - NEO Multi-Person Shared Whiteboard dApp

NEO Blockchain as an Enterprise Application Platform

```
UserCredentials.cs ✘ X UserPoint.cs ✘ X NeoCounter.cs ✘ X
[NPC.dApps.NeoDraw] [NPC.dApps.NeoDraw] [NPC.dApps.NeoDraw]
1 1 using System.Numerics;
2 2 {
3 3     public class UserCredentials {
4 4         public string encodedUsername;
5 5         public string encodedPassword;
6 6     }
7 7 }
8 8 }
9 9 }
10 10 }
11 11 }
12 12 }
13 13 }
14 14 }
15 15 }
16 16 }

[UserPoint.cs]
1 1 using System.Numerics;
2 2 {
3 3     public class UserPoint {
4 4         public int X;
5 5         public int Y;
6 6     }
7 7 }
8 8 }
9 9 }
10 10 }
11 11 }
12 12 }
13 13 }
14 14 }

[NPCLevel0Basic, NPCLevel1Managed, NPCLevel2Persistable, NPCLevel3Deletable, NPCLevel4Collectible, NPCLevel4CollectibleExt]
[NPCLevel1Managed, NPCLevel2Persistable, NPCLevel3Deletable, NPCLevel4Collectible, NPCLevel4CollectibleExt]

[NeoCounter.cs]
1 1 using System.Numerics;
2 2 {
3 3     public partial class NeoCounter:
4 4         public BigInteger currentNumber; // Next number to give out
5 5     }
6 6 }
7 7 }
8 8 }
9 9 }
10 10 }
11 11 }
12 12 }
13 13 }
14 14 }

[NPCLevel0Basic, NPCLevel1Managed, NPCLevel2Persistable, NPCLevel3Deletable, NPCLevel4Collectible, NPCLevel4CollectibleExt]
```

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NPC Layered Functionality

Level 0 Basic

- ▶ Basic class definition with no supporting methods

Level 1 Managed

- ▶ New()
- ▶ New(...)
- ▶ Null()
- ▶ IsNull(e)
- ▶ Set(e, ...)
- ▶ Setfieldname(e, value)
- ▶ Getfieldname(e)
- ▶ Log("label", e)

Level 2 Persistable

- ▶ Missing()
- ▶ IsMissing(e)
- ▶ Put(e, string key)
- ▶ Put(e, byte[] key)
- ▶ Get(string key)
- ▶ Get(byte[] key)

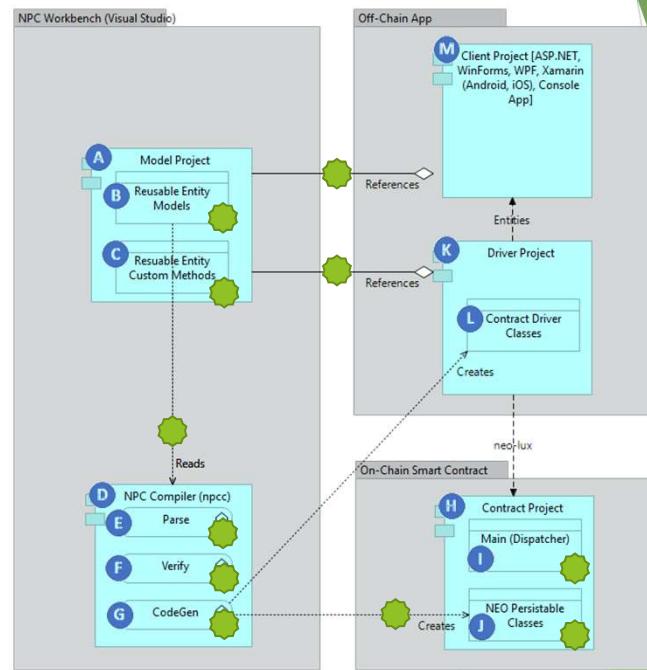
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Architecture

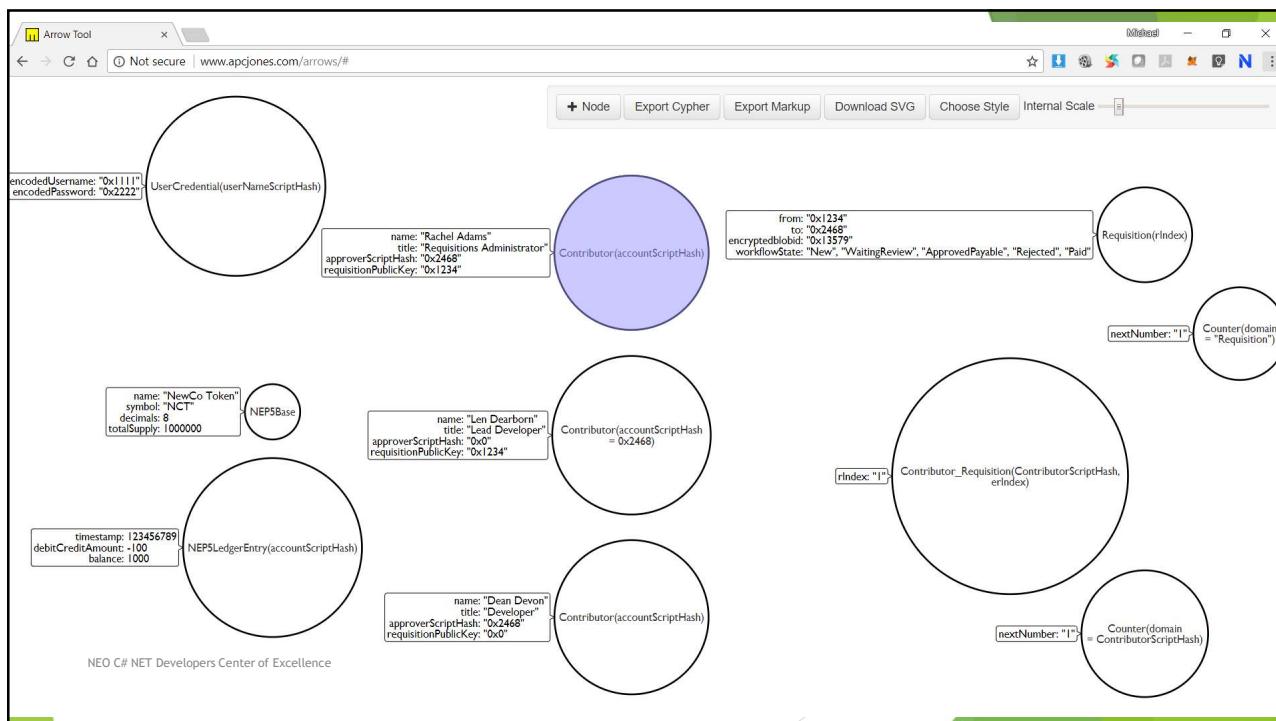
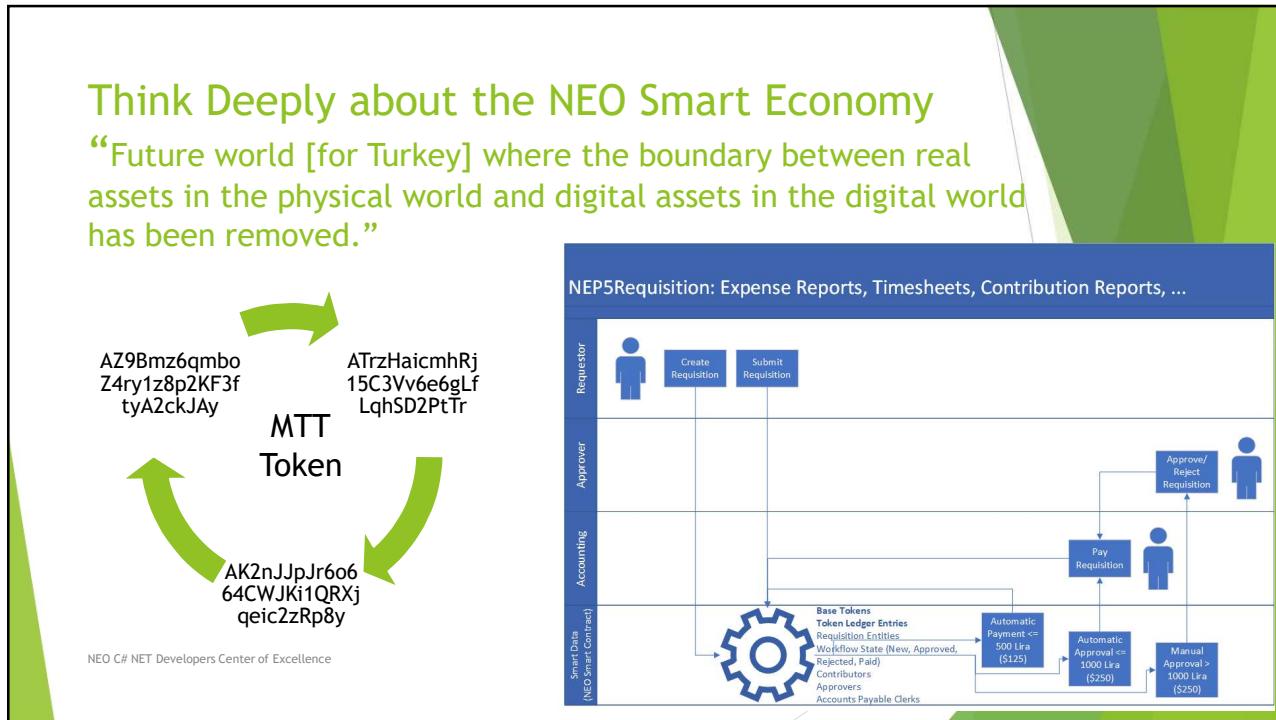
NEO Persistable Classes (NPC)
Platform 2.1 Architecture

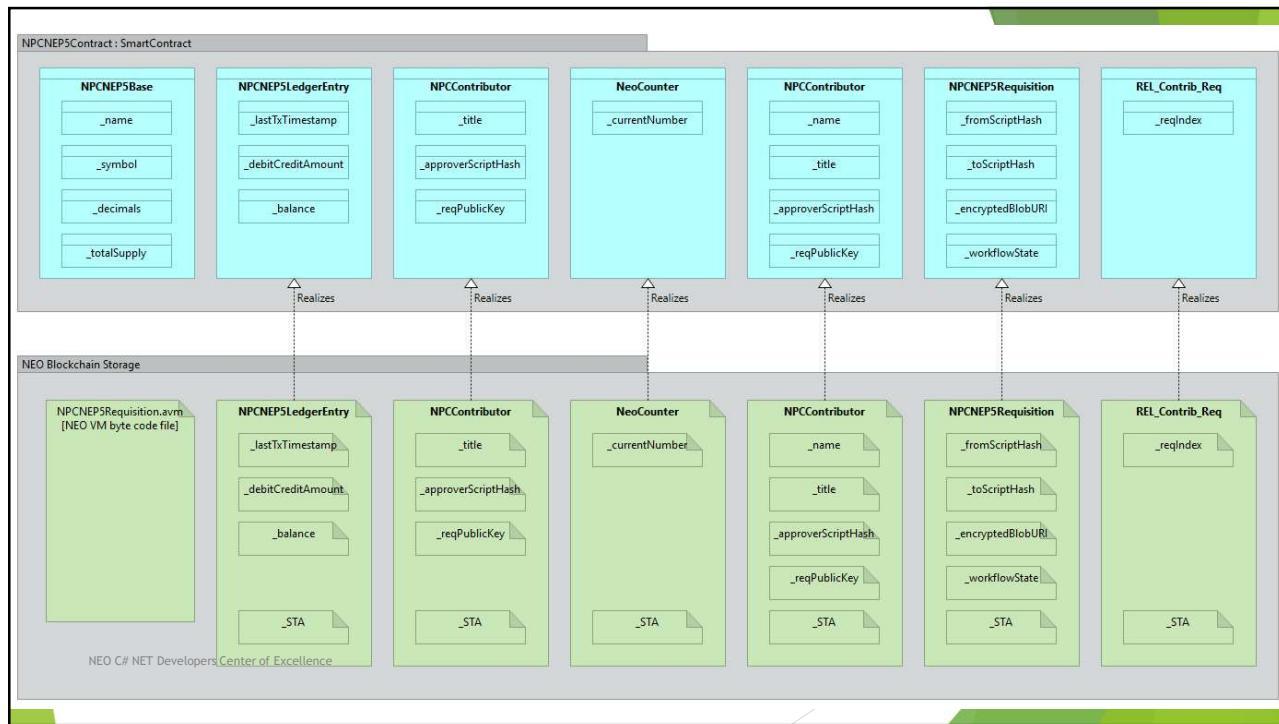


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Think Deeply about the NEO Smart Economy

“Future world [for Turkey] where the boundary between real assets in the physical world and digital assets in the digital world has been removed.”





10. NEO Evidence

NEO Events



Second Wednesday evening of each month



NEO C# NET Developers Center of Excellence
HackCU Episode IV · University of Colorado Boulder
600 Hackers · 24 Hours · February 24th and 25th 2018



March 9th 6pm - 8pm

Sponsored by:
NEX CIC



NEO Events (con't)



Second Thursday evening of each month



NEO C# NET Developers Center of Excellence



1 Week \$NEO Wallet Design Challenge!
I will select 3 designs to each win 5 GAS.

- 1) Create a UI & UX Design for a slick NEO Wallet for desktop.
- 2) Email your submission to challenge@dean.press
- 3) Submission deadline is March 7th.
- 4) Winners announced within a few days.

Good luck! 🍀



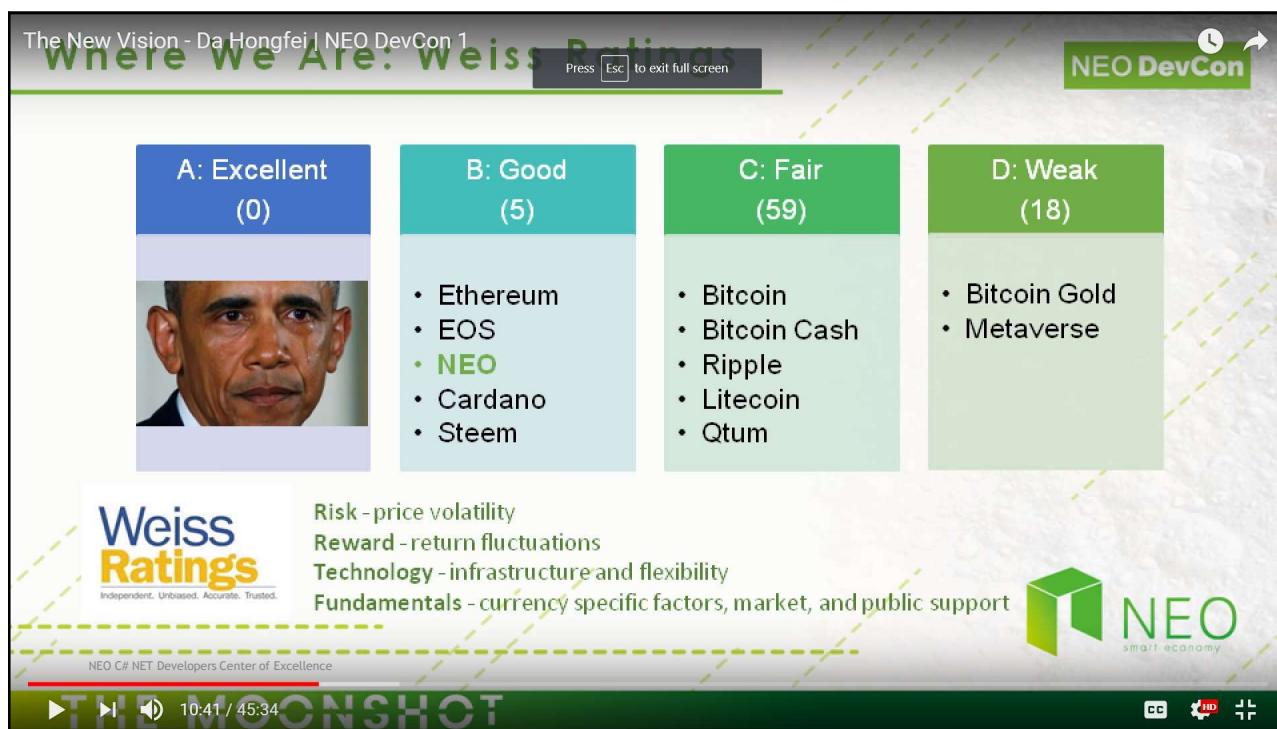
NEO dApp Competitions ~USD\$500K in prizes

1st NEO Dev Competition
Nov. 20, 2017 - Mar. 31, 2018

CITY OF ZION IS LAUNCHING ITS SECOND DAPPS COMPETITION
And we want you to get involved

The City of Zion council is promoting a decentralised apps (dApps) competition to further elevate the NEO developer community.

NEX		Moonlight	Red Pulse	AdEx	NeoAuth	Zeepin	Qlink	Neo Smart IoT	imusify.
NEX	Moonlight	Red Pulse	AdEx	NeoAuth	Zeepin	Qlink	Neo Smart IoT	imusify.	
NEO combined the NEO blockchain with an off-chain matching engine to enable much faster and more complex trades than existing decentralized exchanges.	Moonlight is a distributed blockchain and analytical project management platform, featuring a public ledger of contractor work experience and a new matching algorithm to efficiently match project teams.	Red Pulse Tokens (RPT) are NEO tokens issued by Red Pulse, an event-driven research firm covering major events impacting Chinese companies, sectors and the overall economy.	AdEx is a decentralized exchange built on the blockchain and smart contracts. The core feature of AdEx will be the so-called AdEx User interface - a service that will publish every ad and user to understand and connect the ads delivered to them.	NeoAuth enables authentication over the NEO blockchain, allowing you to log in with a NEO address instead of an email and password.	The Distributed Online New Economy, Zion, a decentralized innovation community, is dedicated to promoting highly efficient circulation of innovation assets: Start-ups, Creative Art.	Qlink is developed by China Foundation in Singapore, adopting the blockchain technology and creates a decentralized mobile network for sharing data and files. It is used in the content distribution, enterprise telecom services and cloud-coupling base stations (including mobile edge computing).	Neo Smart IoT	Concept of Internet of Things devices via Neo smart contracts (not device). An E2E2B.	
Website	Whitepaper	Twitter	LinkedIn	Medium	Demo	Telegram	Medium	GitHub	Website
CHAIN LINE		PHANTASMA	Neo Trade	Turing Complete Smart Contract	Krypton	Switcheo	Trip Shares	Lucky NEO	
Chain Line	Phantasma	NeoTrade	Turing Complete Smart Contract	Krypton	Switcheo	Trip Shares	Lucky NEO		
Peer-to-peer counter platform. Couries transport fees to 100+ operators and save counter fees.	Phantasma is a platform where the users control their own contract, instead of relying in third parties servers. The platform support any kind of payment method, including NEO, fiat, and fiat money transfer. NEO was used for the project due to its fast transactions and C#.	Phantasma is a platform where the users control their own contract, instead of relying in third parties servers. The platform support any kind of payment method, including NEO, fiat, and fiat money transfer. NEO was used for the project due to its fast transactions and C#.	A smart contract which interprets encoded classical Turing machines.	KRYPTONlive is a live content streaming platform built on the NEO blockchain using a KRYPTON compatible SIP provider.	Switcheo is a decentralized exchange built on the NEO blockchain, it supports trading of NEO-S tokens and NEO system assets like GAS & NEO. It aims to be a fast, reliable and low fee exchange while still providing for a superior user experience.	Trip Shares	Lucky NEO		
Website	GitHub	Demo	Website	YouTube	Website	GitHub	Post	GitHub	
Neo Fund		NEO raffle	Nep Swap	Smart Promise	SunnyDapp	NEO Name Service	THEKEY	蓝鲸淘	TRINITY
Neo Fund	Neo Raffle	NepSwap	Smart Promise	SunnyDapp	NEO Name Service	THEKEY	蓝鲸淘	TRINITY	
Neo Fund is a decentralized crowdfunding platform for funding ICOs and other projects. The goal function is to let a goal amount, and date limit. If a goal is reached, the funds will be available to the funds, and if not the contributors can redeem their funds again.	A smart contract that enables a raffle lottery on the NEO blockchain. It's a simple lottery system, it lets you to set a goal amount, and date limit. If a goal is reached, the funds will be available to the funds, and if not the contributors can redeem their funds again.	NepSwap is a platform for trading NEO-based asset holdings. It's a simple swap system, it lets you to set a goal amount, and date limit. If a goal is reached, the funds will be available to the funds, and if not the contributors can redeem their funds again.	Smart Promise is an evolutional journal of smart promise development. Through the process of such an environment receives a reward for the user who has a good record of the promise and the loss contract the possibility to get a strong motivation to action that user primed in.	This dapp allows you to insure against bad weather conditions. If the weather condition is relative sunshine duration on the day is lower than 50 percent, you get paid.	Distributed domain name service ending with .neo based on NEO blockchain.	THEKEY is a Decentralized Ecosystem Identity Verification System, Identity Verification and Blockchain.	蓝鲸淘	TRINITY is a lightning network for blockchain transfer of high-value assets.	
GitHub	Website	GitHub	YouTube	Website	GitHub	Website	GitHub	Website	
GAME.FUND		CONCIERGE	Damn Single	AISC	ORBIS	NARRATIVE	APHELION	BLOCKCHAIN STORE	BRIDGE
GAME.FUND	CONCIERGE	Damn Single	AISC	ORBIS	NARRATIVE	APHELION	BLOCKCHAIN STORE	BRIDGE	
Developers Center of Excellence	Developers Center of Excellence	Developers Center of Excellence	AI SMART CONTRACT	AI SMART CONTRACT	AI SMART CONTRACT	AI SMART CONTRACT	Blockchain Store	Blockchain Store	
Website	GitHub	Website	GitHub	Website	GitHub	Website	GitHub	Website	



NEO News: Switchers

- [QTUM to NEO] THEKEY, a Decentralized Ecosystem of Identity Verification Tool Using National Big-data and [NEO] Blockchain
https://www.reddit.com/r/NEO/comments/7areac/ama_on_9th_nov_thekey_a_decentralized_ecosystem/
- [ETH to NEO] Guardian Circle announce switch to NEO platform
<https://neonewstoday.com/general/guardium-announce-switch-to-neo-platform/>
“...the more we dug into NEO, the more we realized that they had really great answers to every one of our concerns with Ethereum and many additional benefits that are unique to the NEO ecosystem.”
- [ETH to NEO] Narrative project: Big News: KYC and Our Switch to NEO
<https://blog.narrative.network/big-news-kyc-and-our-switch-to-neo-2f34215beef9>
- [ETH to NEO] Concierge.io NEO Token Sale
<https://medium.com/@concierge.io/concierge-io-neo-token-sale-f870a0a27b04>
- [ETH to NEO] IMPORTANT NEWS FOR THE WOWOO COMMUNITY
http://wowoonet.com/news.html#news_2018_6
- [ETH to NEO] Three things to consider when choosing a blockchain for your project—or why Veris chose NEO.
<https://medium.com/verisfoundation/three-things-to-consider-when-choosing-a-blockchain-for-your-project-or-why-veris-chose-neo-b4483135c382>
- [Blockchain agnostic strategy] Jibrel Network founder looking to switch from Ethereum to NEO
<https://imgur.com/oHYTYi2>

THEKEY
A Decentralized Ecosystem of An Identity Verification Tool Using National Big-data and Blockchain

GUARDIUM
Decentralized 9-1-1

NARRATIVE
oncierge.io

Wowoo
Create inspiring value with Wowoo! Wowoo is the service platform which is designed to create value towards inspiring contents using the Wowoo tokens.

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11. Resources

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NEO Resources: Videos and Webcasts

- ▶ The New Vision - Da Hongfei
<https://www.youtube.com/watch?v=th7jZlmoZBc>
- ▶ Malcolm Lerider: Clarification on NEO, GAS and Consensus Nodes
<https://www.youtube.com/watch?v=iV4WREWtCil>
- ▶ A Deep Dive into NeoVM & NeoContract [English Subtitles]
<https://www.youtube.com/watch?v=fLppte-guYE>
- ▶ NEO Persistable Classes (NPC) e-dApp Smart Contract Platform 2.0: Deep Dive
<https://www.youtube.com/watch?v=Nj4-m2o94VE>
- ▶ NEO - Reddit
<https://www.reddit.com/r/NEO/>

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NEO Resources: NEO DevCon 1, January 2018

- ▶ The New Vision - Da Hongfei | NEO DevCon 1
<https://www.youtube.com/watch?v=th7jZlmoZBc>
 - ▶ Opening Address - Scott Hunter, Microsoft | NEO DevCon 1
<https://www.youtube.com/watch?v=ZFsu5HPU2xM>
 - ▶ Ontology, The Technical Vision of Distributed Trust Networks | NEO DevCon 1
<https://www.youtube.com/watch?v=QyaZz0vtONs>
 - ▶ Imusify, Decentralized Platform for Music Related Digital Content | NEO DevCon 1
<https://www.youtube.com/watch?v=dgmfO8nKjE>
 - ▶ NeoAuth, Login Using the NEO Blockchain | NEO DevCon 1
<https://www.youtube.com/watch?v=F7teukbcIbg>
 - ▶ Phantasma, User-Owned Content | NEO DevCon 1
<https://www.youtube.com/watch?v=cinexz6gjsU>
 - ▶ NEO•ONE, Development Framework | NEO DevCon 1
<https://www.youtube.com/watch?v=yWzjNhiZFmA>
 - ▶ THEKEY, A Decentralized Ecosystem of An Identity Verification Tool | NEO DevCon 1
<https://www.youtube.com/watch?v=St-UW0LPB7o>
 - ▶ NEO's Global Vision and the Evolving Regulatory Environment - Miles Graham | NEO DevCon 1
<https://www.youtube.com/watch?v=FidRGNeab3I>
 - ▶ NEX, Decentralized Exchanges | NEO DevCon 1
<https://www.youtube.com/watch?v=1005ed20e0Q>

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NEO Resources

General

- ▶ NEO.org
<http://neo.org>
 - ▶ NEO Tutorials (C#, Java, Python), API docs
<http://docs.neo.org>
 - ▶ NEO DevCon “The New Vision” Keynote by NEO Founder
https://www.youtube.com/watch?time_continue=3&v=th7jZlm0ZBc

Developers

- ▶ N NEO C# Developers Center of Excellence ([neo-csharpcoe](https://github.com/mwherman2000/neo-csharpcoe/blob/master))
<https://github.com/mwherman2000/neo-csharpcoe/blob/master>
 - ▶ Discord NEO Community (like Slack)
<https://discord.gg/gqCYeup>
 - ▶ The NEO Project
<https://github.com/neo-project>
 - ▶ City of Zion **awesome-neo** project: Developer Docs
<https://github.com/CityOfZion/awesome-neo/#developer-documentation>



NEO Blockchain C# Developers Center of Excellence

<https://github.com/mwherman2000/neo-csharpcoe>

- ▶ Founder: Michael Herman (neotoronto@outlook.com)
- ▶ NEO Blockchain end-to-end, detailed guidance for .NET developers
- ▶ Content purposely designed to help .NET developers ramp up and become productive more quickly
- ▶ Repository for content presented at the NEO C# NET Developers Center of Excellence meetup group
- ▶ Contents
 - ▶ NEO Blockchain Quick Start Guide for .NET Developers
<https://github.com/mwherman2000/neo-dotnetquickstart>
 - ▶ NEO Blockchain Architecture Reference Model (ARM) for .NET Developers (neo-charm)
<https://github.com/mwherman2000/neo-charm>
 - ▶ NEO C# NET Developers Center of Excellence
<https://github.com/mwherman2000/neo-windocs/tree/master/events/2018-neo-blockchain-toronto>

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NEO Blockchain Quick Start Guide for .NET Developers

<https://github.com/mwherman2000/neo-dotnetquickstart/blob/master/README.md>

1. Pre-requisites and Recommendations
 2. Download and install Visual Studio 2017 Community Edition integrated development environment (IDE)
 3. Download and unpack NEO developer tool projects (source)
 4. Coffee time: Wait for previous activities to complete
 5. Install NeoContractPlugin Visual Studio extension
 6. Build and test NEO developer tool projects (from source)
 7. Download, install, and test Docker platform
 8. Download and test NEO privatenet Docker container
 9. Create and compile HelloWorld smart contract sample
 10. Deploy and test the HelloWorld smart contract
 11. Celebrate
- ▶ Appendix A - Checklist
 - ▶ Appendix B - Roadmap
 - ▶ Appendix C - Reset NEO privatenet Environment: Container, Wallets, and Clients

Statistics

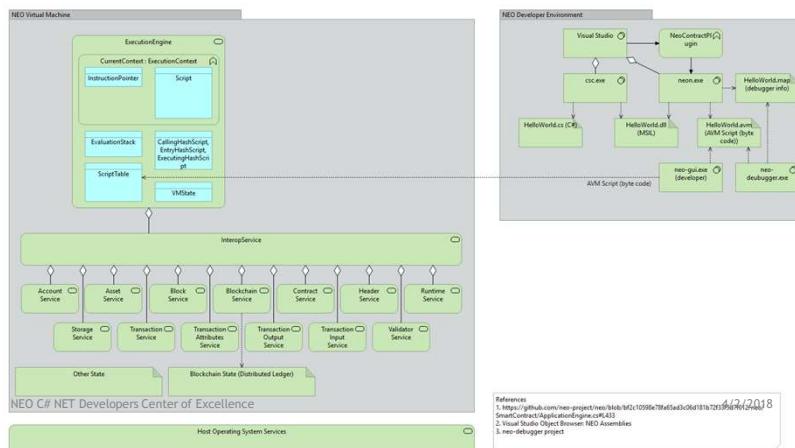
- ▶ 10 activities comprising 130 documented tasks (approximately)
- ▶ 140 screen shots (approximately)
- ▶ 7 batch files
- ▶ 2 JSON configuration files
- ▶ 1 C# code snippet

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NEO Blockchain Architecture Reference Model (ARM) for .NET Developers (neo-charm)

<https://github.com/mwherman2000/neo-charm/blob/master/README.md>



The screenshot shows the Global Blockchain Compliance Hub website. The URL is <https://neo-project.github.io/global-blockchain-compliance-hub/>. The page features a navigation bar with links for **ABOUT**, **BELGIUM**, **GERMANY**, **GIBRALTAR**, **HONG KONG**, **JAPAN**, **LUXEMBOURG**, **NETHERLANDS**, **SINGAPORE**, **SOUTH KOREA**, **SWITZERLAND**, and **THE ISLE OF MAN**. The main content area is titled "Welcome!" and contains a message about the project's goal of compiling a public GitHub database of legal details related to blockchain and cryptocurrency across various jurisdictions. It also provides contact information for contributing partners. A sidebar on the left lists the same jurisdictional links as the navigation bar.

12. Next Steps

NEO C# .NET Developers Center of Excellence

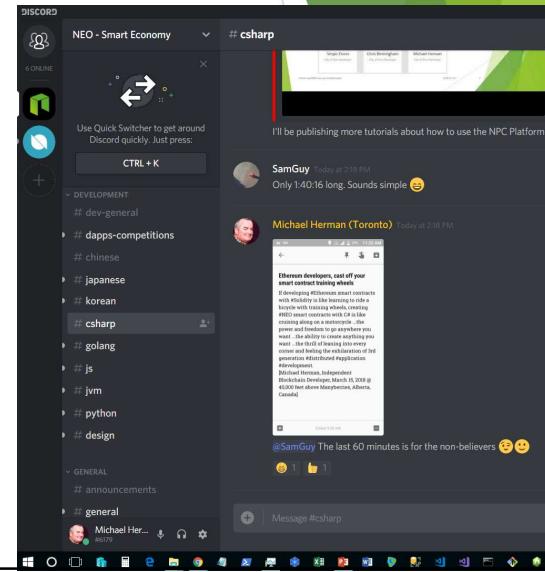
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Call to Action - Your Homework

1. Build something interesting on the NEO Blockchain
2. Join Discord
<https://discord.gg/gqCYeup> /
<https://discord.gg/4TQujHj>
3. Use NEO C# Developers Center of Excellence (neo-csharpcoe)
<https://github.com/mwherman2000/neo-csharpcoe/blob/master/README.md>
4. Start with NEO Blockchain Quick Start Guide for .NET Developers
<https://github.com/mwherman2000/neo-dotnetquickstart/blob/master/README.md>
5. Review Workshop for programming smart contracts with .NET, C# and Visual Studio (csharp-smart-contract-workshop)
<https://github.com/mwherman2000/csharp-smart-contract-workshop/blob/master/README.md>

NEO C# .NET Developers Center of Excellence



BLOCKCHAIN HUB at YORK UNIVERSITY

NEO BLOCKCHAIN ENTERPRISE DEVELOPER (CNED) CERTIFICATION PROGRAM

PROGRAM OVERVIEW	PROGRAM DETAILS
<p>This program will guide the participants through the basics of the NEO Blockchain and the principles of the NEO Smart Economy, while mastering the best practices for NEO Blockchain enterprise application development.</p> <p>By completing the program, participants will be able to create and test their own distributed applications (dApps); while also learning about the best tools and reusable code libraries, frameworks, how-to examples, and best practices for enterprise application development using .NET/C#, C#.NEO, and the NEO Blockchain platform.</p> <p><small>NEO C# .NET Developers Center of Excellence</small></p>	<p>Program Length 3 days plus capstone project</p> <p>Date and Time TODAY-TODAY 9:00 a.m. - 5:00 p.m.</p> <p>Location 4/2/2018 Bergeron Centre for Engineering Excellence, York University</p>

Reminder: When to use Blockchain Technology

“Blockchain: the force multiplier for the smart economy” [Microsoft]

Questions to Ask

1. Is it a business process that crosses **trust boundaries**?
2. Do **multiple parties** manipulate the same data?
3. Are processes operating inefficiently or decisions delayed due to the **number of intermediaries**?
4. Does the business process involve **low-value, manual verification steps**?

Use a Blockchain when there is a Need for

- ▶ Real-time transparency by connecting business processes across organizations
- ▶ Real-time, transparent access to a verifiable source of the truth across organization boundaries
- ▶ Introduce trust and increase efficiency amongst participants - reducing the need for intermediaries
- ▶ Improved efficiencies and increased confidence through automation and smart contracts that execute consistently.

“Use blockchain technology when it matches the requirements of your application. Don’t automatically use blockchain technology simply because you’re re-platforming an existing application.” [Gartner 2018]

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Why is the NEO Blockchain important?

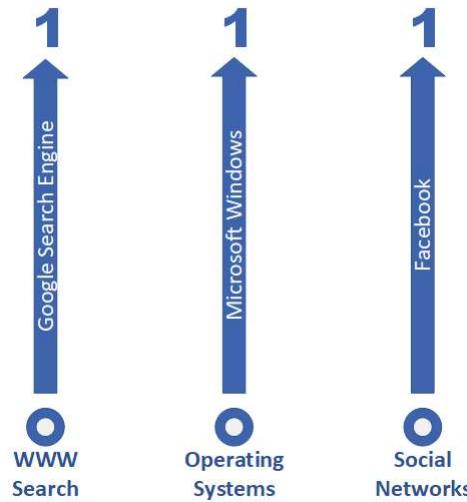
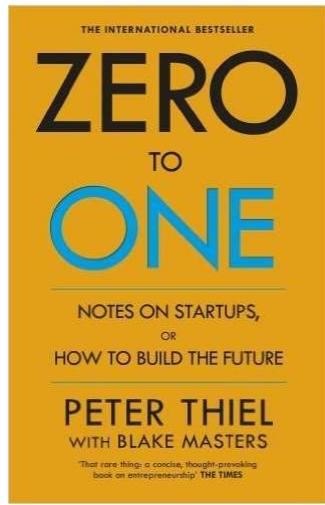
“The NEO Blockchain will as important or more important than Windows for enterprise distributed application development.”
[Michael Herman, March 2018]

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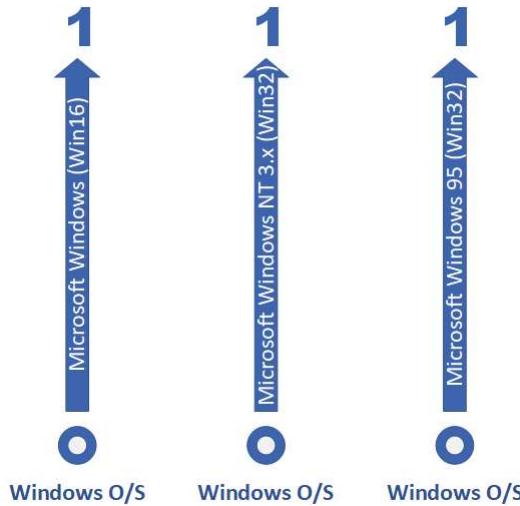
4/2/2018

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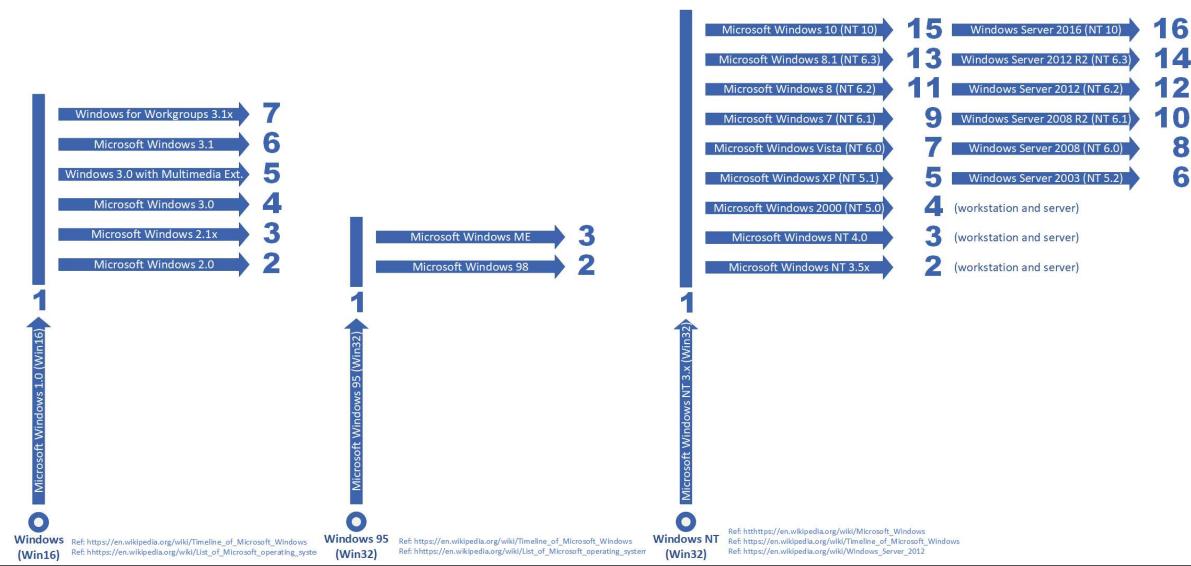
“Zero to One” by Peter Thiel, Founder of PayPal



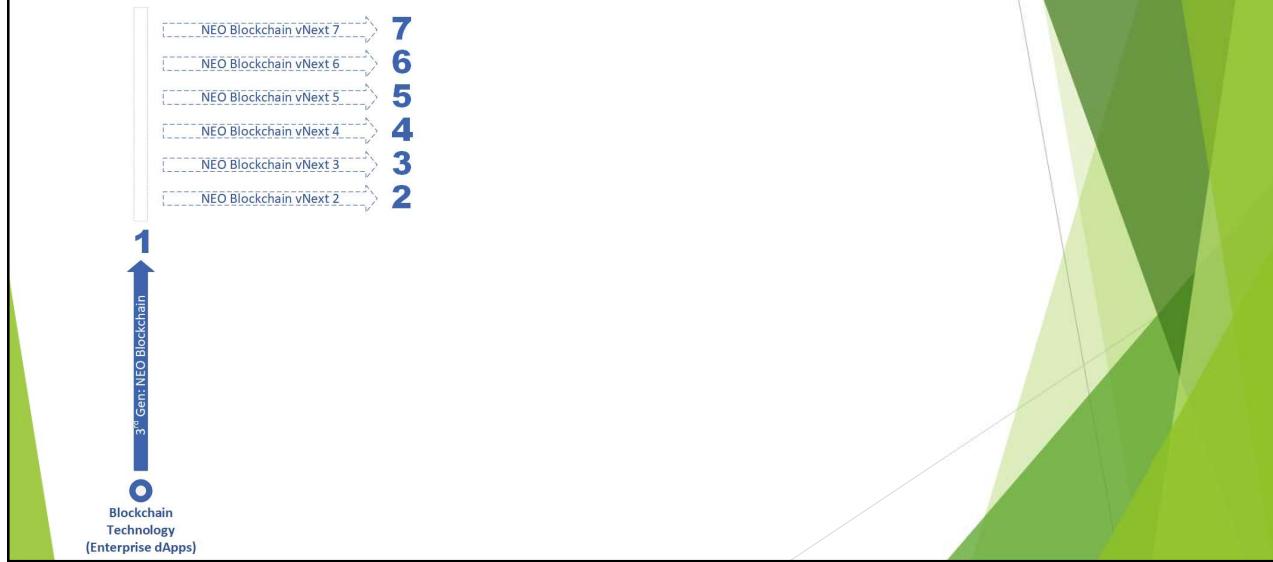
Zero to One: Microsoft Windows



Zero to One: Microsoft Windows



Zero to One: NEO Blockchain Platform



I leave you with a challenge...
Become part of the NEO Smart Economy

TOKENIZE EVERY LITTLE THING #ELT

hyperonomy.com - digital intelligence (my blog)

<https://hyperonomy.com/2018/01/24/tokenization-of-every-little-thing-elt/>

Questions?

Michael Herman (Toronto) - Independent Blockchain Architect and Developer

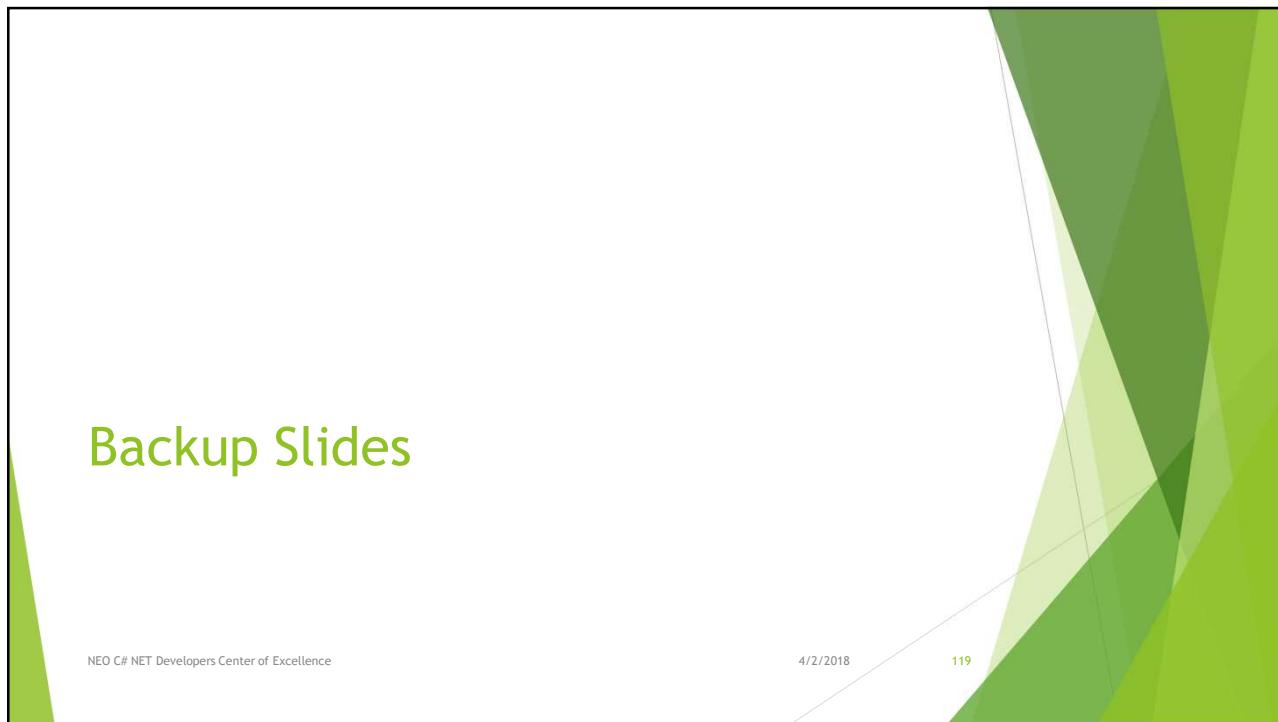
E: <mailto:neotoronto@outlook.com>

M: <https://www.meetup.com/NEO-Blockchain-Toronto>

G: <https://github.com/mwherman2000/neo-csharpcoe/tree/master/events>

F: <https://www.facebook.com/neotoronto/>

T: <https://www.twitter.com/neotoronto>



Our Values as *Neoxplorers*

We operate like the NEO Blockchain

- ▶ Decentralized
- ▶ Community based
- ▶ Consensus driven
- ▶ Creators of value
- ▶ Store of value (knowledge)
- ▶ Transfer of value (training)
- ▶ Multi-disciplinary
- ▶ Multi-application
- ▶ Multi-technology

We behave like the NEO Blockchain

- ▶ Robust
- ▶ Reliable
- ▶ Transparent
- ▶ Smart
- ▶ Open
- ▶ Non-discriminatory
- ▶ Participatory
- ▶ Diversity
- ▶ Committed

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Killer Apps of Blockchain (so far)

NEO DevCon

What's the next category of Blockchain Killer Apps?

Decentralized
“Gold”

Bitcoin

Exchanges

Initial Coin
Offering

Ethereum

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THE MOONSHOT



