# CMSC 398F
# Week #11
# Solidity Continuation

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## Announcements

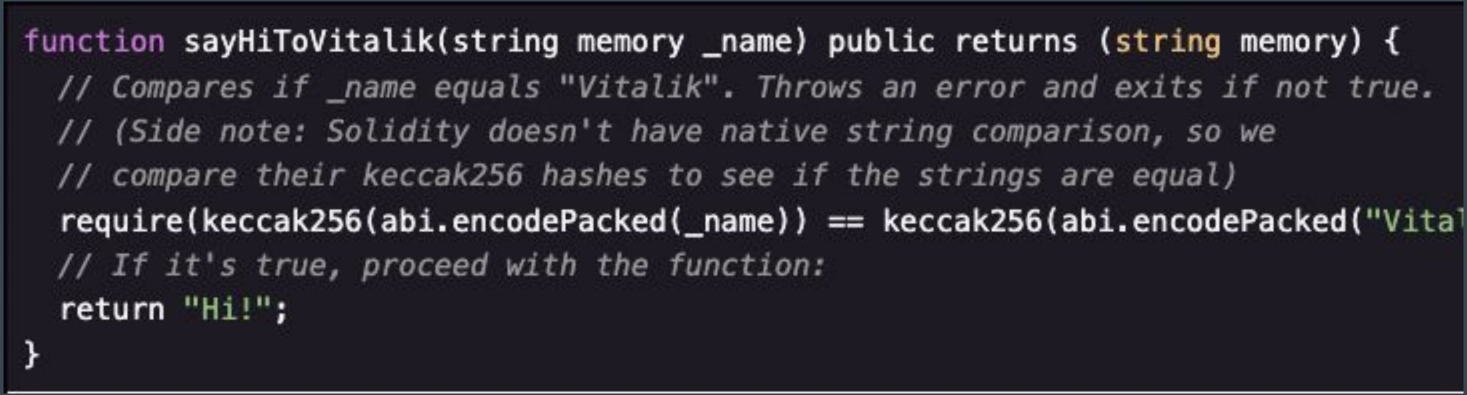
- Quiz 5 will be released soon.
    - Will be on Solidity
        - Specifically information on cryptozombies.io
- Join the class Piazza!
    - piazza.com/umd/fall2022/cmsc398f

## From Last Time

- Four visibility modifiers
    - Private
    - Internal
    - Public
    - External
- Complex Data Types
    - Arrays, Structs, Mappings
- ERC20 - fungible token
    - Requires specific and necessary functions to transfer and receive money
        - transfer(address a, uint256 value), balanceOf(address a), approve(address spender, uint256 value), etc.

## Require Keyword

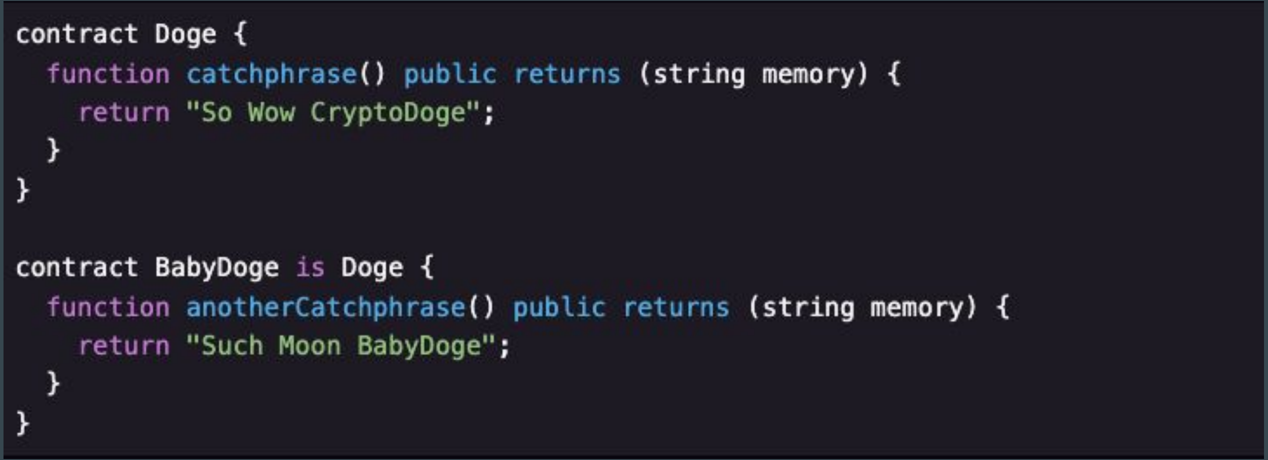
- When the require statement is reached, function will check the condition within the require statement. If it is false, execution will be halted and an error will be thrown.
- There is also revert() and assert(), which will be discussed later.



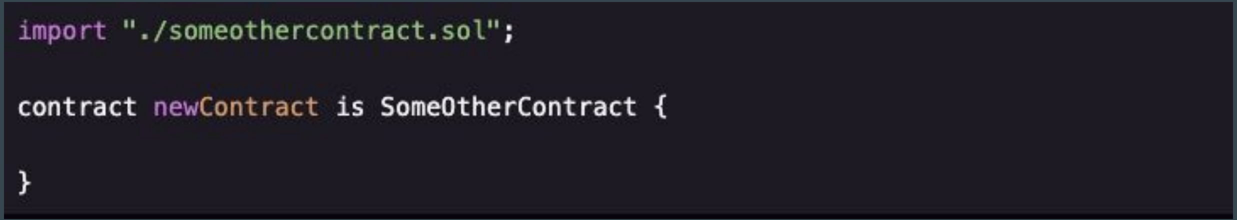
```
function sayHiToVitalik(string memory _name) public returns (string memory) {
  // Compares if _name equals "Vitalik". Throws an error and exits if not true.
  // (Side note: Solidity doesn't have native string comparison, so we
  // compare their keccak256 hashes to see if the strings are equal)
  require(keccak256(abi.encodePacked(_name)) == keccak256(abi.encodePacked("Vita
  // If it's true, proceed with the function:
  return "Hi!";
}
```

## Inheritance

- Contracts can inherit from other contracts (contract inheritance)
- Only public functions can be inherited.



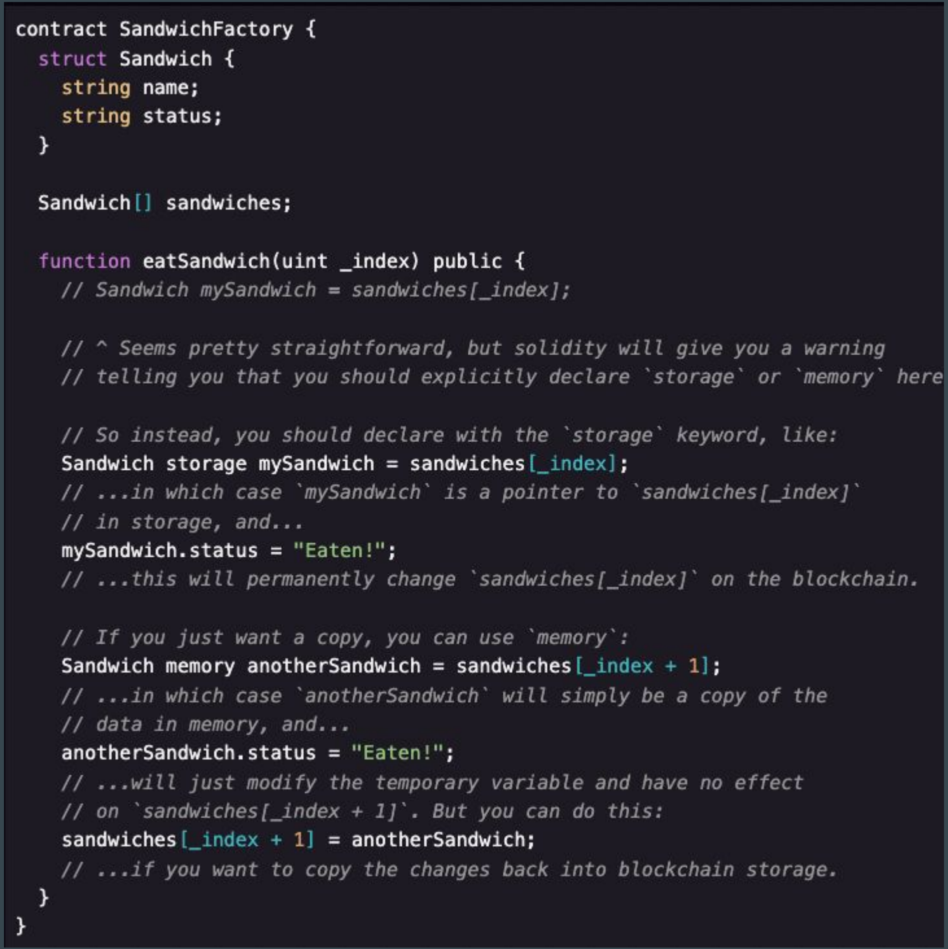
```
contract Doge {
  function catchphrase() public returns (string memory) {
    return "So Wow CryptoDoge";
  }
}

contract BabyDoge is Doge {
  function anotherCatchphrase() public returns (string memory) {
    return "Such Moon BabyDoge";
  }
}
```



```
import "./someothercontract.sol";

contract newContract is SomeOtherContract {

}
```

# Storage vs. Memory

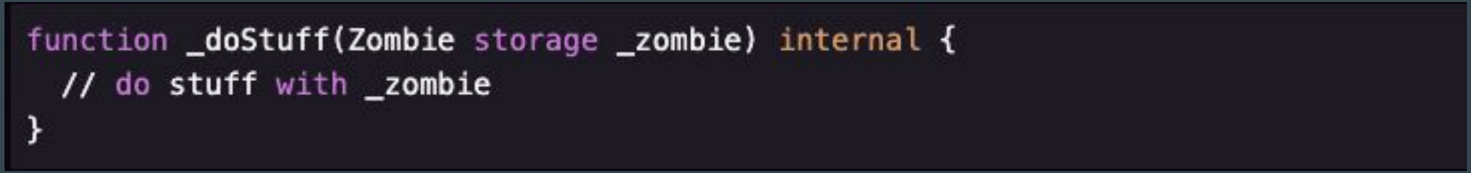
- Storage variables are stored on the blockchain (data is saved between function calls)
- Memory variables are temporary, and are erased between external function calls to your contract
- State variables are storage by default
- Variables declared inside functions are memory variables, and disappear when the function call ends.
- These keywords are important for handling structs and arrays within functions.



```
contract SandwichFactory {
  struct Sandwich {
    string name;
    string status;
  }

  Sandwich[] sandwiches;

  function eatSandwich(uint _index) public {
    // Sandwich mySandwich = sandwiches[_index];

    // ^ Seems pretty straightforward, but solidity will give you a warning
    // telling you that you should explicitly declare `storage` or `memory` here

    // So instead, you should declare with the `storage` keyword, like:
    Sandwich storage mySandwich = sandwiches[_index];
    // ...in which case `mySandwich` is a pointer to `sandwiches[_index]`
    // in storage, and...
    mySandwich.status = "Eaten!";
    // ...this will permanently change `sandwiches[_index]` on the blockchain.

    // If you just want a copy, you can use `memory`:
    Sandwich memory anotherSandwich = sandwiches[_index + 1];
    // ...in which case `anotherSandwich` will simply be a copy of the
    // data in memory, and...
    anotherSandwich.status = "Eaten!";
    // ...will just modify the temporary variable and have no effect
    // on `sandwiches[_index + 1]`. But you can do this:
    sandwiches[_index + 1] = anotherSandwich;
    // ...if you want to copy the changes back into blockchain storage.
  }
}
```

## Storage

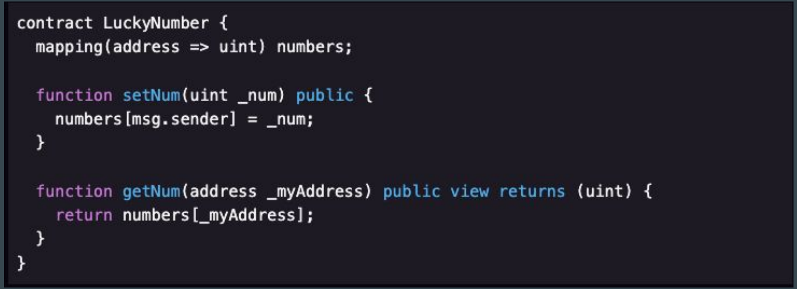
- You can pass structs as arguments to private or internal functions with the storage keyword.
- Sort of like a pointer to something on the Heap in java



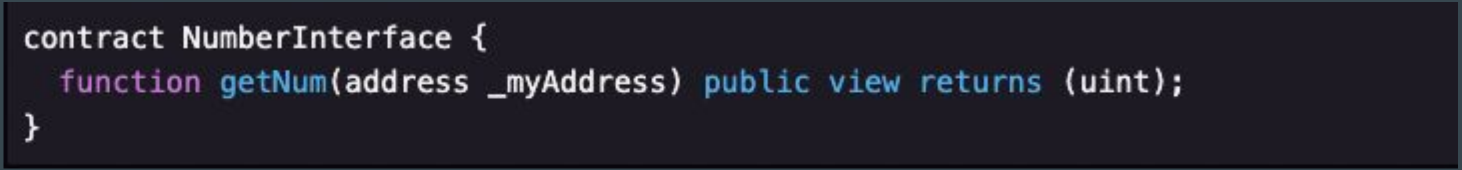
```
function _doStuff(Zombie storage _zombie) internal {
  // do stuff with _zombie
}
```

## Interfacing with other contracts

- Suppose we want our contract to talk to another contract on the blockchain that we don't own. To do this we need to define an interface.
- In an interface, we declare functions we want to interact with.
  - No state variables or function bodies
- Our contract now knows what the other contracts functions look like, how to call them, and what response to expect

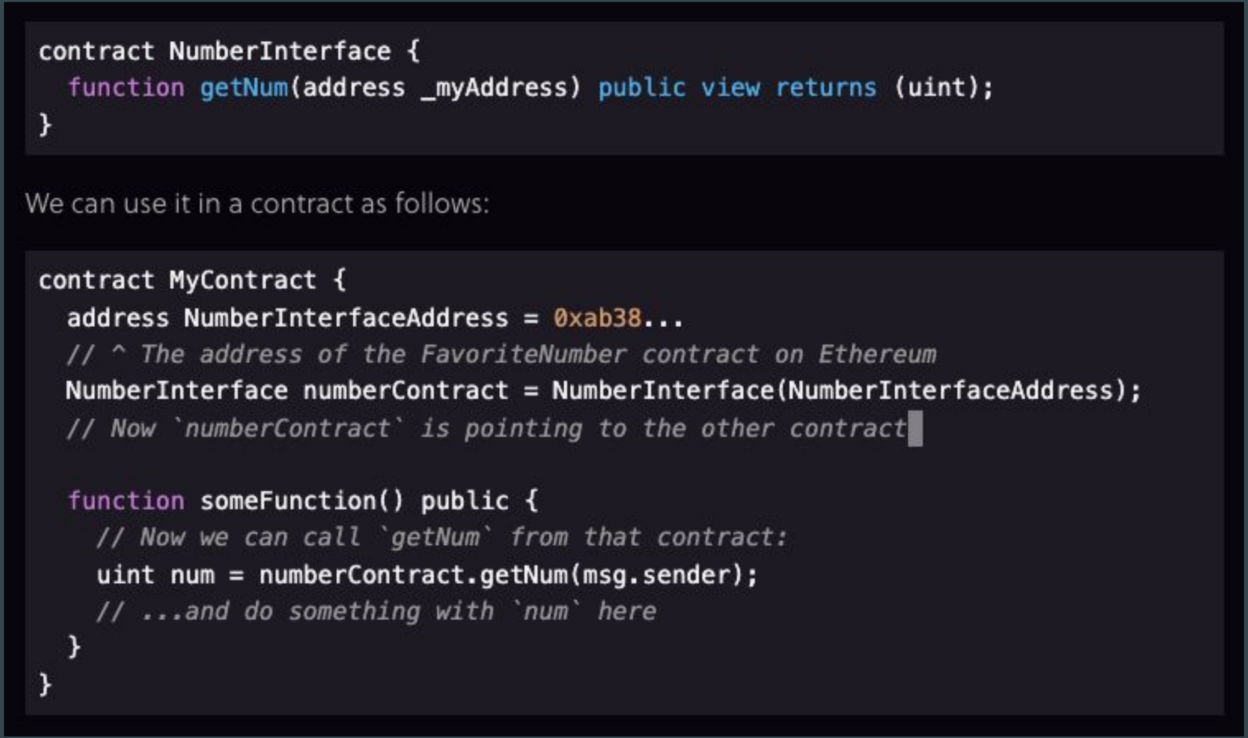


```
contract LuckyNumber {
  mapping(address => uint) numbers;

  function setNum(uint _num) public {
    numbers[msg.sender] = _num;
  }

  function getNum(address _myAddress) public view returns (uint) {
    return numbers[_myAddress];
  }
}
```



```
contract NumberInterface {
  function getNum(address _myAddress) public view returns (uint);
}
```

## Using an Interface



```
contract NumberInterface {
  function getNum(address _myAddress) public view returns (uint);
}
```

We can use it in a contract as follows:

```
contract MyContract {
  address NumberInterfaceAddress = 0xab38...
  // ^ The address of the FavoriteNumber contract on Ethereum
  NumberInterface numberContract = NumberInterface(NumberInterfaceAddress);
  // Now `numberContract` is pointing to the other contract

  function someFunction() public {
    // Now we can call `getNum` from that contract:
    uint num = numberContract.getNum(msg.sender);
    // ...and do something with `num` here
  }
}
```

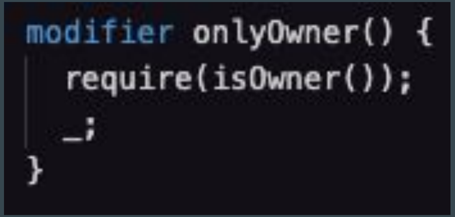
## Immutability

- Ethereum dApps are far different than other applications we see on a daily basis
- After you deploy a contract to Ethereum, it becomes immutable
  - It can never be modified or updated again
- If there's a flaw in your contract code, there's no way for you to patch it later
  - You would have to tell your users to start using a different smart contract address that has the fix
- In order to solve this, it becomes common practice to rely on external dependencies
  - I.E. Use functions with external modifier in order to update key information about your dApp.
  - This can allow you to save your DApp in certain situations

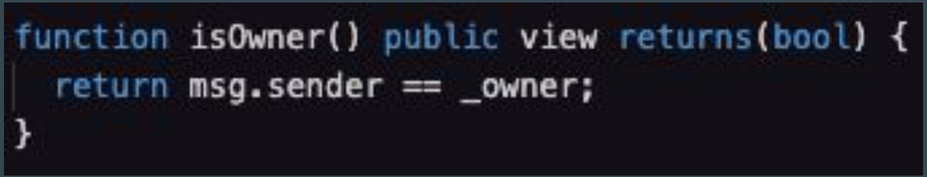
## Contract Ownership

- Solidity offers features of Ownership to allow certain addresses to call functions
- If we want to call a function that only the owner can access, we would need to have specific modifiers in place to ensure this
- OpenZeppelin is an open-source platform for building secure dApps. The framework provides the required tools to create and automate Web3 applications
  - A lot of people will begin their DApp by importing OpenZeppelin’s ownable.sol file
    - Contains everything that is needed to transfer, renounce, and check for ownership

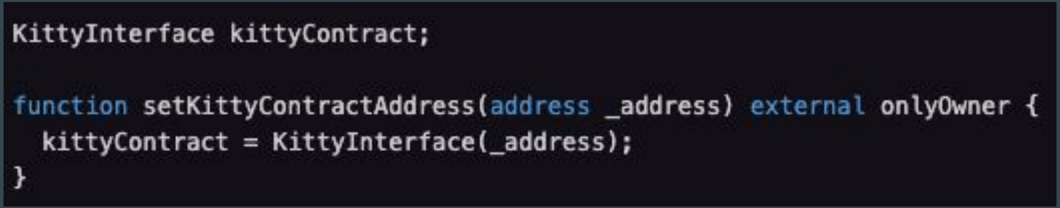
# OpenZeppelin's onlyOwner Modifier



```
modifier onlyOwner() {
  require(isOwner());
  _;
}
```



```
function isOwner() public view returns(bool) {
  return msg.sender == _owner;
}
```



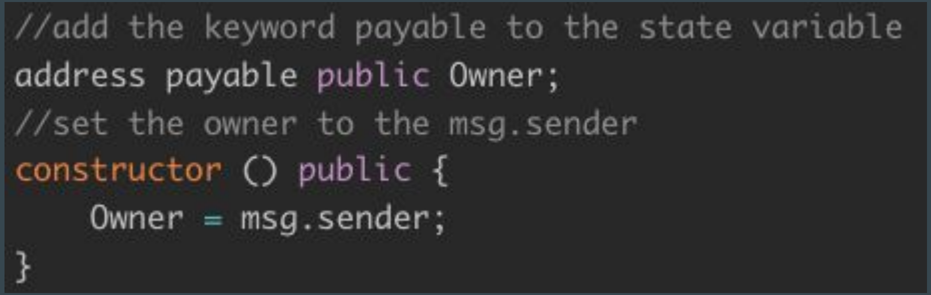
```
KittyInterface kittyContract;

function setKittyContractAddress(address _address) external onlyOwner {
  kittyContract = KittyInterface(_address);
}
```

## Time Units

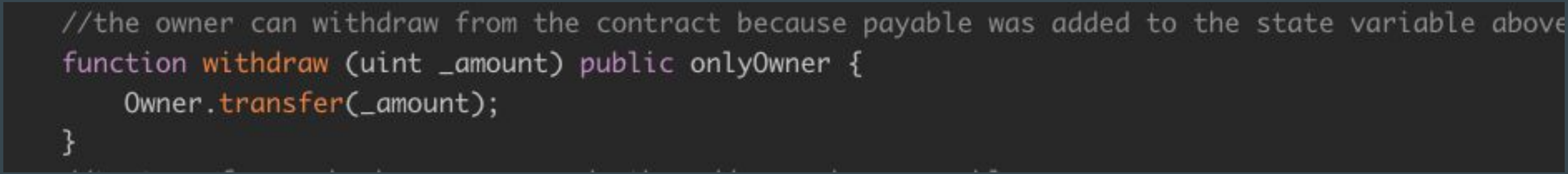
- Solidity provides some native units for dealing with time.
- The global variable **now** will return the current unix (Epoch) timestamp of the latest block
  - the number of seconds that have passed since January 1st, 1970
  - Note: There isn't any difference between block.timestamp and now. But, in Solidity v0.7.0, the now keyword has been deprecated.
- Solidity also contains the time units seconds, minutes, hours, days, weeks and years
  - These will convert to a uint of the number of seconds in that length of time
    - 1 hour -> 60
    - 1 day -> 86400 (24 hours x 60 minutes x 60 seconds)

## Payable

- **payable** is a modifier that can be added to a function or variable
  - ensures that the function/variable can send and receive Ether
- It can process transactions with non-zero Ether values and rejects any transactions with a zero Ether value



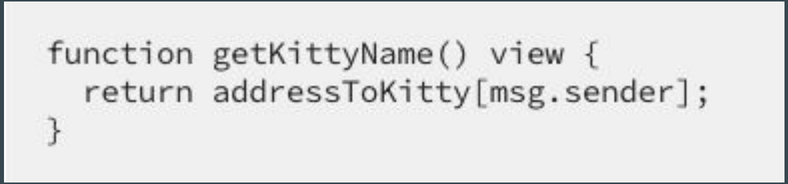
```
//add the keyword payable to the state variable
address payable public Owner;
//set the owner to the msg.sender
constructor () public {
    Owner = msg.sender;
}
```



```
//the owner can withdraw from the contract because payable was added to the state variable above
function withdraw (uint _amount) public onlyOwner {
    Owner.transfer(_amount);
}
```

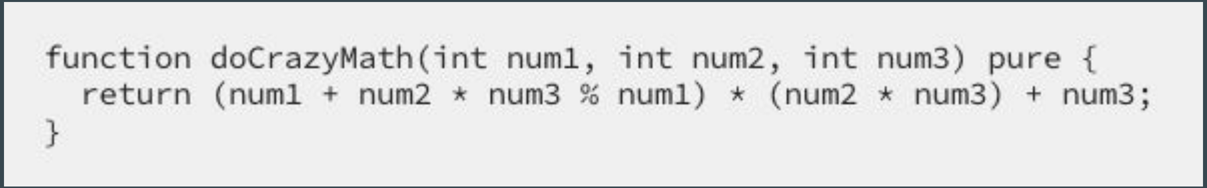
## View and pure

- **view** keyword simply means “this function is read-only”
- They do not cost much to execute since they are not attempting to add anything to the blockchain



```
function getKittyName() view {
  return addressToKitty[msg.sender];
}
```

- **pure** keyword means that it returns a value using only the parameters of the function without any side effects



```
function doCrazyMath(int num1, int num2, int num3) pure {
  return (num1 + num2 * num3 % num1) * (num2 * num3) + num3;
}
```

## Gas Fees when coding

- Gas is an execution fee used to compensate miners for the computational resources required to power smart contracts.
- When coding up smart contracts, it's crucial to write the most efficient code possible. Why?
- Gas-saving patterns:
  - Short-circuiting
  - Library use
  - Explicit function visibility
  - Proper data types

## OpenZeppelin - Smart Contract Library

- A library of modular, reusable, secure smart contracts for the Ethereum network, written in Solidity.
- The contracts are completely modular and reusable and contain the most used implementations of ERC standards.
- This means that the companies do not need to develop security features and tools for smart contracts.
- Popular libraries:
  - Payment: Provides payment-related utilities.
  - Token: Provides the most popular ERC token utilities.
  - Utils: Provides miscellaneous smart contract utility functions.
  - SafeMath: Math operations on solidity

## ERC721 and Minting

- ERC20 – A fungible token standard that follows EIP-20, such as fiat currencies.
- ERC721 – Is an NFT token standard that follows EIP-721.
- ERC1155 – Represents both fungible and non-fungible tokens. It is known as a multi-token contract and follows EIP-1155.
- ERC-721 is another token standard that allows you to mint NFTs.
- Minting an NFT refers to converting digital files into crypto collections or digital assets stored on the blockchain.
- If you sell an NFT through a marketplace like OpenSea, OpenSea will automatically mint your NFT using the ERC-721 (or ERC-1155) NFT token contract.

## OpenZeppelin - ERC721 Token

NFT Creation