







Supply Chain Review

- Supply chain app
 - Framework that connects producers to consumers
 - Manages products and services along that journey
- Blockchain advantages
 - Reduce costs
 - Offer transparency



Supply Chain Design – Process Needs

- Assets
 - The product to be bought by the consumer
- Participants
 - All supply chain participants
 - Manufacturers, suppliers, shippers, consumers



Supply Chain Design – Process Needs

- Ownership structure
 - Which participant currently owns the product
 - Tracks the product
- Payment token
 - Participants pay each other with tokens as ownership changes



Supply Chain Design - Capabilities

- Initialize tokens
 - Establish initial pool of payment tokens
- Transfer tokens
 - Move tokens between accounts as payment
- Authorize token payments
 - Allow token transfers on behalf on another



Supply Chain Design - Capabilities

- Add and update participants
- Move products along the supply chain
 - Transfer product ownership
- Add and update products
- Track an asset
 - Where a product is today
 - Find product provenance (ownership)







- Advantages to decentralized apps (dApps)
 - Automatic history tracking
 - Built-in fault tolerance
 - Trusted data



- Before developing
 - Know what your dApp does
 - Know your goals and how you plan to achieve them
 - Understand why the Ethereum blockchain environment is best

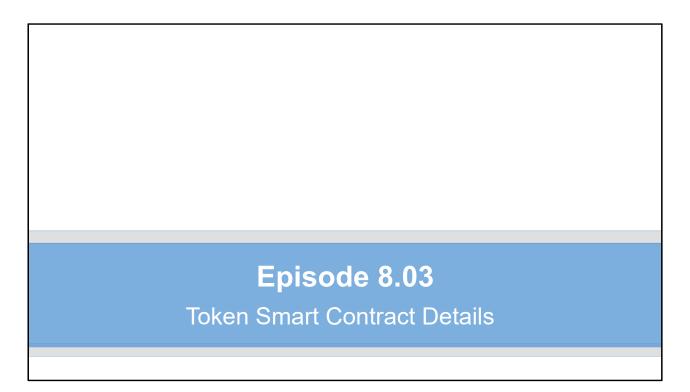


- Allow users to access data stored on the blockchain
 - Unlike "normal" applications, you can't bypass integrity protections



- Understand cost of interacting with the blockchain
- Smart contracts provide the interface between users and the blockchain
 - Making dApps possible







Payment Token Smart Contract Data Items

- totSupply
 - Total number of tokens in circulation
- name
 - Descriptive token name
- decimals
 - Number of decimals to use when displaying token amounts



- •symbol
 - Short identifier
- balances
 - Current balance of each participating account, mapped to the account's address
- allowed
 - Number of tokens authorized to transfer between accounts, mapped to sender's address



Payment Token Smart Contract Functions

- •totalSupply()
 - Returns current total number of tokens
- •balanceOf()
 - Returns current balance of specified account
- •allowance()
 - Returns remaining number of tokens allowed to be transferred from one specific account to another specific account



Payment Token Smart Contract Functions

- •transfer()
 - Transfers tokens from the owner to specified target account
- •transferFrom()
 - Transfers tokens from one specific account to another specific account
- approve()
 - Maximum allowed tokens that can be transferred from one specific account to another specific account







Supply Chain Smart Contract

- Data and functionality to manage products, participants, ownership transfer data
- Everything else except payment



Supply Chain Smart Contract Data Structures

- Product structure
 - Ex: model number, part number, cost, etc.
 - Data that defines a unique product
- Participant structure
 - Data that defines a unique participant
 - Ex: username, password, Ethereum address, etc.



Supply Chain Smart Contract Data Structures

- Ownership structure
 - Data that records product ownership transfer information
 - Ex: product ID, owner ID, transaction time, etc.



Supply Chain Smart Contract Data Variables

- •product id
 - Unique product ID, mapped to product structure
- •participant_id
 - Unique participant ID, mapped to participant structure
- •owner_id
 - Unique owner, mapped to registration structure



Supply Chain Smart Contract Functions

- addParticipant()
 - Create new participant
- •getParticipant()
 - Fetch information about a participant
- addProduct()
 - Create new product
- •getProduct()
 - Fetch information about a particular product



Supply Chain Smart Contract Functions

- •newOwner()
 - Transfer of ownership
- •getProvenance()
 - Record of ownership
- •getOwnership()
 - Owner of a product in a specific point in time
- authenticateParticipant()
 - Confirms participant is allowed to access certain data







Your Smart Contract Road Map

	Payment Token Smart Contract	Supply Chain Smart Contract
Data Items	totSupplynamedecimalssymbolbalancesallowed	 Product structure product_id Participant structure participant_id Ownership structure owner_id
Functions	 totalSupply() balanceOf() allowance() transfer() transferFrom() approve() 	 addParticipant() getParticipant() addProduct() getProduct() newOwner() getProvenance() getOwnership() authenticateParticipant()







• ERC-20 Token Interface Code

```
// ERC Token Standard #20 Interface
// https://github.com/ethereum/EIPs/blob/master/EIPS/eip-20.md
pragma solidity >=0.4.21 <0.6.0;</pre>
contract ERC20Interface {
   uint256 public totSupply;
   function totalSupply() public view returns (uint);
   function balanceOf(address tokenOwner) public view returns (uint balance);
   function allowance(address tokenOwner, address spender) public view returns (uint
remaining);
   function transfer(address to, uint tokens) public returns (bool success);
   function approve(address spender, uint tokens) public returns (bool success);
   function transferFrom(address from, address to, uint tokens) public returns (bool
success);
   event Transfer(address indexed from, address indexed to, uint tokens);
   event Approval(address indexed tokenOwner, address indexed spender, uint tokens);
}
```







Interface

- An agreement
- In order to base your smart contract on an interface, you must follow standards
- Minimum requirements to fit the standard



• ERC-20 Token Code, Part 1





```
// Transfer tokens from msg.sender to a specified address
function transfer(address _to, uint256 _value) public returns (bool success) {
    require(balances[msg.sender] >= _value, "Insufficient funds for transfer source.");
    balances[msg.sender] -= _value;
    balances[to] += _value;
    emit Transfer(msg.sender, _to, _value); //solhint-disable-line indent, no-unused-vars
    return true;
}

// Transfer tokens from one specified address to another specified address
function transferFrom(address _from, address _to, uint256 _value) public returns (bool success) {
    uint256 allowance = allowed[_from][msg.sender];
    require(balances[_from] >= _value && allowance >= _value, "Insufficient allowed funds for transfer source.");
    balances[_to] += _value;
    balances[_to] += _value;
    if (allowance < MAX_UINT250 {
        allowed[_from][msg.sender] -= _value;
    }
    emit Transfer(_from, _to, _value); //solhint-disable-line indent, no-unused-vars
    return true;
}</pre>
```



• ERC-20 Token Code, Part 4

```
// Return the current balance (in tokens) of a specified address
   function balanceOf(address _owner) public view returns (uint256 balance) {
        return balances[_owner];
   }

  // Set
   function approve(address _spender, uint256 _value) public returns (bool success) {
        allowed[msg.sender][_spender] = _value;
        emit Approval(msg.sender, _spender, _value); //solhint-disable-line indent, no-
unused-vars
        return true;
   }

// Return the
   function allowance(address _owner, address _spender) public view returns (uint256
remaining) {
        return allowed[_owner][_spender];
   }

// Return the total number of tokens in circulation
   function totalSupply() public view returns (uint256 totSupp) {
        return totSupply;
   }
}
```









```
mapping(uint32 => product) public products;

struct participant {
    string userName;
    string parsword;
    string participantAddress;
}
mapping(uint32 => participant) public participants;

struct ownership {
    uint32 productId;
    uint32 productId;
    uint32 vownerId;
    uint32 trx!meStamp;
    address productOwner;
}
mapping(uint32 => ownership) public ownerships; // ownerships by ownership ID (owner_id)
mapping(uint32 => uint32[]) public productTrack; // ownerships by Product ID (product_id) / Movement track for a product
```











```
else if(keccak256(abi.encodePacked(p1.participantType)) == keccak256("Supplier") &&
keccak256(abi.encodePacked(p2.participantType))==keccak256("Consumer")){
    ownerships[ownership_id].productId = _prodId;
    ownerships[ownership_id].productOwner = p2.participantAddress;
    ownerships[ownership_id].ownerslip_id].trxTimeStamp = uint32(now);
    product[_prodId].productOwner = p2.participantAddress;
    productTrack[_prodId].push(ownership_id);
    emit TransferOwnership(_prodId);
    return (true);
}

return (false);
}

function getProvenance(uint32 _prodId) external view returns (uint32[] memory) {
    return productTrack[_prodId];
}
```









- Supply Chain Smart Contract Data Code
 - Code can be found in episode 8.08 Supply Chain Smart Contract Data Lab, Part 1
 - Code can also be downloaded from accompanying files, sourceCode > supplyChainApp > contracts > SupplyChain.sol







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 - Code can be found in episode 8.07 Token Smart Contract Data Lab, Part 1
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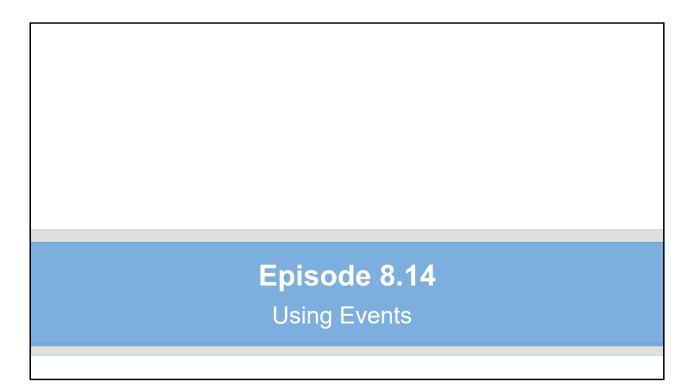






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Smart Contract Issues

- Smart contracts run on each EVM
- Smart contracts are essentially server-side code
 - Smart contracts execute on blockchain nodes, not on the client
 - Issue: communication with client
 - Smart contracts must be called by the client or another smart contract



Server-Side Code

- Server-side code simply listens for requests from clients
- When a request is received, the server-side code responds
- All requests originate with the client



Implementing Events in Solidity

- 1. Define the event
 - Give it a name
 - Define what happens when the event occurs
 - · What type of data is going to be sent with the event
- 2. Trigger the events
 - Smart contract code that detects when an event occurs
 - Use emit statement
- 3. Client receives and responds to the events







Step 1: Define the Events

- ERC-20 token interface
 - Transfer event
 - Approval event
- Supply chain smart contract
 - Transfer of ownership



Step 2: Trigger the Events

- Use emit in Solidity to trigger an event
 - Like calling a function
 - Tell Solidity what event to trigger, provide parameter values







Ownership

- Every action has an owner
- Blockchain apps can be "anonymous"
 - Hard to associate account with real-world identity
- Every time you invoke smart contract functions, owner address is associated
 - Nonrepudiation every action can be attributed to an account



Ownership

- Might want to provide functionality with higher authority and more capability
- Owner is the address of whoever called the function
 - msg.sender is the owner
- Can restrict functionality (or ability to call a function) based on ownership



Modifiers

- Help restrict access for external entities
 - Add-on functionality to make sure things occur







Smart Contract Security

- Smart contracts can be as insecure as any other software
- Must consider security in data and functionality of your design
- Use multi-level security approach
 - Defense in depth



- Randomness
 - Smart contract code must run the same on all EVMs
 - If random number is generated locally, could create different output on different EVMs
 - Avoid random numbers, especially for blockchainrelated data



- Re-entrancy
 - Call function forwards all received gas to the called function
 - Can cause multiple withdrawals
 - Like allowing someone to use one check to withdraw money from your account multiple times
 - Update state data before transferring control to another function



- Overflow
 - Variable that has incremented larger than what is allowed for the stated variable
 - Ex: you defined a uint8 but the value was larger than 8 bits (255 characters)
- Underflow
 - Variable that has decremented to a value not allowed by stated variable
 - Ex: a value that tries to decrement to a negative number, but is an unsigned integer (uint)



- delegate-call function
 - Allows one smart contract to execute a function from another smart contract
 - Causes confusion with who invoked a function
 - Don't allow public/external functions to modify state data
 - Call a local function if public/external functions need to modify state data







Minimal Functionality

- These examples are for instruction
- Only implements basic functionality
- Fully-featured smart contracts are complex
- Coding starts with minimal functionality, then begin building more
- If you create a live smart contract, add more functionality

