ETHEREUM PET SHOP

This series of tutorials will take you through building your first dapp—an adoption tracking system for a pet shop!

This tutorial is meant for those with a basic knowledge of Ethereum and smart contracts, who have some knowledge of HTML and JavaScript, but who are new to dapps.

Note: For Ethereum basics, please read the Truffle Ethereum Overview (/tutorials/ethereum-overview) tutorial before proceeding.

In this tutorial we will be covering:

- Setting up the development environment
- Creating a Truffle project using a Truffle Box
- Writing the smart contract
- Compiling and migrating the smart contract
- Testing the smart contract
- Creating a user interface to interact with the smart contract
- Interacting with the dapp in a browser

Background

Pete Scandlon of Pete's Pet Shop is interested in using Ethereum as an efficient way to handle their pet adoptions. The store has space for 16 pets at a given time, and they already have a database of pets. As an initial proof of concept, **Pete wants to see a dapp which associates an Ethereum address with a pet to be adopted.**

The website structure and styling will be supplied. **Our job is to write the smart contract and front-end logic for its usage.**

Setting up the development environment

There are a few technical requirements before we start. Please install the following:

- Node.js v6+ LTS and npm (comes with Node) (https://nodejs.org/en/)
- Git (https://git-scm.com/)

Once we have those installed, we only need one command to install Truffle:

```
npm install -g truffle
```

To verify that Truffle is installed properly, type `truffle version` on a terminal. If you see an error, make sure that your npm modules are added to your path.

Creating a Truffle project using a Truffle Box

1. Truffle initializes in the current directory, so first create a directory in your development folder of choice and then moving inside it.

```
mkdir pet-shop-tutorial

cd pet-shop-tutorial
```

2. We've created a special Truffle Box (/boxes) just for this tutorial called `pet-shop`, which includes the basic project structure as well as code for the user interface. Use the `truffle unbox` command to unpack this Truffle Box.

```
truffle unbox pet-shop
```

Note: Truffle can be initialized a few different ways. Another useful initialization command is `truffle init`, which creates an empty Truffle project with no example contracts included. For more information, please see the documentation on Creating a project (/docs/getting_started/project).

Directory structure

The default Truffle directory structure contains the following:

- `contracts/`: Contains the Solidity (https://solidity.readthedocs.io/) source files for our smart contracts. There is an important contract in here called `Migrations.sol`, which we'll talk about later.
- `migrations/`: Truffle uses a migration system to handle smart contract deployments. A migration is an additional special smart contract that keeps track of changes.
- `test/`: Contains both JavaScript and Solidity tests for our smart contracts
- `truffle.js`: Truffle configuration file

The `pet-shop` Truffle Box has extra files and folders in it, but we won't worry about those just yet.

Writing the smart contract

We'll start our dapp by writing the smart contract that acts as the back-end logic and storage.

1. Create a new file named `Adoption.sol` in the `contracts/` directory.
2. Add the following content to the file:

```
pragma solidity ^0.4.4;

contract Adoption {

}
```

Things to notice:

- The minimum version of Solidity required is noted at the top of the contract: `pragma solidity ^0.4.4;`. The `pragma` command means "*additional information that only the compiler cares about*", while the caret symbol (^) means "*the version indicated or higher*".
- Like JavaScript or PHP, statements are terminated with semicolons.

Variable setup

Solidity is a statically-typed language, meaning data types like strings, integers, and arrays must be defined. **Solidity has a unique type called an address**. Addresses are Ethereum addresses, stored as 20 byte values. Every account and smart contract on the Ethereum blockchain has an address and can send and receive Ether to and from this address.

1. Add the following variable on the next line after `contract Adoption {`.

```
address[16] public adopters;
```

Things to notice:

- We've defined a single variable: `adopters`. This is an **array** of Ethereum addresses. Arrays contain one type and can have a fixed or variable length. In this case the type is `address` and the length is `16`.
- You'll also notice `adopters` is public. **Public** variables have automatic getter methods, but in the case of arrays a key is required and will only return a single value. Later, we'll write a function to return the whole array for use in our UI.

Your first function: Adopting a pet

Let's allow users to make adoption requests.

1. Add the following function to the smart contract after the variable declaration we set up above.

```
// Adopting a pet
function adopt(uint petId) public returns (uint) {
  require(petId >= 0 && petId <= 15);

  adopters[petId] = msg.sender;

  return petId;
}
```

Things to notice:

- In Solidity the types of both the function parameters and output must be specified. In this case we'll be taking in a `petId` (integer) and returning an integer.

- We are checking to make sure `petId` is in range of our `adopters` array. Arrays in Solidity are indexed from 0, so the ID value will need to be between 0 and 15. We use the `require()` statement to ensure the the ID is within range.
- If the ID is in range, we then add the address that made the call to our `adopters` array. **The address of the person or smart contract who called this function is denoted by `msg.sender`**.
- Finally, we return the `petId` provided as a confirmation.

Your second function: Retrieving the adopters

As mentioned above, array getters return only a single value from a given key. Our UI needs to update all pet adoption statuses, but making 16 API calls is not ideal. So our next step is to write a function to return the entire array.

1. Add the following `getAdopters()` function to the smart contract, after the `adopt()` function we added above:

```
// Retrieving the adopters
function getAdopters() public returns (address[16]) {
  return adopters;
}
```

Since `adopters` is already declared, we can simply return it. Be sure to specify the return type (in this case, the type for `adopters`) as `address[16]`.

Compiling and migrating the smart contract

Now that we have written our smart contract, the next steps are to compile and migrate it.

Truffle has a built-in developer console, which we call Truffle Develop, which generates a development blockchain that we can use to test deploy contracts. It also has the ability to run Truffle commands directly from the console. We will use Truffle Develop to perform most of the actions on our contract in this tutorial.

Compilation

Solidity is a compiled language, meaning we need to compile our Solidity to bytecode for the Ethereum Virtual Machine (EVM) to execute. Think of it as translating our human-readable Solidity into something the EVM understands.

1. Launch Truffle Develop. Make sure you are in the directory that contains the dapp.

```
truffle develop
```

You will see a prompt that shows that you are now in Truffle Develop. All commands will be run from this console unless otherwise stated.

```
truffle(develop)>
```

Note: If you're on Windows and encountering problems running this command, please see the documentation on resolving naming conflicts on Windows (/docs/advanced/configuration#resolving-naming-conflicts-on-windows).

2. Compile the dapp:

```
compile
```

You should see output similar to the following:

```
Compiling ./contracts/Migrations.sol...
Compiling ./contracts/Adoption.sol...
Writing artifacts to ./build/contracts
```

Note: If you're not using Truffle Develop, these commands can be used on your terminal by prefixing them with `truffle`. As in, to compile, run `truffle compile` on a terminal.

However, if you're not using Truffle Develop, you'll have to use another test blockchain such as the TestRPC (https://github.com/ethereumjs/testrpc).

Migration

Now that we've successfully compiled our contracts, it's time to migrate them to the blockchain!

A migration is a deployment script meant to alter the state of your application's contracts, moving it from one state to the next. For the first migration, you might just be deploying new code, but over time, other migrations might move data around or replace a contract with a new one.

> **Note**: Read more about migrations (docs/getting_started/migrations) in the Truffle documentation.

You'll see one JavaScript file already in the `migrations/` directory: `1_initial_migration.js`. This handles deploying the `Migrations.sol` contract to observe subsequent smart contract migrations, and ensures we don't double-migrate unchanged contracts in the future.

Now we are ready to create our own migration script.

1. Create a new file named `2_deploy_contracts.js` in the `migrations/` directory.
2. Add the following content to the `2_deploy_contracts.js` file:

```
var Adoption = artifacts.require("Adoption");

module.exports = function(deployer) {
  deployer.deploy(Adoption);
};
```

3. Back in our console, migrate the contract to the blockchain.

```
migrate
```

You should see output similar to the following:

```
Using network 'develop'.

Running migration: 1_initial_migration.js
  Deploying Migrations...
  Migrations: 0x75175eb116b36ff5fef15ebd15cbab01b50b50d1
Saving successful migration to network...
Saving artifacts...
Running migration: 2_deploy_contracts.js
  Deploying Adoption...
  Adoption: 0xb9f485451a945e65e48d9dd7fc5d759af0a89e21
Saving successful migration to network...
Saving artifacts...
```

You can see the migrations being executed in order, followed by the blockchain address of each deployed contract. (Your addresses will differ.)

You've now written your first smart contract and deployed it to a locally running test blockchain. It's time to interact with our smart contract now to make sure it does what we want.

Testing the smart contract

Truffle is very flexible when it comes to smart contract testing, in that tests can be written either in JavaScript or Solidity. In this tutorial, we'll be writing our tests in Solidity.

1. Create a new file named `TestAdoption.sol` in the `test/` directory.
2. Add the following content to the `TestAdoption.sol` file:

```
pragma solidity ^0.4.11;

import "truffle/Assert.sol";
import "truffle/DeployedAddresses.sol";
import "../contracts/Adoption.sol";

contract TestAdoption {
  Adoption adoption = Adoption(DeployedAddresses.Adoption());

}
```

We start the contract off with 3 imports:

- `Assert.sol` : Gives us various assertions to use in our tests. In testing, **an assertion checks for things like equality, inequality or emptiness to return a pass/fail** from our test. Here's a full list of the assertions included with Truffle (https://github.com/trufflesuite/truffle-core/blob/master/lib/testing/Assert.sol).
- `DeployedAddresses.sol` : When running tests, Truffle will deploy a fresh instance of the contract being tested to the TestRPC. This smart contract gets the address of the deployed contract.
- `Adoption.sol` : The smart contract we want to test.

Note: The first two imports are referring to global Truffle files, not a `truffle` directory. You should not see a `truffle` directory inside your `test/` directory.

Then we define a contract-wide variable containing the smart contract to be tested, calling the `DeployedAddresses` smart contract to get its address.

Testing the adopt() function

To test the `adopt()` function, recall that upon success it returns the given `petId`. We can ensure an ID was returned and that it's correct by comparing the return value of `adopt()` to the ID we passed in.

1. Add the following function within the `TestAdoption.sol` smart contract, after the declaration of `Adoption`:

```
// Testing the adopt() function
function testUserCanAdoptPet() {
  uint returnedId = adoption.adopt(8);

  uint expected = 8;

  Assert.equal(returnedId, expected, "Adoption of pet ID 8 should be
}
```

Things to notice:

- We call the smart contract we declared earlier with the ID of `8`.
- We then declare an expected value of `8` as well.
- Finally, we pass the actual value, the expected value and a failure message (which gets printed to the console if the test does not pass) to `Assert.equal()`.

Testing retrieval of a single pet's owner

Remembering from above that public variables have automatic getter methods, we can retrieve the address stored by our adoption test above. Stored data will persist for the duration of our tests, so our adoption of pet `8` above can be retrieved by other tests.

1. Add this function below the previously added function in `TestAdoption.sol`.

```
// Testing retrieval of a single pet's owner
function testGetAdopterAddressByPetId() {
  // Expected owner is this contract
  address expected = this;

  address adopter = adoption.adopters(8);

  Assert.equal(adopter, expected, "Owner of pet ID 8 should be record
}
```

Since the TestAdoption contract will be sending the transaction, we set the expected value to **this**, a contract-wide variable that gets the current contract's address. From there we assert equality as we did above.

Testing retrieval of all pet owners

Since arrays can only return a single value given a single key, we create our own getter for the entire array.

1. Add this function below the previously added function in `TestAdoption.sol`.

```
// Testing retrieval of all pet owners
function testGetAdopterAddressByPetIdInArray() {
  // Expected owner is this contract
  address expected = this;

  // Store adopters in memory rather than contract's storage
  address[16] memory adopters = adoption.getAdopters();

  Assert.equal(adopters[8], expected, "Owner of pet ID 8 should be re
}
```

Note the **memory** attribute on `adopters`. The memory attribute tells Solidity to temporarily store the value in memory, rather than saving it to the contract's storage. Since `adopters` is an array, and we know from the first adoption test that we adopted pet `8`, we compare the testing contracts address with location `8` in the array.

Running the tests

1. Back in Truffle Develop, run the tests:

```
test
```

2. If all the tests pass, you'll see console output similar to this:

```
Using network 'develop'.

Compiling ./contracts/Adoption.sol...
Compiling ./test/TestAdoption.sol...
Compiling truffle/Assert.sol...
Compiling truffle/DeployedAddresses.sol...

  TestAdoption
    ✓ testUserCanAdoptPet (91ms)
    ✓ testGetAdopterAddressByPetId (70ms)
    ✓ testGetAdopterAddressByPetIdInArray (89ms)


  3 passing (670ms)
```

Creating a user interface to interact with the smart contract

Now that we've created the smart contract, deployed it to our local test blockchain and confirmed we can interact with it via the console, it's time to create a UI so that Pete has something to use for his pet shop!

Included with the `pet-shop` Truffle Box was code for the app's front-end. That code exists within the `src/` directory.

The front-end doesn't use a build system (webpack, grunt, etc.) to be as easy as possible to get started. The structure of the app is already there; we'll be filling in the functions which are unique to Ethereum. This way, you can take this knowledge and apply it to your own front-end development.

Instantiating web3

1. Open `/src/js/app.js` in a text editor.

2. Examine the file. Note that there is a global `App` object to manage our application, load in the pet data in `init()` and then call the function `initWeb3()`. The web3 JavaScript library (https://github.com/ethereum/web3.js/) interacts with the Ethereum blockchain. It can retrieve user accounts, send transactions, interact with smart contracts, and more.

3. Remove the multi-line comment from within `initWeb3` and replace it with the following:

```
// Is there is an injected web3 instance?
if (typeof web3 !== 'undefined') {
  App.web3Provider = web3.currentProvider;
} else {
  // If no injected web3 instance is detected, fallback to the TestRP
  App.web3Provider = new Web3.providers.HttpProvider('http://localhos
}
web3 = new Web3(App.web3Provider);
```

Things to notice:

- First, we check if there's a web3 instance already active. (Ethereum browsers like Mist (https://github.com/ethereum/mist) or Chrome with the MetaMask (https://metamask.io/) extension will inject their own web3 instances.) If an injected web3 instance is present, we get its provider and use it to create our web3 object.
- If no injected web3 instance is present, we create our web3 object based on our local provider. (This fallback is fine for development environments, but insecure and not suitable for production.)

Instantiating the contract

Now that we can interact with Ethereum via web3, we need to instantiate our smart contract so web3 knows where to find it and how it works. Truffle has a library to help with this called `truffle-contract`. It keeps information about the contract in sync with migrations, so you don't need to change the contract's deployed address manually.

1. Still in `/src/js/app.js`, remove the multi-line comment from within `initContract` and replace it with the following:

```
$.getJSON('Adoption.json', function(data) {
  // Get the necessary contract artifact file and instantiate it with
  var AdoptionArtifact = data;
  App.contracts.Adoption = TruffleContract(AdoptionArtifact);

  // Set the provider for our contract
  App.contracts.Adoption.setProvider(App.web3Provider);

  // Use our contract to retrieve and mark the adopted pets
  return App.markAdopted();
});
```

Things to notice:

- We first retrieve the artifact file for our smart contract. **Artifacts are information about our contract such as its deployed address and Application Binary Interface (ABI)**. **The ABI is a JavaScript object defining how to interact with the contract including its variables, functions and their parameters.**
- Once we have the artifacts in our callback, we pass them to `TruffleContract()`. This creates an instance of the contract we can interact with.

- With our contract instantiated, we set its web3 provider using the `App.web3Provider` value we stored earlier when setting up web3.
- We then call the app's `markAdopted()` function in case any pets are already adopted from a previous visit. We've encapsulated this in a separate function since we'll need to update the UI any time we make a change to the smart contract's data.

Getting The Adopted Pets and Updating The UI

1. Still in `/src/js/app.js`, remove the multi-line comment from `markAdopted` and replace it with the following:

```
var adoptionInstance;

App.contracts.Adoption.deployed().then(function(instance) {
  adoptionInstance = instance;

  return adoptionInstance.getAdopters.call();
}).then(function(adopters) {
  for (i = 0; i < adopters.length; i++) {
    if (adopters[i] !== '0x0000000000000000000000000000000000000000')
      $('.panel-pet').eq(i).find('button').text('Success').attr('disa
    }
  }
}).catch(function(err) {
  console.log(err.message);
});
```

Things to notice:

- We access the deployed `Adoption` contract, then call `getAdopters()` on that instance.

- We first declare the variable `adoptionInstance` outside of the smart contract calls so we can access the instance after initially retrieving it.
- Using **call()** allows us to read data from the blockchain without having to send a full transaction, meaning we won't have to spend any ether.
- After calling `getAdopters()`, we then loop through all of them, checking to see if an address is stored for each pet. Since the array contains address types, Ethereum initializes the array with 16 empty addresses. This is why we check for an empty address string rather than null or other falsey value.
- Once a `petId` with a corresponding address is found, we disable its adopt button and change the button text to "Success", so the user gets some feedback.
- Any errors are logged to the console.

Handling the adopt() Function

1. Still in `/src/js/app.js`, remove the multi-line comment from `handleAdopt` and replace it with the following:

```
var adoptionInstance;

web3.eth.getAccounts(function(error, accounts) {
  if (error) {
    console.log(error);
  }

  var account = accounts[0];

  App.contracts.Adoption.deployed().then(function(instance) {
    adoptionInstance = instance;

    // Execute adopt as a transaction by sending account
    return adoptionInstance.adopt(petId, {from: account});
  }).then(function(result) {
    return App.markAdopted();
  }).catch(function(err) {
    console.log(err.message);
  });
});
```

Things to notice:

- We use web3 to get the user's accounts. In the callback after an error check, we then select the first account.
- From there, we get the deployed contract as we did above and store the instance in `adoptionInstance` . This time though, we're going to send a **transaction** instead of a call. Transactions require a "from" address and have an associated cost. This cost, paid in ether, is called **gas**. The gas cost is the fee for performing computation and/or storing data in a smart contract. We send the transaction by executing the `adopt()` function with both the pet's ID and an object containing the account address, which we stored earlier in `account` .

- The result of sending a transaction is the transaction object. If there are no errors, we proceed to call our `markAdopted()` function to sync the UI with our newly stored data.

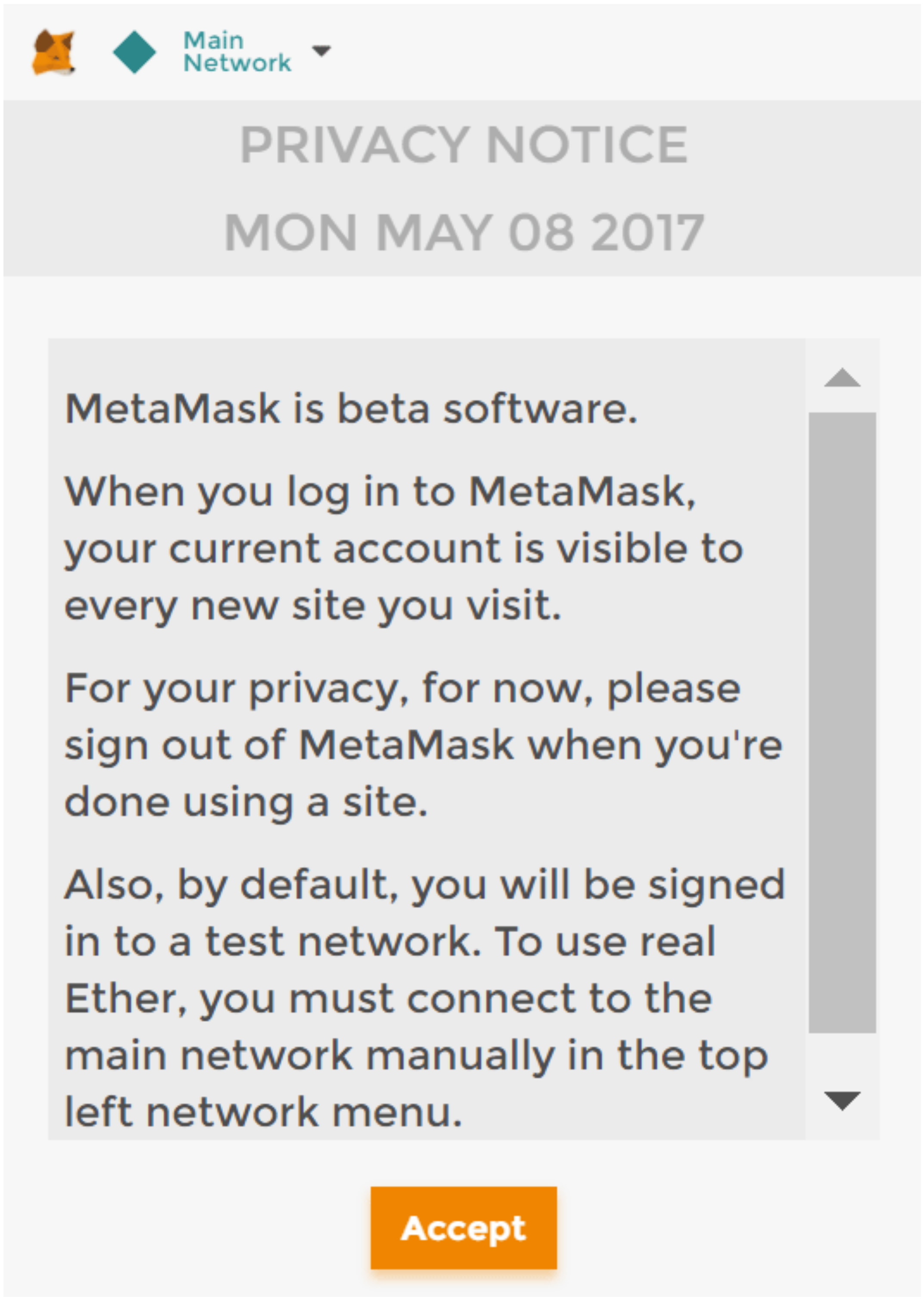
Interacting with the dapp in a browser

Now we're ready to use our dapp!

Installing and configuring MetaMask

The easiest way to interact with our dapp in a browser is through MetaMask (https://metamask.io/), an extension for Chrome.

1. Install MetaMask in your browser.
2. Once installed, you'll see the MetaMask fox icon next to your address bar. Click the icon and you'll see this screen appear:



PRIVACY NOTICE

MON MAY 08 2017

MetaMask is beta software.

When you log in to MetaMask, your current account is visible to every new site you visit.

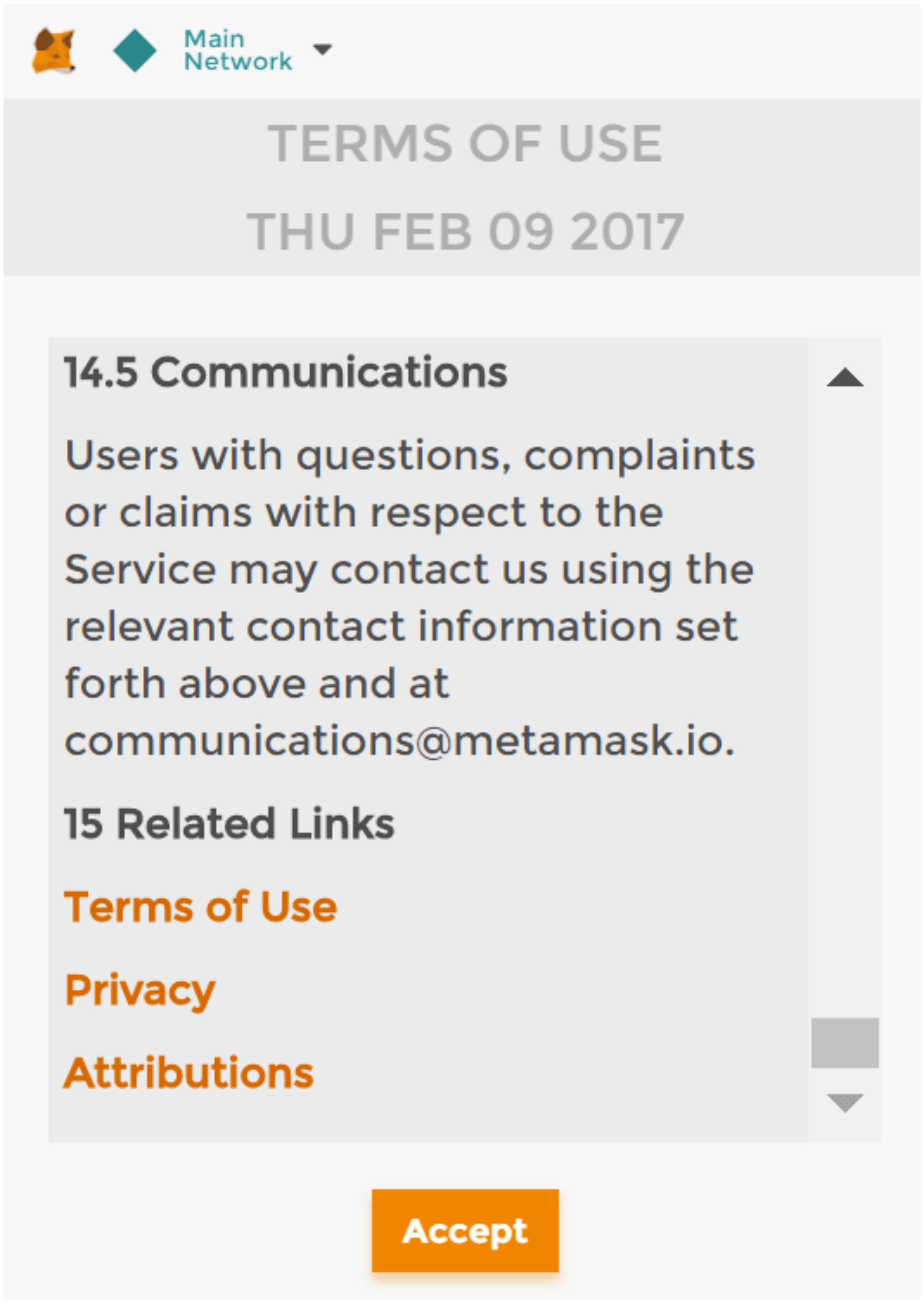
For your privacy, for now, please sign out of MetaMask when you're done using a site.

Also, by default, you will be signed in to a test network. To use real Ether, you must connect to the main network manually in the top left network menu.

Privacy Notice

3. Click Accept to accept the Privacy Notice.

4. Then you'll see the Terms of Use. Read them, scrolling to the bottom, and then click **Accept** there too.



14.5 Communications

Users with questions, complaints or claims with respect to the Service may contact us using the relevant contact information set forth above and at communications@metamask.io.

15 Related Links

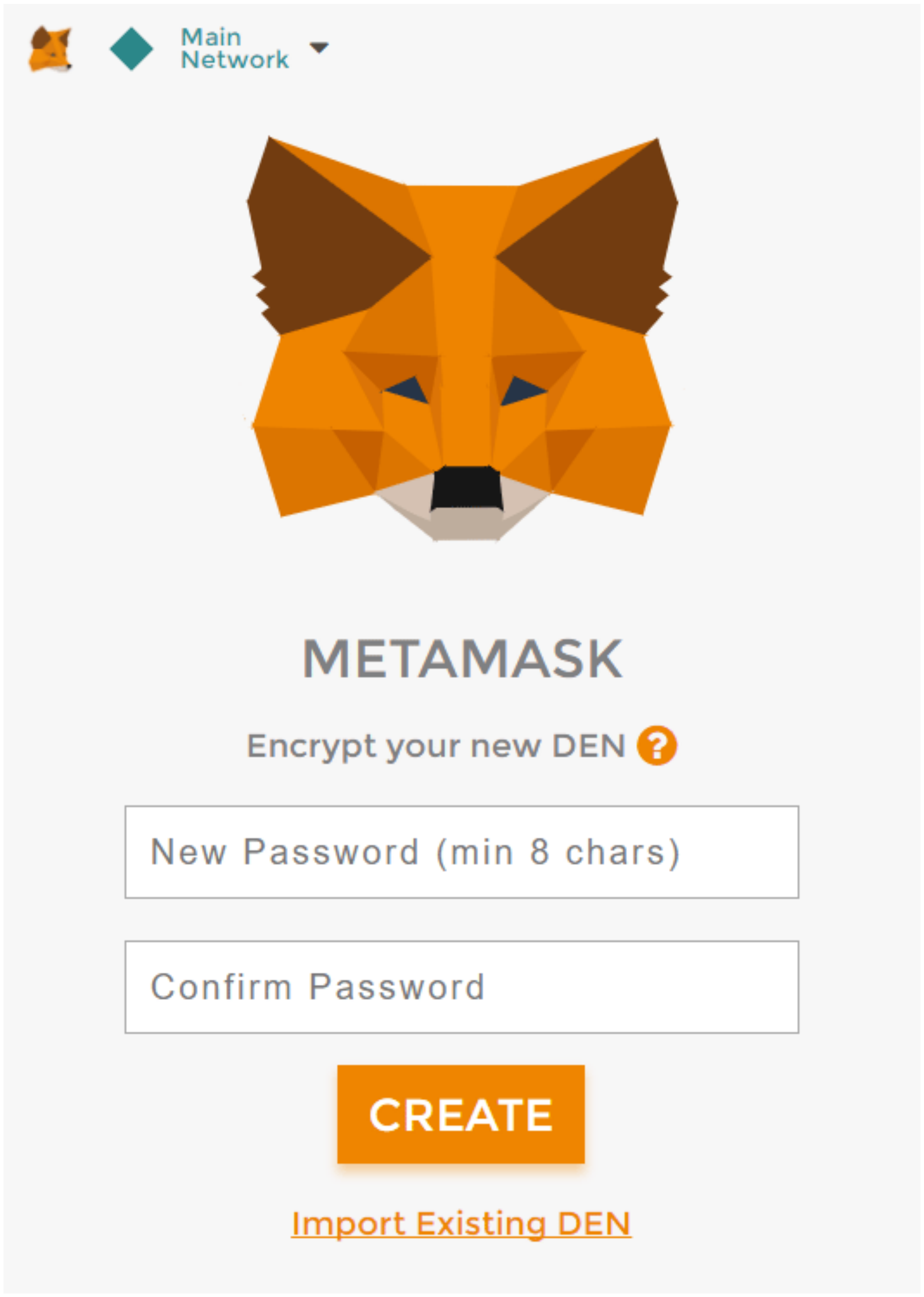
Terms of Use

Privacy

Attributions

Terms of Use

5. Now you'll see the initial MetaMask screen. Click **Import Existing DEN**.

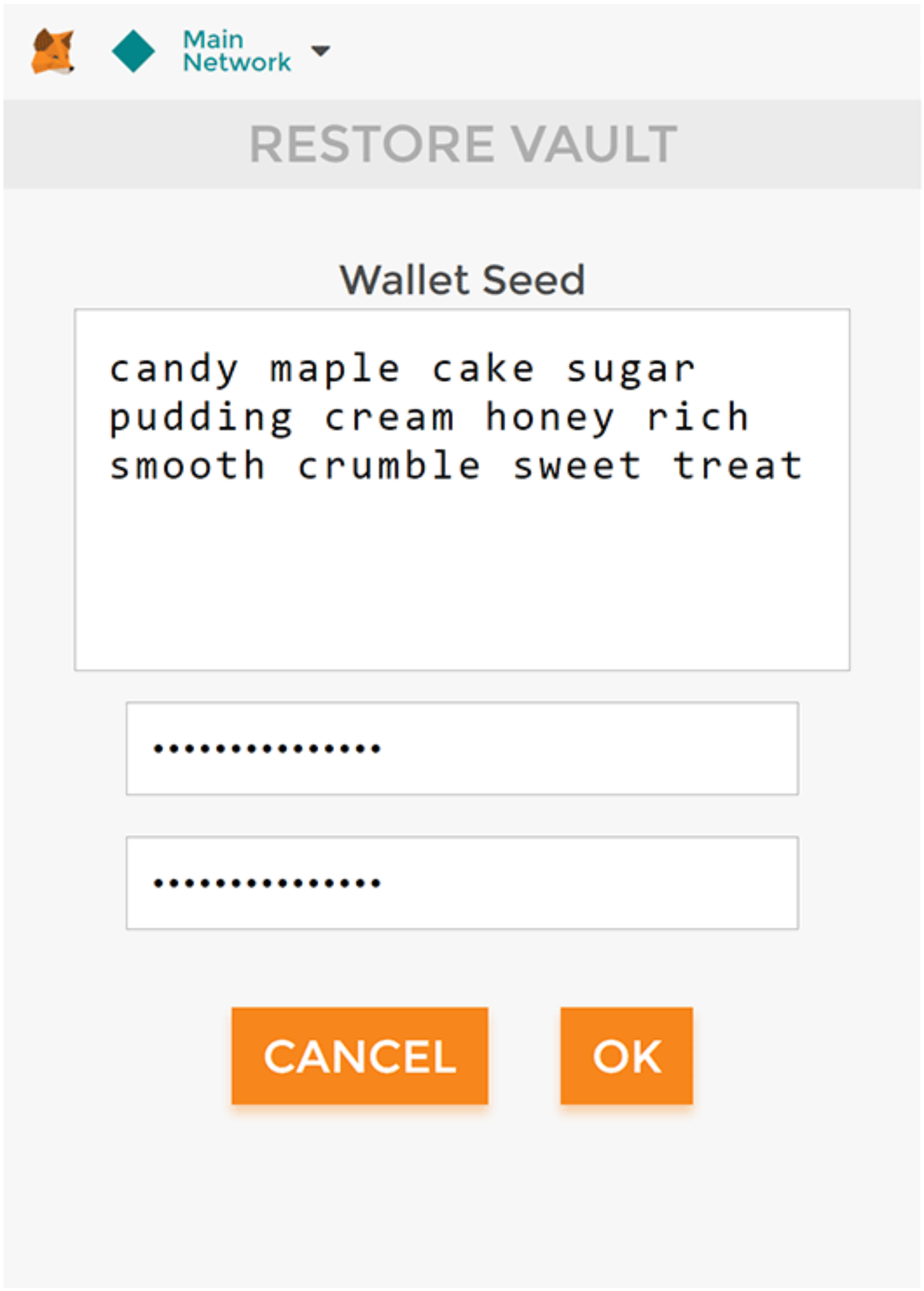


MetaMask initial screen

6. In the box marked **Wallet Seed**, enter the mnemonic that was displayed when launching Truffle Develop:

```
candy maple cake sugar pudding cream honey rich smooth crumble sweet
```

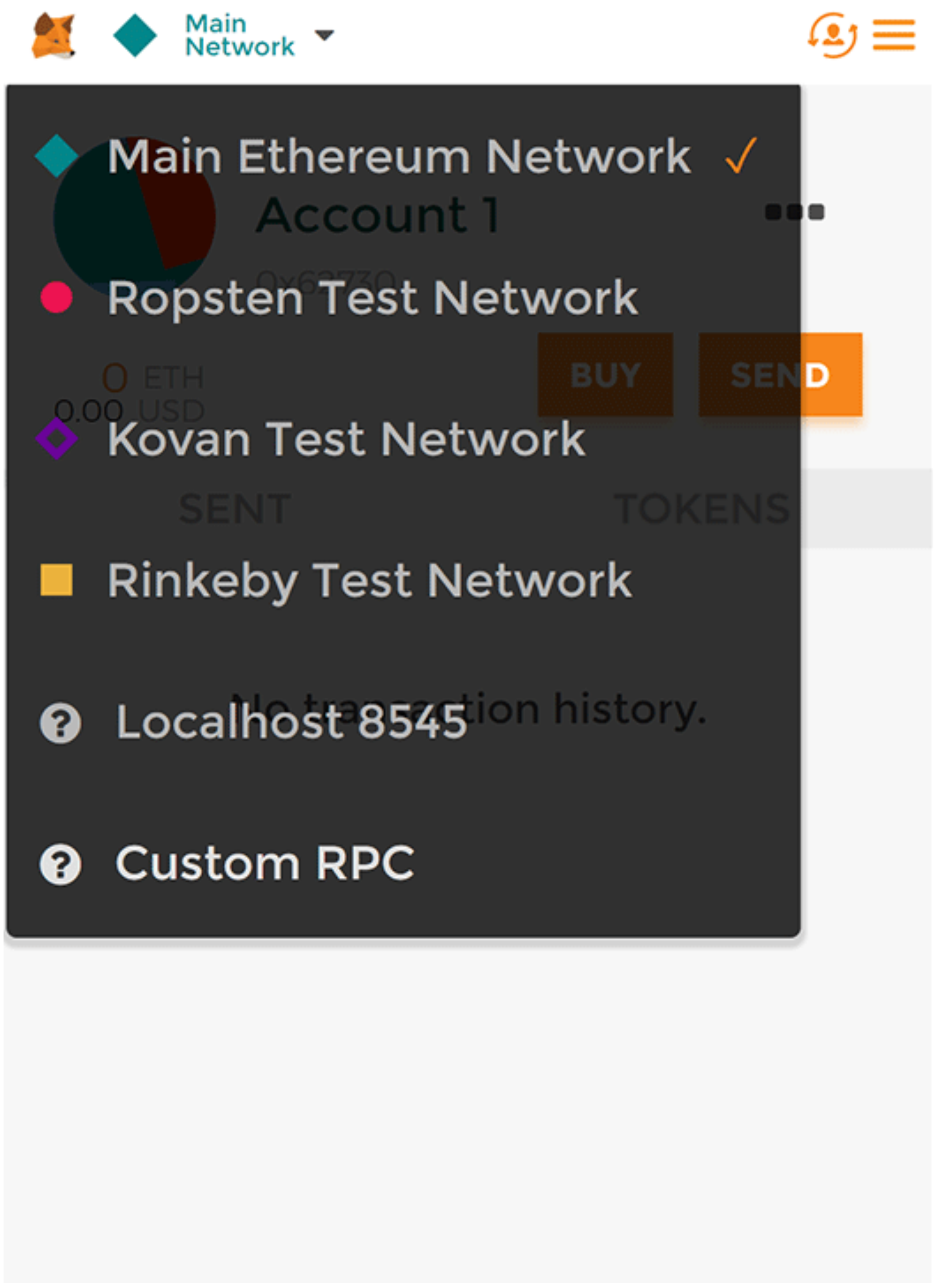
Enter a password below that and click **OK**.



candy maple cake sugar pudding cream honey rich smooth crumble sweet treat

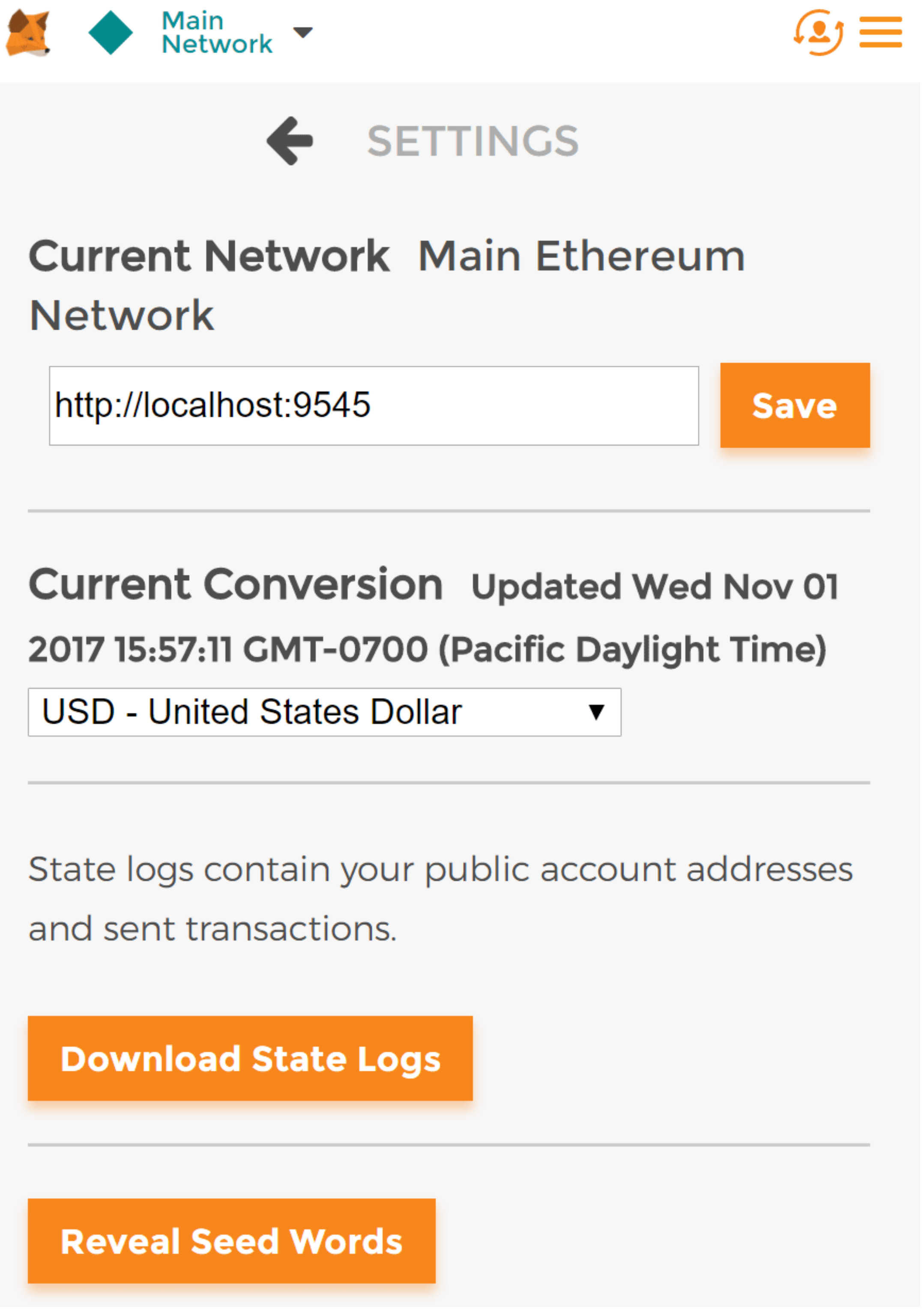
MetaMask seed phrase

7. Now we need to connect MetaMask to the blockchain created by Truffle Develop. Click the menu that shows "Main Network" and select **Custom RPC**.



MetaMask network menu

8. In the box titled "New RPC URL" enter `http://localhost:9545` and click **Save**.



Current Network Main Ethereum Network

http://localhost:9545

Current Conversion Updated Wed Nov 01 2017 15:57:11 GMT-0700 (Pacific Daylight Time)

USD - United States Dollar

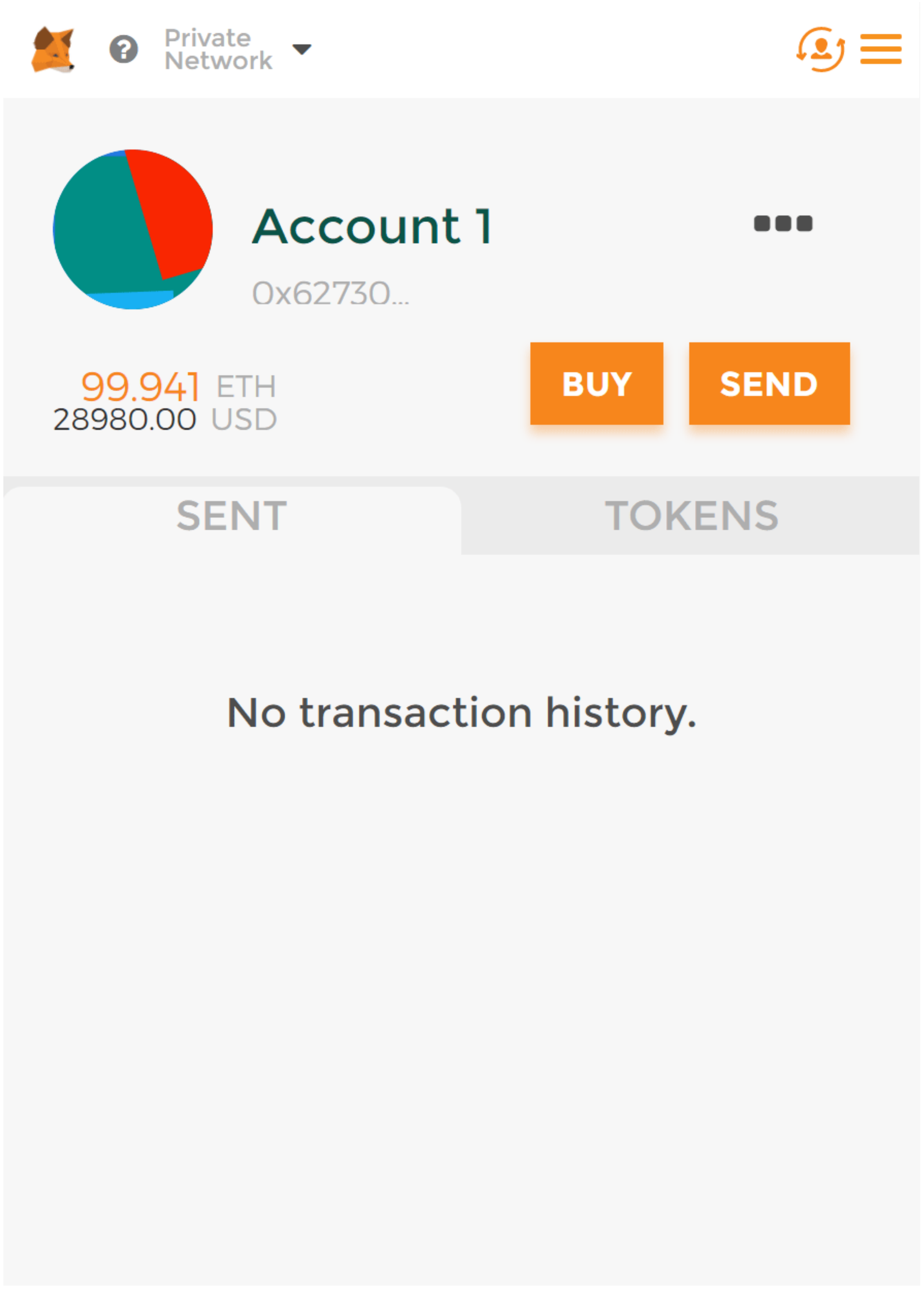
State logs contain your public account addresses and sent transactions.

MetaMask Custom RPC

The network name at the top will switch to say "Private Network".

9. Click the left-pointing arrow next to "Settings" to close out of the page and return to the Accounts page.

   Each account created by Truffle Develop is given 100 ether. You'll notice it's slightly less on the first account because some gas was used when the contract itself was deployed.



MetaMask account configured

Configuration is now complete.

Installing and configuring lite-server

We can now start a local web server and use the dapp. We're using the `lite-server` library to serve our static files. This shipped with the `pet-shop` Truffle Box, but let's take a look at how it works.

1. Open `bs-config.json` in a text editor (in the project's root directory) and examine the contents:

```
{
  "server": {
    "baseDir": ["./src", "./build/contracts"]
  }
}
```

This tells `lite-server` which files to include in our base directory. We add the `./src` directory for our website files and `./build/contracts` directory for the contract artifacts.

We've also added a `dev` command to the `scripts` object in the `package.json` file in the project's root directory. The `scripts` object allows us to alias console commands to a single npm command. In this case we're just doing a single command, but it's possible to have more complex configurations. Here's what yours should look like:

```
"scripts": {
  "dev": "lite-server",
  "test": "echo \"Error: no test specified\" && exit 1"
},
```

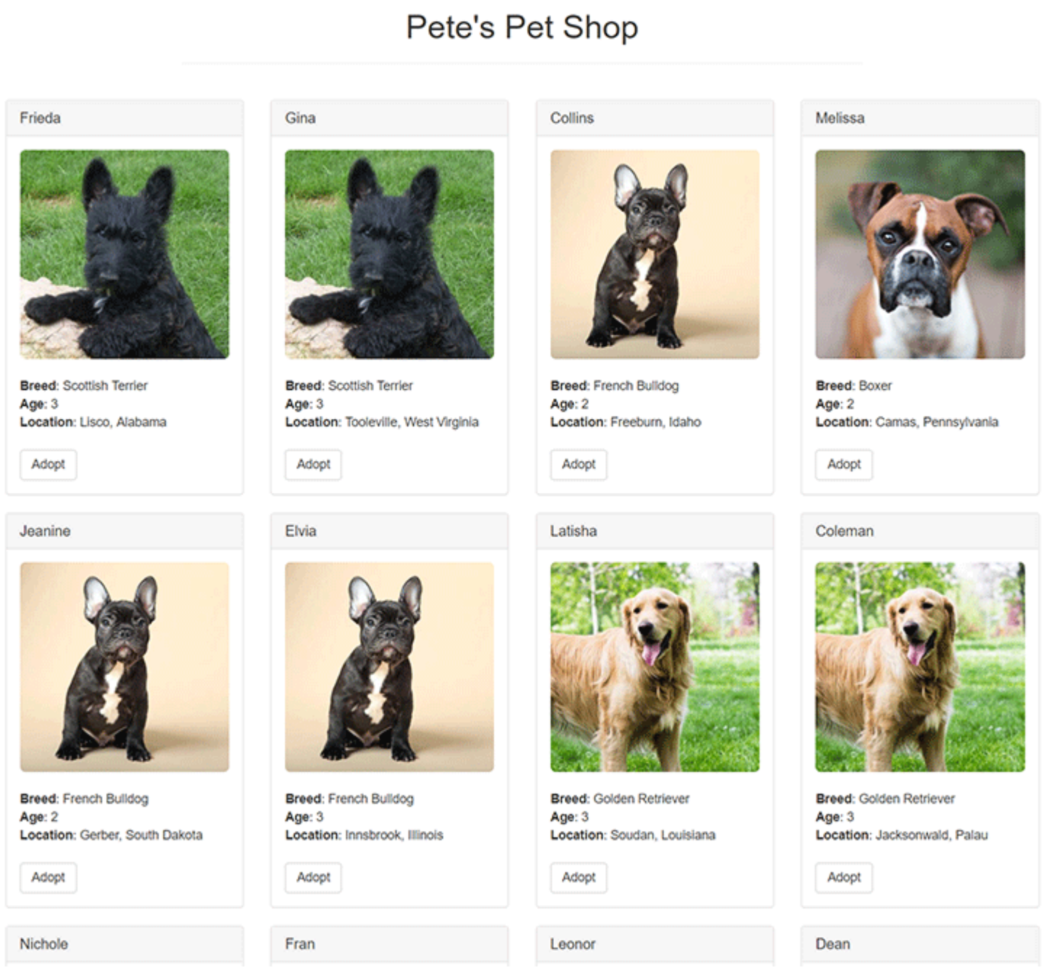
This tells npm to run our local install of `lite-server` when we execute `npm run dev` from the console.

Using the dapp

1. Start the local web server:

```
npm run dev
```

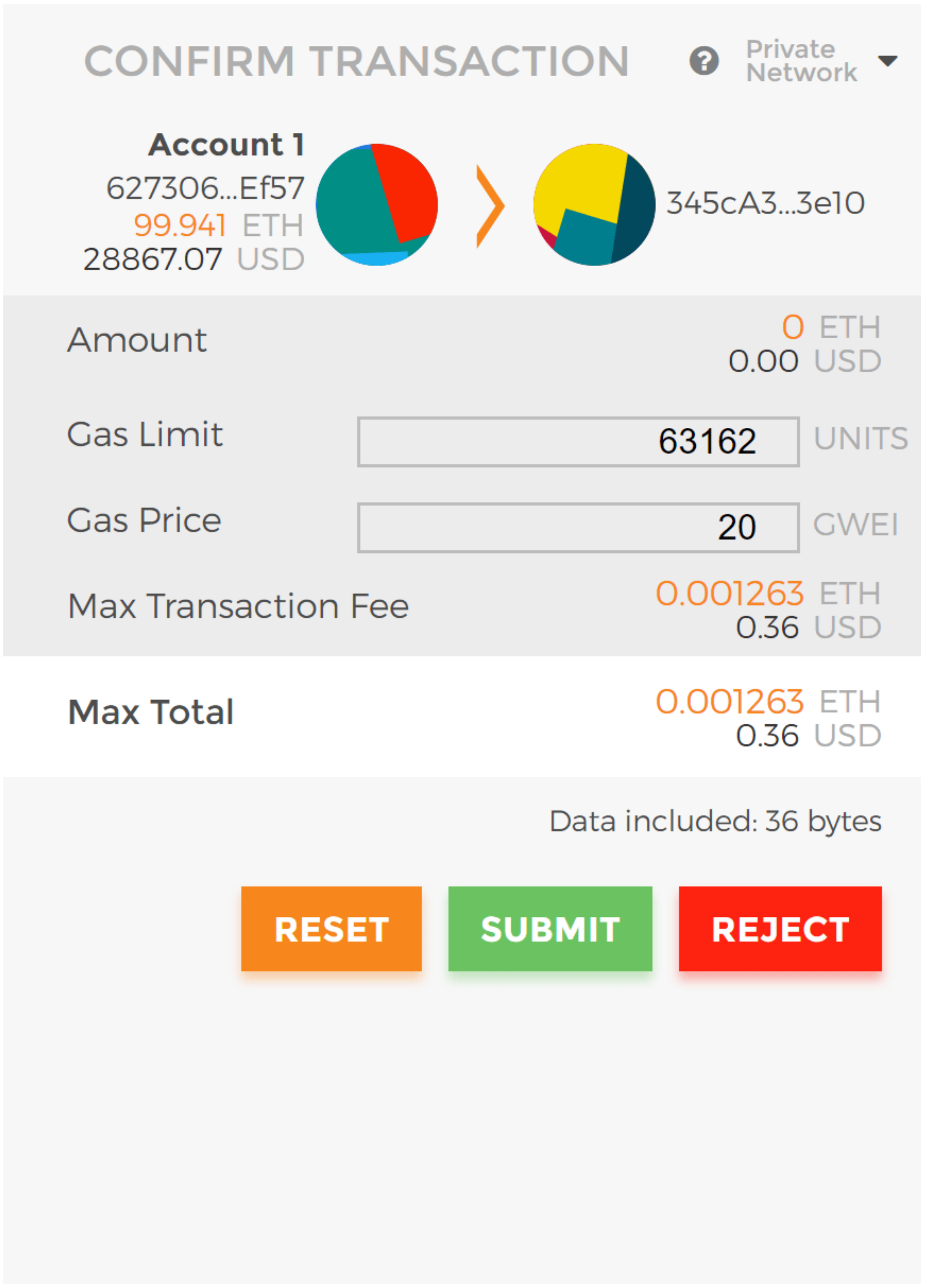
The dev server will launch and automatically open a new browser tab containing your dapp.



Pete's Pet Shop

2. To use the dapp, click the **Adopt** button on the pet of your choice.

3. You'll be automatically prompted to approve the transaction by MetaMask. Click **Submit** to approve the transaction.


CONFIRM TRANSACTION

Private Network

Account 1
627306...Ef57
99.941 ETH
28867.07 USD

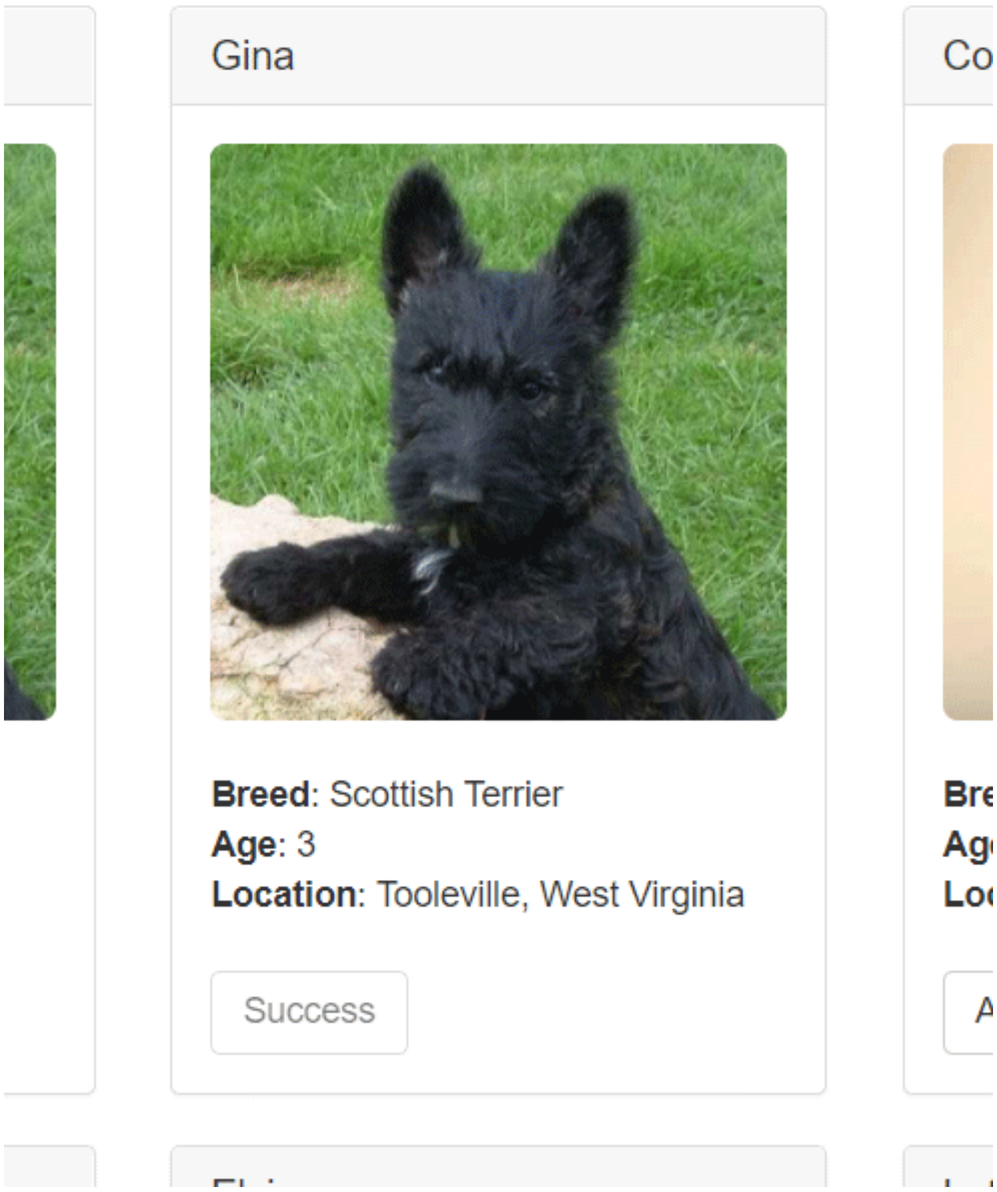
345cA3...3e10

Amount	0 ETH 0.00 USD
Gas Limit	63162 UNITS
Gas Price	20 GWEI
Max Transaction Fee	0.001263 ETH 0.36 USD
Max Total	0.001263 ETH 0.36 USD

Data included: 36 bytes

Adoption transaction review

4. You'll see the button next to the adopted pet change to say "Success" and become disabled, just as we specified, because the pet has now been adopted.

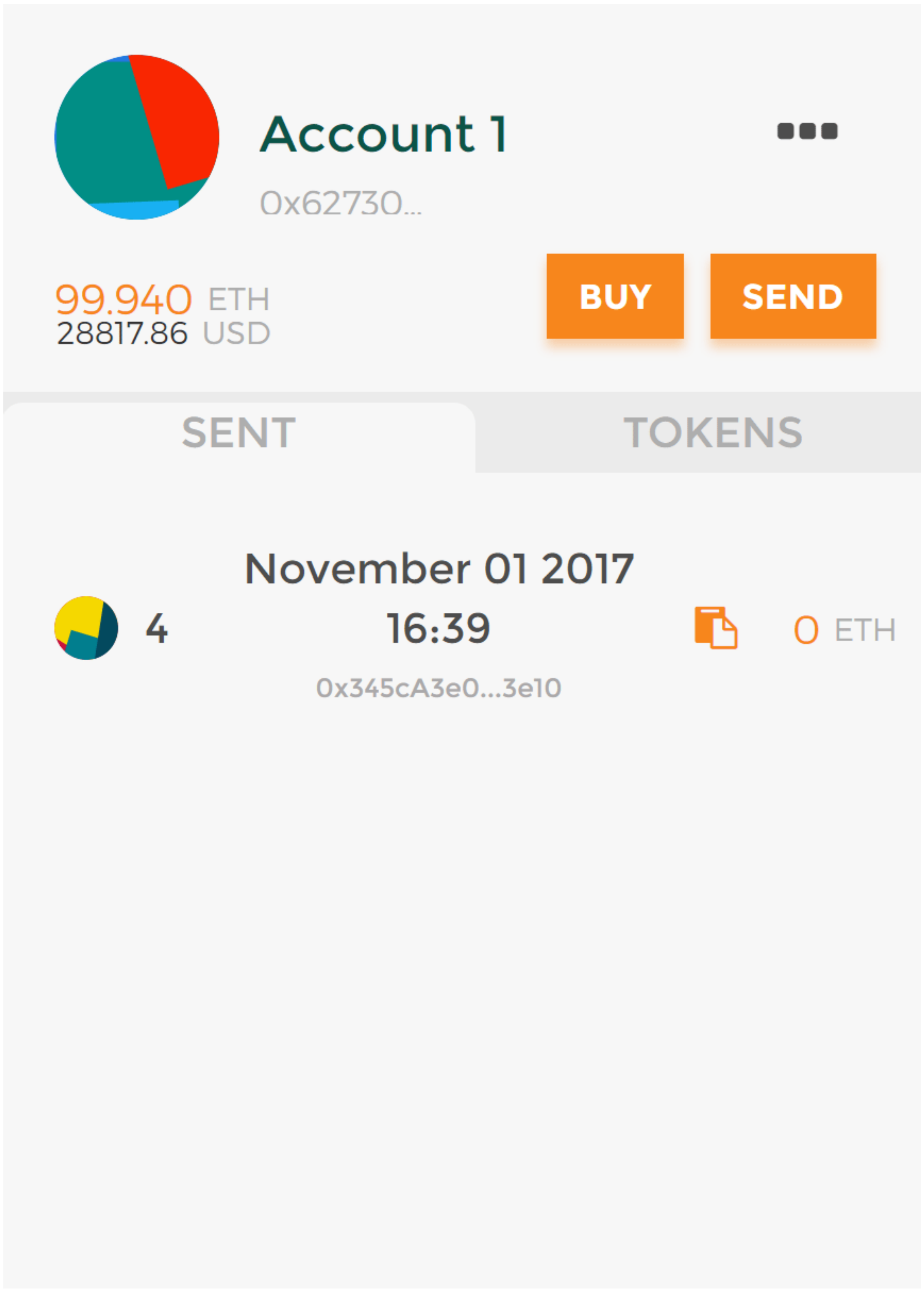


Breed: Scottish Terrier
Age: 3
Location: Tooleville, West Virginia

Adoption success

> **Note**: If the button doesn't automatically change to say "Success", refreshing the app in the browser should trigger it.

And in MetaMask, you'll see the transaction listed:



MetaMask transaction

Congratulations! You have taken a huge step to becoming a full-fledged dapp developer. For developing locally, you have all the tools you need to start making more advanced dapps. If you'd like to make your dapp live for others to use, stay tuned for our future tutorial on deploying to the Ropsten testnet.

See a way to make this page better?
Edit here → (https://github.com/trufflesuite/trufflesuite.com/edit/master/public/tutorials/pet-shop.md)

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