Marlowe CLI

Overview and Tutorial

14 January 2022

Purpose

The `marlowe-cli` tool enables developers to submit transactions and interact from the command line with Marlowe contracts on the Cardano blockchain, just as the `cardano-cli` tool has enabled them to do so for plain transactions, simple scripts, and Plutus scripts.

Use Cases

1. Facilitation of internal development and testing of Marlowe contracts.
    a. Measuring transaction size.
    b. Submitting transactions.
    c. Testing wallet integrations.
    d. Debugging validators.
2. Early access to Marlowe capabilities on testnet and mainnet.
3. Integration with external developer's workflows and toolsets for Marlowe contracts, similar to how the Cardano development community has heavily integrated `cardano-cli` into various services (libraries, faucets, token minting, marketplaces, etc.).
4. Incorporation into training for use of Marlowe.

Two Levels of Interaction with Marlowe on the Blockchain

High Level

- Supports a straightforward workflow for users that just want to run contracts from the command line.
- Hides details of input and state of Marlowe contracts.
- Hides and automates many aspects of Plutus and interaction with the Cardano node.
- Focuses on the Marlowe contract.

Low Level

- Supports developer workflows for debugging and fine-grained control of each atomic operation involved in running Marlowe contracts.
- Controls modification of Marlowe state and construction of Marlowe input.
- Controls construction and submission of validators, datums, and redeemers.
- Focus on the mechanics of Marlowe on Plutus and Cardano.

Simple Installation

Install using Nix and Cabal

```
git clone https://github.com/input-output-hk/marlowe-cardano.git
nix-shell
cabal install exe:marlowe-cli
```

Or install just using Cabal, if Cabal and GHC are already installed:

```
git clone https://github.com/input-output-hk/marlowe-cardano.git
cabal install exe:marlowe-cli
```

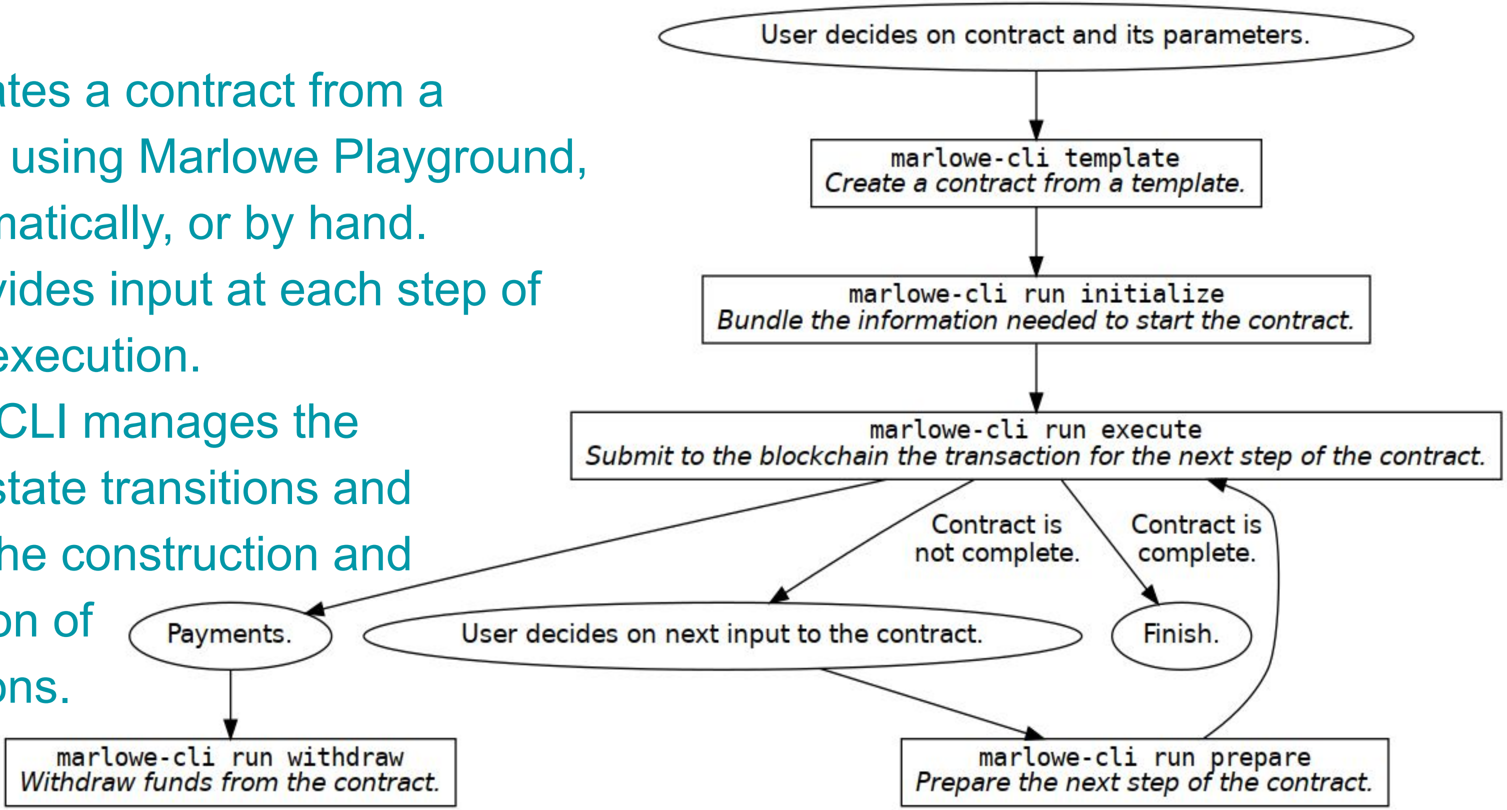
Available Commands

```
$ marlowe-cli --help

Usage: marlowe-cli [--version] COMMAND
  Utilities for Marlowe.

marlowe-cli : a command-line tool for Marlowe contracts

Usage: marlowe-cli [--version] (COMMAND | COMMAND)
  Utilities for Marlowe.

Available options:
  -h,--help                Show this help text
  --version                Show version.

High-level commands:
  run                      Run a contract.
  template                 Create a contract from a template.

Low-level commands:
  contract                 Export contract address, validator, datum, or redeemer.
  input                    Create inputs to a contract.
  role                     Export role address, validator, datum, or redeemer.
  transaction              Create and submit transactions.
  util                     Miscellaneous utilities.
```

https://github.com/input-output-hk/marlowe-cardano/blob/main/marlowe-cli/ReadMe.md

High-Level Workflow

1. User creates a contract from a template, using Marlowe Playground, programmatically, or by hand.
2. User provides input at each step of contract execution.
3. Marlowe CLI manages the contract state transitions and handles the construction and submission of transactions.


User decides on contract and its parameters.
marlowe-cli template
Create a contract from a template.
marlowe-cli run initialize
Bundle the information needed to start the contract.
marlowe-cli run execute
Submit to the blockchain the transaction for the next step of the contract.
Contract is not complete.
Contract is complete.
Payments.
User decides on next input to the contract.
Finish.
marlowe-cli run withdraw
Withdraw funds from the contract.
marlowe-cli run prepare
Prepare the next step of the contract.

Templates for Marlowe Contracts

```
$ marlowe-cli template --help

Usage: marlowe-cli template COMMAND
  Create a contract from a template.

Available options:
  -h,--help                Show this help text

Commands for creating Marlowe contracts from templates:
  escrow                   Create an escrow contract.
  simple                   Create a simple example contract.
  swap                     Create a swap contract.
  zcb                      Create a zero-coupon bond.
```

High-Level Commands for Running Contracts

```
$ marlowe-cli run --help

Usage: marlowe-cli run COMMAND
  Run a contract.

Available options:
  -h,--help                Show this help text

Commands for running contracts:
  execute                  Run a Marlowe transaction.
  initialize               Initialize the first transaction of a Marlowe
                           contract and write output to a JSON file.
  prepare                  Prepare the next step of a Marlowe contract
                           and write the output to a JSON file.
  withdraw                 Withdraw funds from the Marlowe role address.
```

Low-Level Capabilities

Creating Marlowe

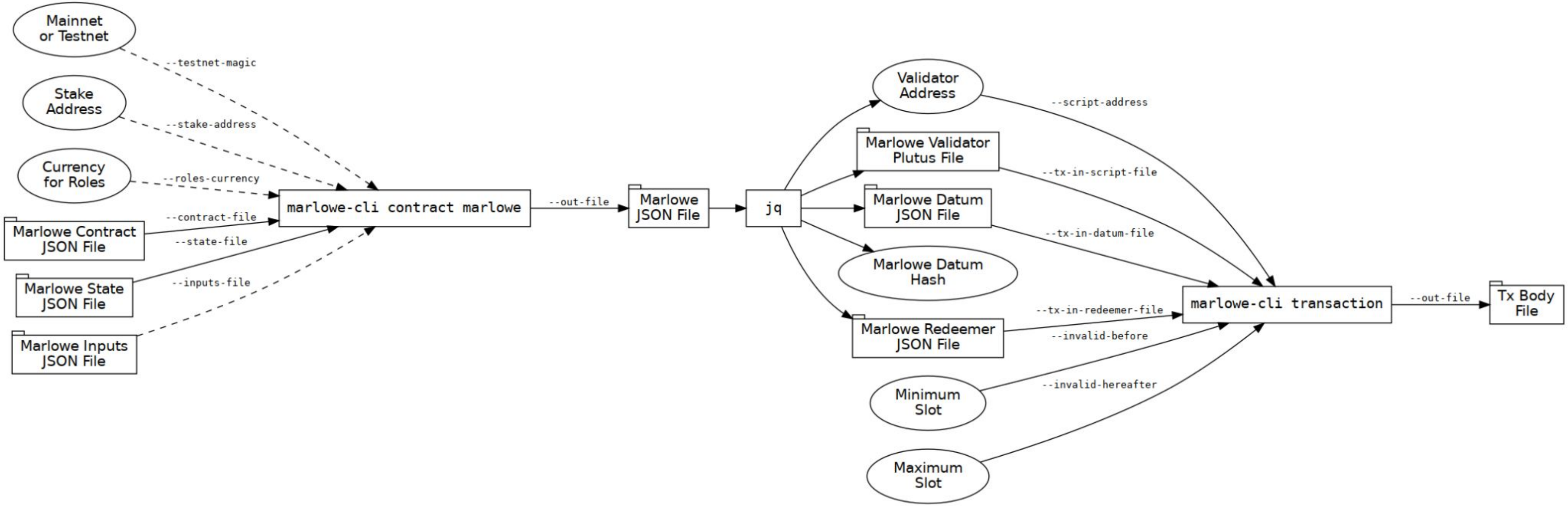
- Script address
- Validator hash
- Datum hash
- CBOR for Plutus script
- JSON and CBOR for datum.
- JSON and CBOR for redeemer.
- Size of the above CBOR in bytes
- Execution cost and memory

Running Marlowe

- Build transaction
- Submit transaction

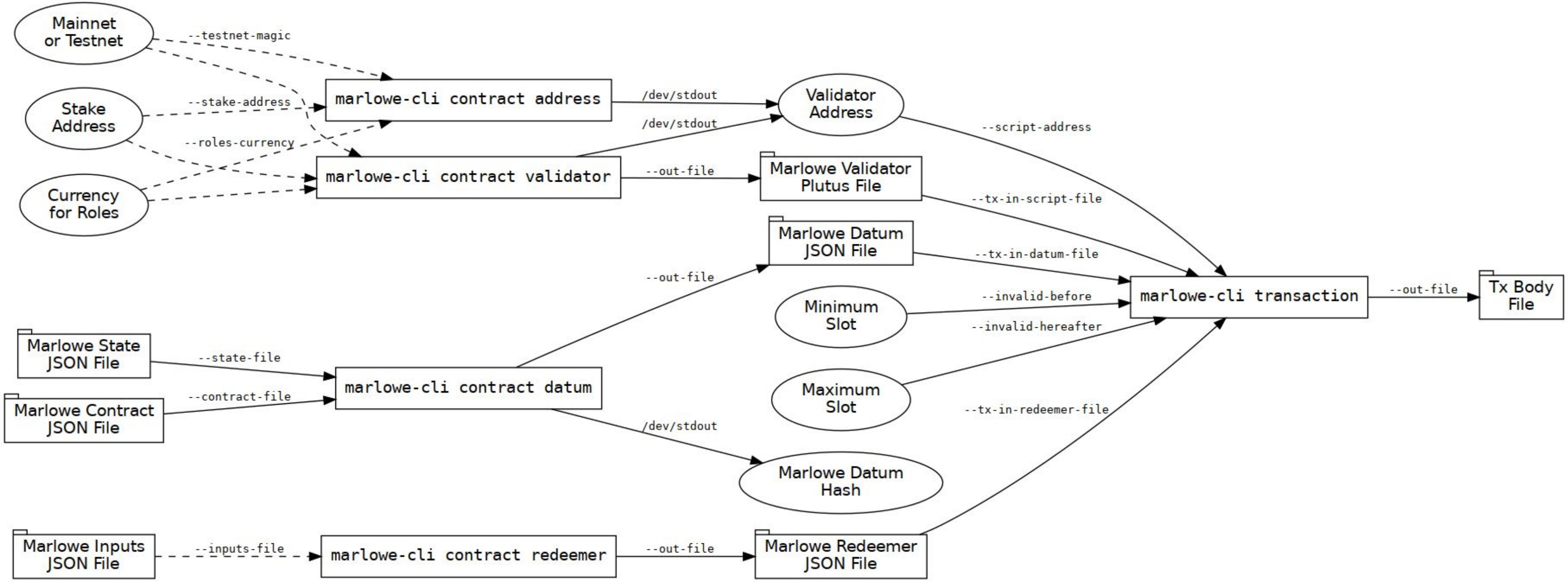
Monolithic Low-Level Workflow

This workflow provides access to scripts, datums, and redeemers, all bundled in a single JSON file that can be queried with tools like `jq`.



Granular Low-Level Workflow

This workflow provides access to scripts, datums, and redeemers as individual JSON files.



Marlowe on Plutus in Cardano

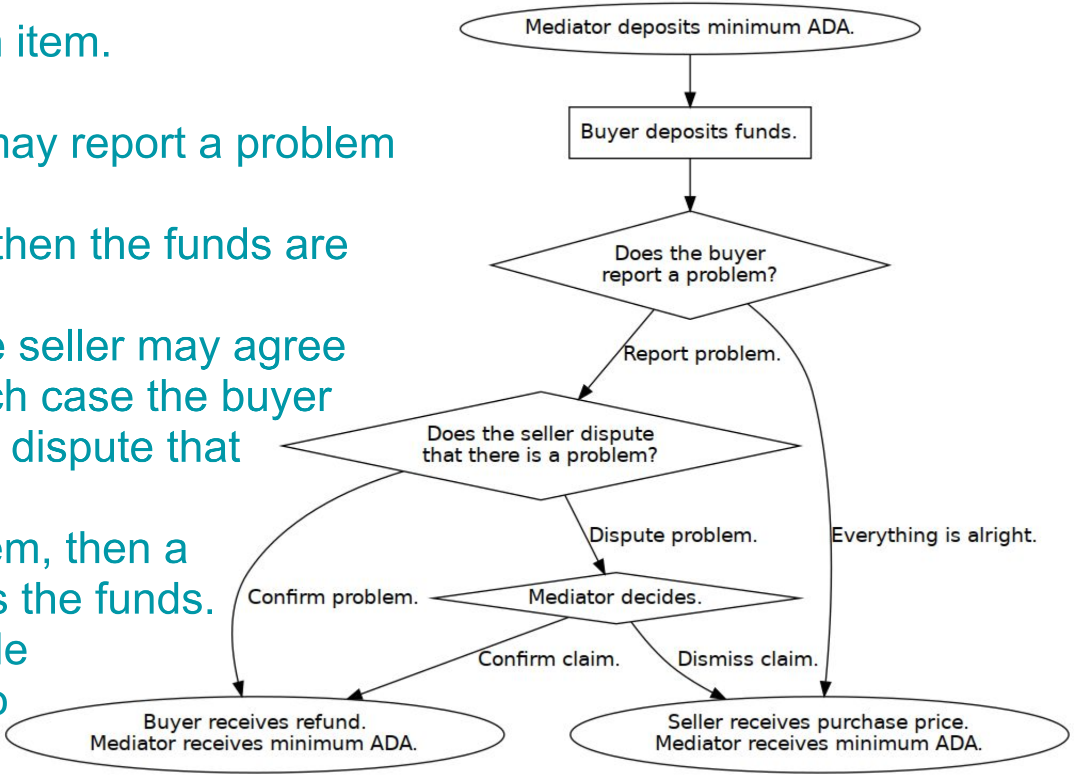
- The Plutus Script
    - There is a generic Plutus validator script for all Marlowe contracts.
    - When a contract is created, this script is specialized to the particular network (via the slot-time parameters) and to the roles for the script (via the role currency symbol).
- The Datum
    - The datum contains the remaining parts of the contract that still haven’t been executed.
    - The datum also contains the state of the contract, which includes the balances for accounts of the contract, a record of past inputs to the contract, and the values of parameters in the contract.
- The Redeemer
    - The redeemer contains the input to the next step of the contract, such as deposits, choices, or notifications.

Roles: Currency, Tokens, and Payout Scripts

- Each Marlowe contract has a *currency symbol* for its roles and a *payout validator script* for receiving and disbursing payments to participants.
- Participants typically interact with Marlowe contracts by including a *role token* in transactions that the participant authorizes.
    - Role tokens are a concatenation of the currency symbol and the *token name*.
- Participants withdraw funds from a special *payout script* using their role token.
    - The payout Plutus script is unique to each role currency symbol.
    - The datum at the payout address is simply the token name for the participant that is allowed to spend that UTxO.
    - The redeemer for spending from the payout script is empty.
- Roles provide a flexible and secure way for participants to interact with Marlowe.

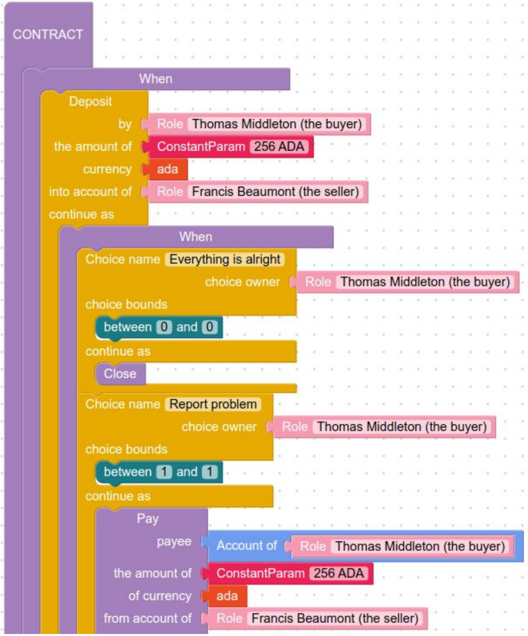
Escrow Example Using High-Level Workflow

- A *buyer* wishes to purchase an item.
- They deposit funds.
- After they deposit funds they may report a problem with the purchase.
- If they don't report a problem, then the funds are released to the *seller*.
- If they do report a problem, the seller may agree that there is a problem (in which case the buyer receives a refund) or they may dispute that there is a problem.
- If the seller disputes the problem, then a *mediator* decides who receives the funds.
- The contract has logic to handle situations where a party fails to act in a timely manner.

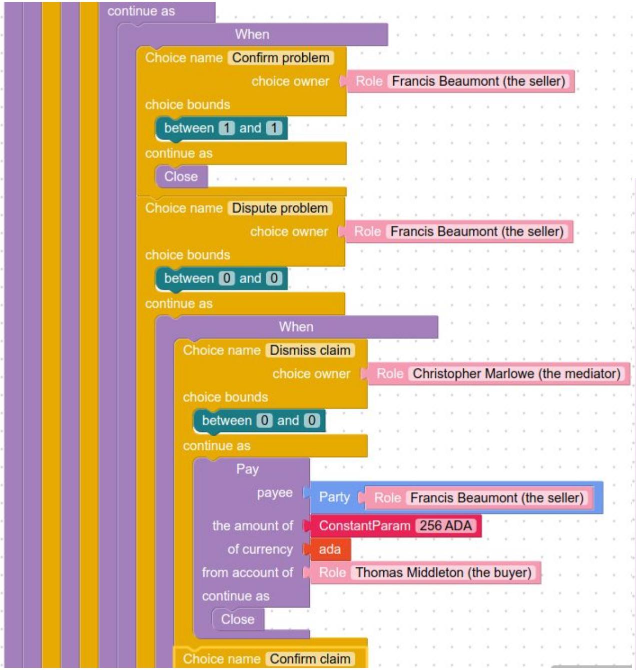


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Everything is alright.
Does the seller dispute that there is a problem?
Dispute problem.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

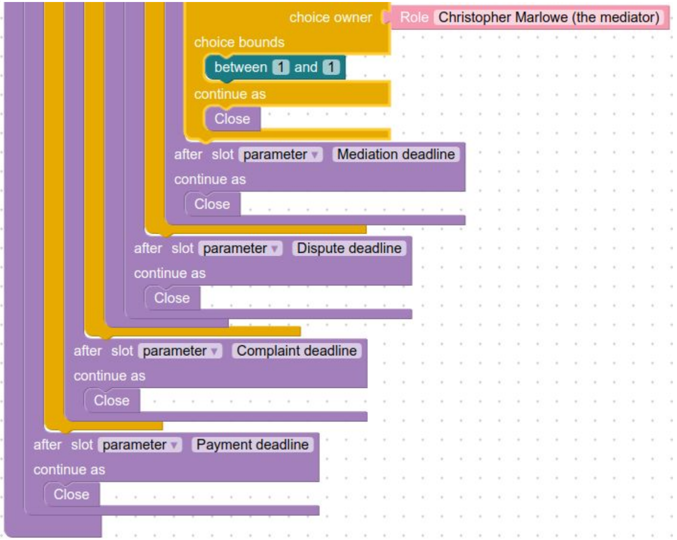
Escrow Contract in Blockly



```
CONTRACT
  When
    Deposit
      by Role Thomas Middleton (the buyer)
      the amount of ConstantParam 256 ADA
      currency ada
      into account of Role Francis Beaumont (the seller)
      continue as
        When
          Choice name Everything is alright
            choice owner Role Thomas Middleton (the buyer)
            choice bounds
              between 0 and 0
            continue as
              Close
          Choice name Report problem
            choice owner Role Thomas Middleton (the buyer)
            choice bounds
              between 1 and 1
            continue as
              Pay
                payee Account of Role Thomas Middleton (the buyer)
                the amount of ConstantParam 256 ADA
                of currency ada
                from account of Role Francis Beaumont (the seller)
```



```
continue as
  When
    Choice name Confirm problem
      choice owner Role Francis Beaumont (the seller)
      choice bounds
        between 1 and 1
      continue as
        Close
    Choice name Dispute problem
      choice owner Role Francis Beaumont (the seller)
      choice bounds
        between 0 and 0
      continue as
        When
          Choice name Dismiss claim
            choice owner Role Christopher Marlowe (the mediator)
            choice bounds
              between 0 and 0
            continue as
              Pay
                payee Party Role Francis Beaumont (the seller)
                the amount of ConstantParam 256 ADA
                of currency ada
                from account of Role Thomas Middleton (the buyer)
                continue as
                  Close
          Choice name Confirm claim
```

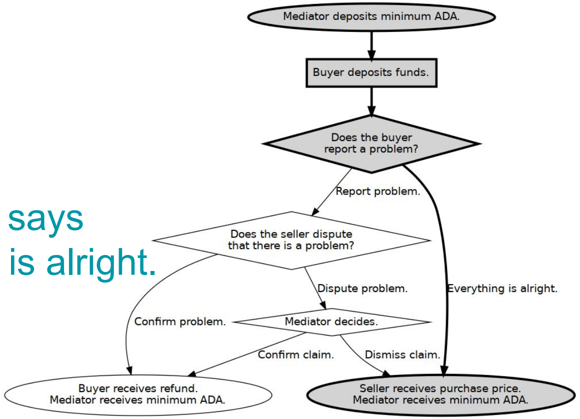


```
            choice owner Role Christopher Marlowe (the mediator)
            choice bounds
              between 1 and 1
            continue as
              Close
          after slot parameter Mediation deadline
          continue as
            Close
      after slot parameter Dispute deadline
      continue as
        Close
    after slot parameter Complaint deadline
    continue as
      Close
  after slot parameter Payment deadline
  continue as
    Close
```

Escrow Contract in Marlowe Format

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

Four of the Eight Possible Outcomes



Buyer says everything is alright.

Mediator deposits minimum ADA.

Buyer deposits funds.

Does the buyer report a problem?

Report problem.

Everything is alright.

Does the seller dispute that there is a problem?

Dispute problem.

Confirm problem.

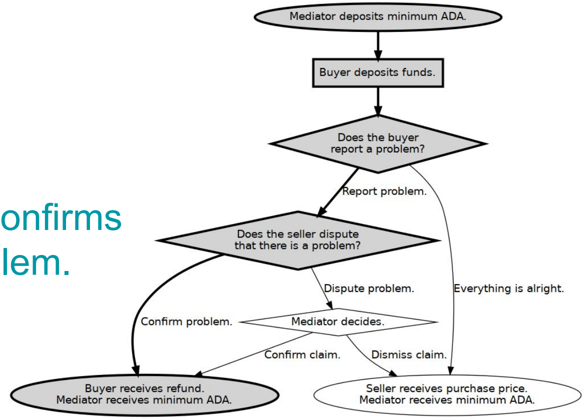
Mediator decides.

Confirm claim.

Dismiss claim.

Buyer receives refund. Mediator receives minimum ADA.

Seller receives purchase price. Mediator receives minimum ADA.



Seller confirms problem.

Mediator deposits minimum ADA.

Buyer deposits funds.

Does the buyer report a problem?

Report problem.

Everything is alright.

Does the seller dispute that there is a problem?

Dispute problem.

Confirm problem.

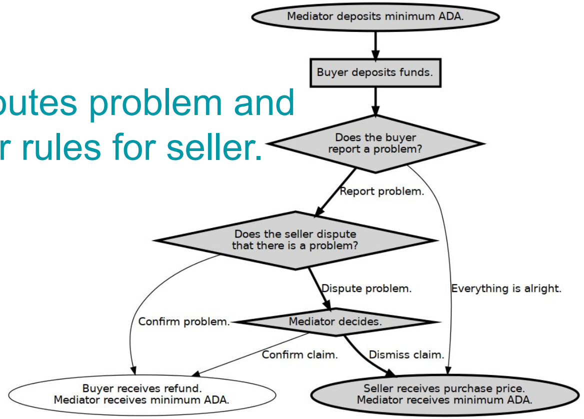
Mediator decides.

Confirm claim.

Dismiss claim.

Buyer receives refund. Mediator receives minimum ADA.

Seller receives purchase price. Mediator receives minimum ADA.



Seller disputes problem and mediator rules for seller.

Mediator deposits minimum ADA.

Buyer deposits funds.

Does the buyer report a problem?

Report problem.

Everything is alright.

Does the seller dispute that there is a problem?

Dispute problem.

Confirm problem.

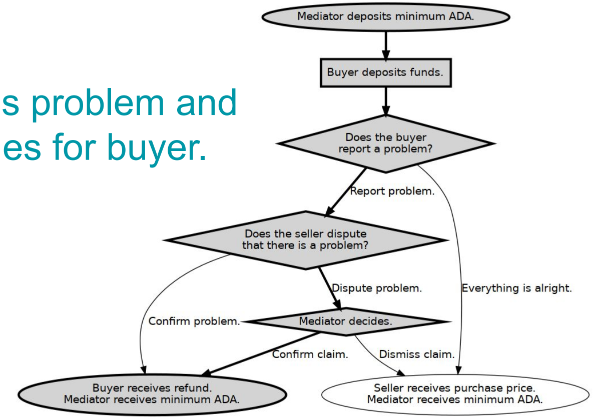
Mediator decides.

Confirm claim.

Dismiss claim.

Buyer receives refund. Mediator receives minimum ADA.

Seller receives purchase price. Mediator receives minimum ADA.



Seller disputes problem and mediator rules for buyer.

Mediator deposits minimum ADA.

Buyer deposits funds.

Does the buyer report a problem?

Report problem.

Everything is alright.

Does the seller dispute that there is a problem?

Dispute problem.

Confirm problem.

Mediator decides.

Confirm claim.

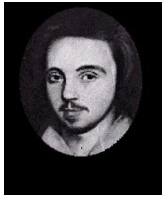
Dismiss claim.

Buyer receives refund. Mediator receives minimum ADA.

Seller receives purchase price. Mediator receives minimum ADA.

Detailed Example

Dramatis Personae



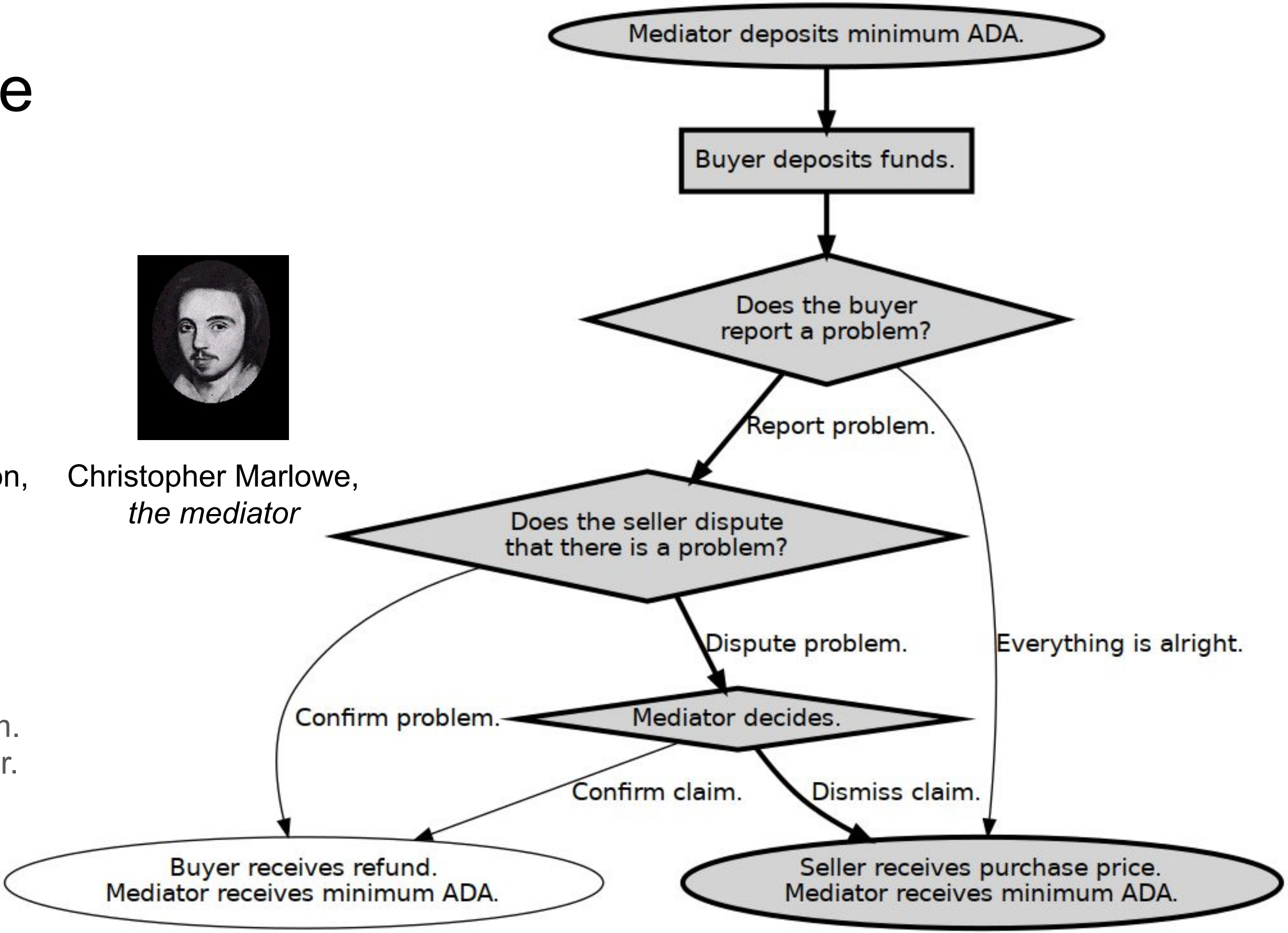
Francis Beaumont,
the seller

Thomas Middleton,
the buyer

Christopher Marlowe,
the mediator

The Plot

1. Buyer deposits funds.
2. Buyer reports a problem.
3. Seller disputes the problem.
4. Mediator rules for the seller.
5. Seller receives the funds.

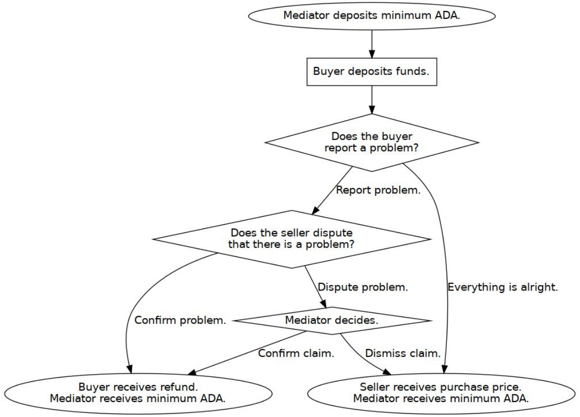


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Does the seller dispute that there is a problem?
Dispute problem.
Everything is alright.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

0. Construct the Contract

Input

- Token names for parties
- Deadlines
- Price of the item
- Minimum ADA


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Does the seller dispute that there is a problem?
Everything is alright.
Dispute problem.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Party	In Contract	At Payout
Francis Beaumont, seller	0 ADA	0 ADA
Thomas Middleton, buyer	0 ADA	0 ADA
Christopher Marlowe, mediator	0 ADA	0 ADA

Remaining Contract

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

Key to Parameters in the Following Examples

```
CARDANO_NODE_SOCKET_PATH=node.socket
ROLE_CURRENCY=8bb3b343d8e404472337966a722150048c768d0a92a9813596c5338d
SELLER_ROLE=FB
SELLER_ADDRESS=addr_test1vrtntkszteptml4e9ce9l3fsmgavwv4ywunvdnhxv6nw5ksq6737a
SELLER_TOKEN=8bb3b343d8e404472337966a722150048c768d0a92a9813596c5338d.FB
SELLER_PAYMENT_SKEY=francis-beaumont.skey
TX_0_SELLER_ADA=56c38f8941152570a4420a40a9ad99132e794d1e2806d2adaaa6d85d13e9e694#0
TX_0_SELLER_TOKEN=56c38f8941152570a4420a40a9ad99132e794d1e2806d2adaaa6d85d13e9e694#1
BUYER_ROLE=TM
BUYER_ADDRESS=addr_test1vzgrqnlp6elmettvuelx5vkn0uxhtu2ewqdhx297ukgjmjgpss5k0
BUYER_TOKEN=8bb3b343d8e404472337966a722150048c768d0a92a9813596c5338d.TM
BUYER_PAYMENT_SKEY=thomas-middleton.skey
TX_0_BUYER_ADA=92d52f47f45aadc93ebf247403e416892ed3e7b6b7a5f239dc98f143c406d977#0
TX_0_BUYER_TOKEN=92d52f47f45aadc93ebf247403e416892ed3e7b6b7a5f239dc98f143c406d977#1
MEDIATOR_ROLE=CM
MEDIATOR_ADDRESS=addr_test1vqhqudxtwqcpjqesns79hqgqq2q0xx5q0hnzz5es9492yaqpxltpy
MEDIATOR_TOKEN=8bb3b343d8e404472337966a722150048c768d0a92a9813596c5338d.CM
TX_0_MEDIATOR_ADA=6bacba798627179750ae5d6f947adfcd6c62a7d899bf264c4fa1660ce5c4ef73#0
TX_0_MEDIATOR_TOKEN=6bacba798627179750ae5d6f947adfcd6c62a7d899bf264c4fa1660ce5c4ef73#1
MINIMUM_ADA=3000000
PRICE=256000000
TIP=46873317
PAYMENT_DEADLINE=46959717
COMPLAINT_DEADLINE=47046117
DISPUTE_DEADLINE=47132517
MEDIATION_DEADLINE=47218917
CONTRACT_ADDRESS=addr_test1wrne597ectcpfjrl3azk4ag9adc47wy8ft4ccxat0q2zurq2fsdjf
ROLE_ADDRESS=addr_test1wpt3m3hnfzystzp6x3n5v4q0jsj5hca4z5drs30us07pe8sslxxqd
TX_1=b1a63c3258e3710ef93795153df253f6d4b34862f258696cb8950f64499607b4
TX_2=3f2cc8ec9b98ea4dbaebab7d1bf37915812de0d1193e7553cf18c8f91a15daf7
TX_3=038159fcd6db522d042968e9d393b255f9660bb93430af49f23f4d49447976e1
TX_4=62a7e1e4ddd43e99085849183036488cee1376e470f1402aad55f58c6dcf950f
TX_5=f8f580ca1adb1cc5dea7687f603c7685c46846e996c8e579a7daa734549d169e
TX_6=5ffc43e74f86c2e63847557288410f662ca5a1a971a34f61b4af7723e748f146
TX_7=b93b551188448223a12c51389bf8946a511297ba7d787277d92760073b4a5642
```

0. Construct the Contract

256 ADA is the price of the item.

3 ADA will be deposited in the contract to satisfy the ledger’s minimum-ADA requirement.

The roles of the three participants are assigned.

```
marlowe-cli template escrow --minimum-ada "$MINIMUM_ADA"                 \
                            --price "$PRICE"                             \
                            --seller "Role=$SELLER_ROLE"                 \
                            --buyer "Role=$BUYER_ROLE"                   \
                            --mediator "Role=$MEDIATOR_ROLE"             \
                            --payment-deadline "$PAYMENT_DEADLINE"       \
                            --complaint-deadline "$COMPLAINT_DEADLINE"   \
                            --dispute-deadline "$DISPUTE_DEADLINE"       \
                            --mediation-deadline "$MEDIATION_DEADLINE"   \
                            --out-contract-file tx-1.contract            \
                            --out-state-file    tx-1.state
```

Use the template for the escow contract.

The contract imposes deadlines for actions.

The Marlowe contract is written to disk in JSON format.

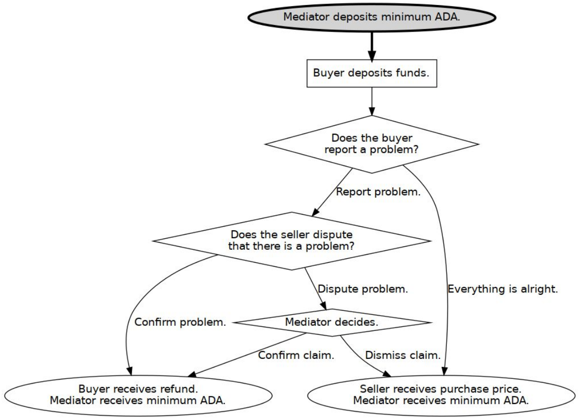
The initial state of the contract is written to disk in JSON format.

1. Create the Contract by Providing the Minimum ADA

Input

- The mediator Christopher Marlowe sends 3 ADA to the script address to create the contract.

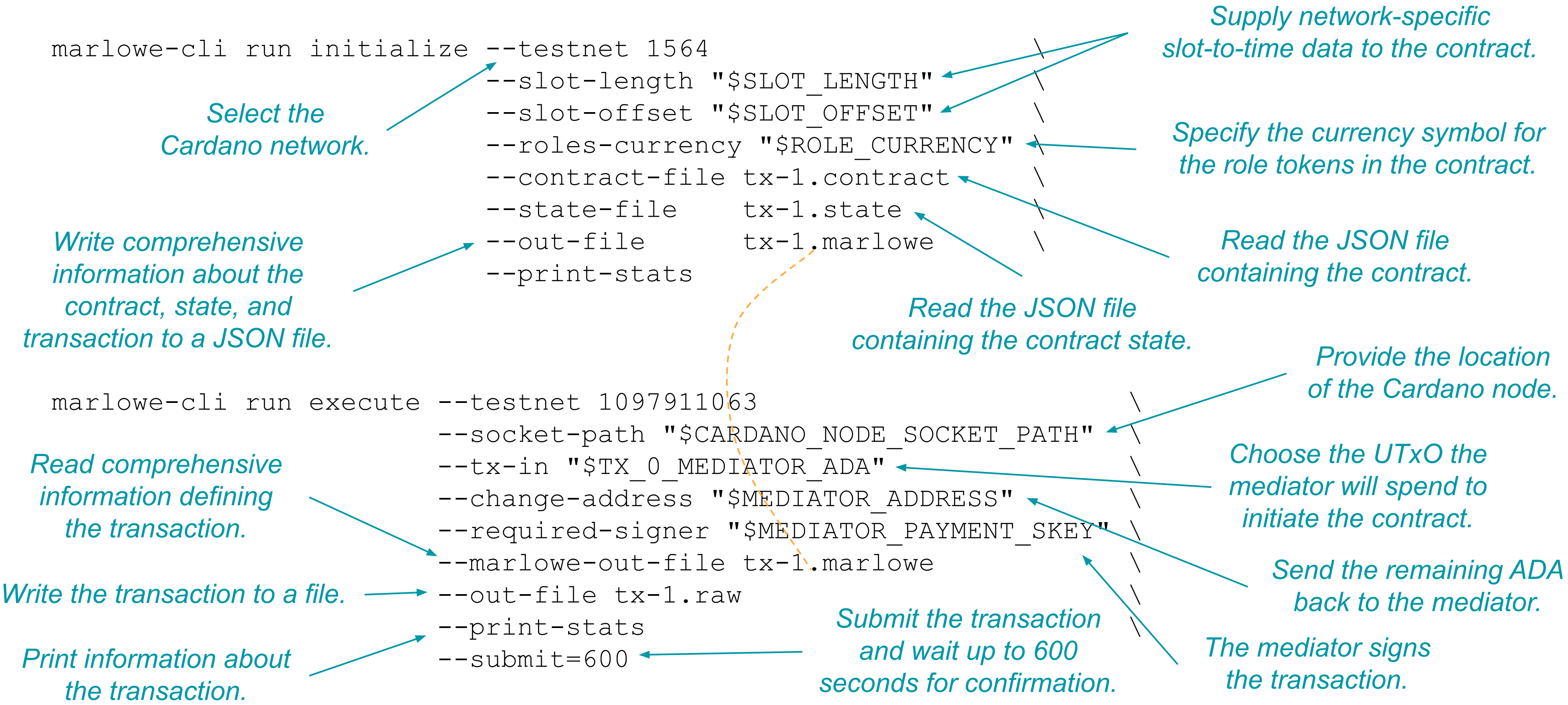
Party	**In Contract**	**At Payout**
Francis Beaumont, seller	0 ADA	0 ADA
Thomas Middleton, buyer	0 ADA	0 ADA
Christopher Marlowe, mediator →	3 ADA	0 ADA


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Everything is alright.
Does the seller dispute that there is a problem?
Dispute problem.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Remaining Contract

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

1. Create the Contract by Providing the Minimum ADA



```
marlowe-cli run initialize --testnet 1564                   \
                           --slot-length "$SLOT_LENGTH"     \
                           --slot-offset "$SLOT_OFFSET"     \
                           --roles-currency "$ROLE_CURRENCY" \
                           --contract-file tx-1.contract    \
                           --state-file    tx-1.state       \
                           --out-file      tx-1.marlowe     \
                           --print-stats
```

```
marlowe-cli run execute --testnet 1097911063                        \
                        --socket-path "$CARDANO_NODE_SOCKET_PATH"   \
                        --tx-in "$TX_0_MEDIATOR_ADA"                \
                        --change-address "$MEDIATOR_ADDRESS"        \
                        --required-signer "$MEDIATOR_PAYMENT_SKEY" \
                        --marlowe-out-file tx-1.marlowe             \
                        --out-file tx-1.raw                         \
                        --print-stats                               \
                        --submit=600
```

Select the Cardano network.

Supply network-specific slot-to-time data to the contract.

Specify the currency symbol for the role tokens in the contract.

Read the JSON file containing the contract.

Read the JSON file containing the contract state.

Write comprehensive information about the contract, state, and transaction to a JSON file.

Provide the location of the Cardano node.

Choose the UTxO the mediator will spend to initiate the contract.

Send the remaining ADA back to the mediator.

The mediator signs the transaction.

Read comprehensive information defining the transaction.

Write the transaction to a file.

Submit the transaction and wait up to 600 seconds for confirmation.

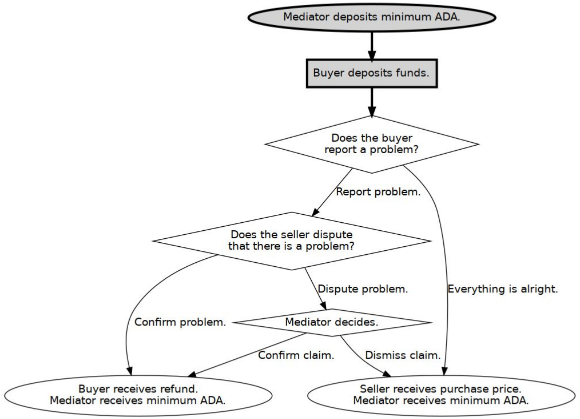
Print information about the transaction.

2. Buyer Deposits Funds into Seller’s Account

Input

- The buyer Francis Middleton uses their role token to deposit 256 ADA into account of the seller Francis Beaumont.

Party	In Contract	At Payout
Francis Beaumont, seller	256 ADA	0 ADA
Thomas Middleton, buyer	0 ADA	0 ADA
Christopher Marlowe, mediator	3 ADA	0 ADA


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Everything is alright.
Does the seller dispute that there is a problem?
Confirm problem.
Dispute problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Remaining Contract

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

2. Buyer Deposits Funds into Seller’s Account

```
marlowe-cli run prepare --marlowe-file tx-1.marlowe           \
                        --deposit-account "Role=$SELLER_ROLE" \
                        --deposit-party "Role=$BUYER_ROLE"    \
                        --deposit-amount "$PRICE"             \
                        --invalid-before "$TIP"               \
                        --invalid-hereafter "$((TIP+4*3600))" \
                        --out-file tx-2.marlowe               \
                        --print-stats
```

Previous Marlowe transaction.

The buyer is making the deposit.

Funds are deposited in the seller’s account.

The transaction must be submitted within a certain slot range.

The buyer is depositing 256 ADA.

New Marlowe transaction.

```
marlowe-cli run execute --testnet 1097911063                                  \
                        --socket-path "$CARDANO_NODE_SOCKET_PATH"             \
                        --marlowe-in-file tx-1.marlowe                        \
                        --tx-in-marlowe "$TX_1"#1                             \
                        --tx-in-collateral "$TX_0_BUYER_ADA"                  \
                        --tx-in "$TX_0_BUYER_ADA"                             \
                        --tx-in "$TX_0_BUYER_TOKEN"                           \
                        --required-signer "$BUYER_PAYMENT_SKEY"               \
                        --marlowe-out-file tx-2.marlowe                       \
                        --tx-out "$BUYER_ADDRESS+$MINIMUM_ADA+1 $BUYER_TOKEN" \
                        --change-address "$BUYER_ADDRESS"                     \
                        --out-file tx-2.raw                                   \
                        --print-stats                                         \
                        --submit=600
```

The buyer offers collateral to the network in case the transaction is invalid.

Spend the eUTxO at the Marlowe script.

The buyer identifies themself using their role token.

The buyer spends a UTxO with at least 256 ADA.

The buyer signs the transaction in order to spend their UTxOs.

The buyer receives their role token back.

The buyer receives any remaining ADA as change.

Example Output of Transaction Command

Transaction cost.

Transaction size.

Transaction 1

```
Fee: Lovelace 197005
Size: 703 / 16384 = 4%
Execution units:
  Memory: 0 / 12500000 = 0%
  Steps: 0 / 10000000000 = 0%
```

Simple transaction.

Plutus execution statistics.

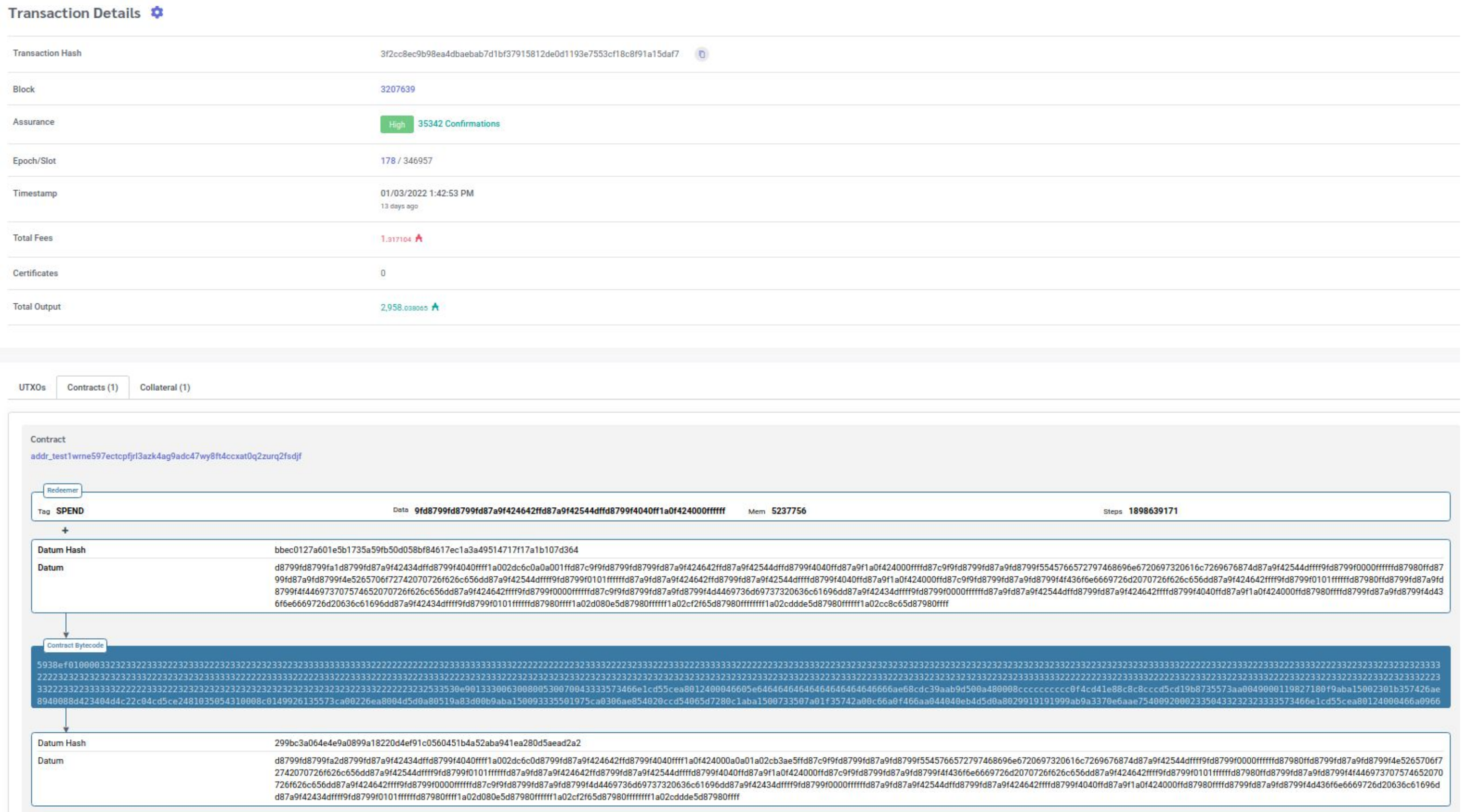
Transaction 2

```
Fee: Lovelace 1317104
Size: 15976 / 16384 = 97%
Execution units:
  Memory: 5237756 / 12500000 = 41%
  Steps: 1898639171 / 10000000000 = 18%
```

Plutus transaction.

Percentages relative to the maximum allowed by the protocol parameters are shown.

Transaction Viewed on Cardanoscan.io



Transaction Details

Transaction Hash	3f2cc8ec9b98ea4dbaebab7d1bf37915812de0d1193e7553cf18c8f91a15daf7
Block	3207639
Assurance	High 35342 Confirmations
Epoch/Slot	178 / 346957
Timestamp	01/03/2022 1:42:53 PM 13 days ago
Total Fees	1.317104 ₳
Certificates	0
Total Output	2,958.038065 ₳

Contract
addr_test1wrne597ectcpfjrl3azk4ag9adc47wy8ft4ccxat0q2zurq2fsdjf

Redeemer

Tag **SPEND** Data **9fd8799fd8799fd87a9f424642ffd87a9f42544dffd8799f4040ff1a0f424000ffffff** Mem **5237756** Steps **1898639171**

+

Datum Hash bbec0127a601e5b1735a59fb50d058bf84617ec1a3a49514717f17a1b107d364

Datum

```
d8799fd8799fa1d8799fd87a9f42434dffd8799f4040ffff1a002dc6c0a0a001ffd87c9f9fd8799fd8799fd87a9f424642ffd87a9f42544dffd8799f4040ffd87a9f1a0f424000ffffd87c9f9fd8799fd87a9fd8799f5545766572797468696e6720697320616c7269676874d87a9f42544dffff9fd8799f0000ffffffd87980ffd87
99fd87a9fd8799f4e5265706f72742070726f626c656dd87a9f42544dffff9fd8799f0101ffffffd87a9fd87a9f424642ffd8799fd87a9f42544dffffd8799f4040ffd87a9f1a0f424000ffd87c9f9fd8799fd87a9fd8799f4f436f6e6669726d2070726f626c656dd87a9f424642ffff9fd8799f0101ffffffd87980ffd8799fd87a9fd
8799f4f446973707574652070726f626c656dd87a9f424642ffff9fd8799f0000ffffffd87c9f9fd8799fd87a9fd8799f4d4469736d69737320636c61696dd87a9f42434dffff9fd8799f0000ffffffd87a9fd87a9f42544dffd8799fd87a9f424642ffffd8799f4040ffd87a9f1a0f424000ffd87980ffffd8799fd87a9fd8799f4d43
6f6e6669726d20636c61696dd87a9f42434dffff9fd8799f0101ffffffd87980ffff1a02d080e5d87980ffffff1a02cf2f65d87980ffffffff1a02cddde5d87980ffffff1a02cc8c65d87980ffff
```

Contract Bytecode

```
5938ef010000332323322233322232333222323322323233223233333333333333222222222222223233333333333332222222222222323333222232333222333222333333332222222323232333222323232323232323232323232323232323232323232323232323233223322323232323233333322222233223332223332223333222332232332232323233333
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33222332233333322222233322232323232323232323232323232323232323223332222223232533530e901333006300800530070043333573466e1cd55cea8012400046605e646464646464646464646666ae68cdc39aab9d500a480008ccccccccc0f4cd41e88c8c8cccd5cd19b8735573aa0049000119827180f9aba15002301b357426ae
8940088d423404d4c22c04cd5ce2481035054310008c0149926135573ca00226ea8004d5d0a80519a83d00b9aba150093335501975ca0306ae854020ccd54065d7280c1aba1500733507a01f35742a00c66a0f466aa044040eb4d5d0a8029919191999ab9a3370e6aae754009200023350433232323333573466e1cd55cea80124000466a0966
```

Datum Hash 299bc3a064e4e9a0899a18220d4ef91c0560451b4a52aba941ea280d5aead2a2

Datum

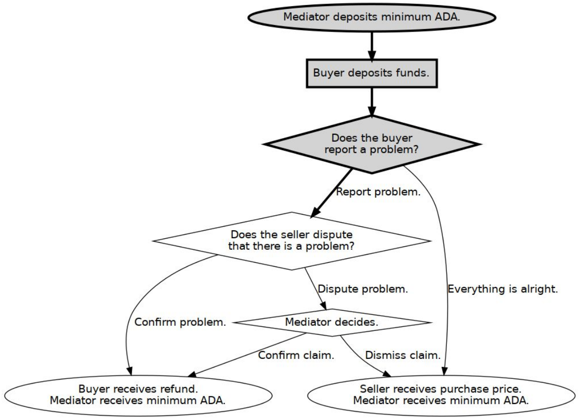
```
d8799fd8799fa2d8799fd87a9f42434dffd8799f4040ffff1a002dc6c0d8799fd87a9f424642ffd8799f4040ffff1a0f424000a0a01a02cb3ae5ffd87c9f9fd8799fd87a9fd8799f5545766572797468696e6720697320616c7269676874d87a9f42544dffff9fd8799f0000ffffffd87980ffd8799fd87a9fd8799f4e5265706f7
2742070726f626c656dd87a9f42544dffff9fd8799f0101ffffffd87a9fd87a9f424642ffd8799fd87a9f42544dffffd8799f4040ffd87a9f1a0f424000ffd87c9f9fd8799fd87a9fd8799f4f436f6e6669726d2070726f626c656dd87a9f424642ffff9fd8799f0101ffffffd87980ffd8799fd87a9fd8799f4f44697370757465207 0
726f626c656dd87a9f424642ffff9fd8799f0000ffffffd87c9f9fd8799fd87a9fd8799f4d4469736d69737320636c61696dd87a9f42434dffff9fd8799f0000ffffffd87a9fd87a9f42544dffd8799fd87a9f424642ffffd8799f4040ffd87a9f1a0f424000ffd87980ffffd8799fd87a9fd8799f4d436f6e6669726d20636c61696d
d87a9f42434dffff9fd8799f0101ffffffd87980ffff1a02d080e5d87980ffffff1a02cf2f65d87980ffffffff1a02cddde5d87980ffff
```

3. The Buyer Reports That There is a Problem

Input

- The buyer Thomas Middleton uses their role token to make choice #1 of “Report problem”.

Party	In Contract	At Payout
Francis Beaumont, seller	0 ADA	0 ADA
Thomas Middleton, buyer	256 ADA	0 ADA
Christopher Marlowe, mediator	3 ADA	0 ADA


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Does the seller dispute that there is a problem?
Dispute problem.
Everything is alright.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Remaining Contract

```
When
 [
  Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
   ( When
    [
     Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
      Close
    , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
      ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
      ( When
       [
        Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
         Close
       , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
        ( When
         [
          Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
           ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
           Close
         , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
           Close
         ]
         (SlotParam "Mediation deadline")
         Close
        )
       ]
       (SlotParam "Dispute deadline")
      ) Close
    ]
    (SlotParam "Complaint deadline")
    Close
   )
 ]
 (SlotParam "Payment deadline")
 Close
```

3. The Buyer Reports That There is a Problem

The buyer makes the choice named “Report problem”.

The buyer’s choice is numbered 1.

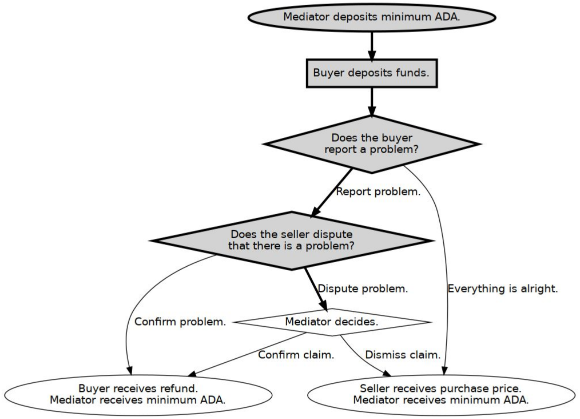
```
marlowe-cli run prepare --marlowe-file tx-2.marlowe          \
                        --choice-name "Report problem"        \
                        --choice-party "Role=$BUYER_ROLE"     \
                        --choice-number 1                     \
                        --invalid-before "$TIP"               \
                        --invalid-hereafter "$((TIP+4*3600))" \
                        --out-file tx-3.marlowe               \
                        --print-stats
```

```
marlowe-cli run execute --testnet 1097911063                                         \
                        --socket-path "$CARDANO_NODE_SOCKET_PATH"                    \
                        --marlowe-in-file tx-2.marlowe                               \
                        --tx-in-marlowe "$TX_2"#1                                    \
                        --tx-in-collateral "$TX_2"#0                                 \
                        --tx-in "$TX_2"#0                                            \
                        --tx-in "$TX_2"#2                                            \
                        --required-signer "$BUYER_PAYMENT_SKEY"                      \
                        --marlowe-out-file tx-3.marlowe                              \
                        --tx-out "$BUYER_ADDRESS+$MINIMUM_ADA+1 $BUYER_TOKEN"        \
                        --change-address "$BUYER_ADDRESS"                            \
                        --out-file tx-3.raw                                          \
                        --print-stats                                                \
                        --submit=600
```

4. The Seller Disputes that There is a Problem

Input

- The seller Francis Beaumont uses their role token to make choice #0 of “Dispute problem”.


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Does the seller dispute that there is a problem?
Dispute problem.
Everything is alright.
Confirm problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Party	**In Contract**	**At Payout**
Francis Beaumont, seller	0 ADA	0 ADA
Thomas Middleton, buyer	256 ADA	0 ADA
Christopher Marlowe, mediator	3 ADA	0 ADA

Remaining Contract

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

4. The Seller Disputes that There is a Problem

The seller makes the choice named "Dispute problem".

The seller's choice is numbered 0.

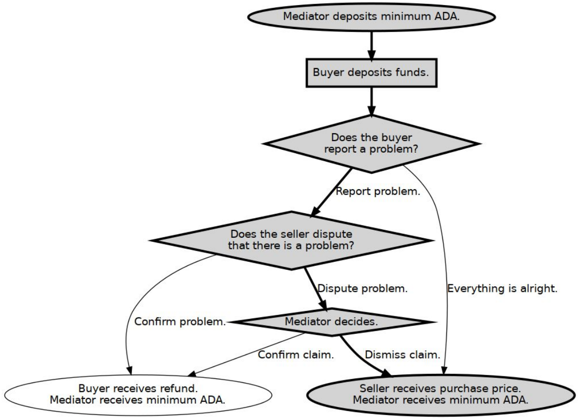
```
marlowe-cli run prepare --marlowe-file tx-3.marlowe            \
                        --choice-name "Dispute problem"        \
                        --choice-party "Role=$SELLER_ROLE" \
                        --choice-number 0                      \
                        --invalid-before "$TIP"                \
                        --invalid-hereafter "$((TIP+4*3600))"  \
                        --out-file tx-4.marlowe                \
                        --print-stats

marlowe-cli run execute --testnet 1097911063                                    \
                        --socket-path "$CARDANO_NODE_SOCKET_PATH"               \
                        --marlowe-in-file tx-3.marlowe                          \
                        --tx-in-marlowe "$TX_3"#1                               \
                        --tx-in-collateral "$TX_0_SELLER_ADA"                   \
                        --tx-in "$TX_0_SELLER_ADA"                              \
                        --tx-in "$TX_0_SELLER_TOKEN"                            \
                        --required-signer "$SELLER_PAYMENT_SKEY"                \
                        --marlowe-out-file tx-4.marlowe                         \
                        --tx-out "$SELLER_ADDRESS+$MINIMUM_ADA+1 $SELLER_TOKEN" \
                        --change-address "$SELLER_ADDRESS"                      \
                        --out-file tx-4.raw                                     \
                        --print-stats                                           \
                        --submit=600
```

5. The Mediator Dismisses the Claim

Input

- The mediator Christopher Marlowe uses their role token to make choice #0 of “Dismiss claim”.

Party	In Contract	At Payout
Francis Beaumont, seller	0 ADA →	256 ADA
Thomas Middleton, buyer	256 ADA ↑	0 ADA
Christopher Marlowe, mediator	0 ADA →	3 ADA


Mediator deposits minimum ADA.
Buyer deposits funds.
Does the buyer report a problem?
Report problem.
Everything is alright.
Does the seller dispute that there is a problem?
Confirm problem.
Dispute problem.
Mediator decides.
Confirm claim.
Dismiss claim.
Buyer receives refund. Mediator receives minimum ADA.
Seller receives purchase price. Mediator receives minimum ADA.

Remaining Contract

```
When
  [
    Case (Deposit (Role "Francis Beaumont (the seller)") (Role "Thomas Middleton (the buyer)") ada 256)
      ( When
        [
          Case (Choice (ChoiceId "Everything is alright" (Role "Thomas Middleton (the buyer)")) [Bound 0 0])
            Close
        , Case (Choice (ChoiceId "Report problem" (Role "Thomas Middleton (the buyer)")) [Bound 1 1])
            ( Pay (Role "Francis Beaumont (the seller)") (Account (Role "Thomas Middleton (the buyer)")) ada 256 )
            ( When
              [
                Case (Choice (ChoiceId "Confirm problem" (Role "Francis Beaumont (the seller)")) [Bound 1 1])
                  Close
              , Case (Choice (ChoiceId "Dispute problem" (Role "Francis Beaumont (the seller)")) [Bound 0 0])
                ( When
                  [
                    Case (Choice (ChoiceId "Dismiss claim" (Role "Christopher Marlowe (the mediator)")) [Bound 0 0])
                      ( Pay (Role "Thomas Middleton (the buyer)") (Account (Role "Francis Beaumont (the seller)")) ada 256 )
                      Close
                  , Case (Choice (ChoiceId "Confirm claim" (Role "Christopher Marlowe (the mediator)")) [Bound 1 1])
                      Close
                  ]
                  (SlotParam "Mediation deadline")
                  Close
                )
              ]
              (SlotParam "Dispute deadline")
            ) Close
        ]
        (SlotParam "Complaint deadline")
        Close
      )
  ]
  (SlotParam "Payment deadline")
  Close
```

5. The Mediator Dismisses the Claim

```
marlowe-cli run prepare --marlowe-file tx-4.marlowe            \
                        --choice-name "Dismiss claim"          \
                        --choice-party "Role=$MEDIATOR_ROLE"   \
                        --choice-number 0                      \
                        --invalid-before "$TIP"                \
                        --invalid-hereafter "$((TIP+4*3600))" \
                        --out-file tx-5.marlowe                \
                        --print-stats
```

The mediator makes the choice named “Dismiss claim”.

The mediator’s choice is numbered 0.

```
marlowe-cli run execute --testnet 1097911063                                  \
                        --socket-path "$CARDANO_NODE_SOCKET_PATH"             \
                        --marlowe-in-file tx-4.marlowe                        \
                        --tx-in-marlowe "$TX_4"#1                             \
                        --tx-in-collateral "$TX_1"#0                          \
                        --tx-in "$TX_1"#0                                     \
                        --tx-in "$TX_0_MEDIATOR_TOKEN"                        \
                        --required-signer "$MEDIATOR_PAYMENT_SKEY"            \
                        --marlowe-out-file tx-5.marlowe                       \
                        --tx-out "$MEDIATOR_ADDRESS+$MINIMUM_ADA+1 $MEDIATOR_TOKEN" \
                        --change-address "$MEDIATOR_ADDRESS"                  \
                        --out-file tx-5.raw                                   \
                        --print-stats                                         \
                        --submit=600
```

6. The Seller Withdraws Their Funds

Input

- The seller Francis Beaumont uses their role token to withdraw 256 ADA from the payout script.

Party	**In Contract**	**At Payout**
Francis Beaumont, seller ←	0 ADA	0 ADA
Thomas Middleton, buyer	0 ADA	0 ADA
Christopher Marlowe, mediator	0 ADA	3 ADA

6. The Seller Withdraws Their Funds

```
marlowe-cli run withdraw --testnet 1097911063                                    \
                         --socket-path "$CARDANO_NODE_SOCKET_PATH"               \
                         --marlowe-file tx-5.marlowe                             \
                         --role-name "$SELLER_ROLE"                              \
                         --tx-in "$TX_4"#0                                       \
                         --tx-in "$TX_4"#2                                       \
                         --tx-in-collateral "$TX_4"#0                            \
                         --required-signer "$SELLER_PAYMENT_SKEY"                \
                         --tx-out "$SELLER_ADDRESS+$MINIMUM_ADA+1 $SELLER_TOKEN" \
                         --change-address "$SELLER_ADDRESS"                      \
                         --out-file tx-6.raw                                     \
                         --print-stats                                           \
                         --submit=600
```

The seller is making the withdrawal.

The seller identifies themself using their role token.

The seller receives all of the funds belonging to them.

The seller receives their role token back.

7. The Mediator Withdraws Their Funds

<u>Input</u>

- The mediator Christopher Marlowe uses their role token to withdraw their 3 ADA from the payout script.

Party	In Contract	At Payout
Francis Beaumont, seller	0 ADA	0 ADA
Thomas Middleton, buyer	0 ADA	0 ADA
Christopher Marlowe, mediator ←	0 ADA	0 ADA

7. The Mediator Withdraws Their Funds

```
marlowe-cli run withdraw --testnet 1097911063                                        \
                         --socket-path "$CARDANO_NODE_SOCKET_PATH"                   \
                         --marlowe-file tx-5.marlowe                                 \
                         --role-name "$MEDIATOR_ROLE"                                \
                         --tx-in "$TX_5"#0                                           \
                         --tx-in "$TX_5"#3                                           \
                         --tx-in-collateral "$TX_5"#0                                \
                         --required-signer "$MEDIATOR_PAYMENT_SKEY"                  \
                         --tx-out "$MEDIATOR_ADDRESS+$MINIMUM_ADA+1 $MEDIATOR_TOKEN" \
                         --change-address "$MEDIATOR_ADDRESS"                        \
                         --out-file tx-7.raw                                         \
                         --print-stats                                               \
                         --submit=600
```

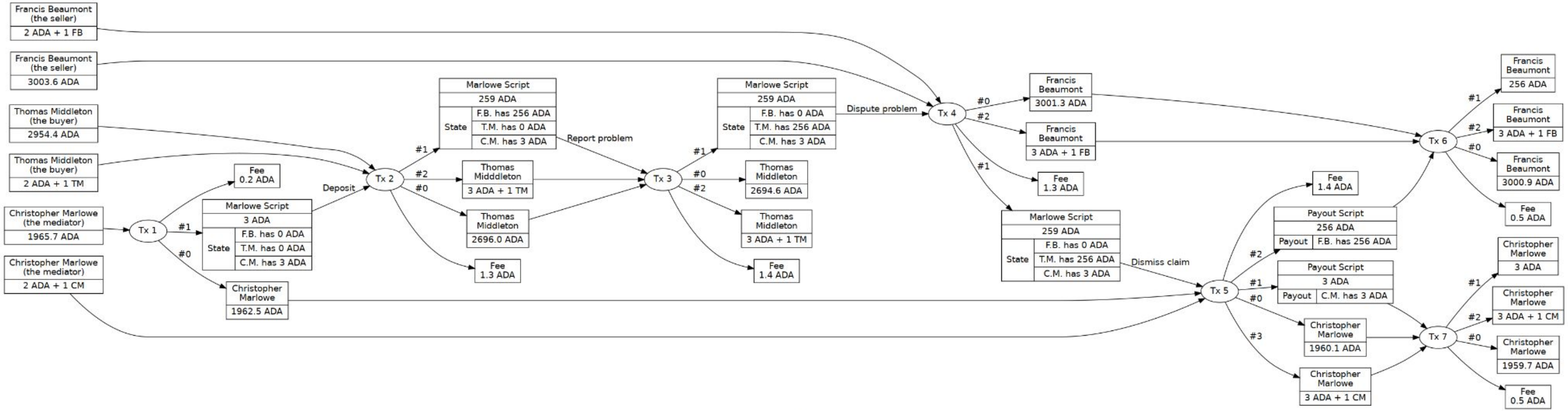
The mediator is making the withdrawal.

The mediator identifies themself using their role token.

The mediator receives all of the funds belonging to them.

The mediator receives their role token back.

Summary of Transactions



Boxes are UTxOs.
Ovals are transactions.
ADA values are rounded to one decimal place.

Prospects

- Marlowe CLI provides both high- and low-level commands for running Marlowe contracts from the command line.
  - The high-level workflow hides details for scripts, datums, redeemers, and contracts.
  - The low-level workflow explicitly manipulates scripts, datums, redeemers, contracts, contract state, and inputs.
- This tool can be used either for applications or for debugging purposes.
- Future work may include:
  - Merkleization of contracts to reduce contract size.
  - Querying contract history.
  - Management of role tokens.
  - Directly accessing contract endpoints on Marlowe’s Plutus Application Backend (PAB).
  - More extensive tutorials.
- Further documentation and examples: https://github.com/input-output-hk/marlowe-cardano/blob/main/marlowe-cli/ReadMe.md