Step by Step Towards a Safe Contract:

Insights from an Undergraduate Ethereum Lab

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Ethereum Lab Setup

- **Students worked in groups of 4.**

- **Each group is assigned one graduate student advisor**
  - My Ph.D. students

Ethereum Lab Setup

- **Phase 1: Proposer phase**
  - – Students develop of choice on Ethereum

- **Phase 2: Amendment/critique phase**
  - – Instructors and graduate TAs give feedback
  - – Students critique each other's designs
  - – Students amend their designs

Ethereum Lab Outcome

The good news:

- An inspiring experience where the students, my Ph.D. students, and I learned together
- Some students said that they really enjoy learning about crypto-currency. Crypto-currency is awesome.
- All students did an impressive job!

Ethereum Lab Outcome

The bad news:

- Some students did not like the experience due to the in-development nature of the Serpent language -- despite the fact that they all did an impressive job!!

Apps Created by Students

- Games (where people play for money)
  - Rock paper scissors, Russian Roulette, and many others
- Escrow service
- Auctions
  - blind auctions, silent auction
- Parking meter
- Stock market app

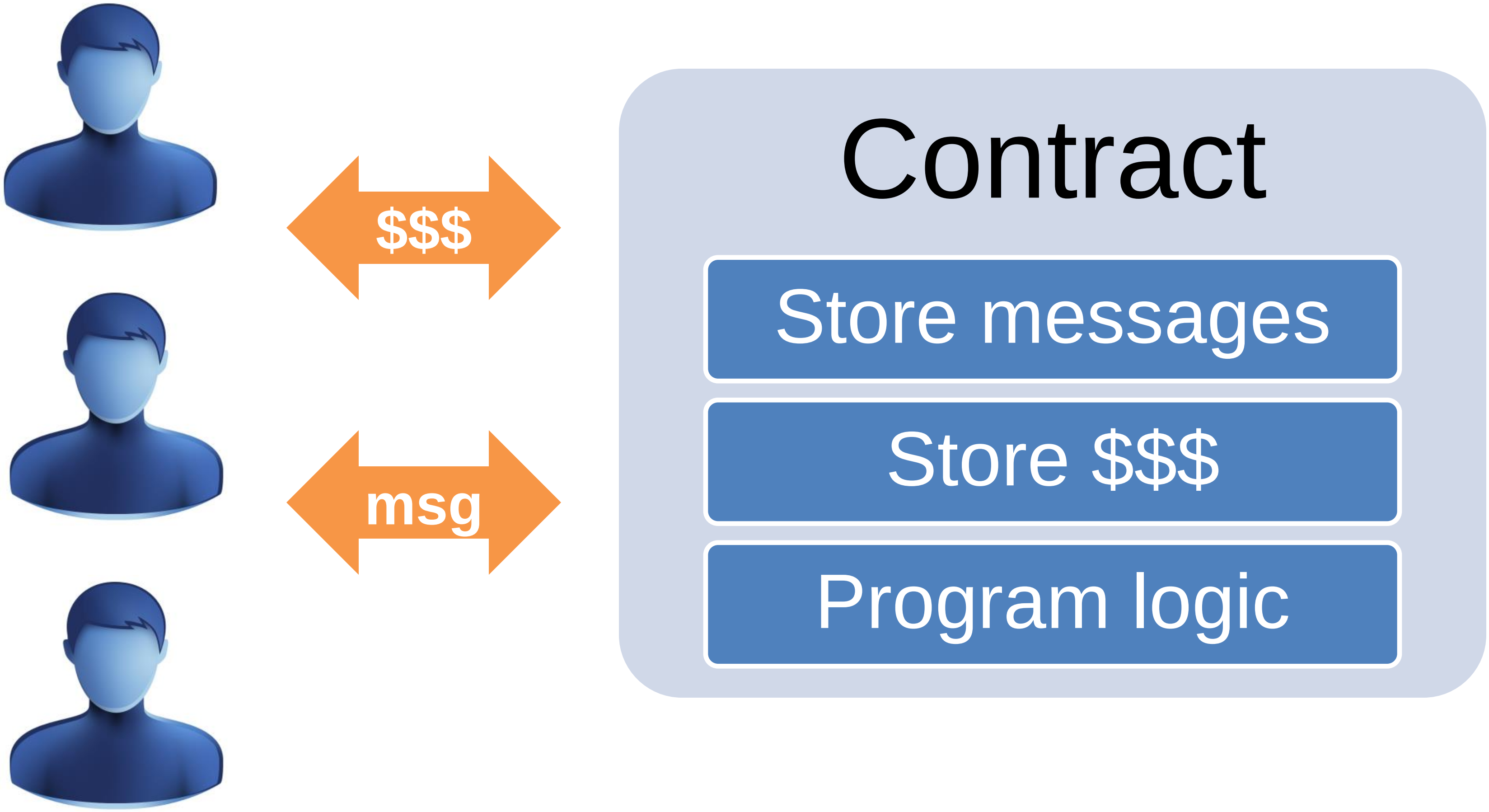
Lessons Learned

- In Phase 1, we noticed that students created many “insecure” contracts.

- Conclusion:
  - **Security is difficult.**
  - Programming smart contracts: **you can mess up in new ways** in comparison with traditional programming.

Step by Step Towards a Safe Contract

The Simplified Contract Programming Model



$$$

msg

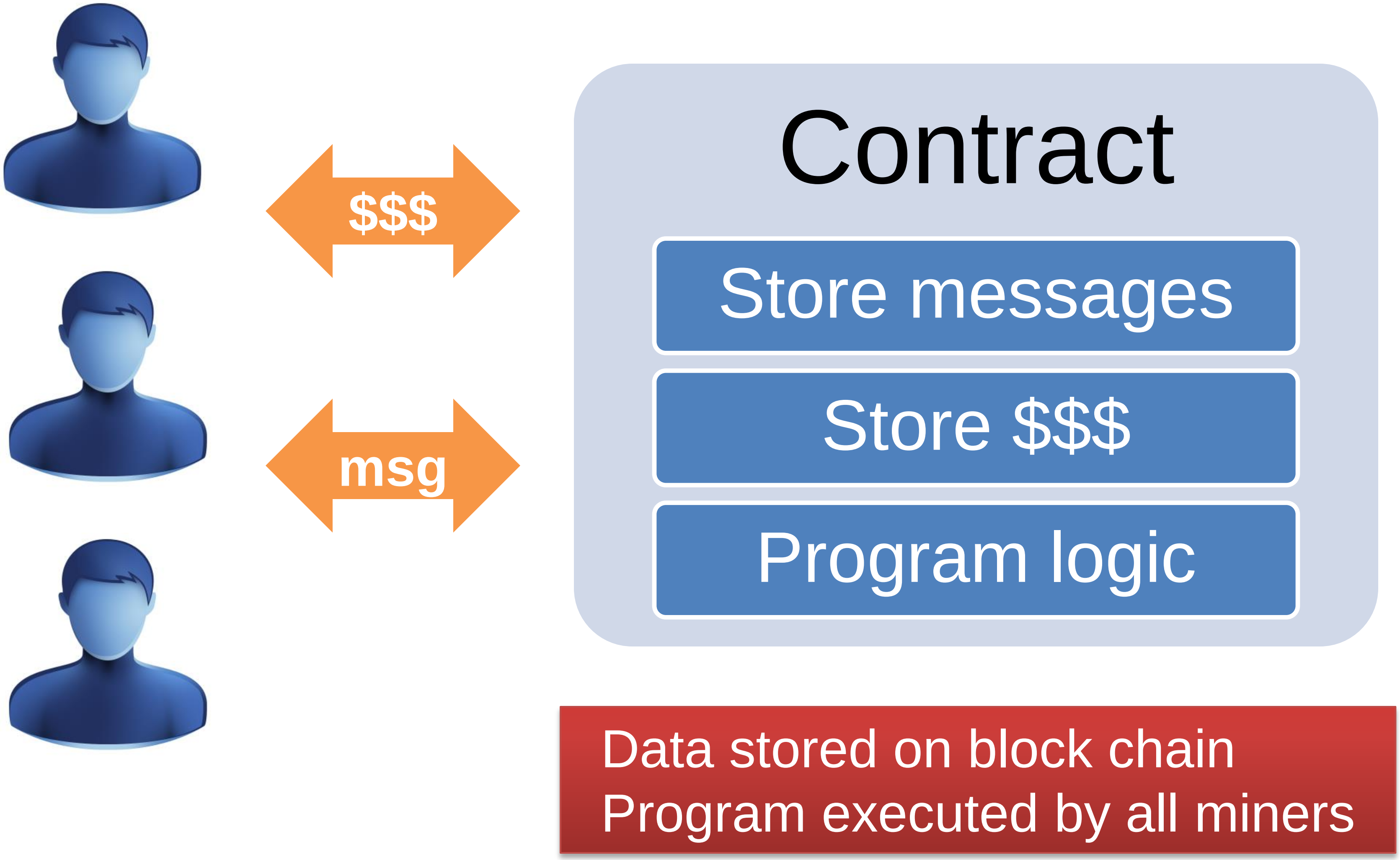
Contract

Store messages

Store $$$

Program logic

The Simplified Contract Programming Model



$$$

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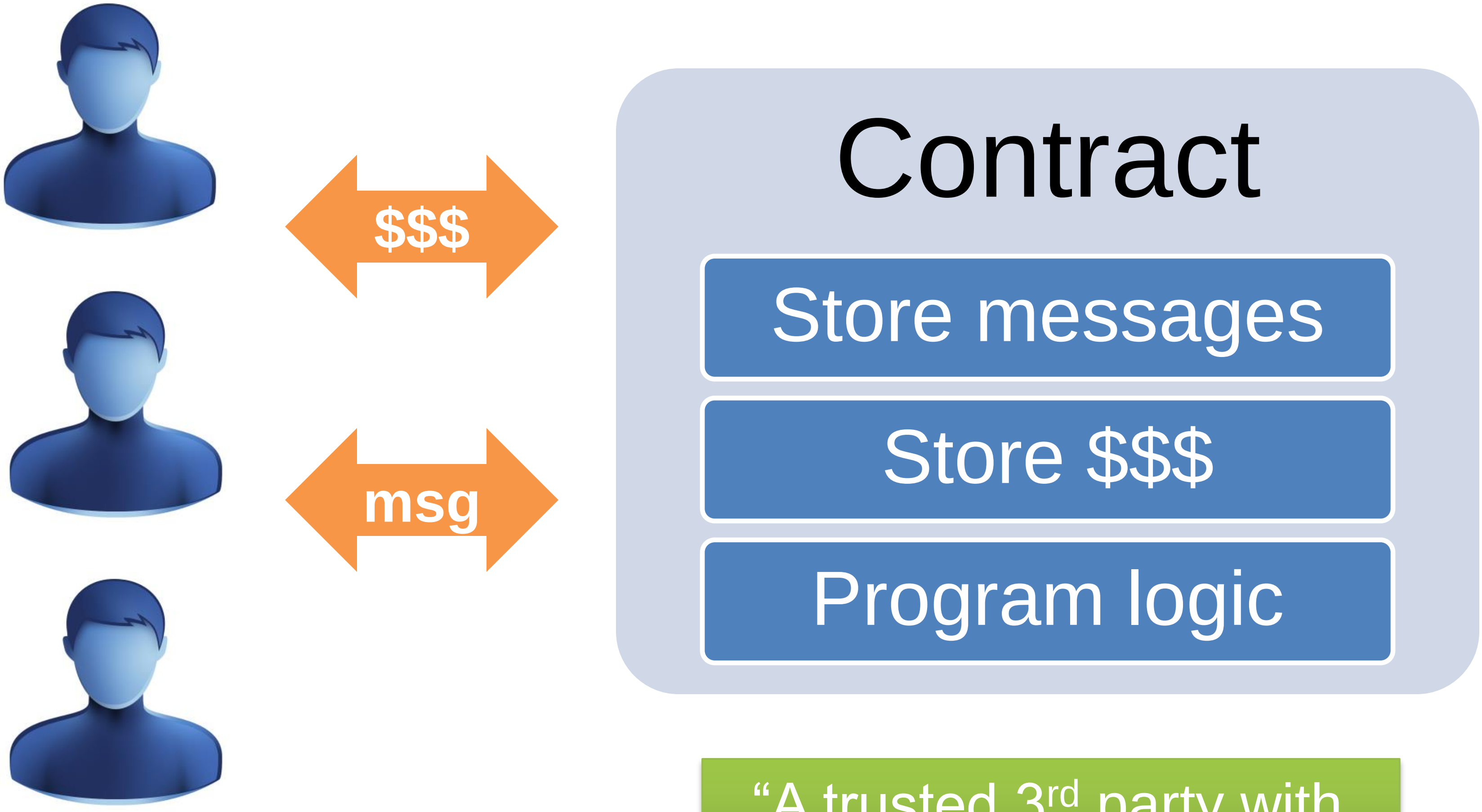
Program logic

Data stored on block chain
Program executed by all miners

The Simplified Contract Programming Model



$$$

msg

Contract

Store messages

Store $$$

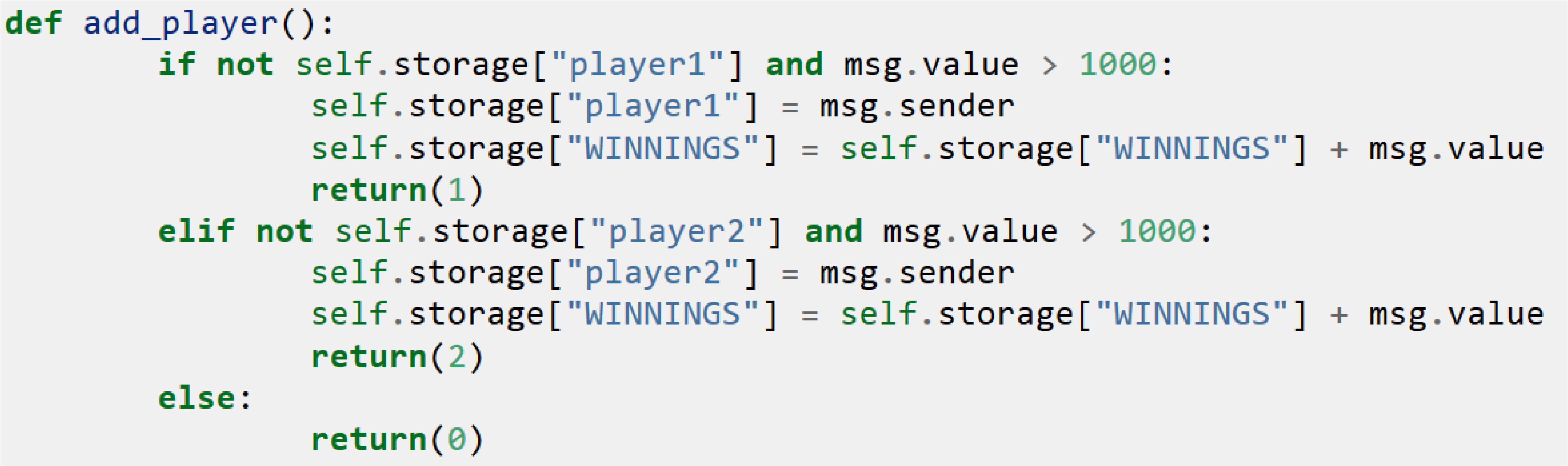
Program logic

“A trusted 3rd party with no privacy”

Rock Paper Scissors Example

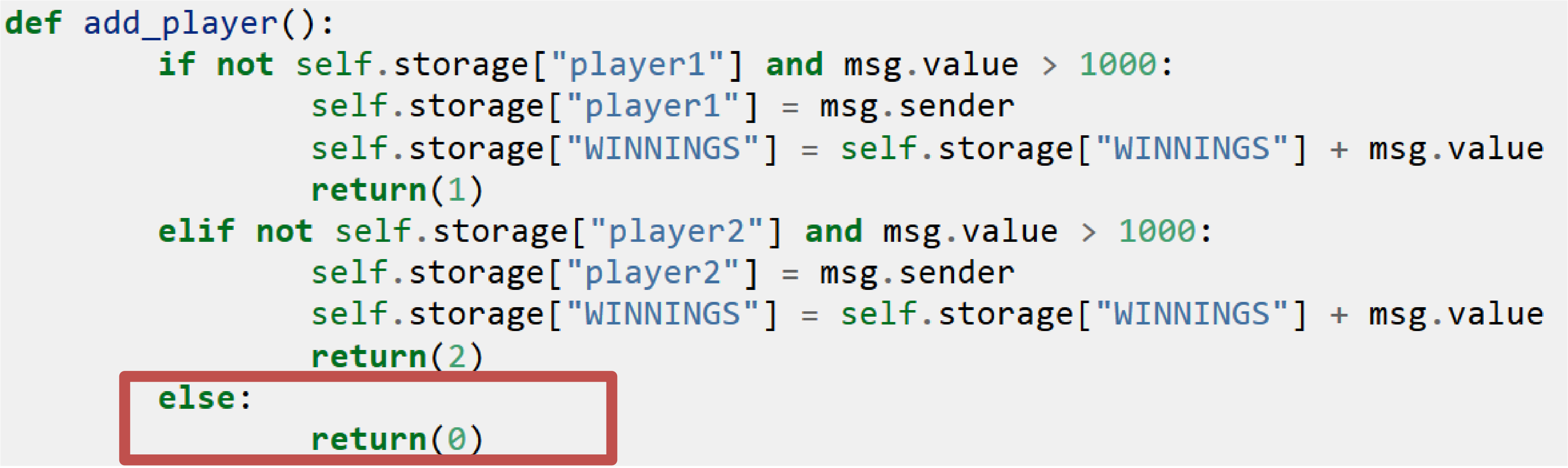
```
def add_player()
/* Player 1 and 2 enter the game by sending money.
   Contract records their identities. */

def input()
/* Player 1 and 2 sends their input to contract
   Contract records their inputs*/

def winner()
/* Decide the winner and sends balance on the contract
   to the winner*/
```

Typical mistake 1:



```
def add_player():
        if not self.storage["player1"] and msg.value > 1000:
                self.storage["player1"] = msg.sender
                self.storage["WINNINGS"] = self.storage["WINNINGS"] + msg.value
                return(1)
        elif not self.storage["player2"] and msg.value > 1000:
                self.storage["player2"] = msg.sender
                self.storage["WINNINGS"] = self.storage["WINNINGS"] + msg.value
                return(2)
        else:
                return(0)
```

Typical mistake 1: corner cases in state machine



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        else:
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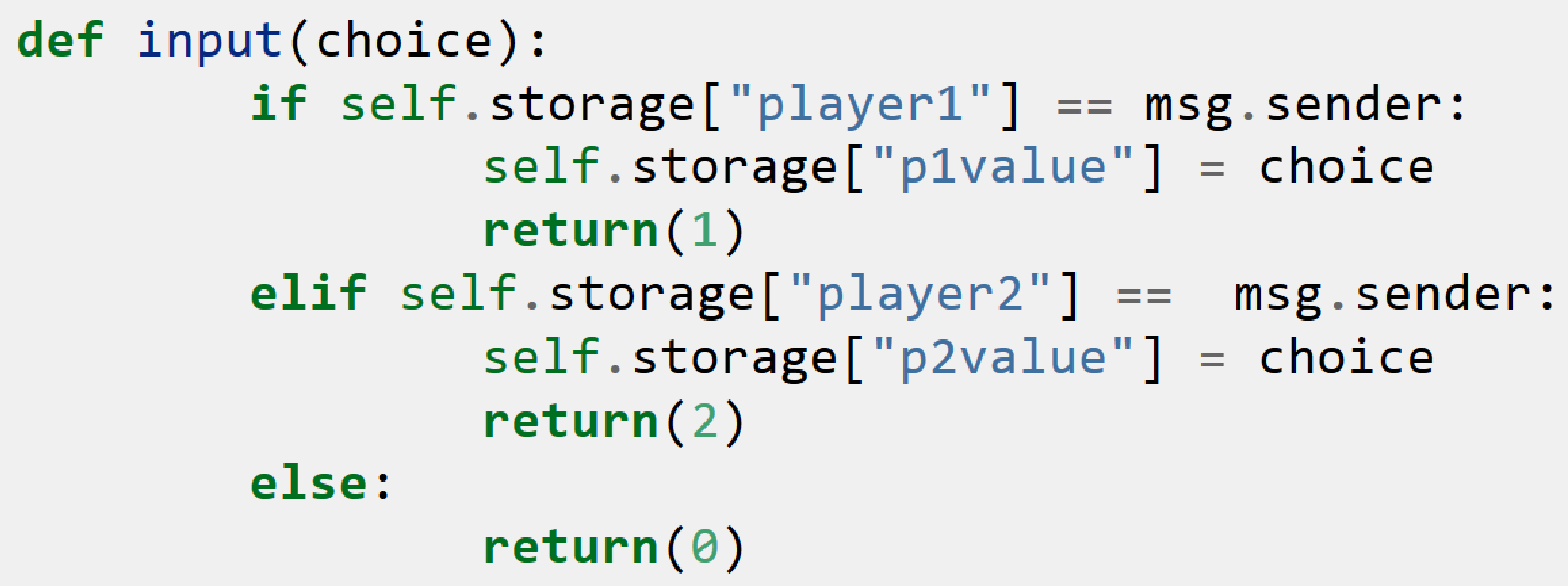
```

If 3rd player enters, or player sends < 1000 ethers, money is leaked

Similar mistakes arise in other applications.

Typical mistake 2:



```
def input(choice):
        if self.storage["player1"] == msg.sender:
                self.storage["p1value"] = choice
                return(1)
        elif self.storage["player2"] ==  msg.sender:
                self.storage["p2value"] = choice
                return(2)
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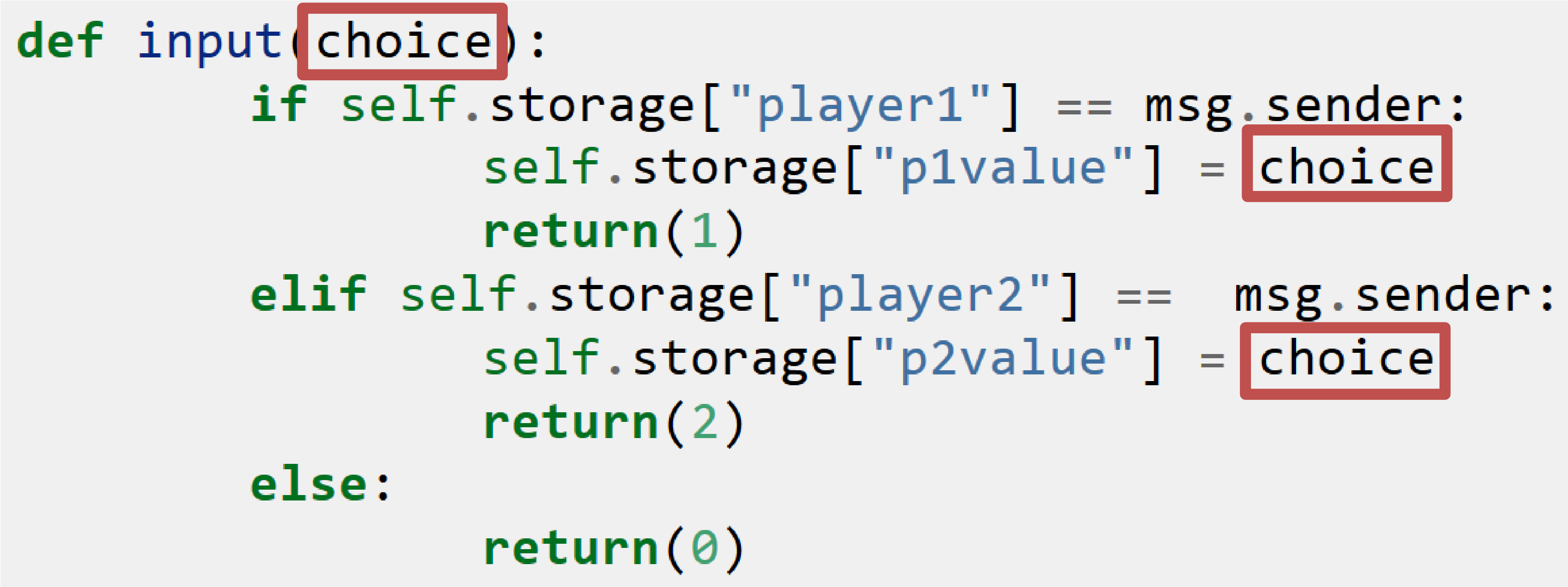
```

Typical mistake 2: failure to use cryptography



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                self.storage["p1value"] = choice
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```
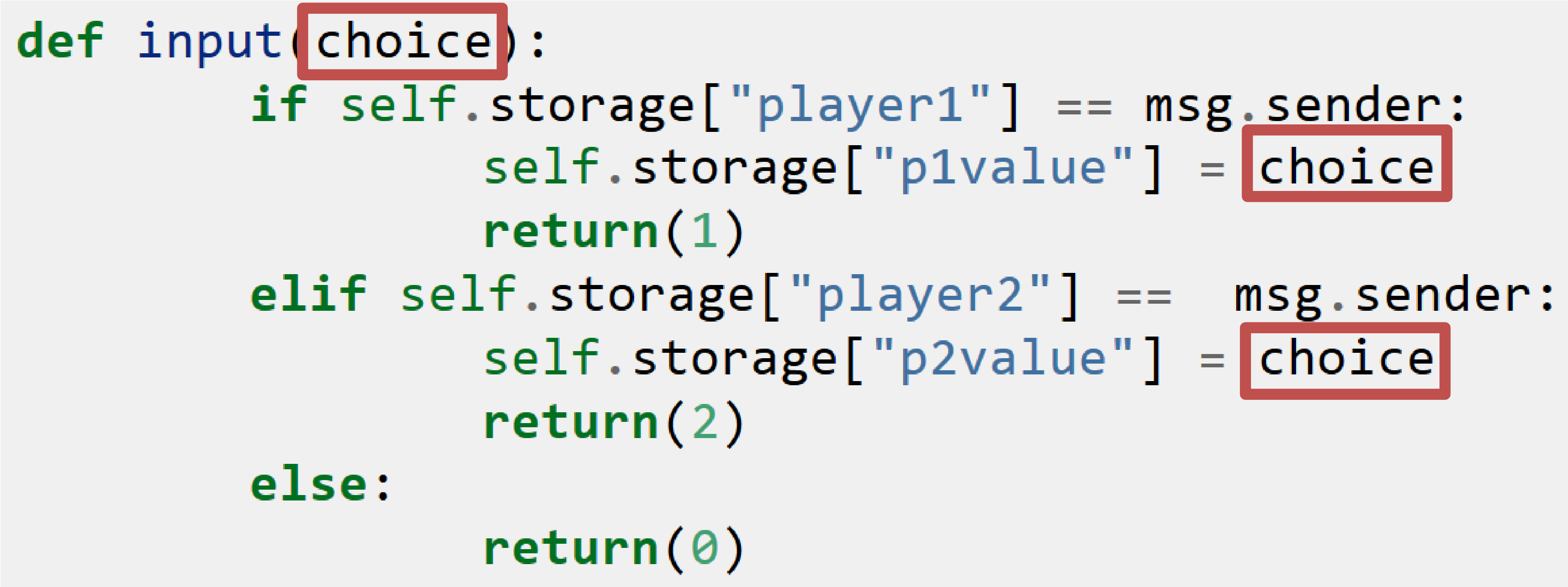

Players' choices sent and stored in cleartext.

Typical mistake 2: failure to use cryptography



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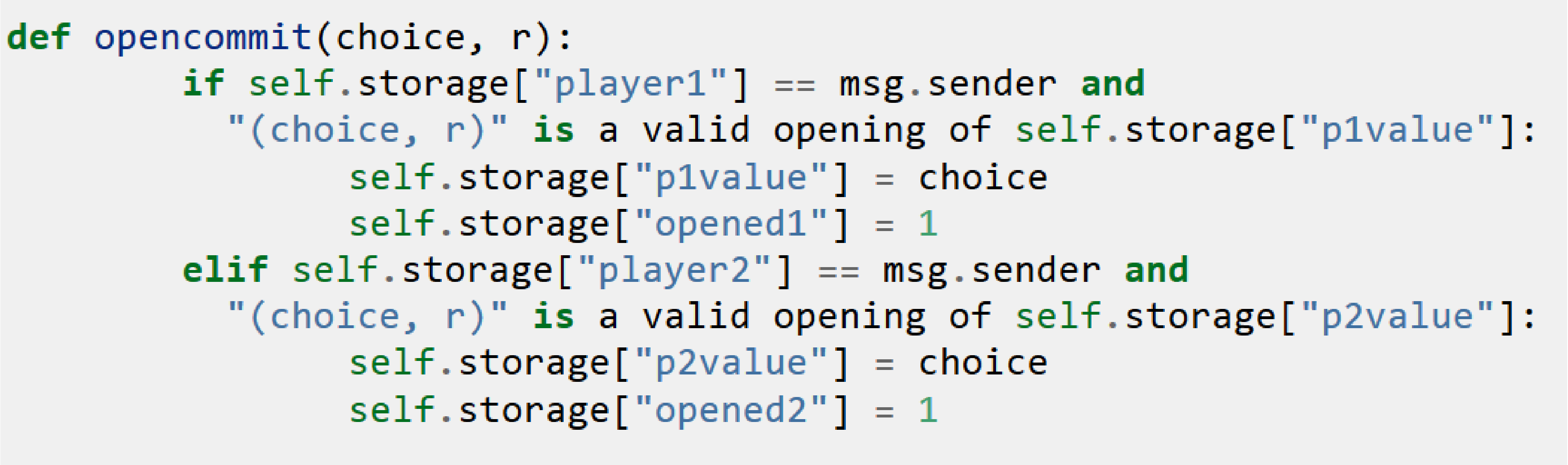
```

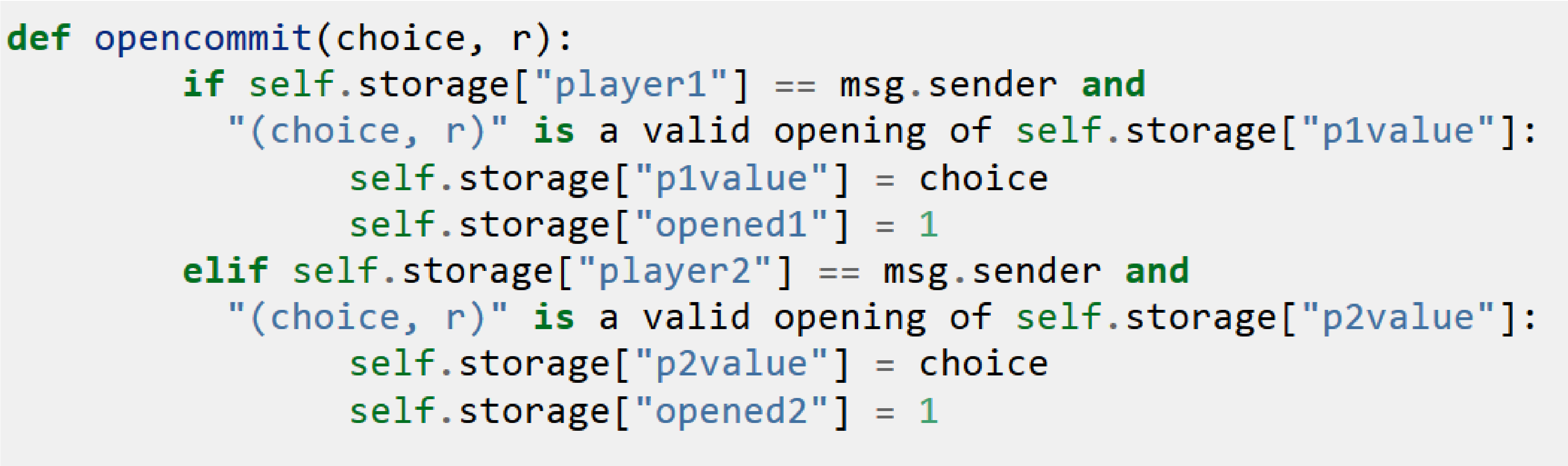
Solution: use cryptographic commitment

Typical mistake 3:



```
def opencommit(choice, r):
        if self.storage["player1"] == msg.sender and
          "(choice, r)" is a valid opening of self.storage["p1value"]:
                self.storage["p1value"] = choice
                self.storage["opened1"] = 1
        elif self.storage["player2"] == msg.sender and
          "(choice, r)" is a valid opening of self.storage["p2value"]:
                self.storage["p2value"] = choice
                self.storage["opened2"] = 1
```

Typical mistake 3: incentive incompatible contracts



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          "(choice, r)" is a valid opening of self.storage["p2value"]:
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```
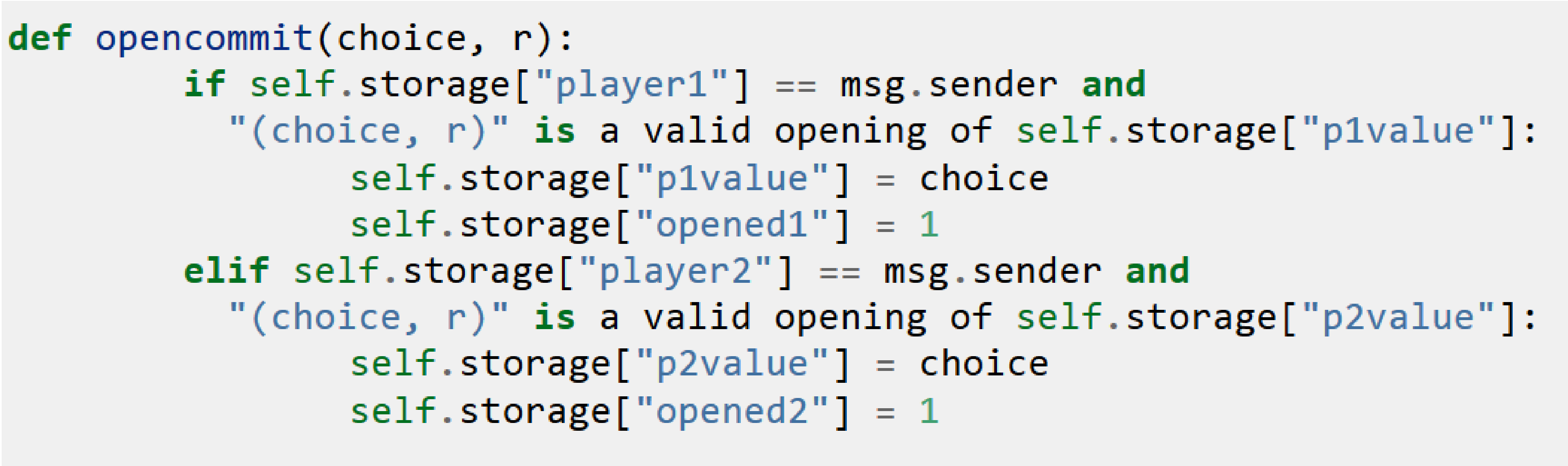

Player has no incentive to open commitment when he sees that he is losing.

Typical mistake 3: incentive incompatible contracts



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```

Solution:

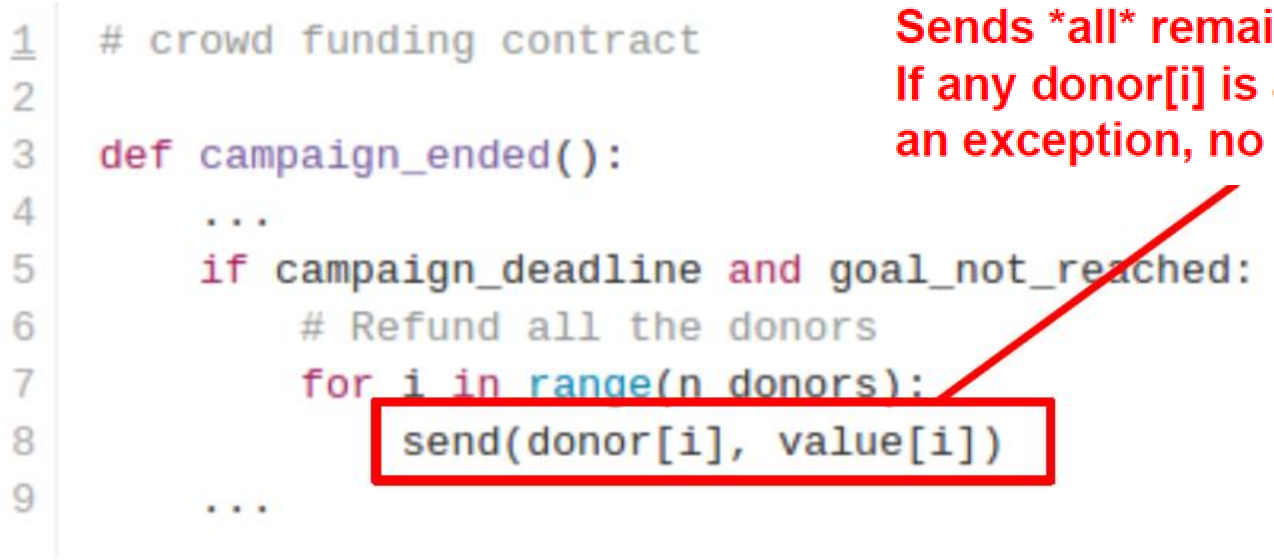
Require deposit to play. Player loses deposit if commitment is not opened after a time-out.

Coming Up Soon

- **Online course materials for programming smart contracts**

- **Lab instructions and accompanying virtual machines**
  - – For instructors teaching cryptocurrency

More Subtle Bugs

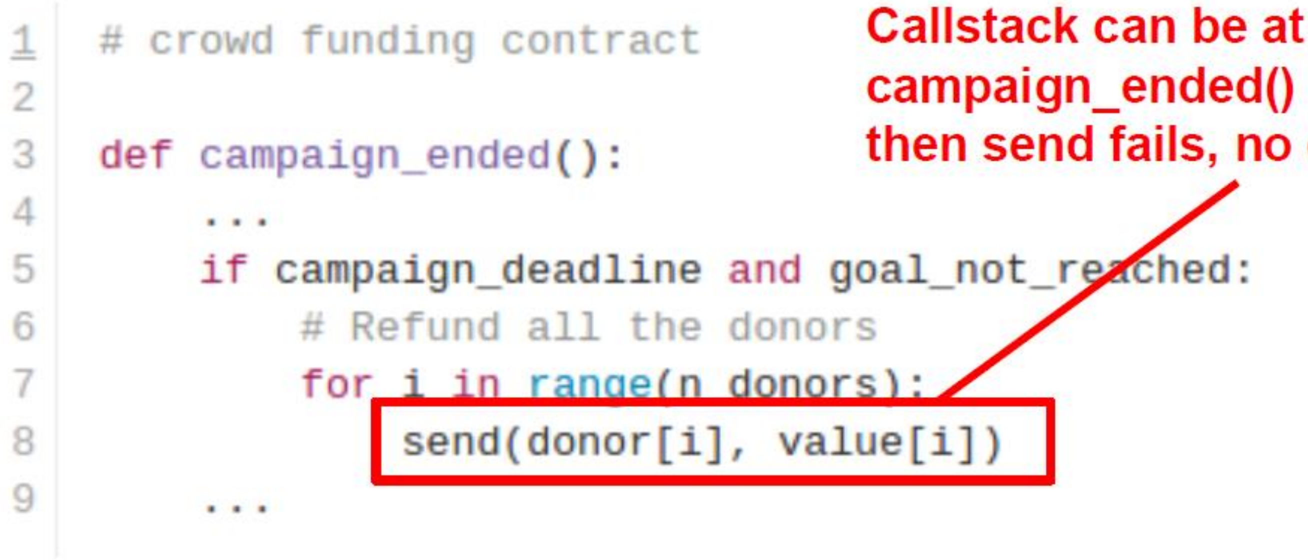


```
# crowd funding contract

def campaign_ended():
    ...
    if campaign_deadline and goal_not_reached:
        # Refund all the donors
        for i in range(n_donors):
            send(donor[i], value[i])
    ...
```

Sends *all* remaining gas to donor[i]
If any donor[i] is a contract that causes an exception, no one gets their refund

More Subtle Bugs



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    ...
```

Callstack can be at most 1024. If campaign_ended() is called at depth 1023, then send fails, no one gets their refund

Thank you!

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