Module 5

States

corda

Learning outcomes

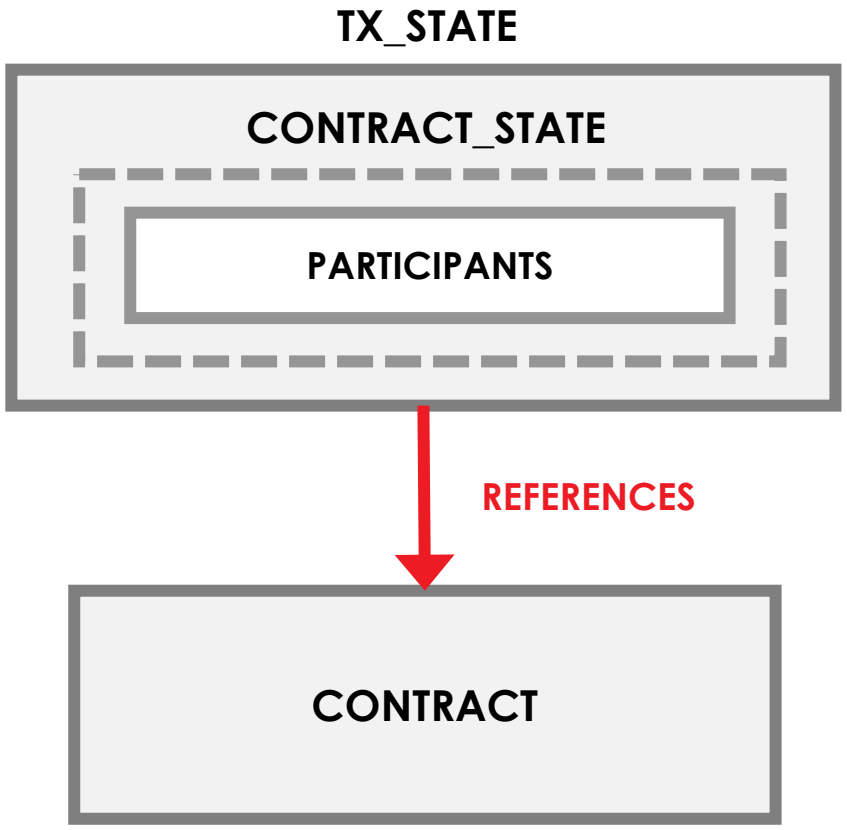
- Learn what key interfaces states need to implement
- Learn how a node's vault decides whether to track a state
- Learn how to design your own states

ContractState and TransactionState

- All states implement the **`ContractState`** interface:

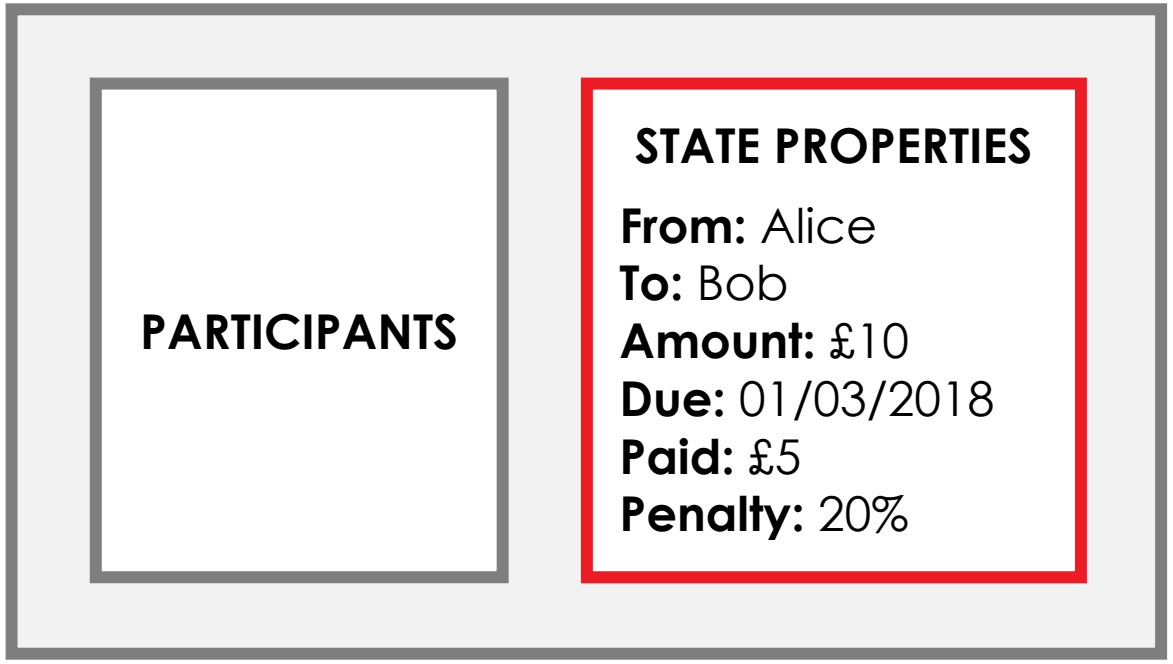
```
interface ContractState {
    val participants:
        List<AbstractParty>
}
```

- Contract state does not refer to a contract directly
- **`contract`** defines the constraints on the evolution of instances of this state type
- **`participants`** lists anyone who is able to evolve this state



User-defined fields

Classes implementing the `ContractState` interface can also have unlimited user-defined fields and methods…



AbstractParty

- In Corda, all nodes are identified as **`AbstractParty`** instances:

```
class AbstractParty(val owningKey: PublicKey)
```

- **`owningKey`** is a **`PublicKey`** representing the node's master public key
- **`AbstractParty`** provides no additional information to identify the node

Party

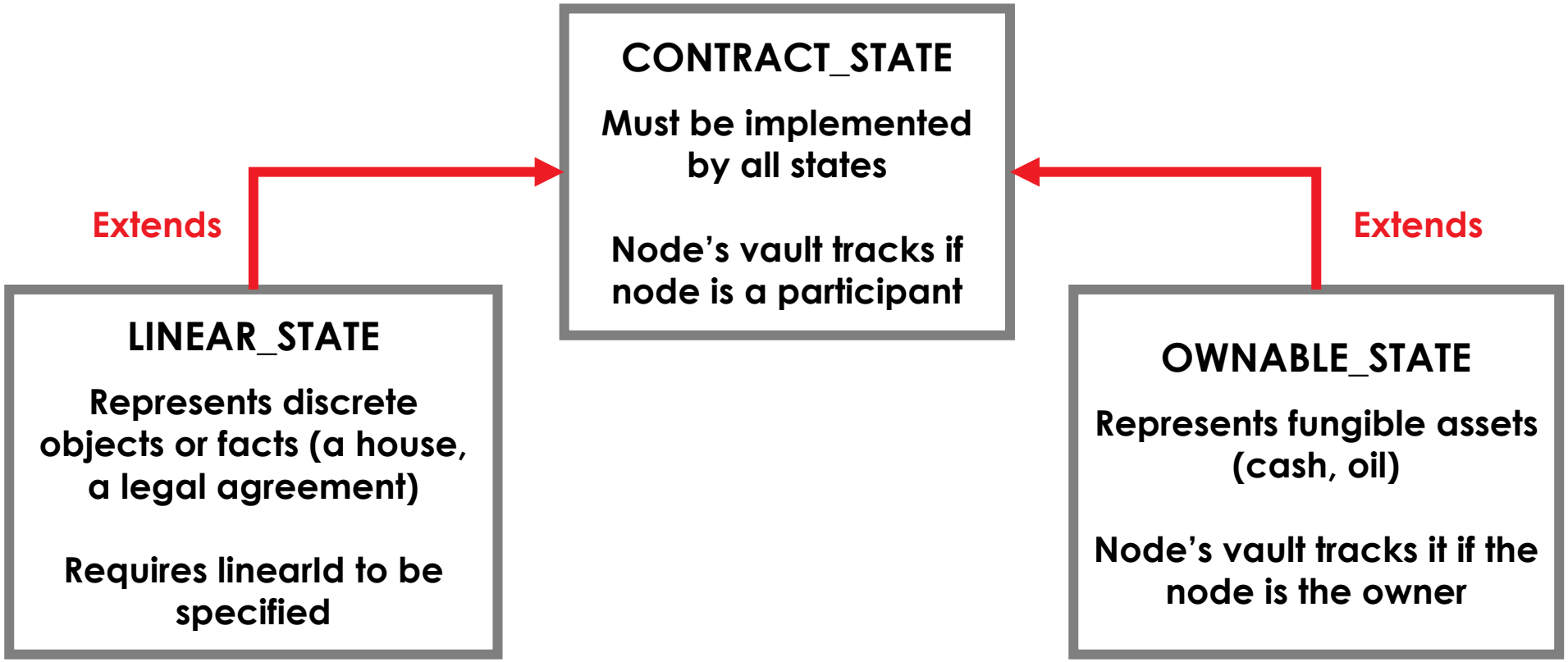
- **`Party`** is an **`AbstractParty`** subclass that associates the master public key with an identity:

```
class Party(val name: CordaX500Name, val owningKey: PublicKey)
```

- **`name`** is the node's X500 name
- **`owningKey`** is the node's master public key, as before

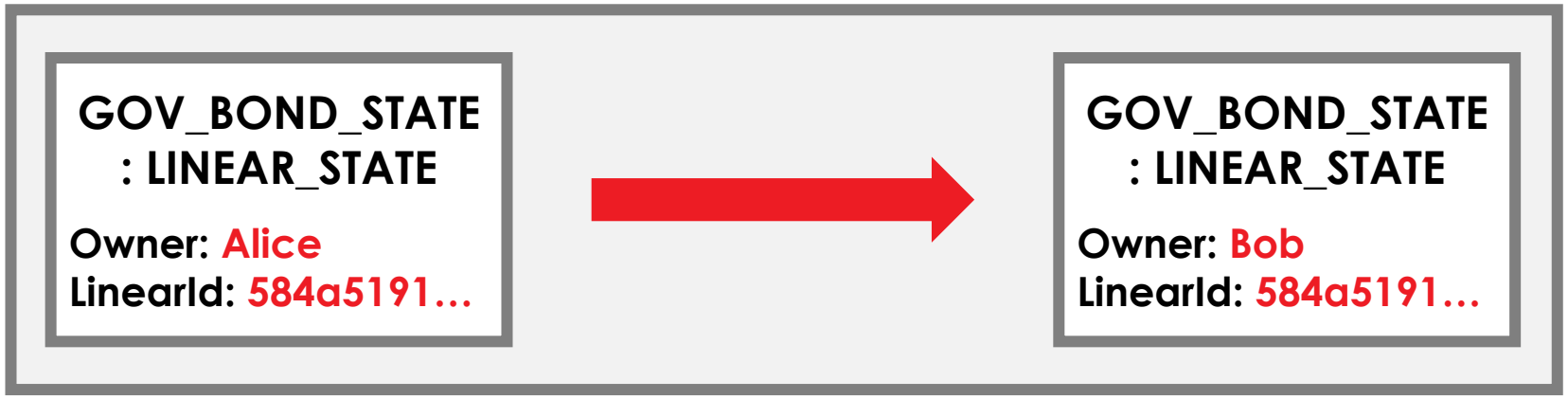
State types

`ContractState` has several key child interfaces:



LinearState

- **LinearState** is used to represent discrete objects or facts that evolve over time (a specific bond, a trade finance deal…)
- In Corda's UTXO model, we can't modify the state directly
- So we evolve the state through a transaction that consumes the old state and creates an updated one with the same ID:



LinearState

`LinearState` attributes and methods:

- `linearId: UniqueIdentifier`
  - A unique ID that allows the fact to be tracked over time and referenced in external systems

A common LinearState usecase: agreements

Agreements (contracts, bilateral derivatives, invoices) are a good fit for `LinearState`:

- A given legal agreement has a single identity over time
- Agreements evolve over time by replacing the existing agreement
- We can only evolve the agreement by modifying the most recent version…
- But we still have access to the old versions if required

An example LinearState: the NumberState

- **NumberState** extends **LinearState** to represent a number on ledger:

```
data class NumberState(
    val number: Int,
    val partyA: Party,
    val partyB: Party,
    override val linearId: UniqueIdentifier =
                                    UniqueIdentifier()
) : LinearState {

    override val participants
        get() = listOf(partyA, partyB)

}
```

OwnableState

- **`OwnableState`** is used to represent fungible assets with an owner (cash, barrels of oil, bushels of corn…)

```
interface OwnableState : ContractState {
    val owner: AbstractParty
    fun withNewOwner(newOwner: AbstractParty):
        Pair<CommandData, OwnableState>
}
```

- **`owner`** is the **`AbstractParty`** that owns the state
- **`withNewOwner()`** creates a copy of the **`OwnableState`** with a new owner
- There is no unique identifier – **`OwnableStates`** with the same attributes (e.g. two £100 cash states) are effectively identical

A common OwnableState usecase: cash

Cash will implement `OwnableState`:

- Two cash states with the same currency and the same value are identical
- Cash states can be split and merged
- Instead of spending a specific cash state, we spend an amount of cash (i.e. a set of states) of a given value

An example LinearState: the BondState

- **BondState** extends **OwnableState** to represent a fungible bond:

```
data class BondState(
    val partyA: Date,
    val partyB: Date,
    val maturityDate: Date,
    val nominal: Int,
    val couponPercent: Int,
    override val owner: AbstractParty
) : OwnableState {

    override val participants
        get() = listOf(partyA, partyB)
}
```

States in summary

- **States** represent shared facts on the ledger
- States must directly or indirectly implement `ContractState`
- All states have a participants list
- States may also wish to implement some child interfaces:
  - `LinearState`
  - `OwnableState`


r3
Practical

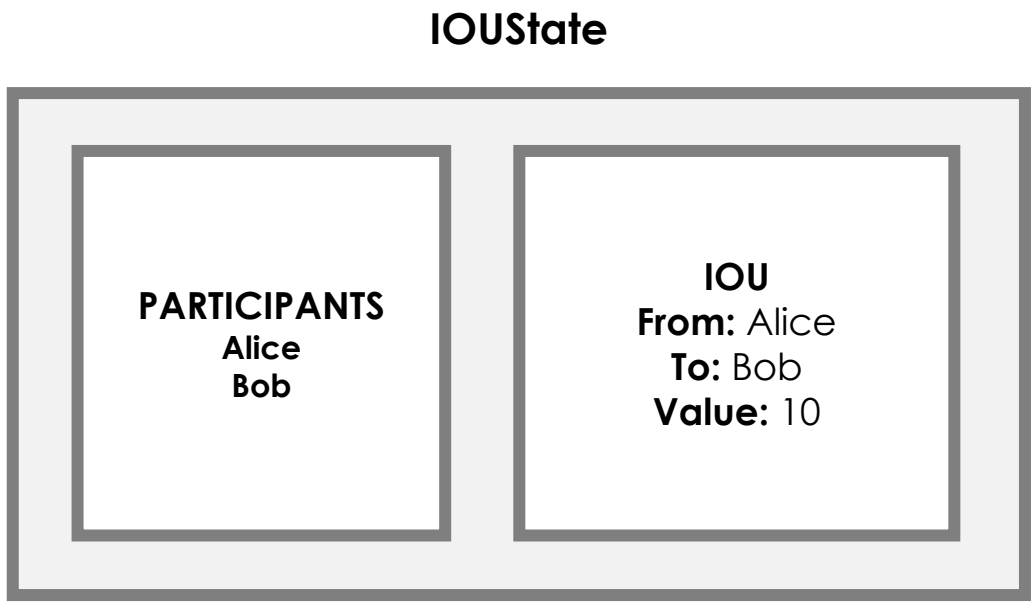
The IOUState Template

- The `IOUState` provided in the template is just a skeleton `ContractState`:

```
data class IOUState(val data: String = "data"): ContractState {
    override val participants: List<AbstractParty> get() = listOf()
}
```

IOUState

- Whereas our `IOUState` has the following design:



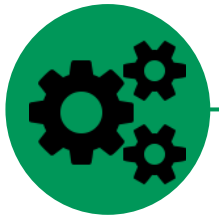
- We are going to use test-driven development to implement this design

Step 1 – The IOU Fields

IOU Fields

- Our `IOUState` needs the following fields:
  - `amount`: the `Amount<Currency>` value of the IOU
  - `lender`: the `Party` lending the amount
  - `borrower`: the `Party` borrowing the amount
  - `paid:` the `Amount<Currency>` of the IOU which has been paid, it should be initialised to an `Amount` of 0
- `Party` is a Corda class representing an entity on the network

IOU Fields - Implementation



Goal	Add the `amount`, `lender`, `borrower` and `paid` fields
Where?	• test/kotlin/states/IOUStateTests.kt • state/IOUState.kt
Steps	1. Uncomment the following tests: • hasIOUAmountFieldOfCorrectType() • hasLenderFieldOfCorrectType() • hasBorrowerFieldOfCorrectType() • hasPaidFieldOfCorrectType() 2. Run the tests: • Press the green arrow/play button next to the IOUStateTests class 3. Modify IOUState.kt to make the tests pass
Key Docs	https://www.jetbrains.com/help/idea/2016.3/run-debug-configurations.html https://docs.corda.net/tutorial-test-dsl.html

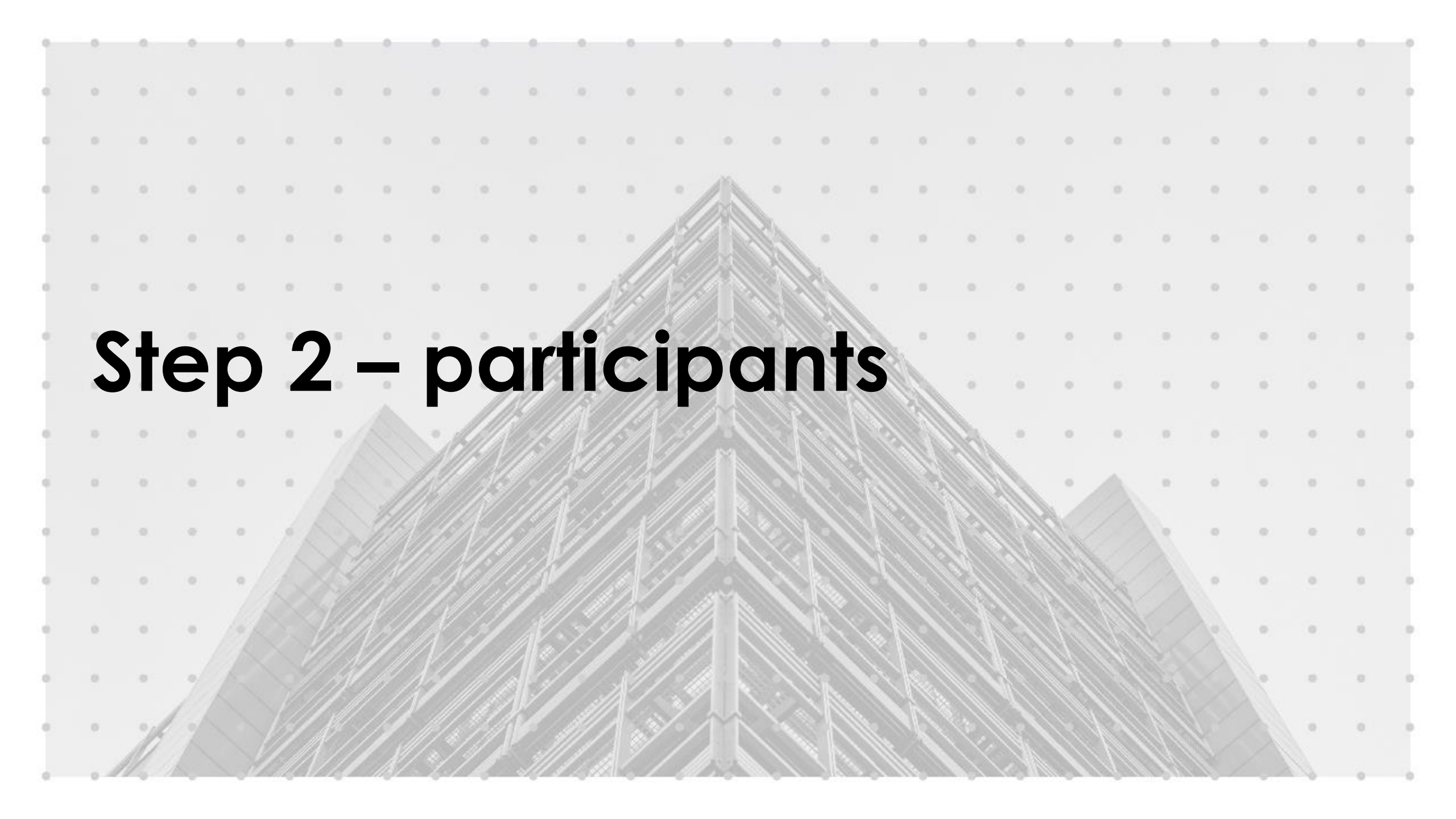
IOU Fields - Solution

Goal	Add the `amount`, `lender`, `borrower` and `paid` fields

Steps	• Add fields of the correct type for:
	  • `amount`
	  • `lender`
	  • `borrower`
	  • `paid`

Code	`data class IOUState(`
	`  val amount: Amount<Currency>,`
	`  val lender: Party,`
	`  val borrower: Party,`
	`  val paid: Amount<Currency> = Amount(0, amount.token))`
	`: ContractState {`
	`  …`
	`}`

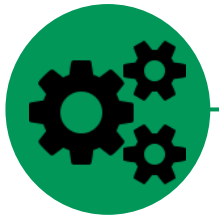
Step 2 – participants



getParticipants()

- Remember that all `ContractState`s have a `participants` field holding a list of the `Party`s involved in the state
- For our `IOUState`, `participants` should return:
  - The `lender`
  - The `borrower`

getParticipants() - Implementation



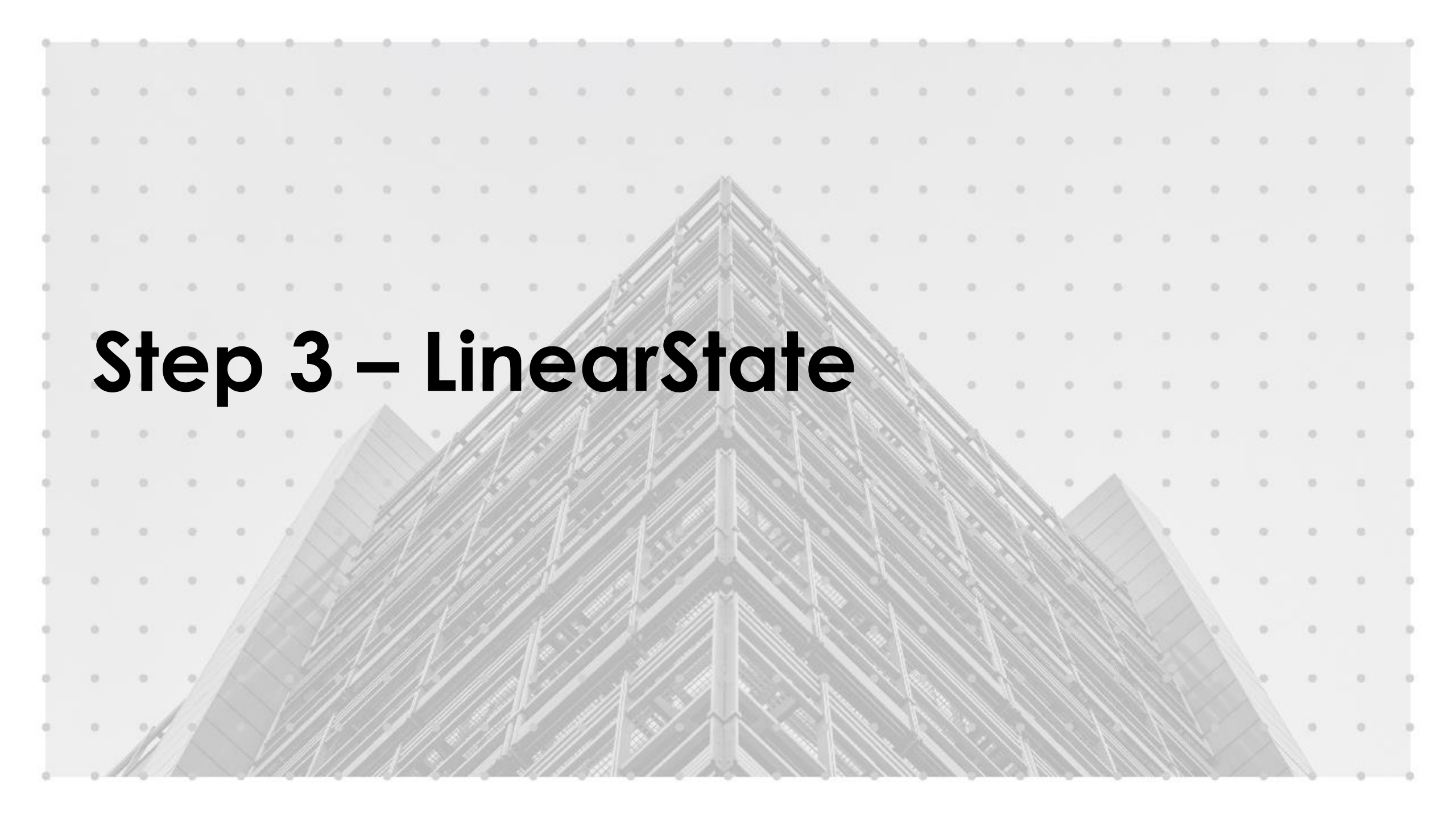
Goal	Return a list of the `lender` and `borrower` from `participants`
Where?	• test/states/IOUStateTests.kt • state/IOUState.kt

Steps	1. Uncomment the following tests:
	  • lenderIsParticipant()
	  • borrowertIsParticipant()
	2. Run the tests:
	  • Press the green arrow/play button
	3. Modify IOUState.kt to make the tests pass

Key Docs	N/A

getParticipants() - Solution

Goal	Return the `lender` and `borrower` `CompositeKey`s from `participants`
Steps	• Retrieve the sender and the recipient's CompositeKeys • Return them as a list
Code	`override val participants get() = listOf(lender, borrower)`



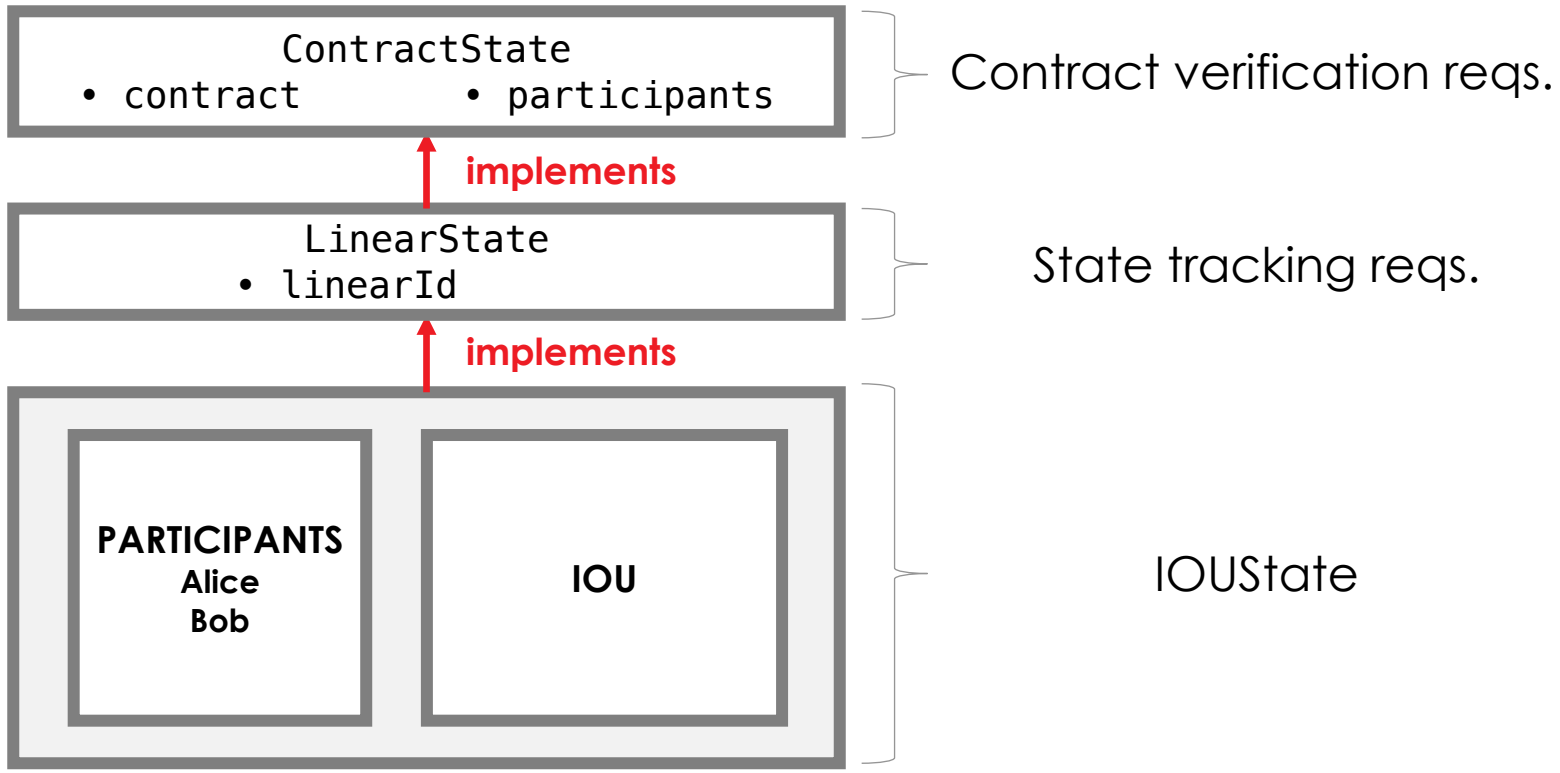
Step 3 – LinearState

LinearState

- Remember that `LinearState` is a child interface of `ContractState` that models facts that evolve over time
- Implementing LinearState will allow the same IOU to be tracked across ledger updates
  - Creation, transfer, redemption…

The IOUState Inheritance Tree

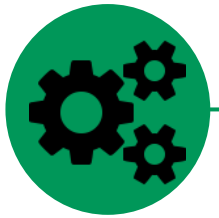
- We need to extend our `IOUState` to implement `LinearState`:



LinearID and isRelevant()

- The `LinearId` for our IOU can simply be a new `UniqueIdentifier` instance

LinearState - Implementation



Goal	Make `IOUState` implement `LinearState`
Where?	• test/states/IOUStateTests.kt • state/IOUState.kt

Steps	1. Uncomment the following test:
	  • isLinearState()
	  • hasLinearIdFieldOfCorrectType()
	2. Run the test:
	  • Press the green arrow/play button
	3. Modify IOUState.kt to make the tests pass

Key Docs	N/A

LinearState - Solution

Goal	Make `IOUState` implement `LinearState`
Steps	• Implement `LinearState` • Override the `linearId` field

Code	`public class IOUState (`
	`    … override val linearId: UniqueIdentifier = UniqueIdentifier())`
	`implements LinearState {`
	`    …`
	`}`

Checkpoint – Progress So Far

Our progress so far

- Our `IOUState` allows us to model an IOU on the ledger:
  - It has `value`/`sender`/`recipient` fields to store IOU information
  - It references an `IOUContract` governing state evolution
  - It implements `LinearState`:
    - To provide a common ID over time
    - To tell the vault when to track the state
- However, the evolution of `IOUState`s is currently completely uncontrolled
- We need to modify `IOUContract`'s logic to control this evolution