On-chain vs. Off-chain

A conceptual overview of the roles and characteristics of on-chain and off-chain code in smart contracts.

OpShin Pioneer Program

Source: Plutus Pioneer Program, PPP 040401

What do we mean by on-/off-chain?

Roles of on-chain and off-chain code in a smart contract:

- **On-chain:** Code that runs in the node during the inclusion of new transactions and data that it's stored in the blockchain.
- **Off-chain:** Code that runs in the user's (or a service provider's) device to query the blockchain and build and submit transactions.

Why is it necessary to decompose our code?

Because both on-chain and off-chain code have inherent advantages and limitations.

- **On-chain:** Ensures integrity, but it's expensive.
- **Off-chain:** Doesn't ensure integrity, but has access to the user's wallet and resources.

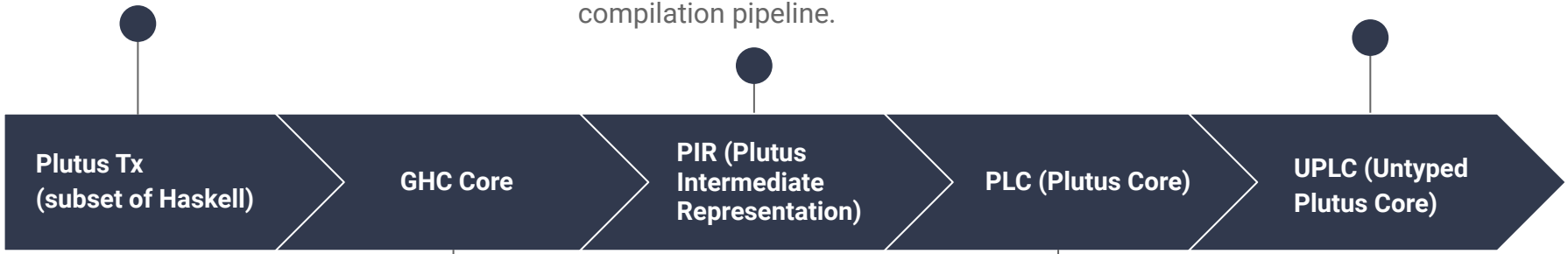
Compiling On-Chain Code

The high-level language developers use to code the script.

Extension of Plutus Core designed to be close to GHC Core.

From now on, we're independent of GHC/Haskell and have total control of the compilation pipeline.

This is what the node actually runs to validate the transaction.
Really hard to code in it directly.
Usually stored in binary representation.



GHC Core is part of GHC's (Glasgow Haskell Compiler) compilation pipeline.

Serves as an intermediate form that the compiler uses to statically check the program.

<pycardano code>

Off-chain: Querying the blockchain

Getting everything we need:

- Cardano validators have access only to:
  - The context of the transaction we want to submit.
  - All its inputs and outputs (with their respective Values, Datums, and Scripts).
  - The Redeemer (our choice).

There are many ways to get this information:

- Local node
- Local Database synchronized with a local or remote node using a chain indexer (e.g., db-sync, Kupo, Scrolls, Carp,...)
- Third-party tools that run their own nodes and databases (e.g., Blockfrost)

<pycardano code>

Off-chain: Building the Tx ("Use" validator)

- Indicating the inputs, reference inputs, and outputs
- Provide Datum
  - UTXO has datum's hash -> Provide the datum on Tx
  - UTXO has datum in Tx body -> Retrieve it from blockchain and provide it in Tx
  - UTXO has inlinde datum
    -> Indicate it's an inline datum (no need to provide it)
- Provide Script
  - No UTXO has the script attached -> Provide the actual script in Tx
  - We attached the script to a UTXO -> Provide the UTXO as a reference script
- Provide Redeemer
- Provide Collateral

<pycardano code>

Off-chain: Signing the Tx

Take into account:

- All transactions need to be signed by at least one key
- This is the only step that MUST be performed on the client (user's wallet) side
- The credentials should be stored in a cryptographic wallet (user's device)
- Provide a way to connect your off-chain code with wallets

<pycardano code>

Off-chain: Submitting the Tx

Phase 1

- Checks whether the Tx was built correctly and can be added to the ledger.
- If it fails, Tx is rejected (no fees or collateral charged)

Phase 2

- We have everything we need. Let's run the scripts!
- If it succeeds, the Tx is added to the ledger, and the fees are used to pay the node
- If it fails, the Tx is ignored, and collateral is used to pay the node

Determinism

- Predictable effects -> Check phases off-chain