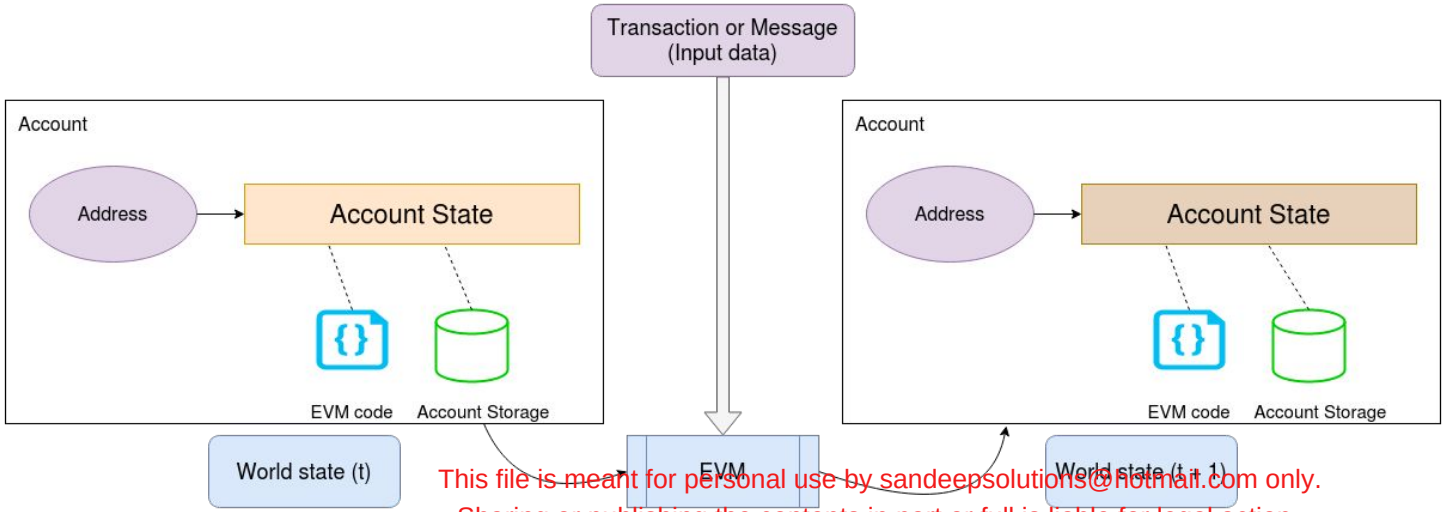
Ethereum Virtual Machine

Outline

- Introduction
- Internals
- Specifics

EVM - Introduction

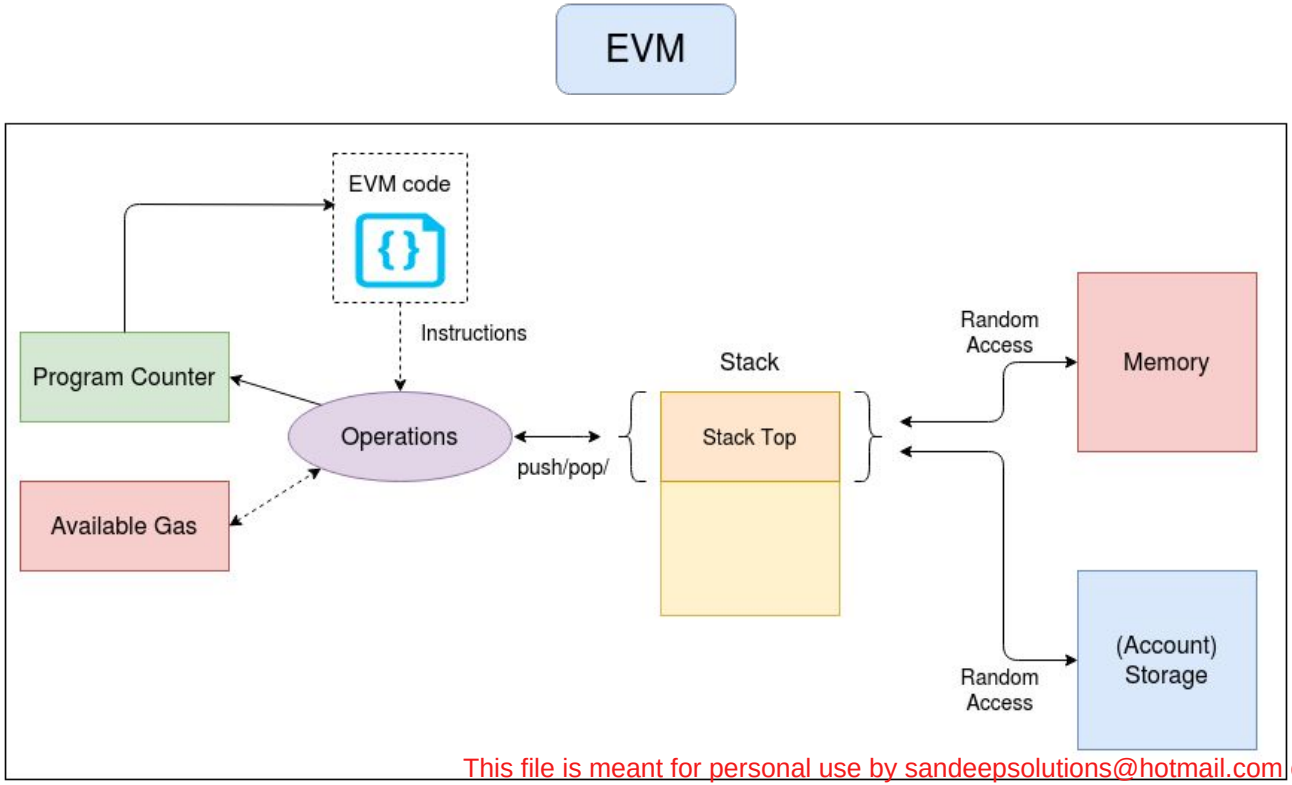
- EVM is the specification for the underlying code and state engine running Ethereum network
- A turing-complete virtual machine, computationally limited (artificially) by gas limits
- Huge, decentralized transaction-based state machine
- Implemented by various open-source groups in multiple languages -
  Geth (Go), Aleth (C++), EthereumJS (Javascript), Trinity (Python), Parity (Rust), EthereumJ (Java), Hyperledger Besu (Java)



EVM - Internals

- Stack-based architecture (LIFO) - Components
  - Everything is 256-bit in length to match common attributes
  - Stack: Size 1024, 256-bit item length
  - Memory: Volatile, word (256 bit) addressable
  - Storage: Persistent, part of world state, 256 bits to 256 bits key-value store per account
  - Virtual ROM: Stores generic and contract code, special access, immutable
- EVM bytecode
  - Special purpose virtual machine bytecode
  - Basic arithmetic, comparison, and memory manipulation opcodes
  - Special blockchain specific opcodes like ADDRESS, BALANCE, GASLIMIT, NUMBER
  - Contract code manipulation opcodes like CALL, CODECOPY, DELEGATECALL
  - General contract programming in higher-level languages like Solidity/Vyper
  - Converted to bytecodes and run on EVM
  - Important to understand, especially due to gas cost
  - Each opcode will have its own cost in gas units
    - ADD - 3, DIV - 5, EQ - 3
    - PUSH1- 3, MLOAD - 3, SLOAD - 800
    - GASLIMIT - 2, BLOCKHASH - 20, CREATE - 32000

EVM - Internals



EVM - Specifics

- Deterministic state machine, has to behave the same on all nodes
- Runs completely isolated and sandboxed - No access to network, other processes or the general file system
- Storage holds all persistent state - each account is a key-value store
- Important exception state - Insufficient gas
- Higher level languages (Solidity/Vyper) are also specialized and specific, due to gas cost of each opcode and immutability of a contract once deployed
- Storage reads and writes are extremely costly - controls the code structure
- EVM is stack-based, not register-based
    - Easier to implement but slower
    - Simple implementations lead to consistency
    - Will require more memory access
    - Due to gas cost, writing contract code becomes particularly specialized

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Power Ahead

Happy Learning !