Realizing the Full Potential of Web3

Turing Hybrid Compute
By Boba Network

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https://bit.ly/getTuring

Fundamental premise of Ethereum:

A ledger is good, a computer is better

Our hypothesis:

More connected computer = more creative and powerful decentralized systems

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Bitcoin

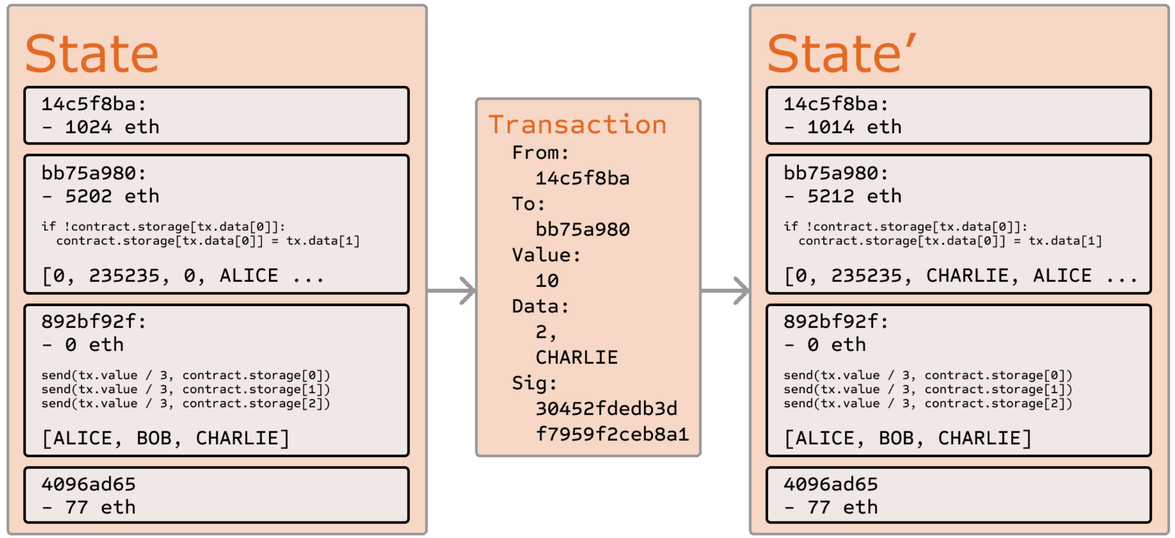
The Bitcoin Transaction Format

	Field		Type (Length)	Comments
	Version		`uint` (4 Byte)	Typically “1”
	Marker		`byte` (1 Byte)	MUST be 0x00, see BIP141
	Flag		`byte` (1 Byte)	MUST be 0x01, see BIP141
	Input count “n”		`var_int` (2 – 9 Byte)	At least 1
n×	Input #i	**TX-ID**	`byte` (32 Byte)	SHA-256d hash of the TX-ID
		TX-Index	`uint32` (4 Byte)	
		unlock script length	`var_int` (2 – 9 Byte)	
		unlock script	`byte` (variable length)	
		sequence	`uint32` (4 Byte)	
	Output count “m”		`var_int` (2 – 9 Byte)	
m×	Output #j	**value**	`uint64` (8 Byte)	Amount to transfer in Satoshi
		lock script length	`var_int` (2 – 9 Byte)	
		lock script	`byte` (variable length)	
n×	Witness	stack item count “p”	`var_int` (2 – 9 Byte)	
p×		stack item length	`var_int` (2 – 9 Byte)	
		stack item #k	`byte` (variable Byte)	NOT Bitcoin Script!
	Lock Time		`uint32` (4 Byte)	

Image by Martin Thoma

Bitcoin Script: a minimal stack-based programming language for locking and unlocking transactions

Ethereum



Ethereum: a blockchain with a built-in Turing-complete programming language

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Unfortunately…

Ethereum Compute Performance July 30, 2015

Ethereum Compute Performance February, 2022

(there are lots of good reasons for that… Ethereum is not really designed for raw compute performance)

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Fundamental issues

Getting many computers to agree on anything **is really hard** unless you put strong constraints on the type of compute you allow

Ethereum's main simplifications are that it (**1**) allows only integers and (**2**) prohibits RAND()

There are more constraints - gas limit, limited memory/stack, everything takes place inside the EVM, but those two are enough for now

That makes it possible for hundreds/thousands/millions of computers to agree on the "right answer" and thus what a correct state/block is

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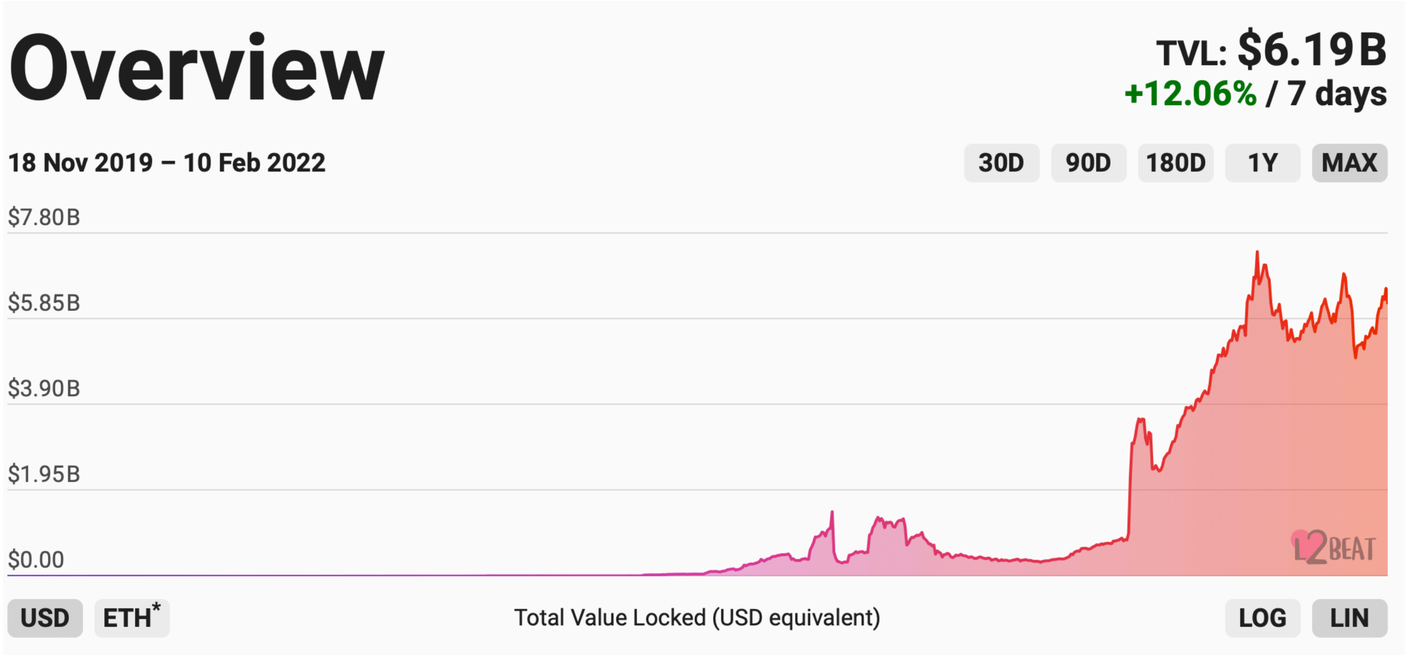
The rise of L2s - unlocking compute?



The original motivation of L2s are to help with **cost** and **scaling/congestion**

Additional major benefit of L2s: **compute**

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Single-sequencer L2s and compute

In a single-sequencer* L2, the original blockers to floats, RAND(), and talking to other APIs/computers, are **removed** since there is no mining / decentralized consensus

Hypothesis: *the next generation of L2s will allow smart contracts to interact with outside computers and act on their responses within one transaction*

***single-sequencer** - Turing can be directly extended to multiple sequencers provided they are **not** separately running their own decentralized consensus (which would be redundant to Ethereum)

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Single-sequencer L2s and compute

We overcame EVM's restrictions by modifying Geth ("L2TGeth")

with **ATOMIC** support for RAND() and client.Call()

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L2TGeth - A Geth flavor for L2s enabling hybrid compute

From the Solidity perspective, easy to use… one line calls

`turing.getRandom()`

```
// ERC721.sol
random_number = turing.getRandom()

// Test/Debug Response
Turing NFT Random 256
  256 bit random number as a BigInt = 612455941595319977171587766669000355729927578575637133505704086435528306264 92n
  Minted an NFT with Attribute A = 135 and Attribute B = 103
  Minted a pirate with a green hat
  ✓ should mint an NFT with random attributes (65ms)
```

`turing.getCurrentQuote()`

```
urlStr = 'https://i9iznmo33e.execute-api.us-east-1.amazonaws.com/quote'
rate = lending.getCurrentQuote(urlStr, "BTC/USD")

// Test/Debug response
Bitcoin to usd price is 42406.68
timestamp 1642104413221
✓ should get the current Bitcoin - USD price (327ms)
```

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L2TGeth - System overview

Central idea

1. L2TGeth intercepts certain calls
2. Then, calls off-chain APIs/RAND()
3. Then, replaces the original call data with modified call data
4. Then, writes both the original transaction and the modified call data into Ethereum L1 for verification, replay, fraud-detection, and replication

Key: **only the sequencer calls APIs** - once the L2 block is written, verifiers and replicas use stored API response data from the block

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1

RPC call

L2TGeth

2

isTuring?

L2TGeth

3

User-designated Endpoint

client.Call

responseString

L2TGeth

4

L2TGeth

- Replaces original callData
- run(evm, contract, updated_input)
- evm.Context.Turing = updated_input
- Forms new block*
  - L1Timestamp/blocknumber
  - rawTransaction
  - Updated calldata ('L1Turing')

L2 Blockchain

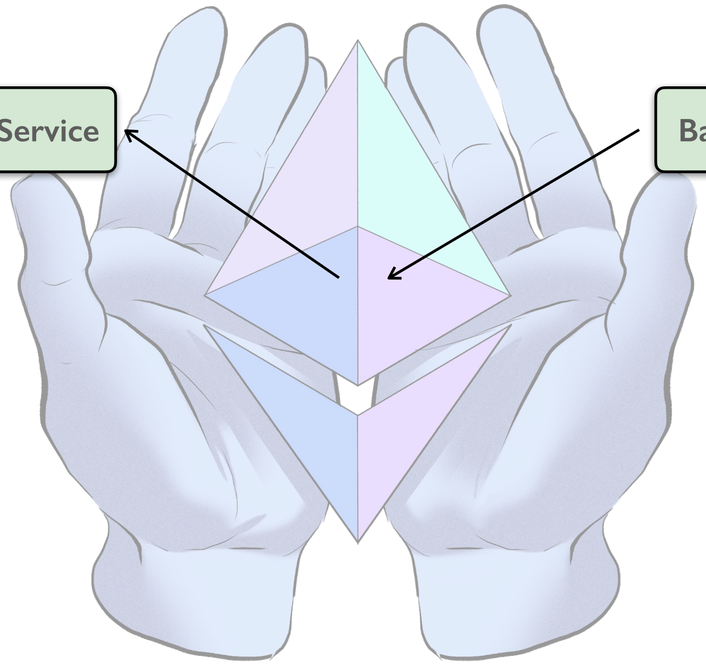
The usual L2 block with updated calldata ('L1Turing')

L2TGeth-Verifier

L1 Data Indexing Service

Batch Submitter

Obtain block
evm.Context.Turing = updated_input
run(evm, contract, evm.Context.Turing)
Forms new block



L2 Data Indexing Service

L2TGeth-Replica

Obtain block
evm.Context.Turing = updated_input
run(evm, contract, evm.Context.Turing)
Forms new block

L2TGeth-Replica

L2TGeth-Replica

L2TGeth-Replica

Boba research

L2TGeth - changes needed - under the hood

- Modify /geth/code/evm.go - especially (evm *EVM) Call()
- Modify the **Ethereum block format** to also include responses from Turing compute requests - *Yes - all data from Off-chain are written to Ethereum L1*
- Add the capability for geth to replay time shifted compute requests based on data written into Ethereum
- Modify transaction/receipt/block/EVM.context and other data types internal to geth
- Modify w.engine.FinalizeAndAssemble and other parts of l2geth/miner/worker.go
- Modify all services that pass data from L2 to L1, and index L1, and inject L1 data into the L2 Geth

The system is live now on mainnet

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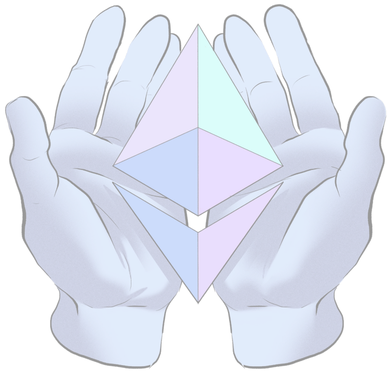
L2TGeth - Example uses

- DeFi protocols based on off-chain assets such as real estate
- NFT lending based on off-chain ML-based valuation models
- On-chain rewards based on off-chain activities such as retweets
- NFTs or DAO memberships that are connected to off-chain identities
- Twitter activity-based token fountain
- Atomic random number generator for NFTs



\+ Any other networked computer = Quickly build interesting new stuff

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L2TGeth - TLDR

- Detailed writeup at https://bit.ly/getTuring
- **Easy to use** on the smart contract level - e.g. if you need a random number or price quote anywhere in your smart contract, just…

```
turing.getRandom()
```

or

```
turing.getCurrentQuote()
```

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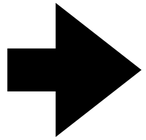
Fundamental premise of Ethereum

A more general and powerful computer unlocks innovation and creativity in decentralized systems

L2s, v0

"Scale Ethereum"

Faster
Cheaper



L2s, v1

"Augment Ethereum"

Faster
Cheaper
& Smarter

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Boba Hybrid Compute - Turing
Supercharge Ethereum with scalable compute power
What do you want to build today?
https://bit.ly/getTuring

FAQs

- Multiple sequencers - working on it - ***but <u>not</u> workable for systems with <u>decentralized</u> consensus***
- Yes, this also works with **Beacon/post merge**
- ***DoS?* -** each Turing calls costs 0.01 BOBA to (help to) prevent DoS - also have rate limiting
- **Write garbage into L1?** -> Massive ETH cost for us -> hard limit on length of off-chain responses - you cannot write LOTR into L1 with Turing
- **Misuse of your data api**? No - you designate the contracts that can use your off-chain API
- **Slow API response?** - 1200 ms timeout -> revert with the usual 404 etc reported to your contract
- **Only one Turing call per raw Transaction** - cannot chain Turing calls (for multiple reasons)

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