How to use Executable Consensus Pyspec

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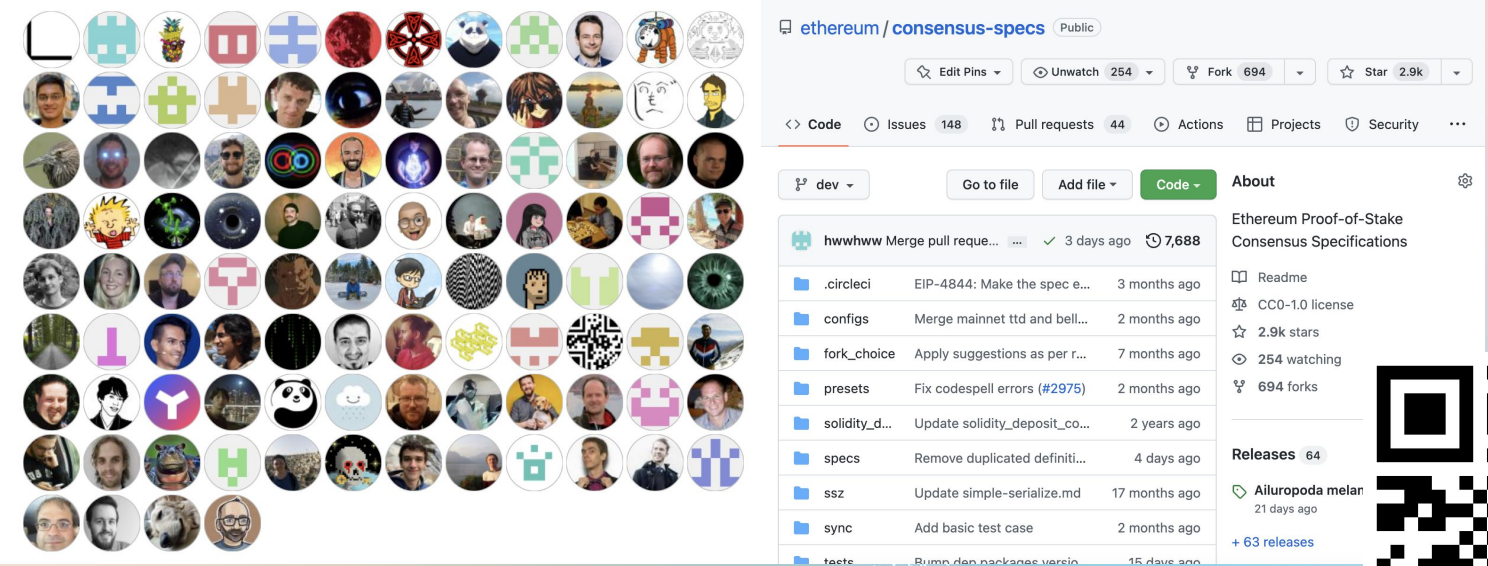
Ethereum Foundation - Consensus R&D

https://github.com/ethereum/consensus-specs



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hwwhww Merge pull reque... ... 3 days ago 7,688

.circleci	EIP-4844: Make the spec e...	3 months ago
configs	Merge mainnet ttd and bell...	2 months ago
fork_choice	Apply suggestions as per r...	7 months ago
presets	Fix codespell errors (#2975)	2 months ago
solidity_d...	Update solidity_deposit_co...	2 years ago
specs	Remove duplicated definiti...	4 days ago
ssz	Update simple-serialize.md	17 months ago
sync	Add basic test case	2 months ago
tests	Bump dep packages versio	15 days ago

About

Ethereum Proof-of-Stake Consensus Specifications

Readme

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1. It’s a collection of Ethereum core **consensus specifications**

Define the consensus protocol that running by the consensus layer (CL) clients

2. It’s **executable** and **verifiable**

It can be built into a Python program that can be executed

3. It’s **test vector generator**

It can generate the test vectors for CL clients to run with and test against the consensus rules.

Adding New Feature Patch

Python is very readable to developers

Credits: r/ProgrammerHumor u/Cant_Grow_a_Stasch [“Python == pseudocode”]

How to read it?

/specs/

- **altair**
- **bellatrix**
- capella
- custody_game
- das
- eip4844
- **phase0**
- sharding

Mainnet protocol upgrades

WIP features

How to read it?

/specs/

- altair
- bellatrix
- phase0
  - **beacon-chain.md**
  - deposit-contract.md
  - fork-choice.md
  - p2p-interface.md
  - validator.md
  - weak-subjectivity.md

Markdown files

Type and Values Definitions

Notation

Code snippets appearing in `this style` are to be interpreted as Python 3 code.

Custom types

We define the following Python custom types for type hinting and readability:

Name	SSZ equivalent	Description
`Slot`	`uint64`	a slot number
`Epoch`	`uint64`	an epoch number
`CommitteeIndex`	`uint64`	a committee index at a slot
`ValidatorIndex`	`uint64`	a validator registry index

Constants

The following values are (non-configurable) constants used throughout the specification.

Misc

Name	Value
`GENESIS_SLOT`	`Slot(0)`
`GENESIS_EPOCH`	`Epoch(0)`
`FAR_FUTURE_EPOCH`	`Epoch(2**64 - 1)`

Preset

Note: The below configuration is bundled as a preset: a bundle of configuration variables which are expected to differ between different modes of operation, e.g. testing, but not generally between different networks. Additional preset configurations can be found in the `configs` directory.

Misc

Name	Value
`MAX_COMMITTEES_PER_SLOT`	`uint64(2**6)` (= 64)
`TARGET_COMMITTEE_SIZE`	`uint64(2**7)` (= 128)
`MAX_VALIDATORS_PER_COMMITTEE`	`uint64(2**11)` (= 2,048)
`SHUFFLE_ROUND_COUNT`	`uint64(90)`

Configuration

Note: The default mainnet configuration values are included here for illustrative purposes. Defaults for this more dynamic type of configuration are available with the presets in the `configs` directory. Testnets and other types of chain instances may use a different configuration.

Genesis settings

Name	Value
`MIN_GENESIS_ACTIVE_VALIDATOR_COUNT`	`uint64(2**14)` (= 16,384)
`MIN_GENESIS_TIME`	`uint64(1606824000)` (Dec 1, 2020, 12pm UTC)

SSZ Containers

Note: we also use SSZ ***hash tree root*** as the digests of consensus objects.

See: https://github.com/ethereum/consensus-specs/blob/dev/ssz/simple-serialize.md

BeaconBlockBody

```
class BeaconBlockBody(Container):
    randao_reveal: BLSSignature
    eth1_data: Eth1Data  # Eth1 data vote
    graffiti: Bytes32  # Arbitrary data
    # Operations
    proposer_slashings: List[ProposerSlashing, MAX_PROPOSER_SLASHINGS]
    attester_slashings: List[AttesterSlashing, MAX_ATTESTER_SLASHINGS]
    attestations: List[Attestation, MAX_ATTESTATIONS]
    deposits: List[Deposit, MAX_DEPOSITS]
    voluntary_exits: List[SignedVoluntaryExit, MAX_VOLUNTARY_EXITS]
```

BeaconBlock

```
class BeaconBlock(Container):
    slot: Slot
    proposer_index: ValidatorIndex
    parent_root: Root
    state_root: Root
    body: BeaconBlockBody
```

State transition function

All are “pure" functions.

Beacon chain state transition function

The post-state corresponding to a pre-state `state` and a signed block `signed_block` is defined as `state_transition(state, signed_block)`. State transitions that trigger an unhandled exception (e.g. a failed `assert` or an out-of-range list access) are considered invalid. State transitions that cause a `uint64` overflow or underflow are also considered invalid.

```
def state_transition(state: BeaconState, signed_block: SignedBeaconBlock, validate_result: bool=True) -> None:
    block = signed_block.message
    # Process slots (including those with no blocks) since block
    process_slots(state, block.slot)
    # Verify signature
    if validate_result:
        assert verify_block_signature(state, signed_block)
    # Process block
    process_block(state, block)
    # Verify state root
    if validate_result:
        assert block.state_root == hash_tree_root(state)
```

```
post_state = state_transition(pre_state, block)
```

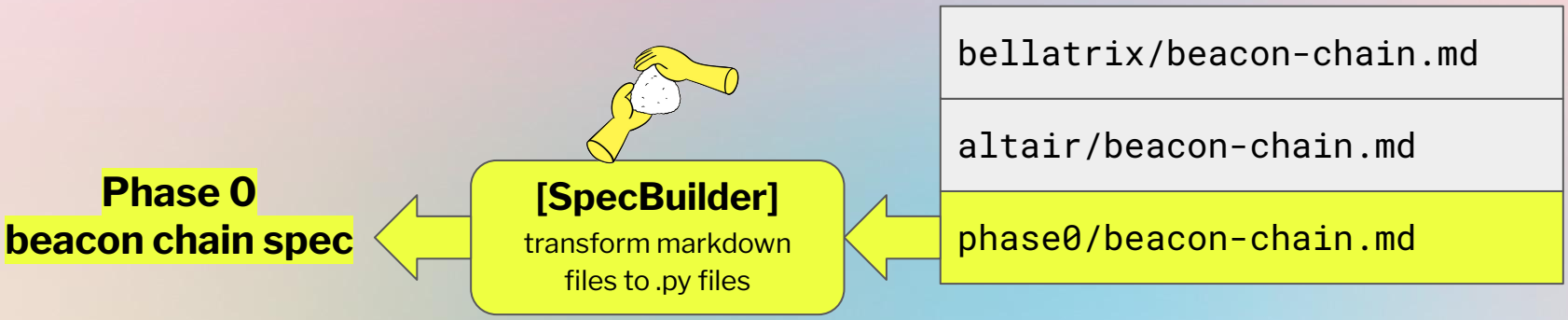
Useful resources to understand CL

- Vitalik Buterin's Annotated spec: https://github.com/ethereum/annotated-spec
- Ben Edgington's Upgrading Ethereum Book: https://eth2book.info

The elf in setup.py

```
879  def _build_spec(preset_name: str, fork: str,
880                  source_files: Sequence[Path], preset_files: Sequence[Path], config_file: Path) -> str:
881      preset = load_preset(preset_files)
882      config = load_config(config_file)
883      all_specs = [get_spec(spec, preset, config) for spec in source_files]
884
885      spec_object = all_specs[0]
886      for value in all_specs[1:]:
887          spec_object = combine_spec_objects(spec_object, value)
888
889      class_objects = {**spec_object.ssz_objects, **spec_object.dataclasses}
890
891      # Ensure it's ordered after multiple forks
892      new_objects = {}
893      while OrderedDict(new_objects) != OrderedDict(class_objects):
894          new_objects = copy.deepcopy(class_objects)
895          dependency_order_class_objects(class_objects, spec_object.custom_types)
896
897      return objects_to_spec(preset_name, spec_object, spec_builders[fork], class_objects)
```

Extend the previous hard forks



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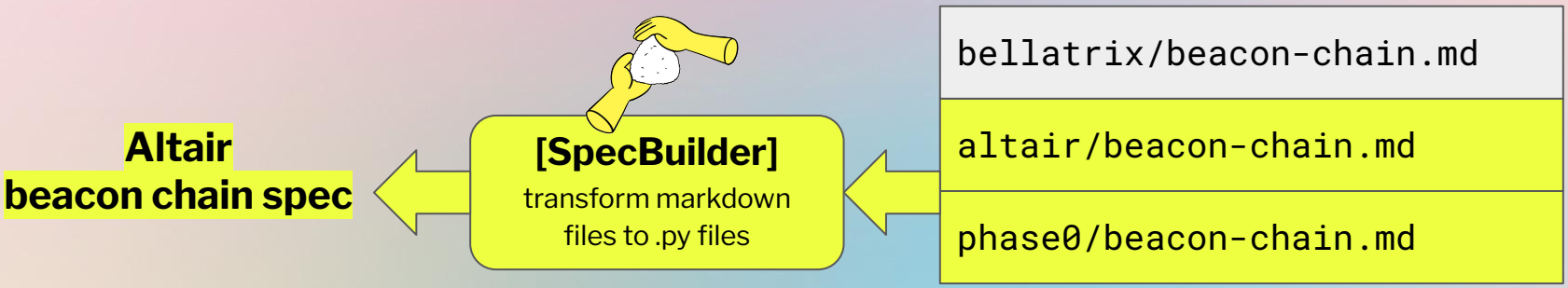

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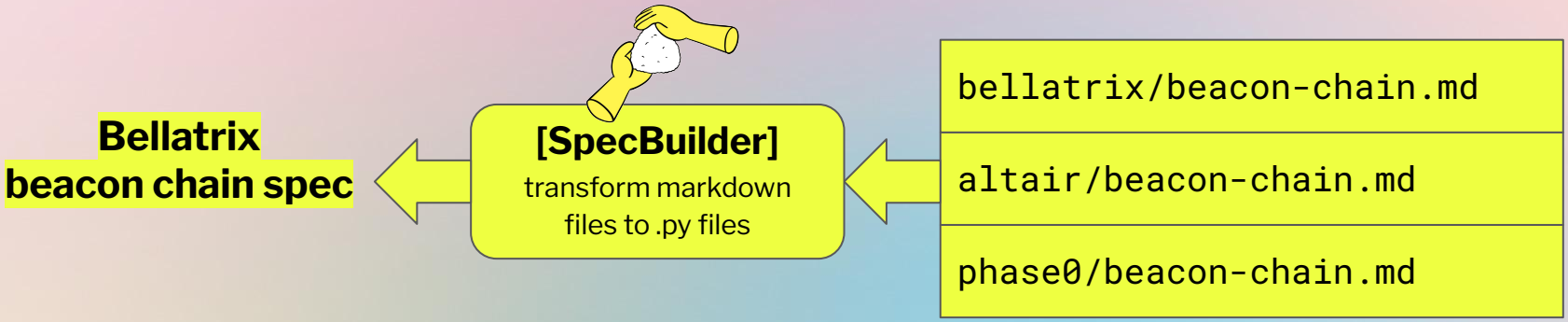

How to use Pyspec?

Installation (Python3.8+)

1. Install from PyPI:

   ```
   pip install eth2spec
   ```

2. Install from source with venv:
   a. Download the source code:

   ```
   git clone https://github.com/ethereum/consensus-specs.git
   ```

   b. Install with Makefile commands

   ```
   cd consensus-specs
   make install_test && make pyspec
   ```

Run your first pyspec program!

```
>> from eth2spec.bellatrix import mainnet as spec

>> hello = b"Hello World"

>> body = spec.BeaconBlockBody(

>>     graffiti=hello + b'\0' * (32 - len(hello))

>> )

>> block = spec.BeaconBlock(body=body)

>> print(block.body.graffiti.decode("utf-8"))

Hello World
```

Write your first pyspec test case!

```
@with_all_phases
@spec_state_test
def test_empty_block_transition(spec, state):
    pre_slot = state.slot
    pre_eth1_votes = len(state.eth1_data_votes)
    pre_mix = spec.get_randao_mix(state, spec.get_current_epoch(state))

    yield 'pre', state

    block = build_empty_block_for_next_slot(spec, state)
    signed_block = state_transition_and_sign_block(spec, state, block)

    yield 'blocks', [signed_block]
    yield 'post', state

    assert len(state.eth1_data_votes) == pre_eth1_votes + 1
    assert spec.get_block_root_at_slot(state, pre_slot) == signed_block.message.parent_root
    assert spec.get_randao_mix(state, spec.get_current_epoch(state)) != pre_mix
```

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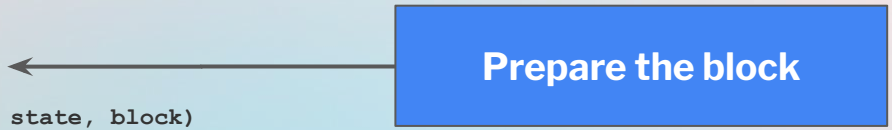

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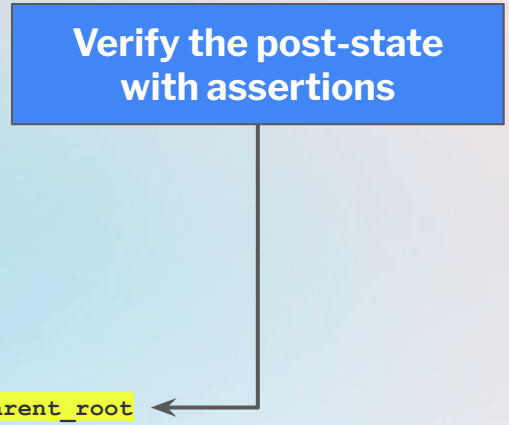

Pyspec as the test vector generator

```python
@with_all_phases
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def test_empty_block_transition(spec, state):
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    yield 'pre', state

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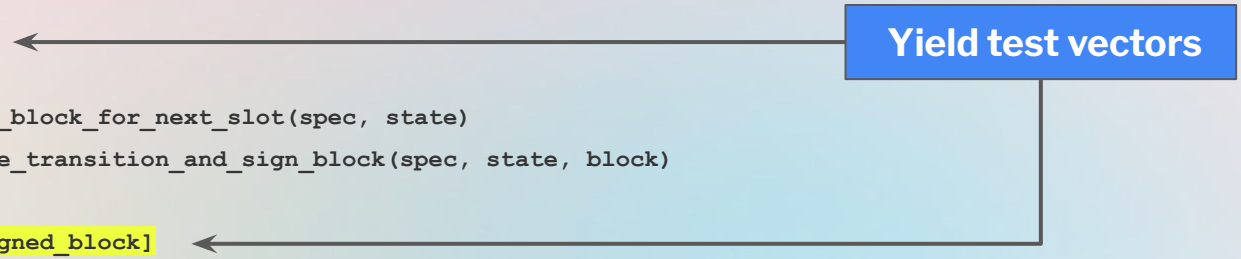
```



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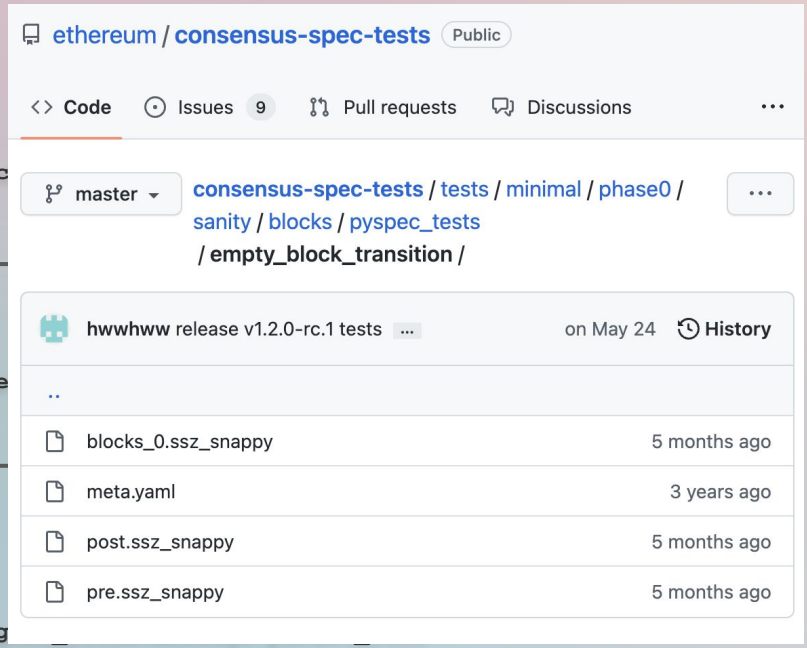
    block = build_empty_block_for_next_slot(spec, state)
    signed_block = state_transition_and_sign_block(spec, state

    yield 'blocks', [signed_block]
    yield 'post', state

    assert len(state.eth1_data_votes) == pre_eth1_votes + 1
    assert spec.get_block_root_at_slot(state, pre_slot) == sig
    assert spec.ge
```




```python
post_state = state_transition(pre_state, block)
```

Documents

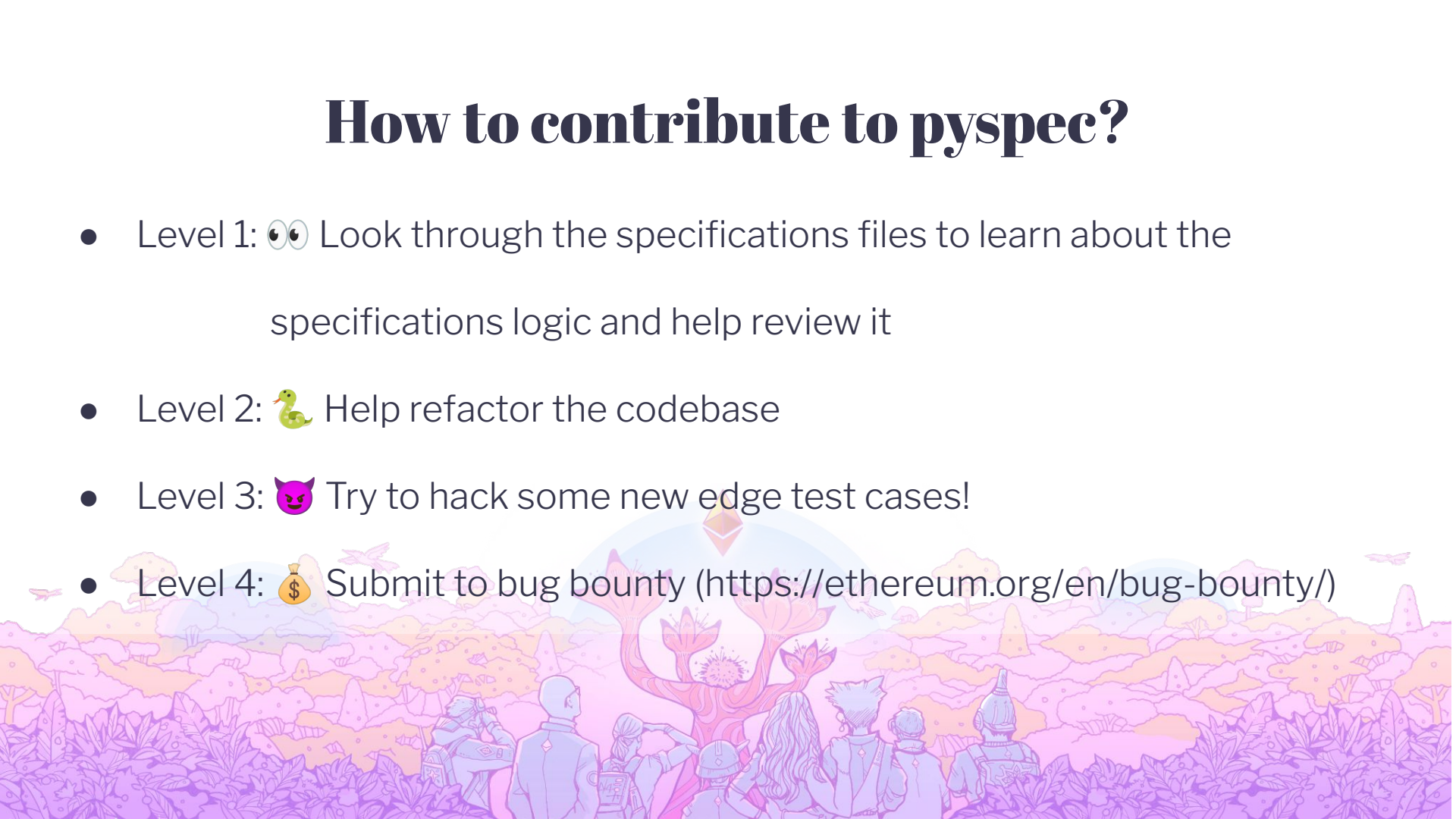
- Pyspec:

  https://github.com/ethereum/consensus-specs/blob/dev/tests/README.md
- Test formats:

  https://github.com/ethereum/consensus-specs/blob/dev/tests/formats/README.md

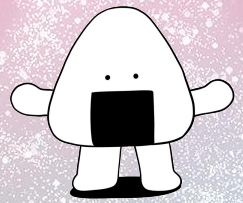
How to contribute to pyspec?

- Level 1: 👀 Look through the specifications files to learn about the specifications logic and help review it
- Level 2: 🐍 Help refactor the codebase
- Level 3: 😈 Try to hack some new edge test cases!
- Level 4: 💰 Submit to bug bounty (https://ethereum.org/en/bug-bounty/)



Job Description

Thank you!



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