



**ANASTASIA LABS**

**Audit Tracker**  
OpShin Audit

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**Project Name:** OpShin Audit

**URL:** Catalyst Proposal

**Project Name:** Opshin Language Audit

**Audit Period:** Oct 27th,2024

**Team Member(s) Assigned:** Suganya Raju, Eric Lee

**Audit Start Date:** Oct 2024

**Audit End Date:**

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## Milestone1 - Project Kickoff and Planning

The milestone1 was approved in November 2024.

## Milestone2 - Language Analysis Report

As part of Milestone2 we are required to submit a detailed analysis report on the OpShin Language.

### Topics to cover

1. UPLC debugging Architectural Decisions
  - How types are mapped to UPLC types
  - Static type Inferencer -> How ATI is implemented within OpShin
  - Mapping of Python -> Pluto -> UPLC
  - Storage of variables in statemonads
2. Opshin compiler pipeline
  - rewrites - how effective it is written and area of improvement
    - [CS] `rewrite/rewrite_cast_condition.py`: is the injected cast removed if it is redundant (i.e. `bool(b: bool)`)?
    - [CS] `rewrite/rewrite_empty_dicts.py`: this is a tiny AST transformation. Should this be merged with `rewrite_empty_lists.py`?
    - [CS] `rewrite/rewrite_import.py`: what does `spec.loader.exec_module(module)` do?
    - [CS] `rewrite/rewrite_import.py`: is the package path resolution correctly implemented, and does it always lead to the expected package being imported? Are there security risks?
  - type inference
    - [CS] `type_inference.py/AggressiveTypeInferencer`: are the more complex visitors (eg. `visit_Call`) implemented correctly
    - [CS] `type_inference.py/AggressiveTypeInferencer.visit_Expr`: why does not setting `.typ` still return a valid `TypedExpr` AST node?

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- ▶ [CS] `type_inference.py/`  
`AggressiveTypeInferencer.visit_NoneType`: the `TypedConstant` return type is confusing, is the `NoneType` AST node a type or a `None` value?
  - ▶ [CS] `type_inference.py/`  
`AggressiveTypeInferencer.visit_ImportFrom`: is this the correct place for the remaining `ImportFrom` `node.module == "opshin.bridge"` assertion?
  - ▶ [CS] `type_inference.py/AggressiveTypeInferencer`: how is the type of empty lists and dicts inferred? What is the same empty list is subsequently used in two different lists with two different item types?
  - ▶ [CS] `type_inference.py`: can a top-down visitor pattern be considered aggressive? (function arg types must always be defined, so this is simple upstream to downstream type propagation)
  - optimization - how effective it is written and area of improvement
    - ▶ [CS] `optimize/optimize_const_folding.py`: some expressions might be valid python at this point, without actually passing the `OpShin` type checker (eg. `int(0.5)`). This leads to inconsistent behavior.
    - ▶ [CS] `optimize/optimize_const_folding.py`: is the evaluated math consistent with the on-chain math?
    - ▶ [CS] `optimize/optimize_const_folding.py/`  
`DefinedTimesVisitor.visit_ImportFrom()`: is incrementing the number of writes of `"*"` spurious?
    - ▶ [CS] `optimize/optimize_const_folding.py`: can `print` be assigned to a variable (thus circumventing the `"print(" in unparse output condition)`? Are there other statements that shouldn't be optimized out?
    - ▶ [CS] `optimize/optimize_remove_comments.py`: the name is confusing. Are only comments being removed, or are all constants that are statements being removed? Are comments treated as constants internally?
    - ▶ [CS] `optimize/optimize_remove_comments.py`: why does this optimization remove AST nodes by returning `None`, and in
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OptimizeRemoveDeadvars AST nodes are removed by returning `Pass()`?

- conversion -> pluto
  - [CS] **pluthon** seems quite low-level. Does this complicate the code generation unnecessarily? Investigate precisely what constructs **pluthon** allows.
  - [CS] verify that the `PlutoCompiler` visitor pattern generates correct **pluthon**
  - [CS] verify python-like builtins defined in `fun_impls.py` and `type_impls.py` are correctly implemented (manual review and unit tests)
  - [CS] verify `check_integrity` generates correct **pluthon** code.
  - [CS] `util.py/opshin_name_scheme_compatible_varname`: is there a performance penalty to using `f"1{n}"`. This seems to be a very frequently used function. Perhaps simple string concatenation makes more sense. At least add a comment about what this name mapping is necessary.
  - [CS] If `str()` is used mainly for debugging we must ensure that it is implemented in a way that can be optimize out. However if `str()` is also used for validation logic a fast, error-throwing, alternative should be made available.

### 3. Performance and script size testing

- [CS] Investigate root cause of maximum recursion limit error
- [CS] Running `opshin compile examples/smart_contracts/assert_sum.py -O3` creates a completely unacceptable output, the contract is extremely simple, yet the purpose debugging print statement can't be optimized out. With the print statement removed the output is still unacceptable: 470 bytes. The Muesli swap governance code-base seems to use some external compression mechanism, how exactly is that done?

### 4. Overall language constructs

- [CS] Does the AST only contain a single Module?

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- [CS] Can polymorphic builtins defined in `fun_impls.py` and `type_impls.py` be assigned to variables?
  - [CS] Can helper functions like `bytes.fromhex` and `.decode` be accessed as first class citizens, or only be called directly? If only called: ensure the error message is sensible when trying to access without calling.
  - [CS] Attempting to import `Self` or `Dict`, `List`, `Union` from typing directly failed
  - [CS] Does the ability to use a getter defined on any member of a `Union` type add a lot of overhead because the field can be in a different position?
  - [CS] Why does down-casting not perform the `isinstance` check?
  - [CS] Verify that bundled std library, written in OpShin itself, is correctly implemented.

## Areas Covered

1. UPLC debugger through Gastronomy
2. Tested Language constructs – output of opshin eval, eval\_uplc,
3. Code Coverage - using Pytest -cov tool
4. Checked build artifacts
5. Tried to replicate aiken acceptance tests in opshin(only first 20 test cases)
  - Challenge - opshin supports only a limited language constructs, its a challenge to replicate most of the aiken acceptance tests.

## Rewrites and Optimizations

6. [SR] rewrite/rewrite\_import.py -
  - Observations:
    1. Relative imports are not supported as the package is always set to none (test cases for relative imports, package is a single or multiple, relative import from local) created two files , tried with imports starting with “.” not working()
    2. assumption of `__spec__` for the parent module, what if `__spec__` is not available for the parent module– may be try catch block?
    3. what if `spec.loaded.exec_module` fails to load -
    4. Line no 76 to 84, checks are for length, empty asnames, and \* as name but no checks on duplicate imports, I am able to import as many times and no warnings/errors thrown
    5. `sys.modules`- As per Python docs If you want to iterate over this global dictionary always use `sys.modules.copy()` or `tuple(sys.modules)` to avoid exceptions as its size may change during iteration as a side effect of code or activity in other threads.
7. [SR] rewrite/rewrite\_empty\_dicts.py
  - Observations -None
8. [SR] rewrite/rewrite\_empty\_lists.py



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- Observations

1. List of Lists is not considered in the empty\_list function the below compiles,

```
def validator(a:List[List[int]])-> List[List[int]]: empty_List :  
List[List[int]]= [[1,2],[2,3]] return empty_List
```

but this fails

```
def validator(a:List[List[int]])-> List[List[int]]: empty_List :  
List[List[int]]= [[]] return empty_List (have to look at the type inference)
```

## 9. [SR] rewrite/rewrite\_import\_dataclasses.py

- Observations

1. error messages can be more descriptive, for all the assertions , the error message is almost same

Example :

```
from dataclasses import dataclass as dc def dataclass(cls): return cls  
  
@dc class MyClass(PlutusData): pass
```

I get the error as “The program must contain one ‘from dataclasses import dataclass”

## 2.Validate Decorator Source: If I define a custom dataclass(rewrite over)

```
from dataclasses import dataclass
```

```
def dataclass(cls): return cls
```

```
@dataclass class MyClass(PlutusData): pass
```

```
def validator(a:int)-> None : return None
```

now the dataclass refers to the custom dataclass instead of import dataclass, the rewrite code checks the format “from import dataclass” and @dataclass decorator is present but it does not validates the source of it.

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10. [SR] `optimize/optimize_const_folding.py` - executes the constant expressions in compile time instead of run time ex:

`x=10 y = x +5`

optimize transforms the code like this

`x =10 y =15`

1. `Visit_ImportForm` in class `DefinedTimesVisitor` - this class collects how often variables are written from `ast import *` - not handled – To be added to finding
11. [SR] `rewrite/rewrite_import_plutusdata.py`
1. all assertions have the same error message, can be informative
  2. suppose the imports are spilt like below, it doesn't work
- Ex : `from pycardano import Datum as Anything from pycardano import PlutusData`
12. [SR] `rewrite/rewrite_import_typing.py` from `typing import Dict, List, Union`
1. More descriptive error messages
  2. What if my program uses only `List`, still need to import `Dict, List, Union` – (combined with 4)
  3. `Self` has to be imported by `typing` (This case also fails , – from `typing import Self` – from `typing import Dict, List, Union, Self`)
  4. `visit_classDef`, checks replace `self` with `classname` (probably for type checking) only checks for `Name` and `Union`, why not `List[Self]` if the `datum` classes are used part of `List` , also for dictionaries - `importerror`, `self` is not from `typing` anymore? - TODO : create a test with `List[Self]` Python docs to be checked - to give the example `self-> Self` (it nor rewritten)
13. [SR] `rewrite/rewrite_forbidden_overwrites.py`
1. Only names are checked against overriding. (covered under finding 27)

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14. [SR] rewrite/rewrite\_forbidden\_return.py - No issues
15. [SR] rewrite/rewrite\_import\_hashlib.py
1. Aliased imports – this transformer handles alias name, What happens if the alias conflicts with an existing variable or function in the scope ?  
- It throws a type inference error, a check for name conflicts can be used instead.
16. [SR] - rewrite/rewrite\_import\_integrity\_check.py Similar to 15, if line 55 has a alias name it will be added to INITIAL\_SCOPE as a new pair
17. [SR] - rewrite/rewrite\_subscript38.py
- Tested for index (python old version of slice)
  - Tested for nested index - worked `def validator(x:List[List[int]]) -> int: x = [[1,2],[3,4]] b = x[1][0] return b`
  - Tried for a complex case - works Ex : `def validator(x:List[int]) -> int: x = [1,2,3,4] index = 1 return (x[index + 1])`
  - mixed slicing and index - works Ex : `def validator(x:List[List[int]]) -> List[int]: x = [[1, 2], [3, 4], [5, 6]] return (x[1:3][0])` Ex2: 

```
@dataclass
class Buy(PlutusData):
    CONSTR_ID = 0
    index : int

    Const_list = [1,2,3,4]

    def validator(x:Buy) -> int:
        return (Const_list[x.index])
```

Edge case:

- Empty index doesn't work - its an invalid syntax in python itself(valid case)
18. [SR]- rewrite/rewrite\_cast\_condition.py -
- if the condition is already a boolean and if its a constant node, explicit cast to bool is redundant
  - small performance overhead - using `timeit` performance with and without bool was analysed
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19. [SR] - rewrite/rewrite\_augassign.py

- checked the order of precedence Ex!: `def validator(x:int,y:int, z:int) -> int: x += y*z return x -> it becomes x= x+(y*z)` Ex2: (Finding) `def validator(x:List[int]) -> int: x =[1,2,3,4] x[0] += 1 return x` Error - “Can only assign to variable names, no type deconstruction” - this is possible in python

20. [SR] - rewrite/rewrite\_remove\_type\_stuff.py - No issues

21. [SR] - rewrite/rewrite\_tuple\_assign.py - need for it if the tuple is complex, reuse and efficiency What is the need of temporary variables like `2_uid_tup` , why can't it be assigned using the tuple itself Ex : `a,b =(1,2) a =(1,2)[0] b =(1,2)[1]`

22- [SR] - rewrite/rewrite\_inject\_builtins.py - no issues

Q - until the aggressive type inference occurs , there wouldn't be any typed modules ,so how can it take an typedmodule node? - maintainability issue, Q - polymorphic functions are skipped, two different ways to find if the node is polymorphic - maintainability - polymorphic func can be known only after type checking

23 - [SR] - rewrite\_inject\_builtin\_constr.py Q - For all the builtins, `constr_type` is polymorphic only, that check is redundant or may be for a future use cases – already there (finding 11 - try to add the comment )

24 - [SR] - rewrite/rewrite\_import\_uplc\_builtins.py

1. line 33 - What if the the function defintion has more than one decorator along with `wraps_builtin`
2. for splitting the function name - relies on the underscore and a digit following

the underscore, `foo_bar_123`, this will be split `foo` and `bar_123` and captilised into `Foo` and `Bar_123` - the logic for splitting may not handle all cases

25 - [SR] - optimize/optimize\_remove\_comments.py If the need is to remove only string comments, checking instance of constant node removes all

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constants Ex: “this is a comment” 42 , if i add this to the code, to debug my on-chain this will be removed as well None x = , here True will be removed as part of this code

if x “some text” - worked fine

26 - [SR]- rewrite/rewrite\_orig\_name.py→ maintainability/minor add finding

- Have to check on annotated nodes, besides names, classdef and function def nodes. x:int = 10 ‘These nodes are not taken into account’ - **add finding** - added

27 - [SR] - rewrite/rewrite\_comparison\_chaining.py

- No other finding other than finding 10

28 - [SR] - optimize/optimize\_remove\_pass.py

- Q - clarify finding 9- Which visit\_pass method?

29 - [SR] - optimize/optimize\_remove\_deadvars.py

visit\_If - it looks for an intersection of the if body and else body, what if there is a break statement ? - as break is not implemented yet, this finding is not needed for now

```
def validator(x:int,y:int):  
    while x == 1:  
        if x > 0:  
            y = 10  
            break  
        else:  
            y = 20  
    print("The value of y is:",y)
```

Notimplemented Error : NotImplementedError: Cannot infer type of non-implemented node <class 'ast.Break'>

30 -[SR] - rewrite/rewrite\_scoping

The process of rewriting the variable names with scope id to resolve scopes and used for debugging

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- How to check if builtins are not rewritten? tried using `test_rewrites.py`- confirmed that builtins are not rewritten

## code Generation parts

1. [SR] - `util.py`
  - 1 followed by variable names like `1val_param0` - affects readability, instead use variable names
  - `O_adhocpattern_hash` of the ast - the hashes are long and affects readability
  - Line 213 – `force_params`-> all parameters - default and correct
2. [SR] - `fun_impls.py` Function: `len`
  - Correctly uses `FoldList`, Integer. starts at 0 and adds 1
  - `ByteString` case (uses `LengthOfByteString`)
  - `List/Dict` case (uses `FoldList` with increment)
  - `Tuple` case (returns fixed length)
  - Raises non implemented error for unsupported types

[x] - empty case of `len` (`len([])`) is not handled here, avoid `indexError: list index out of range` Recom: error message has to be improved visit `_Assign` , check the target is already given a type - Finding

- Function reserved, `print`, `abs` , `all` and `any` - no issues
- `pow(2,3)`, contains `traceerror` in uplc output even if `3<0`, reason is lazy execution of `plt.ite`

[x] - recursion depth can be specified in hex, to avoid max recursion error - finding - recom: `Xor` is not yet implemented, it compiled with optimization

3. `rewrite/rewrite_empty_lists.py` - as per the code

```
def validator(x:List[int]):  
    x : List[int] = []
```

- output builtins in uplc code, builtin `unListData`, builtin `unIData`, (`con (list integer) []`), builtin `constrData`, `con integer 0`, `[(builtin mkNilData) (con unit ())]`, builtin `mkcons`, builtin `chooseList`, builtin `headList`, builtin `tailList`

4. `rewrite/rewrite_empty_dicts.py` - as per the code

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```
def validator(x:Dict[str,int]):
```

```
    x :Dict[str,int] = {}
```

- builtin unMapData, [(builtin constrData) (con integer 0)], [(builtin mkNilData) (con unit ())]

6. rewrite/rewrite\_import\_hashlib.py

```
#from hashlib import sha256 as hsh
```

```
from hashlib import blake2b
```

```
# def validator () -> bytes:
```

```
#     x = sha3_256(b"123").digest()
```

```
#     return x
```

```
def validator () -> bytes:
```

```
    x = blake2b(b"123").digest()
```

```
    return x
```

as expected (lam x [(lam x (lam \_ [(builtin blake2b\_256) x]))])

7.rewrite/rewrite\_integrity\_check.py

```
@dataclass()
```

```
class B(PlutusData):
```

```
    CONSTR_ID = 1
```

```
    foobar: int
```

```
    bar: int
```

```
def validator(x: B) -> None:
```

```
    check_integrity(x)
```

as expected - (lam 1x [(lam 1x (force [[[(force (builtin ifThenElse))

[(builtin equalsData) 1x]

[0p\_AdHocPattern\_6e5e35746e0db09c0956f182750126a838d5650add52b85f95f67e428c

1x]]] (delay (con unit ())))] (delay [(lam \_ (error)) [(force  
(builtin trace)) (con string "ValueError: datum integrity check  
failed")]]]])))]

lazy evaluation of ifThenElse but then trace error always thrown in putput –  
finding

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8. rewrite/rewrite\_import\_UPLC\_builtins.py

```
def validator(x:int):  
    assert x == 1
```

- When there is no return type mentioned, data is constructed for integer 0 in addition to mkNilData

```
@wraps_builtin  
def add_integer(x: int, y: int) -> int:  
    z = x*y  
    return x
```

```
def validator():  
    assert add_integer(1, 2) == 3
```

- this add\_integer is already defined under builtins.py file, if someone tries to define anything at all , this will be directly mapped to uplc builtin, how safe this could be?

Recom : local definition should be declined when builtins are used from builtin.py Why should the user be given a choice to wrap the builtin?

9. transform\_ext\_params\_map(),transform\_output\_map(),empty\_List() - None