OpenSC

- A Smart Contract Language

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OpenSC

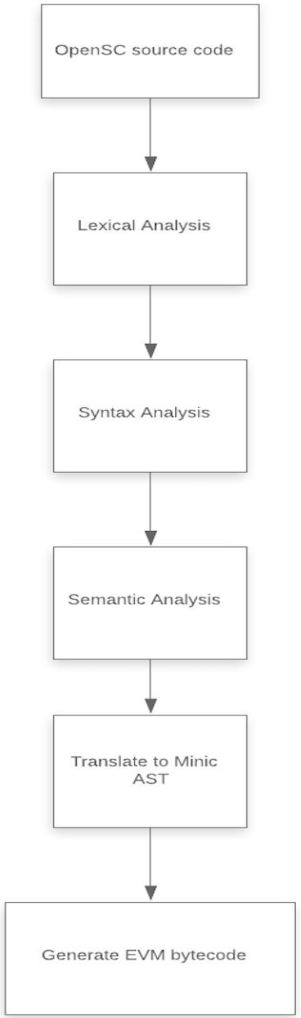
- A Smart Contract Language

- Introduction
- Architecture
- Lexical Analysis
- Syntax Analysis
- Semantic Analysis
- Translate to Minic
- Demo
- Future Work

Introduction

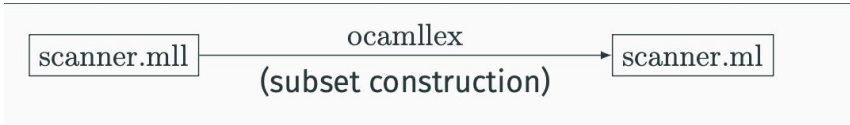
- Similar Languages: Scilla, Pact
- Uniqueness: State Transitions
- Inspiration: DeepSEA
- Smart Contract: Simplestorage, Auction, Token

Compiler Architecture



Lexical Analysis

- Comment
- General operation symbol
- Types
- Literal
- Built-in



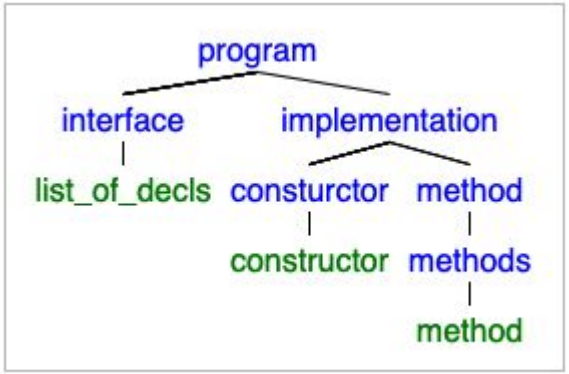

```
{open Parser}

let digits = ['0'-'9']
let letter = ['a'-'z' 'A'-'Z']

rule token = parse
  [' ' '\t' '\r' '\n']   { token lexbuf }
  |"/-"                 {multicomment lexbuf} (* multiple comment *)
  | '('                 { LPAREN }
  | ')'                 { RPAREN }
  | '{'                 { LBRACE }
  | '}'                 { RBRACE }
  | '['                 { LBRACK }
  | ']'                 { RBRACK }
  (*  General op *)
  | "=="                { EQ }
  | "!="                { NEQ }
```

Syntax Analysis

- Ocaml yacc
- CFG with attached semantic actions
- AST
  - op, type, expression, declaration,



OpenSC example

SimpleStorage:

Signature, constructor, methods

```
signature SimpleStorage {
    storage storedData : int;

    constructor c : (void) -> void;
    method get : () -> int;
    method set : (int) -> void;
}

constructor c (){
    storage
    returns void;
}

method get(){
    guard{}
    storage{}
    effects{}
    returns storedData;
}

method set(x: int) {
    guard{
        x > 0;
    }
    storage{
        storedData |-> x;
    }
    effects{}
    returns voidlit;
}
```

Semantic Analysis

Goal:

ast =========> sast

```
18  type expr =
19      | NumLit of int  (* number literal *)
20      | BoolLit of bool
21      | StrLit of string
22      | Id of string
23      | EnvLit of string * string
24      | Mapexpr of expr * expr list
25      | Binop of expr * op * expr
26      | Logexpr of expr * expr list
27      | Storageassign of expr * expr
28      | Comparsion of expr * op * expr
29      | Voidlit of string
```

```
5   type varscope =
6       | Sglobal
7       | Slocal
8
9   type sexpr = typ * sx
10  and sx =
11      | SNumLit of int  (* number literal *)
12      | SBoolLit of bool
13      | SStrLit of string
14      | SId of varscope * string
15      (* | SVar of sexpr * typ *)
16      | SEnvLit of string * string
17      | SMapexpr of sexpr * sexpr list
18      | SBinop of sexpr * op * sexpr
19      | SLogexpr of sexpr * sexpr list
20      | SStorageassign of sexpr * sexpr
21      | SComparsion of sexpr * op * sexpr
22      | SVoidlit of string
```

Semantic Analysis

- expr:
  - assign data type to expr based on each operation
  - check whether variable id in the symbol table; assign scope attribute
  - verify variable data types of binary operator, compare and assign expr
  - match map and event input data types with global variable declaration
  - match expr of method return with it return type
- constructor:
  - one and only one constructor in interface and implementation
- method:
  - match arguments data type with method declaration in interface
  - construct local symbol table

Semantic Analysis

Correct

```
/- correct -/
signature SimpleStorage {
    storage storedData : UInt;
    constructor c : UInt -> void;
    method set : (UInt) -> void;
}
```

✓

```
/- method set : (int, UInt) -> int; -/
/- correct -/
method set(x: int, y: UInt) {
  guard{}
  storage{}
  effects{}
  returns x;
}
```

✓

```
/- map balances : (Address) => UInt; -/
/- a : Address -/
/- correct -/
balances[a]
```

✓

Wrong

```
/- wrong -/
signature SimpleStorage {
    storage storedData : UInt;
    constructor c : UInt -> void;
    constructor c2 : UInt -> void;
    method set : (UInt) -> void;
}
```

✗

```
/- method set : (int, UInt) -> int; -/
/- wrong -/
method set(x: int, y: UInt) {
  guard{}
  storage{}
  effects{}
  returns y;
}
```

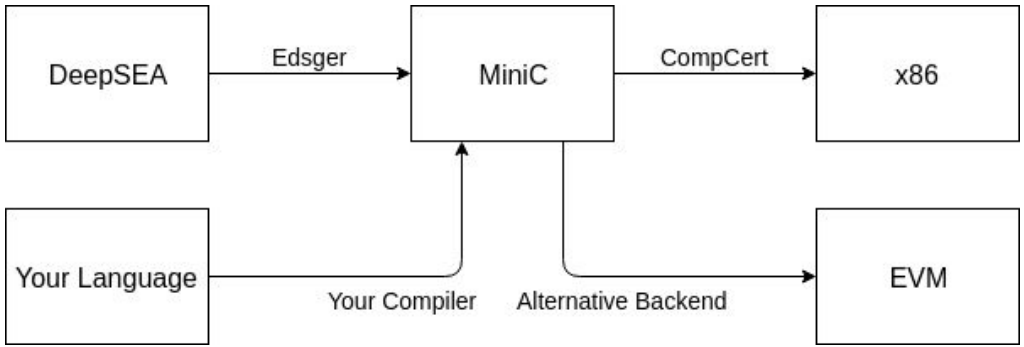
✗

```
/- map balances : (Address) => UInt; -/
/- a : Address -/
/- wrong -/
balances[ ]
/- b : int -/
balances[b]
```

✗

Translate to MiniC

- What is minic ?
  - The “IR”
  - Backend is ready
  - Just in AST format



Translate to MiniC

Goal:

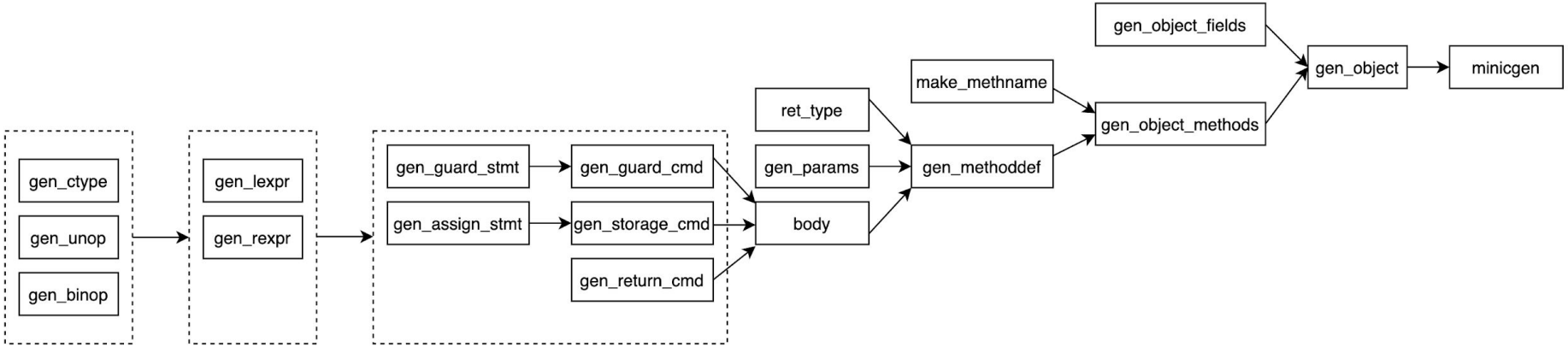
sast ==========> Minic AST

```
5   type varscope =
6       | Sglobal
7       | Slocal
8
9   type sexpr = typ * sx
10  and sx =
11      | SNumLit of int  (* number literal *)
12      | SBoolLit of bool
13      | SStrLit of string
14      | SId of varscope * string
15      (* | SVar of sexpr * typ *)
16      | SEnvLit of string * string
17      | SMapexpr of sexpr * sexpr list
18      | SBinop of sexpr * op * sexpr
19      | SLogexpr of sexpr * sexpr list
20      | SStorageassign of sexpr * sexpr
21      | SComparsion of sexpr * op * sexpr
22      | SVoidlit of string
```

```
9   type expr =
10  | Econst_int of Int.int * coq_type
11  | Econst_int256 of Int256.int * coq_type
12  | Evar of ident * coq_type
13  | Etempvar of ident * coq_type
14  | Ederef of expr * coq_type
15  | Eunop of unary_operation * expr * coq_type
16  | Ebinop of binary_operation * expr * expr * coq_type
17  | Efield of expr * ident * coq_type
18  | Earrayderef of expr * expr * coq_type
19  | Ehashderef of expr * expr * coq_type
20  | Ecall0 of builtin0 * coq_type
21  | Ecall1 of builtin1 * expr * coq_type
```

Translate to MiniC

- How to translate ?
  - Hierarchically



Translate to MiniC

- More Details of translation
  - ABI-compatible method id

Demo

Future Work

- Constructor
- Event and log
- Multi-key Mapping
- Multiple objects
- Control flow statement (if, for statement) “
    - Guard body is now translated into ‘if statement’

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Thank You!