Modelling a Blockchain for Smart Contract Verification using DeepSEA

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

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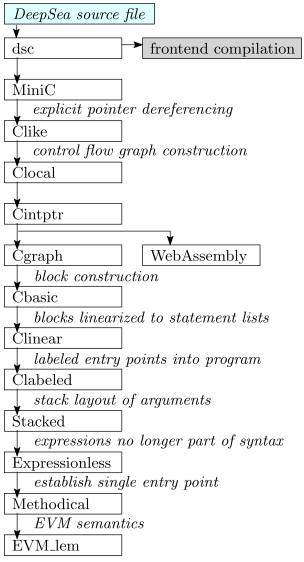
DeepSEA

DeepSEA


DeepSea source file
dsc
frontend compilation
MiniC
explicit pointer dereferencing
Clike
control flow graph construction
Clocal
Cintptr
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WebAssembly
block construction
Cbasic
blocks linearized to statement lists
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EVM semantics
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Example Context - Crowdfunding [4]:

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Example Context - Crowdfunding [4]:

1. “Safety property: donations record backed by ether”
2. “Donation record preserved over time”
3. “Backers can claim back donations after campaign fails”

Providing a blockchain model for DeepSEA

Successful-Calls Approach

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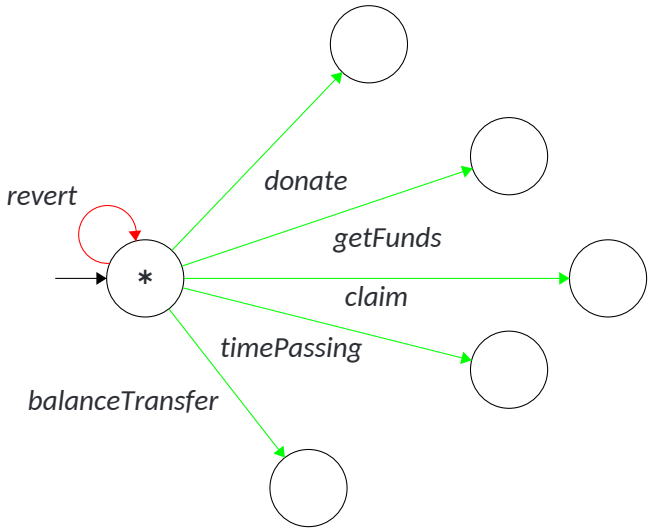
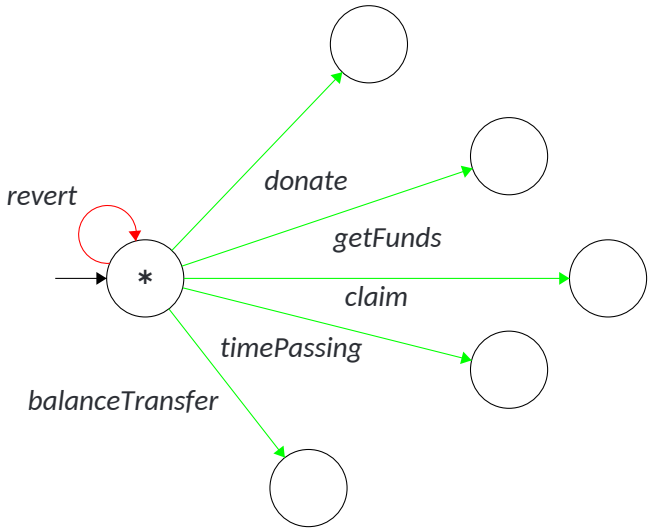


```
Inductive Action (before : BlockchainState) :=
| call_Crowdfunding_donate (context : CallContext)
  (callvalue_prf : noOverflowOrUnderflowInTransfer ...)
  r
  contract_state_after
  (case_donate_prf : runStateT (Crowdfunding_donate_opt
    (make_machine_env contract_address before context ...))
      (contract_state before)
        = Some (r, contract_state_after))
| call_Crowdfunding_getFunds ...
| call_Crowdfunding_claim ...
| externalBalanceTransfer ...
| timePassing ...
| revert.
```

Successful-Calls Approach



Successful-Calls Approach

```
Fixpoint step
  (before : BlockchainState) (action : Action before)
    : BlockchainState :=
match action with
| call_Crowdfunding_donate context
    callvalue_prf r d_after case_donate_prf =>
      next_blockchain_state before d_after
| call_Crowdfunding_claim ...
| call_Crowdfunding_getFunds ...
| timePassing ...
| externalBalanceTransfer ...
| revert => before
end.
```

Usage in a Crowdfunding Proof

```
let donate () =
  ...
  if (blk > _max_block) then
    fail
  else
      if (backers[msg_sender] = 0) then
          backers[msg_sender] := msg_value
      else
        fail
```

Usage in a Crowdfunding Proof

```
Theorem donation_preserved : forall (a : addr) (d : Z),
  (donation_recorded a d) `since` (donation_recorded a d) `as-long-as` (no_claims_from a).
Proof.
unfold since_as_long. intros. induction H; [assumption|]. assert(donation_recorded a d prevSt)
  by (apply IHReachableFromBy; intros; apply H1; apply in_cons; assumption).
clear H0 IHReachableFromBy. unfold donation_recorded in *. Hlinks.
assert (no_claims_from a prev) by (apply H1; destruct HL; subst; right; left; auto).
destruct prev; autounfold in *; simpl in *. clear H1 H HL. unfold no_claims_from in H0.
unfold donation_recorded in *. destruct Step_action0; simpl in *; rewrite <- HS in *; try assumption.
- Transparent Crowdfunding_donate_opt. unfold Crowdfunding_donate_opt in *.
  ds_inv; subst; simpl; inv_FT. destruct (a =? (caller context)) eqn:Case.
  + exfalso. apply Int256eq_true in Case. simpl in *. apply Z.eqb_eq in Heqb0. rewrite <- Case in *.
    rewrite Heqb0 in H2. lia.
  + simpl in *. apply Int256eq_false in Case. rewrite get_default_so; assumption.
- Transparent Crowdfunding_getFunds_opt. unfold Crowdfunding_getFunds_opt in *.
  ds_inv; subst; simpl; lia.
- contradiction.
Qed.
```

Usage in a Crowdfunding Proof

```
Proof.
- (* donate *)
  +
Heqb0
     : get msg_sender backers = 0

  +
Heqb0
     : get msg_sender backers = 0

- (* getFunds *)
- (* claim *)
Qed.
```

Usage in a Crowdfunding Proof

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    fail
  else
      if (backers[msg_sender] = 0) then
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```

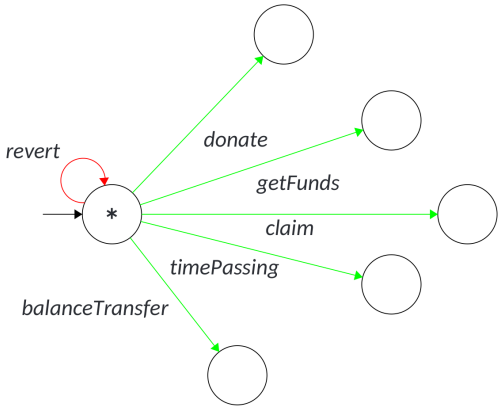
Usage in a Crowdfunding Proof

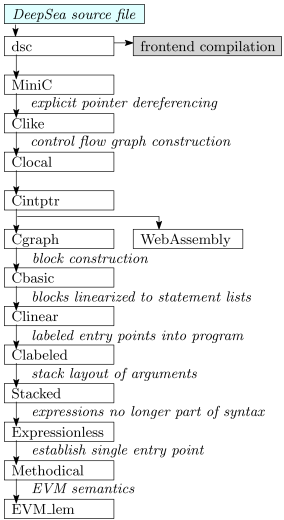
```
Transparent Crowdfunding_donate_opt. unfold Crowdfunding_donate_opt in *.
ds_inv; ...
```

Usage in a Crowdfunding Proof

```
match goal with
  | H : context[runStateT ?X ] |- _
    => destruct (runStateT X) eqn:SSSCase end; [|inversion H0; assumption].
destruct p.
Transparent Crowdfunding_donate_opt.
unfold Crowdfunding_donate_opt in SSSCase.
ds_inv; ...
```

Summary


revert
donate
getFunds
claim
timePassing
balanceTransfer
*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Thank you

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For a full list of references, see the paper [3].

Additional references I

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Snapshot Approach

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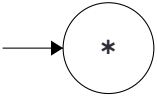
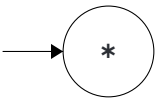
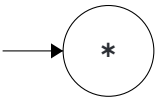


Snapshot Approach



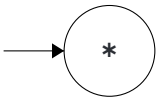

```
Context
  (snapshot_timestamp : int256)
  (snapshot_number : int256)
  (snapshot_blockhash : int256 -> int256)
  (snapshot_balances : addr -> wei).
```

Snapshot Approach




```
Record BlockchainState := mkBlockchainState {
  timestamp : int256;
  block_number : int256;
  balance : addr -> wei;
  blockhash : int256 -> int256;
  contract_state : global_abstract_data_type
}.
```

Snapshot Approach




```
Definition initial_state : BlockchainState :=
  mkBlockchainState
    snapshot_timestamp
    snapshot_number
    snapshot_balances
    snapshot_blockhash
    init_global_abstract_data
.
```

Usage in a Crowdfunding Proof

```
Proof.
```

```
snapshot_timestamp, snapshot_number: int256
snapshot_blockhash: int256 -> int256    snapshot_balances: addr -> wei
```

```
forall (a : addr) (d : Z),
(donation_recorded a d) `since`
donation_recorded a d `as-long-as`
(no_claims_from a)
```