Rich Specifications for Ethereum Smart Contract Verification

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Smart contract verification vs. OOP

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- Execution model
  - Encapsulation
  - Caller-dependent behavior
- Typical application domain
  - Resources and resource transfers

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Go *beyond* pre- and postconditions, invariants.

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- access control
  - enables reasoning about invariants between different contracts
- resource transfers
  - simple specification of common cases

This talk: OOPSLA 2021

Reasoning about (re-entrant) calls

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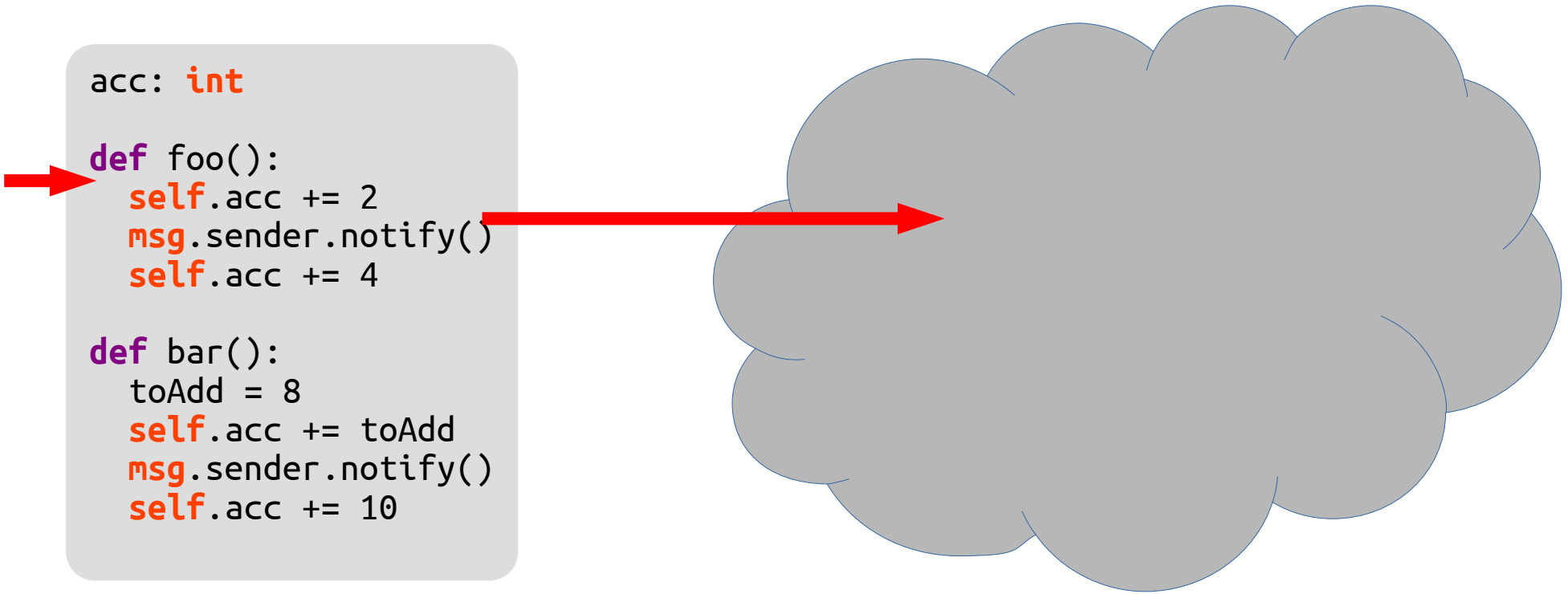

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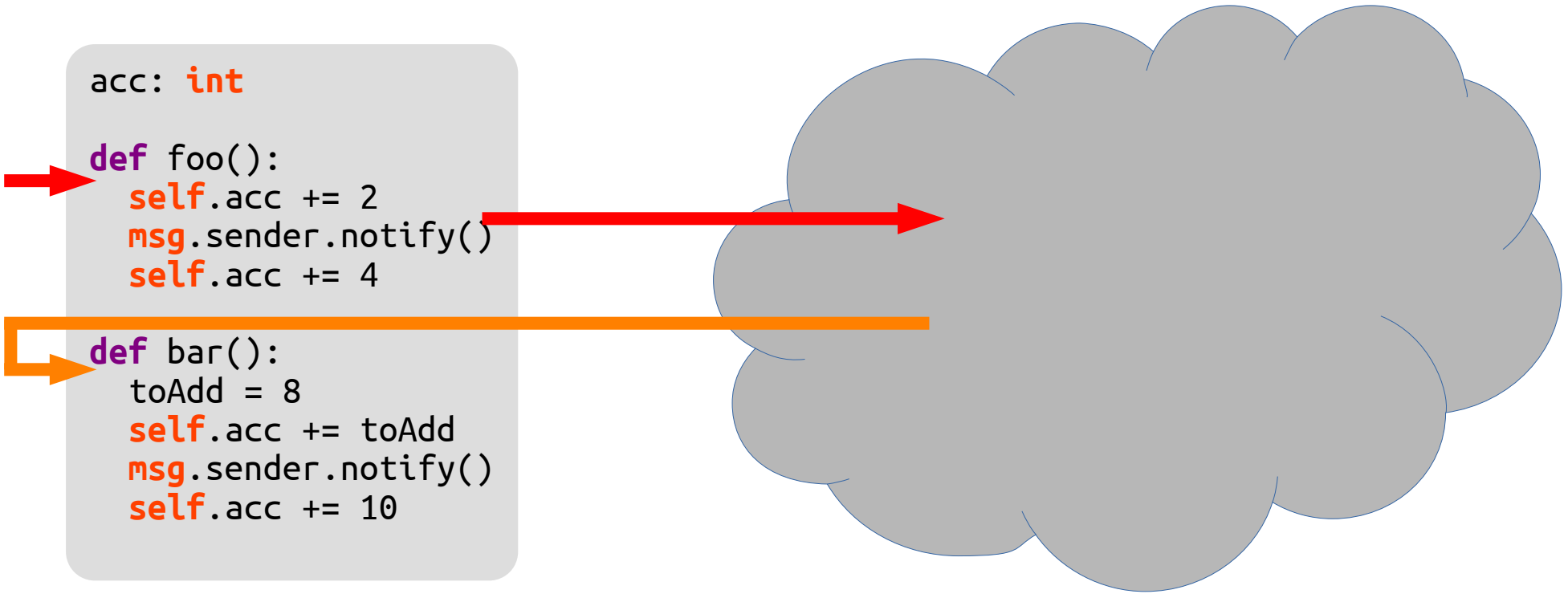

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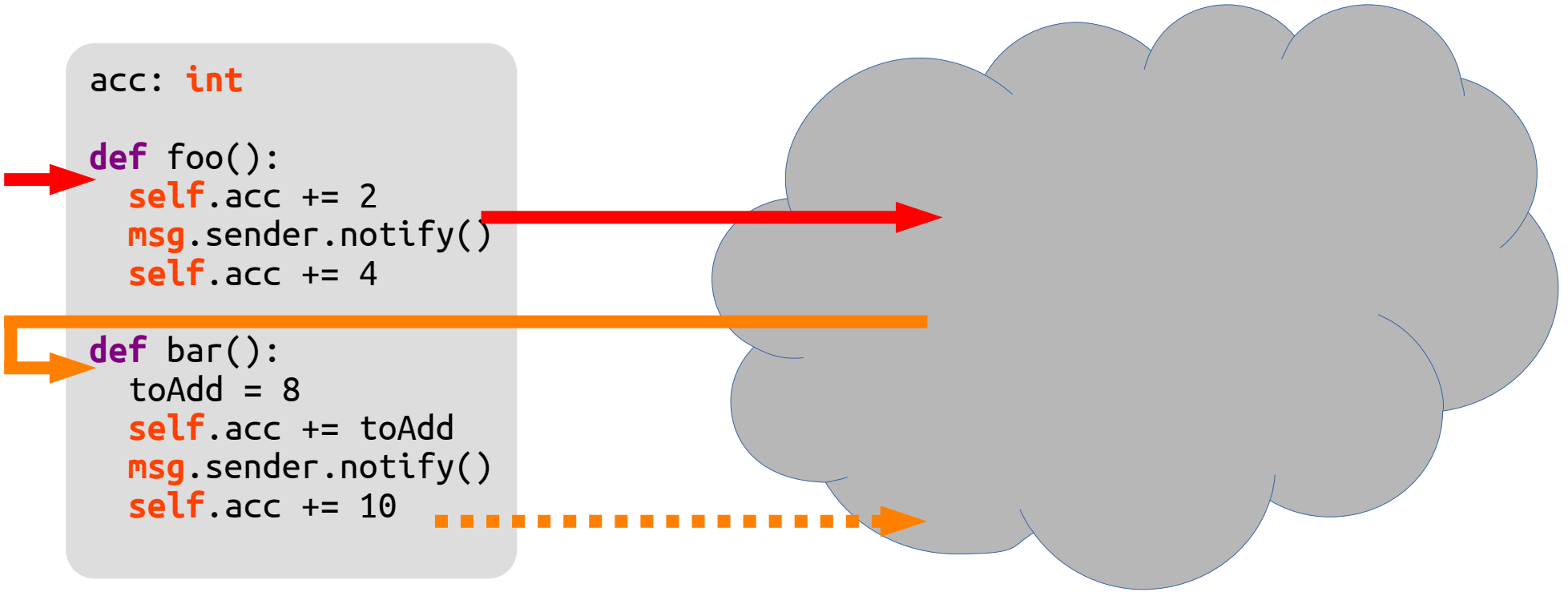

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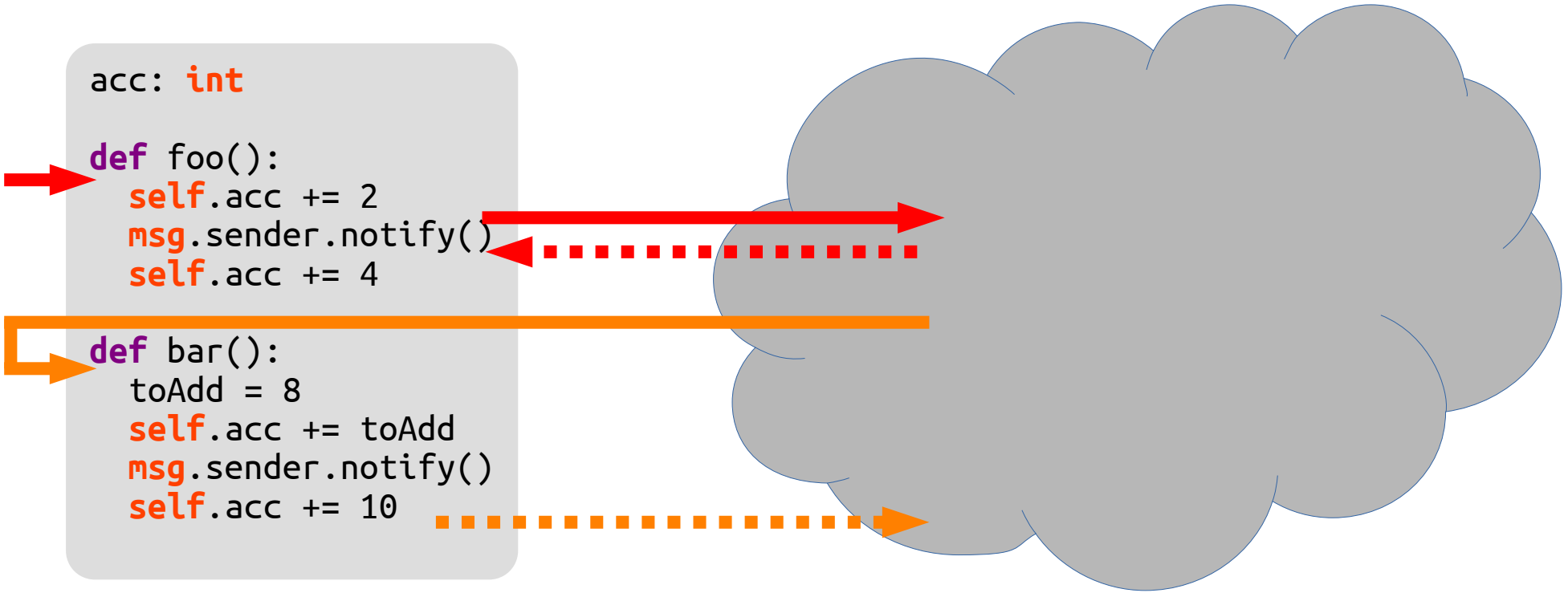

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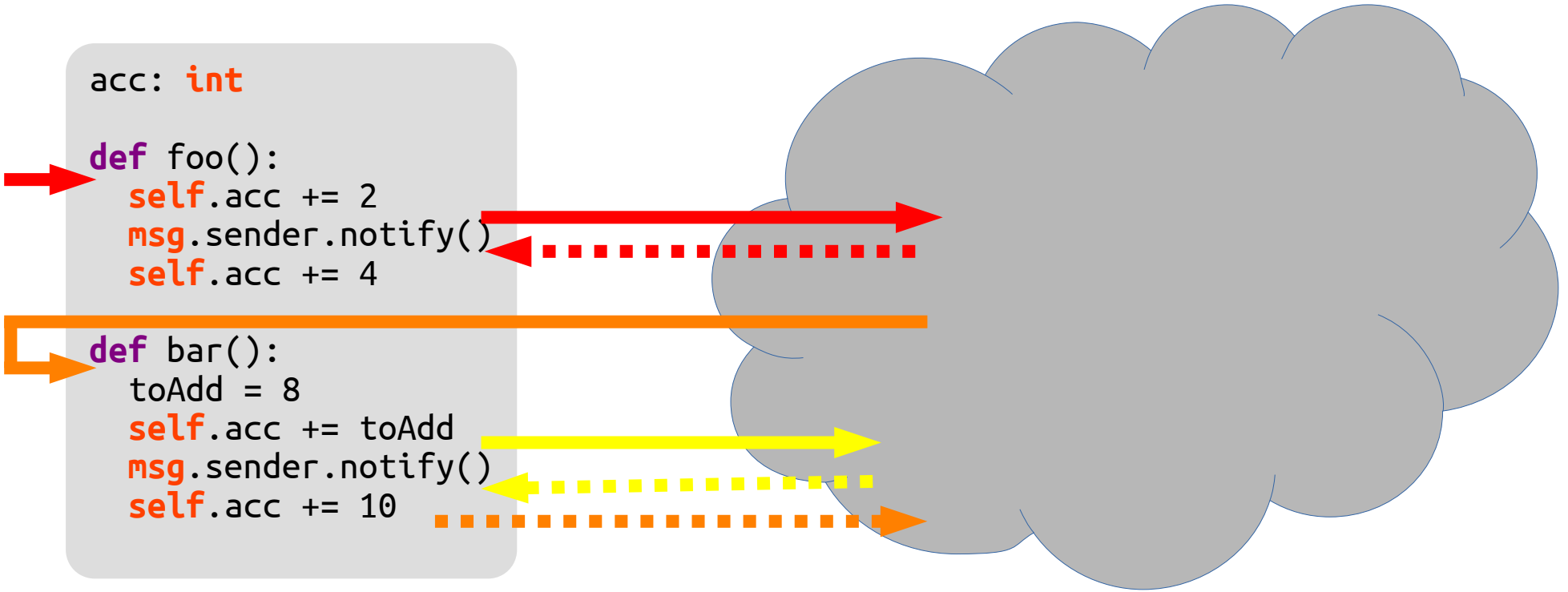

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- *Similar concept: Function constraints*

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Inter-contract invariants

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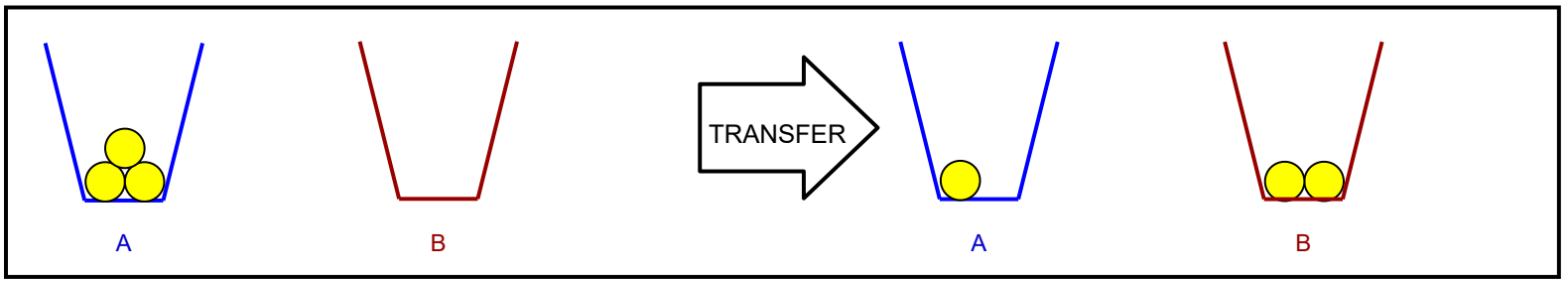

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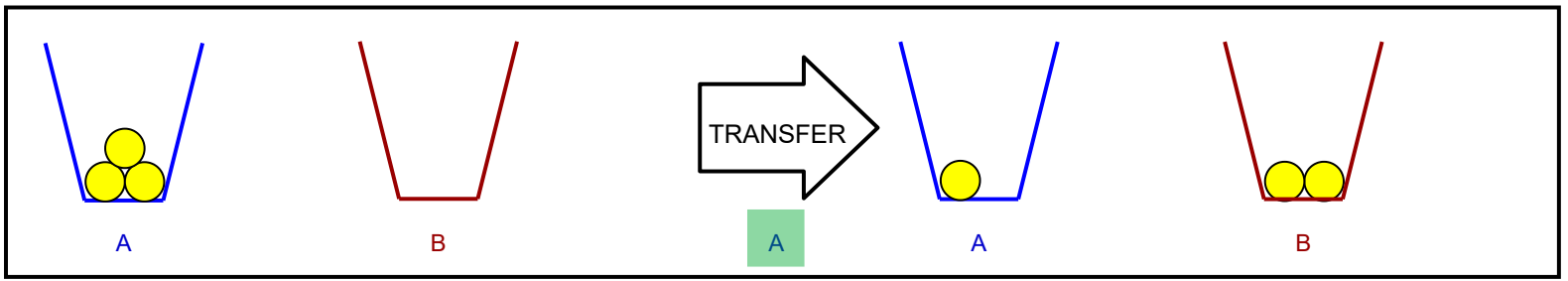

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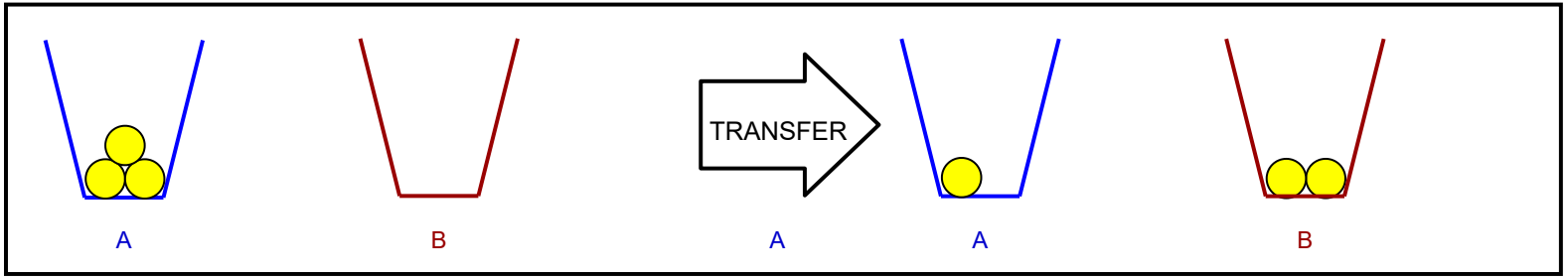

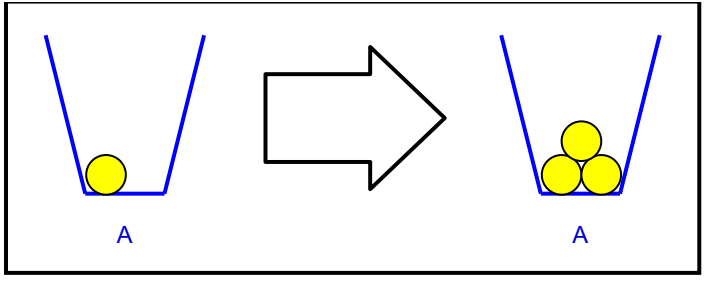

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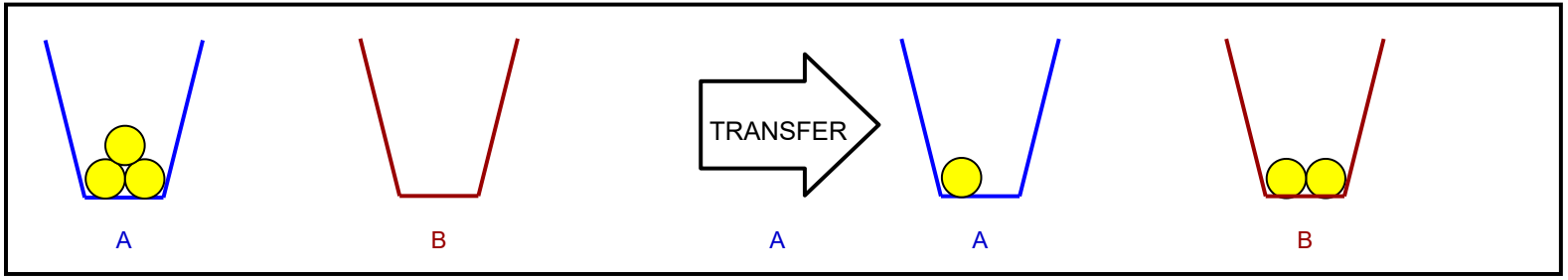

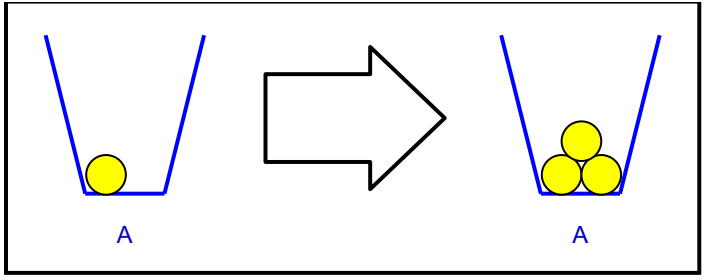

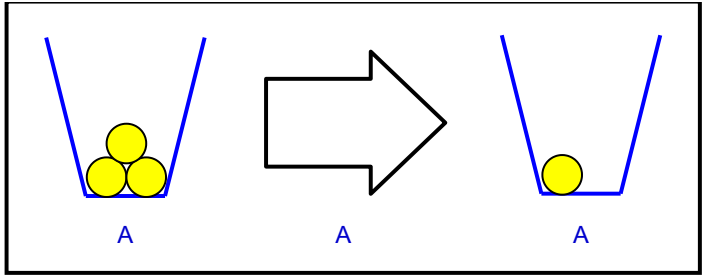

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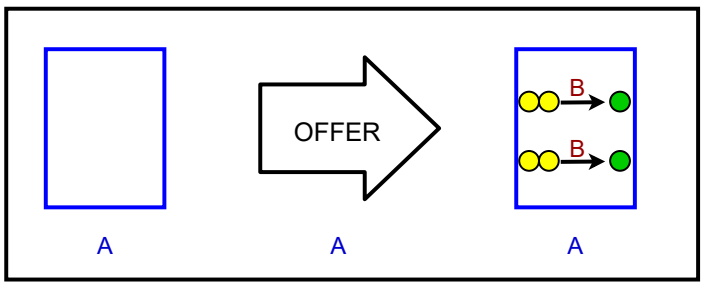

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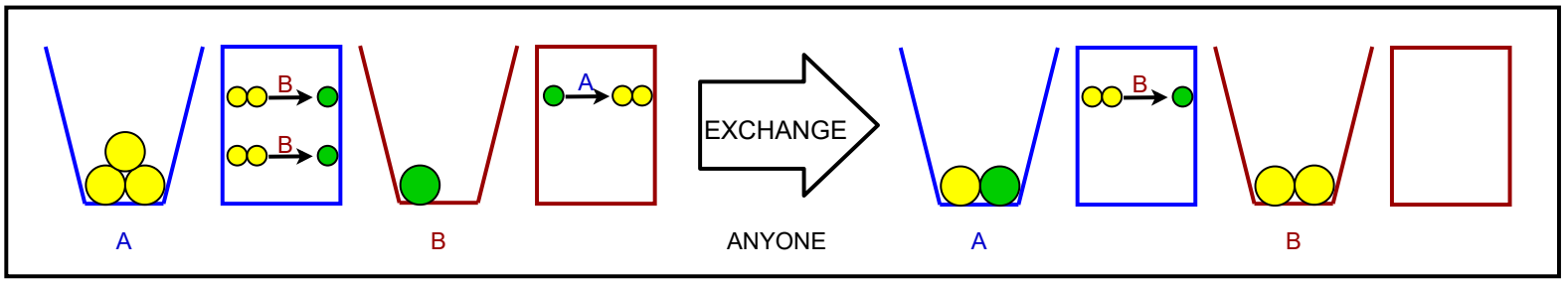

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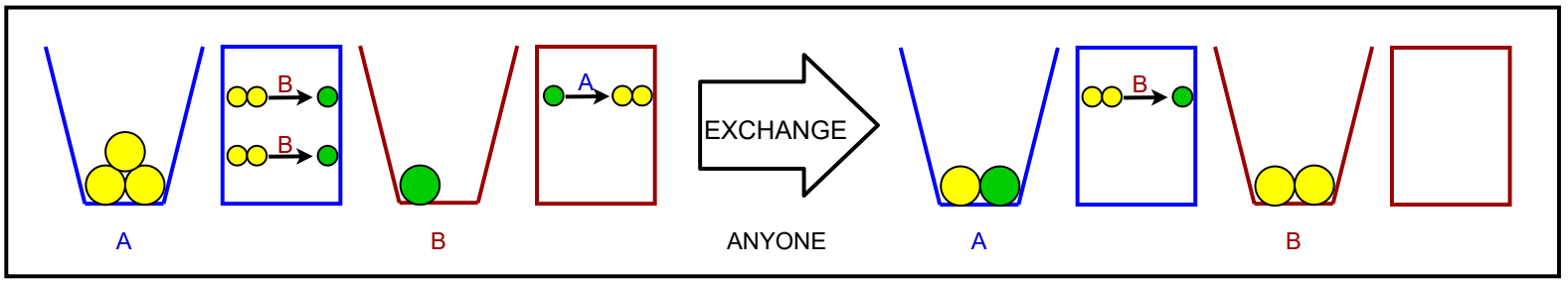

Other concepts:

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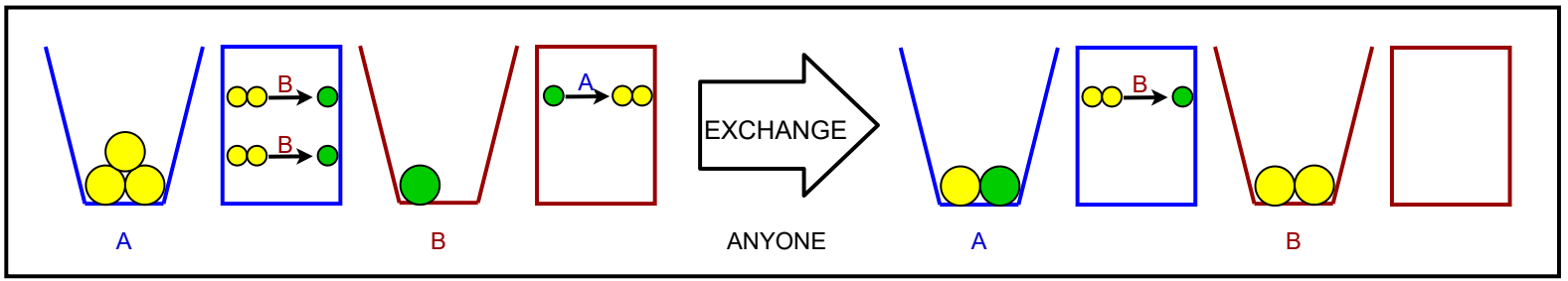

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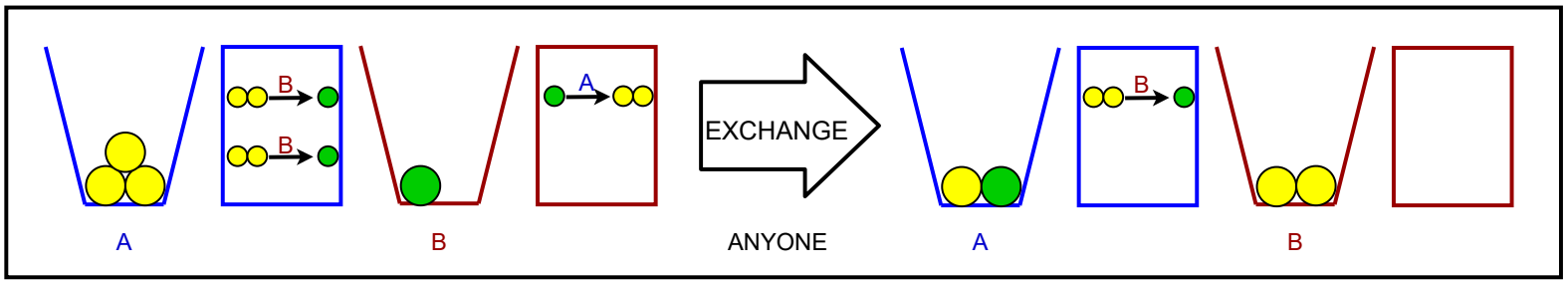

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- Trust: consciously weaken guarantees

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- Supports entire Vyper language modulo bugs
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- All standard specification constructs
  - pre/post, quantifiers, sums, …
- … *plus* segment constraints, inter-contract invariants, resources

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Our tool: 2vyper

```
#@ ensures: implies(_value > old(self.balanceOf[msg.sender]), revert())
#@ seg_constr: implies(success(), event(Transfer(msg.sender, _to, _value)))
@public
def transfer(_to: address, _value: uint256) -> bool:
    self.balanceOf[msg.sender] -= _value
    #@ transfer[token](_value, to=_to)
    self.balanceOf[_to] += _value
    log.Transfer(msg.sender, _to, _value)
    return True
```

```
Verification failed
Errors:
Invariant not preserved by transfer. Assertion (allocated[token]() == self.balanceOf) might not hold.
(ERC20_alloc.vy@112.1, via invariant at ERC20_alloc.vy@68.15)
Counterexample:
   _to = 0x00000000000000000000000000000000000000ea
   _value = 1
   block.coinbase = 0x0000000000000000000000000000000000000000
   block.difficulty = 0
   block.number = 0
   block.prevhash = [ _ -> 0 ]: 32
   block.timestamp = 0
   chain.id = 38
   msg.gas = 574
   msg.sender = 0x00000000000000000000000000000000000000eb
```

Evaluation

Application	Contract	LOC	Ann.	IF LOC	IF Ann.	T
auction	auction	63	30	-	-	12.72
auction_token	auction_token††	96	37	88	33	23.67
DAO	DAO*	17	2	-	-	5.13
ERC20	ERC20	98	31	67	25	11.51
ERC721	ERC721	178	32	-	-	15.95
ERC1363	ERC1363	142	31	88	33	22.59
ICO	gv_option_token	98	26	86	36	10.03
	gv_token	121	24	107	49	15.21
	gv_option_program*	86	12	154	67	29.19
	ico_alloc*	159	30	261	116	101.86
Mana	token*	18	3	50	25	2.78
	crowdsale*	42	14	50	25	5.77
	continuous_sale*	36	8	50	25	3.88
VerX_overview	escrow	60	11	65	33	6.36
	crowdsale	41	9	65	33	6.35
safe_remote_purchase	safe_remote_purchase	71	29	-	-	16.84
serenuscoin	serenuscoin	103	4	-	-	6.40
Uniswap V1	Uniswap†	398	115	105	45	112.81

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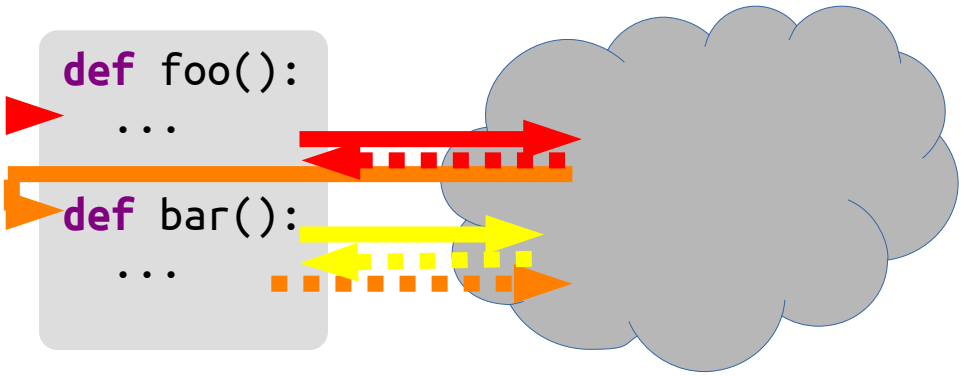
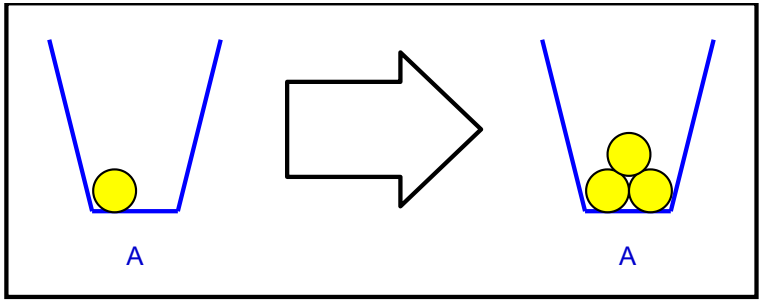
Thank you!





2vyper

VIPER

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https://github.com/viperproject/2vyper