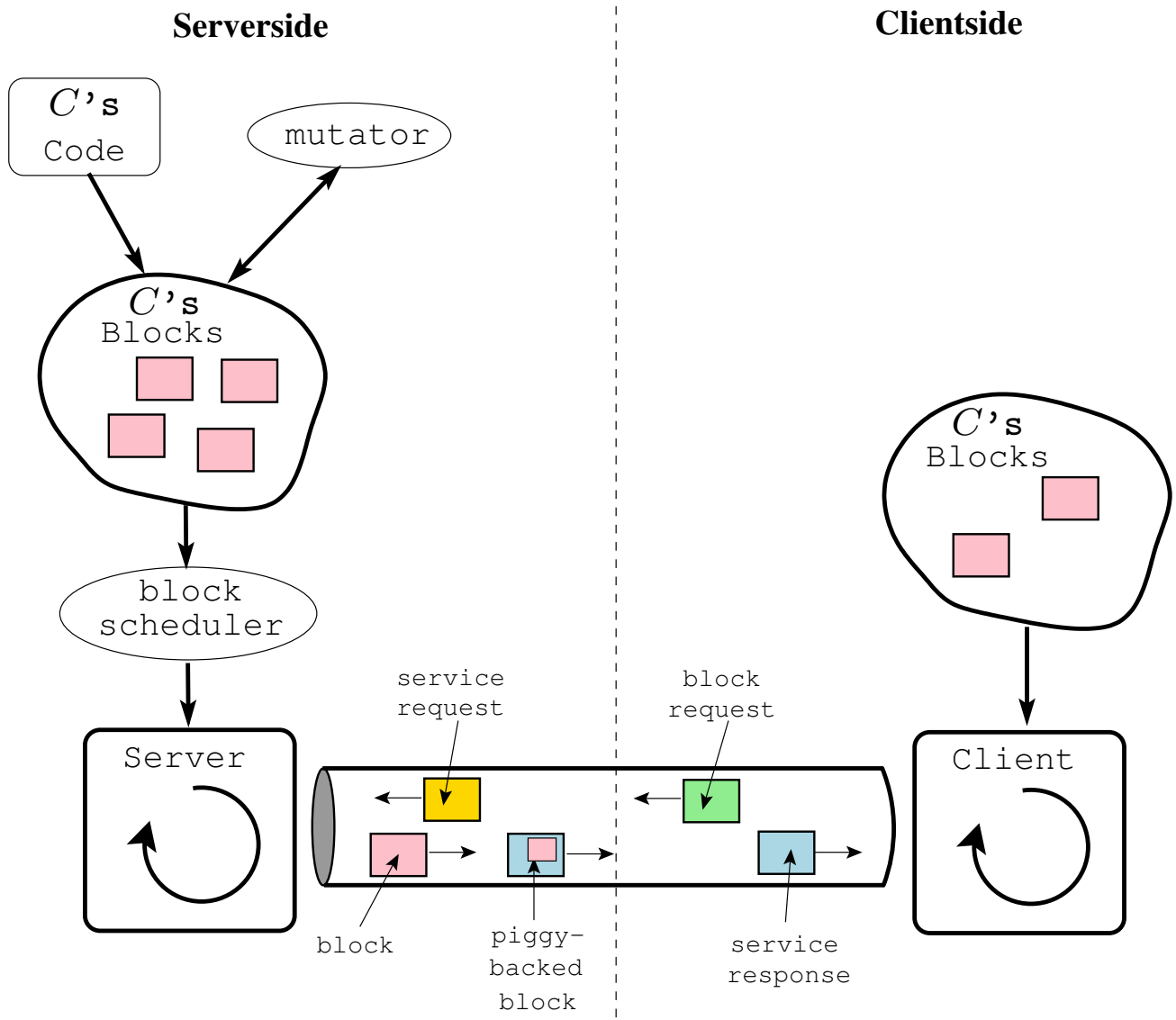
Continuous Replacement

Jasvir Nagra, Christian Collberg

November 19, 2007

Overview


Serverside
Clientside
C's Code
mutator
C's Blocks
block scheduler
Server
service request
block request
block
piggy-backed block
service response
C's Blocks
Client

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2. the rate by which the server pushes mutated blocks to the client
3. the rate by which the adversary can analyze the continuously changing program in the client's bag-of-blocks.

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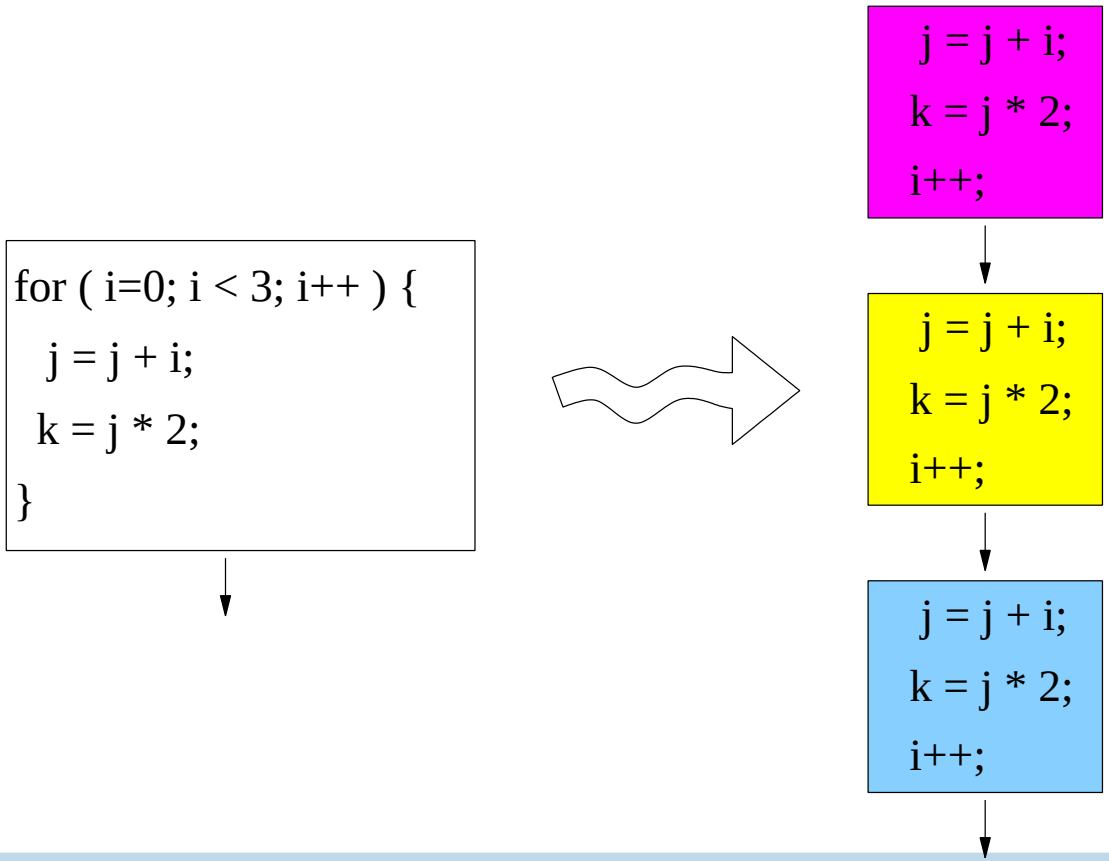
2. Little network traffic $\Rightarrow$ low block replacement rate
3. Client's bag-of-blocks must never contain a complete and correct program.
   - $\Rightarrow$ Prevents the adversary taking snapsshots of the bag to analyze off-line.
   - Ideally, even if the client saves a copy of all the blocks it has ever seen, the adversary still shouldn't be able to fully analyze the code (hard)

Block 1: Unrolled block

- Unroll a loop and send the client one iteration at a time.



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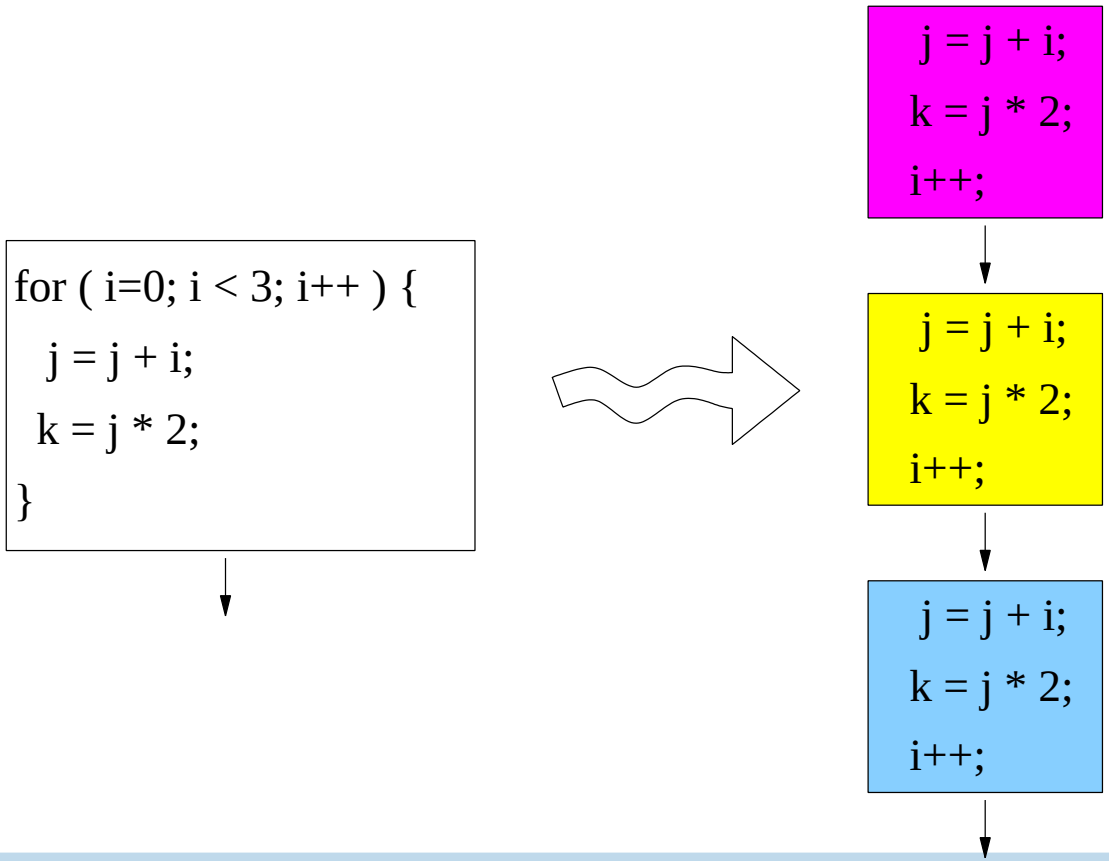

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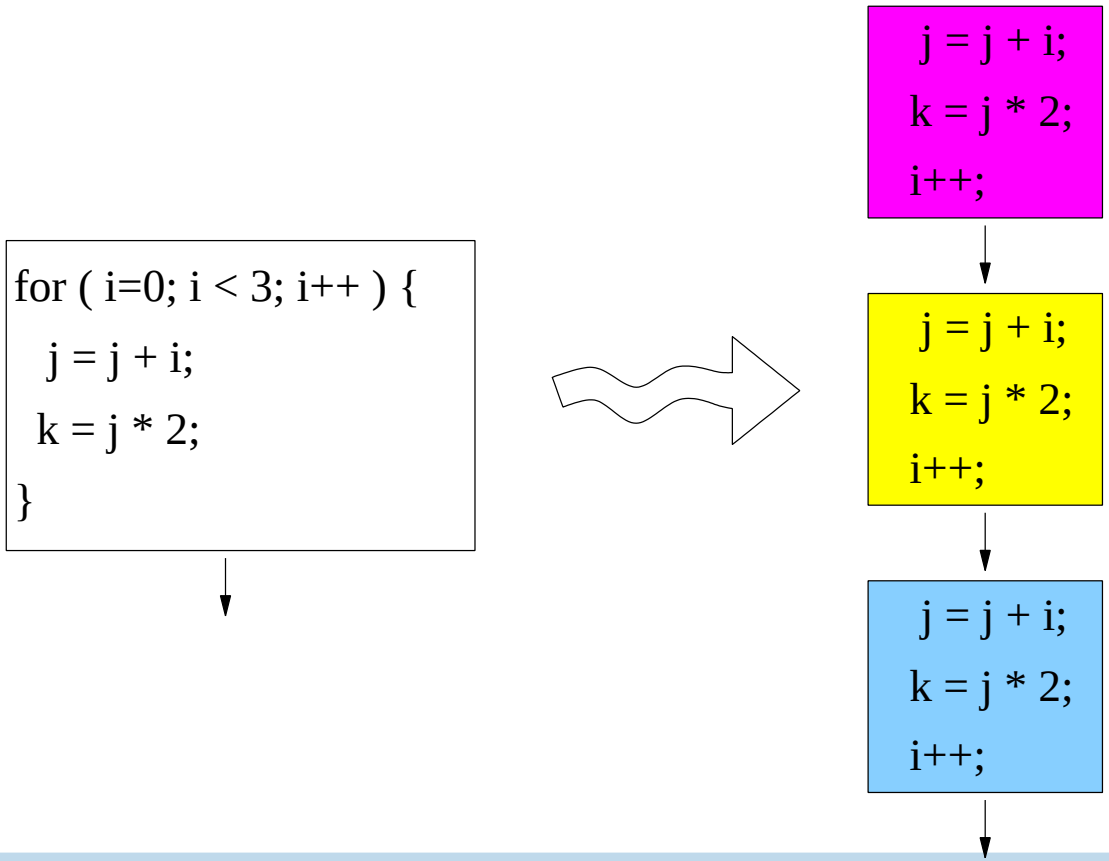
- $\Rightarrow$ Difficult for the adversary to reconstitute the loop.

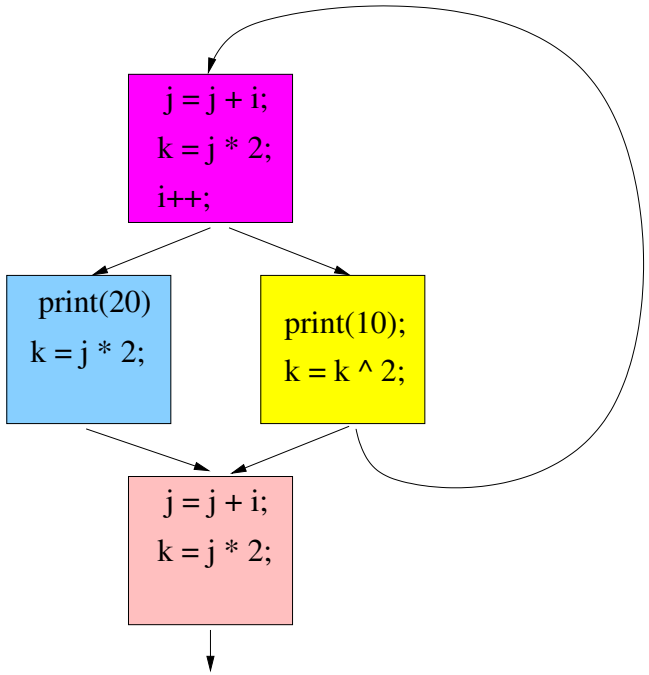


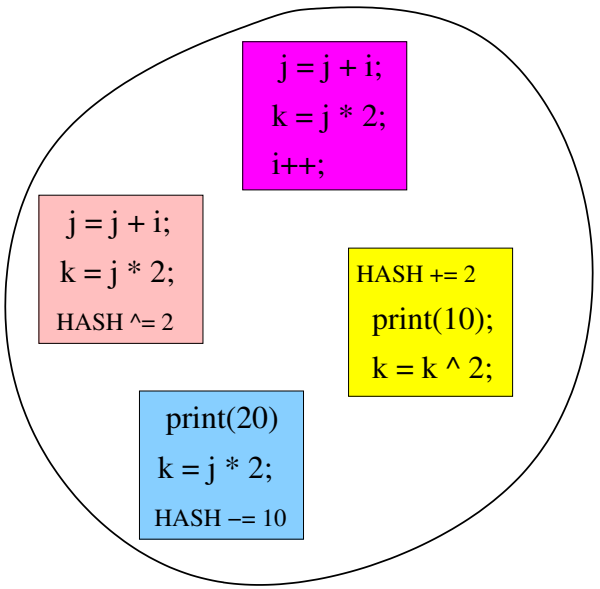
Block 2: Hashing block

- Compute a hash over another block and return the result to the server.

Block 3: Oblivious Hashing Block

- Weave a hash computation into the control flow:





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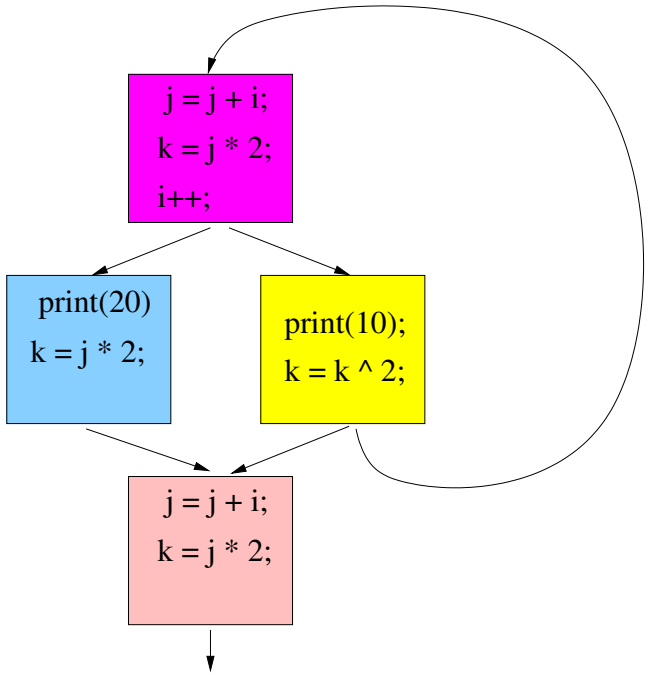

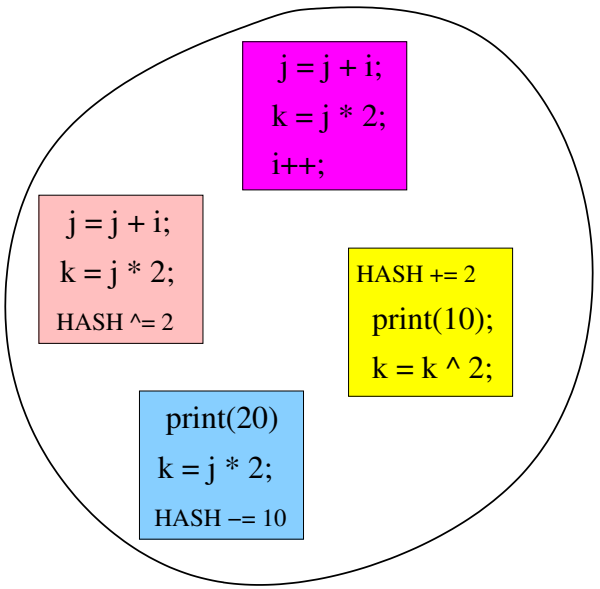

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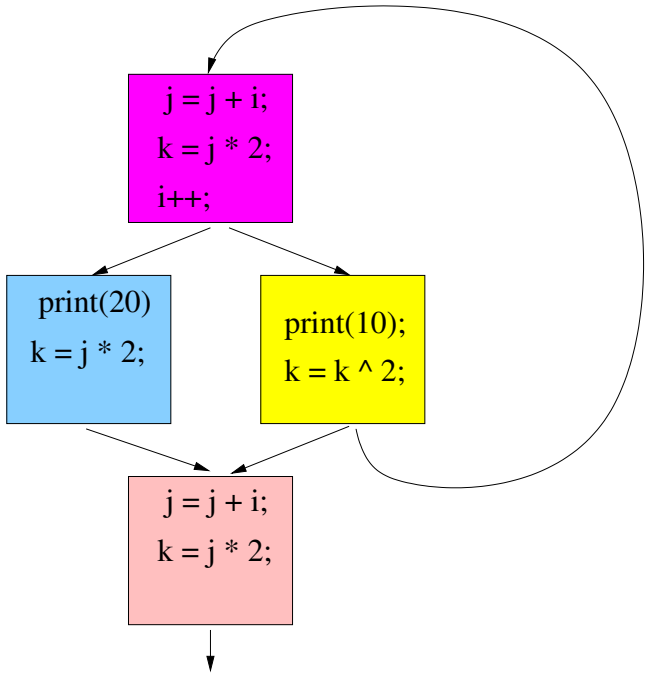

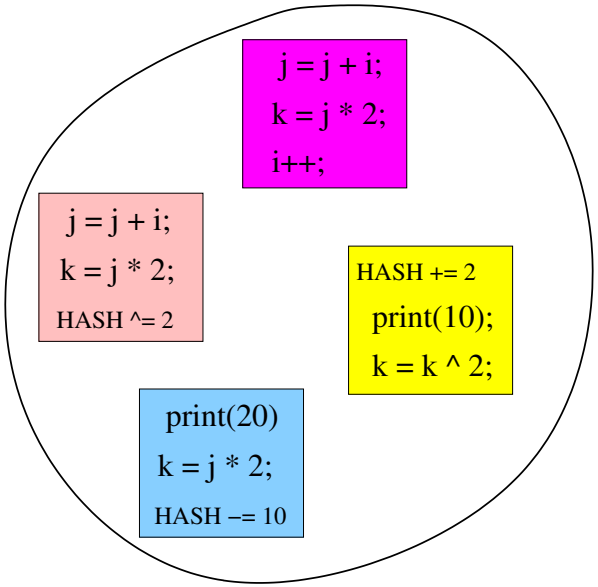

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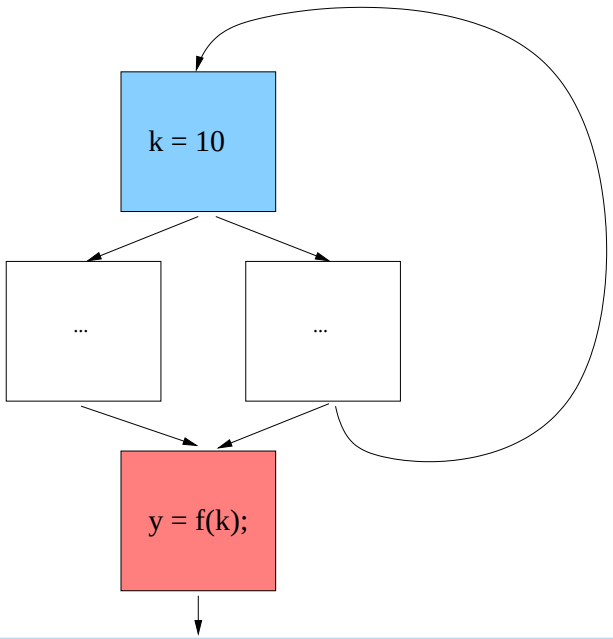

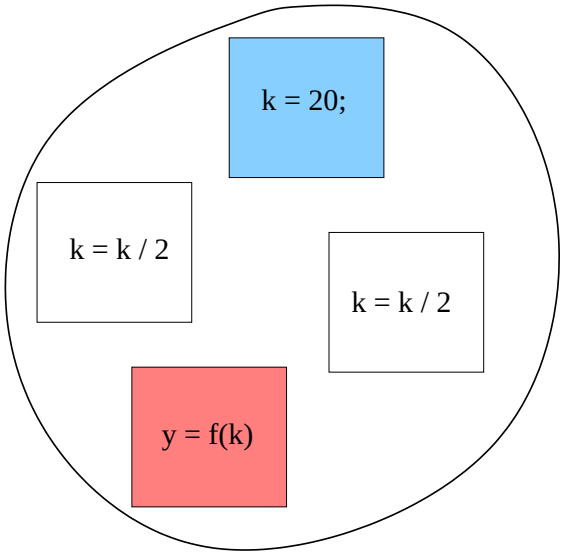

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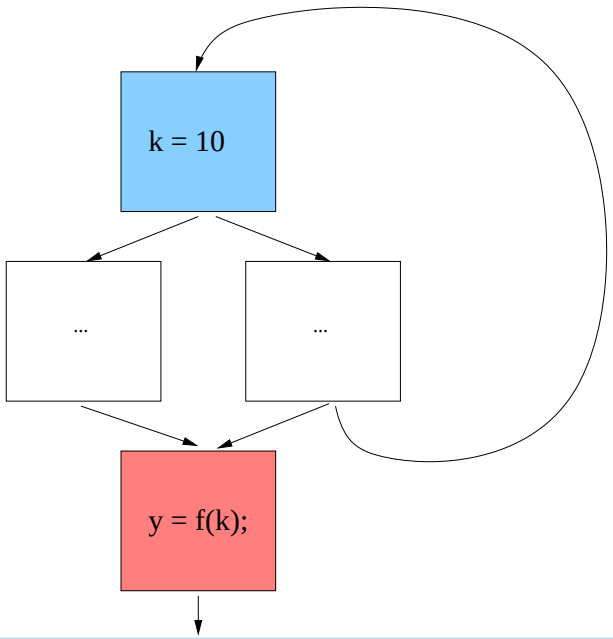

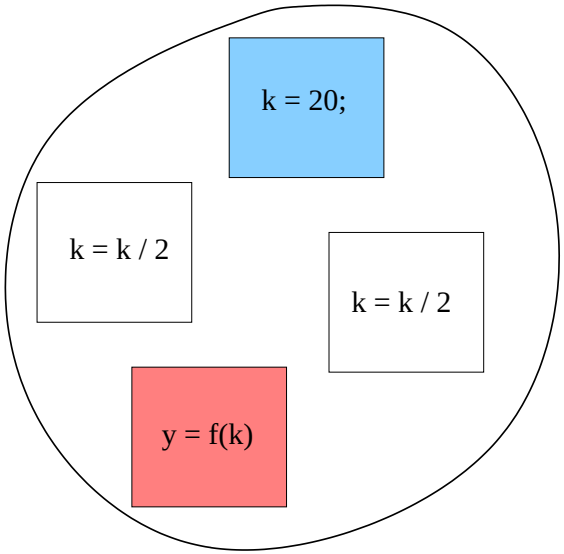

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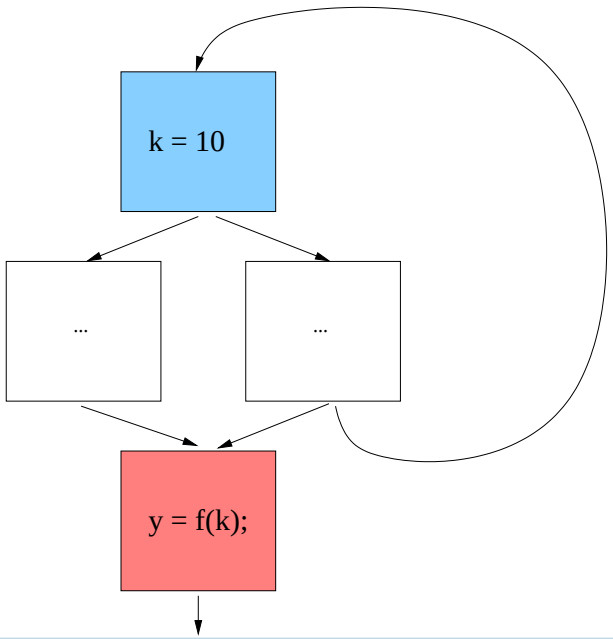

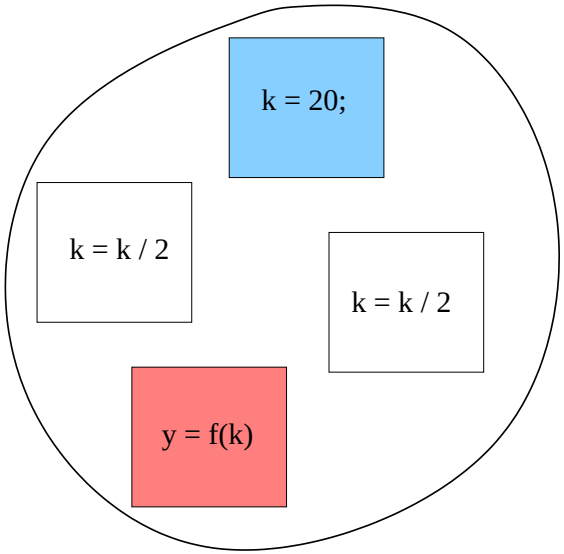

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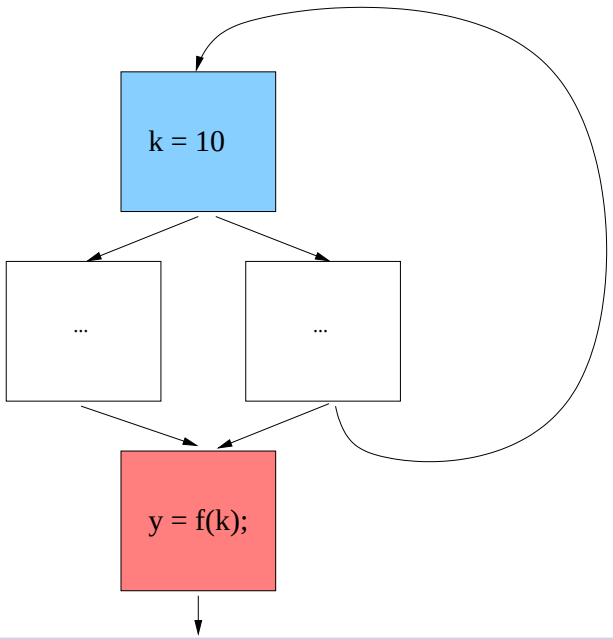

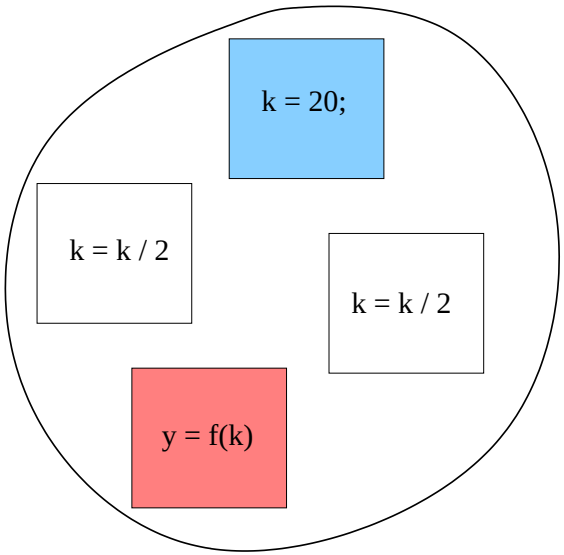

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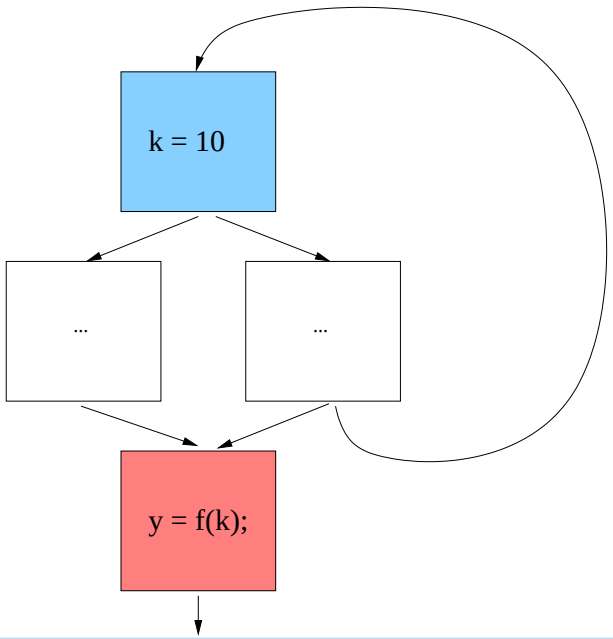
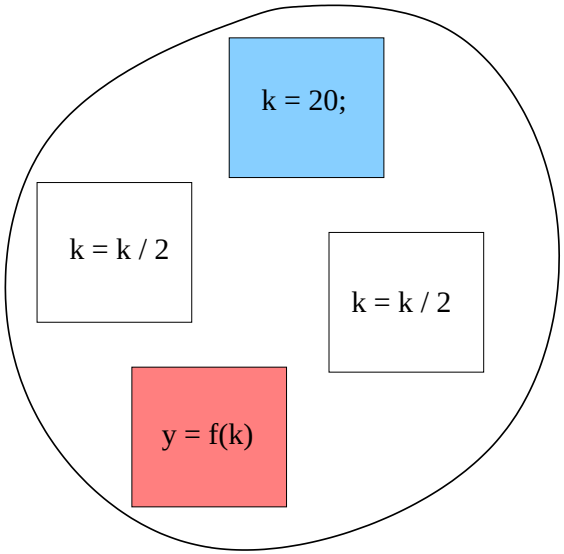
- $\Rightarrow$ Bag-of-blocks is always incorrect.





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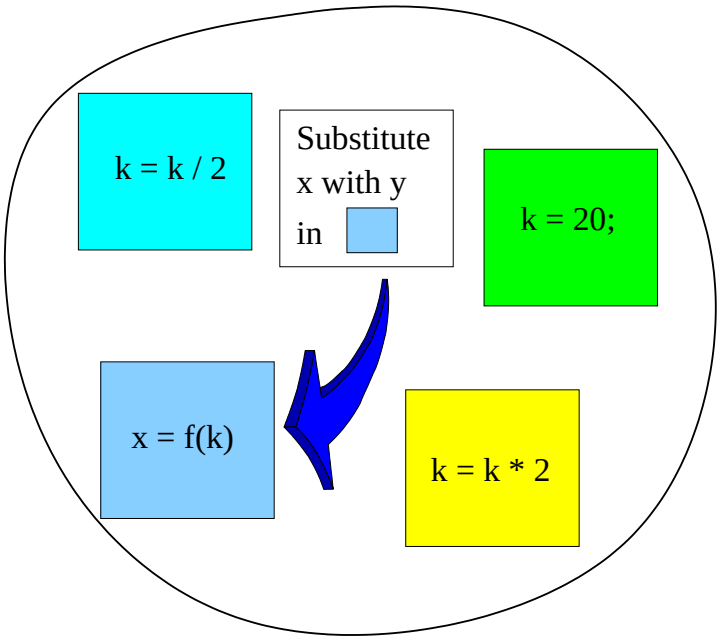

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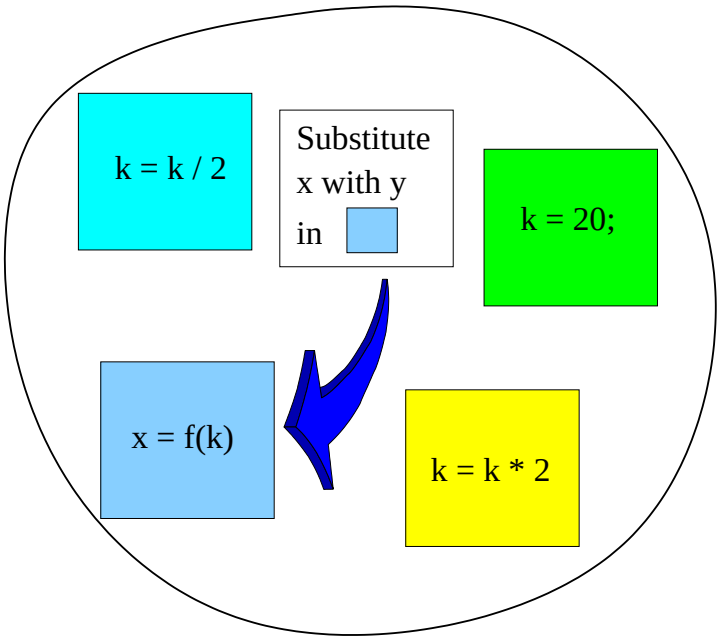

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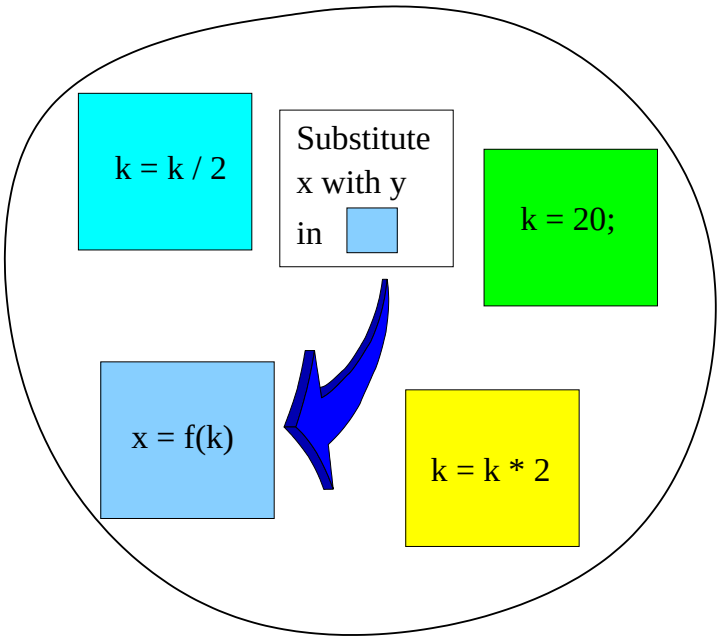

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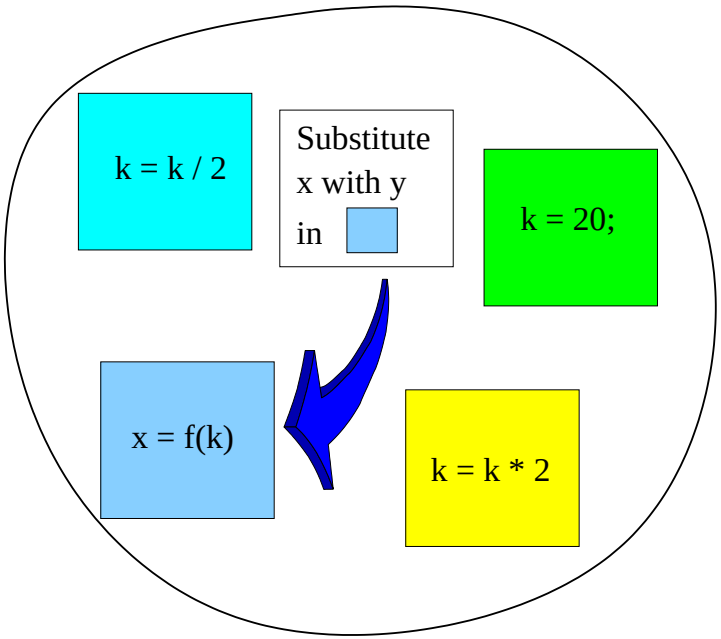

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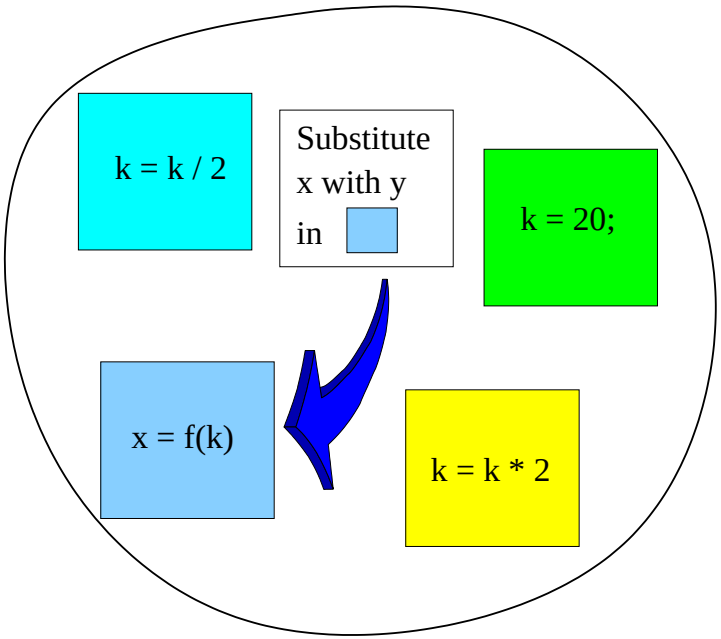
- $\Rightarrow$ keeps mutation-rate high and communication-rate low.



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- $\Rightarrow$ makes it hard for client to ignore *any* blocks.

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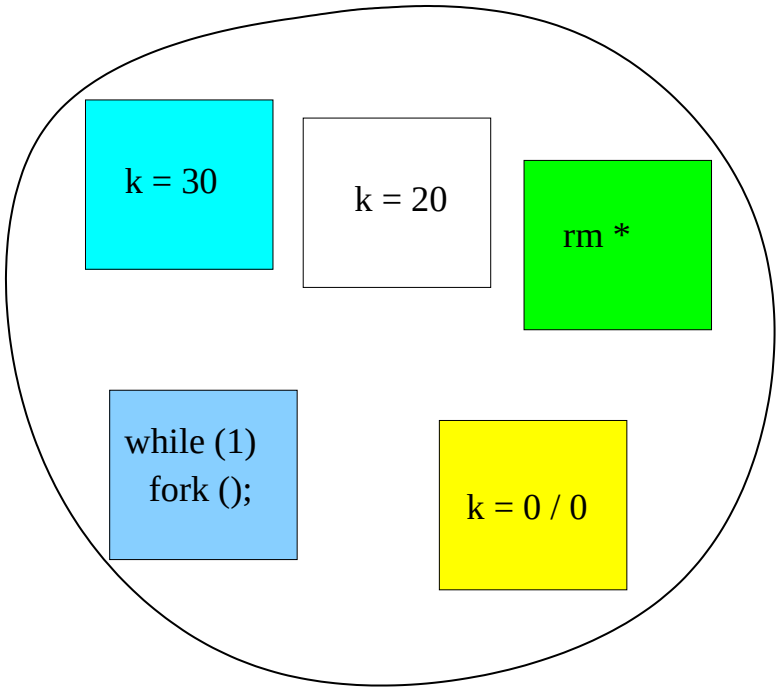
- This type of block will, if executed, cause the program to crash or otherwise malfunction.



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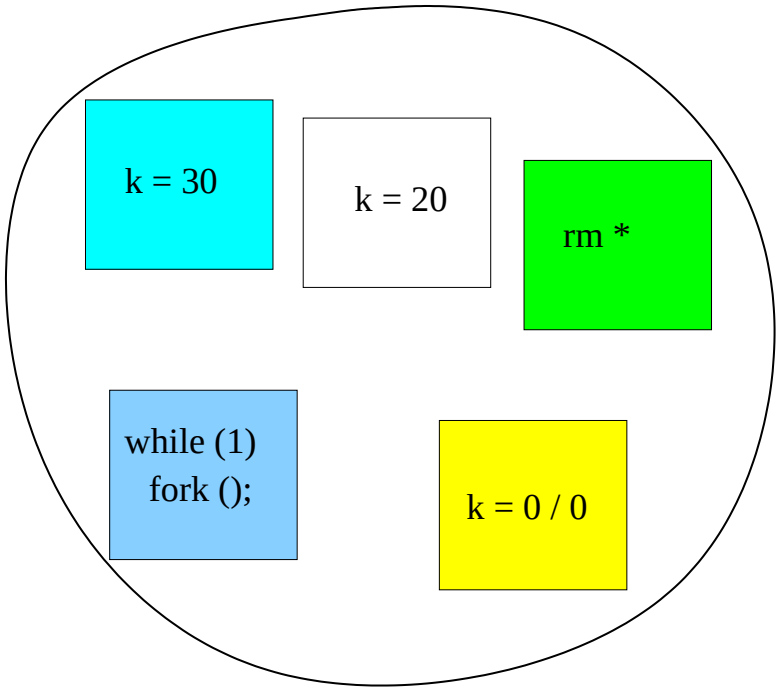
- $\Rightarrow$ makes it harder for the adversary to execute blocks in isolation to experimentally figure out what each one does.



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One Block to rule them all...

- We may be able to get away with just one block kind, provided we allow blocks to access the VM itself.
- The VM consists of the bag of blocks (`$BLOCKS`), the next block to execute (`$NEXT`), the current location (`$PC`), and the interpretation loop.
- We can even get away without an actual interpretation loop by threading the blocks, i.e. as its last instruction, each block jumps to the next block.

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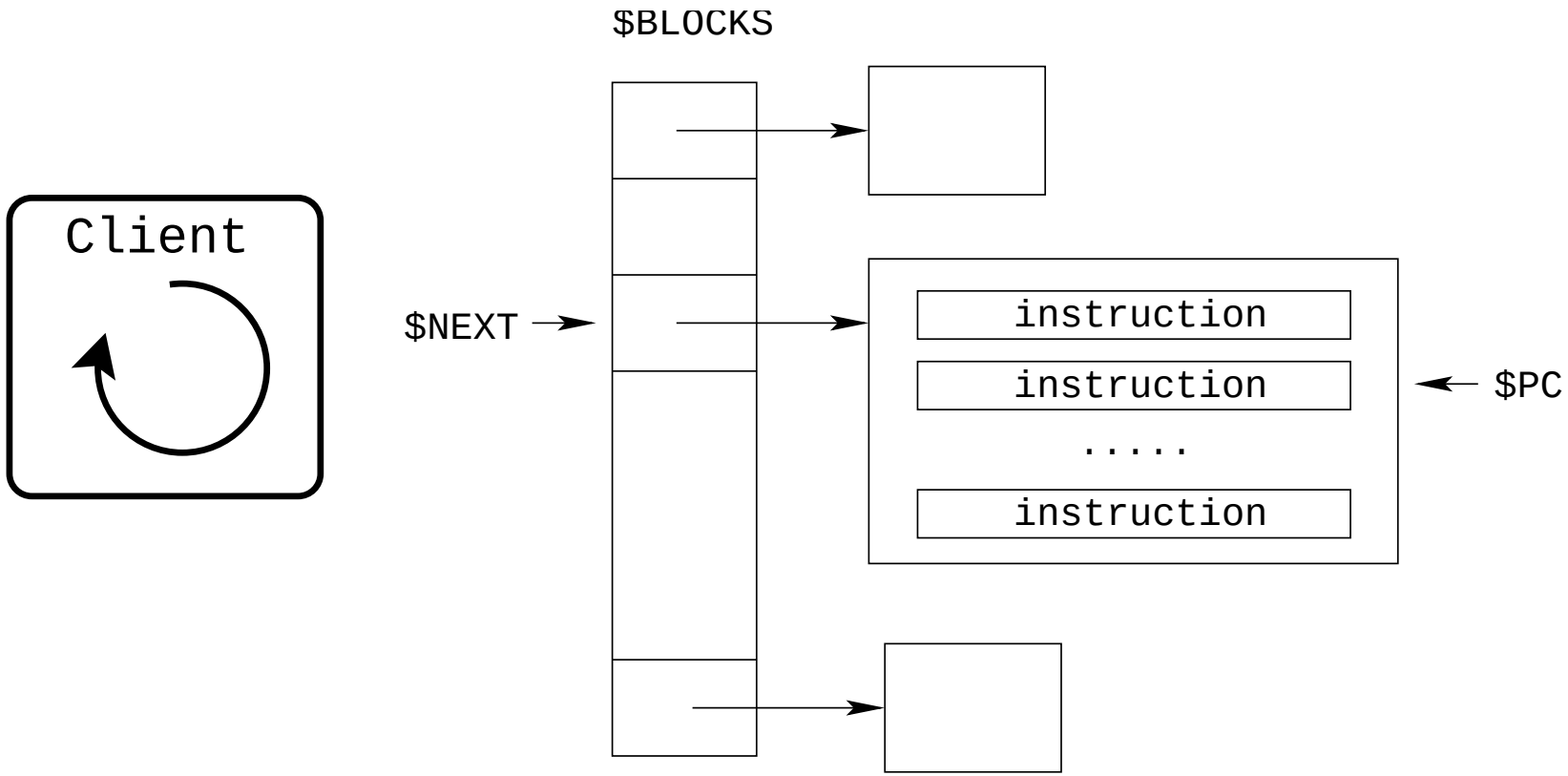

One Block to bring them all...

```
$BLOCKS[84][3] = 'load v' % Modify another block
kill x = x + 1
$BLOCKS[56] = nil         % Invalidate block 56
y = y - 3
$BLOCKS[84][3] = 'load v' % Modify another block
p(5)
$NEXT = 82                % Next block to execute
z = z + 1
$GET(88)                  % Hint: we may need block 88 soon
```

. . . and in the darkness bind them!

- We have two options as to how we should obfuscate the blocks:
- We could try to make the blocks as similar as possible: padded to the same size, obfuscated to have the same structure ("every block contains exactly one loop and one method call"), etc. This increases stealth and makes it hard for the attacker to know which blocks it can ignore and which it has to execute.
- Or, we could try to make the blocks as different as possible to make analysis of the blocks as hard as possible.

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  1. size of the client's bag
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  3. frequency of each kind of block
  4. level of obfuscation of each block
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- Vasanth Bala, Evelyn Duesterwald, Sanjeev Banerjia, *Dynamo: a transparent dynamic optimization system*, PLDI 2000: 1-12