a JIT Smalltalk VM

written in itself

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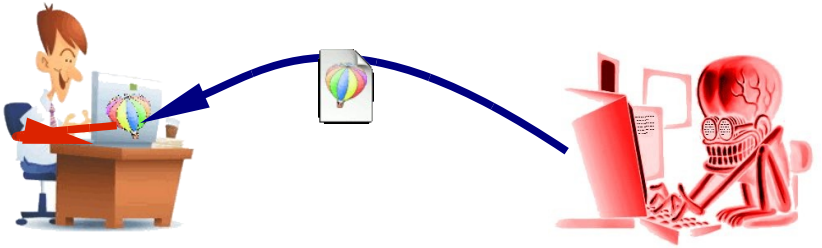
ESUG 2009 – JIT Security



```
test: arg
  ^self with: 0 with: inst with: arg
```

```
1   <13>    PushSmallInteger0
2   <8C>    PushInstance1
3   <55>    PushArgument1
4   <0A>    LoadSelf
5   <E2>    SendSelector1
6   <48>    Return
```

```
@1: 7F647D: push EBP
    7F647E: mov EBP, ESP
    7F6480: push EAX
    7F6481: mov ESI, EAX
    ...
@2: 7F6492: push 1                  ; PushSmallInteger0
    7F6497: push [ESI]              ; PushInstance1
    7F6499: push [EBP+8]            ; PushArgument1
    7F649C: mov EAX, ESI            ; LoadSelf
    7F649E: call 740207             ; SendSelector1
    7F64A3: mov ESP, EBP            ; Return
    7F64A5: pop EBP
    7F64A6: mov ESI, [EBP-4]
    7F64A9: ret 4 NEAR
```

```
BytecodeNativizerPushR
  assembler pushR
```

```
Assembler >> #pushR
  self assembleByte: 16r50  " push eax "
```

Closure Bug (6-Aug-2010)

```
testThomasMuhrNestedBlocks
   | abcdef |
   abcdef := [| var1 |
      var1 := 'AB'.
      [| var2 |
         var2 := 'CD'.
         [| var3 |
            var3 := 'EF'.
            [var1 , var2 , var3] value] value] value] value.
   self assert: abcdef = 'ABCDEF'
```

BOOM!

Fix #1 (7-Aug-2010)

```
IndirectEscapeBytecode >> #assemble
   type := self nextByte.
   argument := type \\ 4 = 0
      ifTrue: [self nextIndex]
      ifFalse: [type \\ 4 + 3].

   type < 5 ifTrue: [^self loadEnvironmentTemporaryIndirect].
   type < 9 ifTrue: [^self pushEnvironmentTemporaryIndirect].
   ^self storeEnvironmentTemporaryIndirect
```

nextIndex + 1

Closure Bug (6-Aug-2010)

```
testThomasMuhrNestedBlocks
  | abcdef |
  abcdef := [| var1 |
    var1 := 'AB'.
    [| var2 |
      var2 := 'CD'.
      [| var3 |
        var3 := 'EF'.
        [var1 , var2 , var3] value] value] value] value.
  self assert: abcdef = 'ABCDEF'
```

BOOM!

Fix #3 (9-Aug-2010)

```
loc_1000ACFA:
push    esi
call    JIT_getNextIndex
mov     edi, [esp+10h+aBytecodeNativizer]
add     esp, 4
dec     eax
mov     [edi+4], eax
jmp     short loc_1000AD29
```

nop

Closure Bug (6-Aug-2010)

```
testThomasMuhrNestedBlocks
  | abcdef |
  abcdef := [| var1 |
    var1 := 'AB'.
    [| var2 |
      var2 := 'CD'.
      [| var3 |
        var3 := 'EF'.
        [var1 , var2 , var3] value] value] value] value.
  self assert: abcdef = 'ABCDEF'
```

BOOM!

Fix #2 (9-Aug-2010)

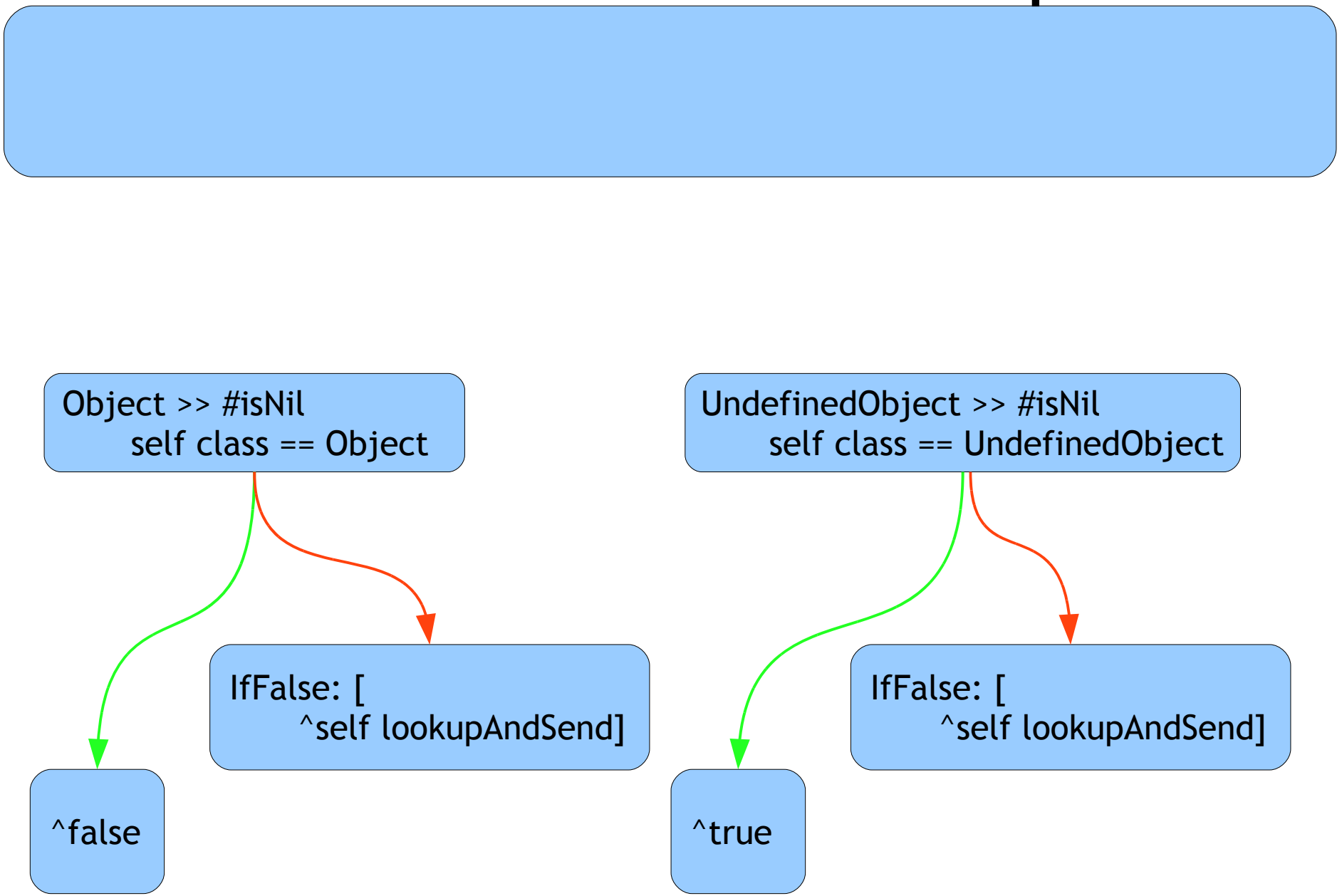
```
putCode: code
min: min
max: max
range: idx
  (idx >= min and: [idx <= max])
    ifTrue: [self putNext: code - max + idx - 1]
    ifFalse: [
      self putNext: code.
      self putIndex: idx]
```

idx + 1

Smalltalks 2009 – code freezer

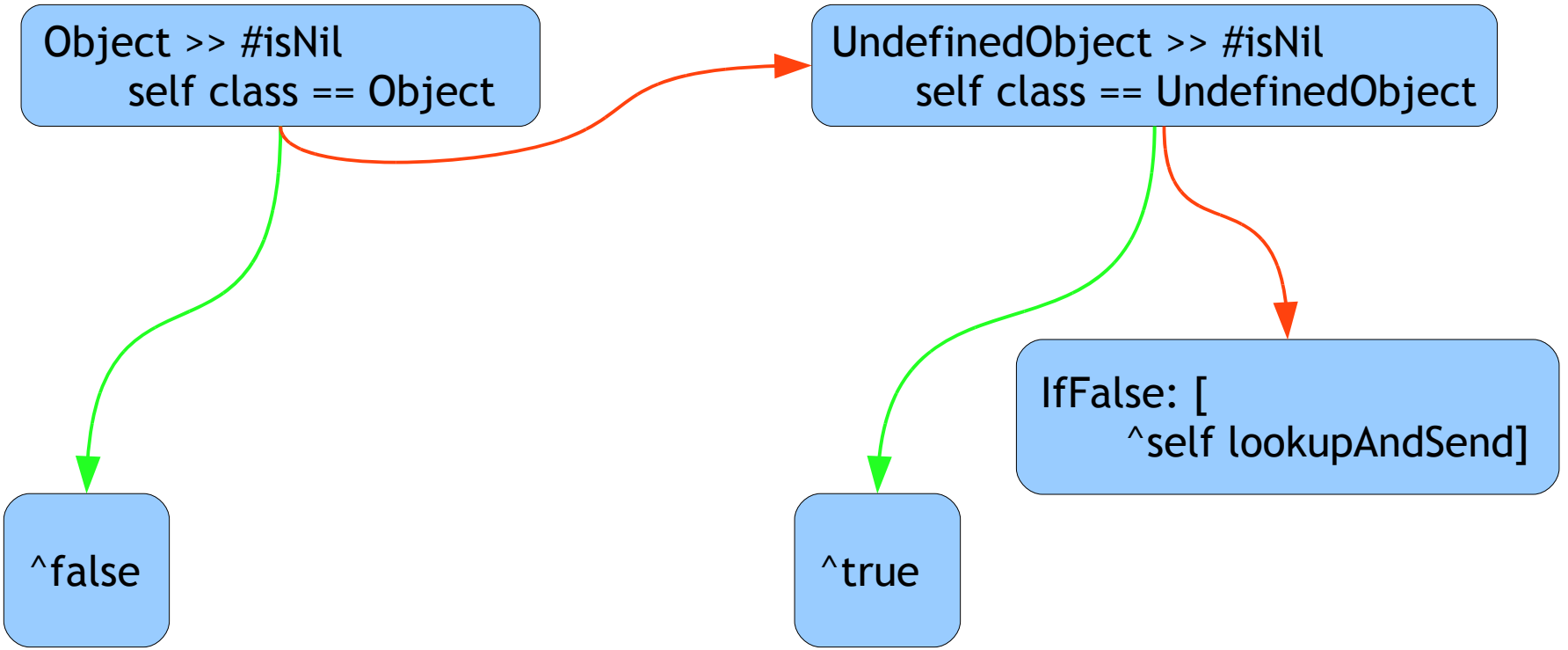
```
GenerationalGCBuilder >> #populateInternals
(nativizer := BigNativizer new)
    addAllMethodsFor: GCSpace;
    addAllMethodsFor: ObjectGenerationalGC;
    at: #isSmallInteger default: Object >> #isSmallInteger;
    at: #isSmallInteger add: SmallInteger;
    at: #bitXor: add: SmallInteger;
    at: #between:and: add: SmallInteger;
    at: #_generation default: ExtensionBytecode class >> #_generation;
    at: #_commit: _primitive: ExtensionBytecode >> #_commit;
    ...
```

Frozen Code: “Lookup”



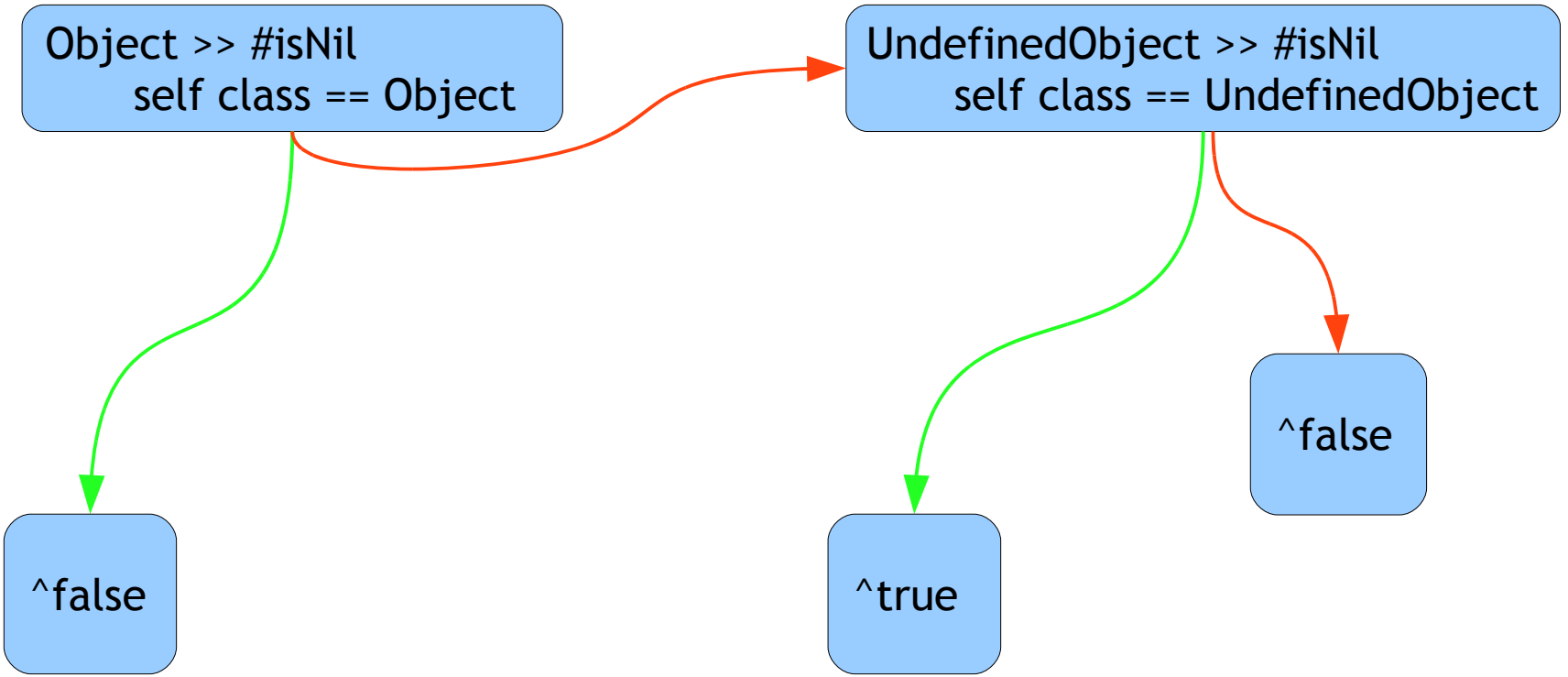
Frozen Code: “Lookup”

```
nativizer
    at: #isNil addAll: (Array with: Object with: UndefinedObject)
```



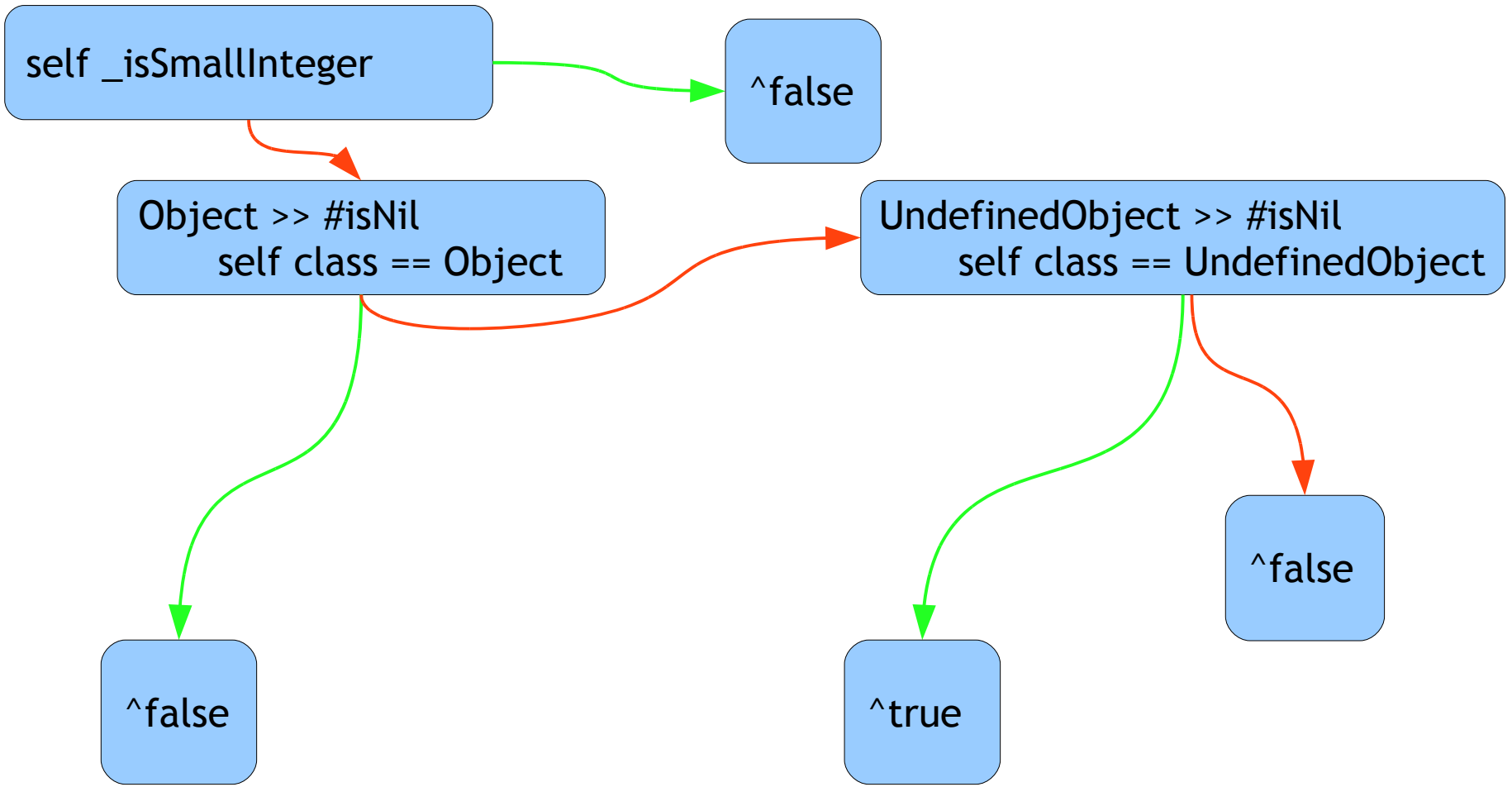
Frozen Code: “Lookup”

```
nativizer
    at: #isNil addAll: (Array with: Object with: UndefinedObject);
    at: #isNil default: Object >> #isNil
```



Frozen Code: “Lookup”

```
nativizer
    at: #isNil addAll: (Array with: Object with: UndefinedObject);
    at: #isNil default: Object >> #isNil;
    at: #isNil add: SmallInteger
```



New Goal

Smalltalk VM

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Written in Smalltalk

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Compatible with Digitalk's (VS)

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Smalltalk VM

Written in Smalltalk

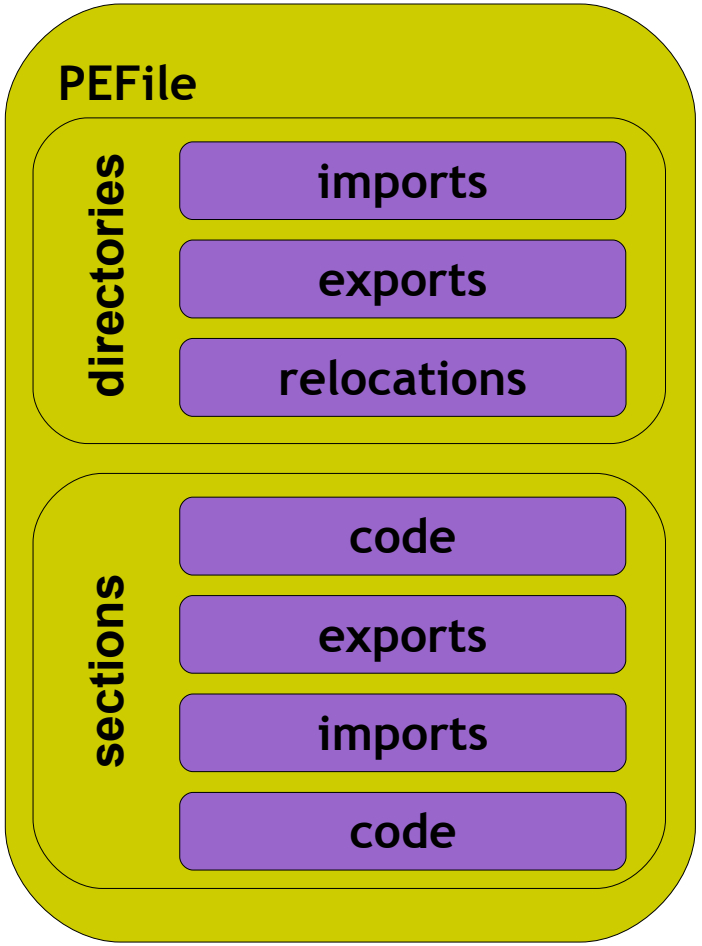
Compatible with Digitalk's (VS)

Leveraging the environment

Smalltalk VM

- Written in Smalltalk
  - .exe generation
- Method lookup
- Object format
- Memory management
  - Object creation / copy
  - GC
  - Become
- Primitives
- FFI
- Processes
- Callbacks
- etc

PE (.exe) generation

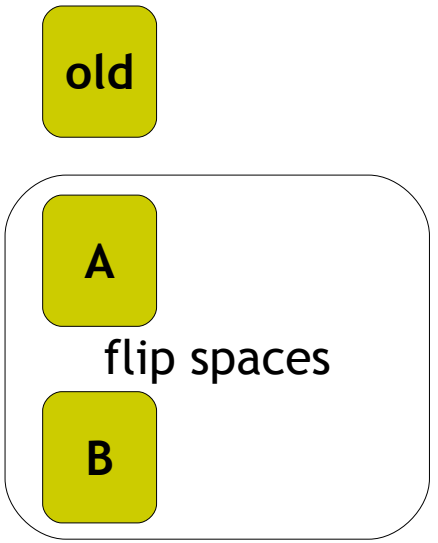



```
_commit: newSize
  assembler
    loadArgFromContext: index;
    convertArgToNative;
    pushArg;
    convertToNative;
    pushR;
    pushConstant: 4;
    pushConstant: 4096;
    pushArg;
    pushR;
    callTo: 'VirtualAlloc' from: 'KERNEL32.DLL';
    convertToSmalltalk
```

```
nativizer
  addAllMethodsFor:
     (Array with: GenerationalGC with: GenerationalGC class with: GCSpace);
  at: #_commit: _primitive: ExtensionBytecode >> #_commit
```

GCSpace

```
Object subclass: #GCSpace
  InstanceVariableNames: '
      contents
      base
      nextFree
      commitLimit
      reservedLimit '
  classVariableNames: ''
  poolDictionaries: ''
```

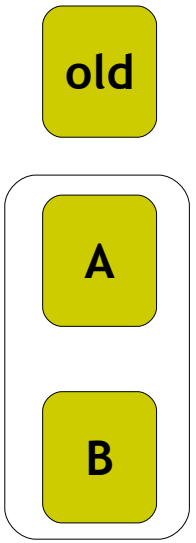



```
includes: anObject
   ^anObject isSmallInteger not
        and: [anObject _oop between: self base and: self commitedLimit]
```

```
reset
   self nextFree: self base
```

GCSpace

```
Object subclass: #GCSpace
  InstanceVariableNames: '
      contents
      base
      nextFree
      commitLimit
      reservedLimit '
  classVariableNames: ''
  poolDictionaries: ''
```



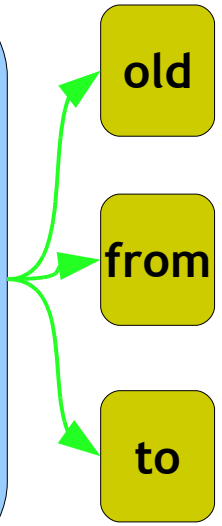
- old includes: anObject
- to reset
- from isReferredBy: object
- old growTo: newLimit
- moved := to shallowCopy: object
- from flipWith: to

```
includes: anObject
   ^anObject isSmallInteger not
        and: [anObject _oop between: self base and: self commitedLimit]
```

```
reset
   self nextFree: self base
```

GenerationalGC

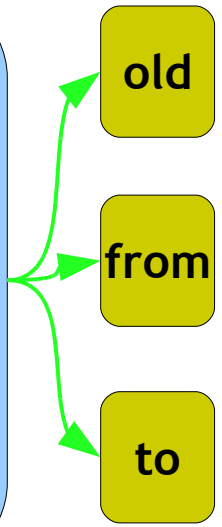
```
Object subclass: #GenerationalGC
  InstanceVariableNames: '
      old from to
      roots literalsReferences
      weakContainers ephemerons
      rescuedEphemerons '
  classVariableNames: ''
  poolDictionaries: ''
```




```
collect
   self
      followRoots;
      walkStack;
      rescueEphemerons;
      traverseWeakContainers;
      flipSpaces
```

GenerationalGC

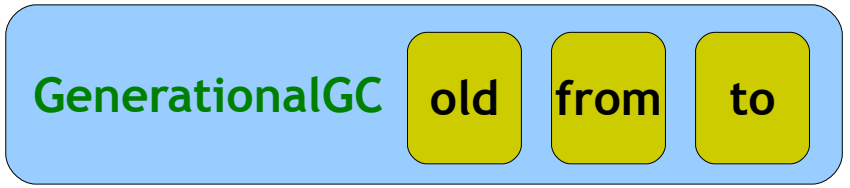
```
Object subclass: #GenerationalGC
  InstanceVariableNames: '
      old from to
      roots literalsReferences
      weakContainers ephemerons
      rescuedEphemerons '
  classVariableNames: ''
  poolDictionaries: ''
```



- flipper purgeRoots
- flipper follow: object
- flipper moveToOldOrTo: object
- flipper
  fixReferencesOrSetTombstone:
  weakContainer
- flipper addInterrupt

```
collect
  self
    followRoots;
    walkStack;
    rescueEphemerons;
    traverseWeakContainers;
    flipSpaces
```

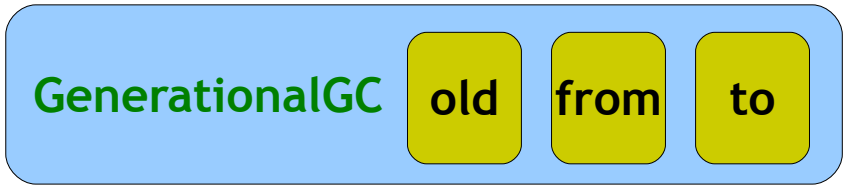
GenerationalGC




```
collect
  self
    followRoots;
    walkStack;
```

```
follow: object
  | size |
  size := 0.
  object _isBytes ifFalse: [
    object _hasWeaks
      ifTrue: [self addWeakOrEphemeron: object]
      ifFalse: [size := object _size]].
  self follow: object count: 1 + size startingAt: 0
```

GenerationalGC

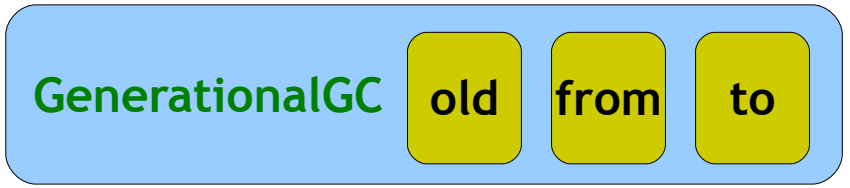



```
collect
  self
    followRoots;
    walkStack;
```

```
follow: objects count: size startingAt: base
  | index |
  index := base - 1.
  size timesRepeat: [| object |
    index := index + 1.
    object := objects _basicAt: index.
    (fromSpace includes: object) ifTrue: [


        moved := self moveToOldOrTo: object.
        objects _basicAt: index put: moved.
        self follow: moved]]
```

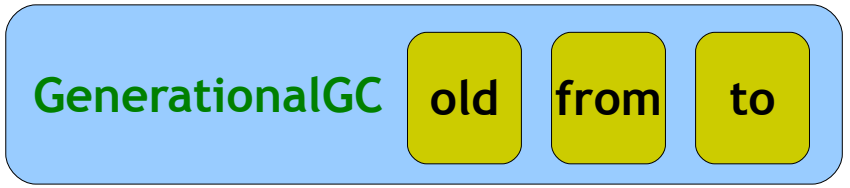
GenerationalGC




```
collect
  self
    followRoots;
    walkStack;
```

```
follow: objects count: size startingAt: base
  | index |
  index := base - 1.
  size timesRepeat: [| object |
    index := index + 1.
    object := objects _basicAt: index.
    (fromSpace includes: object) ifTrue: [
      object _isProxy
        ifTrue: [objects _basicAt: index put: object _proxee]
        ifFalse: [| moved |
          moved := self moveToOldOrTo: object.
          objects _basicAt: index put: moved.
          self follow: moved]]]
```

GenerationalGC

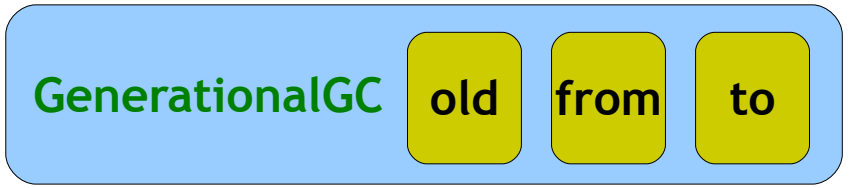



```
collect
  self
    traverseWeakContainers
```

```
traverseWeakContainers
weakContainers
      do: [:weakContainer |
            self fixReferencesOrSetTombstone: weakContainer]
self reset: weakContainers
```

```
fixReferencesOrSetTombstone: weakContainer
   | size |
   size := weakContainer _size.
   1 to: size do: [:index | | instance |
     instance := weakContainer _basicAt: index.
     (instance isSmallInteger not and: [fromSpace includes: instance])
       ifTrue: [| referenceOrThombstone |
         referenceOrThombstone := instance _isProxy
           ifTrue: [instance _proxee]
           ifFalse: [residueObject].
         weakContainer _basicAt: index put: referenceOrThombstone]]
```

GenerationalGC

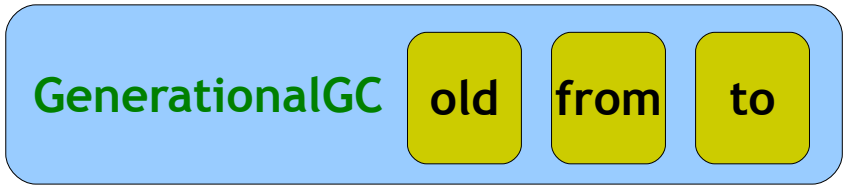



```
collect
  self
    rescueEphemerons
```

```
rescueEphemerons
  | unknowns rescan |
  unknowns := self localStack.
  rescan := false.
  [ephemerons isEmpty] whileFalse: [
    rescan := self followEphemeronsCollectingIn: unknowns.
    rescan
      ifTrue: [ephemerons addAll: unknowns]
      IfFalse: [
        unknowns do: [:ephemeron | self rescueEphemeron: ephemeron]].
    self reset: unknowns]
```

[Hayes1997] Barry Hayes, *Ephemerons: a new finalization mechanism*

GenerationalGC



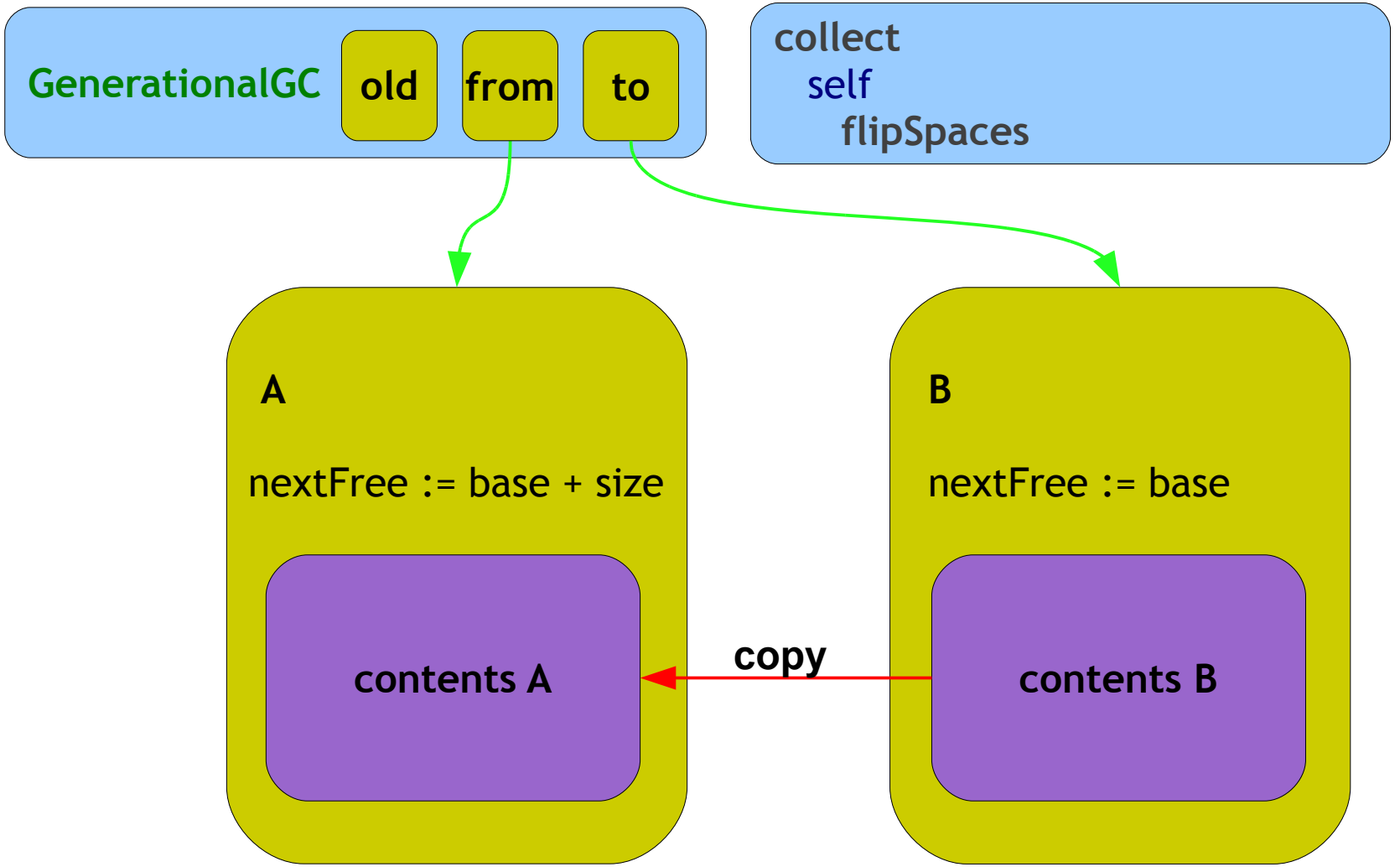

```
collect
  self
    flipSpaces
```

```
flipSpaces
  fromSpace flipWith: toSpace.
  toSpace reset.
```

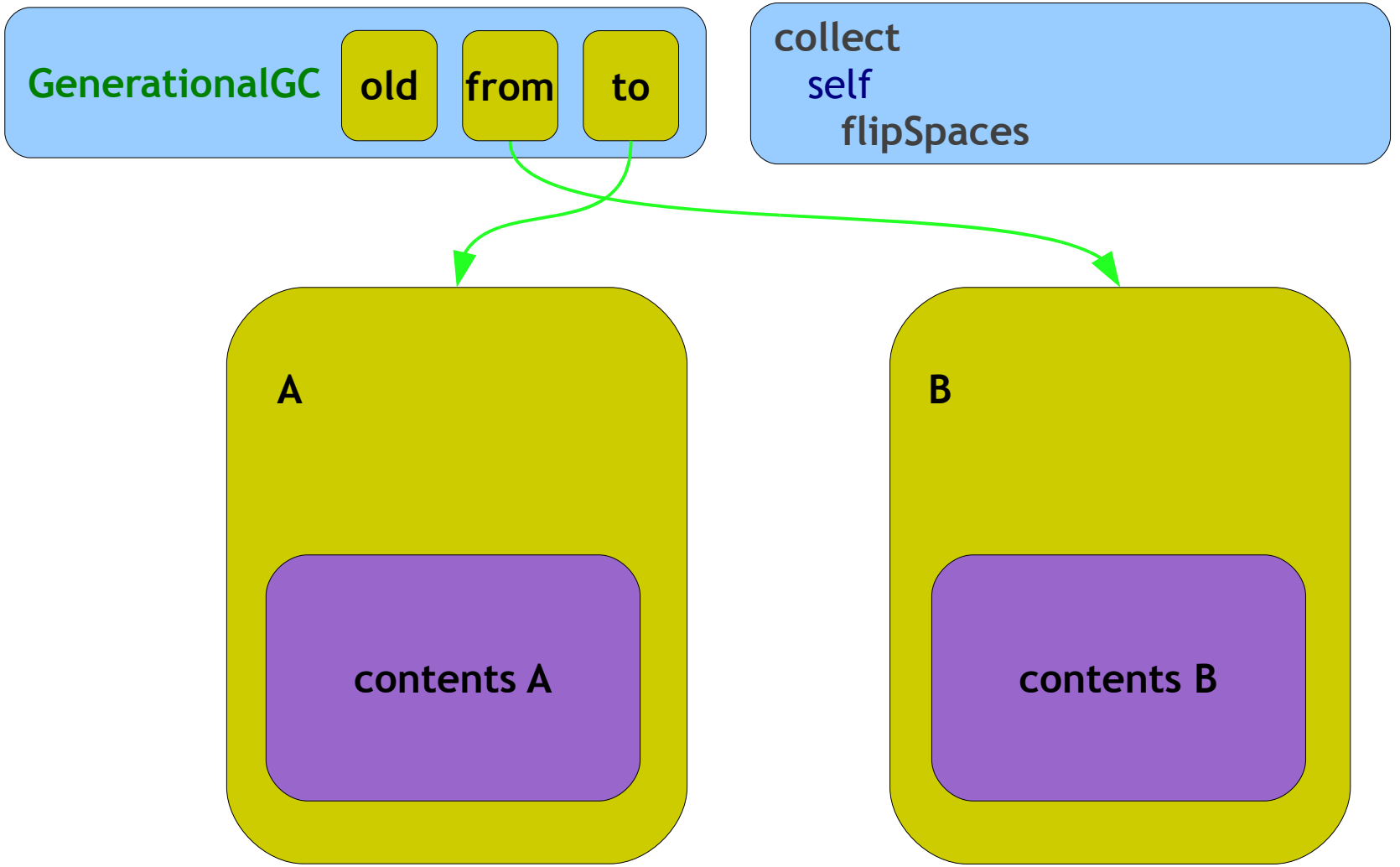
```
GCSpace >> flipWith: space
  | aux |

  aux := space base.
  space base: self base.
  self base: aux.
  ...
```

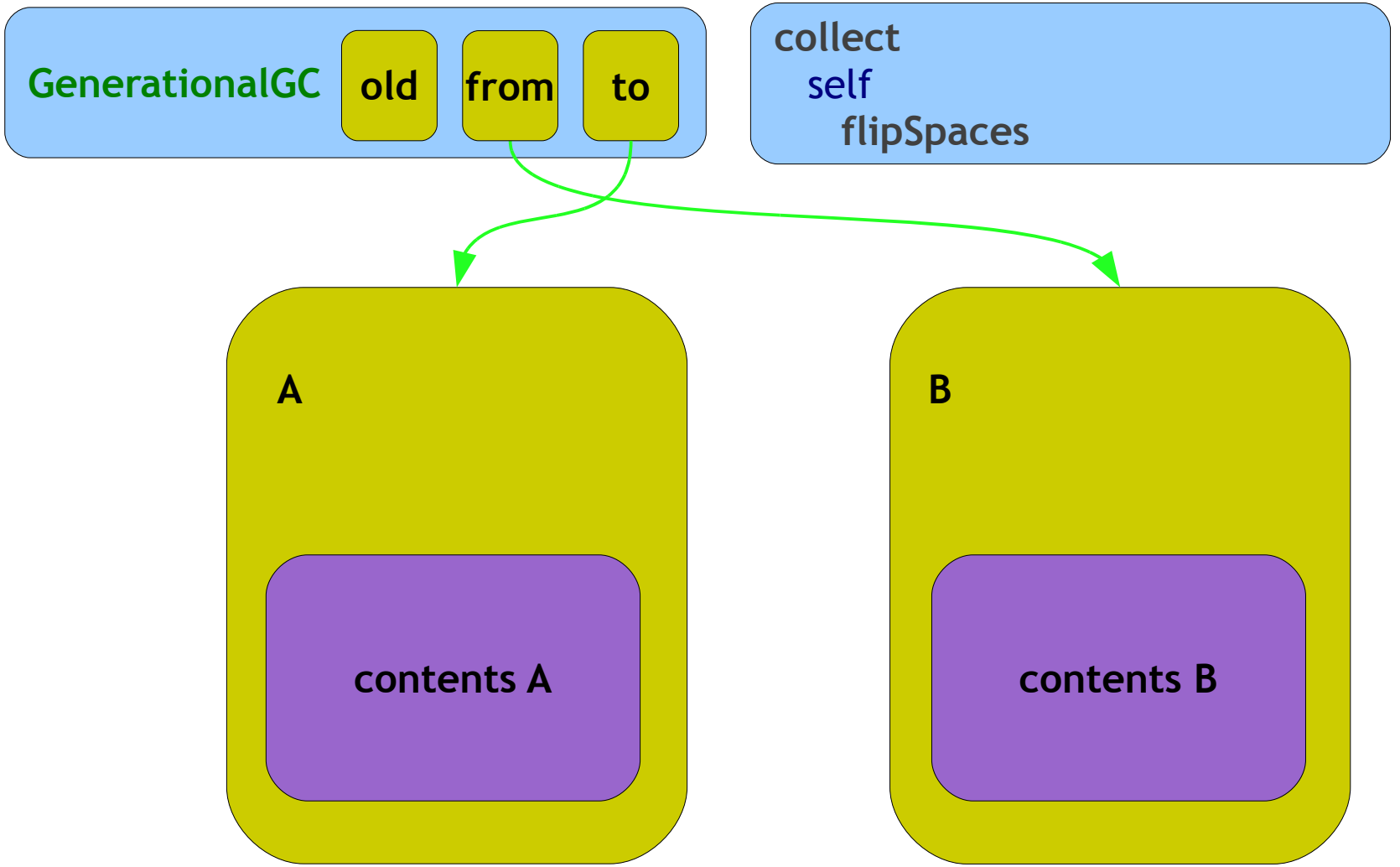
GenerationalGC



GenerationalGC

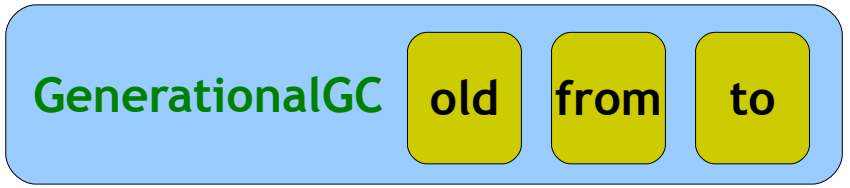


GenerationalGC



VM assumption: from.commitLimit < to.base

GenerationalGC: testing




```
collect
  self
    followRoots
```

```
testFollowObject
  | flipper from array string byteArray root flipSize currentSize |
  flipper := self defaultFlipper.
  from := flipper fromSpace.
  array := from shallowCopy: (Array new: 3).
  string := from shallowCopy: 'a String' copy.
  from shallowCopy: 'leaked' copy.
  byteArray := from shallowCopy: #[1 2 3] copy.
  array
    at: 1 put: 1;
    at: 2 put: string;
    at: 3 put: byteArray.
  root := Array with: array.
  string := byteArray := array := nil.
  flipper addRoot: root; followRoots.
  flipSize := flipper toSpace nextFree - flipper toSpace base.
  currentSize := flipper fromSpace nextFree - flipper fromSpace base.
  self
    assert: flipSize < currentSize;
    assert: currentSize - flipSize = (8 + ('leaked' size roundTo: 4))
```

GenerationalGC: testing

```
testFollowObject
   | flipper from array string byteArray root flipSize currentSize |
   flipper := self defaultFlipper.
   from := flipper fromSpace.
   array := from shallowCopy: (Array new: 3).
   string := from shallowCopy: 'a String' copy.
   from shallowCopy: 'leaked' copy.
   byteArray := from shallowCopy: #[1 2 3] copy.
```

```
testFollowObject
   | flipper from array string byteArray root flipSize currentSize |
   flipper := self defaultFlipper.
   self
      execute: [:from |
         array := from shallowCopy: (Array new: 3).
         string := from shallowCopy: 'a String' copy.
         from shallowCopy: 'leaked' copy.
         byteArray := from shallowCopy: #[1 2 3] copy]
      proxying: flipper fromSpace.
```

a demo

VMBuilder installGenerational

What now?

- Release OpenSource
  - Education!!!
- Closure for JIT
- Memory Management
  - Mark & Sweep
  - new
  - become:
- Method Lookup (strategies)
- etc.

¡gracias!