CPSC 213 Lab 2

CPU and Static Variables

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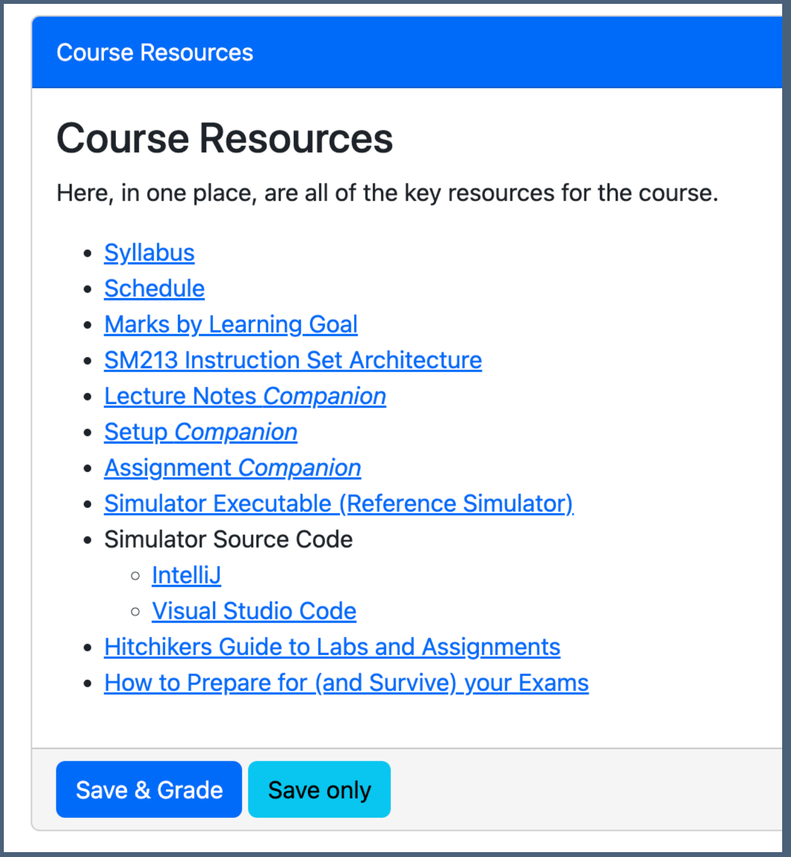
Upcoming Deadlines

- Assignment 2 due this Friday, January 23rd
- Quiz 1 runs next week January 26-30th in CBTF
  - Reservations already open on https://us.prairietest.com/

Helpful Resources



Operation	Machine Language	Semantics / RTL	Assembly
load immediate	`0d--vvvvvvvv`	$r[d] \leftarrow v$	`ld $v,rd`
load base+offset	`1psd`	$r[d] \leftarrow m[(o = p \times 4) + r[s]]$	`ld o(rs),rd`
load indexed	`2sid`	$r[d] \leftarrow m[r[s] + r[i] \times 4]$	`ld (rs,ri,4),rd`
store base+offset	`3spd`	$m[(o = p \times 4) + r[d]] \leftarrow r[s]$	`st rs,o(rd)`
store indexed	`4sdi`	$m[r[d] + r[i] \times 4] \leftarrow r[s]$	`st rs,(rd,ri,4)`
halt	`F0--`	(stop execution)	`halt`
nop	`FF--`	(do nothing)	`nop`
rr move	`60sd`	$r[d] \leftarrow r[s]$	`mov rs, rd`
add	`61sd`	$r[d] \leftarrow r[d] + r[s]$	`add rs, rd`
and	`62sd`	$r[d] \leftarrow r[d]$ & $r[s]$	`and rs, rd`
inc	`63-d`	$r[d] \leftarrow r[d] + 1$	`inc rd`
inc addr	`64-d`	$r[d] \leftarrow r[d] + 4$	`inca rd`
dec	`65-d`	$r[d] \leftarrow r[d] - 1$	`dec rd`
dec addr	`66-d`	$r[d] \leftarrow r[d] - 4$	`deca rd`
not	`67-d`	$r[d] \leftarrow \sim r[d]$	`not rd`
shift	`7dss` $(ss > 0)$	$r[d] \leftarrow r[d] << (v = ss)$	`shl $v, rd`
	`7dss` $(ss < 0)$	$r[d] \leftarrow r[d] >> (v = -ss)$	`shr $v, rd`
branch	`8-pp`	$pc \leftarrow (a = pc + p \times 2)$	`br a`
branch if equal	`9rpp`	if $r[r] == 0$: $pc \leftarrow (a = pc + p \times 2)$	`beq rr, a`
branch if greater	`Arpp`	if $r[r] > 0$: $pc \leftarrow (a = pc + p \times 2)$	`bgt rr, a`
jump	`B---aaaaaaaa`	pc $\leftarrow a$	`j a`
get program counter	`6Fpd`	$r[d] \leftarrow$ pc $+ (o = 2 \times p)$	`gpc $o, rd`
jump indirect	`Cdpp`	$pc \leftarrow r[d] + (o = 2 \times p)$	`j o(rd)`
jump double ind, b+off	`Ddpp`	$pc \leftarrow m[(o = 4 \times p) + r[d]]$	`j *o(rd)`
jump double ind, index	`Edi-`	$pc \leftarrow m[4 \times r[i] + r[d]]$	`j *(rd,ri,4)`
system call	`F1nn`	* See section on next page	`sys $n`

Static vs Dynamic

Q1

- Address of a global variable in C
  - Static
- Address of an instance variable in Java
  - Dynamic

Static vs Dynamic

Q1

- Value of a global variable in C
  - Dynamic
- Address of a function in C
  - Static

RTL to SM213 Assembly

.long = 4 bytes

```
.pos 0x1000
a:  .long 0

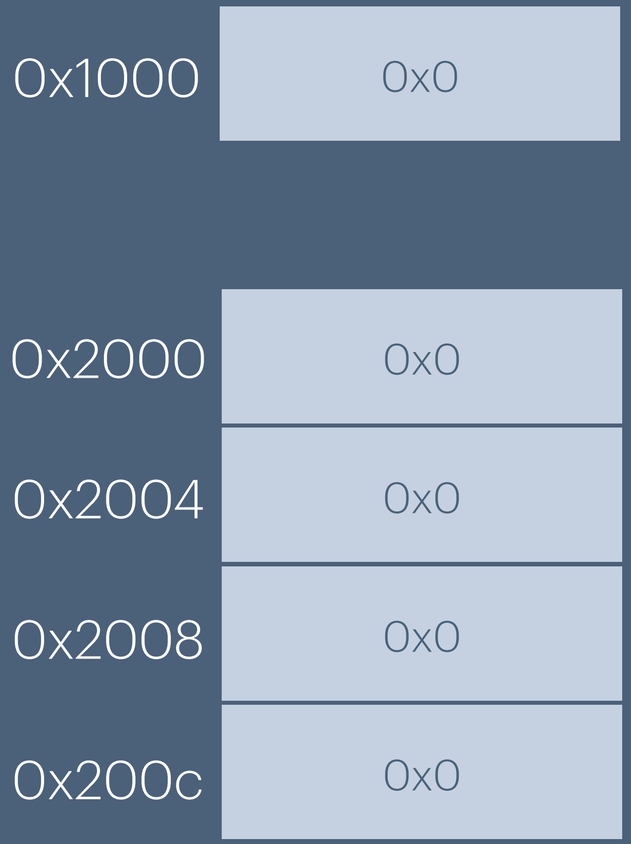
.pos 0x2000
b:  .long 0
    .long 0
    .long 0
    .long 0 # enough times
```

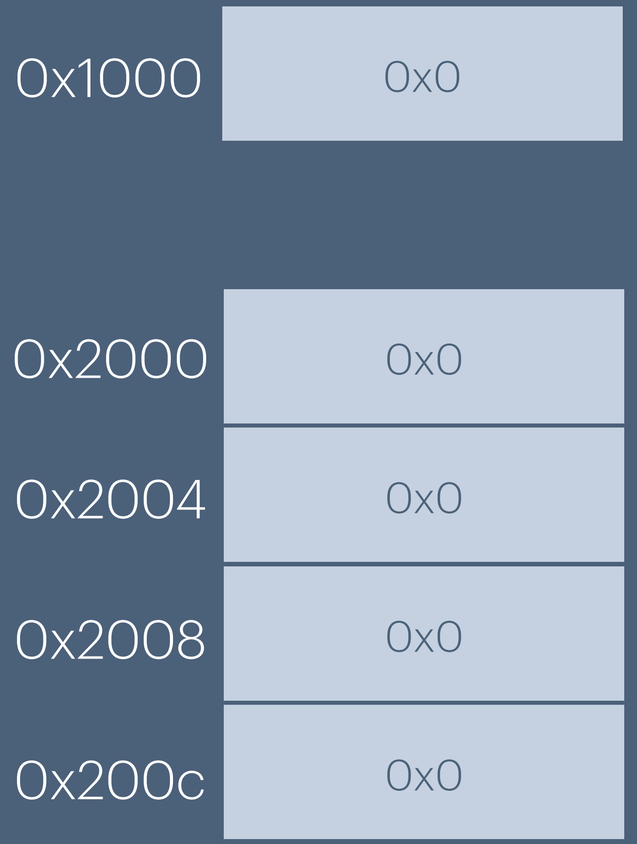
0x1000	0x0

0x2000	0x0
0x2004	0x0
0x2004	0x0
0x2004	0x0

RTL 1

Memory Behaviour

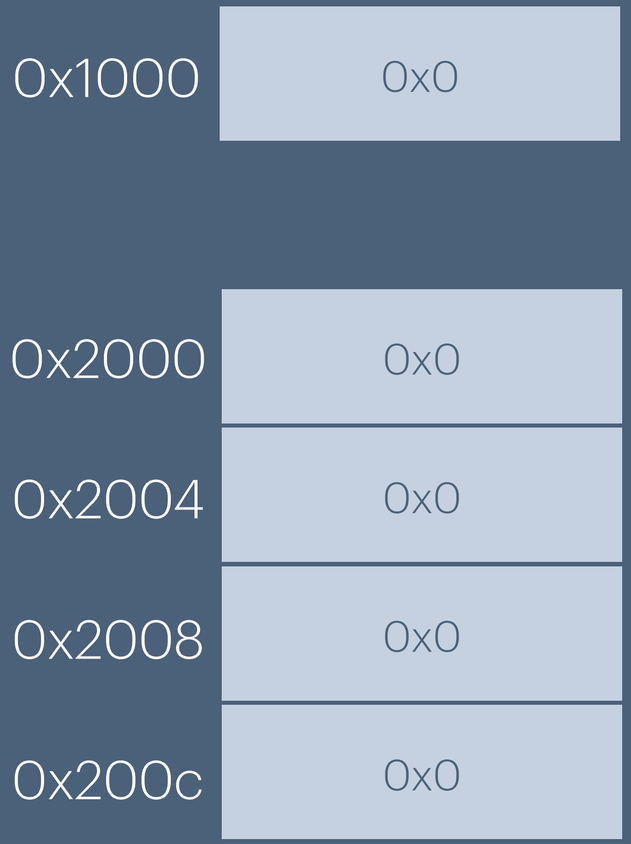


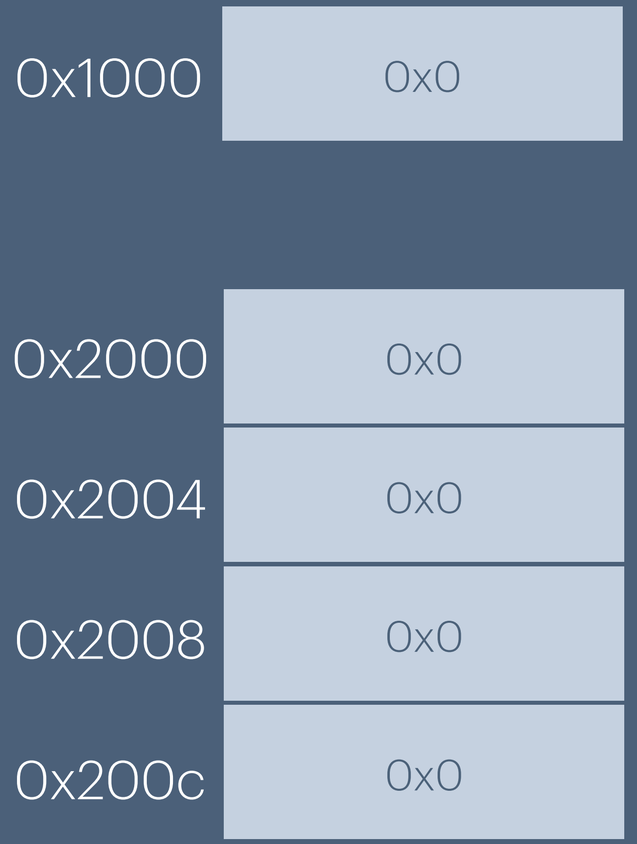


RTL 1

Memory Behaviour

```
r0 <= 0xcafe
```





RTL 1

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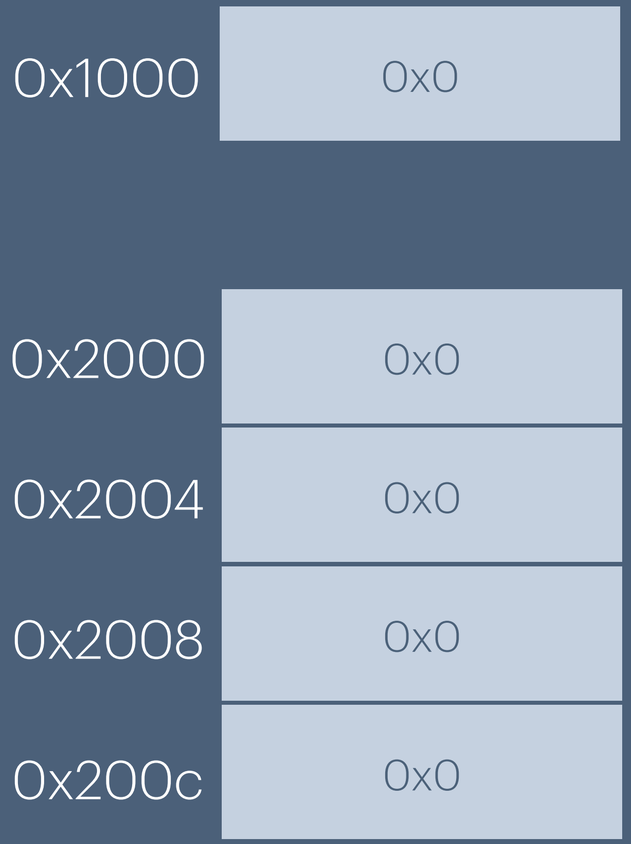
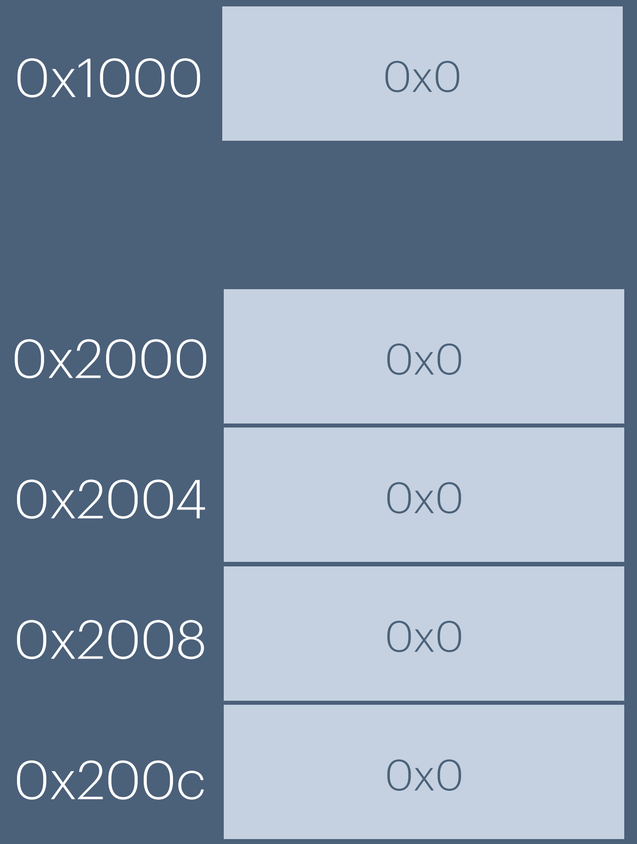


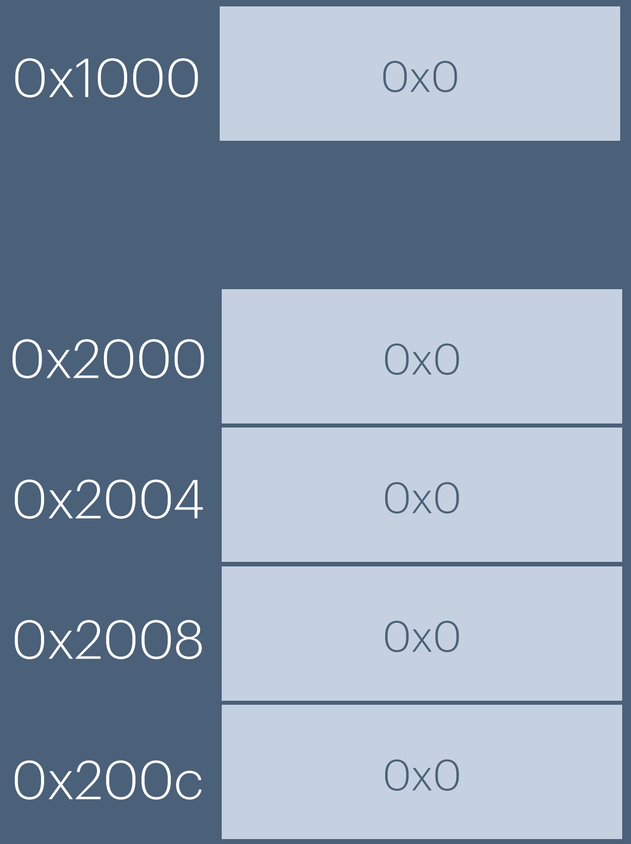


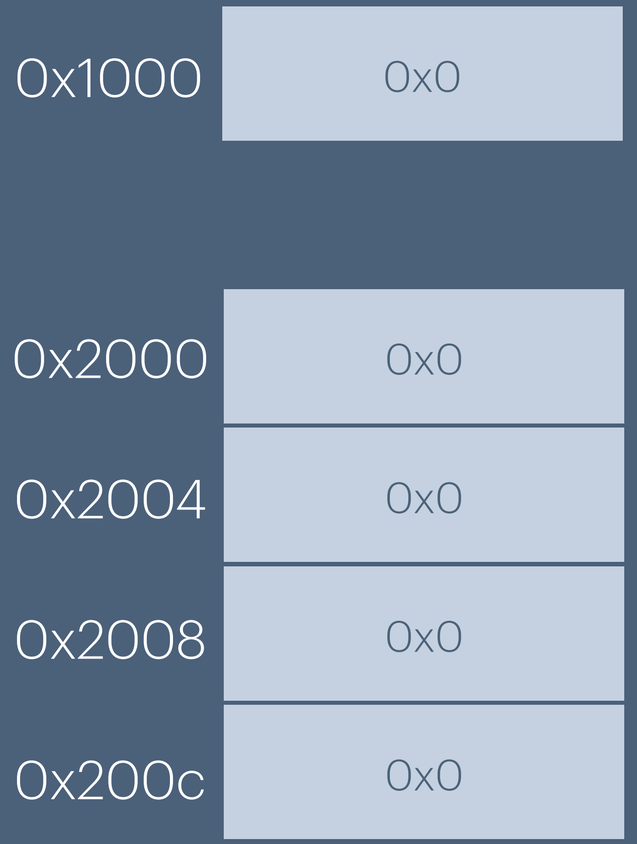
RTL 1

Memory Behaviour

```
r0 <= 0xcafe

r1 <= 0x2000
```





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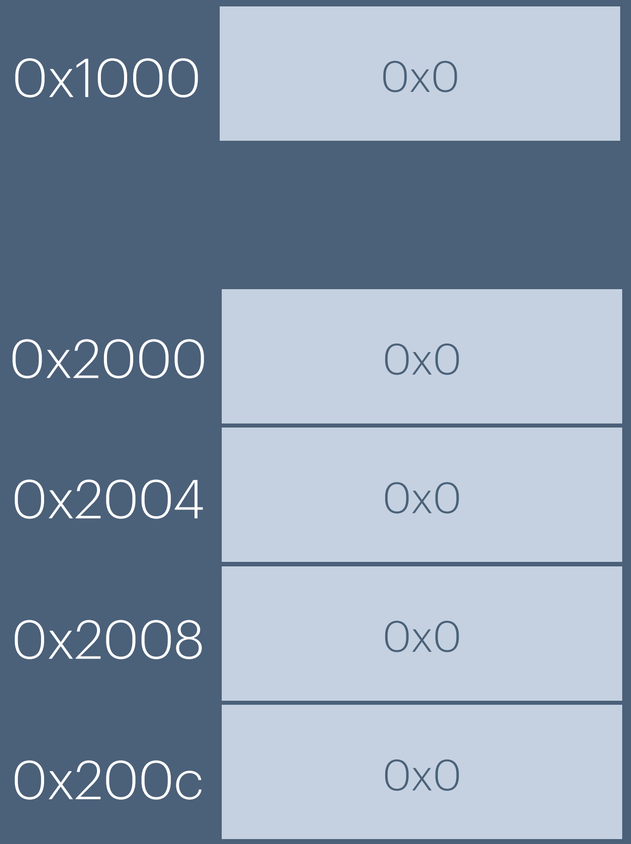
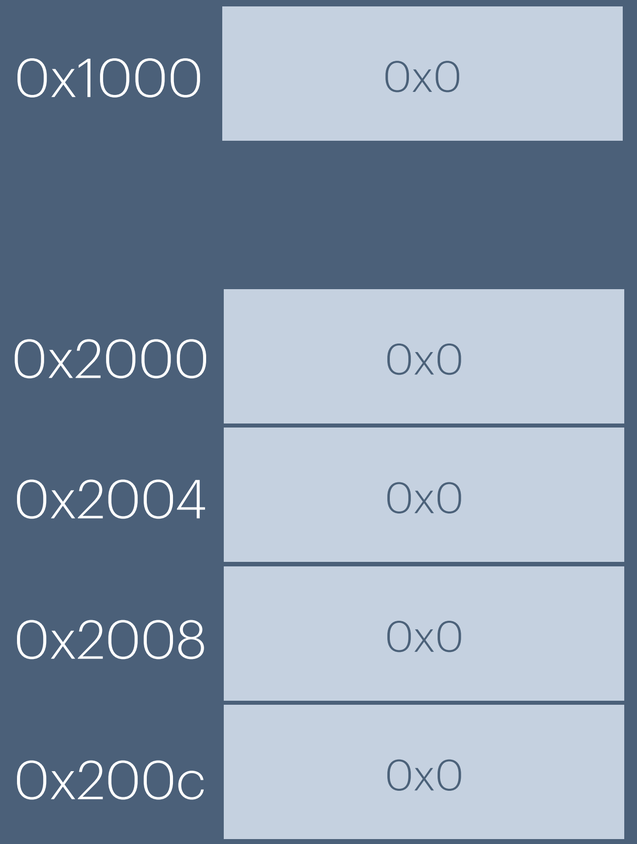




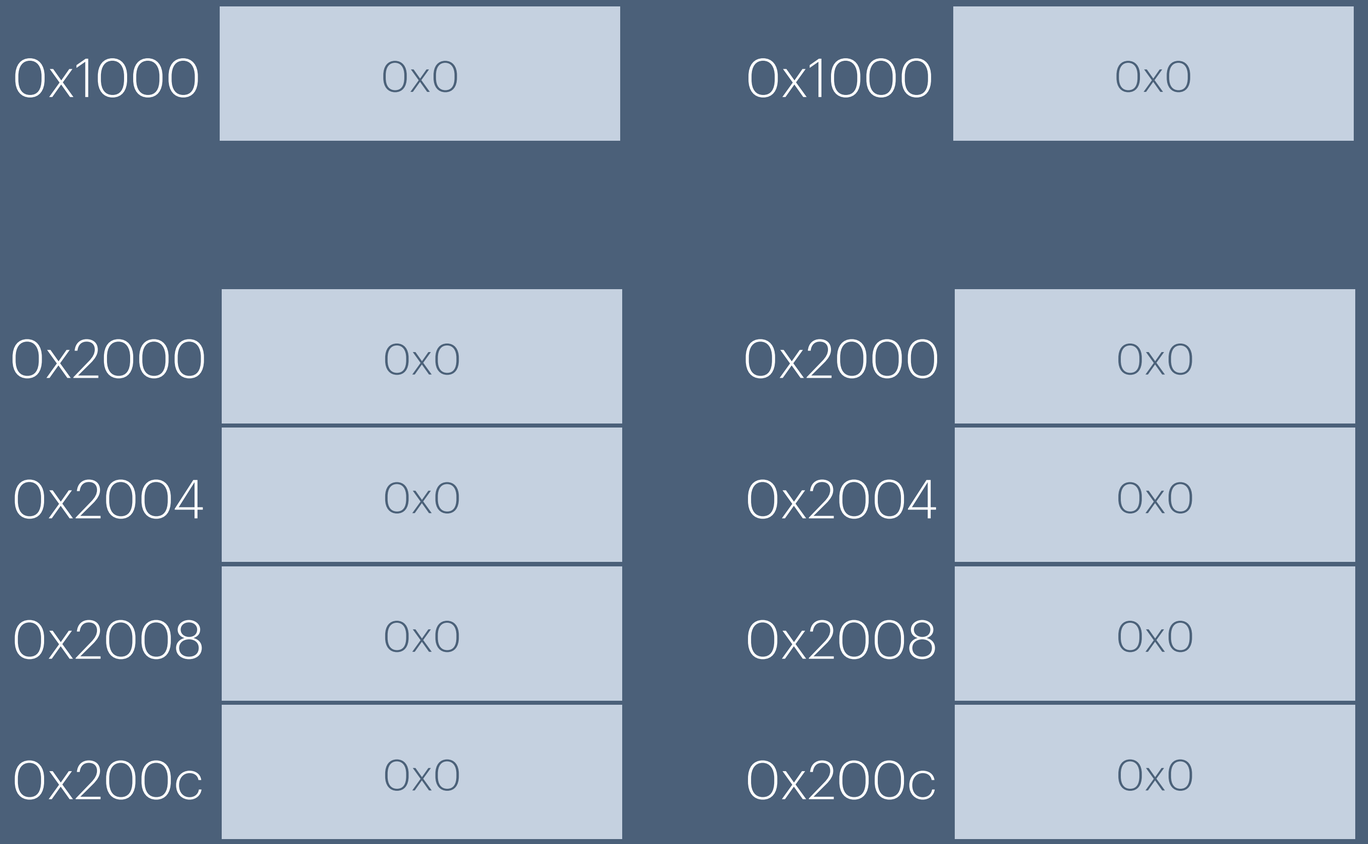
RTL 1

Memory Behaviour

```
r0 <= 0xcafe

r1 <= 0x2000

m[0xc + r1] <= r0
```



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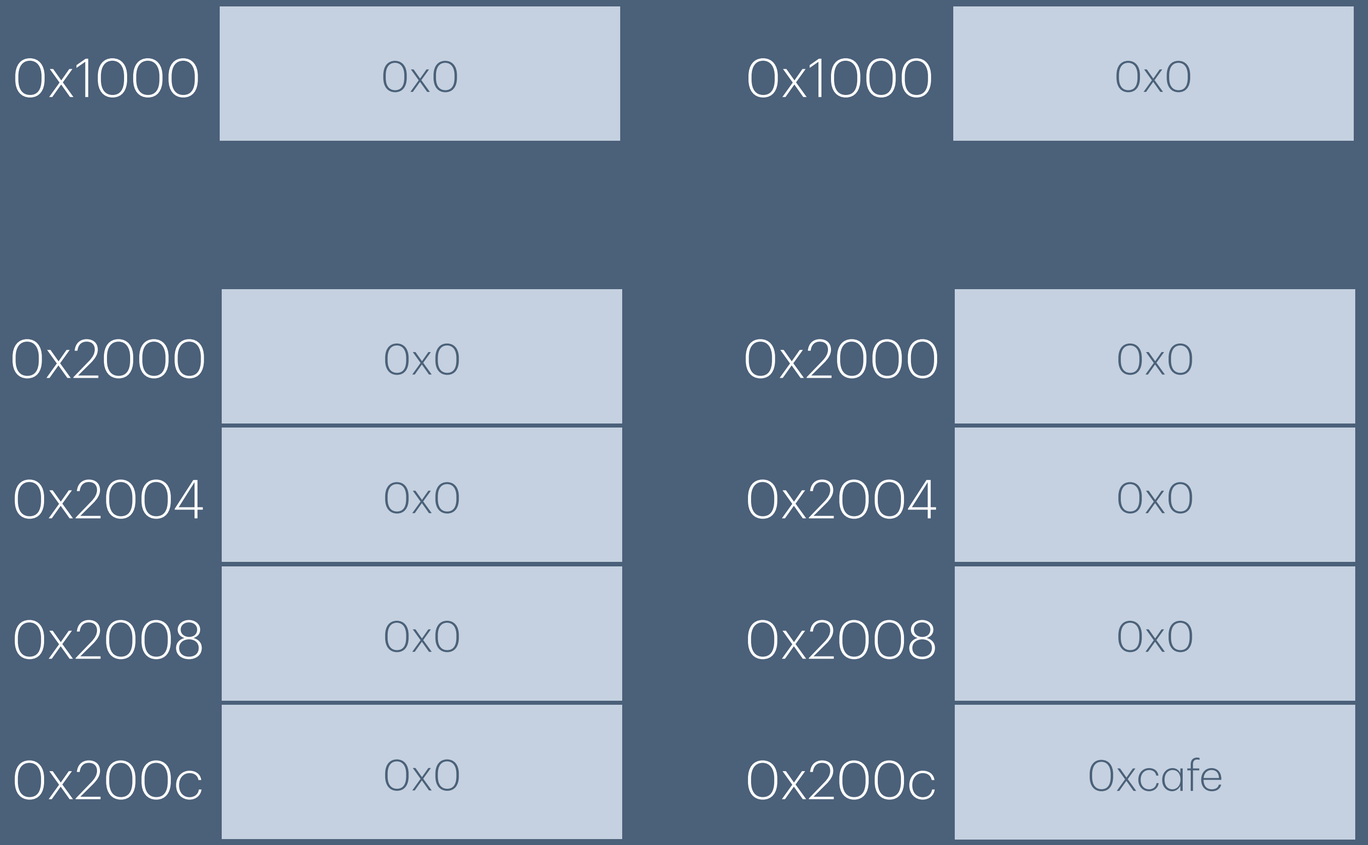
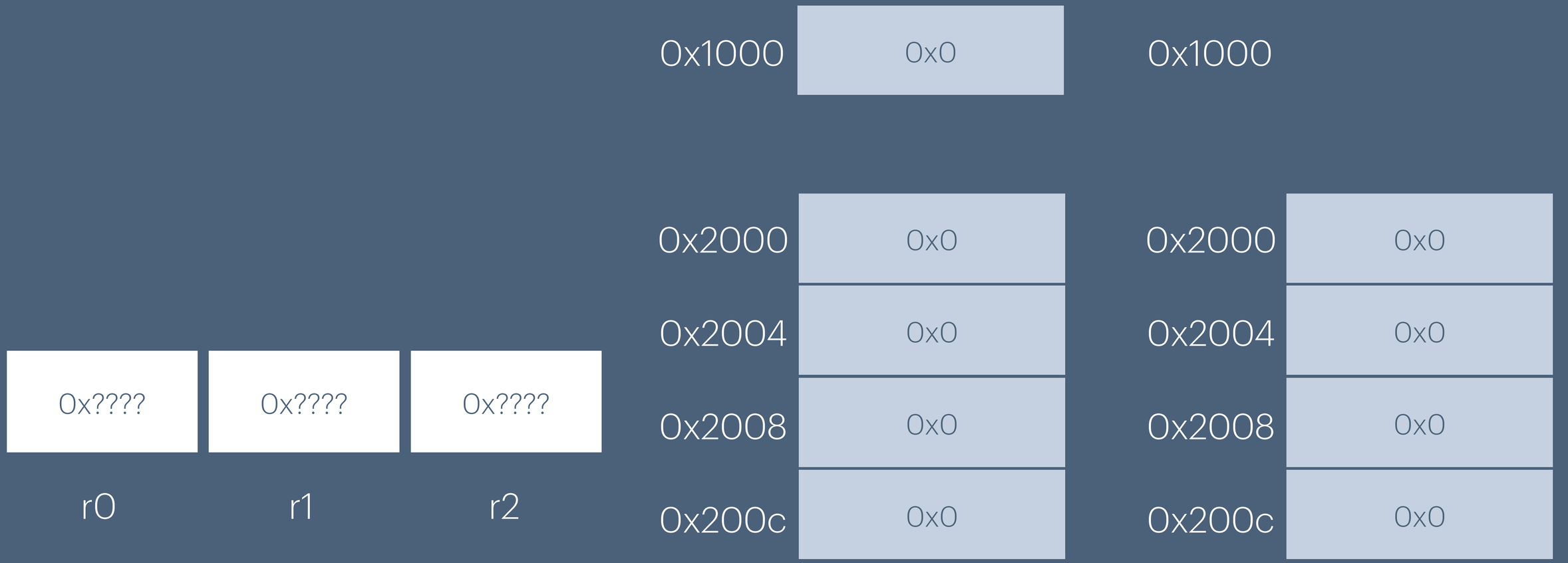


RTL 2

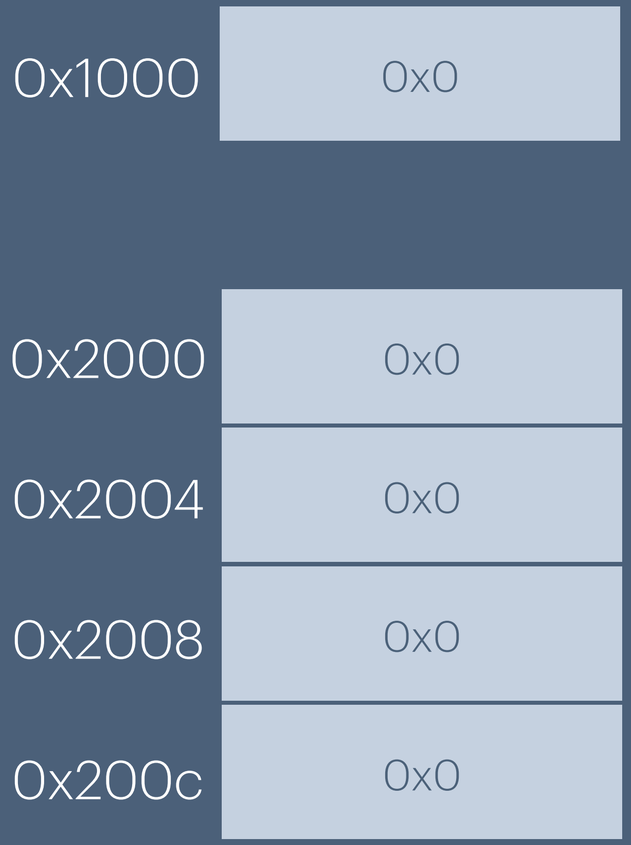
Memory Behaviour

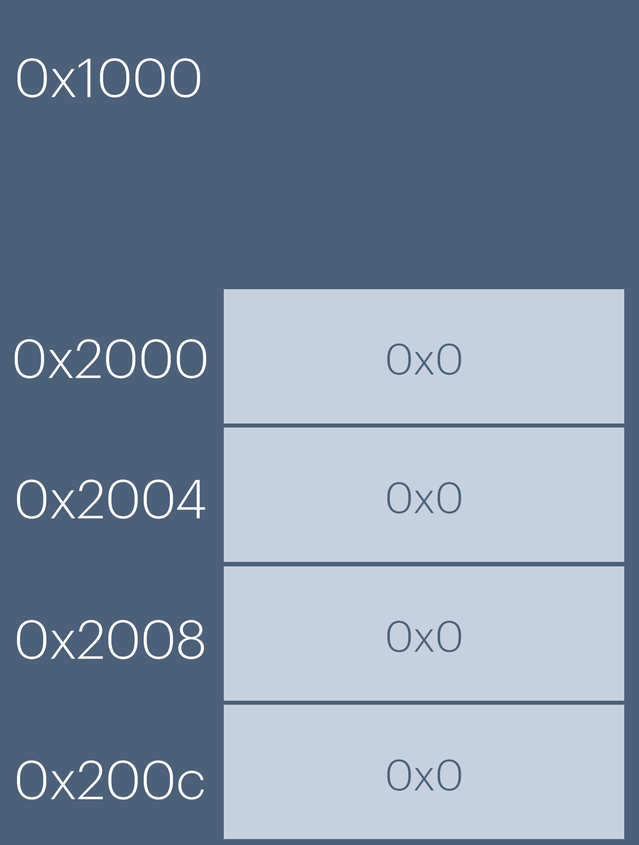


RTL 2

Memory Behaviour

```
r0 <= 0x5
```

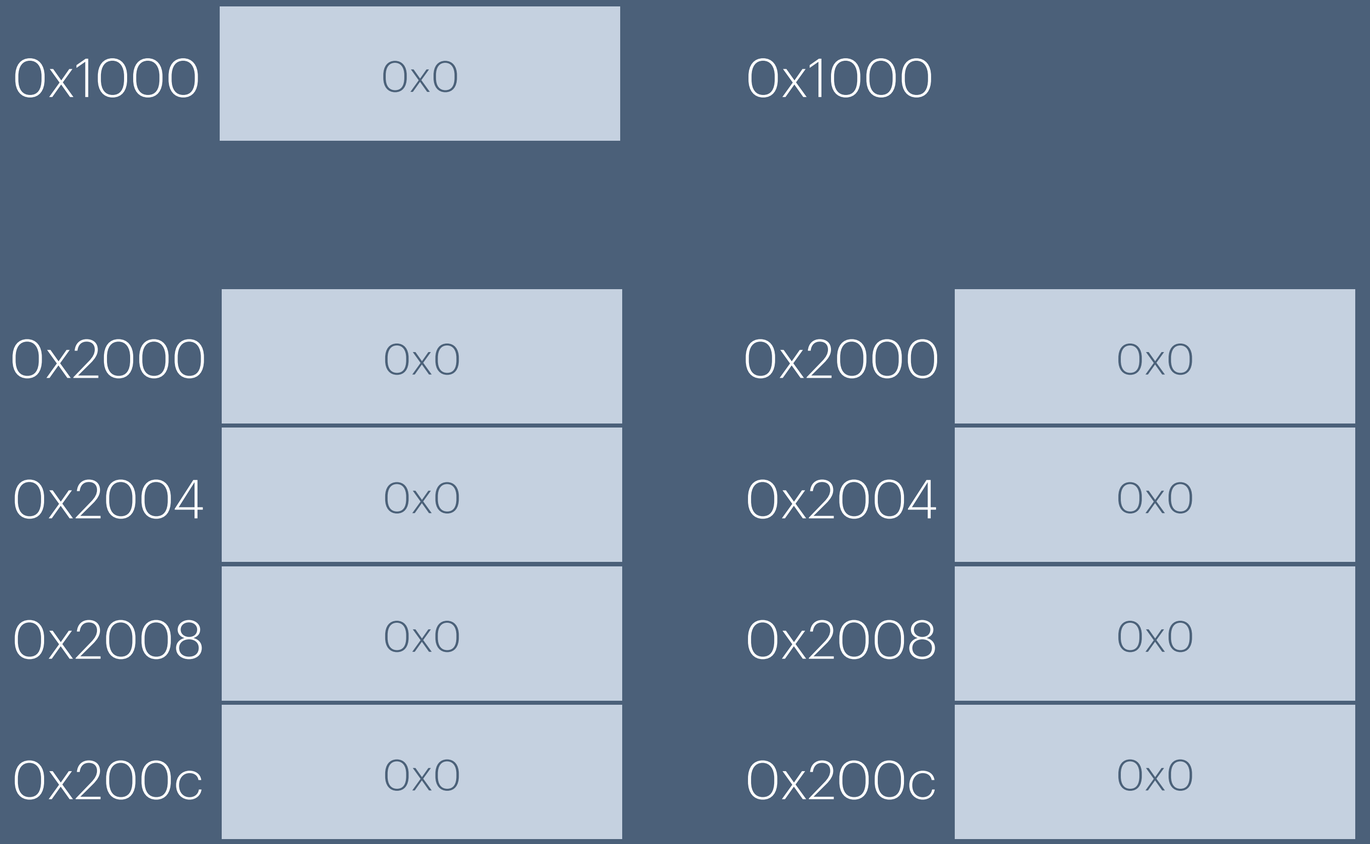




RTL 2

Memory Behaviour

```
r0 <= 0x5
```

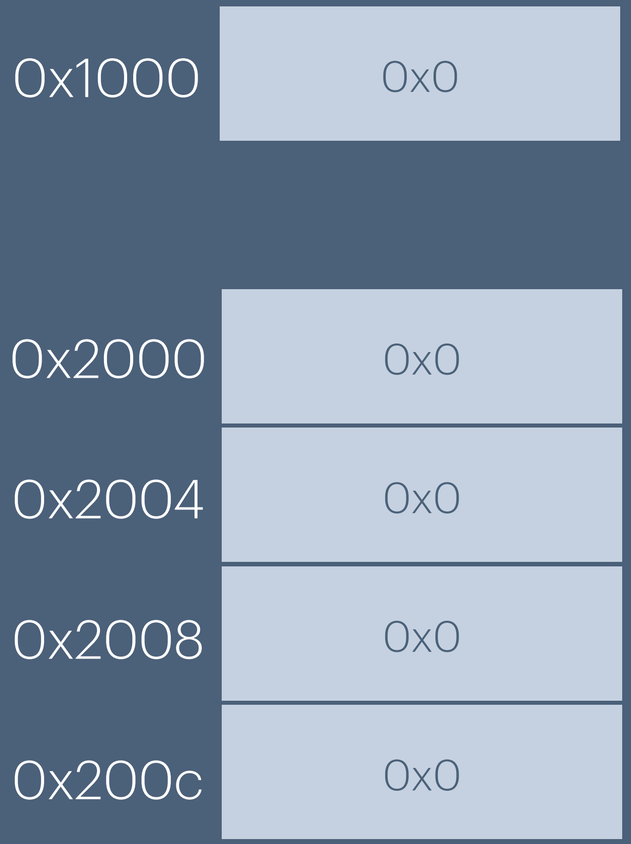


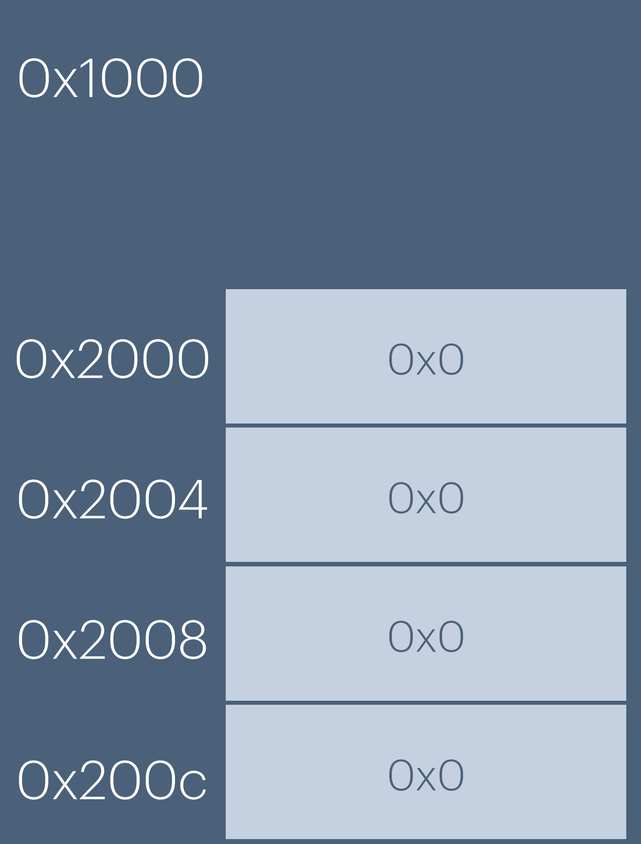
RTL 2

Memory Behaviour

```
r0 <= 0x5

r1 <= 0x1000
```



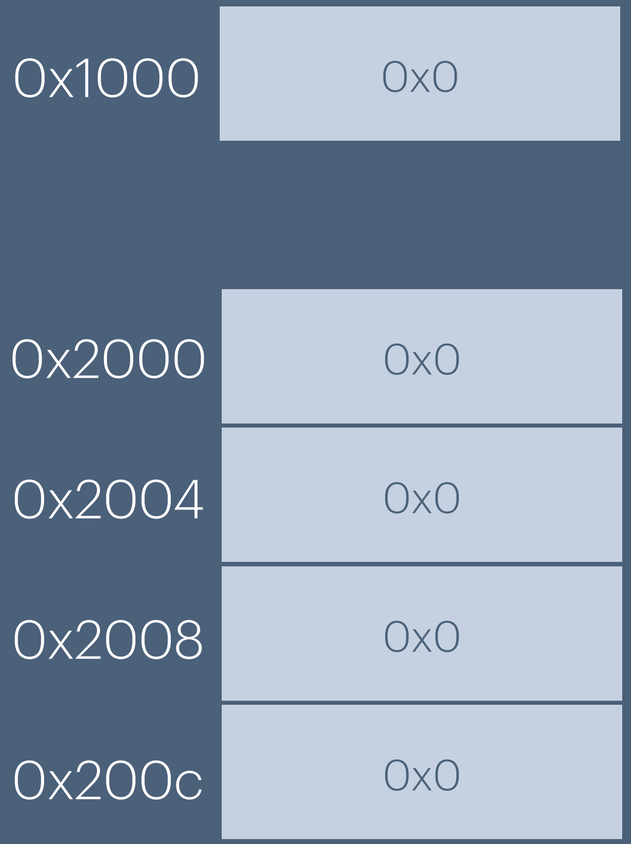


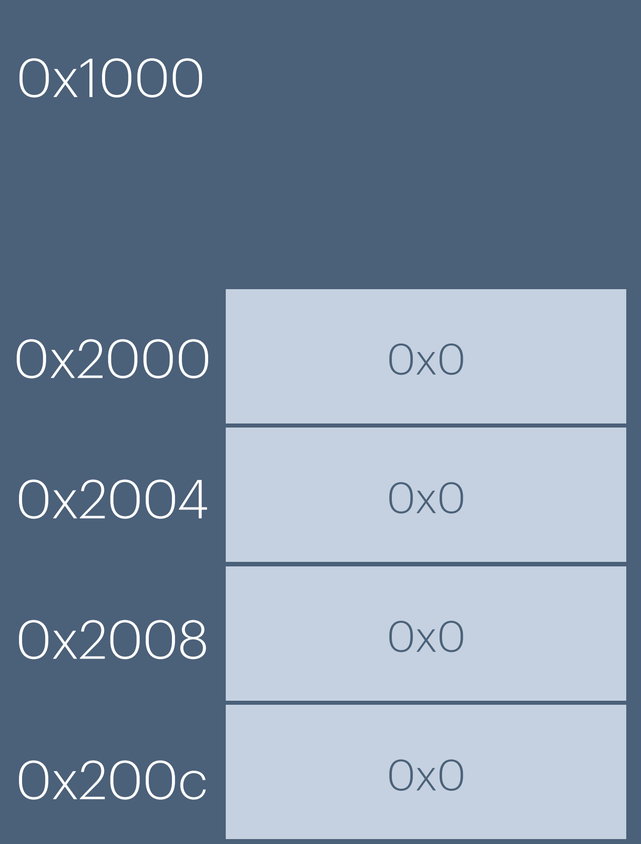
RTL 2

Memory Behaviour

```
r0 <= 0x5

r1 <= 0x1000
```





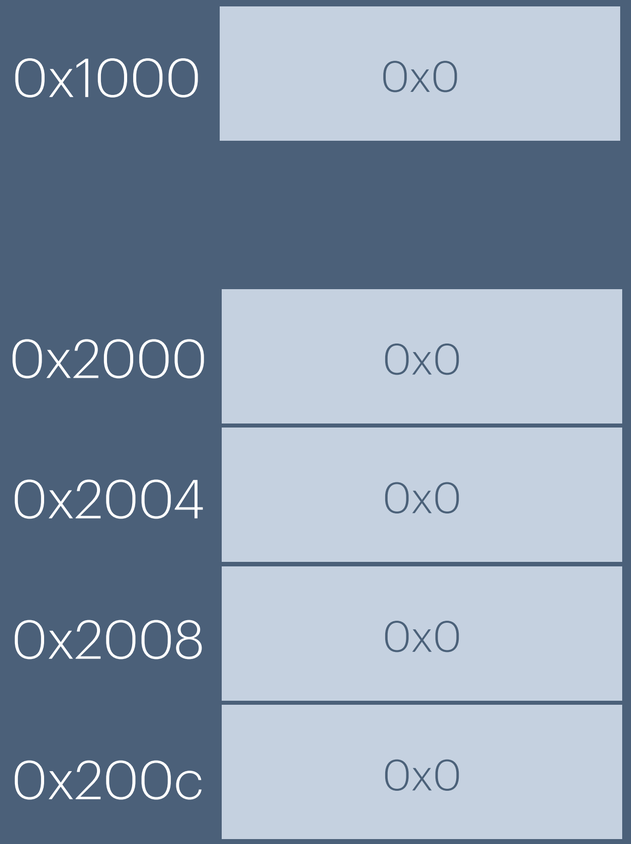
RTL 2

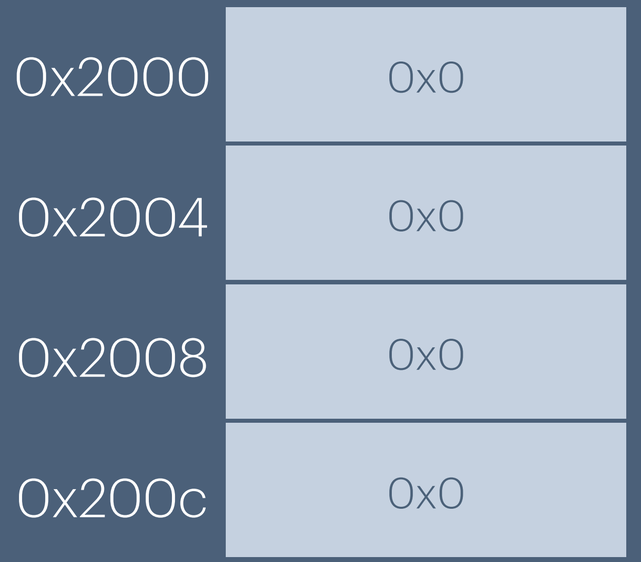
Memory Behaviour

```
r0 <= 0x5

r1 <= 0x1000

r2 <= m[r1]
```





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r2 <= m[r1]
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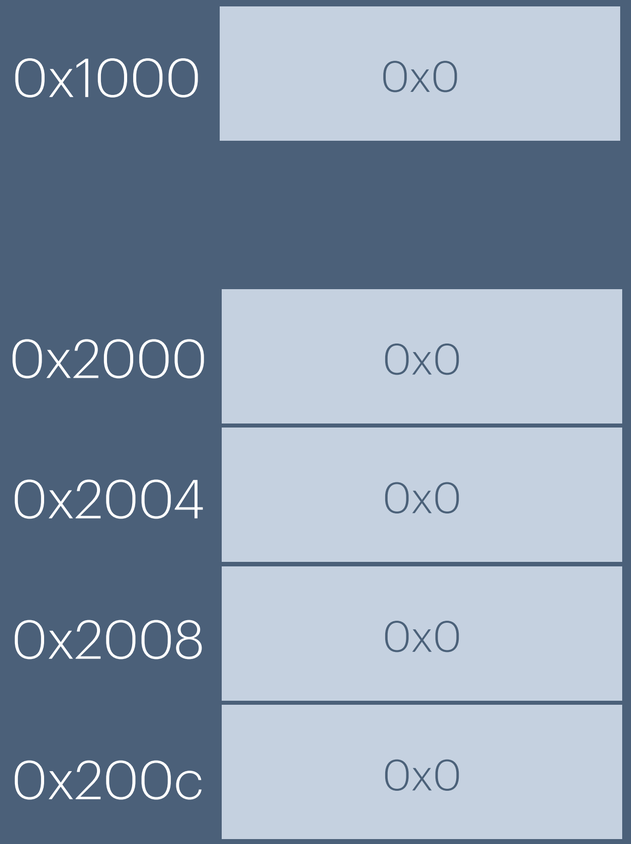
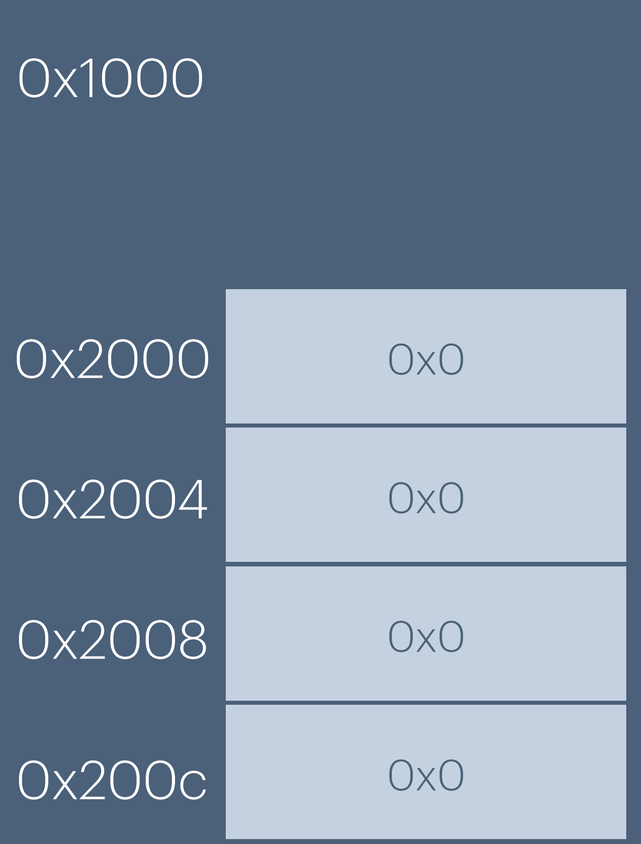




RTL 2

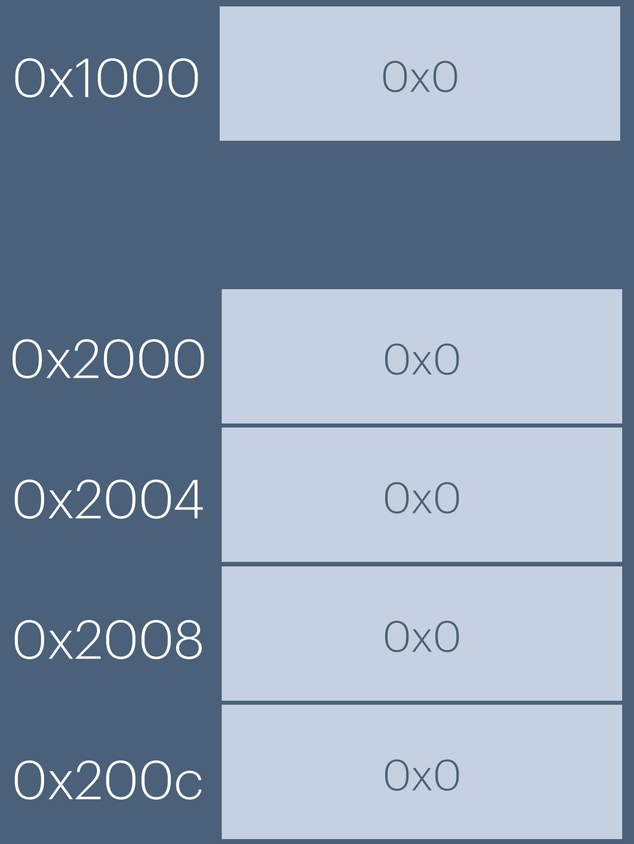
Memory Behaviour

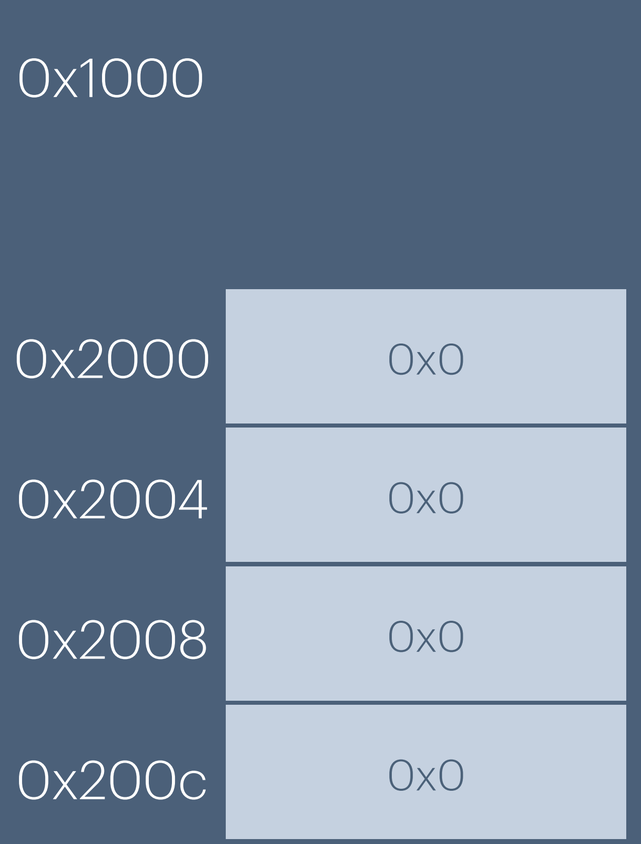
```
r0 <= 0x5

r1 <= 0x1000

r2 <= m[r1]

r0 <= ~r0
```





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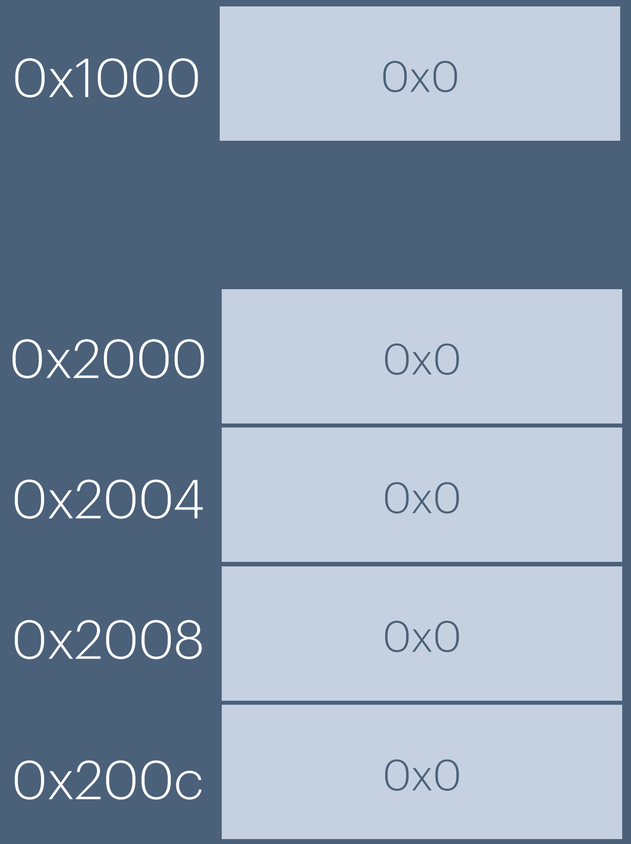
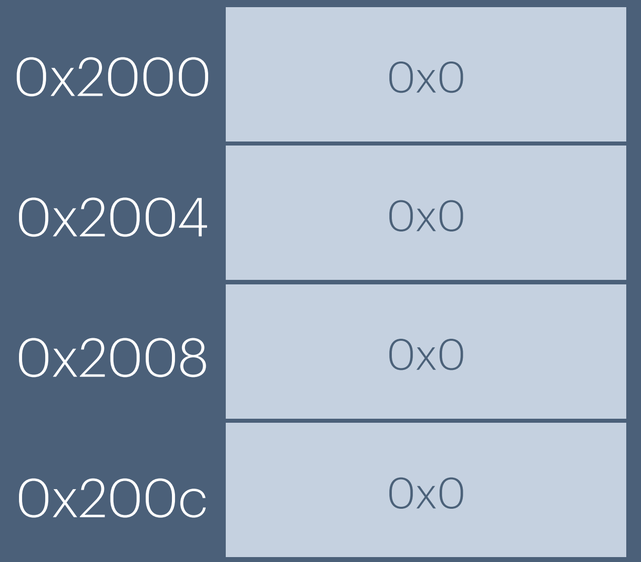




RTL 2

Memory Behaviour

```
r0 <= 0x5     r0 <= r0 + 1

r1 <= 0x1000

r2 <= m[r1]

r0 <= ~r0
```

0xfffa	0x1000	0x0000
r0	r1	r2

0x1000	0x0

0x2000	0x0
0x2004	0x0
0x2008	0x0
0x200c	0x0

0x1000

0x2000	0x0
0x2004	0x0
0x2008	0x0
0x200c	0x0

RTL 2

Memory Behaviour

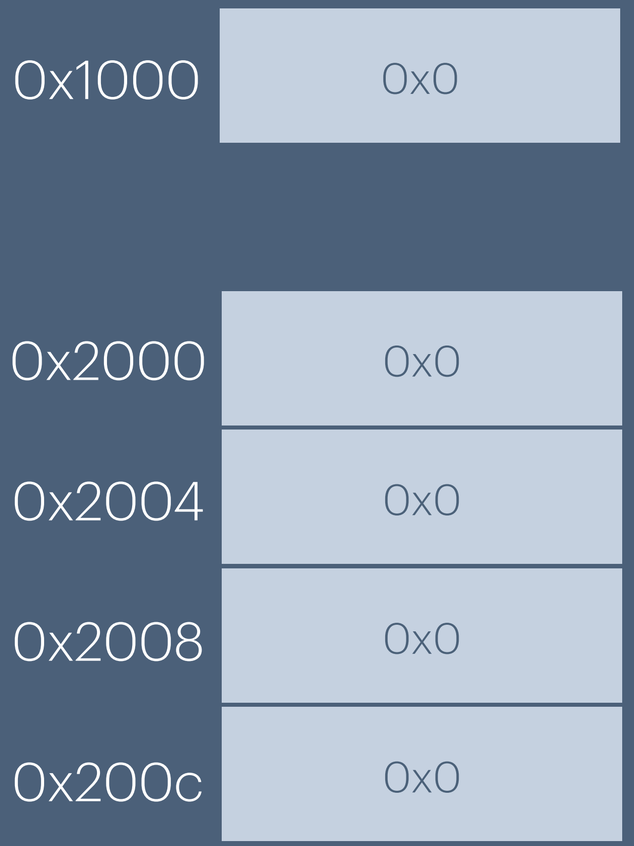
```
r0 <= 0x5     r0 <= r0 + 1

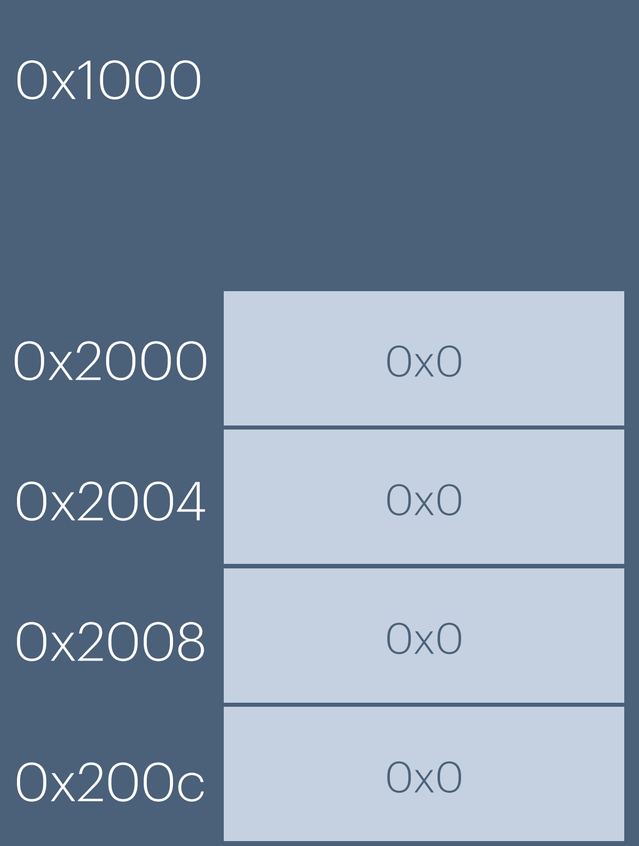
r1 <= 0x1000

r2 <= m[r1]

r0 <= ~r0
```

0xfffb	0x1000	0x0000
r0	r1	r2





RTL 2

Memory Behaviour

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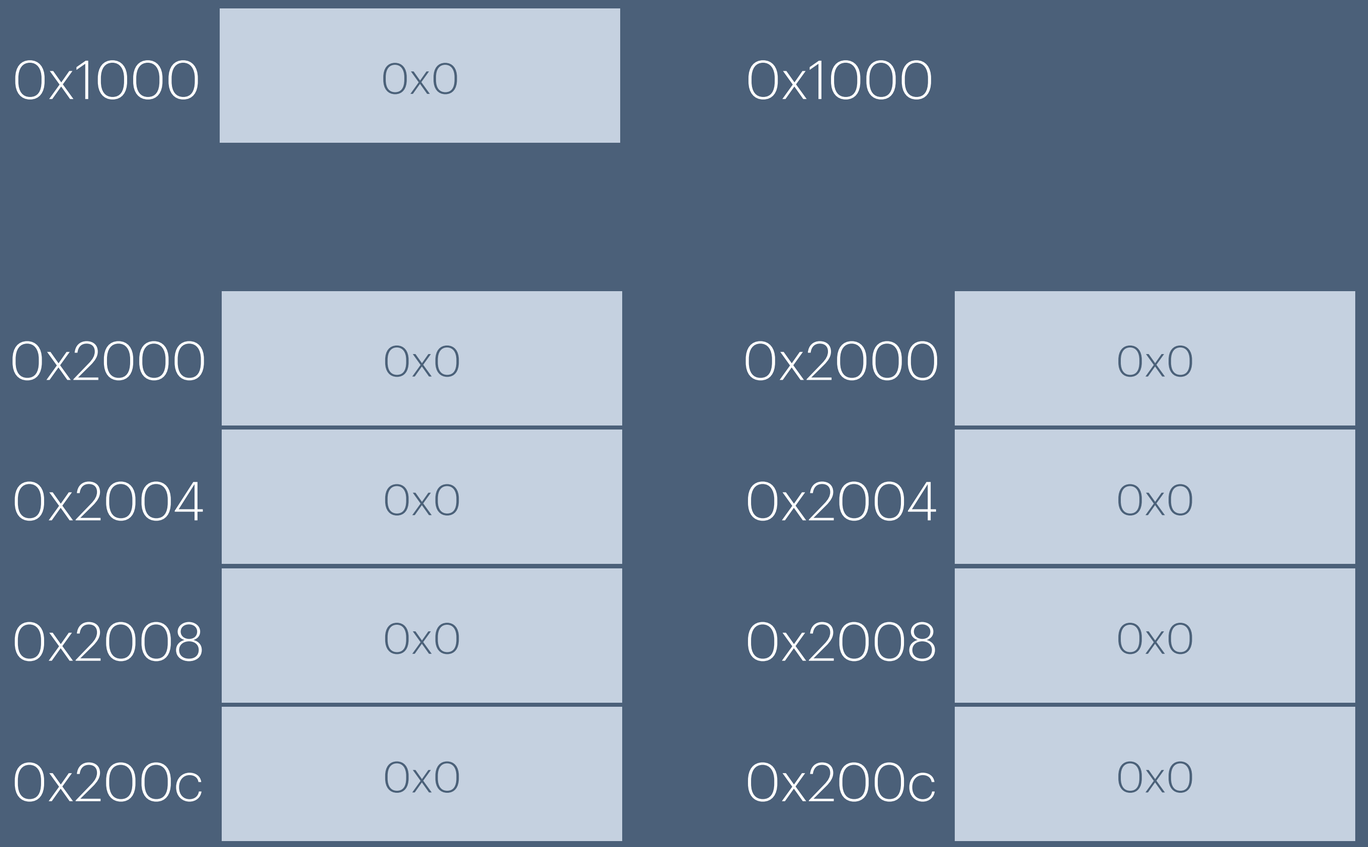
r0 <= 0x5     r0 <= r0 + 1

r1 <= 0x1000  r2 <= r2 + r0

r2 <= m[r1]

r0 <= ~r0
```

0xfffb	0x1000	0x0000
r0	r1	r2



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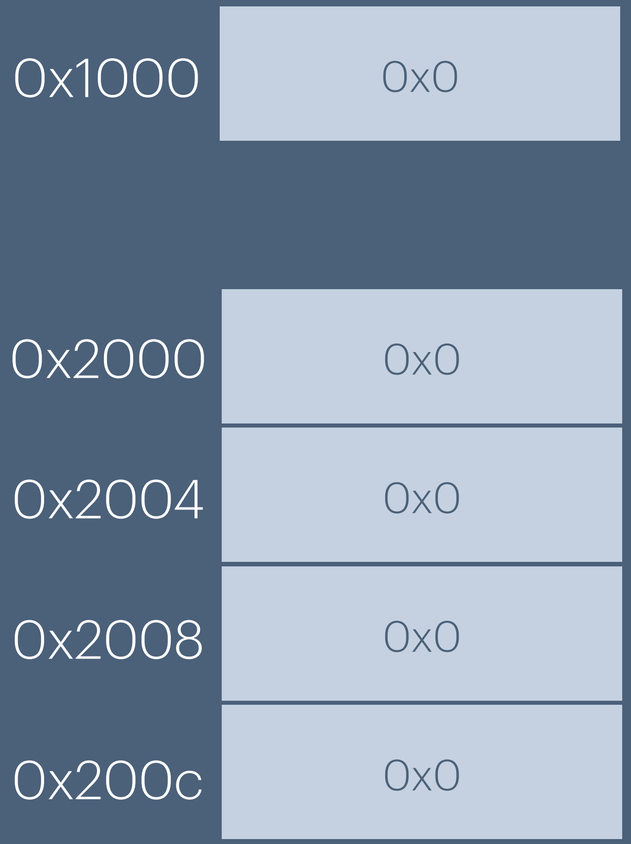

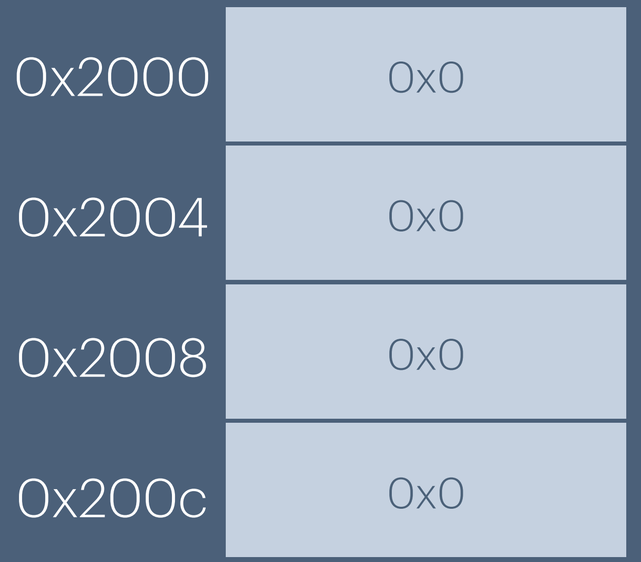

RTL 2

Memory Behaviour

```
r0 <= 0x5      r0 <= r0 + 1

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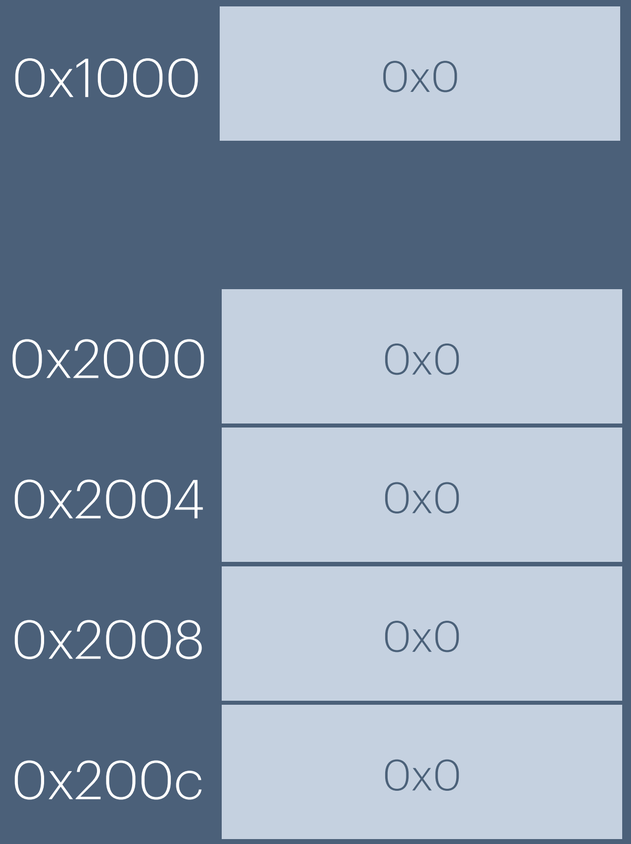
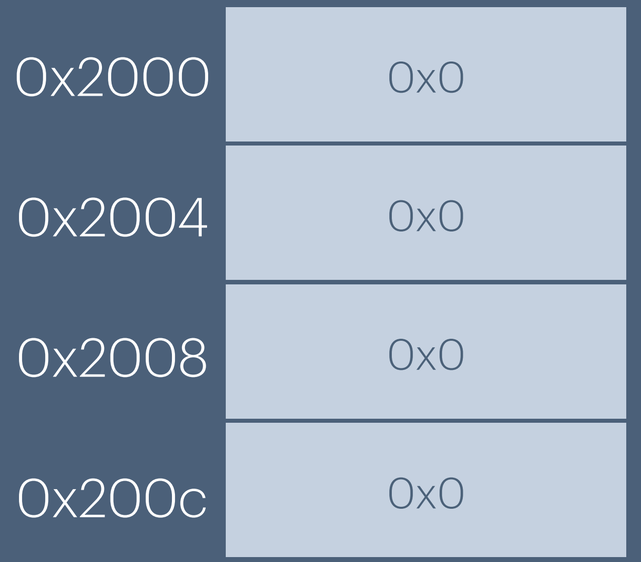
r2 <= m[r1]    m[r1] <= r2

r0 <= ~r0
```

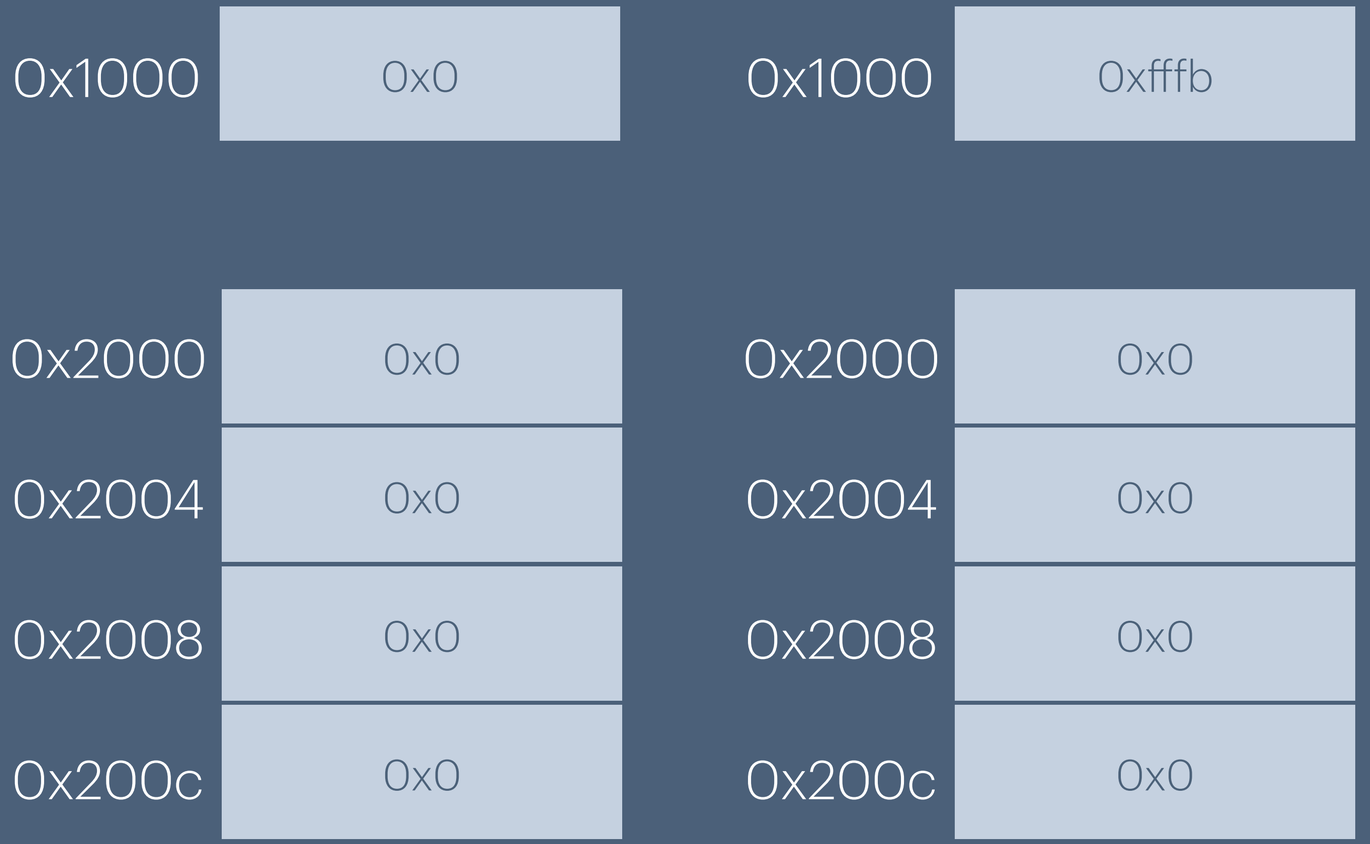




RTL 2

Memory Behaviour

```
r0 <= 0x5      r0 <= r0 + 1
r1 <= 0x1000   r2 <= r2 + r0
r2 <= m[r1]    m[r1] <= r2
r0 <= ~r0
```



RTL 2

Memory Behaviour

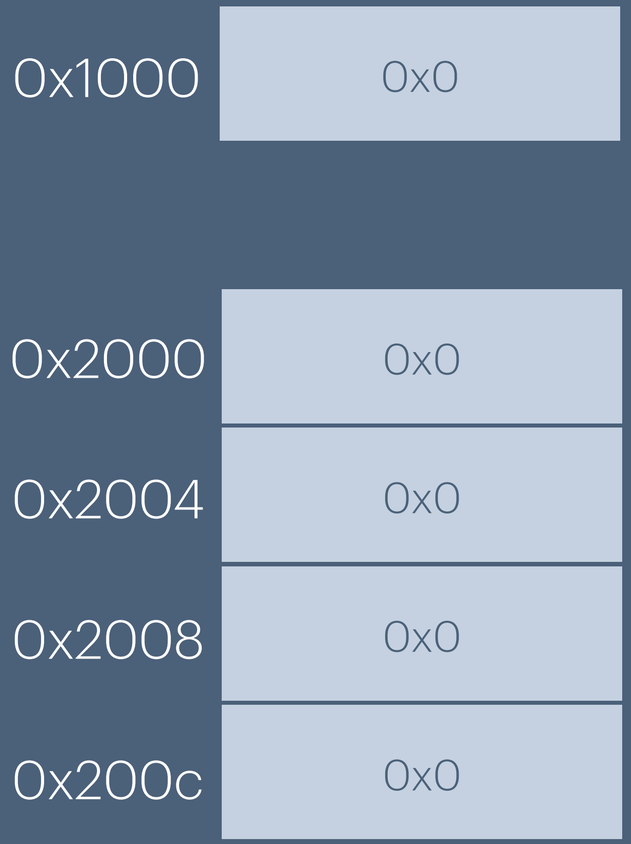
```
r0 <= 0x5      r0 <= r0 + 1

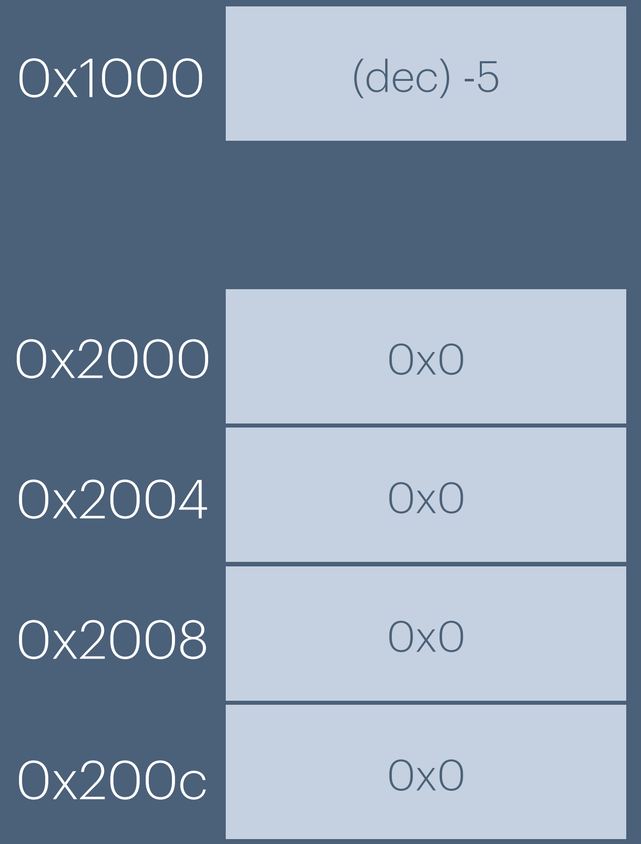
r1 <= 0x1000   r2 <= r2 + r0

r2 <= m[r1]    m[r1] <= r2

r0 <= ~r0
```

0xfffb	0x1000	0xfffb
r0	r1	r2





Lab Code

For attendance

HQLA

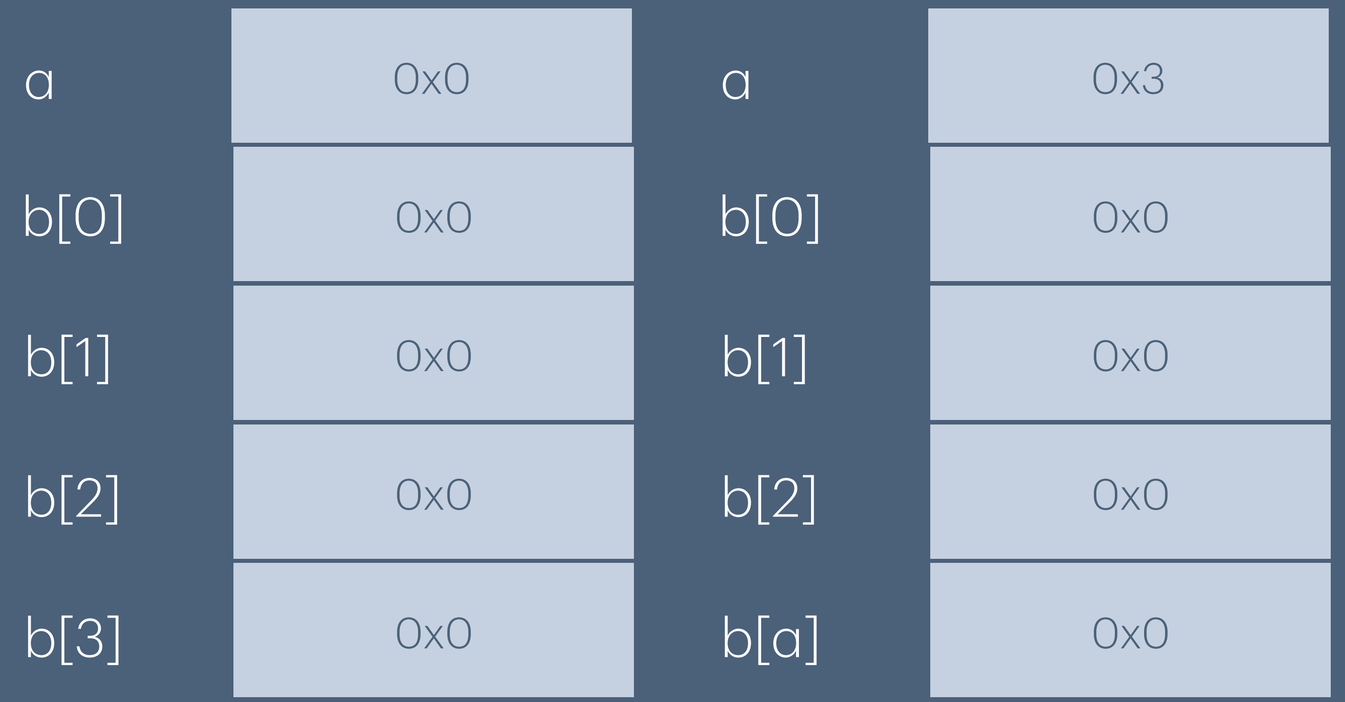
C to SM213 Assembly

Memory layout

```
int a;
int b[10];
```

That is, you can assume that

```
a:   .long 0
b:   .long 0
     .long 0
     .long 0
     .long 0 # enough ti
```



C to SM2132 Assembly

Translate `b[a] = a + b[a];`

- Get value of a
  - Location of a
- Get value of b[a]
  - b starts, and the value of a; need indexed load
- Add them together
- Put it into b[a]
  - b starts and value of a; need indexed store

C to SM2132 Assembly

Get value of a

- I need the value of a

```
ld $a, r1 # where a is

ld (r1), r1 # value of a
```

C to SM2132 Assembly

Get value of b[a]

- I need where b starts, and the value of a

```
ld $b, r0 # where b starts

ld $a, r1 # where a is

ld (r1), r1 # value of a

ld (r0, r1, 4), r2 # r2 = b[a]
```

C to SM2132 Assembly

Add together

- overwrite r2 because the only use for the **value of** b[a] isn't used next

```
ld $b, r0 # where b starts

ld $a, r1 # where a is

ld (r1), r1 # value of a

ld (r0, r1, 4), r2 # r2 = b[a]

add r1, r2 # r2 = b[a] + a
```

C to SM2132 Assembly

Store into b[a]

- r2 = b[a] + a, put into m[b + a * 4]

```
ld $b, r0 # where b starts

ld $a, r1 # where a is

ld (r1), r1 # value of a

ld (r0, r1, 4), r2 # r2 = b[a]

add r1, r2 # r2 = b[a] + a

st r2, (r0, r1, 4)
```