INSTRUMENTATION TO PREVENT PROGRAMS FROM BUFFER-OVERFLOW ATTACKS

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AGENDA

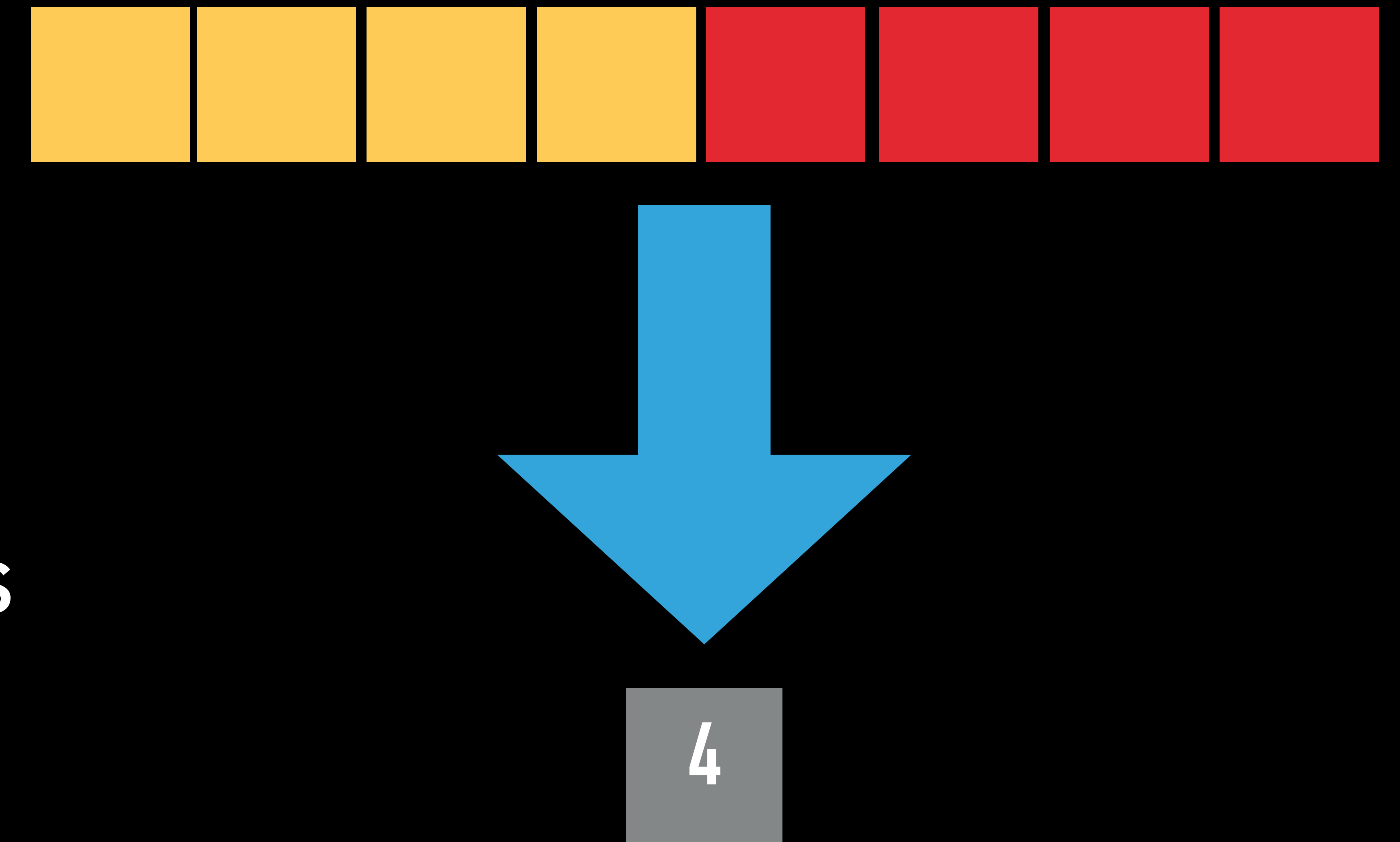
- Buffer-Overflow Attack
- Outline of AddressSanitizer(ASan)
- Instrumentation for Read and Write accesses
- Pointer Aliasing problem
- Optimization
- Conclusion

BUFFER-OVERFLOW ATTACK

- Shell code execution
- Reordering execution of functions
- Application DoS

ADDRESS SANITIZER

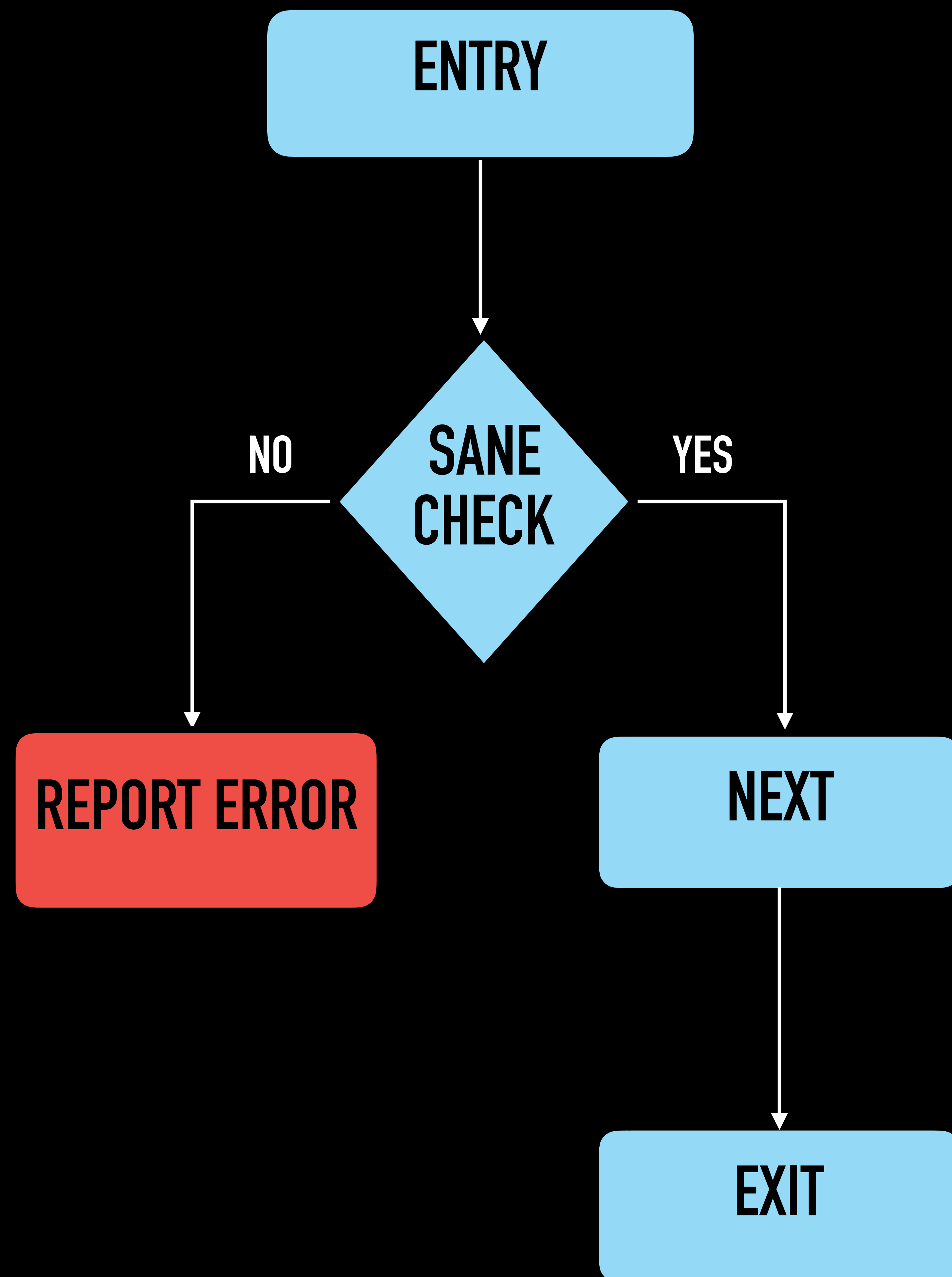
- Tool to **REPORT** memory corruption errors
- Uses shadow memory
- Checks if memory is addressable in 8 byte chunks (Sane Check)
- **STOPS** the execution of program in times of error



INSTRUMENTATION FOR READ ACCESS

- Proxy pointers for primitive data types
- i1/i8/i16/iN : 0
- Float/Double : 0.0
- Can be given as command line argument

INSTRUMENTATION FOR READ ACCESS



ENTRY

NO

SANE CHECK

YES

REL_BLOCK

ϕ((%A, SANE_CHECK), (%PROX_I8, REL_BLOCK))
NEXT

EXIT

INSTRUMENTATION FOR WRITE ACCESS

- Static buffers are moved to the heap by dynamic allocation
- Bounds are inferred for every dynamically allocated buffer through static analysis

Original	Instrumented
`int *A = malloc(n*sizeof(int));`	`int *A = malloc(n*sizeof(int)));` `unsigned int A_size = n;`

INSTRUMENTATION FOR WRITE ACCESS

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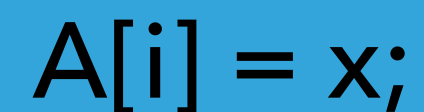
- Bounds are inferred for every dynamically allocated buffer through static analysis

int *A = malloc(n*sizeof(int));	int *A = malloc(n*sizeof(int))); unsigned int A_size = n;
%1 = load i64, 64* %n %mul = mul i64 %1, 4 %call = call i8* @malloc(i64 %mul) %2 = bitcast i8* %call to i32* store i32* %2, i32** %A	%1 = load i64, 64* %n %mul = mul i64 %1, 4 %call = call i8* @malloc(i64 %mul) %2 = bitcast i8* %call to i32* store i32* %2, i32** %A store i64 %1, i64* A.size

INSTRUMENTATION FOR WRITE ACCESS

- Write A[i]. What if “i” is not initialized?
- A check which let us decide whether to expand the bounds or not
- SCALE_OF_RELOCATION (default value is 2)



INSTRUMENTATION FOR WRITE ACCESS

- Write A[i]. What if “i” is not initialized?
- A check which let us decide whether to expand the bounds or not
- SCALE_OF_RELOCATION (default value is 2)

```
A[i] = x;
```

```
if(i <= SCALE_OF_RELOCATION*A_size) {
    A_size = A_size*SCALE_OF_RELOCATION;
    A = realloc(A, A_size);
}
A[i] = x;
```

INSTRUCTIONS FOR WRITE ACCESS

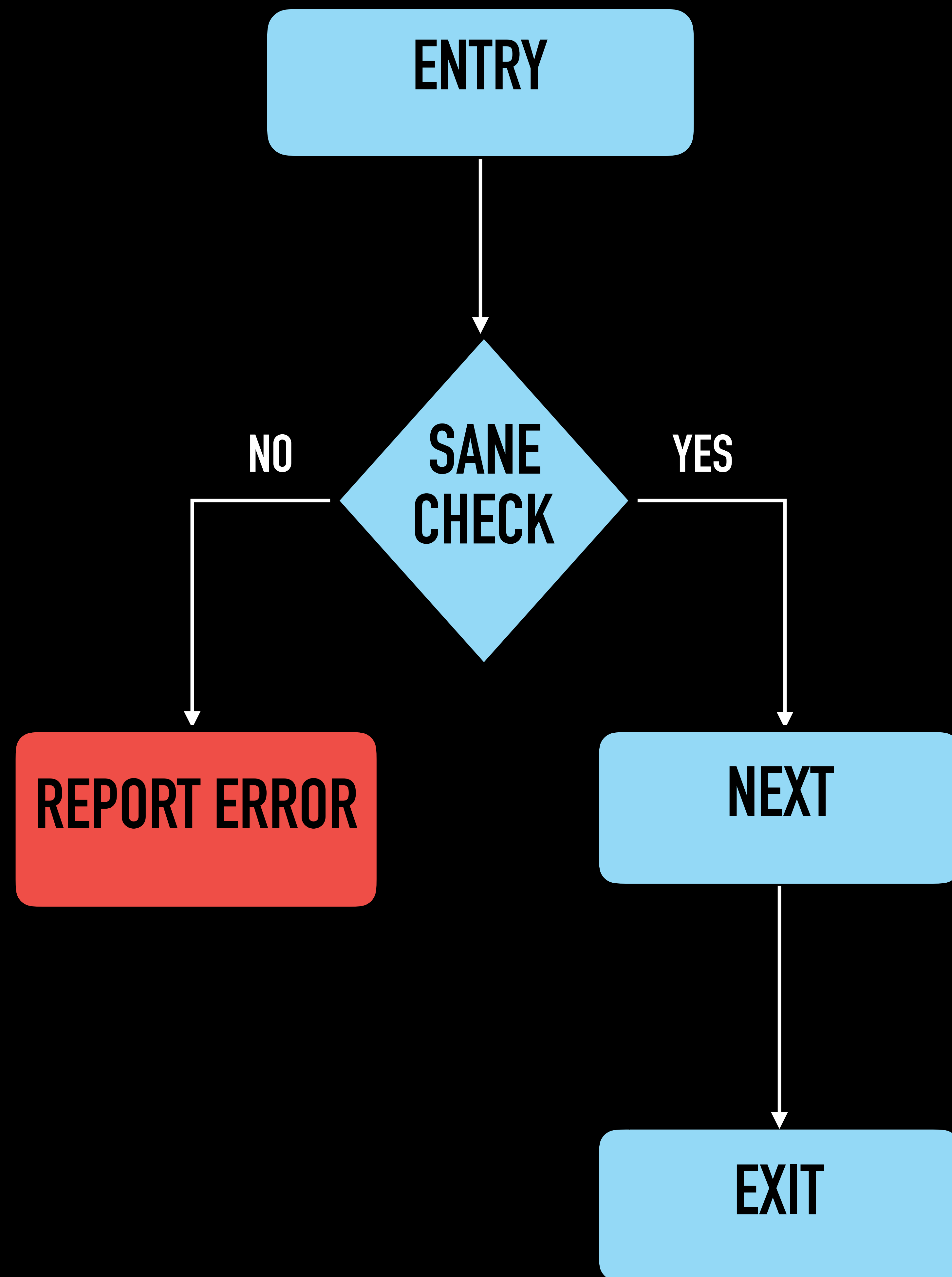
- Split a store statement into a separate basic block

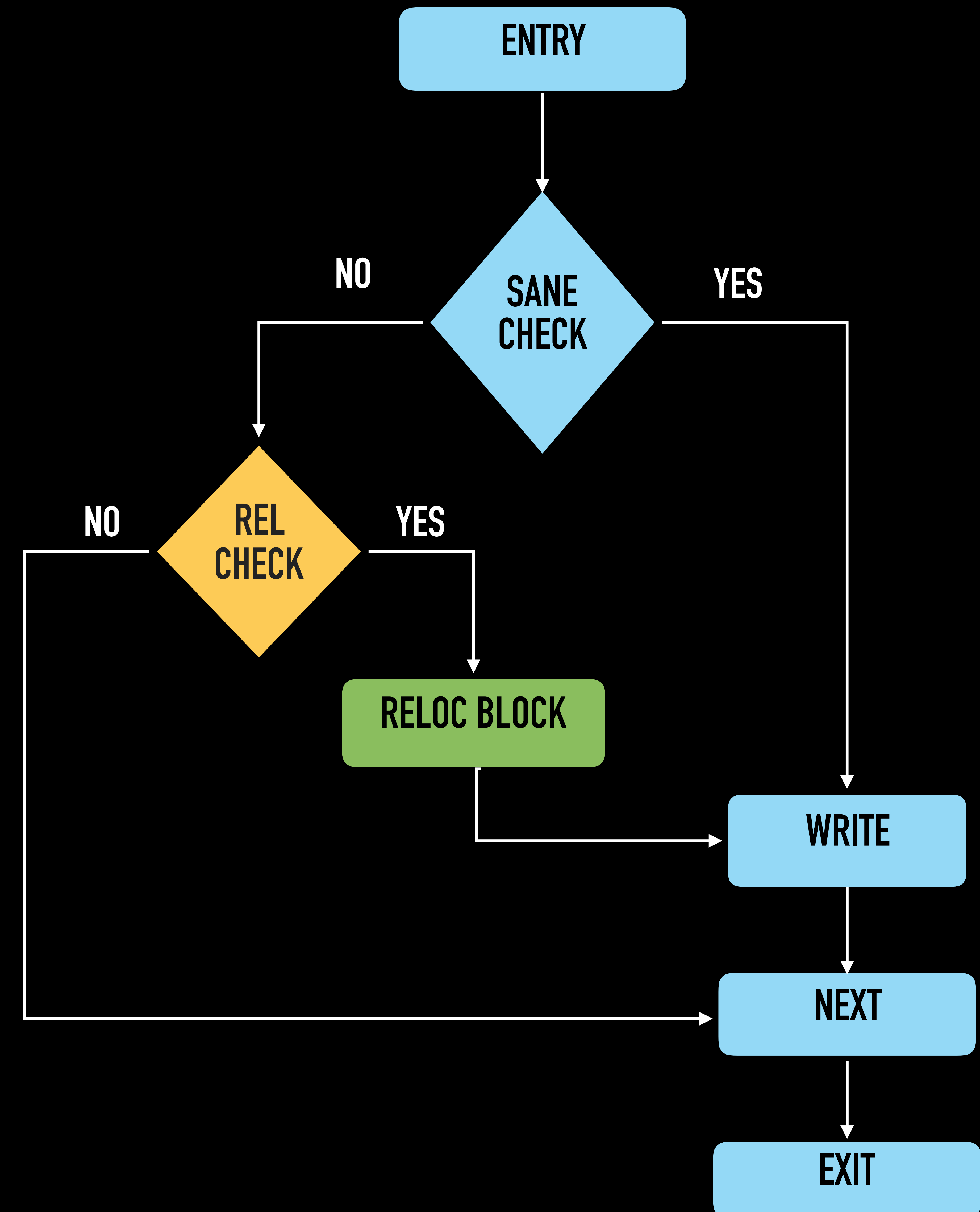
```
store i32 0, i32* p
%1 = load i32, i32* p
....
```

```
store i32 0, i32* p
br %next
```

```
next:
  %1 = load i32, i32* p
  ....
```

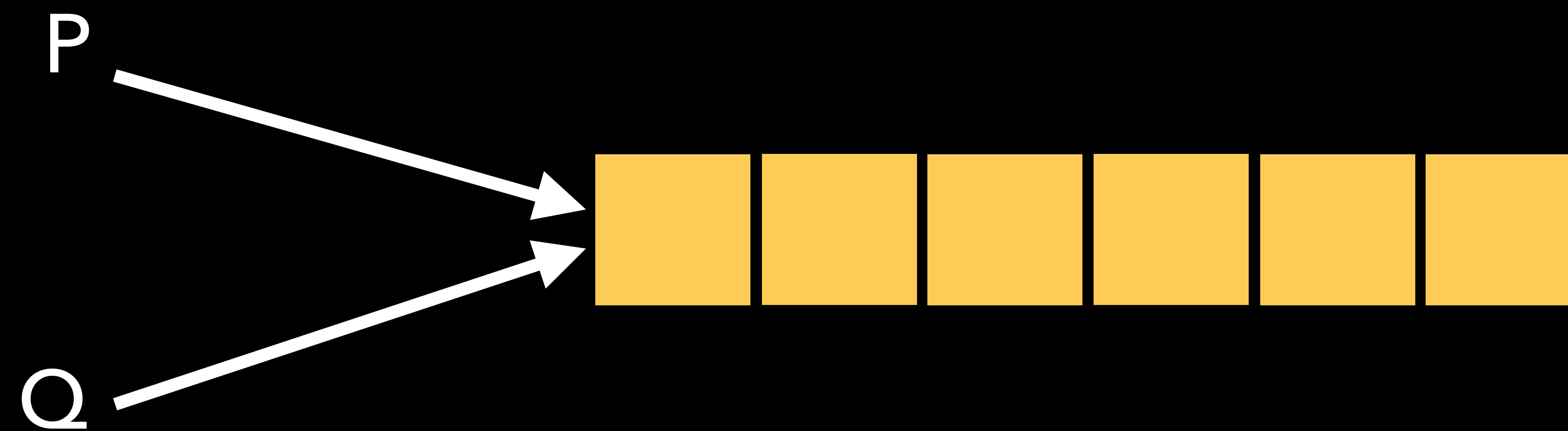
INSTRUMENTATION FOR WRITE ACCESS





POINTER ALIASING PROBLEM

- In case of pointer aliasing and a relocation occurs, all the aliasing pointers need to be updated



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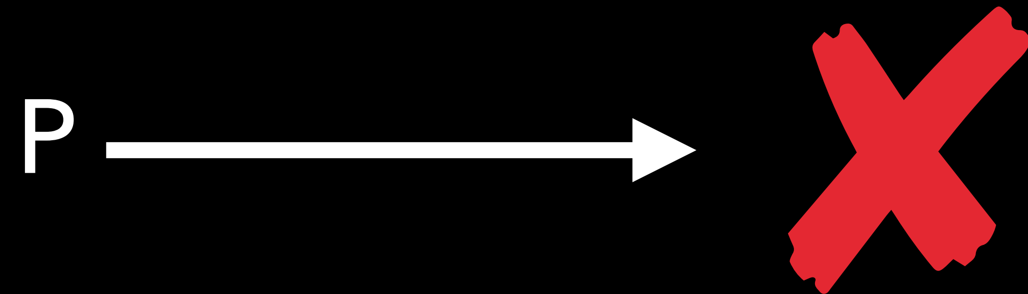

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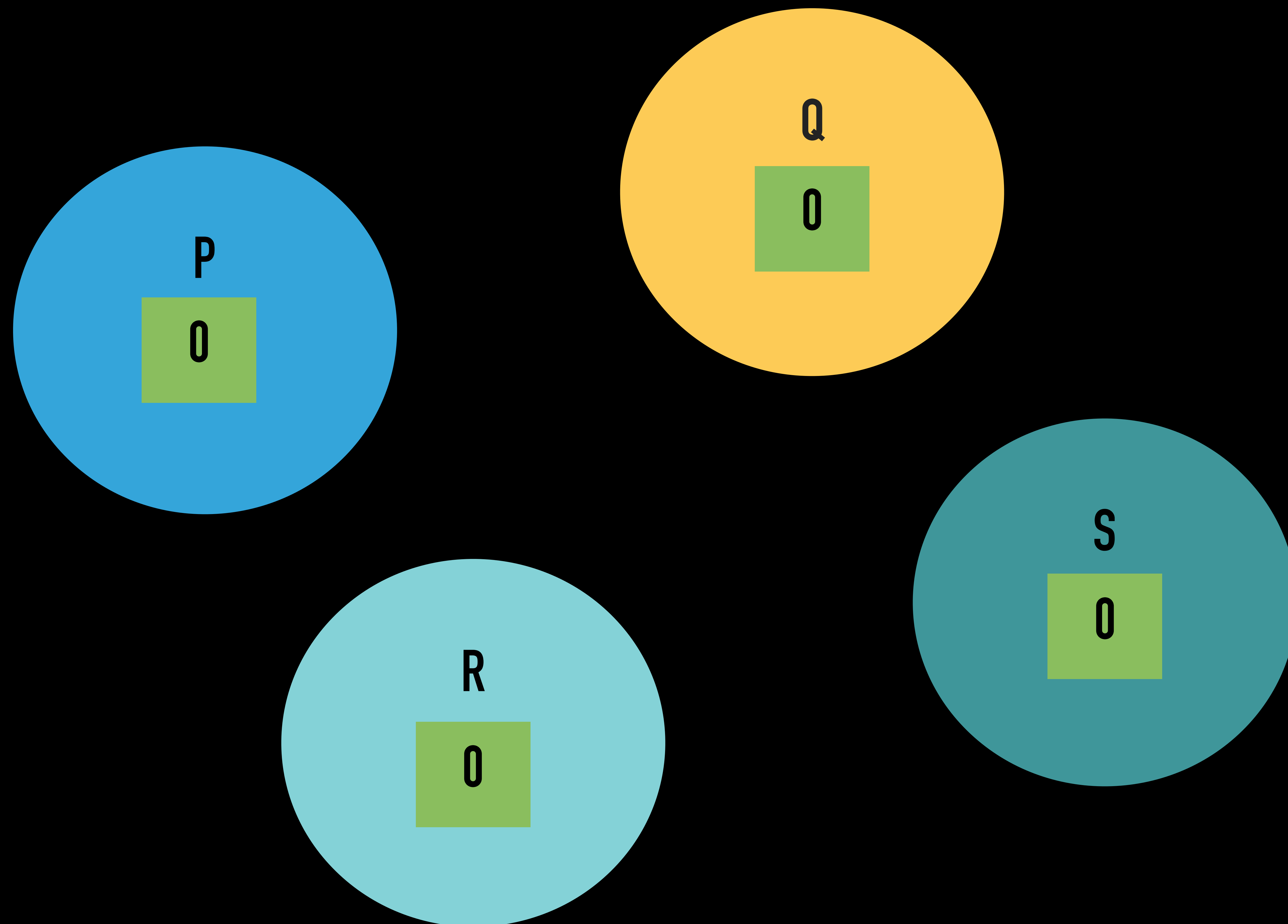
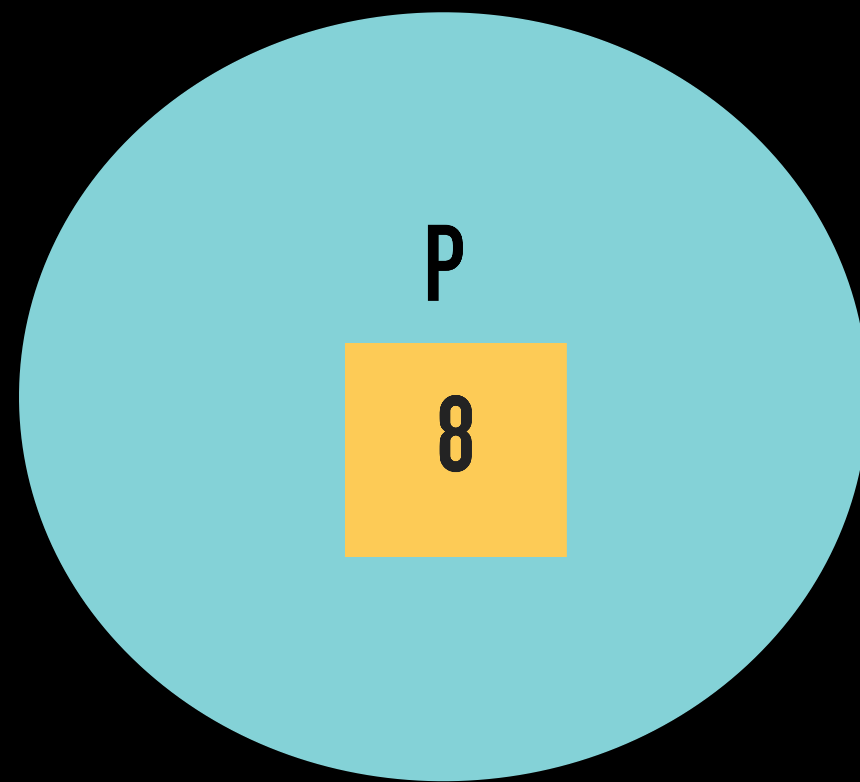



```
int *p,*q,*r,*s;
```

POINTER ALIASING PROBLEM

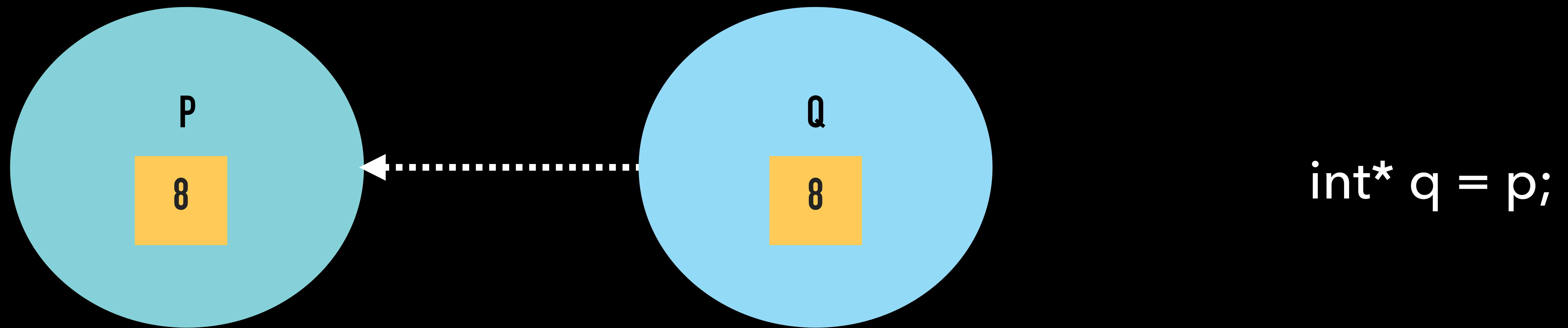
- Allocation of memory




```
int *p = malloc(8*sizeof(int));
```

POINTER ALIASING PROBLEM

- Pointer Assignment



int* q = p;

POINTER ALIASING PROBLEM

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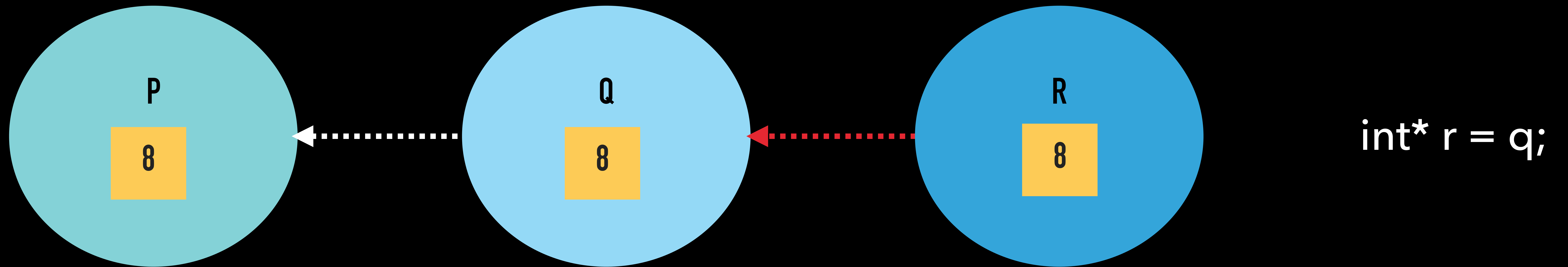

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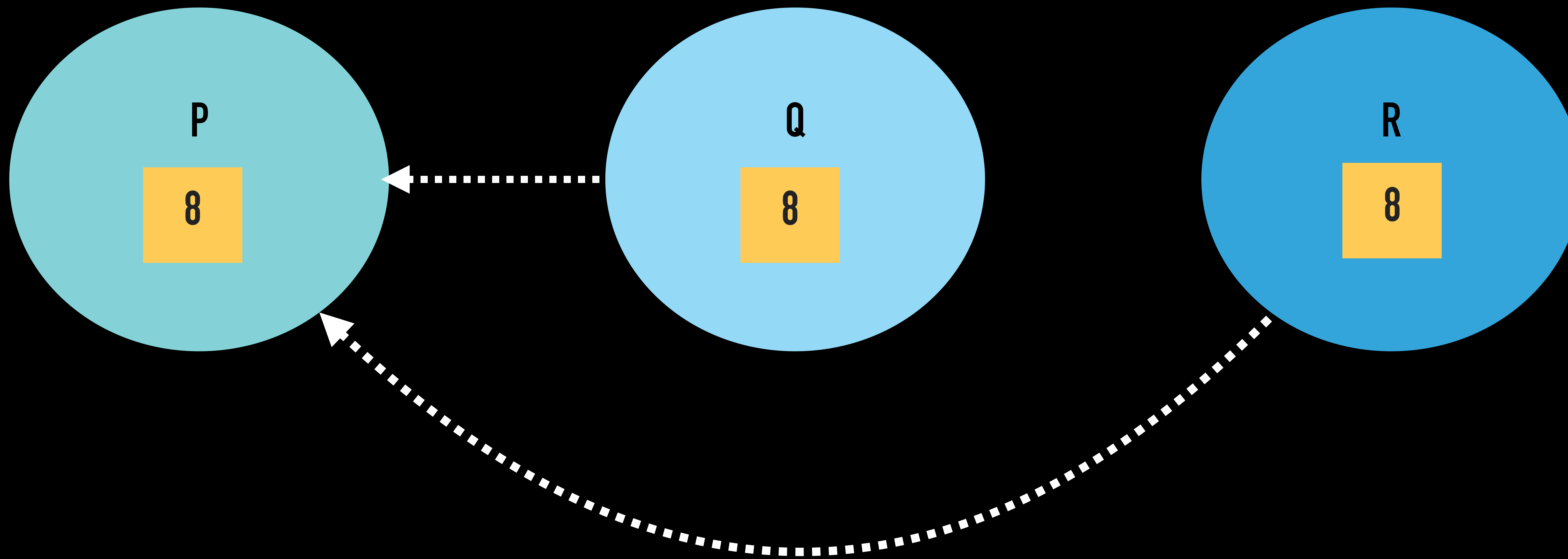

int* r = q;

POINTER ALIASING PROBLEM

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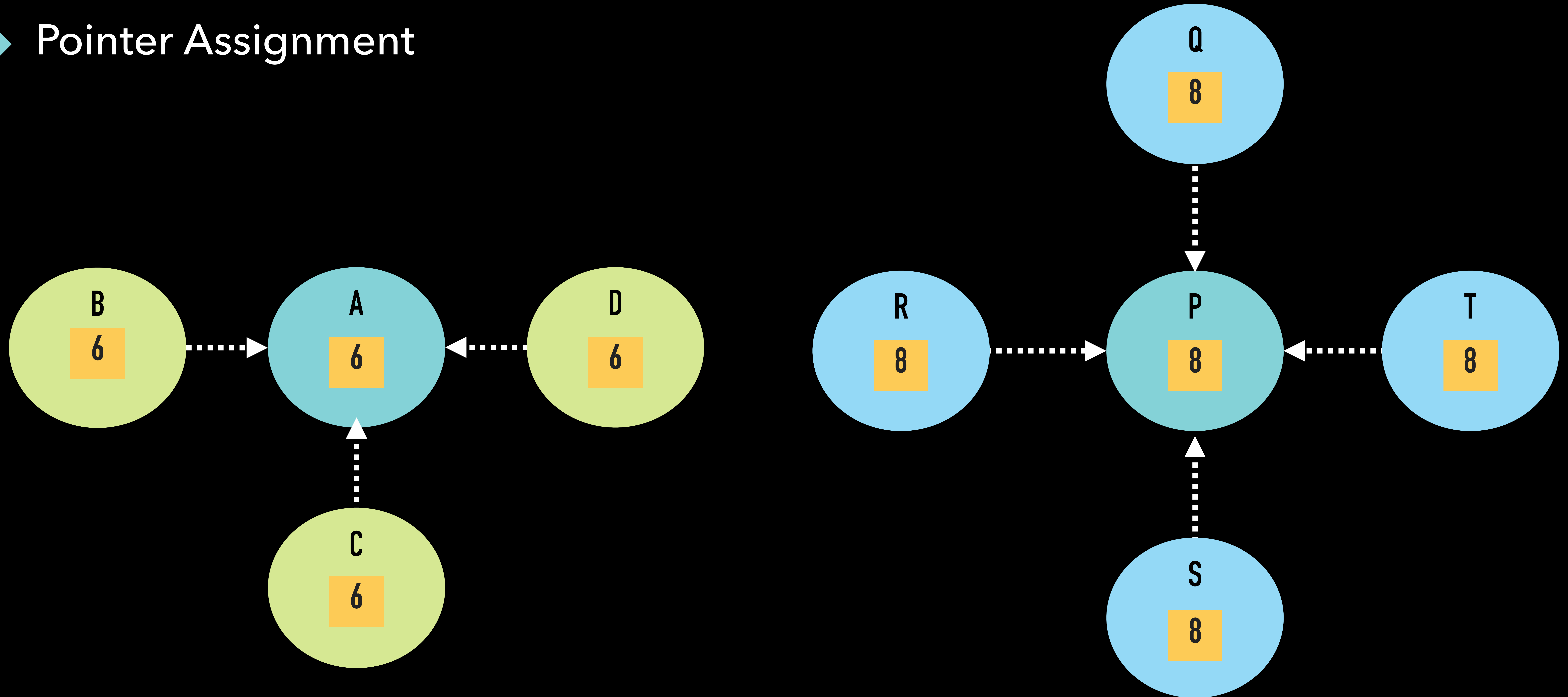
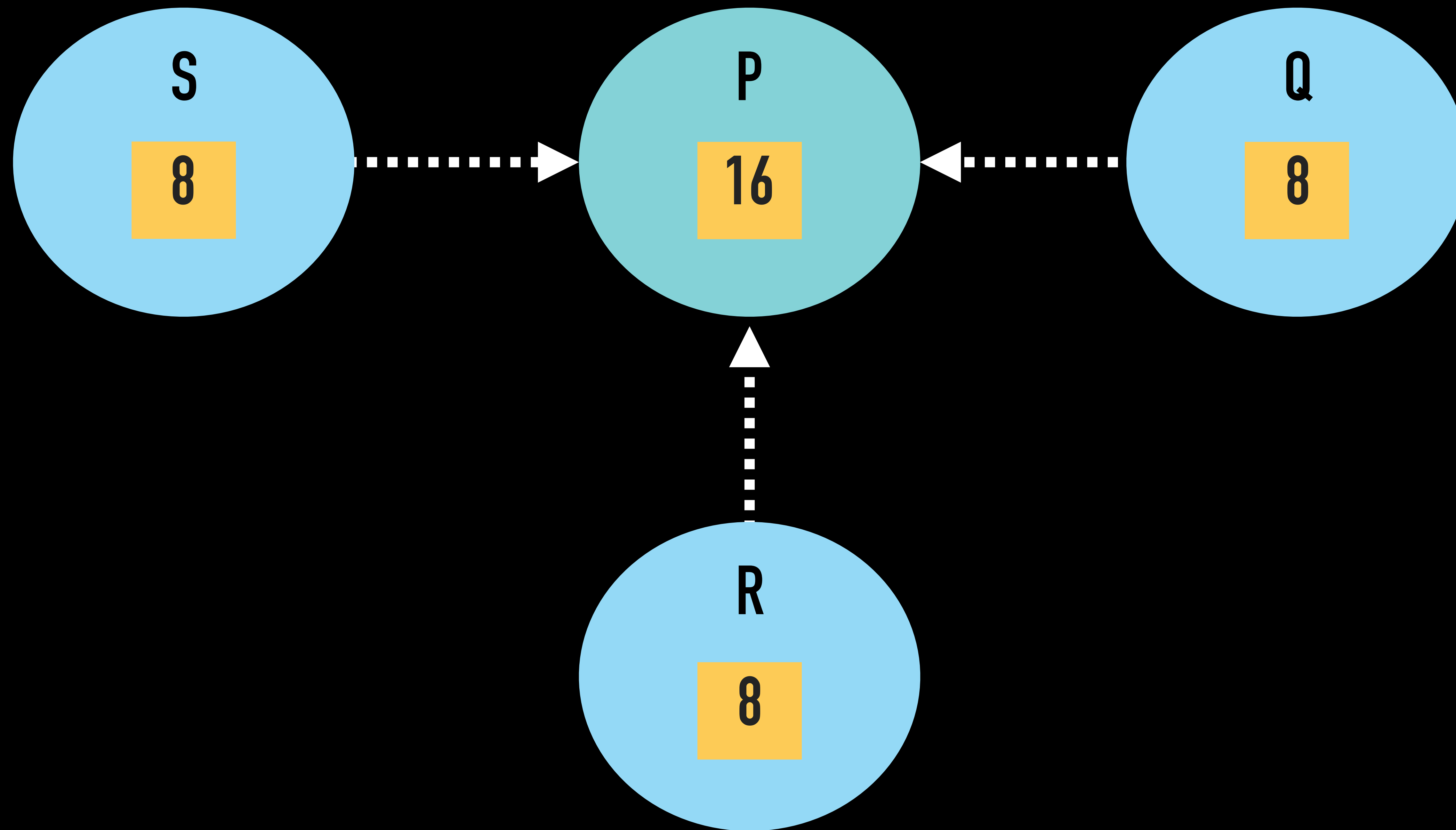


POINTER ALIASING PROBLEM

- Write to memory



p[i]/q[i]/r[i]/s[i] = x;

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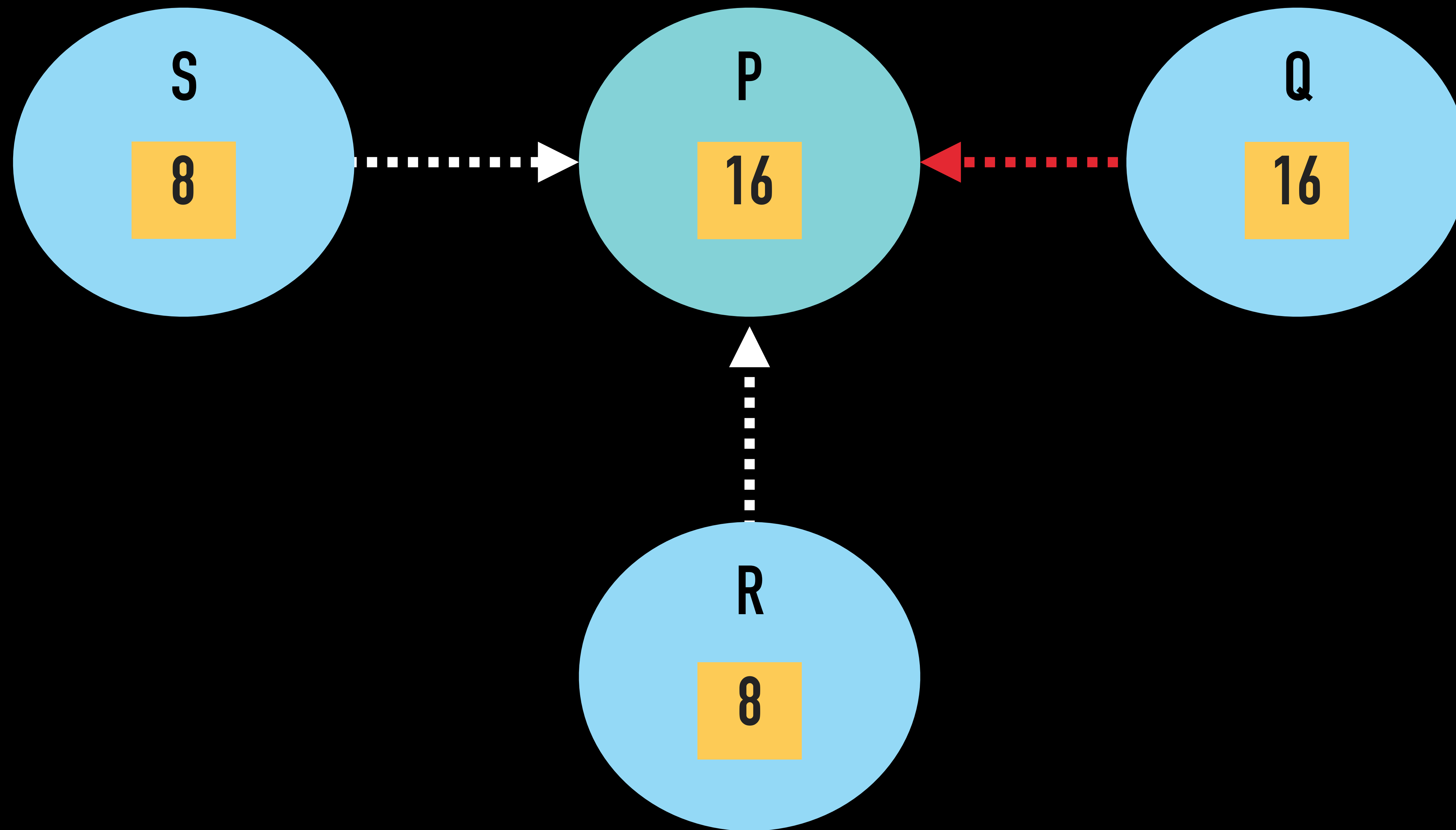

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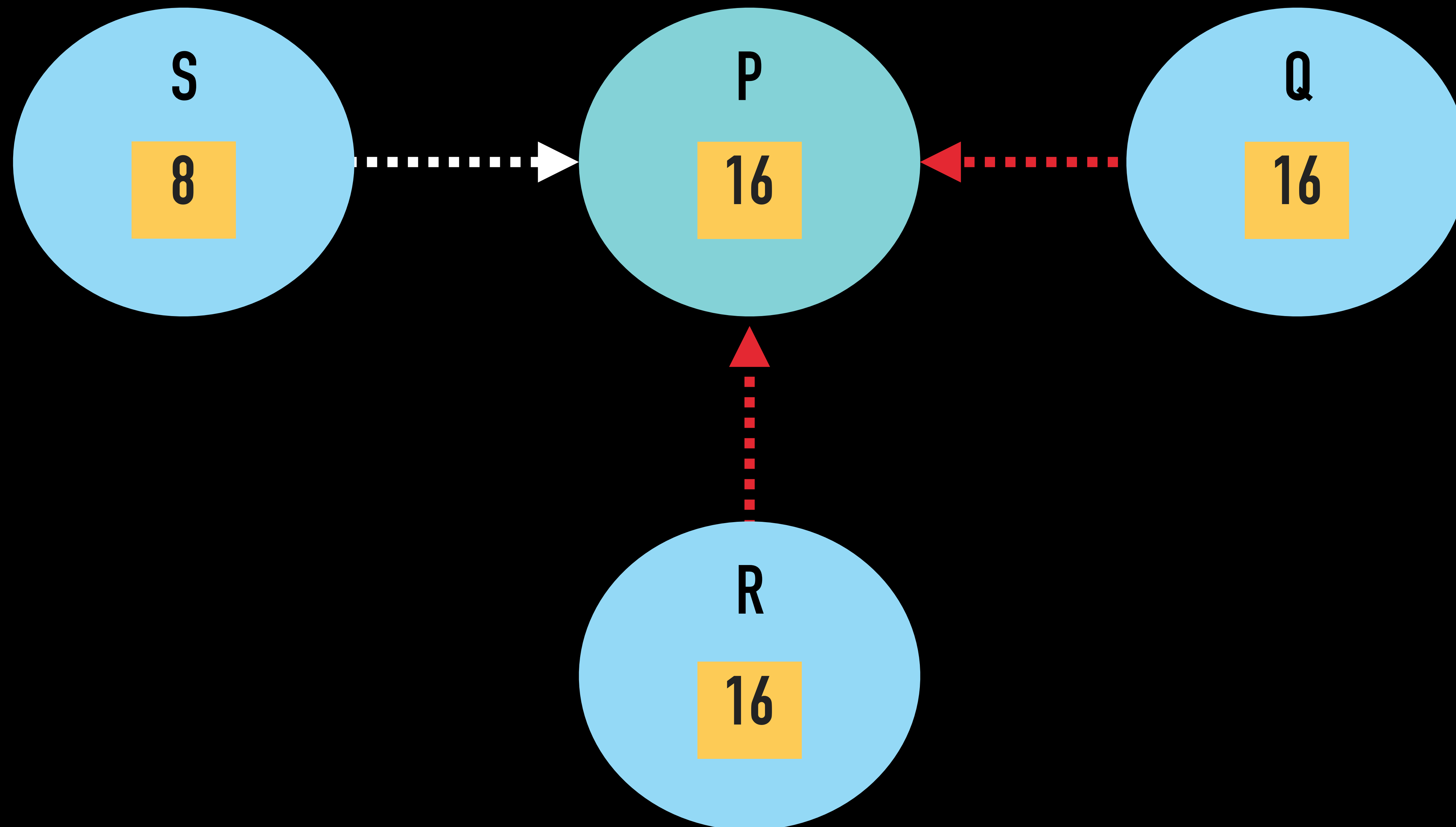

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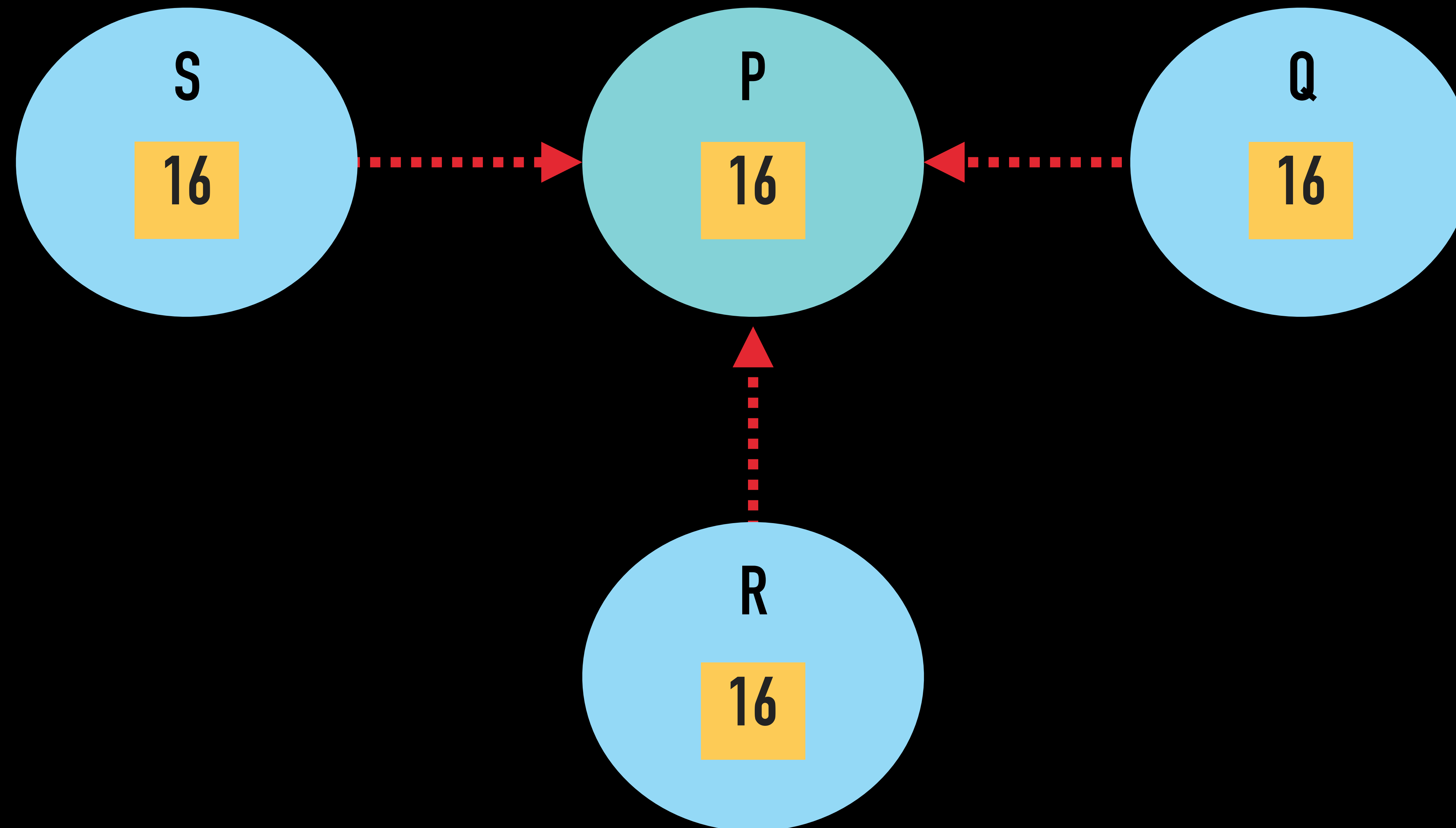

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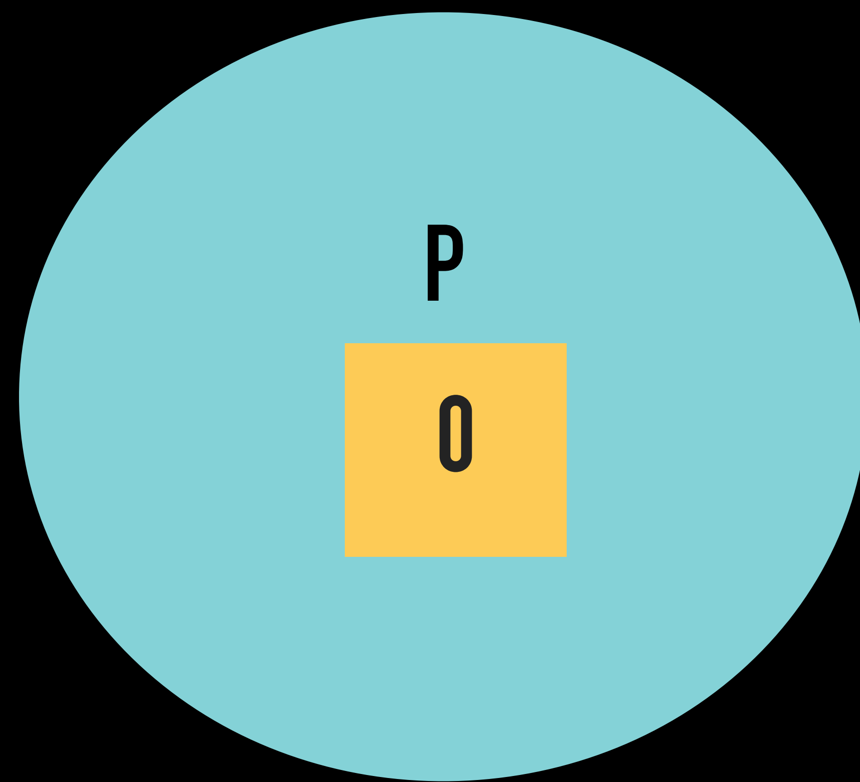
POINTER ALIASING PROBLEM

- Free Memory



The call to free() function can just be skipped

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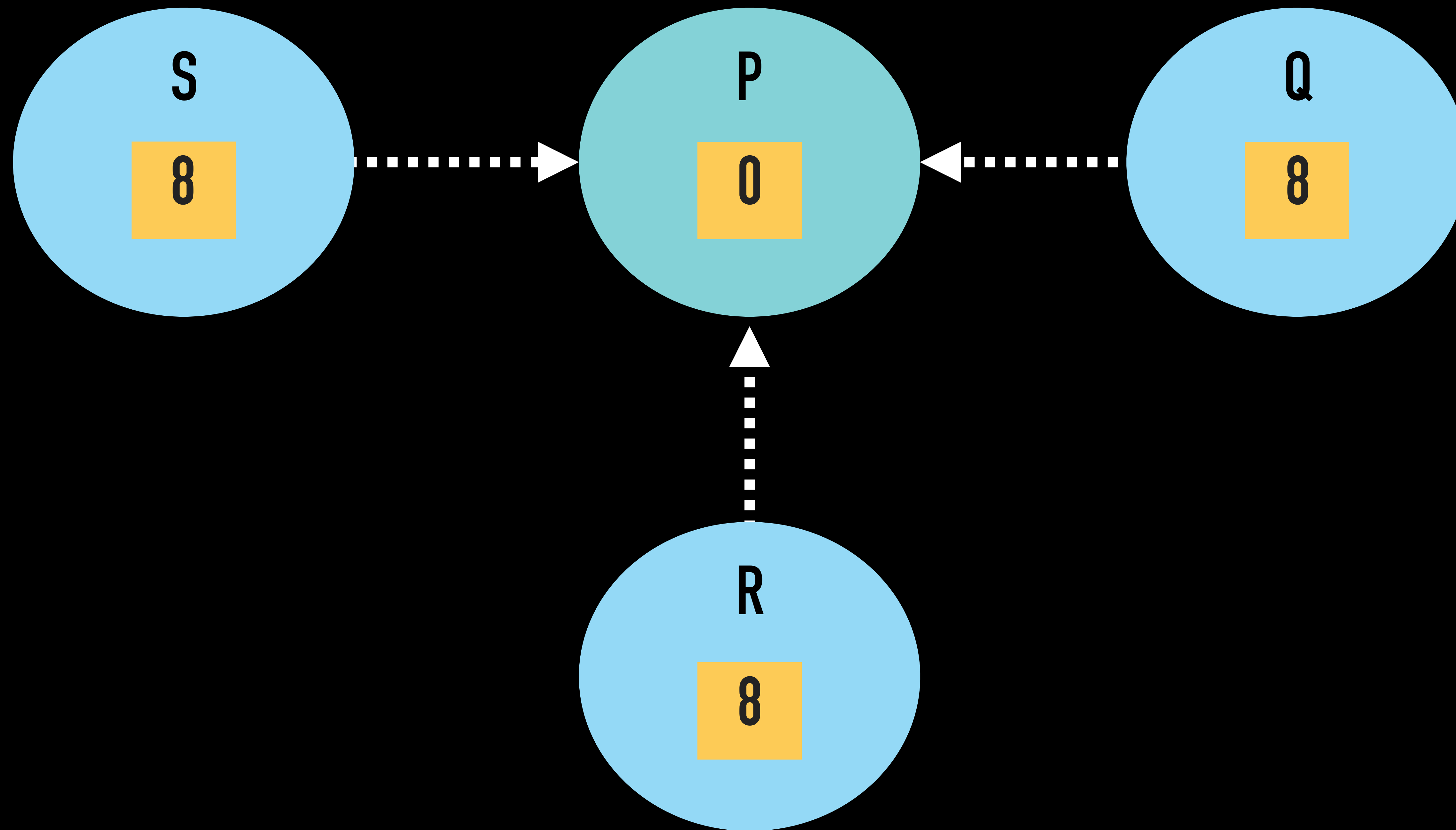

free(p/q/r/s);

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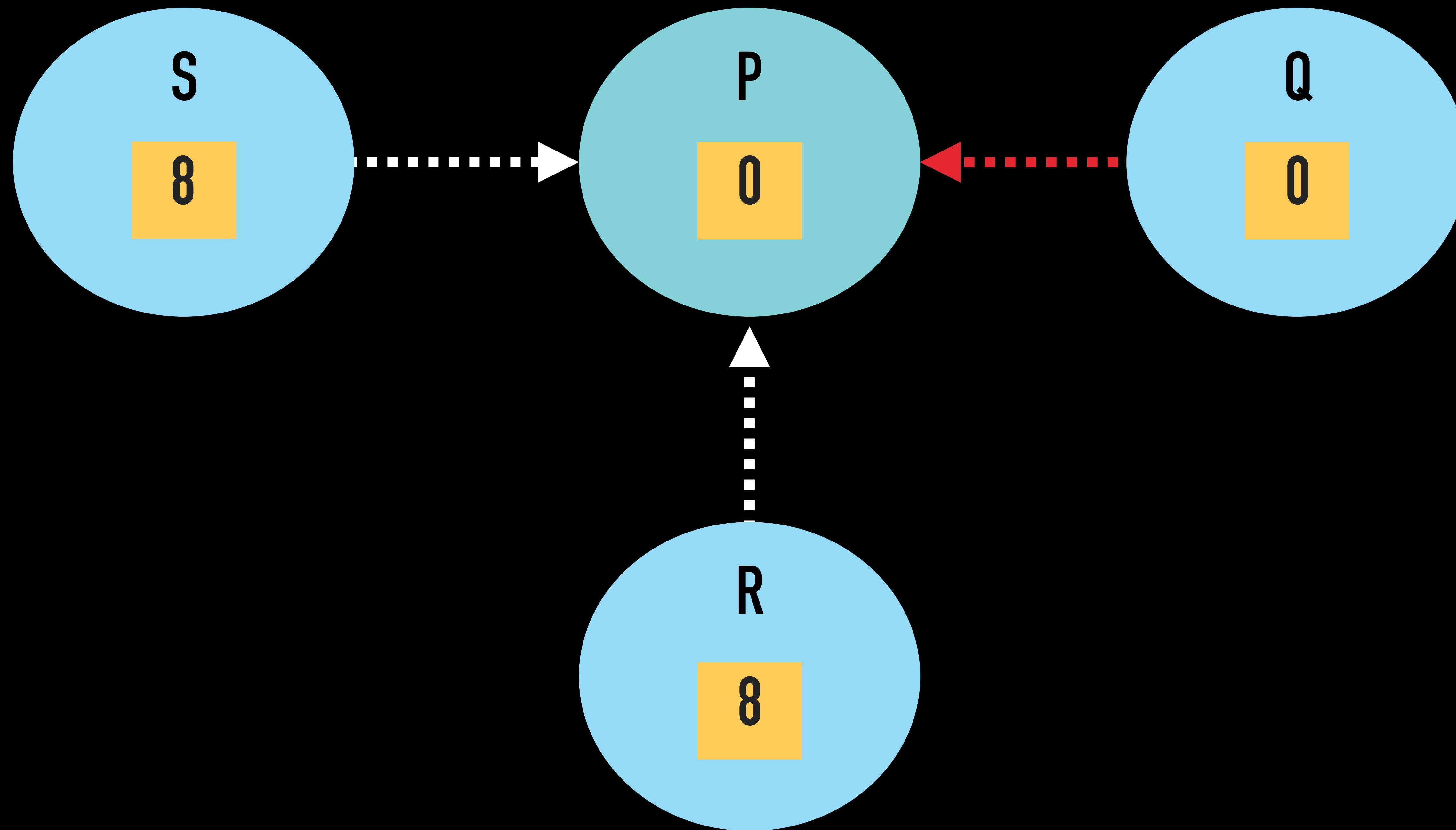

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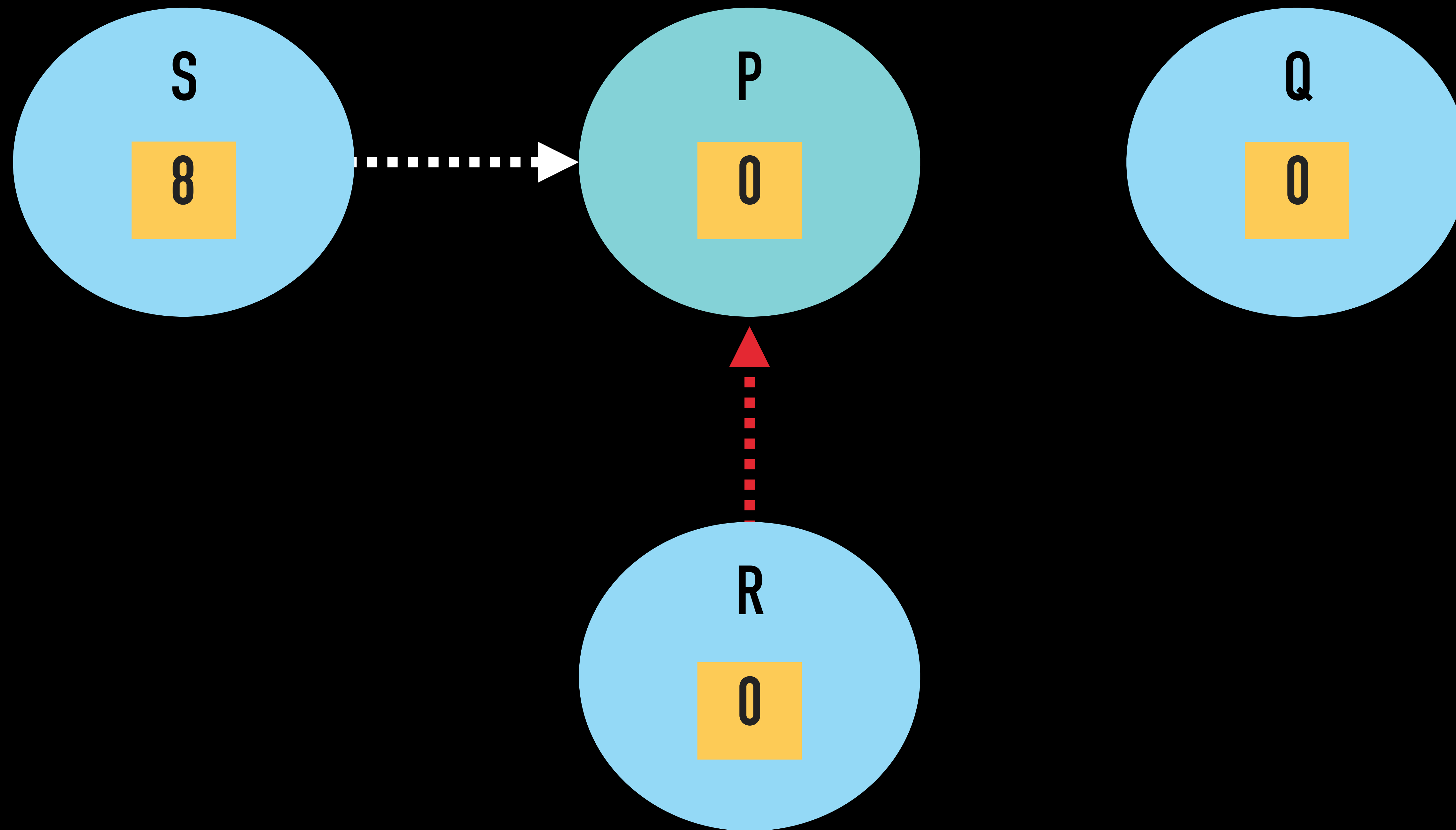

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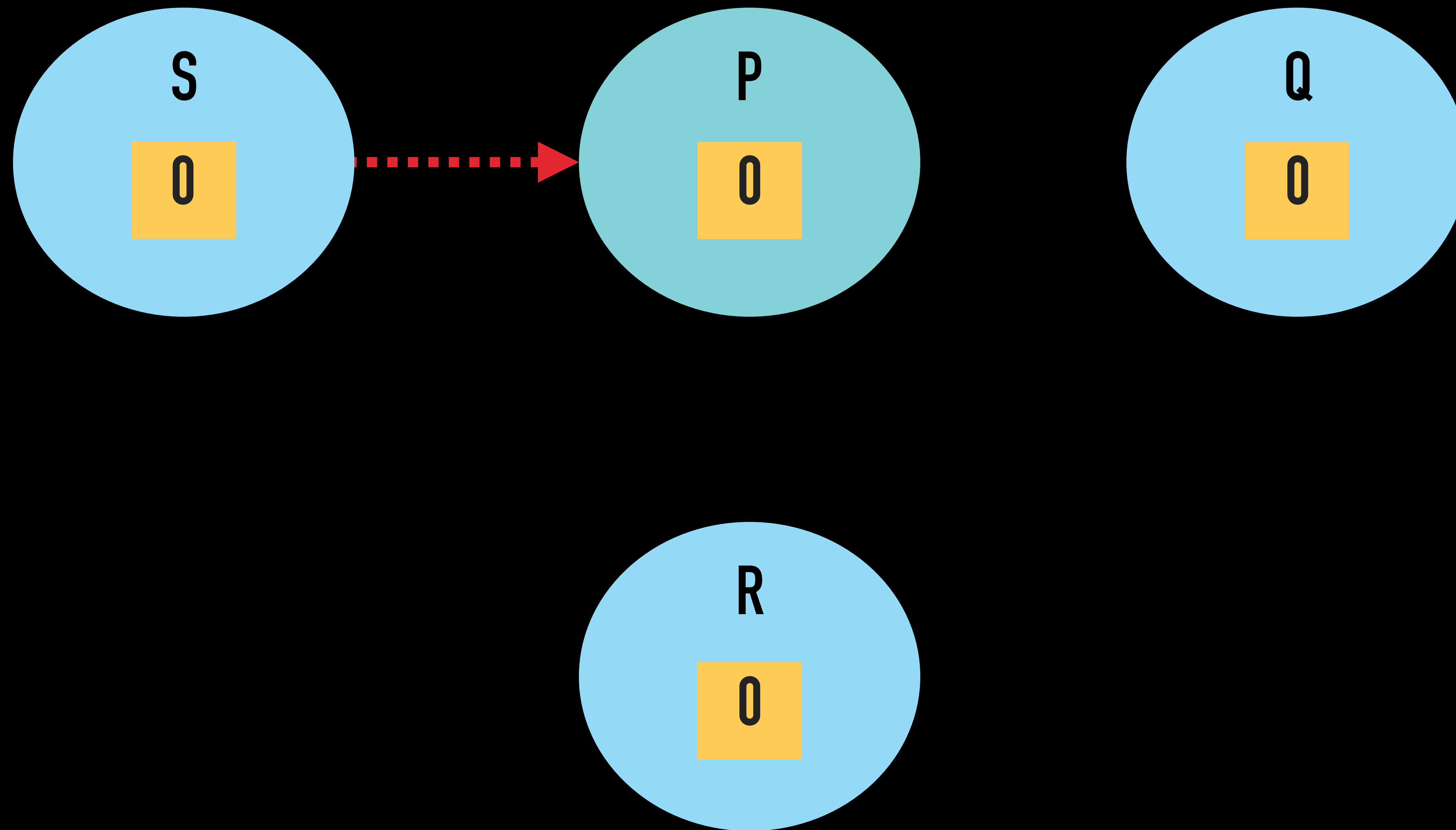

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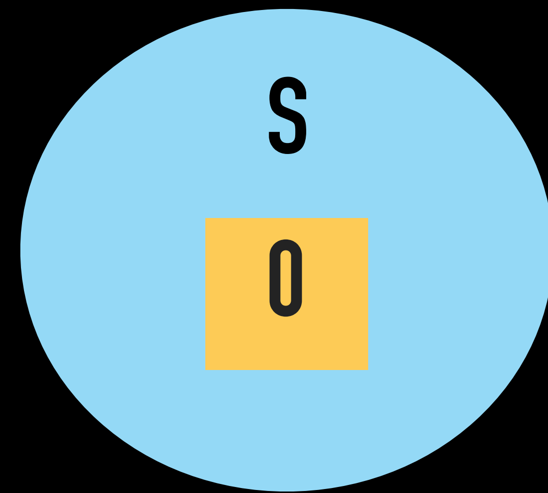

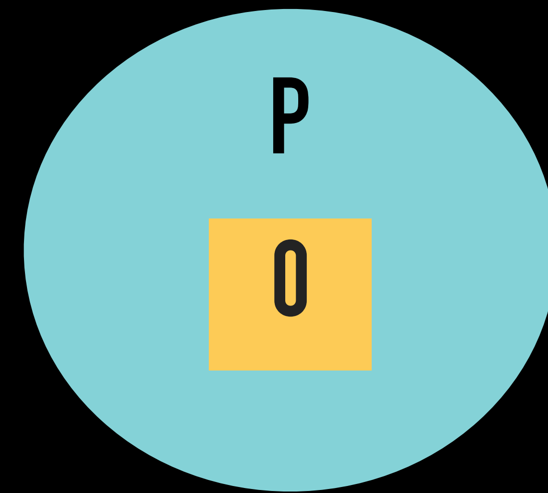

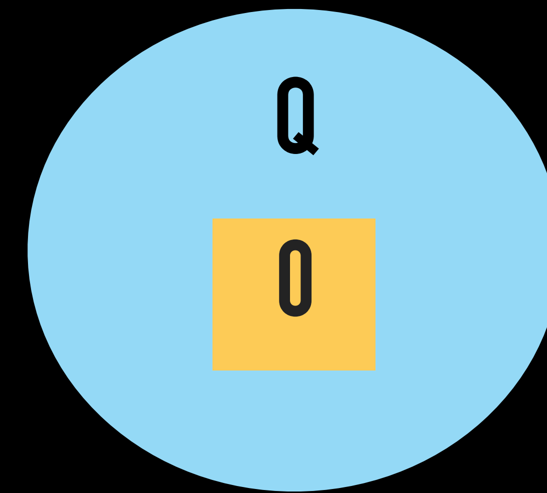

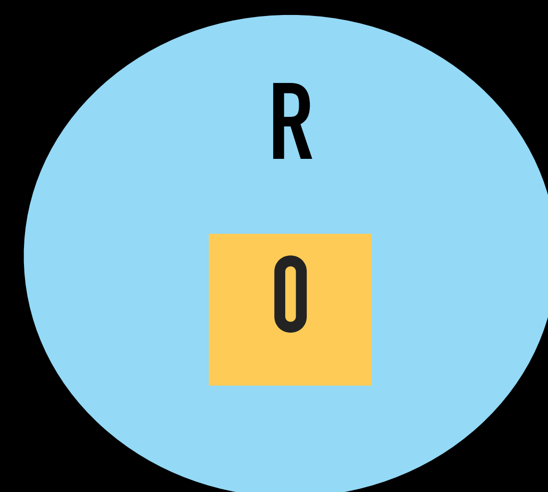

free(p/q/r/s);

OPTIMIZATIONS

- **Live Variable Analysis**
  - Calculates variables which are live at each point
  - Aids to reduce the number of pointers to deal with
  - Substantial improvements in large monolithic function programs

CONCLUSION + FUTURE WORK

- Legacy code can be safely reused
- Buffer-overflow attacks can be eradicated by dynamically expanding memory during run-time
- Can devise a mechanism for inter function memory communication
- Use-after-free, Invalid free, Double free errors can also be mitigated

Thank You!