Pointers II

CS143: lecture 8

Konstantinos Ameranis, July 2

Characters and numbers

Command line arguments

Review

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int main(int argc, char *argv[])
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- `argc` — Argument count

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    2. Using `stdlib.h`

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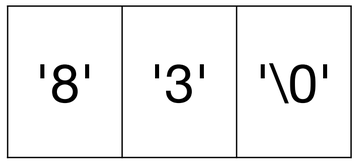
- How to turn string command line arguments to numbers
- Three ways
    1. Pure C, working with ASCII
    2. Using `stdlib.h`
    3. Using `stdio.h`

Strings to numbers

Pure C

*char int

- "83" → 83
- "83" → 

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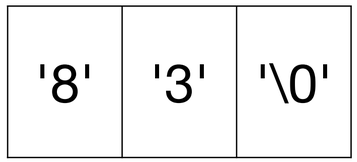
- "83" → 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int digit = '8' - '0';
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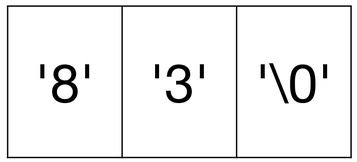
- "83" → 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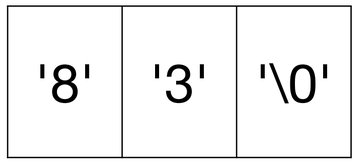
- "83" → 


```
int digit = '8' - '0';
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- By subtracting `'0'` from the character, you can recover the digit
- 83 = 8 * 10 + 3

Strings to numbers

Pure C

```
// Alphanumeric to integer
int atoi(const char *s) {
    int number = 0;
    for (int i = 0; s[i] != '\0'; i++) {
        int digit = s[i] - '0';
        if ((digit < 0) || (digit > 9)) {
            // This is not a valid integer string
            // ??? Error handling?
        }
        number = number * 10 + digit;
    }
    return number;
}
```

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Strings to numbers

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Strings to numbers

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- What should you do if there is an error?

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2. `int atoi(const char *s, int &errno);` → Pass a reference to return an error code (if applicable) → Too cumbersome and ugly

Strings to numbers

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if ((digit < 0) || (digit > 9)) {
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- What should you do if there is an error?

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3. Global `errno` that is set when appropriate

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Strings to numbers

Pure C

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- `errno` is an `enum`
- Different values signify different errors

```
#include <stdio.h>
#include <string.h>
#include <errno.h>
#include <stdlib.h>

int main(void){
    for (int i = 0; i < 134; i++) {
        printf("%3d: %s\n", i, strerror(i));
    }
    return EXIT_SUCCESS;
}
```

Strings to numbers

`stdlib.h`

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- Many different ways to write an integer

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  - `long long atoll(const char *s);` → Alphanumeric to long long

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  - `double atof(const char *s);` → Alphanumeric to float

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  - String → `sscanf`
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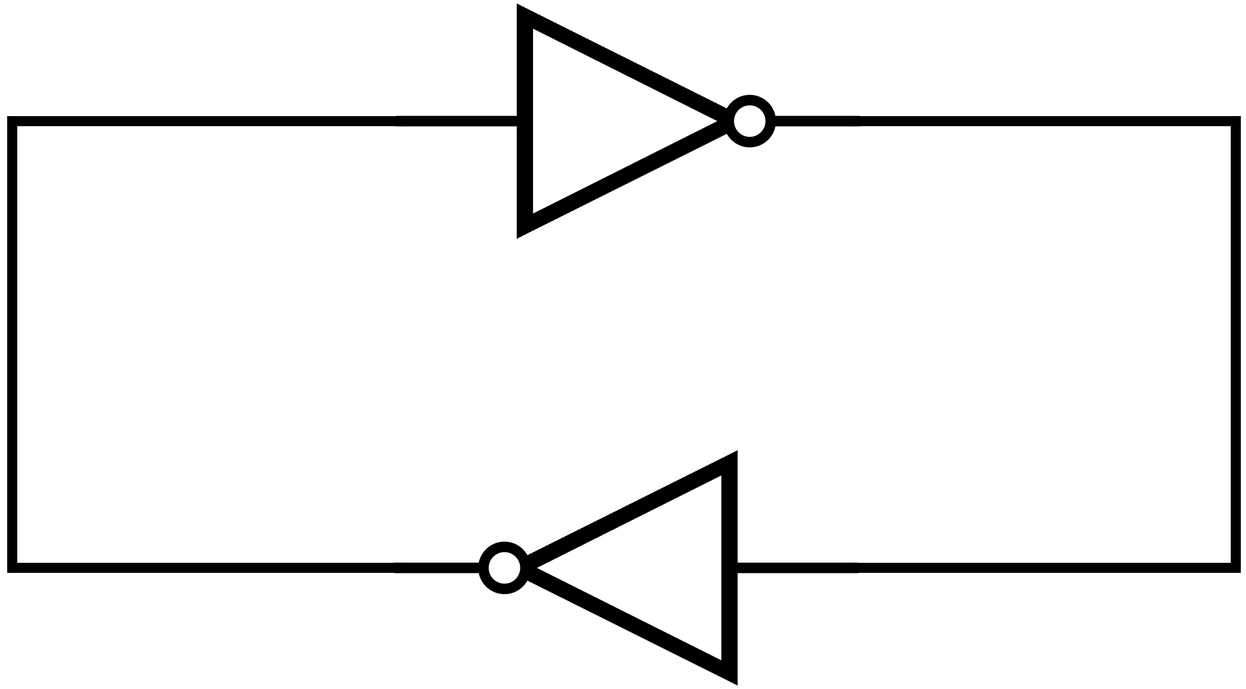
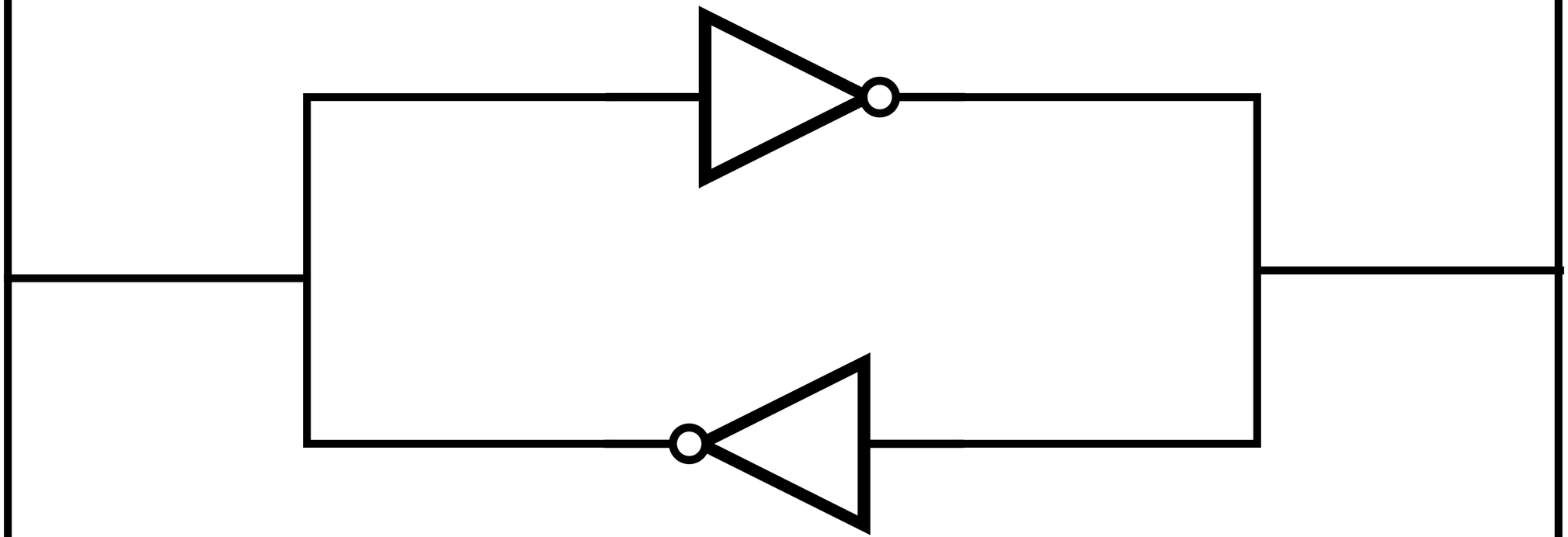
- `sscanf("354", "%d %d %d", &a, &b, &c) == 1`

Accessing Memory

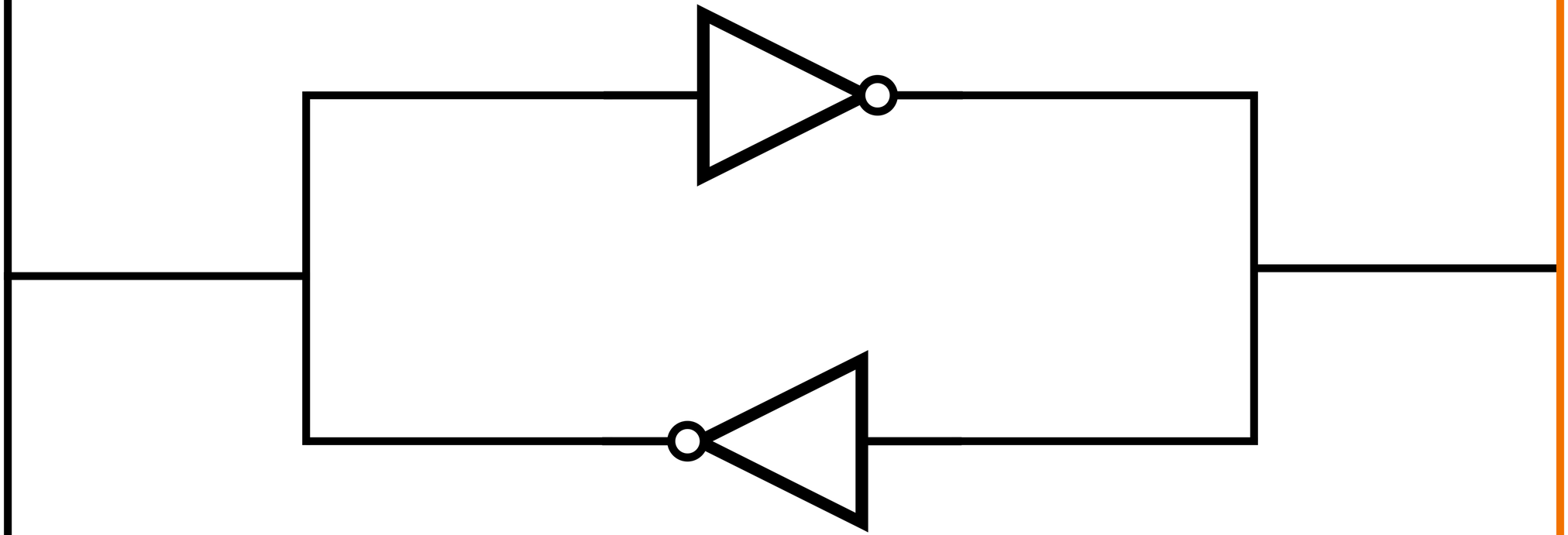
Flip-flop



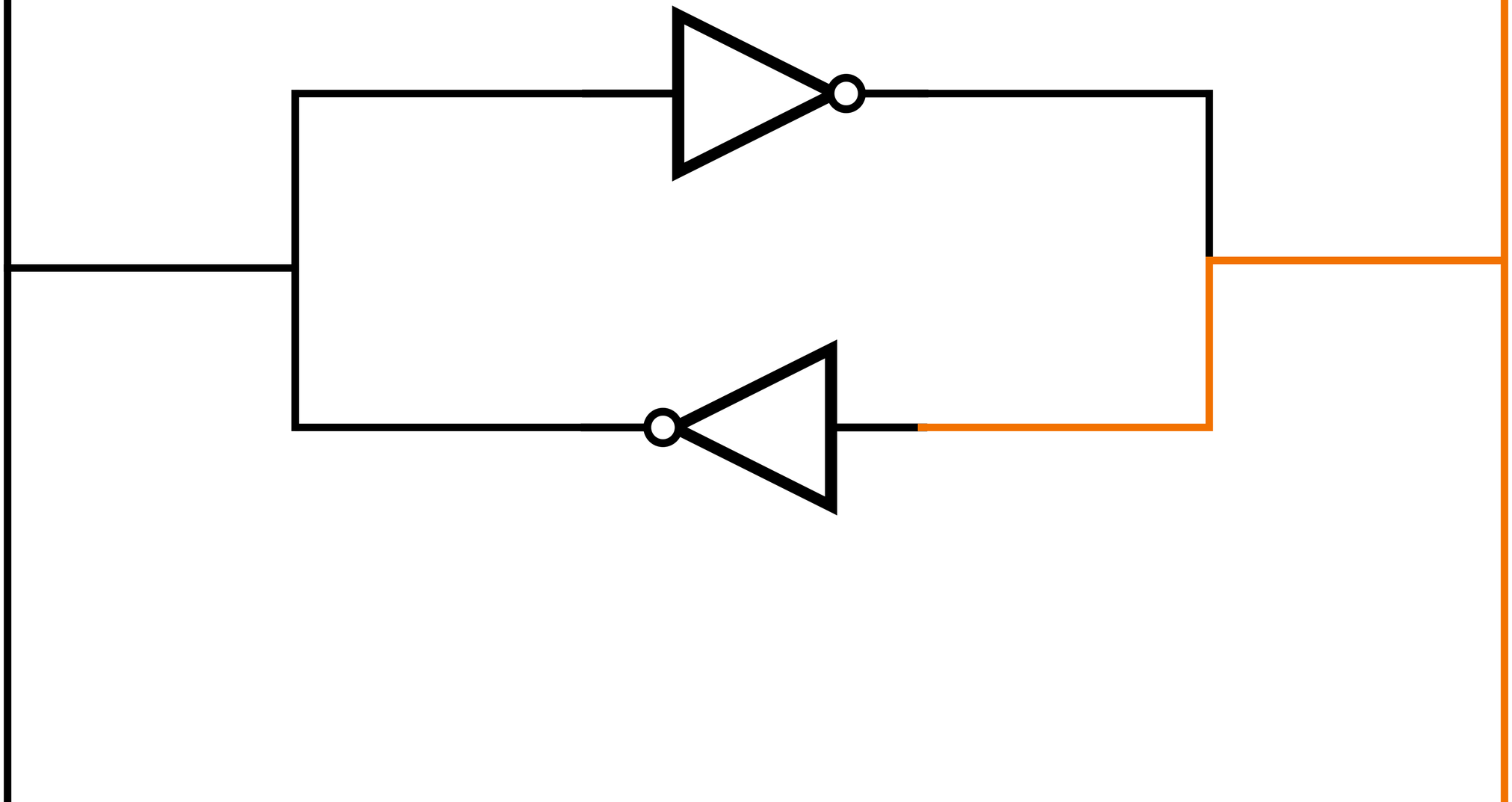
Flip-flop



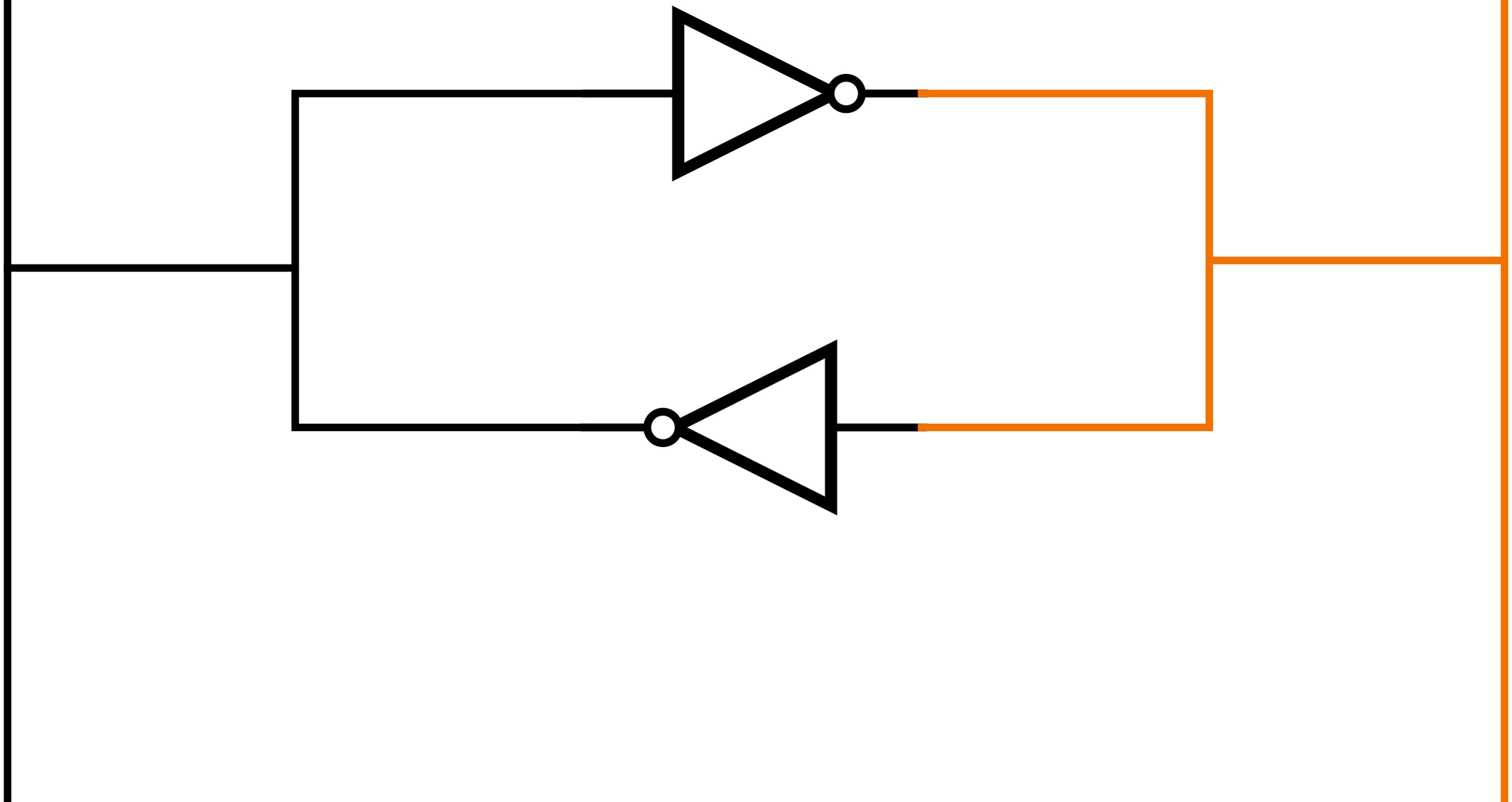
Flip-flop



Flip-flop



Flip-flop



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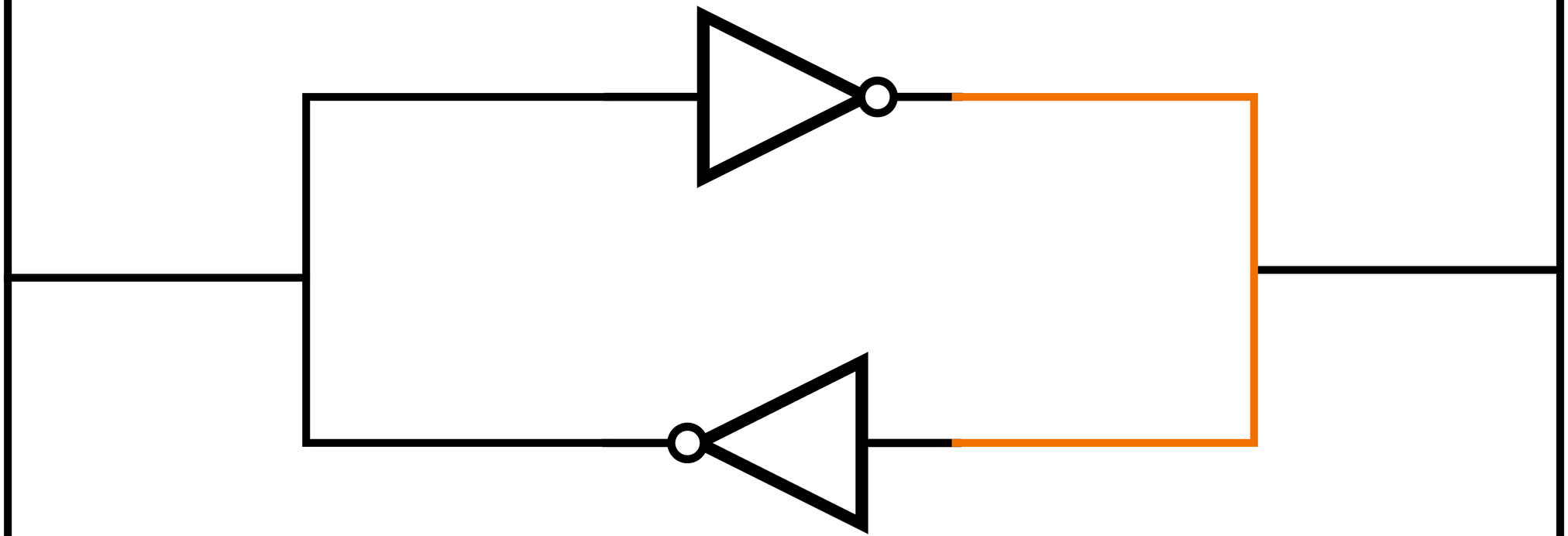

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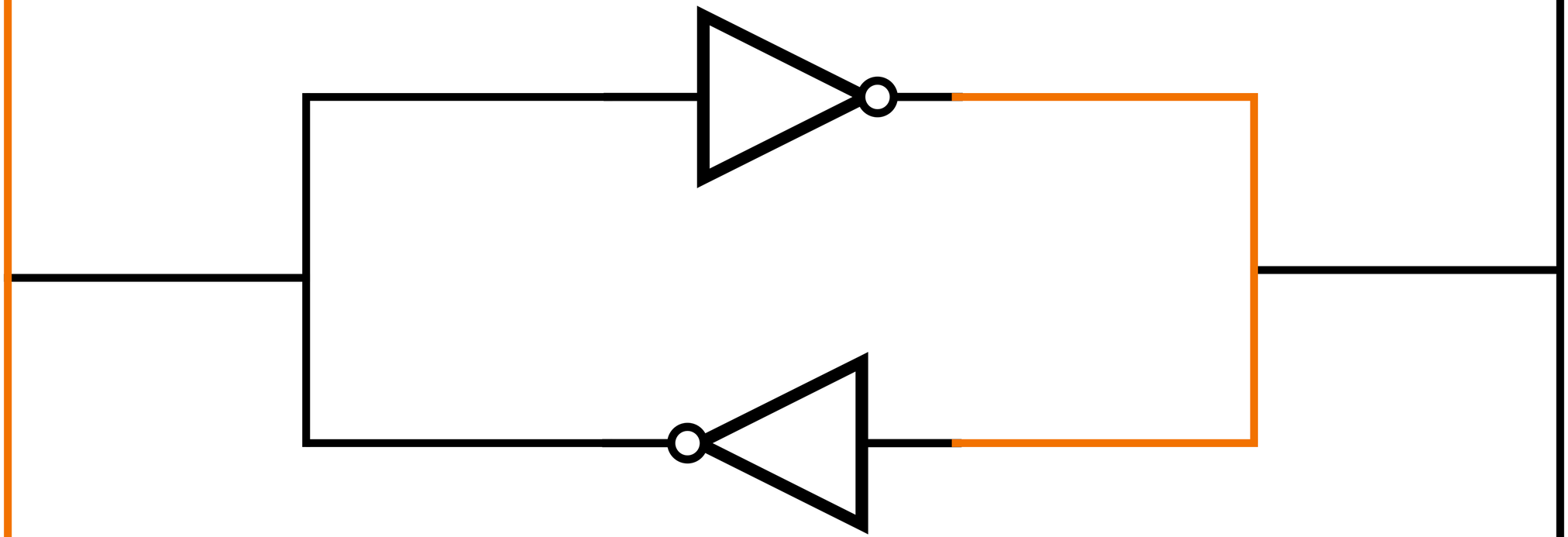

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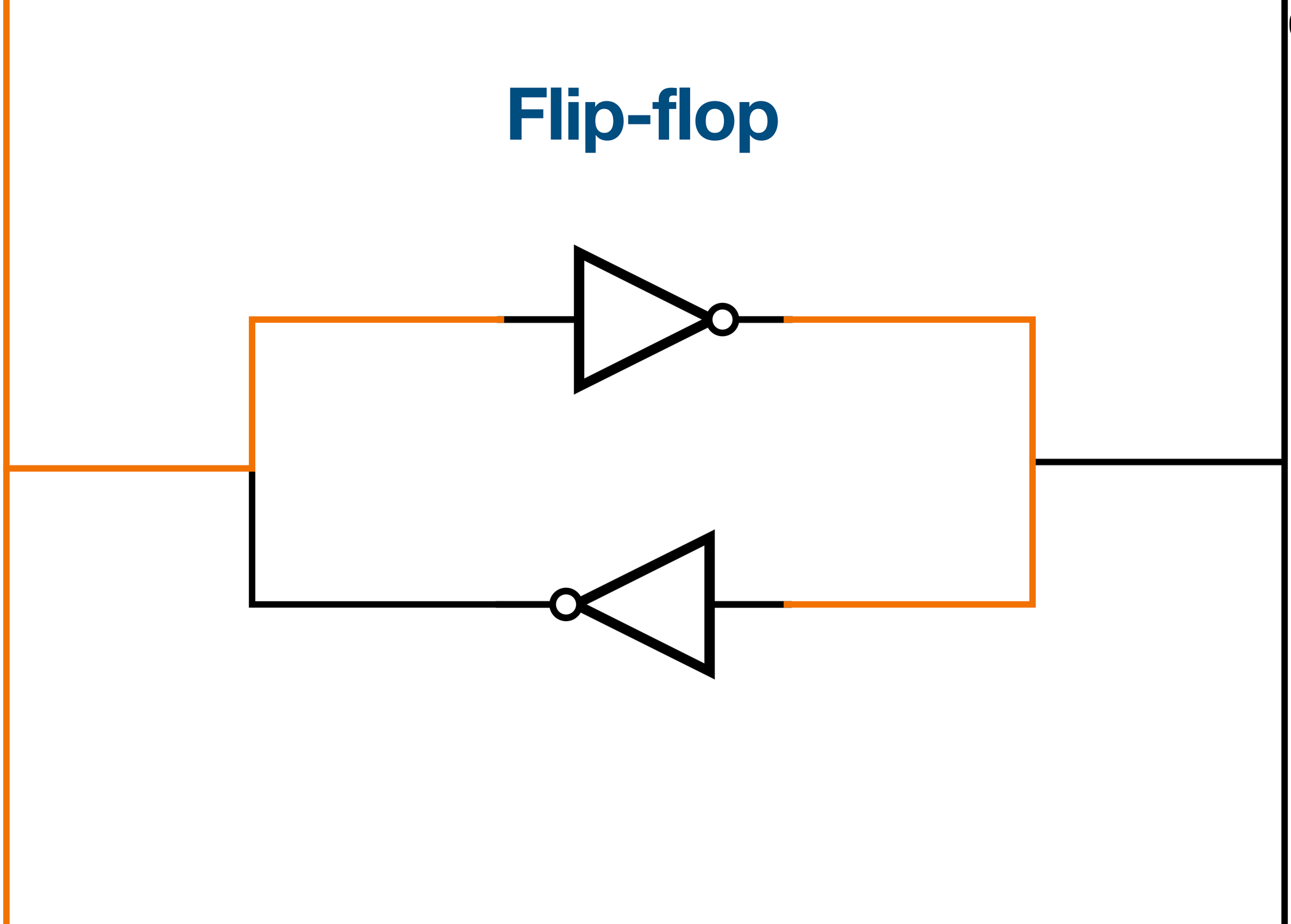

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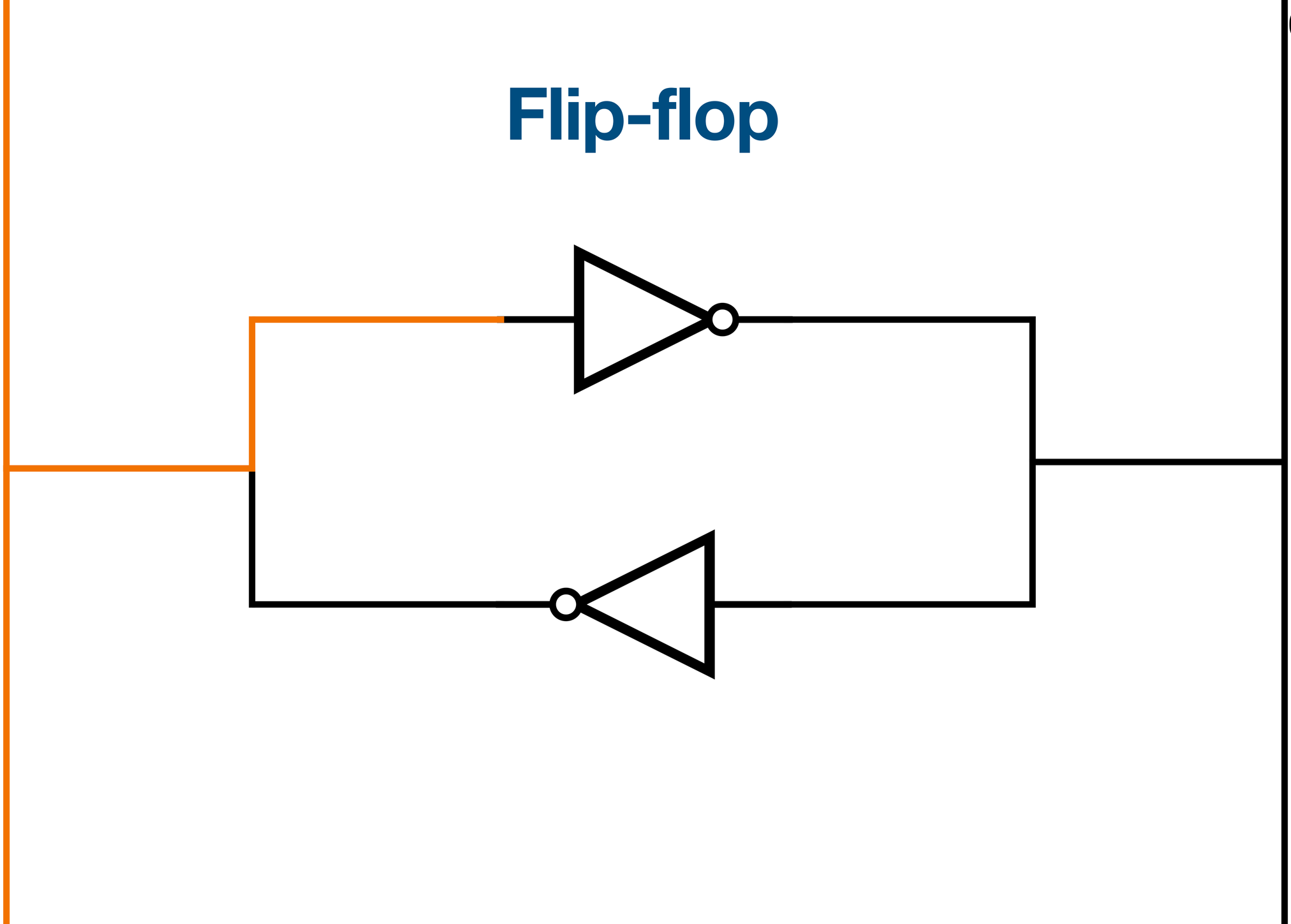

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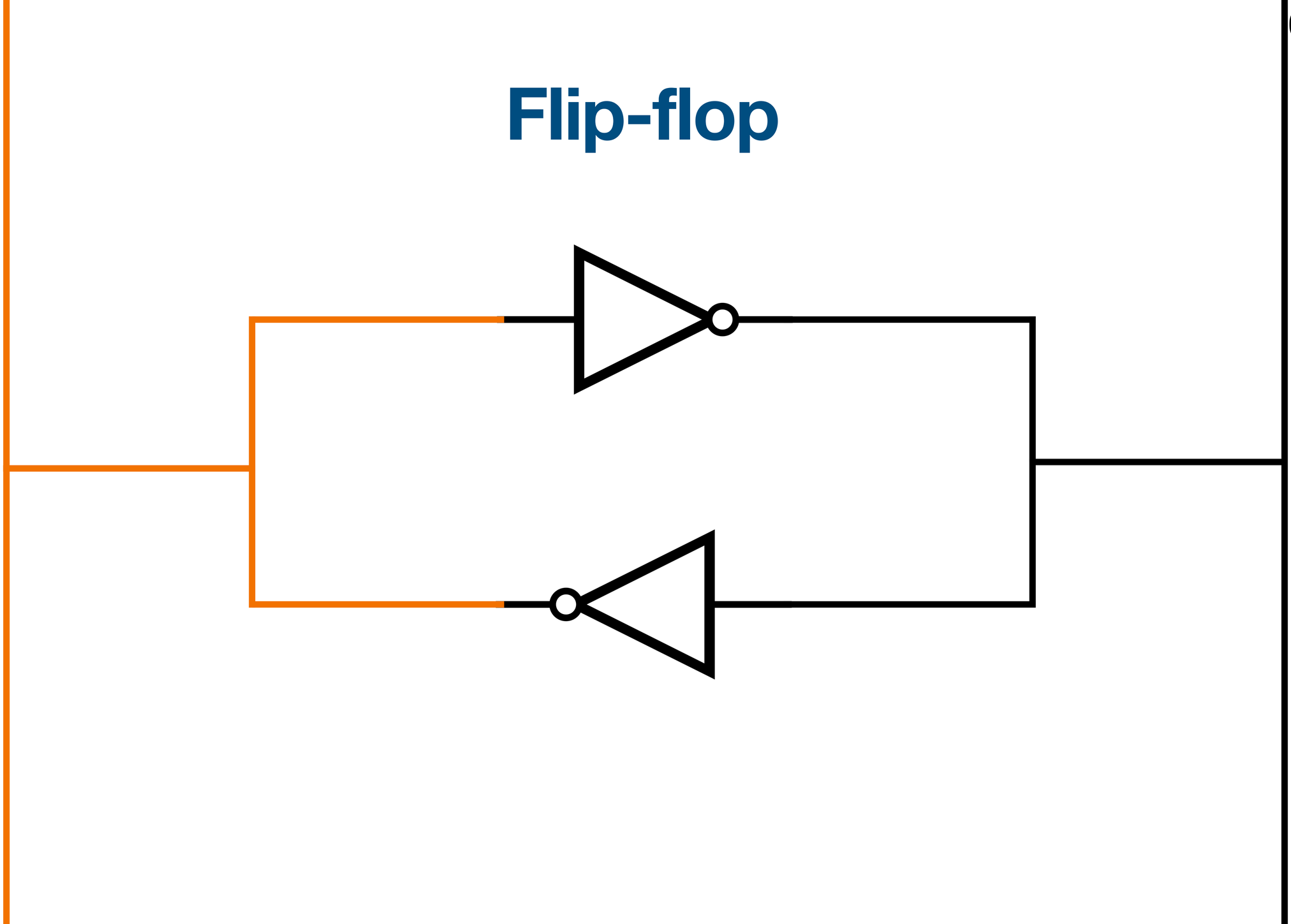

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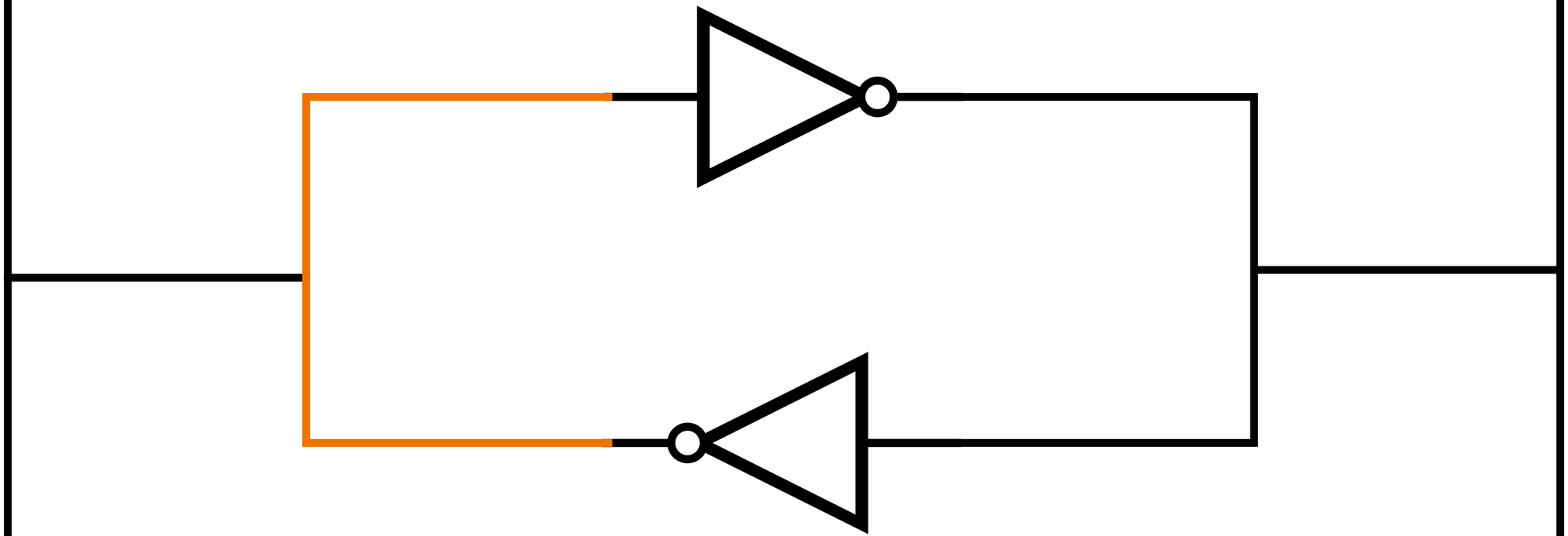

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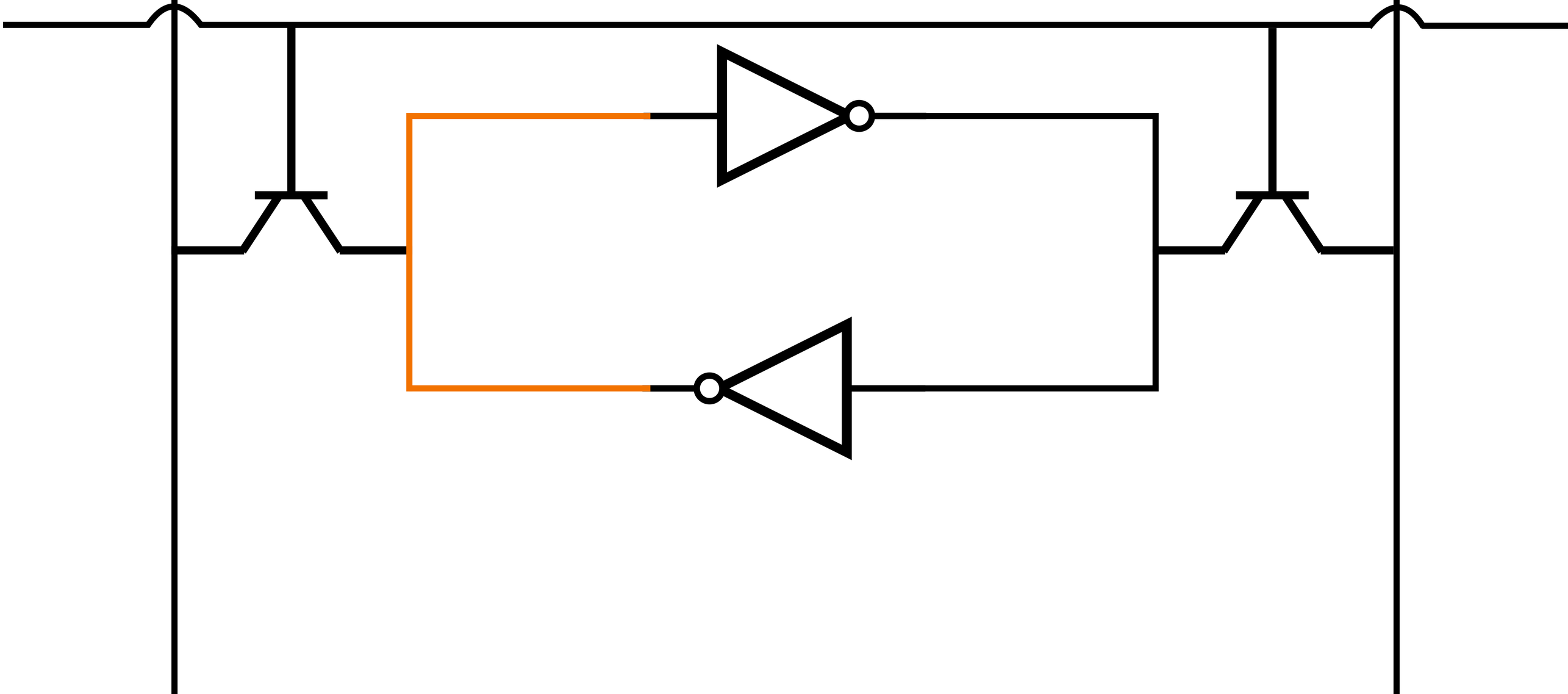
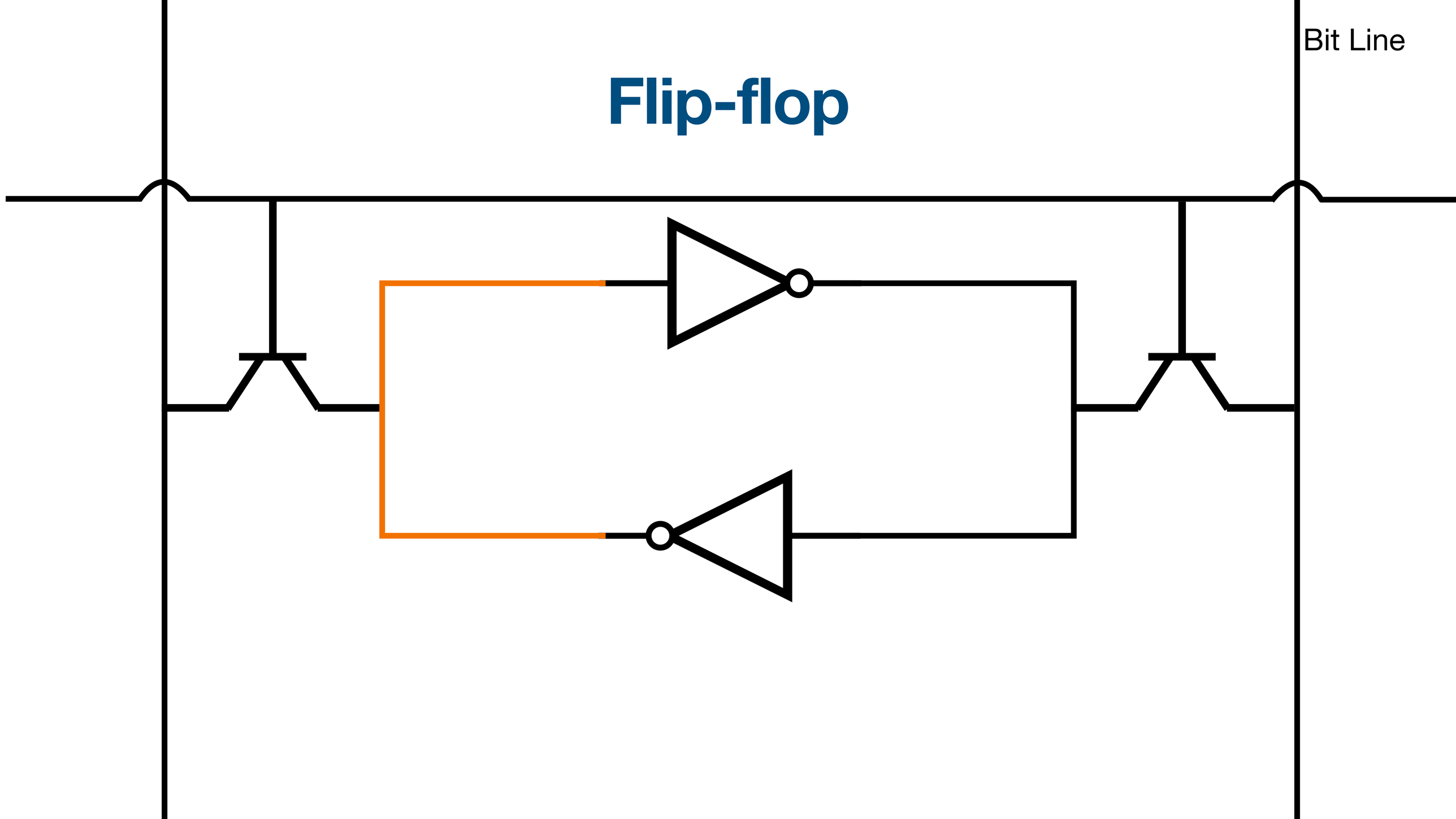


Flip-flop



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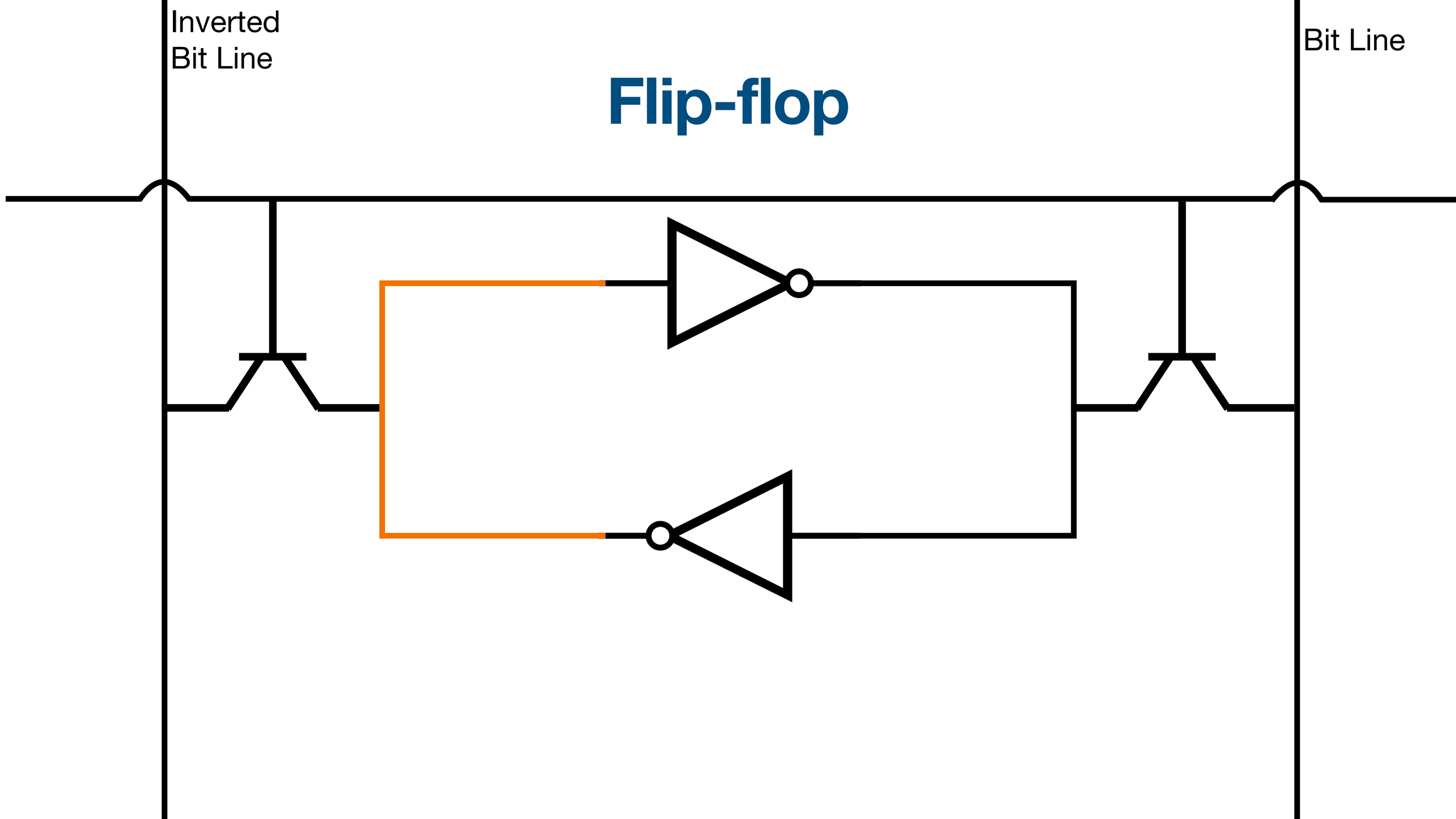

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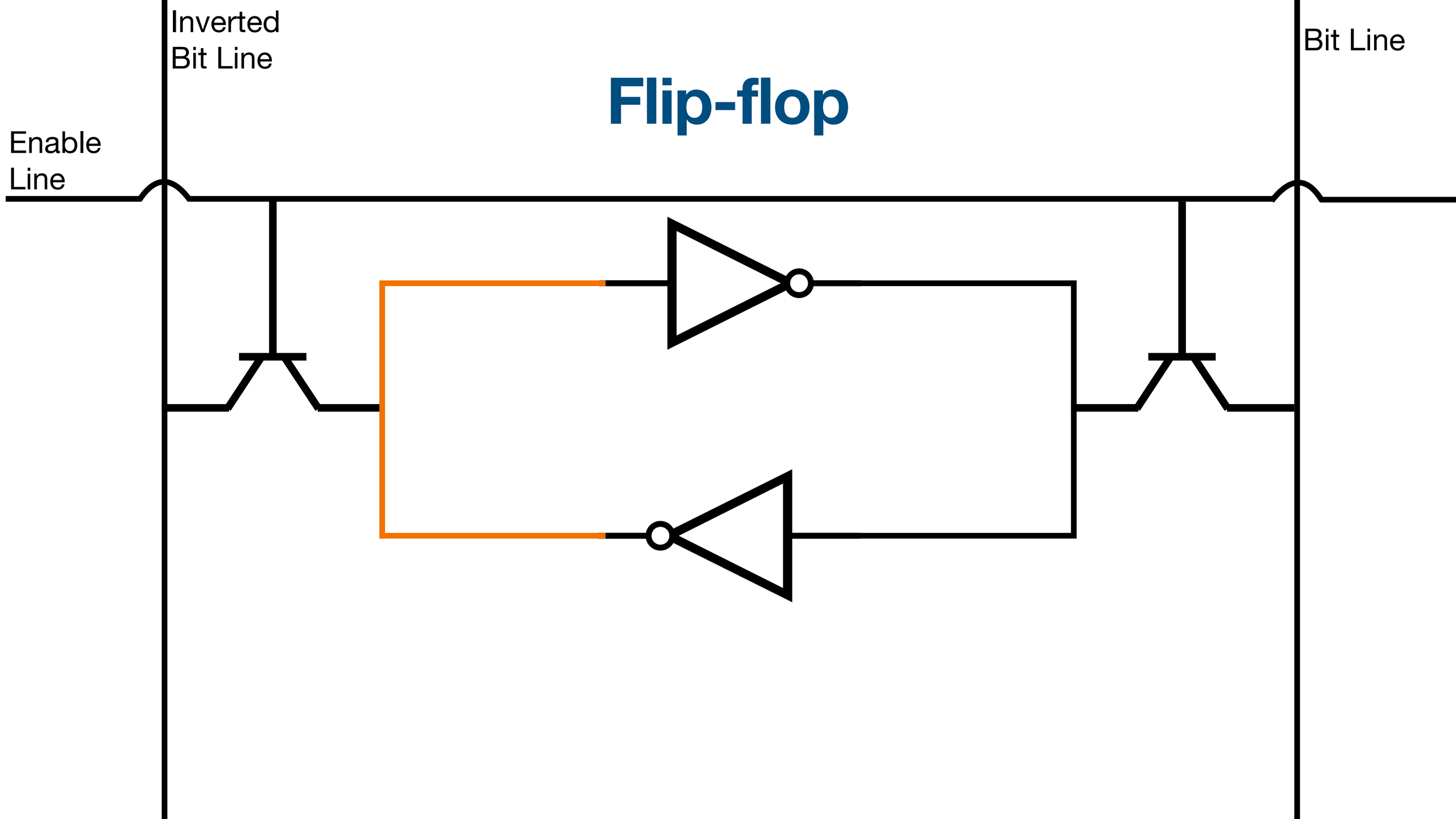

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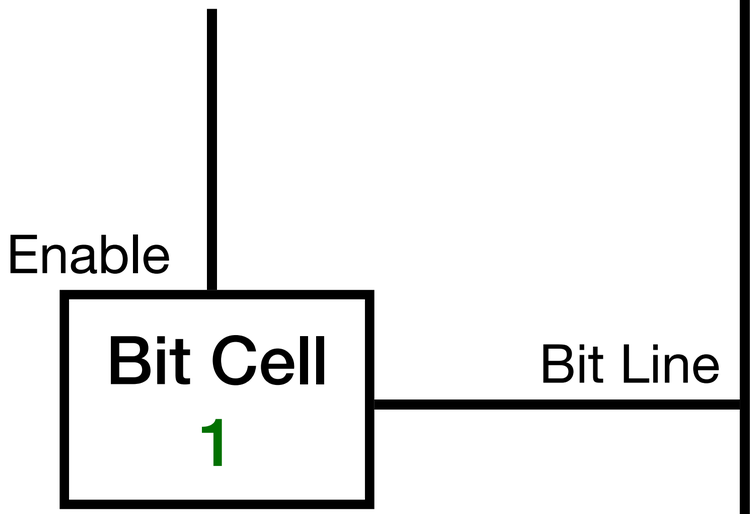

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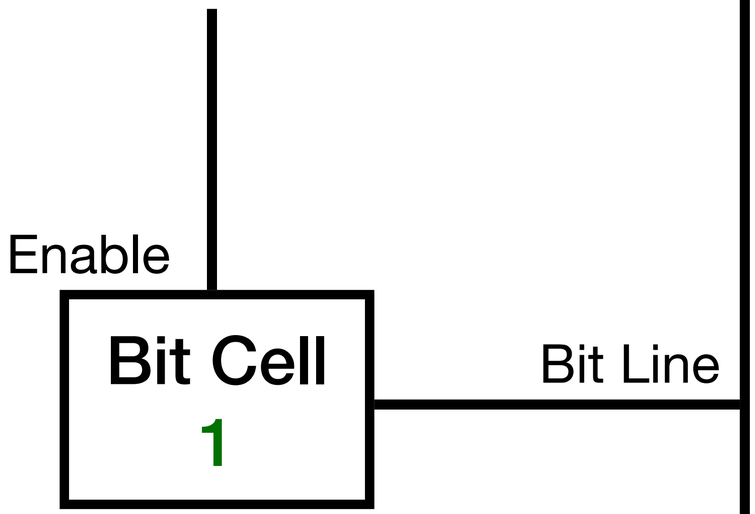

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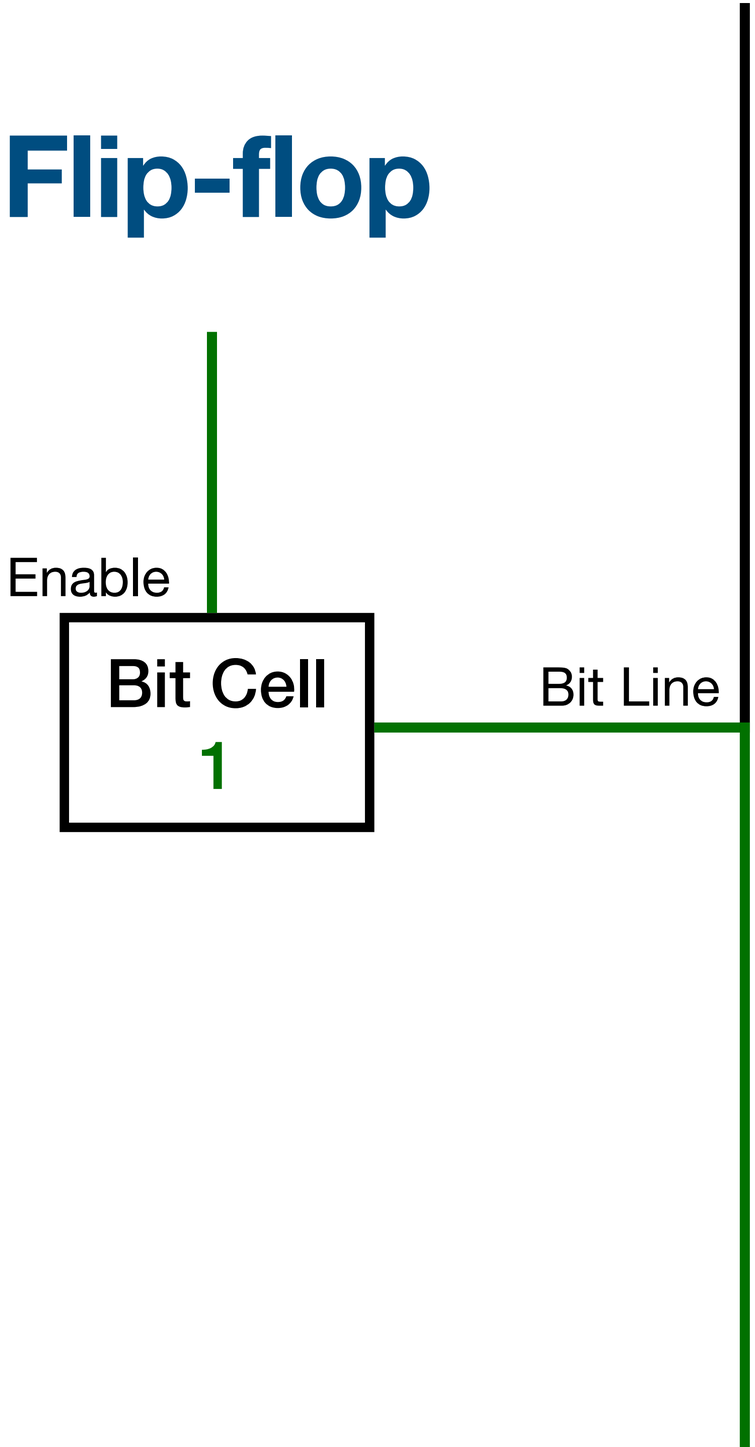

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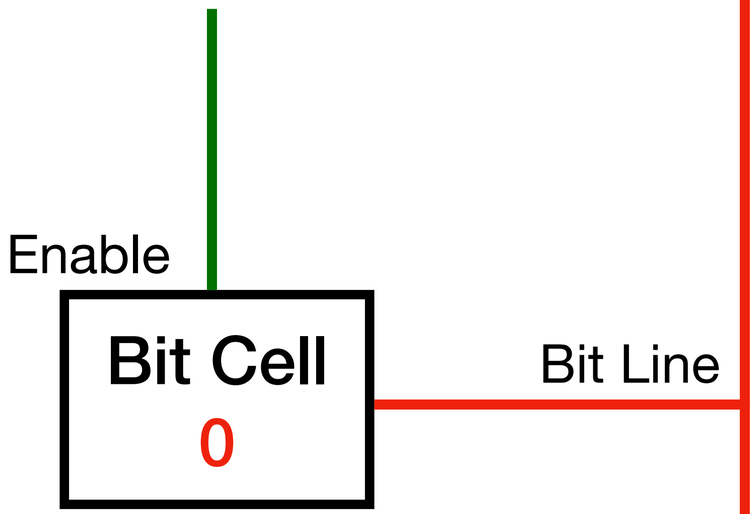

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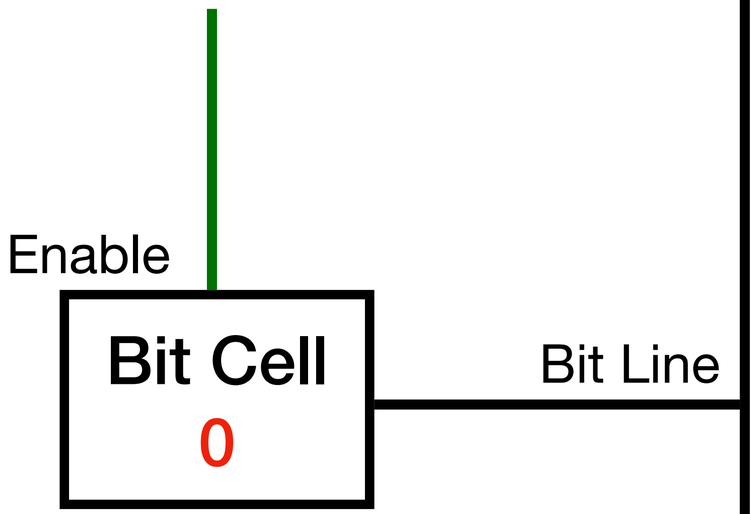

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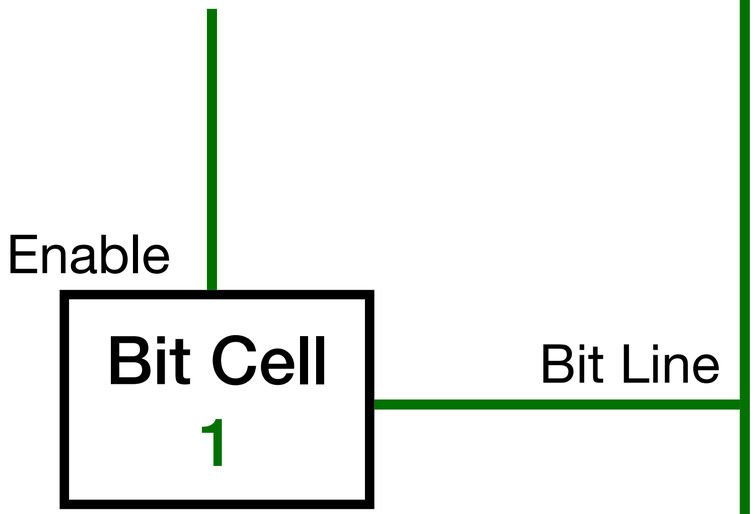
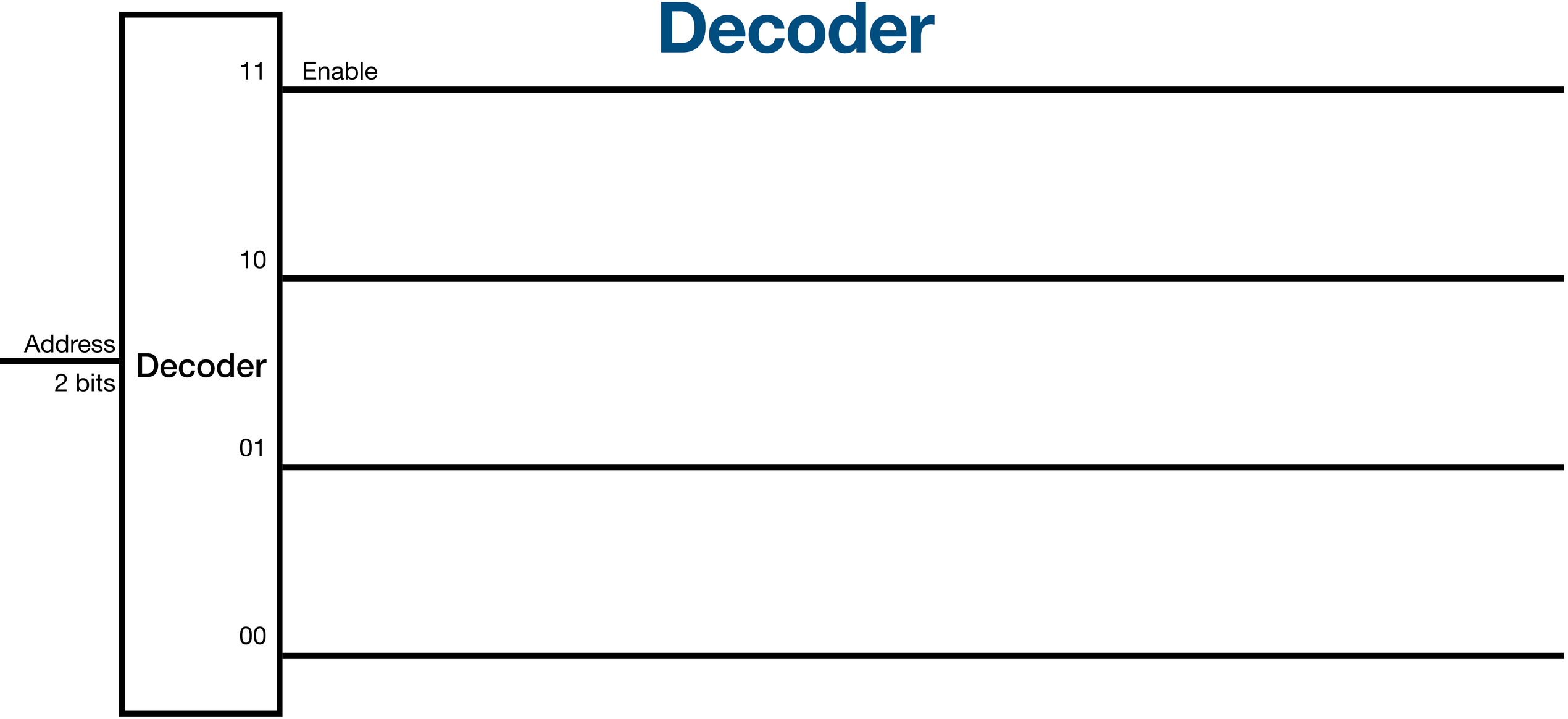
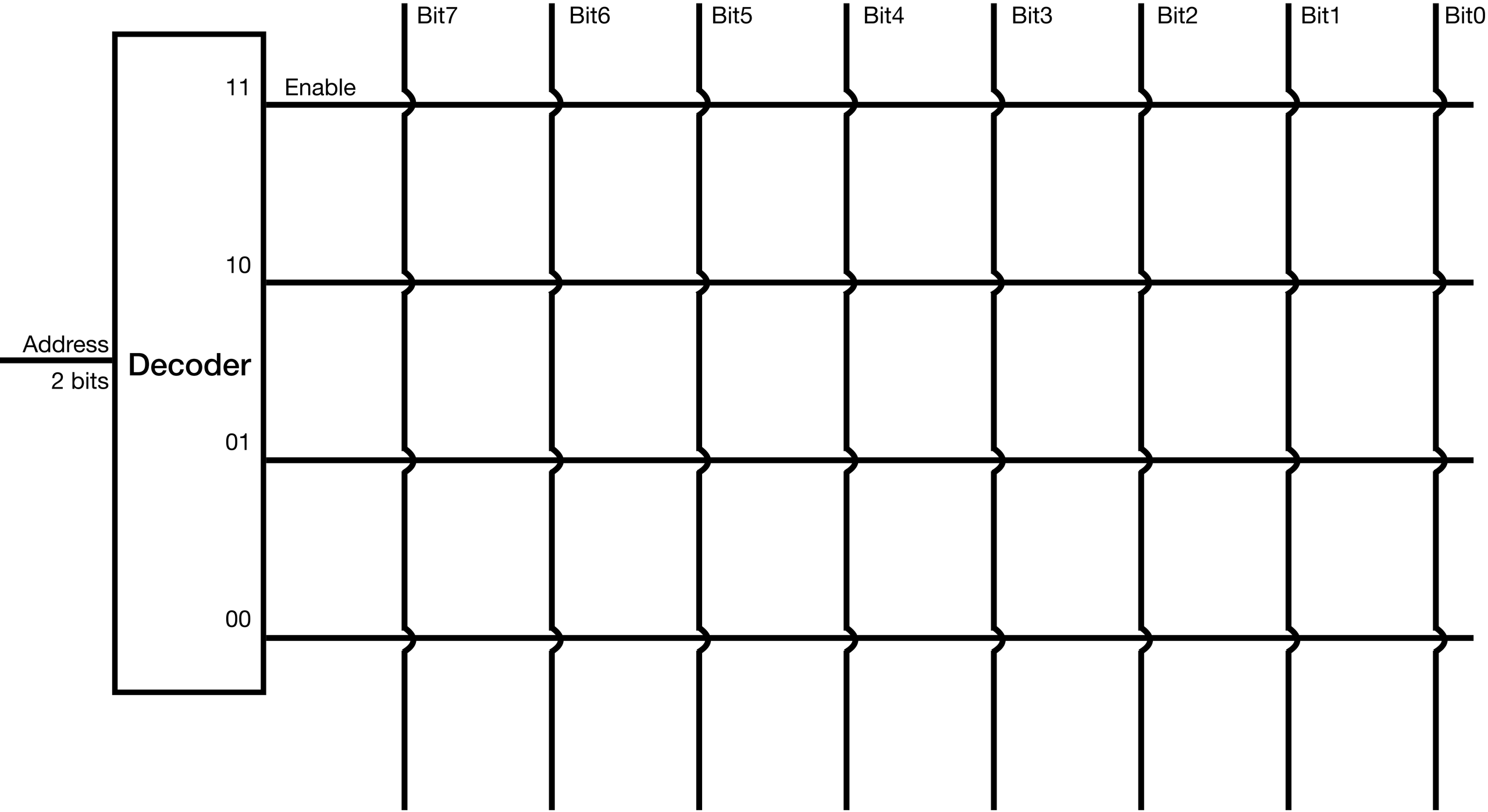
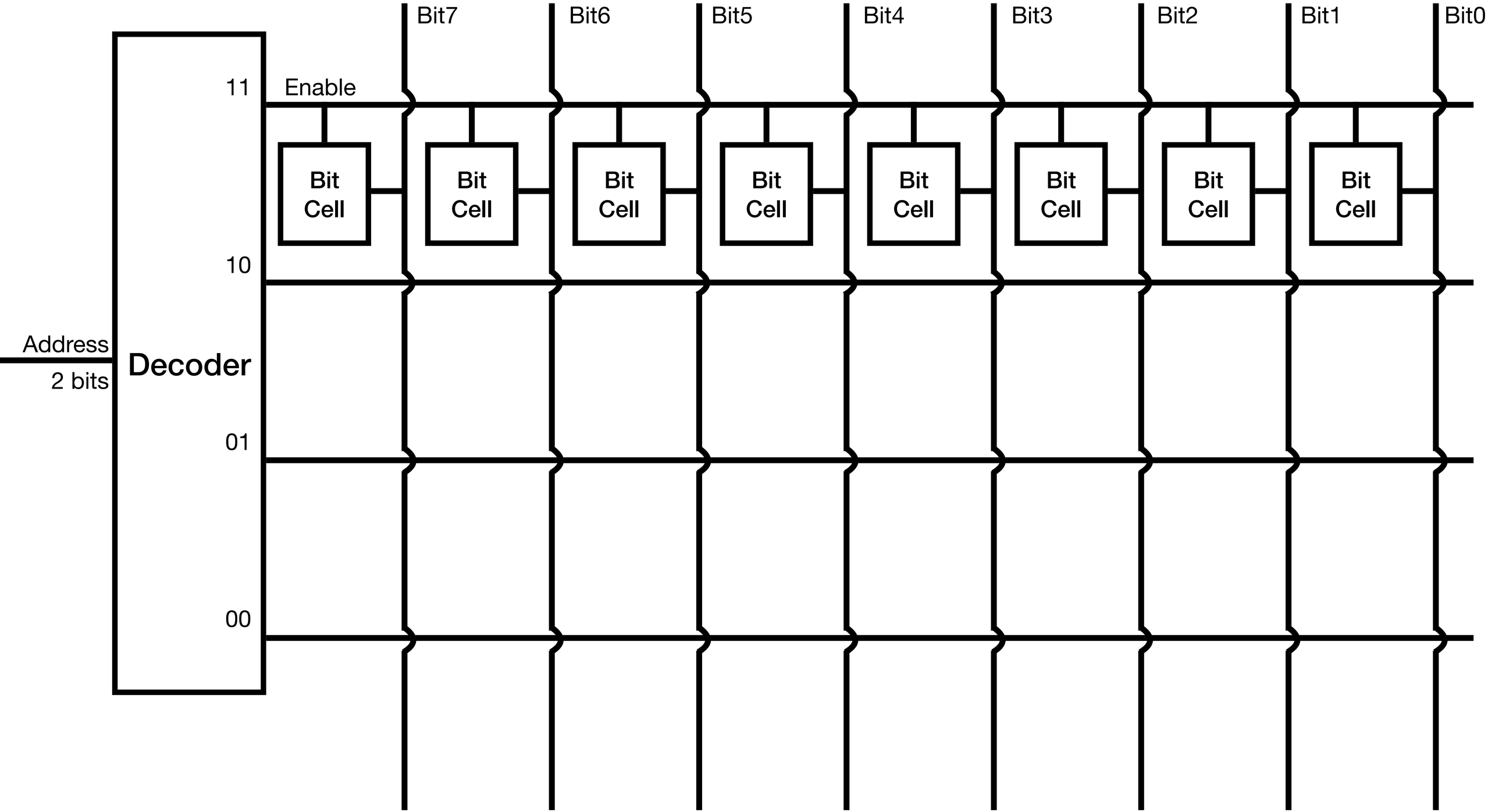


Decoder




Bit7
Bit6
Bit5
Bit4
Bit3
Bit2
Bit1
Bit0
11
Enable
10
Address
2 bits
Decoder
01
00


Bit7
Bit6
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Bit3
Bit2
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11
Enable
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01
00
Address
2 bits
Decoder
Bit Cell
Bit Cell
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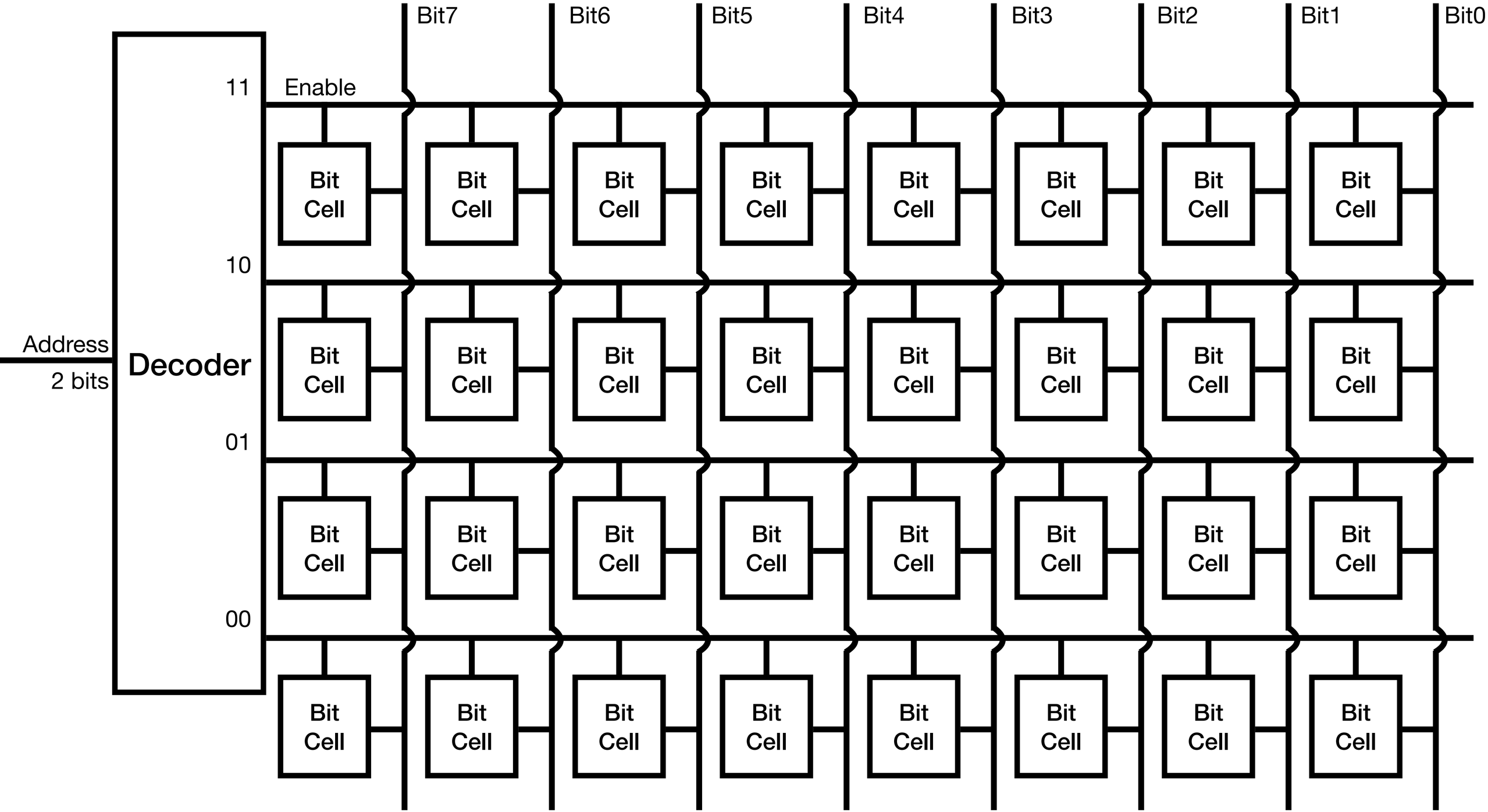
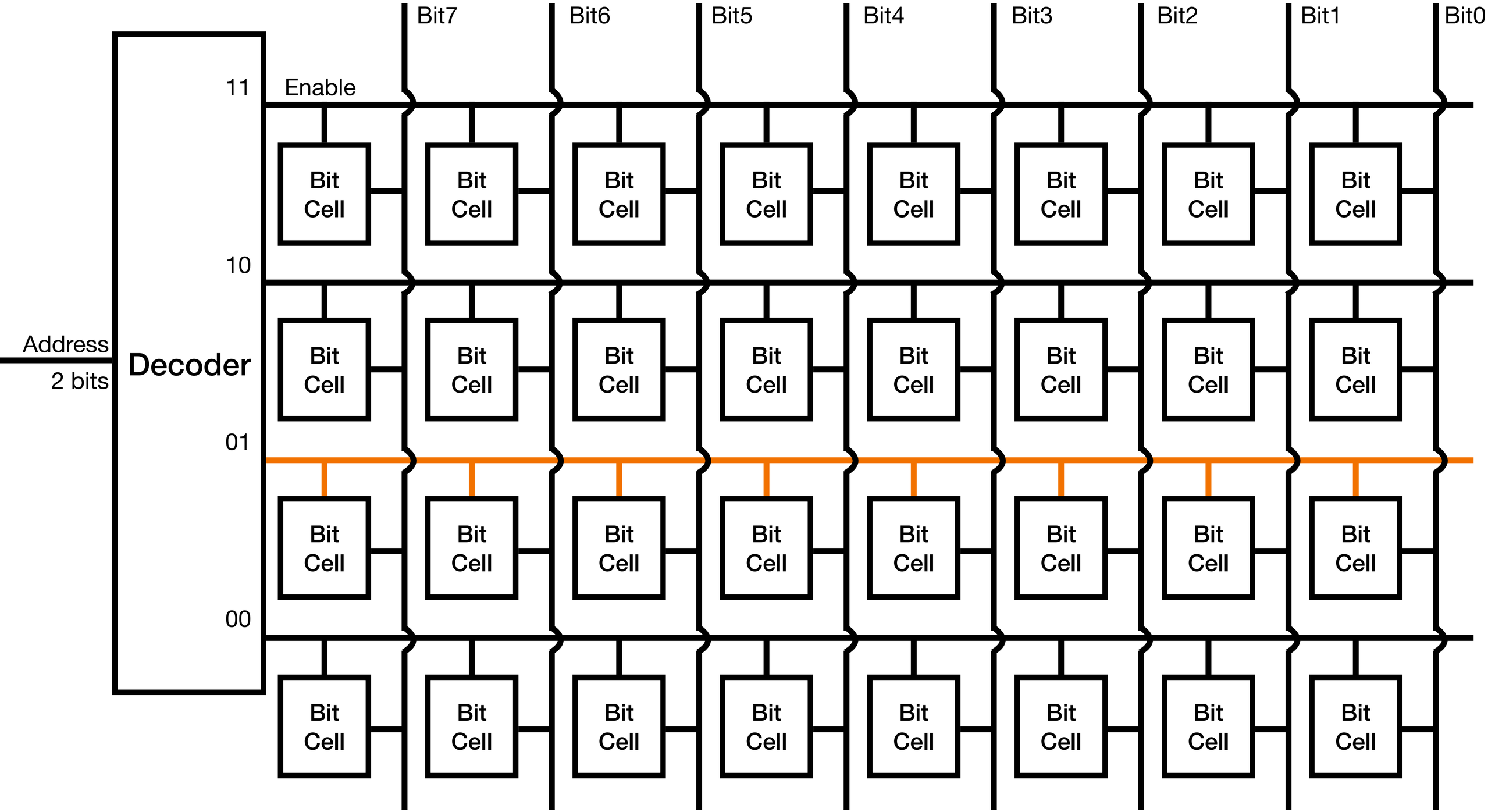

Bit7
Bit6
Bit5
Bit4
Bit3
Bit2
Bit1
Bit0
11
Enable
10
01
00
Address
2 bits
Decoder
Bit Cell


Bit7
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More pointers

Memory Array

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- What is N, the size of a memory address?
  - 64 on *64-bit machine*, 32 on *32-bit machine.*

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- 4.2 gigabytes of addressable memory.
- In order to use beyond 4.2GB, memory addresses need to be bigger.
- 2^{64} = 18,446,744,073,709,551,616 = 18 *exabytes* = ~4.2 million gigabytes

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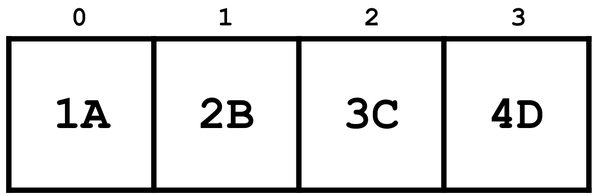

Endian

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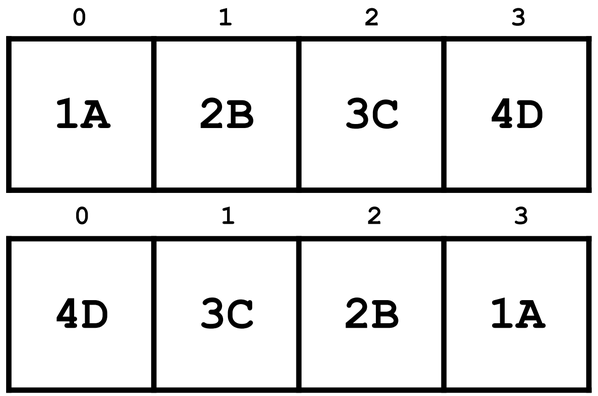

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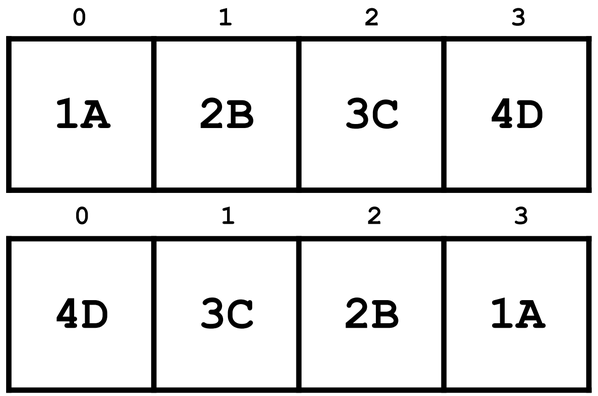

Most significant byte first

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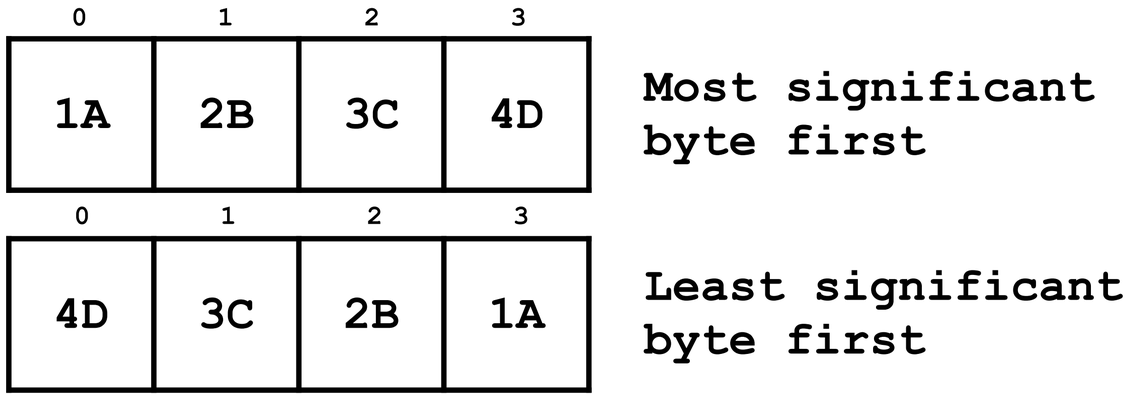

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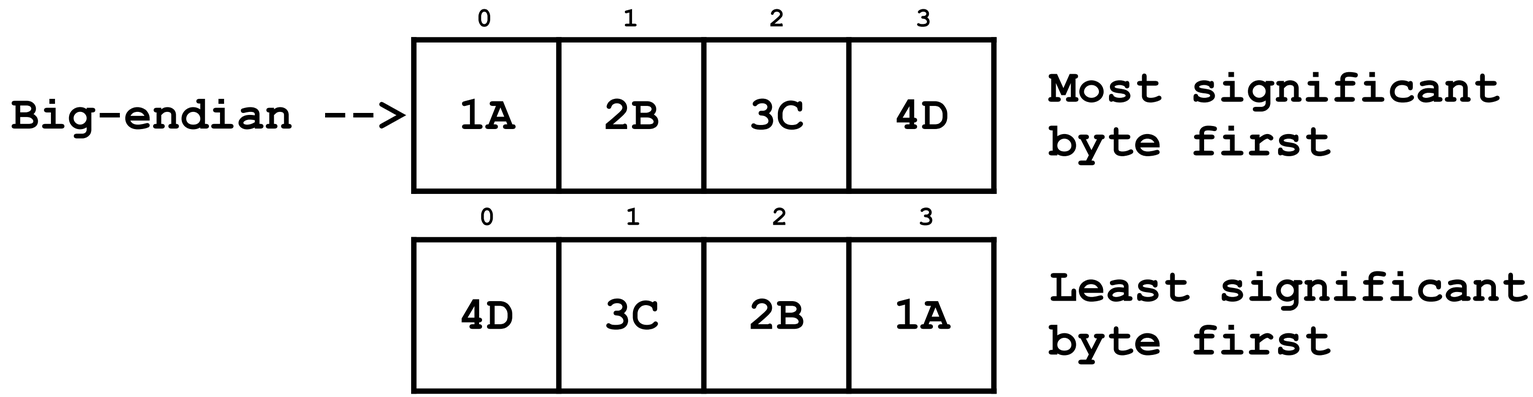

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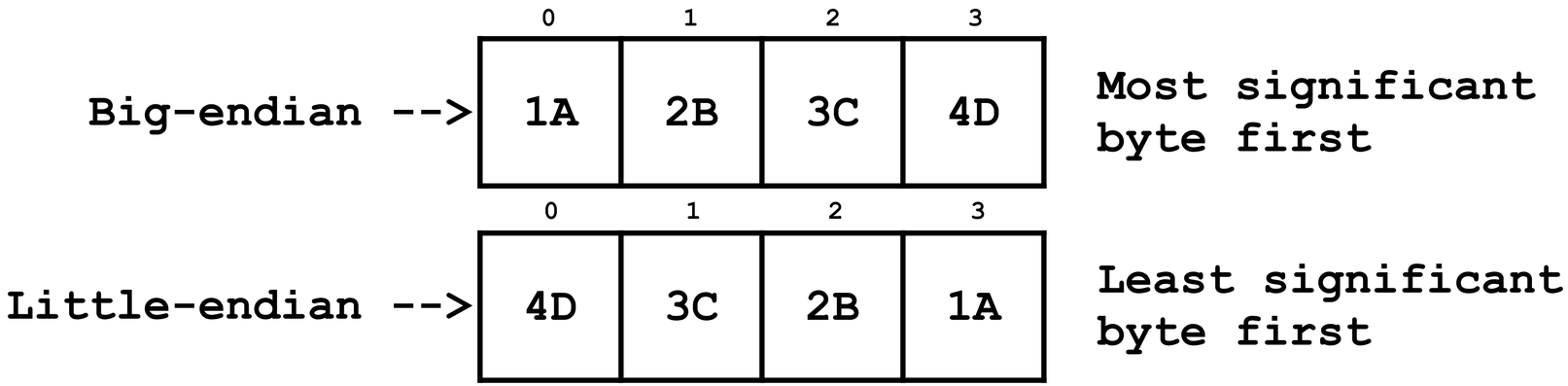

Endian

Endian

- Is my machine little-endian or big-endian?

Endian

- Is my machine little-endian or big-endian?
- Let's find out!

Endian

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  - addition, subtraction circuits work from low to high
  - etc.

Endian

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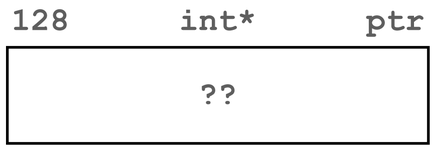
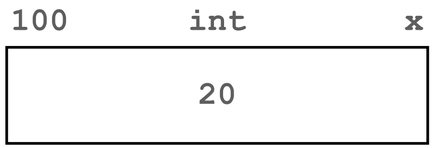
- However, when we serialize data into byte sequences, you need to pay extra attention:
  - Writing a number to a file
  - Sending a number over a network
- You and the reader must agree on byte order
  - For this purpose, *network byte order* is defined for TCP/IP

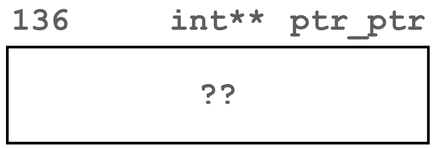
Pointers

Review

```
int x = 20;
int arr[4] = { 0 };
int *ptr;
int **ptr_ptr;
```







Pointers

Review

```
int x = 20;
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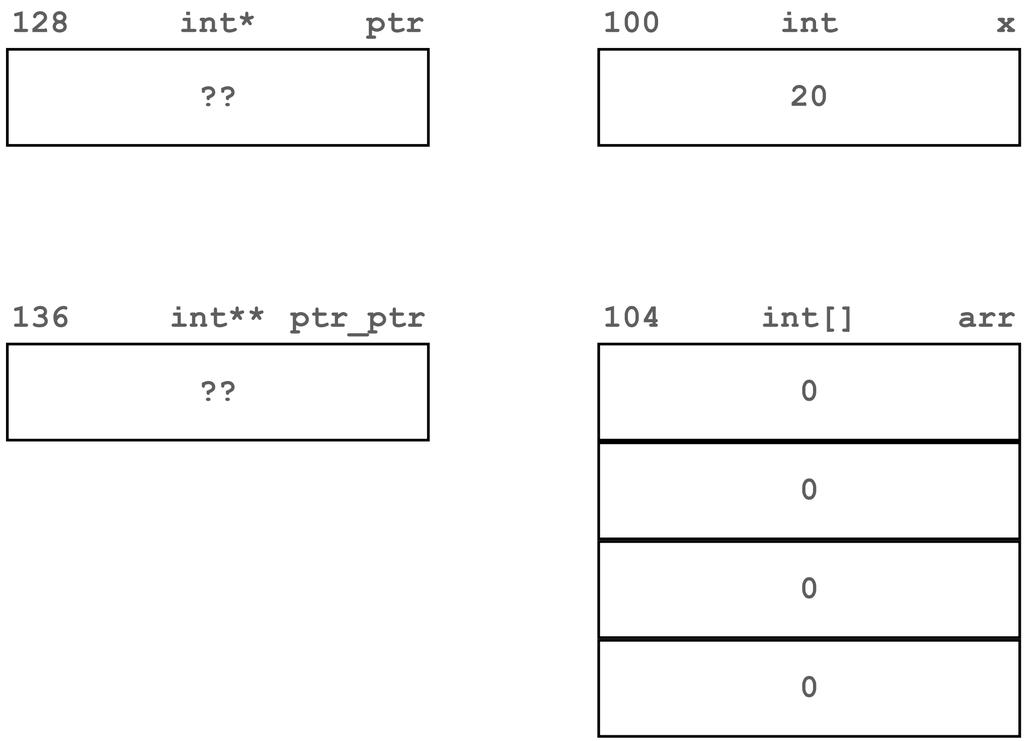
ptr = &x;
```



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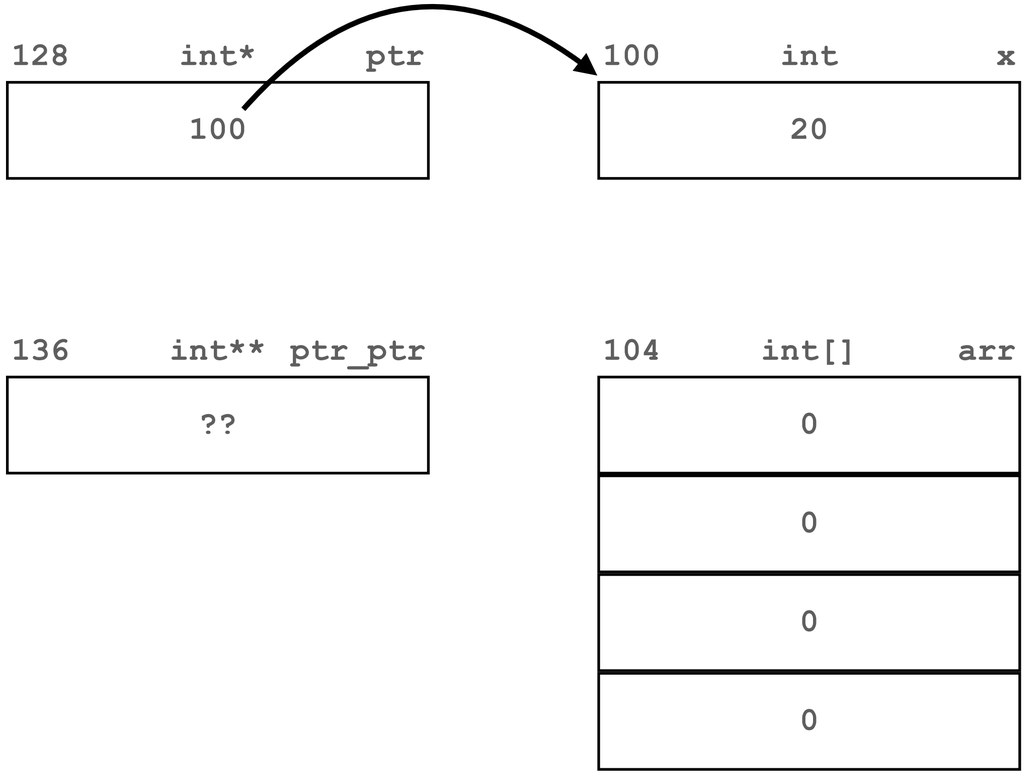

Pointers

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int *ptr;
int **ptr_ptr;

ptr = &x;
printf("%d\n", *ptr);
```
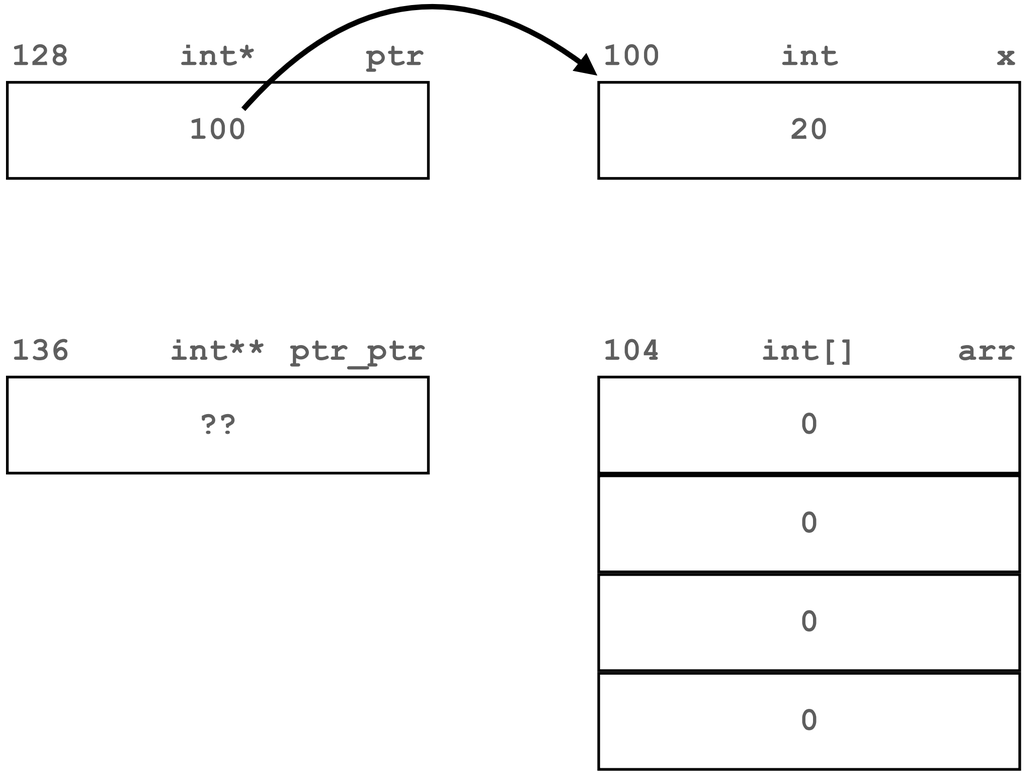
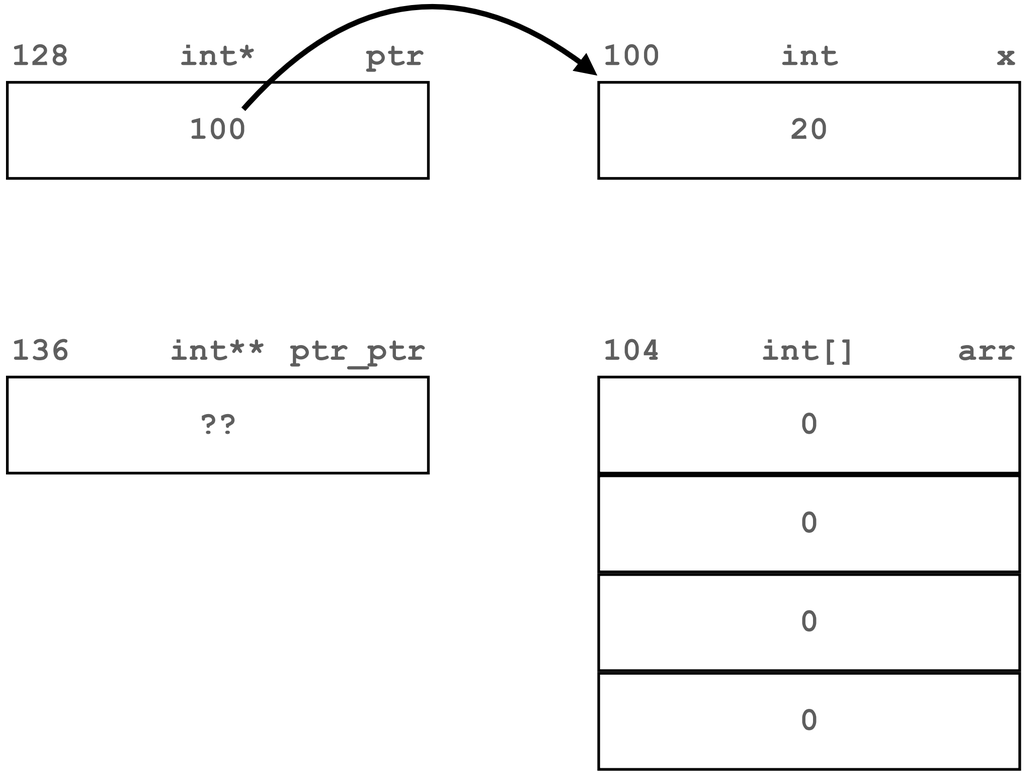



Pointers

Review

```
int x = 20;
int arr[4] = { 0 };
int *ptr;
int **ptr_ptr;

ptr = &x;
printf("%d\n", *ptr);       <-- 20
```



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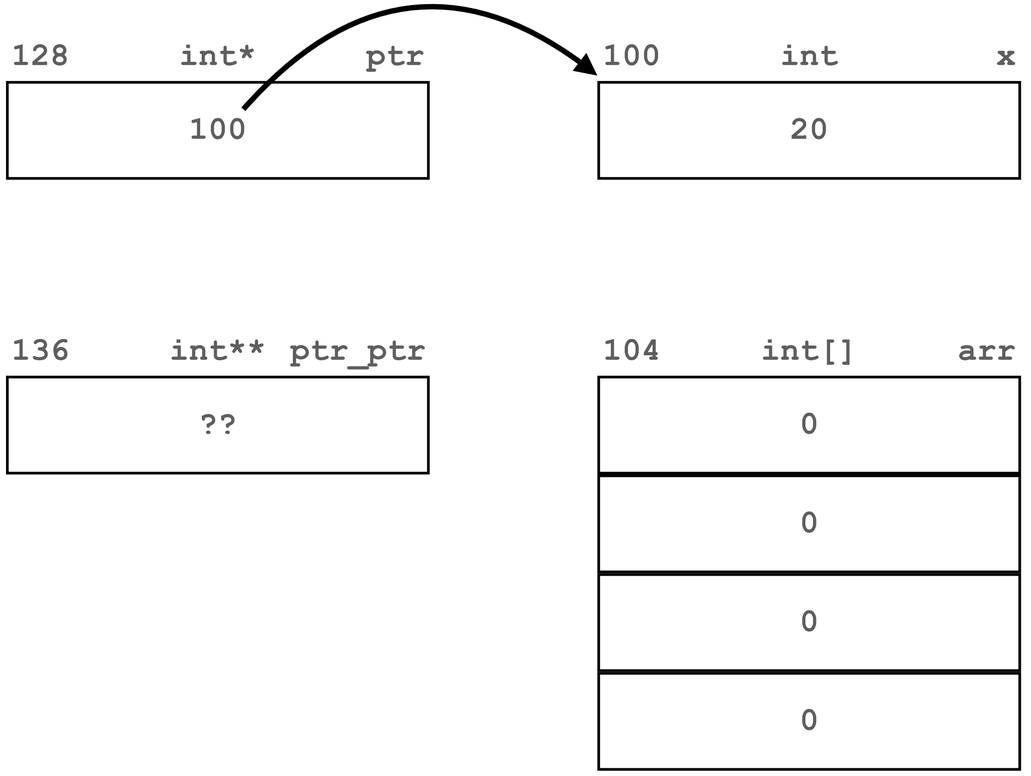

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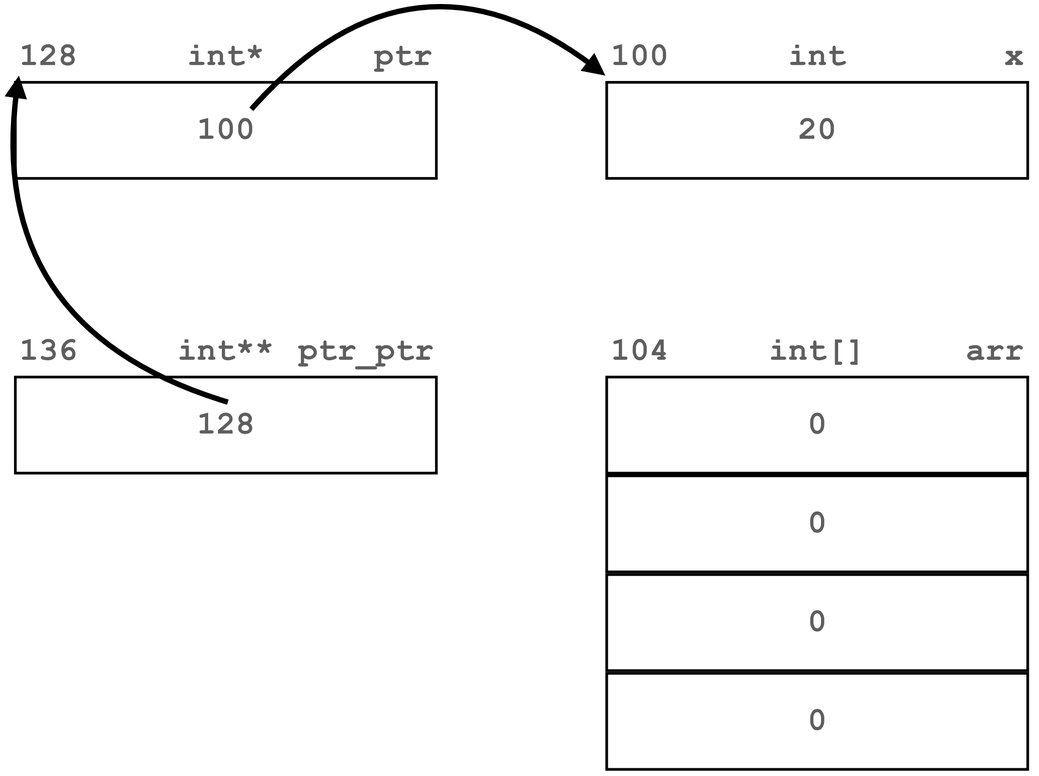

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printf("%d\n", *ptr);

ptr_ptr = &ptr;
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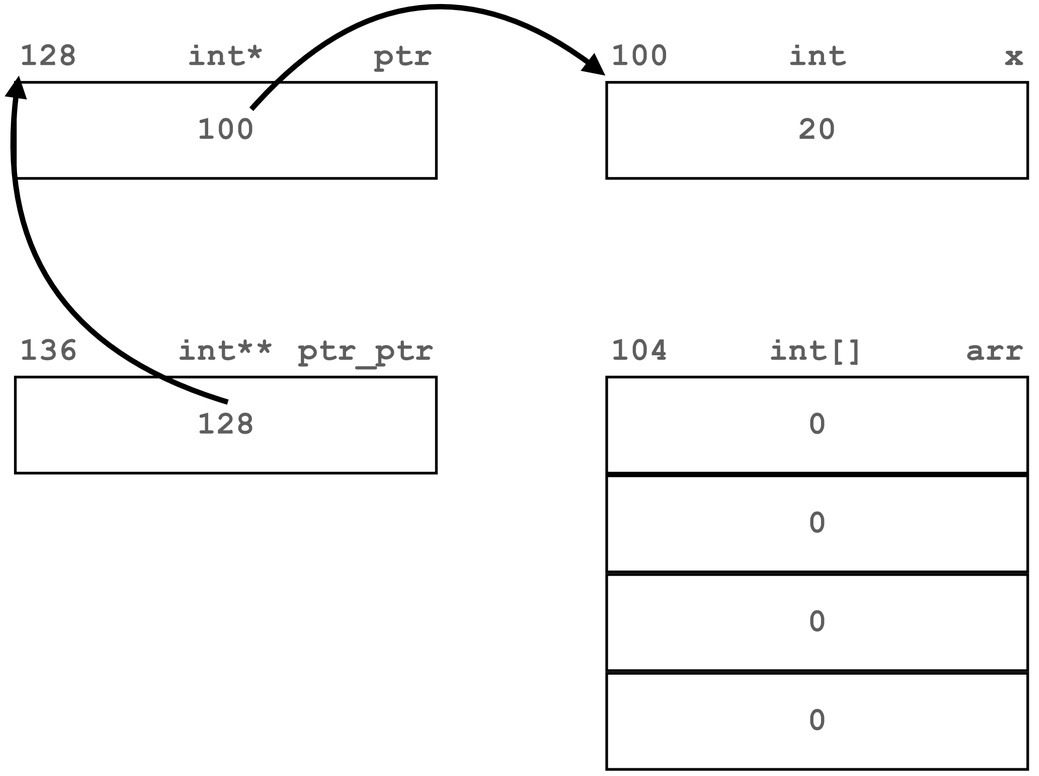
```



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ptr_ptr = &ptr;
printf("%p\n", *ptr_ptr);  <-- 100
```

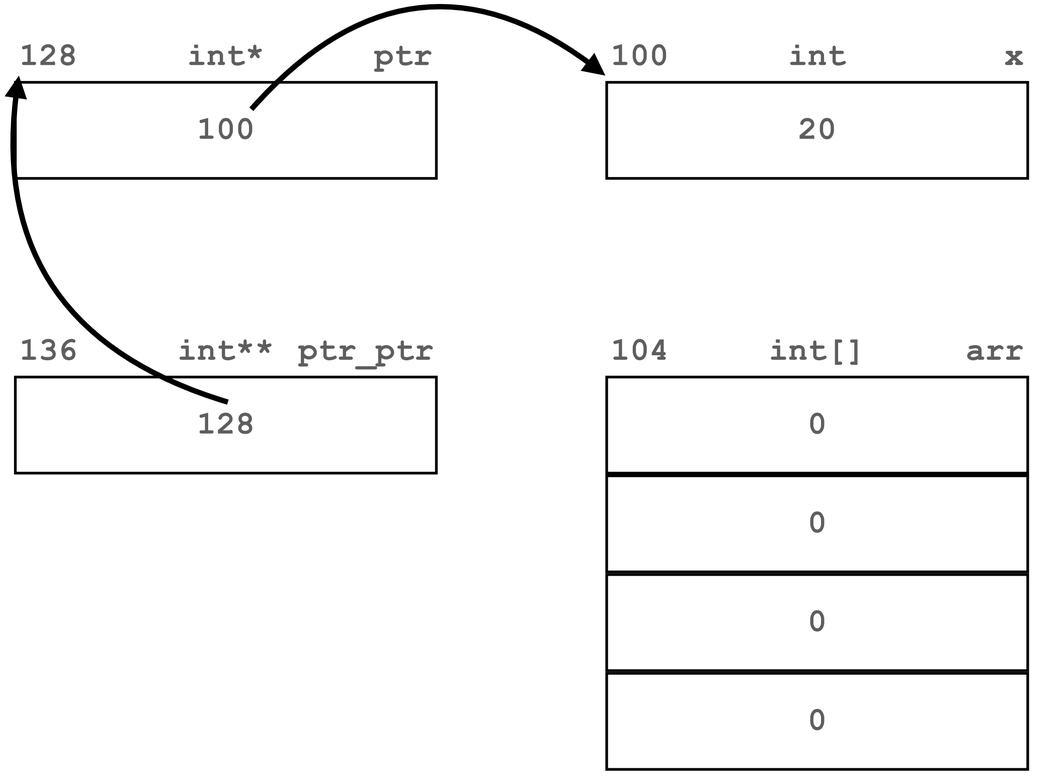

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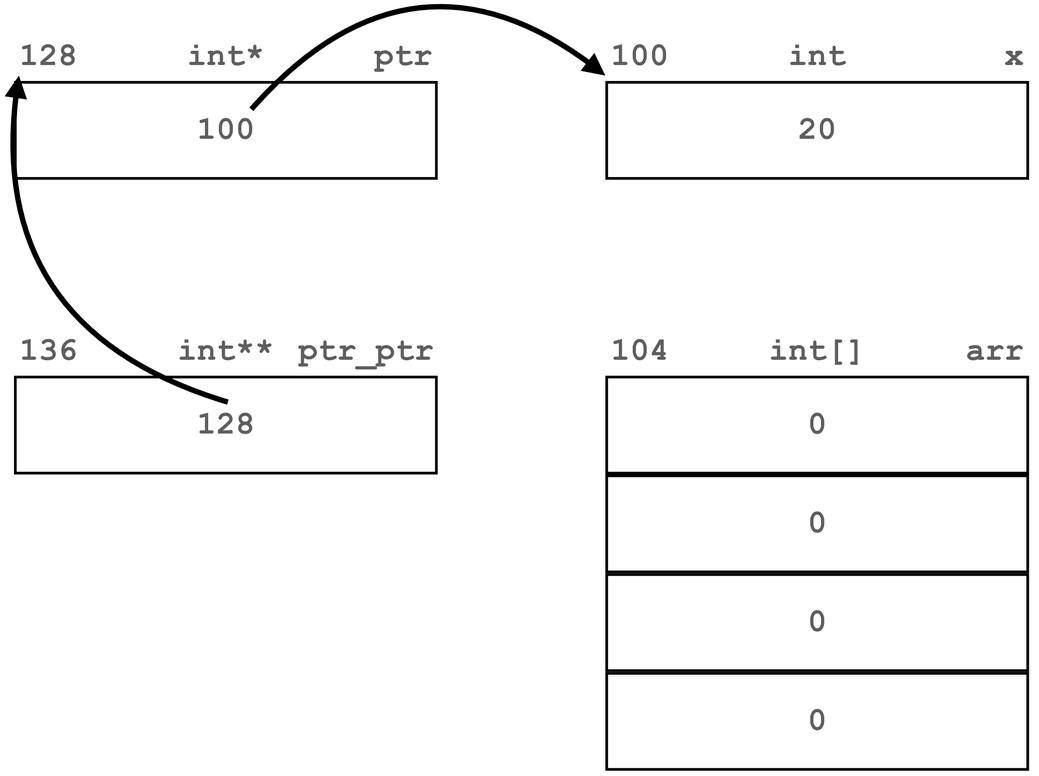

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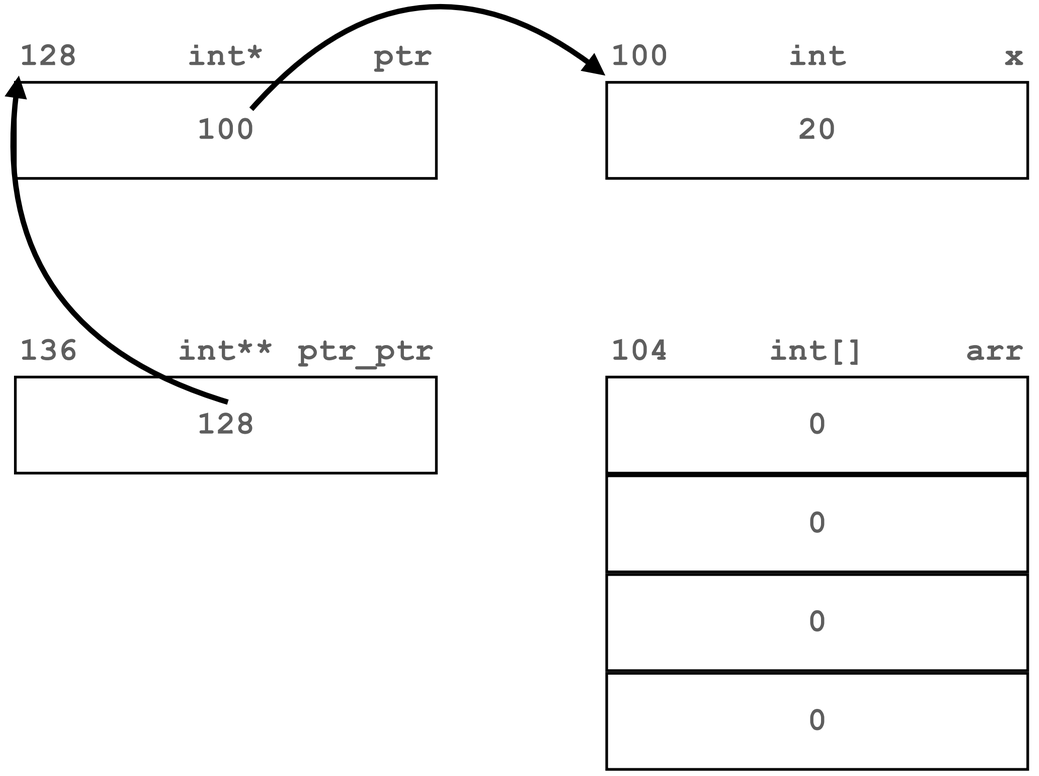
```



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*ptr = 25;
```

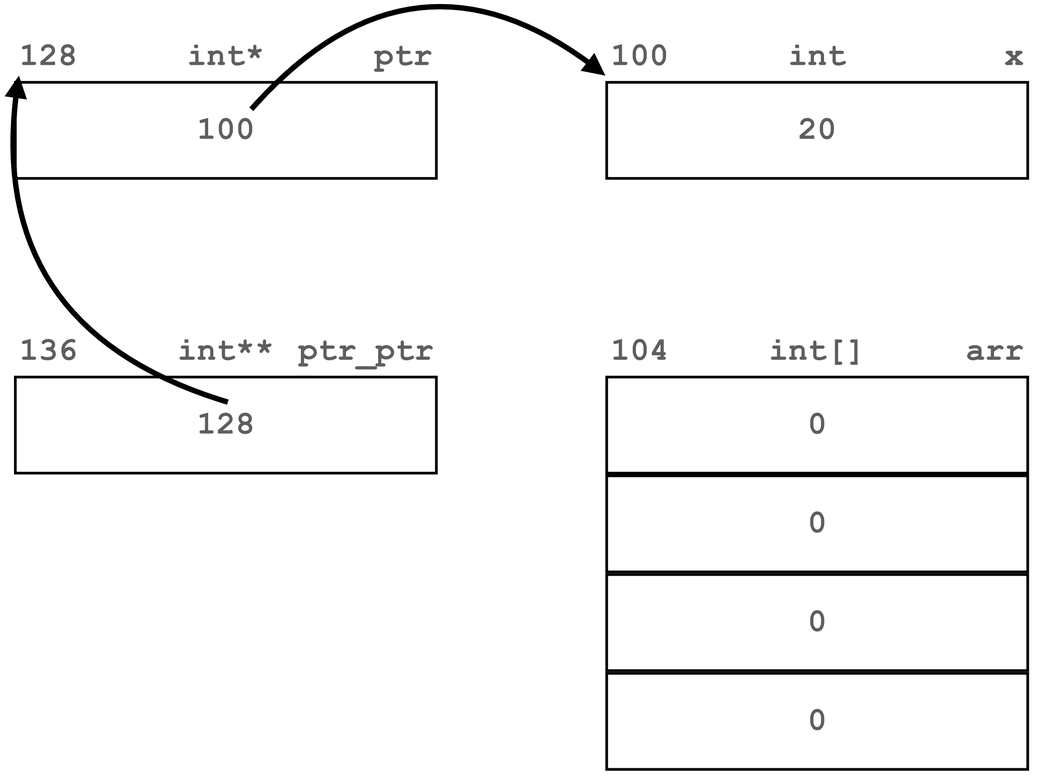

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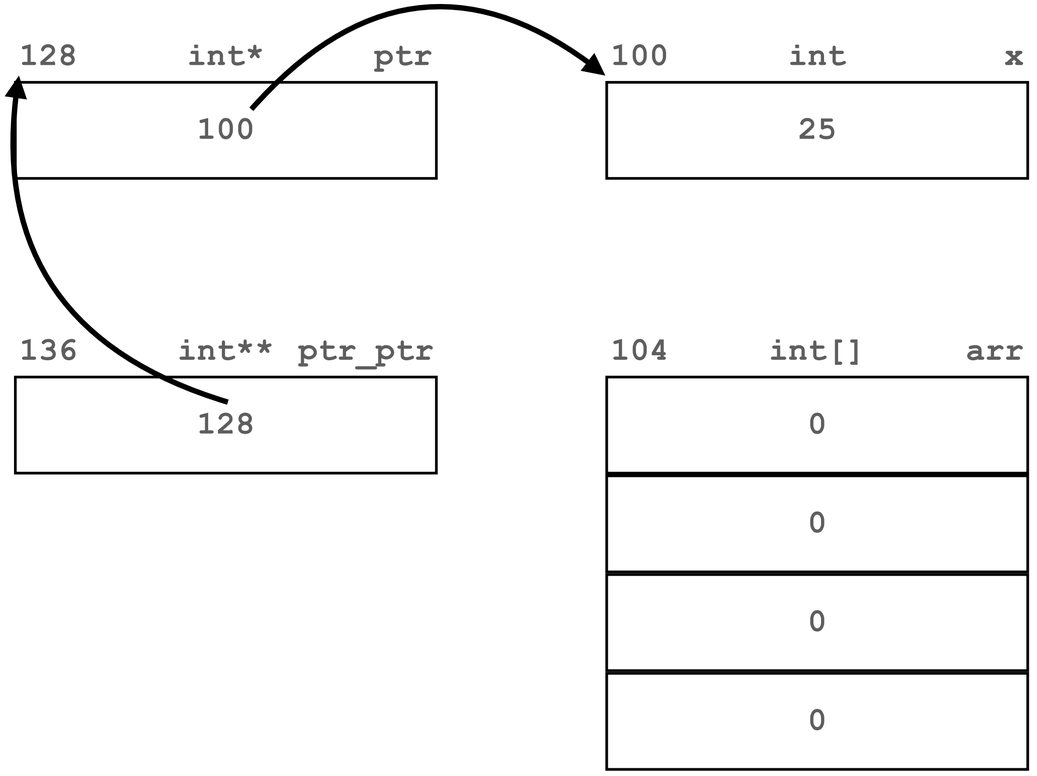

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int **ptr_ptr;

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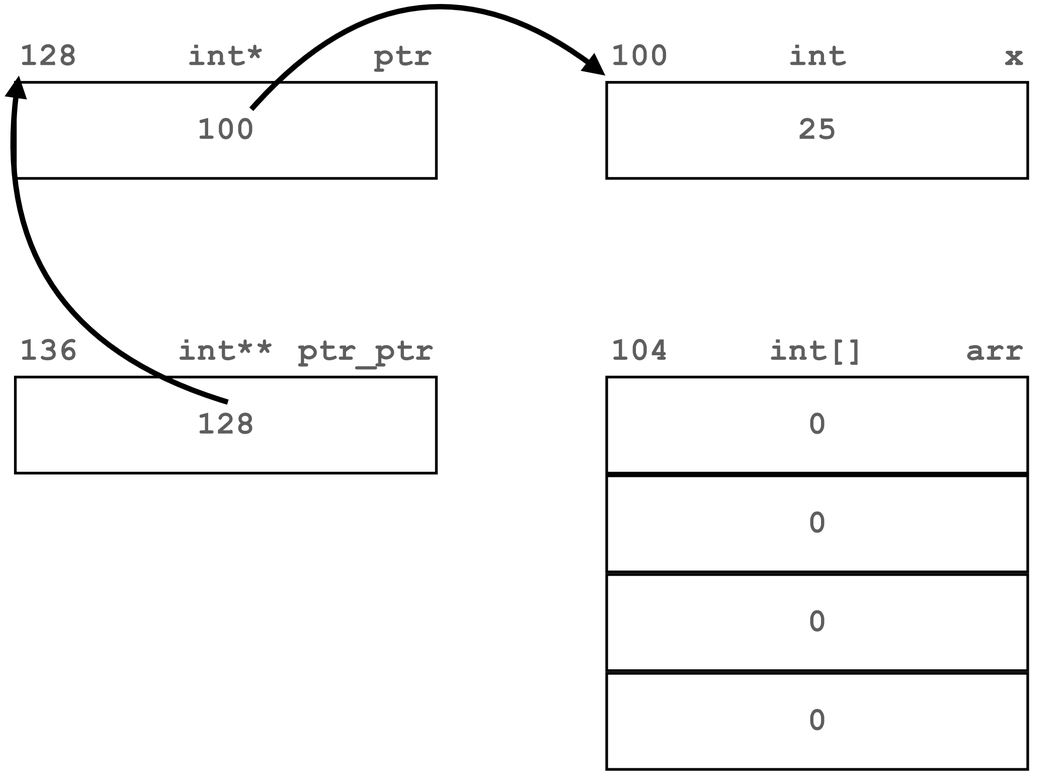

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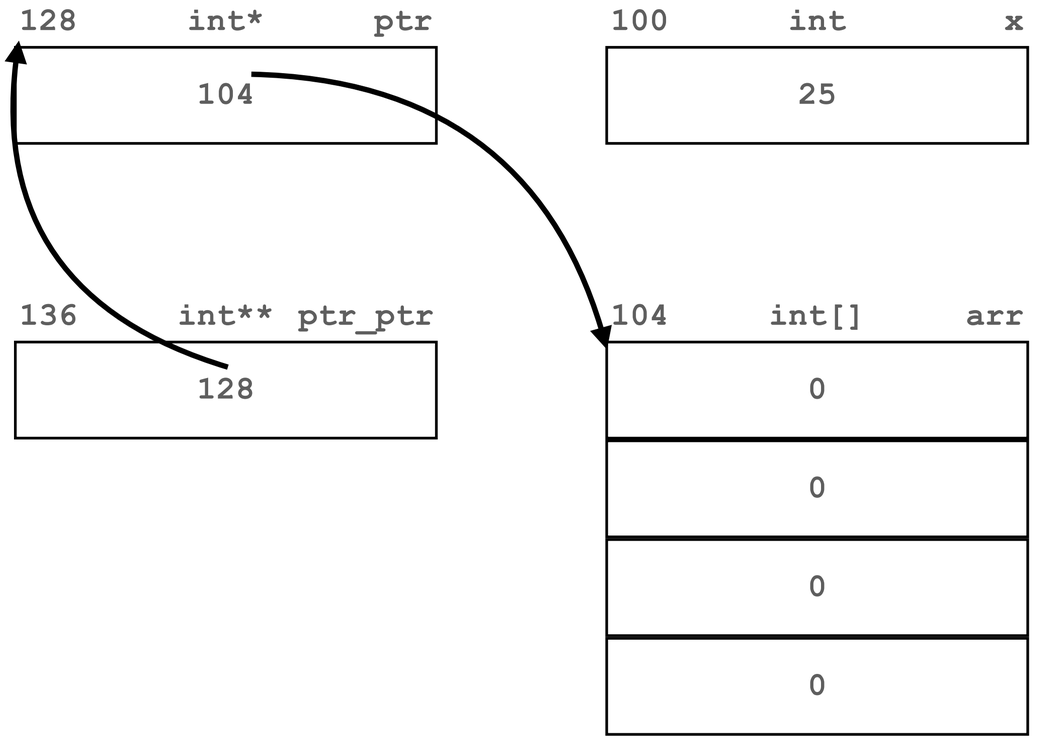

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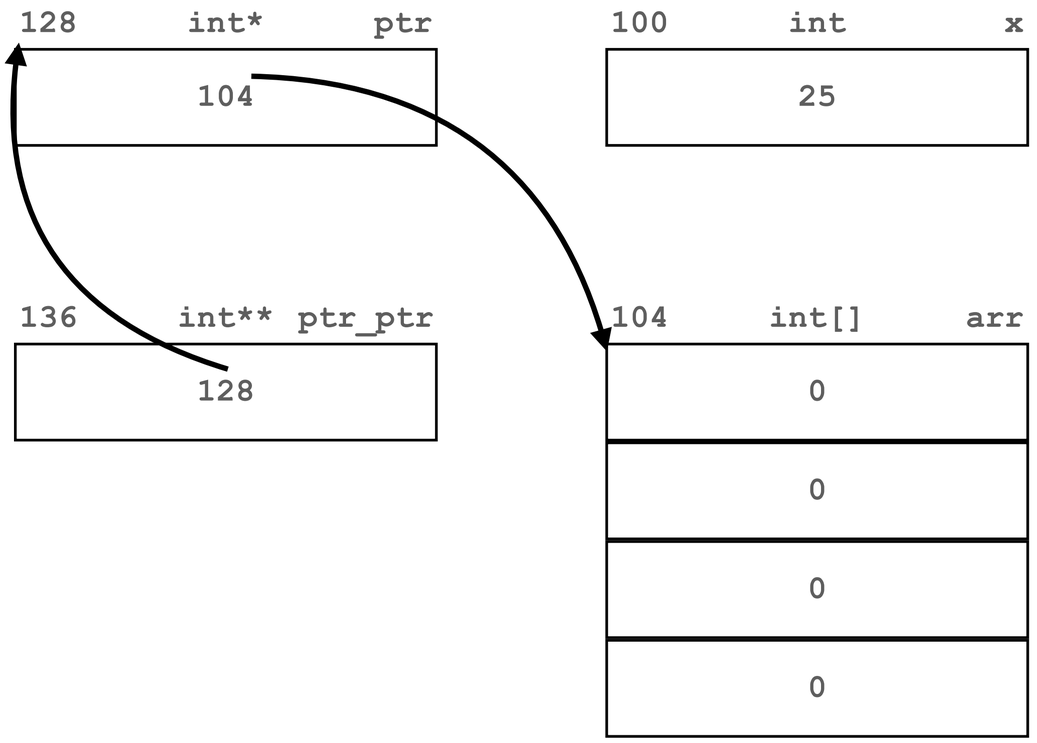

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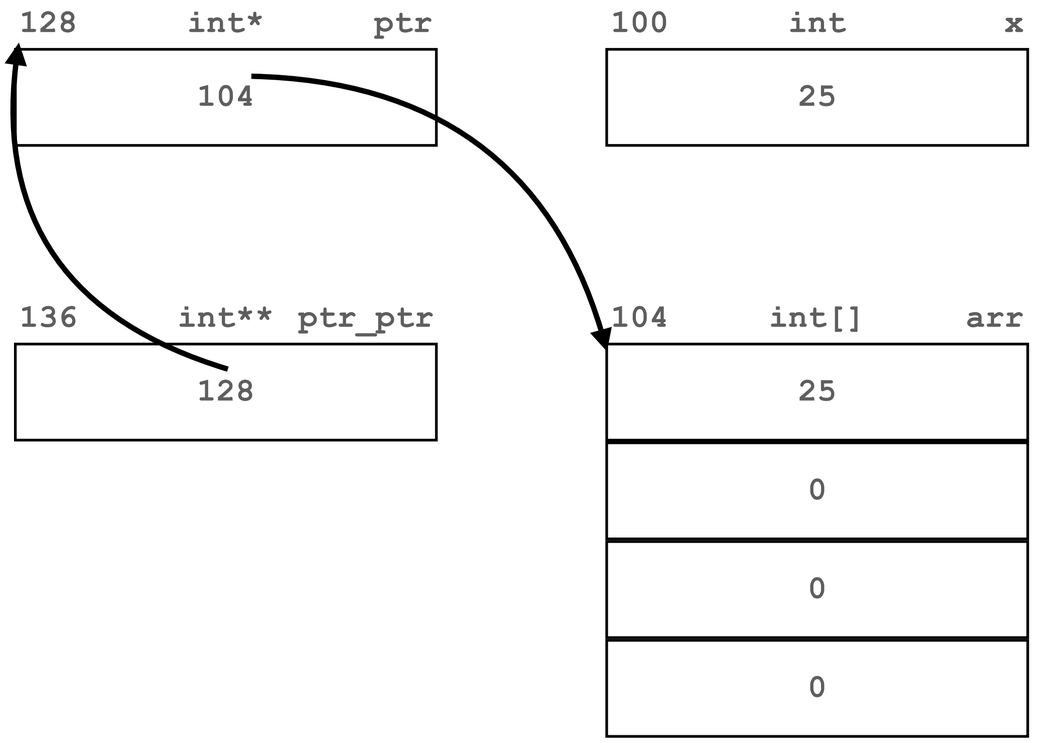

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int **ptr_ptr;

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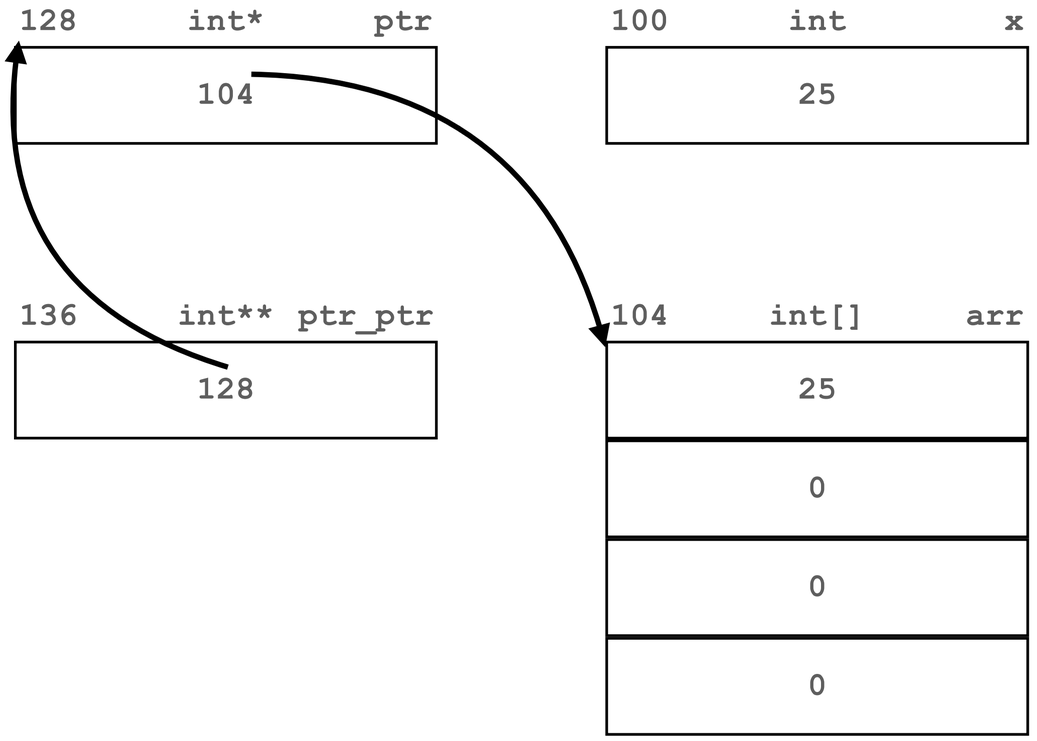
```



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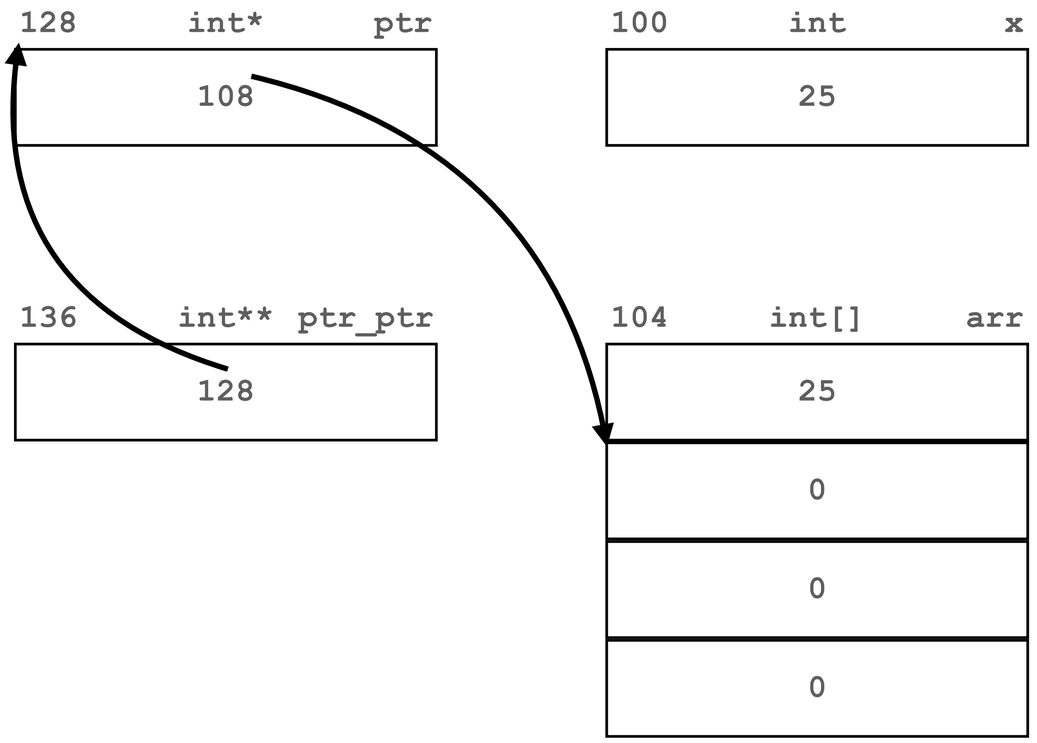

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*ptr = 30;
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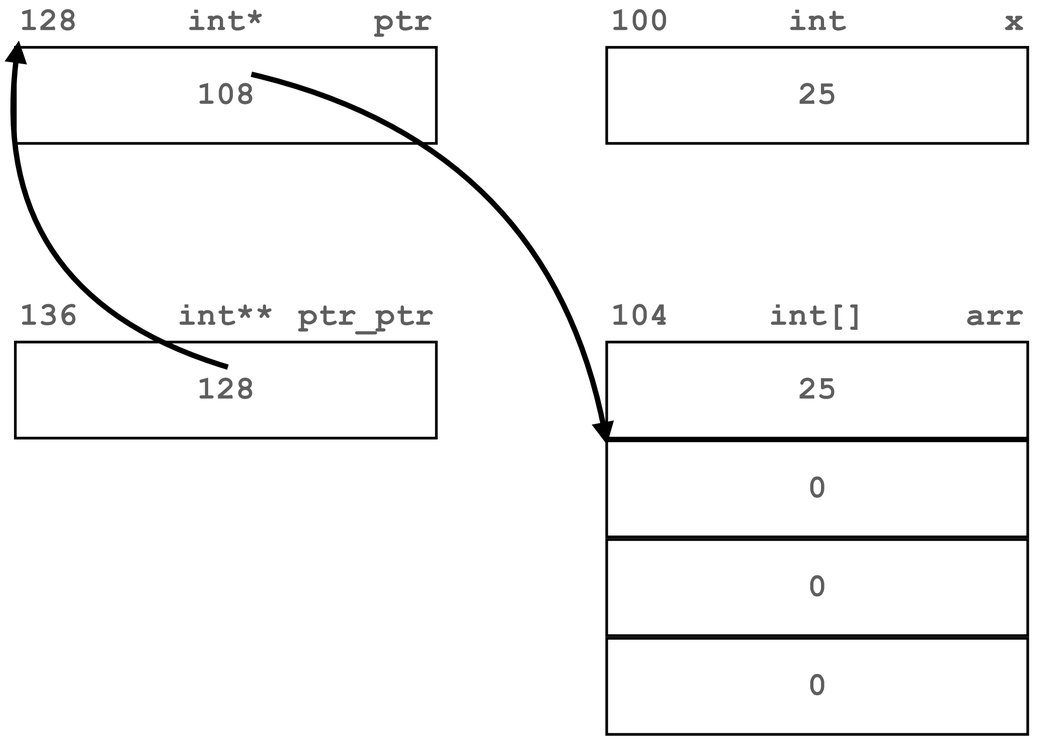

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```

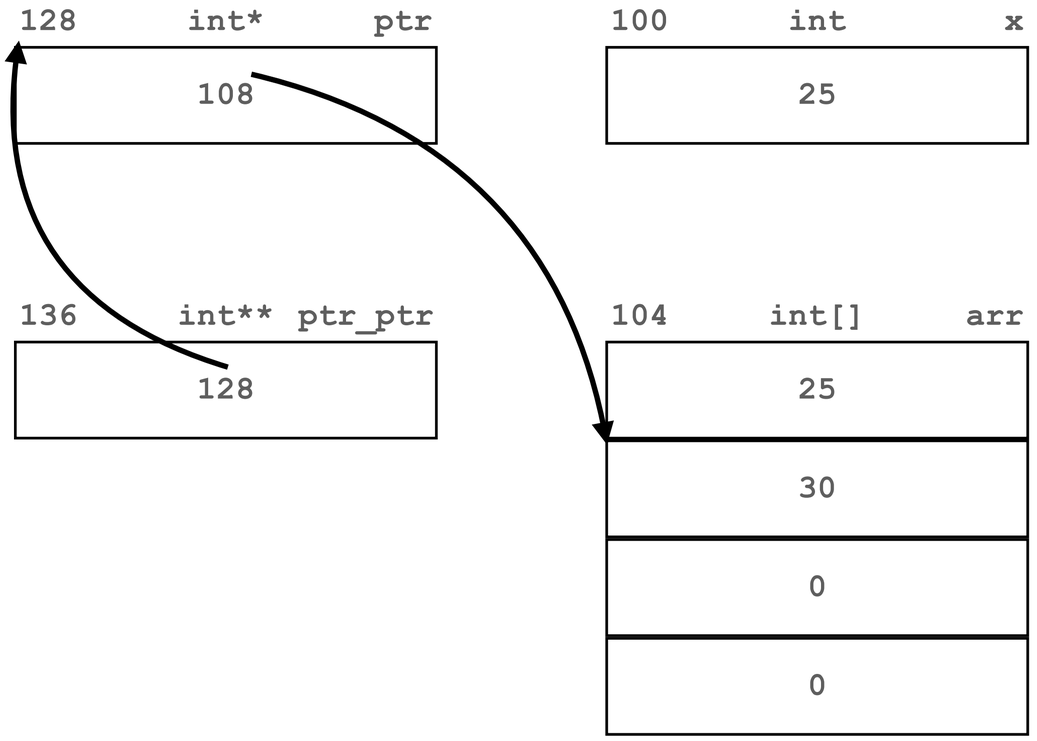

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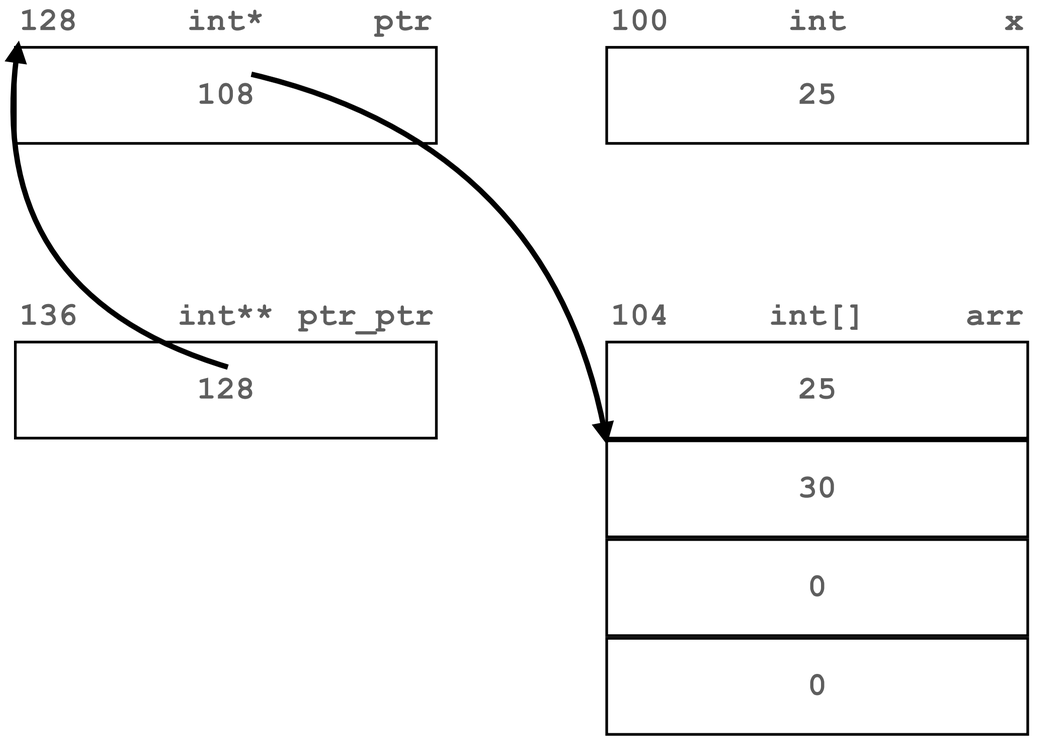
printf("%d\n", **ptr_ptr);

*ptr = 25;
ptr = &arr[0];
*ptr = 25;

*ptr_ptr = &arr[1];
*ptr = 30;
ptr[1] = 40;
```



Pointers

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printf("%d\n", **ptr_ptr);

*ptr = 25;
ptr = &arr[0];
*ptr = 25;

*ptr_ptr = &arr[1];
*ptr = 30;
ptr[1] = 40;
```
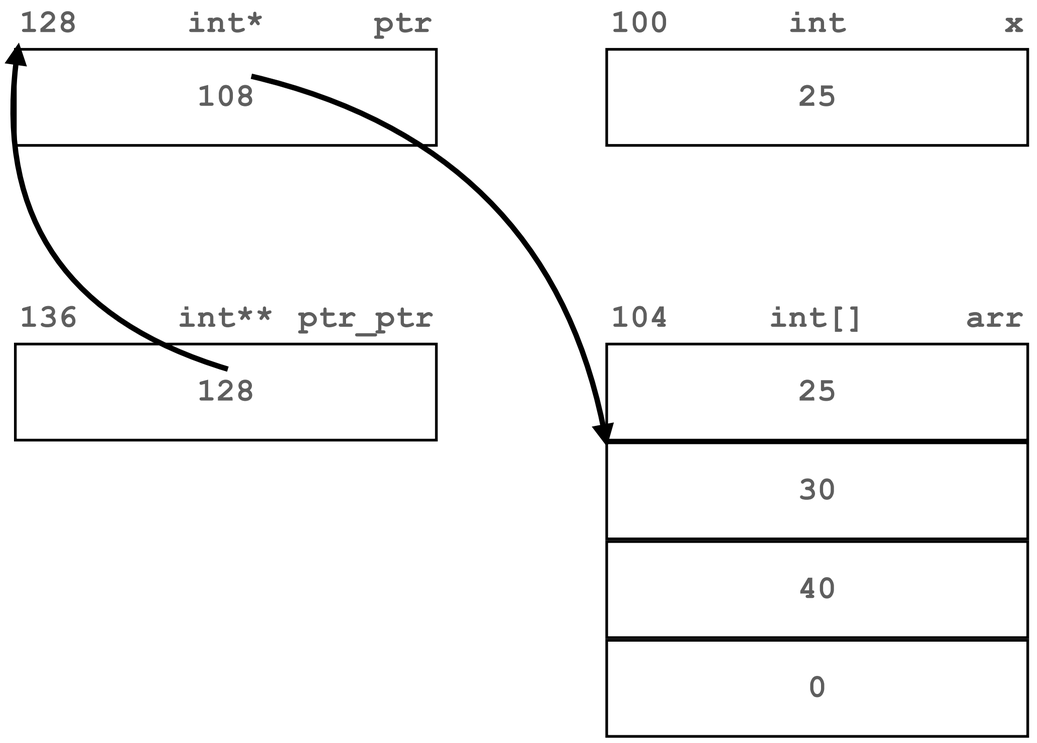
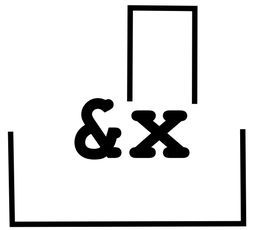



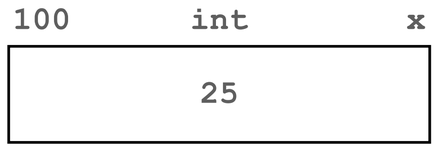
Pointers

Review

```
type : int
value: 25
```




```
type : int *
value: 100
```



Pointers

Review

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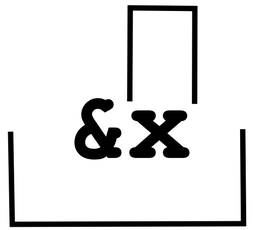
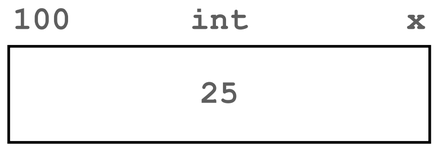
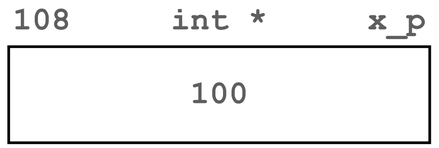
value: 25
```




```
type : int *
value: 100
```

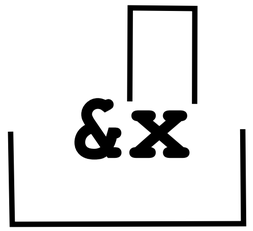




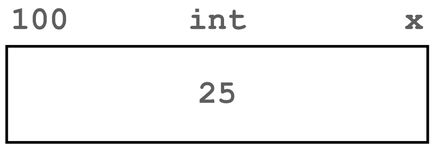
Pointers

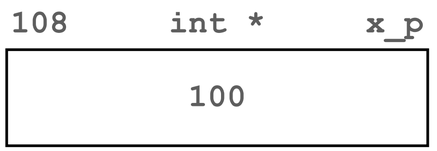
Review

```
type : int
value: 25
```




```
type : int *
value: 100
```






```
type : int *
value: 100
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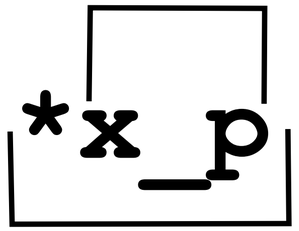


```
type : int
value: 25
```

Pointers

Review

```
type : int
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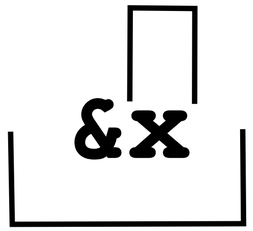


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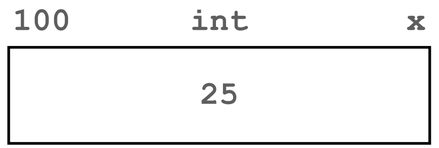

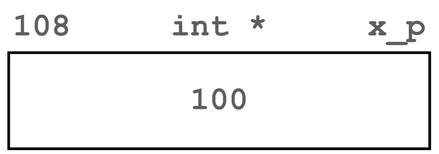


```
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value: 100
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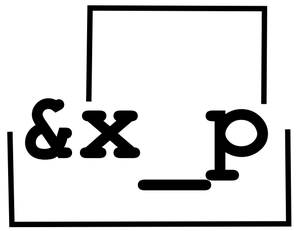
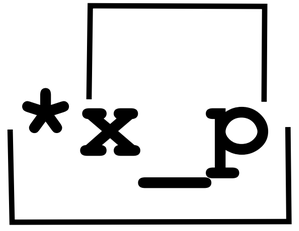



```
type : int **
value: 108
```

```
type : int *
value: 100
```

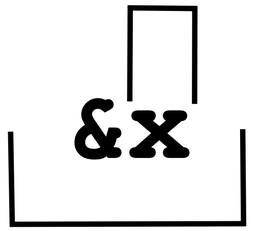



```
type : int
value: 25
```

Pointers

Review

```
type : int
value: 25
```




```
type : int *
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```
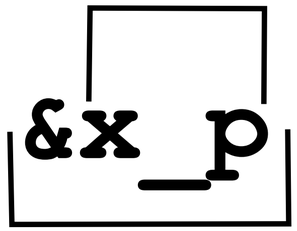
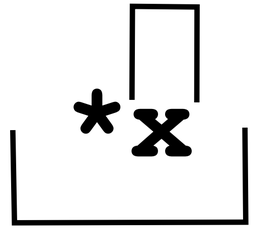
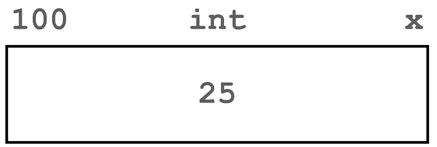



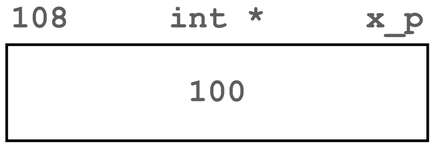

```
type : int **
value: 108
```

```
type : int
value: 25
```




```
error
```



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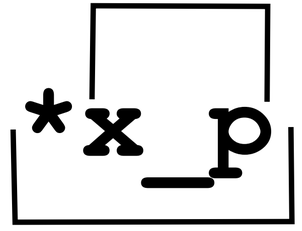



```
type : int
value: 25
```

Pointers

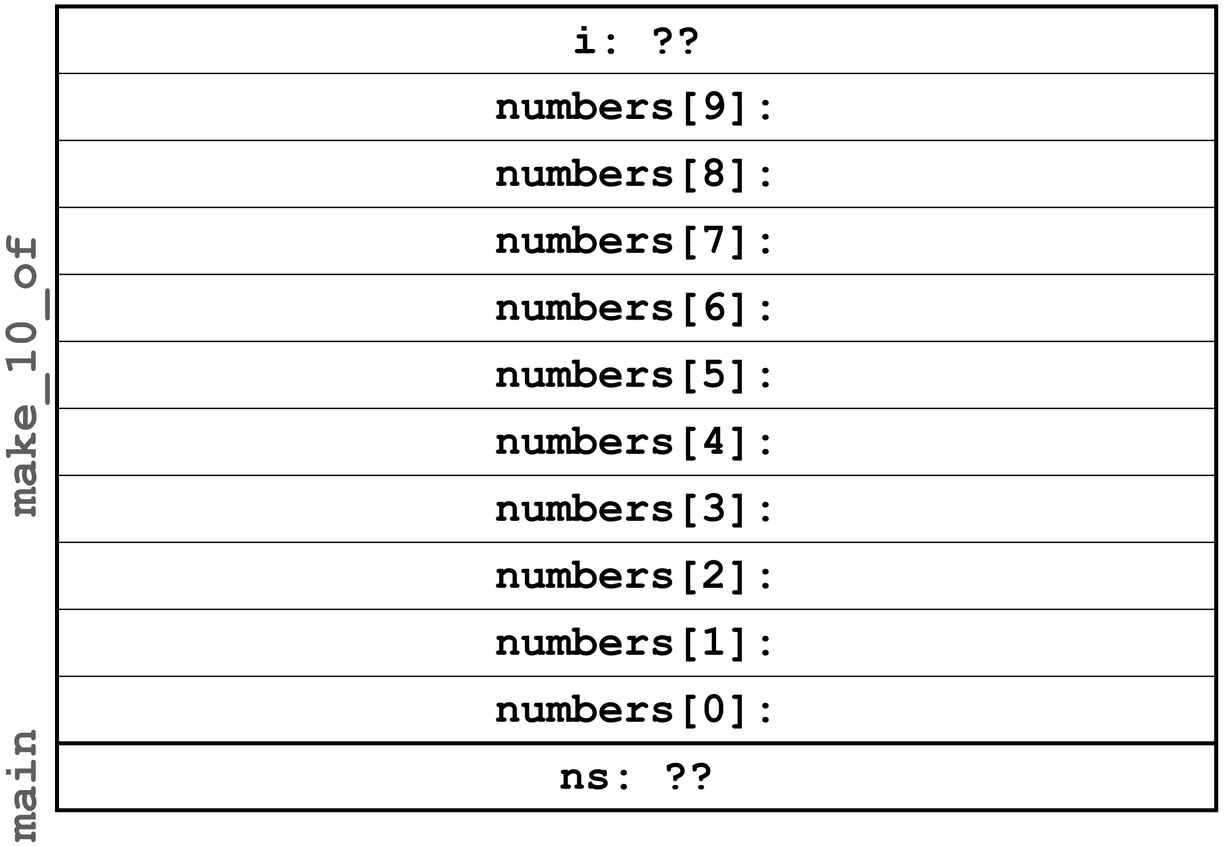
How about returning an array?

```
int *make_10_of(int n)
{
        int numbers[10];

        for (int i = 0; i < 10; i++) {
                numbers[i] = n;
        }

        return numbers;
}


int main()
{
        int *ns = make_10_of(42);
        ...
        return 0;
}
```



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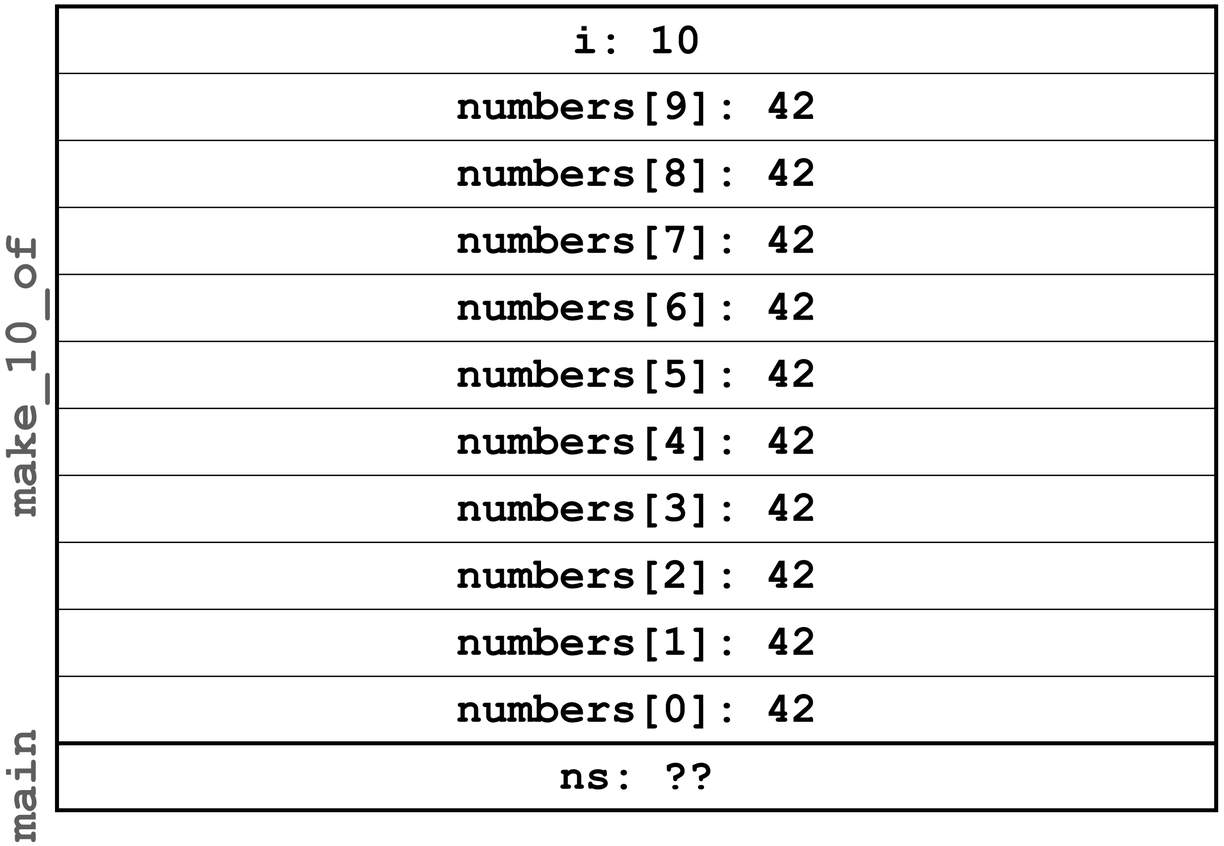

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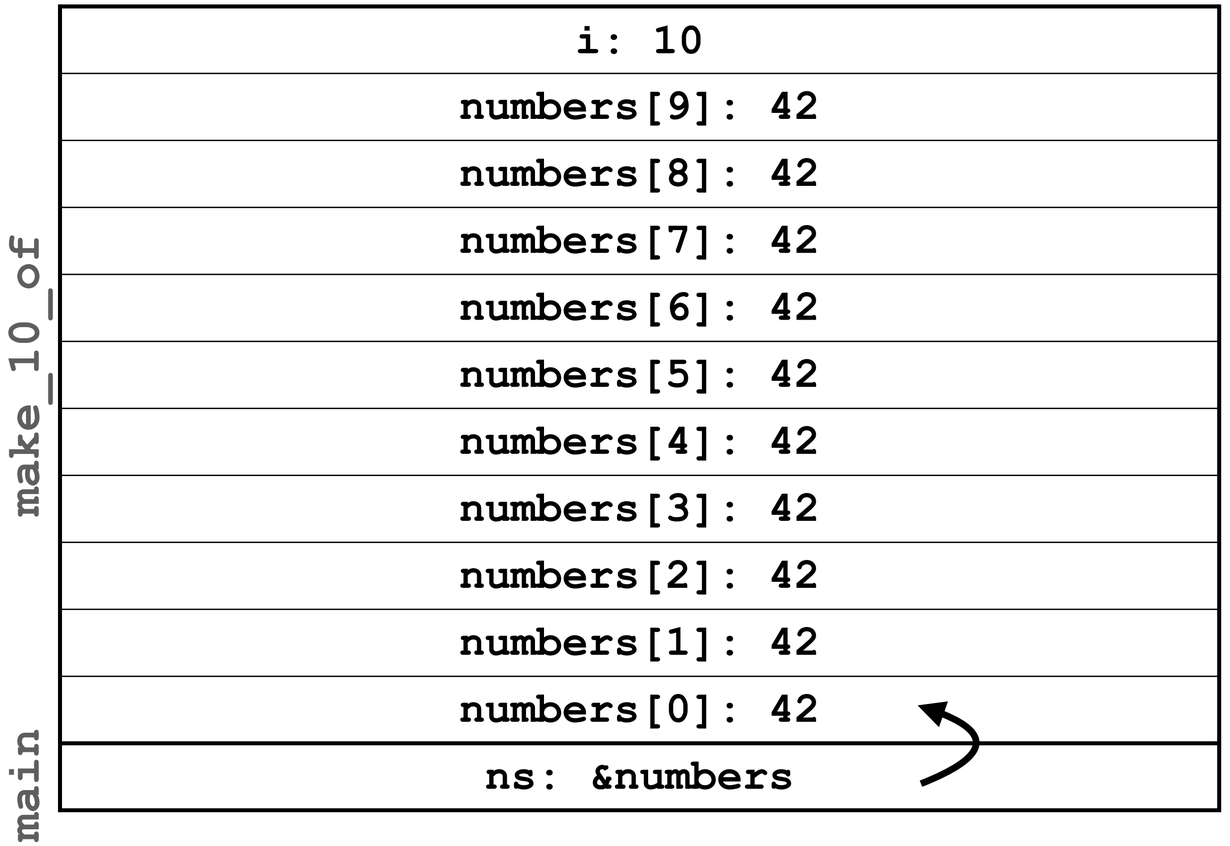

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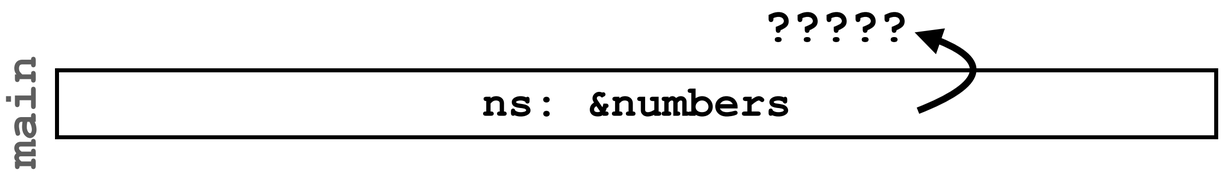

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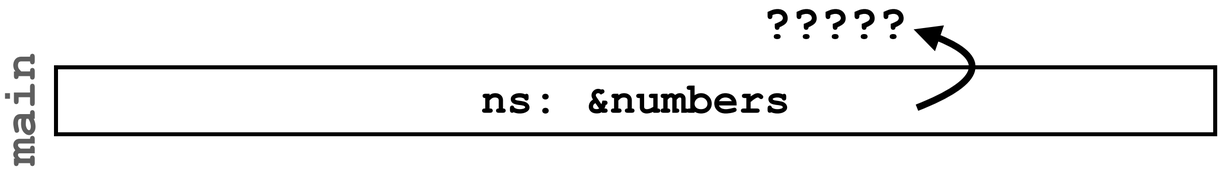
- `numbers` is recycled after returning



Pointers

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        }

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}


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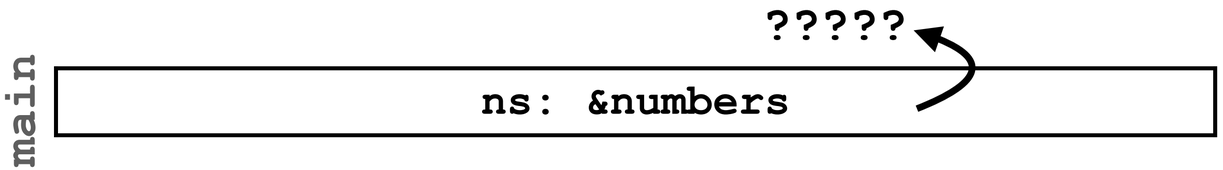
{
        int *ns = make_10_of(42);
        ...
        return 0;
}
```

- `numbers` is recycled after returning
- `ns` becomes a pointer to invalid/ non-existent/dead data.



Pointers

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        }

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}


int main()
{
        int *ns = make_10_of(42);
        ...
        return 0;
}
```

- `numbers` is recycled after returning
- `ns` becomes a pointer to invalid/ non-existent/dead data.
- We call `ns` a dangling pointer