This is CS50

U I J T X B T D T 5 0

This is CS50

```c
#include <stdio.h>

int main(void)
{
    printf("hello, world\n");
}
```

```
01111111 01000101 01001100 01000110 00000010 00000001 00000001 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000010 00000000 00111110 00000000 00000001 00000000 00000000 00000000
10110000 00000101 01000000 00000000 00000000 00000000 00000000 00000000
01000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
11010000 00010011 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 01000000 00000000 00111000 00000000
00001001 00000000 01000000 00000000 00100100 00000000 00100001 00000000
00000110 00000000 00000000 00000000 00000101 00000000 00000000 00000000
01000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
01000000 00000000 01000000 00000000 00000000 00000000 00000000 00000000
01000000 00000000 01000000 00000000 00000000 00000000 00000000 00000000
11111000 00000001 00000000 00000000 00000000 00000000 00000000 00000000
11111000 00000001 00000000 00000000 00000000 00000000 00000000 00000000
00001000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000011 00000000 00000000 00000000 00000100 00000000 00000000 00000000
00111000 00000010 00000000 00000000 00000000 00000000 00000000 00000000
...
```

```
make hello

./hello
```

```
clang hello.c

./a.out
```

```
clang -o hello hello.c

./hello
```

```c
#include <stdio.h>


int main(void)
{
    printf("hello, world\n");
}
```

```c
#include <cs50.h>
#include <stdio.h>

int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
clang -o hello hello.c -lcs50

./hello
```

```
make hello

./hello
```

compiling

preprocessing

compiling

assembling

linking

preprocessing

compiling

assembling

linking

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

/usr/include

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
string get_string(string prompt);
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
string get_string(string prompt);
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
string get_string(string prompt);
int printf(string format, ...);


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
...
string get_string(string prompt);
int printf(string format, ...);
...

int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

preprocessing

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linking

```
...
string get_string(string prompt);
int printf(string format, ...);
...

int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```
...
main:                                   # @main
    .cfi_startproc
# BB#0:
    pushq    %rbp
.Ltmp0:
    .cfi_def_cfa_offset 16
.Ltmp1:
    .cfi_offset %rbp, -16
    movq    %rsp, %rbp
.Ltmp2:
    .cfi_def_cfa_register %rbp
    subq    $16, %rsp
    xorl    %eax, %eax
    movl    %eax, %edi
    movabsq    $.L.str, %rsi
    movb    $0, %al
    callq    get_string
    movabsq    $.L.str.1, %rdi
    movq    %rax, -8(%rbp)
    movq    -8(%rbp), %rsi
    movb    $0, %al
    callq    printf
    ...
```

```
...
main:                                   # @main
    .cfi_startproc
# BB#0:
    pushq    %rbp
.Ltmp0:
    .cfi_def_cfa_offset 16
.Ltmp1:
    .cfi_offset %rbp, -16
    movq    %rsp, %rbp
.Ltmp2:
    .cfi_def_cfa_register %rbp
    subq    $16, %rsp
    xorl    %eax, %eax
    movl    %eax, %edi
    movabsq    $.L.str, %rsi
    movb    $0, %al
    callq    get_string
    movabsq    $.L.str.1, %rdi
    movq    %rax, -8(%rbp)
    movq    -8(%rbp), %rsi
    movb    $0, %al
    callq    printf
    ...
```

```
...
main:                                   # @main
    .cfi_startproc
# BB#0:
    pushq    %rbp
.Ltmp0:
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.Ltmp1:
    .cfi_offset %rbp, -16
    movq    %rsp, %rbp
.Ltmp2:
    .cfi_def_cfa_register %rbp
    subq    $16, %rsp
    xorl    %eax, %eax
    movl    %eax, %edi
    movabsq    $.L.str, %rsi
    movb    $0, %al
    callq    get_string
    movabsq    $.L.str.1, %rdi
    movq    %rax, -8(%rbp)
    movq    -8(%rbp), %rsi
    movb    $0, %al
    callq    printf
    ...
```

preprocessing

compiling

assembling

linking

```
...
main:                                   # @main
    .cfi_startproc
# BB#0:
    pushq    %rbp
.Ltmp0:
    .cfi_def_cfa_offset 16
.Ltmp1:
    .cfi_offset %rbp, -16
    movq    %rsp, %rbp
.Ltmp2:
    .cfi_def_cfa_register %rbp
    subq    $16, %rsp
    xorl    %eax, %eax
    movl    %eax, %edi
    movabsq    $.L.str, %rsi
    movb    $0, %al
    callq    get_string
    movabsq    $.L.str.1, %rdi
    movq    %rax, -8(%rbp)
    movq    -8(%rbp), %rsi
    movb    $0, %al
    callq    printf
    ...
```

```
01111111010001010100110001000110
00000010000000010000000100000000
00000000000000000000000000000000
00000000000000000000000000000000
00000001000000000011111000000000
00000001000000000000000000000000
00000000000000000000000000000000
00000000000000000000000000000000
00000000000000000000000000000000
00000000000000000000000000000000
10100000000000100000000000000000
00000000000000000000000000000000
00000000000000000000000000000000
01000000000000000000000000000000
00000000000000000100000000000000
00001010000000000000000100000000
01010101010010001000100111100101
01001000100000111110110000010000
00110001110000001000100111000111
01001000101111100000000000000000
00000000000000000000000000000000
00000000000000001011000000000000
11101000000000000000000000000000
00000000010010001011111100000000
00000000000000000000000000000000
00000000000000000000000001001000
...
```

preprocessing

compiling

assembling

linking

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
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    printf("hello, %s\n", name);
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```c
#include <cs50.h>
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int main(void)
{
    string name = get_string("What's your name? ");
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```c
#include <cs50.h>
#include <stdio.h>


int main(void)
{
    string name = get_string("What's your name? ");
    printf("hello, %s\n", name);
}
```

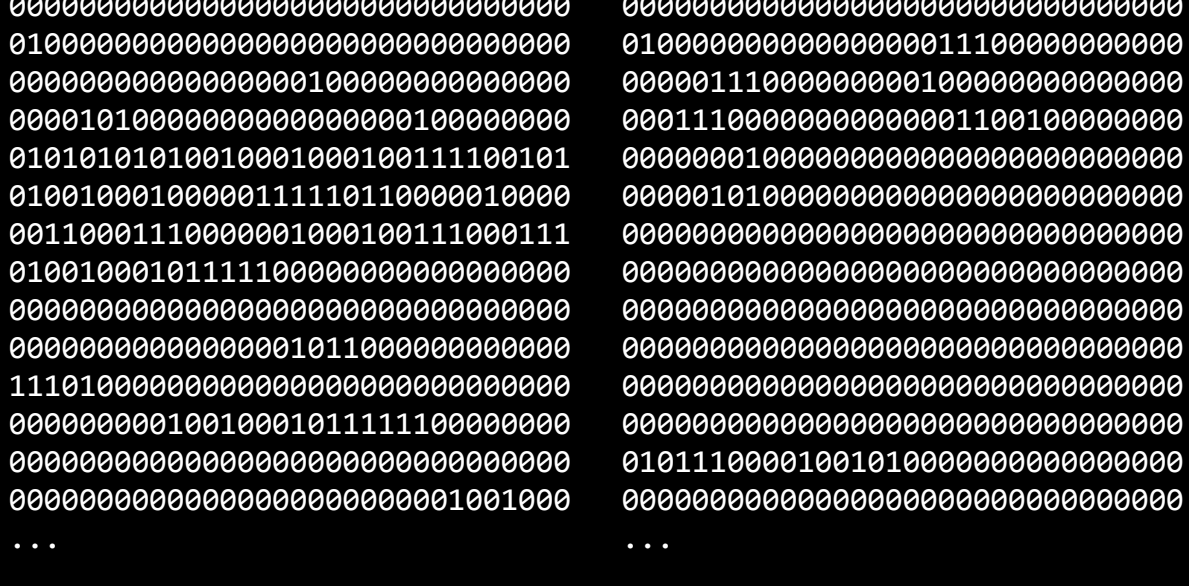
hello.c

hello.c

cs50.c

hello.c cs50.c stdio.c


cs50.c
stdio.c



stdio.c

0111111101000101010011000100011000000010000000010000000100000000000000000000000000000000000000000000000
0000000000000000000000000000000010000000000111110000000000000000000100000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000010100000000000010000000000000000000000000000000000000000000000000000000000000000000000000
0000000001000000000000000000000000000000000000000000000001000000000000000000101000000000000000001000000
0001010101010010001000100111100101010010001000001111101100000100000011000111000000100010011100011101000
1000101111100000000000000000000000000000000000000000000000000000000000000000101100000000000000111010000
0000000000000000000000000000000100100010111111000000000000000000000000000000000000000000000000000000000
0000000001001000...01111111010001010100110001000110000000100000000100000001000000000000000000000000000
0000000000000000000000000000000000000000000000000110000000000111110000000000000000000100000000000000000
0000000110000000000011110000000000000000000000000000000000000000000000100000000000000000000000000000000
0000000000000000000000000000000000010100000110010000000000000000000000000000000000000000000000000000000
0000000000000000000000000000100000000000000000111000000000000000000011100000000001000000000000000011100000
0000000011001000000000000000001000000000000000000000000000000101000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000010111000010010100000000000000
00000000000000000000000000000000000...0010111101101100011010010110001001100011001011100111001101101111
0010111000110110001000000001011110111010101110011011100100010111101101100011010010110001000101111011110
0000111000000110110010111111001101100011010000101101011011000110100101101110011101010111100000101101011 0
0111011011100111010100101111011011000110100101100010011000110101111101101110011011110110111001110011001101
1010000011000010111001001100101011001000010111001100001001000000001000000010000001010100110101111101001110
0100010101000101010001000100010101000100001000000001010000001000000001011110110110001101001011000100010 11
1101111000000111000000110110010111111001101100011010000101101011011000110100101101110011101010111100000 10
1101011001110110111001110101001011110110110001100100001011010110110001101001011011100111010101111000 00
1011010111100000111000001101100010110100110110001101 00...

preprocessing

compiling

assembling

linking

compiling

decompiling

reverse engineering

0111111101000101010011000100011000000010000000010000000100000000000000000000000000000000000000000000000
0000000000000000000000000000000001000000000011111000000000000000001000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000010100000000000010000000000000000000000000000000000000000000000000000000000000000000000000
0000000001000000000000000000000000000000000000000000000001000000000000000000101000000000000000001000000
000101010101001000100010011110010101001000100000111110110000010000001100011100000010001001110001110100
1000101111100000000000000000000000000000000000000000000000000000000000000000010110000000000001110100000
0000000000000000000000000000000100100010111111000000000000000000000000000000000000000000000000000000000
0000000001001000...0111111101000101010011000100011000000010000000010000000100000000000000000000000000
0000000000000000000000000000000000000000000001100000000011111000000000000000000000000001000000000000000
0000000110000000000011110000000000000000000000000000000000000000000000000100000000000000000000000000000
0000000000000000000000000000000000010100000110010000000000000000000000000000000000000000000000000000000
0000000000000000000000000000010000000000000001110000000000000000111000000000100000000000000000111000000
0000000011001000000000000000100000000000000000000000000000101000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000001011100001001010000000000000
00000000000000000000000000000000000...0010111101101100011010010110001001100011001011100111001101101111
001011100011011000100000001011110111010101110011011100100010111101101100011010010110001000101111011110
000011100000110110010111110011011000110100001011010110110001101001011011100111010101111000001011010110
011101101110011101010010111101101100011010010110001001100011010111110110111001101111011011100111001101
101000011000010111001001100101011001000010111001100001001000000010000001000001010100110101111101001110
0100010101000101010001000100010100010000100000001010000010000000101111011011000110100101100010001011
110111100000111000001101100101111100110110001101000010110101101100011010010110111001110101011110000010
110101100111011011100111010100101111011011000110010000101101011011000110100101101110011101010111100000
101101011110000011100000110110001011010011011000110100...

debugging

Photo # NH 96566-KN (Color) First Computer "Bug", 1947

9/9

0800 Arctan started
1000 " stopped - arctan ✓ { 1.2700 9.037 847 025
9.037 846 795 correct
13 "uc (032) MP - MC ~~1.5821000~~ ~~2.13047641 5 (-3)~~ 4.615925059(-2)
(033) PRO 2 2.13047641 5
correct 2.13067641 5
Relays 6-2 in 033 failed special speed test
In relay " 11.00 test.
Relays changed
1100 Started Cosine Tape (Sine check)
1525 Started Mult + Adder Test.

1545 Relay #70 Panel F
(moth) in relay.
First actual case of bug being found.
~~1700~~ 1630 Arctangent started.
1700 closed down.

In relay . 11.00 test.

Relays changed

1100 Started Cosine Tape (Sine check)

1525 Started Multy Adder Test.

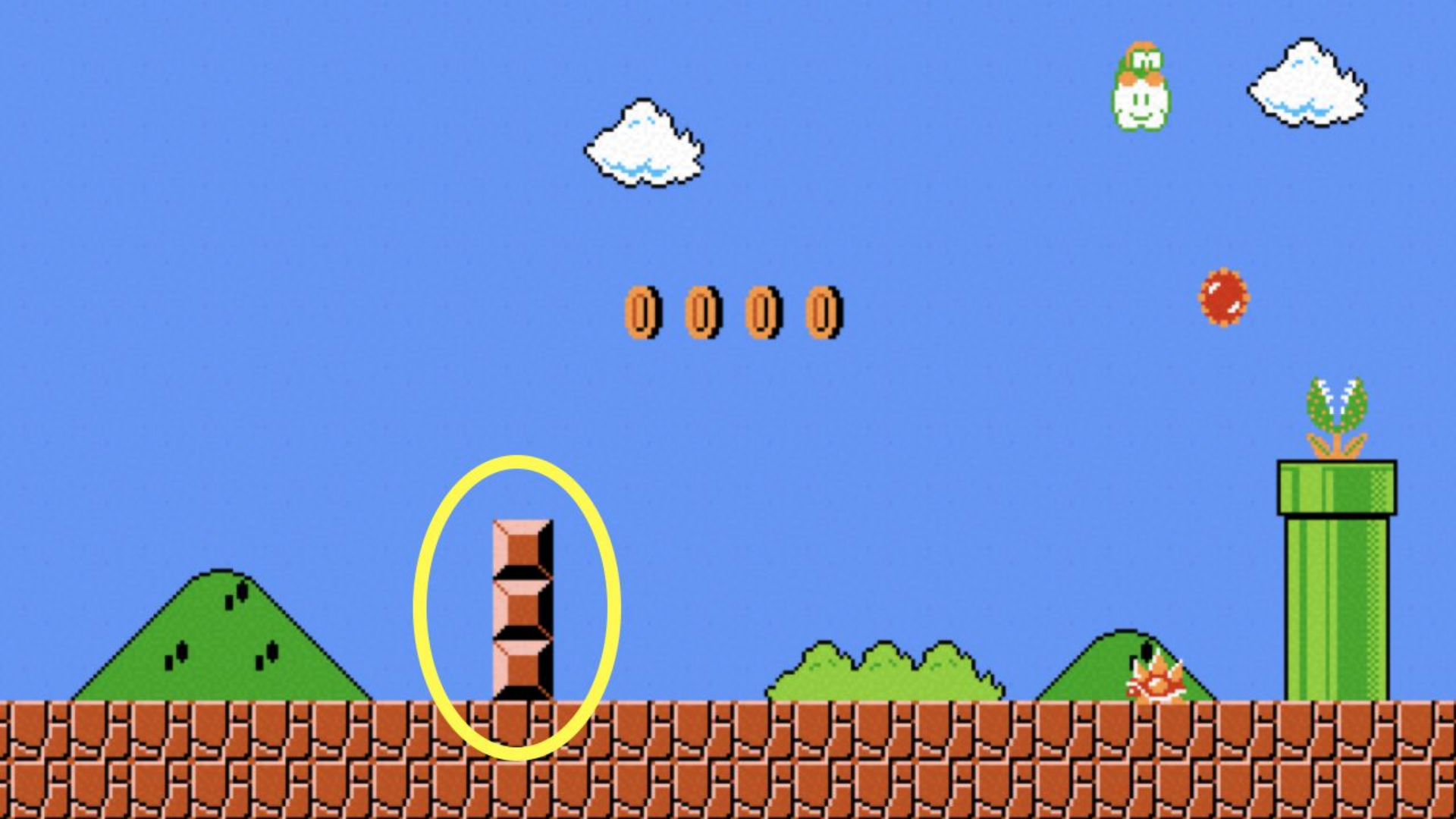
1545  Relay #70 Panel F
(moth) in relay.

First actual case of bug being found.

~~1655~~ 1630 Arctangent started.

1700 closed down.


GRACE HOPPER



printf

`printf`

debugger

`printf`

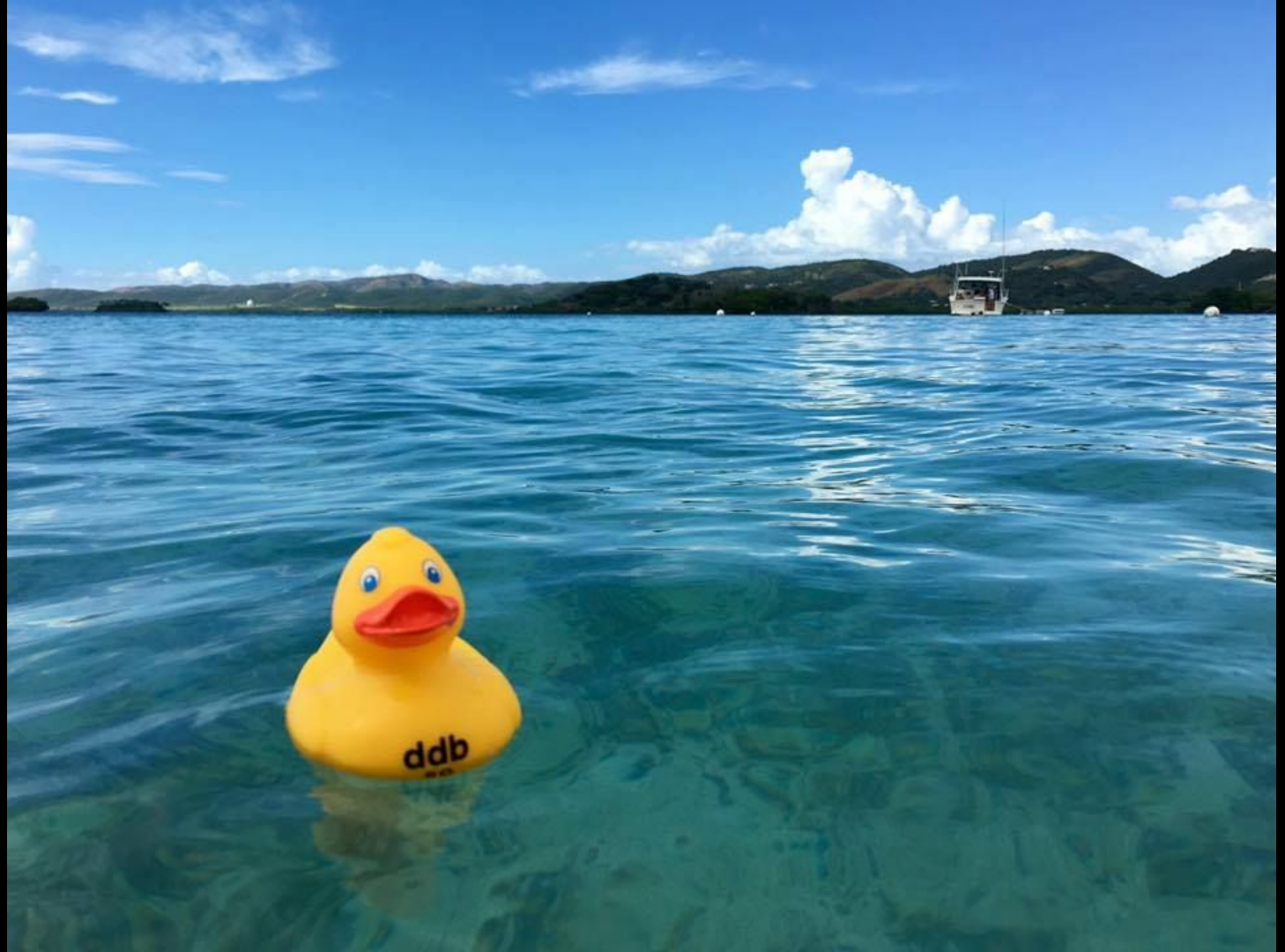
debugger

rubber duck

rubber duck debugging

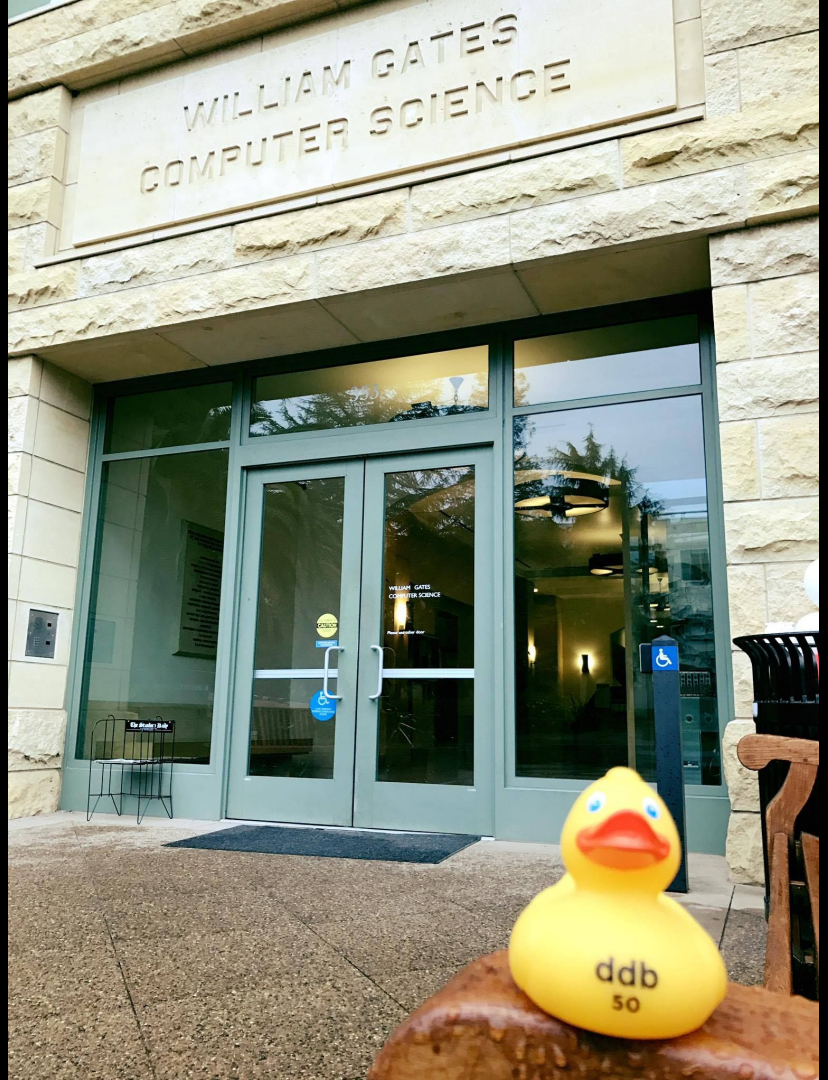

CS50
ddb


ddb
50


ddb


ddb
50


ddb
50


WILLIAM GATES
COMPUTER SCIENCE
ddb
50


ddb
Google


ddb
50


CS50
4m ago
ddb
20
0

representation

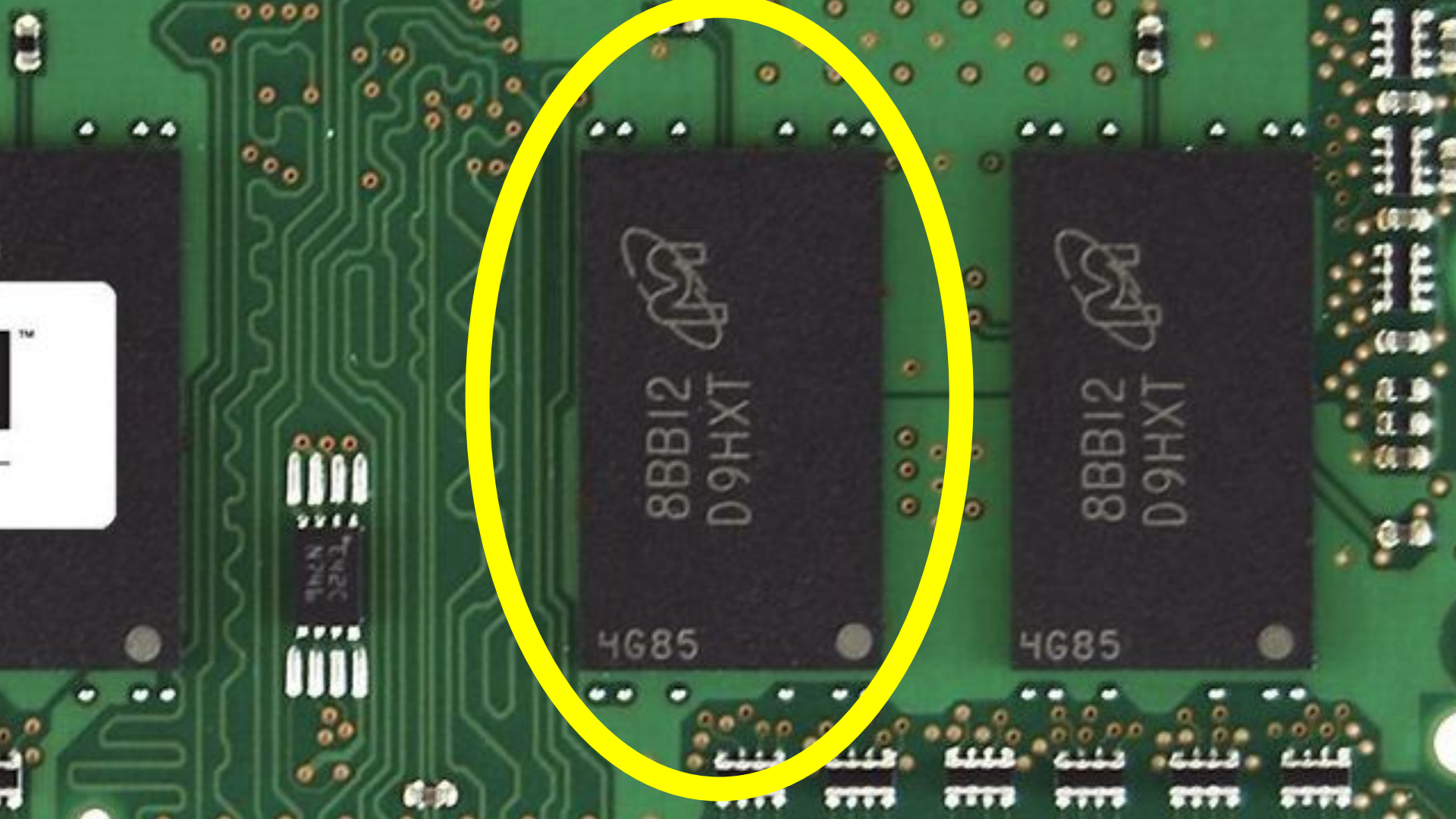
types

```
bool

int

long

float

double

char

string

...
```

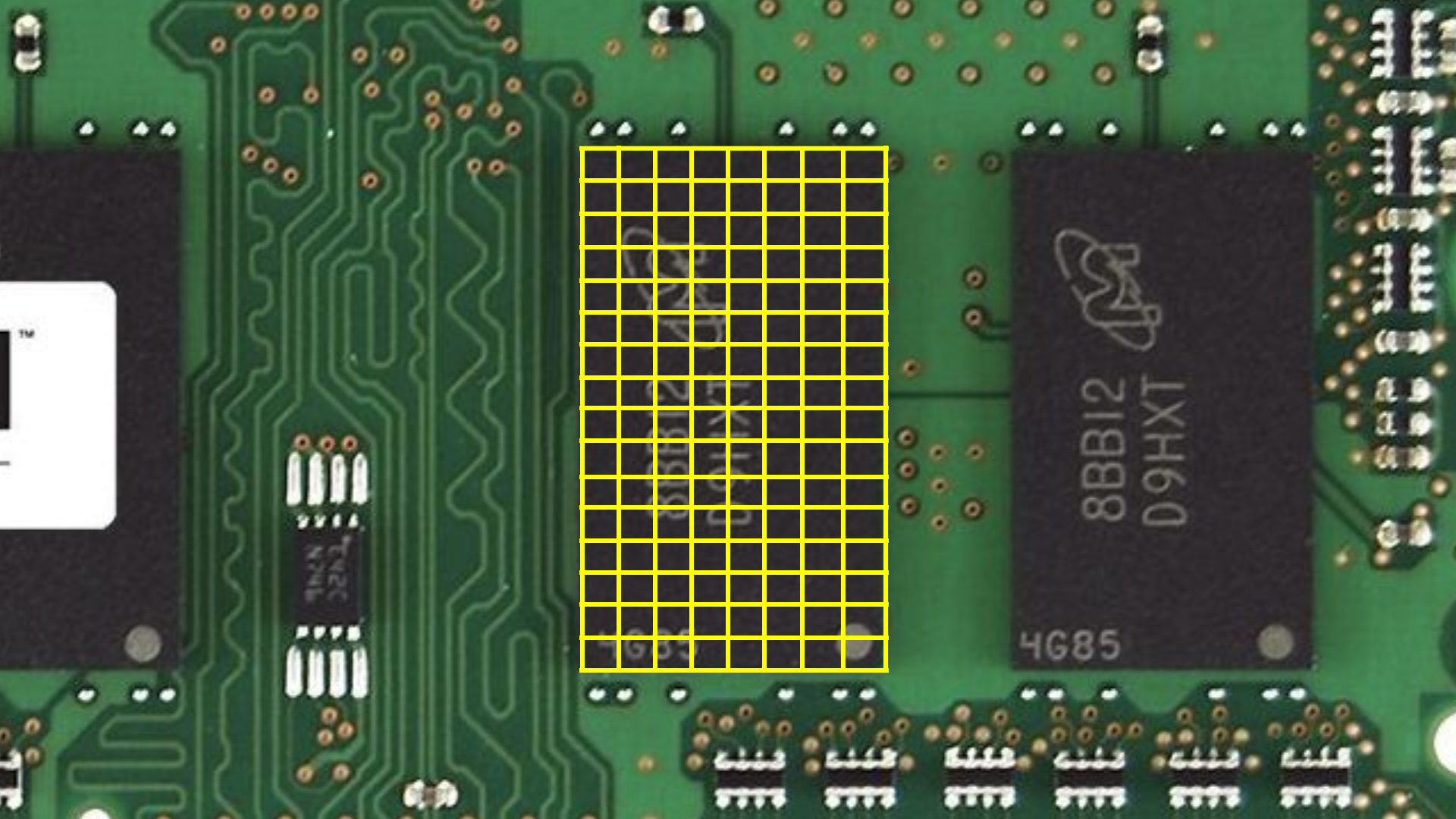
`bool`	1 byte
`int`	4 bytes
`long`	8 bytes
`float`	4 bytes
`double`	8 bytes
`char`	1 byte
`string`	? bytes
...	

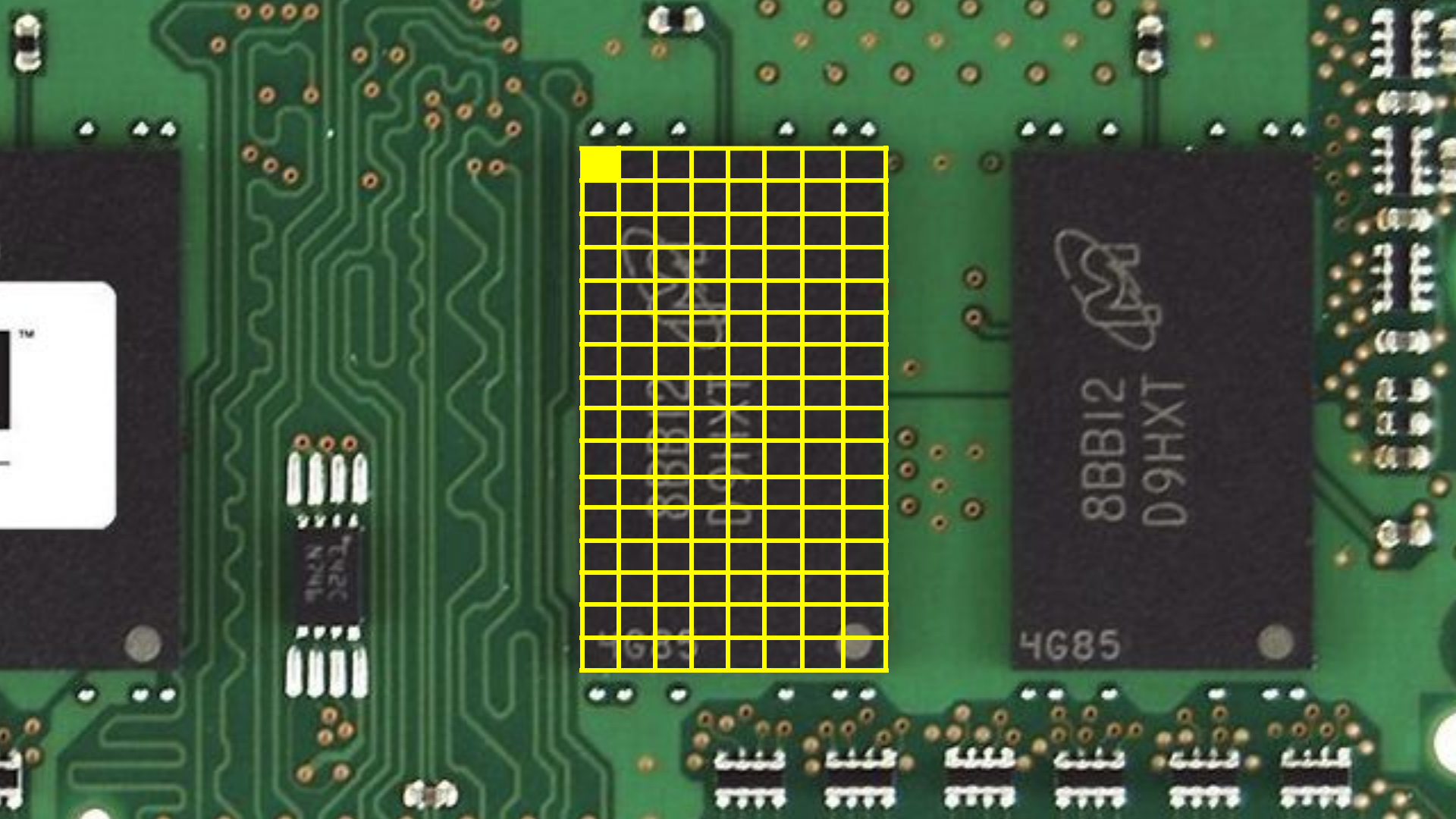

crucial
by Micron
8BBI2
D9HXT
8BBI2
D9HXT
4G85
4G85
4G85
47J6

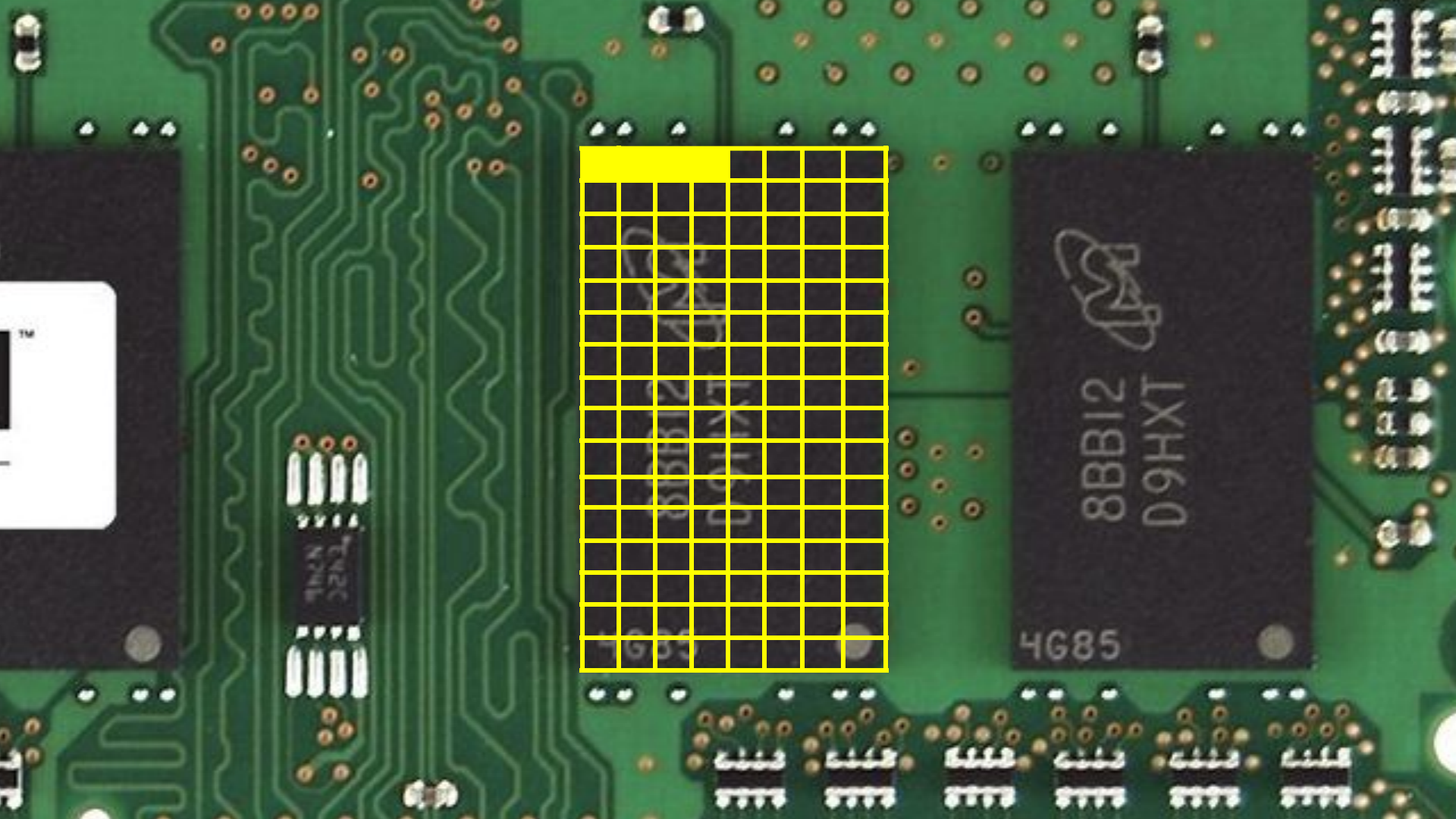

crucial
by Micron
8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85
4G85
47J6
4G85

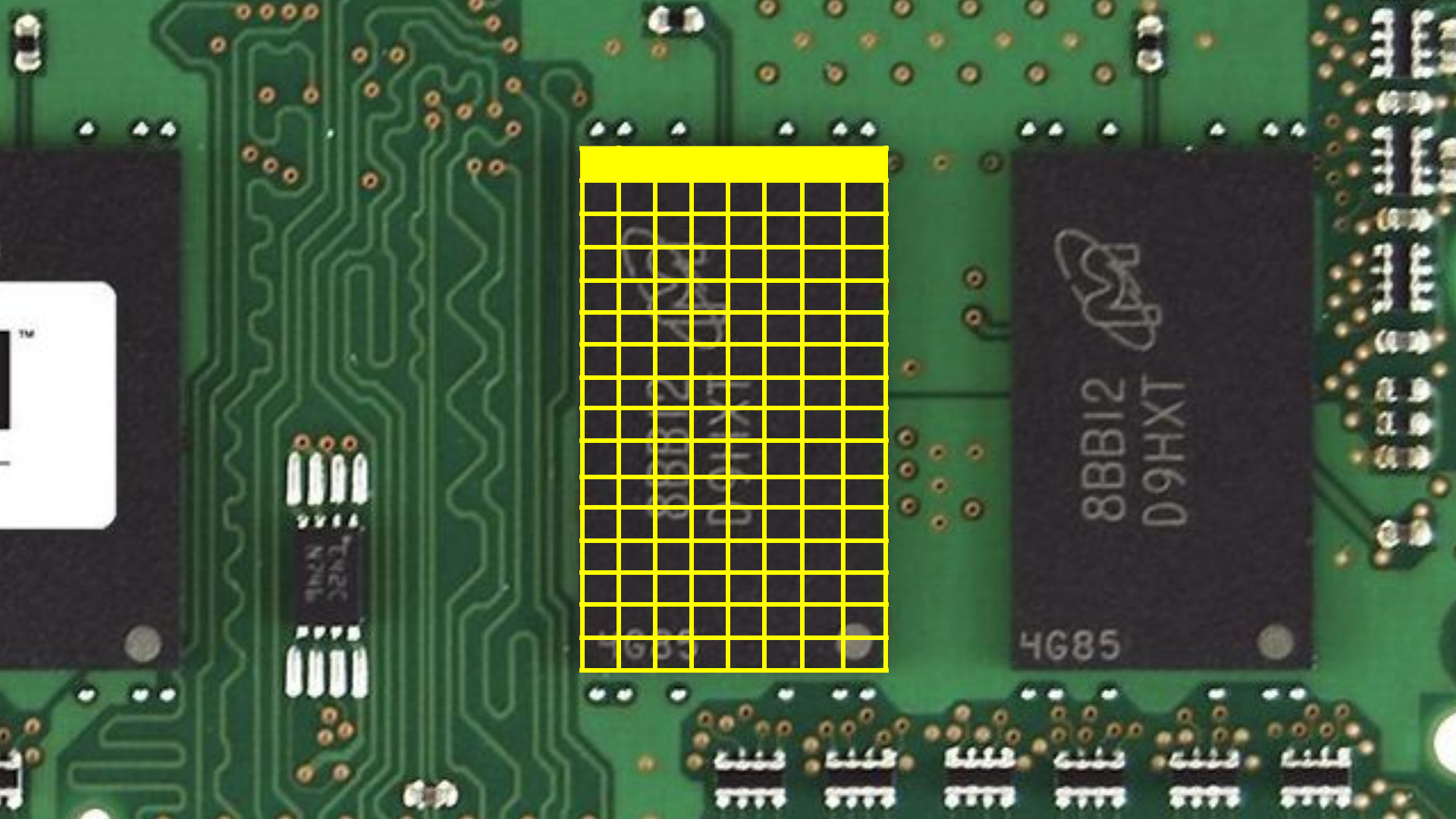

8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85

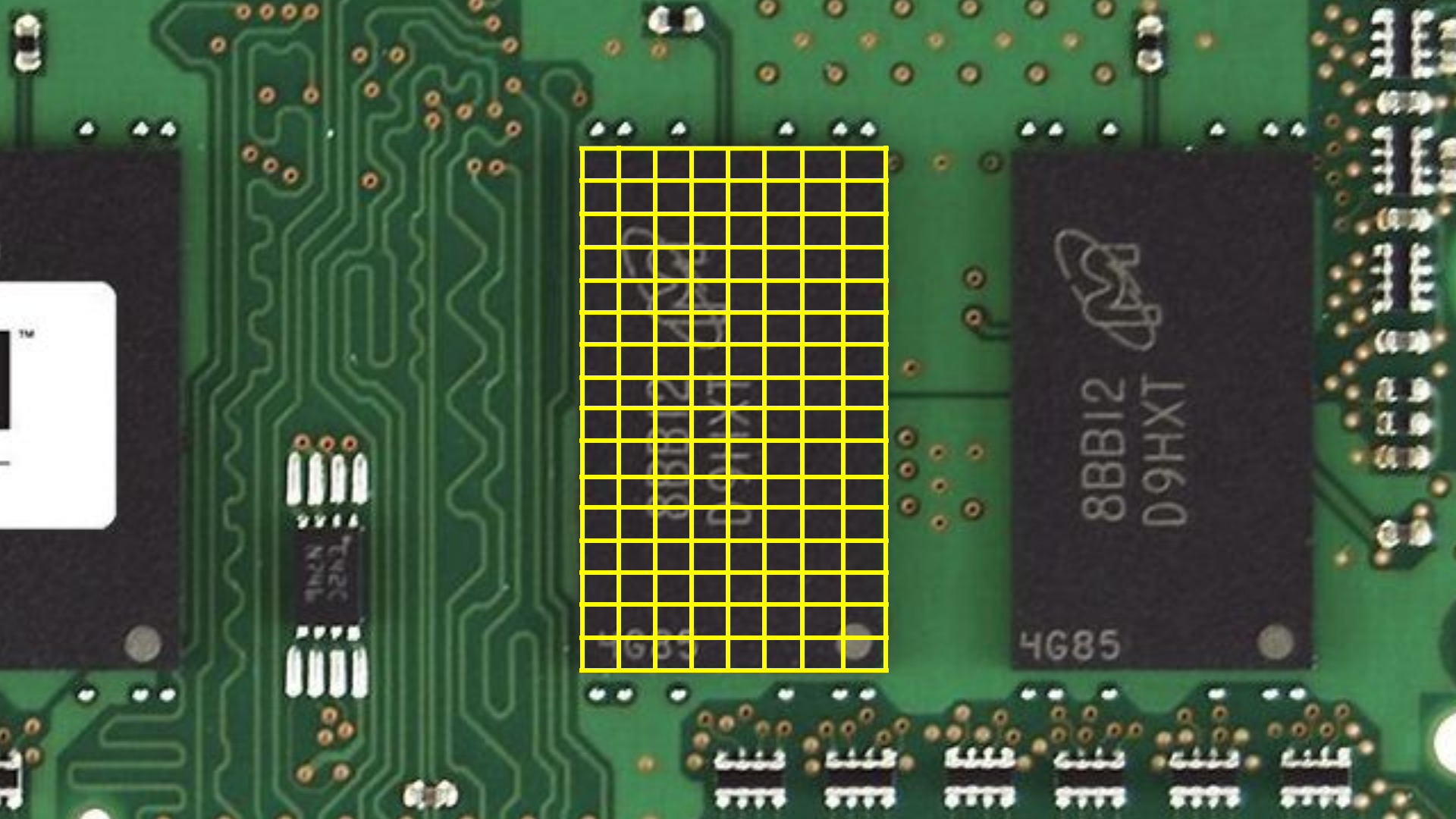

8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85

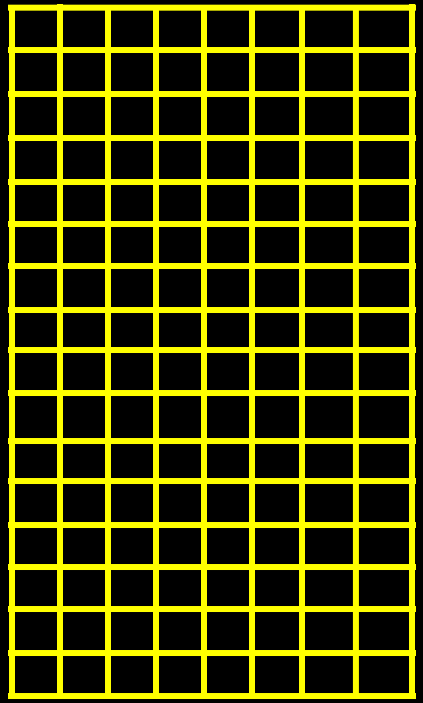

8BBI2
D9HXT
4G85


8BBI2
D9HXT
4G85

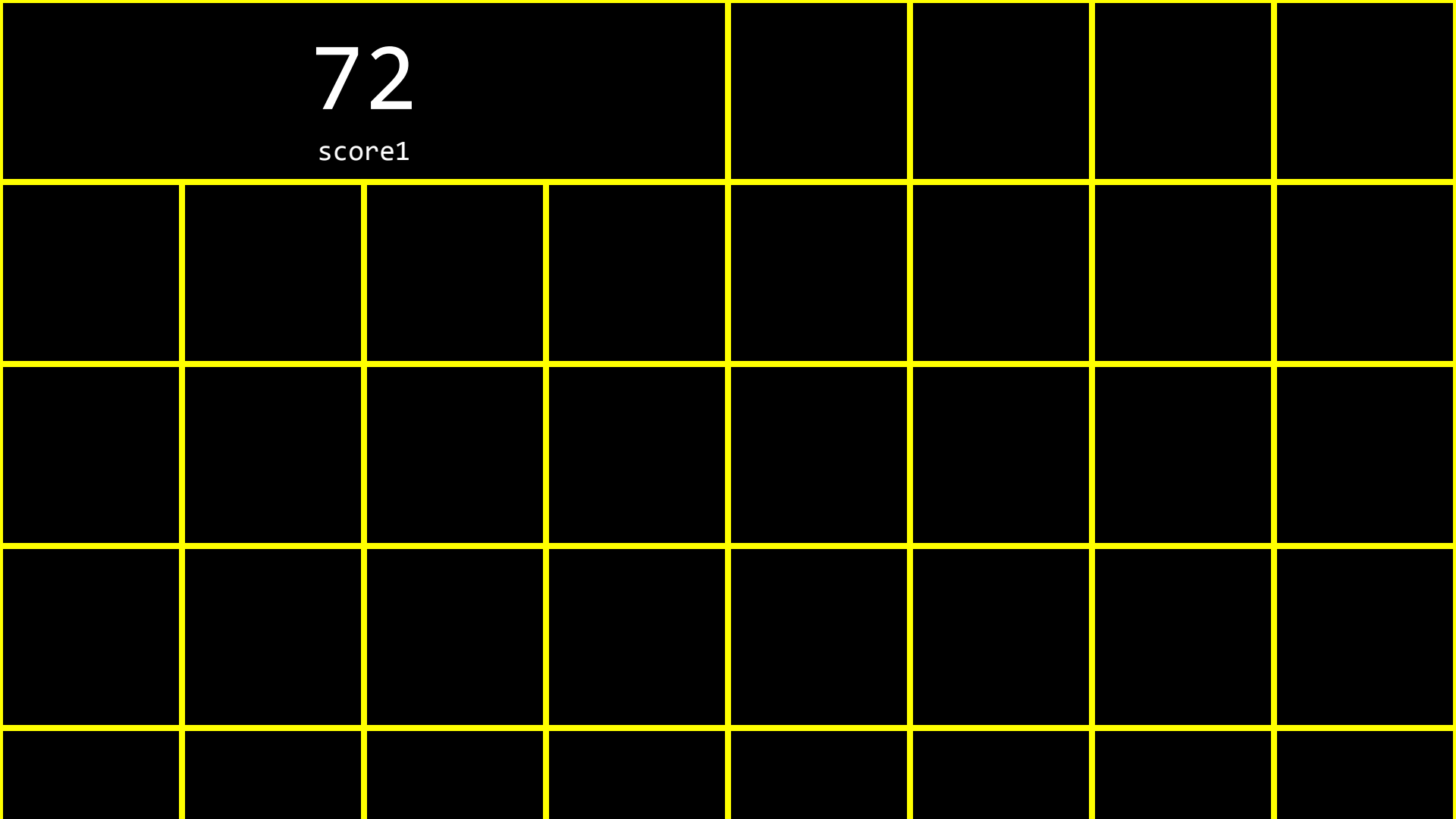

8BBI2
D9HXT
4G85


8BBI2
D9HXT
4G85


8BBI2
D9HXT
4G85



```
int score1 = 72;

int score2 = 73;

int score3 = 33;
```


72
score1

72

score1

73

score2

72

score1

73

score2

33

score3

00000000000000000000001001000

score1

00000000000000000000001001001

score2

00000000000000000000100001

score3

```
int score1 = 72;

int score2 = 73;

int score3 = 33;
```

arrays

```
int scores[3];
```

```
int scores[3];

scores[0] = 72;

scores[1] = 73;

scores[2] = 33;
```

72

scores[0]

73

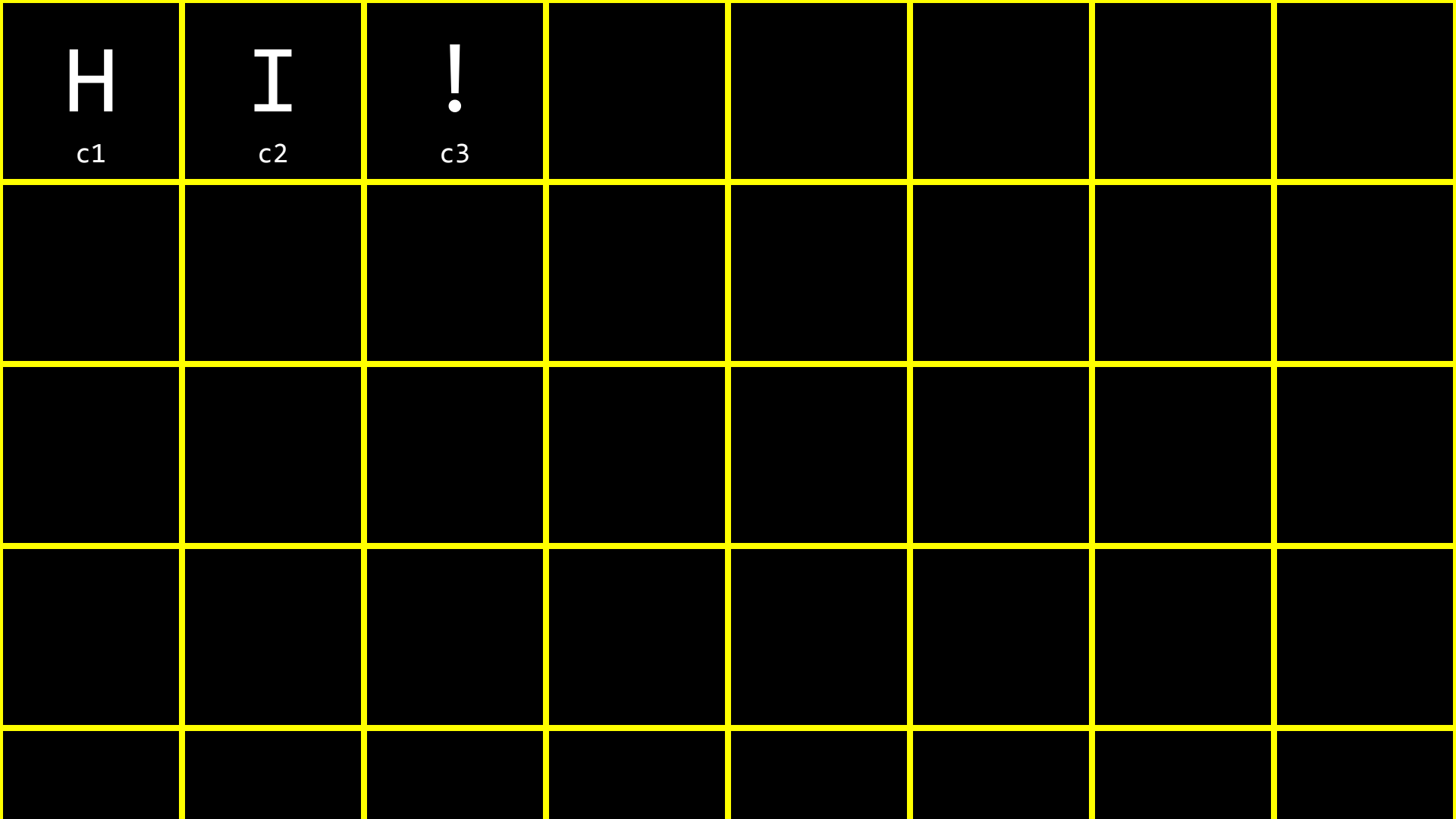
scores[1]

33

scores[2]

arguments

```
char c1 = 'H';

char c2 = 'I';

char c3 = '!';
```


H
I
!
c1
c2
c3

72 c1	73 c2	33 c3					

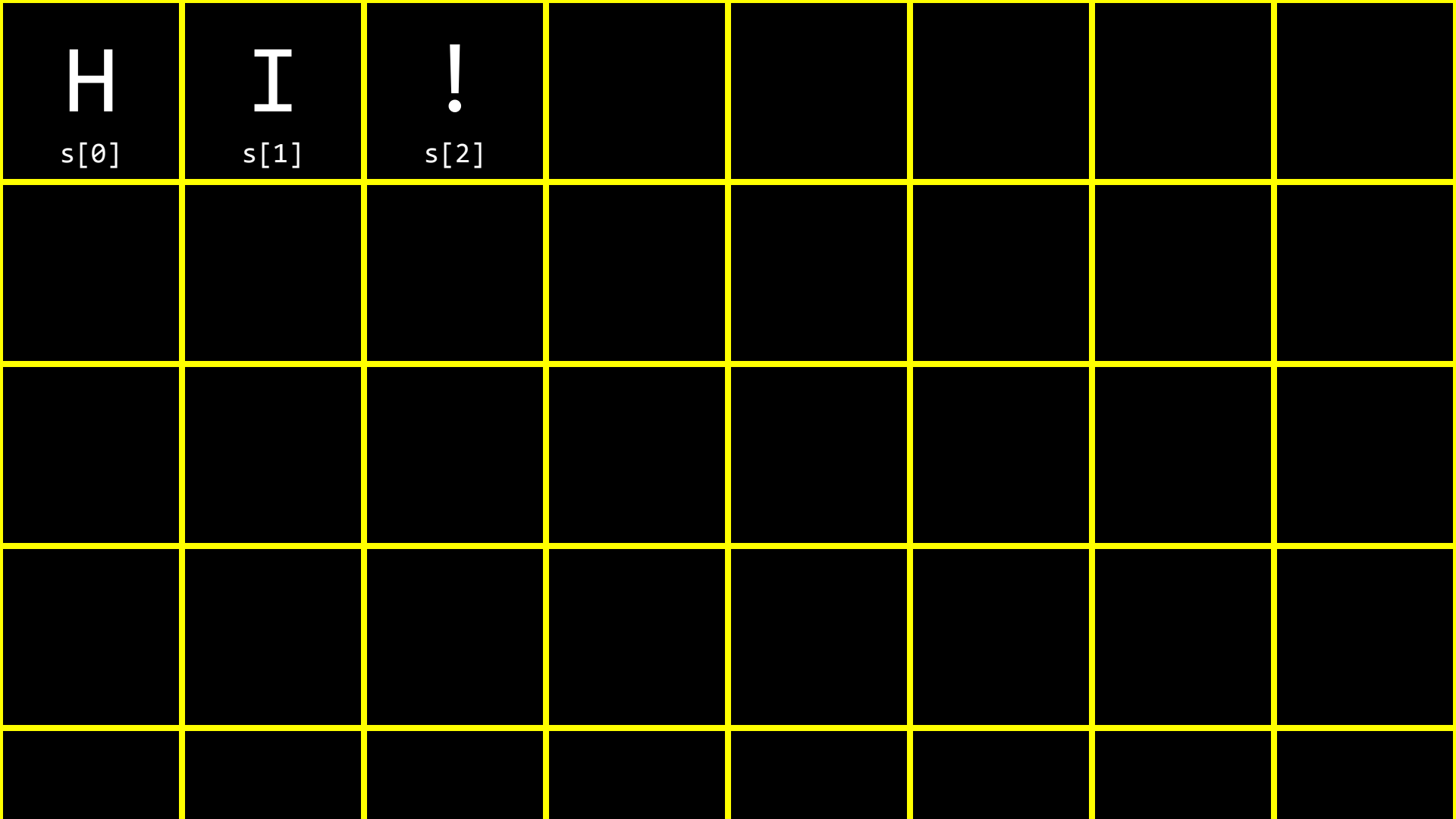
01001000 c1	01001001 c2	00100001 c3					

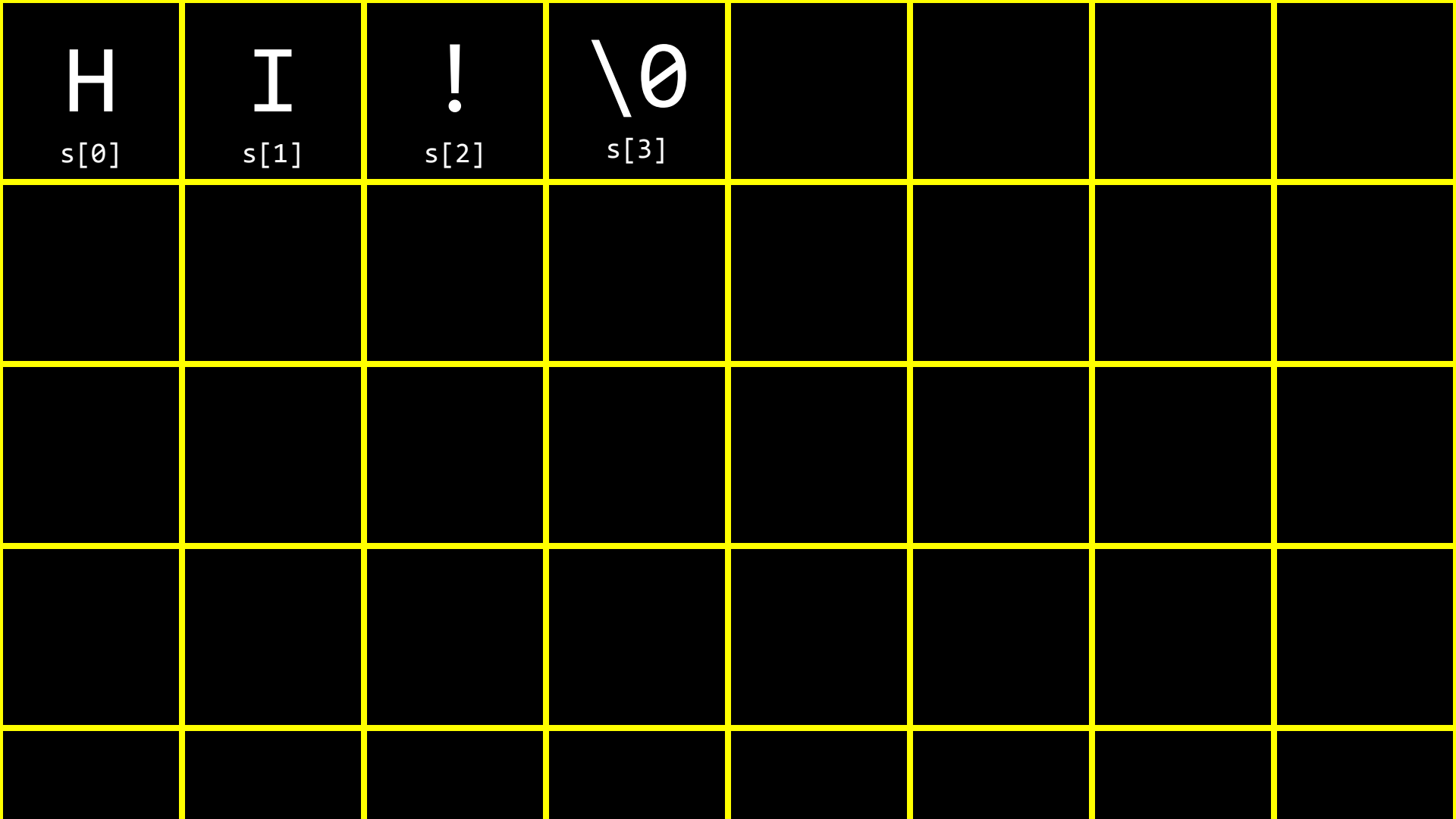
string

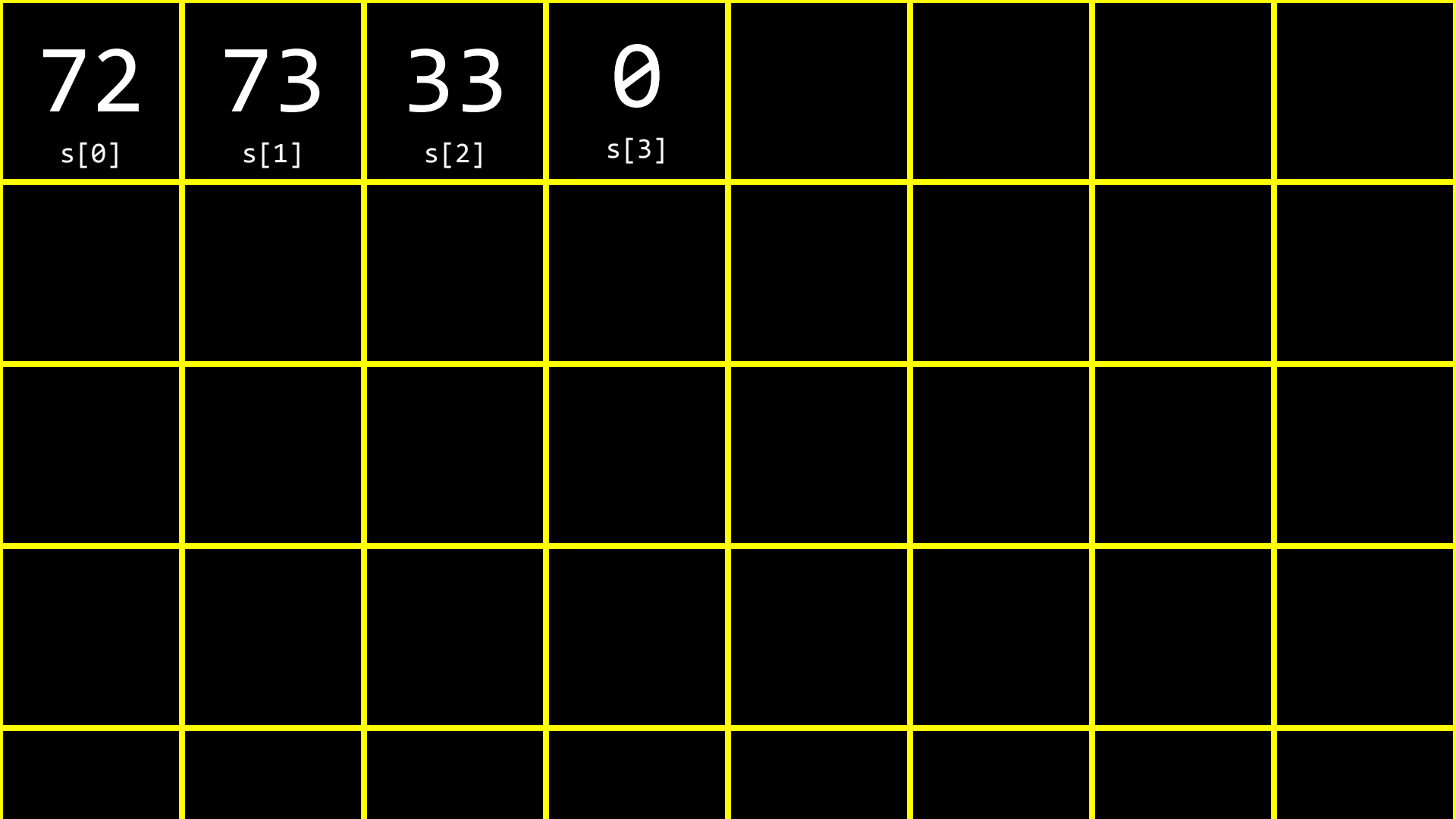
```
string s = "HI!";
```

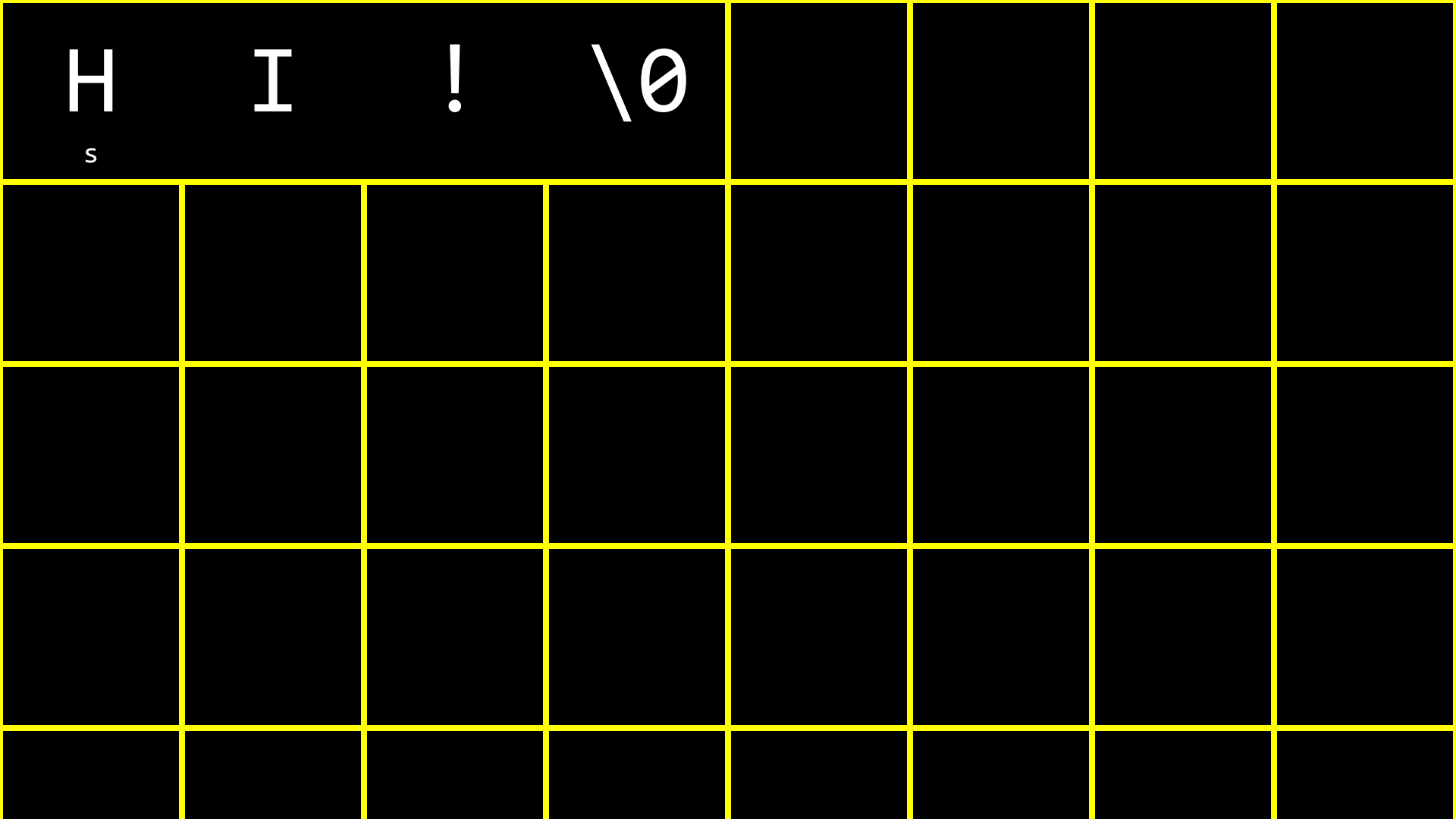
H I !

s


H
I
!
s[0]
s[1]
s[2]


H
I
!
\0
s[0]
s[1]
s[2]
s[3]


72
s[0]
73
s[1]
33
s[2]
0
s[3]

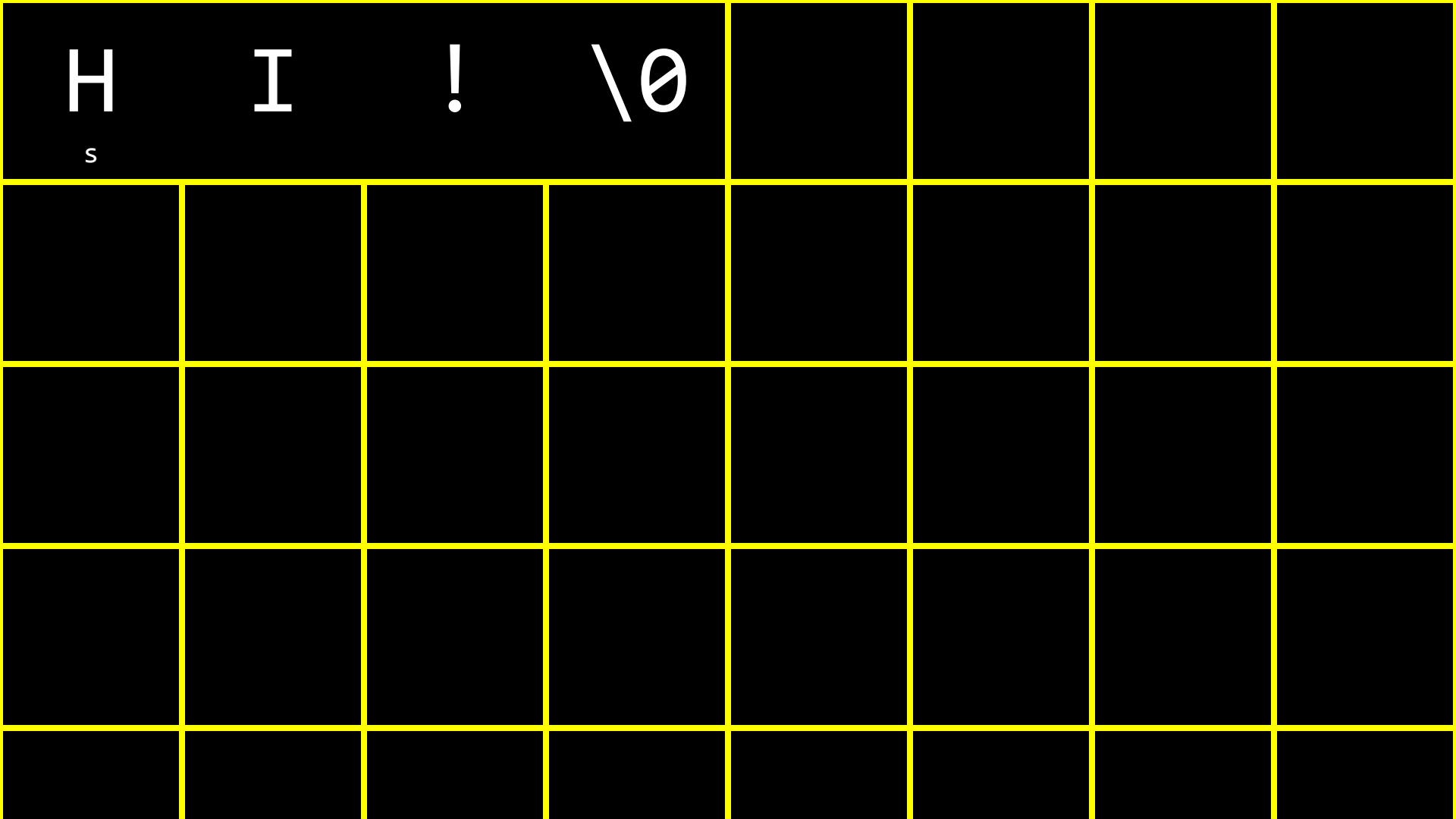

H I ! \0
s

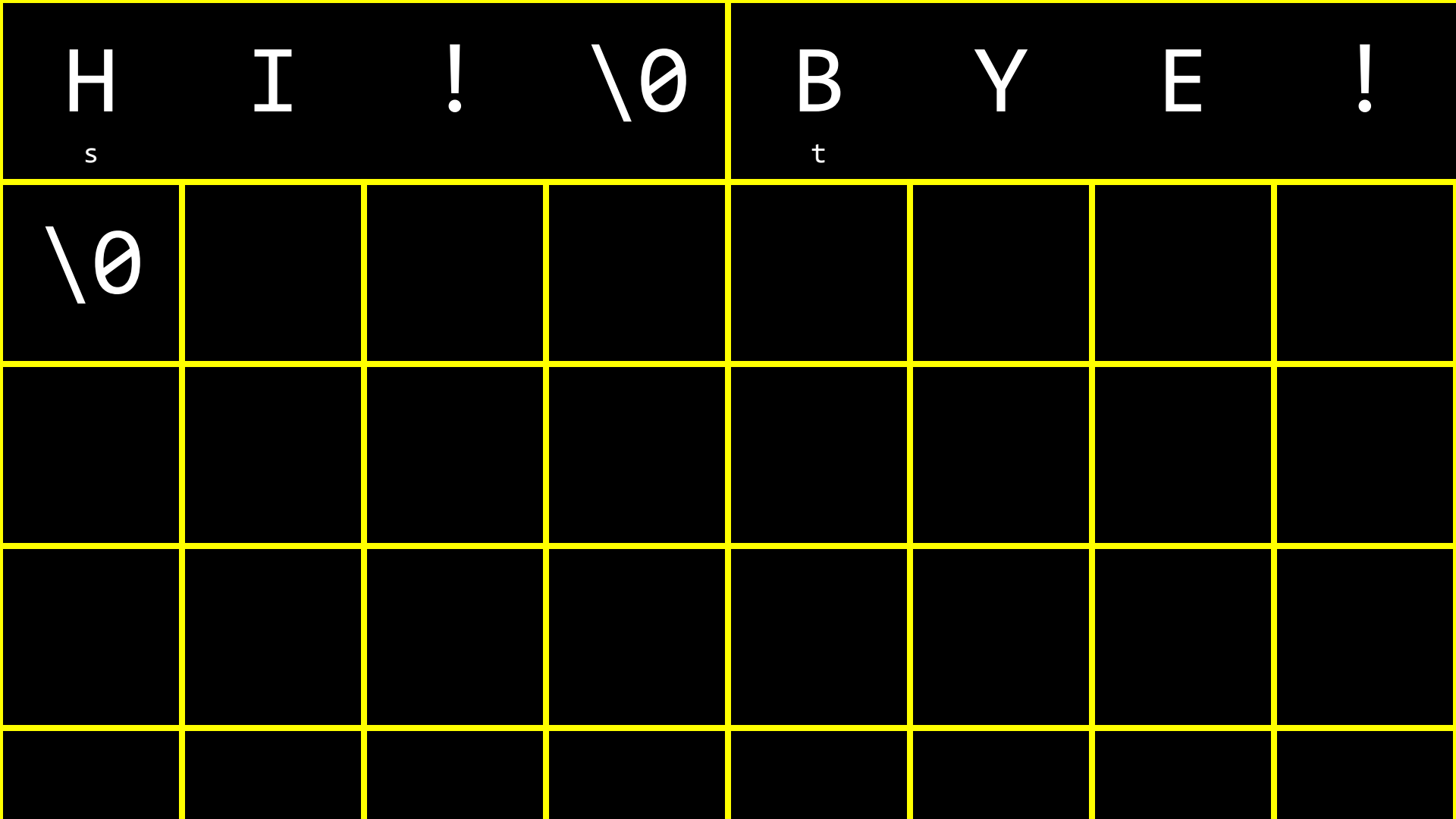
NUL

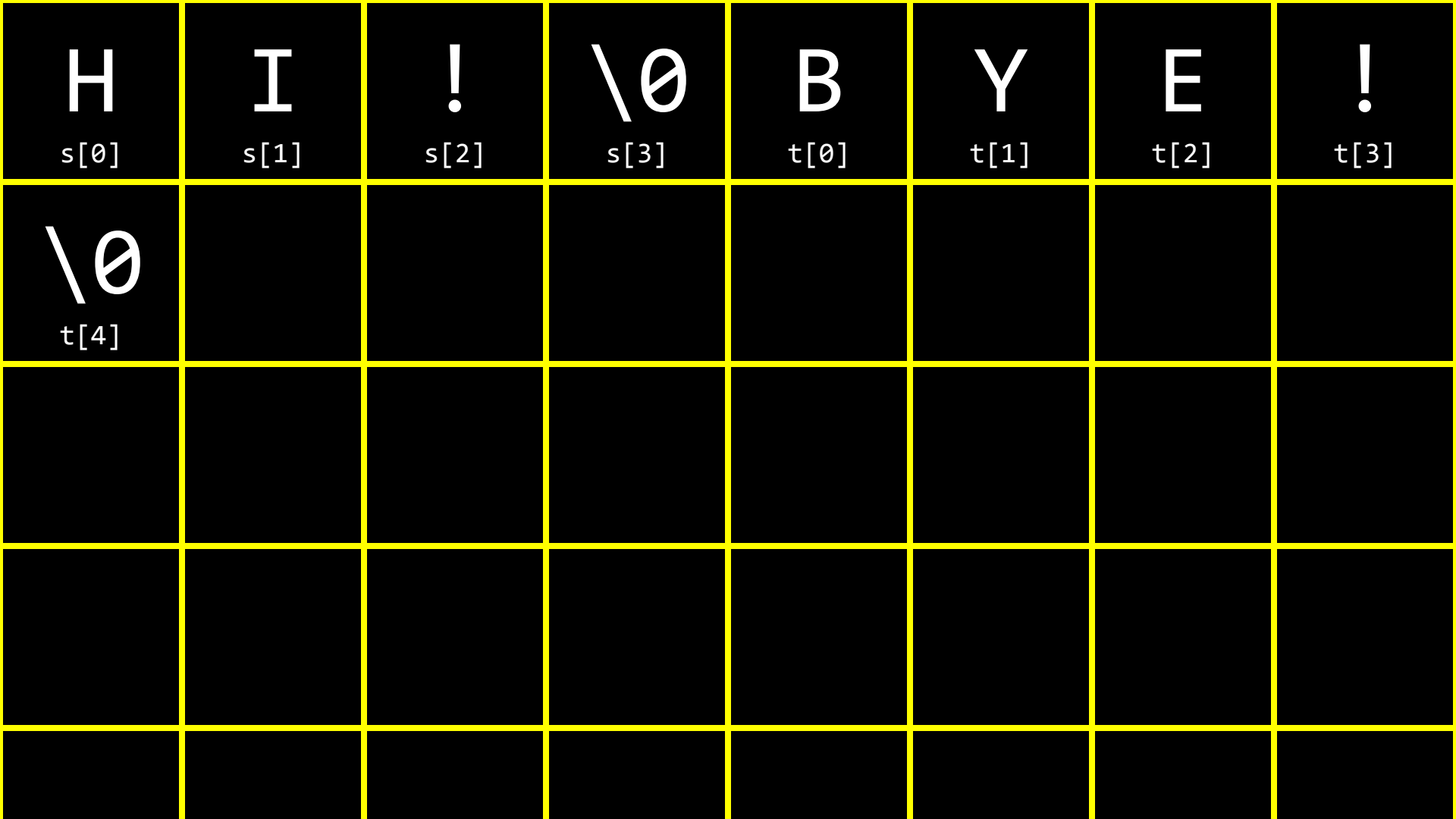
0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

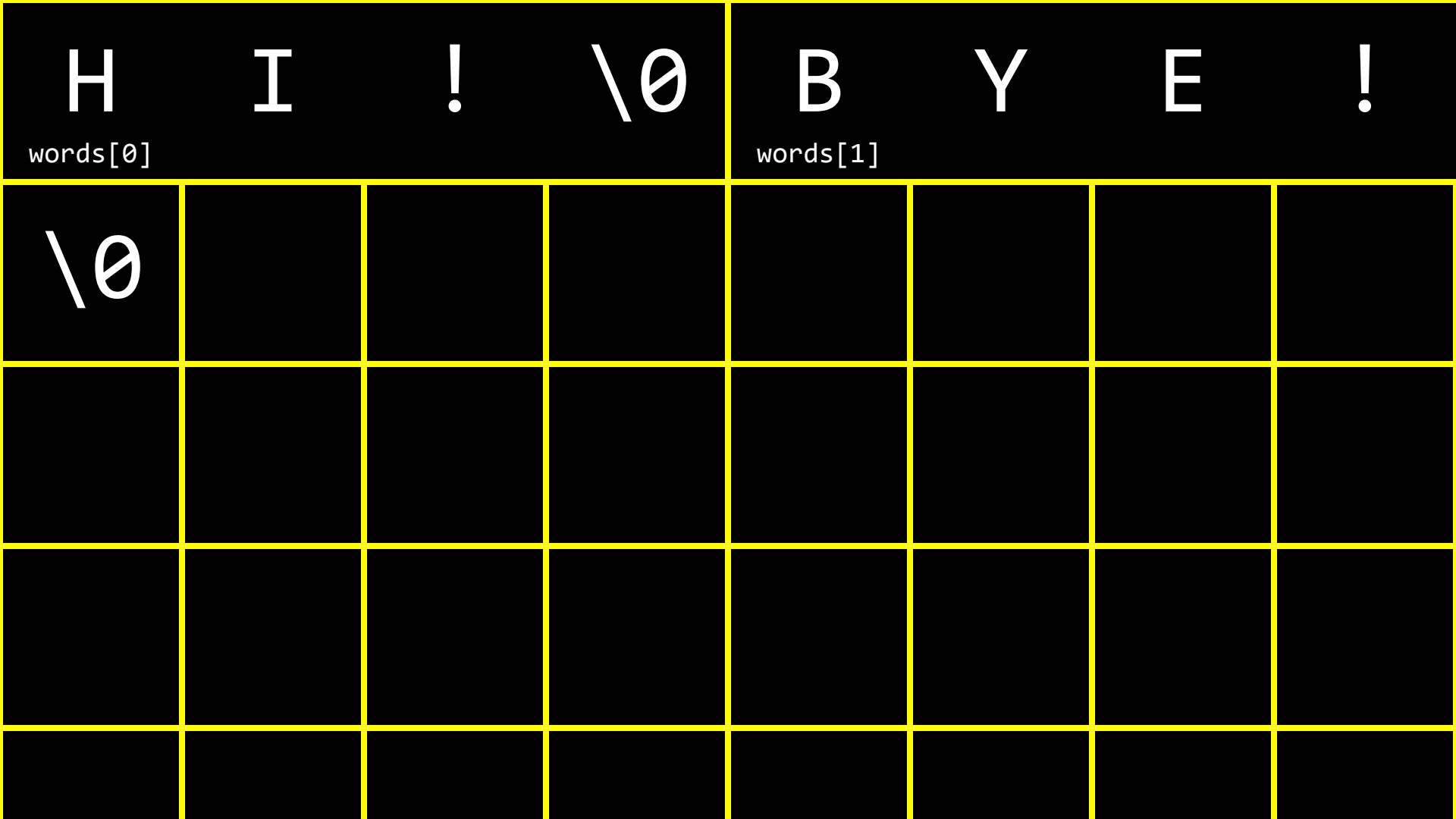
```
string s = "HI!";

string t = "BYE!";
```

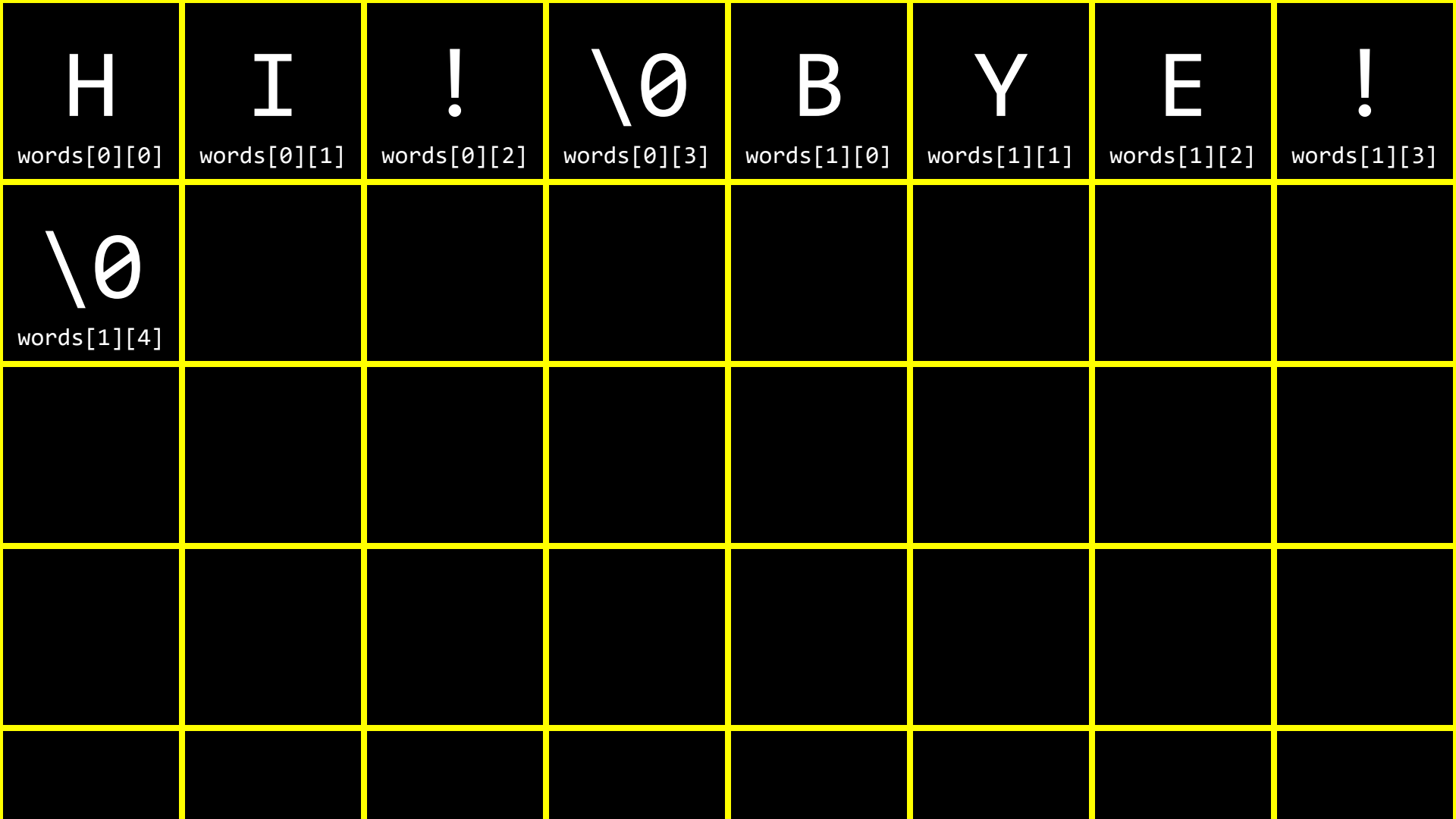

H I ! \0
s


H I ! \0
s
B Y E !
t
\0


H
s[0]
I
s[1]
!
s[2]
\0
s[3]
B
t[0]
Y
t[1]
E
t[2]
!
t[3]
\0
t[4]

```
string words[2];

words[0] = "HI!";

words[1] = "BYE!";
```


H I ! \0
words[0]
B Y E !
words[1]
\0


H
words[0][0]
I
words[0][1]
!
words[0][2]
\0
words[0][3]
B
words[1][0]
Y
words[1][1]
E
words[1][2]
!
words[1][3]
\0
words[1][4]

string

string.h

manual.cs50.io/#string.h

strlen

ctype.h

manual.cs50.io/#ctype.h

command-line arguments

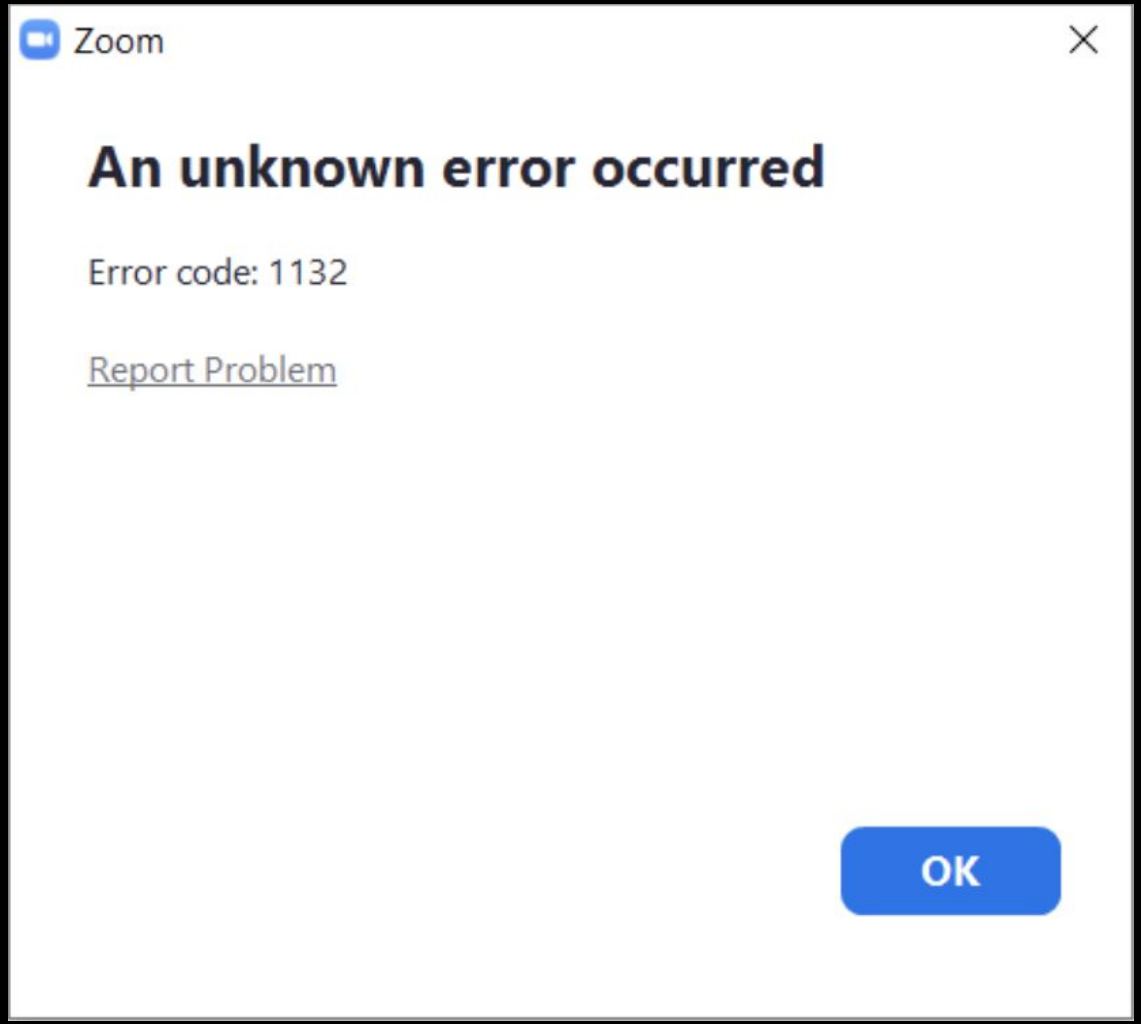
```c
#include <stdio.h>

int main(void)
{
    ...
}
```

```c
#include <stdio.h>

int main(void)
{
    ...
}
```

```
#include <stdio.h>

int main(int argc, string argv[])
{
    ...
}
```

cowsay

exit status


Zoom
An unknown error occurred
Error code: 1132
Report Problem
OK


404
This is not the web page you are looking for.

```
#include <stdio.h>

int main(int argc, string argv[])
{
    ...
}
```

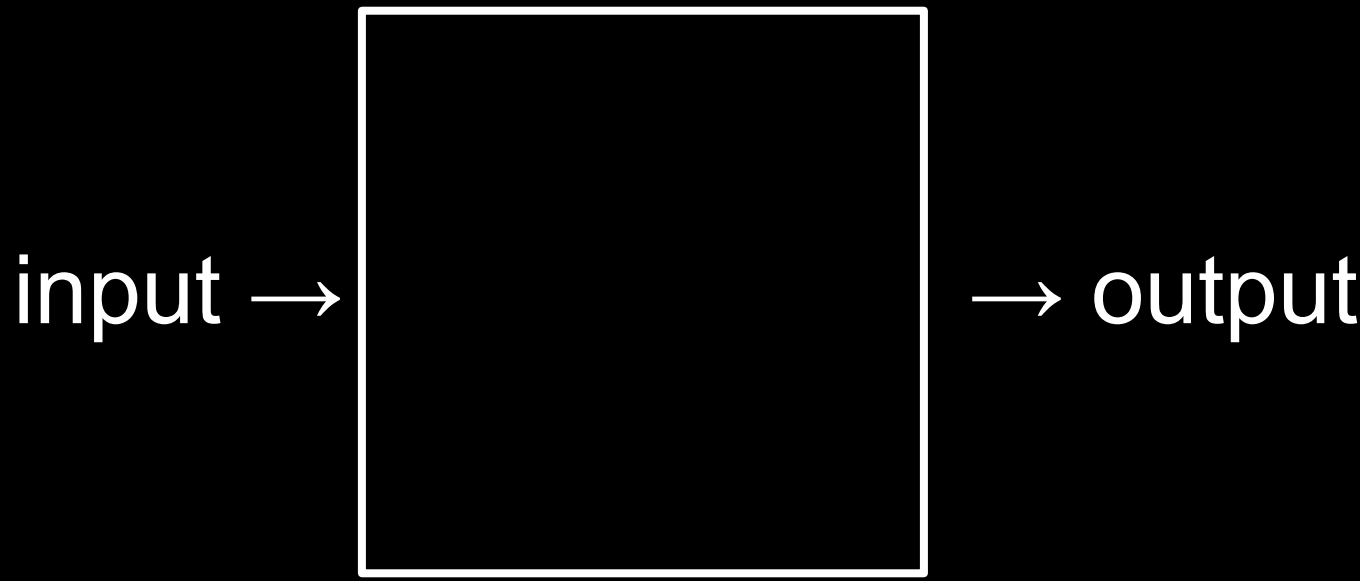
```
#include <stdio.h>

int main(int argc, string argv[])
{
    ...
}
```

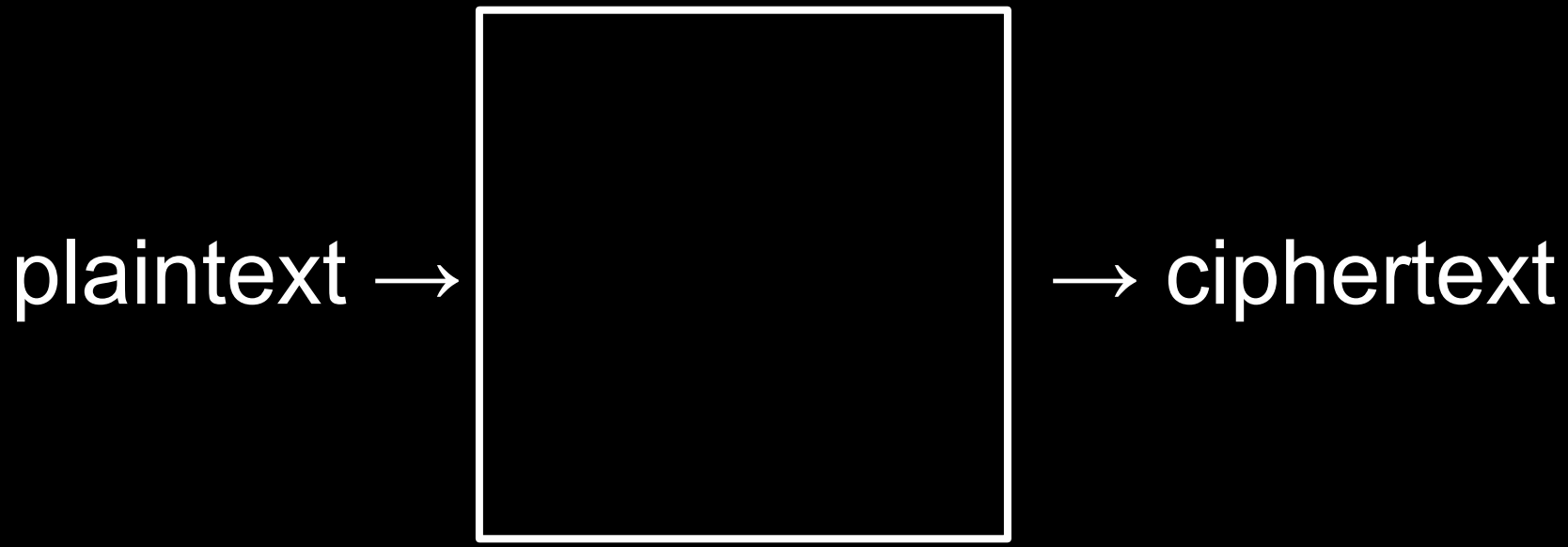
```c
#include <stdio.h>

int main(void)
{
    ...
}
```

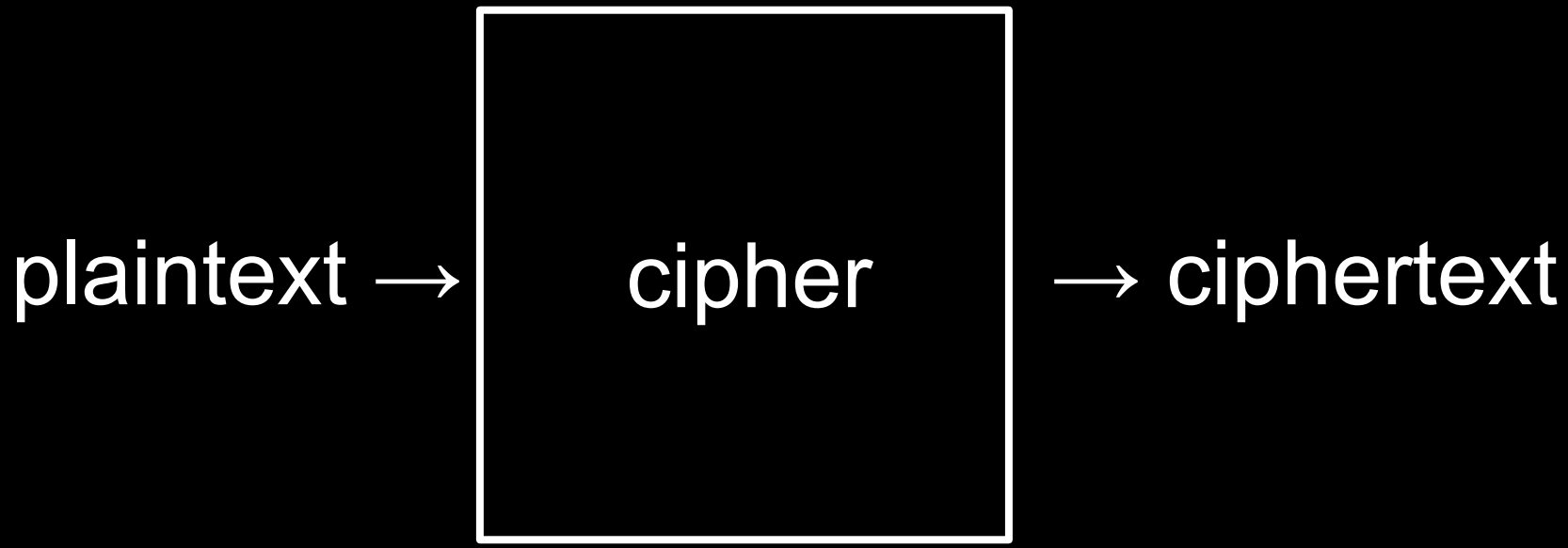
```
echo $?
```

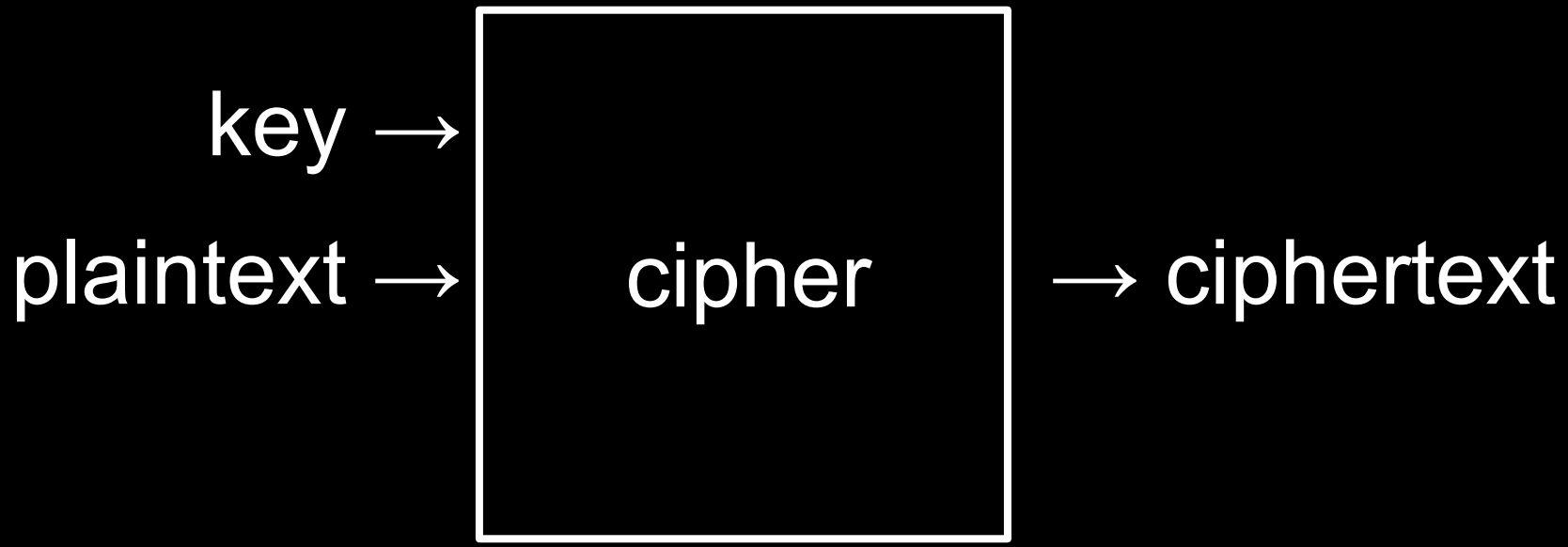
cryptography

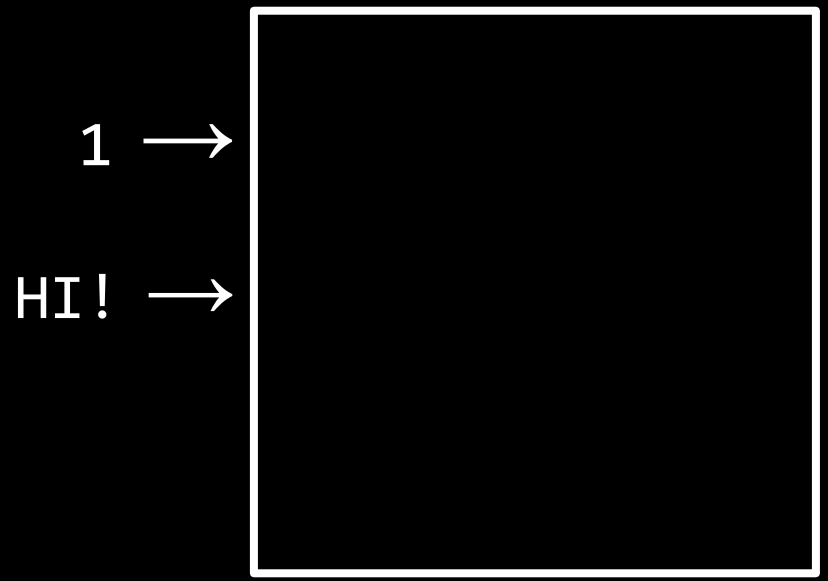
encryption

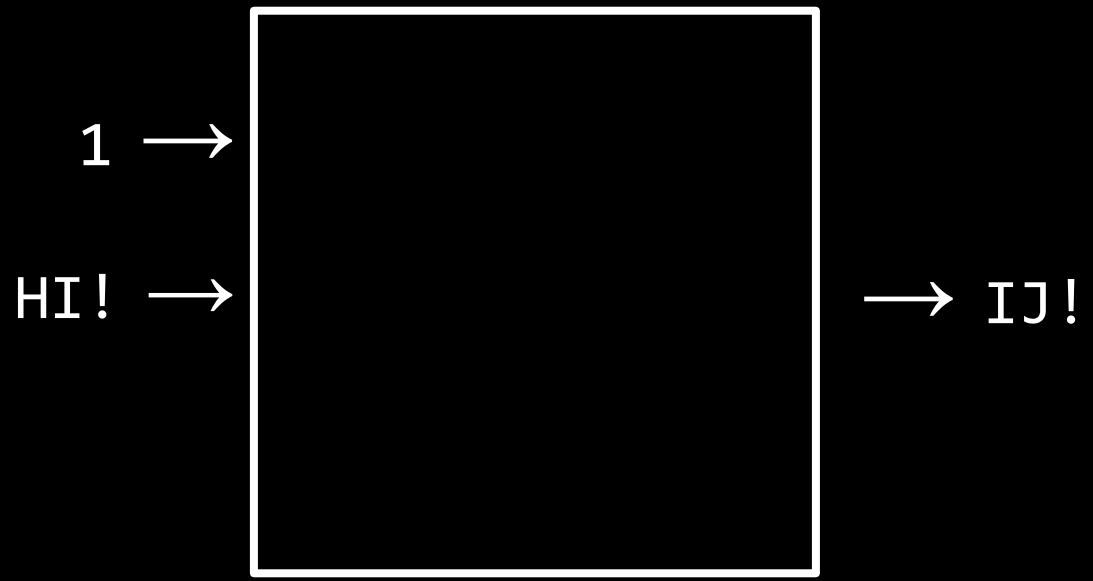

input →
→ output


plaintext →
→ ciphertext

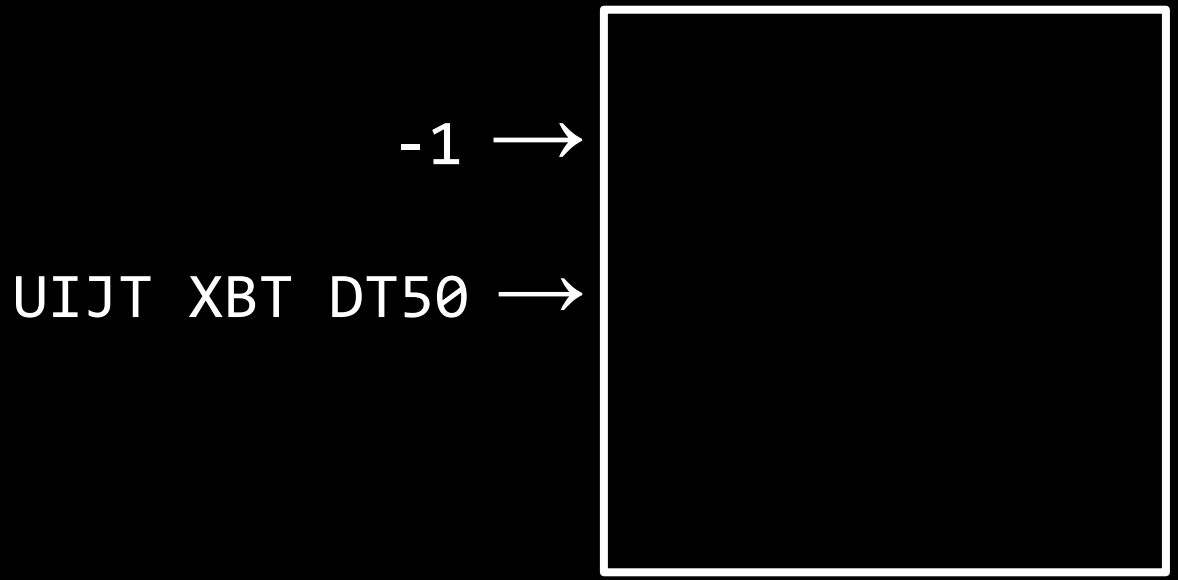

plaintext →
cipher
→ ciphertext


key →
plaintext →
cipher
→ ciphertext


1
HI!


1
HI!
IJ!

decryption


-1
UIJT XBT DT50

U I J T X B T D T 5 0

T I J T X B T D T 5 0

T H J T X B T D T 5 0

T H I T X B T D T 5 0

T H I S X B T D T 5 0

T H I S W B T D T 5 0

T H I S W A T D T 5 0

T H I S W A S D T 5 0

T H I S W A S C T 5 0

T H I S W A S C S 5 0


CS50
ddb

This is CS50