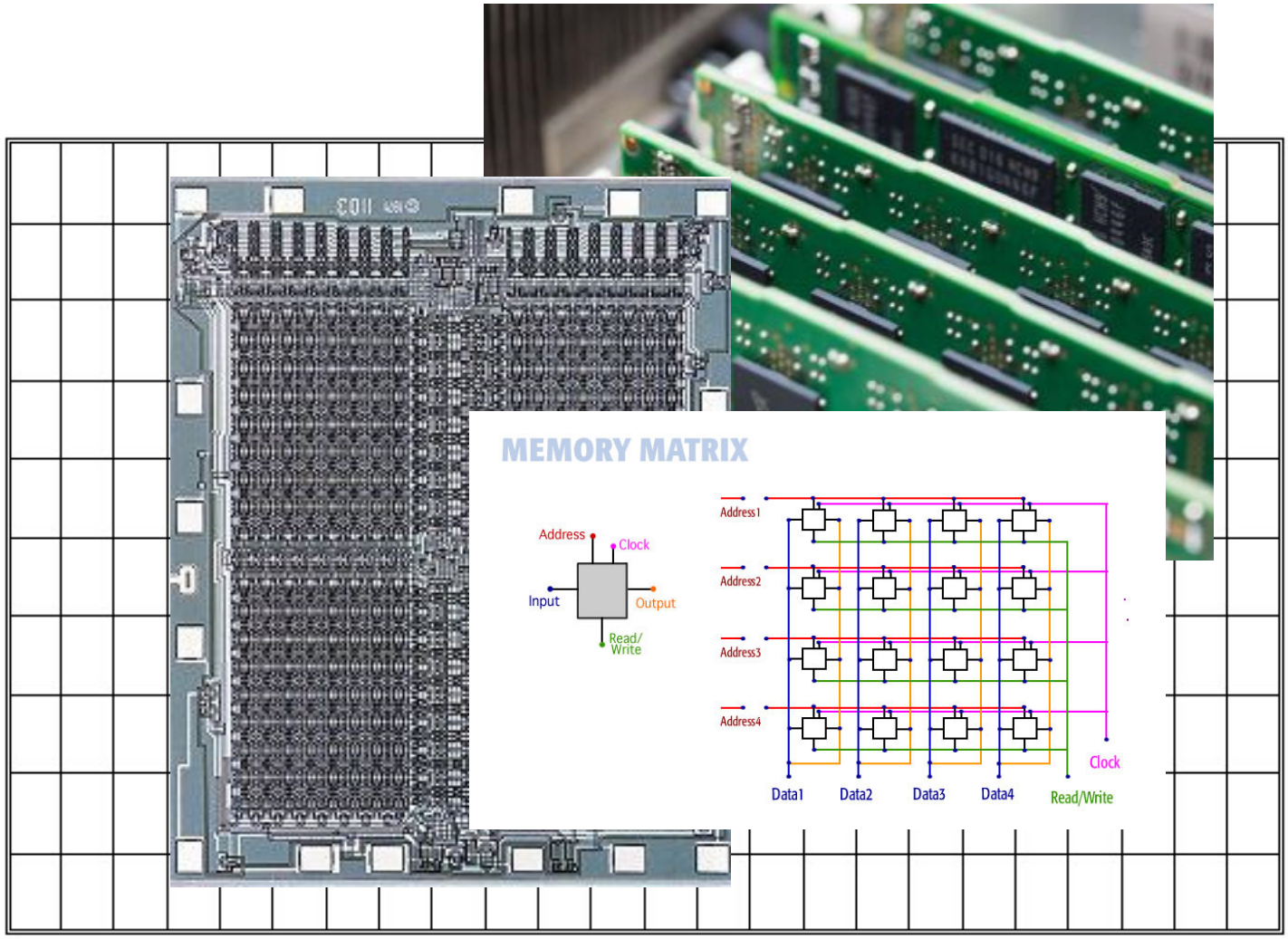
CS 2211
Systems Programming

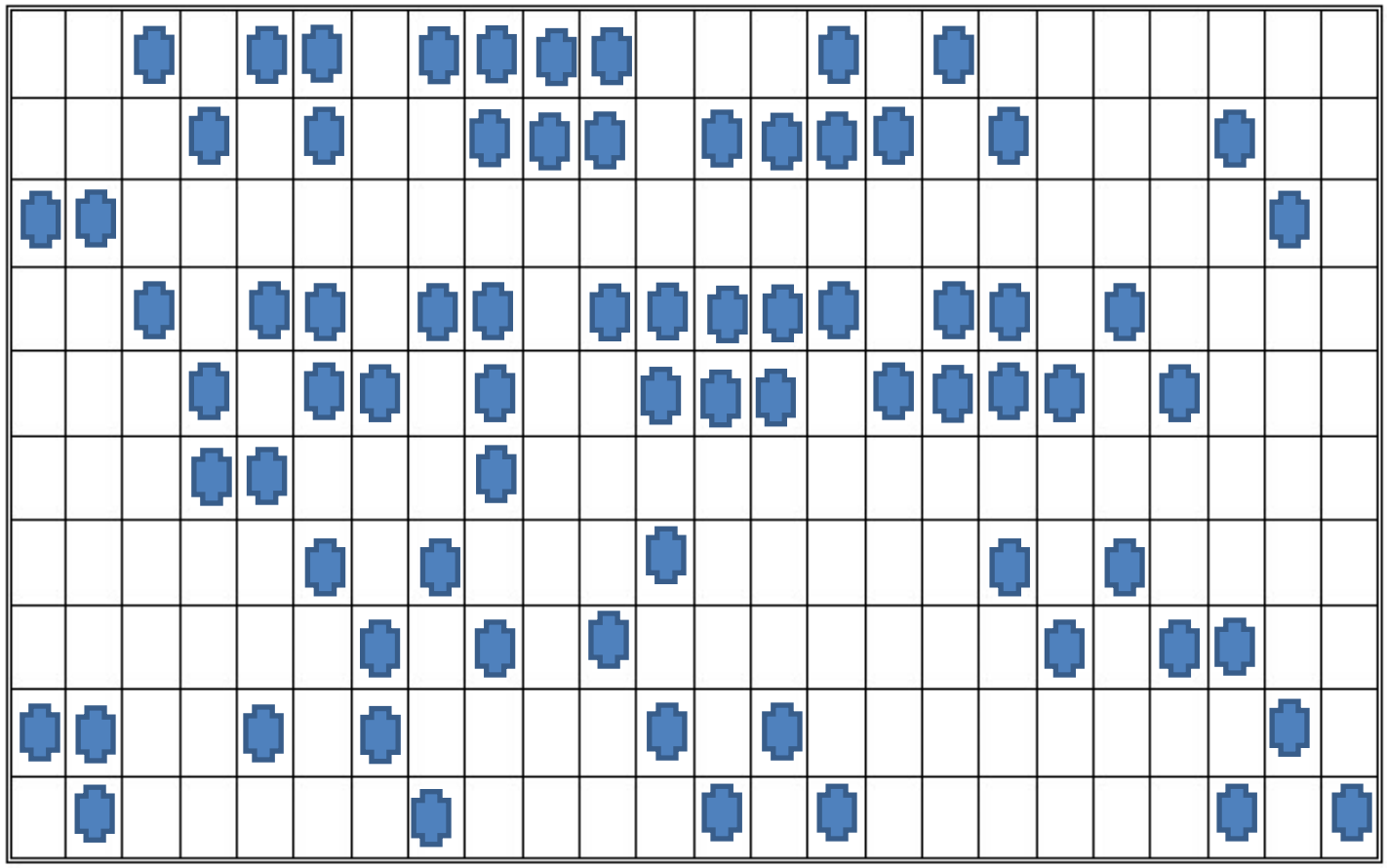
Part Four:

Memory Maps

COMPUTER MEMORY



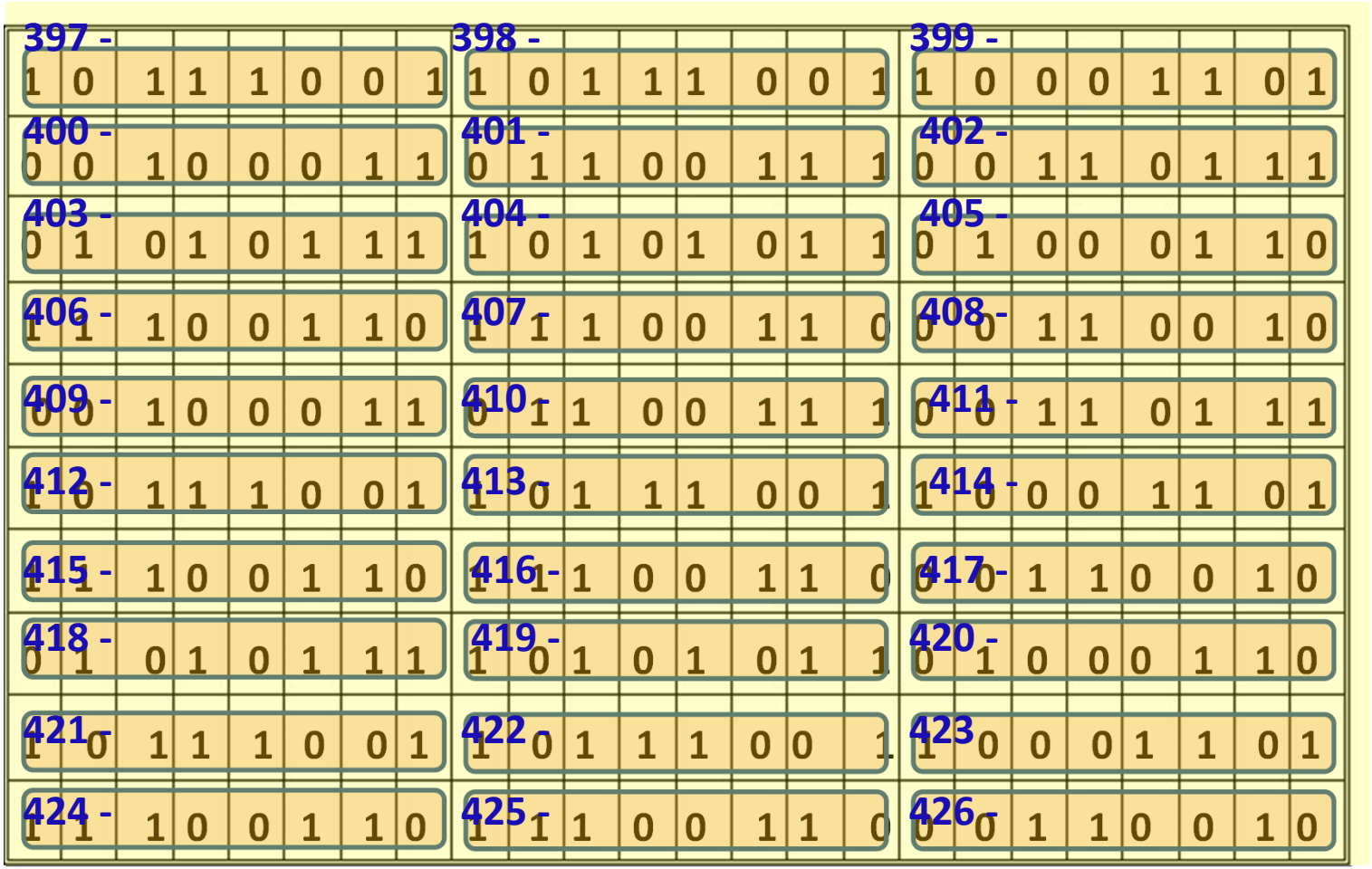
COMPUTER MEMORY



COMPUTER MEMORY

1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0

COMPUTER MEMORY



COMPUTER MEMORY

1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0

COMPUTER MEMORY

397 -							398 -							399 -							
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
400 -							401 -							402 -							
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
403 -							404 -							405 -							
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
406 -							407 -							408 -							
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
409 -							410 -							411 -							
0	0	1	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	1	1
412 -							413 -							414 -							
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1
415 -							416 -							417 -							
1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0
418 -							419 -							420 -							
0	1	0	1	0	1	1	1	1	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0
421 -							422 -							423 -							
1	0	1	1	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	1

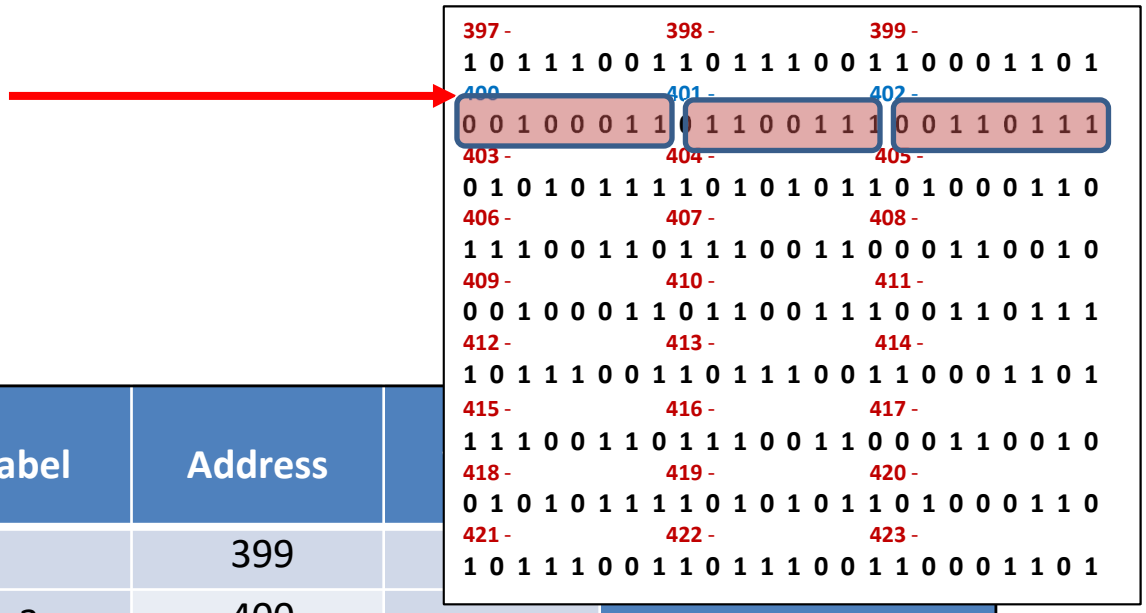
MEMORY MAPPING

```
char a, b, c;
```

Type	Label	Address	Value	Binary
		399		
		400		
		401		
		402		
		403		
		404		
		405		
		406		
		…		

MEMORY MAPPING

```
char a, b, c; /* char – 1 byte each */
```



Type	Label	Address		
		399		
char	a	400		
char	b	401		
char	c	402		
		403		
		404		
		405		
		406		
		…		

MEMORY MAPPING

```
char a, b, c; /* char – 1 byte each */
```

Side bar:

actual computer addresses reflect the size of the available memory.

Actual addresses look like:

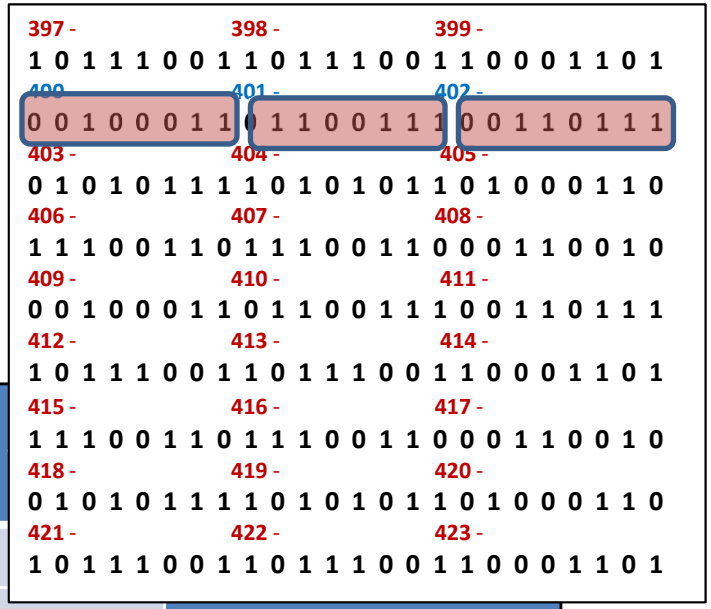
140727232603148
140727232603149
140727232603150

(-or displayed in hex:

0x7ffd9cb5a40c
0x7ffd9cb5a40d
0x7ffd9cb5a40e)

To make it easier to use and understand, we will use artificially small numbers like:

400 – 401 – 402 etc.

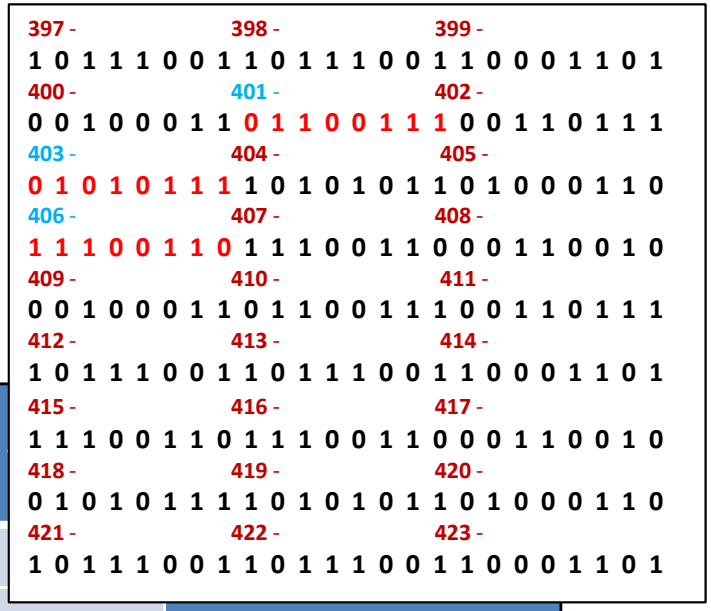


Address
399
400
401
402
403
404
405
406
…

MEMORY MAPPING

```
char a, b, c; /* char – 1 byte each */
```

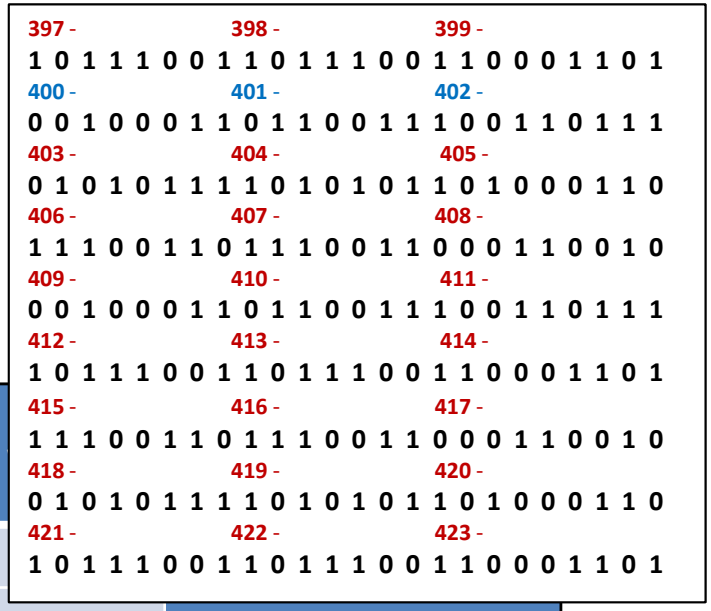
note: not necessarily **contiguous**
assigned to locations that are 'free' and available for the size required.



Type	Label	Address		
		399		
char	a	400		
		401		
		402		
char	c	403		
		404		
char	b	405		
		406		
		…		

MEMORY MAPPING

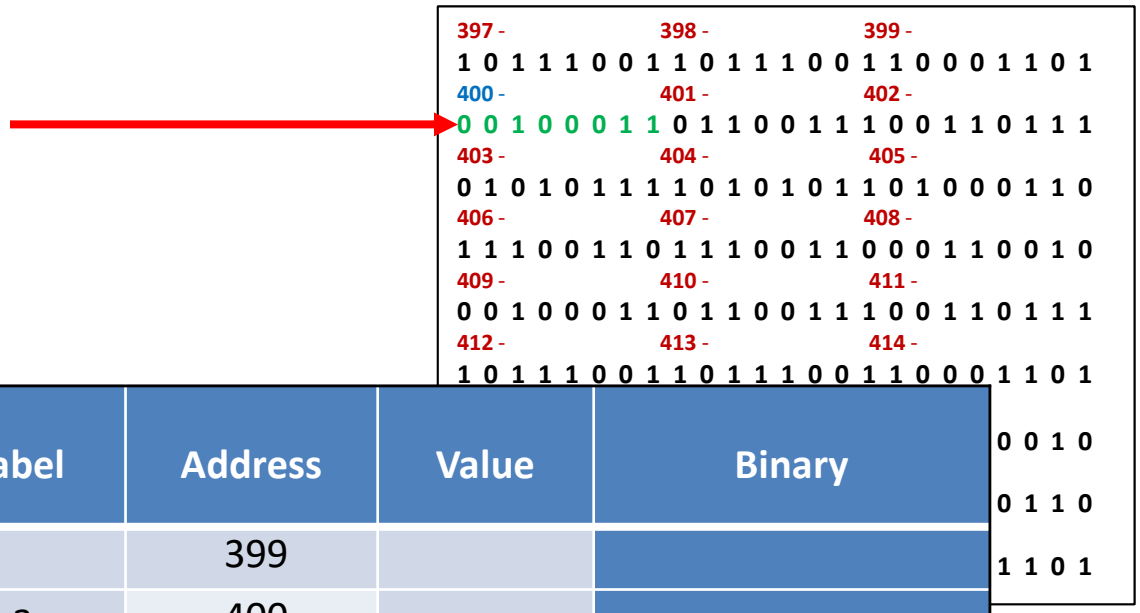
```
char a, b, c; /* char – 1 byte each */
```



Type	Label	Address		
		399		
char	a	400		
char	b	401		
char	c	402		
		403		
		404		
		405		
		406		
		…		

MEMORY MAPPING

```
char a, b, c; /* char – 1 byte each */
```



Type	Label	Address	Value	Binary
		399		
char	a	400		
char	b	401		
char	c	402		
		403		
		404		
		405		
		406		
		…		

MEMORY MAPPING

```
char a, b, c; /* char - 1 byte each */
a = 7;        /* (0000 0111) */
b = -13;      /* (1111 0011) */
c = 0;        /* (0000 0000) */
```

Type	Label	Address	Value	Binary
		399		
char	a	400	7	0000 0111
char	b	401	-13	1111 0011
char	c	402	0	0000 0000
		403		
		404		
		405		
		406		
		...		

Memory Maps

END OF PART 1

MEMORY MAPPING

```
char a = 7;
/* char: 1 byte */
```

Side bar:

char a = 7;

[variable declaration
- AND –
variable definition]

(computer process this as two separate statements)

1.) char a;
2.) a = 7;

Type	Label	Address	Value	Binary
		399		
		400		
		401		
		402		
		403		
		404		
		405		
		406		
		407		
		408		
		409		
		410		
		411		
		412		
		413		
		414		
		415		
		416		
		417		
		418		
		…		

MEMORY MAPPING

```
char a = 7;
/* char: 1 byte */
```

Side bar:

char a = 7;

[variable declaration
- AND –
variable definition]

(computer process this as two separate statements)

1.) char a;
2.) a = 7;

Type	Label	Address	Value	Binary
		399		
		400		
		401		
		402		
		403		
		404		
		405		
		406		
		407		
		408		
		409		
		410		
		411		
		412		
		413		
		414		
		415		
		416		
		417		
		418		
		…		

MEMORY MAPPING

```
char a = 7;
/* char: 1 byte */
```

Side bar:

char a = 7;

[variable declaration
- AND –
variable definition]

(computer process this as two separate statements)

1.) char a;
2.) a = 7;

Type	Label	Address	Value	Binary
		399		
		400		
		401		
		402		
		403		
		404		
		405		
		406		
		407		
		408		
		409		
		410		
		411		
		412		
		413		
		414		
		415		
		416		
		417		
		418		
		…		

MEMORY MAPPING

```
char a = 7;
/* char: 1 byte */

int b = -13;
/* int: 4 bytes */

float c = 0.1;
/* float: 4 bytes */

double d = 42.5;
/* double: 8 bytes */
```

Type	Label	Address	Value	Binary
		399		
char	a	400	7	0000 0111
int	b	401	-13	1111 1111
		402		1111 1111
		403		1111 1111
		404		1111 0011
float	c	405	0.1	0011 1110
		406		0000 0000
		407		0000 0000
		408		0000 0000
double	d	409	42.5	0100 0000
		410		0100 0101
		411		0100 0000
		412		0000 0000
		413		0000 0000
		414		0000 0000
		415		0000 0000
		416		0000 0000
		417		
		418		
		...		

MEMORY MAPPING

```
char a = 7;
/* char: 1 byte */

int b = -13;
/* int: 4 bytes */

float c = 0.1;
/* float: 4 bytes */

double d = 42.5;
/* double: 8 bytes */
```

Type	Label	Address	Value	Binary
		399		
char	a	400	7	0000 0111
int	b	401	-13	1111 1111
		402		1111 1111
		403		1111 1111
		404		1111 0011
float	c	405	0.1	0011 1110
		406		0000 0000
		407		0000 0000
		408		0000 0000
double	d	409	42.5	0100 0000
		410		0100 0101
		411		0100 0000
		412		0000 0000
		413		0000 0000
		414		0000 0000
		415		0000 0000
		416		0000 0000
		417		
		418		
		...		

MEMORY MAPPING

```
char a;
int b;
float c;
double d;

a = 7;          /* 1 byte */
b = -13;        /* 4 bytes */
c = 0.1;        /* 4 bytes */
d = 42.5;       /* 8 bytes */
```

A BETTER WAY OF VISUALIZING THE MAP:

Label	Address	Value
	399	
a	400	7
b	401 - 404	-13
c	405 - 408	0.1
d	409 - 416	42.5
	417	
	418	
	419	
	...	

Memory Maps

END OF PART 2

MEMORY MAPPING

```
char a;
int b;
float c;
double d;
```

ALLOCATION NOT NECESSARILY CONTIGOUS:

Label	Address	Value
	399	
a	400	
	…	
d	409 - 416	
	…	
b	510 - 513	
	…	
c	605 - 608	
	…	
	…	
	…	
	…	

MEMORY MAPPING

```
char a;
int b;
float c;
double d;

a = 7;          /* 1 byte */
b = -13;        /* 4 bytes */
c = 0.1;        /* 4 bytes */
d = 42.5;       /* 8 bytes */
```

ALLOCATION NOT NECESSARILY CONTIGOUS:

Label	Address	Value
	399	
a	400	7
	…	
d	409 - 416	42.5
	…	
b	510 - 513	-13
	…	
c	605 - 608	0.1
	…	
	…	
	…	
	…	

MEMORY MAPPING

```
char a;
int b;
float c;
double d;

a = 7;          /* 1 byte */
b = -13;        /* 4 bytes */
c = 0.1;        /* 4 bytes */
d = 42.5;       /* 8 bytes */
```

ALLOCATION NOT NECESSARILY CONTIGOUS:

Label		
a		
d		
b		
	…	
c	605 - 608	0.1
	…	
	…	
	…	
	…	

397 -	398 -	399 -
1 0 1 1 1 0 0 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 0 1		
400 -	401 -	402 -
0 0 1 0 0 0 1 1 0 1 1 0 0 1 1 1 0 0 1 1 0 1 1 1		
403 -	404 -	405 -
0 1 0 1 0 1 1 1 1 0 1 0 1 0 1 1 0 1 0 0 0 1 1 0		
406 -	407 -	408 -
1 1 1 0 0 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 0 0 1 0		
409 -	410 -	411 -
0 0 1 0 0 0 1 1 0 1 1 0 0 1 1 1 0 0 1 1 0 1 1 1		
412 -	413 -	414 -
1 0 1 1 1 0 0 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 0 1		
415 -	416 -	417 -
1 1 1 0 0 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 0 0 1 0		
418 -	419 -	420 -
0 1 0 1 0 1 1 1 1 0 1 0 1 0 1 1 0 1 0 0 0 1 1 0		
421 -	422 -	423 -
1 0 1 1 1 0 0 1 1 0 1 1 1 0 0 1 1 0 0 0 1 1 0 1		

MEMORY MAPPING

```
char a;
int b;
float c;
double d;
```

VARIABLE DECLARATION VS. VARIABLE DEFINITION:

VARIABLE DECLARATION:
the variable is only declared and allocated a block of memory but still has no value

Label	Address	Value
	399	
a	400	
	…	
d	409 - 416	
	…	
b	510 - 513	
	…	
c	605 - 608	
	…	
	…	
	…	
	…	

MEMORY MAPPING

VARIABLE DECLARATION VS. VARIABLE DEFINITION:

```
a = 7;          /* 1 byte */
b = -13;        /* 4 bytes */
c = 0.1;        /* 4 bytes */
d = 42.5;       /* 8 bytes */
```

VARIABLE DEFINITION:
to assign or initialize it with some specific value

Label	Address	Value
	399	
a	400	7
	…	
d	409 - 416	42.5
	…	
b	510 - 513	-13
	…	
c	605 - 608	0.1
	…	
	…	
	…	
	…	

Memory Maps

END OF PART 3

MEMORY MAPPING

Scalar Variables versus Aggregate Variables

So far, the only variables we've seen are **scalar**: capable of holding a single data item.

C also supports **aggregate** variables, which can store collections of values.

There are two kinds of aggregates in C: **arrays** and **structures**.

We will start by looking at one-dimensional arrays,
which play a much bigger role in C than do multidimensional arrays.

An array is a data structure containing a number of data values, all of which have the same type.

These values, known as elements, can be individually selected by their position within the array.

The elements of a one-dimensional array a are conceptually arranged
one after another in a single row (or column):

MEMORY MAPPING

Scalar Variables versus Aggregate Variables

To declare an array, we must specify the type of the array's elements and the number of elements:

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

The elements may be of any type; the length of the array can be any (integer) constant expression.

An array, like any other variable, can be given an initial value at the time it's declared.
The most common form of array initializer is a list of constant expressions enclosed in braces and separated by commas:

```
int a[10] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
```

If the initializer is shorter than the array, the remaining elements of the array are given the value 0:

```
int a[10] = {1, 2, 3, 4, 5, 6};
/* initial value of a is {1, 2, 3, 4, 5, 6, 0, 0, 0, 0} */
```

If an initializer is present, the length of the array may be omitted:

```
int a[] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
```

The compiler uses the length of the initializer to determine how long the array is.

MEMORY MAPPING [ARRAYS]

```
int a[2];
/* int: 4 bytes */

float b[3];
/* float: 4 bytes */

double c[4];
/* double: 8 bytes */

char d[6];
 /* char: 1 byte */
```

Label	Address	Value	
a[0]	400 - 403		int a[2];
a[1]	404 - 407		
b[0]	408 - 411		float b[3];
b[1]	412 - 415		
b[2]	416 - 419		
c[0]	420 - 427		double c[4];
c[1]	428 - 435		
c[2]	436 - 443		
c[3]	444 - 451		
d[0]	452		char d[6];
d[1]	453		
d[2]	454		
d[3]	455		
d[4]	456		
d[5]	457		

MEMORY MAPPING [ARRAYS]

```
int a[2] = {37, 52};
/* int: 4 bytes */

float b[3] = {26, 54};
/* float: 4 bytes */

double c[4];
/* double: 8 bytes */

char d[6];
 /* char: 1 byte */

c[2] = 14.7;
```

Label	Address	Value	
a[0]	400 - 403	37	`int a[2];`
a[1]	404 - 407	52	
b[0]	408 - 411	26	`float b[3];`
b[1]	412 - 415	54	
b[2]	416 - 419	0	
c[0]	420 - 427	?	`double c[4];`
c[1]	428 - 435	?	
c[2]	436 - 443	14.7	
c[3]	444 - 451	?	
d[0]	452	?	`char d[6];`
d[1]	453	?	
d[2]	454	?	
d[3]	455	?	
d[4]	456	?	
d[5]	457	?	
	...		

MEMORY MAPPING [ARRAYS]

```
int a[2] = {37, 52};
/* int: 4 bytes */

float b[3] = {26, 54};
/* float: 4 bytes */

double c[4];
/* double: 8 bytes */

char d[6];
 /* char: 1 byte */

c[2] = 14.7;

d[4] = 'a';

/* BUT !now what happens if:
(because - this will compile
 and run) */

b[4] = 15.9;
/* memory location 424-427 */
```

Label	Address	Value	
a[0]	400 - 403	37	`int a[2];`
a[1]	404 - 407	52	
b[0]	408 - 411	26	`float b[3];`
b[1]	412 - 415	54	
b[2]	416 - 419	0	
c[0]	420 **424 - 427**	? **15.9**	`double c[4];`
c[1]	428 - 435	?	
c[2]	436 - 443	14.7	
c[3]	444 - 451	?	
d[0]	452	?	`char d[6];`
d[1]	453	?	
d[2]	454	?	
d[3]	455	?	
d[4]	456	a	
d[5]	457	?	
	...		

MEMORY MAPPING [ARRAYS]

```
int a[2] = {37, 52};
/* int: 4 bytes */

float b[3] = {26, 54};
/* float: 4 bytes */

double c[4];
/* double: 8 bytes */

char d[6];
 /* char: 1 byte */

c[2] = 14.7;

d[4] = 'a';

/* OR !! This */

b[3333] = 15.9;
/* memory location 15205 */
```

run time error :
out of program allowed bounds

Label	Address	Value	
a[0]	400 - 403	37	`int a[2];`
a[1]	404 - 407	52	
b[0]	408 - 411	26	`float b[3];`
b[1]	412 - 415	54	
b[2]	416 - 419	0	
c[0]	420 - 427	?	`double c[4];`
c[1]	428 - 435	?	
c[2]	436 - 443	14.7	
c[3]	444 - 451	?	
d[0]	452	?	`char d[6];`
d[1]	453	?	
d[2]	454	?	
d[3]	455	?	
d[4]	456	a	
d[5]	457	?	
b[3333]	15205	15.9	

MEMORY MAPPING [ARRAYS]

If an initializer is present,
the length of the array may be omitted:

```
int a[] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
```

The compiler uses the length of the initializer to determine how long the array is.

Label	Address	Value
a[0]	400 - 403	1
a[1]	404 - 407	2
a[2]	408 - 411	3
a[3]	412 - 415	4
a[4]	416 - 417	5
a[5]	420 - 421	6
a[6]	424 - 425	7
a[7]	428 - 431	8
a[8]	432 - 435	9
a[9]	436 - 439	10

Memory Maps

END OF PART 4

MEMORY MAPPING [ARRAYS – MULTIDIMENSIONAL]

```
int a[3][2];
/* a 3 by 2 table */
/* 3 rows and 2 columns */
/* 6 cells of 4 bytes each */
/* caution: never a[3,2] */
```

	0	1
0	0 0	0 1
1	1 0	1 1
2	2 0	2 1

Label	Address	Value
a[0][0]	400 - 403	
a[0][1]	404 - 407	
a[1][0]	408 - 411	
a[1][1]	412 - 415	
a[2][0]	416 - 419	
a[2][1]	420 - 423	

C stores arrays in ***row-major order,*** with row 0 first, then row 1, and so forth. (sort of ….)

MEMORY MAPPING [ARRAYS – MULTIDIMENSIONAL]

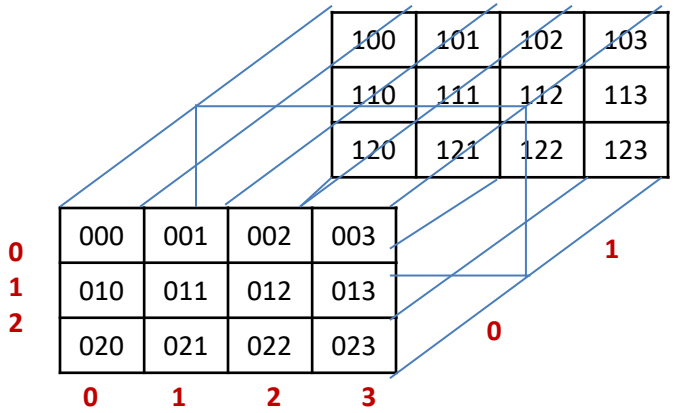
```
int a[3][2];
/* a 3 by 2 table */

a[0][1] = 7;
a[1][0] = 13;
```

	0	1
0		(7)
1	(13)	
2		

Label	Address	Value
a[0][0]	400 - 403	
a[0][1]	404 - 407	7
a[1][0]	408 - 411	13
a[1][1]	412 - 415	
a[2][0]	416 - 419	
a[2][1]	420 - 423	

MEMORY MAPPING [ARRAYS – THREE DIMENSIONAL]

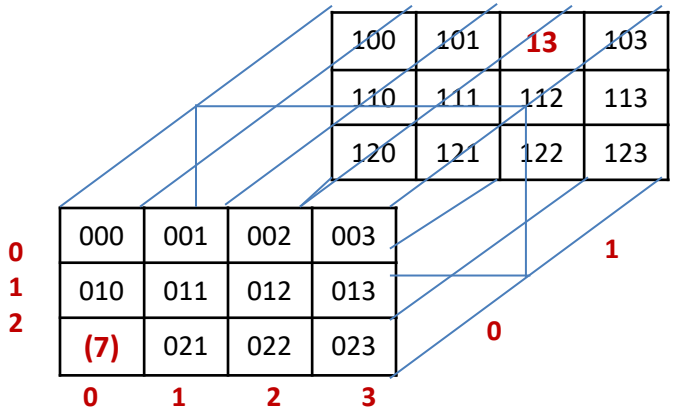
```
int b[2][3][4];
/* a 2 by 3 by 4 table */
/* 2 layers 3 rows 4 columns */
/* 24 cells of 4 bytes each */
```



Label	Address	Value		Label	Address	Value
b[0][0][0]	400 - 403			b[1][0][0]	448 – 451	
b[0][0][1]	404 - 407			b[1][0][1]	452 – 455	
b[0][0][2]	408 - 411			b[1][0][2]	456 – 459	
b[0][0][3]	412 - 415			b[1][0][3]	460 – 463	
b[0][1][0]	416 - 419			b[1][1][0]	464 – 467	
b[0][1][1]	420 - 423			b[1][1][1]	468 – 471	
b[0][1][2]	424 – 427			b[1][1][2]	472 – 475	
b[0][1][3]	428 – 431			b[1][1][3]	476 – 479	
b[0][2][0]	432 – 435			b[1][2][0]	480 – 483	
b[0][2][1]	436 – 439			b[1][2][1]	484 – 485	
b[0][2][2]	440 – 443			b[1][2][2]	488 – 491	
b[0][2][3]	444 - 447			b[1][2][3]	492 - 495	

MEMORY MAPPING [ARRAYS – THREE DIMENSIONAL]

```
int b[2][3][4];
/* a 2 by 3 by 4 table */

 b[0] [2] [0] = 7;
 b[1] [0] [2] = 13;
```



Label	Address	Value		Label	Address	Value
b[0][0][0]	400 - 403			b[1][0][0]	448 – 451	
b[0][0][1]	404 - 407			b[1][0][1]	452 – 455	
b[0][0][2]	408 - 411			b[1][0][2]	456 – 459	13
b[0][0][3]	412 - 415			b[1][0][3]	460 – 463	
b[0][1][0]	416 - 419			b[1][1][0]	464 – 467	
b[0][1][1]	420 - 423			b[1][1][1]	468 – 471	
b[0][1][2]	424 – 427			b[1][1][2]	472 – 475	
b[0][1][3]	428 – 431			b[1][1][3]	476 – 479	
b[0][2][0]	432 – 435	7		b[1][2][0]	480 – 483	
b[0][2][1]	436 – 439			b[1][2][1]	484 – 485	
b[0][2][2]	440 – 443			b[1][2][2]	488 – 491	
b[0][2][3]	444 - 447			b[1][2][3]	492 - 495	

MEMORY MAPPING [VARIABLE LENGTH ARRAYS]

```
int n = 3;
int a[n+1];
/* int: 4 bytes */
```

ARRAY SIZE DETERMINED AT RUN TIME

Label	Address	Value
a[0]	400 - 403	
a[1]	404 - 407	
a[2]	408 - 411	
a[3]	412 - 415	

`int a[n+1];`

Memory Maps

END OF PART 5

MEMORY MAPPING [STRINGS – A SPECIAL ARRAY OF CHARACTERS]

```
char d[8]
/* char: 1 byte */

 d[0] = 'H'
 d[1] = 'e';
 d[2] = 'l;
 d[3] = 'l;
 d[4] = 'o';
 d[5] = '\0';
```

ARRAY OF CHARACTERS IS NOT A STRING
-> until '\0' is assigned (the NULL character)

Label	Address	Value
d[0]	400	H
d[1]	401	e
d[2]	402	l
d[3]	403	l
d[4]	404	o
d[5]	405	\0
d[6]	406	
d[7]	407	

`char d[8];`

STRINGS:
(array of char : terminated with null)

MEMORY MAPPING [STRINGS – A SPECIAL ARRAY OF CHARACTERS]

STRING ARRAY assigned a VALUE

```
char d[8] = "Magic";
/* char: 1 byte */
```

Label	Address	Value
d[0]	400	M
d[1]	401	a
d[2]	402	g
d[3]	403	i
d[4]	404	c
d[5]	405	\0
d[6]	406	0
d[7]	407	0

`char d[8];`

STRINGS:
(when assigned within quotes automatically terminated with null)

STRINGS (SIZE):
(the size of the string at d is: 5
- not 8.
MORE ON THIS LATER…)

MEMORY MAPPING [STRINGS – A SPECIAL ARRAY OF CHARACTERS]

STRING ARRAY assigned a VALUE

```
char d[] = "Code";
/* char: 1 byte */
```

Label	Address	Value
d[0]	400	C
d[1]	401	o
d[2]	402	d
d[3]	403	e
d[4]	404	\0

```
char d[8];
```

STRINGS:
(when no size specified – array of characters automatically assigned just enough memory for characters PLUS the terminating NULL)

STRINGS (SIZE):
(the size of the string at d is: 5
MORE ON THIS LATER…)

Memory Maps

END OF PART 6

Use of a memory map in a dynamic way:

(tracing a program) - what's wrong with this ??

```
int i, sum;
int n = 0;
for ( i=1; i <=10; i++)
   if ( i % 2 == 0 )
        sum = sum + 1 + i;
```

Label	Address	Value
	...	

Memory Maps

END OF PART 7