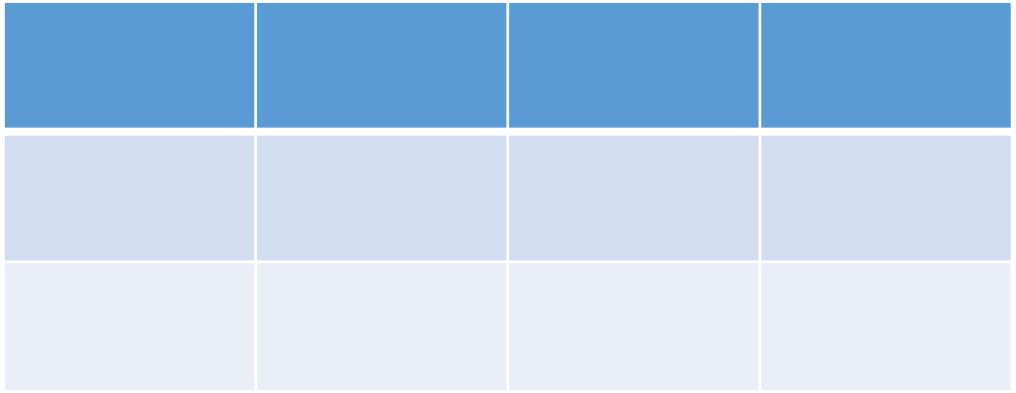
Pointers vs. Arrays

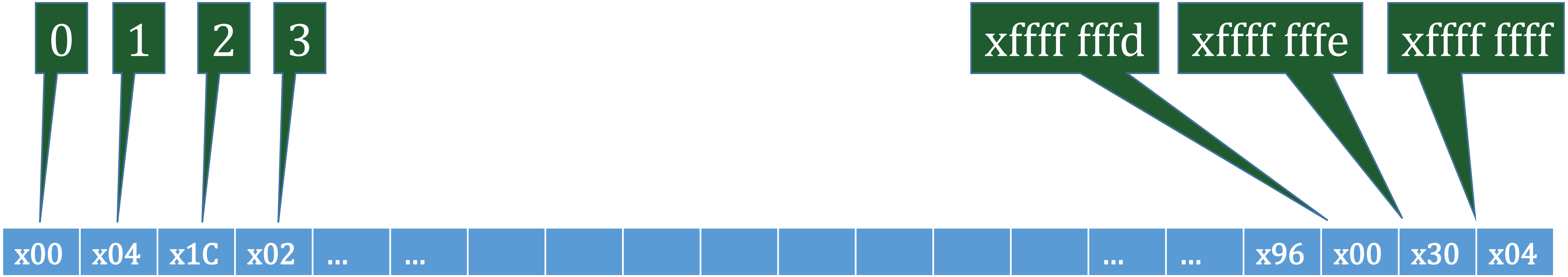


Pointers in C

- Pointers are a special data type
- The VALUE of a pointer is an address
- The TYPE of a pointer is “pointer to <target_type>
  - pointer to character
  - pointer to integer
  - pointer to float
  - pointer to array of integers
  - …

Memory

- Array of bytes
- Each element has a value

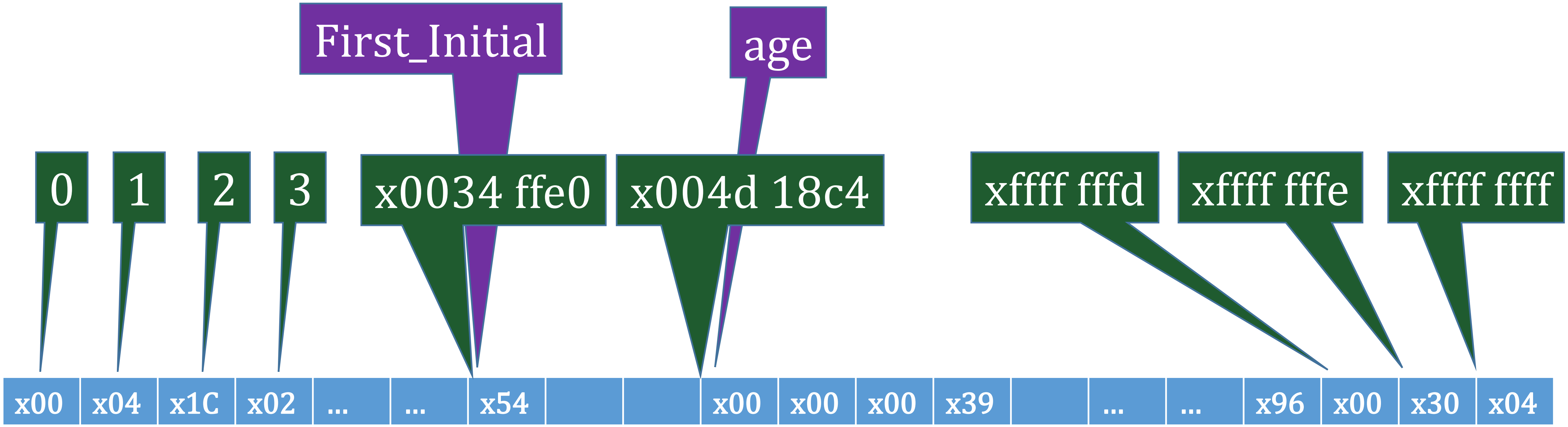


0 1 2 3 xffff fffd xffff fffe xffff ffff

x00 x04 x1C x02 … … … … x96 x00 x30 x04

Variables In Memory

- Every variable starts at a specific location in memory
- Type of variable tells how many bytes (spaces) in memory



Array Values are “Contiguous”

- Right next to each other in memory
- int vec[6]

vec[0]	vec[1]	vec[2]	vec[3]	vec[4]	vec[5]

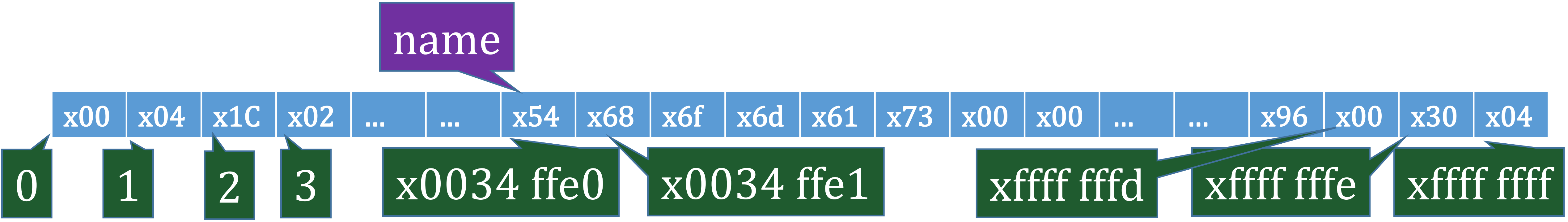
- int m [4][3];

m[0][0]	m[0][1]	m[0][2]	m[1][0]	m[1][1]	m[1][2]	m[2][0]	m[2][1]	m[2][2]	m[3][0]	m[3][1]	m[3][2]

Example Array in Memory

```
char name[8]="Thomas";
printf("name is at %p\n",&name[0]);
```

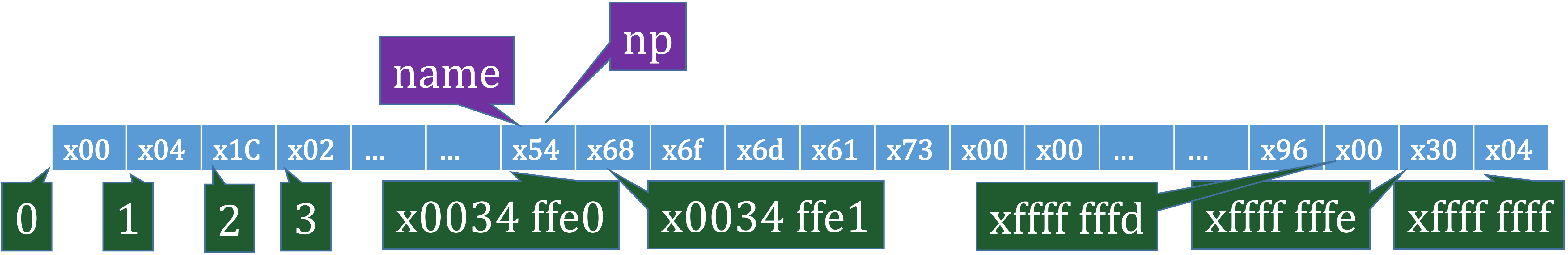
```
name is at 0x34ffe0
```



Pointer to Array in Memory

```
char name[8]=“Thomas”;
char *np=&name[0];
printf(“np is %p\n”,np);
```

np is at 0x34ffe0



name

np

x00 x04 x1C x02 … … x54 x68 x6f x6d x61 x73 x00 x00 … … x96 x00 x30 x04

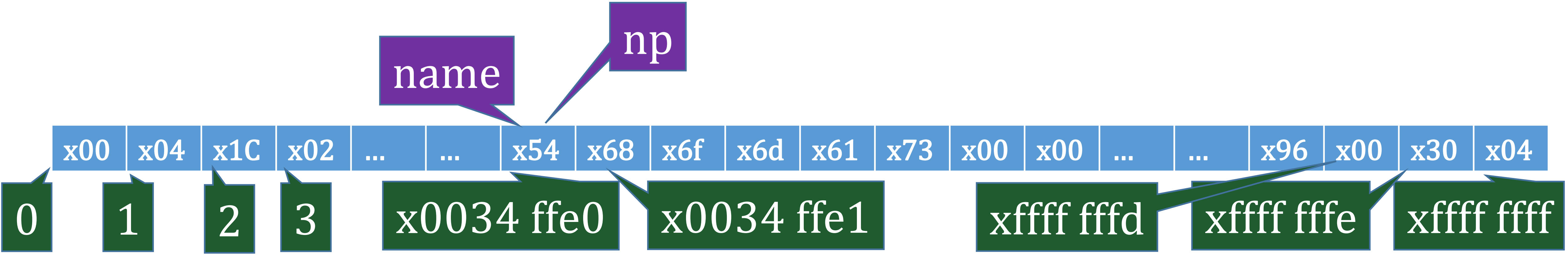
0 1 2 3 x0034 ffe0 x0034 ffe1 xffff fffd xffff fffe xffff ffff

What are we Pointing At?

```
char name[8]=“Thomas”;
char *np=&name[0];
printf(“np -> %c\n”,(*np));
```

```
np -> T
```

Question:
Does np point to a single character?

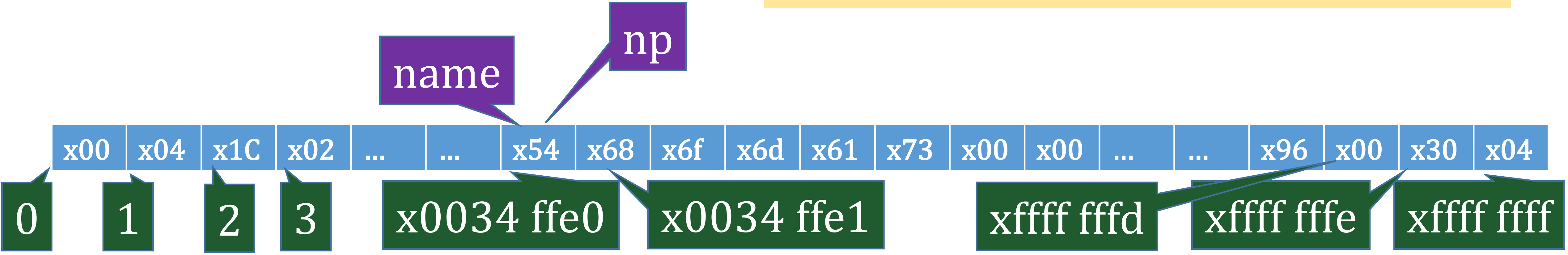


What are we Pointing At?

```
char name[8]=“Thomas”;
char *np=&name[0];
printf(“np ->%c-%c-%c…\n”,*np,*(np+1),*(np+2));
```

```
np -> T-h-o…
```

Question:
Does np point to a single character?
Or an array of characters?



x00	x04	x1C	x02	…	…	x54	x68	x6f	x6d	x61	x73	x00	x00	…	…	x96	x00	x30	x04

What is a “string”?

- A “string” is just a vector of ASCII characters
  - Followed by a “null terminator” – a byte with the value 0x00

char str[14]=“This a string”;

{‘T’, ’h’, ’i’, ’s’, ’ ‘, ’a’, ’ ‘, ’s’, ’t’ ,’r’ ,’i’ ,’n’ ,’g’, x00}

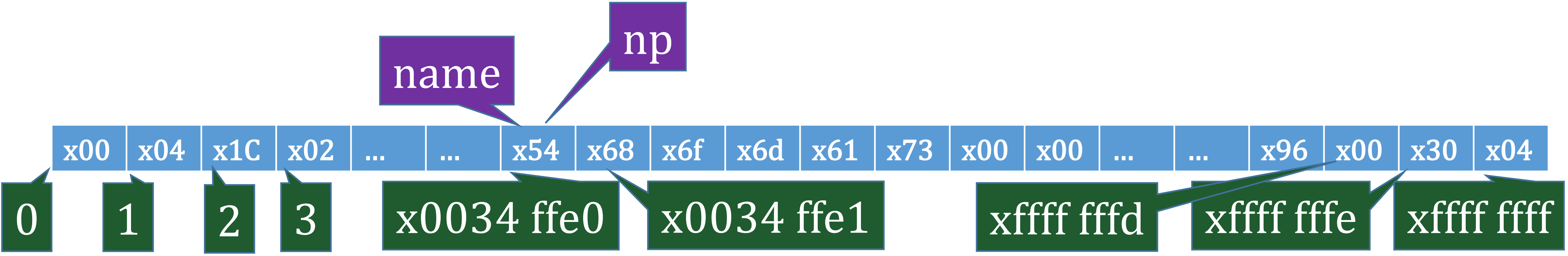
Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13
ASCII	T	h	i	s		a		s	t	r	i	n	g	
Hex	x54	x68	x69	x73	x20	x61	x20	x73	x74	x72	x69	x6e	x67	x00

What are we Pointing At?

```
char name[8]="Thomas";
char *np=&name[0];
printf("np ->%s\n",np);

np -> Thomas
```

Question:
Does np point to a single character?
Or an array of characters?
Or a string?



A Pointer points to one or more elements of a specific type

(Actually, zero or more, but who's counting)

Integer Vector in Memory

```
int v[4]={11,12,13,14};
```

v[0]	v[1]	v[2]	v[3]
x00 00 00 0B	x00 00 00 0C	x00 00 00 0D	x00 00 00 0E
x00c0 0014	x00c0 0018	x00c0 001c	x00c0 0020

```
int *vp=&v[0]; // vp=x00c0 0014
printf(“vp-> %d %d %d … \n”,*vp,*(vp+1),*(vp+2));
```

```
vp-> 11 12 13
```

Pointer Arithmetic

- “Unit” (1) is the size of a single element in bytes
  - For char, unit=1
  - For int, unit=4
  - For float, unit=4
  - For pointers, unit=4

- When we add “1” to an integer pointer, it increases by 4!
  - points to the next integer address!

2D Arrays in Memory

```
int m[4][3]={11,12,13,21,22,23,31,32,33,41,42,43};
```

m[0][0]	m[0][1]	m[0][2]	m[1][0]	m[1][1]	m[1][2]	m[2][0]	m[2][1]	m[2][2]	m[3][0]	m[3][1]	m[3][2]
11	12	13	21	22	23	31	32	33	41	42	43
c0 0014	c0 0018	c0 001c	c0 0020	c0 0024	c0 0028	c0 002c	c0 0030	c0 0034	c0 0038	c0 003c	c0 0040

```
int *mp=&m[0][0]; // mp=x00c0 0014
printf(“mp-> %d %d %d … \n”,*mp,*(mp+1),*(mp+2));
printf(“row 3: %d %d %d\n”,*(mp+6),*(mp+7),*(mp+8));
```

```
mp-> 11 12 13
row 3: 31 32 33
```

What is an un-sub-scripted Array?

```
char name[8]=“Thomas”;
printf(“name[0] is at %p\n”,&name[0]);
printf(“name value is %x\n”,name);
```

```
name[0] is at 0x23cb10
name value is 23cb10
```

```
array == &array[0]
```

What is a String?

```
char name[8]=“Thomas”;
printf(“name[0] is at %p\n”,&name[0]);
printf(“name value is %x\n”,name);
printf(“name string is %s\n”,name);
```

```
name[0] is at 0x23cb10
name value is 23cb10
name string is Thomas
```

A string is a pointer to one or more characters

What is a String?

```
char *name=“Thomas”;
printf(“name[0] is at %p\n”,&name[0]);
printf(“name value is %x\n”,name);
printf(“name string is %s\n”,name);
```

```
name[0] is at 0x23cb10
name value is 23cb10
name string is Thomas
```

In C, Pointers and Arrays are Virtually Interchangeable!

Array vs. Pointer Notation

Array	Pointer
&array[0]	array
array[i]	*(array+i)

strlen implementations

Using array notation

```
int strlen(char str[]) {
        int i=0;
        while(str[i]!=x00) i++;
        return i;
}
```

Using pointer notation

```
int strlen(char *str) {
        int i=0;
        while((*str)!=0) {
                i++; str++;
        }
        return i;
}
```

Resources

- Programming in C, Chapter 10
- Wikepedia Pointers : https://en.wikipedia.org/wiki/Pointer_(computer_programming)
- C Pointer Tutorial : http://www.tutorialspoint.com/cprogramming/c_pointers.htm